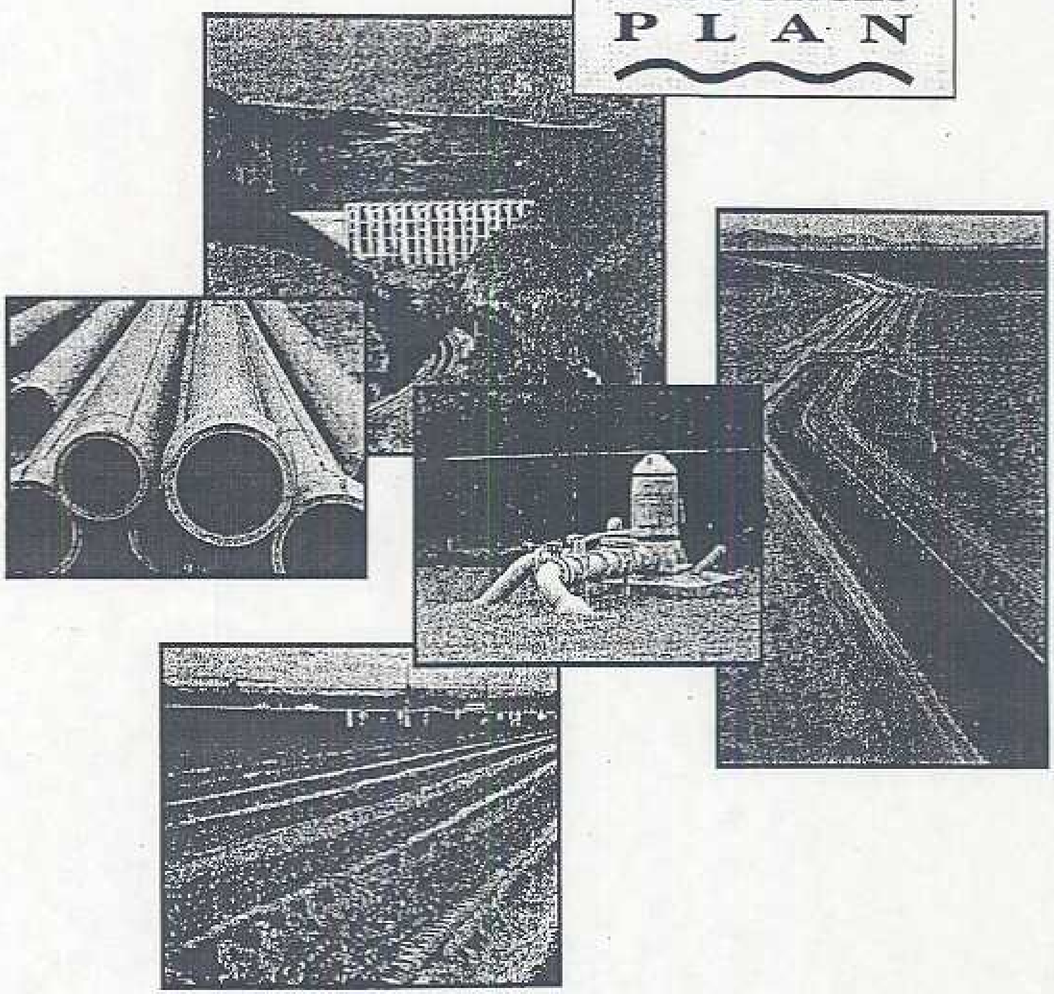
San Diego County Water Authority

WATER RESOURCES PLAN



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San Diego County Water Authority

Water Resources Plan

Prepared by:
San Diego County Water Authority
Water Resources Department
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WATER RESOURCES PLAN
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ABBREVIATIONS

The abbreviations used in this report are:

AAC	All-American Canal
af	acre-feet
af/yr	acre-feet per year
Authority	San Diego County Water Authority
AWRA	American Water Resources Association
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BMPs	Best Management Practices
Bureau	Bureau of Reclamation
CAP	Central Arizona Project
CEQA	California Environmental Quality Act
cfs	cubic feet per second
CIP	Capital Improvements Program
Code	California Water Code
CRA	Colorado River Aqueduct
CRW	Colorado River water
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project

ABBREVIATIONS (Continued)

CVPIA	Central Valley Project Improvements Act
CVWD	Coachella Valley Water District
D-1485	Decision 1485
DFG	Department of Fish and Game
DHS	Department of Health Services
DWA	Desert Water Agency
DWR	Department of Water Resources
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
ESA	Endangered Species Act
ESP	Emergency Storage Project
ESWC	Emergency Storage Working Committee
ESWTR	Enhanced Surface Water Treatment Rule
GIS	geographical information system
gpd	gallons per day
gphd	gallons per hour per day
gpm	gallons per minute
GRP	Groundwater Recovery Program
IAWP	Interim Agricultural Water Program
ID	Irrigation District
IID	Imperial Irrigation District
IRP	Integrated Resources Plan
IWR-Main	Institute for Water Resources - Muncipal and Industrial Needs
KCWA	Kern County Water Agency
LLNL	Lawrence Livermore National Laboratory
LPP	Local Projects Program
LRP	Local Resource Program
M&I	municipal & industrial
maf	million acre-feet
maf/yr	million acre-feet per year
MF	multi-family residential
mg/L	milligrams per liter
mg	million gallons
mgd	million gallons per day
MWWD	City of San Diego Metropolitan Wastewater Department
MOU	Memorandum of Understanding
MWD	Metropolitan Water District of Southern California
NDC	new demand charge
NEPA	National Environmental Policy Act
NPV	net present value
O&M	operations and maintenance
ppm	parts per million
PVID	Palo Verde Irrigation District
RER	Regional Economic Research, Inc.
RO	reverse osmosis
RRP	rate refinement process
RTS	readiness-to-serve charge

ABBREVIATIONS (Continued)

RWDF	Reclaimed Water Development Fund
RWQCB	Regional Water Quality Control Board
RWRC	Repurified Water Review Committee
SANDAG	San Diego Association of Governments
SF	single-family residential
SNWA	Southern Nevada Water Authority
SRF	State Revolving Fund
SSS	Seasonal Storage Service
SWP	State Water Project
SWRCB	State Water Resources Control Board
TDS	total dissolved solids
THMs	trihalomethanes
TODS	Twin Oaks Diversion Structure
ULFTs	ultra-low-flush toilets
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WD	water district
WRLP	Water Reclamation Loan Program
WTP	water treatment plant
YCWA	Yuba County Water Agency
YMWD	Yuima Municipal Water District

Executive Summary

From December 1990 through February 1992, the San Diego region endured water cutbacks and shortages associated with one of the worst droughts in recorded California history. At one point, imported water supplies were cut by 31 percent, and had the drought continued, the area may have faced water reductions of 50 percent. However, management actions by the San Diego County Water Authority (Authority) — including withdrawing water from the State Water Bank and maximizing local water resources — kept cutbacks to a 20 percent level.

This experience underscored the importance of water supply reliability. Accordingly, the Authority expanded efforts begun in 1989 to encourage additional development of local supplies through water recycling, groundwater recovery, seawater desalting, and demand management (water conservation).

The Strategic Plan, adopted in February 1995, established goals and objectives to ensure that the Authority could fulfill its mission to consistently provide a safe and reliable water supply to its member agencies that adequately supports the regional economy. Through its Strategic Plan, the Authority's goal is to meet 100 percent of the annual water supply requests of the member agencies 90 percent of the time, 90 percent of the requests 98 percent of the time, and never less than 80 percent of requests.

PURPOSE OF THE WATER RESOURCES PLAN

The challenge to the Authority is to provide an accurate estimate of future water requirements and to recommend the best mix of water resources for meeting those requirements. The Water Resources Plan is the primary vehicle through which these issues are addressed.

The first Water Resources Plan, published in November 1993, was developed for a planning period through 2010. The Plan highlighted the need for the Authority to improve reliability by diversifying its sources of supply and reducing its dependence on imported water from the Colorado River Aqueduct (CRA) and the State Water Project (SWP). These supplies are transported by the Metropolitan Water District of Southern California (MWD). Future reliability of these sources will be affected by a declining availability of firm Colorado River supplies and uncertainty over the future yield of the SWP. In addition, these supplies are transported by large pipelines that are vulnerable to earthquake and other natural hazards. Thus, a diverse water resources mix is critical to the continued well-being of the San Diego region.

The 1993 Plan projected that normal-year demand in 2010 would be 902,000 acre-feet (af), without adjusting for conservation. Approximately 82 percent of this supply (687,000 af) would be imported water from MWD. The remaining supplies were envisioned to come from conservation (70,000 af), existing local supply (60,000 af), new recycling (50,000 af), new seawater desalination (20,000 af), and new groundwater (15,000 af).

EMERGING OPPORTUNITIES

To maintain flexibility and respond to emerging opportunities, the Plan is updated regularly. This first update, which includes projections through the year 2015, evaluates important new potential supply sources. The most notable is the opportunity for normal-year transfers that could supply more than 60 percent of the total projected 2015 demand. This water could come from either Colorado River or Northern or Central California sources. Transfers of up to 500,000 af/yr are considered for development in this Plan.

A transfer of this or similar magnitude

would have a major impact on water resources management in California, affecting MWD's status as the Authority's sole supplier of imported water. The discussion generated by this Plan should help the Authority determine the proper place of water transfers in the appropriate resources mix through 2015.

Both the Colorado River and the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) sources of transfer have major environmental considerations, as well as institutional and regulatory considerations. Because of the complexity of water rights issues associated with transfers — and because of the potential impact of large-scale transfers on historic water resources management planning — this document takes an extensive look at water transfers: what they are, how they work, and their suitability as a component in the Authority's long-term planning.

A public outreach program was begun to obtain the community's perspective on these opportunities and other water issues, to increase public awareness about the Authority's long-range planning efforts, and to encourage two-way communication on specific relevant issues.

ALTERNATIVES

The 1997 Water Resources Plan assumes a 2015 water resources demand of 870,000 af, before conservation adjustments. Six major alternatives for meeting this demand were developed. Each water resources mix is characterized by a mix of MWD, local, and/or transfer supplies that would be required in 2015. Under this set of alternatives, MWD could be the largest component or a secondary component of the supply. The alternatives are:

Existing Strategy Alternative.

This baseline alternative would continue the resources strategy adopted in the 1993 Water Resources Plan. The mix of resources selected would change from the 1993 Plan to reflect updated cost estimates of both local and imported supplies, as well as revised demand forecasts. However, the 1993 resources development goal would be retained: to pursue an intermediate amount of cost-effective local supplies that would meet the Authority's reliability goal. Analysis was done to compare the benefits and costs of supplementing the existing strategy with transfers during dry years.

Maximum Local Supply Alternative.

This alternative was designed to determine the costs and benefits of developing the maximum amount of local supplies, including recycling, repurification, groundwater, and seawater desalination. It shows the minimum amount of MWD supply that would be required if local resources were developed at the maximum level, both with and without normal-year transfers. Using a maximum effort, about 125,000 af/yr in new local resources could be provided. This would increase the local supply component to about 24 percent of the Authority's 2015 supply, assuming 60,000 af/yr from existing sources.

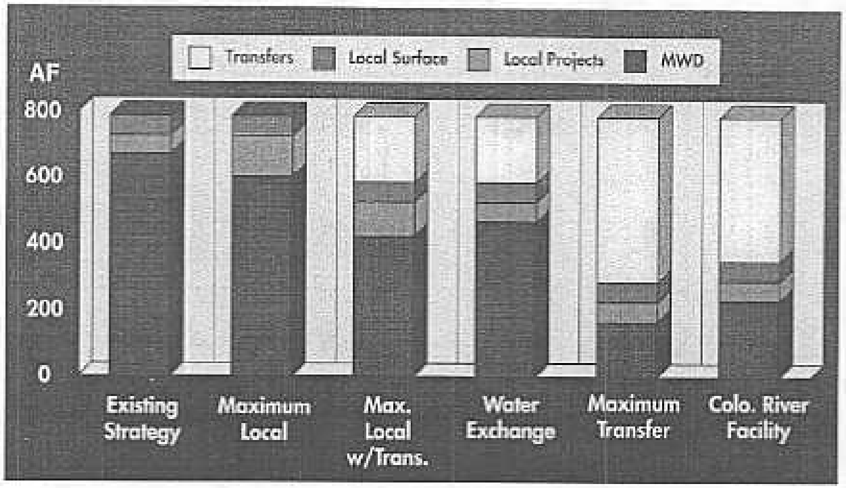
Maximum Local Supply With Transfers Alternative.

This alternative is similar to the previous alternative, with two major exceptions: up to 200,000 af/yr of transfers would be developed, and the seawater desalination project would not be constructed. This would reduce the 2015 new local supply total to about 105,000 af/yr. Transfers would be conveyed through the CRA or SWP.

Intermediate Transfers Alternative.

This alternative would develop an intermediate level of normal-year transfers, defined as transfers up to 200,000 af/yr. Transfers would be acquired from the Colorado River, or from Northern or Central California sources, and transported through the CRA or SWP. Local supplies would be developed only if they were cost-effective, compared with imported water supplies. This results in a projection of about 62,000 af/yr of new local supplies by 2015.

FIGURE ES-1 Alternative Resource Mixes (in thousand af) Year 2015



from San Diego County to the Imperial Valley to transport 500,000 af/yr from the Colorado River. At least a portion of this water would be treated using a reverse osmosis desalination process, causing losses of 13 percent. The yield would thus be about 435,000 af/yr.

Figure ES-1 provides a graphic illustration of the relative size of each component comprising the six alternative resource mixes.

Maximum Transfers Alternative.

This alternative explores the maximum anticipated level of transfer without constructing new, separate facilities. A transfer amount of 500,000 af/yr was modeled. Water from this alternative could be a combination of Colorado River water and water of Northern and/or Central California origin.

Colorado River Facilities Alternative.

The final alternative modeled was a conveyance facility that would be constructed

ALTERNATIVES ANALYSIS

Each of the alternatives was evaluated using the criteria shown in **Table ES-1**. Total costs over the 20-year period were evaluated using an economic optimization model that provided the least cost mix of supplies for a given alternative under a set of assumptions and constraints. Potential rate impacts were evaluated using a financial analysis that showed the average annual costs of untreated

TABLE ES-1 Evaluation Criteria for Resource Selection

Criterion	Description
1. Cost	Minimize total cost of the alternative from 1996-2015.
2. Degree of Authority Control	Maximize control Authority has over water supplies.
3. Environmental Impacts	Minimize amount of environmental harm.
4. Feasibility	Maximize confidence that resources will be developed.
5. Rate Impacts	Minimize increases on Authority water rates.
6. Reliability	Maximize supply availability.
7. Water Quality	Minimize salinity and other undesirable parameters.

TABLE ES-2 Summary of Evaluation

Criteria	Exist Strtgy	Max Local	Max Local w/Trans	Intermed Trans	Max Trans[1]	CR Facility
Degree of Authority Control RATING	Fair	Poor	Fair	Fair	Good	Good
Environmental RATING	Fair	Fair	Fair	Fair	Fair	Poor
Feasibility RATING	Fair	Fair	Good	Good	Fair	Poor
Rates RATING	Good	Fair	Good	Good	Good	Poor
Reliability RATING	Fair	Fair	Good	Good	Good	Good
Total Cost RATING	Good	Poor	Fair	Good	Good	Poor
Water Quality RATING	Good	Good	Fair	Fair	Good	Poor
OVERALL RATING	Fair	Fair	Fair	Good	Good	Poor

Good ● Fair ◍ Poor ○

[1] Water is transferred from Northern/Central California and/or Colorado River.

water under each alternative, and thus the relative risk of rate increases. The remaining five criteria were evaluated using qualitative methods. **Table ES-2** presents a summary of the alternatives analysis.

CONCLUSIONS AND SELECTION OF A RESOURCES MIX

The six alternatives considered in this Water Resources Plan exhibit tradeoffs in satisfying the evaluation criteria. The most visible tradeoff is that between cost and reliability. Each alternative was rated on a "good," "fair," or "poor" basis for each criterion, and the unweighted results were cumulated for the selection process. An initial screening of the results eliminated three alternatives: the Maximum Local Supply Alternative, the Maximum Transfer Alternative, and the Colorado River Facilities Alternative.

The Maximum Local Supply Alternative increased costs substantially without offering significant improvements in reliability or Authority control. The Maximum Transfers

Alternative was eliminated for feasibility reasons and also because at current demand levels, this quantity of transfer (500,000 af/yr) is not needed for supply diversity and reliability reasons. The Colorado River Facilities Alternative had the highest total cost and the greatest potential for rate increases of all six alternatives. This alternative also had serious concerns regarding feasibility and environmental impacts. All three of these alternatives may be reconsidered in future updates of the Water Resources Plan.

Under certain assumptions made in the analysis, the Existing Strategy Alternative was found to be the least-cost alternative. However, the remaining two alternatives utilizing normal-year transfers and increased local supplies offered increased water supply reliability and Authority control over water resources at a modest increase in cost. These alternatives were the Maximum Local Supply With Transfers Alternative and the Intermediate Transfers Alternative. Both of these alternatives remained in the selection process because of these potential benefits.

No single alternative was selected for exclusive development. Instead, the increased local supply and core transfer components of the remaining alternatives were retained to provide a target range of resources development. The additional local supplies and core transfers have some degree of uncertainty attached to future implementation, including additional considerations that Authority member agencies may have regarding local supply development and assumptions used to evaluate core transfers. If these supplies do not materialize, the Authority would have a resources mix similar to that of the Existing Strategy Alternative.

This Water Resources Plan selects a mix of future water supplies that include core (normal-year) transfers of up to 200,000 af/yr and 120,000-165,000 af of local supplies. Best Management Practices (BMPs) for water conservation are recommended that would result in water savings of 82,000 af/yr by 2015. MWD would continue to supply most of the Authority's water, providing up to 467,000 af/yr, or about 60 percent of total demand. **Table ES-3** shows the amounts of various supplies that would be developed under the selected alternative.

TABLE ES-3 Supply Development of the Selected Resource Mix

Year	MWD	Transfer	Recl	Grndwtr	Ext Local	Total
2000	499,000	40,000	18,000	19,000	60,000	636,000
2005	412,000-432,000	140,000	30,000-45,000	23,000-28,000	60,000	685,000
2010	387,000-412,000	200,000	30,000-50,000	32,000-37,000	60,000	734,000
2015	422,000-465,000	200,000	30,000-60,000	32,000-45,000	60,000	787,000

It should be kept in mind that actual resources development over the next 20 years will depend greatly on variables for which assumptions were made in this analysis. The major assumptions include projected MWD rates and non-rate charges, future water demands, costs of development and transportation of transfer supplies, levels of water conservation, and local supply development incentives and conditions.

Chapter 1

1.0 INTRODUCTION

The mission of the San Diego County Water Authority (Authority) is to provide a safe and reliable supply of water to its member agencies serving the San Diego region. This Water Resources Plan presents the Authority's water resources options through 2015. The Authority's first Water Resources Plan was issued in 1993. This document updates that Plan to reflect current conditions, including the development of better planning information and the emergence of potentially significant new water sources.

1.1 HISTORY AND DESCRIPTION OF AUTHORITY

The Authority was established by the California Legislature in 1943 to provide a supplemental supply of water as the region's civilian and military population expanded to meet wartime activities. In 1947, water began to be imported from the Colorado River via a single pipeline that connected to the Metropolitan Water District of Southern California's (MWD) Colorado River Aqueduct (CRA) located in Riverside County. In order to meet the demand for water from a growing population and economy, four additional pipelines were constructed between the 1950s and early 1980s. The Authority is now the predominant source of water, supplying from 70 to 95 percent of the region's needs, depending upon annual runoff into local reservoirs.

The Authority is comprised of 23 member agencies which directly or indirectly purchase water for use at the retail level. The County of San Diego is an ex-officio member. The Authority is governed by a 34-member Board of Directors. The member agencies and service area are described in detail in Chapter 2. The member agencies - six cities, four water districts, eight municipal water districts, three irrigation districts, a public utility district, and a federal military reservation - have diverse and varying water needs.

1.2 OBJECTIVES OF WATER RESOURCES PLAN

The Water Resources Plan presents the basis for projected water resources development in the Authority's service area. The Plan has two primary functions: (1) to provide an accurate estimate of future water requirements, and (2) to recommend the best mix of water resources for meeting those requirements. Currently-available water resources include imported supplies purchased through MWD, local surface water, recycling, and groundwater supplies. Potential local supplies include seawater desalination and the indirect potable reuse of recycled water, known as water repurification. In contrast to the 1993 Plan, which considered only dry year water transfers, the 1997 Plan explores normal year water transfers as well.

1.2.1 Relationship to Strategic Plan

The Authority adopted a Strategic Plan in 1995 that established: (1) a water supply goal, (2) a facilities goal, and (3) a facilities maintenance goal. From the Strategic Plan, the Authority's operating plans and annual budgets are developed. The Water Resources Plan is one of four primary support plans/programs to the Strategic Plan. The other three are the Capital Improvement Program (CIP), the Financing Plan, and the Public Affairs Plan. Through these four programs, the goals of the Strategic Plan are accomplished.

The first goal sets the Authority's standard for water supply reliability, which is to meet

100 percent of the annual water supply requests of the member agencies 90 percent of the time; 90 percent of the requests 98 percent of the time; and never less than 80 percent of the requests. This Water Resources Plan recommends a mix of water resources capable of meeting the 1995 Strategic Plan reliability goal. The 1993 Water Resources Plan had a different reliability goal; at that time, the goal was to provide no less than 88 percent of normal demands by 2010. As the Water Resources Plan is updated, it will account for changes in reliability goals and other water supply considerations.

The second Strategic Plan goal is to provide the necessary facilities for a safe, reliable, and operationally-flexible water storage, treatment, and delivery system. The CIP develops these facilities. The third goal is to maintain the necessary facilities to support the water supply goal and to minimize short-term system outages. This goal is met through the development and implementation of a comprehensive Operations and Maintenance (O&M) program.

1.2.2 Time Frame

The Water Resources Plan was first adopted by the Authority Board of Directors in 1993. To remain current with changes in both water demand and supply conditions, the Plan is updated every two years. The first update for the plan was originally scheduled for November 1995. That completion date was postponed to accommodate several projects deemed critical to resources planning. These projects included a computer model for urban water demand forecasting, a computer model for optimizing water resources opportunities, an assessment of local groundwater potential, and a public outreach program.

Since the publication of the first Water Resources Plan, the Authority has reviewed long-term, or "core," water transfers as a potential supply. Water for these transfers could come from the Colorado River, Central California, or Northern California. Transfers and local supplies could meet up to 87 percent of demand under certain planning scenarios.

The Authority and MWD are currently negotiating a transfer proposal in which the Authority would obtain long-term transfer supplies from the Colorado River and transport the water via MWD's CRA. Issues to be resolved include compensation for the use of MWD's facilities and determining the maximum amount of water to be transferred. The Authority is seeking to transfer about 200,000 af/yr under this proposal. The negotiations are expected to continue into 1997. Because of the potential impact of this proposal on water resource planning, the schedule for the Plan update was adjusted.

1.3 OVERVIEW OF ISSUES

In a general sense, this Water Resources Plan seeks to provide the most reliable, cost effective water supply for the San Diego region. To do this, the Plan attempts to balance the tradeoff inherent in cost versus reliability; greater reliability frequently involves additional expense. Resources selected for development must meet other criteria as well. They must be feasible to develop or construct, minimize negative environmental impacts, avoid spikes in the Authority's water rates, and meet water quality standards. The Authority is also seeking to obtain an increased measure of local control in its resource mix and depend less heavily upon MWD for imported water.

1.3.1 Water Supply Reliability

Until 1991-92, the Authority was able to meet its member agencies' requests for imported water without mandatory water conservation. However, in those two years, MWD was forced by a prolonged statewide drought to reduce water deliveries to its member agencies, and the Authority's member agencies suffered supply cutbacks of up to 20 percent. This brought the issue of supply reliability to the forefront of water resources planning and illustrated the connection between a reliable supply of water and the region's social and economic well being.

The Authority is committed by its Mission Statement and its Strategic Plan to provide a reliable supply of water. The issue of reliability is therefore not whether the supply will be reliable, but instead the degree of reliability. The Strategic Plan directs the Authority to ensure that MWD continues to meet its adopted level of service objective, seek adoption and implementation of a comprehensive state water plan, and develop local water supply options and implement water conservation best management practices (BMPs).

MWD established a reliability policy in December 1995. The policy provides that MWD and its member agencies "will have the full capability to meet full-service demands at the retail level at all times." The policy also indicates that MWD will take all appropriate actions, in coordination with its member agencies and subagencies, to assure that full-service demands at the retail level will be satisfied under all foreseeable hydrologic conditions. This essentially means that MWD believes that its imported supplies, plus its member agency local supplies, will be sufficient to prevent any shortages from occurring during dry years.

Because the Authority is currently dependent on MWD as its sole source of imported water, MWD's new reliability policy is of vital importance. Several factors may affect MWD's ability to meet its reliability goals. These concerns, which are described more fully in Chapter 7, also affect the Authority's ability to meet its own Strategic Plan goals.

Two requirements of water supply reliability must be considered in any analysis of the Authority's needs. The first is to develop and manage water supplies to minimize future shortages. The Authority is considering all water resources on an equal basis, including imported supplies, local supplies, and demand management (water conservation). Various mixes of these supplies are evaluated for impacts on supply availability during normal and dry-weather years. This Plan assumes that increased diversity of sources of supply, including development of local supplies, improves supply reliability.

The second reliability requirement is to construct an infrastructure that is reliable in terms of the physical delivery of water. This is largely handled through the Authority's CIP. The CIP includes options for constructing the facilities necessary to prevent damaging water shortages caused by the lack of system capacity or service interruptions caused by earthquakes or other disasters. This form of reliability is important to the Authority, which is dependent upon hundreds of miles of pipelines for its water supply.

1.3.2 Emerging Resource Opportunities

Since the adoption of the first Water Resources Plan, developments have taken place which have caused the water industry to rethink its approach to resource management The U.S. Bureau of Reclamation, the preeminent federal agency involved in western water issues, has focused its priorities away from capital projects construction to an emphasis on managing water resources through federal-state and federal-local partnerships. By providing a catalyst to water recycling and conservation through targeted funding programs and encouraging water transfers between willing sellers and buyers, the Bureau has become a major investor in reliable water supplies in Southern California. The State Department of Water Resources and MWD have both placed greater emphasis on managing existing resources and investing in projects owned and operated by local agencies as opposed to large scale, capital intensive water supply projects.

Significant opportunities in water supply development have also emerged since the adoption of the 1993 Water Resources Plan in two major areas: the expansion of recycled water markets through water repurification and the consideration of agricultural transfers as a normal-year supply.

Advances in technology and changes in the regulations governing the use of recycled water have opened up the potential for water repurification. The ability to introduce highly treated recycled water to the potable system via a surface water reservoir allows a water reuse project to more fully utilize the production capacity of a water recycling plant by providing a year-round market. This has increased the potential use of recycled water in the Authority's service area.

Drawing upon the successes of energy deregulation, the water industry is employing various types of public-private partnerships as an option to address its resource needs. These partnerships are also being formed to cost-effectively address a growing service need of the public sector. Privatization as a public-private partnership is based on the concept of sharing benefits and risks. In a typical privatization transaction, the private sector receives the business opportunity of owning and/or operating a water or wastewater facility, and the local government receives cost-effective delivery of a necessary service. Privatization may be used for all types of water and wastewater facilities, including distribution and collection systems and treatment plants. Of these, however, the most attractive candidates for privatization are typically stand-alone facilities such as a treatment plant. One Authority member agency, Ramona Municipal Water District, has chosen privatization for the operation of its wastewater treatment plant. The City of San Diego is evaluating various privatization options as a way to finance, construct, and or operate key water facilities within its service area.

The Authority is exploring opportunities for public-public partnerships as a means of furthering the emerging water transfer market in California. This Plan evaluates the potential of public-public partnerships for both supply development and transportation of transfer water. These partnerships would be formed to cost-effectively address the supply needs of the Authority, and at the same time, offer sufficient financial incentives to encourage the development of the transfer opportunity.

The willingness of agricultural interests to enter into long-term transfer agreements with urban water agencies has expanded the potential of water marketing as a source of supply. The establishment of a legal framework has made it easier to implement transfers and has provided more opportunities to wheel water at affordable rates. This Water Resources Plan considers agricultural transfer water as a potential normal-year supply.

It is anticipated that the interest in public-private and public-public partnerships as a means of addressing needs of the Authority will continue to grow in the future. However, short of fundamental changes in the Authority's mission and reliability goals, increased emphasis on partnering should not impact the recommendations contained within this Plan.

1.3.3 Economic Considerations

Historically, the Authority has provided between 70 and 95 percent of the region's water supply through purchases from MWD. Water rates have remained stable at a relatively low price because of the foresight in developing low-cost sources of supply, such as the CRA in the 1930s and the California Aqueduct in the 1960s. The cost of developing new sources of water and serving an increasing population have risen dramatically in the last decade. Because of the increased cost in purchasing water from MWD and the creation of water markets through agricultural transfers, other sources of local and imported water have become more cost competitive.

The increasing cost of water, coupled with the need to maintain a reliable supply, has resulted in an approach to water resources planning that seeks a mix of cost-effective resources. In this approach, multiple resources are developed to minimize cost and avoid reliance on a single source of supply.

The economic evaluation of alternative sources of supply in this Water Resources Plan utilizes a computer model to optimize the cost of various options for meeting future water demand. That information is then used to determine what mix of water resources minimizes cost and meets the Authority's mission of providing a safe and reliable water supply.

1.3.4 Environmental Considerations

The Authority strives to provide water supplies in an environmentally responsible way. As described in Chapter 7, one of the seven criteria used to evaluate potential water resources is the minimization of negative environmental impacts.

Environmental considerations include not only local impacts within the county, but inter-state and intra-state concerns as well. Local impacts are primarily considered potential short- or long-term damage or disruption caused by constructing facilities, such as water desalination or recycling plants. Inter- and intra-state concerns are present in options for securing additional imported water from the State Water Project (SWP) system and the Colorado River.

Supplies utilizing the SWP as a conveyance facility, whether purchased from MWD or from independent sources, affect the fisheries and ecosystem of the Sacramento-San Joaquin Delta. The Authority is an active participant in a process to identify a long-term solution for the Delta that will include environmental protections. Supplies from the Colorado River will require resolution of environmental impacts along the mainstem of the river, in the Imperial Valley, and/or at other locations.

Some environmental considerations are common to all of the water resources options evaluated, and some are resource-specific. For example, brine disposal is an issue only for options involving desalination. Potential construction-related impacts, in contrast, are an issue shared to some degree by all potential resources.

The Authority is committed to complying with all environmental safeguards and regulations, including Section 404 of the Clean Water Act, the National Environmental Policy Act (NEPA), the Fish and Wildlife Coordination Act, the Endangered Species Act (ESA), the National Historic Preservation Act, and the California Environmental Quality Act (CEQA). Issues considered in this Plan include regulatory agency approvals, public acceptance, water quality, fish and wildlife, flora and fauna, energy use, marine environment, and construction impacts.

Water use efficiency is also an environmental consideration. Resources options that increase efficiency of use, such as water conservation and recycling, have positive environmental impacts.

1.4 PLANNING APPROACH

A number of factors were considered in the development of the Water Resources Plan. Authority staff expertise was supplemented by major contributions from member agencies and community "stakeholders."

1.4.1 Methodology

The resources selection process was divided into three parts: (1) developing resources alternatives, (2) scoring the alternatives on a standard set of selection criteria, and (3) performing a final evaluation of each alternative.

Following the preliminary analysis of the resources data, the potential supplies were grouped into six basic resources alternatives, each of which was designed to achieve a specific goal. The alternatives are summarized in this section and described in more detail in Chapter 6.

Existing Strategy Alternative. This baseline alternative would continue the resources strategy recommended in the 1993 Water Resources Plan. The mix of resources recommended would change from the 1993 Plan to reflect updated cost estimates of both local and imported supplies, as well as revised demand forecasts. However, the 1993 resources development goal would be retained: to pursue an intermediate amount of cost-effective local supplies that would meet the Authority's reliability goal.

Maximum Local Supply Alternative. This alternative was designed to determine the costs and benefits of developing the maximum amount of local supplies, including recycling, repurification, groundwater, and seawater desalination. It shows the minimum amount of MWD supply that would be required if local resources were developed at the maximum level. Using a maximum effort, about 125,000 af/yr in new local resources could be provided. This would increase the local supply component to about 24 percent of the Authority's 2015 supply, assuming 60,000 af/yr from existing sources.

Maximum Local Supply With Transfers Alternative. This alternative is similar to the previous alternative, with two major exceptions: up to 200,000 af/yr of transfers would be developed, and the seawater desalination project would not be constructed. This would reduce the 2015 new local supply total to about 105,000 af/yr. Transfers could be developed from either Central or Northern California and/or the Colorado River and conveyed through the CRA or SWP.

Intermediate Transfers Alternative. This alternative is based on achieving long-term water transfers of 200,000 af/yr. Transfers could be obtained from either Central/Northern California and/or the Colorado River, and transported through the CRA or SWP. This alternative assumes 62,000 af/yr of new local supply, with the reduction of local supply assumed in previous alternatives made up by increased deliveries from MWD.

Maximum Transfers Alternative. This alternative explores the maximum anticipated level of transfer without constructing new, separate facilities. A transfer amount of 500,000 af/yr was modeled. Water from this alternative could be a combination of Colorado River water and water from Northern or Central California. However, it is assumed that the maximum amount of transfer water available within California is 150,000 af/yr, leaving 350,000 af/yr to come from the Colorado River.

Colorado River Facilities Alternative. The final alternative modeled was a conveyance facility that would be constructed from San Diego County to the Imperial Valley to transport 500,000 af/yr. At least a portion of this water would be treated using a reverse osmosis desalination process, causing losses of 13 percent. The yield would thus be about 435,000 af/yr.

1.4.2 Planning Tools

This update of the Plan incorporates a number of recently-completed studies and analyses undertaken to improve the Authority's ability to accurately measure water needs and plan for resources development. Highlights include:

- A water demand modeling effort that evaluates demographic data such as population, housing, employment, and income to establish water requirements.
- A water resources modeling effort that prioritizes water supply opportunities on the basis of cost and other planning considerations.
- A comprehensive study evaluating opportunities for groundwater management/development in the Authority's service area.

1.4.3 Public Involvement

In an effort to ensure that community values would be a part of determining the right mix of resources, a public outreach program was initiated. This outreach program consisted of identifying a wide cross-section of "stakeholders" representing business, civic, environmental, agricultural, government, and consumer organizations. The program was developed in recognition of the importance that issues of water supply reliability, cost, and resources selection have for the San Diego County regional community. Benefits to the Authority from the program included obtaining the community's perspective on water issues, increasing public awareness about the Authority's long-range planning efforts, and encouraging two-way communication on specific relevant issues.

Each of the stakeholder groups was interviewed using a standard set of questions related to water issues. The questions were intended to elicit responses about such issues as water costs and reliability, knowledge of existing local resources, viability of potential resources, and willingness to pay for local control over water resources (or degree of water supply "independence"). The interview process helped develop insight on the relative values that are placed on key issues of the day.

Stakeholders were next asked to participate in a "weighting" exercise of the criteria used in the water resources selection process. The weighting exercise was intended to reflect how the stakeholders rated the relative importance of each of the seven resources selection criteria. The stakeholders were convened as a group to conduct the exercise. The exercise was also conducted for the general managers of the Authority's member agencies and for Authority staff. Results of this exercise are discussed in more detail in Chapter 7 of this Plan and in **Appendix** A, which includes a summary of outreach program results.

Draft copies of the Water Resources Plan were made available to all of the outreach program participants in September 1996. Comments on the Plan were taken through December 1996 and have been incorporated throughout this document.

1.4.4 Water Resources Selection Criteria

All potential water resources were evaluated using seven criteria listed below. These are described more fully in Chapter 7.

1. Maximizing the degree of control the Authority has over the resource.
2. Minimizing negative environmental impacts (both local and out-of-area).
3. Maximizing the feasibility of development.
4. Minimizing rate impacts.
5. Maximizing reliability.
6. Minimizing total cost.
7. Maximizing water quality.

1.5 ORGANIZATION OF REPORT

Following this introductory chapter, the 1997 Water Resources Plan is divided into three basic parts: (1) a review of the Authority's existing physical water delivery system and existing and potential water resources, (2) development and evaluation of alternative resources management scenarios, and (3) the recommended mix of resources management alternatives through 2015.

Chapter 2 describes the Authority's system and summarizes the CIP. It also provides two water demand forecasts: a near-term forecast for demands through 2015 and a long-term forecast through 2050. Chapters 3, 4, and 5, respectively, review imported water from MWD, local supplies, and water transfers.

Chapter 6 describes the development of alternatives, and Chapter 7 presents the evaluation criteria and evaluation results. Finally, Chapter 8 presents the selected resource mix.

Chapter 2

2.0 DESCRIPTION OF AUTHORITY SYSTEM

This chapter reviews the Authority's service area characteristics, such as population and demographic information, describes service area water use, and outlines the Authority's physical water delivery system and key components of its Capital Improvement Program (CIP). Two water demand projections are provided, one for the period 1995-2015 and a separate long-range projection to 2050.

2.1 SERVICE AREA CHARACTERISTICS

While the Authority's service area contains many land uses, its most prominent aspect is an urban and suburban character. Large swaths of rural lands were converted for urban uses in the past few decades, as the region's population grew by up to 80,000 people a year. The City of San Diego, which is now the sixth most populous in the nation, anchors the regional population base with 1.2 million people, representing almost half of the total population served by the Authority. Most of the remaining population (1.4 million) is located in smaller cities of up to 150,000 people. The region is expected to grow by an additional 1 million people between 1995 and 2015, further urbanizing its landform.

San Diego County also has a rich history of agriculture, beginning with the large cattle ranches established in the 18th century and continuing through the diverse range of crops and products grown today, such as citrus, avocados, tomatoes, strawberries, flowers, and nursery crops. Like most of Southern California, large areas of agricultural lands gave way to urban and suburban development as the population grew. The loss of such lands slowed beginning in the 1980s. Between 1984 and 1994, only 2,000 acres of agricultural lands were lost out of a total of about 175,000 acres in production. Negative market forces, including the increasing cost of water, may cause some economically marginal lands to be taken out of production in the future.

The military has a large physical presence in the county. The U.S. Navy's Miramar Naval Air Station and the Marine Corps' Camp Pendleton form large open space lands contiguous to otherwise urbanized areas. Camp Pendleton contains 135,000 acres, or about 15 percent of the Authority's total service area.

In addition to its physical presence in the county, the federal government also has a role in water supply development. As a large property-owner and employer, the federal government benefits from a reliable water supply. This has been true ever since the Department of the Navy and the U.S. Bureau of Reclamation arranged for supplemental supplies for the region from the Colorado River Aqueduct (CRA) in the 1940s.

2.1.1 Service Area

The Authority's boundaries extend from the border with Mexico in the south to Orange and Riverside counties in the north and from the Pacific Ocean to the foothills that terminate the coastal plain in the east. With a total of 908,959 acres (1,420.3 square miles), the Authority's service area encompasses the western third of San Diego County. **Figure 2-1** shows the Authority's service area, its member agencies, and aqueducts. A list of Authority member agencies is shown in **Table 2-1**. In terms of land area, the largest member agency is the City of San Diego, with 210,626 acres. The smallest agency is the City of Del Mar, with 1,159 acres. Some member agencies, such as the cities of San Diego and Del Mar, use water

TABLE 2-1 Authority Member Agencies

Carlsbad MWD	Otay WD	San Dieguito WD
Del Mar (City)	Padre Dam MWD	Santa Fe ID
Escondido (City)	Pendleton Military Res.	South Bay ID
Fallbrook PUD	Poway (City)	Vallecitos WD
Helix WD	Rainbow MWD	Valley Center MWD
National City (City)	Ramona MWD	Vista ID
Oceanside (City)	Rincon Del Diablo MWD	Yuima MWD
Olivenhain MWD	San Diego (City)	

almost entirely for municipal and industrial purposes. Other agencies, including Valley Center, Rainbow, and Yuima municipal water districts, deliver water that is used mostly for agricultural production.

2.1.2 Geography and Climate of Service Area

The service area is highly varied geographically, encompassing subregions of coastline, coastal plain, interior uplands, and mountains. The coastal area has broad mesas that gradually rise eastward to the foothills of a series of relatively low-elevation mountain ranges. The northwest trending Peninsula Range includes the Palomar, Volcan, Cuyamaca, and Laguna mountains. Farther east, these mountains drop off sharply to a hilly desert.

Seven principal stream systems originate in the mountains and drain into the Pacific Ocean: the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, Otay, and Tijuana rivers. Major vegetation is concentrated along intermittent streams that usually flow only after severe rainstorms and then dry up for the remainder of the year. Bays, lagoons, and reservoirs contain the only free-standing water in the region. Natural runoff from the region's streams and rivers is highly variable. For planning purposes, local surface water supplies are assumed to be about 60,000 acre-feet (af) during a normal weather year.

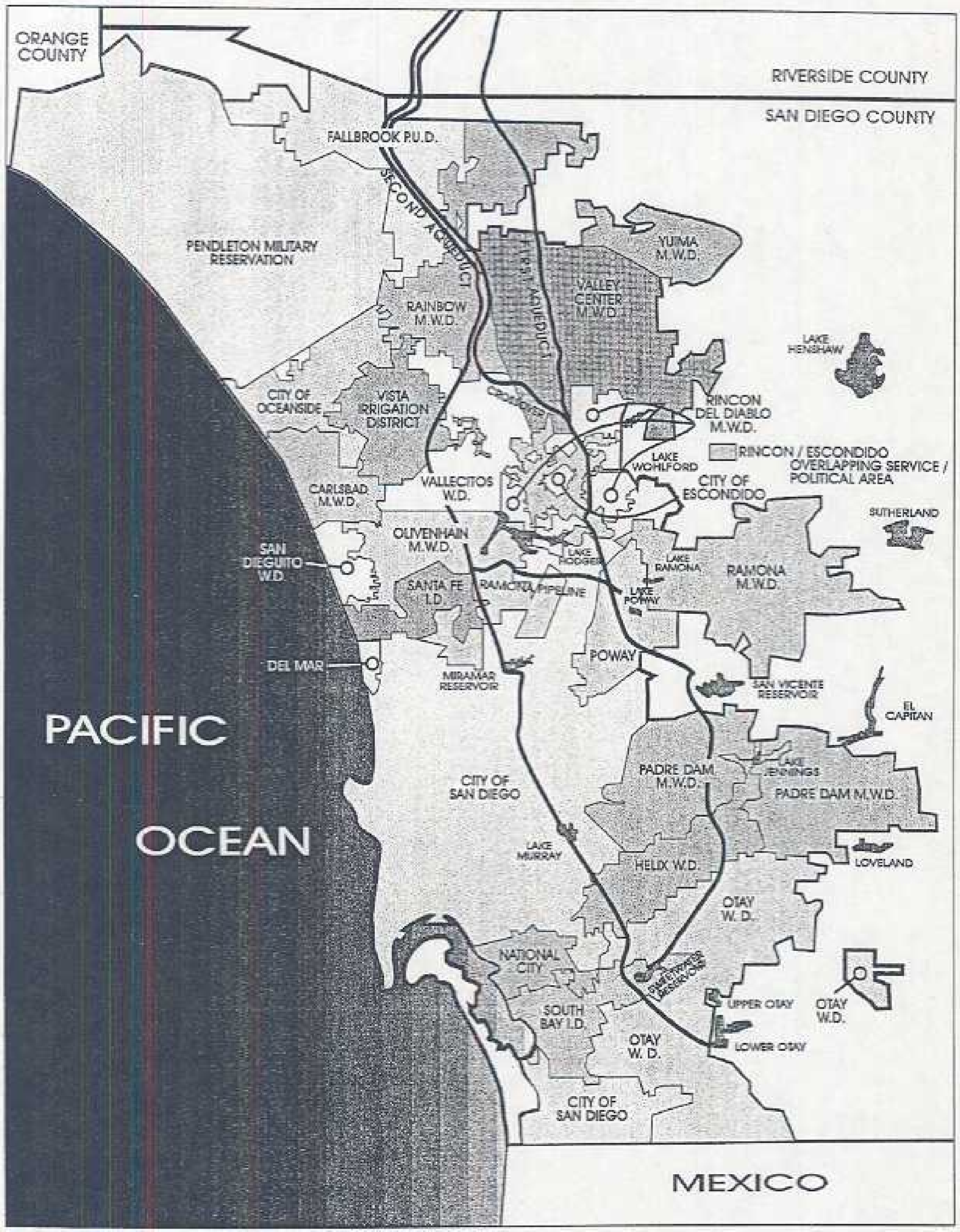
Climate in the service area is characteristically Mediterranean along the coast, with mild temperatures year round. Inland areas are both hotter in summer and colder in winter, with summer temperatures often exceeding 90 degrees and winter temperatures occasionally dipping to below freezing. More than 80 percent of the region's rainfall occurs in the period between December through March. Rainfall amounts vary from about 10-12 inches per year on the coast to more than 40 inches annually in the inland mountains.

Variations in weather affect short-term water requirements, causing demand spikes during hot, dry periods and reductions in use during wet weather. Studies have shown that hot, dry weather may generate urban water demands that are about 7 percent greater than normal and agricultural demands that are about 9 percent greater than normal. Conversely, these percentages can also be used to estimate below-normal demands resulting from wet weather.

2.1.3 Population

San Diego County's population has increased every year since the Authority was formed in 1943. During this time, the region experienced several periods of rapid population growth associated with military and/or economic activity. The fastest rate of growth, 8.7 percent annually, occurred in the decade between 1950 and 1960, at the end of which the county's population reached 1 million people. From 1980 to 1990, the region experienced another period of rapid growth, fueled primarily by expanded job opportunities, and an average of 64,000 people were added annually. Since 1990, regional growth has slowed because of an economic downturn that is still

FIGURE 2-1 Authority Service Area



lingering. Between 1990 and 1995, the growth rate was 1.5 percent per year, with an average annual increase of about 40,000 people. About 96 percent of the county's population resides within the Authority's service area.

Total population in the service area reached 2.6 million people in 1995. The City of San Diego has the largest population of any member agency, with 1.2 million people in 1995. The agency with the least population is the Yuima Municipal Water District (YMWD), at 1,870 people. Average population density is 2.83 people per acre, or 1,811 people per square mile. National City has the highest density (9.33/acre), while YMWD has the lowest (0.14/acre).

Future regional growth has been projected by the San Diego Association of Governments (SANDAG). Its Series 8 Regionwide Forecast, shown in **Table 2-2**, projects growth of 1.3 million people between 1990 and 2015, for a total population of 3.8 million. This gain represents an average annual increase of about 50,000 people, for an annual growth rate of about 2 percent. While the region's projected population growth rate is expected to be lower than historic growth rates, it is still twice the projected national growth rate.

Growth during the 1980s was primarily from in-migration, as job seekers from other parts of the country and abroad took advantage of the region's favorable economy. In recent years, this trend reversed, and natural increase (the difference between births and deaths) became a greater cause of population growth than in-migration. Reduced employment opportunities and higher projected birth rates are expected to continue this development.

Authority member agencies are projected to have varying future growth. Some, such as the Santa Fe Irrigation District and the City of Del Mar, are expected to experience relatively little growth. Others, including the Otay and Vallecitos water districts, anticipate large increases in both population and water demand.

TABLE 2-2
Population Forecast For the San Diego Region
(1995-2015)

Year	Population
1990	2,520,499
1995	2,755,006
2000	3,004,435
2005	3,267,255
2010	3,517,769
2015	3,763,254
Average Annual Growth	50,000

Source: SANDAG Series 8

2.1.4 Regional Economy and Demographics

From the formation of the Authority in 1943 until 1990, the local economy was driven by defense-related manufacturing, especially in the aerospace sector, and tourism. Economic growth in the 1980s was fueled by federal spending, as local defense-related expenditures more than doubled from $4.6 billion in 1983 to $9.6 billion in 1987. When this level of federal spending was sharply cut back in the early 1990s, it resulted locally in waves of layoffs and a recession that lasted until 1995. This also had a profound impact upon population growth, halting the in-migration of job seekers and cutting the annual growth rate of the late 1980s in half.

2.2 AUTHORITY PHYSICAL WATER DELIVERY SYSTEM

The Authority purchases water from the Metropolitan Water District of Southern California (MWD) and delivers it to 23 member agencies through two aqueducts containing five large-diameter pipelines. The aqueducts follow general north-to-south alignments, and the water is delivered largely by gravity. Delivery points from MWD are located about six miles south of the Riverside/San Diego county line. The Authority's total system capacity is about 1,260 cubic feet per second (cfs). The most water the Authority ever delivered in a year was 647,000 af in 1990.

The First Aqueduct comprises Pipelines 1 and 2, which are located in a common right of way, share five common tunnels, and are operated as a unit. These pipelines have a combined capacity of 180 cfs. Pipelines 3, 4, and 5 form the Second Aqueduct. These pipelines are operated independently and are located in separate rights of way from the First Aqueduct. Pipeline 3 has a capacity of 280 cfs, Pipeline 4 is 425 cfs, and Pipeline 5 is 480 cfs. **Figure 2-1** shows the locations of the Authority's aqueducts within San Diego County.

2.2.1 Capital Improvement Program

In 1989, the Authority initiated the CIP to plan and implement projects necessary to meet the region's water needs to 2010. The goals of the program are to: (1) increase pipeline capacity to meet present and future demands, particularly during times of peak usage, (2) eliminate "bottlenecks" in the existing pipeline system, (3) increase reliability where water delivery is dependent on a single pipeline as a source, and (4) increase operational flexibility to make pipeline maintenance easier.

Table 2-3 summarizes the major CIP pipeline projects that have been recently completed or are under way. In addition, a sixth pipeline is being jointly planned with MWD that would extend from Lake Skinner to the Authority Diversion Structure north of San Marcos. This pipeline was originally scheduled for completion in 1998, but has been delayed as MWD and the Authority reassess capital facilities needs. Pipeline 6 is expected to have a capacity of about 620 cfs, which would bring the total Authority system capacity to 1,985 cfs.

2.2.2 Emergency Storage Project

The Authority does not own or operate any treatment or storage facilities. It does have an agreement with the City of San Diego to store up to 40,000 af of water in San Vicente and Lower Otay reservoirs and an agreement with the Ramona MWD to store up to 10,000 af in Lake Ramona. A significant effort is being made to increase local supplies that would be available during times of emergency through an Emergency Storage Project (ESP). While this effort is expected to increase the region's total water storage by 90,000 af, use of the ESP will be limited to emergency situations, such as prolonged drought or the catastrophic failure of one or more of the Authority's pipelines during an earthquake or other disaster. Thus, the project's yield in terms of a future water source is limited, as described in Chapter 4.

Authority supplies are transported by large pipelines that are vulnerable to earthquakes and other hazards. This is true for both Authority and MWD pipelines and facilities. These supply systems are located near several major fault zones. The Authority's pipelines cross the Elsinore fault, and MWD's imported water sources cross both the San Andreas and San Jacinto faults. The ESP is being designed to meet emergency demands through 2030 and to handle two planning scenarios: (1) an interruption in water delivery to MWD for up to six months due to an earthquake along the San Andreas or San Jacinto faults and (2) an interruption in water deliveries from MWD for two months because of an earthquake on the Elsinore Fault.

The Authority has evaluated a wide range of alternatives and combinations of alternatives in an effort to provide a safe and reliable source of emergency water. The highest ranked alternatives were addressed in detail in the Environmental Impact Report/Environmental Impact Statement (EIR/EIS). To maintain public involvement throughout the evaluation process, the Authority established an Emergency Storage Working Committee

TABLE 2-3 Summary of Major Capital Improvement Projects

PROJECT	DESCRIPTION	COST	STATUS
Ramona Pipeline	8-mile, 36- and 54-inch diameter pipeline to provide up to 67 mgd filtered water from Second Aqueduct for delivery to Olivenhain MWD, Rancho Bernardo, and Ramona.	$14 million	Completed 1990
Pipeline 4	Four pipeline segments totaling 32.5 miles of 72-inch to 108-inch diameter pipeline to provide filtered water to Central, South, and East County.		
	• Pipeline 4B, Phase 1 (Scripps Ranch Pipeline); up to 290 mgd.	$58 million	Completed 1994
	• Pipeline 4B, Phase 2 (Mission Trails Pipeline); up to 240 mgd.	$30 million	Completed 1996
	• Pipeline 4 Extension, Phase 1 (La Mesa/ Lemon Grove Pipeline and Cowles Mountain Tunnel); up to 240 mgd.	$130 million	Completed 1994
	• Pipeline 4 Extension, Phase 2 (Lower Otay Pipeline); up to 130 mgd.	$40 million	Completed 1994
Pipeline 5	Two pipeline segments totaling 21 miles of 108-inch diameter pipeline to provide an additional supply of raw water for delivery throughout most of the county.		
	• Pipeline 5 Extension, Phase 1 (San Marcos Pipeline); up to 400 mgd.	$80 million	Completed 1994
	• Pipeline 5 Extension, Phase 2 (Rancho Penasquitos Pipeline); up to 400 mgd.	$88 million	Complete 1998 (est.)
North County Distribution Pipeline	3.4 mile, 72-inch diameter pipeline to provide up to 105 mgd filtered water to Vista Irrigation District, Rainbow MWD, Vallecitos WD, and the City of Oceanside.	$24 million	Completed 1996
Valley Center Pipeline	4.5 mile, 66-inch diameter pipeline to connect the First and Second Aqueducts in order to increase the water delivery system's flexibility.	$21 million	Complete 1997 (est.)
Other CIP Projects	Emergency Preparedness, Aqueduct Control System Improvements, Aqueduct Pipeline Protection Program, Environmental Mitigation Program, San Luis Rey River Crossings Protection Program.	Various	On-Going

(ESWC), composed of members of the general public and representatives from key interests including the agricultural, business, economic development, military, recreation, disaster preparedness, environmental, and engineering communities. Ultimately, four ESP alternatives were considered in detail:

1. *San Vicente Stand Alone.* Expansion of San Vicente Reservoir with all of the increased emergency supply at San Vicente.

2. *Moosa Construction/Lake Hodges Reoperation.* Construction of a new reservoir in Moosa Canyon and connection of Lake Hodges to the Authority's aqueduct system (reoperation).

3. *San Vicente Expansion/Reoperation.* Expansion of San Vicente Reservoir and reoperation of the reservoir system with all of the increased emergency supply at San Vicente.

4. *Olivenhain Construction/Lake Hodges Reoperation/San Vicente Expansion.* Construction of a new reservoir in Olivenhain, connection of Lake Hodges to the Authority's aqueduct system (reoperation), and expansion of San Vicente Reservoir.

The alternatives are summarized in **Table 2-4.** All of the alternatives involve increased surface storage and new distribution systems, and all incorporate the water savings and local water production projected to be available through recycling and conservation activities in the region during the project's lifetime.

Three alternatives involve expanded surface storage and changes in how a reservoir system is operated (reoperation). Reoperation means improving conveyance facilities that connect a reservoir to the Authority's distribution system and instituting changes in storage operations so that, during an emergency, more water can be supplied by that reservoir than currently possible.

Alternative No. 4 was selected as the preferred alternative, and the Authority will proceed with its development and eventual construction.

2.3 CURRENT WATER USE

Water use in the San Diego region is closely linked to the local economy, population growth, and weather. Historically, expansion of the local economy stimulated regional population, which in turn produced a relatively steady increase in water demand. In recent years, however, this pattern has shifted. Population growth is now being generated more by natural increase than job creation, and water demands have fallen well below anticipated demand for the period 1991 through 1995.

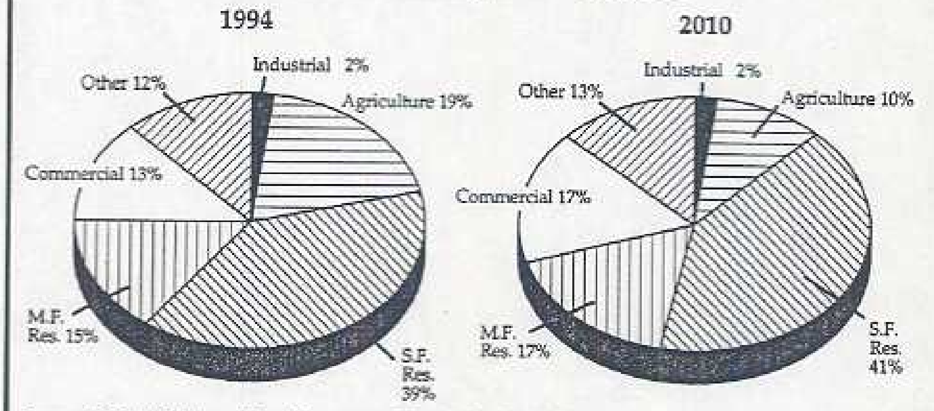
The peak year for water demand in the Authority's service area was 1990, when 646,645 af were used. Since then, despite a growing population, water usage has fallen off considerably, reaching a low of 503,210 af in 1992. In 1995, water use reached 526,053 af. This overall reduction in water use has been influenced by several factors, including a poor economy, water conservation measures taken by the Authority and its member agencies, increased public awareness, and relatively plentiful rainfall.

Demand for water in the Authority's service area is divided into two basic categories: municipal and industrial (M&I), and agricultural. M&I use constitutes about 80 to 85 percent of regional water consumption. Agricultural water, used mostly for irrigating groves and crops, accounts for the remaining 15 to 20 percent of demand. **Figure 2-2** shows the relative percentages of various categories of water use. In this figure, residential demand has been split between single-family residential (SF), and multi-family residential (MF). The "Other" category includes water used for government and institutional purposes, as well as water system losses, includ-

TABLE 2-4 Emergency Storage Project Alternatives			
ALTERNATIVE	DESCRIPTION	CONSTRUCTION STAGING	EST. COST PRESENT WORTH
San Vicente Stand Alone	Raise existing San Vicente Dam by 83 ft. to contain 90,100 af of emergency storage. Other new facilities: 96-inch diameter pipeline to connect to Second Aqueduct. Approximately 5 new pump stations.	No opportunities for construction phasing.	$380 million
Moosa Construction/ Lake Hodges Reoperation	Build new 340 ft. high dam at Moosa Canyon to hold 68,000 af of emergency storage. Reoperate Lake Hodges to hold 22,100 af of emergency storage. Other new facilities: 84-inch pipeline from Moosa to Pipeline 6 and 42-inch pipeline from Lake Hodges to Second Aqueduct. Approximately 5 new pump stations.	Limited opportunities for construction phasing.	$510 million
San Vicente Expansion and Reoperation	Raise existing dam by 65 ft., adding 68,000 af of storage. Reoperate existing reservoir to provide additional 22,100 af of emergency storage. Other new facilities: 96-inch pipeline to connect to Second Aqueduct. Approximately 5 new pump stations.	No opportunities for construction phasing.	$380 million
Olivenhain Construction, Lake Hodges Reoperation, San Vicente Expansion	Build new 320 ft. high dam at Olivenhain site to create 18,000 af of emergency storage. Reoperate Lake Hodges to hold an additional 20,000 af of emergency storage. Raise San Vicente Dam by 54 ft. to hold an additional 52,100 af. Other new facilities: 48-inch pipeline and pump station from Lake Hodges to Olivenhain, 60-inch pipeline and pump station from Olivenhain to Second Aqueduct, 72-inch pipeline from San Vicente to Second Aqueduct.	A number of construction phasing opportunities available.	$440 million

ing evaporation, meter losses (errors), leaks, and seepage.

FIGURE 2-2 Regional Water Use



Source: 1995 MWD Urban Water Management Plan; Authority Ag Forecast

2.3.1 Municipal and Industrial Water Demand

M&I demand can be subdivided into residential demand (water used for human consumption, domestic purposes, and residential landscaping) and water used for commercial and industrial purposes.

Residential Demand

Residential water consumption is composed of both indoor and outdoor uses. Indoor water use includes sanitation, bathing, laundry, cooking, and drinking. Most outdoor water use is for turf and other landscaping irrigation requirements. Other minor outdoor uses include car washing, surface cleaning, and similar activities. For single-family homes and rural areas, outdoor demands may be as high as 60 percent of total residential use.

Based on SANDAG data, the San Diego region housing stock composition in 1995 was approximately 58 percent single-family homes, 37 percent multi-family homes, and 5 percent mobile homes. Single-family residences generally contain larger landscaped areas, predominantly planted in turf, and require more water for outdoor application in comparison to other types of housing.

The general characteristics of multi-family and mobile homes limit outdoor landscaping and water use, although some condominium and apartment developments do contain green belt areas, which are generally landscaped with water-consuming plant stock.

Commercial and Industrial Demand

Between 1950 and 1992, San Diego's economy was heavily reliant on defense spending and was driven largely by the manufacturing sector. Defense spending has since declined, and many of the manufacturing jobs have disappeared. The region lost a total of 75,000 jobs between 1990 and 1993. SANDAG projects that future economic growth will look different than historic growth, with the services and wholesale/retail trade sectors assuming a larger share of total employment. Only modest gains are projected for manufacturing, construction, government, finance, insurance and real estate.

Commercial water demand consists of uses which are generally incidental but necessary for the operation of a business or institution, such as drinking, sanitation, and landscape irrigation. Commercial users include service industries, such as restaurants, car washes, laundries, hotels, and golf courses. Employment data from SANDAG indicate that almost half of San Diego's residents are employed in commercial (trade and service) industries.

The tourism industry in San Diego County affects water usage within the Authority by not only the number of visitors, but also through expansion of service industries and attractions, which tend to be larger outdoor water users. Tourism is primarily concentrated in the summer months and affects seasonal demands and peaking. SANDAG regional population forecasts do not specifically account for tourism, but tourism is reflected in the economic forecasts and causes per capita use to increase.

Industrial water consumption consists of a wide range of uses, including product processing and small-scale equipment cooling, sanitation, and air conditioning. Water-intensive industrial uses in the City of San Diego, such as kelp processing, electronics manufacturing, and aerospace manufacturing, typically require smaller amounts of water when compared to other water-intensive industries found elsewhere in Southern California, such as petroleum refineries, smelters, chemical processors, and canneries.

2.3.2 Agricultural Water Demand

The coastal and inland valley areas of the county possess a moderate and virtually frost-free climate able to support a variety of subtropical crops, making the San Diego area a unique agricultural region. The primary crops grown for the national and international markets are avocados, citrus, cut flowers, and nursery products. To a lesser extent, local fresh market crops and livestock are produced in the Authority's service area. In recent years, agriculture has accounted for between 15 and 20 percent of the Authority's total water demand and generated about 1.5 percent of San Diego County's gross regional product.

The Authority is the largest agricultural water consuming agency within MWD, requiring approximately 50 percent of MWD's total agricultural water supply each year. Agricultural water use within the Authority is concentrated mainly in north county member agencies such as the Rainbow, Valley Center, Ramona, and Yuima municipal water districts, the Fallbrook Public Utility District, and the City of Escondido.

Authority member agencies report agricultural water use each year. The peak year was 1990, when more than 122,297 af was applied to various agricultural crops and products. Since then, reported agricultural use has fallen significantly, reaching just 56,069 af in 1995. Reasons for this decline include the cancellation of the MWD discounted agricultural water rate program between 1992 and 1994.

In May 1994, MWD adopted its Interim Agricultural Water Program (IAWP). The program provides a $113 and $137 discount from MWD's basic M&I water rate for untreated and treated agricultural water supplies, respectively. Shortfalls in revenue to MWD due to the agricultural water discount are funded through a combination of draws from MWD's rate stabilization fund and through increases in MWD's basic M&I water rate. In return for the discounted supplies, agricultural deliveries under the IAWP are subject to mandatory reductions of up to 30 percent prior to MWD imposing reductions in firm water deliveries. Shifting the impact of a shortage to agricultural water users will make more water available for M&I uses, thereby lessening the impacts of the shortage on the M&I users.

Not withstanding the IAWP discount, the agricultural industry served by the Authority pays some of the highest water rates in the state. The rates are more than 30 times that of the Central Valley Project or Imperial Irrigation District rate structures. Because of these high rates and crops adaptable to efficient irrigation technology, irrigation efficiency in the region is very high in comparison to other agricultural regions of the state. Additionally, due to the high water cost, crops grown in the Authority's service area are generally not able to be in direct market competition with other areas operating with lower water costs.

2.4 PROJECTED WATER USE

The Authority conducts separate analysis for M&I and agricultural water use. Historically, M&I forecasts were done using a per capita methodology. Water use was measured at individual consumer levels, then multiplied by projected populations to obtain a demand forecast. While these forecasts proved accurate, they did not account for economic, demographic, and land use changes that affect water use. A computer model was developed and used for this M&I forecast that accounts for these factors.

Two separate forecasts were provided for this Plan. The first is a near-term forecast that extends to 2015, which is the Plan's planning horizon. The second forecast which goes to 2050, was provided to illustrate the range of demands that could be expected for such long-term facilities such as the ESP or proposed water transfers.

2.4.1 Projected M&I Demand

The preparation of a water use forecast is a sequential process that involves database development, water use modeling, verification of model accuracy, calibration of models to historical records, development of a baseline forecast, and adjustment of the baseline forecast to address projected levels of water conservation and agricultural water use.

Under terms of a memorandum of understanding signed in 1992, the Authority is obligated to use SANDAG data for planning purposes. Historically, SANDAG has produced population forecasts that have consistently been slightly below observed population increases, with the projection averaging about 0.6 percent per year under actual increases. The average annual accuracy of projected occupied housing units has been about 0.5 percent low, and non-agricultural employment projections have been about 1.3 percent low.

In addition to projected population growth, several changes are expected to occur within the residential sector that will impact water use. Current SANDAG forecasts show a slight decline in the number of single-family compared to multi-family homes by the year 2015. This shift will tend to lower residential per capita demand. Household size is also forecast to increase from 2.70 persons per dwelling to 2.75 in 2015, which will also tend to reduce per capita water consumption. Other projected changes will tend to increase per capita demand. As lower density residential development proceeds in the hotter, drier, inland areas of the region, higher rates of water use are expected. In addition, indoor water use is expected to increase as the number of bathrooms and water-consuming appliances increase in single-family homes.

Forecasted changes within the nonresidential (commercial/industrial) sector will also impact water use projections. SANDAG projects that future economic growth will be different from historic growth, with the services and wholesale/retail trade sectors assuming a larger share of total employment. SANDAG projections also indicate that a smaller share of the population is expected to be employed in 2015 than in 1995. The net effect of these changes in employment will tend to reduce overall per capita demand. Conversely, similar to the residential sector, employment growth in the hotter, drier areas of the service area will tend to increase overall per capita demand.

To project M&I water use, the Authority selected the IWR-MAIN (Institute for Water Resources - Municipal And Industrial Needs) computer model. Versions of this econometric model have evolved over a 20-year period and are being used by several U.S. cities and water agencies, including MWD. The IWR-MAIN system is designed to translate local demographic, housing, and business statistics into estimates of existing water demand and to utilize projections of local population, housing, and employment to forecast M&I water demand.

The Authority's version of the model, called "CWA-MAIN," utilizes data from SANDAG's Series 8 Economic Prosperity and Interim Series 8 forecasts. This data, including number of persons per household by housing type, housing density, household income, and employment counts by major industry group, reflects demographic and economic trends anticipated to occur in the Authority's service area over the next 20 years. The Authority's model also includes assumptions concerning pricing, demand, and water conservation in the post-1990 period. It assumes that a 10 percent increase in price would translate into a 0.91 percent decrease in average single-family household water use.

Projecting future conservation is the last step in the development of the M&I forecast. This is accomplished through the use of "end user" data, such as the water requirements for indoor and outdoor use, and nonresidential use for industrial and commercial supply.

The model was checked for accuracy using 1990 as a baseline year and projecting 1993 water use to compare the model forecast against observed 1993 water demand **(Appendix E)**. This calibration and "back-casting" of the model showed that, although considerable variation existed for individual member agencies, CWA-MAIN predicted historical total deliveries by the Authority within 3.6 percent of observed levels. Details of these results are available in a technical report prepared for the Authority (Development of Municipal and Industrial Water Use Forecasts for the San Diego County Water Authority), which is available in the Authority's library.

2.4.2 Projected Agricultural Demand

A 1993 study on agricultural water use projected that agricultural water demand will remain at about its current level through the year 2010. This projection was based on the economic outlook for crop production and corresponding estimates of producing acreage and water use. Weather variations significantly affect annual irrigation demand, although it is difficult to establish a true correlation with available data.

Agricultural water usage is tracked by member agency reporting. Member agencies report water that is certified under MWD's discounted agricultural water rate programs, which reduce rates in exchange for service interruptibility. Therefore, historic Authority agricultural water use data are directly tied to MWD's programs. It is clear that some amount of water being used for actual agricultural purposes (irrigating various crops) is not certified by MWD's programs and is not reported by member agencies.

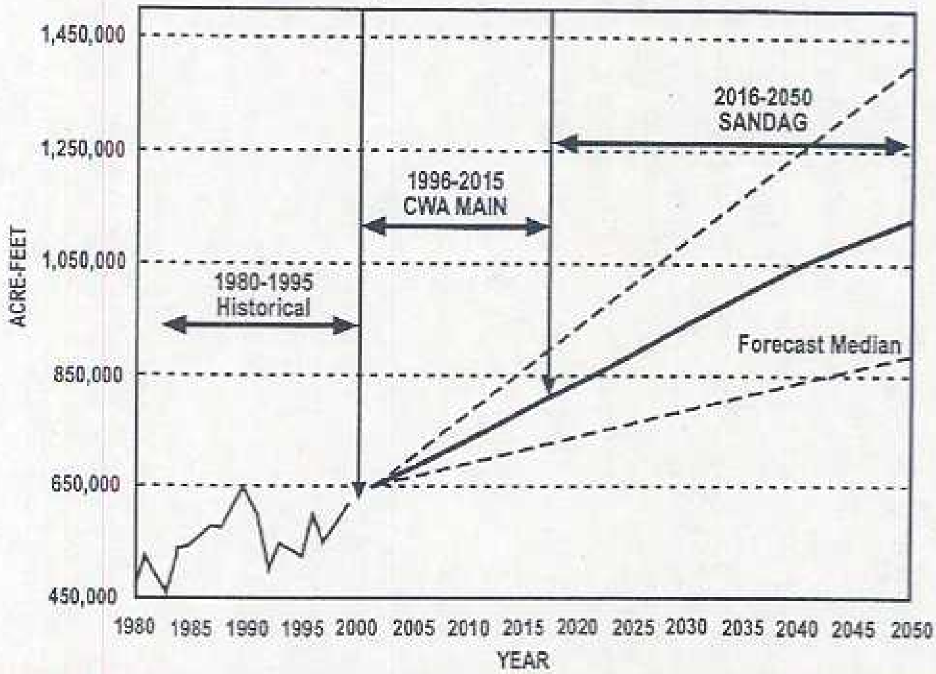
The Authority's projection for future agricultural water use is that 60,000 af will continue to be certified under some form of MWD rate discount program. Another 25,000 af of water is expected to be used for agricultural purposes but not certified under MWD's program. For accounting purposes, that water certified under MWD's agricultural program is designated as agricultural water. The level of agricultural water use is expected to remain constant at 60,000 af/yr throughout the forecast period

TABLE 2-5 Normal Year Water Use Forecasts Adjusted for Water Conservation (1995-2015)

Year	M&I Baseline Forecast (AF)	M&I Forecast Adjusted For Conservation (AF)[1]	Agricultural Forecast (AF)[2]	Total Projected Demand (AF)
1995	574,600	554,100	60,000	614,100
2000	619,300	575,600	60,000	635,600
2005	683,400	624,800	60,000	684,800
2010	743,600	673,600	60,000	733,600
2015	808,700	726,900	60,000	786,900

Source: Development of Municipal and Industrial Water Use Forecasts for the San Diego County Water Authority, April 1996.
[1] Includes 25,000 af of non-certified agricultural water.
[2] Excludes 25,000 af of non-certified agricultural water.

FIGURE 2-3 Preliminary Baseline Regional Water Demand Projections for 2020 to 2050



(until 2015). The remaining 25,000 af/yr of agricultural water use is designated as M&I because it is purchased at MWD's basic noninterruptible rate. The Authority plans to conduct further studies of agricultural water demand and usage and will use the results of these studies to update future Plans.

2.4.3 Total Projected Water Demand

Table 2-5 shows the total projected water demand for the Authority through 2015. M&I demand has been adjusted for expected water conservation and agricultural water use to produce the total. Water conservation measures are expected to reduce total M&I demands by 10.4 percent in 2015, with an estimated savings of 82,000 af/yr by then. This forecast was confirmed by an independent survey of Authority member agency demand forecasts conducted in 1996. Although slightly lower overall, survey results for the combined member agency forecasts were within 2.5 percent of the 2015 total demand projection shown in **Table 2-5**.

Figure 2-3 shows how water demand is projected to behave over the long-term. This figure combines historical water use, the CWA-MAIN projection for the period 1995-2015, and a separate projection from 2015 until 2050. Demand through 2020 was projected using the CWA-MAIN model and SANDAG Series 8 demographic and economic forecast data. To account for the relative level of uncertainty in long-range forecasting, the graph shows a range of forecasted demands based on SANDAG low, middle, and high estimates for key demographic and economic variables such as population, housing, employment, and income.

Beyond 2020, the median forecast represents a continuation of the trends observed in Series 8 through 2015. The range established by the high and low forecasts is not based on formal statistical analysis of error ranges, but rather reflects alternative assumptions about future trends and takes into account the accuracy of past SANDAG regionwide forecasts.

By utilizing the range of forecast data provided by SANDAG, preliminary regional M&I water demand forecasts were generated by the CWA-MAIN model for the years 2020-2050. These forecasts include an adjustment for future conservation which assumes that conservation savings will remain constant at 2015 levels. Since the model does not forecast agricultural demand, it was held constant at 60,000 af for this period. This is the amount of water projected to be certified under some form of MWD discounted agricultural water rate program. Only water so certified is accounted for as agricultural water use. Another 25,000 af projected to be used for agricultural irrigation purposes is classified as M&I because it will be purchased at the full MWD basic non-interruptible water rate.

Chapter 3

3.0 IMPORTED WATER RESOURCES

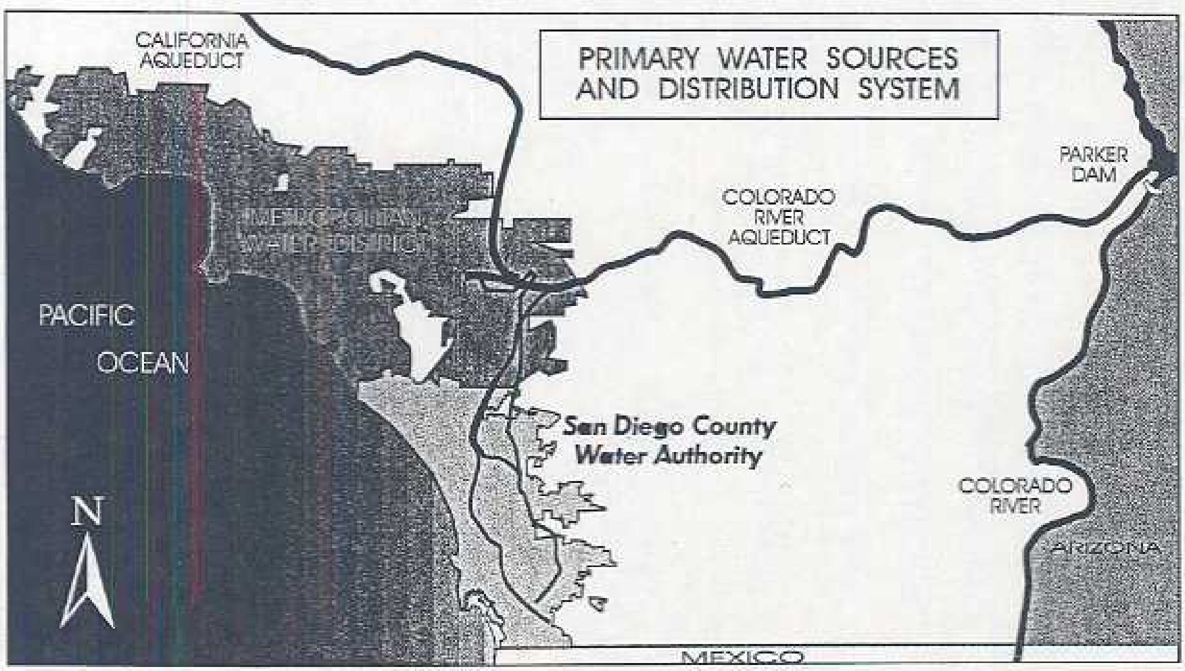
As San Diego County has grown, so has the region's reliance on imported water supplies. Historically, the Authority has imported 70 to 95 percent of the region's water supply. In 1994-95, the Authority supplied 77 percent of the water used in the region. This chapter discusses historic and potential future imported water deliveries from the Metropolitan Water District of Southern California (MWD), as well as other imported supplies with future potential.

3.1 OVERVIEW

MWD is currently the sole source of imported water supply to the Authority. Under supply conditions similar to those existing today, MWD would meet 85 percent of the Authority's total normal year demand in 2015, delivering about 670,000 acre-feet (af) of water. Total normal year demand in 2015 is expected to be about 787,000 af. MWD obtains its water from two sources: the Colorado River Aqueduct (CRA), which it owns and operates, and the State Water Project (SWP).

Water supply options considered in this Plan could reduce Authority purchases from MWD to as low as 21 percent of the total water demand. In this situation, the Authority would purchase about 165,000 acre-feet per year (af/yr) from MWD. In addition to MWD, options for imported supplies include transfers, non-local conjunctive use, and non-traditional sources such as water tankering. This chapter discusses each of these resources, except for transfers, which are discussed in detail in Chapter 5.

FIGURE 3-1 MWD Service Area



3.2 METROPOLITAN WATER DISTRICT - DESCRIPTION

Formed in 1928 to develop, store, and distribute supplemental water in Southern California for domestic and municipal purposes, MWD now supplies water to 16 million people in a service area that includes portions of Ventura, Los Angeles, Orange, San Bernardino, Riverside, and San Diego Counties. More than half of the water used in this 5,200-square-mile region is supplied by MWD, and about 90 percent of its population receives at least some of its water from the district.

The MWD service area, shown in **Figure 3-1**, covers a 70-mile-wide strip of the Southern California coastal plain, extending from the city of Oxnard on the north to the Mexican border. The Authority, one of 27 MWD member agencies, is the largest agency in terms of water purchases. Since 1990, the Authority has purchased about 25 percent of all the water MWD has delivered. **Table 3-1** shows water use by MWD's member agencies for fiscal year 1994-95, the latest year for which data are available.

MWD has two sources of water: the CRA and the SWP. Historically, about 30 percent of the imported water purchased by the Authority came from the SWP and 70 percent from the CRA. However, because of reduced state supplies and system demand, water imported into the Authority's service area was almost entirely of Colorado River origin between 1991-94.

Generally speaking, MWD meets demand first with the CRA and then with SWP supplies in order to take advantage of lower pumping rates on the CRA. Therefore, in periods of reduced demand, Colorado River water (CRW) makes up a greater proportional share of MWD's total supply. However, CRW is less desirable to the Authority in terms of water quality because of its higher salinity content. At the Authority's request, MWD resumed seasonal blending of SWP supplies to about 25 percent of the total in 1995 to improve water quality.

3.2.1 Administration

MWD is governed by a board of directors who are appointed by each member agency. The Authority has six representatives, out of a total of 51 directors on the MWD board. Representation is based upon the assessed valuation of each member agency's taxable property. The basis for this representation had its origin in the need to fund MWD's initial capital facilities after its formation, including the CRA. Property taxes were the primary revenue source at the time, and water sales revenue was a much smaller proportion of the total. This situation has reversed over time; in 1995 water sales contributed 69 percent of MWD's total revenue and taxes only 11 percent.

3.2.2 Facilities

MWD owns and operates 775 miles of pipeline, five filtration plants, eight reservoirs, and 14 hydroelectric power plants to supply its member agencies with water. Five pipelines supply water from MWD's Lake Skinner and the Skinner Filtration Plant in Riverside County to the Authority's First and Second Aqueducts. About half of the Authority's water purchases from MWD are for water treated at the Skinner plant.

MWD has an extensive capital improvement program (CIP) that includes major new water transmission and storage facilities. One of its largest projects is the Eastside Reservoir. This off-stream reservoir, being constructed near the city of Hemet in Riverside County, has a planned capacity of almost 800,000 af. MWD will use it to store imported water available during wet years, providing both operational and emergency storage benefits to the San Diego region. Construction is expected to be complete by 1999.

Another CIP project of importance to the Authority is Pipeline 6. This pipeline is

TABLE 3-1 MWD 1994-95 Water Deliveries and Local Supplies (AF)			
MWD Member Agencies	Local Water Supply	MWD Water Supply	Total Water Use
Anaheim	46,366	21,660	68,026
Beverly Hills	0	12,443	12,443
Burbank	5,305	19,663	24,968
Calleguas M.W.D.	29,355	90,997	120,352
Central Basin M.W.D.	215,010	122,226	337,236
Chino Basin M.W.D.	155,341	39,608	194,949
Coastal M.W.D.	8,161	37,971	46,132
Compton	5,516	3,541	9,057
Eastern M.W.D.	101,856	46,521	148,377
Foothill M.W.D.	6,328	9,988	16,316
Fullerton	23,329	6,865	30,194
Glendale	2,368	26,477	28,845
Las Virgenes	1,644	17,696	19,340
Long Beach	19,651	50,505	70,156
Los Angeles	358,515	210,440	568,955
M.W.D. of Orange County	208,166	224,248	432,414
Pasadena	16,280	16,081	32,361
San Diego C.W.A.	**118,818**	**396,076**	**514,894**
San Fernando	3,393	9	3,402
San Marino	3,672	1,997	5,669
Santa Ana	34,830	12,338	47,168
Santa Monica	9,567	4,813	14,380
Three Valleys M.W.D.*	60,708	58,294	119,002
Torrance	9,077	20,705	29,782
Upper San Gabriel Valley M.W.D.	158,723	7,413	166,136
West Basin M.W.D.	40,956	185,544	226,500
Western M.W.D. of Riverside Co.	180,176	58,070	238,246
TOTALS	1,823,111	1,702,189	3,525,300

* FY 95 local production information for this agency was not available, therefore FY 94 local production was used as a proxy.

planned to provide untreated water from Lake Skinner to a point just north of the city of San Marcos in San Diego County. As discussed in Section 2.2.1, the project would be constructed jointly by MWD and the Authority. MWD would be responsible for the pipeline reach between Lake Skinner and the existing Authority service delivery point six miles north of the Riverside County line. The Authority would be responsible from that point to the southern terminus. With a planned capacity of about 620 cubic feet per second (cfs), Pipeline 6 would increase the Authority's current maximum system capacity by about 40 percent. The current CIP schedule would complete the pipeline by 2005.

Another major pipeline, called the Inland Feeder, is planned to transport water from the East Branch of the California Aqueduct to the CRA near San Jacinto in Riverside County. At 1,000 cfs, this pipeline would more than double the capacity of the East Branch and would allow higher quality SWP supplies to be served more reliably to the Authority service area, helping to meet water quality goals. The pipeline would also be used to fill local reservoirs, including the Eastside Reservoir. Major MWD facilities are shown in **Figure 3-2**.

3.2.3. Issues

Integrated Resources Plan

In 1993, MWD began an Integrated Resources Plan (IRP) that signaled a broad policy shift for the agency. The IRP is an attempt to achieve consensus among MWD's member agencies on how best to meet the region's water requirements using all available resources. It reviews the regional demand and supply balance and meets projected demands with a combination of imported supplies, local supplies, and water conservation. This effort has given MWD new responsibilities as a regional planning forum, in addition to its more narrowly-defined former role as imported water supplier. To succeed, the IRP requires the cooperation of all of MWD's member agencies. Crucial elements of the plan, such as water supply reliability goals, now rely upon achieving certain levels of local resources development and water conservation targets, as well as maintaining a full CRA and improving the yield and reliability of the SWP. **Table 3-2** presents a comparison of current conditions and IRP goals by supply component.

MWD evaluated several alternative resource strategies in the initial phase of the IRP. A range of resource mixes was studied, varying primarily by the amount of local resources and conservation programs the region could develop to offset imported water requirements. Criteria used to evaluate these mixes included reliability, cost, feasibility, public acceptance, and environmental impacts. In 1994, MWD announced its intention of pursuing an intermediate mix that emphasized neither imported nor local supplies. In June 1995, MWD's Board adopted a Preferred Resource Mix that explicitly set targets for member agency local supply development and levels of conservation. The amount of imported water that will be required for the region, and the facilities necessary to provide it, are linked to this local resources effort.

MWD's approach in selecting specific components of the Preferred Resources Mix was to divide future supplies into two categories: "core" supplies, which represent normal year base load supplies, and "flex" supplies, which are used only when core supplies are insufficient to meet demand, such as during dry years. Core supplies include the historically dependable yield of the SWP, MWD's Colorado River entitlement, additional Colorado River water obtained from a conservation program with the Imperial Irrigation District (IID), and implementation of local water recycling and groundwater projects by member agencies and others. Flexible supplies are obtained from sources such as Central Valley transfers and storage of surplus SWP or transfer water in groundwater basins located south of the Delta. Inherent in this approach are two primary IRP

FIGURE 3-2 MWD Facilities

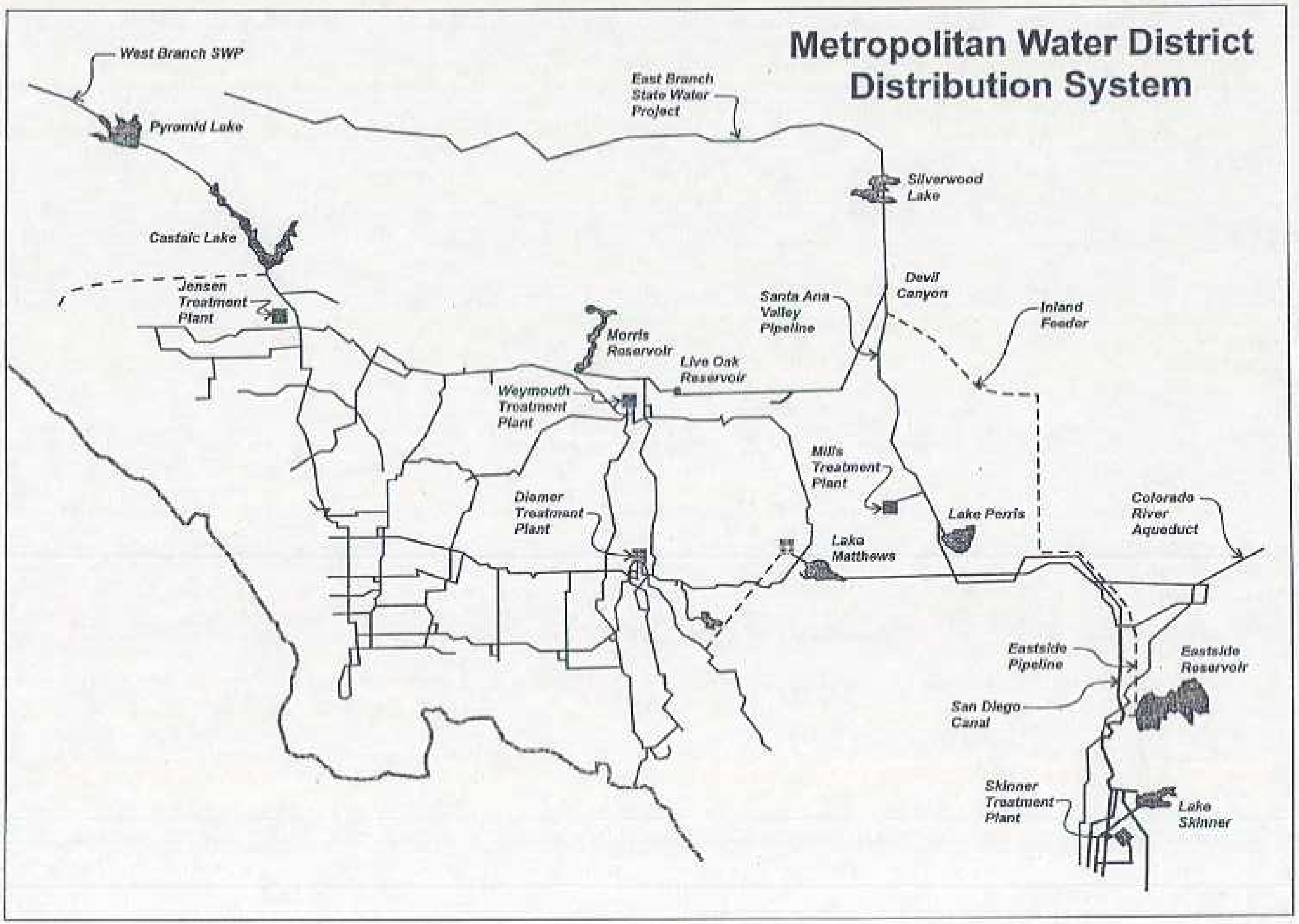


TABLE 3-2 MWD Supply by Component
Current Conditions Versus IRP Goal

	Current MAF	IRP MAF	Increase/ (Decrease) %
LOCAL SUPPLIES			
Local Groundwater & Surface	1.30	1.53	18
Water Recycling & Groundwater Recovery	0.16	0.50	213
Local Groundwater Storage Production	0.10	0.33	230
Total Local Supplies	1.56	2.36	51
IMPORTED SUPPLIES			
Colorado River	1.20	1.20	0
SWP	0.65	1.35	108
MWD Storage & Transfers	0.17	0.46	171
Total Imported Supplies	2.02	3.01	49
Total IRP Supplies	3.58	5.37	50

assumptions: 1) the CRA remains full at no additional cost to MWD for acquisition of Colorado River supplies (such as transfer acquisition costs), and 2) a full Delta fix is implemented by 2010. These two elements are essential to the successful implementation of the IRP.

The IRP is an iterative process that is intended to be adjusted as circumstances warrant. Over the short term, the plan must respond to the actual development of local resources; over the long term, changes in the region's economic, demographic, and water supply conditions must also be reflected.

Revenue Restructuring

In 1993, MWD began a revenue restructuring program intended to correct an imbalance between fixed costs and variable revenues. Historically, MWD has relied upon variable revenue from water sales for the bulk of its revenues. However, water sales fell off in recent years at the same time that MWD was incurring large increases in its fixed costs for capital facilities. This caused upward pressure on rates, which MWD attempted to alleviate by implementing a new revenue structure featuring both fixed and variable charges. These charges include a readiness-to-serve charge (RTS), designed to generate revenue to improve system reliability for existing users, and a new demand charge (NDC), designed to generate revenue for improvements necessary to meet growing demands.

While theoretically bringing fixed and variable costs and revenues into closer balance, the restructuring created a new set of pressures and uncertainties for MWD. For example, under the revised structure, some member agencies that had the capability were given motivation to "roll off" of the MWD system and avoid new demand charges by developing local supplies. This is because these charges were based on rolling averages of demand on MWD. One of the unintended consequences for MWD was the lack of revenue predictability and the potential for experiencing "stranded" assets, or facilities that were constructed to meet levels of demand that may never occur.

Work is now underway on a multi-phase Rate Refinement Process that is re-examining MWD's revenue structure, as well MWD's CIP and the financial incentive programs that support local supply development. Phase 1 of the Rate Refinement Process, which was completed in July 1996, resulted in: (1) the establishment of MWD rate targets for the next five years, (2) the suspension of the NDC until an alternative means of assessing new growth is identified or until demands on MWD reach 2.2 million acre-feet per year (maf/yr), and (3) the establishment of specific RTS obligations for each MWD member agency for the next five years. Phase 2 of the Rate Refinement Process, which is under way, focuses on (1) opportunities for containing MWD costs, (2) an Authority Water Transfer Proposal, and (3) the development of a wheeling policy. Phase 3 of the Rate Refinement Process, scheduled for completion in 1997, will focus on: (1) the development of an MWD drought management policy, (2) the development of alternative revenue sources, and (3) long-term rate structure reforms.

3.3 COLORADO RIVER SUPPLIES

MWD was originally formed to import water from the Colorado River and constructed the CRA during the 1930s to transport this supply. The first deliveries of CRW were made to MWD member agencies in 1941. The aqueduct transports water more than 240 miles, from Lake Havasu on the Colorado River to Lake Mathews in Riverside County, and has a maximum annual capacity of 1.2 maf. **Figure 3-1** shows the location of the aqueduct.

3.3.1 Issues

Entitlement and Reliability

Prior to 1964, MWD was operating under an assumption that its allocation of 1.212 maf of water from the Colorado River through contracts with the U.S. Department of the Interior was a firm entitlement. MWD's allocation was based upon provisions of the Seven Party Agreement, which divided California entitlements to CRW among California water users. However, in 1964, the Supreme Court, in *Arizona v. California,* held that California's firm entitlement is limited to 4.4 maf. MWD's dependable annual supply fell to 550,000 af as a result of the decision. This reduction in firm allocation is the most pressing issue MWD faces regarding its Colorado River supplies. Under the terms of the Seven Party Agreement, further reductions in MWD's supply may occur in the future, including 30,000 af previously reserved for Native American tribes and others along the Colorado River.

Water availability is governed by a system of priorities and water rights that has been established over many years. The lower basin states' annual apportionment of 7.5 maf of water is divided as follows: (1) California, 4.4 maf; (2) Arizona, 2.8 maf; and (3) Nevada, 300,000 af. The priorities for CRW among California agencies were set by the 1931 Seven Party Agreement and are shown in **Table 3-3.** As shown in the table, MWD's priority is junior to that of the California agricultural agencies' first through third priorities of 3.85 maf. These priorities are still in existence today, although agreements in 1946 and 1947 consolidated allocations of water between San Diego and MWD, after the Authority became a member of MWD. Water used to satisfy priorities 5(a)-6(b) comes from unused allocations within California, Arizona, or Nevada or through a declaration of surplus flows on the river by the Secretary of the Interior.

In recent years, MWD has been using an average of 1.2 maf/yr from the Colorado River. To maintain this level of supply, MWD has been relying on water available when Arizona and/or Nevada did not use their full entitlements. In 1996, the Bureau of Reclamation (Bureau) for the first time declared a surplus condition on the Colorado River, making more

TABLE 3-3 Seven Party Agreement Priorities

Priority	Description	AF/YR
1	Palo Verde Irrigation District	Priorities 1, 2, and 3 shall not exceed 3.85 maf/yr
2	Yuma Project Reservation Division	Same as above.
3 (a)	Imperial Irrigation District and lands in Imperial and Coachella valleys to be served by All American Canal	Same as above.
3 (b)	Palo Verde Irrigation District	Same as above.
4	Metropolitan Water District	550,000
5 (a)	Metropolitan Water District	550,000
5 (b)	City/County of San Diego	112,000
6 (a)	Imperial Irrigation District	
6 (b)	Palo Verde Irrigation District	300,000
TOTAL		5,362,000

than 7.5 maf available to the lower basin states. A surplus declaration is also expected for 1997. Without a declaration of a surplus condition on the Colorado River, MWD's ability to maintain a full CRA will be limited.

MWD stands first in line to receive any unused agricultural water available to California. Recently, the amount of unused agricultural water available has varied dramatically. In 1992, 500,000 af were available; by 1996, the agricultural diversions from the Colorado River exceeded the 3.85 maf agricultural entitlement, leaving no unused capacity.

Any surplus water available among the lower basin states is to be divided among the lower basin states according to the following formula: California, 50 percent; Arizona, 46 percent; and Nevada, 4 percent. MWD stands first in line to receive any such surplus allocated to California. Each year, the Department of Interior declares the availability of surplus or unused water that MWD may divert. The availability of surplus water is expected to decline over time as the upper basin states and Arizona take an increasing amount of their respective entitlements. Consequently, MWD's share of CRW is expected to decrease from 1.2 maf/yr to its firm allocation of 550,000 af/yr, plus any supplemental water that MWD is able to develop in the future.

MWD/IID Phase 1 Conservation Program

In 1988, MWD completed an agreement with the IID in which MWD financed various agricultural water conservation projects in the Imperial Valley. MWD is able to divert up to 106,000 af/yr from the program, which has a term through 2035. Because MWD's rights to Colorado River water are junior to those of Coachella Valley Water District (CVWD) and Palo Verde Irrigation District (PVID), the latter two agencies also entered the agreement. CVWD may require MWD to reduce its use of conserved water when the California agricultural agencies total water requests, plus the conserved water, exceed their allocation. As a result, MWD could lose up to 50,000 af/yr from the 106,000 af available under the agreement.

Water Quality

Salinity control has long been an issue on the Colorado River. Agricultural development and water diversions over the past 50 years have increased the already high naturally occurring levels of total dissolved solids (TDS). The federal government sought to control river salinity in the 1972 Clean Water Act and the 1974 Colorado River Basin Salinity Control Act. The Colorado River Basin Salinity Control Forum and Colorado River Basin Salinity Control Advisory Council were created to advise the federal government on developing water quality standards and implementing measures to reduce salinity.

The Authority received essentially 100 percent Colorado River supplies during the period 1991-94. This was caused in part by operational constraints that resulted from reduced demands during the 1986-92 drought and continued post-drought consumer water conservation. High salinity levels can damage water delivery systems and home appliances and also cause problems for recycling projects in the Authority's service area, especially for marketing recycled water to agricultural users growing salt-sensitive crops.

In 1995, MWD agreed to provide a seasonal blend of 25 percent SWP and 75 percent CRA in its Lake Skinner service area. Before blending, the TDS in Authority supplies had averaged in excess of 700 milligrams per liter (mg/L). After the 25-75 blend, this was reduced to about 600 mg/L, bringing some relief to the Authority's service area. However, this marginal improvement in water quality is not adequate to allow water recycling to reach its fullest potential in the Authority's service area and fails to meet standards set forth in MWD's enabling act. Under Section 136 of MWD's Act, MWD is to provide its member agencies with a 50-50 blend to the extent reasonable and practical. The Authority continues to seek a long-term commitment from MWD for a 50-50 blend or maintenance of an average salinity of no more than 500 mg/L. Once MWD's Inland Feeder pipeline and Eastside Reservoir are constructed in Riverside County, proportionately more SWP water is expected to be available for delivery to the Authority.

Environmental Considerations

In 1994, the U.S. Fish and Wildlife Service (USFWS) designated 1,980 miles of the Colorado River and its tributaries in Colorado, Utah, New Mexico, Arizona, California, and Nevada as critical habitat for four endangered species of native fish. The Bureau is conducting a consultation to determine whether existing activities on the river are adversely affecting the fish species. Until this is accomplished and a comprehensive plan for managing the river's resources is established, there will be some degree of uncertainty over the availability and costs of future river water supplies and power generation.

3.3.2 Opportunities

In its IRP, MWD projected the CRA to run at capacity through 2020. To achieve that goal, MWD is working on a program to improve the reliability of its Colorado River supplies and offset the projected decline of surplus supplies available for its use. The program relies upon developing supplies through conservation projects, banking conserved water, and modifying management and operations of the river system. Implementation of MWD's plans would require the support of CRW users in California and the other lower basin states potentially impacted by MWD's plans.

Conservation Projects

MWD has spent $200 million on a variety of conservation programs to increase the availability of water from the Colorado River. The projects include the IID Phase 1 conservation program that is expected to yield 106,000 af/yr through 2035, an agricultural land fallowing program with PVID that saved 186,000 af between 1992-94 (this water is already stored in Lake Mead for use before 2000), and an ongoing underground water storage program with the Central Arizona Water Conservation District, under which MWD has stored 50,000 af to date.

Water Banking

The ability to bank, or store, water on the Colorado River is considered essential to develop conservation projects that will provide new supplies. Banking by MWD could provide incentives for conservation programs and gives MWD and other regional agencies a place to store conserved water for future use.

MWD has linked water banking to the settlement of a decades-old water rights dispute involving Mission Indian Bands along the San Luis Rey River in San Diego County. Under its proposed settlement, MWD would either deliver water or make cash payments to the Bands in exchange for the ability to bank in Lake Mead. Under MWD's proposal, supplies eligible for banking would include water saved through conservation programs and "salinity control water," which represents water available from the Colorado River that MWD cannot deliver because of requirements to control salinity to assist regional recycling and groundwater management efforts. Salinity control is achieved by blending Colorado River supplies with water from the SWP, which has a lower salt content. A banking arrangement of this nature would require approval by the Secretary of the Interior and the support of upper and lower basin states.

Colorado River Reservoir Operations

To further augment available supplies, MWD has urged the U.S. Department of Interior to modify reservoir operations on the Colorado River. By MWD's estimates, supplies exceed demands on the river by an average of 1.8 maf/yr, assuming that the lower basin states are limited to diverting 7.5 maf/yr. By changing its operations, this excess water could be used by MWD and others over some period of time. MWD has asked the Department of Interior to revise the management criteria that determine when surplus water is available on the river and how it is allocated among California, Arizona, and Nevada.

Authority Colorado River Planning

MWD's plans for reoperation of the river currently lack the critical support needed from other CRW users and states, suggesting MWD may have difficulty implementing some or all of its plans. Both upper and lower Colorado River basin states and the Secretary of the Interior have expressed desires for California to live within its 4.4 maf apportionment and are concerned that reoperation could result in continued California reliance on surplus supplies.

3.4 STATE WATER PROJECT SUPPLIES

MWD's other water source, the SWP, is owned by the State of California and operated by the state's Department of Water Resources (DWR). This project pumps water from the Sacramento/San Joaquin River Delta into the California Aqueduct, which extends more than 400 miles south to Lake Perris in Riverside County. The aqueduct serves 29 contract water agencies in the state, including MWD. Water not immediately needed is stored at San Luis Reservoir, which is jointly owned by DWR and the Bureau. The California Aqueduct is shown on **Figure 3-3**.

Initial facilities for the SWP were completed in 1967 and provided an initial annual yield of 2.2 maf. The project was designed to achieve a maximum annual yield of 4.2 maf, with future facilities to be constructed as demand increased. MWD has entitlement to 2.0 maf of the supply. Because of public opposition, some of the major proposed facilities (including the Peripheral Canal) were not constructed. The current annual reliable yield is about 2.4 maf. MWD has taken between 0.4 and 1.4 maf/yr from the SWP in recent years.

Each year, based on weather and hydrology criteria, DWR establishes the quantity of

FIGURE 3-3 Major Water Conveyance Facilities

SWP supplies that will be available to contractors. Supplies are made available as a percentage of contractor requests. During the drought in 1991, the SWP delivered only 549,116 af to its entitlement contractors. Of this total, MWD received 381,070 af, or about 20 percent of its full entitlement.

DWR expects annual entitlement demand to reach 4.2 maf by 2010. A number of supply augmentation programs have been proposed to provide the water needed beyond the current yield. These projects include additional Delta facilities, surface water storage, and conjunctive use of surface storage and groundwater in the Sacramento and San Joaquin Valleys. In addition to increasing the SWP's yield, DWR is working on Delta salinity standards, water quality monitoring, and measures for ecosystem restoration, including guaranteed minimum flows and fish screens.

3.4.1 Issues

Yield and Reliability

Supply yield and reliability are the two most pressing issues facing the SWP. MWD's IRP assumes reliable yield from the SWP more than doubles by 2020. The current reliable yield of the project is well below the amount of contractors' requests, which reached a high in 1994 of 3.85 maf. The SWP was unable to meet contractors' requests in the drought periods of 1977, 1990-92, and 1994. SWP deliveries to MWD reached a high of 1.4 maf in 1990. MWD was unable to obtain its requested SWP deliveries in 1977 and 1991. MWD's IRP assumes that its reliable yield from the SWP will be 1.35 maf, more than doubling the current average yield of 0.65 maf.

In its 1993 California Water Plan Update (Bulletin 160-93), DWR projected that future SWP supplies in normal weather years would be below demand unless additional project facilities were constructed. In 2010, only 3.3 maf of supply would be available during a normal year to meet an estimated 4.2 maf of demand. With the addition of what DWR calls Level I water management programs, normal-year supplies would increase to 3.9 maf, or 93 percent of demand. During drought years, supplies would be only 2.0 maf using existing facilities and 3.0 maf with Level 1 programs.

The supply projections made by DWR are subject to a significant number of qualifications and assumptions. It is not certain, for example, whether the Level 1 programs needed to increase supply can be achieved. These programs include a variety of water management techniques, new Delta conveyance facilities, and ground and surface water storage, including the planned Los Banos Grandes Reservoir, which has been at least temporarily deferred. If these improvements are not implemented, DWR's ability to meet contractor requests for water will be limited.

Protection of San Francisco Bay and Sacramento/San Joaquin Delta

The California Water Plan Update supply projections also assume that water exports from the San Francisco Bay and the Sacramento-San Joaquin Delta (Bay-Delta) are governed by the State Water Resources Control Board's (SWRCB) 1978 Decision 1485 (D-1485), which has been superseded. D-1485 sets flow and water quality requirements for the Delta and places responsibility for meeting the requirements on the SWP and the federal CVP. In May 1995, both the SWP and CVP committed to meeting the operating requirements of a new water quality control plan. These flow and water quality requirements will remain in effect until the SWRCB establishes obligations for meeting the standards by all water users. Responsibility for meeting the standards is a matter of dispute among the various users, including MWD and other urban and agricultural water exporters. Water users from two groups, categorized as Sacramento Valley interests and the San Joaquin River interests, are meeting to negotiate differences before the SWRCB begins its water rights hearings process in 1997.

SWP supply and reliability issues are a result of long-standing problems in the Bay-Delta estuary, which provides water for two-thirds of all Californians. Increasing demands on the Delta from urban and agricultural uses have strained resources to the point where the system is declining in terms of water quality, ecosystem quality, water supply reliability, and vulnerability to both gradual and sudden failure of conveyance facilities. Water diversions have historically been a large part of the cause of Bay-Delta problems, but the region has also suffered from the dredging and filling of tidal marshes, construction of levees, pollution, and the introduction of non-native fishes, such as striped bass.

In addition to its importance to urban and agricultural water users, the Bay-Delta is of critical ecological importance. The region includes 70,000 acres of wetlands that support 120 species of fish, including commercially important fisheries. Fish protections under the federal Endangered Species Act (ESA), especially for winter-run salmon and Delta smelt, have caused supply uncertainty by changing the amounts of water available and the time periods in which it can be exported. However, the quantity and quality of water necessary to support this ecosystem are important issues that must be reviewed in conjunction with the SWP's overall supply reliability and yield. Failure to resolve these issues could lead to decreased exports, and have a negative impact on MWD's ability to meet its IRP supply targets.

Costs and Financing

The SWP was constructed using general obligation and revenue bonds and other capital resources that are repaid through revenues from its 29 contractors. The contractors, including MWD, are required to pay all the capital costs and operations and maintenance costs of the SWP, whether or not water is delivered. The contractors will have paid an estimated $21 billion in these fixed costs by 2035. All 29 contracts are effective until 2035, or until the contractors have retired all outstanding SWP debt, whichever occurs later. The water that contractors purchase is in addition to this cost. Work being done to improve supplies and reliability, including new facilities, will add to the cost burden each contractor shares.

3.4.2 Opportunities

The greatest potential for supply improvement on the SWP is expected to come from work being done by a consortium of state and federal agencies charged with finding long-term solutions for the Bay-Delta. This organization, dubbed CALFED, established a Bay-Delta Program in 1995 that is incorporating input from all three of the major regional water users - agricultural, urban, and environmental. The program is reviewing alternatives for solutions to the water resources problems that affect the SWP. The final product will include a preferred alternative that has both interim and long-term solutions.

Interim measures for improving SWP supply include the installation of screens and acoustic barriers designed to prevent fish from entering the intakes of water diversion points and improving watershed management. Long-term measures could include changing the location of diversion points, construction of new conveyance facilities, and offstream storage. Core actions that will be included in all Bay-Delta Program alternatives include habitat restoration (both in the Delta and upstream), reductions in the effects of diversions, management of anadromous fish, reductions in export reliance, water supply enhancement, increased water supply predictability, management of water quality, and improvements to system reliability.

Proposition 204, approved by California voters in November 1996, will provide about $583 million for environmental improvements to the Bay-Delta ecosystem. About $430 million of matching federal funding is also expected to be available for these purposes through the California Bay-Delta Environmental Enhancement and Water Security Act (HR 4126), which took effect on the date of passage of Proposition 204. Neither measure provides funds for facilities that will increase the yield of the SWP.

MWD's long-range projections for SWP supply rely heavily on providing a "full fix" to reliability problems plaguing the Delta by 2010. This would include the construction of a separate Delta conveyance facility. Any alternative selected that would fall short of that objective would reduce the yield MWD expects from the SWP. This could also limit the amount of transfer water from the Central Valley that MWD projects it will need to fully implement the IRP. At this time, both the total costs and MWD's share of the costs for a full fix, including water supply facilities, are unknown.

In April 1996, the Authority's Board adopted a set of policy principles for input into the Bay-Delta Program. These principles must be satisfied in the water resources alternative recommended for development by this Plan. The principles include measures for improving water supply reliability and quality; protecting Bay-Delta ecosystems; encouraging demand management through the use of conservation, groundwater, recycling, and transfers to reduce demands on the Delta; and providing a cost-effective alternative, when compared with all other alternatives.

3.5 OTHER IMPORTED SUPPLIES

3.5.1 Non-Local Conjunctive Use

The Authority may have the opportunity to purchase imported water from MWD and store it for future use in a groundwater basin located out of the San Diego region. One of the locations being reviewed for such a program is the Raymond Groundwater Basin, located near the City of Pasadena. A potential agreement has been discussed that would create an Authority groundwater account in the Raymond Basin for use during drought.

The main issues for this supply are the cost of placing and removing water from the basin, and "wheeling," or transporting, the water through MWD's distribution system to the Authority. An agreement would have to be made with MWD over compensation for the use of its system, as well as restrictions upon when the water could be delivered. Current estimates are that the cost of the supply would be about $500-$700 per af (this estimate includes the purchase of water at MWD rates, plus pumping and transportation costs).

3.5.2 Non-Traditional Supplies

Many non-traditional imported water supply ideas have been proposed as solutions to water supply problems in recent years. These ideas include constructing offshore pipelines to Southern California from Alaska or Northwest river supply sources, tankering water in ships, and towing giant water "baggies."

The latter proposal is perhaps the most developed of these alternatives. One version of the proposal would deliver water to the Authority in a series of up to 60 large fabric bags that are towed at sea. Each bag would carry about 4.5 million gallons (13.8 af), for a total delivery of about 800 af. Water would be transported in the bags from Washington state and be towed behind a boat to a local site, where it would be offloaded. An initial sea trial conducted in 1990 resulted in failure of the bag. A subsequent trial in 1996 resulted in the failure of one of two bags being towed. No detailed analysis has yet been done on the cost of delivering water in this way to the Authority's system.

The Authority examines each of these proposals and monitors developments in the technology and economics of alternative supply sources. At this time, none of these pro-

TABLE 3-4 Range of Major Potential Imported Water Sources

Source	Potential Amount	Est Cost (1996 $/AF)	Main Issues
Imported From MWD	21-85%[1]	344-426[2]	For CRA supplies: Long-term reliability and loss of firm supply, water quality, environmental, wheeling. For SWP supplies: Near- and long-term yield, cost of Bay-Delta facilities/programs, environmental.
Conjunctive Use	0-30,000 AF	500-700	Operational restrictions, wheeling.
Non-Traditional	Unknown	Unknown	Feasibility, cost, reliability.

[1] Amounts will vary based on Authority demands.
[2] Current MWD basic untreated and treated water rates.

posals is deemed viable as a dependable, cost-effective water resource for the region.

3.5.3 Los Angeles Aqueduct

Another major water supply into the MWD region is the Los Angeles Aqueduct (LAA). The LAA serves only the City of Los Angeles, an MWD member agency, and is filled with surface water and groundwater obtained from the Owens Valley and Mono Basin. This is a major regional water source and bears directly on how much water MWD must provide to the rest of its member agencies. The LAA has in the past provided as much as 534,000 af in one year (1983), but because of recent restrictions on diversions imposed by the State Water Resources Control Board, future diversions are expected to be reduced to about 360,000 af/yr. MWD projects that under certain hydrologic conditions the take from the LAA could be under 200,000 af. This reduction in yield is important to the Authority because it increases pressures on MWD to provide additional CRA and SWP supplies.

In a dry year, this effect is compounded because of similar hydrologies on the LAA and SWP. Reduced flows on the LAA correspond to reduced flows on the SWP. The City of Los Angeles shifts to MWD supplies during these dry weather periods, further stretching MWD's dry year supplies. The IRP addresses this issue through the dry year storage and transfers component of the Preferred Resource Mix. MWD has identified the potential quantities of shortage under various hydrological conditions and has selected Central Valley transfers, combined with the use of groundwater and surface water storage, as the means to mitigate this effect.

3.6 SUMMARY OF IMPORTED WATER SUPPLIES

Table 3-4 summarizes the imported water resources, other than transfers, that are considered in this Plan. Transfers are discussed in Chapter 5.

Chapter 4

4.0 LOCAL WATER RESOURCES

Although imported water meets the majority of the region's needs, local resources are also an important component of the water resources mix. Local resources include surface and groundwater supplies, recycled water, demand management (water conservation) measures, and desalinated seawater.

4.1 OVERVIEW

Before 1947, the San Diego region relied upon local surface water runoff in normal and wet weather years, and upon groundwater pumped from local aquifers during dry years, when stream flows were reduced. As the economy and population grew, local resources were not sufficient to meet the region's water supply needs. From the 1950's onward, the region became increasingly reliant on imported water supplies. Since 1980, a range of 5 to 30 percent of the water used within the Authority's service area has come from local sources, primarily from surface water impounding reservoirs that have yields varying directly with annual rainfall. The average local supply during this period was 19 percent of total water use. A small but growing share of local supply comes from recycled water and groundwater recovery projects. In 1994-95, local water sources provided 118,000 acre-feet (af), or 23 percent of the water used in the Authority's service area.

Water conservation and demand management measures represent another type of local resource. By making more efficient use of existing water supplies, area residents and industries can reduce the need for imported water supplies. In 1994-95, the Authority and its member agencies saved an estimated 20,000 af through the implementation of water conservation Best Management Practices (BMPs).

The 1993 Water Resources Plan emphasized the development of local supplies as a way to enhance reliability and diversify sources of supply within the Authority's service area. A goal was set for meeting 17 percent of the region's water supply needs from local sources during a normal weather year by 2010. This update of the Water Resources Plan evaluates a wide array of local resources opportunities which have the potential to meet up to 24 percent of the region's normal-year water supply needs by 2015. Policy considerations vary depending on the type of local resource and include the resource's reliability, cost, regulatory and/or institutional constraints, quality, environmental impacts, and public acceptance.

4.2 SURFACE WATER

Surface water supplies represent the largest single local resource in the Authority's service area. Because surface water yields are tied to hydrological cycles, however, annual yields can be highly variable. Since 1980, annual surface water yields have ranged from a low of 33,000 af to a high of 174,000 af. For planning purposes, local surface water supplies are assumed to have a dependable yield of 25,000 af and a normal yield of 60,000 af. This is the highest local surface water yield of any member agency of the Metropolitan Water District of Southern California (MWD).

4.2.1 Description

Seven major stream systems originate in the mountains of San Diego County and drain into the Pacific Ocean. Runoff within these watersheds has largely been developed. During extremely wet years, however, local surface reservoirs spill, and significant amounts of surface water are lost to the ocean.

Twenty-four surface reservoirs are located within the Authority's service area, with a combined capacity of approximately 569,000 af. **Table 4-1** lists the 15 largest reservoirs in the county, which have a combined storage capacity of 553,080 af. **Figure 4-1** shows the location of local reservoirs. The Sutherland Reservoir, which was completed in 1953, was the last major reservoir constructed in the Authority's service area.

The Authority's Emergency Storage Project (ESP), discussed in Chapter 2, is expected to increase the region's water storage capacity by 90,000 af. However, use of the ESP will be limited to emergency situations, such as prolonged drought or the catastrophic failure of one or more of the Authority's pipelines during an earthquake or other disaster. The ESP consists primarily of off-stream facilities that will store imported water and capture minimal amounts of local runoff. The ESP will also result in the construction of facilities that will increase the outlet capacity of two existing reservoirs owned by the City of San Diego: Lake Hodges and San Vicente. These water delivery system improvements will allow an increase in the surface water yield from both of these reservoirs in normal and wet weather years.

TABLE 4-1
Major San Diego County Reservoirs

Member Agency	Reservoir	Capacity (AF)
City of Escondido	Wohlford	6,940
City of San Diego	Barret	37,900
City of San Diego[1]	El Capitan	113,000
City of San Diego[2]	Hodges	33,600
City of San Diego	Miramar	7,185
City of San Diego	Morena	50,200
City of San Diego	Lower Otay	49,500
City of San Diego	San Vicente	90,200
City of San Diego	Sutherland	29,700
Helix W D	Cuyamaca	8,195
Helix WD	Jennings	9,790
Ramona MWD	Ramona	12,000
Sweetwater Authority	Loveland	25,400
Sweetwater Authority	Sweetwater	27,700
Vista ID	Henshaw	51,770
Total Storage- 15 Major Reservoirs		**553,080**

= Connected to Authority aqueduct system
1 = Imported water can be delivered via San Vicente
2 = Proposed to be connected as part of the Emergency Storage Project

4.2.2 Issues

Optimization of Reservoir Operations

The management of the region's extensive reservoir system to achieve the optimal use of local and imported water is an important element of resources planning. Local surface water supplies can be used to offset dry-year shortfalls in imported water. However, water use records indicate that local reservoirs are generally operated to maximize the use of local supplies in wet and normal years to reduce the need for imported water purchases. While this mode of reservoir operation reduces losses due to evaporation and spills, it also results in increased demands for imported water during dry years, when imported water is more likely to be in short supply. Reservoirs could be operated to carry over stored water but this would tend to decrease the average annual yield.

San Luis Rey Indian Water Rights

A water rights dispute over supplies from the San Luis Rey River has existed for more than 25 years. Several Mission Indian Bands along the river have litigated during this period to receive local supplies to which they claim entitlement. In 1988, a federal law was passed (Public Law 100-675) that provided up to 16,000 acre-feet per year (af/yr) to the Indian Bands. The law stipulates that the water may originate from one of three sources: California public lands outside of the Central Valley Project service area, water conserved by lining the All American Canal, or through contract with the MWD. To date, no agreement has been reached on developing this supply for the Indian Bands. The failure to resolve this issue threatens the availability of up to 16,000 af/yr of local supply to the City of Escondido and the Vista Irrigation District.

4.2.3 Opportunities

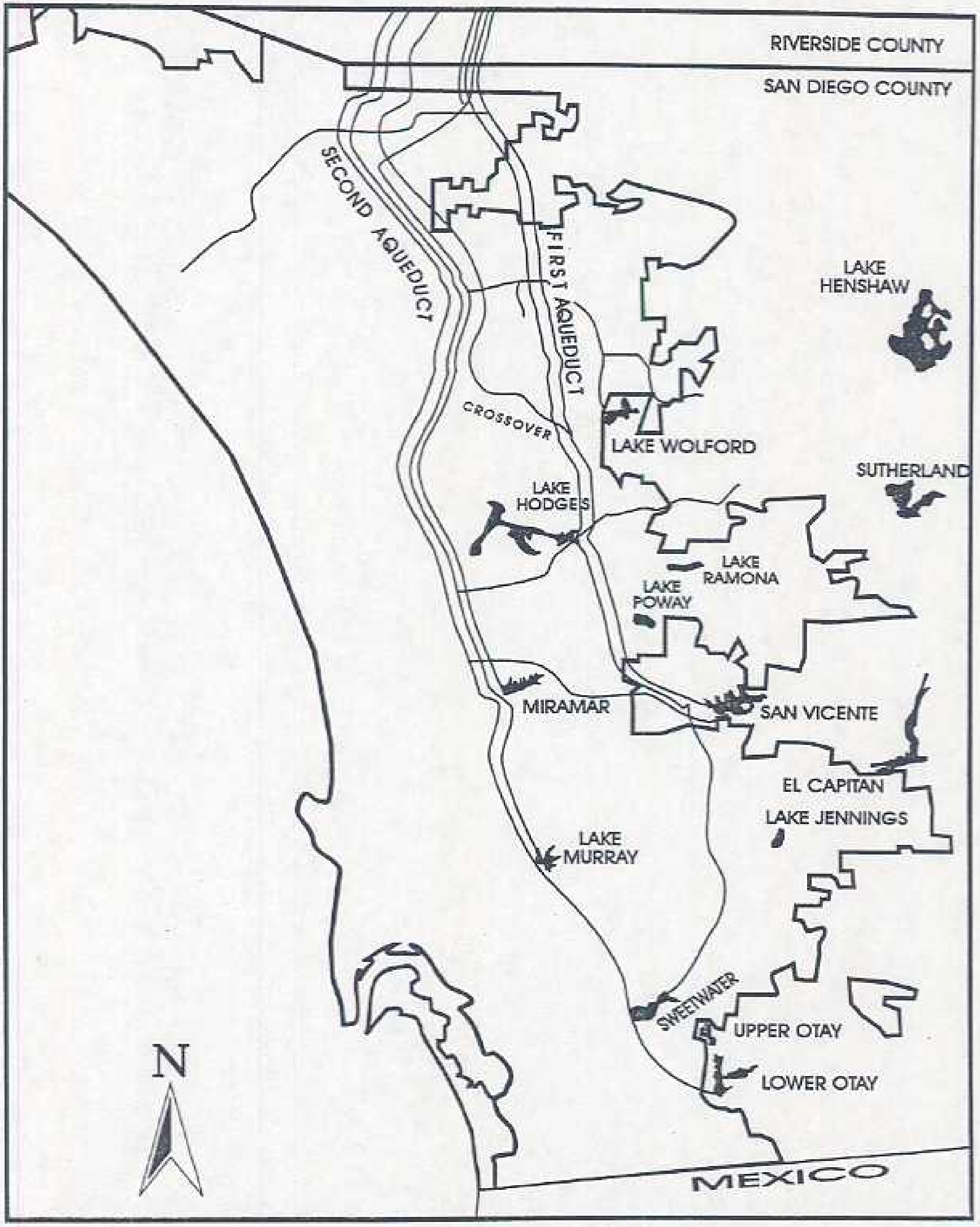
Potential Projects

Although the ESP is not a local supply project, it does provide incidental local supply benefits by allowing the capture of additional winter storm runoff. The project (the Olivenhain/Hodges/San Vicente alternative) is expected to increase surface yields at the San Vicente Reservoir by an average of 800 af/yr by reducing the tendency to spill. Expanded outlet capacity and a new pipeline connecting San Vicente with the Miramar Water Filtration Plant and the Authority's Second Aqueduct will significantly increase the ability to move surface water into the delivery system. Currently, limitations on outlet and pipeline capacity restrict the amount of water that can be drafted from San Vicente Reservoir. The ESP would also provide a means to transport water from Lake Hodges via the Authority's Second Aqueduct to the Miramar Filtration Plant. Historically, Lake Hodges, with its 300 square mile watershed, has been one of the most productive surface water systems in the county. It has also been prone to spills and losses due to evaporation. This component of the ESP is expected to increase average annual local surface water yields from Lake Hodges by 4,500 af and in a wet year by approximately 10,000 af.

Seasonal Water Pricing Programs

In recognition of the important role storage plays in effectively managing water resources, MWD offers pricing discounts to encourage the more efficient use of reservoir and groundwater storage capacity. Seasonal Storage Service (SSS) provides a discount (currently $115 for untreated water) for water purchased during the winter months and stored for use during the summer. This program is primarily used to shift demand on MWD from the summer periods to the wetter winter months when surplus water from the imported sources is available. This seasonal shift water also allows for more regulated use of MWD's and the Authority's distribution systems by reducing the peak demand for imported water during the hotter summer months when pipeline capacity may be limited.

FIGURE 4-1
Major San Diego County Reservoirrs



Because MWD-owned storage is insufficient to capture available surplus flows from the State Water Project (SWP), the use of locally owned storage serves to increase the yield from the imported water system during wet years. Without this added increment of available storage, these surplus supplies would be lost. Several of the Authority's member agencies participate in MWD's SSS program. It is estimated that, over the course of the Water Resources Plan, an average of 50,000 af in seasonal shift water will be purchased annually by Authority member agencies.

MWD also has a Cooperative Storage Program that is designed to provide an incentive for the longer term carryover of surplus supplies as protection against drought. Only limited amounts of water have been stored under this program and there has been no participation by agencies with surface water reservoirs. Currently, local agencies have greater incentive to use stored imported water to shift demand in the year purchased, rather than to carry it over for a longer term and risk spilling and losing the water from the reservoir. The Authority is participating in efforts to identify a means of encouraging more long-term carryover storage to protect against imported water shortages.

San Luis Rey Settlement Process

To resolve a dispute over limited river water resources, a 1988 federal law provided that the Bands and local agencies should receive up to 16,000 af of water annually, in addition to that available from the river.

Parties to the settlement have yet to agree on how the water should be developed, how much it should cost, and who should pay for it. While several proposals have been put forth by the settlement parties and others, resolution of issues has not yet been accomplished.

In a December 19, 1996, speech to the Colorado River Water Users Association, Secretary of Interior Bruce Babbitt indicated the federal government's concern with the lack of progress on implementation of the 1988 settlement act. Secretary Babbitt stated that the federal government will continue to work with California's Colorado River stakeholders in effecting a settlement to San Luis Rey water rights, which he sees as key to advancing issues of interest to California on the river.

4.3 DEMAND MANAGEMENT

Demand management, or water conservation, is frequently the lowest-cost resource available to the Authority and its member agencies. Therefore, it will play a major role in any water resources mix. The 1993 Water Resources Plan projected that the implementation of existing and proposed statewide BMPs would produce water savings of 70,000 af/yr by the year 2010. By comparison, the 1993 Plan assumed a 2010 combined yield of 65,000 af/yr for recycled water and groundwater projects. To meet the 1993 Plan's water savings goal, the Authority has developed an aggressive water conservation program.

Projected conservation savings are based on results from the CWA-MAIN computer model. **Table 4-2** provides a breakdown of sectoral water demand with expected conservation from 1995 to 2010.

4.3.1 Description

The objectives of the Authority's water conservation program are to eliminate wasteful water use practices, develop information on current and potential conservation practices, and implement conservation measures in a timely manner. The scope of the program is described in the Authority's Urban Water Management Plan (December 1995). Major activities include active participation in the development and implementation of statewide BMPs, participation with member

TABLE 4-2
Forecasts of Sectoral Water Demand With Expected Conservation (AF)
(1995 - 2015)

Year	Total Residentl	Single-Famly	Multi-Famly	Total Non-Residentl	Commercl	Industrl	Govt	Other/ Unaccounted	Total M&I
1995	341,958	248,493	93,465	150,032	81,546	14,965	53,520	37,077	529,066
2000	355,377	259,134	96,243	156,585	85,579	15,704	55,302	38,701	550,596
2005	386,114	281,884	104,229	171,326	95,257	17,351	58,718	42,364	599,815
2010	419,752	307,289	112,462	182,774	104,554	17,676	60,544	46,083	648,642
2015	453,445	332,705	120,740	198,321	116,204	18,415	63,703	50,104	701,916
Annual Rate of Growth (%)	1.4	1.5	1.3	1.4	1.8	1.0	0.9	1.5	1.4

Note: Due to rounding, the Total M&I water use for a year will not exactly equal the summation of the individual water use sectors. Approximately 25,000 af/yr of ag M&I use are not included on this table but are reflected on Table 2-5.

agencies and MWD in research and development activities, and implementation of public information and education programs. **Table 4-3** provides a list of urban BMPs that have been implemented by the Authority and its member agencies.

4.3.2 Issues

Revenue Impacts

As a potential resource, water conservation sometimes suffers from the perception that it reduces commodity-based rate revenues. Over the long-term, however, conservation measures serve to defer or limit rate increases by reducing the region's need for other, more expensive water supplies. The cost of water conservation measures ranges from $50 to $400/af. Most measures cost less than $300/af, far less than the cost of most other local supplies. When financial incentives from MWD are included, the cost of these measures to the Authority and its member agencies is even lower.

Demand Hardening

"Demand Hardening" refers to the diminished ability of customers to reduce their water demands during a supply shortage if they are already conserving water. For example, a customer who installs ultra-low-flush toilets and low-flow showerheads during a normal supply period has fewer opportunities for conserving additional water during a drought. Many short-term demand management measures, such as taking shorter showers, save less water after efficient water technology is installed. Even though demand hardening does occur, long-term conservation measures still play an important role in reducing the severity of supply shortages. By lowering normal-year demands, demand management measures result in higher carryover storage for use during shortages. Also, some studies suggest that customers who have practiced long-term conservation techniques may be more willing to reduce demands during a shortage, and may be able to do so with less disruption to their normal lifestyles and/or business operations.

Indoor/Outdoor Use

In designing conservation programs it is useful to know where water is being used so that measures to reduce consumption can be appropriately targeted. One way to analyze how much water is being used indoors is to compare water use in a given area with sewage flows for that same area. Sewage flow levels were compared to water consumption for both the City of San Diego's Metropolitan Wastewater Department (MWWD) and the

FIGURE 4-2
MWWD Sewer Flow Totals and M&I Water Use Totals

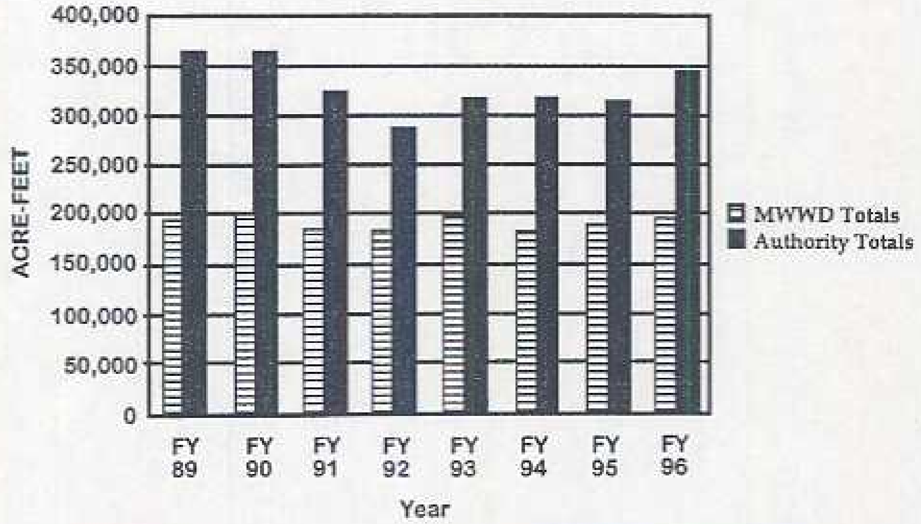
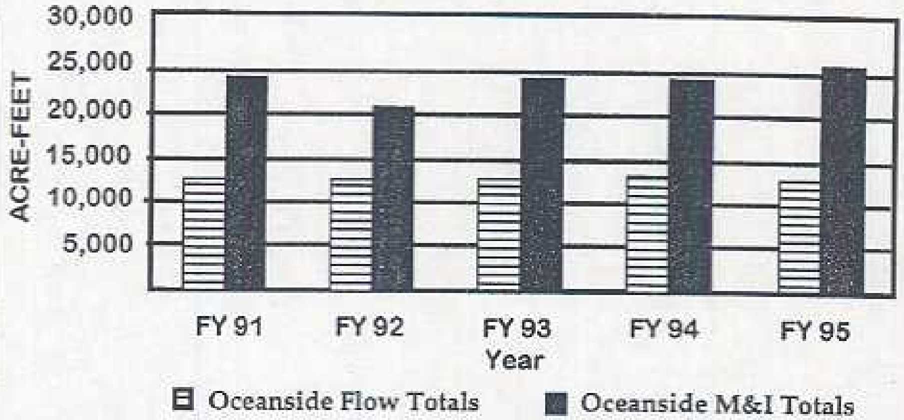


TABLE 4-3
Best Managemnt Practices For Urban Water Conservation in California

Practices	SDCWA Implementation Schedule
1. Interior and exterior water audits and incentive programs for single-family residential, multi-family residential, and governmental/institutional customers.	Implemented.
2. Plumbing, new and retrofit.	Implemented.
a. Enforcement of water conserving plumbing fixture standards including requirements for ultra-low-flush (ULF) toilets in all new construction beginning January 1, 1992.	Authority sponsored legislation adopted.
b. Support of state and federal legislation prohibiting sale of toilets using more than 1.6 gallons per flush.	Implemented.
c. Plumbing retrofit.	Implemented.
3. Distribution system water audits, leak detection and repair.	Implemented.
4. Metering with commodity rates for all new connections.	Implemented.
5. Large landscape water audits and incentives.	Implemented.
6. Landscape water conservation requirements for new and existing commercial, industrial, institutional, governmental and multi-family developments.	Implemented.
7. Public information.	Implemented.
8. School education.	Implemented.
9. Commercial and industrial water conservation.	Implemented.
10. New commercial and industrial water conservation.	Implemented.
11. Conservation pricing.	Implemented.
12. Landscaping water conservation on new and existing single-family homes.	Implemented.
13. Water waste prohibition.	Implemented.
14. Water conservation coordinator. coordinator.	Implemented.
15. Financial incentives.	Implemented.
16. Ultra-low-flush toilet replacement.	Implemented.

City of Oceanside **(Figure 4-2 and Figure 4-3).** These two agencies were selected because of the ability to overlay the sewer service areas on the water agency service areas so that a fairly accurate comparison could be made.

FIGURE 4-3
City of Oceanside Sewer Flow Totals and M&I Water Use Totals



In both cases, the analysis showed much greater elasticity in water consumption than in sewage flow. For instance, between fiscal years 1992-96 MWWD showed a 5 percent increase in sewage flows. However, during the same period, total water consumption for the MWWD service area increased by nearly 19 percent. Therefore, while sewage flow information can play an important role in analyzing consumption of water for purposes that result in sewage flows, its role in projecting total water demands is limited. This analysis also points to the importance of continuing the Authority's landscape water conservation programs that target outdoor water use where the elasticity is concentrated.

4.3.3 Opportunities

Potential Conservation

Projections of water savings provided by this Plan are based upon the best currently available information. These projections tend to be conservative, so as not to underestimate the total demand requirement for which future water must be supplied. As more information becomes available, the projected savings will be revised. The Authority is active in programs that will identify future water conservation opportunities, such as a clothes washer rebate program that provides incentives for installing water-saving washing machines. Projected water savings and effectiveness are based on industry standard methodologies for calculating savings, as defined by the California Urban Water Conservation Council (CUWCC). The Authority assists the CUWCC in conducting pilot programs and analyzing ways to increase the accuracy of savings calculation methodologies.

Current levels of effort by the Authority and its member agencies are projected to result in water savings of almost 82,000 af/yr by 2015 (**Table 4-4**). This conservation target is appropriate for the current staffing and funding levels set by the Board. Additionally, this target coincides with the availability of member agency and MWD matching funds. Some of the BMPs that are not quantified in **Table 4-4**, such as public information and school education, do not directly result in water savings. These BMPs instead result in a decision by a water user to take an action that will result in savings. For example, a water user may learn about the availability of showerheads through a public information program, but water will not be saved until the user installs a water saving showerhead, available through the plumbing retrofit program. To avoid double counting, the projected savings from the showerhead is reflected only in the plumbing retrofits BMP. **Table 4-4** has other BMPs that are not quantified because there are no reliable estimates of savings available at this time. An example of this type of BMP is the new commercial/industrial/institutional program. Once reliable savings estimates are available, they will be used to revise the conservation estimates.

Estimates of savings presented in **Table 4-4** are based on projections of savings from implementation of various conservation measures which is a different method of calculation from that used by CWA-MAIN as reflected in **Table 2-5**. The fact that the aggregate savings levels for 2010 and 2015 as calculated through both methods are very similar indicates that there is a significant level of confidence that those long range projections are accurate. However, the savings levels reflected on **Table 4-3** are included only for comparison purposes. The savings estimates on **Table 2-5** are used for all forecast purposes in this Plan.

Alternative levels of water conservation effort are available to the Authority. The rate of BMP implementation could be decreased. A decreased level of effort could provide small short-term budgetary savings, but would also result in lost short-term and long-term water savings. Lost water savings would mean increased reliance on other, more expensive water sources, such as imported water, recycled water, or groundwater. Additionally, match-

TABLE 4-4
Potential Water Conservation Savings Through 2015

Best Mgt. Practice	2000 (AF)	2005 (AF)	2010 (AF)	2015 (AF)
EXISTING BMPS				
Residential Audits	700	700	700	700
Plumbing Retrofits	8,675	12,600	16,600	20,600
Main Line Leak Detection	8,500	14,150	19,600	19,600
Metering	—[1]	—[1]	—[1]	—[1]
Large Landscape Audits	2,600	2,800	3,000	3,000
Landscape Design Requirements	700	1,050	1,400	1,800
Public Information	—[1]	—[1]	—[1]	—[1]
School Education	—[1]	—[1]	—[1]	—[1]
Commercial/Industrial	1,080	1,080	1,080	1,080
New Commercial/Industrial	—[1]	—[1]	—[1]	—[1]
Conservation Pricing	—[1]	—[1]	—[1]	—[1]
Residential Landscape	900	900	900	900
Waste Prohibition	—[1]	—[1]	—[1]	—[1]
Conservation Coordinator	—[1]	—[1]	—[1]	—[1]
Financial Incentives	—[2]	—[2]	—[2]	—[2]
ULFT Incentives	13,734	19,758	25,764	31,770
Subtotal	**36,889**	**53,038**	**69,044**	**79,450**
PROPOSED BMPS				
Appliance Efficient Standards	0	250	500	1,000
Clothes Washer Incentives	120	240	600	1,000
Car Wash Retrofits	0	250	500	500
Subtotal	**120**	**740**	**1,600**	**2,500**
Total	**37,009**	**53,778**	**70,644**	**81,950**

[1] Not quantified.
[2] Quantified by specific measure.

ing funds from MWD and local agencies would be lost.

Conservation measures could also be more aggressively implemented. This alternative would require increased short-term expenditures, but would also result in water savings being achieved sooner and, consequently, the realization of greater long-term savings. Due to uncertainty about evolving technology, however, it is difficult to project accurately what level of savings could be achieved through this increased level of effort.

One option for increasing the level of water savings is to implement mandatory conservation measures, such as retrofit-on-resale ordinances. These ordinances typically require that water-efficient plumbing fixtures (toilets, showerheads, and faucets, for example) be installed as a condition of the sale of real property. Because of previous efforts with showerhead installations, most of the potential for future water savings to be realized by such an ordinance in the Authority's service area would be from installation of ultra low flush toilets (ULFTs). The cities of Del Mar and San Diego already have such ordinances. The Authority will continue to support legislative efforts to enact similar ordinances.

Although 54 percent of the Authority's service area is operating without the benefit of a retrofit ordinance, the region is on track to achieve a comparable level of water savings as if the entire service area were subject to a retrofit ordinance. California's water conservation goal is based on a level of water savings equal to that which would be achieved through a statewide retrofit-on-resale ordinance. The Authority's conservation savings is presently running within 7 percent of its proportional share of the statewide goal. Should the current level of water conservation funding be sustained, the Authority will be at or above its statewide conservation targets beginning in 1998 and extending through the 2015 horizon year for this Plan.

The role of conservation pricing was also considered in projecting demands. The baseline forecast assumptions used in projecting demands in this Plan include demand reductions resulting from retail conservation pricing changes through 1990. The CWA-MAIN computer model used to calculate demands also includes assumptions concerning pricing and demand in the post- 1990 period. It assumes that a 10 percent increase in price would translate into a 0.91 percent decrease in average single-family household water use.

As noted above, the Authority conducts pilot programs to evaluate the savings and cost effectiveness of potential conservation measures. When measures are proven to be cost effective, the level of implementation is increased. Additionally, there is potential to accelerate the implementation of current programs. Accelerating the programs simply means the savings from the programs will be realized sooner than currently projected. The amount of savings available from conservation programs is finite during the planning horizon of this Plan.

4.4 RECYCLED AND REPURIFIED WATER

Recycled water currently accounts for a relatively small share of the area's local water resources. However, this source will play an increasingly important role as projects currently under design or construction begin production.

4.4.1 Description

Water recycling is the treatment and disinfection of municipal wastewater to provide a water supply suitable for reuse. Non-potable reuse is the term applied to recycled water used for non-drinking water purposes. Examples range from landscape irrigation to recreational impoundments. Agencies in San Diego County use recycled water to fill lakes, ponds, and ornamental fountains; to irrigate parks, campgrounds, golf courses, freeway medians, community greenbelts, school athletic fields, food crops, and nursery stock; to control dust at construction sites; and to recharge groundwater basins. Recycled water can also be used in certain industrial processes and for flushing toilets in non-residential buildings.

In 1995, 17 recycling projects added more than 8,600 af of recycled water to the area's local supplies. Approximately one-half of this water was used for landscape irrigation and other municipal and industrial uses; the remaining half was used for groundwater recharge. These existing projects are ultimately expected to produce up to 12,400 af of recycled water annually.

One significant change that has occurred since the publication of the 1993 Water Resources Plan is the emergence of water repurification, a form of indirect potable reuse, as a potential resource option. Water repurification is the treatment of recycled water to a level suitable for augmentation of the drinking water supply. The City of San Diego, with support from the Authority, is studying a project that would produce up to 15,000 af of repurified water annually. Under the project proposal, 20 million gallons per day (mgd) of recycled water from a City of San Diego recycling plant would be treated using state-of-the-art technology, including microfiltration and reverse osmosis. The repurified water would be delivered to a local surface reservoir, where it would reside for a period of time and blend with local runoff and imported water. The blended water would then be withdrawn by the City on demand, filtered, disinfected, and supplied to customers through the City's treated water distribution system.

4.4.2 Issues

Economic and Financial Considerations

The cost of providing recycled water has traditionally been a barrier to project implementation. The construction of treatment facilities and recycled water distribution systems can be expensive, a situation which is compounded by the seasonal nature of recycled water demands. Recycled water demands tend to peak during the hot summer months and drop off during the winter months when landscape irrigation demands are low. Projects that serve a large proportion of irrigation demands, like the majority of the projects in the Authority's service area, often utilize only half of their annual production capacity due to these seasonal demand patterns. The costs of these projects tend to be higher than those of projects that serve year-round demands, since the project facilities must be sized to accommodate seasonal peaking. Projects that serve mostly irrigation demands also tend to have less stable revenue bases, since irrigation demands are heavily influenced by hydrologic conditions.

The costs of projects proposed in the Authority's service area vary widely, ranging from $300 to $1,200/af. Variations in project costs can be attributed to many factors, including differences in existing treatment capacities and processes, differences in the location of treatment facilities in relation to recycled water markets, and differences in recycled water demands.

To be perceived as financially feasible, a project's benefits must offset or exceed its associated costs. Project benefits can take the form of: (1) revenues from the sale of recycled water, (2) increased supply reliability, (3) increased control over the cost of future water supplies, (4) avoided treatment, storage and conveyance costs, and (5) Authority and MWD financial incentives. Uncertainty regarding the value of these benefits can, by hindering an agency's ability to determine the financial feasibility of a project, serve as a significant barrier to project development.

Uncertainty regarding future MWD rate increases and the long- term availability of MWD incentives may, for example, cause agencies to defer the implementation of projects with unit costs higher than the current MWD/Authority combined water rate. A lack of information regarding the value of increased supply reliability and uncertainty regarding the impact of local resource development on MWD drought allocations can also complicate an agency's decision-making process and lead to the deferral of cost-effective projects.

Water Quality

Water quality is another significant issue, particularly in the Authority's service area. MWD's deliveries to the Authority consist primarily of Colorado River water (CRW), which has a high salinity content, expressed in terms of total dissolved solids (TDS). The TDS content of Colorado River water is more than 700 milligrams per liter (mg/L). By comparison, the TDS content of State Project water ranges from 250 to 350 mg/L.

Excessive salinity in the water supply causes damage to water-using equipment and appliances. A 1988 report titled Estimated Economic Impacts of Salinity of the Colorado River, prepared for the Bureau of Recycling, estimated that annual damages to households receiving high proportions of Colorado River water ranged from $87 to $146 per household. Projected to the San Diego region, this would result in annual salinity damages of between $78 million and $130 million. Excess salinity also increases the cost of production of irrigated agriculture and may decrease crop yield.

High TDS source water poses a special problem for recycling facilities because conventional treatment processes are designed to remove suspended, but not dissolved, particles. TDS removal, or demineralization, requires an advanced treatment process, which can significantly increase project costs.

Residential use of water typically adds 250 to 300 mg/L of TDS to the wastewater stream. Self-regenerating water softeners can add another 60 to 100 mg/L. If an area receives a water supply that has a TDS of more than 700 mg/L, and residents add 300 mg/L or more through normal use, the recycling facility will produce recycled water with a TDS concentration of 1,000 mg/L or higher. This greatly limits the recycled water's potential uses and marketability, particularly for agricultural purposes, because certain crops and nursery stock cannot be irrigated with high-TDS water.

Public Acceptance

Water recycling and reuse have increased in California over the past two decades, and many public opinion surveys and research papers point to growing public acceptance of water recycling for all non-potable uses. The public is less familiar with water repurification, since it is a relatively new concept in California. Increased public understanding and acceptance of the repurification process will be key to the success of any water repurification project.

4.4.3 Opportunities

Financial Incentives

Both MWD and the Authority offer financial incentives to encourage the development of cost-effective water recycling projects. MWD administers two incentive programs: the Local Projects Program (LPP) and the Groundwater Recovery Program (GRP). The LPP, established in 1982, provides financial incentives of $154/af for recycled water projects. The GRP, established in 1991, provides sliding scale incentives of up to $250/af for projects that recover and treat contaminated groundwater. To qualify for funding under either program, a project must reduce demands on MWD and have a unit cost greater than MWD's basic treated water rate (currently $426/af). To date, MWD has entered into 53 LPP and GRP agreements, 16 of which are for projects in the Authority's service area. The ultimate yield of the 16 LPP and GRP projects in the Authority's service area is approximately 41,000 af/yr.

MWD has proposed replacing the LPP and GRP with a single incentive program called the Local Resource Program (LRP). The proposed LRP would provide sliding scale incentives of up to $250/af and could be used to fund both recycling and groundwater recovery projects. MWD has not yet adopted the LRP, although the MWD Board has authorized the voluntary conversion of existing LPP projects to the terms of the proposed LRP. MWD is currently evaluating revisions to the proposed LRP in light of new, lower demand projections. Possible revisions to the LRP include: (1) the establishment of local resource development targets which could effectively limit the number of LRP agreements MWD would enter into during any one year and (2) the development of project selection criteria. These potential revisions to the LRP create significant uncertainty for agencies that are developing local projects, but have not yet entered into LPP or GRP agreements.

The Authority established the Reclaimed Water Development Fund (RWDF) in 1991 to supplement MWD's LPP. The RWDF provides sliding scale incentives of up to $100/af for recycled water projects that offset demands on the Authority and demonstrate a financial need. A project is assumed to have a financial need if its cumulative expenses exceed its cumulative revenues. Once a project reaches a financial "break-even" point, its eligibility for RWDF incentives ends. Projects are eligible to receive RWDF incentives for up to 25 years; however, most projects will break-even long before then. To date, the Authority has entered into RWDF agreements for nine projects with a combined yield of almost 30,000 af/yr.

Federal and State Funding

The U.S. Bureau of Reclamation's (Bureau's) Title XVI Grant Program is a new, and potentially significant, source of funding for certain water recycling and groundwater recovery projects. Title XVI of Public Law 102-575 authorizes the Bureau to fund up to 25 percent of the capital cost of several California water recycling projects. Included is the San Diego Area Water Reclamation Program, a regional program serving portions of the Authority's southern and central service area. To date, the Bureau has provided more than $15 million in grant funding for the San Diego Area Water Reclamation Program. Title XVI was recently amended to include grant authorizations for sixteen additional recycling projects in California and other western states. The expanded Title XVI includes grant authorizations for the City of Oceanside's Mission Basin Desalter and the North San Diego County Area Water Recycling Project, a regional project serving the northern coastal area.

Water recycling projects are also eligible for low-interest loans from the State Revolving Fund (SRF) and the Water Reclamation Loan Program (WRLP). Several of the existing recycling projects in the Authority's service area have secured construction funding through these programs. Funds approved by the voters in 1984 and 1988 for these loan programs have largely been expended. However, as discussed in Section 3.4.2, Proposition 204, approved by state voters in November 1996, will infuse new funding into these programs. SRF funds are matched by federal Clean Water Act monies on a 5:1 basis (i.e., five federal dollars for each state dollar) and may be used to fund both wastewater treatment and water recycling projects. WRLP funds are earmarked exclusively for recycling projects.

Advances in Regulatory Approval

As recycled water projects have developed long and successful operating histories, regulatory agency concerns have been allayed. The San Diego Regional Water Quality Control Board (RWQCB) and the County Department of Environmental Health, the two agencies in San Diego County with primary regulatory authority over recycling projects, are both highly supportive of local recycling efforts. Progress continues to be made on the last two "frontiers": groundwater recharge for potable reuse and surface water injection for potable reuse. Potable reuse projects in Orange County (the

Orange County Water District's groundwater recharge project) and San Diego County (the City of San Diego's water repurification project) are proceeding cautiously with rigorous oversight from the California Department of Health Services (DHS) and the local RWQCBs. DHS has stated that the water repurification project "represents a logical extension of California's existing water resources management strategy."

Increased Level of Public Acceptance

To address questions about water repurification, the Authority and the City of San Diego initiated a comprehensive information-gathering project to identify specific issues of concern. Information was developed through public opinion research, focus groups, and interviews with community leaders. In addition, a citizen's review committee was convened that included representatives from a broad range of community, environmental, medical, business, biotech, and recreational organizations. The Repurified Water Review Committee (RWRC) met over a period of five months to examine issues associated with repurified water. In their final report, RWRC members concluded that repurified water is a suitable supplement to the San Diego region's water supply and that additional planning, economic, and environmental studies should proceed. These and other public information efforts contribute to increased public understanding and acceptance of repurified water as an important new supply source for the San Diego region.

Potential Projects

Agencies within the Authority's service area have identified more than 20 potential recycled or repurified water projects with a combined yield in excess of 53,000 af. Seven of these projects, representing an annual yield of 33,400 af, are currently under design or construction. Three additional projects are in the environmental review phase. The remaining projects are either at the conceptual or preliminary planning stage or have significant unresolved issues which may affect their technical or financial feasibility. **Figure 4-4** shows the location of existing and potential recycled and repurified water projects in the Authority's service area. **Table 4-5** shows potential recycled and repurified water development in the Authority's service area by the year 2015. The projections assume the continued operation of existing projects and the development of those ten new projects for which a sufficient level of planning has been completed to allow an assessment of their feasibility. The ten future projects have an associated yield of 42,600 af.

4.5 GROUNDWATER

Agencies within the Authority's service area currently use about 13,550 af of groundwater annually. Private well owners also draw on local basins for their water supplies. The amount of groundwater pumped by private wells is suspected to be significant, but has not yet been accurately quantified. The 1993 Water Resources Plan projected the development of 15,000 af/yr of additional groundwater supplies by 2010. Recent efforts at project development by member agencies and others suggest that the potential for local groundwater development is more than double the level envisioned in the 1993 Plan.

4.5.1 Description

Groundwater supplies in the Authority's service area are limited by both the geology and the semi-arid hydrologic conditions of the region. Narrow river valleys with shallow alluvial deposits are characteristic of many of the more productive groundwater basins. Outside of these alluvial basins, much of the geology consists of fractured crystalline bedrock and fine-grained sedimentary deposits that are generally only capable of yielding small amounts of groundwater to domestic wells. One notable exception is the San Diego Formation, located

FIGURE 4-4
Existing and Planned San Diego Area Water Recycling Projects

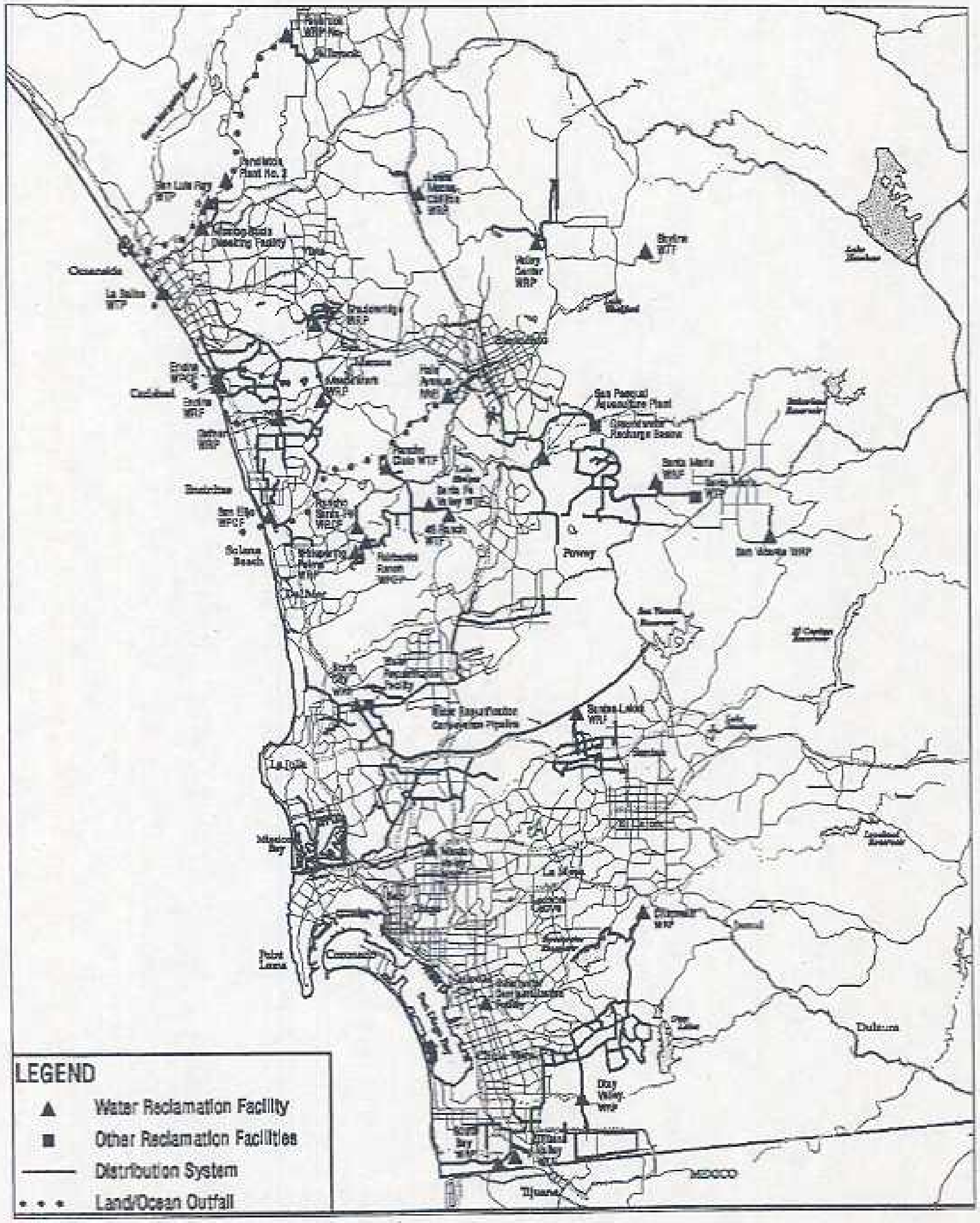
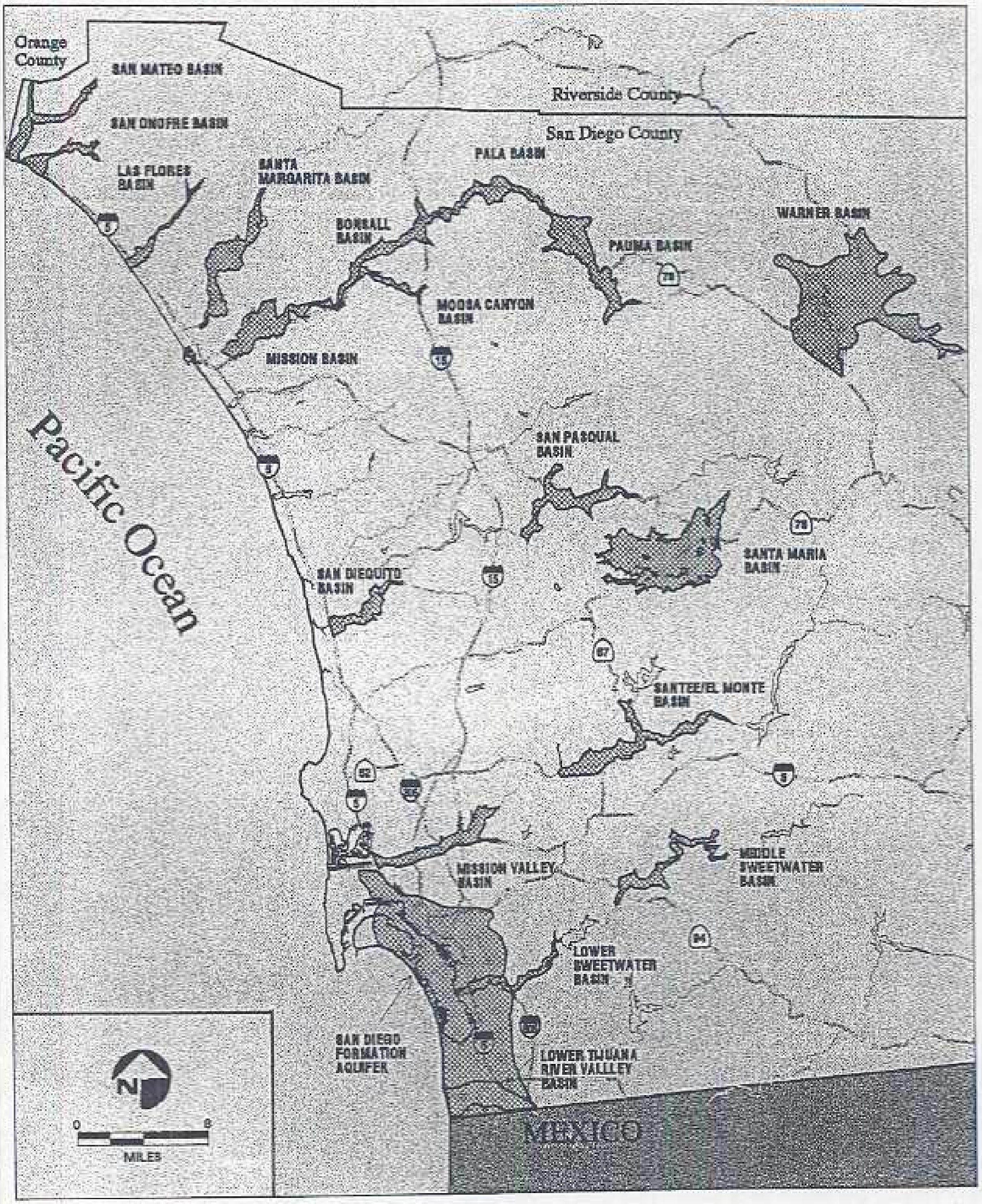


TABLE 4-5
Potential Recycled and Repurified Water Development Through 2015

Agency	2000 (AF)	2005 (AF)	2010 (AF)	2015 (AF)
EXISTING PROJECTS				
Buena SD	300	300	300	300
Carlsbad MWD	2,100	2,100	2,100	2,100
Encina WA	165	165	165	165
Fairbanks Ranch CSD[1]	200	200	200	200
Fallbrook PUD	850	850	850	850
City of Oceanside	300	300	300	300
Otay WD	1,000	1,450	1,450	1,450
Padre Dam MWD[1]	615	615	615	615
Pendleton1	3,400	3,400	3,400	3,400
Ramona MWD[1]	1,000	1,100	1,200	1,200
Rancho Santa Fe CSD[1]	220	220	220	220
City of San Diego	800	1,100	1,100	1,100
San Diego Wild Animal Park[1]	20	20	20	20
Valley Center MWD[1]	225	275	275	275
Whispering Palms CSD[1]	205	205	205	205
Subtotal	**11,400**	**12,300**	**12,400**	**12,400**
FUTURE PROJECTS				
Carlsbad MWD	-	2,800	4,600	5,600
City of Escondido	-	2,800	2,800	2,800
Otay WD	-	-	2,100	2,600
Padre Dam MWD	850	900	900	900
Rincon Del Diablo MWD	-	400	400	400
City of San Diego[2]	4,350	22,700	24,200	27,700
San Elijo JPA	1,600	1,600	1,600	1,600
Vista ID	-	,000	1,000	1,000
Subtotal	6,800	32,200	37,600	42,600
Total	18,200	44,500	50,000	55,000

[1] The Authority's demand projections already account for this project; therefore, the project yield is not considered a "new" local supply.
[2] Includes 15,000 af of repurified water.

FIGURE 4-5
San Diego Area Groundwater Basins



in the southwestern portion of the county. This large and complex aquifer shows special promise as a recycled water storage and brackish groundwater reservoir; however, additional hydrogeological investigations must be completed before the aquifer's groundwater development potential can be fully determined. **Figure 4-5** shows the location of regionally significant groundwater basins in the Authority's service area.

Although groundwater supplies are less plentiful in San Diego than in some other areas of Southern California, such as the Los Angeles Basin, sufficient undeveloped supplies exist to help meet a substantial portion of the region's future water needs. Agencies within the Authority's service area have identified more than a dozen potential groundwater recovery projects with a combined annual yield in excess of 50,000 af. The potential projects fall into three categories:

Groundwater Extraction and Disinfection Projects

These projects are generally located in basins with higher water quality levels, where extracted groundwater requires minimal treatment for use as a potable water supply. The unit cost of water produced from simple groundwater extraction and disinfection projects is usually quite low and rarely exceeds the cost of imported water. Because most of the higher quality groundwater within the Authority's service area is already being fully utilized, a relatively small amount of this "least cost" groundwater is available for the development of new supplies. Nevertheless, several agencies in the Authority's service area have identified potential extraction and disinfection projects. These projects include the initial phase of the proposed Tia Juana Valley County Water District's San Diego Formation groundwater project and several projects planned in the El Monte Basin. The average unit cost of groundwater extraction and disinfection projects proposed within the Authority's service area is approximately $300/af.

Brackish Groundwater Recovery Projects

Brackish water is typically found in basins which have been impacted by imported water irrigation or by seawater intrusion resulting from the overdraft of coastal basins. Brackish groundwater recovery projects use desalination technologies, such as reverse osmosis (RO), to treat extracted groundwater to potable water standards. The City of Oceanside's Mission Basin desalter is an example of a brackish groundwater recovery project, as is the Sweetwater Authority's proposed demineralization facility. Unit costs for brackish groundwater recovery projects are considerably higher than those for simple groundwater extraction projects due to the projects' more extensive treatment requirements and brine disposal needs. The unit costs of brackish groundwater recovery projects proposed within the Authority's service area range from $530 to $620/af.

Groundwater Recharge and Recovery Projects

Recharge projects improve groundwater basin yields by supplementing natural recharge sources with potable or recycled water. The City of San Diego's proposed San Pasqual groundwater project and the proposed Fallbrook Public Utility District/Camp Pendleton conjunctive use project are examples. The unit costs of groundwater recharge and extraction projects proposed within the Authority's service area range from $730 to $1,020/af.

4.5.2 Issues

Economic and Financial Considerations

Like recycled water projects, groundwater recovery projects can be costly to construct and operate. However, because treated groundwater is suitable for all potable uses, groundwater recovery projects face less variation in demand and do not require the construction of separate distribution facilities. Projects dependent on natural recharge sources, such as surface runoff, can be affected by hydrologic conditions and therefore provide less supply reliability than recycled water projects. Projects which use recycled water as a source of recharge are, however, highly reliable.

Institutional and Regulatory Issues

Institutional and water rights issues can be another obstacle to project development. Because most basins contain multiple water agencies, water rights is a potential concern. Agencies are often reluctant to implement groundwater development projects unless jurisdictional and water rights issues are resolved. Frequently, this reluctance stems from the ability of adjoining agencies and property owners to benefit from the groundwater project without sharing in the project costs.

Uncertainty over future regulatory requirements can pose another barrier to project development. When developing facilities and compliance plans for groundwater recharge projects, agencies must take into account proposed or potential regulatory changes. Regulations for which changes are expected over the next decade include (1) state and federal drinking water standards, (2) federal storm water regulations, and (3) DHS groundwater recharge regulations.

Environmental Constraints

Environmental issues common to many of the groundwater projects proposed within the Authority's service area include: (1) potential impacts from groundwater pumping to endangered species or groundwater-dependent vegetation and (2) impacts to other local pumpers. Such impacts may occur if a project results in seasonal or long-term increases in the depth to groundwater. Although potential environmental impacts can generally be mitigated, mitigation costs can reduce the financial feasibility of a project. Brine disposal requirements for brackish groundwater recovery projects can also be a constraint for projects sited in inland basins.

4.5.3 Opportunities

Potential Projects

Local groundwater development efforts have increased significantly since the publication of the 1993 Water Resources Plan. Agencies within the Authority's service area have identified 15 potential groundwater development projects; eight are considered to be far enough along in the planning process to support a forecasted future yield. These eight projects, presented in **Table 4-6**, range from simple extraction and disinfection projects to more highly involved projects incorporating recycled water recharge, extraction, and demineralization. One of the projects, the City of Oceanside's demineralization facility, is an expansion of an existing brackish groundwater recovery project. The other seven projects would construct new facilities.

Current conceptual planning efforts indicate that other potential projects in the Authority's service area, not identified herein, may be implemented. These projects will be monitored by the Authority for possible inclusion in the next Plan update. Based on the current level of effort and planning status of potential groundwater development projects, and assuming the continued availability of MWD incentives described in **Section 4.4.3**, this plan foresees the development of 34,400 af of additional groundwater supplies by the year 2015.

4.6 SEAWATER DESALINATION

Desalinated seawater is widely used as a potable water supply and is sometimes described as the ultimate solution to Southern California's water supply shortfall. In some areas of the world, such as the Middle East, desalinated seawater represents the primary source of potable water. Large-scale desalination projects are relatively uncommon in the United States, due to their relatively high unit costs. Nevertheless, for coastal areas such as

TABLE 4-6
Potential Groundwater Development Through 2015

Agency (Groundwater Basin)	2000 (AF)	2005 (AF)	2010 (AF)	2015 (AF)
EXISTING PROJECTS[1]				
Camp Pendleton (San Juan and Lower Santa Margarita Basins)[2]	4,400	4,400	4,400	4,400
Helix WD/Lakeside WD/Riverview WD (El Monte Basin)	2,050	2,050	2,050	2,050
City of Oceanside (Mission Basin)	2,200	2,200	2,200	2,200
Ramona MWD (Santa Maria Basin)	200	200	200	200
Sweetwater Authority (Lower Sweetwater Basin)	2,000	2,000	2,000	2,000
Yuima MWD (Pala and Pauma Basins)	2,700	2,700	2,700	2,700
Subtotal	**13,550**	**13,550**	**13,550**	**13,550**
FUTURE PROJECTS				
FPUD/Camp Pendleton (Lower Margarita River Basin)	0	2,000	4,000	6,000
Helix WD/ Lakeside WD/Riverview WD (El Monte Basin)	800	1,600	2,400	2,400
City of Oceanside (Mission Basin)	4,900	4,900	4,900	4,900
Padre Dam MWD (Santee Basin)	0	1,700	3,400	3,400
City of San Diego (San Pasqual Basin)	500	2,000	4,000	8,000
San Dieguito Valley Task Force (San Dieguito Valley)	0	2,000	4,000	4,000
Sweetwater Authority (Lower Sweetwater Basin/San Diego Formation)	1,850	3,700	3,700	3,700
Tia Juana Valley CWD (Tijuana Valley/San Diego Formation)	500	1,000	1,500	2,000
Subtotal	**8,550**	**18,900**	**27,900**	**34,400**
TOTAL	**22,100**	**32,450**	**41,450**	**47,950**

1 Vista ID currently pumps approximately 14,000 af/yr of groundwater from the Warner Basin, which it stores in Lake Henshaw. This yield is reflected in the estimated 60,000 af/yr of existing local surface water supplies.

2 Camp Pendleton typically pumps 7,800 af/yr of groundwater. The difference, 3,400 af/yr, is assumed to originate from recycled water recharged into the groundwater basin through percolation ponds.

San Diego, seawater desalination must be considered in the development of any comprehensive water resource management plan.

4.6.1 Description

Processes commonly used for large-scale seawater desalination fall into two general categories: (1) thermal processes and (2) membrane processes. Thermal processes use heat to separate salt and other impurities from seawater. Membrane processes, such as RO, use pressure to force seawater through a semi-permeable membrane. The membrane is constructed of materials which will allow water molecules, but not dissolved impurities, to pass through. Thermal facilities currently represent the largest volume of installed seawater desalination capacity. However, these facilities tend to be located in areas of the world where fuel is inexpensive. As membrane technology continues to improve, RO is gaining popularity as a less costly, more energy-efficient desalination technique.

Over the last five years, the Authority has closely studied the development of seawater desalination facilities. Earlier studies evaluated both thermal and membrane processes and concluded that RO would be the most cost effective desalination technology for this region. Subsequent studies focused on the construction of an RO facility in conjunction with the proposed repowering of the San Diego Gas and Electric South Bay Power Plant. Although the project was found to be technically feasible, many of the benefits anticipated from collocating the facility failed to materialize. As a result, the study found that environmental, regulatory, and cost issues combined to make desalinated seawater more expensive than other available water resource options.

4.6.2 Issues

Economic and Financial Considerations

As with other water supply projects, cost remains the primary barrier to project development. Despite recent advances in desalination technology, particularly in the area of lower-pressure membranes, seawater desalination remains a relatively-costly resource option.

Depending on site-specific conditions, such as the proximity of the desalination facility to brine disposal facilities and the product water distribution system, the estimated unit cost of seawater desalination projects ranges from $1,200 to $2,000/af. This makes desalinated seawater a less attractive option than competing local resources, such as recycled water and groundwater.

Environmental Constraints

Facility siting constraints can also act as a barrier to project development. Given the environmental sensitivity and land use restrictions associated with most of the San Diego County coastline, it is unlikely that many large-scale desalination facilities could be sited along the coast. Coastal power stations are among the few sites along the coastline where large desalination facilities could likely meet permitting and land use restrictions. Although desalination facilities could be sited farther inland, the expense of pumping seawater and brine concentrate over long distances would add to the already high unit costs.

When siting facilities, agencies must also consider the proximity of the site to existing potable water distribution systems. For example, the Authority's distribution system is located several miles from the coast. A large-scale coastal desalination facility would likely require a costly pipeline and pumping system to move product water inland to the Authority's distribution system. Smaller desalination facilities may be able to utilize the local distribution system to serve users along the coast.

Another significant issue affecting the development of seawater desalination facilities is disposal of the brine concentrate produced when fresh water is separated from seawater. For a typical RO seawater desalination facility, the brine concentrate discharge will have a salinity approximately twice that of the source water. Should the concentrate be discharged to the ocean, regulatory agencies are concerned that the high salt concentration could adversely impact the marine environment near the discharge point. Authority studies conducted as part of the South Bay project indicated that the salinity of the concentrate discharge could be reduced by mixing the discharge with another discharge stream, such as treated wastewater or power plant cooling water.

4.6.3 Opportunities

Emerging Technologies

Desalinated seawater does not currently appear to be a cost-effective resource option for the San Diego region. Therefore, the 1997 Plan update does not assume the development of any large-scale seawater desalination projects within the Authority's service area by the year 2015. However, ongoing efforts to develop a "breakthrough" desalination technology could change this situation. One such potential breakthrough technology is MWD's Seawater Desalination Demonstration Project, which seeks to lower desalination costs through the use of aluminum vertical tube evaporator technology.

Preliminary MWD design reports indicate that the costs of this technology, if operated on a large-scale, could be less than $600/af (excluding post-treatment and distribution costs). This cost estimate has not been verified and assumes the availability of low-cost power from a combined-cycle power plant. MWD is currently operating a test unit to evaluate the performance and cost of vertical tube evaporator technology over a wide range of conditions. If the data from the test unit show that the technology is technically and economically feasible, MWD plans to proceed with the design of a 5 mgd demonstration project. One-half of the design effort would be funded through international research and development grant funds. MWD plans to seek a suitable site and power supply for the project, preferably somewhere along the Southern California coastline.

Another potential breakthrough technology is the capacitive deionization process recently developed at the Lawrence Livermore National Laboratory (LLNL). This process utilizes a unique material called "carbon aerogel" to enhance the performance of electrodes, which remove dissolved ions from the source water. Thus far, the capacitive deionization process has only been demonstrated on a small scale in the laboratory. A larger test unit is being constructed to further evaluate the technology. Early estimates indicate that the cost of water produced could range from $400 to $600/af. However, these costs have yet to be practically demonstrated. Toward that end, the City of Carlsbad is developing a pilot plant to investigate the feasibility of the capacitive deionization process for use in large-scale brackish groundwater and seawater desalting facilities. This project, and other pilot projects based on new desalination technologies, will be monitored by staff for possible inclusion in future updates to the Plan.

4.7 SUMMARY OF LOCAL WATER SUPPLIES

The estimated costs, availability and policy considerations for various local water resources are presented in **Table 4-7**. The table does not reflect all local projects which could potentially be developed by 2015; rather, it reflects those projects for which a sufficient degree of planning has been completed to allow an assessment of their technical and financial feasibility.

TABLE 4-7
Range of Potential Normal-Year Local Resources

SOURCE	Potential 2015 Quantity (AF/YR)	Estimated Cost/AF[1]	Reliability	Regulatory/ Institutional Issues	Water Quality	Environmental Constraints	Public Acceptance
Surface Water	65,300	Minimal operation and maintenance costs	Yields vary widely depending on hydrologic	Flood control issues. Connection of existing conditions. Authority aqueducts may increase yields.	Good to excellent	CEQA compliance required. Reservoir management considerations can pose unique constraints.	High
Demand Management	81,950	$50 - $400/AF	Long-term reliability	Not applicable is unknown.	Not applicable	Not applicable	High. Active public outreach has increased knowledge and acceptance
Recycled and Repurified Water	55,000[2]	$300 - $1,200/AF	Slight reduction in project yields during droughts, otherwise highly reliable.	Regulatory issues are generally managable. Institutional issues are less of a problem for projects in the Authority's service area than in other areas of the state	Varies. Quality of recycled water is dependent on quality of influent wastewater supply. Quality of repurified water is extremely high.	CEQA compliance required. Constraints are generally construction related.	High public acceptance for recycled water. Emerging public acceptance for repurified water.
Groundwater	47,950	$300 - $1,000/AF	Varies. Yields from projects dependent on natural recharge can be affected by hydrologic conditions. Projects that use recycled water for recharge are highly reliable	Water rights are a potential for many projects	Varies depending on quality of water in groundwater basin and level of treatment.	CEQA compliance required. Unique constraints include potential impacts to groundwater dependent vegetation and impacts on existing wells. Brine disposal is an issue for some projects.	High
Desalinated Seawater	0	$1,200 - $2,000/AF	High	Requires coastal permit. Few coastal sites available.	High	CEQA compliance required. Discharge of brine concentrate can be a major issue	High

1 Costs exclude MWD and Authority financial incentives.

2 Includes 6,135 AFY of existing yield already accounted for in the Authority's demand projections and therefore not considered a new local water supply.

Chapter 5

5.0 WATER TRANSFERS

Water transfers have emerged as one of the Authority's greatest potential resources outside of purchases from the Metropolitan Water District of Southern California (MWD). A transfer proposal currently being evaluated has the potential to result in an annual supply of water comparable to the amount the Authority purchased from MWD in 1994-95. If a transfer of this magnitude were achieved, it would fundamentally alter the relationship the Authority has with MWD, which has been the primary source of imported water throughout the Authority's history.

Current studies will determine the feasibility of transferring up to 500,000 acre-feet per year (af/yr) from one or more water sources: the Colorado River, Central California, or Northern California. This amount of water would meet more than half of the Authority's anticipated water demand in 2015. Delivering this quantity of water from the Colorado River would require either the significant enlargement or paralleling of the existing Colorado River Aqueduct (CRA) or the construction of separate conveyance facilities from Imperial Valley to the Authority. Transfers from Northern and Central California would utilize State Water Project conveyance capacity.

This Plan presents an overview of various types of transfers and evaluates transfers both as a normal-year and dry-year supply source using the same criteria as for other resource options.

5.1 OVERVIEW

Water transfers have until recently been considered by the Authority primarily as a dry-year supply. The 1993 Water Resources Plan recommended transfers only as required during a drought, for times when normal supplies from MWD were curtailed. This recommendation was based upon Authority experience during the drought that ended in 1992, MWD reduced deliveries to the Authority by as much as 31 percent. The Authority purchased enough transfer supplies from the State Water Bank to reduce the severity of that cutback to 26 percent. Using water bank transfers plus additional local supplies, the Authority was able to reduce the shortage to its member agencies to 20 percent.

Since 1993, market forces have created a situation where water transfers may be attractive as a long-term supply, to be used during normal weather years as well as insuring against droughts. The reasons for this include: passage of the Central Valley Project Improvement Act (CVPIA), increased interest in transfers from parties such as MWD and Central Valley farmers, Orange County Water District and Placer County, and the discussions between the Authority and the Imperial Irrigation District (IID). Transfers are also a consideration in the CALFED Bay-Delta process, being perceived as a contributor to overall water efficiency and as a way to supplement Delta through-flow. Normal-year transfers could diversify the Authority's sources of imported water and enhance overall supply reliability.

Water transfers typically involve purchasing water during a specified period from an agency or district that then reduces its water use by that amount. The principle behind transfers is that market forces may reallocate water. Transfers are typically categorized into the following types:

- *Spot Transfers* - Spot transfers make water available for a limited duration (typically one year or less) through a contract entered into in the same year that the water is delivered.

- *Option Transfers* - Option transfers are multi-year contracts that allow the purchaser to obtain a specified quantity of water at some future date. They usually require a minimum payment for water even if the water is not needed. For example, an agreement may require water to be purchased one out of every five years.

- *Core Transfers* - Core transfers make water available through multi-year contracts that convey a specific amount of water to the purchaser each year.

- *Storage Transfers* - Storage transfers allow the purchaser to place water into storage for delivery at some time in the future.

- *Water Exchanges* - Water exchanges are agreements between the purchasing agency and selling agency that allow for the exchange of water from one source for water from a different source.

Currently, the Authority is considering transfer opportunities involving core transfers and water exchanges. However, this Plan also reviews and evaluates other types of transfers, including spot transfers for dry years only.

Under the California Constitution, every water user has a right only to the amount of water which can be put to reasonable and beneficial use. The California Water Code (Code) empowers local agencies to sell water and to serve as brokers between individual users within their service area and potential buyers.

The Code includes statutory regulation on both short-term and long-term water transfers. Short-term transfers are for a period of one year or less, and transfers meeting these criteria are considered temporary changes. Long-term transfers, i.e., more than one year, may be approved by the State Water Resources Control Board (SWRCB) when the transfer would not result in substantial injury to any legal user and not unreasonably affect fish, wildlife, or other instream beneficial uses. Long-term transfers cannot exceed seven years, unless the transferring agency and transferee agree to a longer period.

While not a new concept, water transfers traditionally did not occur in California because of significant legal, social, and institutional barriers. A major constraint was the requirement that local water agencies, and not the transferor, have the opportunity to prevent or veto the transfer. However, during the past decade, state and federal laws were enacted to encourage transfers, based upon the premise that transfers can result in a more efficient use of water. Three key laws are highlighted in **Table 5-1**.

To gain better insight into the state of practice in water transfers, the Authority authorized a study of recent transfers in seven western states (Index of Western Water Transfers 1986-95, February 1996). The focus was on transfers of more than 10,000 acre-feet (af)

TABLE 5-1
Recent Laws Affecting Transfers

YEAR	LEGISLATION	DESCRIPTION
1986	Water Transfer Act (state)	Provides for coordinated assistance of the Department of Water Resources and other state agencies to accomplish voluntary transfers.
1986	"Katz Bill" (state) (AB 2746)	Directs public water agencies to make unused capacity in their conveyance systems available for transfers.
1992	Central Valley Project Improvement Act (CVPIA)	Permits transfers of Central Valley Project (CVP) water to areas outside of CVP service area.

occurring during 1986 through 1995. **Table 5-2** provides a list of these transfers and summarizes key information about them.

One of the most striking results of the study is how few permanent transfers involve 10,000 af or more. In California, this is probably due to statutory limitations. Results also demonstrated a wide variability in the sale price of water and indicated that the value of water is highly site-specific.

5.2 WATER TRANSFER ISSUES

One of the most important issues for any potential intrastate transfer is the inability to negotiate directly with the user of the water. Most California irrigators receiving surface waters have a contract specifying an amount of water to be delivered to them for beneficial use on their property. The actual water right is most often held by the water district or yet another agency that delivers water to the district. This is different from laws in states such as Arizona and Colorado, where rights are often held by the user and are severable from the land.

Other major issues for successful transfers are the level of compensation paid to the transferring party, environmental considerations, water quality, and the avoidance of potential harmful impacts to third parties. Third party impacts can be economic or social harm related to the transfer of water out of a region. For example, farmers who fallow lands to transfer water may have a harmful impact on farming-related businesses that produce or sell farming equipment, supplies, fuel, etc.

While all of these issues are important, the primary focus of the Authority's initial review of potential transfers is on costs, the reliability of the supply, and the quality of the water delivered. When comparing transfer options from various sources, it is also important to review the rights attached to the water. This has a direct bearing on the reliability of the transfer source and is an especially important consideration when reviewing long-term transfers for delivery during normal weather years. Although a thorough discussion of water rights is beyond the scope of this Plan, some generalizations can be made to illustrate this consideration.

Water Rights Considerations

Intrastate transfers of Colorado River water are considered the best potential source for long-term transfers because of the priority of the water. As discussed in Chapter 3, the agricultural agencies that could provide this water enjoy first through third priorities to 3.85 million acre-feet per year (maf/yr) of the state's 4.4 maf/yr allocation. These priorities are higher than MWD's Priority 4 allocation of 550,000 af. This means that the water would likely remain available for transfer even during drought, because the transferring agency, as holder of the water right, is in a relatively senior position to other water rights holders.

Depending on the source of supply, potential long-term transfers involving the State Water Project (SWP) or CVP offer varying degrees of reliability in terms of water rights. Agencies with rights dating to before 1914 are considered to have the most secure water. These agencies would be able to complete relatively secure long-term transfers. Much of this water is from an "area of origin" designation, so called because the water is located at or near the headwaters of the state's river systems. However, most of the water available for potential transfer is from the SWP and CVP contractors and has post-1914 rights. SWP and CVP rights are considered junior to area of origin rights. These agencies must apply for a permit from the SWRCB before transferring the water. In many cases, the permits must be renewed every seven years, thus clouding any long-term agreement for transfer. This issue is not as important for short-term transfers. Northern California transfer sources have provided the Authority short-term supplies in the past (1991-92 State Water Bank) and could be used for the same purpose in the future. As a practical matter, short-term transfers would be best suited as a dry-year supply.

TABLE 5-2
Representative Water Transfers 1986-95

	Number of Transfers by Year										Quantities Range (af)	Duration	Comments
STATE	86	87	88	89	90	91	92	93	94	95			
Arizona	0	0	0	0	0	0	0	0	0	0	No transfers exceeding 10,000	-----------	Type II groundwater rights transfers most prevalent type.
California	3	3	6	8	7	18	3	10	10	6	10,000 - 186,000	from 1-time only to yearly to 4 years	Ag to ag, exchanges, SWP water for CVP water, groundwater exchange, leasing storage space, environmental uses.
Colorado	0	1	0	0	0	1	1	1	2	0	10,000 - 200,000	3 1-time, 3 permanent	Storage rights, recreational/ wildlife uses, conditional rights to in-stream flow.
New Mexico	0	0	0	0	0	0	1	2	2	0	12,997 - 20,000	3 1-time, 2 year-to-year	Exchange and water for Texas.
Nevada	0	0	1	0	1	0	0	1	0	1	13,000 - 23,000	permanent	Exchange and transfer of contract right.
Utah	0	1	1	1	0	1	0	0	1	0	10,000 - 60,000	permanent	Exchange.
Wyoming	0	0	0	0	0	0	0	0	0	0	No transfers near the 10,000 range	-----------	Water supply not fully appropriated.

Cost Considerations

The cost of transfer water can be divided into two general components: the acquisition cost from the transferring agency and the cost to convey the water to the Authority. The conveyance cost introduces a third party into any transfer agreement because virtually all potential transfers rely upon using MWD, SWP, and/or CVP facilities to transport (or "wheel") the water. Under current state law, these public agencies are required to provide unused capacity in their distribution systems to wheel transferred water, provided that reasonable compensation is made to cover the costs and that no harm is done to other water users. Wheeling would not be an issue if the Authority were to build a separate facility to transfer water from the Colorado River.

Wheeling

For the past few years, MWD has attempted to establish a wheeling policy that would govern how its distribution system would be made available for transfers and the compensation that MWD would consider reasonable for transfer of non-MWD water through their system. In November 1996, MWD adopted a set of principles to be used in setting wheeling rates. A short-term (less than one year) wheeling rate is expected to be set in January 1997. Long-term wheeling rates are expected to be addressed as part of a rate refinement process that MWD has conducted over the past year. Because wheeling charges could exceed the cost of transferred water, this issue will have a major impact on the total cost of transferred supplies.

Environmental

Both the Colorado River and the Bay-Delta sources of transfer raise significant environmental considerations. The environmental focus for both sources has been declining fisheries and aquatic ecosystems. These problems are discussed in more detail in Chapter 3.

Water Quality

Water quality is another important issue. Colorado River supplies are relatively high in salts, in the form of total dissolved solids (TDS), posing potential additional treatment costs. Although SWP supplies have lower salt levels, water from the Bay-Delta can be high in organic compounds that react with chlorine to form various disinfection by-products, including trihalomethanes (THMs), such as chloroform. Higher water treatment costs are incurred to eliminate these potentially harmful compounds.

5.3 TRANSFER EVALUATION METHODOLOGY

This Water Resources Plan reviews and evaluates water transfers on an overall resource basis. Specific projects have not been evaluated or recommended by the Plan. Instead, transfers are evaluated on more general considerations, such as water rights and priorities, other measures of dry- and normal-year availability, and the feasibility of accomplishing a transfer.

Specific water transfer proposals need to be evaluated on a case-by-case basis. A screening process is provided to evaluate the viability of specific water transfer proposals. Through this process, transfer proposals would be evaluated on the ability to improve reliability and local control at a cost comparable to other supply options. The overall feasibility of the transfer proposal would also be evaluated. Feasibility considerations include public and institutional acceptance, regulatory factors, third party effects, water quality, and legal issues.

Using this analytical approach, a determination can be made as to whether the cost of a specific transfer proposal is competitive with purchasing water from other sources. A water transfer "filter" was constructed to provide a framework for assessing the viability of water transfer opportunities. This filter was used to provide a preliminary evaluation of transfers from the three geographic regions where transfer water is currently available: the

Colorado River, Central California, and Northern California. While analysis of specific transfer proposals is beyond the scope of this Plan, this same methodology may be used for that purpose. **Figure 5-1** shows the transfer filter and how stages of the filter are used to determine whether a particular source of transfer water is viable. Those potential transfers which pass through each succeeding stage of the filter are considered viable.

In 1996, the Authority developed draft terms and conditions for a water transfer with the IID. These terms and conditions were derived from studies that provided detailed information about the market price for acquiring transfer water and transportation costs for delivering the water to San Diego County. While each transfer opportunity has a unique set of attributes and circumstances, assumptions were made for evaluation purposes that total costs (acquisition plus transportation) would be equivalent for core transfers from all three geographic regions. It was further assumed that core transfers would be delivered using a schedule developed under the IID proposal. These assumptions (discussed further in Chapter 7), are considered to be the best information available on the structuring of a core transfer agreement.

FIGURE 5-1
Transfer Filtering

5.4 COLORADO RIVER TRANSFER OPPORTUNITIES

The greatest amount of activity in evaluating potential Authority transfers is occurring with Colorado River supplies. Because of its potential size and scope, the IID proposal is the most visible. However, potential transfer water could also be obtained from agricultural users in Central or Northern California.

5.4.1 Transfers from the Imperial Valley

In September 1995, the Authority approved a Memorandum of Understanding (MOU) with IID to negotiate the possibility of a long-term transfer of agricultural water. Since then, the Authority Board and staff have been actively involved in exploring the feasibility of the transfer, determining the amount of water available, and negotiating its acquisition cost.

Water for the transfer would come from extraordinary conservation measures undertaken in Imperial Valley, either by the District or on the farm. IID has rights to more than 3 maf/yr of Colorado River water. Conservation measures could include improvements to irrigation systems and distribution and storage systems and better water management. An IID study completed in 1995 found that up to 400,000 af of water could be made available for transfer using these methods. Permanent removal of land from production is not one of the conservation methods being considered.

The water could be conveyed to the Authority by one of two means: either through MWD's existing CRA or through a separate facility constructed from a point on the All American Canal in Imperial Valley to the Authority. The CRA could also be modified or paralleled to increase its capacity.

An engineering feasibility study conducted for the Authority in 1996 determined several alignments that could be used for a separate facility. A new facility sized to convey 500,000 af of water would cost about $2 billion. The cost includes pipelines, tunnels, power generation and pumping facilities, water storage, and water treatment. Annual operations and maintenance (O&M) costs are projected to be about $73 million.

Projected unit costs for delivering 500,000 af of water are expected to be significantly less than the costs that were estimated for an IID transfer facility in a study conducted for the Authority in 1991. That study projected costs of $1,100/af to transport 100,000 af/yr from the Imperial Valley. The reductions in cost are from improvements in tunneling technology, lower energy costs, and achieving economies of scale.

In July 1996, the Authority and IID agreed to draft terms for a Cooperative Water Conservation and Transfer Program. The duration of the agreement is anticipated to be from 75 to 125 years. A Summary of Draft Terms for this proposal is provided in **Appendix B**. The agreement calls for 200,000-500,000 af/yr of water supply to become available to the Authority.

According to the draft terms, a quantity of 20,000 af/yr or more would be available beginning in 1999. This amount would increase annually by 20,000 af/yr for ten years to a total of 200,000 af/yr. Thereafter, the amount of water would increase annually in increments of 8,000 af/yr.

The price would be $200/af in the first year and escalate to $306/af by the tenth year (2008). A transportation cost of $75/af would bring the costs from $275/af in 1999 to $381/af in 2008. If the transportation costs exceed $75/af in this period, the base cost of water would be adjusted. The acquisition price would be reviewed every 10 years and adjusted up or down to a mutually agreeable transfer "market" price.

A number of issues are yet to be resolved that could affect this transfer. These issues include: legal, governmental, and institutional concerns; environmental impacts; water quality; third party impacts; and supply reliability. The issues are not limited to the feasibility of accomplishing the transfer, but reach to the Authority's relationship with MWD, which has historically been the Authority's sole supplier of imported water.

The transfer would have a major impact on MWD, affecting its status as regional water supplier and reducing its water sales and revenues. MWD water supply planning and capital facilities programs would be impacted. These impacts would in turn be felt by all of MWD's member agencies. The Authority is reviewing each of these issues to determine the feasibility of the transfer.

5.4.2 . Other Potential Colorado River Transfers

There may be other opportunities to transfer Colorado River water to the Authority from agricultural water districts with entitlement to water from the River These transfers could be either intra or interstate. Representative transfers that have already occurred are presented in **Table 5-3**.

One recent example of a potential Colorado River transfer is a proposal to transfer up to 60,000 af/yr to the Authority from the Cibola Valley Irrigation and Drainage District in Arizona. This water would come from a private party that owns more than half of the land in Cibola's service area. The state of Arizona would need to approve such a transfer, and by that state's law, any water not needed by Cibola could first be used by the Central Arizona Project (CAP), which is a major water supplier to the state for both agricultural and urban uses. This constraint and others pose significant hurdles to the transfer proposal. However, the Authority will continue to evaluate the proposal as a potential resource.

5.5 NORTHERN AND CENTRAL CALIFORNIA TRANSFER OPPORTUNITIES

Northern California represents another potential source of transfer water for the Authority. At this time, no proposal exists comparable to the IID transfer evaluation. However, the recent legislation discussed in Section 5.1 has increased the likelihood of future transfers and water marketing.

As also discussed in Section 5.1, while intrastate transfers are simple in concept, they are difficult to achieve because of legal and

TABLE 5-3
Transactions Involving Colorado River Water

Year	Seller	Buyer	Regltry Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1993	Central Arizona Water Conservation District	MWD	Bureau	89,000	$70-114	4 years	Water stored underground in Arizona for future exchange.
1992	Palo Verde ID	MWD	Bureau	186,000	$135	2-year test program	Ag acres fallowed and water stored in Lake Mead.
1988	IID	MWD	Bureau	106,000	$120	35 years	Improvements to IID's delivery system.

institutional constraints. The largest obstacle is that most transfers can only be accomplished with the consent of the water district or agency transferring the water. For example, if an irrigator in the San Joaquin Valley wanted to quit farming and sell water to San Diego, depending on the source of water and amount to be transferred, that irrigator may need the consent of the water district delivering his water.

Potential transfers from the central and northern parts of the state would have to move through the SWP, the CVP, or both. The water would also have to be conveyed through the MWD system. Water pumping costs through the SWP are significantly higher than through the CRA, and it could be expected that wheeling water through the SWP would cost more than through the CRA. Transfer water from the CVP is also subject to a CVP transfer fee of about $50 per af. This fee is for recovery of capital facilities debt service and is in addition to the cost of acquisition. Depending on hydrologic conditions, transfers from north of the Delta may also have a requirement to provide carriage water for environmental purposes. This is currently estimated to be up to 35 percent of every acre-foot transported through the Delta, which would add about $60 per af to the cost of north-of-the-Delta transfers.

One of the key issues for transfers from Central and Northern California is the potential impact that exports from the Delta would have on the Bay-Delta ecosystems. Future transfers would likely have to meet the operating requirements yet to be established by CALFED, as discussed in more detail in Chapter 3. Because of these operating requirements, transfers south of the Delta would probably encounter fewer constraints than those north of the Delta. However, a limiting factor for south of the Delta transports is that groundwater basins are significantly overdrafted. State policy explicitly limits the substitution of transferred surface water with groundwater extracted from an overdrafted basin.

5.5.1 State Water Project

The SWP has significant excess capacity, even during normal years, that could be used for wheeling supplies transferred from Central or Northern California. Recent transfers using the SWP are given in **Table 5-4**.

Perhaps the best example for how such transfers could be made, and what they would cost, is the State Water Bank created during the end of the recent drought. In 1991, as a drought emergency measure, DWR created the bank to enable water-short districts and agencies to purchase supplies from willing water sellers. DWR purchased the water supplies primarily from Northern California agricultural entities and sold these supplies to entities experiencing drought shortages. DWR purchased the water for $125/af and sold it for $175/af. MWD purchased 215,000 af in 1991; the Authority purchased 21,600 af. The bank still exists, and **Table 5-5** shows some of its major recent transactions.

5.5.2 Central Valley Project

The sources of water for the CVP are the Sacramento and San Joaquin rivers and their tributaries. On average, the CVP delivers about 7.3 maf to 250 contractors, making it the largest water project in California.

Transfers among CVP contractors or users on an informal basis have been common for years. Between 1981 and 1989, more than 1,200 such transfers were made to meet agricultural irrigation needs. **Table 5-6** shows some of the larger recent transfers. Because these transfers do not require a change in the Bureau's water rights permits for the CVP, they are not subject to SWRCB jurisdiction.

In addition to transfers between individual contractors, two groups of contractors have set up permanent transfer pooling systems. The Sacramento River Contractors Association entered into a pooling agreement in 1974, and the Tehama-Colusa Canal Authority set up one in 1981. The pools establish banks where participants can deposit water when they have excess and withdraw water when they need it.

TABLE 5-4
Transfers Involving SWP Supplies

Year	Seller	Buyer	Reg Agency	(AF)	Amount ($/AF)	Price Duration	Comments
1995	Kern County Water Agency (KCWA)	Tulare Lake Basin Water Services District	DWR	41,500	Unknown	one-time	Ag to ag
1995	KCWA	Westlands WD (WWD)	DWR	10,875	Unknown	one-time	Exchange
1995	KCWA	WWD	DWR	49,803	Unknown	one-time	Ag to ag
1995	Dudley Ridge WD	WWD	DWR	14,446	Unknown	one-time	Ag to ag
1995	MWD	Coachella Valley WD (CVWD)	DWR	23,100	Unknown	yearly	SWP water for CRA water
1995	MWD	Desert Water Agency (DWA)	DWR	38,100	Unknown	yearly	SWP for CRA
1994	MWD	CVWD	DWR	14,102	Unknown	yearly	SWP for CRA
1994	MWD	DWA	DWR	23,257	Unknown	yearly	SWP for CRA
1993	MWD	CVWD	DWR	23,100	Unknown	yearly	SWP for CRA
1993	MWD	DWA	DWR	38,100	Unknown	yearly	SWP for CRA
1993	KCWA	WWD	DWR	77,600	Unknown	one-time	Exchange
1993	KCWA	WWD	DWR	10,000	Unknown	one-time	Ag to ag
1993	Semitropic WSD	MWD	DWR	50,000	Unknown	one-time	Leasing storage space for 1992 MWD SWP entitlement
1990	MWD	CVWD	DWR	23,100	Unknown	yearly	SWP for CRA
1990	MWD	DWA	DWR	38,100	Unknown	yearly	SWP for CRA
1989	MWD	CVWD	DWR	21,873	Unknown	yearly	SWP for CRA
1989	MWD	DWA	DWR	36,500	Unknown	yearly	SWP for CRA
1989	KCWA	WWD	DWR	55,000	Unknown	one-time	SWP for CRA
1988	MWD	CVWD	DWR	20,652	Unknown	yearly	SWP for CRA
1988	MWD	DWA	DWR	34,000	Unknown	yearly	SWP for CRA
1987	MWD	CVWD	DWR	19,341	Unknown	yearly	SWP for CRA
1987	MWD	DWA	DWR	31,500	Unknown	yearly	SWP for CRA
1986	MWD	CVWD	DWR	18,210	Unknown	yearly	SWP for CRA
1986	MWD	DWA	DWR	29,000	Unknown	yearly	SWP for CRA

TABLE 5-5
Transfers Involving the State Water Bank

Year	Seller	Buyer	Reg Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1994	Sac'to River Water Contractors Assn.	State Water Bank	DWR	25,000	$50	one-time	Groundwater exchange
1994	Placer County Water Agency	State Water Bank	DWR	20,000	$50	one-time	Reservoir storage
1992	Oakdale ID/S. San Joaquin ID	State Water Bank	DWR	50,000	$50	one-time	Groundwater exchange
1992	Merced ID	State Water Bank	DWR	11,705	$50	one-time	Reservoir storage
1991	Joint Water District Board	State Water Bank	DWR	60,000	$125	one-time	Groundwater exchange
1991	Orville-Wyandotte ID	State Water Bank	DWR	10,000	$125	one-time	Reservoir storage
1991	Yuba County Water Agency	State Water Bank	DWR	127,200	$125	one-time	Reservoir storage
1991	Brophy WD	State Water Bank	DWR	36,000	$125	one-time	Groundwater recharge
1991	Raminez WD	State Water Bank	DWR	13,277	$125	one-time	Groundwater recharge
1991	South Yuba WD	State Water Bank	DWR	17,000	$125	one-time	Groundwater recharge
1991	Western Canal WD	State Water Bank	DWR	40,000	$125	one-time	Groundwater recharge
1991	RD 1044	State Water Bank	DWR	24,077	$125	one-time	Groundwater recharge
1991	Conaway Conservancy	State Water Bank	DWR	44,774	$125	one-time	Groundwater recharge

TABLE 5-6
Transfers Involving CVP Supplies

Year	Seller	Buyer	Reg Agency	Amount (AF)	Price ($/AF)	Duration	Comments
1994	San Luis Canal Co.	Water Acquisition Program	Bureau	12,000	$50	one-time	Environmental uses
1994	Western Canal WD	Water Acq. Prog	Bureau	82,403	$50	one-time	Environmental uses
1994	Richvale ID	Water Acq. Prog	Bureau	31,825	$50	one-time	Environmental uses
1994	Ramirez WD	Water Acq. Prog	Bureau	12,658	$50	one-time	Environmental uses
1994	Bureau	Kern Natl Wildlife Refuge	Bureau	12,473	n/c	one-time	Environmental uses
1993	Bureau	Kern Natl Wildlife Refuge	Bureau	12,552	n/c	one-time	Environmental uses
1993	Central Calif ID	Westlands WD	Bureau	18,000	$18.07	one-time	Ag to ag
1993	San Luis Canal Co.	Panoche WD	Bureau	10,000	$17.52	one-time	Ag to ag
1993	San Luis Canal Co.	Westlands WD	Bureau	12,000	$18.07	one-time	Ag to ag
1989	Bureau	Calif Dept of Fish & Game (DFG)	Bureau	30,000	n/c	one-time	Environmental uses
1989	Bureau	DWR	Bureau	10,000	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	100,000	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	85,500	Unknown	one-time	Multiple purposes
1988	Bureau	DWR	Bureau	126,500	Unknown	one-time	Environmental uses
1986	Bureau	DFG	Bureau	100,000	Unknown	one-time	Environmental uses

TABLE 5-7 Range of Potential Transfer Water Sources			
Source	Potential Amount (AF/YR)	Est. Cost (1996 $/AF)	Main Issues
Colorado River - IID and other intrastate	0-500,000	275-383	Feasibility of potential new facility, long-term cost and reliability, water quality, environmental impacts, conservation measures.
Colorado River - interstate	0-60,000	275-383	Interstate legal/feasibility considerations, length of term, cost, and reliability.
Northern California - SWP	0-150,000	275-383	Long-term reliability, cost, Bay-Delta operational and facilities restrictions.
Northern California - CVP	0-150,000	275-383	Long-term reliability, cost, Bay-Delta operational and facilities restrictions.

Passage of the CVPIA has provided the opportunity for CVP water to be considered a major potential resource for Southern California. The CVPIA allows not only districts but individual farmers to transfer water. Districts only have veto rights if the transfer is more than 20 percent of their contracted CVP supply. These requirements have simplified the transfer of CVP water to other areas of the state. As a result of the CVPIA, MWD is pursuing CVP and other transfers to meet the goal of MWD's Integrated Resources Plan (IRP) of providing 460,000 af of transfer water during a dry year.

5.6 SUMMARY OF POTENTIAL TRANSFER SUPPLIES

Table 5-7 summarizes potential transfers that are considered and evaluated in this Plan.

Chapter 6

6.0 DEVELOPMENT OF ALTERNATIVES

Six basic water resources mixes were evaluated in this Plan. The alternatives vary primarily upon the source of imported water, whether from the Metropolitan Water District of Southern California (MWD) or through long-term transfers, and upon the amount of local resources that could be developed. This chapter describes the development of the alternatives. Chapter 7 presents an evaluation of the alternatives, using a standard set of resources selection criteria, and Chapter 8 recommends one of the alternatives for future development.

6.1 OVERVIEW

Under existing conditions, the Authority receives all of its water supplies from MWD. The region relies upon this water for about 70 percent of its needs during wet years, 80 percent during normal years, and up to 95 percent during dry years. The remaining supplies are obtained from local sources, primarily surface water runoff into reservoirs. The significance of this situation is that local surface water supplies are weather-dependent and highly variable and that the Authority has relatively few supply options during dry years to offset shortages that MWD may experience.

Accordingly, this Water Resources Plan emphasizes developing alternatives that increase the diversity of the Authority's supply, especially during dry years. Diversity of supply is considered a key element of reliability, giving the Authority the ability to draw upon multiple sources of supply during future dry years. The alternatives developed in this plan evaluate opportunities to increase the sources of both local and imported water supplies.

The recent six-year drought provided an illustration of the benefits of having a diverse supply. The Authority was not subject to water shortages during the first four years of the 1986-92 drought because three primary sources of water were available: the Colorado River, the State Water Project (SWP), and local surface water. Those areas of the state that were solely dependent on the SWP or local surface waters were affected immediately and suffered severe cutbacks during the initial years of drought. It was only when the drought entered into a fifth year that severe shortages on the SWP caused MWD to implement drought allocations. That experience led to an emphasis in resources planning of creating a diversified mix of water resources. Uncertainties that affect long-term supplies from both the SWP and Colorado River have also pointed to the need for diversification.

Recent opportunities for water transfers and local water supply development have dramatically changed the potential mix of water resources that the Authority could pursue. These opportunities could significantly enhance reliability. Large-scale transfers, in particular, have made possible the consideration of resource mixes that reduce the MWD component of supply to as low as 20 percent of the total 2015 normal year demand. By comparison, the 1993 Water Resources Plan recommended a mix of supplies in which MWD met 82 percent of 2010 demand.

6.2 RECOMMENDATIONS OF THE 1993 PLAN

The development of alternatives in the 1997 Water Resources Plan is best understood within the framework of the recommendations of the 1993 Plan and the subsequent emergence of potential new water supplies. The Authority's 1993 Water Resources Plan sought to enhance reliability by diversifying the sources of supply and reducing dependence on MWD. A specific mix of resources, including water conservation, was recommended for development by 2010. **Table 6-1** provides highlights of the resources

TABLE 6-1
1993 Water Resources Plan Recommended Resources

Demand/Supply (AF)	1995	2000	2005	2010
Normal Demand	709,000	789,000	842,000	902,000
Conservation	21,000	37,000	52,000	70,000
Existing Local Supply	60,000	60,000	60,000	60,000
Water Recycling	11,000	18,000	36,000	50,000
Groundwater	2,000	5,000	10,000	15,000
Desalination	0	0	0	20,000
MWD Required	615,000	669,000	684,000	687,000

recommended in the 1993 Plan.

The 1993 Plan noted that the Authority's imported supply from MWD had suffered a shortage of 31 percent in 1991, during the fifth year of a drought. This shortage would have been greater if water transfers had not been arranged by MWD through the State Water Bank. The 1993 Plan anticipated that the Authority would need dry-year transfers of 75,000 acre-feet (af) by 2010 to meet its own reliability goal. However, transfers were not part of any normal-year resources option. The 1993 Plan concluded that, even after undertaking an ambitious effort to develop local supplies, the Authority would continue to be dependent upon MWD for a substantial portion of its total water needs. The most striking difference between the resource mixes being considered in this Plan and those considered in the 1993 Plan is the emphasis placed on the potential use of water transfers as a normal-year supply option. The 1993 Plan examined alternatives that relied on MWD for 70-82 percent of the total supply; this Plan evaluates resource mixes under which MWD would provide 20-85 percent of the supply.

6.3 WATER RESOURCES ALTERNATIVES

Six major water resources alternatives are considered in this Plan. Each alternative was designed with a specific goal in mind. The first alternative was designed as a base case and continues the strategy used in the 1993 Plan. The remaining alternatives were designed to evaluate: varying levels of transfers that would be conveyed through the CRA or SWP, maximum levels of local supply development, and the construction of a separate water conveyance facility to receive Colorado River water. Each alternative was also designed to meet or exceed the Authority's current water reliability goal. All alternatives assume a 2015 demand of 787,000 acre-feet per year (af/yr), adjusted for demand management (water conservation).

An economic optimization computer model was used to refine the alternatives. This model, developed for the Authority by Regional Economic Research, Inc. (RER), of San Diego, identifies the least cost mix of local and imported water resources under given sets of constraints and assumptions. This provided an opportunity to identify the most cost-effective mix of resources given a set of specific conditions. In this way, quantities for each potential component of supply were identified, and the lowest cost possible for the specified conditions was determined. Water resource costs were based on information from MWD, local agencies, the July 1996 Summary of Draft Terms for transferring water from the Imperial Irrigation District

(IID), and an engineering feasibility study for Colorado River conveyance facilities. Cost assumptions are discussed in detail in Chapter 7.

Existing Strategy Alternative.

This baseline alternative would continue the resources strategy recommended in the 1993 Water Resources Plan. The mix of resources recommended would change from the 1993 Plan to reflect updated cost estimates of both local and imported supplies, as well as revised demand forecasts. However, the 1993 resources development goal would be retained: to pursue an intermediate amount of cost-effective local supplies that would meet the Authority's reliability goal.

This represents a baseline case for the economic optimization model. Local resources only appear in this alternative if they are cost-competitive with projected supplies from MWD (based upon average MWD costs), or if they are already operating or under construction. This alternative does not utilize transfers during normal weather years. Rate sensitivity was performed by increasing MWD's projected baseline water rate by 3 percent annually beginning in 2002, the last year covered by the Phase 1 Rate Refinement Process. A similar sensitivity analysis was also performed for the other alternatives.

Maximum Local Supply Alternative.

This alternative was designed to determine the costs and benefits of developing the maximum amount of local supplies, including recycling, repurification, groundwater, and seawater desalination. It shows the minimum amount of MWD supply that would be required if local resources were developed at the maximum level, both with and without normal-year transfers. Using a maximum effort, local resources, including local surface water, would account for 185,000 af of supply, or 24 percent of the Authority's 2015 supply, assuming 60,000 af/yr from existing sources.

For modeling purposes, the Maximum Local Supply Alternative uses the same general conditions as the baseline case, but makes an assumption that all local recycling, groundwater, and seawater desalination projects at a certain planning stage would be constructed. This affects both the total cost of the alternative and the amount of imported water required to meet total demand (there is not sufficient local supply to meet all demand). This is the only alternative in which seawater desalination appears as a resource; the model was "forced" to select it. In other alternatives, desalination was not selected because of its relatively high cost. A separate run of the model was conducted to determine local resources that would result if 200,000 af/yr were developed as long-term transfers, this time without forcing the model to accept seawater desalination.

A sensitivity analysis was performed using the high range of MWD rates. The increase in rates not only increases the costs paid for imported water, but increases the share of local project costs that Authority member agencies bear, because MWD local supply development incentives are tied to the level of MWD rates.

Maximum Local Supply With Transfers Alternative.

This alternative is patterned after the Maximum Local Supply Alternative with two major exceptions: transfers of up to 200,000 af/yr would be developed and conveyed through the SWP or CRA, and seawater desalination would not be pursued. All other local supplies were selected based on cost-effectiveness. Under this alternative, MWD supplies would constitute 54 percent of the Authority's total mix, transfers would comprise 25 percent, and local supplies 21 percent.

The Maximum Local Supply with Transfers Alternative was modeled to wheel 200,000 af/yr. It would "construct " only the most cost-effective local supply projects. This analysis constrained the model to accept a schedule of transfers beginning at 20,000 af/yr in 1999 and increasing by 20,000 af/yr increments until 200,000 af/yr is reached in 2008. Transfers were left at this maximum annual level from 2009 through 2015.

Intermediate Transfers Alternative.

This alternative is based on developing an intermediate level (200,000 af/yr) of long-term, core water transfers. The normal-year transfers would be conveyed through the CRA or SWP. The Intermediate Transfers Alternative was modeled using the same assumptions regarding acquisition costs, transportation costs, and scheduled deliveries of transfers as the preceding alternative (Maximum Local Supply with Transfers). However, this alternative would construct only the most cost-effective local supply projects. By 2015, the Authority's supply mix under this alternative would be 60 percent MWD, 25 percent transfer, and 15 percent local. The 60 percent level of supply from MWD would make the Authority resemble the "average" MWD member agency in terms of water supply and would more closely match the Authority's preferential rights to MWD water.

Maximum Transfers Alternative.

This alternative explores the maximum anticipated level of transfer without constructing new, separate facilities. A transfer amount of 500,000 af/yr was modeled. Similar to the Intermediate Transfers Alternative, transfer deliveries begin in 1999, with 20,000 af/yr. This is ramped up by 20,000 af/yr increments until 200,000 af/yr is reached in 2008. After this point, deliveries increase by 50,000 af/yr until 2014, when 500,000 af/yr is reached. After that point, deliveries would remain at 500,000 af/yr during normal years.

Water from this alternative could be from a combination of Colorado River and Northern or Central California origin. However, it is assumed that the maximum amount of transfer water available within Northern and Central California is 150,000 af/yr, leaving 350,000 af/yr to come from the Colorado River.

Colorado River Facilities Alternative.

The final alternative modeled was a conveyance facility that would be constructed from San Diego County to the Imperial Valley to transport 500,000 af/yr. Because of high salinity levels, this water would be treated using reverse osmosis demineralization technology, which would cause estimated water losses of 13 percent, or 65,000 af/yr. Therefore, the total annual supply from this alternative would be 435,000 af/yr.

Table 6-2 provides a summary of the water that would be developed under each alternative. The quantities of supply were determined by the economic optimization model, except for transfers and seawater desalination. **Appendix C** provides detailed information about the model and the assumptions made for operating it.

TABLE 6-2
Summary of Supply Amounts for Alternatives
(Based on Normal-Year 2015 Demand of 787,000 AF)

Alternative	MWD	Transf	Existing Local	Recl Water[1]	Ground Water	Seawater Desal
Existing Strategy	671,000	-	60,000	24,000	32,000	-
Maximum Local	602,000	-	60,000	60,000	45,000	20,000
Maximum Local W/ Transfers	422,000	200,000	60,000	60,000	45,000	-
Intermediate Transfers	465,000	200,000	60,000	30,000	32,000	-
Maximum Transfers	165,000	500,000	60,000	30,000	32,000	-
CR Facilities	230,000	435,000[2]	60,000	30,000	32,000	-

1 Includes repurification.
2 Adjusts for demineralization losses of 65,000 af/yr.

Chapter 7

7.0 ANALYSIS OF ALTERNATIVES

The primary objective of the Water Resources Plan is to identify a resources alternative that best meets the needs of the Authority through 2015. This chapter presents the methodology and the evaluation processes used to determine the selection of a water resources mix. The alternatives evaluated, listed below, were developed in Chapter 6.

- Existing Strategy Alternative
- Maximum Local Supply Alternative
- Maximum Local Supply With Transfers Alternative
- Intermediate Transfers Alternative
- Maximum Transfers Alternative
- Colorado River Facilities Alternative

7.1 OVERVIEW

Alternatives analysis focused on seven criteria used to select the mix of resources best meeting the Authority's needs for a safe and reliable water supply. The criteria, listed in **Table 7-1**, are defined in more detail later in this chapter. Two of the criteria are based upon quantitative analyses, and the approach taken is a straightforward ranking of alternatives. These criteria are the total cost of the alternative and the potential impact that implementation of the alternative would have on water rates. The remaining criteria are more subjective, and the decision-making process relied upon judgment calls regarding issues of reliability, feasibility, water quality, degree of Authority control over the resource, and estimated environmental impacts.

The Authority conducted a public outreach program as part of the Water Resources Plan update. The Authority received input from a variety of individuals, community organizations, and interest groups on key water demand and supply issues. Individual interviews were conducted with representatives of these groups to obtain their viewpoints, and a weighting exercise was held for the water resources selection criteria to determine the relative importance of each criterion. Detailed results of the public outreach program are given in **Appendix A**.

As a general rule, stakeholders tended to rank rate impacts and reliability as the two most important criteria in the weighting exercise. This concern was also voiced during the

TABLE 7-1 Evaluation Criteria

CRITERION	DESCRIPTION
1. Cost	Minimize total cost of the alternative from 1996-2015.
2. Degree of Authority Control	Maximize control Authority has over water supplies.
3. Environmental Impacts	Minimize amount of environmental harm.
4. Feasibility	Maximize confidence that resources will be developed.
5. Rate Impacts	Minimize water rate increases.
6. Reliability	Maximize supply availability.
7. Water Quality	Minimize salinity and other undesirable parameters.

interviews. Results of the outreach program were used as a qualitative tool in the evaluation of the alternatives; the criteria were not numerically weighted for use in the evaluation.

7.2 QUANTITATIVE CRITERIA EVALUATION

This section presents evaluation results for the two resources selection criteria that are quantitative: minimize total cost and minimize rate impacts. Evaluation results for these criteria are based upon the computer optimization model and a separate Authority rate modeling analysis. The remaining five criteria are considered qualitative and involve subjective evaluations. These criteria are evaluated in Section 7.3.

7.2.1 Criterion: Minimize Total Cost

Definition of Criterion: This criterion measures the total cost of each alternative from the Authority's perspective over the 20-year planning horizon of the Water Resources Plan (1996-2015). Costs include water purchases; capital, operations, and maintenance costs for local water supply projects; and estimated demand management costs. Metropolitan Water District of Southern California (MWD) costs are measured by projected water rates and associated charges, including the Readiness-to-Serve Charge (RTS). Water transfer costs are divided into acquisition costs, or the cost of purchasing the supply from the transferring party, and transportation costs, which include "wheeling" charges from MWD, the State Water Project (SWP), or other conveyance facilities owners. Total cost is net of financial incentives for supply development provided by MWD, the federal government, or others. Avoided costs are also calculated, where applicable, to reduce the total cost of an alternative.

Analysis and Results.

The Authority's economic optimization computer model, H2Optimum, was used to derive least-cost resource mixes for each alternative. Under the constraints identified in each alternative, the model selected the least costly mix of resources over the 20-year planning horizon. Total costs were calculated net of benefits and avoided costs and expressed as a Net Present Value (NPV) in 1996 dollars. The costs do not represent the alternatives' actual monetary costs. However, the costs can be used for economic comparisons between and among alternatives.

The model used detailed data on the costs of individual local supply projects, water transfers, conservation programs, and future MWD water rates and charges. Additional information was collected on the avoided costs resulting from local supply projects or water transfers. Avoided costs include savings resulting from the deferred construction of an Authority Pipeline 6 and avoided treatment plant expansion resulting from local supplies and conservation. Outside funding sources were identified, including MWD incentives and federal construction grants, that would reduce the cost of supply development to the Authority or its member agencies.

Water rate projections provided by MWD staff were used to estimate the cost of MWD deliveries under each of the alternative resource mixes. In order to determine the sensitivity of each alternative to increases in MWD rates, Authority staff developed a high rate projection by assuming that MWD commodity rates increase by 3 percent annually after 2002. The rates used to conduct the cost analyses in the Water Resources Plan are provided in **Appendix C.**

MWD staff provided the Authority with rate projections under three scenarios: a no transfer scenario, a 200,000 acre-feet per year (af/yr) transfer scenario, and a 500,000 af/yr transfer scenario. These rate projections reflect the outcome of the Phase 1 Rate Refinement and Cost Containment processes completed in July 1996. As a result of the Cost Containment Process, MWD's capital improvement program

(CIP) was reduced by $200 million, from $4.1 billion to $3.9 billion, and additional savings were achieved by the deferral of certain capital expenditures. The Phase 1 Rate Refinement Process (RRP) resulted in the temporary suspension of the New Demand Charge (NDC). MWD adopted the NDC in 1996 as a means of paying for those facilities needed to serve new demand. The rate projections provided to the Authority assume that revenues which would have been collected through the NDC will be collected through the basic water rate. The potential impact of a reinstated NDC on the cost of the six alternatives is discussed in greater detail in Section 7.2.3.

Least-cost planning principles generally utilize the cost of water shortages to find an "optimum" cost position. This position is a balance between expected shortage costs and the cost necessary to prevent the shortage from occurring. Much recent work has been done in this field for water supply, including studies of observable losses and contingent valuation studies, in which respondent surveys are used to elicit responses that can be used to estimate the value of water supply reliability.

As part of its optimization modeling effort, Regional Economic Research, Inc. (RER), reviewed existing studies on the economic damages inflicted by water shortages. In general, it was found that these studies produced questionable monetary values for shortages. Therefore, they were not directly used in the modeling effort to locate the optimum least-cost position. However, because the studies consistently indicated a strong public aversion to shortages, RER concluded that the public did place a high value on the avoidance of shortages. The RER results of this study are given in **Appendix D.**

The economic optimization model was used to derive the total cost of each alternative under low and high supply cost assumptions. The upper range of costs was obtained by using the high projected MWD water rates for each alternative and assuming that the market rate for transfers increases by 25 percent after 10 years, pursuant to the escalation formula outlined in the Summary of Draft Terms between the Authority and the Imperial Irrigation District (IID) for the conservation and transfer of water **(Appendix B)**. The lower range of costs was obtained by using low MWD rate projections for each alternative and by assuming the acquisition price for transfer water falls by 25 percent after 10 years, as outlined in the Summary of the Draft Terms. Transfer acquisition costs are provided in **Table C-1** of **Appendix C**.

Transportation costs for transfer water were based on an Authority proposal to MWD, which provides for a wheeling charge consisting of incremental operations and maintenance (O&M) and power costs. MWD's incremental cost of transporting water through the Colorado River Aqueduct (CRA) is estimated at $58 per acre-feet (af): $40 for power and $18 for O&M. MWD's cost to transport State Project water is estimated at $115 per af: $70 for power and $45 for O&M. For the purposes of the total cost analysis, a $75/af wheeling charge was used. Total costs for Northern California transfers were assumed to equal those for Colorado River transfers, with lower acquisition costs offsetting higher transportation costs. MWD is finalizing its wheeling policy, and the outcome of that process will influence the results of this analysis. To the extent that the wheeling charge is substantially different from the amount used in this Plan, the total cost and rate impact criterion will require reevaluation.

The analysis performed for the Colorado River Facilities Alternative was based on cost estimates contained in a study titled *Feasibility Level Engineering for Facilities to Transfer Water from the Imperial Irrigation District* (Feasibility Study). The Feasibility Study identified five alternative pipeline corridors and associated treatment and pumping facilities. Feasibility level cost estimates were prepared for facilities sized to convey from 300,000 to 500,000 af/yr.

The purpose of the Feasibility Study was to develop a range of costs for conveyance facilities, rather than to identify a single low-cost alternative. The cost estimates do suggest, however, that there are economies of scale associated with larger capacity facilities. The total cost analysis prepared for this Plan assumed the construction of conveyance facilities with a capacity of 500,000 af/yr along a central corridor identified in the Feasibility Study as Corridor 5A.

The total capital cost of the conveyance pipeline and associated facilities, excluding those facilities included in the Authority's Emergency Water Storage Project (ESP), is estimated in the Feasibility Study at $1.85 billion in 1996 dollars. Power costs, estimated at $41.9 million, were assumed to remain level throughout the planning period. Remaining operating costs, estimated at $31.9 million, were assumed to increase by 3 percent annually beginning in 1997. The brine stream from the demineralization process is estimated at 65,000 af/yr, reducing the facilities' net yield to 435,000 af/yr.

The total cost to the Authority of the Colorado River Facilities Alternative may be affected by the availability of outside funding. Potential funding sources include a public-private partnership, the U.S. federal government, and Mexico, which has expressed interest in financial participation in some form of a joint project. Because of uncertainties relating to these outside funding sources, the total cost analysis assumes that Authority water rates represent the sole source of funding for the conveyance facilities.

The results of the total cost economic analysis and the alternatives' ratings for the total cost criterion are presented in **Table 7-2.** The total costs are not the monetary costs of each alternative, or the cost that the Authority would actually incur for implementing the alternative. The total costs are instead an economic evaluation of each alternative's capital and O&M costs, in 1996 dollars, net of certain avoided costs for facilities construction and water treatment and financial contributions from MWD, the state, and the federal government.

Total costs for the Existing Strategy, Intermediate Transfers, and Maximum Transfers Alternatives were found to be the lowest. Total costs for these alternatives ranged from $3.33 to $3.58 billion. The total cost of the Maximum Local Supply With Transfers Alternative, while somewhat higher, was still lower than that of the Maximum Local Supply

TABLE 7-2 Water Resources Plan 1997 Update
Comparative Evaluation of Total Cost

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
Total Cost (billion)[2]	3.33- 3.57	3.53- 3.99	3.47-3.66	3.37-3.58	3.35-3.58	3.78-4.03
RATING	Good	Poor	Fair	Good	Good	Poor

● Good ◍ Fair ○ Poor

1 Water is transferred from Northern/Central California and/or Colorado River.

2 Expressed as net present value in 1996 dollars.

Alternative. Total costs for the Colorado River Facilities and Maximum Local Supply Alternatives, which ranged from $3.53 to $4.03 billion, were significantly higher than those of the other alternatives. Those alternatives' higher total costs were contributable both to larger capital requirements and higher O&M costs. The Colorado River Facilities Alternative assumes the use of reverse osmosis (RO), an energy-intensive process, to reduce the salinity of the transfer water. The Maximum Local Supply Alternative includes two seawater desalination projects, which also require large amounts of power. The upper range of costs for all alternatives was heavily influenced by the use of high MWD rate projections.

The facilities contemplated under the Colorado River Conveyance Facilities Alternative would have a useful life of 50 years or more, making the alternative difficult to analyze within the context of a twenty-year planning document. Because the conveyance facilities were assumed to begin operation in 2012, only four years of amortized capital costs were included in the alternative's total cost. If the analysis were extended beyond 2015, the total cost would more accurately reflect the alternative's total costs and benefits.

In each of the resource mixes, all conservation Best Management Practices (BMPs) were implemented. Conservation consistently proved to be the lowest cost source of water for the Authority under any conditions modeled. This is because of both the low cost to implement the BMPs and the availability of outside funding to reduce Authority and member agency costs.

7.2.2 Criterion: Minimize Water Rate Impacts

Definition of Criterion: This criterion measures potential impacts on water rates. Each alternative is evaluated for potential upward pressure on Authority and Authority member agency water rates. Alternatives in which costs increase gradually are considered superior to those in which costs escalate rapidly.

Analysis and Results.

Each of the resource mixes analyzed in this Plan includes a local supply element which will be funded by local agencies. In keeping with the total cost analysis in Section 7.2.1, the financial analysis conducted for the Plan considers expenditures at both the regional and the local agency levels. Alternatives with the highest combined regional and local agency costs are assumed to have the highest potential rate impacts. The analysis does not provide a forecast of water rates at either the Authority or the local agency level. However, it does allow a comparison among alternatives of the potential need for future rate increases.

Local costs are defined as local agencies' costs of building, operating, and maintaining local supply projects, less MWD and Authority financial incentives; the cost of operating local reservoirs; and the cost of conservation incentive programs. Not included in the financial analysis are water treatment costs, local agency storage and delivery costs, and costs borne directly by consumers (e.g., conservation devices purchased and installed by consumers). For purposes of this analysis, it is assumed that the cost of treatment to meet Safe Drinking Water Act primary standards is equal regardless of whether the water is treated locally or by MWD. Those alternatives with local projects that do not require surface water treatment are credited for that avoided cost.

Table 7-3 provides a summary of the assumptions used in the analysis of each alternative. More detailed information is provided in **Appendix C**. Water rate projections were developed by MWD for a "base case" (i.e., no transfer) scenario and two transfer scenarios: 200,000 af/yr and 500,000 af/yr. These rate projections were used to develop a "low" cost estimate for each alternative. MWD's projected 2002 water rates were increased by 3 percent annually during the remainder of the planning period to obtain a "high" base case. The high

TABLE 7-3
Summary of Financial Analysis Assumptions

Alternative	2015 MWD Untreated Water Rate[1]	Wheeling Charge	Transfer Acquisition Cost	Transfer Quantity	Local Projects Developed
Existing Strategy	$434- 543/af	Not applicable.	Not applicable.	None.	Projects under construction and future projects that are cost effective from a regional perspective.
Maximum Local Supply	$434-543/af	Not applicable.	Not applicable.	None.	All local projects that have completed completed a minimum level of planning.
Maximum Local Supply With Transfers	$455-570/af	$75/af in 1999 non-power costs increase by 3 percent annually.	$306/af by 2008, cost decreases to $231/af in 2009 under the low cost scenerio and increases to $385/af in 2008 under the high cost scenerio. [2]	Increases by 20,000 af/yr from 20.000 af in 1999 to 200,000 af by 2008. Quantity fixed at 200,000 af/yr thereafter. [3]	All local projects that have completed a minimum level of planning except seawater desalination projects.
Intermediate Transfers	$455-570/af	Same as above.	Same as above.	Same as above.	Projects under construction and future projects that are cost effective from a regional perspective.
Maximum Transfers	$535- 670/af	Same as above.	Same as above.	200,000 af/yr by 2008, 50,000 af/yr increase thereafter to 500,000 af/yr.[3]	Same as above.
Colorado River Facilities[4]	$535-670/af	Same as above. Wheeling charges end in 2012 when conveyance facilities begin operation.	Same as above.	200,000 af/yr by 2008. Increases to 500,000 af/yr in 2012.[3]	Same as above.

1 Low range rates provided by MWD. High range rates produced by escalating MWD rates by 3%/yr after 2002. All rate scenarios assume a fixed RTS share of $27.9 million after 2001 and the continuation of agricultural and seasonal storage discounts.
2 Costs adjusted as per the Summary of Draft Terms for transferring water from the IID.
3 Quantities for the years 1999 - 2008 adjusted as per the Summary of Draft Terms for transferring water from the IID.
4 Facility capital costs are assumed to be financed with a combination of cash, short-term debt, and 40-year bonds. The Authority is not authorized under its enabling act to issue 40-year debt; financing of the conveyance facilities through this mechanism would require action by the State Legislature.

base case was adjusted by the differential between the base case and transfer scenarios to obtain rates for use in the development of high-cost transfer scenarios. All scenarios assume a fixed RTS obligation on the part of the Authority of $27.9 million per year after 2001 and the continuation of MWD's agricultural and seasonal storage water discounts. Assumptions regarding MWD wheeling rates, transfer acquisition costs, and delivery schedules, and the cost of constructing and operating Colorado River conveyance facilities are the same as those used in the total cost analysis.

FIGURE 7-1
Projected Untreated Water Supply Costs
Low-Cost Water Supply Scenerio

Figure 7-1 shows the projected annual cost of untreated water for each alternative under the low-cost scenario. The projected annual cost of untreated water is roughly similar throughout the planning period under the Existing Strategy, Maximum Local Supply With Transfers, and Intermediate Transfers Alternatives. Projected costs under the Maximum Local Supply Alternative are expected to increase relative to those under other alternatives in 2007, when a seawater desalination project is assumed to begin operation. Projected costs under the Colorado River Facilities Alternative are significantly higher than those under the other alternatives throughout the planning period.

Under optimum conditions, annual costs under the Intermediate Transfers Alternative are projected to fall below those of the Existing Strategy Alternative at the end of the planning period, when a 25 percent reduction in transfer acquisition costs is assumed to take full effect. This trend is more pronounced under the Maximum Transfers Alternative, as transfers make up a far greater share of the region's water supply under that alternative. Under the latter alternative, lower cost transfers fully offset higher MWD rates by 2012, resulting in a lower average cost for the entire resource mix.

Figure 7-2 shows the projected average annual cost of untreated water for each alternative under the high-cost scenario. The trends projected under the high-cost scenario are similar to, if less pronounced than, those projected under the low-cost scenario. Projected costs under the transfer alternatives approach, but do not fall below, those projected under the Existing Strategy Alternative during the planning period.

Table 7-4 summarizes the results of the financial analysis for each alternative under the low- and high-cost scenarios. The annual cost projections suggest that the Existing Strategy Alternative has the lowest potential for rate

FIGURE 7-2
Projected Untreated Water Supply Costs
High-Cost Water Supply Scenario

"spikes" and is least sensitive to fluctuations in water sales. The Colorado River Facilities Alternative has a highest ratio of fixed to variable costs, making it most sensitive to reductions in water sales. The Maximum Local Supply and Colorado River Facilities Alternatives show the greatest potential for rate spikes. The projected maximum annual cost increase is quite close under the remaining alternatives, with no single alternative showing a pronounced potential for rate spikes, with a maximum annual cost increase ranging from 5.8 to 6.4 percent.

TABLE 7-4
Summary of Projected Untreated Water Costs

Alternative	2015 Cost (AF)	Average Annual Increase[1]	Maximum Annual Increase[1]
Existing Strategy	$547 - 645	1.6 - 2.7%	4.9%
Maximum Local Supply	$596 -685	2.1 - 3.0%	6.4%
Maximum Local Supply w/Transfers	$547 - 656	1.6 - 2.8%	5.2%
Intermediate Transfers	$535 - 650	1.5 - 2.7%	5.1%
Maximum Transfers	$511 - 648	1.2 - 2.7%	5.1%
Colorado River Facilities	$693 - 844	2.8 - 4.1%	5.8%

[1] 1999-2015

7.2.3 Sensitivity Analysis

The six resource mixes were analyzed under five additional cost and rate scenarios to determine the sensitivity of the alternatives to factors beyond the Authority's control. The first sensitivity scenario, the "low MWD rates/high transfer acquisition costs" scenario, assumes transfer acquisition costs increase while MWD rates remain flat. The second scenario, the "high MWD rates/low transfer acquisition costs" scenario, shows the potential savings available to the Authority if MWD rates increase by 3 percent annually and transfer acquisition costs decrease. Together, these two scenarios provide an indication of the Authority's financial exposure if MWD rates and transfer acquisition costs move in opposite directions. The third scenario, the "MWD transfer" scenario, shows the potential impact of MWD transfer purchases on the cost of the Existing Strategy and Maximum Local Supply Alternatives. The final two scenarios show the potential impact of a reinstated NDC on the alternatives' costs.

FIGURE 7-3
Projected Untreated Water Supply Costs
Low MWD Rates and High Transfer Acquisition Costs

Figure 7-3 shows the projected average cost of untreated water for each alternative under a "low MWD rates/high transfer acquisition costs" scenario. The scenario utilizes low MWD rate projections and assumes transfer acquisition costs increase in 2009 by the maximum 25 percent provided for in the Summary of Draft Terms. The trends projected under this scenario are quite different from those projected under either the low or high water supply cost scenarios. The low and high water supply cost analyses suggest that the average cost of untreated water under the Existing Strategy and three wheeled transfer alternatives will converge toward the end of the planning period. Under the low MWD rates/high transfer acquisition costs scenario, the transfer alternatives become more expensive relative to the Existing Strategy Alternative after 2008. This trend is particularly pronounced under the Maximum Transfers and Colorado River Facilities Alternatives, where transfers provide the majority of the region's water supply. The projected costs shown in **Figure 7-3** represent the high end of the Authority's financial exposure under the water transfer alternatives.

Figure 7-4 shows the projected average cost of untreated water under a "high MWD rates/low transfer acquisition costs" scenario. The scenario utilizes high MWD rate projections and assumes transfer acquisition costs decrease in 2009 by the maximum 25 percent provided for in the Summary of Draft Terms. This scenario represents the potential savings available to the region if MWD rates increase and transfer acquisition costs decrease. Under this scenario, low-cost transfers serve to, in part, offset the impact of MWD rate increases. The low MWD rates/high transfer acquisition costs and high MWD rates/low acquisition costs scenarios represent "best case" and "worst case" outcomes under the transfer scenarios.

A basic assumption behind the rate projections supplied to the Authority is that surplus Colorado River water will continue to be available to MWD at no charge except for the incremental cost of transportation. In the event surplus water is not available and MWD needs to purchase transfer water, the MWD rates used to evaluate the Existing Strategy and Maximum Local Supply Alternatives are understated.

Figure 7-5 shows the potential impact of MWD transfer purchases on the cost of the Existing Strategy and Maximum Local Supply Alternatives. The scenario assumes MWD purchases 200,000 af/yr of transfer water under the same price and delivery schedule that the Authority experiences under the Maximum Local Supply With Transfers and Intermediate Transfers Alternatives. MWD base case rates were adjusted to reflect the costs associated with the transfer purchases. Rate projections for the 200,000 af/yr and 500,000 af/yr transfer scenarios were assumed to remain unchanged since under those scenarios Authority transfers would offset the need for MWD transfer purchases.

The results of this analysis suggest that the purchase of transfers by MWD would have roughly the same impact on MWD rates as a 200,000 af/yr reduction in Authority purchases. Under these circumstances the rate impact potential of the Maximum Local Supply With Transfers, Intermediate Transfers, and Maximum Transfers Alternatives would be similar to that of the Existing Strategy Alternative for the first eight to ten years. At that point, if transfer acquisition costs decrease relative to MWD rates, the average cost of untreated water would be lower under the transfer alternatives than under the Existing Strategy Alternative.

The last two sensitivity scenarios were developed to provide an indication of the potential impact of a reinstated NDC on the cost of the six alternatives. MWD adopted the NDC as a means of paying for those facilities needed to serve increased demands. The NDC was suspended as a result of the Phase 1 RRP and a committee was formed to identify an alternative growth charge, such as a connection fee. If MWD fails to identify and implement an alternative growth charge, the NDC will be reinstated when MWD sales reach 2.2 million acre-feet per year (maf/yr).

The two NDC sensitivity analyses are based on a nexus study adopted by MWD in 1995. The reinstatement of the NDC, or adoption of an alternative growth charge, will ultimately require the development of a new methodology for assigning costs to growth and the preparation of a new study to determine the nexus between new demand and the facilities needed to serve it.

Table 7-5 summarizes the major assumptions used in the two NDC sensitivity scenarios. Both scenarios assume that transfer water is exempt from the NDC. Pursuant to MWD's proposed Local Resources Program (LRP) guidelines, the analysis assumes a reduction in LRP funding for the most cost-effective local projects when Authority purchases subject to the NDC plus local project production exceed the Authority's NDC base. As part of this analysis, MWD's basic untreated water rate was reduced to reflect additional revenues resulting from the reinstatement of the NDC. The adjusted rates reflect the amortization of the NDC over a period of 15 years.

Figures 7-6 and **7-7** show the projected average cost of untreated water under the two NDC scenarios using low MWD rate and transfer acquisition cost assumptions. The reinstatement of the NDC would shift costs currently covered by the MWD water rate directly to the

FIGURE 7-4
Projected Untreated Water Supply Costs
High MWD Rates and Low Transfer Acquisition Costs

FIGURE 7-5
Projected Untreated Water Supply Costs
Adjusted to Reflect MWD Purchase of Transfers

FIGURE 7-6
Projected Untreated Water Supply Costs
Adjusted To Reflect Reinstatement of NDC in 2003

FIGURE 7-7
Projected Untreated Water Supply Costs Adjusted to Reflect
Reinstatement of NDC When MWD Sales Reach 2.2 MAF

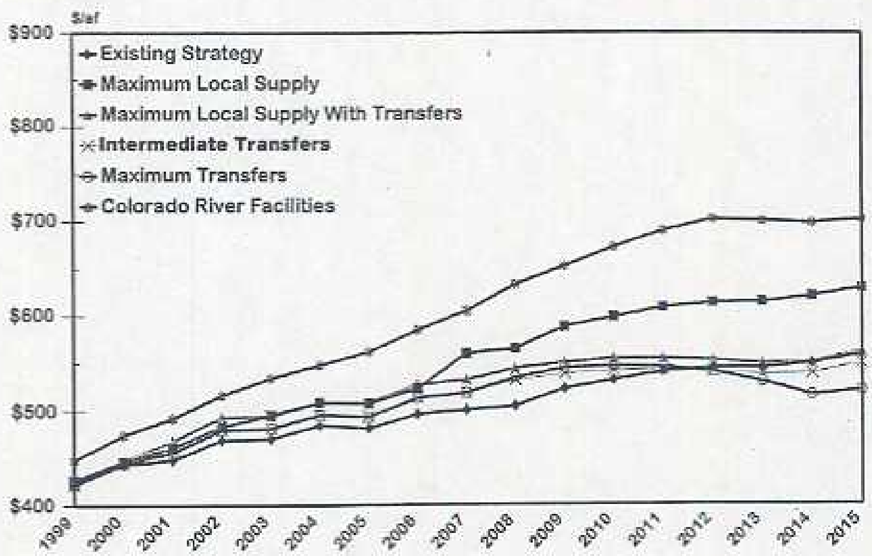


TABLE 7-5
Summary of Assumptions for NDC Scenerios

Assumptions	Scenario 1	Scenario 2
Reinstatement of NDC	NDC reinstated when Phase 1 RRP rate targets expire	NDC reinstated when MWD sales reach 2.2 maf
First Year of Revenue Collection	2003	Varies by alternative
NDC ($/AF)	$1,675	$1,675
Amortized NDC ($/AF)[1]	$168	$168
Authority NDC Base	NDC base established in 1995 Nexus Study (559,247 af)	NDC base equals purchases during the year MWD sales exceed 2.2 maf
Purchases Subject to NDC	Average purchases over s 4 year	Annual purchases
Reduction in 2015 Basic Untreated Water Rate	Varies by alternative; ranges from $13/af to $19/af	Varies by alternative; ranges from $0/af to $16/af

[1] Amortized over 15 years at interest rate of 5.6 percent.

Authority and other agencies with increasing demands on MWD. Under the four transfer alternatives, the Authority's demands on MWD are projected to remain relatively flat, or decrease, during the planning period. The primary impact of a reinstated NDC would therefore be an increase in the costs of the Existing Strategy and Maximum Local Supply Alternatives relative to those of the transfer alternatives. The analysis suggests, however, that potential rate impacts under the Existing Strategy, Maximum Local Supply With Transfers, Intermediate Transfers and Maximum Transfers Alternatives are close, even assuming the reinstatement of the NDC. Under the first NDC scenario, the 2015 average cost of untreated water under the Existing Strategy Alternative is projected to increase by $15/af, or 2.75 percent, over the base case projection. Under the second scenario, the 2015 average cost of untreated water under the Existing Strategy Scenario is projected to increase by $11/af, or 2 percent, over the base case projection. The impact of the reinstated NDC on the Existing Strategy and Maximum Local Supply Alternatives under either scenario is, in part, offset by a reduction in water rates for "existing" demands. A secondary impact of a reinstated NDC is an increase or acceleration of local supply development under some of the resource mixes. To avoid paying an NDC, agencies may choose to build local projects that were not considered cost-effective in the absence of an NDC.

7.2.4 Summary of Rate Impact Analysis

Total annual and cumulative expenditures for the six alternatives under each of the cost and rate scenarios are presented in **Tables C-2** through **C-8** in **Appendix C**. Taken together, the sensitivity analyses suggest that potential rate impacts under the Existing Strategy,

TABLE 7-6 Water Resources Plan 1997 Update
Comparative Evaluation of Rate Impacts

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
Rate Impacts Projected Rate/ Charge	Good	Fair	Good	Good	Good	Poor
Rate/Charge Ramp up	Good	Fair	Good	Good	Good	Fair
Sensitivity to Water Sales	Good	Fair	Fair	Fair	Fair	Poor
RATING	●	◍	●	●	●	○

● Good ◍ Fair ○ Poor

1 Water is transferred from Northern/Central California and/or Colorado River.

Maximum Local Supply With Transfers, Intermediate Transfers, and Maximum Transfer Alternatives are extremely close under the MWD transfers scenarios and the two NDC scenarios. The low MWD rates/high transfer acquisition costs and high MWD rates/low transfer acquisition costs scenarios show both the potential risks and benefits associated with the transfer alternatives: risks if transfer acquisition costs increase relative to MWD rates; benefits if acquisition costs move in the opposite direction.

The potential rate impact associated with the Colorado River Facilities Alternative is significantly higher than those of the other alternatives, even under the high MWD rates/low transfer acquisition costs scenario. The potential rate impact associated with the Maximum Local Supply Alternative, while higher than those of the Existing Strategy, Maximum Local Supply With Transfers, Intermediate Transfers, and Maximum Transfers Alternatives, is still significantly lower than that of the Colorado River Facilities Alternative.

Table 7-6 shows the comparative ranking of each alternative for the water rate criterion.

7.3 QUALITATIVE CRITERIA EVALUATION

Qualitative criteria include degree of Authority control, feasibility, reliability, environmental impacts, and water quality. The approach taken in this Plan is to disaggregate each alternative by supply component, then evaluate the component separately for the criterion under consideration. These evaluations are then cumulated to produce an overall descriptive rating of good, fair, or poor for each alternative. This process is repeated for each qualitative criterion. The final evaluation step is to combine the results of the qualitative evaluation with results from the quantitative evaluation to derive overall rankings for alternatives.

Qualitative assessments of future MWD supplies were made based upon data from MWD's Integrated Resources Plan (IRP). Under the IRP, demand in MWD's six-county service area is met using all available resources, including demand management, local supplies, and imported water supplies. MWD identified specific water supply goals in the IRP and is making substantial investments in local supply development with the intention of reducing demand for imported water. Failure to meet the local supply or demand management goals has a direct impact upon the level of imported supply MWD must provide to its member agencies and the confidence that MWD can supply it. This is a major issue for the San Diego region, which imports up to 95 percent of its water supply from MWD during dry years.

Each component of IRP supply has been evaluated for each of the five qualitative criteria. To accomplish this, an analysis was conducted of the IRP supply and demand balance for the MWD Board-adopted Preferred Resources Mix. As part of this analysis, local supplies and the associated demand for the Authority's service area were deducted from the total supply and demand numbers and evaluated separately. It should be noted that more recent demand projections by MWD indicate a decrease in future water requirements that would necessitate a revision to the IRP and possibly result in modification of the Preferred Resources Mix. However, that revision has not been conducted.

7.3.1 Criterion: Maximize Supply Reliability

Definition of Criterion: This criterion measures the ability of the alternative to meet full retail level service demands during normal and dry years and the minimization of drought and seismic risks. Options that increase the diversity of supply are considered superior. Factors affecting reliability include sensitivity to weather conditions, regulatory constraints on facilities operations, and potential for drought supply allocations.

Analysis and Results.

Water sources are considered to have good reliability only if none of the factors described in the criterion definition substantially affect supply availability during a drought. A source of supply was considered to have fair reliability if no more than two factors could affect its availability. A rating of poor reliability was given to those sources of supply that were substantially affected by two or more of the factors and for which there is limited assurance of availability during a drought. **Table 7-7** provides an evaluation of the reliability for each individual source of supply.

Local Supplies.

Local reclamation projects, groundwater projects relying on recycled water as a source of recharge, firm local surface water yields, and seawater desalination are all considered highly reliable. Groundwater relying upon natural recharge is subject to reductions during dry years. Firm local surface water is the minimum amount of water drafted from local reservoirs, based upon historical data reported to the Authority from member agencies.

Wastewater flows to a reclamation plant are not significantly impacted by drought. Thus, users of non-potable reclaimed supplies or potable repurified supplies would not likely be subject to cutbacks in dry years. Regulatory constraints could affect reclamation, especially those related to increases in Total Dissolved Solids (TDS) above groundwater basin plan objectives. In the past, this issue has been successfully addressed through revisions to the Basin Plan or the introduction of demineralization treatment. During the last drought the Regional Water Quality Control Board (RWQCB) was consistent in allowing use of recycled water in excess of Basin Plan TDS Objectives. Regulatory constraints are not considered to impact the reliability of local reclamation projects either within the Authority's service area or the MWD service area as a

TABLE 7-7
Reliability of MWD Service Area Supplies[1]

SUPPLY	AMT / AF	REL.	COMMENTS
IMPORTED SUPPLIES			
State Water Project - Historic Firm Supplies	400,000	Good	Based on historic deliveries during recent droughts.
State Water Project - IRP Firm Supplies	250,000	Fair	Based on MWD projections for IRP using 1994 Bay-Delta Accord conditions.
State Water Project - Interim Delta Fix	150,000	Fair	Subject to regulatory constraints, weather conditions.
State Water Project - Full Delta Fix	550,000	Fair	Subject to regulatory constraints, weather conditions.
Colorado River - Firm Supplies	626,000	Good	Fourth priority within state allocation plus IID [1].
Colorado River - Surplus Supplies	574,000	Poor	Subject to reductions as unused allocations from other state increase.
Storage Agreements/Transfers [2]	460,000	Fair	Subject to weather conditions, limits in extraction capabilities, and possible Bay-Delta restrictions.
Total Imported Supplies	**3,010,000**		
LOCAL SUPPLIES			
Existing Local Projects - Current Production	148,000	Good	Reclaimed water and groundwater recovery.
Existing Local Projects - Increased Production	98,000	Good	Reclaimed water and groundwater recovery.
Future Local Projects	208,000	Good	Reclaimed water and groundwater recovery.
Existing Groundwater Storage	100,000	Fair	Relies on imported water availability.
Future Groundwater Storage	230,000	Fair	Relies on imported water availability.
Existing Firm Groundwater and Surface Water	1,430,000	Good	Recharge from firm yields.
Total Local Supplies	**2,214,000**		
Total Imported And Local Supplies	**5,224,000**		

CWA Service Area Supplies

SUPPLY	AMT / AF	REL.	COMMENTS
Transfers Wheeled, 0 - 200,000 af	0 to 200,000	Good	High priority water.
Transfers Wheeled, 200,001 - 500,000 af	200,001 to 349,999	Good	High priority if Colorado River. A portion may be subject to sharing with MWD in a cutback situation. Varying priority and more susceptible to drought cutbacks if SWP.
	350,000 to 500,000	Fair	N. California portion may be subject to Delta restrictions.
Colorado River Conveyance Pipeline	200,000 to 500,000	Good	High priority through contract with Bureau of Reclamation.
Existing Firm Surface Water Supplies	25,000	Good	Dry-year yields.
Existing Normal-Year Surface Water Supplies	35,000	Fair	
Existing Reclamation and Groundwater	20,000	Good	
Future Reclamation and Groundwater	85,000	Good	
Seawater Desalination	20,000	Good	
Total CWA Supplies	**685,000**		

1 Source of data: MWD draft Integrated Resources Plan (December 1995). MWD 2020 service area supplies are dry year and exclude Authority local supplies.
2 In a normal year, this source would be replaced by SWP supplies.

whole. Groundwater basins may also be subject to regulatory constraints, including requirements to maintain minimum water table levels to support habitat and limitations imposed by upstream water rights holders on the amount of water available for recharge. These constraints are not as serious if the source of recharge is recycled water.

Imported Supplies: State Water Project.

Drought in California has had significant impacts on the reliability of water imported from the SWP. Over the past 25 years, severe droughts in Northern California twice caused the SWP to sharply limit deliveries to its contractors. In 1977 and 1991, MWD received less than 400,000 af, which is about a third of normal year deliveries. Forty-two of the last 90 years were classified by the state's Department of Water Resources (DWR) as either below normal runoff, dry, or critically dry. Two sustained droughts (1929-34 and 1987-92) occurred during this period, where flows in the Sacramento River dropped to half of average. In 1977, annual flows to the Delta reached an all time recorded low of 5 maf, compared to the 50-year average of 18.4 maf. Storage in the system mitigates some of the drought impacts, but SWP storage of 5.3 maf is not adequate to meet full demands during a prolonged drought, such as occurred from 1987-92, or to take advantage of above-normal runoff during wet years. As part of the 1994 Monterey Agreement between DWR and SWP contractors, MWD received access of up to 200,000 af of storage in SWP reservoirs. This helps mitigate the variation of flows on the SWP and provides added protection during dry weather years. Construction of new south of the Delta off-stream storage as part of the "full Delta fix" described in Chapter 3, provides the SWP with greater operational flexibility to deal with variations in weather conditions.

Drought impacts in Northern California are compounded by environmental and water quality issues surrounding the Sacramento-San Joaquin Delta, discussed in Chapter 3. Regulatory restrictions imposed to protect endangered species and improve Delta water quality could constrain Delta exports even in average runoff years. Under the IRP, MWD will rely on a dry year yield from the SWP of 1.35 maf by 2020. In order to achieve this quantity both an interim and a full fix of the Delta must be accomplished by 2010. Analysis contained in the IRP indicates that if no additional investment is made to improve conditions in the Delta, regulatory restrictions imposed to protect endangered species and improve Delta water quality could constrain Delta exports 50 percent of the time or every other year including average runoff years. Export restrictions could limit deliveries to MWD during a dry year to about 400,000 to 600,000 af, less than half of the IRP goal for SWP supplies.

The issue of water rights has an impact in times of shortage and influences the reliability of SWP supplies. The SWP has the most junior water rights on the Sacramento and San Joaquin Rivers. As discussed in Chapter 5, pre-1914 rights holders and the Central Valley Project (CVP) have superior rights to the SWP and would receive their allocations of water during a shortage before the SWP. Coupled with dry-year environmental priorities, this would reduce the amount of water available to the SWP. For this reason, transfer water from the pre-1914 rights holders and even the CVP is rated higher in this aspect of reliability.

The SWP is integral to MWD being able to meet increasing demands within its service area. The uncertainties about future regulatory restrictions, the history of the SWP's susceptibility to extended periods of drought, the inadequate carry-over storage in the SWP system, and the Project's junior water rights raise serious reliability concern and highlights the importance that successfully implementing a Delta fix has in ensuring the certainty of the state's main water supply. Transfer water from the CVP, areas of origin with pre-1914 rights, or from SWP contractors south of the Delta, is more reliable and would be a strategy for enhancing reliability, such as occurred with the State Water Bank in 1991 (see Section 5.4.1).

As discussed in Chapter 3, interim Delta improvements consisting of fish screens and acoustic barriers followed by a full fix of the Delta would enhance the reliability of the SWP and is considered in evaluating its overall reliability as a source of supply. Taking that into account, it can be assumed that the potential for operating restrictions would be reduced and additional storage would be capable of partially mitigating the wide variation in weather conditions. For these reasons, SWP supplies above the minimum historical deliveries to MWD are less reliable than the historic firm supplies and were rated as having fair reliability. The historic firm SWP deliveries were considered to have good reliability.

Imported Supplies: Colorado River.

The key reliability issue for Colorado River supplies is whether MWD will be able to deliver the full capacity of its CRA (1.2 maf/yr) in future years. MWD has firm entitlement to only about half the aqueduct's capacity. In the past, the non-firm half of CRA deliveries came from other lower basin states' unused allocations. But in 1996, the lower basin exceeded its 7.5 maf entitlement, and unused allocations were not available. MWD was able to keep the aqueduct full after the U.S. Bureau of Reclamation (Bureau) declared a surplus on the Colorado River. A surplus declaration will likely be needed again in 1997, and the Bureau has indicated that water supply conditions may warrant the surplus.

Computer modeling analysis performed by the Colorado River Board of California (CRB) in 1996 showed that MWD will on average be unable to keep the CRA full without annual surplus declarations. MWD has suggested reoperation criteria for the Bureau to consider that would allow surplus declarations to continue. The analysis conducted by the CRB shows that MWD would benefit from such reoperation over the next 10 to 15 years. However, Arizona users would face increased risk of shortages under the reoperation criteria. Upper basin states have also raised concerns over the proposed criteria and have expressed a desire for California to reduce its Colorado River diversions to the 4.4 maf basic entitlement. The CRB analysis showed that even under the proposed criteria, MWD could begin experiencing some level of supply shortage by 2010.

The Arizona Legislature recently adopted a groundwater banking law which provided funding for groundwater replenishment and off-stream banking. With this new law, Arizona recently revised and accelerated its water demand projections on the Colorado River. The CRB estimated that Arizona's 1996 water will be about 2.7 maf, close to its 2.8 maf apportionment. As Arizona's usage increases, less unused apportionment will be available to California, making MWD more dependent upon surplus declarations.

Supplies from the Colorado River were also reviewed under varying weather conditions. Historical records indicate that lower basin allocations (7.5 maf) could not be met during two years of a period dating back to 1906. Studies published by the American Water Resources Association (AWRA) show that severe sustained droughts of up to 20 years would not cause a reduction in California deliveries below the basic entitlement of 4.4 maf. This is because of a combination of large volumes of storage in the lower basin as well as an upper basin obligation to deliver an aggregate of 75 maf to the lower basin over a 10-year period. The AWRA study also concluded that surplus water that MWD currently relies upon to maintain a full CRA would not be available under this scenario.

On average, Colorado River recorded inflows have exceeded use by 1.0 to 1.9 maf annually. However, averages can greatly mask variability in river flows. For many years, actual flows were either considerably lower or higher than total system demand. During the recorded 1906-95 period, the estimated natural flow at Lee Ferry, the compact point, was less than 12 maf about 30 percent of the years, and more than 21 maf in 12 percent of the years. Compounding this variability is the tendency for "persistence" in flows. Both low- and high-flow years are more likely to occur in a series. When this happens in low-flow years, the reservoirs are not always able to recover rapidly. **Table 7-8** shows average historical inflows and uses of the river.

TABLE 7-8
Colorado River Inflows and Uses

Average Inflow (1906-95)	**16.4 MAF**
Current Uses	
Upper Basin	3.8 maf
Lower Basin	7.5 maf
Mexico	1.5 maf
Sub-total	12.8 maf
Evaporation and System Losses[1]	1.7 to 2.6 maf
Total System Needs	14.5-15.4 maf
Average Difference, Inflow to Use	1.0 - 1.9 maf

[1] Losses and evaporation are dependent upon storage levels in reservoirs. Presently the figure is nearer 2.6

As upper and other lower basin states increase water use on the Colorado River, the average surplus shown above could diminish quickly, and less surplus water from unused entitlements will be available. Even during a normal weather year, surplus flows may not be available.

Much has been done in the past to drought-proof Colorado River users. Storage in excess of 60 maf, equal to about 4 times the average annual flow, has been built into the system, all but ensuring that any short-term drought would not impact deliveries of basic apportionments. In addition, the upper basin obligation to deliver at least 75 maf over a 10-year period moderates the impact on lower basin deliveries in times of drought. Priorities and water rights become the major factors determining reliability on the Colorado River during times of sustained drought.

Agricultural agencies in California have higher priority to Colorado River water than MWD. The IID has some of the highest priority water on the river, with present perfected rights to most of its allocation that pre-date the Colorado River Compact. MWD's basic entitlement plus conserved water through its agreement with IID is considered reliable water even in times of drought. In the event of shortage, California users have higher priority than the other lower basin states, which would see reductions in their basic entitlements before California agencies. Because of MWD's reliance on surplus water over and above its basic entitlement, it will lose a major portion of its current Colorado River supply if Arizona and Nevada begin taking their full entitlement.

Environmental issues on the Colorado are primarily related to operating dams to protect endangered fish. This has minimal effect on water supply and is more likely to limit the production of hydroelectric power. When compared to the SWP, the Colorado River has less variable hydrology, very senior water rights, and significantly more storage capacity. As a result, Colorado River entitlement water is considered to be more reliable and have a lower risk of not being available during a drought than that portion of SWP supplies above the historic SWP firm yield.

Surplus Colorado River water is considered unreliable both as a dry-year supply and to meet increasing demands even in normal weather years. By its very definition, surplus Colorado River water is less reliable than California's first through fourth priority entitlements. It is available only if the Bureau declares a surplus and only after the basic entitlements have been satisfied. Reliance by MWD on surplus water during prolonged periods of drought would provide a significantly higher risk of shortage when compared to the basic entitlements. Current discussion between the U.S. Department of Interior and the Colorado River water users centers in great part on the need for California to move towards staying within its annual 4.4 maf entitlement. This emphasis on reducing reliance on surplus water reinforces the conclusion that even with reoperation, long-term reliance on this source provides an excessive reliability risk. Compared to surplus supplies, transfer supplies that come from agricultural agencies with entitlement or present perfected rights are highly reliable.

Storage Agreements and Transfers.

The IRP relies on storage agreements and transfer water from Northern California sources to meet dry year demands. This water is available under dry year option agreements or stored in groundwater basins south of the Delta. The water could be either from north or south of the Delta and have a variety of water rights attached to it. This makes it difficult to generalize as to what the potential for allocation during drought would be. There may also be a restriction on exports if the transfer is from north of the Delta and requirements for environmental water are imposed. With the level of information available on Northern California transfers it was only possible to rate this supply as having fair reliability.

Overall Evaluation.

Based on the evaluation provided in **Table 7-7**, a listing can be developed of the quantities of water by each category of reliability (good, fair and poor) for the optimized resource mixes. This analysis has been performed using normal-year and dry-year demands on the Authority and MWD and assumes that the Authority would receive a proportional share of MWD water equal to its level of purchases. **Table 7-9** presents the results of this exercise.

The Colorado River Facilities and the

TABLE 7- 9
Quantites of Water Rated by Reliability Year 2015 (AF)

	Existing Stategy	Max Local	Max Local w/Trans	Intermed Transfr	Max Transfr	CR Facility
NORMAL YEAR						
Good	362,884	410,250	527,407	499,065	523,398	638,820
Fair	422,385	376,750	259,593	287,935	263,602	148,180
Poor	1,731	-	-	-	-	-
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	347,809	397,516	522,241	491,783	533,996	644,690
Fair	401,668	375,153	299,191	319,175	306,004	195,310
Poor	90,523	67,331	18,568	29,042	-	-
Total Supply	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Dry-year 2015 revised demands. Assumes Authority receives proportional share of available MWD water.

Maximum Transfer Alternatives have the largest amounts of reliable water. This is because up to 500,000 af of highly reliable transfer water from the Colorado River would be the predominant source of supply, and the remaining water needed would also be considered highly reliable. A variation of the Maximum Transfers Alternative envisions 150,000 af of the 500,000 af total coming from Northern California. This was rated as having fair reliability and does not change the relative rankings of the alternatives.

The Maximum Local Supply With Transfers Alternative and the Intermediate Transfers Alternative have the next highest block of water considered to be highly reliable. This is because the addition of agricultural transfers and local supplies reduce the need for SWP and Colorado River surplus water inherent in the mixes relying most heavily on MWD. These two alternatives also result in the greatest diversification of supply, which is another criterion used in evaluating reliability. The Maximum Transfers and the Colorado River Facilities Alternatives shift primary reliance on one single provider, MWD, to primary reliance on another source, the Colorado River. Further diversification can be achieved by acquiring a portion of the transfer water under the Maximum Transfers Alternative from Northern California.

The four proposals that incorporate transfers also have the least amount of water considered to be of questionable reliability. In the event of shortages, it can be assumed that poor reliability water would be the most likely to experience cutbacks. Reducing reliance on poor reliability supplies is key to enhancing overall reliability.

MWD's IRP And Reliability.

Through the implementation of its IRP, MWD anticipates it will meet normal- and dry-year demands through 2015. However, should full implementation of the IRP fall short of expectations, MWD may have difficulty meeting demands. The reliability of the IRP rests on three basic premises: 1) the CRA remains full through efforts at reoperation and water banking; 2) future demand on MWD is met by the SWP through implementation of a full Delta fix by 2010; and 3) local projects are implemented to the extent estimated in the IRP. These sources make up 35 percent of the MWD service area's supply in 2020 as envisioned in the IRP. In the event any or all of these premises are less than fully realized, pressure will be exerted to make up those shortages through

TABLE 7-10
Impacts of Less Than Full Implementation of IRP
(No new local projects or increased production from existing local projects)
By Ratings of Reliability (AF) Dry Year 2015

	Existing Stategy	Max Local	Max Local w/Trans	Intermed Transfr	Max Transfr	CR Facility
Good	321,435	372,490	501,572	469,897	522,302	653,323
Fair	365,422	340,761	270,786	289,098	304,977	186,613
Poor	134,512	124,473	67,642	81,005	12,721	18,065
Total Supply	821,370	837,723	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000
Balance	(18,630)	(2,277)	-	-	-	-

NOTE: Dry-year 2015 revised demands. Assumes Authority receives proportional share of available MWD water.

increased reliance on the other water resources. **Table 7-10** provides an evaluation of the relative reliability of each alternative in a dry year where the Authority's demands increase by approximately 7 percent and MWD's local production falls 306,000 af/yr short of IRP goals.

If all water identified were available, there would be minor shortages of no more than 3 percent with no shortages occurring in the alternatives that incorporate transfers. One effect of this scenario would be to increase the amount of water in each of the mixes that is considered to be of poor reliability, i.e., surplus Colorado River water. Shortages would increase substantially under the Existing Strategy and Maximum Local Supply Alternatives if any or all of the poor-reliability water were not available. The remaining alternatives, which reduce dependence on poor-reliability water, would be less vulnerable to shortages.

Table 7-11 provides a similar dry-year analysis assuming interim Delta improvements but not a full fix to the Delta and assuming an increment of 550,000 af is not available in a critically dry year.

In this analysis, shortages are apparent under all alternatives. The shortages increase as dependence on MWD increases to the point where 10 percent shortages are reached in the Existing Strategy Alternative. This would be compounded in the event that other poor-reliability water, such as surplus Colorado River water, is limited in availability. Mixes with the least amount of water rated as poor would be considered the most reliable in this type of drought risk analysis.

Table 7-12 provides a qualitative evaluation of each component of reliability for the alternatives.

7.3.2 Criterion: Maximize Supply Feasibility

Definition of Criterion: This criterion measures the probability that a future source of water will actually be developed or available as planned. Factors considered in feasibility include public acceptance, regulatory agency approval, Authority/MWD member agency acceptance, engineering/construction difficulty, third party effects from transfers, compatibility with existing Authority facilities and operations, and water rights and legal aspects.

Feasibility affects both existing and future water sources. For the most part, existing sources of supply are considered feasible by the very fact of their existence. However, in certain cases, feasibility for existing supplies bears further scrutiny. For example, feasibility issues affect MWD's ability to maintain a full CRA over the long term. **Table 7-13** provides an evaluation of regional supplies for feasibility.

Local Supplies.

An assumption was made that all existing local supplies will continue to provide water. These supplies have the highest level of feasibility. Future local projects were affected primarily by the requirement for local agency funding approval. Because these types of projects have a proven track record, regulatory approval was not considered a limiting factor. The only uncertainty is then the need for certified environmental documents to actually construct. Public acceptance is considered good for almost all local projects. Public perception of the water repurification project has yet to be fully determined and is considered fair at this point, although that issue will be more fully known at the conclusion of the environmental process, and before the next Water Resources Plan update.

Seawater desalination, although technically feasible, raises issues of regulatory approval for brine discharge, compatibility with existing power generation facilities, and the need for integration with a domestic water distribution system. A "stand-alone" project located on the coast could be difficult to site and may encounter lack of public acceptance. Collocating with an existing power plant with access to an ocean outfall, such as San Diego Gas & Electric Company's Encina Plant, would

TABLE 7-11
Impacts of Less Than Full Implementation of IRP (no full fix to Delta) By Ratings of Reliability (AF)
Dry Year 2015

	Existing Stategy	Max Local	Max Local w/Trans	Intermed Transfr	Max Transfr	CR Facility
Good	347,809	397,516	522,241	491,783	533,996	644,690
Fair	258,641	242,469	196,138	208,327	267,979	139,516
Poor	149,268	138,474	107,550	115,685	37,026	54,794
Total Supply	755,718	778,459	825,929	815,795	839,000	839,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000
Balance	(84,282)	(61,541)	(14,071)	(24,205)	(1,000)	(1,000)

NOTE: Dry-year 2015 revised demands. Assumes Authority receives proportional share of available MWD water.

TABLE 7-12
Water Resources Plan 1997 Update
Comparative Evaluation of Reliability

CRITERION	Existing Stategy	Max Local	Max Local w/Trans	Intermed Transfr[1]	Max Transfr	CR Facility
Reliability						
Meet Increasing Demands	Fair	Fair	Good	Good	Good	Good
Increase Supply Diversity	Poor	Fair	Good	Good	Good	Poor
Minimize Droughts	Fair	Fair	Good	Good	Good	Good
Limit Cutbacks During Drought	Fair	Fair	Good	Good	Good	Good
Limit Regulatory Constraints	Poor	Fair	Good	Good	Fair[2]	Good
RATING	Fair	Fair	Good	Good	Good	Good

● Good ◍ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.
[2] If transfers from non-Colorado River sources are used.

TABLE 7-13
Feasibility of MWD Service Area Supplies[1]

SUPPLY	AMT / AF	FEAS.	COMMENTS
IMPORTED SUPPLIES			
State Water Project - Historic Firm Supplies	400,000	Good	Based on historic low deliveries.
State Water Project - IRP Delta Fix	250,000	Fair	Assumes continuation of 1994 accord-need statewide cooperation.
State Water Project - Interim Delta Fix	150,000	Fair	Assumes fish screens and acoustic barriers work, currently unfunded.
State Water Project - Full Delta Fix	550,000	Fair	Requires approval of Delta facilities and funding, acceptance by statewide publics. Cooperating Cal-Fed process underway.
Colorado River - Firm Supplies	626,000	Good	Existing entitlement plus conserved IID water.
Colorado River - Surplus Supplies	574,000	Poor	Requires multi-state agreements and intra-state agreement.
Storage Agreements/Transfers[2]	460,000	Fair	Requires signed contracts, SWRCB approval, Delta if from north.
Total Imported Supplies	**3,010,000**		
LOCAL SUPPLIES			
Existing Local Projects - Current Production	148,000	Good	Existing projects in production.
Existing Local Projects - Increased Production	98,000	Good	Proven track record. Requires expansion of existing projects.
Future Local Projects	208,000	Fair	Requires new project construction, funding, environmental approvals, public acceptance.
Existing Groundwater Storage	100,000	Good	Existing.
Future Groundwater Storage	230,000	Fair	Requires change in how basins are currently operated. Relies on available storage.
Existing Firm Groundwater and Surface Water	1,430,000	Good	Existing supplies.
Total Local Supplies	**2,214,000**		
Total Imported and Local	**5,224,000**		

1 Source of data: MWD draft Integrated Resources Plan (December 1995). MWD 2020 service area supplies are dry year and exclude Authority local supplies.
2 In a normal year, this source would be replaced by SWP supplies.

TABLE 7-13 (Continued)
Feasibility of Supply

SUPPLY	Authority Service Area Supplies AMT / AF	FEAS.	COMMENTS
Transfers Wheeled, 0 - 200,000 af	0 to 200,000	Good	Conservation attainable per IID study. MWD wheeling policy is being drafted.
Transfers Wheeled, 200,001 - 500,000 af	200,001 to 500,000	Fair	Quantities can actually be conserved. Regulatory and public acceptance issues; inter-state agreements if outside California.
Colorado River Conveyance Pipeline	300,000 to 500,000	Poor	Public acceptance, regulatory, third party impacts, legal and institutional issues.
Existing Firm Surface Water Supplies[1]	25,000	Good	Existing.
Existing Normal-Year Surface Water Supplies[1]	35,000	Good	Existing.
Existing Reclamation and Groundwater[1]	20,000	Good	Existing.
Future Reclamation and Groundwater	85,000	Fair	Requires funding and environmental approval, public acceptance for repurification.
Seawater Desalination	20,000	Fair	Requires cogeneration opportunity, regulatory approval for brine discharge.
Total Authority Supplies	**685,000**		

[1] Source of data: MWD draft Integrated Resources Plan (December 1995). MWD 2020 service area supplies are dry year and exclude Authority local supplies.

enhance the feasibility of such a project. Studies undertaken by the Authority indicate that a collocated project at an existing site is feasible, but enough uncertainty exists to rate seawater desalination as having only fair feasibility in relation to other supplies.

Imported Supplies: MWD State Water Project.

Imported water is an exception to the high feasibility given to existing supplies. The SWP supplies above historic low deliveries were considered to have only fair feasibility. These additional SWP supplies depend upon continuation of the terms of the 1994 Bay-Delta accord, which expires in 1997, and upon an interim Delta "fix" to secure these supplies. Renewal of the 1994 terms would require agreement of all the concerned parties, which at this point has some degree of uncertainty. An interim fix is to date unfunded and has not been officially adopted. SWP deliveries of a full entitlement to MWD require a full Delta fix, subject to regulatory approval, statewide public acceptance, agreement of all concerned water users, identification of a preferred alternative, and approval of funding. All of these elements contain a large degree of uncertainty. Efforts by Cal-Fed and cooperation among urban, agricultural, and environmental water interests have resulted in continued progress toward agreement on a Delta fix. Recent approval of Proposition 204 by California's voters has provided a significant step forward in the process of funding Bay-Delta environmental restoration improvements. However, because it is still relatively early in the implementation process and because funding has not been identified for those elements that would increase yield, the feasibility of implementing an interim and full Delta fix in relation to other supply opportunities is rated as fair.

Storage Agreements and Transfers.

MWD has negotiated and implemented storage agreements south of the Delta. The Semi-Tropic Water District agreement is a successful example. Feasibility questions in this supply component center on the acquisition of transfers from Northern California. To date MWD has not finalized agreements for option transfers originating from Northern or Central California.

Water rights are varied on the Sacramento and San Joaquin Rivers, and transfers must be approved by the State Water Resources Control Board (SWRCB) for water transferred beyond its original area of use. Transportation is considered feasible since there is excess capacity in the California Aqueduct and the DWR has a wheeling policy in place. A major issue in evaluating the feasibility of Northern California transfers is limitations on exports through the Delta. Uncertainties surrounding the allowable exports and reliance on a Delta fix would be applicable feasibility considerations for a transfer from north of the Delta. If most or all of the transfer water came from south of the Delta, this would not affect the feasibility of the transfer. Because of the uncertainties of where the water originates and the issues surrounding Delta export restrictions, the IRP's Northern California transfer component was rated as having fair feasibility.

Imported Supplies: MWD Colorado River.

Surplus Colorado River water was evaluated for feasibility on the basis of MWD's efforts to firm up Colorado River supplies above the MWD entitlement of 550,000 af/yr. Sufficient progress has not been made by MWD in these efforts to indicate good or fair feasibility. Current plans by MWD to reoperate the river and expand water banking opportunities would require agreement of all seven states and the federal government. These issues are complex and may take years to resolve. Other specific plans to purchase long term transfers to maintain a full CRA are not being pursued by MWD at this time. Given these uncertainties, this source of supply was rated as having poor feasibility.

On-stream banking in Colorado River

reservoirs has been suggested as one way to increase the reliability of Colorado River supplies. This concept, sometimes termed "top water banking", would allow agencies to store water in reservoirs if such water meets yet-to-be-agreed-upon eligibility criteria. Arizona has proposed inter-state groundwater banking of Colorado River supplies within the context of its new groundwater banking program. Discussions are ongoing as to how such a program would be operated.

MWD has proposed that it be allowed to bank three categories of water: 1) continued banking of savings which resulted from its Palo Verde test land fallowing program (186,000 af); 2) conserved supplies which resulted from its IID conservation agreement (106,000 af/yr); and 3) salinity control water. Salinity control banking represents water available from the Colorado River that MWD cannot deliver because of requirements to control salinity in its distribution system.

California agencies support banking water that is produced from conservation programs, provided all agencies are allowed to participate. To date, MWD has sought a preferred banking position by linking its water banking to the settlement of the San Luis Rey Indian water rights dispute (Section 4.3.2), and therefore resolution within California has not yet been achieved. Resolution of on-stream banking must also be achieved among the other lower basin states, which have expressed concerns with MWD proposals put forth to date. In particular, questions have been raised about the eligibility of banking salinity control water and water already being conserved that is currently considered "system water."

MWD's proposed operating criteria has not received support from all agencies within California, nor officially from other states. Other states appear to support annual evaluations of surplus supplies, but not changes in operating criteria that could cause long-term impacts. California users and other states would likely want extensive input on any new operating criteria.

In an address given December 19, 1996, to the Colorado River Water Users Association, U.S. Secretary of Interior Bruce Babbitt, emphasized the federal government's concern with California's continued reliance on surplus water. In his remarks, the Secretary stated the fact that other lower basin states are increasing their uses of CRW and that lower basin users cannot continue to depend on the availability of surplus water. Secretary Babbitt went on to say that surplus water will not be available to indefinitely meet demands beyond California's 4.4 maf entitlement and the effective implementation of surplus criteria depends on a well conceived strategy to manage California's demands on the Colorado River. He went on to conclude that California must put in place a realistic strategy that will ensure the ability to reduce its use when necessary or to meet its needs from sources that do not impact other users entitlements.

Consequently, there is a high degree of uncertainty associated with implementation of the operational changes proposed by MWD. Secretary Babbitt's remarks as well as those of Colorado River users, indicates a serious lack of support for MWD's proposals. Due to the lack of a clear plan on the part of MWD to gain consensus in support of MWD's continued reliance on surplus Colorado River water, the feasibility of this supply component is considered to be poor.

Transfers: Colorado River.

Agricultural transfers from the Imperial Valley of up to 200,000 af/yr were considered to have good feasibility because that amount is well within the quantities IID identified as being attainable through conservation. Draft terms have been developed to sell the water, and MWD is working on a wheeling policy that would enable transportation. Water rights are firmly established, and a precedent for transferring conserved Colorado River water exists through an MWD-IID program, which conserves 106,000 af/yr. This level of transfer appears to have good public acceptance in both counties and is not considered to result in third-party impacts. Regulatory approval may be relevant to impacts on Salton Sea levels and water constituent concentrations. This may cause some uncertainty, but is not considered as significant as it is at higher quantities of transfers. An agreement signed by all seven California parties with priority rights and the Bureau is required to implement the program. In his recent remarks to the Colorado River Water Users Association (December 19, 1996), Secretary of Interior Babbitt reiterated the federal government's support for Colorado River transfers. He also stated that the Bureau can help effectuate transfers within the Law of the River if the water can verifiably be conserved. Agricultural transfers of up to 500,000 af are considered to be less feasible than the 200,000 af level, but to have fair feasibility in relation to other supply options.

In its Water Availability Study, IID identified a maximum 400,000 af/yr as attainable through extraordinary conservation. Achieving quantities in excess of that amount is presently uncertain, pending further study. Regulatory approval and public acceptance become more of an issue at this level of transfer. Concentrations of constituents in the Salton Sea may be more affected, which would increase uncertainty regarding regulatory approval. Public perception in the Imperial Valley may not be as accepting of a transfer of this magnitude without clear consensus that third-party economic impacts would not occur or would be mitigated.

The economic benefits realized by Imperial County from payments for the water, combined with the knowledge that the transfer water is the result of conservation and not the permanent retirement of agricultural land, could provide the necessary assurances that any third-party impacts would be alleviated. Reliance on the CRA for a transfer of 500,000 af would require more than 40 percent of the available aqueduct capacity for the term of the transfer agreement, a major commitment on the part of MWD. This is balanced to some degree by the uncertainties surrounding MWD's long-term ability to maintain a full CRA. Capacity may be available for amounts above MWD's basic entitlement. Transfer water from other Colorado River users, both within and outside California, may be pursued but are considered to have some of the same feasibility issues.

The evaluation of a separate conveyance facility to the Colorado River to transport 500,000 af of water from the Colorado River raises several feasibility issues. The transfer of 500,000 af from the Imperial Valley has the same regulatory and public acceptance uncertainties as the wheeled alternative. Although construction of a conveyance system is considered technically feasible, gaining regulatory approval for construction can only be considered fair at the level of studies conducted to date.

Issues specific to the feasibility of a separate pipeline are mainly institutional and legal. A new conveyance line to the Colorado River would require a direct contract with the Bureau. Challenges to that contract by the upper basin states and other lower basin states may arise due to a perception that a "new" allocation is being made to California. Public perception within the Imperial Valley may also be more of a factor if a pipeline is viewed as a more permanent arrangement than a wheeled transfer.

Efforts to revise the current operations of the river to make allocations more flexible and responsive to needs can alleviate some of these uncertainties. Positive public response to lower levels of transfer and their economic benefit can change public perception over the significance of a pipeline. This is a changing situation, and these changes could be reflected in the next update of the Water Resources Plan. For purposes of the current plan, Colorado River water (CRW) conveyed in a separate pipeline is considered to have poor feasibility in relation to the other supply options.

Transfers: Northern and Central California.

Northern and Central California were assumed to provide a maximum of 150,000 af/yr of transfer supply, based upon recent and reasonably expected transfer activity in the region. Wheeled transfers of 500,000 af were evaluated in terms of this amount coming via the California Aqueduct, thereby reducing the requirement for CRW below what IID identified as the maximum conservable amount. This lessens the uncertainties related to water availability, regulatory approval, public acceptance, and available CRA capacity.

The term of a transfer from Northern California matching the 75-125 year term of the IID-Authority proposal is not considered likely. Current transfers have been one-time only or dry-year occurrences. However, within current market conditions and the existing legal framework, it is feasible that a term encompassing this 20-year planning period could be arranged for these quantities with multiple parties.

Transfers from SWP contractors would require water agency approval and SWRCB approval. CVP transfers may require fewer approvals and in some quantities could be arranged directly with the farmer. However, to achieve major long-term transfers, it must be assumed that SWRCB approval would be required and third-party impacts mitigated, because it is not known whether this would be conserved water. Public acceptance of large-scale transfers from the Central Valley has been an issue of concern in those areas and would need to be addressed prior to implementing such a program. This is balanced to some extent by market forces which are generating a lot of interest in the agricultural community to pursue these arrangements.

Water rights are more varied on the Sacramento and San Joaquin Rivers, but could be assumed to be firm enough to ensure delivery if an agreement were entered into and approved by the SWRCB. Transportation is considered feasible since there is excess capacity in the California Aqueduct and DWR has a wheeling policy in place. Development of a wheeling policy by MWD may enable a non-SWP contractor to wheel at the same cost as a SWP contractor, thereby reducing the cost, although at this point MWD has yet to adopt a wheeling policy. A major issue in evaluating the feasibility of Northern California transfers is limitations on exports through the Delta. As stated previously, if this large-scale transfer is from north of the Delta, uncertainties surrounding the allowable exports and reliance on a Delta fix would be applicable. If most or all of the transfer water came from south of the Delta, this would not affect the feasibility of the transfer. Northern California transfers were rated as having fair feasibility.

Overall Evaluation.

Table 7-14 provides a listing of the quantities of water in each rating category based on the qualitative evaluation conducted in **Table 7-13** for both normal-year demand and dry-year demand scenarios. **Table 7-15** provides a qualitative rating of feasibility for each alternative.

7.3.3 Criterion: Maximize Water Quality

Definition of Criterion: This criterion measures the overall quality of water delivered by the Authority to its member agencies. The evaluation favors water low in salinity, or TDS, and low in trihalomethane (THM) precursors, which form potentially harmful compounds when combined with chlorine-based disinfectants.

Analysis and Results.

Water quality characteristics vary between the regions of origin of the Authority's major potential supply sources. Water from Northern and Central California, including the SWP and

TABLE 7-14
Quantities of Water Rated by Feasibility
Year 2015 (AF)

	Existing Strtgy	Max Local	Max Local w/Trans	Intermed Transfr	Max Transfr	CR Facility
NORMAL YEAR						
Good	361,884	340,250	477,407	494,065	368,398	398,820
Fair	423,385	446,750	309,593	292,935	418,602	153,180
Poor	1,731	-	-	-	-	235,000
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	346,809	327,516	472,241	486,783	486,783	404,690
Fair	402,668	445,153	349,191	324,175	353,217	200,310
Poor	90,523	67,331	18,568	29,042	-	235,000
Total Supply	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Based on revised 2015 demands on MWD.
Assumes Authority receives proportional share of available MWD water.

transfers, are generally low in TDS, but high in the organic compounds that are precursors to THMs and other potentially-harmful disinfection by-products. Colorado River supplies are generally high in TDS, but low in THM precursors. Local supplies are highly variable in water quality, ranging from the relatively pure supplies that would be produced from a seawater desalination or water repurification facility, to recycled water supplies that are limited to non-potable usage because of water quality considerations. **Table 7-16** provides a qualitative evaluation of water quality for each source of supply.

For some alternatives, potential water quality problems are mitigated by proposed treatment processes. For example, the Colorado River Facilities Alternative draws water from the All American Canal (AAC), which has salinity exceeding in excess of 800 milligrams per liter (mg/L). This alternative includes reverse osmosis (RO) treatment to reduce the finished water to a TDS of about 500 mg/L. Likewise, future supplies from the Bay-Delta may be treated using ozonation, reducing THM water quality considerations. The salinity of water supplied by MWD is contingent on the blending ratio of SWP water and CRW. Under its enabling act, MWD is obligated to provide its member agencies a 50-50 blend of SWP water and CRW to the extent reasonable and practical. To the extent that blend is not reached, salinity of MWD water would exceed that of the partially-demineralized water in the Colorado River Facilities Alternative and may also require ozonation to reduce THM formation potential.

Table 7-17 provides a listing of the quantities of water that would have good, fair, or poor ratings for water quality based on the ratings given in **Table 7-16**. This is done for both normal and dry years.

Because the Authority's imported water supply is a blend of CRW, with its higher TDS, and SWP water which is higher in THM precursors, the effort to blend the two sources to reduce one constituent can result in an increase in the other constituent. The six resource mixes under consideration provide for various blends of these imported water supplies. The increased use of Colorado River transfers increases salinity while reducing the organic precursors to THMs contributed by SWP supplies. Conversely, the Existing Strategy and Maximum Local Supply rely exclusively on MWD blended supplies which will reduce salinity but increase THM precursors.

In San Diego County, the high TDS levels in the water supply results in increased costs to consumers and a decrease in project yield from water recycling projects. A 1988 report titled *Estimated Economic Impacts of Salinity of the Colorado River*, prepared for the Bureau, estimated the annual damages to households receiving municipal and industrial water containing high proportions of CRW. The damage estimates range from $87 to $146 (escalated to 1996 dollars). These were derived from baseline salinity levels of 500 mg/L TDS and 344 mg/L TDS, respectively. Extrapolated to the 890,000 households in the Authority's service area, this "damage" is between $78 million and $130 million a year.

The development of recycled water sources is an important element in securing a reliable supply of water for San Diego County. High TDS levels in the imported supply can jeopardize utilization of recycled water due to marketability constraints. With imported supplies in San Diego County at close to 700 mg/L TDS and 300 mg/L to 600 mg/L TDS added through normal indoor water use, the recycled water produced in the Authority's service area is between 1,000 mg/L and 1,300 mg/L TDS.

TABLE 7-15
Water Resources Plan 1997 Update
Comparative Evaluation of Feasibility

CRITERION	Existing Stategy	Max Local	Max Local w/Trans	Intermed Transfr[1]	Max Transfr	CR Facility
Feasibility						
Public Acceptance	Fair	Fair	Good	Good	Fair	Fair
Institutional Acceptance	Fair	Fair	Fair	Fair	Fair	Poor
Regulatory Approval	Fair	Fair	Good	Good	Fair	Poor
Engineering/ Construction	Fair	Fair	Good	Good	Good	Fair
3rd Party Economic Impacts	Fair	Fair	Fair	Fair	Fair	Poor
Compatibility W/Existing Facilities	Good	Good	Good	Good	Good	Fair
Water Rights	Poor	Poor	Fair	Fair	Good	Good
Legal Aspects	Good	Good	Fair	Fair	Fair	Poor
RATING	◍ (Fair)	◍ (Fair)	● (Good)	● (Good)	◍ (Fair)	○ (Poor)

● Good ◍ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.

TABLE 7-16
Water Quality MWD Service Area Supplies[1]

SUPPLY	AMT / AF	QUAL	COMMENTS
IMPORTED SUPPLIES			
State Water Project - Historic Firm Supplies	400,000	Fair	THMs mitigated by treatment.
State Water Project - IRP Firm Supplies	250,000	Fair	THMs mitigated by treatment.
State Water Project - Interim Delta Fix	150,000	Fair	THMs mitigated by treatment.
State Water Project - Full Delta Fix	550,000	Fair	THMs mitigated by treatment.
Colorado River - Firm Supplies	626,000	Fair	Relatively high salinity.
Colorado River - Surplus Supplies	574,000	Fair	Relatively high salinity.
Storage Agreements/Transfers[2]	460,000	Fair	Mostly Northern California sources with THMs.
Total Imported Supplies	**3,010,000**		
LOCAL SUPPLIES			
Existing Local Projects - Current Production	148,000	Fair	Uses of recycled water for irrigation and groundwater recharge.
Existing Local Projects - Increased Production	98,000	Fair	Uses of recycled water for irrigation and groundwater recharge.
Future Local Projects	208,000	Fair	Uses of recycled water for irrigation and groundwater recharge.
Existing Groundwater Storage	100,000	Fair	Groundwater basin provides good organics removal, TDS varies.
Future Groundwater Storage	230,000	Fair	Groundwater basin provides good organics removal, TDS varies.
Existing Firm Groundwater and Surface Water	1,430,000	Good	Low THM precursors. Salinity generally good.
Total Local Supplies	**2,214,000**		
Total Imported and Local	**5,224,000**		
	Authority Service Area Supplies		
Transfers Wheeled, 0 - 200,000 af	0 to 200,000	Fair	Same quality as existing Colorado River supplies.
Transfers Wheeled, 200,001 - 500,000 af	200,001 to 500,000	Fair	Same quality as existing Colorado River supplies.
Colorado River Conveyance Pipeline	200,000 to 500,000	Good	Demineralization treatment would reduce salinity.
Existing Firm Surface Water Supplies[1]	25,000	Fair	Low Salinity. Higher potential for THMs.
Existing Normal-Year Surface Water Supplies[1]	35,000	Fair	Low Salinity. Higher potential for THMs.
Existing Reclamation and Groundwater[1]	20,000	Poor	Limited uses for recycled water.
Future Reclamation and Groundwater	85,000	Fair	Limited uses for recycled water; repurified water is high quality.
Seawater Desalination	20,000	Good	Product water is very high quality.
Total Authority Supplies	**685,000**		

1 Source of data: MWD draft Integrated Resources Plan (December 1995). MWD' s 2020 service area supplies are dry year and exclude Authority local supplies.
2 In a normal year, this source would be replaced by SWP supplies.

Certain crops and ornamental vegetation cannot be irrigated with high TDS waters. Avocados and citrus, significant crops in San Diego County, produce best with water containing TDS concentrations of less than 555 mg/l and 768 mg/l respectively.

MWD currently has an interim policy to lower TDS levels by providing a 25 percent blend for the April through September period in the Weymouth, Diemer and Skinner service areas. This strategy was adopted in response to marketing problems encountered by reclamation projects in the Authority's service area. MWD has stated that variations of this strategy will be employed until demands reach sufficient levels and the Eastside Reservoir is operational. This is expected to occur in approximately 10 years. At that time, the impacts of high-TDS concentrations will cease as sufficient State Project water will need to be imported to meet demands, providing blended supplies in the process.

Additional SWP water deliveries to the Authority can reduce salinity but would require ozone retrofit once the blend of SWP water at Lake Skinner reaches 35 percent. This could be accomplished at both the MWD's Skinner Treatment Plant and locally by those Authority member agencies operating treatment plants. Because of the existing levels of THM precursors in local surface waters, the Authority's member agencies with treatment facilities could also be required to construct ozonation facilities in order to comply with Stage 1 of the Disinfection/Bisinfection By-Products (D/DBP) Rule regardless of the blend of SWP supplies.

As stated above, a water quality goal of 500 mg/L was set for the transfer water delivered to member agencies in the Colorado River Facilities Alternative. This reduction in salinity was achieved through advanced treatment by RO. Reaching 500 mg/L would bring those supplies into compliance with secondary drinking water standards, which are aesthetic rather than public health standards. In an effort

TABLE 7-17
Quantities of Water Rated by Water Quality
Year 2015 (AF)

	Existing Strtgy	Max Local	Max. Local w/Trans	Intermed Transfr	Max Transfr	CR Facility
NORMAL YEAR						
Good	-	35,000	15,000	-	-	435,000
Fair	787,000	752,000	772,000	787,000	787,000	352,000
Poor	-	-	-	-	-	-
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	-	35,000	15,000	-	-	435,000
Fair	840,000	805,000	825,000	840,000	840,000	405,000
Poor	-	-	-	-	-	-
Total Supply	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Based on revised 2015 demands on MWD. Assumes Authority receives proportional share of available MWD water.

TABLE 7-18
Water Quality Comparative Cost Analysis Assumptions[1]

	Capital Cost[2]	O&M[3]	Requirement
Ozone	$12/af	$4/af	SWP blend consistently exceeds 35 percent of total imported supplies
Reverse Osmosis	$87/af	$220	TDS exceeds 500 mg/L from all imported sources combined.

1 All costs are in 1996 dollars.
2 Capital Costs are amortized for 30 years at 6.5 percent.
3 Non-power O&M is inflated at 3 percent annually.

to analyze imported water quality on an equal basis for each of the various resource mixes, a salinity goal of 500 mg/L was set and compliance with Stage 1 of the D/DBP Rule was assumed.

For comparison purposes, this analysis assumed that a 50-50 blend was provided by MWD shortly after 2010, increasing incrementally as system demands on MWD increase. In this analysis, Authority transfer supplies wheeled through MWD's distribution system are assumed to be blended with MWD supplies at Lake Skinner. In this manner a percentage blend of total CRW supplies and Northern/Central California supplies (SWP and transfer water) obtained from both MWD and transfer sources can be determined. These blend ratios are then used to determine the need for salinity reduction and ozone retrofit.

Salinity levels for each resource mix are based on the blended salinity of all sources of imported water, both MWD and water transfers, for that alternative. Salinity reduction is required to reduce TDS for the entire imported water supply to 500 mg/L. The treatment process used to meet that TDS goal is RO. Reverse osmosis treatment varies in each alternative based on the amount of salt removal required to reach the 500 mg/L TDS goal. In this case, those blends with higher TDS require more salt removal and thus incur higher costs for the resource mix as a whole. Cost estimates for RO are based on projects treating water with equivalent TDS levels as those experienced in the resource mixes under consideration.

The need for ozone retrofit is based upon information obtained from MWD indicating that ozone disinfection would be required when the total blend of Northern/Central California supplies exceeds 35 percent. Cost estimates for ozone treatment are based on MWD's current estimates to retrofit the Skinner Treatment Plant. The cost for ozonation for each individual resource mix reflects only treated water deliveries to the Authority. Untreated water would require disinfection with ozone at member agency treatment plants because of local water quality concerns and thus is considered to be the same cost for all alternative resource mixes.

Both salinity reduction and ozonation are assumed to begin no earlier than 2003. **Table 7-18** provides a summary of the key assumptions.

From the results in **Table 7-19** it can be concluded that the blend of SWP water to Colorado River water can be adjusted through the use of transfers so as to avoid exceeding the 35 percent limit and thereby postpone the need for ozonation at the Skinner Treatment Plant. However, the cost of ozonation, even when treating the entire flow is less than the cost of salinity reduction through treatment of a portion of the flow with RO. The use of RO is required in all resource mixes to achieve the water quality goal of 500 mg/L TDS. At a minimum of 525 mg/L, the Existing Strategy and Maximum Local Supply Alternatives provide the lowest TDS prior to RO. Both the Intermediate Transfers and the Maximum Transfers Alternative with Northern/Central California transfer water rarely exceed 600 mg/L prior to RO treatment. **Figures 7-8** and **7-9** chart the blended TDS level and ratio of SWP water of the six resource mixes.

In recent discussions with the California Department of Health Services (DHS), it was stated to the Authority that in recognition of the existing nature of Colorado River salinity and the lack of concern from a public health and safety standpoint, the achievement of 500 mg/L TDS was not considered a priority. Concerns over public health occur when salinity exceeds 1000 mg/L. It may be necessary to determine whether the cost of reaching a specific goal of 500 mg/L TDS may outweigh the economic benefits realized.

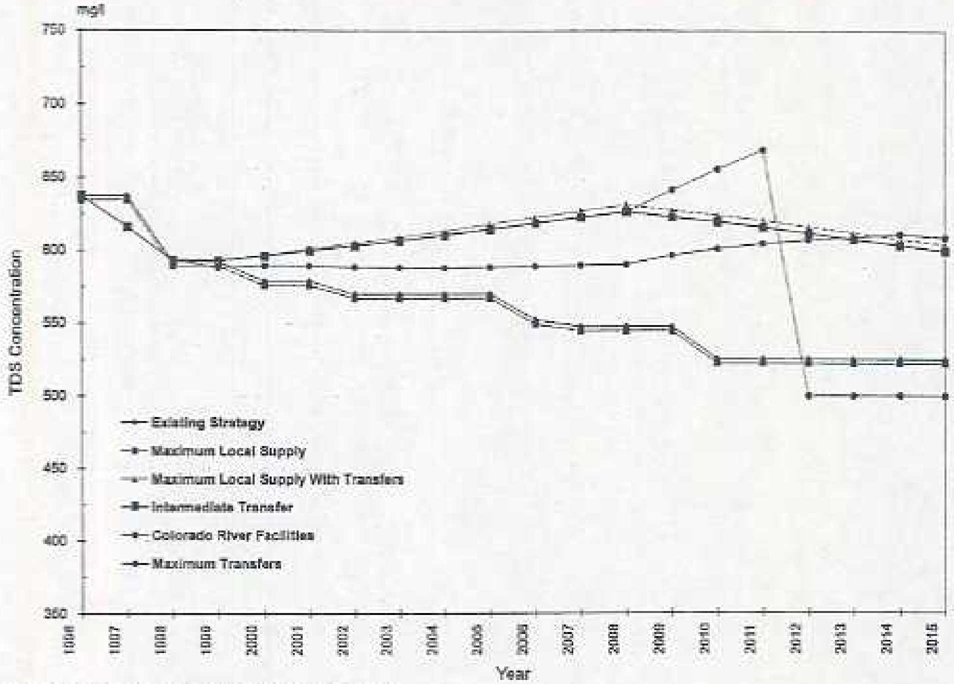
Table 7-20 provides an evaluation of water quality for the six alternatives based on the qualitative and quantitative analyses performed in this section. The Existing Strategy, Maximum Local Supply, and Maximum Transfers Alternatives ranked highest in overall water quality, with the lowest TDS or THM impacts at the lowest cost on water delivered by the Authority to its member agencies. All other alternatives received a fair rating, because each has higher blended salinity thus requiring more costly treatment. Because of the higher salinity of CRW taken in the AAC, as envisioned in the Colorado River Facilities Alternative, treatment of larger quantities of water is required resulting in higher desalination costs for that resource mix. This additional cost has been reflected in the evaluation of the Colorado River Facilities Alternative in the Total Cost and Rate Impact criteria. A water quality benefit of that mix is the overall reduction in organic precursors of

TABLE 7-19
TDS and THMs Comparable Cost Analysis[1]

Resource Alternative	Salinity Reduction[2] ($/AF)	Ozone Treatment[3] ($/AF)	Total Added Treatment ($/AF)
Existing Strategy	$26	$6	$32
Maximum Local Supply	$26	$6	$32
Maximum Local Supply w/ Transfers		-	
100 percent CRA	$43	-	$43
Intermediate Transfers			-
100 percent CRA	$43	-	$43
Maximum Transfers[4]	$22	-	$22
Maximum Transfers	-	-	-
100 percent CRA	$52	-	$52
Colorado River Facilities	$80	-	$80

1 All costs are a net present value in 1996 dollars.
2 Brine costs are based on Black & Veatch Feasibility Level Engineering Study, Sept. 1996, on transferring water from IID.
3 Source is MWD Technical Information Document on Water Quality Issues, Nov. 25, 1996.
4 Assumes 30 percent of transfer water from Northern California sources.
5 RO costs based on Black & Veatch study, Sept. 1996; and Water Repurification Feasibility Study, Montgomery Watson, July 1994.

FIGURE 7-8
Projected TDS Levels Prior to Reverse Osmosis[1]



[1] Colorado River Facilities Project includes RO.

FIGURE 7-9
Percentage of SWP Supplies

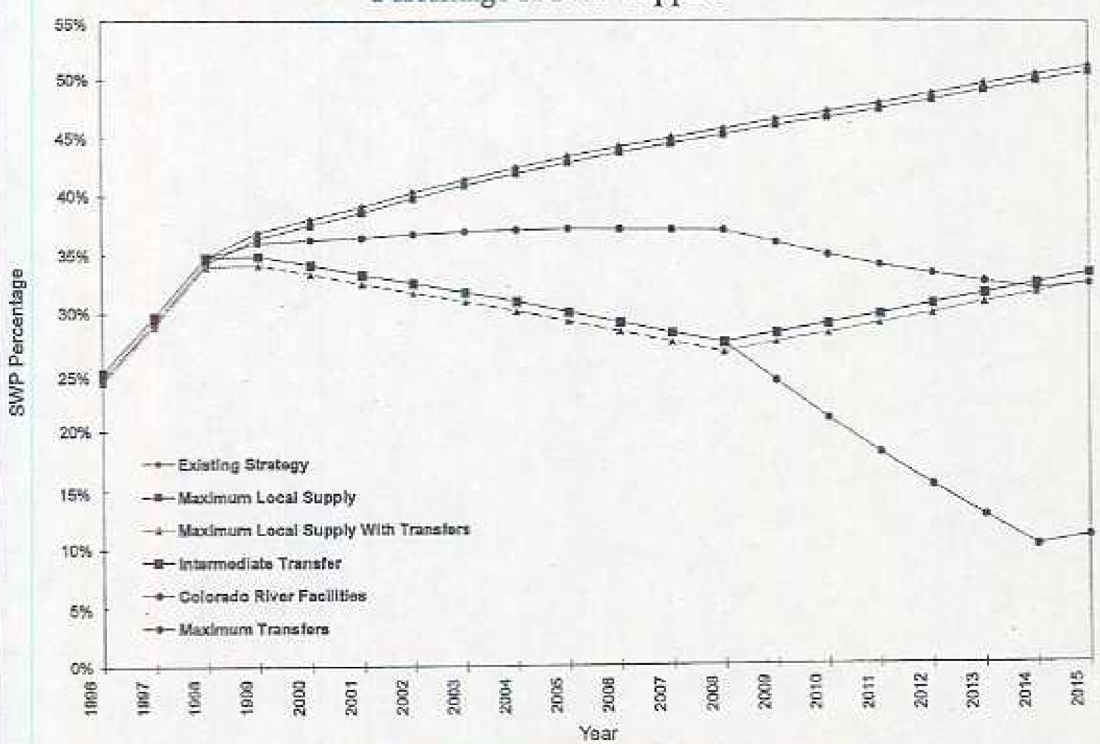


TABLE 7-20
Water Resources Plan 1997 Update
Comparative Evaluation of Water Quality

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
Water Quality TDS/THMs	Good	Good	Fair	Fair	Good	Poor
RATING	●	●	▨	▨	●	○

● Good ▨ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.

THMs. This mix results in the lowest THMs in the finished water which partially offsets the higher costs. Because of the higher treatment cost, however, the Colorado River Facilities Alternative was rated poor in the combined qualitative and quantitative evaluation of water quality.

7.3.4 Criterion: Maximize Degree of Authority Control Over Resources

Definition of Criterion: This criterion measures the degree of control that the Authority exerts over its water resources, both imported and local supplies. Authority control increases the confidence of resources development and availability.

Analysis and Results.

The degree of Authority control over water resources was measured by proximity of a resource to the Authority's "sphere of influence." **Table 7-21** provides an evaluation of regional supplies for Authority control over the resource.

The highest degree of control exists at the local level, where decision-making can occur at the Authority to promote development of local supply projects, conservation programs, or transfers. This can occur either directly, such as the construction of an Authority owned and operated desalination plant, or indirectly, by the provision of technical and financial assistance to Authority member agencies to develop a reclamation or groundwater project. A long-term transfer agreement between the Authority and another party is assumed to have a high degree of Authority control.

The next highest level of control exists over resources developed directly or indirectly by MWD. The Authority, as a member agency of MWD, exerts influence over MWD's direct decisions to pursue water supplies and demand management programs in its service area. This includes funding levels for local projects and programs that affect not only the development of water supplies, but how they are allocated in a dry year or drought. The Authority also has indirect influence in decisions affecting MWD imported supplies on the SWP and Colorado River, based upon MWD's contractor status on the SWP and allocation from the river. The Authority has a representative on California's Colorado River Board.

The Authority exerts the least control over resource decisions made by state or federal governments or other MWD member agencies. Examples include the annual amount and schedule of water exports from the Bay-Delta, declarations of surplus conditions on the

Colorado River, or annual supply availability from the SWP. The decision on whether to actually construct a local project outside the Authority's service area is considered to be beyond the Authority's control.

Table 7-22 shows the amounts of water by criterion rating in each of the alternatives. The most water directly under the control of the Authority was in the two alternatives that relied upon large-scale water transfer agreements. Because these are negotiated directly with another party, long-term transfers are considered to offer the best degree of Authority control and certainty for imported water supplies. Alternatives with lesser amounts of transfer supplies were rated "fair," while the Existing Strategy Alternative and Maximum Local Supply Alternative were rated "poor," because they relied heavily upon water from MWD, for which the Authority has less control. **Table 7-23** shows how the alternatives ranked overall for the criterion.

7.3.5 Criterion: Minimize Negative Environmental Impacts

Definition of Criterion: This criterion measures the impacts that developing the alternatives would have on the natural environment. The highest-rated alternative is that which minimizes the damaging, harmful, or otherwise negative impacts of supply development. Environmental harm can result locally, from local water development projects, as well as from activities from out of the region, including impacts to the Bay-Delta, Colorado River Basin, or Salton Sea. Consideration is also made for maximizing beneficial aspects of environmental impacts, such as efficiency of water use achieved through conservation and water recycling.

Analysis and Results.

Environmental impacts on local and non-local supplies were evaluated separately. **Table 7-24** provides a summary of environmental impacts expected to be associated with each component of supply.

All supply components were rated "fair" for local construction impacts, with the exception of a seawater desalination plant and Authority Colorado River facilities, which were rated "poor." Seawater desalination was downgraded because it would result in an escalation of construction of major desalination facilities located along the coast. Colorado River facilities were considered to be poor in local impacts because of the need to construct a separate waste discharge pipeline from demineralization facilities located north of Interstate 8 to the new South Bay outfall. This pipeline is required to dispose of the concentrated salts removed in the demineralization process that reduces the higher salinity of CRW from the AAC. Both of these alternatives have intensive energy requirements which would require consideration in an evaluation of potential environmental impacts. The remaining alternatives could be achieved without a significant increase in the level of construction activity.

All components of supply were rated fair for non-local environmental impacts, except a new Colorado River pipeline, which was rated poor. The primary reasons for this rating include construction activities associated with the pipeline and potential impacts that conservation and the transfer of 500,000 af/yr from the Salton Sea watershed may have on water quality in the Salton Sea. The latter also applies to any arrangement to wheel 500,000 af of transfer water through the CRA.

Impacts to the Bay-Delta region are expected to improve from current conditions as a result of the Cal-Fed Process. It was assumed that the negative impacts of a partial or full Delta fix, including constructing a Delta conveyance facility, would be offset by improvements in water quality and ecosystem management. Environmental considerations on the Colorado River Basin were considered nominal. The fact that much of the river has been designated as critical habitat is expected to have more of an impact upon reservoir and hydropower operations than

TABLE 7-21
Degree of Authority Control Over Resources
MWD Service Area Supplies

SUPPLY	AMT / AF	CONTROL	COMMENTS
IMPORTED SUPPLIES			
State Water Project - Historic Firm Supplies	400,000	Fair	Indirect control as MWD member agency.
State Water Project - IRP Firm Supplies	250,000	Fair	Indirect control as MWD member agency.
State Water Project - Interim Delta Fix	150,000	Poor	Cal-Fed Process involves number of other agencies and interests.
State Water Project - Full Delta Fix	550,000	Poor	Cal-Fed Process involves number of other agencies and interests.
Colorado River - Firm Supplies	626,000	Fair	Indirect control as MWD member agency. Member of CR Board.
Colorado River - Surplus Supplies	574,000	Poor	Dependent upon federal government decisions.
Storage Agreements/Transfers[2]	460,000	Fair	Indirect control as MWD member agency.
Total Imported Supplies	3,010,000		
LOCAL SUPPLIES			
Existing Local Projects - Current Production	148,000	Poor	Dependent upon other MWD member agencies.
Existing Local Projects - Increased Production	98,000	Poor	Dependent upon other MWD member agencies.
Future Local Projects	208,000	Poor	Dependent upon other MWD member agencies.
Existing Groundwater Storage	100,000	Poor	Dependent upon other MWD member agencies.
Future Groundwater Storage	230,000	Poor	Dependent upon other MWD member agencies.
Existing Firm Groundwater and Surface Water	1,430,000	Poor	Dependent upon other MWD member agencies.
Total Local Supplies	**2,214,000**		
Total Imported and Local	**5,224,000**		

Authority Service Area Supplies

SUPPLY	AMT / AF	CONTROL	COMMENTS
Transfers Wheeled, 0 - 200,000 af	0 to 200,000	Good	Would control through direct contract.
Transfers Wheeled, 200,001 - 500,000 af	200,001 to 500,000	Good	Would control large percent of supply through contract.
Colorado River Conveyance Pipeline	300,000 to 500,000	Good	Would control supply through contract & facilities.
Existing Firm Surface Water Supplies1	25,000	Good	Supply is in local region.
Existing Normal-Year Surface Water Supplies[1]	35,000	Good	Supply is in local region.
Existing Reclamation and Groundwater[1]	20,000	Good	Supply is in local region.
Future Reclamation and Groundwater	85,000	Good	Can construct project or promote through member agencies.
Seawater Desalination	20,000	Good	Would likely be Authority owned and operated.
Total CWA Supplies	**685,000**		

1 Source of data: MWD draft Integrated Resources Plan (December 1995). MWD 2020 service area supplies are dry year and exclude Authority local supplies.
2 In a normal year, this source would be replaced by SWP supplies.

TABLE 7-22
Quantities of Water Rated by Degree of Authority Control Year 2015 (AF)

	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
NORMAL YEAR						
Good	116,000	184,000	364,000	320,000	620,000	557,000
Fair	476,950	440,346	334,014	362,200	149,570	201,044
Poor	194,050	162,654	88,986	104,800	17,430	28,956
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	116,000	184,000	364,000	320,000	620,000	557,000
Fair	451,444	419,284	325,829	349,878	167,501	209,674
Poor	272,556	236,716	150,171	170,122	52,499	73,326
Total Supply	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Based on revised 2015 demands on MWD. Assumes Authority receives proportional share of available MWD water.

deliveries of water, at least for this 20-year planning horizon.

Table 7-25 shows the quantities of water for each alternative by rating category.

The analysis provided in **Table 7-25** indicates that the alternative yielding the greatest quantity of water with the least environmental impact is the Existing Strategy Alternative.

The Maximum Local Supply With Transfers and the Intermediate Transfers Alternatives are relatively equal to the Existing Strategy Alternative in terms of water rated as good and fair in potential environmental impacts. The Maximum Local Supply With Transfers Alternative may have slightly more environmental issues to consider because of the addi-

TABLE 7-23
Water Resources Plan 1997 Update
Comparative Evaluation of Degree of Authority Control

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf[1]	CR Facility
Degree of Authority Control	Poor	Poor	Fair	Fair	Good	Good
RATING	○	○	◍	◍	●	●

● Good ◍ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.

tional construction of local projects when compared with the other two resource mixes. The Colorado River Facilities Alternative has the highest amount of water considered to be poor in relation to potential environmental impacts. Because all of the alternatives have most of their water rated as environmentally fair, the only distinguishing characteristic is the amount of water rated as poor.

Table 7-26 provides a qualitative evaluation for each of the alternatives.

7.3.6 Dry Year Analysis

Thus far, this Water Resources Plan has considered transfers only as long-term core supplies, to be used during normal weather years. This is a departure from the 1993 Water Resources Plan, which considered transfers only as dry-year supplies, used only to offset shortages in normal-year supplies. To determine other possible resource strategies that the Authority may consider, an evaluation of the use of option transfers as part of the Existing Strategy Alternative was conducted. This strategy is consistent with the approach adopted in the 1993 Water Resources Plan to increase reliability and Authority control in dry years. The analysis was conducted to determine whether a dry-year option strategy would be as reliable as the alternatives using core transfers.

To be considered highly reliable, dry-year transfers must be free from Delta export restrictions and originate either south of the Delta or from the Colorado River, or have superior water rights equivalent to these two sources. As discussed in Chapter 5, option transfers provide a contractual means to guarantee delivery of water during a certain number of years in exchange for annual payments. Although potentially less expensive than option agreements, spot transfers or dependence on the State Water Bank are considered to be less reliable and provide less Authority control over the resource. This is because of the uncertainty that transfer water in the large quantities anticipated would be available on a spot basis, and because spot market and State Water Bank supplies are not committed to the Authority before they are needed.

A hydrological data review was conducted to determine how often the Authority might require dry year transfers during the 20 year planning period of the Water Resources Plan. The review incorporated 90 years of hydrology for the Sacramento and Colorado River basin watersheds, as well as data from MWD's computerized hydrologic simulation model, IRPSIM. This model uses 70 years of hydrology to estimate supplies from local and imported sources and balances those supplies with projected demand.

The amount of shortage estimated from IRPSIM ranges from a low of 2,000 af at approximately the 20th percentile to a 1 percent probability of an 800,000 af shortage or a 200,000 af shortage to the Authority under the Existing Strategy Alternative. The median shortage during these seven years is approximately 100,000 af. For purposes of this analysis, a dry-year transfer amount of 200,000 af was selected to account for the worst-case hydrology scenario and for less severe hydrologies in which the IRP is not fully implemented, such as unavailability of surplus Colorado River water. Although seven critically dry years were identified in the simulated hydrologies, use of storage locally and on the SWP helps mitigate the need for transfers in some of those critically dry years. A maximum dry year transfer requirement of five years out of twenty was assumed.

Cost Assumptions.

To date, no long-term option transfer agreements have been finalized. Any option agreement will require payment in years when water is not actually transferred. In this analysis a goal was set of high reliability option transfers costing no more than $150/af on a present worth basis for the term of the agreement. The low range acquisition price is equivalent to that used in the alternative mixes with

TABLE 7-24

Minimize Negative Environmental Impacts MWD Service Area Supplies[1]

SUPPLY	AMT / AF	CONTROL	COMMENTS
IMPORTED SUPPLIES			
State Water Project - Historic Firm Supplies	400,000	Good	Uses existing facilities. Does not impact water quality or fish.
State Water Project - IRP Firm Supplies	250,000	Good	Uses existing facilities. Does not impact water quality or fish.
State Water Project - Interim Delta Fix	150,000	Fair	Moderate construction impacts.
State Water Project - Full Delta Fix	550,000	Fair	Construction impacts offset by water quality, management improvements.
Colorado River - Firm Supplies	626,000	Fair	Potential impacts from hydroelectric operations.
Colorado River - Surplus Supplies	574,000	Fair	Potential impacts from hydroelectric operations.
Storage Agreements/Transfers[2]	460,000	Fair	Potential Bay-Delta impacts if north of Delta transfers.
Total Imported Supplies	**3,010,000**		
LOCAL SUPPLIES			
Existing Local Projects - Current Production	148,000	Good	Uses existing facilities.
Existing Local Projects - Increased Production	98,000	Fair	Moderate construction impacts.
Future Local Projects	208,000	Fair	Moderate construction impacts.
Existing Groundwater Storage	100,000	Good	Uses existing facilities.
Future Groundwater Storage	230,000	Fair	Moderate construction impacts.
Existing Firm Groundwater and Surface Water	1,430,000	Fair	Moderate construction impacts.
Total Local Supplies	**2,214,000**		
Total Imported and Local	**5,224,000**		

Authority Service Area Supplies

SUPPLY	AMT / AF	CONTROL	COMMENTS
Transfers Wheeled, 0 - 200,000 af	0 to 200,000	Fair	Uses existing facilities. Same as Colorado River impacts.
Transfers Wheeled, 200,001 - 500,000 af	200,001 to 500,000	Fair	Uses existing facilities. Potential impact to Salton Sea or increase in Delta exports.
Colorado River Conveyance Pipeline	200,001 to 500,000	Poor	Potentially significant local & non-local construction, water quality, and energy impacts.
Existing Firm Surface Water Supplies[1]	25,000	Good	No additional impacts.
Existing Normal-Year Surface Water Supplies[1]	35,000	Good	No additional impacts.
Existing Reclamation and Groundwater[1]	20,000	Good	No additional impacts.
Future Reclamation and Groundwater	85,000	Fair	Moderate local construction impacts.
Seawater Desalination	20,000	Poor	Potentially significant construction and energy impacts.
Total CWA Supplies	**685,000**		

1 Source of data: MWD draft Integrated Resources Plan (December 1995). MWD 2020 service area supplies are dry year and exclude Authority local supplies.

2 In a normal year, this source would be replaced by SWP supplies.

TABLE 7-25
Quantities of Water Rated by Negative Environmental Impacts Year 2015 (AF)

	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf	Max Transf	CR Facility
NORMAL YEAR						
Good	189,896	181,462	156,962	163,456	114,463	126,324
Fair	597,104	585,538	630,038	623,544	672,537	425,676
Poor	-	20,000	-	-	-	235,000
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	184,019	176,497	154,948	160,617	118,595	128,612
Fair	655,981	643,503	685,052	679,383	721,405	476,388
Poor	-	20,000	-	-	-	235,000
Total Supply -	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Based on revised 2015 demands on MWD. Assumes Authority receives proportional share of available MWD water.

TABLE 7-26
Water Resources Plan 1997 Update
Comparative Evaluation of Environmental Impacts

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf[1]	Max CR Transf	Facility
Environmental Local CIP Construction Impacts	Fair	Poor	Fair	Fair	Fair	Poor
Non-Local Areas Impacts	Fair	Fair	Fair	Fair	Fair	Poor
RATING	◍	◍	◍	◍	◍	○

● Good ◍ Fair ○ Poor

[1] Water is transferred from Northern/Central California and/or Colorado River.

core transfers. It was also assumed that most of these options would come from Northern California sources and be transported through the SWP system. The wheeling charge was considered to be the incremental cost of power and O&M to transport water through the system. **Table 7-27** summarizes the assumptions for the Dry-Year Options analysis.

Evaluation of Existing Strategy Alternative with Dry Year Option Transfers.

Inclusion of a dry-year transfer component within the Existing Strategy Alternative results in an improvement in dry-year reliability under full or partial implementation of the IRP. Dry weather results in an increase in overall water demand of approximately 7 percent. Dry-year transfers of a maximum of 200,000 af would be in excess of the increase in demand attributable solely to dry weather. This causes MWD purchases in the years that transfers occurred to be significantly reduced compared to what was envisioned under the Existing Strategy Alternative. This results in a credit given to the Dry-Year alternative. In evaluating this modified mix for the total cost criterion, staff concluded that the net total cost of the Existing Strategy Alternative would increase $36 million to $70 million in 1996 dollars.

For comparison purposes, a dry-year analysis was conducted of the total cost of the Intermediate Transfer Alternative, which includes 200,000 af of core transfers. In this scenario, it was assumed that increases in demand during dry weather were met through increased purchases of MWD supplies. The revised evaluation in the total cost criterion is provided in **Table 7-28**.

The results following indicate that the additional cost to improve the reliability of the Existing Strategy mix through the use of dry-year transfers remains good in comparison to a dry-year scenario for the Intermediate Transfers Alternative.

In estimating the potential for rate increases, the estimated total cost of the option agreement is spread evenly over the term of an 18 year contract to avoid rate spikes in those years when water is actually transferred. The result is a nominal change in the 2015 rate under both the high and low scenarios that is not significant enough to affect its current ranking of good in the rate impact criterion.

Qualitative Criteria.

The inclusion of dry-year transfers in the Existing Strategy Resources mix improves the dry-year reliability, feasibility and control of this alternative to the point where it is equivalent with the mixes incorporating normal-year core transfers. Reliability is improved through a contractual obligation to deliver transfer water during anticipated periods of severe drought in quantities sufficient to avoid cutbacks. **Table 7-29** provides the revised quantities of water, rated for reliability, when dry-year transfers are included in the Existing Strategy Alternative.

Authority control over its resources in a dry-year, which is of critical importance, is improved through the direct contractual nature of the option agreement. Although control over the Authority's resources is improved, the amount of water rated as having good control is not equivalent to the alternatives with core transfers. Dry-year transfers also enhance the feasibility of the Existing Strategy mix in a dry-year by replacing supplies considered to be less feasible, i.e.; surplus Colorado River water, with higher feasibility supplies that could be relied on in times of drought. It is more likely that surplus Colorado River water will not be available in future normal years because operating limitations may prevent the Bureau from declaring a surplus on the River.

As discussed earlier in this chapter, a surplus was declared in 1996 and is likely to be repeated in 1997. The availability of surplus water in 1998 and beyond is uncertain and reliance on future declarations is discouraged.

Analysis by the CRB indicates that even with the MWD proposed changes in operating criteria, surplus supplies cannot be counted upon past 2010. Plans for the Colorado River, as reflected in remarks from Secretary Babbitt in December 1996, is to move towards California staying within its basic 4.4 maf entitlement. Thus the feasibility of year to year reliance on surplus water extends beyond hydrologic conditions that would be *mitigated* by dry-year option transfers. Anticipation of a constraint on the availability of surplus water during the planning period does not support a change in the feasibility rating for the Existing Strategy.

Effects of Dry Year Transfers on Normal Year Reliability.

Although equivalent with the core transfer alternatives during a dry-year, the dry-year option transfer strategy does not minimize the risk which may exist during normal years due to less than full implementation of the IRP. The IRP relies on surplus Colorado River water being available to maintain a full CRA in every year until 2020, and a full Delta fix and its resultant increase in SWP yield, occurring by 2010. MWD's ability to meet its member agencies demands would be severely impacted if these resources do not become available. This would be further compounded if local projects

TABLE 7-27
Dry Year Options Analysis Assumptions

Option Amount	Agreement Term	Frequency	Low Acquisition	High Acquisition	Wheeling O&M	Wheeling Power
1,000,000 af	18 yrs	5 out of 20 yrs	$125/af	$175/af	$70/af	$45/af
Maximum required by 2015	Payments spread evenly	(200,000 af Dry-Yr)	Infl. @ 3% annually	Infl. @ 4% annually	Infl. @ 3% annually	No infl.

TABLE 7-28
Water Resources Plan 1997 Update Comparative Evaluation of Total Cost

Criterion	Exist Strtgy Normal-Yr	Exist Strtgy w/Dry-Yr Transf	Intermediate Transfers Normal-Yr	Intermediate Transfers w/Dry-Yr MWD Purchases
Total Cost (billion)[1]	3.33-3.57	3.37-3.64	3.37-3.58	3.43-3.65
RATING	●	●	●	●

● Good ◍ Fair ○ Poor

[1] Expressed as net present value in 1996 dollars.

are not constructed as envisioned in the preferred IRP mix. To the extent that any of these goals is not fully realized, shortages could occur in normal years and not just be dependent on variations in hydrology.

Table 7-30 illustrates the potential range of normal-year shortages in two scenarios of less than full implementation of the IRP. The year 2010 was selected because it is the critical IRP year. In that year a full Delta fix is assumed to be completed and it is the last year of projections for continued surplus Colorado River water under the MWD proposed revised Colorado River operating criteria. The Low Risk scenario assumes a 15 percent shortfall in the IRP's local reclamation and groundwater goals, while MWD purchases 200,00 af of Colorado River transfer water to partially make up for the loss of surplus water (see sensitivity analysis on Page 7-10 and **Figure 7-5**). This scenario uses the high end of the average SWP deliveries in an above normal runoff year without a full Delta fix. The High Risk scenario assumes that only 50 percent of IRP local resource goals are achieved, MWD does not purchase Colorado River Transfers to offset the loss of surplus water, and SWP deliveries are at the average for a normal year without a full Delta fix.

From the above results, the risk of potential shortage to the Authority under these two normal weather year scenarios ranges from a low of 30,000 af to a high of 220,000 af. MWD could mitigate these shortages by calling in option transfers or withdrawing water from storage, but this would decrease reliability in dry years, when MWD was relying on those sources to make up weather-based shortages. The Authority could also call on dry year options under the Existing Strategy Alternative, but that would also reduce dry-year reliability. Spot transfers could be used, but the availability of

TABLE 7-29
Quantities of Water Rated by Reliability (Revised) Year 2015 (AF)

	Exist[1] Strtgy	Max Local	Max Local W/Transf	Intermed Transf[1]	Max Transf	CR Facility
NORMAL YEAR						
Good	362,884	410,250	527,407	499,065	523,398	638,820
Fair	422,385	376,750	259,593	287,935	263,602	148,180
Poor	1,731	-	-	-	-	-
Total Supply	787,000	787,000	787,000	787,000	787,000	787,000
Total Demand	787,000	787,000	787,000	787,000	787,000	787,000
DRY YEAR						
Good	489,051	397,516	522,241	491,783	533,996	644,690
Fair	320,918	375,153	299,191	319,175	306,004	195,310
Poor	30,032	67,331	18,568	29,042	-	-
Total Supply	840,000	840,000	840,000	840,000	840,000	840,000
Total Demand	840,000	840,000	840,000	840,000	840,000	840,000

NOTE: Based on revised 2015 demands on MWD. Assumes Authority receives proportional share of available MWD water.
[1] During a dry year, option transfers are used in lieu of MWD purchases

TABLE 7-30
Water Balance
Normal Year Less Than Full Implementation of IRP

Normal Year Risk Analysis Year 2010	Low Risk (MAF)	High Risk (MAF)
2010 MWD Demand	2.27	2.27
Unrealized Local Projects [1]	0.05	0.15
Adjusted MWD Demand	2.32	2.42
CRA w/o Surplus Water	0.82[2]	0.62
SWP w/ Delayed Full Fix	1.30	0.90
Water Balance	(0.20)	(0.90)
CWA Shortage	(0.05)	(0.22)

1 Results in an increase in MWD demand.
2 MWD Basic Entitlement plus IID 1 less Native American Rights water plus .2 maf in purchased transfers

those supplies would be less certain than core transfers. Storage within the Authority's service area is currently operated to maximize local yield in normal years and an additional drafting of local reservoirs may drop reservoirs below their minimum pools. Because of this potential risk in a normal year, the rating for the reliability criterion for the Existing Strategy Alternative remained fair.

7.4 OVERALL EVALUATION OF RESOURCE MIXES

Table 7-31 provides a summary of the individual analyses conducted for each of the selection criteria for all six alternatives. Based on these individual criteria, an overall evaluation was made.

TABLE 7-31
Water Resources Plan 1997 Update
Summary of Evaluation

CRITERION	Exist Strtgy	Max Local	Max Local W/Transf	Intermed Transf[1]	Max Transf	CR Facility
Degree of Authority Control RATING	Fair	Poor	Fair	Fair	Good	Good
Environmental RATING	Fair	Fair	Fair	Fair	Fair	Poor
Feasibility RATING	Fair	Fair	Good	Good	Fair	Poor
Rates RATING	Good	Fair	Good	Good	Good	Poor
Reliability RATING	Fair	Fair	Good	Good	Good	Good
Total Cost RATING	Good	Poor	Fair	Good	Good	Poor
Water Quality RATING	Good	Good	Fair	Fair	Good	Poor
OVERALL RATING	Fair	Fair	Fair	Good	Good	Poor

● Good ◍ Fair ○ Poor

1 Includes Dry Year Option Transfers 5 out of 20 years
2 Water is transferred from Northern/Central California and/or Colorado River.

Chapter 8

8.0 CONCLUSIONS

This chapter presents conclusions drawn from the analysis conducted in the Water Resources Plan, and provides direction for future water resources development. Selection of a resource mix is based upon the ratings process that was conducted for the six water resources alternatives, including the dry-year option transfer analysis, using the selection criteria presented in Chapter 7. Consideration was also given to public participation in the resources planning process, and comments received on the draft Water Resources Plan since its first release on September 12, 1996.

8.1 OVERVIEW

Six main water resources alternatives were considered in this Water Resources Plan. One of the alternatives, the Existing Strategy Alternative, is an updated version of the resources mix selected for development in the 1993 Water Resources Plan. The remaining five "new" alternatives represent opportunities to improve supply reliability and the degree of control the Authority has over resources development. These alternatives either maximized local supply development, developed large-scale core (normal-year) water transfers, or provided a combination of increased local supplies and core transfers. Analysis was also done to compare the benefits and costs of flexible (dry-year) transfers with core transfers.

Each of the five new alternatives was found to improve certain aspects of reliability and Authority water resources control over the Existing Strategy Alternative. However, the new alternatives represented tradeoffs in other criteria that were considered on an equal basis, including feasibility, total cost, potential rate impacts, environmental impacts, and water quality. For example, the objective of minimizing cost competes with the objective of maximizing reliability, which tends to drive up costs.

The goal of the Water Resources Plan evaluation was to compare the alternatives against each other and develop a plan for future resources development that collectively maximized the criteria. In the end, this Water Resources Plan did not select a single "best" alternative water resources mix from among the six competing alternatives. Instead, the Plan recognizes the potential benefits of incrementally developing additional local supplies and adding an intermediate level of core transfers to the resources strategy adopted in the Authority's 1993 Water Resources Plan.

Substantial improvements in reliability, Authority control, and feasibility could be achieved with alternatives that feature core transfers of up to 200,000 acre-feet per year (af/yr). This is true both in the case of core transfers, as proposed in four of the alternatives, or through the use of dry-year options in the Existing Strategy Alternative. However, core transfers are considered to provide greater reliability than dry-year options. This is because core transfers also minimize the risk of the Metropolitan Water District of Southern California (MWD) being unable to fully implement its Integrated Resources Plan (IRP) in a normal-weather year (see discussion in Chapter 7).

Selection of a resources mix was based upon an overall evaluation of the criteria. No criterion was weighted more heavily than the others. Instead, overall judgments for each alternative were made using the rating system of "good," "fair," and "poor" for each criterion. Using this methodology, it was possible to isolate alternatives and potential resources that best balanced the competing criteria.

The Public Outreach Program was used as guidance in the evaluation of alternatives. Results from a selection criteria weighting exercise conducted by community stakeholders showed in general terms that reliability and water rate impacts were considered by participants to be two of the most important criteria. This preference, which correlated with individual interviews conducted with outreach program participants, was considered in making value judgments for qualitative criteria. Comments received from the Authority Board of Directors, member agencies, and the public were incorporated into this final document.

8.2 INITIAL SCREENING OF ALTERNATIVES

An initial screening of the analysis presented in Chapter 7 resulted in the elimination of two alternatives: the Maximum Local Supply Alternative and the Colorado River Facilities Alternative. These alternatives should be reconsidered in future updates of the Water Resources Plan, as water demand and supply conditions change and as more information is gained about potential funding sources for an Authority owned Colorado River conveyance system and the success of MWD's supply development program outlined in the IRP.

The Maximum Local Supply Alternative was eliminated from further consideration largely because of its higher projected total cost and increased risk of causing upward pressure on water rates. With only 69,000 af/yr of additional local supplies (compared with the Existing Strategy Alternative), this alternative did not offer significant improvements in Authority control over water resources or overall reliability in exchange for its higher costs and potential rate impacts.

The Colorado River Facilities Alternative had the highest cost of all six alternatives and the greatest risk of rate impacts. There were also major uncertainties related to feasibility and environmental impacts. For these reasons this alternative was deleted from further consideration, but should be retained for further study. Some potential has been demonstrated for funding participation from the U.S. federal government and Mexico, which would reduce the cost of such a project to the Authority. However, at this time, such funding is speculative. For this analysis it has been assumed that the Authority is the sole funder of the project.

8.3 FINAL SCREENING OF ALTERNATIVES

The remaining alternatives to be considered are the Existing Strategy, Maximum Local Supply With Transfers, Intermediate Transfers, and Maximum Transfers. The Intermediate and Maximum Transfers alternatives received an overall rating of good, while the Existing Strategy and Maximum Local Supply With Transfers were rated fair. The fair rating for the latter alternative was primarily because of the additional local agency cost for recycling and groundwater projects. Because concerns beyond cost contribute to a local agency decision on implementing local projects, the Maximum Local Supply With Transfer Alternative was carried forward into the final screening process.

Even though a weighting of individual criteria was not applied in arriving at an overall rating, conducting a final screening of the alternatives requires consideration of the importance of each criterion in contributing towards the Authority's ability to fulfill its mission and meet its reliability goals. In the public outreach efforts conducted as part of this Water Resource Plan update process, the consistent theme from the various stakeholders was that the two most important considerations in selecting a mix of resources were maximizing reliability and minimizing rate impacts. The analysis conducted in Chapter 7 also highlighted the importance that feasibility has in determining whether a mix can be implemented and reliability achieved. It is in these three areas that distinctions between the remaining alternatives can be made.

Although the Maximum Transfers Alternative was found attractive in terms of cost, reliability, Authority control, and reduced risk of rate impacts, there is considerable uncertainty in recently emerging market conditions over the feasibility of obtaining this quantity of water on a long-term basis. Potential environmental impacts from transferring this quantity of water require further evaluation as well. Therefore, this alternative was not selected for further development at this time. At projected demand levels, if this transfer were achieved from a single source, it would displace reliance on the current source of imported water (MWD) for another source, losing some of the supply diversity benefits that core transfers are intended to achieve.

The Existing Strategy Alternative provided the lowest overall cost of any of the resource mixes evaluated in this plan. Concerns over the feasibility of implementing the IRP led to a resources strategy that improved reliability by adding water transfers to the resource mixes. The Existing Strategy Alternative was supplemented with up to 200,000 acre-feet (af) of dry-year option transfers. This improved the Existing Strategy Alternative in terms of the reliability, feasibility, and Authority control criteria, but only in dry years, when shortages were driven by hydrologic conditions. Dry-year options were not effective in responding to normal-year shortfalls in MWD's core supplies, which may result from a lack of surplus Colorado River water or delay in a full fix to the Sacramento-San Joaquin Bay-Delta. Shortfalls in either one of these sources would impact the normal-year reliability of the Existing Strategy Alternative.

The Maximum Local Supply With Transfers and Intermediate Transfers Alternatives provide high reliability and Authority control over supply through long-term core transfer agreements. Both resource mixes effectively minimized reliability risks in both normal- and dry-weather years. They also were highly rated for feasibility. The distinguishing criterion for these two alternatives is total cost. The Intermediate Transfers Alternative is lower in total cost because of a lower commitment to capital expenditures related to local supply development. Both resource mixes are essentially equivalent in potential water rate impacts. However, through its contribution of up to 37,000 af/yr of additional local supply, the Maximum Local Supply With Transfers Alternative further improves the reliability and diversity of the resource mix offered by the Intermediate Transfers Alternative.

8.3.1 Conclusions of Final Screening

The purpose of the final screening exercise is to identify the criteria that separate the remaining alternatives and provide a means to determine a selected resource strategy for the Authority to pursue. In the case of the Maximum Transfers Alternative, feasibility considerations regarding the magnitude of the transfer component eliminated that mix from further consideration in this update of the Water Resources Plan. Reliability concerns relating to the Existing Strategy, even when supplemented with dry-year option transfers provide a distinct difference between that mix and the two alternatives with 200,000 af of core transfers. Because it was considered to provide less reliability than the Maximum Local Supply With Transfers and Intermediate Transfers, the Existing Strategy was eliminated from further consideration.

Because of the relative similarity of the remaining two mixes, both the Maximum

Local Supply With Transfers and the Intermediate Transfers Alternatives were carried forward for further analysis.

8.4 DEVELOPMENT OF A SELECTED RESOURCE MIX

Both the Maximum Local Supply With Transfers and the Intermediate Transfers Alternatives involve the purchase of transfers by the Authority, beginning with 20,000 af/yr in 1999 and increasing to 200,000 af/yr by 2008. The primary difference between the two alternatives is the amount of water to be derived from local sources.

Local projects in the Intermediate Transfers Alternative were economically optimized from the Authority's perspective. However, the decision point for constructing local projects depends upon a local agency perspective, which may be quite different from that of the Authority. From the Authority's perspective, economic optimization requires viewing the cost effectiveness of a local project in terms of a comparison to the cost of MWD supplies, less any relevant incentives. In addition to these costs, local member agencies also take into consideration the Authority's water rate and any financial assistance which may be available for local supply development. Other factors that may influence local supply development include avoided wastewater treatment and disposal costs, emergency storage costs, and non-economic considerations.

Estimates of local supply development potential (described in Chapter 4) suggest that the 2015 local supply yield potential is approximately 165,000 af/yr. New yield expected to be developed between now and the end of the planning horizon includes 27,000 af of recycled water, 15,000 af of repurified water, and 34,000 af of groundwater. These additional local projects would increase the total amount of local supply to approximately 20 percent of 2015 normal-year demand. If this increase in local supply were to materialize, the resulting local supply element of the resources mix would closely resemble the Maximum Local Supply With Transfers Alternative. Increased local supplies would provide the Authority with greater benefits in terms of supply diversity, reliability, and degree of control over the resource.

Because of uncertainties in local supply development, the selected resources mix envisions a local supply component ranging from 122,000 to 165,000 af/yr in the year 2015.

8.5 SELECTED RESOURCE MIX

The selected resource mix would supplement imported water purchased from MWD with normal-year transfers of up to 200,000 af/yr. Local supplies would provide between 122,000 to 165,000 af/yr. Implementation of conservation Best Management Practices (BMPs) would result in an annual savings of 82,000 af/yr by the end of the planning horizon. MWD would continue to be the primary supplier of water to the Authority. Purchases from MWD would range from 422,000 to 465,000 af/yr, or about 54 to 59 percent of the total demand. A summary of the selected resources development is given in **Table 8-1**.

8.6 IMPLEMENTATION OF THE SELECTED MIX

The primary distinguishing characteristics between the selected water resources mixes of the 1993 Water Resources Plan and this update is the development of normal-year transfers of up to 200,000 af/yr, the development of additional local groundwater supplies, and the deletion of seawater desalination as a selected resource.

While scheduling and cost components of

TABLE 8-1 Selected Resource Mix (Based on Normal-Year Demand) (AF)						
Year	MWD	Transfer	Recl	Ground Water	Local Surface Water	Total
2000	499,000	40,000	18,000	19,000	60,000	636,000
2005	412,000-432,000	140,000	30,000-45,000	23,000-28,000	60,000	685,000
2010	387,000-412,000	200,000	30,000-50,000	32,000-37,000	60,000	734,000
2015	422,000-465,000	200,000	30,000-60,000	32,000-45,000	60,000	787,000

the transfers included in the selected mix are based on the terms and conditions of the proposed Imperial Irrigation District (IID) water transfer, the evaluation of water transfers is considered generally representative of the emerging market for transfers. The role of the Water Resources Plan is to provide a framework whereby future resource decisions, such as the acquisition of transfers, can be evaluated against other water supply options. As discussed in Chapter 5, specific water transfer proposals need to be evaluated on a case-by-case basis. A screening process would be used to evaluate the viability of specific water transfer proposals. Through this process, transfer proposals would be evaluated on the ability to improve reliability and local control at a cost comparable to purchasing water from MWD. The overall feasibility of the transfer proposal would also be evaluated. Feasibility considerations include public and institutional acceptance, regulatory factors, third party effects, water quality, and legal issues.

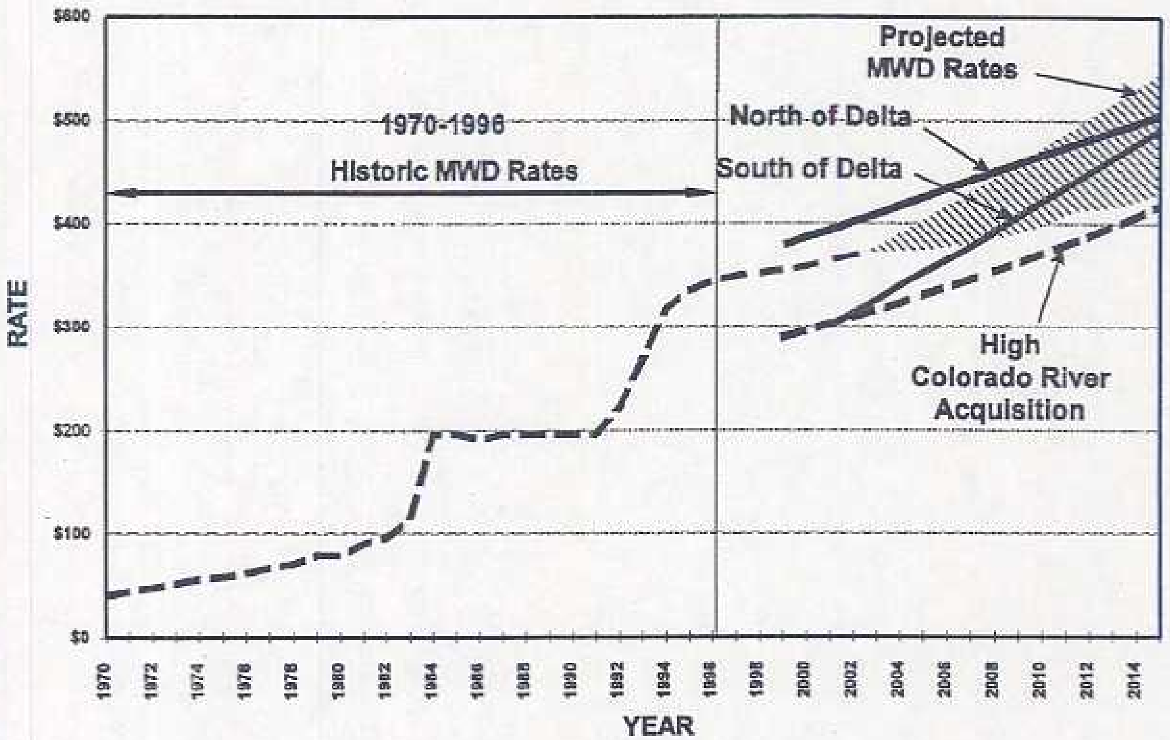
Using this analytical approach, a determination can be made as to whether the cost of a specific transfer proposal is competitive with purchasing water from MWD. By way of illustration, **Figure 8-1** provides a comparison of the anticipated costs of Colorado River and Northern and Central California transfers to a likely range of MWD rates. While the evaluation of specific transfer proposals is beyond the scope of the Water Resources Plan, the same methodology may be used for that purpose.

It should be kept in mind the actual resource development over the next 20 years will depend greatly on variables for which assumptions were made to carry out the analysis contained in this Plan. The major assumptions include future water demands, projected MWD water rates and charges, and the cost of development and transportation of water transfers. In the event that implementation of a resources mix with core transfers is delayed or not achievable, the Existing Strategy Alternative would continue to be the basis for the Authority's imported water supply component. The local supply and conservation components of the selected resources alternative can proceed within the existing Authority levels of involvement, with the exception of approximately 36,000 af of additional groundwater and recycled water projects, which may require expansion of the Authority's current local projects incentive program

8.7 RELATIONSHIP TO AUTHORITY RELIABILITY GOAL

Each alternative evaluated in this Plan has the potential to meet the Authority's current reliability goal, which was set forth in the Authority's 1995 Strategic Plan and is described in Chapter 1. The key reliability objective of this Plan was to identify a mix of water resources that reduces the risk of not meeting that goal at an acceptable cost. After a thorough analysis of all selection criteria, the selected resource mix is considered to best meet the Authority's reliability goal in a manner that reduces the risk of not meeting the goal and is cost-effective.

FIGURE 8-1
Non-Interruptible Imported Water Rates



Appendix A

WATER RESOURCES PLAN
PUBLIC OUTREACH PROGRAM
PHASE 1 REPORT

Presented to
The San Diego County Water Authority
Water Resources Division

Presented by
Katz & Associates
May 1. 1996

Water Resources Plan
Stakeholder Executive Summary Report

Intent of Interviews

The Water Resources Plan Stakeholder Executive Summary Report includes an overview of the feedback from a collection of interviews held with individual representatives of key San Diego associations and organizations who have a specific interest in the water resources of San Diego. These interviews were held from December 1995 through April 1996 and were conducted to provide the San Diego County Water Authority staff input from a diverse cross-section of constituencies.

The information included in this report was summarized from responses to a questionnaire developed and approved by the Authority to garner specific input on the Water Resources Plan. Therefore, the executive summary may not necessarily reflect all additional conversation topics discussed between the stakeholders and the interview team. The interviews were conducted by Dave Fogerson of the Authority's Water Resources Department, Sara Katz and Laurie Sargent of Katz & Associates.

The contents of this report are being used by the San Diego County Water Authority to assist them in updating the Water Resources Plan. Because the stakeholders input covers a wide-range of opinions, some of them even contradictory, the Authority is using this input as a guide to be taken into consideration along with the expertise of the Authority's water resource planners for developing the best, most cost-effective Water Resources Plan update. This information is also used to assist the Authority in planning and implementing additional outreach/stakeholder activities for the Water Resources Plan update.

Upon completion of the draft Water Resources Plan, it will then be presented to the Authority board of directors who will make the final determination about the allocation of water resources for the county.

Interviews Conducted

Interviews were conducted with individuals representing a cross-section of interests. The Authority recognizes the challenge in meeting with individuals who represent every possible perspective, and the Authority endeavored to reach as many viewpoints as possible. The objective was to meet with individuals who represent the perspective of an organization or association with a key interest in water resources in the county. In order to conduct interviews based on a substantive dialogue about water resources, the Authority worked to locate representatives who have had some experience with water resources and a basic understanding of the issues. Following is the list of stakeholders represented.

Alliance for Water Reliability
Biocom
Building Industry Association
Citizens Coordinate for Century III (C-III)
Greater San Diego Chamber of Commerce Water Committee
Greater San Diego Chamber of Commerce CEO Roundtable
Industrial Environmental Association (IEA) Water Committee
League of Women Voters
Mayor Susan Golding's Office
Regional Water Quality Control Board
San Diego Apartment Association
San Diego Association of Governments (SANDAG)
San Diego Convention & Visitors Bureau
San Diego County Farm Bureau
San Diego Economic Development Corporation (EDC)
San Diego Gas & Electric
San Diego Military Users
San Diego Rotary
Sierra Club (Water subcommittee)
United Consumers Action Network (UCAN)

<u>Summary</u>

Following is a summary of the feedback received from San Diego stakeholder representatives. The overview does not contain verbatim stakeholder comments, but provides a general summary of themes discussed in the interviews and the various viewpoints that came through during the interviews.

<u>Operations</u>

Mostly all stakeholders had a clear perspective of San Diego's water supply, where it comes from and something about San Diego's need to make up for current and projected shortfalls. No stakeholder expressed thoughts that the current supply is, or has been unreliable, however, many of them are aware of San Diego's vulnerability to earthquakes and are concerned about having sufficient emergency storage.

There were however, some opposing views on the amount of water needed to ensure future reliability. Some stakeholders feel strongly that the Authority should do as much possible to provide as much water as possible to the county. They are strong advocates of storage and doing whatever it takes, while remaining cost effective, to make San Diego independent of MWD and other outside water suppliers. Other stakeholders want to see extensive economic analysis done on the issue of current supply versus future supply to determine exactly what is necessary and what are the most economical and environmentally conscious ways of providing water.

Water Resources

Although most every stakeholder wants to see local water resource development, the preferences for the types of water supply options to be pursued varied greatly among the stakeholders. Most groups agree that desalination is currently too expensive of an option, but may potentially become a viable option when technology is improved.

Feedback regarding reclamation and repurification was extremely diverse. Some stakeholders feel these are important opportunities and should be pursued. Others are concerned about the costs associated with these resource options and environmental impacts required for dual piping of reclaimed water. Some stated that repurified water should still be viewed as experimental before it's used on a widescale basis.

Groundwater was not listed among top water supply options primarily due to quality and availability as well as its limited reliability for emergency storage use.

Emergency storage was favored by almost every stakeholder. Again, some are unsure about the necessary quantity, but most feel it is an important resource and should be provided.

Every stakeholder indicated a need to pursue conservation. Some expressed conservation should be considered as any other resource is considered. Others were concerned that there are limits to conservation and that it is important, but cannot take the place of providing additional local resource options. A number of stakeholders expressed the need to continue an extensive public education program to encourage more residential conservation practices.

Given the current limited information about agricultural transfers, most of the stakeholders expressed reluctance to commit to such options until more specific information is provided. However, the feedback on agricultural transfers as a potential resource varied tremendously. Some stakeholders would like to see agricultural transfers aggressively pursued, and are willing to pay more for the independence that water will bring. They are not sure how much more they would pay and would need to see the economic analysis before supporting the option. Others are worried about the reliability of the source of agricultural water and are concerned that San Diego will end up in a situation similar to the current one in terms of independence and cost control.

Some stakeholders expressed a concern about the quality of the agriculturally transferred water (TDS levels) as well as the environmental impacts created by developing the appropriate infrastructure to get the water here.

Rates

With rare exception, each stakeholder expressed that the current cost of water is fair and reasonable, however, every stakeholder is concerned about future water costs and how further water resources development will affect water rates. Water rate predictability was also stressed as an important factor. Businesses need to be able to plan accordingly for future rate increases...not if, but how much and when. An extensive cost analysis was requested by various stakeholders, as well as a listing of who will pay for what portions of specific water resource options such as repurification, reclamation, etc.

Responses on the cost for specific supply options ranged widely with some stakeholders willing to pay more for more independence from MWD, etc. Others feel that new water resources should not cost more than the current imported water rates.

Other Issues

Some stakeholders expressed the concern that the Water Resource Plan not recommend we provide more water than is truly necessary because they feel it will induce growth in the region. Opposing viewpoints see the lack of future water reliability as a major economic problem for the region and stated that without a more reliable, cost-competitive water supply, San Diego will no longer be able to compete economically because large San Diego corporations/industries will leave and other industries will not want to be located in San Diego. Others noted that regardless of business interests, San Diego will continue to grow in population and our residents need to be assured of a reliable source of water.

Another issue raised was the lack of coordination between county land-use planners and water resource planners. This is due to the fact that no planning can take place where water is unavailable, therefore, the planners and elected officials need to be more aware of the water supply issues San Diego faces.

Poor water quality was an issue raised in several stakeholder meetings. Many are concerned that not enough steps are being taken to ensure the quality of water to San Diego meets adequate standards. Each new supply option should also require specific steps be taken to ensure water quality is not compromised and this will influence the cost of each option.

Conclusion

The most important issues the stakeholders repeatedly expressed regarding San Diego's water supply include cost, quality, reliability, and keeping the measure of control consistent with investment. Another issue commonly raised was in making sure that the resource options are analytically studied before decisions are made. Stakeholders feel that decisions need to make economic and practical sense as well as political sense.

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Appendix B

San Diego County Water Authority
and
Imperial Irrigation District

COOPERATIVE WATER CONSERVATION AND TRANSFER PROGRAM

SUMMARY OF DRAFT TERMS

Overview

On September 19, 1995, the Authority and the District entered into a Memorandum of Understanding to explore the potential for a joint Water Conservation and Transfer Program ("Program"). Since that time, the Agencies have prepared technical analyses and conducted extensive public involvement programs. Based upon that information and in response to policy direction from their respective Boards of Directors, the staffs of the Agencies have developed a draft of possible terms under which a Program could be implemented.

The purpose of this document is to summarize the draft as to price, term and quantity as well as certain of the other relevant terms and make the summary available for broad public review and comment. Based upon the input that is received through that dialog, the terms would be revised and the resultant concepts would be incorporated into the form of Final Agreement for the Agencies' consideration. The essential terms for such a program, as developed by the staffs of the Agencies are as follows:

Quantity and Schedule of Transferred Water

To meet future demands, the Authority seeks a firm, affordable and price certain water supply of 500,000 AF/Y. Depending upon factors such as landowner participation, environmental compliance, community support, and availability of approvals agreed to be obtained, it is expected that between 200,000 AF/Y and 500,000 AF/Y of firm water supply will be available to the Authority, the actual maximum quantity to be incorporated into the Final Agreement. The Agencies agree that the water conservation programs of the District shall not include permanent retirement of farm land. Subject to the availability of transportation on terms satisfactory to the Authority for the water supplied by the District, the District will offer to the Authority and the Authority will purchase, all water made available by the District, not to exceed 500,000 AF/Y, as provided below.

The water available shall be delivered by the United States to the Authority at an acceptable delivery point commencing in 1999 at a quantity of 20,000 AF/Y, or a greater amount mutually agreed upon, increasing each year by 20,000 AF/Y for ten years, to a total of 200,000 AF/Y and thereafter, subject to the needs and water quality objectives of the Authority, increasing each year by an estimated increment of 8,000 AF/Y to the total to be made available by the District. Thereafter, delivery of such total will continue each year unless the delivery is reduced or discontinued pursuant to the recapture and other termination provisions described herein. The District will accelerate delivery at the request of the Authority. The parties recognize that the Authority, in order to secure transportation to deliver the supplies to San Diego and to attain such water quality objectives, may have to buy several hundred thousand acre feet from others, at least for a time.

The right and ownership to all water will remain with the District, subject to the right of the Authority to have delivery and use the water as agreed. All water delivered to and used by the Authority shall be a part of the District's Present Perfected Rights to Colorado River water. The District expects to create conserved water as defined in California Water Code Section 1011 in quantities equal to the deliveries to the Authority and, not inconsistent with such present perfected rights, all such conserved water is intended to be included in such delivery.

Delivery Location: Transportation

All water will be delivered by the United States to the Authority on the Colorado River at Imperial Dam or other location and it will be the responsibility of the Authority to arrange for transportation of such water from there to the service area of the Authority. Should the Authority desire to use the All American Canal to connect to any aqueduct to San Diego, the District would make capacity available or participate in capacity enlargement under an arrangement that takes into account the arrangement that currently exists with the City of San Diego.

Price

The Authority shall pay the District the following sums:

Year #	Year	$ Per AF
1	1999	$200
2	2000	$212
3	2001	$224
4	2002	$235
5	2003	$247
6	2004	$259
7	2005	$271
8	2006	$282
9	2007	$294
10	2008	$306

If at any time during the above ten years the Authority's Colorado River Aqueduct transportation costs exceed $75 per acre foot, the above prices for such time shall be adjusted according to a method to be negotiated.

After the first ten years, the prices selected in accordance with the Ten Year Price Adjustment section below shall be paid.

The above prices are subject to the negotiation of a Ten-Year Price Adjustment clause that is satisfactory to both parties.

Ten Year Price Adjustment

Either party may, before the end of each ten-year period, suggest a new price. If the other party does not accept the suggested price, and if the parties, through good faith negotiations, do not select a new price, the new price shall be selected by arbitration ("Market Price"). The Market Price, whether selected by agreement or arbitration, shall be market-based, but, to lessen the impact on the agencies from radical swings in market conditions, shall not vary from the Market Price selected 10 years previously, or from $306 in the case of the first ten-year adjustment, by more than 25% thereof. For example, at the first 10-year adjustment the limit on the selected Market Price shall be based on $306, and shall be no greater than $383 and no less than $229, and, as a further example, if the Market Price selected at the first 10-year adjustment is $360, then the Market Price selected at the next 10-year adjustment shall be no greater than $450 and no less than $270. Again, to lessen the impact of such swings in market conditions, the new selected price shall be phased in gradually over the first five years of the relevant ten year period. In case of upward price adjustments only, each of the first five-year phase-in payments shall be increased by 2% and the Market Price shall be increased as follows: by 2% for year 6, 4% for year 7, 6% for year 8, 8% for year 9 and 10% for year 10 ("Percentage Increase"). When the selected new price represents a downward price adjustment, the Market Price shall be so paid over the 10-year period without any percentage adjustments. Also, during years 6 through 10, the Authority in the case of an upward price adjustment, and the District in the case of a downward price adjustment, shall pay or credit, the other agency the difference between the selected new price and such five year phased-in payments.

Before the end of each ten-year period (except for the initial period), either party may also request that a market-based price be determined for each year of the expiring ten-year period ("Determined Price"). For each such year, the Determined Price shall not vary by more than 10% from the Market Price selected ten years previously. For example, if the Market Price applicable during such expiring 10-year period should be $360, then the Determined Price for each such year shall be no greater than $396 and no less than $324. Then for each such year, the water delivery shall be repriced according to the Determined Price. The difference for each year between the repriced amount and the amount actually paid for such deliveries including any Percentage Increase, shall be paid or credited over the next 10-year period according to a method to be negotiated.

Subject to such variation limits, the Market Price and the Determined Price shall be that price indicated by comparison to then recent water transfers and other market activity data, after adjustment for all relevant factors, including but not limited to the value of reliability, priority, volume, duration, base load or peaking character, price and terms and water quality, and excluding transportation and taking into account the cost of delivering water to the Authority. The initial price, having been formulated during an emerging market, shall not be regarded as a market price indication.

Term of Agreement and Recapture/Termination Procedures

The initial term shall be 75 years from the commencement of deliveries with each agency, subject to the terms of the next paragraph, having the option after such initial term to reduce the total quantity by no more than two percent each year. Water so recaptured by the District shall be used solely for new municipal and industrial uses and shall be so used only after similar use is first made of all water hereafter transferred by the District to others. Notwithstanding the foregoing, the Agreement will terminate at the end of the 125th year.

If the Authority decides to construct a new conveyance facility for transportation of the water made available by the District, the term of the Agreement shall be 125 years from such commencement of deliveries and shall terminate at the end of the 125th year, with no right of recapture during the term.

Responsibilities for Environmental Compliance

Each agency shall be solely responsible for compliance with environmental laws for programs under the leadership of that agency. For example, the District will have lead responsibility for environmental compliance associated with any Final Agreement and the water conservation programs and the Authority will have lead responsibility for subsequent environmental compliance associated with transportation of water.

Each agency shall be solely responsible for the cost of environmental compliance undertaken by it.

Contingencies Which Could Prevent Implementation of Program

District Environmental Contingency: The obligations of the District to perform under the Program shall be voidable if environmental compliance cannot be accomplished, such decision to be in the sole discretion of the District.

Authority Transportation Contingency: The obligations of the Authority to perform under this Program shall be voidable if the Authority is unable to arrange for transportation of the water from the Colorado River to the Authority's system for the term of the Agreement through the Colorado River Aqueduct on terms satisfactory to the Authority or by other means satisfactory to the Authority.

Court Validation of Final Agreement: The obligation of the Agencies to perform under this program shall be voidable if validation or declaratory judgment as to the Final Agreement is not obtained; provided, however, that the Agencies have the option to agree to waive portions or all of such validation requirements. Judgments shall be obtained without expense to the Authority.

Interim Assignment of Authority's Rights

The Authority shall have the right to assign to any other Metropolitan Member Agency, on an interim basis, any of the Authority's rights and responsibilities under the Program.

Shortage Sharing

During any period when deliveries of Colorado River water to the District for reasonable beneficial use or the deliveries of Colorado River water to the Authority for reasonable beneficial use are curtailed by the Secretary of the Interior, pursuant to Article II(B)(3) of the decree in Arizona v. California, the Authority and the District will share the same percentage reduction in water availability, but, following court validation of the Final Agreement, the District will be responsible for all claims by any junior priorities in California or elsewhere that such deliveries should not be made.

Confirmation of Mutual Understanding

Although neither the District nor the Authority is bound by this Summary of Draft Terms, nevertheless, this Summary confirms their mutual understanding and desire to enter within 90 days from the respective Board's approval hereof into a more detailed formal and binding agreement (the Final Agreement) that is generally consistent with the provisions hereof as those provisions may be modified through public review and input.

Appendix C

APPENDIX C

WATER RESOURCES PLAN 1997 UPDATE
KEY ASSUMPTIONS FOR COSTS OF ALTERNATIVES

The following assumptions were made to conduct cost and potential rate impact analysis in the 1997 Water Resources Plan. Projected MWD water commodity rates and non-rate charges are provided in Table C-1.

1. Rates and charges. Evaluation uses MWD projected water commodity rates and readiness-to-serve (RTS) charges shown in Table C-1. The total amount of RTS charges was held constant for all alternatives, regardless of MWD purchases. Analysis did not include new demand charge.

2. Transfer Costs. Costs for IID transfers were taken from the Authority's Summary of Draft Terms. Costs were evaluated using the lower and upper ranges of the 10-year market adjustment. Assumed transportation charges (wheeling charges) are shown in Table C-1.

3. Capital Costs. Capital costs for all local projects and the IID facilities were pro-rated over the life of each project.

5. Demand Adjustment. Water demand associated with Colorado River facilities alternative was increased by 65,000 af/yr to account for RO losses (13% of 500,000 af).

TABLE C-1

WATER RESOURCES PLAN 1997 UPDATE

KEY ASSUMPTIONS FOR COST AND RATE IMPACT ANALYSIS OF ALTERNATIVES

(ALL FIGURES EXCEPT RTS IN $/AF; RTS IN TOTAL $)

	METROPOLITAN WATER DISTRICT PROJECTED RATES						ASSUMED	PROJECTED
	BASE CASE		WHEELING 200,000 AF		WHEELING 500,000 AF		WHEELING	AUTHORITY
YEAR	LOW	HIGH	LOW	HIGH	LOW	HIGH	CHARGE	RTS SHARE
1996	344	344	344	344	344	344	-	14,867,000
1997	349	349	349	349	349	349	-	16,454,000
1998	352	352	352	352	352	352	-	20,447,000
1999	355	355	355	355	355	355	75	22,563,000
2000	360	360	365	365	365	365	76	24,712,000
2001	365	365	380	380	380	380	77	26,860,000
2002	370	370	390	390	390	390	78	27,935,000
2003	375	381	395	401	395	401	79	27,935,000
2004	375	393	395	413	395	413	81	27,935,000
2005	375	404	395	426	395	426	82	27,935,000
2006	380	416	405	444	405	444	83	27,935,000
2007	385	429	410	457	410	457	84	27,935,000
2008	389	442	425	483	430	488	86	27,935,000
2009	394	455	435	502	450	520	87	27,935,000
2010	404	469	445	516	470	545	88	27,935,000
2011	414	483	450	525	490	571	90	27,935,000
2012	419	497	450	534	510	605	91	27,935,000
2013	419	512	450	550	520	636	93	27,935,000
2014	424	528	455	566	530	659	95	27,935,000
2015	434	543	455	570	535	670	96	27,935,000

TABLE C-2
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW COST WATER SUPPLY SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 298.8	$ 1,304.1	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 306.8	$ 1,610.9	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 325.9	$ 1,936.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.3	$ 2,269.1	$ 347.9	$ 2,308.3	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.1	$ 2,616.2	$ 362.7	$ 2,671.0	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.4	$ 2,966.6	$ 367.0	$ 3,038.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 366.9	$ 3,333.6	$ 383.5	$ 3,421.5	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 374.9	$ 3,708.5	$ 411.2	$ 3,832.7	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.0	$ 4,091.4	$ 419.5	$ 4,252.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 394.1	$ 4,485.5	$ 431.0	$ 4,683.2	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 406.1	$ 4,891.6	$ 443.2	$ 5,126.4	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 418.1	$ 5,309.7	$ 455.4	$ 5,581.8	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 427.3	$ 5,737.0	$ 465.0	$ 6,046.9	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 432.9	$ 6,169.9	$ 471.0	$ 6,517.9	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 442.0	$ 6,611.9	$ 480.5	$ 6,998.4	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 454.7	$ 7,066.6	$ 493.5	$ 7,492.0	$ 453.4	$ 7,289.8	$ 444.9	$ 7,163.8	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-3
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
HIGH COST WATER SUPPLY SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.2	$ 1,005.6	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.3	$ 1,304.8	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.4	$ 1,612.2	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.6	$ 1,938.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 336.7	$ 2,275.5	$ 351.0	$ 2,311.5	$ 349.2	$ 2,317.2	$ 341.7	$ 2,289.0	$ 341.7	$ 2,289.0	$ 379.5	$ 2,426.4
2004	$ 358.8	$ 2,634.2	$ 372.7	$ 2,684.1	$ 370.0	$ 2,687.2	$ 363.0	$ 2,651.9	$ 363.0	$ 2,651.9	$ 401.5	$ 2,827.9
2005	$ 369.8	$ 3,004.0	$ 384.0	$ 3,068.2	$ 380.4	$ 3,067.6	$ 373.1	$ 3,025.0	$ 373.1	$ 3,025.0	$ 423.3	$ 3,251.1
2006	$ 391.2	$ 3,395.2	$ 405.1	$ 3,473.3	$ 402.8	$ 3,470.4	$ 396.3	$ 3,421.3	$ 396.3	$ 3,421.3	$ 449.9	$ 3,701.0
2007	$ 404.5	$ 3,799.7	$ 437.0	$ 3,910.3	$ 414.8	$ 3,885.2	$ 408.7	$ 3,830.0	$ 408.7	$ 3,830.0	$ 473.5	$ 4,174.6
2008	$ 418.9	$ 4,218.6	$ 451.2	$ 4,361.5	$ 433.2	$ 4,318.3	$ 428.0	$ 4,258.0	$ 430.8	$ 4,260.8	$ 505.7	$ 4,680.2
2009	$ 436.1	$ 4,654.7	$ 468.2	$ 4,829.7	$ 454.7	$ 4,773.0	$ 450.2	$ 4,708.2	$ 451.7	$ 4,712.5	$ 536.7	$ 5,216.9
2010	$ 451.3	$ 5,106.0	$ 483.3	$ 5,313.0	$ 470.4	$ 5,243.4	$ 466.1	$ 5,174.3	$ 466.9	$ 5,179.4	$ 567.0	$ 5,783.9
2011	$ 466.7	$ 5,572.8	$ 498.7	$ 5,811.8	$ 483.6	$ 5,727.0	$ 479.3	$ 5,653.7	$ 481.5	$ 5,660.9	$ 594.6	$ 6,378.5
2012	$ 483.4	$ 6,056.1	$ 515.1	$ 6,326.9	$ 497.9	$ 6,224.9	$ 493.8	$ 6,147.4	$ 498.1	$ 6,159.0	$ 633.8	$ 7,012.3
2013	$ 500.4	$ 6,556.6	$ 531.7	$ 6,858.6	$ 515.1	$ 6,740.1	$ 511.7	$ 6,659.2	$ 510.8	$ 6,669.9	$ 658.5	$ 7,670.8
2014	$ 518.1	$ 7,074.6	$ 549.0	$ 7,407.7	$ 532.8	$ 7,272.9	$ 530.0	$ 7,189.1	$ 521.8	$ 7,191.6	$ 681.8	$ 8,352.6
2015	$ 536.1	$ 7,610.8	$ 567.0	$ 7,974.7	$ 543.6	$ 7,816.5	$ 540.5	$ 7,729.6	$ 536.5	$ 7,728.1	$ 698.7	$ 9,051.3

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-4
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW MWD RATES AND HIGH TRANSFER ACQUISITION COSTS SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 298.8	$ 1,304.1	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 306.8	$ 1,610.9	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 325.9	$ 1,936.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.3	$ 2,269.1	$ 347.9	$ 2,308.3	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.1	$ 2,616.2	$ 362.7	$ 2,671.0	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.4	$ 2,966.6	$ 367.0	$ 3,038.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 366.9	$ 3,333.6	$ 383.5	$ 3,421.5	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 374.9	$ 3,708.5	$ 411.2	$ 3,832.7	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.0	$ 4,091.4	$ 419.5	$ 4,252.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 394.1	$ 4,485.5	$ 431.0	$ 4,683.2	$ 425.6	$ 4,657.3	$ 417.9	$ 4,579.4	$ 423.3	$ 4,587.1	$ 505.8	$ 5,089.3
2010	$ 406.1	$ 4,891.6	$ 443.2	$ 5,126.4	$ 438.9	$ 5,096.2	$ 431.3	$ 5,010.7	$ 439.3	$ 5,026.4	$ 533.6	$ 5,622.9
2011	$ 418.1	$ 5,309.7	$ 455.4	$ 5,581.8	$ 449.9	$ 5,546.1	$ 442.1	$ 5,452.8	$ 454.9	$ 5,481.4	$ 558.9	$ 6,181.8
2012	$ 427.3	$ 5,737.0	$ 465.0	$ 6,046.9	$ 459.1	$ 6,005.2	$ 451.1	$ 5,903.8	$ 470.5	$ 5,951.8	$ 609.6	$ 6,791.4
2013	$ 432.9	$ 6,169.9	$ 471.0	$ 6,517.9	$ 467.9	$ 6,473.1	$ 459.8	$ 6,363.6	$ 483.0	$ 6,434.8	$ 627.8	$ 7,419.1
2014	$ 442.0	$ 6,611.9	$ 480.5	$ 6,998.4	$ 479.2	$ 6,952.3	$ 471.2	$ 6,834.8	$ 496.4	$ 6,931.2	$ 646.1	$ 8,065.3
2015	$ 454.7	$ 7,066.6	$ 493.5	$ 7,492.0	$ 487.2	$ 7,439.4	$ 478.6	$ 7,313.5	$ 508.8	$ 7,440.0	$ 660.0	$ 8,725.3

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-5
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
HIGH MWD RATES AND LOW TRANSFER ACQUISITION COSTS SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.2	$ 1,005.6	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.3	$ 1,304.8	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.4	$ 1,612.2	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.6	$ 1,938.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 336.7	$ 2,275.5	$ 351.0	$ 2,311.5	$ 349.2	$ 2,317.2	$ 341.7	$ 2,289.0	$ 341.7	$ 2,289.0	$ 379.5	$ 2,426.4
2004	$ 358.8	$ 2,634.2	$ 372.7	$ 2,684.1	$ 370.0	$ 2,687.2	$ 363.0	$ 2,651.9	$ 363.0	$ 2,651.9	$ 401.5	$ 2,827.9
2005	$ 369.8	$ 3,004.0	$ 384.0	$ 3,068.2	$ 380.4	$ 3,067.6	$ 373.1	$ 3,025.0	$ 373.1	$ 3,025.0	$ 423.3	$ 3,251.1
2006	$ 391.2	$ 3,395.2	$ 405.1	$ 3,473.3	$ 402.8	$ 3,470.4	$ 396.3	$ 3,421.3	$ 396.3	$ 3,421.3	$ 449.9	$ 3,701.0
2007	$ 404.5	$ 3,799.7	$ 437.0	$ 3,910.3	$ 414.8	$ 3,885.2	$ 408.7	$ 3,830.0	$ 408.7	$ 3,830.0	$ 473.5	$ 4,174.6
2008	$ 418.9	$ 4,218.6	$ 451.2	$ 4,361.5	$ 433.2	$ 4,318.3	$ 428.0	$ 4,258.0	$ 430.8	$ 4,260.8	$ 505.7	$ 4,680.2
2009	$ 436.1	$ 4,654.7	$ 468.2	$ 4,829.7	$ 448.3	$ 4,766.6	$ 443.8	$ 4,701.8	$ 443.7	$ 4,704.5	$ 530.3	$ 5,210.5
2010	$ 451.3	$ 5,106.0	$ 483.3	$ 5,313.0	$ 458.8	$ 5,225.4	$ 454.5	$ 5,156.4	$ 449.6	$ 5,154.1	$ 555.4	$ 5,765.9
2011	$ 466.7	$ 5,572.8	$ 498.7	$ 5,811.8	$ 466.9	$ 5,692.4	$ 462.6	$ 5,619.0	$ 452.2	$ 5,606.3	$ 577.9	$ 6,343.8
2012	$ 483.4	$ 6,056.1	$ 515.1	$ 6,326.9	$ 476.0	$ 6,168.4	$ 471.9	$ 6,090.9	$ 454.3	$ 6,060.6	$ 579.1	$ 6,922.9
2013	$ 500.4	$ 6,556.6	$ 531.7	$ 6,858.6	$ 488.1	$ 6,656.4	$ 484.7	$ 6,575.5	$ 449.9	$ 6,510.6	$ 590.8	$ 7,513.7
2014	$ 518.1	$ 7,074.6	$ 549.0	$ 7,407.7	$ 500.6	$ 7,157.0	$ 497.7	$ 7,073.2	$ 441.2	$ 6,951.8	$ 601.2	$ 8,114.9
2015	$ 536.1	$ 7,610.8	$ 567.0	$ 7,974.7	$ 509.8	$ 7,666.9	$ 506.7	$ 7,579.9	$ 452.1	$ 7,403.9	$ 614.3	$ 8,729.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-6
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
ADJUSTED TO REFLECT MWD PURCHASE OF TRANSFERS

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 276.3	$ 1,006.6	$ 278.3	$ 1,010.6	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 301.3	$ 1,307.8	$ 302.9	$ 1,313.6	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 311.1	$ 1,619.0	$ 319.2	$ 1,632.8	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 331.5	$ 1,950.4	$ 340.5	$ 1,973.3	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 341.6	$ 2,292.1	$ 356.4	$ 2,329.7	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 358.5	$ 2,650.6	$ 373.2	$ 2,702.9	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 367.0	$ 3,017.6	$ 382.2	$ 3,085.1	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 385.8	$ 3,403.3	$ 400.7	$ 3,485.8	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 396.0	$ 3,799.3	$ 430.0	$ 3,915.8	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 403.7	$ 4,203.0	$ 438.1	$ 4,353.9	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 417.8	$ 4,620.8	$ 452.2	$ 4,806.2	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 428.8	$ 5,049.6	$ 463.5	$ 5,269.7	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 436.9	$ 5,486.5	$ 472.3	$ 5,742.0	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 441.4	$ 5,927.9	$ 477.7	$ 6,219.7	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 450.0	$ 6,377.9	$ 486.5	$ 6,706.1	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 463.0	$ 6,840.9	$ 499.5	$ 7,205.6	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 478.6	$ 7,319.5	$ 515.2	$ 7,720.8	$ 453.4	$ 7,289.8	$ 444.9	$ 7,163.8	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-7
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW-COST WATER SUPPLY SCENARIO ADJUSTED TO REFLECT REINSTATEMENT OF NDC IN 2003

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.1	$ 1,005.5	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 300.4	$ 1,305.9	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 308.4	$ 1,614.3	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 328.0	$ 1,942.4	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 338.2	$ 2,280.6	$ 347.5	$ 2,307.9	$ 347.2	$ 2,315.1	$ 339.2	$ 2,286.5	$ 339.2	$ 2,286.5	$ 377.1	$ 2,424.0
2004	$ 354.7	$ 2,635.3	$ 364.2	$ 2,672.1	$ 360.7	$ 2,675.9	$ 352.9	$ 2,639.4	$ 352.9	$ 2,639.4	$ 391.4	$ 2,815.4
2005	$ 359.1	$ 2,994.4	$ 368.8	$ 3,040.9	$ 365.6	$ 3,041.4	$ 356.7	$ 2,996.1	$ 356.7	$ 2,996.1	$ 406.9	$ 3,222.3
2006	$ 374.4	$ 3,368.8	$ 385.3	$ 3,426.2	$ 384.3	$ 3,425.8	$ 375.7	$ 3,371.8	$ 375.7	$ 3,371.8	$ 429.3	$ 3,651.5
2007	$ 382.9	$ 3,751.8	$ 419.4	$ 3,845.6	$ 392.8	$ 3,818.6	$ 384.2	$ 3,756.0	$ 384.2	$ 3,756.0	$ 449.0	$ 4,100.6
2008	$ 390.9	$ 4,142.6	$ 428.5	$ 4,274.0	$ 406.1	$ 4,224.7	$ 398.0	$ 4,153.9	$ 400.3	$ 4,156.3	$ 475.5	$ 4,576.1
2009	$ 401.9	$ 4,544.6	$ 440.3	$ 4,714.3	$ 416.0	$ 4,640.7	$ 408.0	$ 4,561.9	$ 412.1	$ 4,568.3	$ 495.8	$ 5,071.9
2010	$ 414.6	$ 4,959.2	$ 453.6	$ 5,167.9	$ 423.5	$ 5,064.2	$ 415.6	$ 4,977.5	$ 418.5	$ 4,986.8	$ 517.8	$ 5,589.7
2011	$ 426.7	$ 5,385.9	$ 466.4	$ 5,634.3	$ 429.3	$ 5,493.6	$ 421.1	$ 5,398.6	$ 422.1	$ 5,409.0	$ 537.9	$ 6,127.6
2012	$ 436.8	$ 5,822.7	$ 477.3	$ 6,111.6	$ 432.8	$ 5,926.4	$ 424.3	$ 5,822.9	$ 423.6	$ 5,832.6	$ 552.2	$ 6,679.8
2013	$ 442.4	$ 6,265.1	$ 484.5	$ 6,596.1	$ 435.8	$ 6,362.2	$ 427.3	$ 6,250.2	$ 419.0	$ 6,251.6	$ 556.3	$ 7,236.1
2014	$ 452.3	$ 6,717.5	$ 495.8	$ 7,091.9	$ 441.4	$ 6,803.6	$ 432.8	$ 6,683.0	$ 413.0	$ 6,664.5	$ 561.1	$ 7,797.2
2015	$ 465.1	$ 7,182.5	$ 510.0	$ 7,601.8	$ 446.7	$ 7,250.4	$ 437.6	$ 7,120.6	$ 421.1	$ 7,085.6	$ 570.9	$ 8,368.1

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-8

WATER RESOURCES PLAN 1997 UPDATE

TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION'

LOW-COST WATER SUPPLY SCENARIO ADJUSTED TO REFLECT REINSTATEMENT OF NDC WHEN MWD SALES REACH 2.2 MAF

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.1	$ 1,304.4	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.1	$ 1,611.5	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.4	$ 1,938.0	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.8	$ 2,270.8	$ 349.0	$ 2,309.5	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.7	$ 2,618.4	$ 364.1	$ 2,673.5	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.9	$ 2,969.3	$ 368.5	$ 3,042.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 367.5	$ 3,336.8	$ 385.2	$ 3,427.3	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 375.4	$ 3,712.3	$ 418.9	$ 3,846.1	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.5	$ 4,095.8	$ 428.1	$ 4,274.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 400.9	$ 4,496.7	$ 451.9	$ 4,726.0	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 413.3	$ 4,910.0	$ 465.3	$ 5,191.4	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 425.3	$ 5,335.2	$ 478.8	$ 5,670.2	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 434.0	$ 5,769.3	$ 489.0	$ 6,159.2	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 439.8	$ 6,209.0	$ 496.3	$ 6,655.5	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 449.0	$ 6,658.0	$ 507.0	$ 7,162.5	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 461.8	$ 7,119.8	$ 521.2	$ 7,683.7	$ 461.7	$ 7,298.1	$ 453.7	$ 7,172.6	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

2

The H_2OPTIMUM Model

2.1 Introduction

The H_2OPTIMUM model is a water resource planning tool that is designed to compile a mix of water resource options that minimizes total cost subject to a set of constraints. These constraints include the service obligations of the water agency constructing the plan, the physical constraints imposed by the output capacity of available projects, the possibility of drought conditions, the availability of imported water, and the storage capacity of reservoirs. This section is organized as follows:

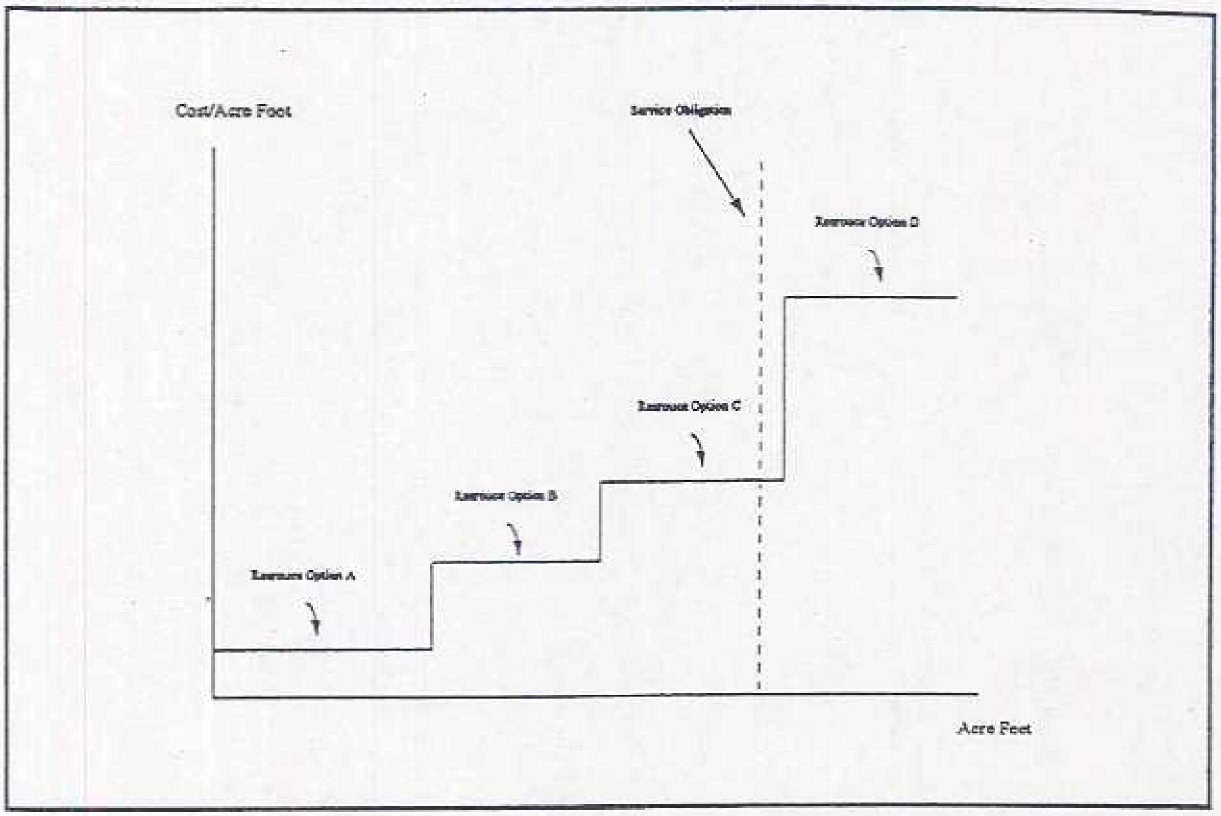
- A description of the nature of the water resource planning problem,
- A brief description of the techniques that are used in the solution of the water resource planning problem and other similar operation planning problems,
- A discussion on the databases that are used in the model, as well as the transfer of data from the input modules to the solution modules, and
- A detailed description of the structure of the optimization process that underlies H_2OPTIMUM.

2.2 The Nature of the Resource Planning Problem

The planning of water resource acquisition is quite similar to the problems faced by planners in other government agencies and private industry. Planners are faced with the requirement to meet obligations, have a limited set of options that are available to meet those obligations, and have the desire to minimize cost.

Figure 2-1 illustrates a simple version of the resource planning problem. The planner has an obligation to provide a level service illustrated by the dashed vertical line. The planner has four sources of supply available, represented by the segments of the stairstep function in the illustration. The cost of each option is equal to the height of each step. The potential supply from each option is equal to the width of each step. It is intuitively clear that the service obligation is met most efficiently by ordering the sources of supply based on cost and tapping each supply, in turn, until demand is met.

Figure 2-1: A Simplified Resource Planning Framework



The solution of this planning problem is complicated by the fact that most interesting planning problems are long range in nature. This may introduce several issues.

- There may be a fixed cost involved in employing a resource for the first time. The most obvious illustration of this is the construction of a water reclamation, repurification or desalination plant that has large capital cost. In order to plan on taking water from the plant, the planner must first decide if it is reasonable to incur the construction costs. Once the plant has been built, those construction costs are sunk and the decision to use water should be based on operation costs. Combining the capital and operating costs into a single number and levelizing over time and output, although reasonable in a static environment, may produce errors if the cost of alternative resources or demand change appreciably over time.
- The cost of utilizing a particular resource may change over time. An example of this would be a plan that uses appreciable amounts of energy. If energy costs are expected to rise (or fall) rapidly over the planning horizon, the order of the plant in the cost ranking illustrated above may change over time.
- The cost of a resource may be subject to discontinuities. An example of this is a water transfer sold under a pricing structure, like the MWD new demand charge, in which a fee is charged for exceeding a historic rate of delivery.

- Supplies may be interruptible. Sources of transfer water or supplies from local resources may be curtailed during periods of dry weather.
- It may be possible to store the product. If it is, service obligations can be met during periods of low availability or high cost by drawing down stocks instead of building new sources of supply. Reservoir storage is available to the water resource planner and should be used strategically.

Because of these factors, it was decided to use an optimization approach that accounts for changes in the availability and cost of alternative water resources over time as well as the possibility of water storage as an alternative to local resource construction.

2.3 Numerical Optimization and the Simplex Algorithm

At the heart of H_2OPTIMUM is what is known in the field of operations research as a *linear program*. Linear programs are a special case of a broader class of models known as *constrained optimization* models. Linear programs are special in the sense that the objective function (the numerical expression that the user wishes to either minimize or maximize) and the constraints (the numerical expressions that define possible solutions) are restricted to be linear equations. Linear equations are distinguished by the absence of terms in which decision variables (quantities that are controlled by the decision maker using the model) are multiplied by themselves, multiplied by other decision variables, or otherwise transformed by anything other than multiplication by a constant (i.e., no logarithms, exponents, trigonometric functions, etc.).

Linear programs are solved using an iterative numerical process known as the *simplex algorithm*. In short, the simplex algorithm finds the combination of decision variables that maximize or minimize the objective function in two ways:

- It locates an initial feasible solution (a combination of decision variables that satisfies all of the constraints), and
- It moves to other feasible solutions that improve the outcome (i.e., increase or decrease the objective function) by incrementing the decision variables until no better solution can be found.[1]

[1] For a more complete explanation of the simplex method, see Hillier and Lieberman, *Introduction to Operations Research*

2.4 The H_2OPTIMUM Data Structure

The H_2OPTIMUM spreadsheet passes the information necessary to optimize the resource mix to a SAS program which organizes the data, constructs an objective function, and constructs a set of constraints that restricts the resource plan to one that is possible given the limits imposed on SDCWA by its operating charter and nature's ability to provide water.

The general form of the information flows in H_2OPTIMUM are shown in Figure 2-2. There are four general classes of information:

- ***Information on local projects.*** The H_2OPTIMUM worksheets contain an inventory of water supply projects that currently exist or that are currently contemplated. For each project, the worksheet contains data on the construction cost for the project (which will be zero if the project has already been built, the sources and cost of financing for the project, and the annual cost per acre foot of operating the project), and the yield of the project in wet, normal and dry years.
- ***Information about reservoirs.*** The H_2OPTIMUM worksheets contain information that tell the model the capacity of each reservoir system, the rate at which water naturally flows into the reservoir, the rate at which water can be purchased from other sources and deposited into the reservoir, the rate at which water can be withdrawn from the reservoir to meet current year demand, and whether or not the reservoir's storage can be used to satisfy minimum emergency storage requirements.
- ***Information about conservation opportunities.*** Conservation opportunities are expressed as: (a) *programs*, or mutually exclusive groups of conservation measures that the planner wishes to include as a resource option, and (b) *program options*, which express different implementation schedules for each program.

  For each program option, the H_2OPTIMUM worksheet has three input areas:

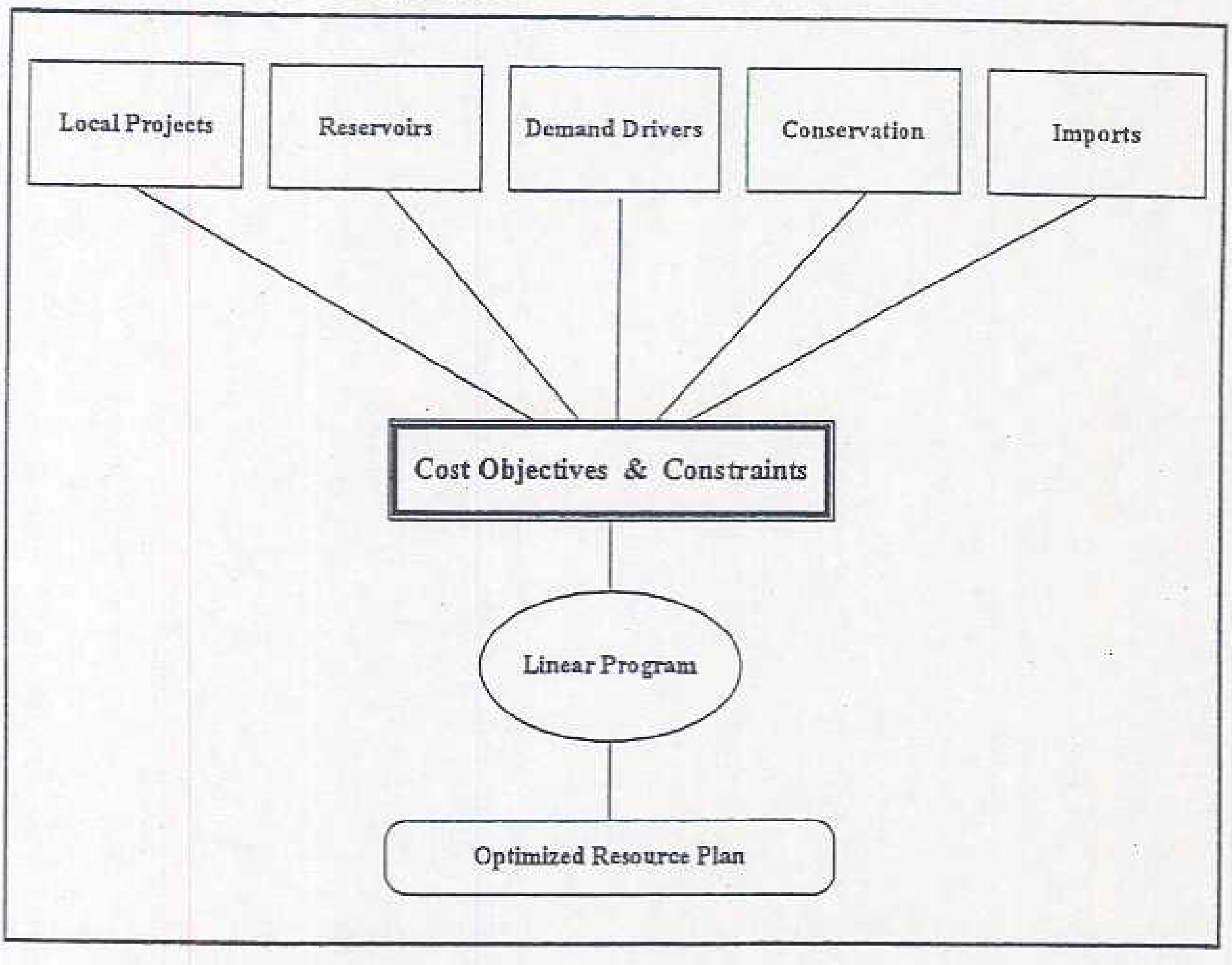
  - A single cell where the planner inputs the present value cost of that program option,
  - A single cell where the planner inputs the potential savings for the program option. This number should be the same for each option within a program.
  - A series of cells where the planner inputs the percent of potential savings achieved during each year of the forecast horizon.

  This framework allows the planner to evaluate the cost effectiveness of individual conservation measures or groups of conservation measures.

  Presumably, the total savings potential from a measure package can be achieved more quickly if the planner is willing to accept a greater present-value cost. This framework allows the planner to evaluate the desirability of pursuing groups of measures more or less aggressively.

- ***Information about transfers.*** The H_2OPTIMUM worksheets contain information about the cost and availability of water from the Metropolitan Water District as well as other sources. It is assumed that MWD water is available in all years and that the quantities are unlimited except during spells of extended dry weather. The worksheet also contains a schedule of curtailment of MWD deliveries during those periods. For sources other than MWD, the worksheet contains a single cell that allows the planner to specify whether those sources are available during all years or only during years of curtailment of supplies from MWD.
- ***Information about the assumptions underlying the resource plan.*** This includes data on the expected service obligations, the weather conditions underlying the resource plan (i.e., no drought, short drought, or long drought), the interest rate used for discounting future costs and benefits, and the perspective from which costs are to be minimized (i.e., regional or local).

Figure 2-2: The H_2OPTIMUM Logic



2.5 The Structure of the Optimization Model

As shown in Figure 2-2, the linear program contained in the H_2OPTIMUM model is based on an objective function and a set of constraints. Both the objective function and the constraints can be expressed as equations or inequalities that are relationships among subsets of the decision variables in the model. In summary, these equations are:

- The function that defines the objective of the resource plan, which is to minimize total costs.
- A set of equations that constrain the resource plan to one that allows SDCWA to meet its service obligations in every year of the forecast horizon.
- A set of equations that defines the constraints facing SDCWA with respect to the construction and utilization of prospective local resource supply projects.
- A set of constraints that defines the relationship between conservation programs and conservation program options.
- A set of constraints that defines the ability of SDCWA to use imported water, both from MWD and other sources.
- A set of constraints that deal with the storage of water by SDCWA and its member agencies. These include the following:
  - A set of inequalities that defines the maximum amount of water that can be stored in each reservoir system,
  - A set of equalities that relates current year storage to previous year storage, current year purchases, current year reservoir withdrawals, runoff and evaporation, and
  - A set of inequalities that limits the amount of water that can be purchased for storage and withdrawn from storage in any one year.
- A set of constraints that defines the extent and cost of shortages.
- A set of constraints that relates the amount of water purchased from MWD in the current year to the previous peak demand for the purposes of calculating the New Demand Charge.
- A set of equations that defines the impact of local resource supplies on the MWD rate structure. This impact is characterized as an indirect cost of the local supply and appears in the optimization model as an increment to the marginal cost of using a local resource.

These sets of expressions are explained in detail below.

Cost Minimization

The central element of the linear program used by H_2OPTIMUM is the equation that defines the present value cost of service for SDCWA. The cost of service has many components.

- The cost associated with the MWD commodity charge,
- The cost associated with the MWD new demand charge,
- The cost associated with the MWD readiness-to-serve charge,
- The cost of constructing local water resource projects,
- The annual cost of operating local water resource projects,
- The cost of operating conservation programs, and
- The cost associated with failure to meet SDCWA service obligations to member agencies.

In the spirit of the long-range integrated planning framework, all of these costs are consolidated into a single expression and all future costs are discounted using a discount rate that reflects the SDCWA cost of capital. This cost expression enters the linear program in the following form:

$$
\begin{aligned}
COST = & \sum_{YEAR=1}^{NYEARS} \tfrac{1}{(1+r)^{YEAR}} \times MWDRATE_{YEAR} \times MWD_{YEAR} \\
& + \sum_{YEAR=1}^{NYEARS} \tfrac{1}{(1+r)^{YEAR}} \times NDCRATE_{YEAR} \times POSNEWDEM_{YEAR} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{PROJECT=1}^{NPROJECTS} \tfrac{1}{(1+r)^{YEAR}} \times CAPCOST_{PROJECT} \times CONSTRUCT_{YEAR,PROJECT} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{PROJECT=1}^{NPROJECTS} \tfrac{1}{(1+r)^{YEAR}} \times OPCOST_{YEAR,PROJECT} \times LOCALAF_{YEAR,PROJECT} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{SOURCE=1}^{NSOURCES} \tfrac{1}{(1+r)^{YEAR}} \times TRANCOST_{YEAR,SOURCE} \times TRANSFER_{YEAR,SOURCE} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{PROJECT=1}^{NPROJECTS} \tfrac{1}{(1+r)^{YEAR}} \times WDCOST_{YEAR,PROJECT} \times WITHDRAWAL_{YEAR,PROJECT} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{SOURCE=1}^{NSOURCES} CONSRVCOST_{PROJECT,ALTERNATIVE} \times CONSERVPROJ_{PROJECT,ALTERNATIVE} \\
& - \sum_{YEAR=1}^{NYEARS} \sum_{PROJECT=1}^{NPROJECTS} \tfrac{1}{(1+r)^{YEAR}} \times STORVAL_{YEAR} \times STORAGE_{YEAR,PROJECT} \\
& + \sum_{YEAR=1}^{NYEARS} \sum_{BLOCK=1}^{NSHORTBLOCK} \tfrac{1}{(1+r)^{YEAR}} \times SHORTAGE_{YEAR,BLOCK} \times SHORTCOST_{YEAR,BLOCK}
\end{aligned}
$$

where

$MWDRATE_{YEAR}$ is defined as the cost of an incremental acre foot of water purchased from MWD.

MWD_{YEAR} is a variable that indicates the number of acre feet that SDCWA purchases from the Metropolitan Water District in a given year.

$POSNEWDEM_{YEAR}$ is defined as the number of acre feet purchased from MWD in a given year that is subject to the New Demand Charge. The definition of this variable in the model is explained below.

$NDCRATE_{YEAR}$ is defined as the rate per acre foot which is used to determine the New Demand Charge in a given year.

$CAPCOST_{PROJECT}$ is the capital cost of a project. In scenarios in which the cost perspective is regional, this is defined as the cash cost of the project. In scenarios in which the cost perspective is that of the SDCWA, it is defined as the cash flow associated with the repayment of loans used to finance the project. If these loans have below-market interest rates, this cost will be smaller than the cash cost of the project.

$CONSTRUCT_{YEAR,PROJECT}$ is a binary variable indicating whether or not a particular project (denoted by the subscript *PROJECT*) is built in a particular year.

$OPCOST_{YEAR,PROJECT}$ is the cost per acre foot of water produced of operating a given project in a particular year.

$LOCALAF_{YEAR,PROJECT}$ is a variable that indicates the number of acre feet produced by a given project in a given year.

$TRANCOST_{YEAR,SOURCE}$ is defined as the cost of an acre foot of water purchased from a particular source (denoted by the subscript *SOURCE*) in a given year.

$TRANSFER_{YEAR,SOURCE}$ is a variable that indicates the number of acre feet purchased from a source other than MWD during a given year.

$WDCOST_{YEAR,PROJECT}$ is the cost of removing an acre foot of water from a reservoir project in a given year. It represents the cost of pumping water from the reservoir to the place where it will be treated.

$WITHDRAWAL_{YEAR,PROJECT}$ is a variable that indicates the amount of water withdrawn from a reservoir project in a given year.

$CONSRVCOST_{PROJECT,ALTERNATIVE}$ is the cost of implementing a set of conservation measures at a given rate (denoted by the subscript *ALTERNATIVE*).

$CONSERVPROJ_{PROJECT,ALTERNATIVE}$ is a binary variable indicating the selection of a given alternative implementation of a set of conservation measures.

$STORVAL_{YEAR}$ is the value that SDCWA attaches to having an inventory of water on hand in a given year. This value is an offset against total cost and can be interpreted as the benefit of insurance against shortages.

$STORAGE_{YEAR,PROJECT}$ is a variable that represents the quantity of water (in acre feet) that is stored in the project denoted by the subscript *PROJECT* during a given year.

$SHORTCOST_{YEAR,BLOCK}$ represents the cost that SDCWA associates with failure to meet its obligation to provide water to its member agencies in a given year. Shortages are assumed to occur in blocks of limited size (denoted by the subscript *BLOCK*) which have increasing cost.

$SHORTAGE_{YEAR,BLOCK}$ is a variable indicating some number of acre feet by which the SDCWA fails to meet its delivery obligations in a given year subscript *YEAR*. Again, shortages are assumed to occur in blocks of limited size which have increasing cost.

r is defined as the real cost of capital to the SDCWA. This interest rate determines the rate at which costs that are incurred in future years are discounted for the purposes of determining optimal deferral of project construction.

The expression $\frac{1}{(1+r)^{YEAR}}$ in each of the cost terms represents the discount factor for each element of the total cost over the planning horizon. This discounting is important because it causes the model, all other things constant, to defer the construction of large capital projects. As a result, projects that are marginally competitive with imported water will be deferred until the availability of that water is constrained.

Demand-Supply Constraints

In the linear program used by H_2OPTIMUM, the cost function described above is minimized subject to a set of constraints. The most important subset of those constraints is the demand-supply constraint shown below. If not for the presence of this constraint, the minimization routine used by the program would choose to provide no water at zero cost. The constraint takes the form:

$$\begin{aligned} DEMAND_{YEAR} = [& MWD_{YEAR} + \sum_{PROJECT=1}^{NPROJ} LOCALAF_{YEAR,PROJECT} + \sum_{PROJECT=1}^{NPROJ} WITHDRAWAL_{YEAR,PROJECT} \\ & - \sum_{PROJECT=1}^{NPROJ} DEPOSITS_{YEAR,PROJECT} + \sum_{SOURCE=1}^{NTRANS} TRANSFERS_{YEAR,SOURCE} \\ & + \sum_{CPROJ=1}^{NCPROJ} \sum_{CALTERN=1}^{NCALTERN} SAVINGS_{YEAR,CPROJECT,CALTERN} \\ & \times CONSERVPROJ_{CPROJECT,CALTERN} + \sum_{BLOCK=1}^{NSBLOCKS} SHORTAGE_{YEAR,BLOCK}] \end{aligned}$$

where

> $DEPOSIT_{YEAR,PROJECT}$ is a variable indicating the amount of transfer water placed in a given reservoir (denoted by the subscript *PROJECT*) in a given year (denoted by the subscript *YEAR*). Note that this excludes natural runoff, which is counted as an addition to the inventory of the reservoir and is available for withdrawal during the current year or later years.
>
> $SAVINGS_{YEAR,CPROJECT,CALTERN}$ is a variable that indicates the savings associated with a given alternative implementation (denoted by the subscript *CALTERN*) of a given mix of conservation measures (denoted by the subscript *CPROJECT*) in a given year (denoted by the subscript *YEAR*).

All other variables are defined as before. Several aspects of the demand-supply constraint should be noted:

- The sum of the third and fourth terms of the left-hand side of the equation (those involving *WITHDRAWAL* and *DEPOSIT*) are intended to represent the use of MWD, and to a lesser extent other transfer water, as a stored resource. To the extent that reservoir withdrawals exceed deposits, water that was purchased in previous years is being used to meet current year demand. To the extent that deposits exceed withdrawals, water is being purchased in the current year that can be used to meet demand in subsequent years.
- The term involving the *SAVINGS* and *CONSERVPROJ* terms is equal to the offset against forecast demand accounted for by conservation efforts. Recall that the *CONSEVPROJ* is a binary variable indicating the choice of an alternative implementation of a set of conservation measures. If the binary variable takes the value 1, the effective demand that is met by transfers, reservoir draw down and local resource utilization is reduced by the amount *SAVINGS*.
- The term involving the *SHORTAGE* variable represents the gap between demand and water available from MWD, local projects, and reservoir draw down. The model logic also allows SDCWA to fail to meet its service obligation, at no cost, by 20% one year during the planning horizon. This is accomplished by reducing the right-hand side of the demand-supply constraint by 20% in the third consecutive year that is designated as "dry" by the planner. The treatment of shortages is discussed below.

The right-hand side of the constraint ($DEMAND_{YEAR}$) is equal to the current forecast of water demands placed on SDCWA and local resources by its member agencies assuming the current level of conservation and projected growth in population. This forecast assumes no additional conservation activity beyond that already in place. New conservation efforts are modeled explicitly as a resource that can be employed to meet forecast demand.

Project Constraints

In the H_2OPTIMUM model, there are two sets of decision variables associated with each of the local projects contained in the database. First, there is the collection of variables previously referred to as *CONSTRUCT* which indicate whether or not a given project is constructed in a given year. Second, there is *AFLOCAL*, which is the quantity of water produced by each project in each year. Two sets of constraints are imposed on the solution to ensure that the resource plan is consistent with the following:

- The principles of common sense in that local projects appearing in the H_2OPTIMUM database are built only once, and
- Actual capacity of resources to deliver water.

The first constraint can be expressed as follows:

$$\sum_{YEAR=FIRSTYEAR}^{LASTYEAR} CONSTRUCT_{PROJECT,YEAR} \leq 1$$

where the variable *CONSTRUCT* is previously defined. There is one binary variable for each year of the resource plan so that the optimization model can defer the construction of the project to most efficiently meet demand growth. This constraint is imposed once for each project and states that the sum across years of the *CONSTRUCT* variable can be no larger than 1.

The second, more crucial constraint can be expressed as:

$$AFLOCAL_{YEAR,PROJECT} \leq CAPACITY_{PROJECT} \times \sum_{PREVYEAR=FIRSTYEAR}^{YEAR} CONSTRUCT_{PREVYEAR,PROJECT}$$

where $CAPACITY_{PROJECT}$ is defined as the maximum yield of the project denoted by the subscript *PROJECT*. This inequality says that the yield of any project must be lower than the product of the maximum yield and the sum of the *CONSTRUCT* binaries from the beginning of the planning period until the current period. Another way of expressing this is to say that the yield of the project is constrained to 0 until the year in which the project is "built" and is constrained to the capacity of the projects for years thereafter.

It should be remembered that the optimized value of the *CONSTRUCT* and *AFLOCAL* variables are determined simultaneously and not sequentially. In other words, the model does not first determine whether to build a given project and then, given the construction decision, determine the utilization. Instead, these values are determined jointly, with the model implicitly making the tradeoffs between the benefits of construction deferral (or avoidance) and the availability of water from the project.

Treatment of Conservation Projects

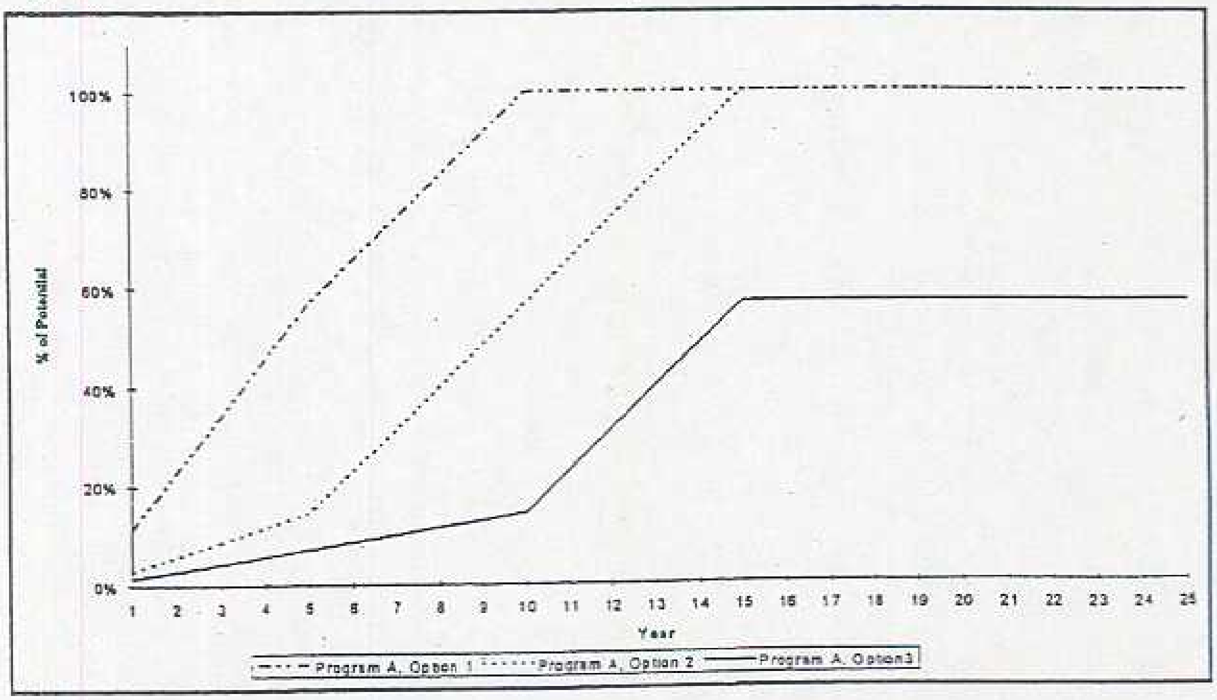
Like construction projects, conservation opportunities can only be exploited once. However, conservation projects are different in two senses:

- First, there is no year index on the binary variables representing the selection of conservation project alternatives. Because the decision to pursue the adoption of a conservation measure is made once implies a long-lived stream of demand reduction, the appearance of a "1" in the optimal resource plan implies the purchase of a multi-year reduction in supply obligations. The project alternatives represent more (or less) rapid achievement of potential savings. The nature of conservation impacts is impact is illustrated in Figure 2-3.
- Second, project alternatives represent mutually exclusive versions of the same program (i.e., collection of conservation measures). In order to enforce this structure, the model has the following constraint embedded in it:

$$\sum_{ALTERNATIVE=1}^{NALTERNATIVE} CONSERVPROJ_{PROJECT,ALTERNATIVE} \leq 1$$

The intuition for this constraint is relatively straightforward. It says that if a set of project alternatives are variations of the same collection of conservation measures, then only one (or zero) alternative can be used as an offset to demand in the final resource plan.

Figure 2-3: Treatment of Conservation Options



Treatment of Transfers

The treatment of water transfers is relatively intuitive in the model. Transfer water from MWD and other sources is counted as a potential means of meeting supply obligations. Its cost in the optimization framework in H_2OPTIMUM depends on the source.

- For MWD water, the cost of water is equal to the MWD commodity rate.
- For other transfers, the cost is equal to the price paid to the original owner of the water rights plus the charges that MWD levies for the transportation of the water for SDCWA.

The availability of transfer water is also constrained. For MWD water, the constraint can be expressed as:

$$MWD_{YEAR} \leq MWD_{YEAR}^{MAX}$$

where MWD^{MAX}_{YEAR} is equal to the maximum amount of water that can be obtained from MWD. MWD water is, for all intents and purposes, available without limit under ordinary circumstances. In the baseline databases provided to SDCWA, the MWD availability constraint is set so high as to be meaningless (approximately 2,000,000 acre feet per year). The exception to this rule is during extended periods of dry weather, when the maximum availability of MWD water is set equal to some fraction of the forecast purchase of MWD water. This fraction decreases, on a schedule chosen by the planner, as the period of dry weather becomes longer.

For transfers from sources other than MWD, the logic used by H_2OPTIMUM limits the availability of non-MWD transfer water using the following constraint:

$$TRANSFER_{YEAR,SOURCE} \leq TRANSFER_{YEAR,SOURCE}^{MAX}$$

where $TRANSFER_{YEAR,SOURCE}^{MAX}$ is equal to a maximum set by the planner for each transfer opportunity. At the option of the planner, transfers can be unavailable entirely during periods of normal rainfall. In this case, the maximum transfer from each source is set equal to 0.

Treatment of Storage

The ability to account for the storage of water is an important feature of the H_2OPTIMUM framework. The framework explicitly accounts for the possibility of reservoir construction and the drawing down of reservoir inventories during extended spells of dry weather as an alternative to local resource construction. In order to deal with storage in a manner that accurately reflects the use of reservoirs to absorb variations in water supply, the model imposes four classes of constraints:

- First, the model imposes a constraint on the total stock of water that can be held in each reservoir project at any time. This constraint takes the form:

$$STORAGE_{PROJECT,YEAR} \leq STORECAP_{PROJECT} \times \sum_{PREVYEAR=FIRSTYEAR}^{YEAR} CONSTRUCT_{PROJECT,PREVYEAR}$$

where $STORAGE_{PROJECT,YEAR}$ is equal to the annual stock of water in each project (denoted by the subscript *PROJECT*), and the end of each year (denoted by the subscript *YEAR*) and $STORCAP_{PROJECT}$ is equal to the maximum storage capacity of the reservoir.

The mechanics of this constraint are similar to those imposed on project yield. If a reservoir project has not yet been built (i.e., the *CONSTRUCT* variable has the value 0 in all years previous), its storage capacity is constrained to 0. If the *CONSTRUCT* variable takes the value 1 in any year, the maximum capacity is equal to *STORCAP* in all subsequent years.

- Second, the model imposes two constraints that limit the flow of water into each reservoir from transfer sources (deposits) and out of the reservoir into treatment plants (withdrawals). These constraints take the following form:

$$DEPOSIT_{PROJECT,YEAR} \leq DEPOSITCAP_{PROJECT} \times \sum_{PREVYEAR=FIRSTYEAR}^{YEAR} CONSTRUCT_{PROJECT,PREVYEAR}$$

and

$$WITHDRAWAL_{PROJECT,YEAR} \leq WDCAP_{PROJECT} \times \sum_{PREVYEAR=FIRSTYEAR}^{YEAR} CONSTRUCT_{PROJECT,PREVYEAR}$$

Again, withdrawals and deposits are constrained to 0 until the year of construction. In later years, withdrawals and deposits are constrained to an upper limit specified by the planner.

- Third, the model imposes an equality constraint that, in effect, defines the amount of water in storage at the end of each year. This constraint takes the form:

$$STORAGE_{YEAR,PROJECT} = [STORAGE_{(YEAR-1),PROJECT} + AFLOCAL_{YEAR,PROJECT}$$
$$- EVAP_{YEAR,PROJECT} + DEPOSIT_{YEAR,PROJECT}$$
$$- WITHDRAWAL_{YEAR,PROJECT}]$$

where $EVAP_{YEAR,PROJECT}$ is equal to the rate of evaporation (in acre feet) from a given project (denoted by the subscript *PROJECT*) in a given year (denoted by the subscript *YEAR*). It should be noted that *EVAP* is not a choice variable but is set by the planner.

- Finally, the model imposes a set of constraints that places a lower limit on the amount of water stored at any time at reservoirs qualifying as "emergency storage" facilities. This constraint is expressed as:

$$\sum_{PROJECT1}^{NPROJECTS} STORAGE_{YEAR,PROJECT} \times ESPIND_{PROJECT} \geq ESPLIMIT_{YEAR}$$

  where $ESPIND_{PROJECT}$ is either 0 or 1, depending on whether or not the project qualifies as emergency storage, and $ESPLIMIT_{YEAR}$ is the minimum storage in a given year defined by the planner.

As with the construction and utilization of local supply projects, it should be remembered that the decision to construct a reservoir project and the decisions to deposit, store and withdraw water are made simultaneously and not sequentially. In other words, the optimization model implicitly trades off the benefits of deferring (or avoiding) construction against the benefits of storing water for future use.

Treatment of Shortages

As mentioned above, the H_2OPTIMUM model allows SDCWA to fail to meet its projected service obligation. The treatment of the shortage issue takes two forms:

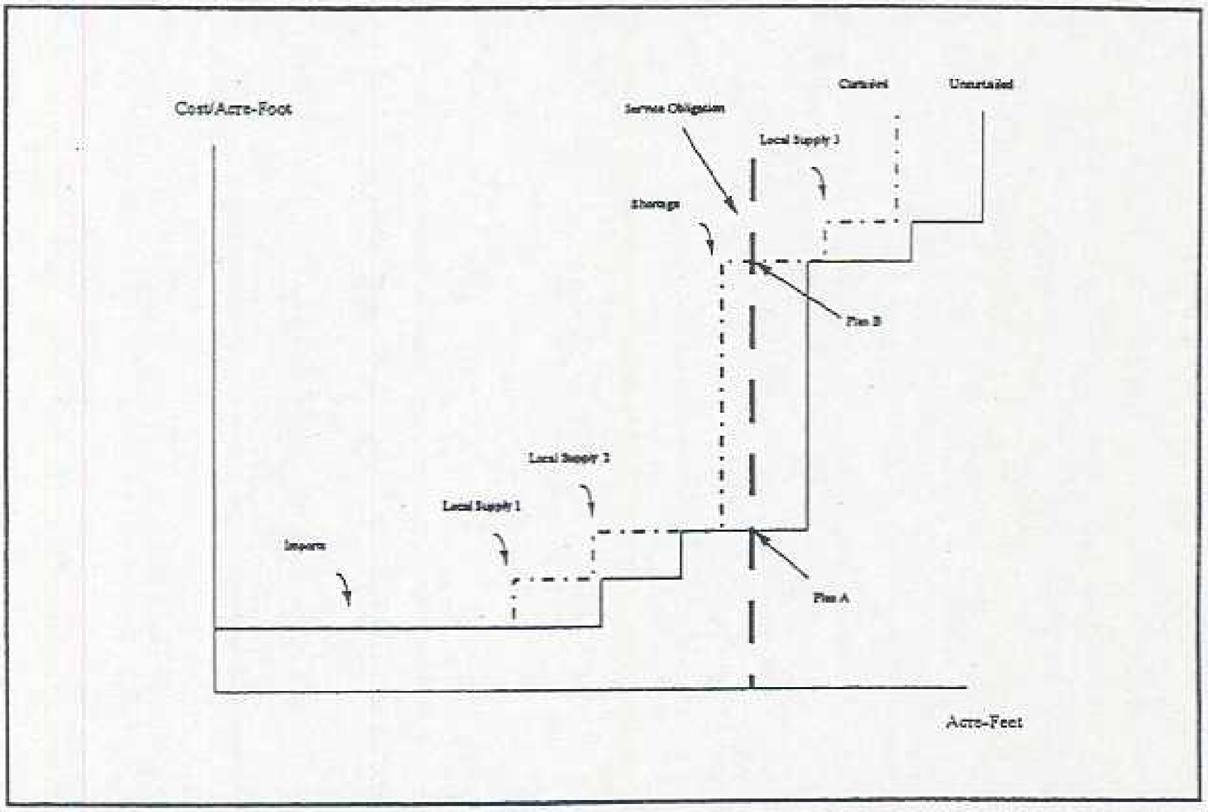
- First, SDCWA is allowed to curtail deliveries (at no cost) to member agencies by 12% during one year in a period of extended dry weather. For the purposes of this modeling effort, the one-year reduction in deliveries is assumed to occur in the third consecutive year of dry weather.
- Second, SDCWA can fall short of its scheduled deliveries to member agencies by any amount. These shortages are assumed to occur at a cost that is defined by the user and increases with the size of the curtailment.

The H_2OPTIMUM model assumes that shortages occur in blocks. In effect, these shortage blocks are equivalent to an alternative resource that is very costly. Consequently, shortages will occur in an optimized resource plan only when either no alternative is available or when the available alternatives are prohibitively expensive. An example of this might be when normal deliveries of imported water are severely curtailed.

A simplified illustration of this situation for a single-year resource plan is illustrated in Figure 2-4. The solid stairstep line represents the merit ordering of the available resources under normal conditions. The dashed vertical line represents the agency's delivery obligations. Under these conditions, the agency takes all available imports, all of the output from local resource 1, and some of the output from local resource 2. Under a curtailment, represented by the dashed stairstep, the optimal resource plan takes all of the curtailed imports, all of the output from local resources 1 and 2, and accepts a shortage which is less costly than local resource 3.

In practice, the value of avoiding shortages is quite large. Therefore, there are a large number of local resource and transfer options that can be efficiently exercised instead of shortages. A detailed discussion of the nature of shortage costs is contained in Section 3.

Figure 2-4: Illustration of Shortage Costs



In addition to the appearance of shortages in the cost expression and the demand-supply constraint explained above, H_2OPTIMUM imposes a set of constraints restricting the size of the shortage blocks. This set of constraints can be expressed as:

$$SHORTAGE_{YEAR,BLOCK} \leq BLOCKSIZE_{BLOCK}$$

where $BLOCKSIZE_{BLOCK}$ is the size of the shortage blocks. The size of the blocks, the cost of the first curtailed acre foot and the rate at which shortage cost increases with respect to the total shortage is specified by the planner.

Treatment of the New Demand Charge

Beginning in 1996, water purchases from MWD will be subject to a New Demand Charge (NDC). The intent of the NDC is to compensate MWD for the construction of the facilities necessary to accommodate growth in demand. SDCWA incurs an NDC when its demand exceeds a base of approximately 559,000 acre feet per year. When a new demand charge is paid, the NDC base is increased to the demand in that year. In reality, the basis of this charge is a four-year average of annual demand. However, using a four-year average increases the complexity of the overall problem and computational effort necessary to solve it. As a result, after consulting with SDCWA staff, a simplifying assumption that the NDC is based on one-year demands was used.

The H_2OPTIMUM model treats the NDC by creating a pair of variables representing the difference between current year demand and the NDC base. In any given year, SDCWA is in either a state of negative new demand or a state of positive new demand. The positive new demand variable enters the cost function with a coefficient equal to the NDC rate. The negative new demand variable does not enter the cost equation but is necessary to create the constraints that determine the size of the positive new demand variable.

The first constraint sets the demand for MWD water in any given year equal to the following:

- The original new demand charge base, plus
- The sum of all of the new demands from all previous years, which accounts for the increase of the base when a NDC is paid, plus
- The current year's increment to the demand base (the positive new demand) if current year demand exceeds the historic peak, minus
- The difference between the current year demand and the historic peak if the current year demand is less than the historic peak.

Mathematically, this is expressed as follows:

$$MWD_{YEAR} = NDCBASE + \sum_{PYEAR=1}^{YEAR-1} POSNEWDEM_{PYEAR} + POSNEWDEM_{YEAR}$$

$$- NEGNEWDEM_{YEAR}$$

where

> *NDCBASE* is the number of acre feet that the new demand charge is based on at the outset of the planning period.

> $NEGNEWDEM_{YEAR}$ is a variable that represents the number of acre feet that the demand from MWD in a given year falls short of the peak demand established in previous years. If demand exceeds the previous peak, $NEGNEWDEM_{YEAR}$ is equal to 0.
>
> $POSNEWDEM_{YEAR}$ is a variable which represents the number of acre feet taken in a given year (denoted by the subscript *YEAR*) in excess of the peak demand established in previous years. If demand is less than the previous peak, $POSNEWDEM_{YEAR}$ is equal to 0.

In order to prevent positive new demand and negative new demand from occurring in the same year, two additional variables and three additional constraints are added to the model. The two variables are a pair of binary variables (taking a value 0 or 1) that indicate if SDCWA is in a state of positive or negative new demand in the current year. These variables enter into a pair of constraints that have the effect of restricting the positive new demand to 0 when the positive new demand indicator is 0 and restricting the negative new demand to 0 when the negative new demand indicator is equal to 0. These constraints take the following form:

$$POSNEWDEM_{YEAR} \leq 1{,}000{,}000 \times POSNDIND_{YEAR}$$

and

$$NEGNEWDEM_{YEAR} \leq 1{,}000{,}000 \times NEGNDIND_{YEAR}$$

where

> $POSNDIND_{YEAR}$ is a binary variable indicating whether total SCDWA demand in a given year (denoted by the subscript *YEAR*) has exceeded either 1) the initial benchmark established for new demand charges, or 2) some new higher threshold established by demand in a previous forecast year.
>
> $NEGNDIND_{YEAR}$ is a binary variable indicating whether total SCDWA demand in a given year (denoted by the subscript *YEAR*) is below either 1) the initial benchmark established for new demand charges, or 2) some new higher threshold established by demand in a previous forecast year.

The last constraint restricts the sum of the negative new demand indicator and the positive new demand indicator to 1.

$$POSNDIND_{YEAR} + NEGNDIND_{YEAR} \leq 1$$

The Impact of Local Resources on MWD Rates

A remaining element of the H_2OPTIMUM logic is the treatment of local resources on MWD rates. This element is important because the cost savings associated with local resource development may be partially canceled out by the fact that MWD rates (which are based on average costs) are sensitive to the number of acre feet that MWD sells. This effect is particularly important in light of the fact that up to 85% of MWD's costs are fixed. SDCWA will continue to absorb a large fraction of those fixed costs, regardless of the amount of water that it buys from MWD.

In order to quantify this effect, we begin by noting that the total cost of water to SDCWA can be expressed as follows:

$$TC_{SDCWA} = C_{LOCAL} AF_{LOCAL} + VARC_{MWD} AF_{MWD} + FIXC_{MWD} AF_{MWD}$$

where

C_{LOCAL} is the marginal cost of producing water from local projects,
AF_{LOCAL} is the number of acre feet produced locally,
$VARC_{MWD}$ is the variable cost component of the MWD rate,
$FIXC_{MWD}$ is the fixed cost component of the MWD rate, and
AF_{MWD} is the number of acre feet bought from MWD.

Taking the change and rearranging terms yields the following equation:

$$\frac{\Delta TC}{\Delta AF_{LOCAL}} = C_{LOCAL} + \left(\frac{AF_{MWD}}{FIXC_{MWD}} \frac{\Delta FIXC_{MWD}}{\Delta AF_{MWD}} \right) FIXC_{MWD}$$

The interpretation of this expression is that the incremental cost of obtaining an acre foot of water locally is equal to the marginal operating cost of the local project plus an adder that is related to the fixed-cost component of the MWD rate. The bracketed term in this expression is the elasticity of the fixed-cost component of the MWD rate with respect to SDCWA purchases from MWD. This is approximately equal to the share of total MWD sales made to the SDCWA (between 25% and 30%%).

The impact of this procedure is to increase the cost of locally produced water by about $90 per acre foot. It should be noted that the inclusion of the price feedback effect is an optional aspect of an H_2OPTIMUM resource plan. The planner has the ability to construct resource plans that ignore price feedback by specifying that option in the "Define Scenario" module of the H_2OPTIMUM worksheet.

It should be noted that this adjustment assumes that the reduction in MWD water purchases is small relative to the total and that fixed costs are reallocated to MWD customers in proportion to remaining demand. If a local project were to displace a significant fraction of MWD demand, it is likely that the fixed cost component of the MWD rate would be reallocated disproportionately to SDCWA agencies and that the adjustment described above and used in H_2OPTIMUM would no longer apply.

Appendix D

Appendix D

Shortages

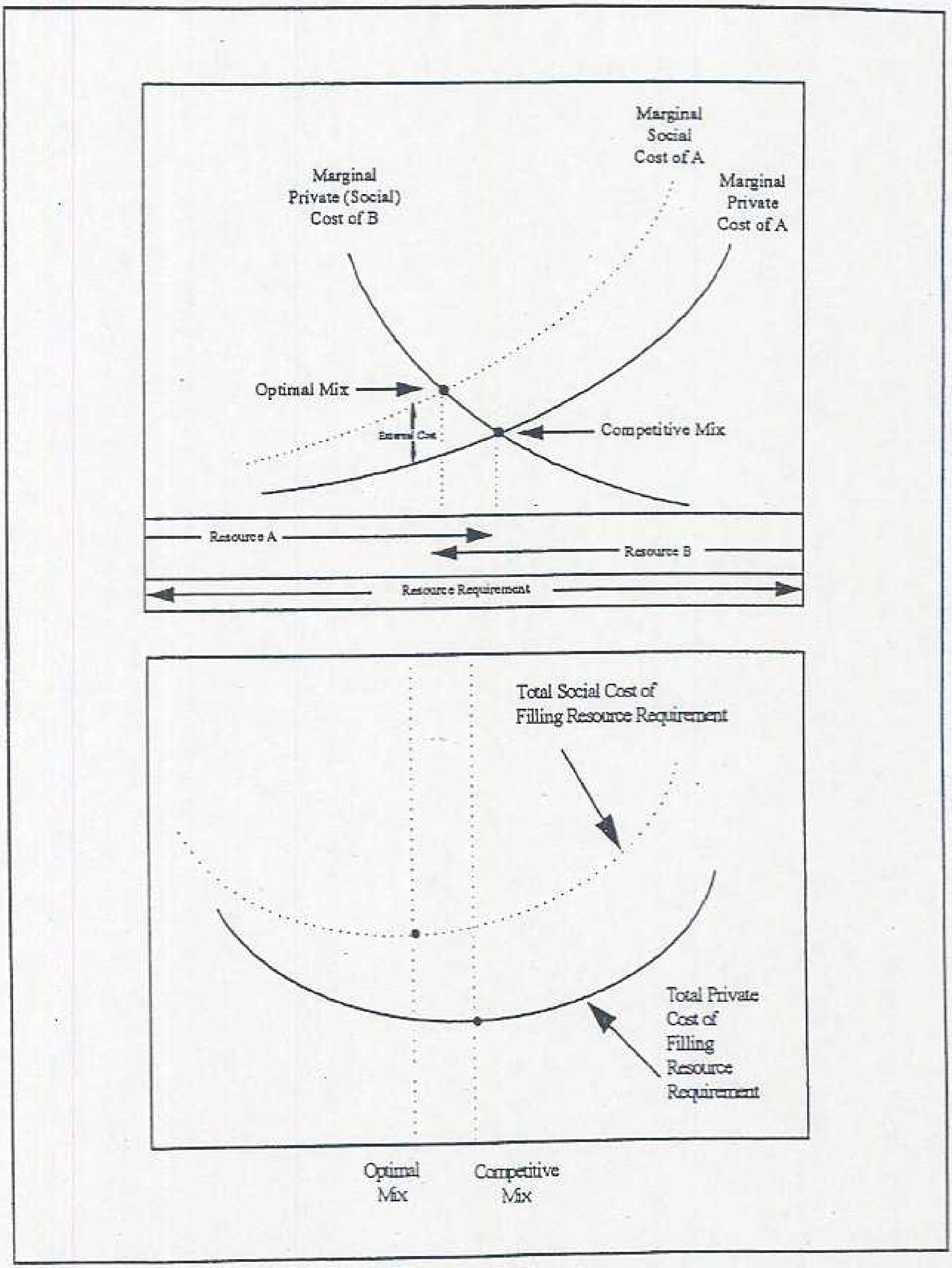
D.1 Water Shortages as a Resource

The reliability of an urban water system is often taken for granted. However, reliability or the lack of water shortages requires significant investments in facilities (conveyance, storage) to offset natural variations in precipitation. Thus, one can insure that water deliveries are not interrupted by investing in sufficient water delivery and storage facilities. On the other hand, one can risk water shortages given a smaller investment. If shortages do occur, then consumers and producers bear the burden of smaller water allocations in terms of lost satisfaction and profits.

The optimal amount of reliability can be determined through an examination of the tradeoff between the cost of water delivery and storage facilities and the cost to consumers and producers of water shortages. This type of analysis is demonstrated in Figure D-1 where dollars and reliability are measured on the vertical and horizontal axes, respectively. As is illustrated, any specific level of reliability will have two cost components: the cost of new facilities, and the cost of customer losses. The cost-minimizing level of reliability is established at the point where the sum of these two cost components is minimized (shown as R* in panel A of the figure). The point R* is sometimes referred to as a *interior* solution. It should also be noted that R* occurs at the point at which the marginal (or incremental) cost of water delivery and storage is equal to the marginal cost to customers of water shortages (panel B of Figure D-1).

In effect, one can view water shortages as a potential resource that should be utilized optimally. In the general case, the water authority should not overinvest in facilities in order to minimize shortage costs, nor should it underinvest in facilities, thereby exposing its customer base to excessive shortage costs. Rather, the reliability of the system should be determined optimally in a general planning framework.

Figure D-1: Determination of Optimal Total Water Supply



D.2 Water Shortage Costs

As indicated above, the costs associated with a water shortage are a significant determinant of the optimal level of reliability for an urban water system. In this section we describe cost estimates of these shortage costs.

The first method used to evaluate customer costs of a water shortage involves direct estimation of observable losses (lawns and gardens, lost profits, etc.) to water users. Russell, et al., (1970) found these observable losses to be surprisingly small. Kates and Dworkin (1973) found a similar result: estimated drought-induced water shortage costs are approximately three to five dollars per capita. Estimates from the 1976-77 drought in Northern California indicate that out-of-pocket costs were approximately $570 per single family dwelling in Marin County (see Meral, 1979).

The general conclusion of the observable cost studies is that system shortages do not mean disaster. In fact, these cost magnitudes are quite small relative to the cost that would be incurred to reduce the shortage potential through additions to water delivery and storage systems. In terms of Figure D-1, above, these values indicate that water systems are likely too reliable and that efficiency would be increased by reducing reliability. However, directly observable out-of-pocket expenses are an underestimate of the real shortage cost since they ignore the loss in customer utility or satisfaction associated with using less water. For example, an individual may wash his/her car weekly at home given normal water conditions. Under drought conditions, car washing may be prohibited except at facilities that use recycled water. If the individual uses the car washing facilities, then it is likely that two types of costs would be incurred. First, the individual would have to pay out-of-pocket to utilize the car wash facility. Second, the individual would wash his/her car less often (price has risen), thereby incurring a loss in utility associated with driving a clean car. Cost estimates that examine only out-of-pocket expenses would be an underestimate of total costs.

In order to estimate the true cost of water shortages, an alternative to directly observable estimates is required. The contingent valuation method, which involves the use of respondent surveys to elicit the value that individuals attach to hypothetical projects or programs, has been used recently to estimate the economic value of water supply reliability. Three studies that are remarkably similar in method and corresponding results have been completed in the last decade (see Mitchell and Carson, 1987; Howe and Smith, 1994; Barakat & Chamberlin, 1994). The most relevant of these contingent valuation studies was conducted for the California Urban Water Agencies (CUWA) in 1994 (see Barakat & Chamberlin). In fact, one of the sub-sample surveys in this study was conducted among a sample of users in the SDCWA region. The results of the study indicate that SDCWA water users would be willing to pay an additional $10.23 per month per household to prevent one year of 10% water shortage over the next 10 years. Household willingness to pay increases with both the frequency (number of shortages per specified time period) and the severity of the shortages (percentage reduction from full service). For instance, SDCWA households are willing to pay $10.67 to prevent one 10% shortage every three years and $16.67 to prevent one 40% shortage every 10 years.

There are two important implications of these values. First, the water agency should plan to have no water shortages since households are willing to pay large amounts to prevent even rare and/or small shortages. Second, if any water shortage is economically viable, then more frequent and larger shortages are even more economically viable. These conclusions, when taken together, imply that R* does not occur as an interior solution as in Figure D-1, but rather occurs as a *corner*, or all or nothing, solution (shown as R_{min} or R_{max}).

These conclusions can be illustrated with the following example. Since the average household uses approximately one-half acre foot of water per year, then households in the SDCWA region are willing to pay an additional $10.23 per month every month for 10 years to prevent the loss of .05 acre feet of water (10% reduction of .5 acre feet). This implies a value of $18,954/acre foot using a 5% discount rate over the specified 10-year period. Of course, higher discount rates produce smaller values per acre foot and vice versa. This value per acre foot is significantly higher than any alternative demand management or supply resource option. Thus, if these values are representative of customer preferences then the water authority should plan for zero periods of shortage since even a single shortage causes very large economic losses.

The second implication (that if some shortage is economically warranted, then more frequent and larger shortages are even more economically viable) can be seen as follows. As indicated above, SDCWA customers are willing to pay approximately $18,954/acre foot to prevent a one-year 10% water shortage. The Barakat & Chamberlin report also indicates that SDCWA customers are willing to pay $12.24/month ($14.40/month, $16.67/month) to prevent a one year 20% (30%, 40%) water shortage over the next 10 years. This monthly value translates into $11,339/acre foot ($8,893/acre foot, $7,721/acre foot). Thus, as the percent shortage increases the acre foot value declines, indicating that shortages can be supplied with declining marginal cost (customers are willing to accept less compensation per unit as the percent shortage increases). Customers are seemingly willing to part with their most valued water uses in times of shortage while maintaining their relatively less valued uses for potential larger and/or more frequent shortages.

If one accepts the notion of declining marginal cost, which is indicated by the Barakat & Chamberlin data, then it seems reasonable to expand the frequency and magnitude of the shortages to take advantage of these declining costs. That is, one should expand shortages until they can not be expanded further. The corresponding policy prescription is for the authority to not supply any water and have 100% shortage all the time. Of course, this policy prescription is nonsense, which leaves one to question the validity of the Barakat & Chamberlin contingent valuation results. Also, since these results are quite similar to those offered by Mitchell and Carson (1987) and Howe and Smith (1994), one might question the general contingent valuation method. In Appendix E, we describe the contingent valuation method in detail. In the next subsection, we attempt to explain the Barakat & Chamberlin results in this context.

D.3 Review of Barakat & Chamberlin Contingent Valuation Results

As indicated above, the Barakat & Chamberlin (1994) contingent valuation results lead to an all-or-nothing public policy which seems counter-intuitive. Relative to the NOAA survey guidelines outlined previously, the Barakat & Chamberlin survey has several deficiencies which could account for the results. First, the survey was conducted using a combination mail/telephone approach. NOAA recommends the use of personal interviews. Second, the description of the consequences of a water shortage is quite accurate. However, since the material was sent in the mail and it required the respondent to read and understand without interviewer assistance, there might not have been adequate confirmation that respondents fully understood that their least-valued water uses would be eliminated first in any shortage. This type of misunderstanding could account for the survey results, which seem to indicate that individuals place the highest value on the last units of water purchased, contrary to all economic theory. Third, the survey does use the recommended willingness-to-pay design in a referendum elicitation format. However, the monthly payment vehicle is not the recommended conservative design and would imply that the survey results are overestimates of true values. Finally, the survey results seem beset by the embedding problem, in which respondents are willing to pay similar amounts for both small and large changes from the status quo. This list of deficiencies in the Barakat & Chamberlin (1994) study, together with the counter-intuitive results, are sufficient for us to conclude that the reliability values that were generated should be considered highly suspicious.

D.4 Recommended Position On Reliability

Our review of the Barakat & Chamberlin study, as well as other literature in this area, indicates that the estimated monetary shortage values should be questioned. However, all the studies show that respondents are highly averse to the possibility of water shortages by consistently ranking water reliability as an important public concern. Thus, we conclude that customers do not want any more water shortages than those currently planned by MWD (one 20% shortage over the next 50 years, one 10% shortage over the next 10 years) and the

SDCWA (one 12% shortage over the next 20 years). That is, the current water reliability goals should be adopted and that an increase in water shortages as a resource should not be considered.

Appendix E

IV. VERIFICATION AND CALIBRATION OF FORECAST MODELS

This chapter details the verification of the uncalibrated forecast models, the steps required in calibration, and final verification of the calibrated forecast models. Indicators of model performance are provided by individual agency and for the SDCWA service area as a whole.

FORECAST MODEL VERIFICATION

Verification of the econometric models is an important step in the forecast process. The process of verification assesses the ability of the three models to produce estimates within acceptable bounds of observed historical values. The magnitude of the differences between predicted and observed values is taken as an indicator of model performance. Models that consistently produce estimates in close proximity of observed values are desired.

Verification of the SDCWA models was performed for the base year of 1990 and the intermediate forecast year of 1993. For the purposes of verification and calibration, 1990 was selected as the base year because it was a census year with a likely higher degree of accuracy in estimates of housing units, employment, and other important variables. The required set of explanatory and driver variables were derived from SANDAG Series 8 demographic projections. Actual total annual M&I (non-agricultural) water demands for each SDCWA member agency were derived for 1990 and 1993 from monthly summary demand data provided by the Authority.

Table IV-1 presents the results of verification of the uncalibrated sectoral models for 1990. The predicted and the reported water use are listed by agency in the second and third columns, respectively. The absolute difference between the predicted and reported values is presented in the fourth column. The last column of the table presents the discrepancy between predicted and reported water use in percentage terms.

The uncalibrated models provide a varying degree of accuracy for individual agencies for 1990. The variation in error is a direct product of the ordinary least squares (OLS) regression technique used to estimate the models. In minimizing the sum of squared errors among a set of observations, one should expect OLS to balance over- and under-predictions for individual observations (as well as subgroups such as agencies and sectors) to produce the best fitting regression line to the data. Another important factor that contributes to the variation of error among the sites is the degree of accuracy of SANDAG estimates regarding the number of housing units, population, and employment levels. This error (or sometimes called *uncertainty*) enters both the estimation of the water use model parameters and the resultant water use forecasts.

The largest percentage discrepancy between predicted and total water use is for the SDCWA's smallest agency, Yuima (over-prediction by 69.6 percent). The largest absolute difference between predicted and reported water use is registered by Sweetwater Authority (over-prediction of 10,601 acre-feet).[9] The uncalibrated models perform well for SDCWA's largest water using agencies, the City of San Diego (+0.9 percent), Helix (+0.5 percent), a composite agency of Rincon del Diablo and Escondido[10] (-1.9 percent), and Oceanside (+3.1 percent). As the table summary indicates, the model produced an overall uncalibrated discrepancy of 1.6 percent for the base year 1990.

To further verify the accuracy of the uncalibrated model, the set of explanatory variables for 1993 were input into the sectoral water use models and used to prepare water use estimates for 1993. Demographic data for housing units and employment are known with less certainty for 1993, since they were interpolated between SANDAG estimates for 1990 and 1995. Table IV-2 presents the results of verification of the uncalibrated forecast model on 1993.

Just as in 1990, model performance for individual agencies varies, but overall model performance is quite good. As shown, the uncalibrated models once again perform well for SDCWA's largest agencies. Similar to 1990 verification, the largest percentage and absolute differences between predicted and reported water use are registered by Yuima and Sweetwater Authority, respectively. For the SDCWA service area as a whole, the models produced a prediction of 483,263 acre-feet (AF), approximately 5 percent more than what was actually reported.

FORECAST MODEL CALIBRATION

The process of calibration seeks to fine-tune within-agency model performance by adjusting the model intercepts for each agency. In order to calibrate each of the three models for each agency, the model intercepts are adjusted uniformly to equate the predicted value of water use for each agency to its reported value for the base year 1990. In other words, calibration results in agency-level predictions that are exact for the base year.

The performance of the calibrated models can be ascertained by comparing predicted and reported water use for the secondary verification year of 1993. The overall performance of the calibrated models is presented in Table IV-3. As shown, the predictions exhibit a varying degree of accuracy among the SDCWA agencies, which originates from the OLS regression procedure and uncertainty in the values of the SANDAG data. However, a comparison of the uncalibrated and calibrated results for 1993 indicates that predictions improved for 12 agencies as a result of calibration. Predictions for 6 agencies became slightly worse, while no change in performance was observed for 2 agencies. The overall prediction for the SDCWA service area in 1993 was 477,235

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[9] Due to data limitations, neither Yuima nor Sweetwater Authority were included in the water use modeling process. Therefore, for prediction, these agencies received the model intercept terms unadjusted for their respective unique water use characteristics.

[10] It was not possible to correctly differentiate the service area boundaries for Rincon del Diablo and Escondido. Therefore, the SANDAG demographic and water use data for these agencies were combined to form a composite agency.

TABLE IV-1

VERIFICATION OF UNCALIBRATED FORECAST MODELS FOR YEAR 1990

Agency	Predicted (AF)	Reported (AF)	Difference (AF)	Discrepancy (%)
Carlsbad	13,687	15,526	-1,838	11.8
Del Mar	1,637	1,636	2	0.1
Fallbrook	6,702	6,755	-53	-0.8
Helix	41,042	40,819	223	0.5
Oceanside	26,341	25,555	786	3.1
Olivenhain	13,000	11,613	1,387	11.9
Otay	17,889	22,295	-4,406	-19.8
Padre Dam	19,346	18,113	1,233	6.8
Poway	9,526	13,012	-3,486	-26.8
Rainbow	6,133	5,536	197	10.8
Ramona	5,302	7,169	-1,867	-26.0
San Diego	228,278	226,300	1,978	0.9
San Dieguito	6,976	6,779	597	2.9
Santa Fe	10,025	11,069	-1,045	-9.4
Sweetwater	35,263	24,662	10,601	43.0
Vallecitos	10,167	9,744	424	4.3
Valley Center	7,565	6,948	617	8.9
Vista	22,089	19,073	3,016	15.8
Yuima	318	187	130	69.6
Composite*	28,332	28,866	-534	-1.9
SDCWA Service Area	509,618	501,656	7,962	1.6

*Composite represents Rincon del Diablo and Escondido

Note: Due to rounding, the Difference for each agency and the SDCWA Service Area totals may not exactly equal the summation of the individual agencies.

TABLE IV-2

VERIFICATION OF UNCALIBRATED FORECAST MODELS FOR YEAR 1993

Agency	Predicted (AF)	Reported (AF)	Difference (AF)	Discrepancy (%)
Carlsbad	13,650	13,692	-42	-0.3
Del Mar	1,483	1,352	131	9.7
Fallbrook	6,376	6,093	283	4.6
Helix	37,349	36,850	499	1.4
Oceanside	25,465	23,564	1,901	8.1
Olivenhain	12,316	10,919	1,397	12.8
Otay	18,620	20,557	-1,937	-9.4
Padre Dam	17,992	17,582	410	2.3
Poway	9,041	10,586	-1,545	-14.6
Rainbow	5,934	4,605	1,329	28.9
Ramona	5,048	7,121	-2,073	-29.1
San Diego	214,947	209,315	5,632	2.7
San Dieguito	6,424	5,473	951	17.4
Santa Fe	9.216	9,785	-569	-5.8
Sweetwater	33,025	21,780	11,245	51.6
Vallecitos	10,565	9,845	720	7.3
Valley Center	7,306	7,918	-612	-7.7
Vista	20,861	17,377	3,484	20.0
Yuima	412	141	271	192.7
Composite*	27,234	26,231	1,003	3.8
SDCWA Service Area	483,263	460,785	22,478	4.9

*Composite represents Rincon del Diablo and Escondido

Note: Due to rounding, the Difference for each agency and the SDCWA Service Area totals may not exactly equal the summation of the individual agencies.

TABLE IV-3

APPLICATION OF CALIBRATED FORECAST MODEL FOR YEAR 1993

Agency	Predicted (AF)	Reported (AF)	Difference (AF)	Discrepancy (%)
Carlsbad	15,495	13,692	1,804	13.2
Del Mar	1,483	1,352	131	9.7
Fallbrook	6,426	6,093	333	5.5
Helix	37,144	36,850	295	0.8
Oceanside	24,702	23,564	1,138	4.8
Olivenhain	11,000	10,919	81	0.7
Otay	23,260	20,557	2,703	13.2
Padre Dam	16,836	17,582	-746	-4.2
Poway	12,425	10,586	1,839	17.4
Rainbow	5,357	4,605	751	16.3
Ramona	6,831	7,121	-291	-4.1
San Diego	213,080	209,315	3,764	1.8
San Dieguito	6,241	5,473	768	14.0
Santa Fe	10,178	9,785	393	4.0
Sweetwater	23,948	21,780	2,168	10.0
Vallecitos	10,125	9,845	280	2.8
Valley Center	6,708	7,918	-1,210	-15.3
Vista	18,007	17,377	630	3.6
Yuima	244	141	104	73.9
Composite*	27,746	26,231	1,515	5.8
SDCWA Service Area	477,235	460,785	16,451	3.6

*Composite represents Rincon del Diablo and Escondido

Note: Due to rounding, the Difference for each agency and the SDCWA Service Area totals may not exactly equal the summation of the individual agencies.

AF (overestimate of + 3.6 percent), an improvement of 1.3 percent over the uncalibrated model. Since the year 1993 was characterized by greater than normal precipitation, as well as on-going conservation programs and drought restrictions, the small value of the discrepancy is a pleasing confirmation of the models' performance.

The next chapter presents sectoral baseline forecasts for the SDCWA service area over the 1995-2015 planning horizon using the calibrated forecast models.

Chapter 8

8.0 CONCLUSIONS

This chapter presents conclusions drawn from the analysis conducted in the Water Resources Plan, and provides direction for future water resources development. Selection of a resource mix is based upon the ratings process that was conducted for the six water resources alternatives, including the dry-year option transfer analysis, using the selection criteria presented in Chapter 7. Consideration was also given to public participation in the resources planning process, and comments received on the draft Water Resources Plan since its first release on September 12, 1996.

8.1 OVERVIEW

Six main water resources alternatives were considered in this Water Resources Plan. One of the alternatives, the Existing Strategy Alternative, is an updated version of the resources mix selected for development in the 1993 Water Resources Plan. The remaining five "new" alternatives represent opportunities to improve supply reliability and the degree of control the Authority has over resources development. These alternatives either maximized local supply development, developed large-scale core (normal-year) water transfers, or provided a combination of increased local supplies and core transfers. Analysis was also done to compare the benefits and costs of flexible (dry-year) transfers with core transfers.

Each of the five new alternatives was found to improve certain aspects of reliability and Authority water resources control over the Existing Strategy Alternative. However, the new alternatives represented tradeoffs in other criteria that were considered on an equal basis, including feasibility, total cost, potential rate impacts, environmental impacts, and water quality. For example, the objective of minimizing cost competes with the objective of maximizing reliability, which tends to drive up costs.

The goal of the Water Resources Plan evaluation was to compare the alternatives against each other and develop a plan for future resources development that collectively maximized the criteria. In the end, this Water Resources Plan did not select a single "best" alternative water resources mix from among the six competing alternatives. Instead, the Plan recognizes the potential benefits of incrementally developing additional local supplies and adding an intermediate level of core transfers to the resources strategy adopted in the Authority's 1993 Water Resources Plan.

Substantial improvements in reliability, Authority control, and feasibility could be achieved with alternatives that feature core transfers of up to 200,000 acre-feet per year (af/yr). This is true both in the case of core transfers, as proposed in four of the alternatives, or through the use of dry-year options in the Existing Strategy Alternative. However, core transfers are considered to provide greater reliability than dry-year options. This is because core transfers also minimize the risk of the Metropolitan Water District of Southern California (MWD) being unable to fully implement its Integrated Resources Plan (IRP) in a normal-weather year (see discussion in Chapter 7).

Selection of a resources mix was based upon an overall evaluation of the criteria. No criterion was weighted more heavily than the others. Instead, overall judgments for each alternative were made using the rating system of "good," "fair," and "poor" for each criterion. Using this methodology, it was possible to isolate alternatives and potential resources that best balanced the competing criteria.

The Public Outreach Program was used as guidance in the evaluation of alternatives. Results from a selection criteria weighting exercise conducted by community stakeholders showed in general terms that reliability and water rate impacts were considered by participants to be two of the most important criteria. This preference, which correlated with individual interviews conducted with outreach program participants, was considered in making value judgments for qualitative criteria. Comments received from the Authority Board of Directors, member agencies, and the public were incorporated into this final document.

8.2 INITIAL SCREENING OF ALTERNATIVES

An initial screening of the analysis presented in Chapter 7 resulted in the elimination of two alternatives: the Maximum Local Supply Alternative and the Colorado River Facilities Alternative. These alternatives should be reconsidered in future updates of the Water Resources Plan, as water demand and supply conditions change and as more information is gained about potential funding sources for an Authority owned Colorado River conveyance system and the success of MWD's supply development program outlined in the IRP.

The Maximum Local Supply Alternative was eliminated from further consideration largely because of its higher projected total cost and increased risk of causing upward pressure on water rates. With only 69,000 af/yr of additional local supplies (compared with the Existing Strategy Alternative), this alternative did not offer significant improvements in Authority control over water resources or overall reliability in exchange for its higher costs and potential rate impacts.

The Colorado River Facilities Alternative had the highest cost of all six alternatives and the greatest risk of rate impacts. There were also major uncertainties related to feasibility and environmental impacts. For these reasons this alternative was deleted from further consideration, but should be retained for further study. Some potential has been demonstrated for funding participation from the U.S. federal government and Mexico, which would reduce the cost of such a project to the Authority. However, at this time, such funding is speculative. For this analysis it has been assumed that the Authority is the sole funder of the project.

8.3 FINAL SCREENING OF ALTERNATIVES

The remaining alternatives to be considered are the Existing Strategy, Maximum Local Supply With Transfers, Intermediate Transfers, and Maximum Transfers. The Intermediate and Maximum Transfers alternatives received an overall rating of good, while the Existing Strategy and Maximum Local Supply With Transfers were rated fair. The fair rating for the latter alternative was primarily because of the additional local agency cost for recycling and groundwater projects. Because concerns beyond cost contribute to a local agency decision on implementing local projects, the Maximum Local Supply With Transfer Alternative was carried forward into the final screening process.

Even though a weighting of individual criteria was not applied in arriving at an overall rating, conducting a final screening of the alternatives requires consideration of the importance of each criterion in contributing towards the Authority's ability to fulfill its mission and meet its reliability goals. In the public outreach efforts conducted as part of this Water Resource Plan update process, the consistent theme from the various stakeholders was that the two most important considerations in selecting a mix of resources were maximizing reliability and minimizing rate impacts. The analysis conducted in Chapter 7 also highlighted the importance that feasibility has in determining whether a mix can be implemented and reliability achieved. It is in these three areas that distinctions between the remaining alternatives can be made.

Although the Maximum Transfers Alternative was found attractive in terms of cost, reliability, Authority control, and reduced risk of rate impacts, there is considerable uncertainty in recently emerging market conditions over the feasibility of obtaining this quantity of water on a long-term basis. Potential environmental impacts from transferring this quantity of water require further evaluation as well. Therefore, this alternative was not selected for further development at this time. At projected demand levels, if this transfer were achieved from a single source, it would displace reliance on the current source of imported water (MWD) for another source, losing some of the supply diversity benefits that core transfers are intended to achieve.

The Existing Strategy Alternative provided the lowest overall cost of any of the resource mixes evaluated in this plan. Concerns over the feasibility of implementing the IRP led to a resources strategy that improved reliability by adding water transfers to the resource mixes. The Existing Strategy Alternative was supplemented with up to 200,000 acre-feet (af) of dry-year option transfers. This improved the Existing Strategy Alternative in terms of the reliability, feasibility, and Authority control criteria, but only in dry years, when shortages were driven by hydrologic conditions. Dry-year options were not effective in responding to normal-year shortfalls in MWD's core supplies, which may result from a lack of surplus Colorado River water or delay in a full fix to the Sacramento-San Joaquin Bay-Delta. Shortfalls in either one of these sources would impact the normal-year reliability of the Existing Strategy Alternative.

The Maximum Local Supply With Transfers and Intermediate Transfers Alternatives provide high reliability and Authority control over supply through long-term core transfer agreements. Both resource mixes effectively minimized reliability risks in both normal- and dry-weather years. They also were highly rated for feasibility. The distinguishing criterion for these two alternatives is total cost. The Intermediate Transfers Alternative is lower in total cost because of a lower commitment to capital expenditures related to local supply development. Both resource mixes are essentially equivalent in potential water rate impacts. However, through its contribution of up to 37,000 af/yr of additional local supply, the Maximum Local Supply With Transfers Alternative further improves the reliability and diversity of the resource mix offered by the Intermediate Transfers Alternative.

8.3.1 Conclusions of Final Screening

The purpose of the final screening exercise is to identify the criteria that separate the remaining alternatives and provide a means to determine a selected resource strategy for the Authority to pursue. In the case of the Maximum Transfers Alternative, feasibility considerations regarding the magnitude of the transfer component eliminated that mix from further consideration in this update of the Water Resources Plan. Reliability concerns relating to the Existing Strategy, even when supplemented with dry-year option transfers provide a distinct difference between that mix and the two alternatives with 200,000 af of core transfers. Because it was considered to provide less reliability than the Maximum Local Supply With Transfers and Intermediate Transfers, the Existing Strategy was eliminated from further consideration.

Because of the relative similarity of the remaining two mixes, both the Maximum

Local Supply With Transfers and the Intermediate Transfers Alternatives were carried forward for further analysis.

8.4 DEVELOPMENT OF A SELECTED RESOURCE MIX

Both the Maximum Local Supply With Transfers and the Intermediate Transfers Alternatives involve the purchase of transfers by the Authority, beginning with 20,000 af/yr in 1999 and increasing to 200,000 af/yr by 2008. The primary difference between the two alternatives is the amount of water to be derived from local sources.

Local projects in the Intermediate Transfers Alternative were economically optimized from the Authority's perspective. However, the decision point for constructing local projects depends upon a local agency perspective, which may be quite different from that of the Authority. From the Authority's perspective, economic optimization requires viewing the cost effectiveness of a local project in terms of a comparison to the cost of MWD supplies, less any relevant incentives. In addition to these costs, local member agencies also take into consideration the Authority's water rate and any financial assistance which may be available for local supply development. Other factors that may influence local supply development include avoided wastewater treatment and disposal costs, emergency storage costs, and non-economic considerations.

Estimates of local supply development potential (described in Chapter 4) suggest that the 2015 local supply yield potential is approximately 165,000 af/yr. New yield expected to be developed between now and the end of the planning horizon includes 27,000 af of recycled water, 15,000 af of repurified water, and 34,000 af of groundwater. These additional local projects would increase the total amount of local supply to approximately 20 percent of 2015 normal-year demand. If this increase in local supply were to materialize, the resulting local supply element of the resources mix would closely resemble the Maximum Local Supply With Transfers Alternative. Increased local supplies would provide the Authority with greater benefits in terms of supply diversity, reliability, and degree of control over the resource.

Because of uncertainties in local supply development, the selected resources mix envisions a local supply component ranging from 122,000 to 165,000 af/yr in the year 2015.

8.5 SELECTED RESOURCE MIX

The selected resource mix would supplement imported water purchased from MWD with normal-year transfers of up to 200,000 af/yr. Local supplies would provide between 122,000 to 165,000 af/yr. Implementation of conservation Best Management Practices (BMPs) would result in an annual savings of 82,000 af/yr by the end of the planning horizon. MWD would continue to be the primary supplier of water to the Authority. Purchases from MWD would range from 422,000 to 465,000 af/yr, or about 54 to 59 percent of the total demand. A summary of the selected resources development is given in **Table 8-1**.

8.6 IMPLEMENTATION OF THE SELECTED MIX

The primary distinguishing characteristics between the selected water resources mixes of the 1993 Water Resources Plan and this update is the development of normal-year transfers of up to 200,000 af/yr, the development of additional local groundwater supplies, and the deletion of seawater desalination as a selected resource.

While scheduling and cost components of

TABLE 8-1 Selected Resource Mix (Based on Normal-Year Demand) (AF)						
Year	MWD	Transfer	Recl	Ground Water	Local Surface Water	Total
2000	499,000	40,000	18,000	19,000	60,000	636,000
2005	412,000-432,000	140,000	30,000-45,000	23,000-28,000	60,000	685,000
2010	387,000-412,000	200,000	30,000-50,000	32,000-37,000	60,000	734,000
2015	422,000-465,000	200,000	30,000-60,000	32,000-45,000	60,000	787,000

the transfers included in the selected mix are based on the terms and conditions of the proposed Imperial Irrigation District (IID) water transfer, the evaluation of water transfers is considered generally representative of the emerging market for transfers. The role of the Water Resources Plan is to provide a framework whereby future resource decisions, such as the acquisition of transfers, can be evaluated against other water supply options. As discussed in Chapter 5, specific water transfer proposals need to be evaluated on a case-by-case basis. A screening process would be used to evaluate the viability of specific water transfer proposals. Through this process, transfer proposals would be evaluated on the ability to improve reliability and local control at a cost comparable to purchasing water from MWD. The overall feasibility of the transfer proposal would also be evaluated. Feasibility considerations include public and institutional acceptance, regulatory factors, third party effects, water quality, and legal issues.

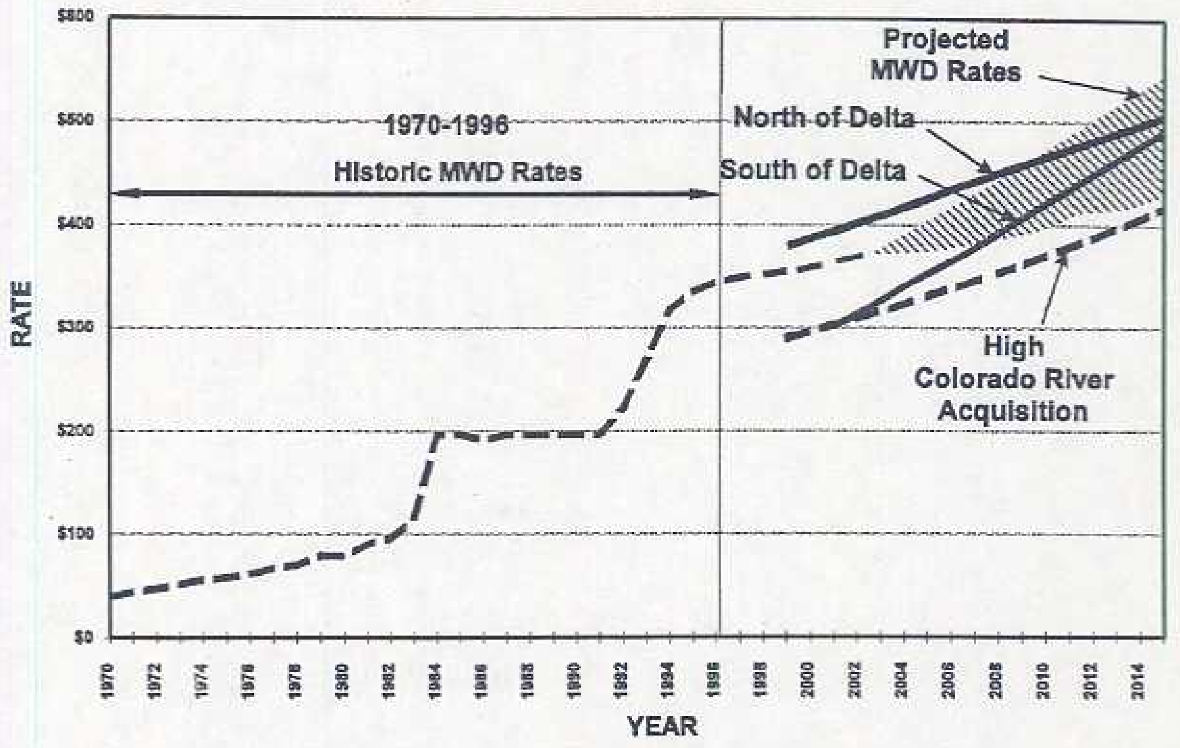
Using this analytical approach, a determination can be made as to whether the cost of a specific transfer proposal is competitive with purchasing water from MWD. By way of illustration, **Figure 8-1** provides a comparison of the anticipated costs of Colorado River and Northern and Central California transfers to a likely range of MWD rates. While the evaluation of specific transfer proposals is beyond the scope of the Water Resources Plan, the same methodology may be used for that purpose.

It should be kept in mind the actual resource development over the next 20 years will depend greatly on variables for which assumptions were made to carry out the analysis contained in this Plan. The major assumptions include future water demands, projected MWD water rates and charges, and the cost of development and transportation of water transfers. In the event that implementation of a resources mix with core transfers is delayed or not achievable, the Existing Strategy Alternative would continue to be the basis for the Authority's imported water supply component. The local supply and conservation components of the selected resources alternative can proceed within the existing Authority levels of involvement, with the exception of approximately 36,000 af of additional groundwater and recycled water projects, which may require expansion of the Authority's current local projects incentive program

8.7 RELATIONSHIP TO AUTHORITY RELIABILITY GOAL

Each alternative evaluated in this Plan has the potential to meet the Authority's current reliability goal, which was set forth in the Authority's 1995 Strategic Plan and is described in Chapter 1. The key reliability objective of this Plan was to identify a mix of water resources that reduces the risk of not meeting that goal at an acceptable cost. After a thorough analysis of all selection criteria, the selected resource mix is considered to best meet the Authority's reliability goal in a manner that reduces the risk of not meeting the goal and is cost-effective.

FIGURE 8-1
Non-Interruptible Imported Water Rates



Appendix A

WATER RESOURCES PLAN
PUBLIC OUTREACH PROGRAM
PHASE 1 REPORT

Presented to
The San Diego County Water Authority
Water Resources Division

Presented by
Katz & Associates
May 1. 1996

Water Resources Plan
Stakeholder Executive Summary Report

Intent of Interviews

The Water Resources Plan Stakeholder Executive Summary Report includes an overview of the feedback from a collection of interviews held with individual representatives of key San Diego associations and organizations who have a specific interest in the water resources of San Diego. These interviews were held from December 1995 through April 1996 and were conducted to provide the San Diego County Water Authority staff input from a diverse cross-section of constituencies.

The information included in this report was summarized from responses to a questionnaire developed and approved by the Authority to garner specific input on the Water Resources Plan. Therefore, the executive summary may not necessarily reflect all additional conversation topics discussed between the stakeholders and the interview team. The interviews were conducted by Dave Fogerson of the Authority's Water Resources Department, Sara Katz and Laurie Sargent of Katz & Associates.

The contents of this report are being used by the San Diego County Water Authority to assist them in updating the Water Resources Plan. Because the stakeholders input covers a wide-range of opinions, some of them even contradictory, the Authority is using this input as a guide to be taken into consideration along with the expertise of the Authority's water resource planners for developing the best, most cost-effective Water Resources Plan update. This information is also used to assist the Authority in planning and implementing additional outreach/stakeholder activities for the Water Resources Plan update.

Upon completion of the draft Water Resources Plan, it will then be presented to the Authority board of directors who will make the final determination about the allocation of water resources for the county.

Interviews Conducted

Interviews were conducted with individuals representing a cross-section of interests. The Authority recognizes the challenge in meeting with individuals who represent every possible perspective, and the Authority endeavored to reach as many viewpoints as possible. The objective was to meet with individuals who represent the perspective of an organization or association with a key interest in water resources in the county. In order to conduct interviews based on a substantive dialogue about water resources, the Authority worked to locate representatives who have had some experience with water resources and a basic understanding of the issues. Following is the list of stakeholders represented.

Alliance for Water Reliability
Biocom
Building Industry Association
Citizens Coordinate for Century III (C-III)
Greater San Diego Chamber of Commerce Water Committee
Greater San Diego Chamber of Commerce CEO Roundtable
Industrial Environmental Association (IEA) Water Committee
League of Women Voters
Mayor Susan Golding's Office
Regional Water Quality Control Board
San Diego Apartment Association
San Diego Association of Governments (SANDAG)
San Diego Convention & Visitors Bureau
San Diego County Farm Bureau
San Diego Economic Development Corporation (EDC)
San Diego Gas & Electric
San Diego Military Users
San Diego Rotary
Sierra Club (Water subcommittee)
United Consumers Action Network (UCAN)

<u>Summary</u>

Following is a summary of the feedback received from San Diego stakeholder representatives. The overview does not contain verbatim stakeholder comments, but provides a general summary of themes discussed in the interviews and the various viewpoints that came through during the interviews.

<u>Operations</u>

Mostly all stakeholders had a clear perspective of San Diego's water supply, where it comes from and something about San Diego's need to make up for current and projected shortfalls. No stakeholder expressed thoughts that the current supply is, or has been unreliable, however, many of them are aware of San Diego's vulnerability to earthquakes and are concerned about having sufficient emergency storage.

There were however, some opposing views on the amount of water needed to ensure future reliability. Some stakeholders feel strongly that the Authority should do as much possible to provide as much water as possible to the county. They are strong advocates of storage and doing whatever it takes, while remaining cost effective, to make San Diego independent of MWD and other outside water suppliers. Other stakeholders want to see extensive economic analysis done on the issue of current supply versus future supply to determine exactly what is necessary and what are the most economical and environmentally conscious ways of providing water.

Water Resources

Although most every stakeholder wants to see local water resource development, the preferences for the types of water supply options to be pursued varied greatly among the stakeholders. Most groups agree that desalination is currently too expensive of an option, but may potentially become a viable option when technology is improved.

Feedback regarding reclamation and repurification was extremely diverse. Some stakeholders feel these are important opportunities and should be pursued. Others are concerned about the costs associated with these resource options and environmental impacts required for dual piping of reclaimed water. Some stated that repurified water should still be viewed as experimental before it's used on a widescale basis.

Groundwater was not listed among top water supply options primarily due to quality and availability as well as its limited reliability for emergency storage use.

Emergency storage was favored by almost every stakeholder. Again, some are unsure about the necessary quantity, but most feel it is an important resource and should be provided.

Every stakeholder indicated a need to pursue conservation. Some expressed conservation should be considered as any other resource is considered. Others were concerned that there are limits to conservation and that it is important, but cannot take the place of providing additional local resource options. A number of stakeholders expressed the need to continue an extensive public education program to encourage more residential conservation practices.

Given the current limited information about agricultural transfers, most of the stakeholders expressed reluctance to commit to such options until more specific information is provided. However, the feedback on agricultural transfers as a potential resource varied tremendously. Some stakeholders would like to see agricultural transfers aggressively pursued, and are willing to pay more for the independence that water will bring. They are not sure how much more they would pay and would need to see the economic analysis before supporting the option. Others are worried about the reliability of the source of agricultural water and are concerned that San Diego will end up in a situation similar to the current one in terms of independence and cost control.

Some stakeholders expressed a concern about the quality of the agriculturally transferred water (TDS levels) as well as the environmental impacts created by developing the appropriate infrastructure to get the water here.

Rates

With rare exception, each stakeholder expressed that the current cost of water is fair and reasonable, however, every stakeholder is concerned about future water costs and how further water resources development will affect water rates. Water rate predictability was also stressed as an important factor. Businesses need to be able to plan accordingly for future rate increases...not if, but how much and when. An extensive cost analysis was requested by various stakeholders, as well as a listing of who will pay for what portions of specific water resource options such as repurification, reclamation, etc.

Responses on the cost for specific supply options ranged widely with some stakeholders willing to pay more for more independence from MWD, etc. Others feel that new water resources should not cost more than the current imported water rates.

Other Issues

Some stakeholders expressed the concern that the Water Resource Plan not recommend we provide more water than is truly necessary because they feel it will induce growth in the region. Opposing viewpoints see the lack of future water reliability as a major economic problem for the region and stated that without a more reliable, cost-competitive water supply, San Diego will no longer be able to compete economically because large San Diego corporations/industries will leave and other industries will not want to be located in San Diego. Others noted that regardless of business interests, San Diego will continue to grow in population and our residents need to be assured of a reliable source of water.

Another issue raised was the lack of coordination between county land-use planners and water resource planners. This is due to the fact that no planning can take place where water is unavailable, therefore, the planners and elected officials need to be more aware of the water supply issues San Diego faces.

Poor water quality was an issue raised in several stakeholder meetings. Many are concerned that not enough steps are being taken to ensure the quality of water to San Diego meets adequate standards. Each new supply option should also require specific steps be taken to ensure water quality is not compromised and this will influence the cost of each option.

Conclusion

The most important issues the stakeholders repeatedly expressed regarding San Diego's water supply include cost, quality, reliability, and keeping the measure of control consistent with investment. Another issue commonly raised was in making sure that the resource options are analytically studied before decisions are made. Stakeholders feel that decisions need to make economic and practical sense as well as political sense.

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Appendix B

San Diego County Water Authority
and
Imperial Irrigation District

COOPERATIVE WATER CONSERVATION AND TRANSFER PROGRAM

SUMMARY OF DRAFT TERMS

Overview

On September 19, 1995, the Authority and the District entered into a Memorandum of Understanding to explore the potential for a joint Water Conservation and Transfer Program ("Program"). Since that time, the Agencies have prepared technical analyses and conducted extensive public involvement programs. Based upon that information and in response to policy direction from their respective Boards of Directors, the staffs of the Agencies have developed a draft of possible terms under which a Program could be implemented.

The purpose of this document is to summarize the draft as to price, term and quantity as well as certain of the other relevant terms and make the summary available for broad public review and comment. Based upon the input that is received through that dialog, the terms would be revised and the resultant concepts would be incorporated into the form of Final Agreement for the Agencies' consideration. The essential terms for such a program, as developed by the staffs of the Agencies are as follows:

Quantity and Schedule of Transferred Water

To meet future demands, the Authority seeks a firm, affordable and price certain water supply of 500,000 AF/Y. Depending upon factors such as landowner participation, environmental compliance, community support, and availability of approvals agreed to be obtained, it is expected that between 200,000 AF/Y and 500,000 AF/Y of firm water supply will be available to the Authority, the actual maximum quantity to be incorporated into the Final Agreement. The Agencies agree that the water conservation programs of the District shall not include permanent retirement of farm land. Subject to the availability of transportation on terms satisfactory to the Authority for the water supplied by the District, the District will offer to the Authority and the Authority will purchase, all water made available by the District, not to exceed 500,000 AF/Y, as provided below.

The water available shall be delivered by the United States to the Authority at an acceptable delivery point commencing in 1999 at a quantity of 20,000 AF/Y, or a greater amount mutually agreed upon, increasing each year by 20,000 AF/Y for ten years, to a total of 200,000 AF/Y and thereafter, subject to the needs and water quality objectives of the Authority, increasing each year by an estimated increment of 8,000 AF/Y to the total to be made available by the District. Thereafter, delivery of such total will continue each year unless the delivery is reduced or discontinued pursuant to the recapture and other termination provisions described herein. The District will accelerate delivery at the request of the Authority. The parties recognize that the Authority, in order to secure transportation to deliver the supplies to San Diego and to attain such water quality objectives, may have to buy several hundred thousand acre feet from others, at least for a time.

The right and ownership to all water will remain with the District, subject to the right of the Authority to have delivery and use the water as agreed. All water delivered to and used by the Authority shall be a part of the District's Present Perfected Rights to Colorado River water. The District expects to create conserved water as defined in California Water Code Section 1011 in quantities equal to the deliveries to the Authority and, not inconsistent with such present perfected rights, all such conserved water is intended to be included in such delivery.

Delivery Location: Transportation

All water will be delivered by the United States to the Authority on the Colorado River at Imperial Dam or other location and it will be the responsibility of the Authority to arrange for transportation of such water from there to the service area of the Authority. Should the Authority desire to use the All American Canal to connect to any aqueduct to San Diego, the District would make capacity available or participate in capacity enlargement under an arrangement that takes into account the arrangement that currently exists with the City of San Diego.

Price

The Authority shall pay the District the following sums:

Year #	Year	$ Per AF
1	1999	$200
2	2000	$212
3	2001	$224
4	2002	$235
5	2003	$247
6	2004	$259
7	2005	$271
8	2006	$282
9	2007	$294
10	2008	$306

If at any time during the above ten years the Authority's Colorado River Aqueduct transportation costs exceed $75 per acre foot, the above prices for such time shall be adjusted according to a method to be negotiated.

After the first ten years, the prices selected in accordance with the Ten Year Price Adjustment section below shall be paid.

The above prices are subject to the negotiation of a Ten-Year Price Adjustment clause that is satisfactory to both parties.

Ten Year Price Adjustment

Either party may, before the end of each ten-year period, suggest a new price. If the other party does not accept the suggested price, and if the parties, through good faith negotiations, do not select a new price, the new price shall be selected by arbitration ("Market Price"). The Market Price, whether selected by agreement or arbitration, shall be market-based, but, to lessen the impact on the agencies from radical swings in market conditions, shall not vary from the Market Price selected 10 years previously, or from $306 in the case of the first ten-year adjustment, by more than 25% thereof. For example, at the first 10-year adjustment the limit on the selected Market Price shall be based on $306, and shall be no greater than $383 and no less than $229, and, as a further example, if the Market Price selected at the first 10-year adjustment is $360, then the Market Price selected at the next 10-year adjustment shall be no greater than $450 and no less than $270. Again, to lessen the impact of such swings in market conditions, the new selected price shall be phased in gradually over the first five years of the relevant ten year period. In case of upward price adjustments only, each of the first five-year phase-in payments shall be increased by 2% and the Market Price shall be increased as follows: by 2% for year 6, 4% for year 7, 6% for year 8, 8% for year 9 and 10% for year 10 ("Percentage Increase"). When the selected new price represents a downward price adjustment, the Market Price shall be so paid over the 10-year period without any percentage adjustments. Also, during years 6 through 10, the Authority in the case of an upward price adjustment, and the District in the case of a downward price adjustment, shall pay or credit, the other agency the difference between the selected new price and such five year phased-in payments.

Before the end of each ten-year period (except for the initial period), either party may also request that a market-based price be determined for each year of the expiring ten-year period ("Determined Price"). For each such year, the Determined Price shall not vary by more than 10% from the Market Price selected ten years previously. For example, if the Market Price applicable during such expiring 10-year period should be $360, then the Determined Price for each such year shall be no greater than $396 and no less than $324. Then for each such year, the water delivery shall be repriced according to the Determined Price. The difference for each year between the repriced amount and the amount actually paid for such deliveries including any Percentage Increase, shall be paid or credited over the next 10-year period according to a method to be negotiated.

Subject to such variation limits, the Market Price and the Determined Price shall be that price indicated by comparison to then recent water transfers and other market activity data, after adjustment for all relevant factors, including but not limited to the value of reliability, priority, volume, duration, base load or peaking character, price and terms and water quality, and excluding transportation and taking into account the cost of delivering water to the Authority. The initial price, having been formulated during an emerging market, shall not be regarded as a market price indication.

Term of Agreement and Recapture/Termination Procedures

The initial term shall be 75 years from the commencement of deliveries with each agency, subject to the terms of the next paragraph, having the option after such initial term to reduce the total quantity by no more than two percent each year. Water so recaptured by the District shall be used solely for new municipal and industrial uses and shall be so used only after similar use is first made of all water hereafter transferred by the District to others. Notwithstanding the foregoing, the Agreement will terminate at the end of the 125th year.

If the Authority decides to construct a new conveyance facility for transportation of the water made available by the District, the term of the Agreement shall be 125 years from such commencement of deliveries and shall terminate at the end of the 125th year, with no right of recapture during the term.

Responsibilities for Environmental Compliance

Each agency shall be solely responsible for compliance with environmental laws for programs under the leadership of that agency. For example, the District will have lead responsibility for environmental compliance associated with any Final Agreement and the water conservation programs and the Authority will have lead responsibility for subsequent environmental compliance associated with transportation of water.

Each agency shall be solely responsible for the cost of environmental compliance undertaken by it.

Contingencies Which Could Prevent Implementation of Program

District Environmental Contingency: The obligations of the District to perform under the Program shall be voidable if environmental compliance cannot be accomplished, such decision to be in the sole discretion of the District.

Authority Transportation Contingency: The obligations of the Authority to perform under this Program shall be voidable if the Authority is unable to arrange for transportation of the water from the Colorado River to the Authority's system for the term of the Agreement through the Colorado River Aqueduct on terms satisfactory to the Authority or by other means satisfactory to the Authority.

Court Validation of Final Agreement: The obligation of the Agencies to perform under this program shall be voidable if validation or declaratory judgment as to the Final Agreement is not obtained; provided, however, that the Agencies have the option to agree to waive portions or all of such validation requirements. Judgments shall be obtained without expense to the Authority.

Interim Assignment of Authority's Rights

The Authority shall have the right to assign to any other Metropolitan Member Agency, on an interim basis, any of the Authority's rights and responsibilities under the Program.

Shortage Sharing

During any period when deliveries of Colorado River water to the District for reasonable beneficial use or the deliveries of Colorado River water to the Authority for reasonable beneficial use are curtailed by the Secretary of the Interior, pursuant to Article II(B)(3) of the decree in Arizona v. California, the Authority and the District will share the same percentage reduction in water availability, but, following court validation of the Final Agreement, the District will be responsible for all claims by any junior priorities in California or elsewhere that such deliveries should not be made.

Confirmation of Mutual Understanding

Although neither the District nor the Authority is bound by this Summary of Draft Terms, nevertheless, this Summary confirms their mutual understanding and desire to enter within 90 days from the respective Board's approval hereof into a more detailed formal and binding agreement (the Final Agreement) that is generally consistent with the provisions hereof as those provisions may be modified through public review and input.

Appendix C

APPENDIX C

WATER RESOURCES PLAN 1997 UPDATE
KEY ASSUMPTIONS FOR COSTS OF ALTERNATIVES

The following assumptions were made to conduct cost and potential rate impact analysis in the 1997 Water Resources Plan. Projected MWD water commodity rates and non-rate charges are provided in Table C-1.

1. Rates and charges. Evaluation uses MWD projected water commodity rates and readiness-to-serve (RTS) charges shown in Table C-1. The total amount of RTS charges was held constant for all alternatives, regardless of MWD purchases. Analysis did not include new demand charge.

2. Transfer Costs. Costs for IID transfers were taken from the Authority's Summary of Draft Terms. Costs were evaluated using the lower and upper ranges of the 10-year market adjustment. Assumed transportation charges (wheeling charges) are shown in Table C-1.

3. Capital Costs. Capital costs for all local projects and the IID facilities were pro-rated over the life of each project.

5. Demand Adjustment. Water demand associated with Colorado River facilities alternative was increased by 65,000 af/yr to account for RO losses (13% of 500,000 af).

TABLE C-1

WATER RESOURCES PLAN 1997 UPDATE

KEY ASSUMPTIONS FOR COST AND RATE IMPACT ANALYSIS OF ALTERNATIVES

(ALL FIGURES EXCEPT RTS IN $/AF; RTS IN TOTAL $)

	METROPOLITAN WATER DISTRICT PROJECTED RATES						ASSUMED	PROJECTED
	BASE CASE		WHEELING 200,000 AF		WHEELING 500,000 AF		WHEELING	AUTHORITY
YEAR	LOW	HIGH	LOW	HIGH	LOW	HIGH	CHARGE	RTS SHARE
1996	344	344	344	344	344	344	-	14,867,000
1997	349	349	349	349	349	349	-	16,454,000
1998	352	352	352	352	352	352	-	20,447,000
1999	355	355	355	355	355	355	75	22,563,000
2000	360	360	365	365	365	365	76	24,712,000
2001	365	365	380	380	380	380	77	26,860,000
2002	370	370	390	390	390	390	78	27,935,000
2003	375	381	395	401	395	401	79	27,935,000
2004	375	393	395	413	395	413	81	27,935,000
2005	375	404	395	426	395	426	82	27,935,000
2006	380	416	405	444	405	444	83	27,935,000
2007	385	429	410	457	410	457	84	27,935,000
2008	389	442	425	483	430	488	86	27,935,000
2009	394	455	435	502	450	520	87	27,935,000
2010	404	469	445	516	470	545	88	27,935,000
2011	414	483	450	525	490	571	90	27,935,000
2012	419	497	450	534	510	605	91	27,935,000
2013	419	512	450	550	520	636	93	27,935,000
2014	424	528	455	566	530	659	95	27,935,000
2015	434	543	455	570	535	670	96	27,935,000

TABLE C-2
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW COST WATER SUPPLY SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 298.8	$ 1,304.1	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 306.8	$ 1,610.9	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 325.9	$ 1,936.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.3	$ 2,269.1	$ 347.9	$ 2,308.3	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.1	$ 2,616.2	$ 362.7	$ 2,671.0	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.4	$ 2,966.6	$ 367.0	$ 3,038.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 366.9	$ 3,333.6	$ 383.5	$ 3,421.5	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 374.9	$ 3,708.5	$ 411.2	$ 3,832.7	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.0	$ 4,091.4	$ 419.5	$ 4,252.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 394.1	$ 4,485.5	$ 431.0	$ 4,683.2	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 406.1	$ 4,891.6	$ 443.2	$ 5,126.4	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 418.1	$ 5,309.7	$ 455.4	$ 5,581.8	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 427.3	$ 5,737.0	$ 465.0	$ 6,046.9	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 432.9	$ 6,169.9	$ 471.0	$ 6,517.9	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 442.0	$ 6,611.9	$ 480.5	$ 6,998.4	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 454.7	$ 7,066.6	$ 493.5	$ 7,492.0	$ 453.4	$ 7,289.8	$ 444.9	$ 7,163.8	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-3
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
HIGH COST WATER SUPPLY SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.2	$ 1,005.6	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.3	$ 1,304.8	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.4	$ 1,612.2	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.6	$ 1,938.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 336.7	$ 2,275.5	$ 351.0	$ 2,311.5	$ 349.2	$ 2,317.2	$ 341.7	$ 2,289.0	$ 341.7	$ 2,289.0	$ 379.5	$ 2,426.4
2004	$ 358.8	$ 2,634.2	$ 372.7	$ 2,684.1	$ 370.0	$ 2,687.2	$ 363.0	$ 2,651.9	$ 363.0	$ 2,651.9	$ 401.5	$ 2,827.9
2005	$ 369.8	$ 3,004.0	$ 384.0	$ 3,068.2	$ 380.4	$ 3,067.6	$ 373.1	$ 3,025.0	$ 373.1	$ 3,025.0	$ 423.3	$ 3,251.1
2006	$ 391.2	$ 3,395.2	$ 405.1	$ 3,473.3	$ 402.8	$ 3,470.4	$ 396.3	$ 3,421.3	$ 396.3	$ 3,421.3	$ 449.9	$ 3,701.0
2007	$ 404.5	$ 3,799.7	$ 437.0	$ 3,910.3	$ 414.8	$ 3,885.2	$ 408.7	$ 3,830.0	$ 408.7	$ 3,830.0	$ 473.5	$ 4,174.6
2008	$ 418.9	$ 4,218.6	$ 451.2	$ 4,361.5	$ 433.2	$ 4,318.3	$ 428.0	$ 4,258.0	$ 430.8	$ 4,260.8	$ 505.7	$ 4,680.2
2009	$ 436.1	$ 4,654.7	$ 468.2	$ 4,829.7	$ 454.7	$ 4,773.0	$ 450.2	$ 4,708.2	$ 451.7	$ 4,712.5	$ 536.7	$ 5,216.9
2010	$ 451.3	$ 5,106.0	$ 483.3	$ 5,313.0	$ 470.4	$ 5,243.4	$ 466.1	$ 5,174.3	$ 466.9	$ 5,179.4	$ 567.0	$ 5,783.9
2011	$ 466.7	$ 5,572.8	$ 498.7	$ 5,811.8	$ 483.6	$ 5,727.0	$ 479.3	$ 5,653.7	$ 481.5	$ 5,660.9	$ 594.6	$ 6,378.5
2012	$ 483.4	$ 6,056.1	$ 515.1	$ 6,326.9	$ 497.9	$ 6,224.9	$ 493.8	$ 6,147.4	$ 498.1	$ 6,159.0	$ 633.8	$ 7,012.3
2013	$ 500.4	$ 6,556.6	$ 531.7	$ 6,858.6	$ 515.1	$ 6,740.1	$ 511.7	$ 6,659.2	$ 510.8	$ 6,669.9	$ 658.5	$ 7,670.8
2014	$ 518.1	$ 7,074.6	$ 549.0	$ 7,407.7	$ 532.8	$ 7,272.9	$ 530.0	$ 7,189.1	$ 521.8	$ 7,191.6	$ 681.8	$ 8,352.6
2015	$ 536.1	$ 7,610.8	$ 567.0	$ 7,974.7	$ 543.6	$ 7,816.5	$ 540.5	$ 7,729.6	$ 536.5	$ 7,728.1	$ 698.7	$ 9,051.3

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-4
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW MWD RATES AND HIGH TRANSFER ACQUISITION COSTS SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 298.8	$ 1,304.1	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 306.8	$ 1,610.9	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 325.9	$ 1,936.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.3	$ 2,269.1	$ 347.9	$ 2,308.3	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.1	$ 2,616.2	$ 362.7	$ 2,671.0	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.4	$ 2,966.6	$ 367.0	$ 3,038.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 366.9	$ 3,333.6	$ 383.5	$ 3,421.5	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 374.9	$ 3,708.5	$ 411.2	$ 3,832.7	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.0	$ 4,091.4	$ 419.5	$ 4,252.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 394.1	$ 4,485.5	$ 431.0	$ 4,683.2	$ 425.6	$ 4,657.3	$ 417.9	$ 4,579.4	$ 423.3	$ 4,587.1	$ 505.8	$ 5,089.3
2010	$ 406.1	$ 4,891.6	$ 443.2	$ 5,126.4	$ 438.9	$ 5,096.2	$ 431.3	$ 5,010.7	$ 439.3	$ 5,026.4	$ 533.6	$ 5,622.9
2011	$ 418.1	$ 5,309.7	$ 455.4	$ 5,581.8	$ 449.9	$ 5,546.1	$ 442.1	$ 5,452.8	$ 454.9	$ 5,481.4	$ 558.9	$ 6,181.8
2012	$ 427.3	$ 5,737.0	$ 465.0	$ 6,046.9	$ 459.1	$ 6,005.2	$ 451.1	$ 5,903.8	$ 470.5	$ 5,951.8	$ 609.6	$ 6,791.4
2013	$ 432.9	$ 6,169.9	$ 471.0	$ 6,517.9	$ 467.9	$ 6,473.1	$ 459.8	$ 6,363.6	$ 483.0	$ 6,434.8	$ 627.8	$ 7,419.1
2014	$ 442.0	$ 6,611.9	$ 480.5	$ 6,998.4	$ 479.2	$ 6,952.3	$ 471.2	$ 6,834.8	$ 496.4	$ 6,931.2	$ 646.1	$ 8,065.3
2015	$ 454.7	$ 7,066.6	$ 493.5	$ 7,492.0	$ 487.2	$ 7,439.4	$ 478.6	$ 7,313.5	$ 508.8	$ 7,440.0	$ 660.0	$ 8,725.3

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-5
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
HIGH MWD RATES AND LOW TRANSFER ACQUISITION COSTS SCENARIO

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.2	$ 1,005.6	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.3	$ 1,304.8	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.4	$ 1,612.2	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.6	$ 1,938.8	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 336.7	$ 2,275.5	$ 351.0	$ 2,311.5	$ 349.2	$ 2,317.2	$ 341.7	$ 2,289.0	$ 341.7	$ 2,289.0	$ 379.5	$ 2,426.4
2004	$ 358.8	$ 2,634.2	$ 372.7	$ 2,684.1	$ 370.0	$ 2,687.2	$ 363.0	$ 2,651.9	$ 363.0	$ 2,651.9	$ 401.5	$ 2,827.9
2005	$ 369.8	$ 3,004.0	$ 384.0	$ 3,068.2	$ 380.4	$ 3,067.6	$ 373.1	$ 3,025.0	$ 373.1	$ 3,025.0	$ 423.3	$ 3,251.1
2006	$ 391.2	$ 3,395.2	$ 405.1	$ 3,473.3	$ 402.8	$ 3,470.4	$ 396.3	$ 3,421.3	$ 396.3	$ 3,421.3	$ 449.9	$ 3,701.0
2007	$ 404.5	$ 3,799.7	$ 437.0	$ 3,910.3	$ 414.8	$ 3,885.2	$ 408.7	$ 3,830.0	$ 408.7	$ 3,830.0	$ 473.5	$ 4,174.6
2008	$ 418.9	$ 4,218.6	$ 451.2	$ 4,361.5	$ 433.2	$ 4,318.3	$ 428.0	$ 4,258.0	$ 430.8	$ 4,260.8	$ 505.7	$ 4,680.2
2009	$ 436.1	$ 4,654.7	$ 468.2	$ 4,829.7	$ 448.3	$ 4,766.6	$ 443.8	$ 4,701.8	$ 443.7	$ 4,704.5	$ 530.3	$ 5,210.5
2010	$ 451.3	$ 5,106.0	$ 483.3	$ 5,313.0	$ 458.8	$ 5,225.4	$ 454.5	$ 5,156.4	$ 449.6	$ 5,154.1	$ 555.4	$ 5,765.9
2011	$ 466.7	$ 5,572.8	$ 498.7	$ 5,811.8	$ 466.9	$ 5,692.4	$ 462.6	$ 5,619.0	$ 452.2	$ 5,606.3	$ 577.9	$ 6,343.8
2012	$ 483.4	$ 6,056.1	$ 515.1	$ 6,326.9	$ 476.0	$ 6,168.4	$ 471.9	$ 6,090.9	$ 454.3	$ 6,060.6	$ 579.1	$ 6,922.9
2013	$ 500.4	$ 6,556.6	$ 531.7	$ 6,858.6	$ 488.1	$ 6,656.4	$ 484.7	$ 6,575.5	$ 449.9	$ 6,510.6	$ 590.8	$ 7,513.7
2014	$ 518.1	$ 7,074.6	$ 549.0	$ 7,407.7	$ 500.6	$ 7,157.0	$ 497.7	$ 7,073.2	$ 441.2	$ 6,951.8	$ 601.2	$ 8,114.9
2015	$ 536.1	$ 7,610.8	$ 567.0	$ 7,974.7	$ 509.8	$ 7,666.9	$ 506.7	$ 7,579.9	$ 452.1	$ 7,403.9	$ 614.3	$ 8,729.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-6
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
ADJUSTED TO REFLECT MWD PURCHASE OF TRANSFERS

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 276.3	$ 1,006.6	$ 278.3	$ 1,010.6	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 301.3	$ 1,307.8	$ 302.9	$ 1,313.6	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 311.1	$ 1,619.0	$ 319.2	$ 1,632.8	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 331.5	$ 1,950.4	$ 340.5	$ 1,973.3	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 341.6	$ 2,292.1	$ 356.4	$ 2,329.7	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 358.5	$ 2,650.6	$ 373.2	$ 2,702.9	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 367.0	$ 3,017.6	$ 382.2	$ 3,085.1	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 385.8	$ 3,403.3	$ 400.7	$ 3,485.8	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 396.0	$ 3,799.3	$ 430.0	$ 3,915.8	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 403.7	$ 4,203.0	$ 438.1	$ 4,353.9	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 417.8	$ 4,620.8	$ 452.2	$ 4,806.2	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 428.8	$ 5,049.6	$ 463.5	$ 5,269.7	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 436.9	$ 5,486.5	$ 472.3	$ 5,742.0	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 441.4	$ 5,927.9	$ 477.7	$ 6,219.7	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 450.0	$ 6,377.9	$ 486.5	$ 6,706.1	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 463.0	$ 6,840.9	$ 499.5	$ 7,205.6	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 478.6	$ 7,319.5	$ 515.2	$ 7,720.8	$ 453.4	$ 7,289.8	$ 444.9	$ 7,163.8	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-7
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION[1]
LOW-COST WATER SUPPLY SCENARIO ADJUSTED TO REFLECT REINSTATEMENT OF NDC IN 2003

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.4	$ 730.4	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.1	$ 1,005.5	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 300.4	$ 1,305.9	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 308.4	$ 1,614.3	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 328.0	$ 1,942.4	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 338.2	$ 2,280.6	$ 347.5	$ 2,307.9	$ 347.2	$ 2,315.1	$ 339.2	$ 2,286.5	$ 339.2	$ 2,286.5	$ 377.1	$ 2,424.0
2004	$ 354.7	$ 2,635.3	$ 364.2	$ 2,672.1	$ 360.7	$ 2,675.9	$ 352.9	$ 2,639.4	$ 352.9	$ 2,639.4	$ 391.4	$ 2,815.4
2005	$ 359.1	$ 2,994.4	$ 368.8	$ 3,040.9	$ 365.6	$ 3,041.4	$ 356.7	$ 2,996.1	$ 356.7	$ 2,996.1	$ 406.9	$ 3,222.3
2006	$ 374.4	$ 3,368.8	$ 385.3	$ 3,426.2	$ 384.3	$ 3,425.8	$ 375.7	$ 3,371.8	$ 375.7	$ 3,371.8	$ 429.3	$ 3,651.5
2007	$ 382.9	$ 3,751.8	$ 419.4	$ 3,845.6	$ 392.8	$ 3,818.6	$ 384.2	$ 3,756.0	$ 384.2	$ 3,756.0	$ 449.0	$ 4,100.6
2008	$ 390.9	$ 4,142.6	$ 428.5	$ 4,274.0	$ 406.1	$ 4,224.7	$ 398.0	$ 4,153.9	$ 400.3	$ 4,156.3	$ 475.5	$ 4,576.1
2009	$ 401.9	$ 4,544.6	$ 440.3	$ 4,714.3	$ 416.0	$ 4,640.7	$ 408.0	$ 4,561.9	$ 412.1	$ 4,568.3	$ 495.8	$ 5,071.9
2010	$ 414.6	$ 4,959.2	$ 453.6	$ 5,167.9	$ 423.5	$ 5,064.2	$ 415.6	$ 4,977.5	$ 418.5	$ 4,986.8	$ 517.8	$ 5,589.7
2011	$ 426.7	$ 5,385.9	$ 466.4	$ 5,634.3	$ 429.3	$ 5,493.6	$ 421.1	$ 5,398.6	$ 422.1	$ 5,409.0	$ 537.9	$ 6,127.6
2012	$ 436.8	$ 5,822.7	$ 477.3	$ 6,111.6	$ 432.8	$ 5,926.4	$ 424.3	$ 5,822.9	$ 423.6	$ 5,832.6	$ 552.2	$ 6,679.8
2013	$ 442.4	$ 6,265.1	$ 484.5	$ 6,596.1	$ 435.8	$ 6,362.2	$ 427.3	$ 6,250.2	$ 419.0	$ 6,251.6	$ 556.3	$ 7,236.1
2014	$ 452.3	$ 6,717.5	$ 495.8	$ 7,091.9	$ 441.4	$ 6,803.6	$ 432.8	$ 6,683.0	$ 413.0	$ 6,664.5	$ 561.1	$ 7,797.2
2015	$ 465.1	$ 7,182.5	$ 510.0	$ 7,601.8	$ 446.7	$ 7,250.4	$ 437.6	$ 7,120.6	$ 421.1	$ 7,085.6	$ 570.9	$ 8,368.1

[1] Annual and cumulative costs are expressed in future dollars.

TABLE C-8
WATER RESOURCES PLAN 1997 UPDATE
TOTAL ANNUAL AND CUMULATIVE UNTREATED WATER COSTS IN $ MILLION'
LOW-COST WATER SUPPLY SCENARIO ADJUSTED TO REFLECT REINSTATEMENT OF NDC WHEN MWD SALES REACH 2.2 MAF

	EXISTING STRATEGY		MAXIMUM LOCAL SUPPLY		MAXIMUM LOCAL SUPPLY W/TRANSFERS		INTERMEDIATE TRANSFERS		MAXIMUM TRANSFERS		COLORADO RIVER FACILITIES	
YEAR	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL	ANNUAL	TOTAL
1996	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5	$ 232.5
1997	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 236.5	$ 469.0	$ 243.4	$ 475.9
1998	$ 261.3	$ 730.3	$ 263.3	$ 732.3	$ 263.3	$ 732.3	$ 261.4	$ 730.4	$ 261.4	$ 730.4	$ 266.8	$ 742.7
1999	$ 275.0	$ 1,005.3	$ 277.1	$ 1,009.4	$ 275.5	$ 1,007.8	$ 273.5	$ 1,003.9	$ 273.5	$ 1,003.9	$ 289.9	$ 1,032.7
2000	$ 299.1	$ 1,304.4	$ 300.5	$ 1,309.9	$ 300.4	$ 1,308.2	$ 299.2	$ 1,303.1	$ 299.2	$ 1,303.1	$ 319.7	$ 1,352.4
2001	$ 307.1	$ 1,611.5	$ 315.2	$ 1,625.1	$ 319.1	$ 1,627.3	$ 311.7	$ 1,614.7	$ 311.7	$ 1,614.7	$ 336.3	$ 1,688.7
2002	$ 326.4	$ 1,938.0	$ 335.3	$ 1,960.4	$ 340.7	$ 1,968.0	$ 332.6	$ 1,947.3	$ 332.6	$ 1,947.3	$ 358.2	$ 2,046.9
2003	$ 332.8	$ 2,270.8	$ 349.0	$ 2,309.5	$ 346.4	$ 2,314.4	$ 338.4	$ 2,285.7	$ 338.4	$ 2,285.7	$ 376.2	$ 2,423.1
2004	$ 347.7	$ 2,618.4	$ 364.1	$ 2,673.5	$ 361.6	$ 2,676.0	$ 353.6	$ 2,639.3	$ 353.6	$ 2,639.3	$ 392.1	$ 2,815.2
2005	$ 350.9	$ 2,969.3	$ 368.5	$ 3,042.0	$ 366.5	$ 3,042.5	$ 357.7	$ 2,997.0	$ 357.7	$ 2,997.0	$ 407.9	$ 3,223.1
2006	$ 367.5	$ 3,336.8	$ 385.2	$ 3,427.3	$ 385.7	$ 3,428.2	$ 377.3	$ 3,374.3	$ 377.3	$ 3,374.3	$ 430.9	$ 3,654.0
2007	$ 375.4	$ 3,712.3	$ 418.9	$ 3,846.1	$ 394.7	$ 3,822.9	$ 386.2	$ 3,760.5	$ 386.2	$ 3,760.5	$ 451.1	$ 4,105.1
2008	$ 383.5	$ 4,095.8	$ 428.1	$ 4,274.2	$ 408.8	$ 4,231.7	$ 400.9	$ 4,161.4	$ 403.3	$ 4,163.8	$ 478.5	$ 4,583.6
2009	$ 400.9	$ 4,496.7	$ 451.9	$ 4,726.0	$ 419.2	$ 4,650.9	$ 411.6	$ 4,573.0	$ 415.3	$ 4,579.1	$ 499.4	$ 5,082.9
2010	$ 413.3	$ 4,910.0	$ 465.3	$ 5,191.4	$ 427.3	$ 5,078.2	$ 419.7	$ 4,992.7	$ 422.0	$ 5,001.1	$ 522.0	$ 5,604.9
2011	$ 425.3	$ 5,335.2	$ 478.8	$ 5,670.2	$ 433.2	$ 5,511.4	$ 425.4	$ 5,418.1	$ 425.7	$ 5,426.8	$ 542.1	$ 6,147.1
2012	$ 434.0	$ 5,769.3	$ 489.0	$ 6,159.2	$ 437.2	$ 5,948.6	$ 429.2	$ 5,847.2	$ 426.7	$ 5,853.4	$ 554.9	$ 6,701.9
2013	$ 439.8	$ 6,209.0	$ 496.3	$ 6,655.5	$ 440.8	$ 6,389.4	$ 432.8	$ 6,280.0	$ 422.1	$ 6,275.5	$ 560.1	$ 7,262.1
2014	$ 449.0	$ 6,658.0	$ 507.0	$ 7,162.5	$ 447.0	$ 6,836.4	$ 439.0	$ 6,718.9	$ 415.8	$ 6,691.4	$ 565.5	$ 7,827.6
2015	$ 461.8	$ 7,119.8	$ 521.2	$ 7,683.7	$ 461.7	$ 7,298.1	$ 453.7	$ 7,172.6	$ 424.4	$ 7,115.7	$ 575.6	$ 8,403.2

2

The H_2OPTIMUM Model

2.1 Introduction

The H_2OPTIMUM model is a water resource planning tool that is designed to compile a mix of water resource options that minimizes total cost subject to a set of constraints. These constraints include the service obligations of the water agency constructing the plan, the physical constraints imposed by the output capacity of available projects, the possibility of drought conditions, the availability of imported water, and the storage capacity of reservoirs. This section is organized as follows:

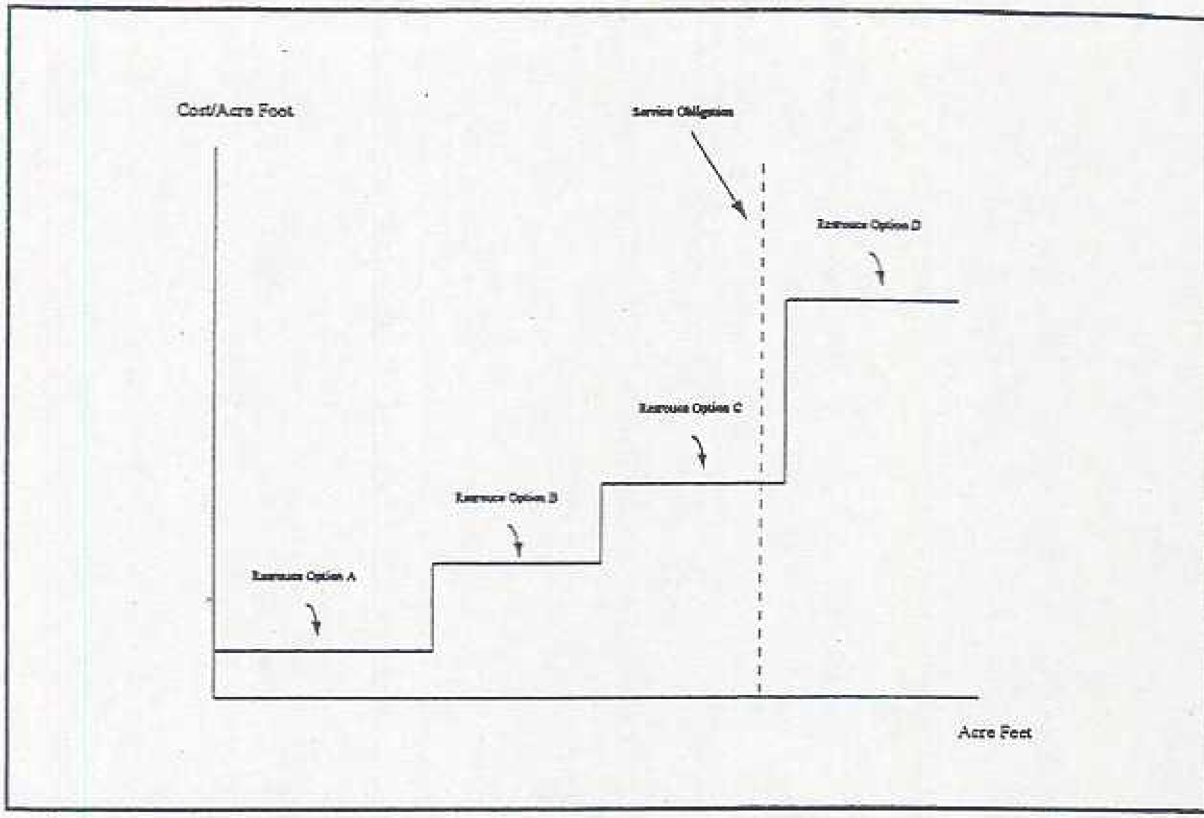
- A description of the nature of the water resource planning problem,
- A brief description of the techniques that are used in the solution of the water resource planning problem and other similar operation planning problems,
- A discussion on the databases that are used in the model, as well as the transfer of data from the input modules to the solution modules, and
- A detailed description of the structure of the optimization process that underlies H_2OPTIMUM.

2.2 The Nature of the Resource Planning Problem

The planning of water resource acquisition is quite similar to the problems faced by planners in other government agencies and private industry. Planners are faced with the requirement to meet obligations, have a limited set of options that are available to meet those obligations, and have the desire to minimize cost.

Figure 2-1 illustrates a simple version of the resource planning problem. The planner has an obligation to provide a level service illustrated by the dashed vertical line. The planner has four sources of supply available, represented by the segments of the stairstep function in the illustration. The cost of each option is equal to the height of each step. The potential supply from each option is equal to the width of each step. It is intuitively clear that the service obligation is met most efficiently by ordering the sources of supply based on cost and tapping each supply, in turn, until demand is met.

Figure 2-1: A Simplified Resource Planning Framework



The solution of this planning problem is complicated by the fact that most interesting planning problems are long range in nature. This may introduce several issues.

- There may be a fixed cost involved in employing a resource for the first time. The most obvious illustration of this is the construction of a water reclamation, repurification or desalination plant that has large capital cost. In order to plan on taking water from the plant, the planner must first decide if it is reasonable to incur the construction costs. Once the plant has been built, those construction costs are sunk and the decision to use water should be based on operation costs. Combining the capital and operating costs into a single number and levelizing over time and output, although reasonable in a static environment, may produce errors if the cost of alternative resources or demand change appreciably over time.
- The cost of utilizing a particular resource may change over time. An example of this would be a plan that uses appreciable amounts of energy. If energy costs are expected to rise (or fall) rapidly over the planning horizon, the order of the plant in the cost ranking illustrated above may change over time.
- The cost of a resource may be subject to discontinuities. An example of this is a water transfer sold under a pricing structure, like the MWD new demand charge, in which a fee is charged for exceeding a historic rate of delivery.

- Supplies may be interruptible. Sources of transfer water or supplies from local resources may be curtailed during periods of dry weather.
- It may be possible to store the product. If it is, service obligations can be met during periods of low availability or high cost by drawing down stocks instead of building new sources of supply. Reservoir storage is available to the water resource planner and should be used strategically.

Because of these factors, it was decided to use an optimization approach that accounts for changes in the availability and cost of alternative water resources over time as well as the possibility of water storage as an alternative to local resource construction.

2.3 Numerical Optimization and the Simplex Algorithm

At the heart of H_2OPTIMUM is what is known in the field of operations research as a *linear program*. Linear programs are a special case of a broader class of models known as *constrained optimization* models. Linear programs are special in the sense that the objective function (the numerical expression that the user wishes to either minimize or maximize) and the constraints (the numerical expressions that define possible solutions) are restricted to be linear equations. Linear equations are distinguished by the absence of terms in which decision variables (quantities that are controlled by the decision maker using the model) are multiplied by themselves, multiplied by other decision variables, or otherwise transformed by anything other than multiplication by a constant (i.e., no logarithms, exponents, trigonometric functions, etc.).

Linear programs are solved using an iterative numerical process known as the *simplex algorithm*. In short, the simplex algorithm finds the combination of decision variables that maximize or minimize the objective function in two ways:

- It locates an initial feasible solution (a combination of decision variables that satisfies all of the constraints), and
- It moves to other feasible solutions that improve the outcome (i.e., increase or decrease the objective function) by incrementing the decision variables until no better solution can be found.[1]

[1] For a more complete explanation of the simplex method, see Hillier and Lieberman, *Introduction to Operations Research*

2.4 The H_2OPTIMUM Data Structure

The H_2OPTIMUM spreadsheet passes the information necessary to optimize the resource mix to a SAS program which organizes the data, constructs an objective function, and constructs a set of constraints that restricts the resource plan to one that is possible given the limits imposed on SDCWA by its operating charter and nature's ability to provide water.

The general form of the information flows in H_2OPTIMUM are shown in Figure 2-2. There are four general classes of information:

- ***Information on local projects.*** The H_2OPTIMUM worksheets contain an inventory of water supply projects that currently exist or that are currently contemplated. For each project, the worksheet contains data on the construction cost for the project (which will be zero if the project has already been built, the sources and cost of financing for the project, and the annual cost per acre foot of operating the project), and the yield of the project in wet, normal and dry years.
- ***Information about reservoirs.*** The H_2OPTIMUM worksheets contain information that tell the model the capacity of each reservoir system, the rate at which water naturally flows into the reservoir, the rate at which water can be purchased from other sources and deposited into the reservoir, the rate at which water can be withdrawn from the reservoir to meet current year demand, and whether or not the reservoir's storage can be used to satisfy minimum emergency storage requirements.
- ***Information about conservation opportunities.*** Conservation opportunities are expressed as: (a) *programs*, or mutually exclusive groups of conservation measures that the planner wishes to include as a resource option, and (b) *program options*, which express different implementation schedules for each program.

  For each program option, the H_2OPTIMUM worksheet has three input areas:

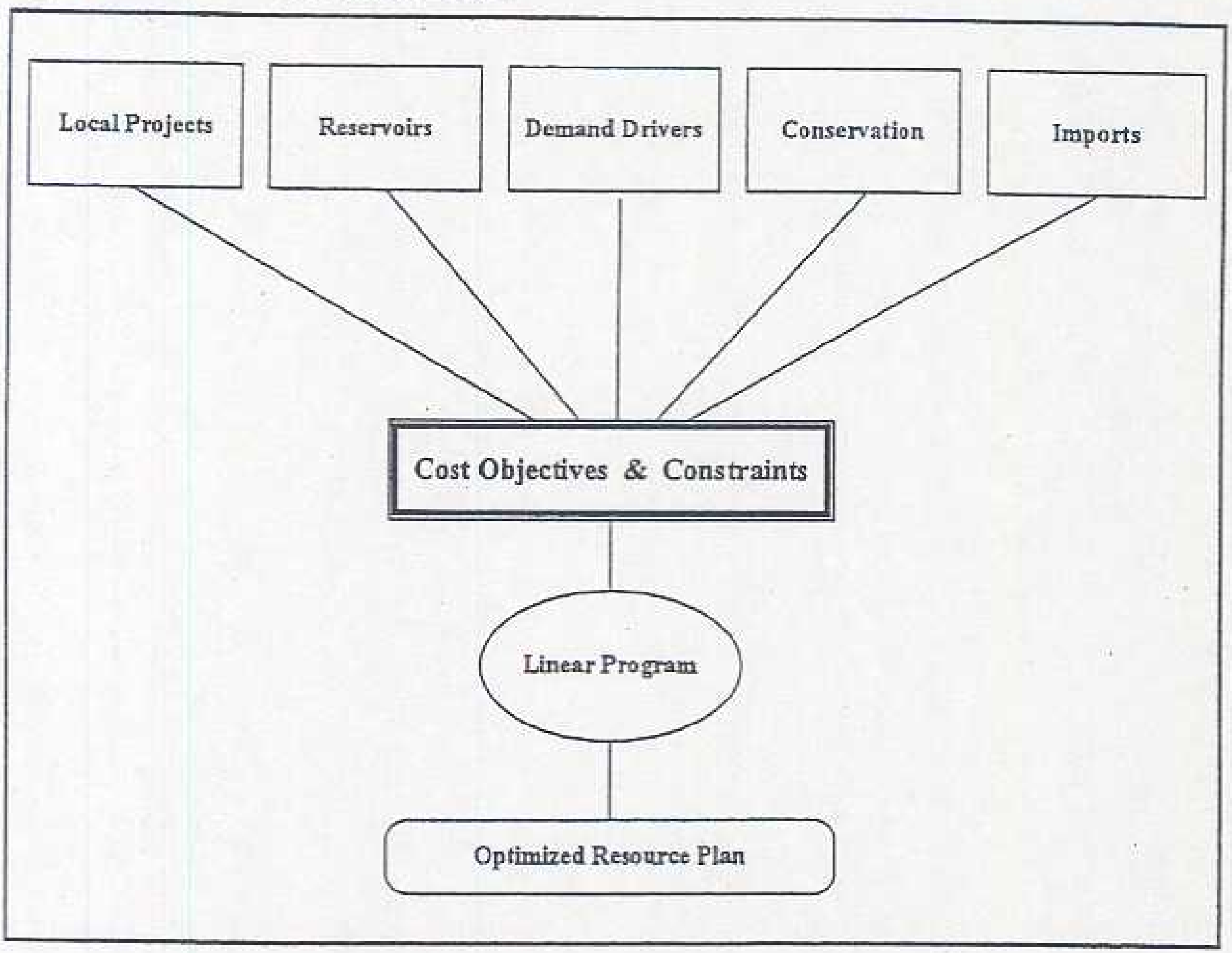
  - A single cell where the planner inputs the present value cost of that program option,
  - A single cell where the planner inputs the potential savings for the program option. This number should be the same for each option within a program.
  - A series of cells where the planner inputs the percent of potential savings achieved during each year of the forecast horizon.

  This framework allows the planner to evaluate the cost effectiveness of individual conservation measures or groups of conservation measures.

  Presumably, the total savings potential from a measure package can be achieved more quickly if the planner is willing to accept a greater present-value cost. This framework allows the planner to evaluate the desirability of pursuing groups of measures more or less aggressively.

- ***Information about transfers.*** The H_2OPTIMUM worksheets contain information about the cost and availability of water from the Metropolitan Water District as well as other sources. It is assumed that MWD water is available in all years and that the quantities are unlimited except during spells of extended dry weather. The worksheet also contains a schedule of curtailment of MWD deliveries during those periods. For sources other than MWD, the worksheet contains a single cell that allows the planner to specify whether those sources are available during all years or only during years of curtailment of supplies from MWD.
- ***Information about the assumptions underlying the resource plan.*** This includes data on the expected service obligations, the weather conditions underlying the resource plan (i.e., no drought, short drought, or long drought), the interest rate used for discounting future costs and benefits, and the perspective from which costs are to be minimized (i.e., regional or local).

Figure 2-2: The H_2OPTIMUM Logic



2.5 The Structure of the Optimization Model

As shown in Figure 2-2, the linear program contained in the H_2OPTIMUM model is based on an objective function and a set of constraints. Both the objective function and the constraints can be expressed as equations or inequalities that are relationships among subsets of the decision variables in the model. In summary, these equations are:

- The function that defines the objective of the resource plan, which is to minimize total costs.
- A set of equations that constrain the resource plan to one that allows SDCWA to meet its service obligations in every year of the forecast horizon.
- A set of equations that defines the constraints facing SDCWA with respect to the construction and utilization of prospective local resource supply projects.
- A set of constraints that defines the relationship between conservation programs and conservation program options.
- A set of constraints that defines the ability of SDCWA to use imported water, both from MWD and other sources.
- A set of constraints that deal with the storage of water by SDCWA and its member agencies. These include the following:
  - A set of inequalities that defines the maximum amount of water that can be stored in each reservoir system,
  - A set of equalities that relates current year storage to previous year storage, current year purchases, current year reservoir withdrawals, runoff and evaporation, and
  - A set of inequalities that limits the amount of water that can be purchased for storage and withdrawn from storage in any one year.
- A set of constraints that defines the extent and cost of shortages.
- A set of constraints that relates the amount of water purchased from MWD in the current year to the previous peak demand for the purposes of calculating the New Demand Charge.
- A set of equations that defines the impact of local resource supplies on the MWD rate structure. This impact is characterized as an indirect cost of the local supply and appears in the optimization model as an increment to the marginal cost of using a local resource.

These sets of expressions are explained in detail below.