Alameda County Water District

INTEGRATED RESOURCES PLANNING STUDY

Summary Report

August 1995

ACWD
ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

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ALAMEDA COUNTY WATER DISTRICT

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ACRONYMS AND ABBREVIATIONS

ABAG	Association of Bay Area Governments
ACWD	Alameda County Water District
af	acre-foot (feet)
afy	acre-foot (feet) per year
AHF	above the Hayward Fault
ARP	Aquifer Reclamation Program
BEME	Bookman-Edmonston and Metcalf & Eddy (authors of the 1986 study)
BHF	below the Hayward Fault
BMP	Best Management Practices
$CaCO_3$	calcium carbonate
ccf	hundred cubic feet
cfs	cubic foot (feet) per second
CUWA	California Urban Water Agencies
CVP	Central Valley Project
DWR	(California) Department of Water Resources
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
gpd	gallons per day
gpm	gallons per minute
IGSM	Integrated Groundwater–Surface Water Model
IRP	integrated resource planning
IRPM	(District's) Integrated Resource Planning Model
MCL	Maximum Contaminant Level
mgd	million gallons per day
MOU	Memorandum of Understanding Regarding Urban Water Conservation in California
MSJWTP	Mission San Jose Water Treatment Plant
MSL	mean sea level
NUMMI	New United Motor Manufacturing, Inc.
ppm	parts per million
SBA	South Bay Aqueduct
SBP	Salinity Barrier Program
SDWA	Safe Drinking Water Act
SEP	Salt Evaporator Pond
SFWD	San Francisco Water Department
sq. ft.	square foot (feet)

ACRONYMS AND ABBREVIATIONS (continued)

SWP	State Water Project
SWRCB	State Water Resources Control Board
ULFT	ultra low flush toilet
USBR	U.S. Bureau of Reclamation
USD	Union Sanitary District
USGS	U.S. Geological Service
WTP	water treatment plant
WTP 2	(District's) Water Treatment Plant Number 2
Zone 7	Zone 7 of the Alameda County Flood Control and Water Conservation District

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

The Integrated Resources Planning Study provides the Alameda County Water District (hereafter referred to as the "District") with long-term direction for facility and resource development. This planning effort applies the approaches and techniques of integrated resource planning (IRP) to ensure that appropriate facility and resource decisions are made.

This study outlines the District's resource development strategy through the year 2030 and incorporates many of the conditions that have changed since the District's last supply and facilities planning study, which was completed in 1986.[1] This study also presents documentation to:

- Determine how updated economic growth forecasts and demand projections affect the District's need for water;

- Define the District's resource planning goals and objectives;

- Develop measurable evaluation criteria associated with each policy objective;

- Define major future uncertainties;

- Evaluate the adequacy of existing supplies to meet long-term water demand under current operating criteria;

- Assess and characterize supply-side and demand-side resource options;

- Formulate and evaluate resource sequences; and

- Formulate final recommendations.

The tasks covered in a section are highlighted in the process diagram at the beginning of each section.

The study was prepared as a cooperative effort of District staff, Barakat & Chamberlin, Inc., and Water Resources Management, Inc.; the study incorporates

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[1]Bookman-Edmonston and Metcalf & Eddy (BEME), *Supply and Facilities Planning Study* (Fremont, Calif.: Alameda County Water District, 1986).

results from the Phase 1 Water Demand Investigation.[2] The study team worked closely with staff advisory committees during the course of this study. In addition, the Board of Directors reviewed progress and provided guidance at key decision points. At various points throughout the study, District staff also met with managers and staff from the Union Sanitary District and the cities of Fremont, Newark, and Union City to ensure proper coordination, review, and exchange of information.

The public also provided valuable input throughout the course of this study. Two bill inserts that introduced the IRP planning effort were prepared and sent to customers. A hotline was set up for customers to call to request additional information. A brochure describing plan progress was prepared and sent to over 400 customers, local officials, and interest groups. A public meeting was held to provide additional information on the IRP process and to give citizens an opportunity to express their opinions on the issues being addressed. A final brochure was prepared describing the study conclusions and recommendations. An announcement of the presentation of the conclusions and recommendations to the Board of Directors was sent to those on the mailing list to provide further opportunity for public comment.

WATER DEMAND FORECAST

Realistic forecasting of water demands is key to determining the actions needed to provide a reliable water supply to existing and future customers. Since the last demand forecast was completed in 1986, changes in future land uses, growth rates, population projections, and customer water uses have affected the District's demand forecast. To more accurately forecast water demands and to facilitate future changes, a different and more rigorous approach is taken to develop

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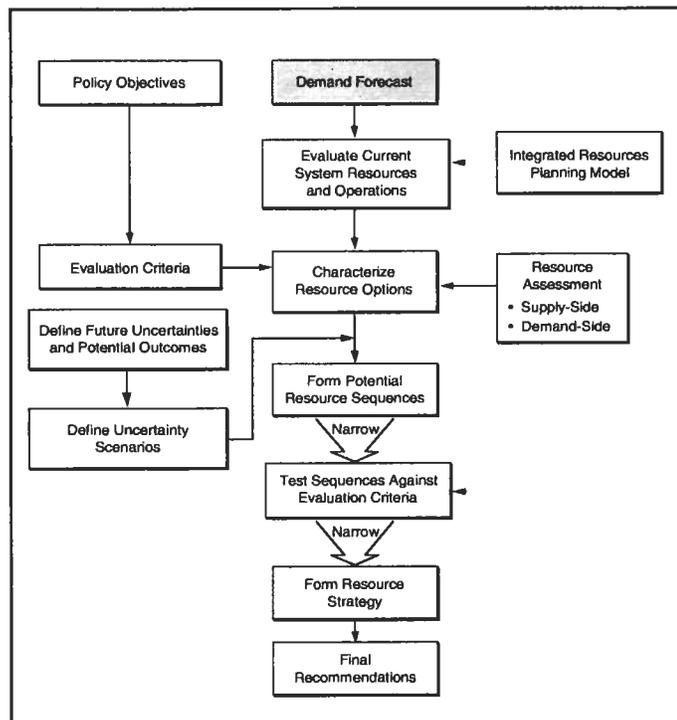
[2]Brown & Caldwell, *Water Demand Investigation* (Fremont, Calif.: Alameda County Water District, 1993).

the demand forecasts used in this study. In-depth analyses of historical water use, varying rates of development and land use scenarios, variations in water use under different climatological conditions, and adjustments in future water use for naturally occurring conservation[3] are used to develop a range of water demand forecasts (see Figure ES-1).

Figure ES-1
**Water Use Forecast
Adjusted for Naturally Occurring Conservation**

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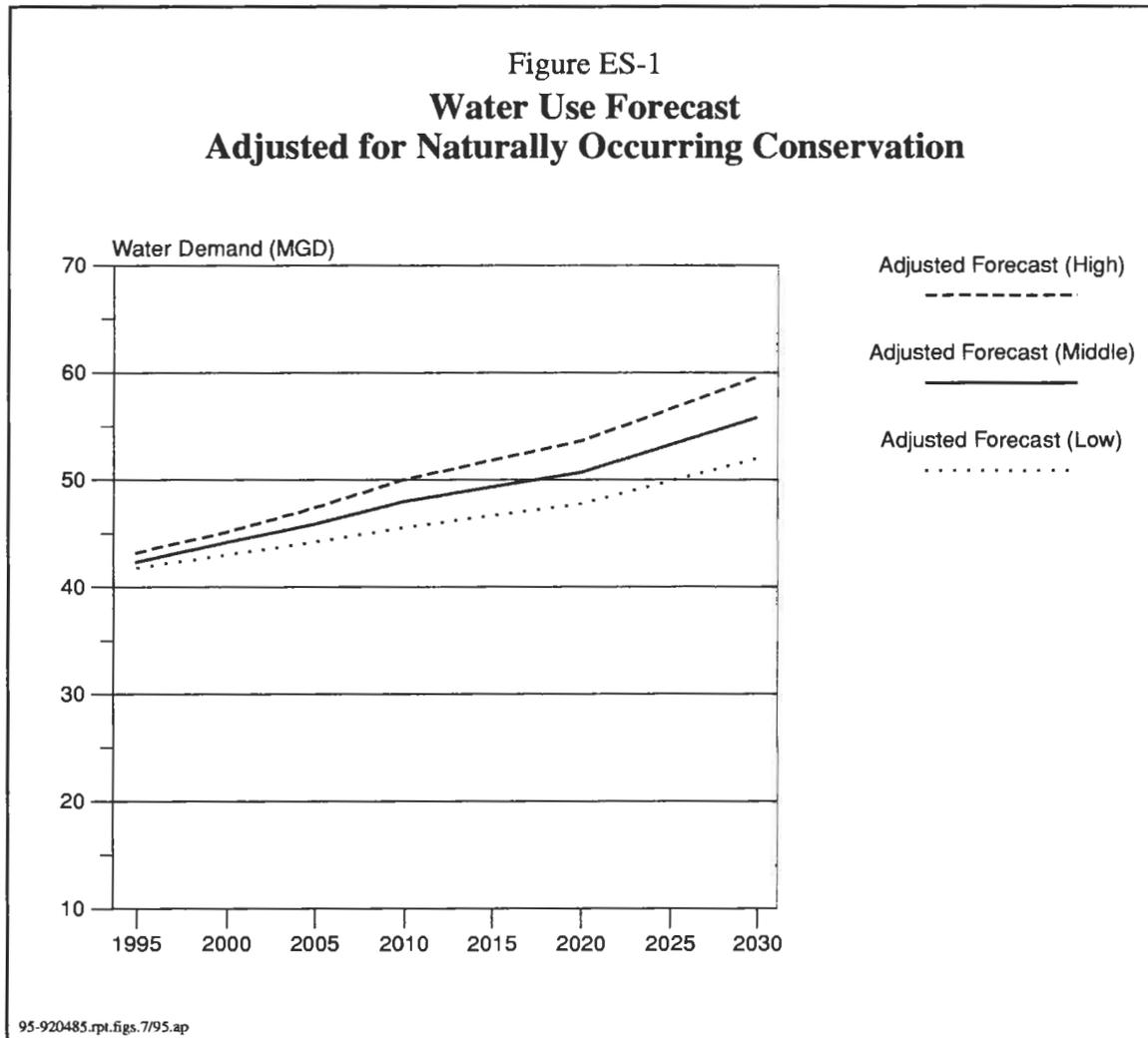
[3]In 1993, the California State Legislature passed legislation that required the sale and manufacture of 1.6 gallons per flush toilets, 2.5 gpm faucets, and 2.5 gpm showerheads for residential application beginning January 1, 1994. New construction will incorporate these water-efficient fixtures. Over time higher flow fixtures in existing construction will turn over and be replaced with water-efficient models.

ANALYTICAL TOOLS

Because of the comprehensive nature of this planning process, a computer model was developed. This analytical tool, called the Integrated Resource Planning Model (IRPM), was used to evaluate current and future system reliability and the cost, reliability, and water quality consequences of potential resource development paths. In addition, the IRPM was used in conjunction with the District's Integrated Groundwater–Surface Water Model (IGSM) to reevaluate the District's Aquifer Reclamation Program (ARP) pumping requirements and to optimize the conjunctive use of existing groundwater and surface water supplies.
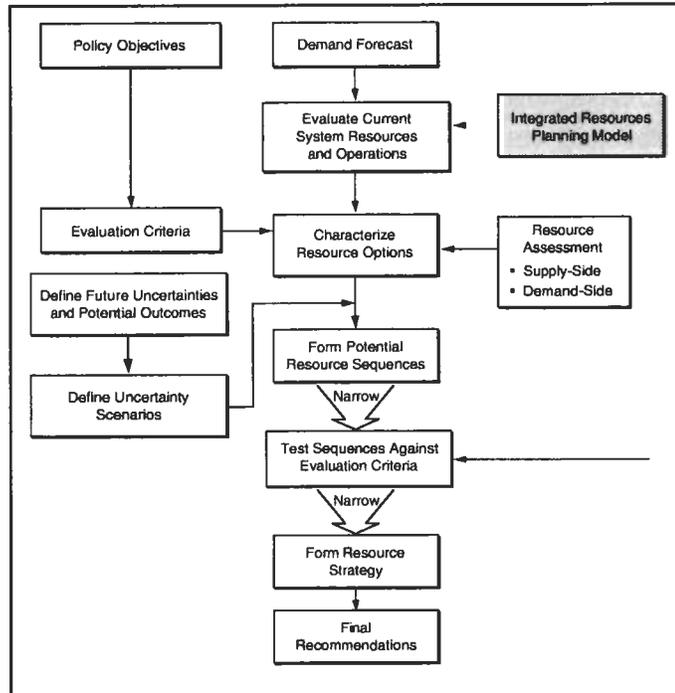
POLICY OBJECTIVES

An important step in the IRP process was to develop explicit policy objectives. Policy objectives in the areas of water supply reliability, economic impact, water quality, and environmental protection served as a guide in formulating and evaluating potential resource strategies. The policy objectives identified include:
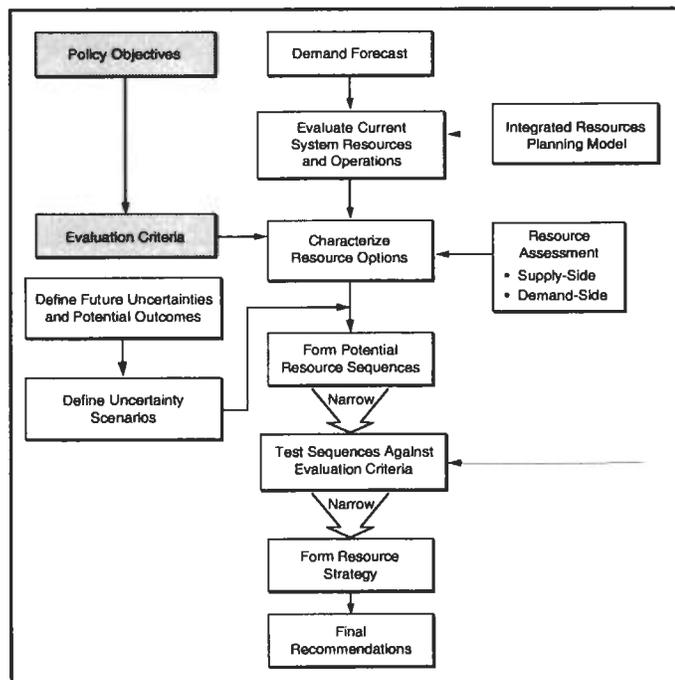
Costs

- Minimize resource costs
- Maintain low average customer bills
- Avoid rate shocks

Reliability

- Maintain a high level of service reliability

Water Quality

- Avoid sudden changes in water taste or appearance
- Maximize health-related quality

Environmental Impacts

- Avoid or mitigate environmental impacts
- Protect groundwater resources

Local Control

- Maximize District control of resources
- Avoid chronic shortages

Risk

- Minimize risks due to future uncertainty

For each policy objective, one or more measurable evaluation criteria were defined. These criteria were subsequently used to assess the performance of individual resource alternatives and combined resource strategies and sequences.

FUTURE UNCERTAINTIES

There are many future uncertainties that are largely beyond the District's control that could impact water demand, existing supply reliability, and the ability to develop future resources. Since the actual outcomes of these uncertainties cannot be predicted, the District's resource plan should be flexible enough to enable it to adapt to differing outcomes. The strategy recommended in this study specifies District courses of actions in anticipation of or in response to these future uncertainties.
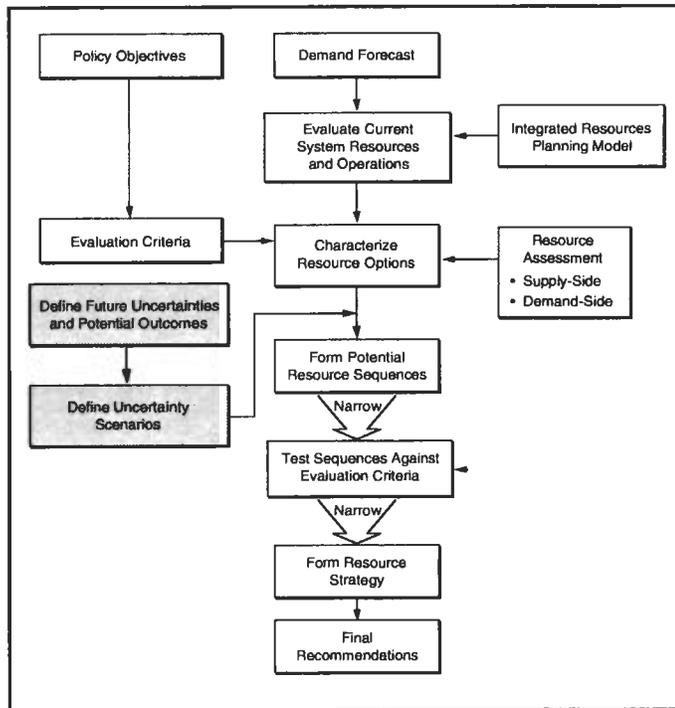
Three uncertainties were identified as being critical in their impact on the District's future resource decisions:

1. The demand forecast;

2. Regulatory restrictions that may affect supply availability (i.e., the availability of SFWD and SWP deliveries); and

3. Drinking water regulations (as they pertain to surface treatment plant capacities).

For each of these uncertainties, a range of potential outcomes was developed. To make the analysis manageable, the uncertainty outcomes were combined into three future scenarios, which are summarized in Table ES-1.

Table ES-1
SUMMARY OF UNCERTAINTY SCENARIOS

	Best Case	Middle Case	Worst Case
Demand forecast	Low development	Middle development	High development
SWP deliveries	Cal-Fed decision	Cal-Fed decision	EPA proposal
SFWD deliveries	Additional 1.7 mgd	Additional 0.7 mgd	No additional allocation
Treatment plant capacities	37 mgd (WTP 2 capacity: 28 mgd)	32 mgd (WTP 2 capacity: 23 mgd)	30 mgd (WTP 2 capacity: 21 mgd)

WATER SUPPLY AND OPERATIONAL ANALYSIS

To determine the resource alternatives that will be needed to meet the water demands of existing and future customers, the adequacy of existing supplies, facilities, and current operations was evaluated under each of the uncertainty scenarios previously described. The IRPM was used to simulate the use of existing facilities and supplies only (i.e., the "no action" alternative). The resulting simulated system capacity constraints and the extent and frequency of future shortages provided the basis for developing alternatives to meet supply reliability criteria and other goals. The results of this analysis are summarized below.
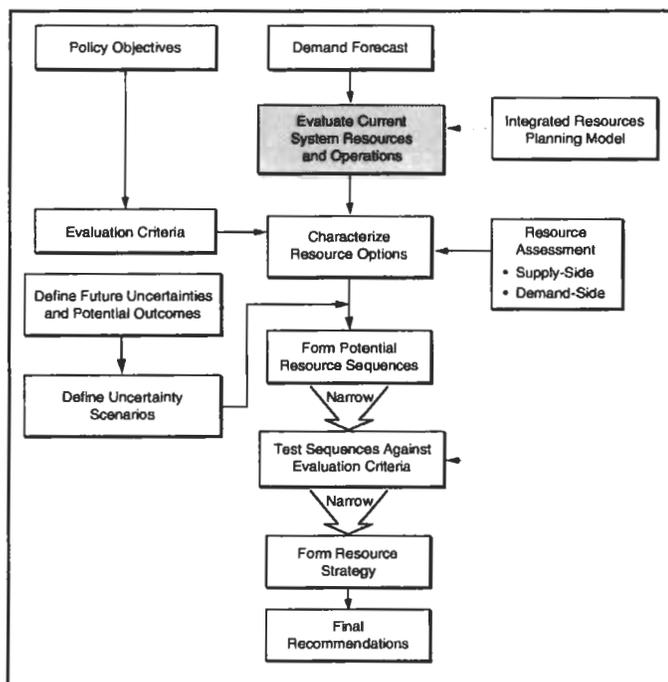
Under normal water year conditions,[4] annual water supply shortages would not occur under the best-case and middle uncertainty scenarios. On the contrary, surpluses would occur throughout the planning horizon under both scenarios. Under the worst-case uncertainty scenario, shortages would begin to occur by the year 2020 (see Figure ES-2).

Figure ES-2
Water Availability in a "Normal" Water Year

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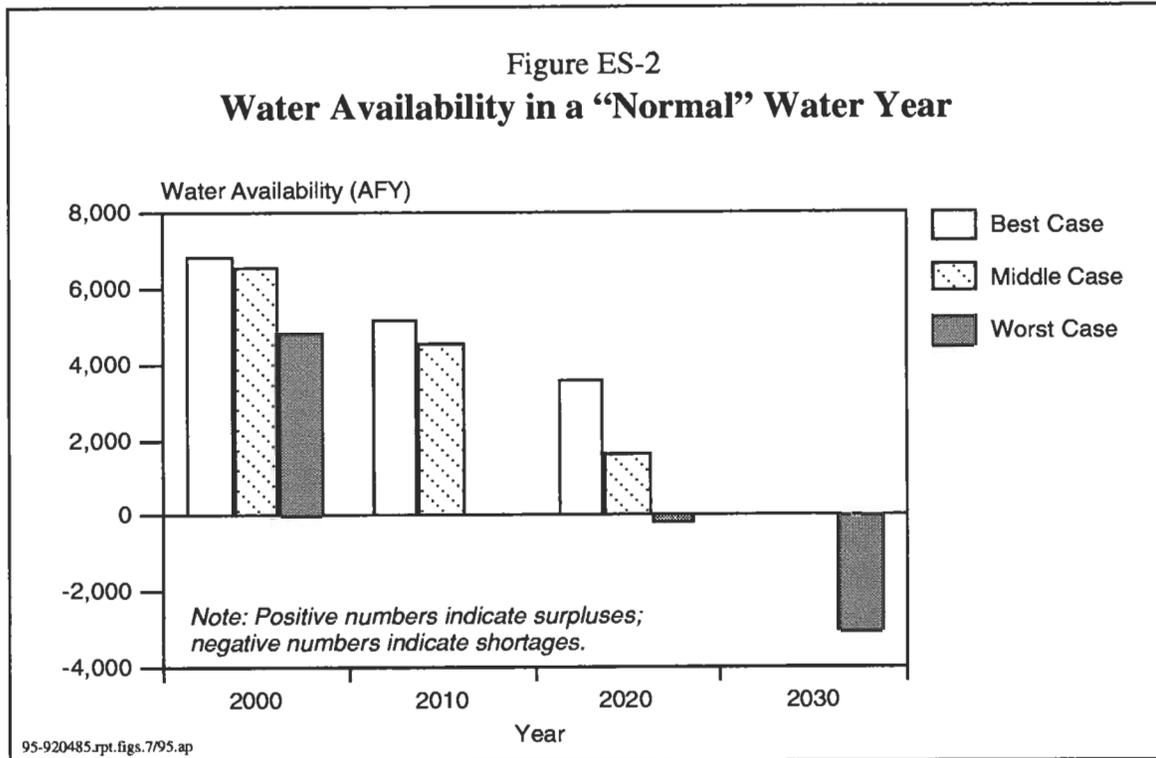
Under wet water year conditions,[5] water surpluses are expected under all uncertainty scenarios (see Figure ES-3). The District is not able to use all of its available supplies during wet years because its long-term storage is limited to groundwater storage (approximately 30,000 acre-feet of usable storage) and surface storage in Del Valle

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[4]A *normal water year* is defined as a year in which the District receives approximately 85% of its SWP entitlement, 100% of its SFWD its allocation, and is able to pump the average safe yield of 22,000 acre-feet from its groundwater basin.

[5]A *wet water year* was defined as a year in which the District receives 100% of its imported supplies with local supplies available in an amount sufficient to continuously recharge the groundwater basin at the maximum rate.

Figure ES-3
Water Availability in a "Wet" Water Year

Water Availability (AFY)
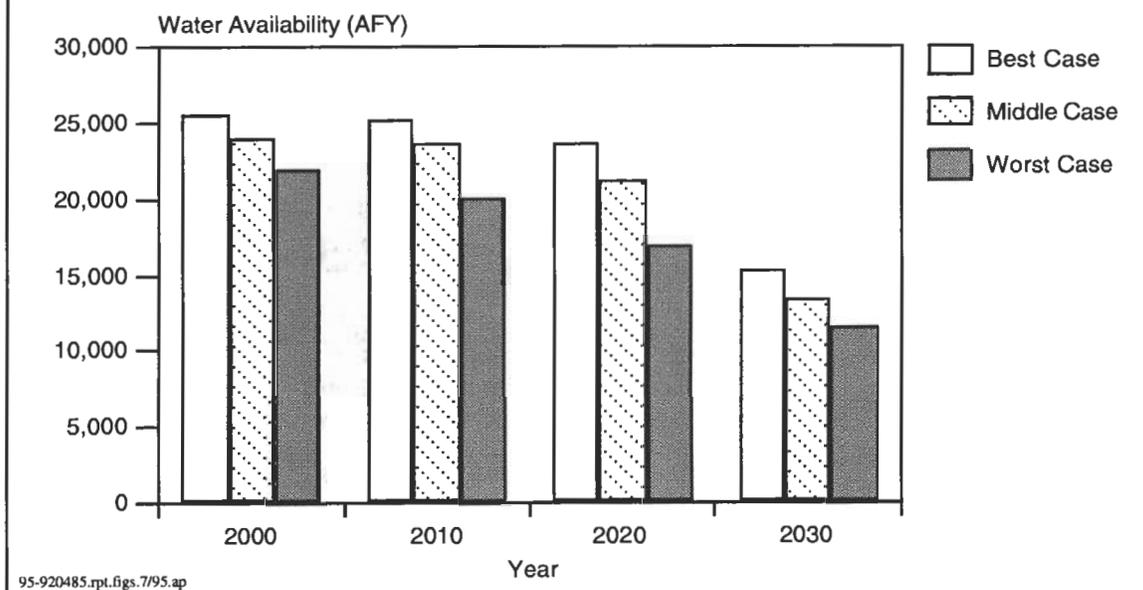
(approximately 7,500 acre-feet). In addition, groundwater model analyses indicate that groundwater losses to San Francisco Bay occur during wet years when the groundwater elevation below the Hayward Fault is greater than ten feet above mean sea level (+10 MSL).

Under dry water year conditions,[6] annual shortages are expected under all uncertainty scenarios by the year 2000 (see Figure ES-4.) A comparison of wet year surpluses and dry year shortages shows the variability of water supply reliability. Supplies can range over time from as much as 38,600 acre-feet of annual water surplus to as much as 37,400 acre-feet of water shortage. This variability indicates a need to store water in wet years for use in dry years.

Maximum-day shortages are expected to occur much sooner due to water treatment plant capacity and blending limitations. Based on the historical record, maximum daily demand is assumed to be 1.8 times greater than average annual demand. Applying this factor to the average annual demand shows that maximum daily demand may exceed existing capacity by as much as 7 mgd by the year 2000 and by as much as 27 mgd by the 2030 in the worst-case scenario.

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[6]A *dry water year* was defined as a year in which the District receives less than 25% of SWP entitlement, approximately 60% of SFWD allocation, and less than 5,000 acre-feet of local water.

Figure ES-4
Water Shortages in a "Dry" Water Year

Water Shortages (AFY)

Best Case
Middle Case
Worst Case

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POTENTIAL RESOURCES

This study began with an extensive list of potential resources. These resources included supply-side alternatives (supplemental sources, facilities, and operational modifications) and demand-side (conservation) alternatives.

The identified resources were then filtered through a succession of more and more finely meshed screens to eliminate the options that were inappropriate. The initial screens are rather

coarse, whereas the later screens are more detailed. The goal was to end with a manageable number of the most effective resource options.

Supply-Side Resource Options

Potential supply-side options include supplemental supplies, storage facilities, treatment facilities, and operational modifications (see Figure ES-5.) The initial screening process eliminated as many less feasible supply-side alternatives as possible. After the less feasible alternatives were eliminated, those remaining were characterized in terms of the following attributes:

- Nominal yield or capacity
- Capital and operating costs
- Operational feasibility
- Construction and regulatory lead times
- Qualitative evaluation factors

The costs of the supply-side options are summarized in Table ES-2.

Conservation Options

As is the case with the supply-side options, a systematic approach is applied to develop the conservation options. The conservation analysis included the following steps:

- Disaggregate demand data to determine water-use patterns in the District;

- Carefully screen conservation measures to determine the ones that are appropriate for use in the District;

- Target specific water uses with cost-effective conservation measures;

- Design appropriate delivery mechanisms, including incentives and marketing approaches;

Figure ES-5
Summary of Supply-Side Options

Reclamation	Desalination	Agricultural Purchase	Additional Storage	Surface WTP	Operational Modifications
Direct Potable Reuse	Brackish Water	Annual	Local Recharge	Upgrade Existing WTP	Seasonal Hardiness Variation
Indirect Potable Reuse	Seawater	Drought Year	San Joaquin Valley G/W Banking	Construct New WTP	Eliminate Hardness Constraint
Irrigation	Reclaimed Water		Livermore Valley G/W Banking		Draw G/W Basin Below Sea Level: w/SBP Pumping
			Dual Use of Existing Recharge		Draw G/W Basin Below Sea Level: w/o SBP Pumping
			Dumbarton Quarry Pits		Increase Groundwater Pumping
			Raise Calaveras Dam		Pump More ARP When G/W Elevation Is High
			Construct Upper Del Valle		
			Sunol Valley Quarry Pits		
			Chain of Lakes Quarry Pits		
			Sunol Valley G/W Recharge		
			San Luis Reservoir		

▢ Option eliminated

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Table ES-2
SUMMARY OF THE COST OF SUPPLY-SIDE OPTIONS

	Total Capital Cost ($000)	Annual Operational Cost ($/afy)	Total Annual Cost ($/afy)
Storage Options*			
San Joaquin Valley groundwater banking**	—	—	100–180
Livermore Valley groundwater banking**	—	—	100–180
San Antonio Dam	13,000	243,000	20
Upper Del Valle	72,600	2,100,000	170
Sunol Valley quarry pits**	—	—	100–180
Chain of Lakes quarry pits**	—	—	100–180
San Luis Reservoir	0	0	0
New Sources of Supply			
Water Reclamation			
Phase 1: 1,626 afy	14,282	182	935
Phase 2: 1,045 afy	13,621	213	1,331
Phase 3: 1,360 afy	23,210	241	1,705
*Salt Water Desalination****			
1 mgd plant: 1,120 afy	2,293	433–531	628–726
3 mgd plant: 3,360 afy	4,237	403–501	523–621
5 mgd plant: 5,600 afy	7,464	399–497	526–624
8 mgd plant: 8,960 afy	10,887	397–495	513–611
10 mgd plant: 11,200 afy	14,324	396–494	518–616
Agricultural Purchase			
Annual purchase	1/af	40	162
Drought-year purchase	0	250	250
Facility/Operational Modifications*			
Existing treatment plant upgrades	2,000/mgd	0	153
Groundwater management alternatives	0	53	53

Note: All costs are in 1994$.
*Costs do not include the cost of supply or treatment.
**Estimated costs. Actual costs based on contractual arrangements and/or pending further evaluation by lead agency.
***Operational and total costs/afy include cost of using concentrate for environmental enhancement or for concentrate disposal.

- Characterize the programs, including participation levels, program costs, water savings, revenue impacts, demand hardening impacts,[7] and staffing requirements; and

- Package conservation programs into logical groups for integration with supply options.

Four conservation packages were developed. Each package calls for a different intensity of District effort and targets different end uses. The packages may be described as follows:

- Package 1 represents the minimum level of District effort;

- Package 2 focuses on reducing outdoor water demands;

- Package 3 focuses on reducing indoor water demands; and

- Package 4, the most aggressive package, includes all 12 conservation programs under consideration.

Table ES-3 summarizes the programs contained in each conservation package, and Table ES-4 summarizes the associated costs and water savings.

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[7]*Demand hardening* is a term used to describe the diminished ability or willingness of customers to reduce demand during a supply shortage.

Table ES-3
PROGRAMS CONTAINED IN THE CONSERVATION PACKAGES

PACKAGE 1: MINIMAL DISTRICT EFFORT	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 8. Business/Industrial Audits and Customized Rebates	10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates

PACKAGE 2: SEASONAL DEMAND REDUCTION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 6. Residential New Construction: Low-Water-Use Landscaping 7. Residential Water-Efficient Landscape Design Workshops	8. Business/Industrial Audits and Customized Rebates 9. Industrial Cooling Tower Workshops 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates

PACKAGE 3: ANNUAL DEMAND REDUCTION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 3. ULFT Replacement 4. Low-Income Direct Installation	5. Student Home Water Audit Program 8. Business/Industrial Audits and Customized Rebates 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebate

PACKAGE 4: COMPREHENSIVE CONSERVATION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 3. ULFT Replacement 4. Low-Income Direct Installation 5. Student Home Water Audit Program 6. Residential New Construction: Low-Water-Use Landscaping	7. Residential Water-Efficient Landscape Design Workshops 8. Business/Industrial Audits and Customized Rebates 9. Industrial Cooling Tower Workshops 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates 12. Irrigation Workshops

Table ES-4
COSTS AND SAVINGS OF THE CONSERVATION PACKAGES

	Package 1	Package 2	Package 3	Package 4
Present value of utility costs ($)[a, b]	4,218,000– 5,768,000	5,101,000– 11,071,000	8,866,000– 17,877,000	9,742,000– 19,230,000
Total water savings over 35-year planning horizon (af)[b]	41,230	43,200– 116,670	65,310– 135,590	66,820– 145,780
Maximum annual savings (afy)[b]	1,510	1,550– 4,900	2,540– 4,490	2,570–4,840
Equivalent unit cost ($/af)[b, c]	290–400	340–350	370–410	400–420

[a]Includes staffing costs.
[b]A range of savings and costs is provided in most cases to account for uncertainties.
[c]Present value of utility costs divided by the discounted stream of water savings that are expected from the conservation package. Does not include participant costs or revenue losses.

The conservation packages were evaluated using the IRPM. Packages 2, 3, and 4 reduced water demand at critical times (i.e., during periods of peak season demand and during drought years) better than package 1. When compared with packages 2 and 3, package 4, the most aggressive and costly package, did not reduce demand during critical periods by enough to warrant the additional costs. Therefore, packages 1 and 4 were eliminated. Packages 2 and 3 were passed on to the resource plan integration phase and combined with supply-side alternatives to meet water supply reliability goals.

Qualitative Evaluation of Resource Alternatives

Three of the policy objectives were evaluated by examining the qualitative characteristics of the individual resource alternatives. The three policy objectives were:

- Avoid or mitigate any negative environmental impacts that may result from water supply or facility additions;

- Maximize local control of existing and future resources; and

- Minimize risk due to future uncertainties, including financial risk, water supply availability risk, and water quality regulatory risk.

Resource alternatives were rated using a (+), (✓), and (−) scale. When individual resource alternatives were combined into resource sequences, the ratings were respectively converted into a 1, 2, and 3 scale. The lower the score, the more favorable the rating. The qualitative rating of the individual resource alternatives are summarized in Table ES-5.

Table ES-5
QUALITATIVE EVALUATION OF SUPPLY OPTIONS

	Environmental Issues	ACWD Control	Risk		
			Availability	Financial	Water Quality
Ag transfer—annual	✓	−	−	✓	−
Ag transfer—drought year	✓	−	−	+	−
Desalination	✓	+	+	✓	✓
Reclamation	✓	+	+	−	+
Surface WTP upgrade	✓	+	+	✓	−
Storage—banking	✓	✓	+	+	−
Storage—surface reservoir	−	✓	+	−	−
G/W basin mgt					
$-5 \leq BHF \leq 3$	✓	+	+	+	✓
$BHF < -5$	−	+	+	+	✓
$BHF > 3$	+	+	+	+	✓
Drought yr hardness variation	+	+	+	+	✓
Conservation	+	+	✓	✓	+
Note: (+) is more favorable than (✓), which is more favorable than (−).					

RESOURCE PLAN INTEGRATION AND EVALUATION

The results of the evaluation of the water system reliability under a "no action" alternative and the characterization of individual supply-side and conservation resource options served as the basis for formulating the alternative implementation strategies. Individual resource alternatives were combined into progressions of actions, termed *resource sequences*, to be phased in over the 35-year study period. The resource sequences were designed to allow the District to meet additional capacity needs, water supply needs, and to optimize the use of existing and future resources. In addition, the resource sequences allow the District to evaluate the trade-offs among the evaluation criteria.
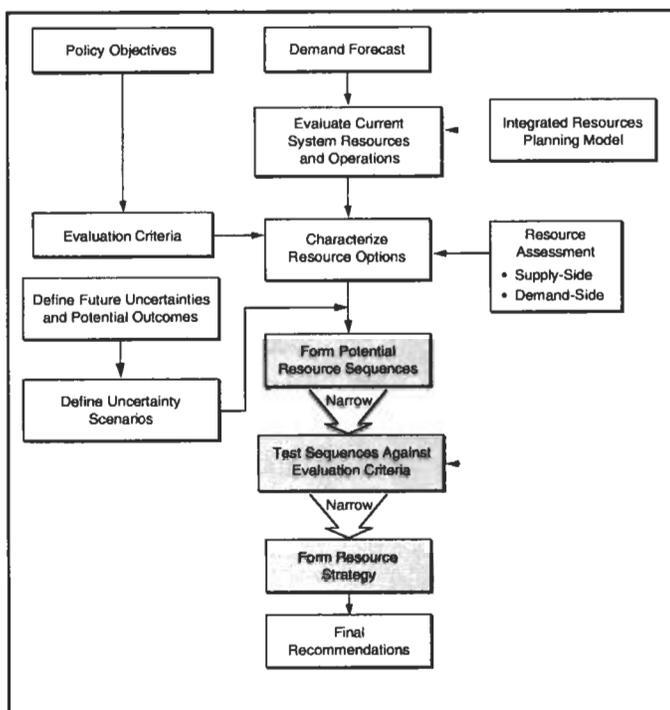
Nine resource sequences were developed and evaluated for the middle case uncertainty scenario. The resource sequence that best meets the District's objectives under the middle case uncertainty scenario was then modified to meet District objectives under the best- and worst-case scenarios.

Resources were combined to attain a range of reliability goals. The lowest level of reliability considered had a maximum annual shortage of 30% occurring once in 30 years; the highest level of reliability had no shortages. Using the results of a contingent valuation survey prepared for CUWA,[8] and public input at District presentations, the District set a reliability goal of no more than a 10% shortage once in 30 years. Therefore, most resources sequences were designed to attain this reliability goal. The resource alternatives included in each resource sequence over the 35-year study period are shown in Table ES-6.

Diagram boxes:
- Policy Objectives
- Demand Forecast
- Evaluate Current System Resources and Operations
- Integrated Resources Planning Model
- Evaluation Criteria
- Characterize Resource Options
- Resource Assessment • Supply-Side • Demand-Side
- Define Future Uncertainties and Potential Outcomes
- Form Potential Resource Sequences
- Define Uncertainty Scenarios
- Narrow
- Test Sequences Against Evaluation Criteria
- Narrow
- Form Resource Strategy
- Final Recommendations

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[8]Barakat & Chamberlin, *The Value of Water Supply Reliability* (Oakland, Calif.: Barakat & Chamberlin, prepared for CUWA, August 1994).

Table ES-6
SUMMARY OF RESOURCE SEQUENCES

Sequence Number	Conservation	Hardness (mg/L)	BHF Level (ft below MSL*)	Agricultural Transfer		Storage/ Banking	Desalination	Reclamation			Additional WTP Capacity
				Annual	Drought			Phase 1	Phase 2	Phase 3	
1	•	UNLTD	−40			•					•
2		150			•		•	•	•	•	
3	•	150	±5			•	•	•	•		•
3A	•	150–175	±5			•	•	•	•		
4	•	150–175	±5	•		•					
5	•	150–175		•		•		•	•	•	
6	•	150		•		•	•				
6A	•	UNLTD		•		•					
7	•	150		•	•	•	•	•			

[1]MSL—mean sea level.

The resource sequences were evaluated against the District's policy objectives based on the qualitative ratings of the individual resource alternatives contained in each resource sequence, the total cost of the new resource alternatives, and the resulting water supply reliability and hardness obtained. The results of the evaluation of resource sequences is shown in Table ES-7.

Comparisons of pairs of resource sequences and their respective ratings against the evaluation criteria served to identify the trade-offs to be evaluated. For example, resource sequences that were more costly often resulted in higher quality or a more reliable water supply. Sequences that were clearly inferior to others were eliminated. In other cases, the District weighed trade-offs between conflicting policy objectives and selected the resource sequence that, overall, best met policy objectives.

RECOMMENDATION

After comparing the resource sequences, Sequence 3 was determined to best meet the District's policy objectives. The timing of resource implementation for Sequence 3 under the middle case uncertainty scenario is shown in Figure ES-6. To provide the flexibility needed to meet District objectives under changing future conditions, Sequence 3 was modified to respond to the worst- and best-case uncertainty scenarios, as shown in Figure ES-7.
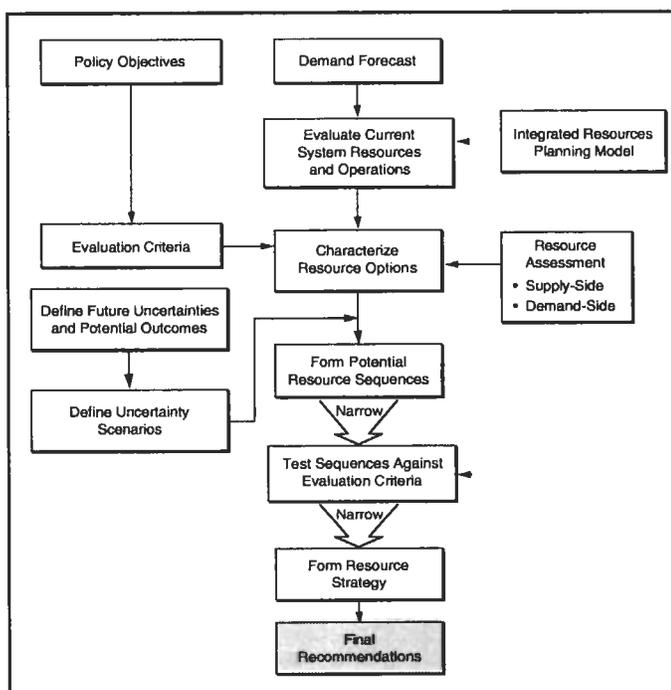
To implement this strategy, it is recommended that the District undertake the following courses of action:

- **Further investigate near-term storage options.** This study did not differentiate between the locations or types of storage options available. The quantity of additional storage identified represents the total storage required. The amount of storage required is likely to result from

Table ES-7
EVALUATION OF RESOURCE SEQUENCES

Evaluation Criteria	Sequence 1	Sequence 2	Sequence 3	Sequence 3A	Sequence 4	Sequence 5	Sequence 6	Sequence 6A	Sequence 7
Cost ($ millions)[a]	$25	$104	$62	$61	$41	$54	$51	$34	$49
Reliability (expected unserved demand in drought years)[b]	24%	10%	10%	10%	10%	10%	10%	10%	10%
Maximum monthly hardness (mg/L)	238[b]	150	150	150–175[c]	150–175[c]	150–175[c]	150	175–238[d]	150
Environmental impact	1.3	1.8	1.3	1.4	1.3	1.2	1.2	1.0	1.4
ACWD control	1.3	1.5	1.3	1.3	2.1	1.9	1.9	1.9	1.8
Water availability risk	1.2	1.5	1.1	1.1	2.0	1.8	1.8	1.8	1.5
Financial risk	1.5	1.9	1.7	1.7	1.5	1.8	1.7	1.5	1.6
Water quality risk	2.4	2.1	2.2	2.1	2.6	2.3	2.5	2.5	2.4

Note: Lower numbers are preferable.

[a] Net present value of capital and variable operating costs of new resources.

[b] 1 in 30 years probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.

[c] Seasonal increases in hardness.

[d] 175 mg/L annually, up to 238 mg/L during drought years.

Figure ES-6

Recommended Resource Implementation
Middle Case Uncertainty Scenario

Latest On-Line Date: →	2000	2010	2020	2030
Conservation	Package 2	→	→	→
Desalination (mgd)	3	3	3	8
Storage (KAF)	65	95	100	140
Minimum G/W Level (BHF, ft)	+1	-5	-5	-5
Treatment Plant Upgrades (mgd)				4
Reclamation			Phase 1	Phase 2

implementing more than one of the storage options evaluated. The most likely near-term options include utilizing carryover storage in the SWP system and banking SBA entitlement water in the San Joaquin Valley. The District will need to:

- Meet with potential San Joaquin Valley banking partners to determine specific banking arrangements (e.g., cost, storage terms, and ability to "put" and "take " banked water);

- Investigate the water supply benefits of carryover storage in the SWP system and the risk of losing stored water; and

- Conduct additional operational studies to optimize the quantity of water diverted for storage, the timing of diversions, and the location of storage.

■ **Continue to pursue long-term storage options.** Some of the storage options considered, including storage in the Livermore Valley and storage in Sunol Valley, have either not been fully investigated, or are not

Figure ES-7
Recommended Strategy

Storage + Conservation + Ph 1 Desal (3 mgd)

Minimum Action

Storage + Conservation + Ph 1 Desal (3 mgd)

Storage + Conservation + Ph 1 Desal (3 mgd) + Dry Year Mining (-5)

Storage + Conservation + Ph 1 Desal (3 mgd) + Dry Year Mining (-5) + Ph 1 Reclamation + Additional Storage

Best Case

Storage Conservation Ph 1 Desal (3 mgd)

Middle Case

Dry Year Mining (-5) + Additional Storage

Ph 1 Reclamation + Additional Storage

WTP 2 Upgrades + Ph 2 Desal (8 mgd) + Ph 2 Reclamation

Middle Case

Maximum Action

Transfers + Ph 1 Reclamation

WTP 2 Upgrades + Ph 2 Desal (5 mgd) + Additional Storage + Transfers + Ph 2 Reclamation

Ph 3 Desal (10 mgd) + Additional Storage + Transfers + Ph 3 Reclamation

Worst Case

Year   2000   2010   2020   2030

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available in the near term. The District should continue to work with the associated agencies to further investigate future opportunities. Due to the high environmental impacts associated with raising the Calaveras Dam and constructing Upper Del Valle Reservoir, these alternatives are not recommended for further action at this time.

- **Begin a more detailed study of saltwater desalination.** This study should include:

  • Selecting plant location;

  • Refining distribution system configuration and cost estimates;

  • Refining well collection system configuration and cost estimate;

ES-23

- Continuing to investigate opportunities for beneficial use and/or disposal of concentrate;

- Pursuing opportunities for a joint pilot or demonstration program; and

- Investigating project financing options including state and/or federal low-interest loans and grants.

- **Develop an implementation plan for the Package 2 conservation programs.** The plan would contain an implementation schedule, organizational and staffing requirements, and a marketing plan for each conservation program. In addition, the District should further evaluate the implementation of an ultra-low-flush toilet program to replace higher flow toilets for those portions of the customer base for which it would be most cost-effective to do so.

- **Continue to work with the USD to pursue a water reclamation project.** It is recommended that Phase 1 reclamation be constructed after 2010 in the middle-case scenario, or after 2000 in the worst-case scenario. The District should continue cooperation with USD to develop appropriate cost-sharing arrangements, funding sources, and opportunities for the accelerated construction of a reclamation project.

- **Continue to investigate water entitlement transfer opportunities.** Under the recommended resource strategy, this option is included only under the worst-case scenario. Water transfers were not selected as a high priority option due to uncertainties in the availability of transferred water. Since the evaluation of this option, however, an opportunity has arisen to purchase additional SWP entitlement water. SWP entitlement water would be a more reliable supply than was originally considered. As a participant in the urban state water contractors buyers group, the District is investigating opportunities for the transfer of entitlement water from agricultural contractors in Kern County. The District should continue to investigate entitlement water transfers and to evaluate the benefits of implementing this option.

- **Continually update the Integrated Resources Plan.** This Plan is dynamic and should be modified as uncertainty outcomes are resolved. Also, the cost assumptions need to be revised periodically. The availability of federal and/or state low-interest loans and grants or outside agency cost

sharing for a particular resource alternative may accelerate construction due to increased cost-effectiveness.

District staff recommend the following modifications to current operations to maximize resource utilization:

- **Implement revised ARP pumping rules.** To counteract further migration of saline water toward the District's potable well field and to remove the intruded saltwater plume, ARP pumping should be increased. For every 2 acre-feet of water produced below the Hayward Fault, 1 acre-foot of water must be produced from the ARP wells when operating the groundwater basin when the groundwater elevation below the Hayward Fault is approximately +5 MSL. The proportion of ARP pumping required increases when the groundwater basin is operated at lower elevations and decreases when it is operated at higher elevations.

- **Increase aquifer reclamation pumping** when BHF groundwater elevation is above +10 MSL. Model analyses indicate that groundwater supplies are lost to the Bay when BHF groundwater elevation rises above +10 feet MSL. In this situation, additional ARP production may increase the rate of basin remediation without affecting the quantity of supplies available for potable use.

- **Delay construction of the additional salinity barrier wells** recommended in the 1986 Water Supply and Facilities Planning Study. Model analyses indicate that, with the full amount of barrier pumping needed to prevent seawater intrusion, no additional water supply is obtained by drawing the basin below sea level.

- **Maintain BHF groundwater elevation** above +3 MSL. To prevent seawater intrusion without salinity barrier pumping, groundwater elevation should be maintained at above +3 MSL. Limited short-term basin mining during critically dry years should not adversely affect groundwater supplies.

- **Reevaluate the salinity barrier program and aquifer reclamation pumping requirements** when the water quality model is completed. Since the IGSM is not yet equipped with the ability to show water quality trends, this analysis did not consider the increased rate of basin remediation that may result from additional salinity barrier and aquifer reclamation pumping. Full basin remediation may result in improved water quality

below the fault and increased storage capacity for potable supplies. The water quality model will provide a more accurate means of assessing these benefits.

- **Place higher priority on the use of groundwater resources after securing additional storage.** Under current management of District supplies, use of groundwater supplies is the lowest priority. When additional storage is obtained, production pumping should be increased to maximize utilization of local water so that SWP water can be diverted to storage.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

INTRODUCTION

I. INTRODUCTION

The Alameda County Water District (hereafter referred to as the "District") is located in southwestern Alameda County adjacent to the southern portion of San Francisco Bay (see Figure I-1). The District is a retail water purveyor that serves a population of approximately 286,000 in the cities of Fremont, Newark, and Union City. The current service area encompasses approximately 101 square miles.

The District was established in 1914 by the state legislature under the California County Water District Act and is governed by a five-member Board of Directors. It was originally created to protect the groundwater basin, conserve the waters of the Alameda Creek Watershed, and develop supplemental water supplies, primarily for agricultural use. In 1930, urban water distribution became an added function of the District. Today, the District provides water primarily to urban customers: 70% of supplies are used by residential customers, 24% by business and industrial customers, and 6% by municipal and institutional customers. Total water use was nearly 42 million gallons per day (mgd) in 1994 (see Figure I-2).

The Niles Cone groundwater basin was the principal source of water supply for the District until 1962. Groundwater use by the District and numerous private pumpers exceeded recharge, which permitted salt water from the Bay to intrude into the basin and severely limited its use. In 1962, the District was the first state contractor to receive water from the State Water Project (SWP). State water was used to recharge the groundwater basin. As a result, groundwater levels rose and prevented additional saltwater intrusion. Today, the District's primary sources of supply come from the Bay Delta (via the SWP) and the SFWD's Hetch Hetchy system; a small portion of the District's supply comes from local runoff.

BACKGROUND

In 1986, the District prepared a Water Supply and Facilities Planning Study to chart future development to the year 2010.[9] Since then, many conditions have changed, so it is necessary to update that plan. The results documented in this study provide the District with guidance for resource development until the year 2030.

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[9]Bookman-Edmonston and Metcalf & Eddy (BEME), *Supply and Facilities Planning Study* (Fremont, Calif.: Alameda County Water District, 1986).

Figure I-1
District Service Area

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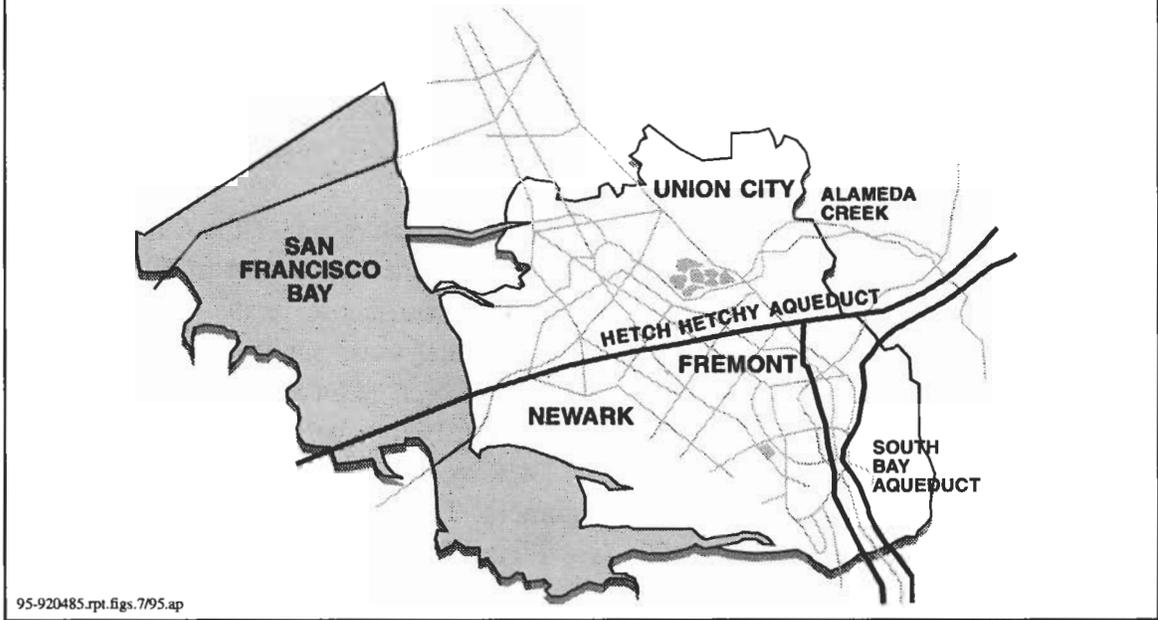
Figure I-2
Relative Water Use by Customer Class

Municipal and Institutional
6%

Industrial
12%

Single Family Residential
52%

Business
12%

Multiple Family Residential
18%

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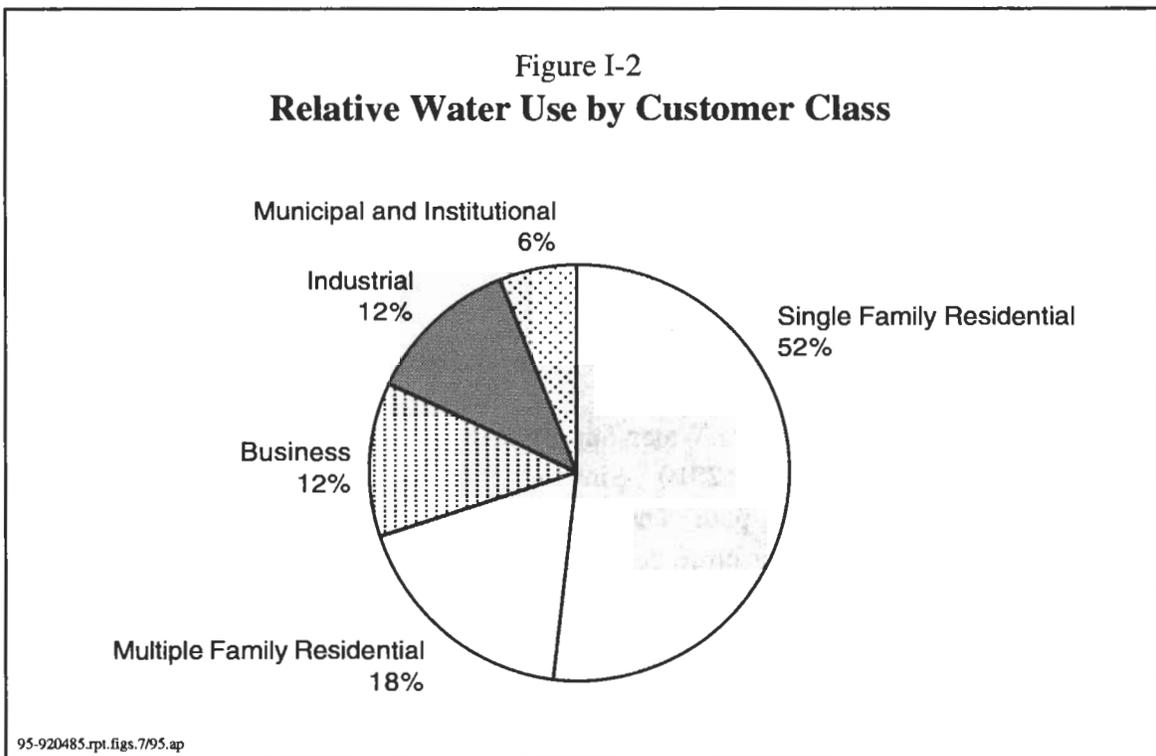
Several changes since 1986 have affected water demand forecasts: the 1990 census now provides new population data; cities served by the District have modified their general plans; and the drought has modified (perhaps permanently) long-standing patterns of water consumption.

By signing the "Memorandum of Understanding Regarding Urban Water Conservation in California" (hereafter referred to as the "Best Management Practices MOU"), the District has committed itself to implementing a comprehensive package of conservation programs. This commitment has the potential of altering future demand for water. Moreover, new legislative and regulatory requirements, most notably those contained in the Energy Policy Act of 1992, will dramatically affect water consumption patterns.[10]

Changes since 1986 have also affected the water supply. The recent six-year drought and the accompanying reductions in deliveries from the District's two main suppliers of imported water, SWP and the SFWD, have raised questions concerning the future reliability of the District water supply under the current capital improvement and water management plan. Uncertainty concerning SWP capital improvements is acute. Increasing controls on Delta water to protect sensitive, threatened, or endangered species (e.g., the winter-run salmon and the Delta smelt) will have a tremendous impact on the reliability of this supply source for the District.

Moreover, potential resources, such as water banking and agricultural water purchases, were not available in 1986 but have since appeared.

In light of the rapidly changing circumstances of the last six years, the District concluded that the 1986 study must be updated and must place a greater emphasis on including a broader and more sophisticated representation of supply, demand management, and operational alternatives. In addition, the District recognizes that an explicit and rigorous analytical treatment of uncertainty is essential. Most of the parameters that guide a complex resource plan are uncertain. Customer demands, water availability from SWP, and future legislation are but a few of the uncertainties that must not only be recognized but explicitly integrated into the strategic recommendations that emerge from this water supply planning effort.

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[10]The Energy Policy Act of 1992 and California regulations require the sale and manufacture of 1.6 gallons per flush toilets (also known as ULFTs), 2.5 gpm faucets, and 2.5 gpm showerheads for residential application beginning January 1, 1994. New construction will incorporate these water-efficient fixtures. In addition, over time higher flow fixtures in existing construction will turn over and be replaced with water-efficient models.

SCOPE OF STUDY

This planning effort applies the approaches and techniques of integrated resource planning (IRP) to ensure that appropriate facility and resource decisions are made. IRP is inclusive. It begins with the premise that a wide range of traditional and innovative supply-side and demand-side (conservation) resources must be considered. It also provides information on potential consequences and aids in judging the value of the trade-offs among resource strategies. IRP, when properly applied, is a process that leads to sound long-term decisions.

The IRP Framework

Figure I-3 illustrates the key components of the District's Integrated Resources Planning Study process. Briefly, the major steps are as follows:

- **Define policy objectives.** A distinguishing feature of this study is the careful definition of multiple and often-conflicting policy objectives. Policy objectives are what the District is trying to achieve through its resource-planning efforts. Conflicts among these objectives are the rule rather than the exception, and the process undertaken in this study explicitly attempts to measure the ensuing trade-offs.

- **Develop measurable evaluation criteria.** Associated with each policy objective is one or more evaluation criteria. Evaluation criteria are designed to measure the performance of a *resource sequence*—this term is defined below—against the policy objectives.

- **Assess and characterize supply-side and demand-side resource options.** This study begins with an extensive list of potential resources. These resources include supply-side alternatives (supplemental sources, facilities, and operational modifications) and demand-side (conservation) alternatives. One of the hallmarks of successful IRP is the treatment of conservation as a resource—one that is evaluated as rigorously as a supply option.

  The identified resources are filtered through a succession of more and more finely meshed screens to eliminate options that are inappropriate. The initial screens are rather coarse; the later screens are more detailed. The goal is to end up with a manageable number of resource options to combine into resource sequences and, ultimately, into resource strategies.

Figure I-3
ACWD Integrated Resources
Planning Study Process

```
┌──────────────────┐         ┌──────────────────┐
│ Policy Objectives │         │  Demand Forecast  │
└──────────────────┘         └──────────────────┘
         │                            │
         │                            ▼
         │                  ┌──────────────────┐      ┌──────────────────┐
         │                  │ Evaluate Current  │◄·····│Integrated Resources│
         │                  │ System Resources  │      │  Planning Model   │
         │                  │  and Operations   │      └──────────────────┘
         │                  └──────────────────┘
         ▼                            │
┌──────────────────┐                  ▼                ┌──────────────────┐
│Evaluation Criteria│────────►┌──────────────────┐     │    Resource       │
└──────────────────┘         │   Characterize    │◄────│   Assessment      │
                             │ Resource Options  │     │  • Supply-Side    │
┌──────────────────┐         └──────────────────┘     │  • Demand-Side    │
│Define Future      │                 │                └──────────────────┘
│Uncertainties      │                 ▼
│and Potential      │         ┌──────────────────┐
│Outcomes           │         │  Form Potential   │
└──────────────────┘         │ Resource Sequences│
         │                    └──────────────────┘
         ▼                          Narrow
┌──────────────────┐                 ▼
│Define Uncertainty │────────►┌──────────────────┐
│Scenarios          │         │Test Sequences Against│
└──────────────────┘         │ Evaluation Criteria │◄········
                             └──────────────────┘
                                   Narrow
                                     ▼
                             ┌──────────────────┐
                             │  Form Resource    │
                             │    Strategy       │
                             └──────────────────┘
                                     │
                                     ▼
                             ┌──────────────────┐
                             │      Final        │
                             │ Recommendations   │
                             └──────────────────┘
```

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- **Define major future uncertainties.** The planning horizon for this planning effort goes more than 30 years into the future—to the year 2030. Over that period, there is a myriad of uncertainties that can affect the efficacy of particular resource strategies. This study recognizes and explicitly treats these future uncertainties. The key uncertainties that may affect the District's resource decisions are defined, and potential outcomes are hypothesized for each uncertainty. Furthermore, to make the analysis tractable and to increase its value to decision makers, this study combines potential outcomes into scenarios. Three uncertainty scenarios are explicitly considered.

- **Formulate and evaluate resource sequences.** Once the individual resource options have been carefully analyzed, the "integration" phase begins. This phase involves the systematic assessment and narrowing of *resource sequences.* A resource sequence is defined as a *deterministic progression of utility actions regarding facility and (demand-side and supply-side) resource additions. This set of actions presumes a particular set of uncertainty scenarios.* Thus, a resource sequence differs from a resource strategy, which may be defined as a *probabilistic multibranched "tree" of sequences that defines the utility actions that should be taken under various sets of uncertainty outcomes.*

- **Formulate final recommendations.** In this study, a resource strategy that best meets the District's policy objectives is developed. This strategy specifies District actions in anticipation of or as a result of the three previously defined uncertainty scenarios.

Development of Analytical Tools in the IRP Process

Because of the comprehensive nature of the IRP process, the selection and development of appropriate analytical tools are crucial to the successful execution of this study. As discussed above, IRP:

- Considers a variety of supply-side and conservation option
- Combines these options into numerous resource sequences
- Characterizes the resource sequences in light of future uncertainties
- Allows staff to continuously update and reassess planning results

Due to the complexity of the IRP analysis, computerized analytical tools are often used to assist in the planning efforts. As discussed in Section VI, an Integrated Resources Planning Model (IRPM) was developed. IRPM simulates District operations for the period of record, 1922–1992, using a monthly time step. The model's computational driver is a series of linear programs used to route water through the system for each time step. IRPM is used in this study to examine the District's current and future reliabilities with and without resource development and to compare the costs of alternative resource developments.

COORDINATION AND REVIEW

This study was prepared as a cooperative effort of District staff, Barakat & Chamberlin, and Water Resources Management. District staff had the lead role in the evaluation of existing resources and supply reliability analyses, the evaluation of supply-side and operational alternatives, the development of resource sequences, and coordination with outside agencies and the public. Barakat & Chamberlin had the lead role in the development of demand-side alternatives, the development of policy objectives, and the development and facilitation of the resource evaluation process. Water Resources Management had the lead role in the development of the IRPM.

Two advisory committees played a key role in this study. A Technical Advisory Committee, consisting of representatives from the Engineering Department, Operations Department, Finance Department, and Administration Department, reviewed the progress and findings of technical analyses at key points in the study. A Project Advisory Committee, consisting of department managers, participated in the evaluation of resources and the recommendation of the preferred resource scenario. In addition, the Board of Directors reviewed progress and provided guidance at key decision points throughout the study.

At various points throughout the study, District staff met with managers and staff from the Union Sanitary District and the cities of Fremont, Newark, and Union City to ensure proper coordination, review, and exchange of information.

Two bill inserts that introduced the IRP program were prepared and sent to customers. A hotline was set up for customers to call to request additional information. A brochure describing the program and progress was prepared and sent to over 400 customers, local officials, and interest groups. A public meeting was held to provide additional information on the IRP process and to give citizens an opportunity to express their opinions on the issues being addressed. A final brochure was prepared describing the study conclusions and recommendations. An

announcement of the presentation of the conclusions and recommendations to the Board of Directors was sent to those on the mailing list to provide a second opportunity for public comment. A summary of comments received is included in Appendix A.

REPORT ORGANIZATION

This report documents Phases 1–4 of the District's plan to update the 1986 Water Supply and Facilities Planning Study, as follows:

- **Phase 1.** Analyze water demand. This analysis was conducted by Brown & Caldwell. The completed study provides a range of water demand growth patterns through District build-out under differing assumptions on future land use, growth, and per customer water use. The results from Phase 1 constitute a key input to this study and are briefly summarized in Section III.

- **Phase 2.** Examine District operating procedures under past and potential future water supply conditions using a detailed operations model. Using the results of these assessments and the Phase 1 demand projections, develop forecasts of water supply reliability for the next 25 years, assuming no new water supplies, demand management resources, or operational changes. Describe the impacts of this level of system reliability on customers and the condition of the local groundwater basin. This discussion is presented in Section VII.

- **Phase 3.** Develop, evaluate, screen, and group a set of appropriate supply resources, demand management, and operational alternatives. Combine them into "resource sequences" to be evaluated against the District's policy objectives.

- **Phase 4.** Carefully define the District's policy objectives and associated evaluation criteria. Evaluate the resource sequences against these criteria.

This report is organized into eleven sections, as follows:

- Section II characterizes the District's current resources.

- Section III summarizes the demand forecasts developed in Phase 1.

- Section IV provides a discussion of the process used by the District to develop the policy objectives and evaluation criteria.

- Section V characterizes the uncertainties explicitly considered in the plan and discusses how IRP addresses these uncertainties.

- Section VI describes IRPM, the prime analytical tool developed to evaluate the cost, reliability, and water quality consequences of potential resource combinations. A brief description of IRPM's input and modeling algorithm is provided. Appendix D provides a more detailed description of the Local Model.

- Section VII summarizes the results of an evaluation of the near- and long-term capabilities of the District's current resources.

- Sections VIII and IX detail the evaluation of the supply/operational additions and modifications (Section VIII) and the conservation options (Section IX) considered in this plan. These sections describe the processes undertaken to identify and characterize these potential resources.

- Section X combines supply-side options with conservation programs. These resource sequences are assessed against the District's evaluation criteria. The results are merged into an evaluation matrix. The matrix facilitates the understanding and consideration of the key trade-offs among the resource sequences.

- Section XI presents the final conclusions and recommendations of the IRP process.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

EXISTING RESOURCES AND OPERATIONS

II. EXISTING RESOURCES AND OPERATIONS

The District presently obtains its water supplies from both surface and groundwater sources. Surface supplies include local runoff and water imported under contracts with the SFWD for Hetch Hetchy water and with the State of California for delivery from the SWP through the South Bay Aqueduct (SBA). Groundwater is augmented by artificially recharging Alameda Creek runoff and by water from SWP.

The District is committed to maintaining a high-quality, reliable water supply at a reasonable cost to its customers. An important aspect of continuing to meet this goal is to ensure that existing water supplies are used as efficiently as possible.

EXISTING SOURCES OF SUPPLIES

The District presently imports 55% of its supply from the SWP and 30% from Hetch Hetchy. The remaining 15% of the District's supply comes from local runoff (see Figure II-1).

Figure II-1
District Sources of Supply

Local Runoff 15%

State Water Project 55%

San Francisco Water 30%

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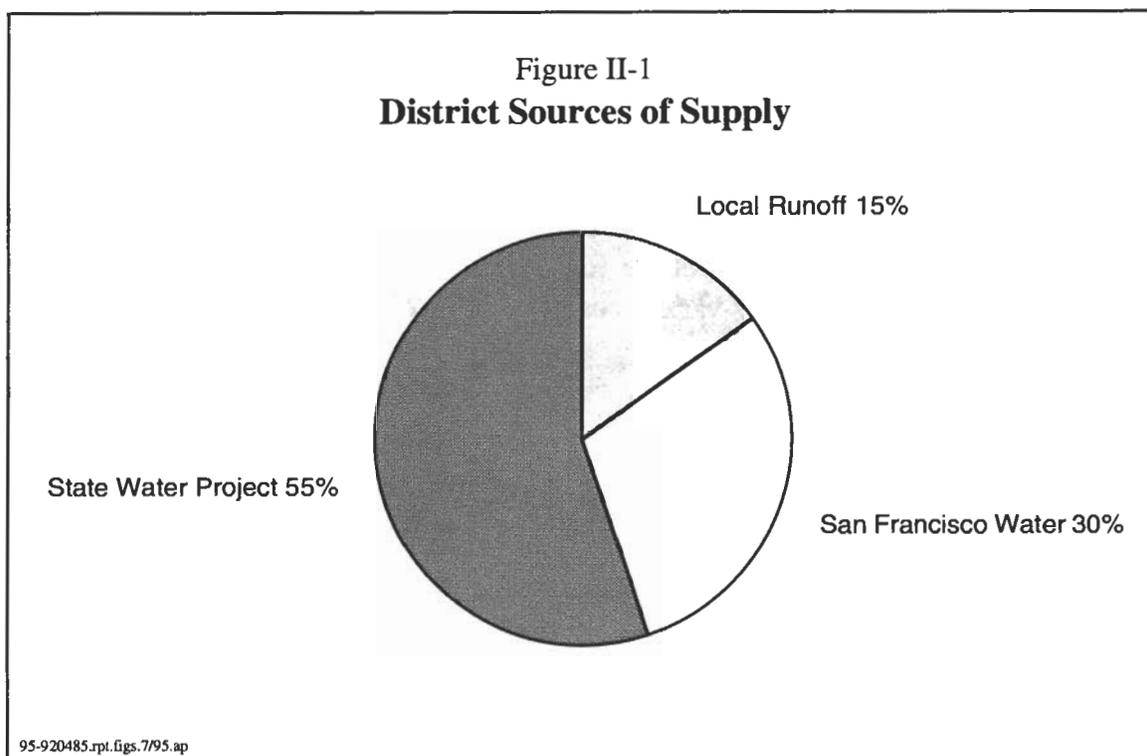
Local Sources

The principal source of local runoff into the District's service area is Alameda Creek, which discharges into the Bay Plain at Niles. Runoff from hills east of the Bay Plain is concentrated mainly in Dry Creek and Mission Creek. Alameda Creek's natural annual runoff has varied from a recorded minimum of 650 acre-feet in 1960–1961 to a recorded maximum in 1982–1983 of 360,000 acre-feet.

The District, along with Zone 7 of the Alameda County Flood Control and Water Conservation District (hereafter referred to as "Zone 7"), has rights on Arroyo Del Valle to divert water for storage. When the DWR constructed Del Valle Dam, those rights were subjugated to a contract between DWR, the District, and Zone 7. Zone 7 and the District share approximately 15,000 acre-feet of storage made available annually in Del Valle Reservoir. The average amount of water released from Del Valle Reservoir for the District's use for the 1971–1993 period is approximately 4,100 acre-feet per year.

The District overlies an aquifer system known as the Niles Cone Basin. The Niles Cone Basin is a large and deep alluvial fan formed at the western front of the Mission Hills that extends west under San Francisco Bay. The Hayward Fault, which trends in a northwest-to-southeast direction, divides the basin in two. The portions of the basin northeast of the fault are referred to as "above the fault," and the portions southwest of the fault are referred to as "below the fault." The Niles groundwater subarea is composed of a series of flat-lying gravel aquifers separated by extensive clay layers that do not readily transmit water. Specific aquifers can be delineated and have been named (in increasing order of depth) the Newark, Centerville, and Fremont Aquifers. Deeper aquifers are also present at 400 feet and 500 feet. The District has wells and recharge facilities on both sides of the Hayward Fault. Annual groundwater production by the District has varied from 17,900 to 26,700 acre-feet over the 1984–1994 period.

Imported Supplies

In 1961, the District signed a contract with the State DWR for water from SWP. Water from the Sacramento–San Joaquin Delta is pumped into the California Aqueduct, the backbone of SWP, then diverted into the SBA and delivered to the District. The District has a maximum annual entitlement of 42,000 acre-feet from SWP.

In 1964, the District was one of 30 suburban agencies to contract with the City of San Francisco for a water supply delivered through the Hetch Hetchy aqueducts. The supply is predominantly from the Sierra Nevada, but it also includes treated water produced by SFWD from its facilities in the Alameda Creek watershed. In 1984, the District and SFWD signed a 25-year contract that provided for an annual delivery of 13,400 acre-feet. Recently, SFWD made available an additional 16 mgd for allocation among its suburban contractors. In 1994, the District contracted for an additional 1.7 mgd, increasing its maximum annual delivery to 15,300 acre-feet from SFWD.

The amount of water SWP and SFWD will be able to deliver to the District depends on several physical, environmental, and political factors, which are discussed in Section V.

EXISTING FACILITIES

Existing District facilities include those necessary for producing and distributing groundwater and surface water supplies and protecting and managing the groundwater resources. Distribution system facilities, which are shown in Figure II-2, include the Mission San Jose Water Treatment Plant (MSJWTP), Water Treatment Plant No. 2 (WTP 2), the blending facility, takeoffs from the SFWD Hetch Hetchy pipelines, and distribution system tanks and reservoirs. Groundwater facilities, which are shown in Figure II-3, include rubber dams, diversion facilities, recharge ponds, production wells, reclamation wells, and salinity barrier wells.

Mission San Jose Water Treatment Plant

Water is pumped from the Alameda-Bayside Takeoff of the SBA to the MSJWTP. The treatment process includes chlorination, flash mixing, upflow solids contact clarification, and filtration through anthracite coal and sand filter beds. The plant was designed for a nominal flow rate of 7.8 mgd and a maximum design flow of 10.3 mgd. However, it is currently operated at a rate of 4 to 8 mgd throughout the year, except for maintenance periods. Future plans include modifications to the treatment process to upgrade the clarification and filtration process, upgrades to the chemical storage and feeding facilities, and the addition of ozone as the primary disinfectant.

CANYON HEIGHTS
TANK

APPIAN
TANK

MISSION SAN JOSE
WATER TREATMENT PLANT

WATER TREATMENT
PLANT NO 2

MAYHEW

VINYARD
HEIGHTS
TANK

238

DECOTO

BLENDING FACILITY

MISSION BLVD

MISSION

PALM

WASHINGTON

HIDDEN VALLEY
TANK

HAYWARD

HAYWARD FAULT

PKWY

WHITFIELD

ALAMEDA

WHIPPLE RD

DECOTO RD.

ALVARADO-NILES RD.

DRY CREEK

PERALTA BLVD

PASEO PADRE

FREMONT BLVD.

WASHINGTON

DURHAM RD.

SOUTH BAY AQUEDUCT

FREMONT BLVD.

OSGOOD RD.

MIDDLEFIELD

680

AVALON TANK

SMITH

ALVARADO BLVD.

THORNTON AVE.

CENTRAL AVE.

MOWRY AVE.

SFWD HETCH-HETCHY PIPELINES 1&2

STEVENSON BLVD

FREMONT BLVD.

GRIMMER BLVD

AUTO MALL PKWY

FREMONT BLVD.

SFWD HETCH-HETCHY PIPELINES 3&4

WARM SPRINGS BLVD

WARREN AVE.

ALAMEDA CREEK

880

DISTRICT H.Q.

NEWARK BLVD

CHERRY ST.

BOYCE RD.

JARVIS ROAD

CENTRAL
& CHERRY

SYCAMORE

84

ENTERPRISE

WILLOW ST.

PATTERSON

COYOTE CREEK

LEGEND

KE OFFS

IR (OR TANK)

NT FACILITY

FACILITY

NDS

SCALE OF MILES

0   1   3   5

ALAMEDA COUNTY WATER DISTRICT
FREMONT, CALIFORNIA

EXISTING DISTRIBUTION
SYSTEM FACILITIES

FIGURE II-2

NURSERY WELL

WHIPPLE WELL

238

WHIPPLE RD

DECOTO RD.

ALVARADO-NILES RD.

RD#3
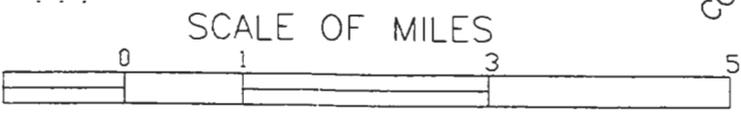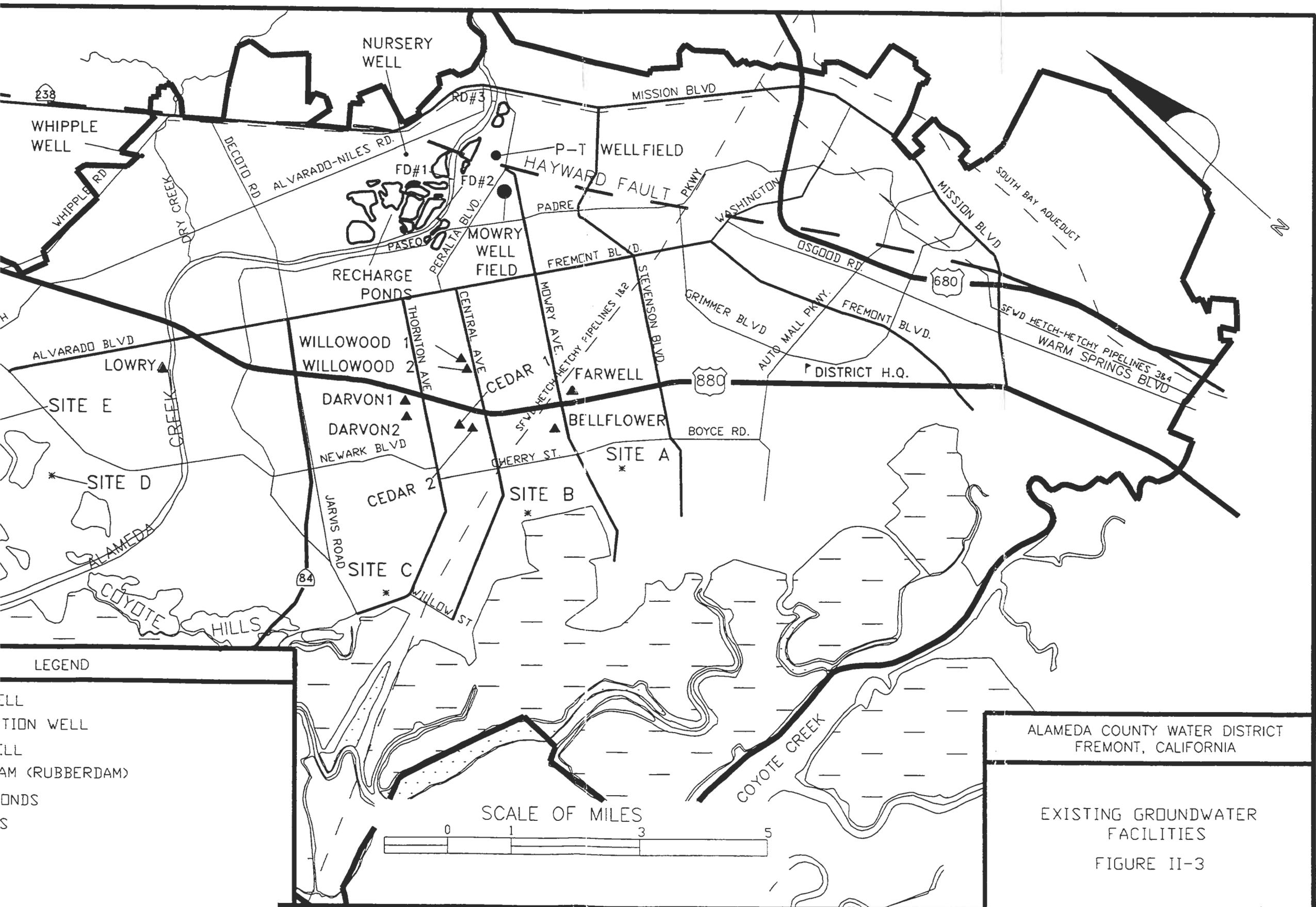
MISSION BLVD

P-T WELLFIELD

HAYWARD FAULT

FD#1

FD#2

PADRE

PKWY

WASHINGTON

MISSION BLVD

SOUTH BAY AQUEDUCT

N

DRY CREEK

PERALTA BLVD.

PASEO

MOWRY WELL FIELD

RECHARGE PONDS

FREMONT BLVD.

OSGOOD RD.

680

SFWD HETCH-HETCHY PIPELINES 3&4

ALVARADO BLVD

LOWRY

SITE E

WILLOWOOD 1

WILLOWOOD 2

THORNTON AVE.

CENTRAL AVE.

MOWRY AVE.

STEVENSON BLVD

SFWD HETCH-HETCHY PIPELINES 1&2

CEDAR 1

FARWELL

GRIMMER BLVD.

AUTO MALL PKWY.

FREMONT BLVD.

WARM SPRINGS BLVD

880

DISTRICT H.Q.

CREEK

DARVON1

DARVON2

NEWARK BLVD

CEDAR 2

BELLFLOWER

BOYCE RD.

SITE A

ALAMEDA

SITE D

CHERRY ST.

SITE B

84

JARVIS ROAD

SITE C

WILLOW ST.

COYOTE HILLS

COYOTE CREEK

ALAMEDA COUNTY WATER DISTRICT
FREMONT, CALIFORNIA

SCALE OF MILES

0   1   3   5

EXISTING GROUNDWATER
FACILITIES

FIGURE II-3

Water Treatment Plant No. 2

The 1986 Water Supply and Facilities Planning Study recommended that the District provide for additional surface water treatment of SBA water. Construction of WTP 2 was completed in 1993; the plant began delivering water to customers in October 1993.

Water is pumped from the Alameda–Bayside Takeoff to WTP 2. Because of the elevation difference between the SBA and WTP 2, the District installed turbines to generate electricity. The hydroelectric power facility at the plant can produce enough electricity to run all the treatment processes. Excess power is exported to Pacific Gas and Electric Company and will be exported to other District facilities in the future.

Ozone is the primary disinfectant in the treatment process. After ozonation, the water moves through a flash mix chamber, where coagulants are added. The water then flows to the flocculation and sedimentation basins, where it is filtered through layers of coarse media (anthracite or granular activated carbon) and sand. The plant currently can deliver 17 mgd, but ultimately it will have the capacity to treat 21 to 28 mgd, depending on source water quality, process limitations, and regulatory requirements.

Blending Facility

From the recommendations of the 1986 Water Supply and Facilities Planning Study, the District constructed a blending facility to eliminate the need for water softening. Construction was completed in 1992, and blended water was first delivered in March 1992.

The blending facility combines lower hardness SFWD water with higher hardness groundwater to provide a more uniform, aesthetically pleasing water supply. The total plant capacity is 60 mgd. The actual quantity of water produced at the facility is limited by the amount of available SFWD water needed to stay below the maximum hardness limitation and by distribution system hydraulic constraints. An additional SFWD takeoff and pipeline to the blending facility and additional distribution system pipelines will be required to deliver the full 60 mgd capacity and meet the District's blended water quality goal of no more than 175 ppm (parts per million, equivalent to milligrams per liter) hardness as $CaCO_3$.

Existing and planned delivery capacity from the treatment and blending facilities is shown in Table II-1:

Table II-1
EXISTING AND PLANNED DISTRICT TREATMENT FACILITIES

	Existing Capacity (mgd)	Planned Capacity (mgd)
MSJWTP	9	9
WTP 2	17	28
Blending facility	60	60
Total	86	97

Groundwater Facilities

Currently, 16 wells are available for water production. Seven of the wells are located in the Peralta-Tyson Well Field above the Hayward Fault. Each well has a capacity of 3.2 to 4.4 mgd. The remaining nine wells, seven of which are located in the Mowry Well Field, are below the fault and range in capacity from 0.9 to 4.3 mgd. Total well production capacity is approximately 47 mgd.

The Niles Cone Basin is recharged by the natural runoff from Alameda Creek and releases from the SBA into Vallecitos Creek, a tributary of Alameda Creek. Water percolates into the groundwater basin through the channel bed and through off-stream recharge pits. The District uses pits previously excavated for aggregate production and has constructed facilities in the channel to divert water from the creek into the pits. Six pits are located above the fault and 19 are located below the fault. The pits penetrate into the saturated portion of the aquifer, so not all of the excavated volume is usable surface water storage. Active surface water volume is 10,700 acre-feet. The pits are 25 to 125 feet deep (elevation 65 feet above sea level to 70 feet below sea level) and are capable of recharging the aquifer system at an estimated recharge rate of 60 cubic feet per second (cfs) in the summer and 45 cfs in the winter.

The Aquifer Reclamation Program (ARP), which is designed to remove and control movement of intruded saline water, has been in operation since 1974. The program facilities presently consist of nine wells: three tap into the Newark Aquifer, five into the Centerville-Fremont Aquifer, and one into the Deep Aquifer. The capacities of the wells range from 0.9 to 3.8 mgd.

To operate the groundwater basin with the Newark Aquifer groundwater elevation[11] below sea level and to help prevent further sea water intrusion, the Salinity Barrier Program (SBP) was developed by the DWR in cooperation with the District. Five of the 14 to 20 wells recommended for this program have been drilled, and over 100 piezometers[12] have been installed along an alignment paralleling and landward of the barrier. The barrier program is currently inactive and is discussed further in Section VII.

The long-term safe yield[13] is dependent on the potential amount of natural and artificial recharge, groundwater storage natural losses, and the timing of demand relative to replenishment. The construction of facilities for artificial recharge or diversion, in conjunction with the availability of imported water, has increased the safe yield of the basin. The theoretical physical limit of safe yield can be considered equal to the annual natural amount of percolation from direct rain plus the percolation capacity of the recharge facilities. Together, these amounts equal approximately 50,000 acre-feet per year. This limit assumes that groundwater is pumped as necessary, without regard to hardness restrictions, so that basin levels are regulated to preclude losses to San Francisco Bay and diminished recharge rates. It also assumes that a supply of water for artificial recharge is always present. These assumptions, of course, are unrealistic with respect to the current management of supplies and production. Since construction of Rubber Dam No. 3, the approximate average annual amount of water recharged to the groundwater minus natural losses (safe yield) is estimated to be 38,000 acre-feet per year. Of this quantity, 45% was derived from imports delivered from the SBA, Lake Del Valle, and/or the SFWD, and 55% from the Alameda Creek watershed and direct rainfall in ACWD.[14]

MANAGEMENT AND DISTRIBUTION OF SUPPLIES

With local water and two sources of imported water, the District has the flexibility to change the timing and use of supplies to best meet its water management objectives, which include:

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[11]The term *groundwater elevation* is used interchangeably with *piezometric head* and is defined as the level to which water would rise under unconfined conditions.

[12]A *piezometer* is a device used to measure water levels.

[13]The *long-term safe yield* of the groundwater basin is the average annual amount of water that can be extracted without resulting in long-term decreases in well levels or loss in water quality.

[14]See the 1993, 1994, and 1995 ACWD survey reports.

- Maximize total usable supply
- Maximize water quality/provide uniform water quality
- Protect groundwater resources from degradation due to previously intruded seawater
- Protect groundwater resources from further seawater intrusion

District customers receive water from one or more of four production sources: SFWD's Hetch Hetchy system, the District's MSJWTP, the District's WTP 2, and wells in the Niles Cone Basin. The distribution system sources of supply are shown in Figure II-4.

Figure II-4
Distribution System Sources of Supply

Groundwater 20%

San Francisco Water 30%

Treated Surface Water 50%

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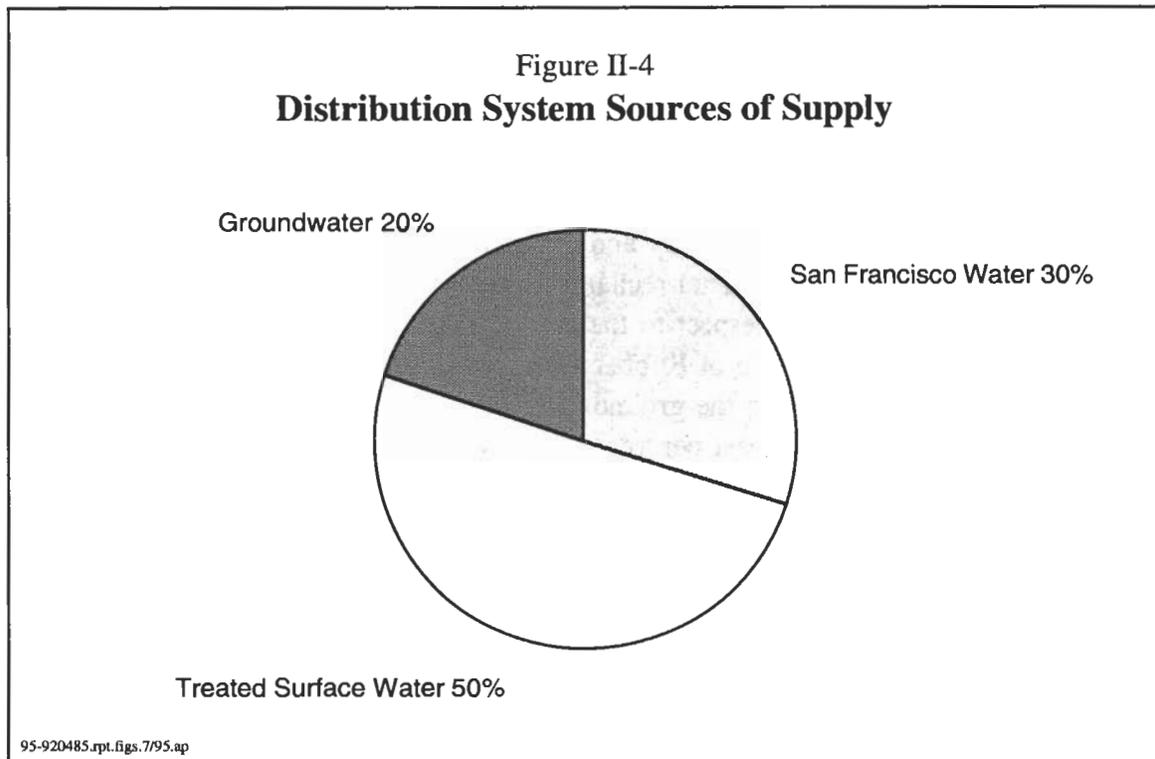
Flow from the SBA and releases from Del Valle Reservoir may be diverted into either of the two treatment plants, diverted into Alameda Creek, or both. Depending on the water quality and flow in Alameda Creek, water can also be diverted into percolation ponds for off-stream groundwater recharge. Hetch Hetchy water is either directly supplied to users or is routed to the blending plant. A schematic of the District's system supply and production is shown in Figure II-5.

Figure II-5
Water Supply and Production

Supply — Production — Consumption

- SBA
- Direct Rain
- Del Valle
- SFWD
- Applied Water
- Evaporation
- Runoff
- Recharge Area Facilities
- MSJWTP/WTP #2
- Blending Facility
- ACWD Wells
- Private Wells
- ARP Wells
- ACWD Distribution System
- Independent Consumption
- Saline Outflow
- To SF Bay
- Niles Cone Groundwater Basin

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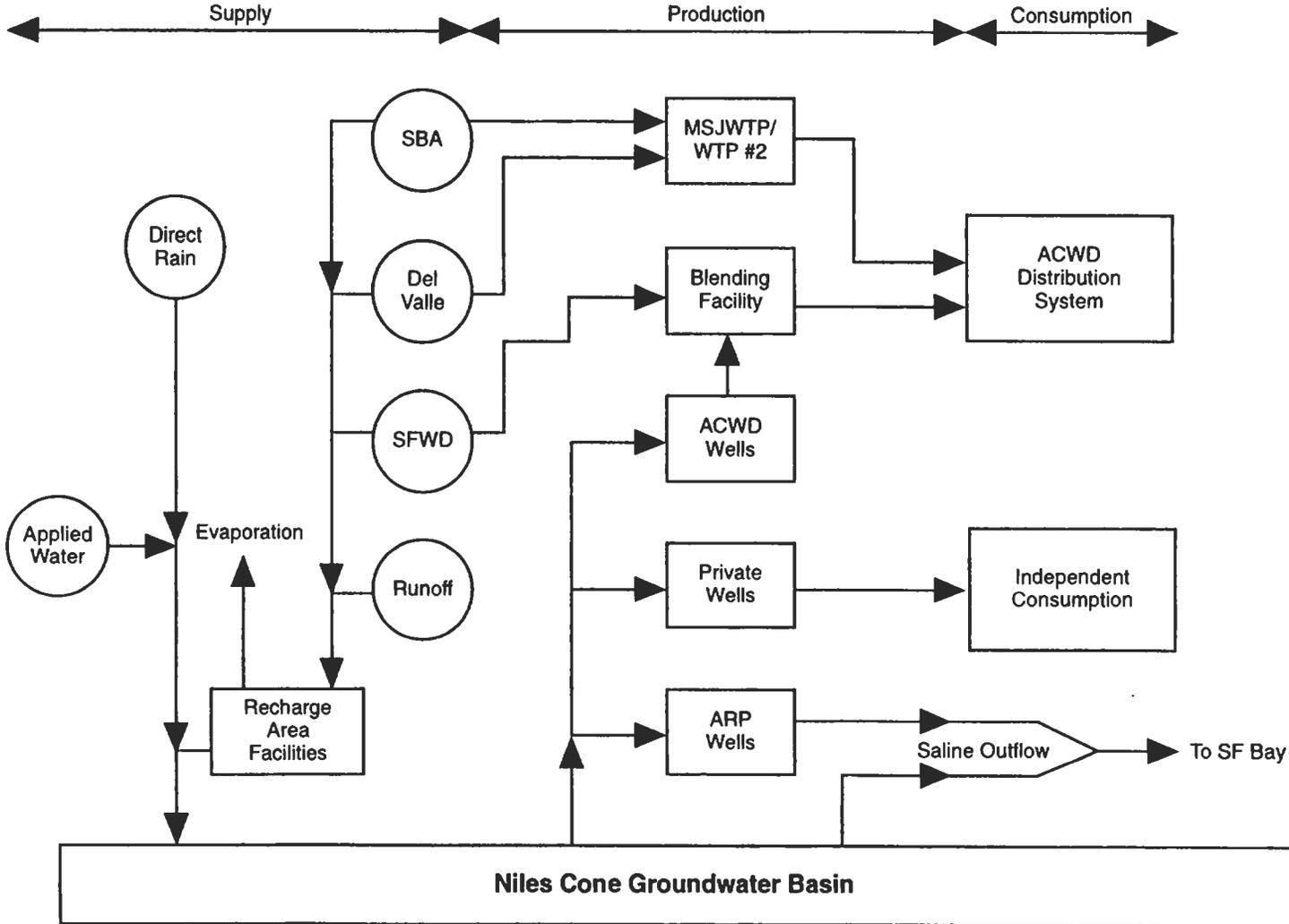
Del Valle Supplies

In December 1968, the District and the Pleasanton Township County Water District, now represented by Zone 7, contracted with the State of California to utilize unused storage in the Del Valle Reservoir for detention of local runoff. This contract was to be renewed in 1994 but was instead extended to October 1, 1995.

Zone 7 and the District share approximately 15,000 acre-feet of storage in the Del Valle Reservoir. The District must submit to DWR, on or before March 1 of each year, a schedule of the amount and timing of expected releases from Del Valle Reservoir. The District can request releases from either stored water or from natural inflow to the reservoir. Water can be released into Arroyo Del Valle Creek, where it flows to Alameda Creek and can be used for groundwater recharge. Alternatively, water can be delivered via SWP facilities and either taken at Vallecitos Takeoff and discharged into Alameda Creek or taken at one of the two Alameda-Bayside Takeoffs, where it can be delivered to the treatment facilities.

The State may deliver SBA water in exchange for release of natural Del Valle inflow or for release of stored water retained for the State in Del Valle Reservoir.

Typically, all stored Del Valle water is used by the fall to maximize the capture of local runoff during the winter and spring seasons. In decreasing order of priority, Del Valle water is delivered:

- Via the SBA to treatment facilities
- Via the SBA and released into Alameda Creek at Vallecitos Takeoff
- Into Arroyo Del Valle Creek, where it flows to Arroyo de la Laguna and eventually into Alameda Creek

Water stored in Del Valle may also be carried over from year to year to provide a dry year reserve.

Inflow into Del Valle generally occurs only during the winter and spring months and can vary greatly in both quantity and quality. The quantity of water available for release to the District has varied from 0 acre-feet per year to 16,700 acre-feet per year. Estimates made by DWR of the long-term yield indicate that the District can expect to obtain an average of about 3,100 acre-feet per year.

South Bay Aqueduct Water

Water from the SBA can either be taken at Vallecitos Takeoff and discharged to Alameda Creek for groundwater basin recharge or taken at the Alameda-Bayside Takeoffs for delivery to the treatment plants. The District, by October 1 of every year, must submit its anticipated requests for monthly deliveries for the upcoming year. The State confirms the District's request or provides the District with the anticipated percentage reduction in deliveries by December 1. The estimated percentage delivery is then adjusted during the spring based on estimated runoff.

The first priority of SBA water use is the treatment plants. The remaining supply is delivered to the recharge ponds via Alameda Creek.

Blending of SFWD Water with Groundwater

SFWD water can be taken at any of nine takeoffs throughout the distribution system. However, since the blending facility came on-line, most of the SFWD water is taken at the Fremont takeoff for delivery to the blending facility. The New United Motors Manufacturing, Inc. (NUMMI) plant, and a few small industrial customers receive SFWD water directly. The District must take and/or pay for a minimum of 8 mgd on an annual basis with a maximum delivery of 13.7 mgd.

Hetch Hetchy water is basically unfiltered Sierra snow melt and thus has excellent physical characteristics and very low hardness. Because of the high water quality, the District has historically taken the maximum contractual yearly limit of water deliveries. SFWD can also deliver water from local reservoirs after filtration at its Sunol Valley Water Treatment Plant. Low-hardness SFWD water is blended with higher hardness groundwater to provide a uniform water quality with hardness levels similar to those of other sources of supply.

SFWD water has an average delivered hardness of 35 ppm as $CaCO_3$. Groundwater hardness averages 240 ppm for wells located above the fault and 360 ppm for wells located below the fault. As discussed previously, groundwater is blended with SFWD water to attain an average blended hardness of approximately 175 ppm as $CaCO_3$.

Groundwater Recharge

During wet periods, natural flow in Alameda Creek is diverted into the recharge ponds. When natural flow is not available, water may be released from Del Valle

Reservoir or from the SBA. The District operates three inflatable dams to capture and divert Alameda Creek flow into the percolation ponds. Diversions take place when Alameda Creek flow at the diversion point is less than 500 cfs. The dams are deflated for protection from debris when creek flow is above 500 cfs.

Groundwater Management and Protection

The Niles Cone aquifer system was once filled with fresh water. The hydraulic gradient was westerly toward San Francisco Bay; natural discharge from the system occurred through numerous springs located generally at the toe of the alluvial cone. Groundwater pumping beginning in the 1920s lowered water levels below sea level and subsequently caused saline water intrusion. Consequently, the District began drilling wells deeper into the underlying Centerville-Fremont and Deep Aquifers. In about 1950, saline water was also detected in these aquifers.

The lowering of water levels in the Newark Aquifer, which created a landward gradient, continued until 1962. At that time, the District began importing water from the SWP. State water was used to artificially recharge the groundwater basin. The District's aggressive artificial recharge program and its use of imported water in lieu of groundwater have caused water levels to slowly rise above sea level (see Figure II-6). Thus, further seawater intrusion was prevented and saline water in the Newark Aquifer was flushed toward San Francisco Bay. However, because the Centerville-Fremont and Deep Aquifers are not in direct hydraulic connection with San Francisco Bay, saline water in those deeper aquifers cannot be easily flushed back by simply raising groundwater levels. Consequently, there are trapped pockets of saline water in these deeper aquifers.

Salinity Barrier Program

The District has operated groundwater recharge facilities to maintain a bayward gradient in the Newark Aquifer. The 1986 Water Supply and Facilities Planning Study recommended constructing salinity barrier wells in the Newark Aquifer. The purpose of these wells is to provide assurance against further seawater intrusion if it becomes necessary to draw groundwater elevation in the Newark Aquifer below sea level. The barrier design includes 14 to 20 extraction wells in the Newark Aquifer along a line north and south of the Coyote Hills. Five of the wells have been drilled, but they are presently inactive. The continuation of the SBP is discussed in Section VII.

Figure II-6
Groundwater Inventory Accumulated Change in Storage
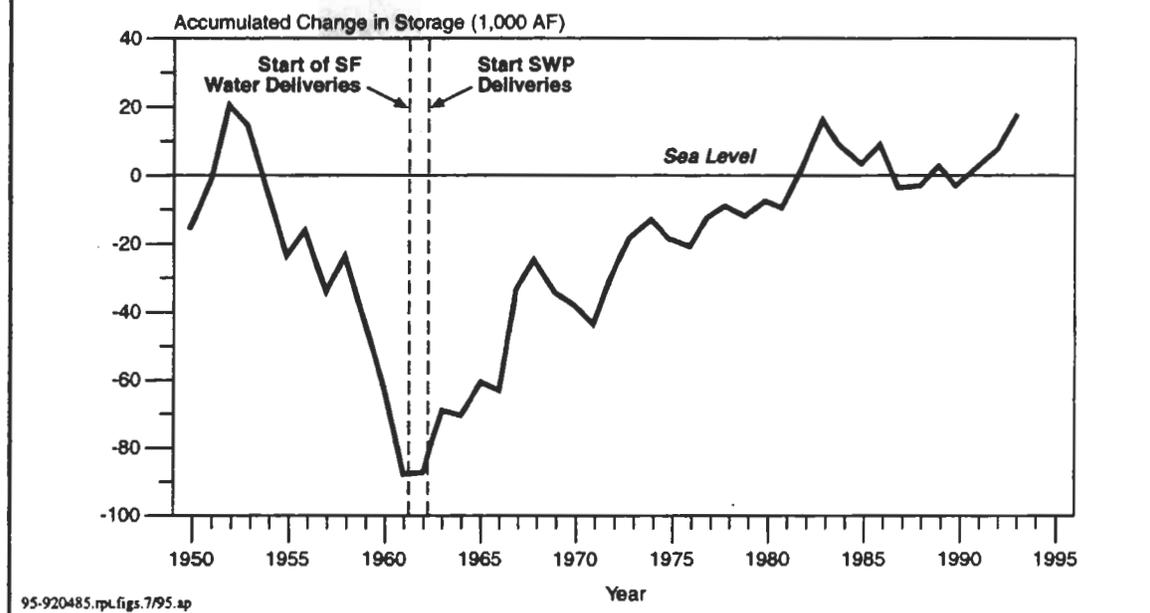
Aquifer Reclamation Program

In 1974, the District initiated a pumping program to remove the saline water trapped in the deeper aquifers. Nine wells are utilized for reclamation pumping: three in the Newark Aquifer, five in the Centerville-Fremont Aquifer, and one in the Deep Aquifer. The water is pumped and discharged to San Francisco Bay through flood control channels. The amount of pumping each year has been determined by the availability of local and imported water supplies, and by the elevation of groundwater levels. From 1975 through 1987, ARP pumping averaged 8,800 acre-feet per year, or about 43% of production pumping. Due to the drought conditions prevailing from 1987 to 1992, ARP pumping during this period averaged only 2,600 acre-feet per year, or about 11% of production pumping. Even though groundwater levels in the Newark Aquifer were maintained above sea level during this time, well data show that the saltwater plume in the Centerville-Fremont and the Deep Aquifers migrated further inland. This indicates that movement of the saltwater plume in these deeper aquifers is affected by factors other than groundwater elevation. The benefits of ARP pumping are evaluated in this study (see Section VI).

A schematic of the operation of the groundwater basin is shown in Figure II-7.

II-14

Figure II-7
Niles Cone Groundwater Basin Schematic

"Below the Fault"

"Above the Fault"

Percolation Area

Barrier Well   Reclamation Wells

San Francisco Bay

Salt Ponds

Newark Aquifer

Forebay

Centerville Aquifer

Hayward Fault

Fremont Aquifer

Deep Aquifer

Saline Water
Fresh Water
Direction of Groundwater Movement
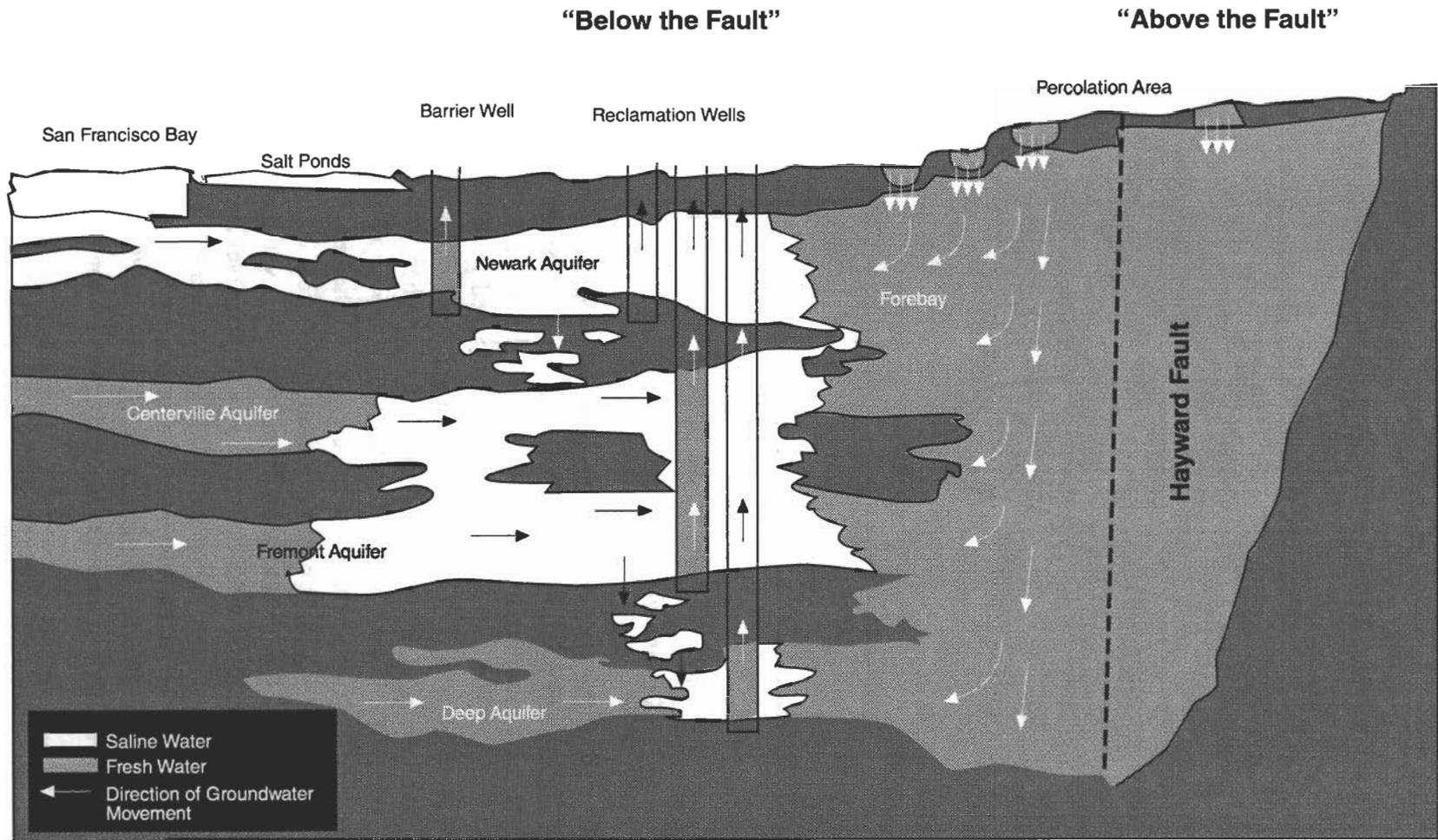
MANAGEMENT OF DEMANDS

During the 1976–1977 drought, the District began efforts to increase water awareness among its customers. Those activities focused on public information and educational programs. The onset of the 1987–1992 drought underscored the need to conserve resources. During that time, the District significantly expanded its conservation program. The purpose of the program is threefold:

- Reduce District operating costs
- Reduce the cost and environmental impacts of new water supplies
- Allocate water supplies in times of shortage or emergency

To further its water conservation goals, in 1991 the District signed a Best Management Practices MOU sponsored by the California Urban Water Conservation Council. Those practices and the District's progress in meeting them are summarized in Table II-2.

Table II-2
SUMMARY OF CURRENT DISTRICT BMP IMPLEMENTATION

BMP	District Progress
1: Single-family interior and exterior audits	▪ Identified top 20% users ▪ Began 1,000 customer pilot program
2: Plumbing retrofit	▪ Distributed more than 75,000 kits to date
3: System water audits	▪ Inspected 150 sites of distribution system for leaks ▪ Instituted corrosion protection program
4: Metering	▪ All accounts are metered
5: Large landscape audit & incentives	▪ Worked with landscape customers to develop water budgets ▪ Conducted workshops for landscape professionals
6: Landscape water conservation requirements for new and existing CI&I and MFR developments	▪ Assisted cities in service areas to develop water ordinances based on AB 325
7: Public information	▪ Ongoing general education programs
8: School education	▪ Developed and implemented school education beginning in 1981
9: Commercial/industrial audits	▪ Formed Water Conservation Roundtable and Industrial Conservation Committee ▪ Developed self-audit program for C/I customers; follow-up District audits as necessary
10: New commercial/industrial use	▪ Ongoing review of new construction plans
11: Conservation pricing	▪ Currently using uniform rate structure ▪ Implemented an inverted block rate structure to encourage conservation during drought
12: Residential landscape	▪ Begun pilot audit program. ▪ Provide CIMIS information ▪ Developed Demonstration Garden ▪ Provided computer program for residential landscape design
13: Water waste prohibition	▪ Implemented ordinance during drought
14: Water conservation coordinator	▪ Position staffed since May 1991

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

WATER DEMAND FORECAST

ACWD Integrated Resources
Planning Study Process

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┌─────────────────────┐                   ┌─────────────────────┐
│  Policy Objectives  │                   │   Demand Forecast   │
└─────────────────────┘                   └─────────────────────┘
          │                                          │
          │                                          ▼
          │                               ┌─────────────────────┐         ┌─────────────────────┐
          │                               │   Evaluate Current  │ ◄······ │ Integrated Resources│
          │                               │   System Resources  │         │   Planning Model    │
          │                               │    and Operations   │         └─────────────────────┘
          │                               └─────────────────────┘                   ┊
          ▼                                          │                               ┊
┌─────────────────────┐                              ▼                               ┊
│ Evaluation Criteria │ ────────►  ┌─────────────────────┐        ┌─────────────────────┐
└─────────────────────┘            │    Characterize     │ ◄───── │      Resource       │
                                   │  Resource Options   │        │     Assessment      │
┌─────────────────────┐           └─────────────────────┘        │  • Supply-Side      │
│Define Future Uncer- │                       │                   │  • Demand-Side      │
│tainties and Poten-  │                       ▼                   └─────────────────────┘
│tial Outcomes        │           ┌─────────────────────┐
└─────────────────────┘           │  Form Potential     │
          │                       │ Resource Sequences  │
          ▼                       └─────────────────────┘
┌─────────────────────┐                    ▽ Narrow
│ Define Uncertainty  │ ───────►  ┌─────────────────────┐
│     Scenarios       │           │ Test Sequences Against│ ◄········
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                                  │  Recommendations    │
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III. WATER DEMAND FORECAST

Realistic water demand forecasting is key to determining the actions needed to provide a reliable water supply to existing and future customers. Since the last demand forecast was completed in 1986, changes in future land uses, growth rates, population projections, and customer water uses have affected the District's demand forecast. To more accurately forecast water demands and to more easily update demand forecasts in the future, a different and more rigorous approach is taken to develop the demand forecasts used in this study. In-depth analyses of historical water use, varying rates of development and land use scenarios, and variations in water use under different climatological conditions are used to develop a PC-based model. This model is subsequently used to develop a range of water demand forecasts for this study.

The Phase 1 Water Demand Investigation was prepared independent of this study by Brown & Caldwell and District staff. The complete report is included in Appendix B.

DEVELOPMENT OF WATER USE EQUATIONS

An important feature of the water demand model is that it allows the District to change its forecast as water use patterns and growth rates change. This feature provides District staff with a flexible planning tool to continuously update forecasts to reflect the current conditions affecting water demand. To implement this model, the District needs to determine and measure the variables that affect water demand.

Water demand is affected by numerous economic, demographic, and climatic variables. The PC-based model is based on a regression analysis that develops relationships between water demand and factors that affect water demand. Ten years of monthly water consumption data (1982 to 1991), tax assessor records, 1990 census data, and sewer and water price data were used in the regression analysis.

A series of water-use equations was developed for each of the District's major customer classes—residential, business, industrial, and institutional customers. In addition, water demand models were produced for single-family, multifamily, office, retail establishment, industrial, and landscape customers. These equations were used to forecast demands under different growth rates and land use assumptions. These water-use equations show that water consumption can best be explained by relating usage levels to seasonal irrigation requirements, property value, building size, and lot

size. The equations also show that recent droughts have had a significant impact on water demand.

LAND USE AND POPULATION FORECASTS

To predict future water demand, an understanding of the current and future land use in the District's service area is essential. City general plans and land use maps, 1990 census data, and 1992 Association of Bay Area Governments (ABAG) data were used to estimate current land use conditions and to predict future conditions and growth rates.

In the District's 1986 study, the bulk of development (excluding potential infill projects) was expected to occur by the year 2000, with minimal growth occurring between 2000 and 2010.[15] From discussions with city planning staffs, the Phase 1 demand investigation assumes that residential build-out will occur in 2010 and that business and industrial build-out (including potential infill projects) will occur in 2030 (due to the economic slowdown since 1986 and anticipated slow recovery).

To account for uncertainties in the amount of infill that will occur, the Phase 1 demand investigation includes "high" development and "low" development scenarios. "High" development assumes that all residential land is developed at 90% of city-specified density levels and that business and industrial land is fully developed. The difference between development levels for residential and business/industrial customers can be attributed to the current level of residential development. Residential development is closer to build-out than business and industrial development and therefore would require more infill than is anticipated to reach 100% maximum density levels. "Low" development assumes that residential, commercial, industrial, and institutional land is developed at 80% of maximum density levels.

By the year 2010, population is expected to increase from 263,700 in 1990 to 309,900 under the low development scenario and to 335,400 under the high development scenario (Figure III-1). This rate of increase is 18% to 27% over the 20-year period. As a result, the number of housing units served by the District is expected to increase from 90,800 units in 1990 to between 108,300 and 117,100 units in 2010 (Figure III-2). As shown in Figure III-1, these forecasts correspond well with the 1992 ABAG forecast. When compared with the District's 1986 forecast (which was based on 1983 ABAG data), the new high and low development figures are 14% and

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[15]Bookman-Edmonston and Metcalf & Eddy (BEME), *Supply and Facilities Planning Study* (Fremont, Calif.: Alameda County Water District, 1986).

Figure III-1
Population Forecast

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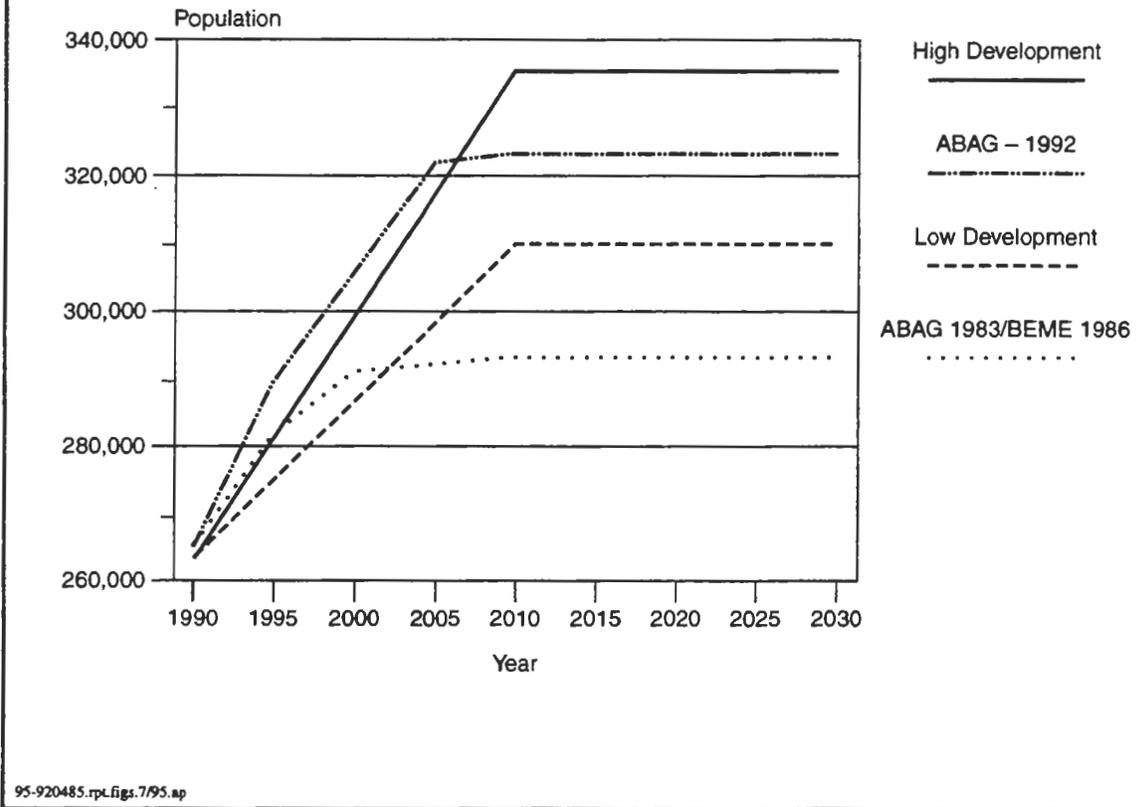
6% higher, respectively. This change reflects that the Phase 1 demand forecast includes future residential development in the hill areas north and west of the District service area and major changes from industrial to residential land uses that were not included in the 1986 study.

By the year 2030, commercial building space is expected to increase from 14.6 million square feet (sq. ft.) to between 27.7 and 33.2 million sq. ft. (Figure III-3), an increase of 90% to 127%. Industrial building space is expected to increase from 42.3 million sq. ft. in 1990 to between 78.8 and 97.0 million sq. ft. (Figure III-4), an increase of 86% to 129%.

Figure III-2
Housing Units Forecast
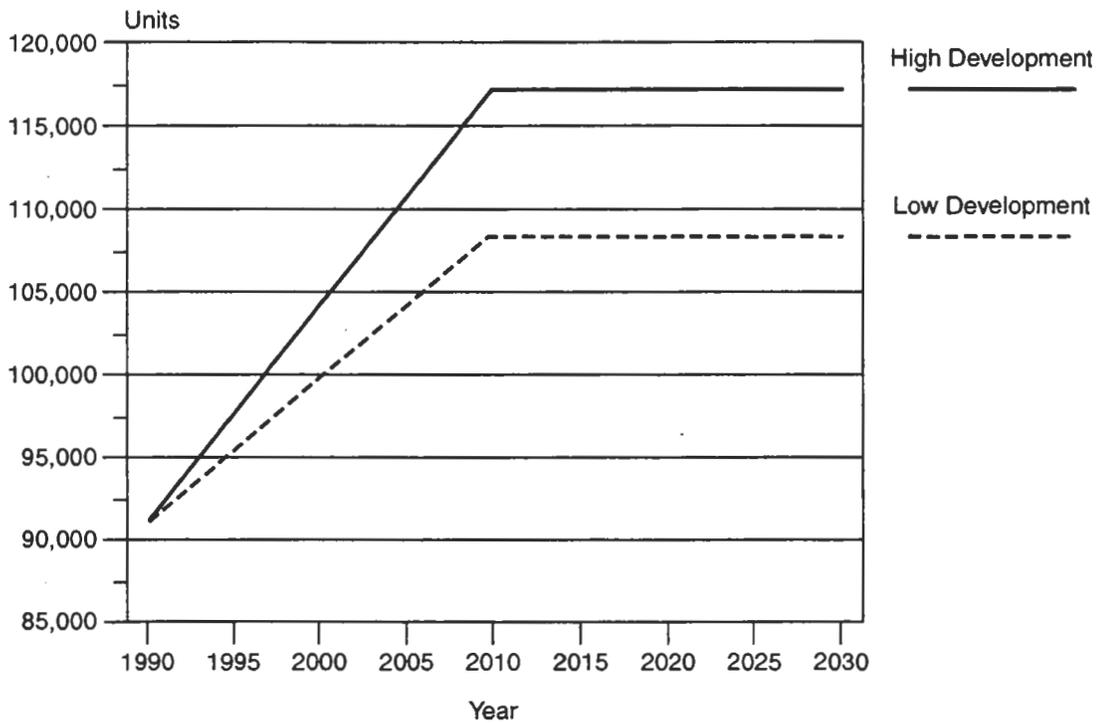
WATER DEMAND FORECASTS

The water demand forecasts for each customer class are calculated by multiplying the forecast water use per unit, as calculated from the water-use equations, by the appropriate forecast units (housing units, building space, or lot size). The forecast presented in this study is calculated using the set of equations for each customer class that best predicts long-term baseline demands multiplied by the expected rate of growth. This forecast does not include any reductions in demand that may occur as a result of the potential implementation of conservation measures. Opportunities to reduce demand are addressed separately.

III-4

Figure III-3
Commercial Building Space Forecast
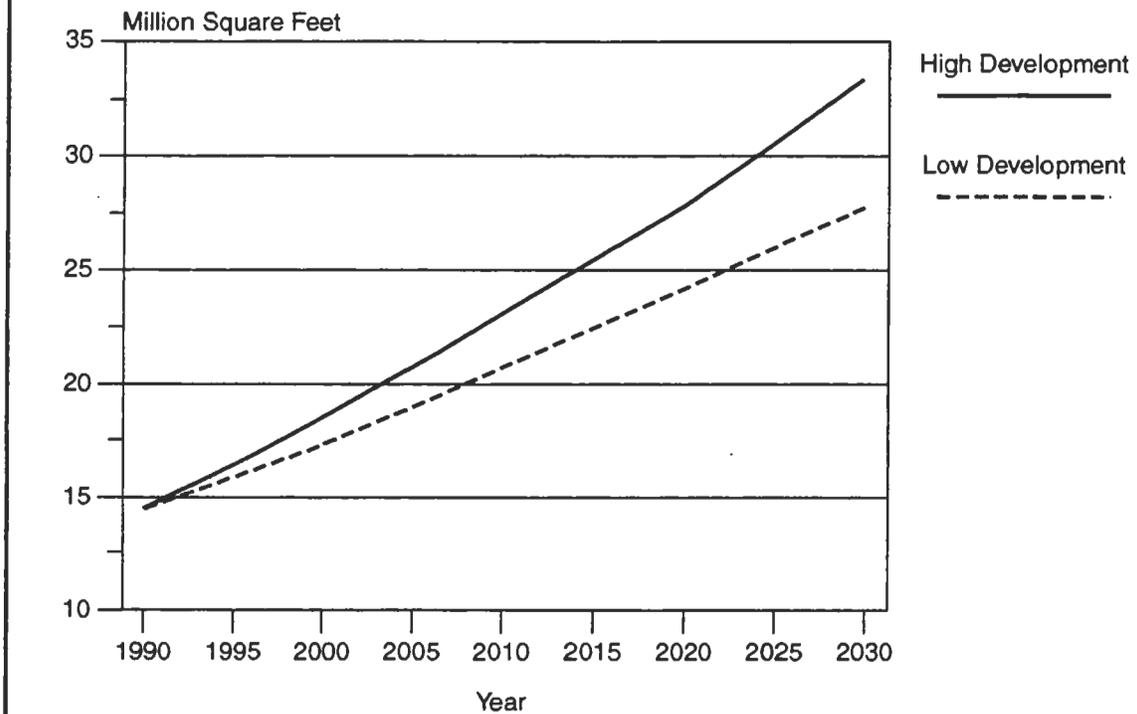
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Figure III-5 shows actual water use from 1974 through 1992, the 1986 BEME forecast, and the high and low forecasts used in this study. From 1974 to 1987, water use increased at over 5% per year with the exception of the decrease in water use as a result of the 1976 to 1977 drought. Per capita water use dropped 25% in 1977 and recovered to predrought levels by 1979. Water use peaked in 1987 at 39.1 mgd. Customers responded to the six-year drought that started in 1987; by 1991 customers had reduced water use to a seven-year low of 33.2 mgd, 17% below predrought levels.

The 1986 forecast assumed water use would continue to increase at the pre-1986 rate and begin leveling off in 1995, with an ultimate water use of 54.1 mgd in 2010. This forecast overestimated water use from 1988 to 1992 (water use during this period

Figure III-4
Industrial Building Space Forecast
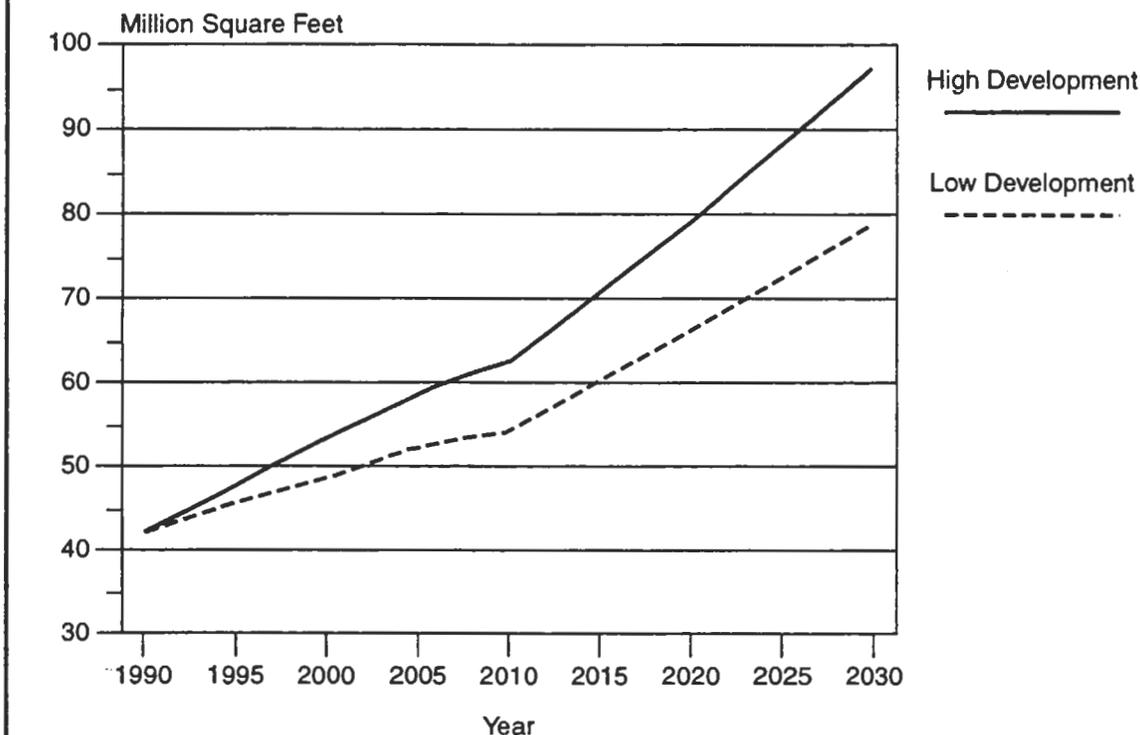

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decreased because of the drought). Although the new population forecast is higher than that used in the 1986 study, commercial and industrial development has not occurred as quickly as anticipated in 1986. As a result, the 1986 water use forecast for 1993 to 2010 is significantly higher than the new forecast. The water use forecast after 2010 increases from 7% to 22% above that forecast in the 1986 report, as commercial and industrial development is expected to continue.

The forecasts used in this study represent long-term baseline water use under the high and low development scenarios previously described. The rebound in water use seen in 1992 is expected to continue until 1995. Water use from 1995 to 2010 is expected to increase at a rate of 1% to 2% per year until residential build-out in 2010; after 2010, water use is expected to continue at a slightly decreased rate until commercial

Figure III-5
Actual and Forecast Water Use

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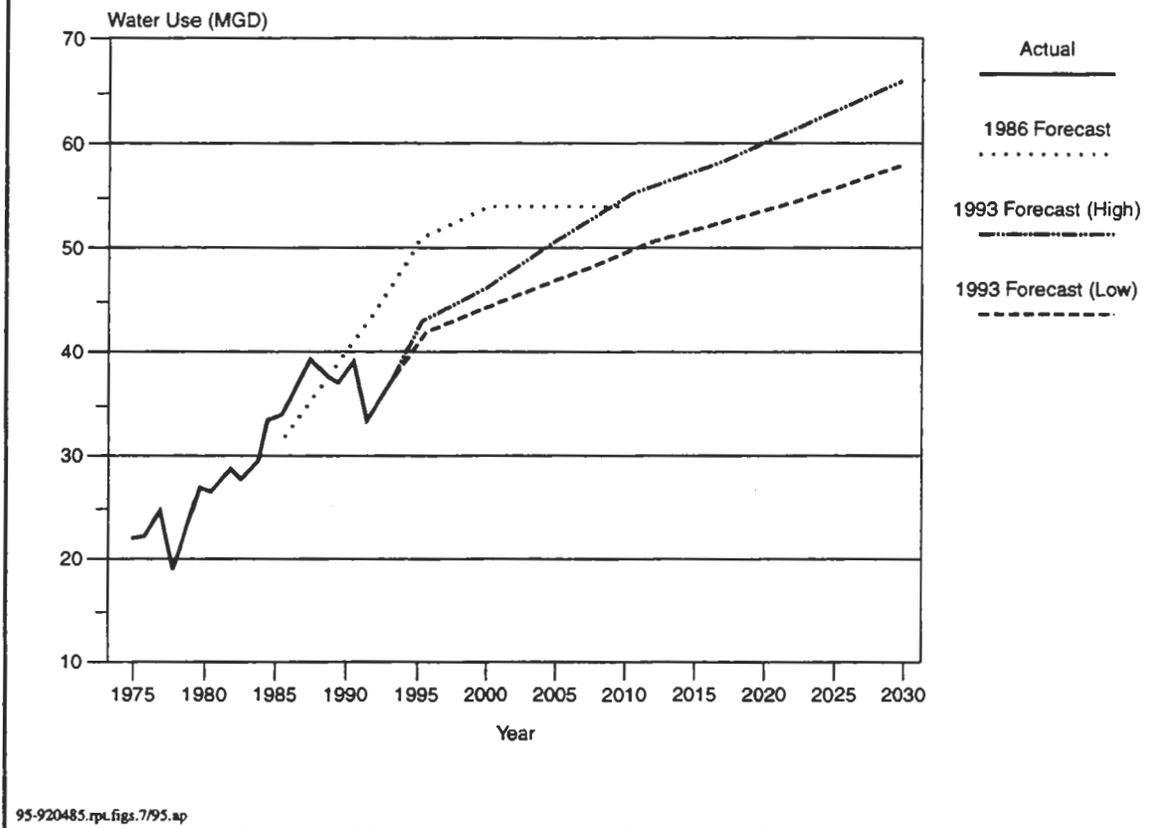
and industrial build-out in 2030. Water use in 2030 is expected to be between 57.9 and 66.0 mgd.

ADJUSTMENT FOR NATURALLY OCCURRING CONSERVATION

In 1993, the California State Legislature passed legislation that required the sale and manufacture of 1.6-gallons-per-flush toilets (also known as ultra-low-flush toilets, or ULFTs), 2.5 gpm faucets, and 2.5 gpm showerheads for residential application beginning January 1, 1994. New construction will incorporate these water-efficient fixtures. In addition, over time higher flow fixtures in existing construction will turn over and be replaced with water-efficient models.

The intent of the Phase 1 water demand investigation is to calculate a "base" range of forecasts without adjustments for future conservation or code changes. Therefore, these forecasts do not account for the water savings that will result from the 1993 code change.

The amount of water savings that can be expected from "naturally occurring conservation" depends on the efficiency of the installed fixture, the intensity of fixture use, and equipment turnover. Due to past code changes and natural market transformations, the efficiency of a plumbing fixture can be deduced from its age. For example, toilets installed before 1980 typically use 5 to 7 gallons per flush, whereas toilets installed between 1980 and 1994 typically use 3.5 gallons per flush. The age of homes is used as a proxy for equipment age. The intensity of use is calculated using engineering estimates, demographics data (e.g., the number of people per household), and data from plumbing end-use studies.

The expected reduction in water use for new construction is assumed to be the same as that for end-of-life replacement because historical water consumption is used to project future demands; inherent in the historical consumption pattern is the efficiency mix of the plumbing fixtures. In this simplified analysis, changes in future household composition are ignored.

From estimates of construction starts in the District's service territory, the average water savings per household are 44 gallons per day after the installation of ULFTs and 11 gallons per day after the installation of low-flow showerheads and faucets. It is assumed that higher flow toilets in pre-1994 homes are completely replaced over a 25-year period and that higher flow faucets and showerheads are completely replaced over a 15-year period.

The total amount of naturally occurring conservation due to the installation of low-flow fixtures is expected to be over 6 million gallons per day by the year 2030. This reduces the base water demand forecast by as much as 10%, as shown in Figure III-6. Assumptions and calculations of water savings are shown in Appendix C.

Figure III-6
Water Use Forecast
Adjusted for Naturally Occurring Conservation
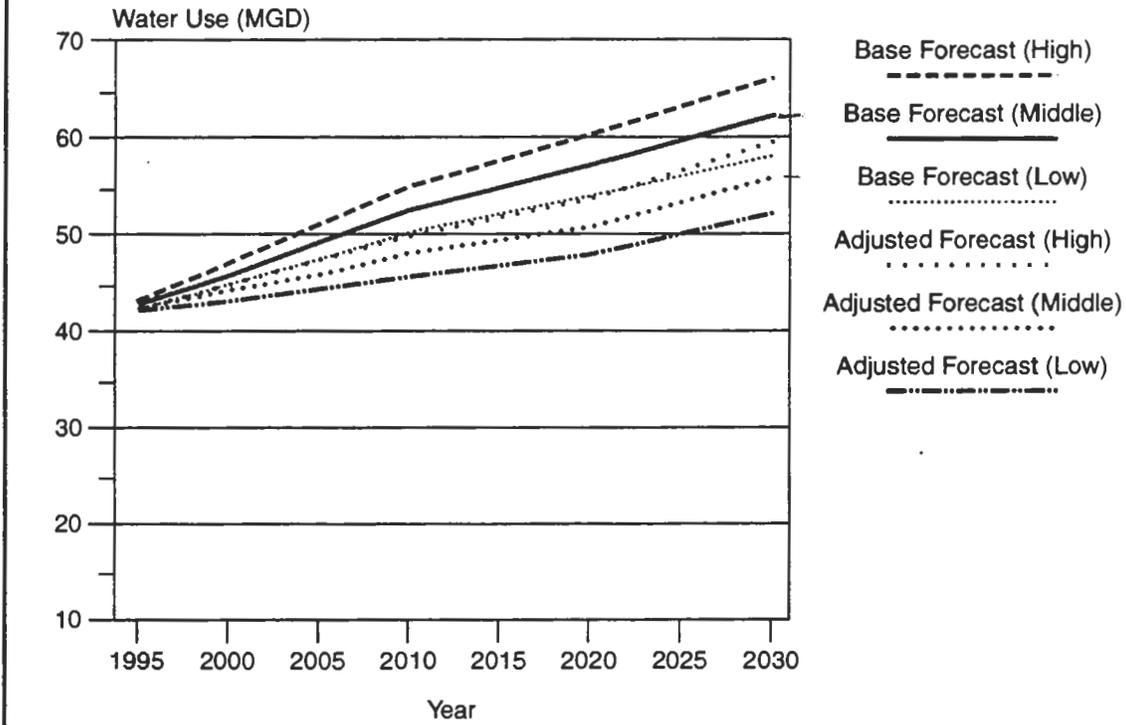
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III-9

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

POLICY OBJECTIVES AND EVALUATION CRITERIA

ACWD Integrated Resources
Planning Study Process

Policy Objectives

Demand Forecast

Evaluate Current
System Resources
and Operations

Integrated Resources
Planning Model

Evaluation Criteria

Characterize
Resource Options

Resource
Assessment
• Supply-Side
• Demand-Side

Define Future Uncertainties
and Potential Outcomes

Form Potential
Resource Sequences

Narrow

Define Uncertainty
Scenarios

Test Sequences Against
Evaluation Criteria

Narrow

Form Resource
Strategy

Final
Recommendations

95-920485.rpt.figs.7/95.ap

IV. POLICY OBJECTIVES AND EVALUATION CRITERIA

A critical early step in IRP is to develop explicit policy objectives. Policy objectives are statements of the critical issues that must be considered in evaluating alternative resource strategies. Policy objectives should typically not be viewed as constraints. Rather, each objective is a goal that can be achieved to a greater or lesser degree. Often, the attainment of one objective depends on others.

Thus, the concept of *trade-offs* among conflicting policy objectives is central to IRP. One key role of IRP, then, is to illuminate the trade-offs that the District will ultimately have to make. For example:

- A more reliable system is usually a more expensive one;

- A facility/resource sequence that provides softer water may result in reduced reliability; and

- A less expensive alternative may have more severe environmental impacts than a more expensive alternative.

These and other conflicts reflect the District's planning environment. The plan must not mask these conflicts or "assume them away." Rather, it should provide explicit information that will enable decision makers to make the difficult trade-offs that are required.

The consultant team first met with the Technical Advisory Committee to determine the District's perspectives on various policy issues, such as cost, revenues, rates, etc. These policies were then reviewed and confirmed by the District's Board of Directors. The purpose was to reach a consensus on the meaning and importance of these issues in the context of this study. From these discussions, a set of policy objective statements was developed. For each policy objective, one or more measurable *evaluation criteria* were defined. These criteria were subsequently used to assess the performance of the resource sequences.

In this section descriptions of the policy objectives and their associated evaluation criteria are provided. It should be noted that the evaluation criteria take different forms and are measured in different units; many are *ordinal scales*. The assessment of resource sequences against these scales are based primarily on best professional judgment. The discussions that accompany the evaluation criteria indicate the factors considered in rating the resource alternatives.

All ordinal scales range from 1 to 3; a 1 is the highest rating and a 3 the lowest.

In addition to the objectives listed below, the District will meet the following primary goals regardless of the resource strategy chosen:

- Avoid rate shocks
- Avoid chronic shortages
- Maximize the health-related treated water quality
- Protect groundwater basins

Section VIII discusses the evaluation of the individual resource options against the criteria. Section X discusses the manner in which the evaluations of individual resources are combined to develop composite evaluations of resource sequences.

COSTS

Objectives

- Minimize resource costs
- Maintain low average customer bills

Criterion

- Net present value of fixed and variable costs

Discussion

- The District believes that keeping costs, and therefore customer bills, low is a paramount objective. The most appropriate measure of the success of a particular resource sequence in meeting this objective is the discounted net present value of all of the costs that the District faces over the 1994–2030 planning period.

- The annual capital recovery costs of individual resource options were based on a facility life of 35 years and a nominal interest rate of 8%. The net present value of resource sequences was calculated assuming a nominal interest rate of 8% and an inflation rate of 5%.

RELIABILITY

Objective

- Maintain a high level of service reliability

Criterion

- Unserved demand in drought conditions, expressed as a percentage of annual demand, for the benchmark years 2000, 2010, 2020, and 2030.

Discussion

- The District intends to maintain a high level of service reliability for its current and future customers. The District's primary concern is long-term reliability (i.e., reliability beyond the year 2000) because it has contingency plans and internal standards (e.g., storage standards and peak-day spare capacity for pumps and tanks) to address short-term reliability issues in the intervening years. Until the recent drought, the District had not adopted explicit reliability standards because it had assumed a 100% reliable supply from the SWP.

- The District has determined that a shortage of greater than 10% in 1 out of every 30 years is unacceptable. Likewise, frequent small shortages (i.e., chronic shortages) have also been deemed unacceptable. Hence, resource strategies that result in shortages of greater than 10% or chronic shortages are not considered.

WATER QUALITY

Objective

- Avoid sudden changes in water taste or appearance

Criterion

- Maximum monthly hardness during drought years

Discussion

- Aesthetics, especially taste, is extremely important to District customers. Major fluctuations in aesthetics are noticeable to customers and may generate customer inquiries. One determinant of taste is hardness, expressed as mg/L (or ppm) of $CaCO_3$.

ENVIRONMENTAL IMPACTS

Objective

- Avoid or mitigate environmental impacts

Criterion

- Ordinal score based on current knowledge of potential environmental impacts

Discussion

- This criterion measures the *long-term* environmental impacts associated with a resource option. The short-term impacts associated with project construction are not included. It was determined that, with appropriate mitigation, all resource options that pass the fatal flaw analysis do not have significant long-term environmental impacts. Therefore, the environmental scoring compares the relative long-term impact of the resource options.

LOCAL CONTROL

Objective

- Maximize District control of resources

Criterion

- Ordinal score rating for District control

Discussion

- In light of the current uncertainties associated with the District's imported supplies, the District determined that local control of future resources is desirable. The rating of a resource against this evaluation criterion is based on the following characteristics:

    - The number of entities involved in developing or acquiring the resource options;

    - The firmness of the District's water rights or contractual allocations;

    - The amount of water that the District would have to share with other contractors; and

    - Whether state or federal agencies are involved in allocating water deliveries.

RISK

Objective

- Minimize risks due to future uncertainty

Criteria

- Ordinal score that rates financial risk
- Ordinal score that rates water quality risk
- Ordinal score that rates water availability risk

Discussion

- A flexible resource plan allows the District to adapt to future uncertainties. The key future uncertainties are explicitly considered in this study (see Section V). However, there are other nonquantifiable uncertainties that the District believes should be addressed in this study. These include:

  - **Financial risk.** The likelihood of spending more money than expected or spending money unnecessarily. This rating is affected by factors such as the ratio of fixed to variable cost, construction and permitting lead times, and resource size. For example, resources with high capital cost are more financially risky than resources characterized by variable costs.

  - **Water quality regulator risk.** The likelihood of being unable to comply with future health-related water quality regulations. Even though the cost of treatment needed to comply with current standards is included for all source options being considered, some sources have an inherently higher risk of not meeting future standards with existing treatment facilities. For example, groundwater may be a risky source of supply because of potential radon standards. Similarly, surface waters may be risky because of potential *cryptosporidium* regulations. The inherent difference in risk between surface waters and groundwaters, as reflected in the uncertainty of water quality regulations, is discussed in Section V.

  - **Availability risk.** The likelihood that a supply source is not available due to external legal or regulatory changes or uncertainties in the quantity of supply provided or saved. For example, agricultural transfers may be risky because of contractual and delivery (i.e., through the Delta) issues.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

FUTURE UNCERTAINTIES

ACWD Integrated Resources
Planning Study Process

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┌─────────────────────┐          ┌─────────────────────┐
│  Policy Objectives  │          │   Demand Forecast   │
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           │                                ▼
           │                     ┌─────────────────────┐      ┌─────────────────────┐
           │                     │  Evaluate Current   │      │ Integrated Resources│
           │                     │  System Resources   │◄·····│  Planning Model     │
           │                     │   and Operations    │      └─────────────────────┘
           │                     └─────────────────────┘
           ▼                                │
┌─────────────────────┐                     ▼                 ┌─────────────────────┐
│ Evaluation Criteria │────────►┌─────────────────────┐       │      Resource       │
└─────────────────────┘         │    Characterize     │◄──────│     Assessment      │
                                │  Resource Options   │       │  • Supply-Side      │
┌─────────────────────┐         └─────────────────────┘       │  • Demand-Side      │
│ Define Future       │                    │                  └─────────────────────┘
│ Uncertainties       │────┐               ▼
│ and Potential       │    │    ┌─────────────────────┐
│ Outcomes            │    │    │   Form Potential    │
└─────────────────────┘    │    │  Resource Sequences │
           │               │    └─────────────────────┘
           ▼               │               │  Narrow
┌─────────────────────┐    │               ▼
│ Define Uncertainty  │────┘    ┌─────────────────────┐
│    Scenarios        │         │ Test Sequences Against
└─────────────────────┘         │  Evaluation Criteria │◄········
                                └─────────────────────┘
                                            │  Narrow
                                            ▼
                                ┌─────────────────────┐
                                │   Form Resource     │
                                │     Strategy        │
                                └─────────────────────┘
                                            │
                                            ▼
                                ┌─────────────────────┐
                                │       Final         │
                                │  Recommendations    │
                                └─────────────────────┘
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V. FUTURE UNCERTAINTIES

There are many future uncertainties that are largely beyond the District's control or influence. The manner in which these uncertainties are resolved may have a critical impact on the District's water demand or its ability to develop future resources. Since the actual outcomes of these uncertainties cannot be predicted, the District's resource plan should be flexible enough to enable it to adapt to differing outcomes.

A critical feature of this study is the careful and explicit consideration of future external uncertainties. An important distinction must be made between *uncertainties* and *decisions*. Uncertainties are events that are largely beyond the District's control. Decisions are actions that a utility undertakes in anticipation of or as a result of possible uncertainty outcomes. For example, demand growth is an uncertainty, but the development of a particular resource as a result of, say, a high demand forecast is a decision.

The first step in considering uncertainties is defining the key external factors that may affect the District's resource development. Three uncertainties were identified to be critical in their impact on the District's future resource decisions:

1. The demand forecast
2. Regulatory restrictions that may affect supply availability
3. Drinking water regulations

For each of these uncertainties, the next step is to develop an analytically rigorous method to characterize and analyze the range of potential outcomes. To make the analysis manageable and the results understandable to decision makers, the uncertainty outcomes were combined into three future scenarios.

This section describes the District's planning uncertainties in detail and discusses how these uncertainties are addressed in this study.

RANGES OF FUTURE DEMANDS

Future water demands can vary widely with changes in land use designations, population forecasts, rates of growth, weather, consumer water use habits, and use of water-saving devices. Accurate forecasts of water needs is a key component of planning for future supply-side, demand-side, and operational alternatives. If resource development is based on an overly high forecast, the result can be the implementation

of programs or the construction of facilities that are not needed, either of which involves unnecessary costs to customers. Conversely, underestimating water needs can result in unacceptable shortages to customers or the need to purchase expensive emergency supplies.

As described in Section III, a range of demands was developed to capture the uncertainties in land rezoning, level of development, and weather conditions. Three future demands are defined as follows:

- **Middle development.** This demand represents the District's estimate of the degree of residential and industrial build-out that is most likely to occur. Residential land is assumed to be developed at 85% of city-specified density levels, and commercial and industrial land is assumed to be developed at 90% of specified levels.

- **High development.** This demand assumes that residential land is developed at 90% of city-specified density levels, and commercial and industrial land is fully developed.

- **Low development.** This demand assumes that residential land is developed at 80% of city-specified density levels, and commercial and industrial land is developed at 80% of specified levels.

WATER SUPPLY AVAILABILITY

Water supply availability is affected by climatic and legal/institutional conditions. The effect of climatic variations on water supply availability is addressed in the IRPM. The IRPM uses a 70-year period of record to probabilistically calculate system reliability.

A key uncertainty pertaining to water supply availability is legislative, regulatory, and contractual requirements that limit the amount and timing of diversions. These uncertainties affect the District's current imported supplies and may well affect potential future supplies. The future supply availability risk due to regulatory uncertainties is addressed in the qualitative evaluation of resource options (Section VIII). The remainder of this section discusses the potential regulatory/institutional factors that affect the availability of the District's current imported supply sources from the SWP and the SFWD.

Uncertainties Pertaining to SWP Water Availability

SWP water originates from the runoff of tributaries to the Sacramento and San Joaquin Rivers. Some of the runoff is stored in the SWP's Oroville Reservoir on the Feather River for later release and use. Some water flows directly to the Sacramento-San Joaquin Bay/Delta, where it is pumped at the SWP export facilities and delivered to the District through the SBA.

The Delta is the heart of California's largest water delivery systems, the federal Central Valley Project (CVP) and the SWP. As such, the Delta has been the subject of much controversy regarding water allocations for farms and cities and fish and wildlife. Over the last decade, a number of factors have increased pressure on the Delta system and heightened interest in attaining a solution to Delta problems. These factors include a precipitous decline in many fish species that live in or migrate through the Delta, laws and public pressure to protect the environment, unprecedented urban population growth and the corresponding need for more water, and the 1987–1992 drought.[16]

In this study, two factors were identified that have a significant impact on SWP availability: structural modifications that increase project yield and environmental regulations that affect the timing and amount of exports from the Delta. Each factor is discussed in turn.

Proposed SWP Facilities

When the SWP was authorized by the Burns-Porter Act in 1960, it was recognized that additional facilities would need to be constructed to maintain the minimum project yield as project demands increased over time and upstream depletions occurred. Furthermore, the Burns-Porter Act authorized facilities to transfer water across the Delta to the pumping plants. These facilities have not been constructed.

The California DWR has been evaluating projects to ameliorate these SWP facility limitations. The South Delta Water Management Plan EIR/EIS document describes a number of these structural changes in the southern Delta, including the Clifton Court Forebay enlargement and channel dredging. These changes were proposed to improve and maintain water levels, circulation patterns, and water quality in the south Delta channels as well as to allow the Banks Pumping Plant to pump to capacity. Also, facilities such as Los Banos Grandes Reservoir and the Peripheral Canal have been

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[16]S. McClurg. "The Delta Dilemma Continues," *Western Water*, March/April 1993.

proposed. The implementation of the South Delta Water Management Plan and/or the introduction of new facilities would certainly influence supply reliability for water users south of the Delta.

Even though the State has identified several structural modifications to the Delta, it is uncertain whether approval for the construction of additional facilities can be obtained due to regulatory and political constraints. Because of this uncertainty, new projects have not been included in the evaluation of SWP supply.

Environmental Factors

In its natural state, the Delta was a giant swamp where fresh water from the Sacramento and San Joaquin Rivers mixed with salt water from San Francisco Bay, creating a unique ecosystem for plants, fish, and wildlife. As upstream users began diverting water from rivers for use on farms and major Sierra tributaries were dammed and their waters diverted for growing Bay Area cities, fresh water flows into the estuary were reduced. Pumps for the CVP and SWP, constructed at the southern end of the Delta to collect and distribute freshwater to farms and cities in Central and Southern California further reduced freshwater flows into the estuary. The resulting changes in the timing of freshwater flow to the estuary have impacted its ecological system. Most affected are the Delta smelt and migratory winter-run chinook salmon—which have been listed as threatened species under the Endangered Species Act.

To protect the Bay/Delta from further ecological degradation and to restore the ecological system, the State Water Resources Control Board (SWRCB), in conjunction with other agencies, is developing a water quality control plan. These Bay/Delta protection standards are meant to protect all beneficial water uses; thus, they were used in evaluating SWP supply reliability. To provide a range of water supply reliability, four scenarios were initially considered in this study. Figure V-1 shows annual SWP water supply reliability under each of these scenarios. Scenarios 1 and 2 were used to quantify SWP deliveries to the District in the initial evaluation of existing supply reliability and in the initial evaluation of future resource options. Scenarios 3 and 4 were used in the final evaluation of existing supply reliability and in the development of the final resource sequences.

- Scenario 1 is based on the SWRCB's Decision 1485, which was made in 1978. D-1485 revised previous standards for flow and salinity in the Delta's channels and ordered USBR and DWR to meet these standards by reducing pumping (exports), releasing water stored in upstream reservoirs,

Figure V-1
SWP Water Supply Reliability

Annual SWP Water Supply (AC-FT)

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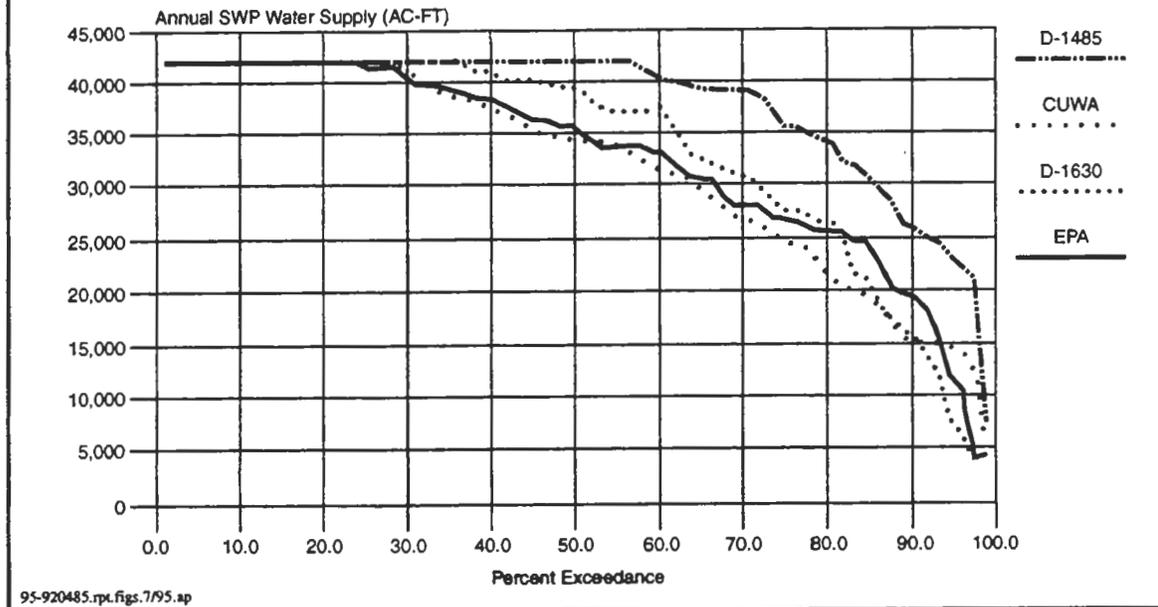
or both. The operating criteria described in D-1485 were in effect until early 1995, when CVP and SWP voluntarily adopted the provisions contained in the Cal-Fed Decision, discussed below.

- Scenario 2 is based on SWRCB Draft Decision 1630, which was published in April 1993. To better address environmental concerns, draft D-1630 specified even more stringent standards for the Delta. Some of the proposed standards contained in draft D-1630 were specifically designed to increase fish populations and included, among other things, the reduction of reverse flows in the western Delta, pulse flows from both the Sacramento and the San Joaquin Rivers, curtailment of pumping during certain spring and fall months, and real-time management of the Delta–Cross Channel gates.

Provisions included in draft D-1630 would have had considerable impact on water users, particularly those dependent on exports from the Delta. Soon after the release of draft D-1630, Governor Wilson initiated a process to evaluate the long-term and far-reaching project management

options available; because of this process the final decision will be made by the SWRCB at a later date.

- Scenario 3 is based on a set of proposed U.S. Environmental Protection Agency (EPA) standards. Concerned with the pace of reaching a Bay/Delta decision, EPA proposed its own set of criteria in January 6, 1994, as follows:

  - Salinity criteria to protect estuarine habitat in the Suisun Bay area;

  - Salmon smolt survival indices to protect salmon migration; and

  - Electrical conductivity criteria to protect striped bass spawning on the lower San Joaquin River.

  Implementation of EPA standards would require, among other operational procedures, greater Delta outflow, curtailment of pumping, and the closure of channel gates at specific periods of the year.

- Scenario 4 is based on the CUWA/Agricultural Coalition Standards. Representing a broad spectrum of urban and agricultural water users, the CUWA/Agricultural coalition formulated what is known as the "CUWA/Ag Proposal." The CUWA/Ag Coalition proposed a set of operating criteria also aimed at improving estuarine habitat. Among the proposed operational criteria are:

  - Closure of Cross-Channel gates at specific times of the year;

  - Minimum flows at Rio Vista and Freeport, on the Sacramento River, and Vernalis on the San Joaquin River;

  - Reduction of reverse flows in the western Delta;

  - Making average monthly exports dependent on flows on the San Joaquin River at Vernalis and limiting exports to a maximum monthly value; and

  - Minimum required Delta outflow.

The CUWA/Ag and other proposals were presented at hearings held by the SWRCB during 1994. On December 15, 1994, the most recent changes to the Bay-Delta

protection standards were announced. This decision, known as the "Cal-Fed Decision," represents an agreement between a consortium of state and federal officials, environmental groups, and water users regarding limits in Delta water diversions.

Although it is still unclear at this time how reductions in diversions will be allocated, this analysis assumes that the allocation of water reductions under the December 15 accord will be similar to that under the CUWA/Ag agreement. In addition, restrictions on water diversions from the Delta are not likely to be any less severe than those under the December 15 decision, and, in fact may be more severe if additional species are listed as "threatened" or "endangered." Therefore, this study assumes two outcomes on SWP deliveries: CUWA/Ag agreement and EPA standards. The CUWA/Ag agreement represents both the most likely scenario and the best-case scenario. Because the EPA standards are more restrictive than the Cal-Fed Decision, they represent the worst-case scenario.

Uncertainties Pertaining to SFWD Water Availability

Two regulatory/institutional constraints might affect delivery of SFWD's Hetch Hetchy water to the District: the Bay/Delta standards and SFWD's obligations to its other contractors. The effect of each constraint is discussed in turn.

SFWD's Hetch Hetchy water is diverted from the Tuolumne River watershed. Because this water does not flow through the Delta, it is not currently affected by the Bay/Delta protection standards. However, SWRCB is considering proposals that require all water projects to contribute in protecting the Delta; if this were to occur, the Hetch Hetchy Project might have to release a portion of its supply to the Delta. It was determined that the SWRCB would probably not direct Hetch Hetchy water to be released to the Delta due to its very high quality, its high-value end use, and SFWD's ability to financially contribute in protecting the Delta. Thus, this study assumes that future SWRCB actions that address water obligations for Bay/Delta standards will not impact Hetch Hetchy water availability.

The Hetch Hetchy supply is also influenced by the regulatory actions of the Federal Energy Regulatory Commission (FERC). In particular, FERC release requirements for the Turlock and Modesto Irrigation Districts' New Don Pedro Power Plant can affect the upstream Hetch Hetchy Project because of San Francisco's contractual relationship with these districts. In 1991, FERC initiated Proceeding 2299-024. This "20-year reopener" was an action specified in the original 50-year FERC license for New Don Pedro Power Plant, issued in 1971. This proceeding is reevaluating the

license terms and conditions in the area of fishery requirements. As of July 1995, these proceedings were not concluded; however, SFWD believes that the Hetch Hetchy water supply forecasts provided to the District have accounted for the anticipated FERC ruling.

As discussed in Section II, the District has recently contracted for an additional 1.7 mgd of previously unallocated SFWD water. However, the District may not get the full additional amount in the future because other SFWD contractors who do not have allocation limits and whose contracts predate the District's contract may take additional deliveries in the future; if this were to occur, SFWD would not be able to deliver the additional 1.7 mgd to the District.

DRINKING WATER REGULATIONS

Currently, all water sources are treated to meet or exceed current state and federal drinking water standards. Water production at the District's surface water treatment facilities is limited by both influent water quality variations and facility limitations. Consequently, the amount of surface water that can be treated is uncertain. The uncertainty in maximum rate of plant production is addressed by specifying three different average production rates:

- **37 mgd (28 mgd WTP 2).** This rate assumes that the District can maintain the maximum filtration rate of 6.0 gpm/sq. ft. for dual-media filters under gravity flow conditions, as specified in the EPA drinking water standards.

- **32 mgd (23 mgd WTP 2).** This rate assumes a mid-range value of the treatment plants' monthly maximum capacity.

- **30 mgd (21 mgd WTP 2).** This rate assumes that the maximum production rate is limited due to influent water quality variations and sedimentation and equalization basin sizes.

Numerous future drinking water regulations will also impact the District's current operations and selection of future water resources. These regulations may require treatment modifications to bring water produced from each source into compliance. Table V-1 lists some of the potential water quality regulations and the facilities and sources of supply that might be impacted.

Table V-1
IMPACTS OF POTENTIAL WATER QUALITY REGULATIONS
ON THE DISTRICT'S SYSTEM

Water Quality Regulations	Mission San Jose WTP	WTP 2	Groundwater	SFWD	Distribution
Total coliform					?
Surface water treatment	✓			✓	?
Enhanced surface water treatment	✓	?		✓	
Cryptosporidium	✓	?		✓	
Information collection	✓	✓	✓	✓	✓
Disinfectant/disinfection by-products	✓	✓	?	✓	✓
Lead and copper			✓	✓	✓
Groundwater disinfection			?		
Radionuclides			?		
Arsenic			?		
Residuals disposal	✓	✓		✓	
Nonpoint source discharges		?	?	?	✓

✓ = Impact
? = Impact unknown
Blank = No impact

The 1986 Safe Drinking Water Act (SDWA) mandates that the EPA set 25 new maximum contaminant levels (MCLs) every three years. Future water quality rules that may affect the level of treatment required of existing and future District source waters include, but are not limited to, the Disinfectants/Disinfection By-Products Rule, the Enhanced Surface Water Treatment Rule, the Radionuclides Rule, the Arsenic Rule, and the Groundwater Disinfection Rule. Although the intent of these regulations is clear, it is not feasible to quantify their potential impacts on cost of treatment or use of existing and future resources, as the detail of these regulations has not been finalized. Therefore, the potential impacts of these regulations on resource allocation are addressed in a qualitative manner.

The uncertainty associated with the unknown impacts of these future water quality rules on the District's surface and groundwater supplies is considered in the evaluation of resource sequences. As discussed in Section VIII, individual resources were evaluated according to their ability to minimize the risk of noncompliance or the risk of high costs to ensure continued compliance with future water quality regulations.

UNCERTAINTY SCENARIOS

As described above, three outcomes are delineated for each major uncertainty. Figure V-2 illustrates the potential outcomes for all the key uncertainties considered in this study. There are 54 ($3 \times 2 \times 3 \times 3$) possible combinations of outcomes for these uncertainties. It does not make sense to examine every combination, and even if it did, the analysis would be too complicated to provide meaningful results to decision makers.

To make the analysis manageable and understandable, the uncertainty outcomes were combined into three future scenarios. The three scenarios span the range of demand, water availability, and drinking water regulation outcomes. They are also realistic representations of future outcomes in the sense that they are neither overly pessimistic nor overly optimistic. The three uncertainty scenarios are shown in Table V-2.

Table V-2
DESCRIPTION OF UNCERTAINTY SCENARIOS

	Best Case	Middle Case	Worst Case
Demand forecast	Low development	Middle development	High development
SWP deliveries	Cal-Fed decision	Cal-Fed decision	EPA decision
SFWD deliveries	Additional 1.7 mgd	Additional 0.7 mgd	No additional allocation
Treatment plant capacities	37 mgd (WTP 2: 28 mgd)	32 mgd (WTP 2: 23 mgd)	30 mgd (WTP 2: 21 mgd)

The paths that result in these three scenarios are shown in bold in Figure V-2.

Figure V-2
Potential Uncertainty Outcomes

| Demand
Forecast | SWP
Availability | SFWD
Availability | TP2
Capacity |
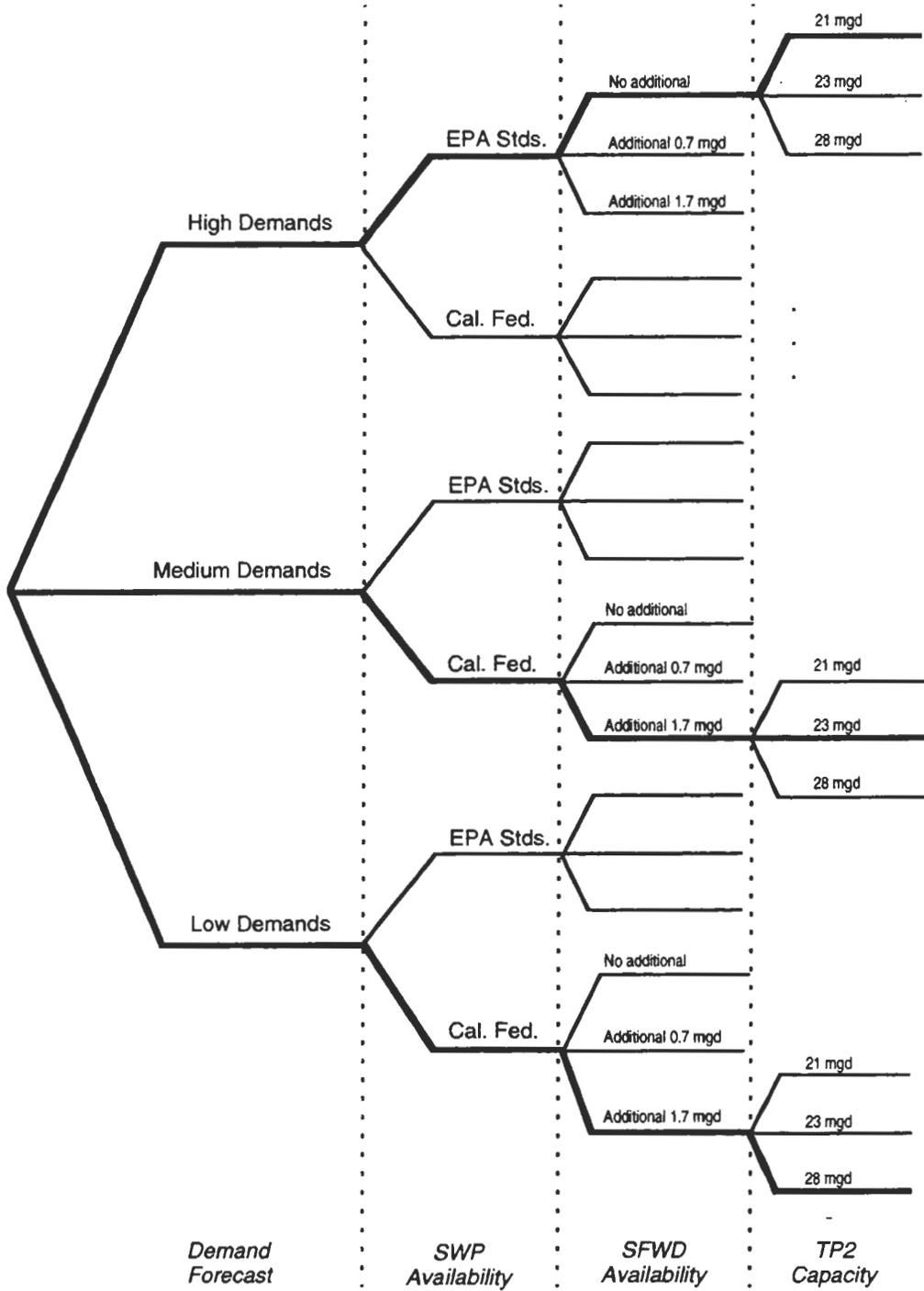
ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

MODEL DEVELOPMENT

ACWD Integrated Resources
Planning Study Process

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┌──────────────────┐        ┌──────────────────┐
│ Policy Objectives │        │ Demand Forecast  │
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         │                  │ Evaluate Current │ ◄···· │ Integrated Resources │
         │                  │ System Resources │       │    Planning Model    │
         │                  │   and Operations │       └──────────────────────┘
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         ▼                           │                            :
┌──────────────────┐       ┌──────────────────┐       ┌──────────────────────┐
│ Evaluation       │ ────► │ Characterize     │ ◄──── │ Resource             │
│ Criteria         │       │ Resource Options │       │ Assessment           │
└──────────────────┘       └──────────────────┘       │  • Supply-Side       │
┌──────────────────────┐            │                 │  • Demand-Side       │
│ Define Future        │            │                 └──────────────────────┘
│ Uncertainties and    │────────────┤
│ Potential Outcomes   │            ▼
└──────────────────────┘   ┌──────────────────┐
         │                 │ Form Potential   │
         ▼                 │ Resource         │
┌──────────────────┐       │ Sequences        │
│ Define           │       └──────────────────┘
│ Uncertainty      │─────┐        │ Narrow
│ Scenarios        │     │        ▼
└──────────────────┘     │ ┌──────────────────┐
                         └►│ Test Sequences   │ ◄···············
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VI. MODEL DEVELOPMENT

The IRPM was developed to help the District assess its current and future system reliability, that is, to answer questions such as:

- How reliable is the system under current conditions? What are the probabilities of shortage?

- How will reliability change with increasing water demands?

- How will reliability change under future regulatory restrictions?

- How will adding facilities, modifying system operations (e.g., changing hardness), or implementing conservation programs affect system reliability?

This section provides a brief description of the model, its use in this Plan, and its modeling algorithm. Appendix D presents a detailed description of the model.

MODEL DESCRIPTION

The IRPM simulates operations for the period of record (1922–1992) by using a monthly time step and user-specified assumptions about water demand. The user-specified demand is imposed on the hydrologic record to examine system reliability over time. This fixed water demand can be either current or future estimated demand.

The IRPM was designed to be nearly completely data-driven. That is, most of the system and its operations are specified through input data, rather than being specified within the program. Because it is data-driven, the model is flexible; facilities (e.g., reservoirs) may be added or removed through changes in input data files. The user can examine "what-if" scenarios with a minimum of trouble and without program modifications.

A linear program (LP) "engine" was chosen as the most flexible yet powerful means of modeling the ACWD system. The LP is embedded in the simulation to route water through the system for each time step.

In an LP, the problem is described by a set of linear algebraic expressions. An LP is solved when values for unknown variables (decision variables) are found so that a

particular expression (the objective function) in the problem description is maximized or minimized when subject to a set of constraints.

For example, $3X + 4Y - Z$, $2X - Y < 3$, and $X + Y + 3Z = 10$ are linear algebraic expressions that can be used in an LP. Decision variables X, Y, and Z represent model unknowns (e.g., end-of-month storage in Del Valle Reservoir, reclamation pumping, or amounts of water from different sources mixed at the blending plant). The expression $3X + 4Y - Z$ can be an objective function in an LP, in which case the values for X, Y, and Z must be found so that this expression is maximized (as in the IRPM) or minimized for the given constraints.

Constraints define the system, its capabilities, supplies, etc. An example of a constraint is to limit the water stored in Del Valle Reservoir to capacity (i.e., $X \leq$ capacity, where X represents the end-of-month storage). Other examples of constraints are limiting water delivery at a demand point to no more than its total demand, keeping surface and groundwater storage above predefined minimum values, and limiting water at the treatment plant to no more than its capacity.

MODEL CAPABILITIES AND USE IN THE IRP PROCESS

The development of an LP model that has data-driven specifications provides significant latitude in problem solving and optimization. With independent modules for describing both physical features and operating rules, the capability to model alternative system configurations and/or alternative water supplies is limitless. This capability fits well with the IRP process in that it allows an analysis of both supply-side and demand-side options.

Numerous supply-side and demand-side options were evaluated in the course of this study. Because of the simplicity of adapting the IRPM to alternatives, variations on the following parameters were included in the studies:

- Treatment plant sizes
- Allowable hardness levels
- Annual and seasonal water transfers
- Reservoir sizes and operating criteria
- Aquifer reclamation program (ARP) quantities
- Barrier pumping quantities
- Desalination plant sizes
- Reclaimed water supplies
- Allowable groundwater mining

- New water supply sources
- Storage locations and sizes

After the system configuration has been described, the IRPM solves for flows, storage levels, groundwater levels, hardness, and deliveries. Values are calculated for each variable for each month of the input data set. The user may select the variables of interest to be viewed in an output file. Spreadsheet postprocessors were developed to further examine the output. The spreadsheets create graphs of shortages and tables of fixed and variable annual costs by facility and/or resource.

MODEL INPUTS

Input to the IRPM is required for both the physical configuration of the water supply system and the quantity and quality of water supplies. Each type of input is discussed in turn.

System Operations and Constraints

The IRPM requires information on the maximum and minimum flow capabilities at each point in the system. These maxima and minima apply to the contractual terms of the water supply contracts with DWR and SFWD, the capacities of the treatment plants, and distribution system capacity. Also included in the model are the operating rules and constraints that apply to the operation of Del Valle Reservoir, inflatable dam operations on Alameda Creek, and groundwater pumping at the production, reclamation, and barrier wells. These data were provided by the District.

Water Forecasts/Hydrology

The quantity of water received from local and imported sources depends on precipitation, both locally and in Northern California, and varies widely from year to year. U.S. Geological Service (USGS) historical streamflow data from the years 1922 to 1992 are used to simulate the quantity of local water the District would receive if any of the past hydrologic conditions occur in the future. Information regarding the quantity of imported water the District could expect to receive under 1922 to 1992 hydrologic conditions was obtained from SFWD and the SWP system simulations, as described below.

South Bay Aqueduct Supply

DWR planning studies provide input data for the SBA supply. Since the water needs and uses affecting the SWP will be different in the future, DWR has generated a hydrology input set that estimates future development. This data set was used for IRPM studies of future levels of District demand.

Hetch Hetchy Aqueduct Supply

Input data for the Hetch Hetchy water supply were provided by consultants to SFWD.

Local Supply

Local runoff to Alameda Creek was developed as part of this study. Streamflow, water use, and precipitation records for locations within and adjacent to the basin were used to develop runoff and accretion/depletion relationships. These relationships were then applied to historical conditions during the period of record.

MODELING ALGORITHM

As stated earlier, the IRPM was formulated as an LP. The District's operations, described above, were used to form the constraint set. A priority-based objective function was chosen for the IRPM. To illustrate a priority-based objective function, consider $3X + 4Y - Z$. The priorities are the coefficients of the decision variable (i.e., 3, 4, and -1). If the objective of the LP is to maximize $3X + 4Y - Z$, the LP will assign the greatest value possible to the decision variable with the highest priority, in this case, Y. Since the priority associated with Z is negative, the LP, in attempting to maximize the value of $3X + 4Y - Z$, will assign the least possible value to Z. By carefully selecting priorities associated with the decision variables, the system can be calibrated to operate in the desired fashion.

The IRPM works on a monthly time step. Each month, an LP is generated using inflows, accretions/depletions, initial reservoir storages, and demands for that month. The LP is then solved to determine the best way (i.e., the way that results in the highest value for the objective function) to route water through the system for the month. The solution is saved, and the program proceeds to the next month.

The physical configuration of the ACWD system is represented by "arcs" and "nodes." An arc represents a flow of water, typically a reach of stream, canal, or pipeline. A node represents a point of interest, such as a storage unit, a demand location, or a junction of two or more arcs. A schematic representation of the system that shows arcs and nodes is shown in Figure VI-1.

Priority of Water Use

The LP is "driven" by the priorities associated with each decision variable in the objective function. These priorities force the model to act in certain ways, that is, to meet particular demands or operations before others.

The priorities used in the model are intended to accomplish the following monthly operations:

- Meet all demands
- Recharge the groundwater as much as possible
- Keep water in surface reservoir storage
- Minimize "spill" on Alameda Creek

The LP supplies water according to the priority associated with each decision variable, allocating as much water as possible to the facility with the highest priority, then next highest priority, and so on. The relative ranking of priorities in the objective function is important to ensure that the model operates in the desired manner.

Facility Constraints

The constraints used by the LP are relatively simple, and include:

- Limit deliveries to demands
- Maintain reservoir storages within acceptable limits
- Limit flows through treatment and blending plants to plant capacity
- Limit diversions from Hetch Hetchy and SBA to appropriate amounts
- Meet minimum flow requirements
- Provide flow continuity at each node
- Limit the hardness of water leaving the blending facility

Figure VI-1
Current Demand Study
Alameda County Water District Water Resources Management
Planning Study
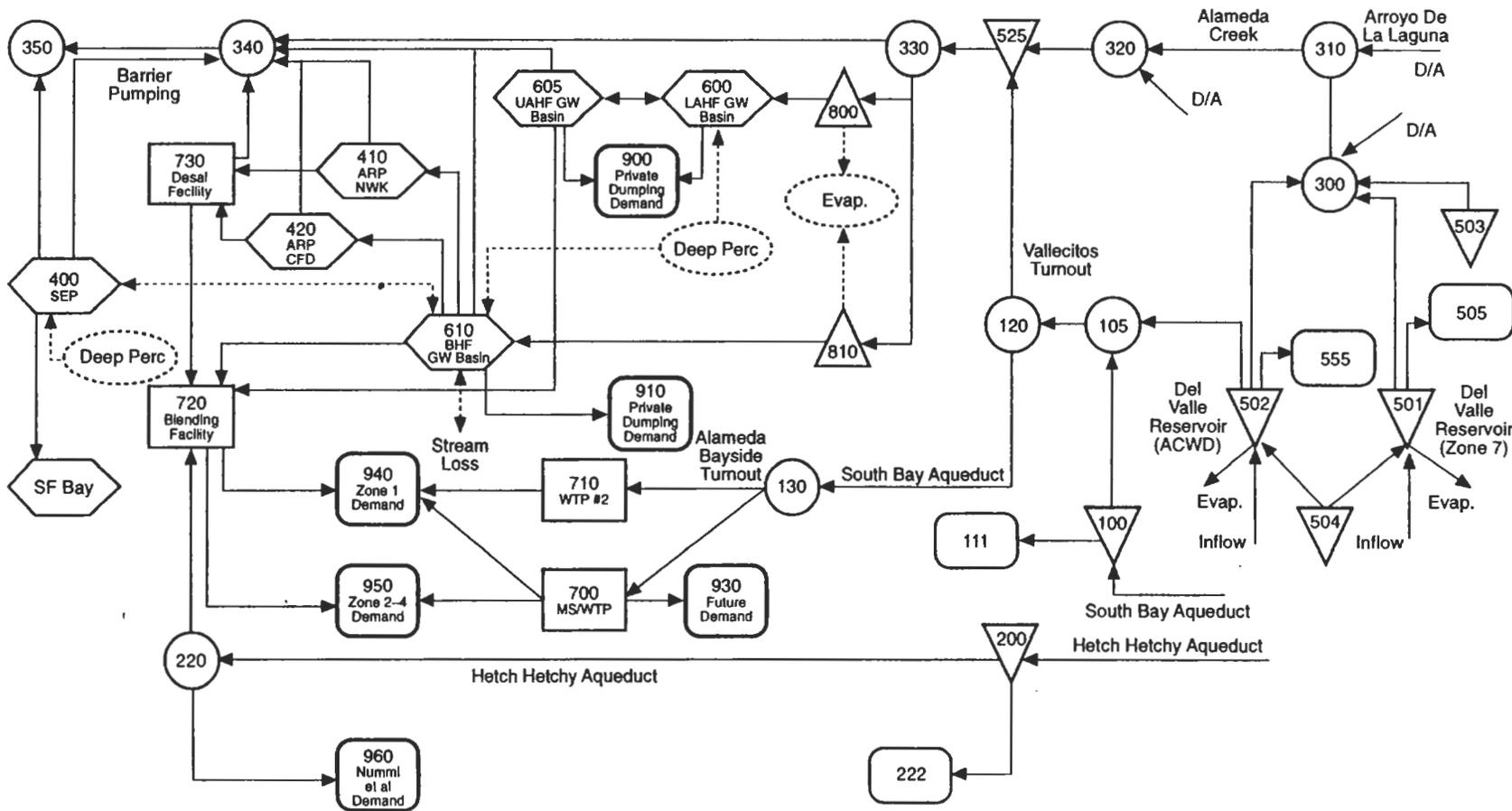
The first five constraints are self-explanatory, but the last two require further description.

The continuity constraint ensures that mass balance is maintained at each node in the system. In other words, the difference between inflow and outflow results in a change in storage for storage nodes, and total outflow equals total inflow for nonstorage nodes.

The hardness constraints are addressed in three different ways:

- Constrained Hardness. Ensures that water leaving the blending facility has a predefined hardness level. The model either meets the hardness constraint or does not find a feasible solution.

- Drought Year Hardness. This constraint provides added operational flexibility because hardness is not constrained during drought years.[17]

- Unconstrained Hardness. Hardness is allowed to rise to whatever level is required to meet demands. The model maximizes the use of high-priority sources of supply. Hetch Hetchy water is a high-quality source of supply and therefore has the highest priority of use in the IRPM. To maximize water quality, the model gives preference to meeting demands with Hetch Hetchy water over the use of higher hardness groundwater.

Groundwater Operations

ACWD maintains a comprehensive groundwater flow model, the Integrated Groundwater–Surface Water Model (IGSM). Its complexity, however, precludes it from being incorporated into a planning and operations model like the IRPM. For the purposes of a planning and operations model, the groundwater portion of the ACWD system must be considerably simplified. The IRPM's groundwater routine uses a mass balance approach to approximate the flow of the complex Niles Cone Basin.

Physical Configuration

Although the IGSM models the groundwater flow with a high degree of spatial resolution, the IRPM divides the groundwater basin into three adjacent segments:

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[17]The concept of a drought year is defined in Section VII.

above the Hayward Fault (AHF), below the Hayward Fault (BHF), and the Salt Evaporator Pond (SEP).

The AHF segment is assumed to act completely independently of the other two aquifer segments. The AHF boundaries, which are treated as impermeable, include the Hayward Fault to the west and the hills of the Diablo Range to the north, east, and south.

The BHF segment, the largest of the three, includes the portion of the groundwater basin bounded by the Hayward Fault to the east and the alignment of ACWD's salinity barrier wells to the west. The northern and southern boundaries of the BHF segment are also modeled as being impermeable.

The SEP segment encompasses the portion of the groundwater basin under the saltwater evaporation ponds. The SEP is bounded by the barrier well alignment to the east and San Francisco Bay to the west. The inclusion of the SEP segment is necessary to enable simulation of the salt water "barrier" that develops in the Newark Aquifer as a result of operating the salinity barrier wells.

At the western boundary of the SEP segment, water is freely exchanged between San Francisco Bay and the SEP. This exchange is driven by the difference in head between the Bay and the aquifer. Likewise, the exchange of groundwater between the BHF and SEP segments at the barrier well alignment is also assumed to be driven by groundwater head differences between these two segments. The extreme northern and southern boundaries of the SEP segment are considered as impermeable in the model.

Despite the well-known layering of the Niles Cone Basin into at least three aquifer units west of the fault (the Newark, Centerville-Fremont, and Deep Aquifers), the vertical definition of the aquifers was not taken into account in this modeling effort. The IRPM simulates monthly heads in the Newark Aquifer only. It is based on the assumption that Newark Aquifer piezometric pressure is instantly responsive, at least within the duration of a single time step, to sources and sinks occurring in any one of the layers.

Because of the high permeability of gravel in much of the Niles Cone Basin, the lateral variation in pressure in the Newark Aquifer tends to be mild over relatively small distances. This condition gives some justification to the IRPM's segmentation scheme for mass balance analysis. This lateral segmentation and the absence of vertical definition of the aquifers is acceptable for the purposes of general water supply planning and the preliminary evaluation of the potential water supply benefits of the SBP. The IRPM cannot be used, however, to determine the effectiveness of the

SBP in accelerating the remediation of the Newark Aquifer or the optimal placement of SBP and ARP wells. These investigations would require the use of the IGSM or another groundwater model of equivalent or greater complexity.

Development of Groundwater Relationships

For the IRPM to adequately simulate time-variant groundwater elevation in each of the three segments, it is necessary to derive linear mathematical equations that represent groundwater and/or surface water exchanges within the groundwater basin. The IGSM was used to develop expressions for lateral exchanges of groundwater between neighboring segments, piezometric head as a function of storage in each segment, and the magnitude of inputs and losses from groundwater sources and sinks.

Runs of the IGSM provided information on fluxes of water across the boundaries delimiting the three IRPM groundwater segments. IGSM-simulated pressure at representative points was compared with water storage to develop the relationship between storage and representative head for each segment. The relationship that describes the head-driven exchange of water across the SEP/BHF boundary along the barrier well alignment was developed by correlating the water exchanged with the difference in head. A relationship for the exchange between the SEP segment and San Francisco Bay was similarly obtained. Linear regression on the data pairs was performed to derive the linear equations required by the IRPM.

Linear regression on IGSM output was also used to develop equations that describe head-driven losses of groundwater to Alameda Creek in the BHF segment, the head-driven exchange of water between the salt ponds and the aquifer in the SEP segment, and the deep percolation in each segment resulting from direct rain and applied water (e.g., irrigation or lawn watering).

In cases in which the relationships did not follow a clearly linear pattern, the data set was split into distinct subsets, each containing a portion of the data. Linear regression was performed on each subset, and the resulting linear equations were applicable over each subset. Storage in the BHF segment is plotted as a function of piezometric head in Figure VI-2. This figure is an example of how nonlinear relationships were approximated by linear equations arranged in piece-wise fashion.

To ensure reliability over any likely range of basin conditions, the IGSM modeled the groundwater basin under various extreme conditions. The degree of correlation in the linear regressions was generally good. As a check on the reliability of the IRPM's groundwater routine, both the IGSM and the IRPM were run with the same quantities

Figure VI-2
BHF Storage versus Head

Storage (1,000 Acre-Feet)
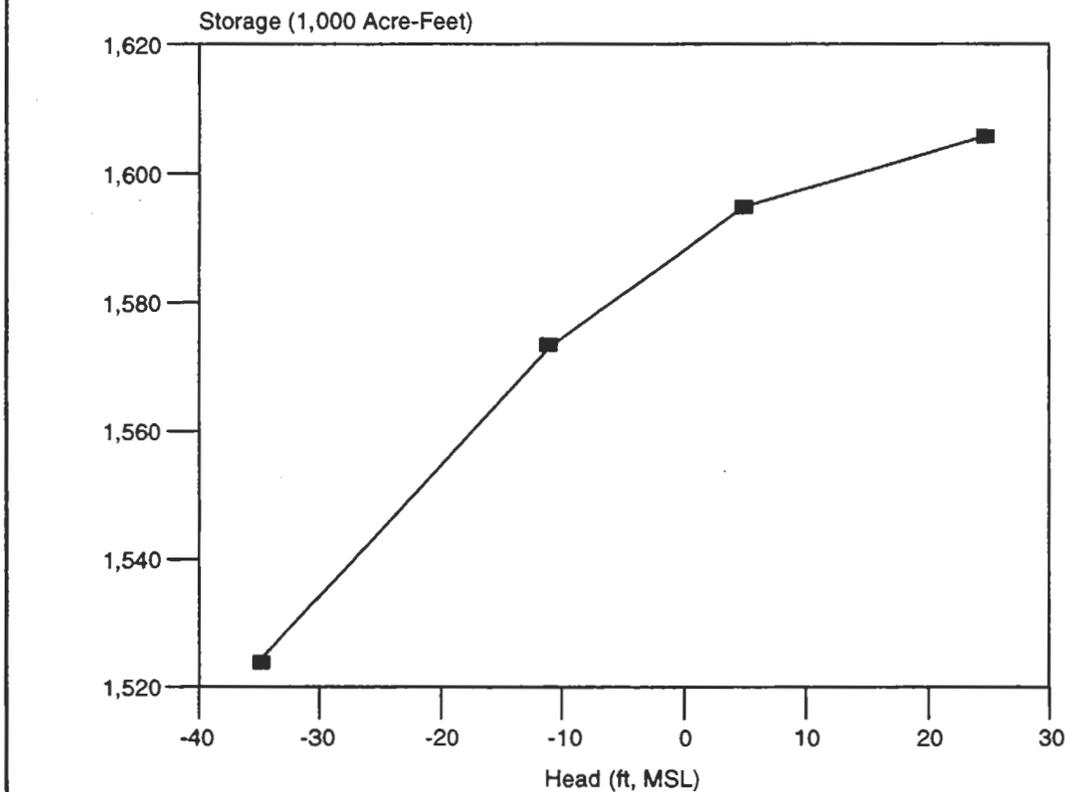
of total pumping, rainfall, and recharge. The output of piezometric head for the two models tracked reasonably well, except when the groundwater basin was simulated at levels significantly below sea level. The difference in this area was attributed to the way in which the IGSM allows Alameda Creek (downstream of the rubber dams) to act as a source of groundwater when the groundwater basin pressure is low and surface water flow in the creek is high. The IRPM allows Alameda Creek (downstream of the rubber dams) to act as a sink for groundwater only.

The relationship obtained for IGSM-simulated deep percolation as a function of rainfall was the least satisfactory portion of the groundwater routine used in the IRPM. Unlike the IGSM, the IRPM does not directly account for complex processes, such as surface water runoff, water retention in soil, evapotranspiration, and

unsaturated flow in deep layers of the vadose zone. Nor does the IRPM directly account for agricultural irrigation and applied water from outdoor urban water use as a potential contribution to percolation for a given hydrologic pattern. For this reason, the IGSM must be run to adjust coefficients in the IRPM's calculation of net deep percolation when outdoor water use and hydrologic patterns differ substantially from those involved in the initial formulation of the relationship between percolation and rainfall. It may be desirable, therefore, for a future version of the IRPM to have a more rigorous method of calculating deep percolation.

EVALUATION OF AQUIFER RECLAMATION PROGRAM

The purpose of the District's ARP is to remove saline water that has intruded into the groundwater basin and to stop further inland movement of the saltwater plume. Aquifer reclamation wells are pumped and discharged to San Francisco Bay through flood control channels. Gradual restoration of the aquifers occurs as higher quality water from outside the saline zones flows toward the ARP wells and ultimately replaces the extracted saline water. The sampling results of basin-wide chloride measurements in the fall of 1994 indicated that the edge of the saltwater plume, which exceeds drinking water action levels (250 mg/L total chlorides), appears to be approximately 4,000 feet from the Mowry well field.

Due to concerns over the potential movement of the saltwater plume and the ability of the IGSM to perform more sophisticated groundwater analyses, the ARP pumping requirements identified in the 1986 Water Supply and Facilities Planning Study were reevaluated. The 1986 report suggested that the amount of required ARP pumping was proportional only to the amount of production pumping in the Centerville-Fremont and Deep (C-F-D) Aquifers. With the use of the IGSM and the analysis of historical plume movement compared to historical ARP pumping, new rules were developed and integrated into the IRPM. Analyses indicated that required ARP pumping was not only a function of production pumping in the C-F-D aquifers, but also a function of groundwater head and production in the C-F-D aquifers and the Newark Aquifer. A summary of that analysis is described below. The complete analysis is included in Appendix E.

The revised ARP pumping rules attempt to meet two priorities: (1) pump the ARP wells in the Newark Aquifer and the C-F-D aquifers sufficiently to counteract further inland movement of saline water toward the well field and (2) ensure a minimum level of pumping to encourage continued plume shrinkage. To meet the first priority, the required ARP pumping in the C-F-D aquifers depends on the quantity of production at the Mowry well field. No Newark Aquifer ARP pumping is required to

meet the first priority, provided that the Newark Aquifer is sufficiently above sea level, that is, approximately two to three feet above mean sea level (MSL).

The following equations dictate the amount of ARP pumping required from the C-F-D aquifers and the amount of ARP pumping required from the Newark Aquifer:

(1) $\quad Q_{CFD} = Q_{BHF\text{-}CFD} \times (0.5 - .04 \times h_{CFD})$

(2) $\quad Q_{NWK} = Q_{BHF\text{-}NWK} \times (0.2 - 0.05 \times h_{NWK})$

where,

Q_{CFD}	=	Amount of ARP pumping required from the C-F-D aquifers;
$Q_{BHF\text{-}CFD}$	=	Quantity of Mowry well field production from the C-F-D aquifers;
h_{CFD}	=	Piezometric head in the C-F-D aquifers;
Q_{NWK}	=	Amount of ARP pumping required from the Newark Aquifer;
$Q_{BHF\text{-}NWK}$	=	Quantity of Mowry well field production from the Newark Aquifer; and
h_{NWK}	=	Piezometric head in the Newark Aquifer.

Equation 2 assumes that the SBP wells are pumped when the head in the Newark Aquifer drops below sea level. SBP pumping tends to reduce the amount ARP pumping required to prevent the landward movement of the existing saltwater plume in the Newark Aquifer. Equation 2a was developed for when the SBP is not in operation. Under such circumstances, more Newark ARP pumping would be required:

(2a) $\quad Q_{NWK} = Q_{BHF} \times (0.3 - 0.07 \times h_{BHF})$

The IRPM uses either Equation 2 or Equation 2a, depending on whether or not the SBP wells are operating. Although no Newark ARP pumping is required if the Newark Aquifer is above sea level, aquifer remediation may be accelerated if the Newark Aquifer is pumped.

The total amount of ARP pumping required under the revised pumping rules is significantly higher than that determined in the 1986 Water Supply and Facilities Planning Study. For example, Figure VI-3 shows the total amount of ARP pumping required under the revised pumping rules and the total amount required under the 1986 rule—assuming that the basin groundwater head is maintained between −5 and

Figure VI-3
ARP Production Requirements

ARP Production
(MGD)

30

25

20

15

10

5

0

10   15   20   25

Groundwater Production
(MGD)

ARP Requirements at BHP −5

ARP Requirements at BHP −6

ARP
Requirements

95-920485.rpt.figs.7/95.ap
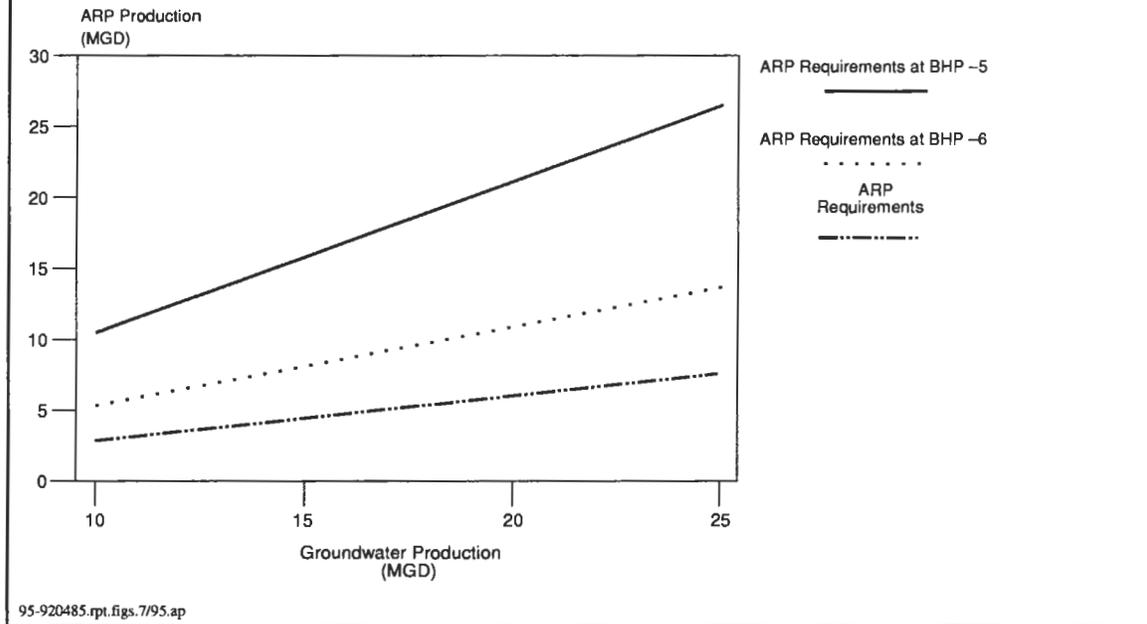
+5 feet above sea level. In this example, ARP production under the new rules would be two to three times the amount of ARP pumping required under the 1986 rule. Although current ARP operations are guided by the 1986 pumping requirements, the new pumping rules were incorporated into future year IRPM operational simulations so that future pumping and the resulting groundwater replenishment requirements are not underestimated.

The District is in the process of modifying the groundwater model to be able to simulate saltwater plume movement and remediation. As part of this modification, the model will contain a higher resolution finite element grid that may allow the District to provide a more accurate ARP production rule.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

WATER SUPPLY AND OPERATIONAL ANALYSIS

ACWD Integrated Resources
Planning Study Process

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Policy Objectives          Demand Forecast

                                │
                                ▼
                    ┌──────────────────────┐          Integrated Resources
                    │  Evaluate Current     │ ◀┈┈┈     Planning Model
                    │  System Resources     │
                    │  and Operations       │
                    └──────────────────────┘

      │                         │
      ▼                         ▼
Evaluation Criteria ──▶   Characterize      ◀──  Resource
                          Resource Options        Assessment
                                                   • Supply-Side
                                                   • Demand-Side
Define Future Uncertainties        │
and Potential Outcomes             ▼
      │                     Form Potential
      ▼                     Resource Sequences
Define Uncertainty                 │ Narrow
Scenarios ──────────────┘          ▼
                          Test Sequences Against  ◀┈┈┈┈┈┈┈
                          Evaluation Criteria
                                   │ Narrow
                                   ▼
                          Form Resource
                          Strategy
                                   │
                                   ▼
                          Final
                          Recommendations
```

VII. WATER SUPPLY AND OPERATIONAL ANALYSIS

The purpose of this section is to use the IRPM to simulate the District's current operations to evaluate the adequacy of existing supplies and facilities to meet future water demands under a range of future conditions. For this phase of the study, the IRPM simulated use of *existing* facilities and supplies only (i.e., the "no action" alternative). The resulting simulated system capacity constraints and the extent and frequency of future shortages provided the basis for developing alternatives to meet supply reliability and other District goals.

The IRPM was used to determine the frequencies and magnitudes of the future shortages and surpluses that might occur under the three uncertainty scenarios described in Section V. Eight percent was added to the water demand forecasts to account for the system water losses that occur between the point of delivery of raw water and the point of delivery to customers. The simulations were also based on existing facility and pipeline capacity constraints and current operating criteria, which are described below.

THE "NO-ACTION" MODEL ASSUMPTIONS

The minimum and maximum deliveries for imported water were based on existing monthly and annual contractual constraints. Takeoff, blending, and treatment facility capacities were based on the existing system capacities and the system upgrades projected to be completed by the year 2000 (the first year simulated on the IRPM).[18] The maximum capacity constraints used are listed in Table VII-1.

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[18]Source: Alameda County Water District's Capital Improvement Program (CIP).

Table VII-1
SYSTEM LIMITATION ASSUMPTIONS

Facility	Maximum Monthly Capacity
SBA—South Bay Pumping Plant to Vallecitos	78 cfs
Vallecitos Takeoff	120 cfs
Alameda–Bayside Takeoffs	71 cfs
SFWD Hetch Hetchy Aqueduct	37 cfs
Fremont Blvd. Takeoff to Blending Facility	25 cfs
Warren Ave. Takeoff to NUMMI	32 cfs
Blending Facility	60 mgd
MSJWTP	9 mgd
Del Valle Pipeline to SBA	50 cfs
Alameda Creek diversion to recharge ponds	250 cfs
AHF rate of recharge	15 cfs Oct.–Mar. 21 cfs Apr.–Sept.
BHF rate of recharge	30 cfs Oct.–Mar. 39 cfs Apr.–Sept.
AHF production to Blending Facility	49 cfs
BHF production to Blending Facility	33 cfs
ARP production and discharge	50 cfs

Operational criteria, with the exception of ARP production requirements, were defined in the IRPM to simulate the existing management and distribution of supplies as described in Section II. The revised ARP production rules, described in Section VI, rather than current ARP production rules, were used in all no-action simulations so that future pumping and groundwater replenishment requirements are not underestimated.

The same operating criteria were used for all three uncertainty scenarios. The no-action case operating criteria are summarized in Table VII-2.

Table VII-2
"NO-ACTION" OPERATIONAL CRITERIA

Constraint	Criteria
Priority for use of source water	Highest priority: SFWD and local water Secondary priority: SWP water
Priority for use of distribution system sources	(1) SFWD water; (2) Treated surface water; (3) Groundwater
Blending Facility hardness	Blended water hardness maintained at less than 175 ppm.
Diversion of Alameda Creek water	No diversions when flow is greater than 500 cfs. Water diverted first to AHF recharge ponds and second to BHF recharge ponds.
Groundwater production and protection	Priority given to AHF production when AHF water levels are 15 feet above MSL. Revised ARP production rules applied. BHF Newark water levels maintained above sea level in lieu of barrier pumping.
Del Valle operations	Priority given to (1) releases for delivery to treatment plants; (2) releases from Vallecitos turnout to Alameda Creek; (3) in-stream releases. Stored local water used by October 1 of every year. Zone 7 use of water assumed to increase as planned recharge improvements are made and treatment capacity increased.

MODEL ANALYSES

Given the above constraints, modeling runs were performed for each uncertainty scenario for years 2000 through 2030 in ten-year intervals (2000, 2010, 2020, and 2030) for a total of 12 model runs. Each model run simulated future monthly production and distribution of supplies that would be available if the hydrologic conditions of the past 70 years were repeated in the future. There were a total of 840 possible yearly outcomes (12 model runs $\times$ 70 years). These data were used in developing the frequency and magnitude of possible shortages under the best-case, middle, and worst-case scenarios.

In addition to the water supply reliability analyses, the key IRPM analyses for this phase of the study included future:

- Use and distribution of supply sources
- Coordinated use of groundwater and surface water supplies
- Blended water hardness
- Distribution system capacity constraints
- Frequency and magnitude of wet year water surpluses

The results of the IRPM simulations were used to assess the need for increased production capacity and additional supply-side, demand-side, and/or operational alternatives to meet future demands. Results of model runs are summarized in Appendix F.

Use and Distribution of Supplies

The results of the simulated use and distribution of supplies reflected the District's operational strategy of minimizing blended water hardness and maximizing use of local supplies. Figure VII-1 shows the simulated average yearly sources of supply for the years 2000 to 2030. Since the highest priority is placed on using SFWD water, the highest quality source, and local water, the use of these sources is maximized and, therefore, remains constant over time. The use of SWP water increases over time as water demands increase.

Figure VII-2 shows the simulated average annual surface water treatment and blending facility production (which is a combination of SFWD water and groundwater) for the years 2000 to 2030. This simulation shows surface water production remaining relatively constant over time. This trend reflects the objective of base loading the surface water treatment facilities. Blending facility production increases over time due to greater dependence on groundwater supplies in the absence of new resources. The use of local water remains constant over time, yet the amount of groundwater production increases. Because both local water and SWP water are used to recharge the groundwater basin, the amount of SWP water diverted for recharge will increase over time.

As shown in Figure VII-3, approximately two-thirds of groundwater production is from above the Hayward Fault and one-third of production is from below the Hayward Fault in year 2000. By the year 2030, the use of these two sources becomes approximately equal. This change reflects the following operational objectives, which are listed in order of priority: (1) maximizing water quality (water quality above the

Figure VII-1
Simulated Average Yearly Sources of Supply

Production (MGD)

Legend:
- Local
- SFWD
- SWP

Year: 2000, 2010, 2020, 2030
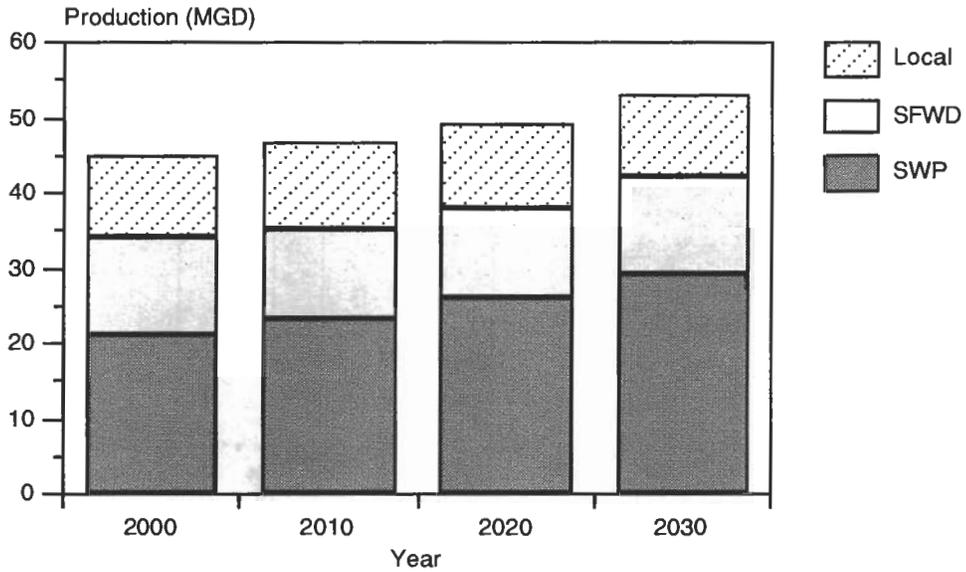
95-920485.rpt.figs.7/95.ap

Figure VII-2
Simulated Average Yearly Water Production

Average Daily Production (MGD)

Legend:
- Groundwater
- SFWD
- MSJWTP
- WTP2

Year: 2000, 2010, 2020, 2030
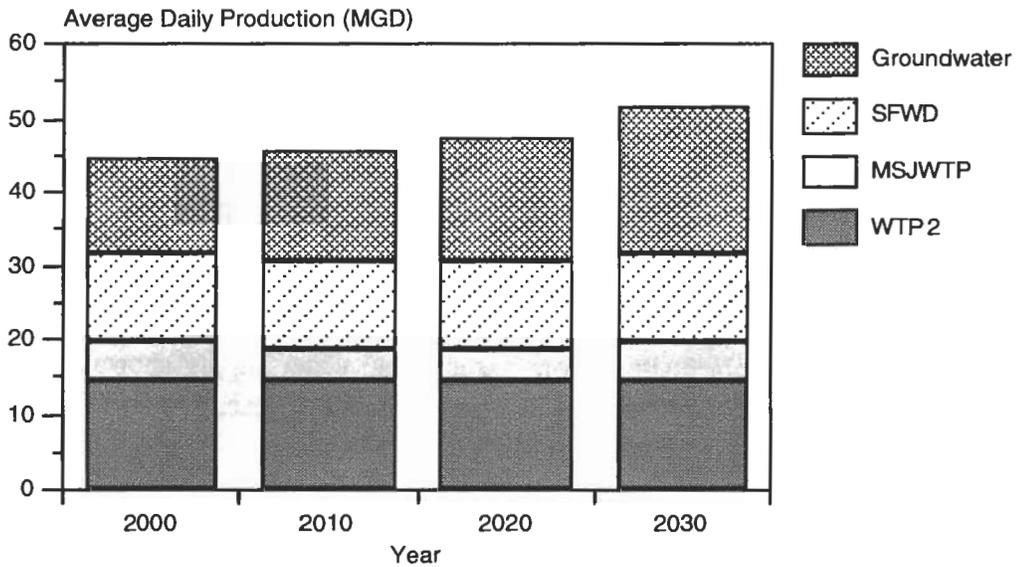
95-920485.rpt.figs.7/95.ap

Figure VII-3
Simulated Average Yearly Groundwater Production

95-920485.rpt.figs.7/95.ap
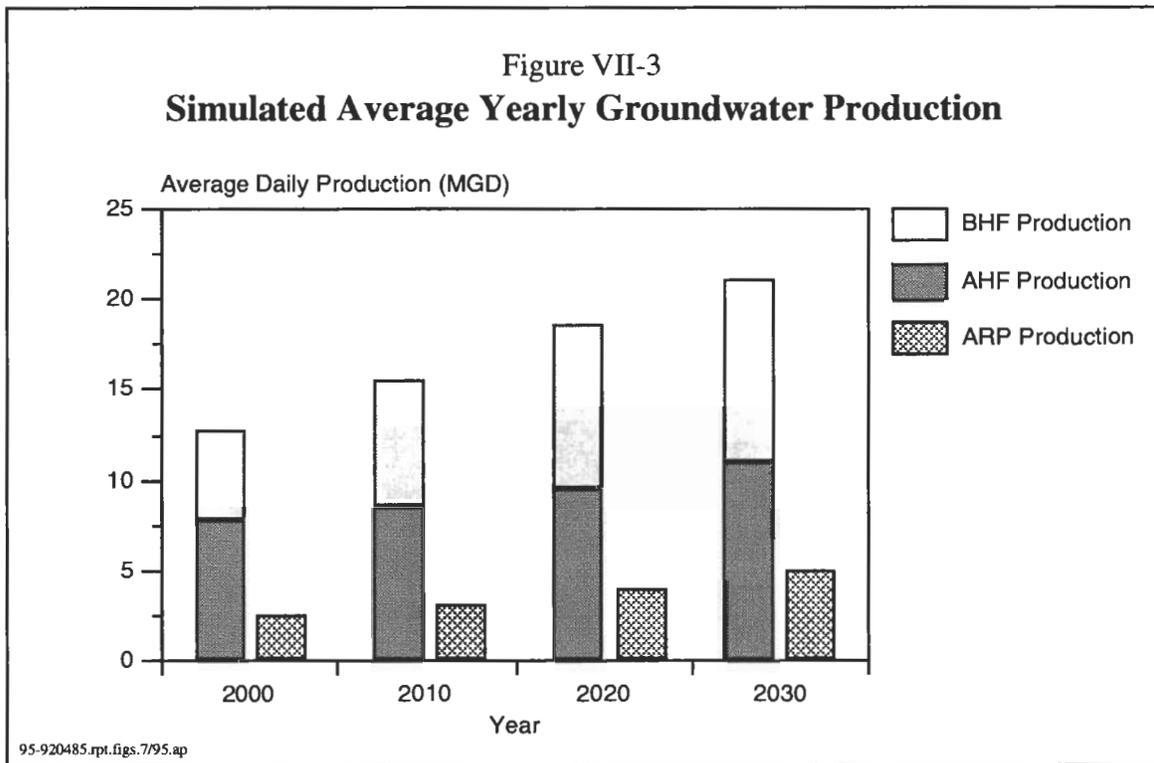
Hayward Fault is better than that below the Hayward Fault), (2) maintaining BHF groundwater head at greater than +3 feet above sea level, and (3) maximizing groundwater storage. As demand increases, more of the higher hardness BHF water is needed to meet demands. The increased use of groundwater and increased BHF production over time will result in higher hardness levels at the blending facility (see Figure VII-4.

Distribution System Capacity Constraints

To evaluate existing production capacity and the potential need for increased future capacity, monthly production simulations were evaluated for the three uncertainty scenarios. The production simulations assumed no water supply shortages. The results showed that existing production capacity is sufficient to meet average monthly demand in all three uncertainty scenarios up to 2020.

As shown in Figure VII-5, monthly demand begins to exceed production in 2020 by a monthly average of approximately 3 mgd in the worst-case scenario. As shown in Figure VII-6, by 2030 monthly demand exceeds production capacity by 5 mgd in the

Figure VII-4
Simulated Blended Water Quality
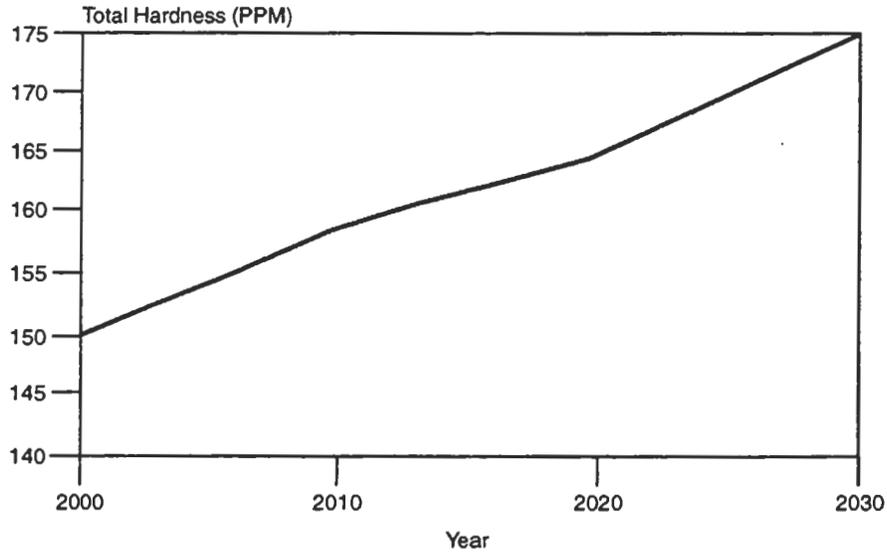
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Figure VII-5
**Existing Monthly Production Capacity versus Forecast Demand
Year 2020**
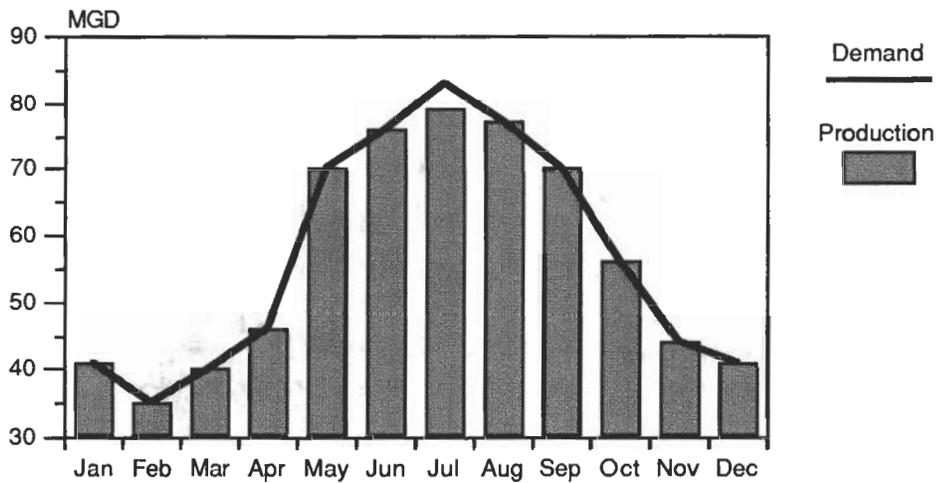
Worst Case

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Figure VII-6
Existing Monthly Production Capacity versus Forecast Demand
Year 2030

Middle Case
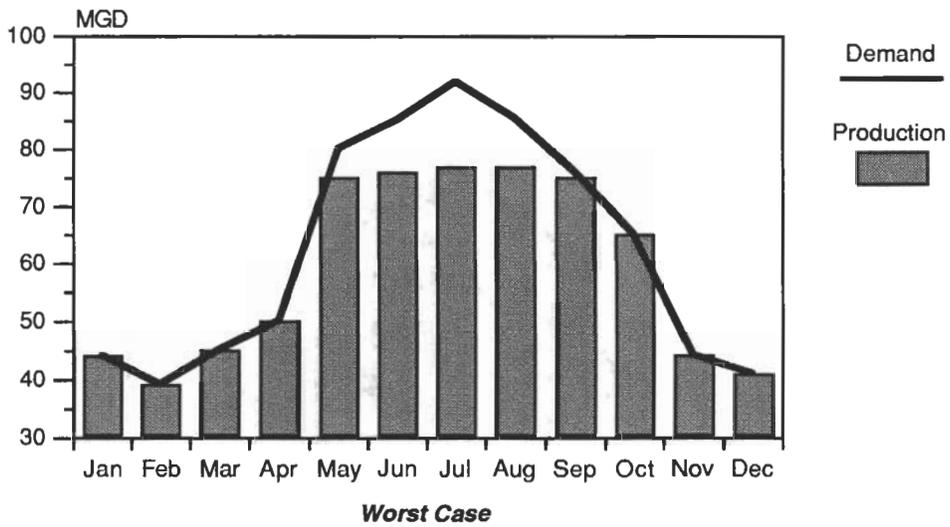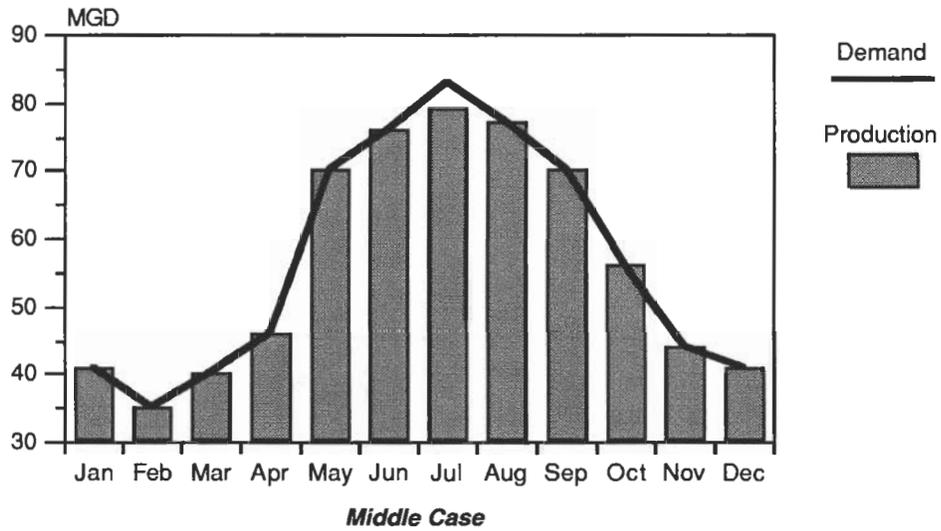
Worst Case

middle case scenario and by 13 mgd in the worst-case scenario. Total production capacity is limited by surface water treatment production and by maximum hardness limitations at the blending facility. If WTP 2 is able to produce its full 28 mgd, as assumed in the best-case scenario, no additional average monthly production capacity is required. If hardness at the blending facility is allowed to go above the existing 175 ppm limitation by increasing groundwater production, total production capacity may also increase. This alternative is discussed in more detail in Section VIII.

Historical data show that maximum daily demand exceeds average yearly demand by a factor of 1.8. As shown in Table VII-3, if this factor is applied to the simulated average annual production requirements over time, the maximum daily demand may exceed existing capacity in the worst-case scenario by as much as 7 mgd by the year 2000 and by as much as 27 mgd by the year 2030. Since the IRPM simulates production on a monthly basis and does not consider potential distribution system capacity constraints, additional analysis of maximum daily production requirements will be included in the Capital Improvement Program Engineering Report.

Table VII-3
ESTIMATED ADDITIONAL CAPACITY NEEDED
TO MEET MAXIMUM DAY DEMAND
(mgd)

Year	Best Case	Middle Case	Worst Case
2000	0	6	7
2010	4	11	12
2020	8	15	17
2030	17	24	27

Frequency and Magnitude of Water Shortages and Surpluses

The historical hydrologic record was used to simulate the quantity of water that would be available if any of the hydrologic conditions of the past 70 years were repeated under future demands with the use of existing facilities, supplies, and operational criteria. The results of these simulations were used to estimate the frequency and magnitude of the future water shortages and surpluses that might occur for each uncertainty scenario under a no-action alternative. This information was then used to assess the adequacy of existing supplies and facilities to meet demands during dry years and to assess the ability to use and/or store water in wet years.

VII-9

IRPM analyses indicate that in a normal water year[19] no water supply shortages would occur under the best-case and middle uncertainty scenarios, and water surpluses would occur through 2020. Under the worst-case uncertainty scenario, shortages would begin to occur by 2020. The potential water shortages and surpluses that may occur are listed in Table VII-4.

Table VII-4
RANGE OF WATER AVAILABILITY IN A NORMAL WATER YEAR

Year	Water Availability (afy)*		
	Best Case	Middle Case	Worst Case
2000	+6,900	+6,600	+4,900
2010	+5,200	+4,600	0
2020	+3,600	+1,700	−200
2030	0	0	−3,100
*Positive numbers indicate surpluses; negative numbers indicate shortages.			

The District's long-term storage is limited to groundwater storage (approximately 30,000 acre-feet of useable storage) and surface water storage in Del Valle (approximately 7,500 acre-feet). Consequently, the District is not able to use all available supplies during wet years. In addition, IGSM analyses indicate that groundwater losses to San Francisco Bay occur during wet years, when the groundwater elevation below Hayward Fault rises above +10 feet MSL. The amount and frequency of wet year water surpluses and groundwater losses is shown in Table VII-5.

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[19]A *normal water year* is defined as a year in which the District receives approximately 85% of its SWP entitlement, 100% of its SFWD allocation, and is able to pump the average safe yield of 22,000 acre-feet from its groundwater basin.

Table VII-5
RANGE OF WATER SURPLUSES AND GROUNDWATER LOSSES

Year	Water Year Type*	Frequency of Occurrence	Water Surplus (afy)			Groundwater Losses (afy)		
			Best Case	Middle Case	Worst Case	Best Case	Middle Case	Worst Case
2000	Wet	1 in 5 years	25,500	24,000	21,800	20,800	20,000	12,100
	Very wet	1 in 10 years	31,900	27,600	25,300	25,900	24,500	16,100
	Extremely wet	1 in 30 years	38,600	34,100	30,600	30,000	28,700	25,200
2010	Wet	1 in 5 years	25,200	23,500	19,900	15,200	14,400	13,400
	Very wet	1 in 10 years	28,700	27,400	24,100	22,700	20,700	15,200
	Extremely wet	1 in 30 years	34,900	33,800	31,300	28,900	25,900	23,800
2020	Wet	1 in 5 years	23,600	21,100	16,800	8,600	7,900	5,500
	Very wet	1 in 10 years	29,100	25,200	20,800	19,000	17,600	14,200
	Extremely wet	1 in 30 years	37,300	32,200	29,100	27,000	24,200	20,400
2030	Wet	1 in 5 years	15,200	13,400	11,500	8,000	6,800	3,000
	Very wet	1 in 10 years	20,100	19,000	16,800	18,500	16,200	10,400
	Extremely wet	1 in 30 years	28,700	27,500	26,800	25,900	20,000	15,100

*Years representative of "wet" years include water years 1941, 1970, and 1979; "very wet" years include 1938, 1973, and 1975; "extremely wet" years include 1974, 1980, and 1982.

The amount and frequency of dry year water shortages is shown in Table VII-6. The comparison of wet year surpluses and dry year shortages shows the variability of water supply reliability. Supplies can range over time from as much as 38,600 acre-feet of water surplus to as much as 37,400 acre-feet of water shortage. This variability indicates a need for storing water when it is available for later use during dry periods.

Table VII-6
RANGE OF WATER SHORTAGES IN DRY YEARS

Year	Water Year Type*	Frequency of Occurrence	Water Shortage (afy)		
			Best Case	Middle Case	Worst Case
2000	Slightly dry	1 in 3 years	0	0	0
	Dry	1 in 5 years	2,300	6,700	8,600
	Very dry	1 in 10 years	11,600	15,500	20,100
	Extremely dry	1 in 30 years	14,900	17,600	23,200
2010	Slightly dry	1 in 3 years	0	0	800
	Dry	1 in 5 years	6,700	7,900	12,000
	Very dry	1 in 10 years	15,700	18,100	24,100
	Extremely dry	1 in 30 years	19,300	20,600	27,500
2020	Slightly dry	1 in 3 years	0	0	3,000
	Dry	1 in 5 years	10,200	10,700	15,200
	Very dry	1 in 10 years	19,500	21,400	27,800
	Extremely dry	1 in 30 years	22,700	24,300	31,200
2030	Slightly dry	1 in 3 years	1,900	3,800	9,400
	Dry	1 in 5 years	14,100	14,400	22,800
	Very dry	1 in 10 years	22,200	26,700	34,200
	Extremely dry	1 in 30 years	24,000	29,200	37,400

*Years representative of "slightly dry" years include water years 1926 and 1936; "dry" years include 1932, 1950, and 1964; "very dry" years include 1933, 1949, and 1990; "extremely dry" years include 1929, 1931, and 1977.

Figures VII-7, VII-8, and VII-9 show the magnitude and frequency of shortages that may occur, respectively, under the best-case, middle, and worst-case scenarios. The shortages are expressed as a percentage of full service demand and indicate the percentage of total water use that would have to be curtailed under a no action alternative.

As part of a report prepared for the California Urban Water Agencies (CUWA), District customers were asked to rate the importance of various public problems, including future water shortages. Water shortages were categorized at the same level of importance as crime, air pollution, and overcrowding. A contingent valuation methodology was used to elicit information from residential customers regarding their willingness to pay to avoid shortages of 10% to 50% at a frequency ranging from 1 in 3 years to 1 in 30 years. Approximately 84% of survey respondents indicated a willingness to pay to avoid shortages. To avoid even apparently minor shortage scenarios (e.g., a 10% shortage once every 10 years), respondents were willing to pay substantial amounts. These survey results provide one indication that District customers value reliability highly.

The results of the no-action shortage analyses show that under a no action alternative potential dry year shortages can range from 5% to 41% by 2000 and from 5% to 53% by 2030. The foregoing survey results and the District's own understanding of the needs of its customers both indicate that these levels of reliability are unacceptable. The no-action case range of magnitude and frequency of potential shortages was used as a guide in evaluating the mix of additional resource alternatives needed to provide adequate supply reliability.

Figure VII-7
**Potential Dry Year Water Shortage
No Action Alternative—Best Case Scenario**
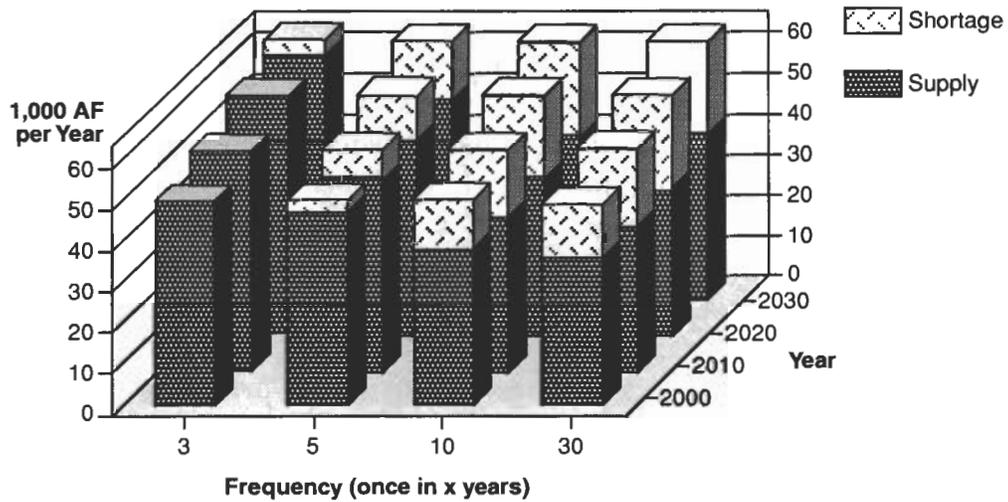
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Figure VII-8
**Potential Dry Year Water Shortage
No Action Alternative—Middle Case Scenario**
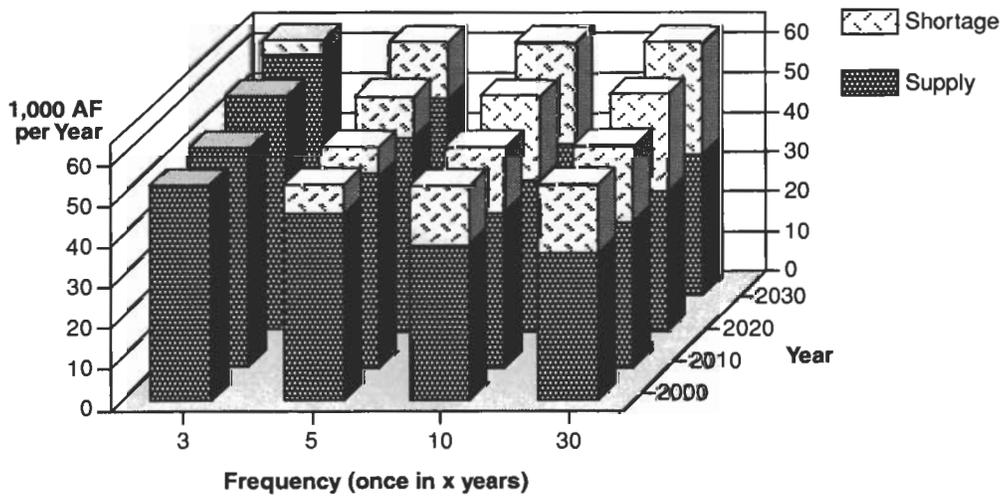
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Figure VII-9
**Potential Dry Year Water Shortage
No Action Alternative—Worst Case Scenario**
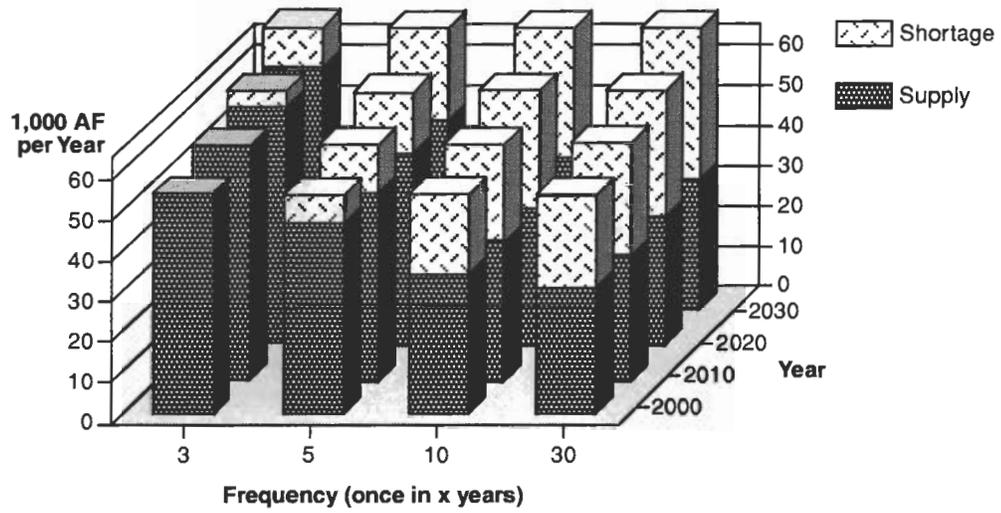
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ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

ASSESSMENT OF POTENTIAL SUPPLY OPTIONS

ACWD Integrated Resources
Planning Study Process

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┌─────────────────────┐              ┌─────────────────────┐
│  Policy Objectives  │              │   Demand Forecast   │
└─────────────────────┘              └─────────────────────┘
           │                                    │
           │                                    ▼
           │                         ┌─────────────────────┐      ┌─────────────────────┐
           │                         │  Evaluate Current   │◄·····│ Integrated Resources│
           │                         │  System Resources   │      │   Planning Model    │
           │                         │    and Operations   │      └─────────────────────┘
           │                         └─────────────────────┘                │
           ▼                                    │                           :
┌─────────────────────┐              ┌─────────────────────┐      ┌─────────────────────┐
│ Evaluation Criteria │─────────────►│    Characterize     │◄─────│      Resource       │
└─────────────────────┘              │  Resource Options   │      │     Assessment      │
                                     └─────────────────────┘      │  • Supply-Side      │
┌─────────────────────┐                         │                │  • Demand-Side      │
│Define Future        │                          │               └─────────────────────┘
│Uncertainties        │──────────┐               ▼
│and Potential        │          │    ┌─────────────────────┐
│Outcomes             │          │    │   Form Potential    │
└─────────────────────┘          │    │  Resource Sequences │
           │                     │    └─────────────────────┘
           ▼                     │               │ Narrow
┌─────────────────────┐          │               ▼
│ Define Uncertainty  │──────────┘    ┌─────────────────────┐
│     Scenarios       │               │ Test Sequences      │◄·····················
└─────────────────────┘               │ Against Evaluation  │
                                      │     Criteria        │
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                                      │   Form Resource     │
                                      │      Strategy       │
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                                      │       Final         │
                                      │  Recommendations    │
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VIII. ASSESSMENT OF POTENTIAL SUPPLY OPTIONS

A key task of the resource planning process is to identify and evaluate the District's supply-side resource options. The supply options that emerged from this evaluation process were combined with conservation programs to form resource sequences that achieve the District's policy objectives.

Supply options were assessed through a multilevel screening process which began with a large list of all potential alternatives. This list was then narrowed by first identifying technological, legal, political, or institutional "fatal flaws" which would eliminate an option. In some cases, more analyses were required to determine whether an option should be removed. After the clearly inappropriate alternatives were eliminated, those that remained were characterized for consideration in the development of integrated resource sequences.

POTENTIAL SUPPLY OPTIONS

Potential supply options included supplemental supplies, storage facilities, treatment facilities, and operational modifications. This Plan evaluated alternatives included in the *1986 Water Supplies and Facilities Planning Study*[20] as well as others that were identified during the course of this study. Those options, summarized in Figure VIII-1, are discussed below.

Wastewater Reclamation

Reclaimed water is potentially available from Union Sanitary District (USD) and from the Livermore Valley via discharge into Alameda Creek. Three classes of reclamation alternatives were evaluated:

1. *Direct potable use.* Tertiary treated and demineralized reclaimed water would be delivered directly to District customers for potable consumption.

2. *Indirect potable use.* Reclaimed water would be used to recharge either local or off-site groundwater basins.

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[20]*Op. Cit.*

Figure VIII-1
Summary of Supply-Side Options

Reclamation	Desalination	Agricultural Purchase	Additional Storage	Surface WTP	Operational Modifications
Direct Potable Reuse	Brackish Water	Annual	Local Recharge	Upgrade Existing WTP	Seasonal Hardness Variation
Indirect Potable Reuse	Seawater	Drought Year	San Joaquin Valley G/W Banking	Construct New WTP	Eliminate Hardness Constraint
Irrigation	Reclaimed Water		Livermore Valley G/W Banking		Draw G/W Basin Below Sea Level: w/SBP Pumping
			Dual Use of Existing Recharge		Draw G/W Basin Below Sea Level: w/o SBP Pumping
			Dumbarton Quarry Pits		Increase Groundwater Pumping
			Raise Calaveras Dam		Pump More ARP When G/W Elevation Is High
			Construct Upper Del Valle		
			Sunol Valley Quarry Pits		
			Chain of Lakes Quarry Pits		
			Sunol Valley G/W Recharge		
			San Luis Reservoir		

[ ] Option eliminated

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3. *Irrigation.* This reclamation alternative was the subject of the wastewater master plan study conducted jointly with USD.[21] This study considered the use of reclaimed water to irrigate golf courses, parks, and street medians in areas where reclaimed water is least likely to percolate into potable groundwater supplies. Such uses of reclaimed water are by far the most common in urban areas.

Desalination

Three desalination options were evaluated in the 1992 Desalination Feasibility Study:[22]

1. *Saline water.* The District is currently discharging water pumped from ARP wells into the Bay. Since groundwater analyses show that continued ARP pumping is critical to protecting potable groundwater supplies, desalinating this water would provide an additional source of supply. Desalinated water could be either blended with groundwater or blended with feedwater from the ARP wells for potable use.

2. *Seawater.* Since the District's service area lies adjacent to the San Francisco Bay, an abundant supply of seawater would be available for desalination. Water pumped from salinity barrier wells could also be used as a source. The quality of this water is similar to seawater but would require less pretreatment than seawater due to natural filtration through aquifer materials.

3. *Reclaimed water.* Treated wastewater generally has a high mineral content. Traditional tertiary treatment does not remove minerals. Wastewater effluent could be demineralized and may be more suitable for use than wastewater treated by traditional methods. This option entails desalinating reclaimed wastewater.

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[21]CH2M Hill. "Non-Potable Wastewater Reuse Master Plan." Prepared for Alameda County Water District and Union Sanitary District. September 1993.

[22]Separation Processes, Inc. "Desalination for the Alameda County Water District." November, 1992.

Agricultural Purchase

Two types of agricultural purchase contracts were examined:

1. *Annual purchase.* The District would contract for an annual delivery of a predetermined amount of water every year, regardless of District need.

2. *Seasonal or drought year purchase.* Under this type of purchase agreement, the District would only receive delivery of water when needed—during the summer or during droughts.

Additional Storage

As discussed in Section VII, there are occasions when SWP or Alameda Creek water is available and the District cannot use it either directly or for groundwater recharge. This Plan considered eleven options for surface and underground storage of unused surface water:

1. *Additional local recharge.* As discussed in Section II, captured local surface flows are currently used to recharge the groundwater basins. The natural runoff is diverted into recharge ponds adjacent to Alameda Creek. This alternative would supplement the current recharge program. Additional recharge facilities, either slow sand filters or injection wells, would be constructed along Alameda Creek on a 33-acre site near existing recharge ponds.

2. *San Joaquin Valley groundwater banking.* Unused SWP entitlement water could be banked, either directly or indirectly, in the aquifer underlying the San Joaquin Valley. SWP water could be delivered to the bank for direct recharge to the aquifer, or used for irrigation in the valley in exchange for an equal amount of SWP or CVP entitlement water when needed by the District.

3. *Livermore Valley groundwater banking.* Unused SWP water would be stored in the Livermore Valley groundwater basin. At a later date, the District could either exchange the stored water with Zone 7 for Del Valle water or SWP delivery, or the water could be pumped into Arroyo Del Valle, then flow into Alameda Creek, ultimately to the District.

4. *Dual use of existing recharge ponds.* Existing recharge ponds would be used for surface water storage as well as groundwater recharge. Water could be pumped from the ponds to either existing or new facilities for treatment and use.

5. *Dumbarton quarry pits.* The District would purchase the Dumbarton quarry pits for additional storage of recharge water. Water could be piped back to the District's recharge ponds for groundwater recharge, or pumped to facilities for treatment and use.

6. *Raise Calaveras and/or San Antonio Dam.* Raising either of these dams would provide additional storage capacity for imported Hetch Hetchy water, SWP water, and Alameda Creek Watershed runoff. The project would require cooperation among many entities, including the SFWD, State DWR, and other SWP and SFWD contractors.

7. *Construct an additional reservoir in Alameda Creek Watershed (Upper Del Valle).* This reservoir would be used to capture local runoff as well as store unused SWP delivery. Storage and additional water supply could be shared with Santa Clara Valley Water District, Zone 7, DWR, and other State water contractors. This option was evaluated in a report prepared for the District, Zone 7, and the Santa Clara Valley Water District.[23]

8. *Sunol Valley quarry pits.* Quarry operations on SFWD-owned land in the Sunol Valley could potentially provide a significant amount of storage. At the end of the quarry life, abandoned pits could be used to store unused SWP water or local surface water.

9. *Chain of Lakes quarry pits.* Quarry operations in the Livermore Valley have created what is known as the Chain of Lakes. Past quarry operations have created pits that are currently being used for recreational purposes. Continued quarry operations are expected to provide additional pits that will be used by the Zone 7 Water District for groundwater and/or surface water storage. A cooperative storage program with Zone 7, similar to that discussed under the Livermore Valley groundwater storage option, may be possible.

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[23]Camp, Dresser, & McKee. "Report on Supplemental Water and Storage for South Bay Aqueduct Contractors." Prepared for Zone 7, Alameda County Water District, and Santa Clara Valley Water District. February, 1992.

10. *Sunol Valley groundwater recharge.* This alternative was recommended for further analysis in the 1986 Supply and Facilities Planning Study. Unused SWP or local water may be used to recharge the Sunol groundwater basin. When needed, water would be extracted and discharged to Alameda Creek for eventual local recharge, or pumped to the SBA for delivery to treatment facilities.

11. *San Luis Reservoir.* Pursuant to the pending Monterey Agreement,[24] storage in SWP reservoirs may be made available for carry-over of unused entitlement water.

Surface Water Treatment Plant

The supply and operational analysis shows that additional production capacity is needed to meet peak monthly and daily demands. This Plan examined two treatment plant alternatives.

1. *Existing treatment plant capacity upgrade.* Additional filters would be added to an existing treatment plant, either MSJWTP or WTP 2, thereby increasing treatment capacity.

2. *New surface water treatment plant.* An additional treatment plant would be constructed at a site near the recharge ponds.

Operational Modifications

In addition to developing new supplies and storage facilities, modifying current operation may increase production capacity or help make more efficient use of existing supplies. Six operational modifications were considered:

1. *Seasonal hardness variations.* The District currently blends its groundwater with Hetch Hetchy water to achieve an average hardness of approximately 175 mg/L. Total blending facility production is limited during summer months by the hardness constraint. Relaxing this hardness

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[24]The Monterey Agreement was developed by SWP agricultural and urban contractors, in cooperation with the DWR, to settle disputes among contractors and to make the SWP operate more effectively for all contractors. The agreement includes several proposed amendments to the State water supply contracts. The EIR is in the public review stage and is expected to be finalized in July of 1995.

constraint by using a greater proportion of higher hardness groundwater in summer months would increase blending facility production capacity.

2. *Elimination of hardness constraints.* Operating the blending facility without any hardness limitation would allow greater use of groundwater resources and provide additional storage for recharging local water or SWP water.

3. *Draw groundwater basin below sea level with Salinity Barrier Program (SBP) pumping.* The 1986 Supply and Facilities Planning Study recommended constructing additional SBP wells. The intent of this program was to allow greater use of groundwater resources by drawing the basin below sea level while protecting the basin from seawater intrusion.

4. *Draw groundwater basin below sea level without SBP pumping as an emergency measure.* When the basin is drawn below sea level, a great deal of SBP pumping is required. Groundwater studies have shown that most of the water pumped from SBP wells comes from inland sources rather than from the Bay. Therefore, eliminating SBP pumping in an emergency may make more water available for potable production.

5. *Increase groundwater pumping such that groundwater supplies are not lost to the San Francisco Bay.* Groundwater losses to the Bay increase as groundwater elevation below the fault rises. A gradient toward the Bay is needed to repulse seawater, but if the gradient is too high, unnecessary losses may occur. Optimization of the quantity and timing of water diverted for recharge may help minimize unnecessary groundwater losses.

6. *Take advantage of ability to pump additional water from ARP wells when groundwater elevations are high.* Section VII discussed the quantity of ARP pumping required to stop movement of the saline plume toward the potable water production wells. Additional ARP pumping when supplies are available may speed up remediation of the basin without affecting the quantity of supplies available for potable use.

INITIAL SCREENING OF OPTIONS

The initial screening process was intended to eliminate as many less feasible alternatives as possible. Rather than focusing on a detailed characterization of each alternative, the effort attempted to identify fatal flaws.

The initial screening process eliminated eleven alternatives from further consideration, as follows:

- **Direct potable reuse.** Although the City of San Diego is in the process of pilot testing direct potable use of reclaimed water, it is not allowed as common practice under California Department of Health Services regulations. While direct potable reuse is technically feasible, there are significant legal, institutional, and regulatory constraints to implementation. In addition, there is still public concern about the safety of potable use of reclaimed water. Therefore, reclaimed water for direct potable use was eliminated from further consideration. As treatment technology improves, regulations may change and potable reuse may become more viable in the future.

- **Indirect potable reuse.** While reclaimed water is currently being used by some utilities to recharge their groundwater basins, its use is still not widely accepted. Compared to other potential supply options, indirect potable reuse may cause significant public acceptance issues. Reclaimed water for indirect potable use was eliminated on this basis.

- **Seawater desalination.** Desalination of seawater was eliminated because it is prohibitively expensive compared to other desalination alternatives. Moreover, unlike desalination of ARP water, desalination of seawater does not provide the additional benefit of groundwater protection.

- **Reclaimed water desalination.** Desalination of reclaimed water was eliminated because it is prohibitively expensive compared to traditional tertiary treatment of wastewater effluent and is more expensive than desalination of salt water.

- **Raising Calaveras Dam.** This option was eliminated due to the proximity of the Calaveras fault and possible stability problems with the hydraulic fill portion of the dam if dam height is raised.

- **Draw groundwater basin below sea level with salinity barrier pumping.** Operations analyses using the IRPM indicated that, with the full amount of barrier pumping needed to prevent seawater intrusion when the basin is operated below sea level, no additional water supply is obtained. Placement of future barrier wells may be optimized to require less SBP pumping.

  Additional operations analyses showed that if SBP pumping is reduced by 50%, a water supply increase of less than 200 acre-feet per year is obtained. Due to the relatively small water supply benefit compared to the cost of additional barrier wells and pumping costs, this alternative was eliminated from further consideration at this time.

  Because the groundwater model does not yet have the ability to predict changes in groundwater quality under various basin operating criteria, this analysis did not take basin remediation into consideration. Full basin remediation would result in improved water quality below the fault and increased storage capacity for potable supplies. The District is in the process of modifying the groundwater model to be able to simulate saline plume movement and remediation. The Salinity Barrier Project will be revisited when modifications are complete.

- **Dumbarton quarry pits.** These quarry pits are not suitable for storage due to highly fractured bedrock that may provide a conduit for leakage of highly saline water into the reservoir or loss of stored water into the basin.

- **Sunol Valley groundwater recharge.** As recommended in the 1986 Water Supply and Facilities Planning Study, a report was prepared for the District that evaluated the potential for storing SWP water in the Sunol Valley groundwater basin.[25] The report concluded that the clay layer in the upper aquifer would limit the transmissivity of the aquifer and the production capacity of any wells constructed within the aquifer. Based on this conclusion, groundwater storage in the Sunol Valley was eliminated from further consideration.

- **Local recharge.** This option was evaluated with the use of the IRPM. An increased recharge rate of 2, 4, and 6 cfs, based on recharge rates of existing ponds, was assumed for the construction of a 33-acre recharge

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[25]"Sunol Valley Groundwater Study." Converse Consultants Northern California. December, 1986.

pond. Model results indicated that existing recharge facilities are sufficient to recharge the groundwater basin at the rate needed to maximize existing groundwater capacity. Increased recharge provides very little water supply increase (less than 50 acre-feet per year). Therefore, this option was eliminated.

- **New Surface Water Treatment Facility.** This was eliminated from further consideration since the necessary additional capacity can be more economically obtained by upgrading existing treatment facilities or adding other production facilities.

- **Dual Use of Recharge Ponds.** The IRPM model was used to evaluate the potential water supply benefit of using water stored in recharge ponds for both groundwater recharge and as source water for surface water treatment. Model results indicated that the amount of surface water storage in the ponds is not sufficient to adequately supply both recharge needs and a surface water treatment plant. In addition, construction of a new treatment facility in proximity to the recharge ponds would be needed to make this a viable option.

CHARACTERIZATION OF REMAINING SUPPLY OPTIONS

After the unsuitable options were eliminated, those remaining were characterized by assessing the following attributes:

- **Yield or capacity.** The additional nominal supply or capacity provided by each option. The resulting increase in reliability from implementing a supply option is evaluated using the IRPM.

- **Capital and operating costs.** For the characterization of individual alternatives, capital costs were annualized based on a 35-year life of facilities and a nominal interest rate of 8%. The annual cost per acre-foot of water is the sum of the annual operating, maintenance, and capital costs divided by the total yearly water production or additional supply provided for each alternative. All costs are expressed in 1994 dollars. The level of precision of these cost estimates is such that they are assumed to be between 85% and 115% of actual costs.

- **Operational Feasibility.** The ability to integrate the new supply or facility into the existing system and the ability to deliver the required amount of supplemental water.

- **Construction and regulatory lead times.** In calculating the cost of resource sequences, capital costs are assumed to be incurred during project construction, which differs from the project on-line date.

- **Qualitative evaluation factors.** As discussed in Section IV, resource sequences are evaluated against the District's policy objectives. For some of these objectives, the evaluation of the sequence is based upon the evaluation of individual resources. In other words, the score of the sequence is the composite score of the individual resource options. The characterization of individual resources against these factors is described in this section.

The following provides a detailed description of the remaining supply side options.

Reclamation for Landscape Irrigation

In 1991, the District and USD jointly sponsored a study to assess the market and financial feasibility of nonpotable wastewater reuse.[26] The study concluded that landscape irrigation shows the greatest potential. The study also presented a three-phase implementation plan which allows the most cost-effective users to be connected to the system first, as follows:

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[26]"Non-Potable Wastewater Reuse Master Plan." *Op. Cit.*

Table VIII-1
RECLAMATION COSTS AND YIELDS

	Phase 1	Phase 2	Phase 3
Total Capital Costs ($000)	14,282	13,621	23,210
Annualized Capital Costs ($/yr)	1,225,424 (612,710)	1,168,760 (584,380)	1,991,480 (995,740)
Total Annual Operating Costs ($/AF)	182 (91)	213 (107)	241 (120)
Annual Production (AF)	1,626	1,045	1,360
Maximum demand (mgd)	3	2	3
Total Cost $/AF/Year	935 (468)	1331 (665)	1705 (853)

Note: Numbers in parentheses denote ACWD's portion of the costs assuming 0.00/ cost sharing with USD All costs are expressed in dollars

This Plan assumes that the District and USD would each pay half of the capital and operating costs.

Reclaimed water distribution pipelines would be separate from the existing distribution system and would, therefore, not affect existing operations. The volume of reclaimed water produced would be the same in drought years as in normal years. Demand for reclaimed water for irrigation purposes is highest in the summer months. Therefore, in addition to increasing water supply, use of reclaimed water would help meet peak monthly and daily production capacity needs identified in Section VII.

Salt Water Desalination

In 1992, a reconnaissance level report was prepared for the District that included an evaluation of the feasibility of salt water desalination.[27] Water pumped from ARP wells would be desalinated and blended with groundwater and Hetch Hetchy water at the blending facility or blended with feedwater from ARP wells to provide a hardness level consistent with other sources of supply. Two prospective plant sites were evaluated: (1) the Blending Facility site in Fremont where product water could be

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[27]"Desalination for the Alameda County Water District." *Op. Cit.*

blended with SFWD water and well water; and (2) a site near the ARP wells in Newark where SFWD or ARP feedwater could be blended with product water. Several plant sizes were also evaluated. Costs shown in Table VIII-2 assume desalination plant construction at the Central Avenue site.

Table VIII-2
DESALINATION CAPITAL AND OPERATING COSTS

	1 mgd	3 mgd	5 mgd	8 mgd	10 mgd
Total Capital Costs ($000)	2,293	4,237	7,464	10,887	14,324
Annualized Capital Costs ($/yr)	196,755	363,524	640,419	934,165	1,229,054
Total Annual Operating Costs ($/AF)	426	396	392	390	389
Concentrate Disposal ($/AF of product water)	7–105	7–105	7–105	7–105	7–105
Total Cost ($/AF/Year)	628–726	523–621	526–624	513–611	518–616

Note: All costs are expressed in 1994 dollars. Cost per acre-foot are based on reverse osmosis product only.

Options for concentrate disposal were evaluated in a report prepared in 1994.[28] The disposal options evaluated include:

- Discharge to Union Sanitary District downstream of the Alvarado Wastewater Treatment Plant;

- Discharge to the Alameda County Flood Control Channel;

- Discharge to an enhanced tidal marsh along the Newark Slough; and

- Discharge by injection into a Salinity Barrier Program well.

Cost of concentrate disposal was estimated to range between $7 and $105 per acre-foot of desalinated product water and are included in the cost of desalination.

The desalination facility would be designed to deliver the amount of product water shown in Table VIII-2. However, actual production may be limited by the need to maintain BHF groundwater elevation at no less than +3 feet MSL.

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[28]Camp, Dresser, & McKee. "Desalter Concentrate Disposal Evaluation." December 1994.

In addition to the quantity of water produced, a desalination facility may indirectly increase overall water supply reliability by increasing use of groundwater resources. This, in turn, allows for greater groundwater capture and storage of SWP water that would otherwise be lost.

Operation studies also indicate that in addition to new supplies, additional production capacity may be needed to meet peak-day demands by the year 2000. Desalination also allows for increased production capacity over the capacity of the plant. This is because the very low hardness product water can be mixed with above- or below-Hayward fault groundwater. For example, if a 5 mgd desalination plant is constructed and hardness is constrained to 175 ppm, the total peak production rate would be approximately 14 mgd when blended with groundwater above the fault, 9 mgd when blended with groundwater below the fault, and 6 mgd when blended with ARP water.

Additional Storage

The Water Supply and Operations Analysis (summarized in Section VII), indicated that a significant quantity of water is lost due to the inability to store surplus wet year water with existing facilities. This Plan evaluates several local and out-of-area options for surface and/or groundwater storage. Additional storage may be obtained through one or more storage alternatives considered. As such, this study assumed no constraint on the total amount of storage available.

The resulting additional supply resulting from adding storage facilities depends upon many factors, including the water availability of existing sources of supply as well as the mix of new resources. The IRPM was used to simulate the quantity of water that would be available for storage and the resulting additional supply under a range of scenarios and mix of resources.

Estimated costs and quantities of storage potentially available for each alternative are shown in Table VIII-3. Some of the storage options considered have not been fully investigated and may require additional input from other agencies to determine costs and/or amounts of storage that may be available to the District.

Table VIII-3
SUMMARY OF STORAGE OPTIONS

Storage Option	Storage Capacity (AF)	Cost (1994 $)			Comments
		Total Capital ($)	Annual Operational ($/yr)	Total $/AFY of Stored Water	
San Joaquin Valley Groundwater Banking	> 1,000,000	—	—	100–180	▪ Large storage capacity potentially available in the Central and Southern portions of the San Joaquin Valley. ▪ Potential for storage/exchange of SWP water; may require SWP/CVP exchange. ▪ Actual cost dependent on storage location, operational arrangements with the banking partner(s).
Livermore Valley Groundwater Banking	Unknown	—	—	100–180	▪ Costs and storage capacity unknown—pending further conjunctive use analysis by Zone 7. ▪ Potential for storage/exchange of local water and/or SWP water.
Raise San Antonio Dam	35,000	13,000,000	243,000	21	▪ Proposed by SFWD in 1986.* ▪ Potential for storage of local water and/or SWP water. ▪ 35,000 AF of total additional storage provided by raising the dam; portion available, if any, for District use unknown. ▪ Potential water quality concerns if mixed with SBA water (i.e., increased TOC or algae growth) resulting in disinfection by products and odors.
Upper Del Valle	28,000	72,600,000	2,100,000	171	▪ Potential for storage of SWP and local water. ▪ Storage to be shared among South Bay SWP contractors.
Sunol Valley Quarry Pits	Up to 45,000 in existing mining areas; up to 74,000 acre-feet if existing mining areas are expanded	—	—	100–180	▪ Storage capacity in quarry pits would come available in phases at the end of the economic life of each quarry area; 15-20,000 acre-feet potentially available sometime after year 2005-2010, remainder of storage sometime after year 2020 ▪ Timing/phasing and actual costs pending further evaluation by SFWD. ▪ Potential for storage of SWP and local water.
Chain of Lakes Quarry Pits	Unknown	—	—	100–180	▪ Potential for storage/exchange of SWP and/or local water. ▪ Total storage/potential storage available to ACWD may be limited by high groundwater elevation restricting surface water storage to the portion in the pits that is above groundwater elevation. ▪ Actual costs/potential for storage pending Zone 7 operational analyses. ▪ Pits not available for storage until after 2005.
San Luis Reservoir	Proportional to Table A entitlement of other contractors requesting carry-over storage	0	0	0	▪ Carryover storage of yearly SWP entitlement made available to all contractors as part of the Monterey Agreement. ▪ Carryover water in SWP conservation facilities is subject to "spill" in the following priority: (1) water stored for non-SWP contractor; (2) water stored for a SWP contractor above its proportional share based on Table A entitlement; (3) water stored for a contractor within its proportional share based on Table A entitlement; (4) Project water.

*"Alternative Means of Providing Additional Water to San Francisco Water Department." Prepared by Kennedy/Jenks Engineers in association with Tudor Engineering Company, January 1886.

Note: Costs shown do not include cost of water supply or treatment.

pd920483/table-3.8/7-31-95

Agricultural Purchase

This Plan assumed that water would be available for purchase from other SWP contractors, or through transfer and exchange of CVP water.[29] Two types of purchase agreements were evaluated: annual and drought year transfers/exchanges, as discussed below.

Annual Agricultural Purchase. This study assumed that up to 15,000 acre-feet of agricultural water would be available for purchase every year. Purchased water would be delivered through SWP facilities and would be subject to existing facility and contractual monthly/instantaneous delivery constraints. In addition, it was assumed that water supply availability would be subject to the same regulatory limitations as current SWP supplies. Estimated cost to purchase the water right included a one-time fee of $1,000 per acre-foot of purchased water plus reimbursement of costs to the seller for the fixed components of the SWP transportation charge. Transportation charge is estimated to be $22 per acre-foot of entitlement water.[30] Total fixed cost of purchased entitlement water is approximately $108 per acre-foot per year. The fixed cost would be paid every year regardless of whether the full transferred entitlement is taken. Model analyses indicate the average reliability of entitlement water is approximately 75%. Therefore average actual cost of "delivered wet" water would be approximately $144 per acre-foot per year ($108 divided by 75%) plus the variable SWP transportation charge of $18 per acre-foot, or $162 per acre-foot per year.

Drought Year Purchase. This study assumed that up to 25,000 acre-feet of water would be available for drought year purchase. Cost of drought year water is highly variable based on market conditions. For purposes of analysis, a cost of $250 per acre-foot was assumed.

Surface Water Treatment Plant Modification

Additional production capacity will be needed to meet peak monthly and daily demands. The addition of filters and/or other process expansions at existing surface

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[29]The recent enactment of the CVP Improvement Act (H.R. 429) opens the possibility of CVP water purchase either directly through transfers and exchanges with current CVP water users, or through DWR and/or USBR as "brokers."

[30]Based on DWR Bulletin 132-93, Table B-24, transportation charge less variable component. For purposes of cost analysis, this plan assumes that the seller is in the Kern County Water Agency Service Area.

water treatment plants would increase production capacity. This study evaluated scenarios that increased surface water production by 2 to 7 mgd at an estimated cost of $2 million per mgd of increased production capacity.

Operational Modifications

In addition to adding or purchasing supplies and facilities, the District may be able to increase system capacity and/or water supply reliability by modifying its current operations. The actual quantity of water that can be provided by modifying current system operations varies and is contingent upon the quantity of local runoff, availability of imported water, and the mix of new resources. The variations of increased yield due to operational modifications are calculated within the IRPM. Based on IRPM model results, the potential ranges of increased yield and/or production capacity and cost for each operational alternative are summarized in Table VIII-4.

Operational alternatives do not require construction of new facilities. Costs per unit of increased yield and/or increased production capacity are based on variable operational costs of production pumping and operation of the blending facility. Cost of water is not included.

Table VIII-4
OPERATIONAL ALTERNATIVES

Operational Alternative	Potential Range of Increase in Production Capacity	Potential Range of Supply Increase	Variable Cost/Unit of Increased Supply or Capacity	Comments
Seasonal hardness variation	Up to 12 mgd for a 25 ppm hardness increase	minimal	$53/af	■ Groundwater production is limited in drought years by the need to maintain BHF groundwater elevation above +3.
Elimination of hardness constraint	Up to 12 mgd for a 25 ppm hardness increase	Up to 3,500 AFY	$53/AF	■ Hardness at the Blending Facility rises to 238 ppm.

Operational Alternative	Potential Range of Increase in Production Capacity	Potential Range of Supply Increase	Variable Cost/Unit of Increased Supply or Capacity	Comments
Draw BHF g/w basin below +3 during drought without SBP pumping at:				■ Increased water availability benefits when either hardness at the blending facility is allowed to increase, or when desalination is operated.
-5 ≤ BHF ≤ +3	0	Up to 1,000 AFY; 5,000 AFY—no hardness limits	$53/AF	■ Groundwater production is limited by hardness constraint at the blending facility.
-10 ≤ BHF ≤ +3	0	Up to 2,000 AFY; 7,500 AFY—no hardness limits		
-40 ≤ BHF ≤ +3	0	Up to 4,000 AFY; 32,000 AFY—no hardness limits		
Increase ground-water production to prevent losses to the Bay	0	No water supply benefit alone—up to 15,000 AFY with additional storage	$53/AF	■ When g/w elevation is such that losses occur to the Bay (EL > +10), other sources of supply are also plentiful. Thus, without additional storage, increased g/w production would only result in loss of other sources of supply.
Pump additional ARP water when BHF water levels are above +10	0	Indirect water supply benefit of unknown quantity	$16/AF	■ Helps speed up g/w remediation. ■ Provides additional g/w storage. Water quality modeling needed to quantify resulting increased water supply benefit.

Qualitative Evaluation of Supply Options

Three of the policy objectives can be evaluated by examining the characteristics of the individual resources. They are as follows:

- Avoid or mitigate any negative environmental impacts that result from water supply additions;

- Maximize local control; and

- Minimize risk due to future uncertainties.

As discussed in the policy objectives section, there is more than one way to measure risk due to future uncertainties. The three measures of risk are:

- Financial risk
- Availability risk
- Water quality regulatory risk

The PAC rated the supply options using a (+), (✓), and (−) scale; a (+) is preferred over (✓) and (−). For computational ease, these ratings were later converted to a 1-to-3 ordinal score, with a 1 corresponding to (+), and so forth; in each case, a lower score is more favorable. Following are brief discussions and characterization of resource options against these criteria; these characterizations are summarized in Table VIII-5.

Table VIII-5
CHARACTERIZATION OF SUPPLY OPTIONS

	Environmental Issues	ACWD Control	Risk		
			Availability	Financial	Water Quality
Ag Transfer—Annual	✓	−	−	✓	−
Ag Transfer—Drought Year	✓	−	−	+	−
Desalination	✓	+	+	✓	✓
Reclamation	✓	+	+	−	+
Surface WTP Upgrade	✓	+	+	✓	−
Storage—Banking	✓	✓	+	+	−
Storage—Surface Reservoir	−	✓	+	−	−

G/W Basin Mgt
  −5 ≤ BHF ≤ 3
  BHF < −5
  BHF > 3
	✓
	−
	+
		+
		+
		+
			+
			+
			+
				+
				+
				+
					✓
					✓
					✓

Drought Yr Hardness Variation	+	+	+	+	✓
Conservation	+	+	✓	✓	+
(+) is more favorable than (✓), which is more favorable than (−).					

Environmental Impacts. Supply options were ranked based on current knowledge of potential environmental impact. As discussed in Section IV, it was assumed that all long-term environmental impacts will be mitigated. Short-term environmental impacts

associated with project construction are not included in the scoring shown in Table VIII-6.

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Table VIII-6

CHARACTERIZATION OF SUPPLY OPTIONS—ENVIRONMENTAL ISSUES

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Supply Option	Explanation
The following options were ranked (–):	
Surface reservoir	Wildlife habitat changes, disturbance of environment during construction, dam safety risks.
Basin mgt—BHF < -5	High environmental issues due to risk of seawater intrusion and groundwater basin contamination.
The following options were ranked (✓):	
Reclamation	Some environmental issues due to siting of distribution system. Potentially fewer environmental issues than treatment plant because site is not proximate to residences. In addition, the plant would be situated on the existing wastewater treatment plant facility.
Desalination	Some environmental issues associated with brine disposal.
Basin mgt— $-5 \leq BHF \leq 3$	Minimal environmental issues.
WTP upgrade	Minimal environmental issue because treatment plant situated at existing facility.
Banking	Minimal environmental issues.
Agricultural transfer (Annual and drought year)	Minimal environmental issues.
The following options were ranked (+):	
Basin mgt— BHF > 3	Keeping groundwater level high protects the basin from seawater intrusion. May also assist in reversing the saltwater gradient.
Conservation	No environmental issues.
Hardness variation	No environmental issues.

Local (ACWD) Control. Resource sequences were evaluated based on the number of involved entities, the status of District water rights to the supply option, the extent to which the District has to share water with other contractors, and whether State or

Federal agencies are involved in allocating water deliveries. The scoring of supply options are shown in Table VIII-7.

Table VIII-7
CHARACTERIZATION OF SUPPLY OPTIONS—ACWD CONTROL

Supply Option	Explanation
The following options were ranked (−):	
Agricultural transfer (Annual and drought year)	ACWD has little control because of a lack of water rights and the dependence on a contract with one or more agricultural sellers.
The following options were ranked (✓):	
Banking	ACWD cannot control operation of external groundwater basin(s) used for banking.
Surface reservoir	ACWD shares control of reservoir with other SWP contractors and the Bureau.
The following options were ranked (+):	
Reclamation	High degree of control because of Memorandum of Understanding between ACWD and USD.
Desalination	Local supply
WTP upgrade	Local supply
Basin management	Local supply
Hardness variation	Local supply
Conservation	Local source. District able to influence customer action through effective marketing.

Financial risk. Financial risk is the likelihood of spending more money than expected or spending unnecessary money. Factors such as fixed cost, lead time, and resource size would affect financial risk. Resources with high capital cost (e.g., surface storage) would be more financially risky than resources with only variable costs (e.g., drought year agricultural purchase). The characterization of supply options is summarized in Table VIII-8.

Table VIII-8
CHARACTERIZATION OF SUPPLY OPTIONS—FINANCIAL RISK

Supply Option	Explanation
The following options were ranked (–):	
Surface reservoir	High capital cost project. Inability to phase project. Final cost harder to estimate than other options.
Reclamation	High capital cost. Less financially risky than surface reservoir because project can be phased. Cost sharing assumption with USD is uncertain.
The following options were ranked (✓):	
Desalination	Lower capital cost than reclamation. Project can be phased. Facility would always be used for blending. Better estimate of final cost than other options (e.g., new surface water WTP).
Annual agricultural exchange	More risky than drought year ag purchase because water may not be put to beneficial use in all years. Risk is mitigated when implemented with storage.
WTP upgrade	Less costly than desalination. Project can be phased.
Conservation	All costs incurred up-front. Uncertainty in natural turnover of indoor plumbing.
The following options were ranked (+):	
Drought year ag exchange	Not very risky because ACWD buys water when needed. ACWD can also sell unused water on the market. No fixed cost.
Banking	Not very risky because ACWD buys water when needed. No fixed cost. It was assumed that cost per acre-foot would not vary with quantity of water purchased.
Basin management	No financial risk.
Hardness variation	No financial risk.

Water Availability Risks. This criterion represents the likelihood of a supply source not being available due to exogenous legal/regulatory changes (e.g., the ability to do agricultural exchanges through the Delta) or uncertainties in magnitude of resources (e.g., conservation). This criterion takes into account availability risks which have not been captured in the uncertainty scenarios or IRPM. Table VIII-9 summarizes the evaluation of options against this criterion.

Table VIII-9
CHARACTERIZATION OF SUPPLY OPTIONS—
WATER AVAILABILITY RISK

Supply Option	Explanation
The following options were ranked (−):	
Drought year ag transfer	Water may not be available for institutional reasons and/or worse drought than period of record.
Annual ag transfer	Uncertain whether supply will be available on a long-term basis because option has not been demonstrated on a long-term basis. Water may not be available for institutional reasons and/or worse drought than period of record.
The following option was ranked (✓):	
Conservation	Savings are uncertain. However, savings estimates erred on the conservative side.
The following options were ranked (+):	
Reclamation	Quantity not affected by drought.
Basin management	Water availability risk already captured in local model.
Desalination	Uncertainty in groundwater availability already captured in local model.
Surface storage	Water availability (based on SWP availability) already captured in local model and uncertainty scenarios.
Banking	Water availability (based on SWP availability) already captured in local model.
Hardness variation	Availability of water from hardness variation already captured in local model.
WTP upgrade	Not applicable.

Water Quality Risk. Water quality risk is the likelihood of not being able to comply with future water quality regulations. This evaluation criterion differs from the "maximizing the health-related component of water quality" policy objective. Even though all water sources will be treated to meet quality standards and the cost of treatment is included in other evaluation criteria, some water sources have an inherent higher risk difficulty in meeting future standards and may require expensive upgrades to existing treatment facilities. For example, surface waters may be a risky source of supply because of potential enhanced surface water treatment rules. This type of risk would be captured in this evaluation criterion, as shown in Table VIII-10.

Table VIII-10
CHARACTERIZATION OF SUPPLY OPTIONS—WATER QUALITY RISK

Supply Option	Explanation
The following options were ranked (–):	
Surface waters (annual and drought year agricultural exchange, WTP upgrade, surface reservoir, banking)	May be affected by SWTR, *cryptosporidium*, and D/DBP rules.
The following options were ranked (✓):	
Groundwater options (desalination, basin mgt, hardness variation)	May be affected by radon, arsenic, groundwater disinfection rules. These regulations may be less problematic than those affecting surface water sources.
The following options were ranked (+):	
Conservation and reclamation	No drinking water quality risk.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

ASSESSMENT OF CONSERVATION OPTIONS

ACWD Integrated Resources Planning Study Process

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┌─────────────────┐          ┌─────────────────┐
│ Policy Objectives│          │ Demand Forecast │
└─────────────────┘          └─────────────────┘
         │                            │
         │                            ▼
         │                   ┌─────────────────┐        ┌─────────────────┐
         │                   │ Evaluate Current│ ◄┈┈┈┈┈ │ Integrated      │
         │                   │ System Resources│        │ Resources       │
         │                   │ and Operations  │        │ Planning Model  │
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│ Evaluation      │ ───────► ┌─────────────────┐ ◄───── │ Resource        │
│ Criteria        │          │ Characterize    │        │ Assessment      │
└─────────────────┘          │ Resource Options│        │ • Supply-Side   │
                             └─────────────────┘        │ • Demand-Side   │
┌─────────────────┐                   │                 └─────────────────┘
│ Define Future   │ ──────────────────┤
│ Uncertainties   │                   ▼
│ and Potential   │          ┌─────────────────┐
│ Outcomes        │          │ Form Potential  │
└─────────────────┘          │ Resource        │
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┌─────────────────┐              │ Narrow
│ Define          │              ▼
│ Uncertainty     │ ──► ┌─────────────────┐
│ Scenarios       │     │ Test Sequences  │ ◄┈┈┈┈┈┈┈┈┈
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                        │ Form Resource   │
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IX. ASSESSMENT OF CONSERVATION OPTIONS

As is the case with supply options, a systematic and step-by-step approach is applied to develop conservation options. This approach begins with an extensive list of potential options, which are then subjected to a succession of more finely meshed screens to focus on those that are most appropriate for the District.

The conservation analysis included the following steps:

- Carefully screening conservation measures to determine the ones that are appropriate for use in the District;

- Disaggregating demand data to determine water use patterns in the District;

- Targeting specific water uses with cost-effective conservation measures;

- Designing appropriate delivery mechanisms, including incentives and marketing approaches;

- Clarifying the criteria against which to evaluate the conservation programs;

- Characterizing the programs, including participation levels, program costs, water savings, revenue impacts, demand "hardening" impacts, and staffing requirements; and

- Packaging conservation programs into logical groups for integration with supply options.

The remainder of this chapter summarizes these steps. Appendix G contains a detailed description of the study's conservation element.

CONSERVATION MEASURE SCREENING

As a first step, a comprehensive list of conservation measures was developed. This study distinguishes between conservation measures and programs. The term "measure" denotes conservation devices (e.g., water-efficient plumbing fixtures) or practices (e.g., turf reduction). "Programs" are groupings of measures that pass the

qualitative and economic screen, and the appropriate delivery mechanisms to target markets.

This list of comprehensive conservation measures goes well beyond those conservation measures defined as Best Management Practices in the Urban Conservation Memorandum of Understanding, to which the District is a signatory. The goal in developing this list was to include *all* measures that might be applicable to the District's needs. The list of measures was developed from literature and database reviews, project reports from other water utilities, and consultant and staff knowledge and experience with conservation program planning and design.

Two successive screening analyses were performed to narrow this list. The purpose of these screens was to eliminate from consideration those measures that are clearly inappropriate for the District to pursue. The screens were, therefore, intentionally permissive to prevent the elimination of measures that might prove valuable to the District. Following are descriptions of the qualitative and economic screens.

Qualitative Screen

The qualitative screen tested whether a variety of specific factors or criteria would limit the applicability of measures in the District's service area. Based on this assessment, those measures that were clearly inappropriate for the District were eliminated.

Measures that have nonquantifiable costs and savings were not evaluated in the qualitative screen. Instead, they were retained for customized application.

The following qualitative criteria were used to screen the measures:

- **Better measure available.** Another clearly more appropriate measure to address the specific inefficiency in water use is available. For example, low-flow faucets were screened out in favor of faucet aerators because both are equally effective, but aerators are less expensive and easier to install than low-flow faucets.

- **Technological/market maturity.** The technology is not commercially available and/or not supported by the necessary service industry. For example, Swedish one-quart flush toilets were eliminated because they are not yet commercially available in the United States. Similarly, ultrasonic dishwashers were eliminated because there are few manufacturers in this

country and the technology has not been adequately tested for commercial application.

- **Poor utility match.** The technology is not applicable to the climate, building stock, or equipment that is typical in the District's service territory. For example, agricultural measures were eliminated from further consideration because of the negligible amount of agriculture in the District.

- **Poor customer acceptance.** District customers will be unwilling to implement the measure, resulting in unacceptably low penetration rates and/or customer incentives that are too high. For example, point-of-use hot water heaters severely limit the flow rate of hot water and may result in insufficient hot water for showers.[31] Thus, most customers will be unwilling to adopt the measure. Similarly, soil sensors for residential application were eliminated because they require periodic and time-consuming maintenance.

- **Environmental and health concerns.** The measure raises unacceptable concerns regarding health, safety, or environmental impacts. Thus, greywater systems for commercial/industrial application were screened out because applicable health and safety regulations are in flux.

Economic Screen

The measures that passed the qualitative screen were then subjected to an economic screen. The economic screen was used to eliminate those measures that are *clearly not* cost-effective for the District to implement. The economic screen compared the present value of the estimated avoided supply costs due to each conservation measure to the present value of the measure's costs. As is the case with the qualitative screen, the economic screen was intended to be permissive; measures that have any chance of serving the District's needs *were not* eliminated. Therefore, a relatively high estimate of avoided cost of water supply, namely the cost of desalination (approximately $700 per acre-foot) was used.

The calculation of a measure's cost distinguishes between early replacements (i.e., retrofits) and new installations or end-of-life replacements. In the former case,

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[31]Alex Wilson and John Morrill, *Consumer Guide to Home Energy Savings* (Washington, D.C.: American Council for an Energy-Efficient Economy, 1991).

still-useful fixtures, equipment, landscapes, etc. are replaced solely to gain the water-efficiency advantages of new technologies. The incremental cost is the actual cost of the new technology. (No scrap value of the replaced equipment is assumed.) In the latter case, it is assumed that the purchaser must make a purchase in any event and is facing a choice between technologies that are more or less water efficient. The incremental cost of the water-efficient technology is therefore the difference in cost between the two technology types. California and federal regulations mandate the sale of water-efficient residential plumbing fixtures. Therefore, these measures were not screened for end-of-life replacements.

Note that the economic screen is not, and was not intended to be, a detailed cost-effectiveness analysis. It is a tool to quickly identify those measures that are clearly inappropriate for ACWD. For example, it only considers the cost of the measure itself. Program delivery costs, administrative and marketing costs, incentive payments, potential "freeriders,"[32] dropout rates, etc., are considered in the more complete cost-effectiveness analysis of conservation *programs* that is described below.

At this point, the present value cost of the conservation *measure* was simply compared to the water supply development costs that would be avoided as a result of the conservation associated with that measure.

Tables IX-1 to IX-3 contain the results of the economic screen. Several general conclusions can be drawn:

- Residential indoor plumbing retrofits are highly cost-effective. The large savings due to plumbing conservation measures combined with the high avoided cost of alternative supply explain these results.

- Outdoor retrofits (i.e., irrigation system replacement and relandscaping) for residential and large landscape customers were generally less cost-effective than indoor retrofits. The high cost of these outdoor retrofits, which includes the cost of the technology, cost to remove the water-inefficient technology and the subsequent cost to install the water-efficient technology, cannot justify the resulting water savings. However, these measures are cost-effective at the time of natural replacement or new construction because the incremental cost of the technology is negligible.

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[32]"Freeriders" are customers who would have implemented the conservation measure even without District intervention.

still-useful fixtures, equipment, landscapes, etc. are replaced solely to gain the water-efficiency advantages of new technologies. The incremental cost is the actual cost of the new technology. (No scrap value of the replaced equipment is assumed.) In the latter case, it is assumed that the purchaser must make a purchase in any event and is facing a choice between technologies that are more or less water efficient. The incremental cost of the water-efficient technology is therefore the difference in cost between the two technology types. California and federal regulations mandate the sale of water-efficient residential plumbing fixtures. Therefore, these measures were not screened for end-of-life replacements.

Note that the economic screen is not, and was not intended to be, a detailed cost-effectiveness analysis. It is a tool to quickly identify those measures that are clearly inappropriate for ACWD. For example, it only considers the cost of the measure itself. Program delivery costs, administrative and marketing costs, incentive payments, potential "freeriders,"[32] dropout rates, etc., are considered in the more complete cost-effectiveness analysis of conservation *programs* that is described below.

At this point, the present value cost of the conservation *measure* was simply compared to the water supply development costs that would be avoided as a result of the conservation associated with that measure.

Tables IX-1 to IX-3 contain the results of the economic screen. Several general conclusions can be drawn:

- Residential indoor plumbing retrofits are highly cost-effective. The large savings due to plumbing conservation measures combined with the high avoided cost of alternative supply explain these results.

- Outdoor retrofits (i.e., irrigation system replacement and relandscaping) for residential and large landscape customers were generally less cost-effective than indoor retrofits. The high cost of these outdoor retrofits, which includes the cost of the technology, cost to remove the water-inefficient technology and the subsequent cost to install the water-efficient technology, cannot justify the resulting water savings. However, these measures are cost-effective at the time of natural replacement or new construction because the incremental cost of the technology is negligible.

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[32]"Freeriders" are customers who would have implemented the conservation measure even without District intervention.

Table IX-1
CONSERVATION MEASURES PASSING ECONOMIC
AND QUALITATIVE SCREENS—RESIDENTIAL SECTOR

Measure	Base Comparison	Potential Savings	Benefit/Cost Ratio*
Leak detection tablet and toilet repair	Leaking toilet	47 gpd/toilet	6
Ultra-Low-Flush Toilet (ULFT); 1.6 gallons per flush (gpf)	5.5 gpf toilet 3.5 gpf toilet	28 gpd/toilet 22 gpd/toilet	3 2
Dual flush adapters	5.5 gpf toilet 3.5 gpf toilet	41 gpd/toilet 12 gpd/toilet	14 4
Toilet displacement devices Dams Bags Bottles	Unmodified toilet	 12 gpd/toilet 8 gpd/toilet 6 gpd/toilet	 22 120 65
Ultra-low-flow showerhead	Installed nonconserving Installed low-flow New low-flow	16 gpd/device 5 gpd/device 5 gpd/device	8 2 3
Low-flow showerhead	Installed nonconserving	11 gpd/device	17
Low-flow faucet aerators	Nonconserving	5 gpd/faucet	17
Fill cycle regulators	Unmodified toilet	5 gpd/toilet	167
Garden hose timers	Hose without timer	20 gpd	4
Hose control nozzles	Hose without nozzle	7 gpd	13
Sprinkler timers	Manual shutoff	20 gpd	3
Controllers	Manual shutoff	20 gpd	2
Turf reduction/replacement	Average landscape turf area	41 gpd	0.76
Drought tolerant landscape, new construction	Nonconserving landscape	25 gpd	> >1
High-efficiency sprinkler heads, valves, times, sensors and computer stations	Standard irrigation system	N/A	N/A
Irrigation and soil practices modification, existing homes	Existing, nonconserving practices	N/A	N/A
Irrigation and soil practices modification, new construction	Nonconserving practices	N/A	> >1

*Benefit-cost ratios are based on retail prices and will be higher for measures purchased wholesale or in bulk.

Table IX-2
CONSERVATION MEASURES PASSING QUALITATIVE
AND ECONOMIC SCREENS—LARGE LANDSCAPE SECTOR

Measure	Base Comparison	Potential Savings	Benefit/Cost Ratio*
Controllers	Manual shutoff	1,015 gpd	3
Drought tolerant landscape, retrofit	Nonconserving landscaping	305 gpd	0.87
Drought tolerant landscape, new construction	Nonconserving landscape	305 gpd	>>1
Irrigation and soil practices modification, new construction	Nonconserving practices	N/A	>>1

*Benefit-cost ratios are based on retail prices and will be higher for measures purchased wholesale or in bulk.

Table IX-3
CONSERVATION MEASURES PASSING ECONOMIC
AND QUALITATIVE SCREENS—NONRESIDENTIAL SECTOR

Measure	Base Comparison	Potential Savings	Benefit/Cost Ratio*
Commercial ULFT valve replacement	5.5 gpf toilet	38 gpd/toilet	5
Commercial ULFT	4.5 gpf toilet	35 gpd/toilet	3
Commercial ULF urinal valve replacement	1.5 gpf urinal	5 gpd/urinal	5
Commercial ULF urinal	4.5 gpf urinal	5 gpd/urinal	5
Pressure closing faucet Spring loaded faucet Foot pedal operated faucets Ultrasonic faucet (mechanism only)	Installed manual closing (nonconserving)	11 gpd/faucet	1.1 0.73 0.73 0.91
Air cooled drinking fountain	Water cooled fountain	15 gpd/ fountain	0.79
Air cooled ice makers	Water cooled ice makers	162 gpd/ 100 lb ice	>>1
All water-conserving measures, new construction	Nonconserving measures	N/A	>>1

*Benefit-cost ratios are based on retail prices and will be higher for measures purchased wholesale or in bulk.

- Plumbing retrofits, end-of-life replacements, and new construction for the business sector also appear to be highly cost-effective. This result applies to both large and small businesses. Most businesses use water mainly for sanitation. As with residential plumbing fixtures, the savings realized from the conservation measures are high. This, in addition to the high avoided cost of alternative supply, creates an economic incentive for water-efficient plumbing fixtures.

- The installation of all types of water-conserving technologies in new construction is almost always highly cost-effective because the incremental cost of water-conserving installations over standard technologies is very small.

The District should consider joint programs with other utilities for some of the conservation measures that fail the economic screen. For example, retrofits or end-of-life replacement of appliances, such as washing machines, are not cost-justified solely by their water-saving potential. However, the water-efficient machines generally also save significant amounts of energy. If these energy savings are considered, water-efficient washing machines may be cost-effective. A joint program with Pacific Gas and Electric under which the two utilities share program costs may prove beneficial to both agencies.

Several conservation measures were not evaluated in the economic screen because of their site-specific nature. These include various industrial conservation measures, such as timer-controlled solenoid valves. These measures are well suited for customized programs and were included in several customized conservation programs.

DEMAND DISAGGREGATION

Because conservation measures address a particular water sector and a specific end use, water demand needs to be disaggregated on this basis to design conservation programs. Furthermore, a conservation program uses a specific delivery mechanism to target specific audiences with a bundle of conservation measures. Therefore, demand disaggregation allows for the determination of parameters that are required for effective program design, as follows:

- Customer segment and customer types for effective program targeting;

- Size of the market and *program* conservation potential. Information about the amount of water used by each customer segment and each end use is one of the pieces of information needed to calculate the potential savings of implementing a conservation program;

- A means to bundle conservation measures. Measures that pass the qualitative and economic screen need to be grouped for delivery to the target customer segment; it would be infeasible to deliver each measure individually. Measures are bundled on the basis of common characteristics such as the similarity of targeted end uses or customer classes. For example, ULFTs, low-flow faucet aerators, and showerheads may be bundled to target a common end use—plumbing fixtures. Alternatively, these plumbing fixtures may be bundled with outdoor conservation measures to target the entire residential customer class.

  Thus, to develop conservation bundles requires an understanding of how each customer class uses its water.

To obtain the above information, demand data were disaggregated as follows:

- Major customer classes
- End uses by customer class
- Major water use accounts

Data from the District, USD, and the Alameda County Tax Assessor's Office were analyzed to disaggregate water demand. The following section describes the results of the demand disaggregation.

A Profile of Water Usage by ACWD Customers

The District classifies its customers into five major classes, as follows:

- Residential, comprising single-family and multifamily residences;

- Business;

- Industrial;

- Institutional, including schools, churches, government, and other "tax-exempt" customers; and

- Landscape—accounts that have dedicated landscape meters; also includes large landscape accounts that have combined meters for irrigation and indoor use. These include irrigated open space (e.g., golf courses, parks), multiresidential, business, industrial, and institutional customers that have large landscapes.

Based on the water demand forecast developed for the District by Brown & Caldwell,[33] and additional data on 1992 water consumption provided by ACWD, water use by customer class is as described in Table IX-4.

Table IX-4
WATER USE BY CUSTOMER CLASS

Customer Class	1992 Number of Accounts	1992 Annual Usage (ccf/year)	% of Total Usage	Average Daily Usage (1982–1991)*
Residential				
Single-family	60,879	8,528,020	49	332 gpd/home
Multifamily	2,368	3,272,900	19	238 gpd/unit
Business	2,778	1,689,050	10	1,717 gpd/meter
Industrial	915	1,914,730	11	6,317 gpd/meter
Other	540	749,500	4	2,709 gpd/meter
Landscape	1,102	1,230,180	7	2,263 gpd/meter
Total	68,582	17,384,380	100	

*The amounts listed in this column are averages for the 1982–1991 period—used in developing the demand forecasts.

Identification of End Uses by Customer Class

Water demand for the above customer classes were further disaggregated. This additional disaggregation—into end uses—facilitates the selection of conservation

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[33]Brown & Caldwell, *Water Demand Investigation and Forecast* (Fremont, Calif.: ACWD, February 1993).

measures and projection of the savings that would result from implementing those measures.

A fundamental step in conservation design is to identify the customer end uses that have the highest potential for conservation. The conservation potential for any end use depends in part on how efficiently water is currently being used. In assessing conservation potential, the end uses that consume large amounts of water should be examined first, because even a small percentage improvement in the efficiency of these end uses can result in a large volume of savings. Thus, the end use disaggregation serves several purposes:

- Develop a better understanding of the composition of each customer class;

- Define consumption patterns for each major customer category within a customer class;

- Quantify the amount of water consumed by each end use; and

- Identify the largest water uses and users.

End-use estimates were derived from a variety of sources, including the 1993 Brown & Caldwell water demand forecast, USD discharge records, USD discharge permits, and the ACWD Urban Water Management Plan. The following sections summarize the results of these analyses. Appendix G presents a more detailed discussion of the end-use demand disaggregation.

Residential Class

The ACWD residential class includes approximately 66% single-family households and 34% multifamily households. According to tax assessor information, 99% of the multifamily households are in condominiums or apartment buildings with more than five units.

The Brown & Caldwell demand forecast estimates that approximately 37% of single family residential water use and 25% of multifamily residential water occurs outdoors. According to the ACWD Urban Water Management Plan, residential indoor

water use can be disaggregated as shown in Figure IX-1. This disaggregation is consistent with estimates from other studies.[34]

Figure IX-1
RESIDENTIAL INDOOR WATER USE

Washing machine 22%

Toilets 35%

Faucets 13%

Dishwasher 2%

Baths 10%

Showers 18%
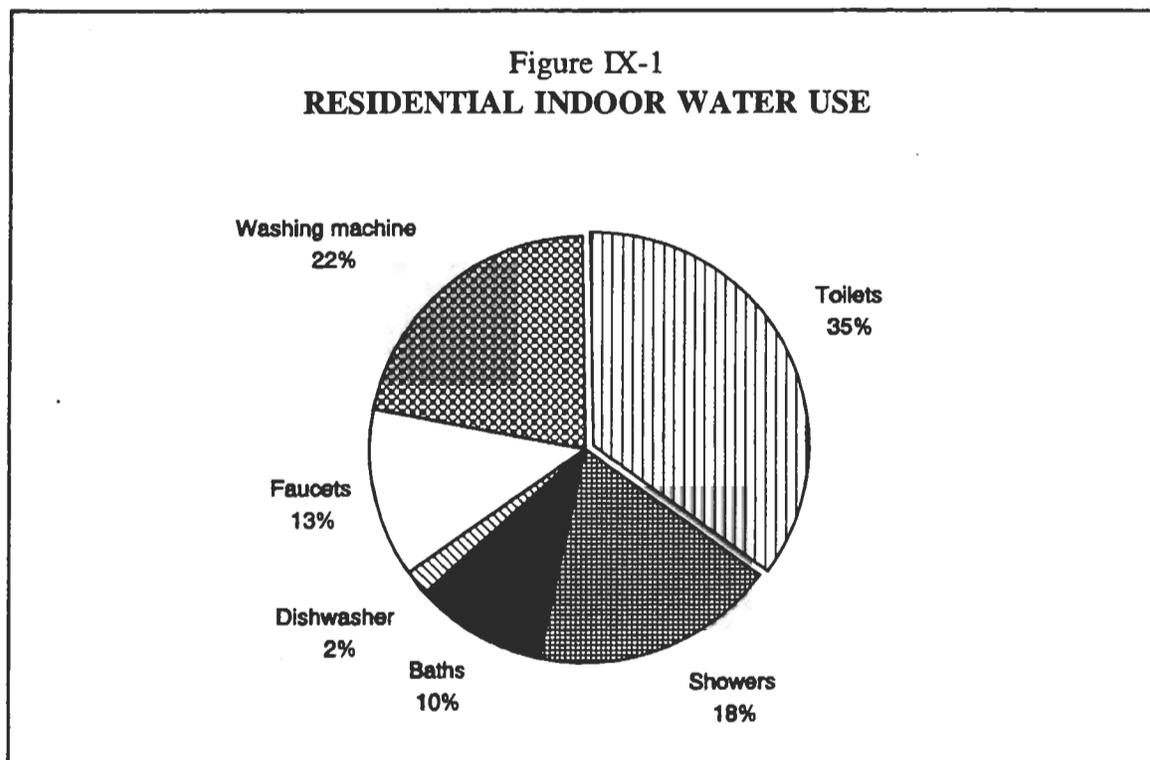
Business Class

To identify appropriate conservation programs for nonresidential classes, data that categorize the use of each parcel in the District were obtained from the Alameda County Tax Assessor. In spite of the imperfect correspondence between tax assessment units and ACWD accounts, this information can still provide insight into the composition of each customer class.

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[34]See Planning and Management Consultants, Ltd., *Seasonal Components of Urban Water Use in Southern California* (Los Angeles: Metropolitan Water District of Southern California, February 1990); and Brown and Caldwell, *Residential Water Conservation Projects Summary Report* (Washington, D.C.: U.S. Department of Housing and Urban Development, June 1984).

Table IX-5 shows the breakdown of the business sector by tax assessment units. The business sector consists of 2,778 ACWD accounts.

Table IX-5
BUSINESS CLASS CATEGORIES

Category	Tax Assessment Units	Percent
Retail	2,145	46%
Hotels and Motels	1,854	36%
Offices	547	11%
Hospitals	163	3%
Service stations and carwashes	69	1%
Other	173	3%
Total	5,221	100%
Source: Alameda County Tax Assessor.		

Table IX-6 presents estimates of indoor and outdoor usage for key sectors of the business class. Indoor use constitutes between 80% and 90% of total water demand by business customers. This large end use represents great potential for conservation.

The hotel/motel sector has both highest indoor and the highest outdoor water consumption per square foot; this sector comprises a large (36%) share of business class assessment units (i.e., large market size). Therefore, this category may offer great potential for conservation.

Table IX-6
INDOOR/OUTDOOR WATER USE IN THE BUSINESS CLASS

Customer Sector	Indoor Use	Outdoor Use
Office	211 gpd/1,000 sq. ft. (80%)	49 gpd/1,000 sq. ft. (20%)
Retail	231 gpd/1,000 sq. ft. (90%)	23 gpd/1,000 sq. ft. (10%)
Hotels/Motels	667 gpd/1,000 sq. ft. (84%)	123 gpd/1,000 sq. ft (16%)
Source: Brown & Caldwell, *Water Demand Investigation and Forecast* (Fremont, Calif.: ACWD, July 1993).		

Office buildings and retail establishments are unlikely to have extensive landscaping; approximately 17% of total water consumption in these categories is for outdoor uses.[35] Even though outdoor use represents a small portion of total demand for these customer segments, this end use should be targeted for conservation. This is because it is common for small landscape plots to be irrigated inefficiently. Thus, conservation programs that target office and retail businesses should focus on both indoor and outdoor water use.

Industrial Class

Table IX-8 shows the breakdown of the industrial sector by tax assessment units. the industrial sector consists of 195 ACWD accounts.

Table IX-8
INDUSTRIAL SECTOR CATEGORIES

Category	Tax Assessment Units	Percent
Warehouses	6,443	75%
Light Industry	1,256	15%
Heavy Industry	79	9%
Other	798	1%
Total	8,576	100%
Source: Alameda County Tax Assessor		

The industrial sector uses 12% of the total water supplied by the District, but has the highest use per account (6,317 gpd/account), according to the Brown & Caldwell demand study. Although warehouses constitute the largest segment of the industrial sector, it is likely that they are not heavy water users. Therefore, the per account water use for light and heavy industry is probably even higher than the per account average indicates for this sector. This demand disaggregation implies that conservation programs should target the industrial sector even though it represents a small portion of demand compared to the residential sector. This is because even a small percentage water savings for each account could result in a significant volume of savings overall.

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[35]*Ibid.*

Industrial end uses are more diverse than residential end uses. Therefore, conservation efforts aimed at industrial customers must be based on an understanding of how these customers use water.

New United Motors Manufacturing, Inc. (NUMMI) represents over 25% of total industrial water demand. However, NUMMI has a progressive water conservation program and has made significant reductions in water consumption by recycling water used for air conditioning and by reusing wet sanding water. These two systems have saved over 295,000 gpd, or 19% of average daily use. Therefore, the reduction potential in NUMMI's demand is not addressed in this study. Consequently, NUMMI's water use was not included in the industrial water end-use disaggregation.

Because ACWD does not have end-use data for its business and industrial customer, permit data from Union Sanitary District (USD) was used as a proxy. USD requires permits for business and industrial accounts that discharge more than 25,000 gpd or that have effluent that requires pre-treatment before discharge. Approximately 16% of the ACWD industrial accounts are permitted.

The specific water use patterns of USD-permitted industrial customers are not generalizable to the entire service area. However, they can be extrapolated to provide a picture of industrial water use and to target particular end uses for conservation.

USD discharge data indicate that for permitted accounts, irrigation represents 7% of total water demand. USD discharge data for permitted *and* nonpermitted accounts show that, overall, 12% of industrial water is used for irrigation. This is more consistent with the Brown & Caldwell study (17%) as well as the ACWD Urban Water Management Plan (15%). This difference may be attributable to the fact that permitted accounts are likely to be more process-intensive and therefore use a greater percentage of their water in their industrial processes than unpermitted accounts.

End uses for permitted industrial customers were used to extrapolate water end uses for the entire industrial class. This was done by adjusting the percentage of water used for irrigation to correspond with the Brown & Caldwell study and accordingly calibrating the percentages for other end uses. The extrapolated end uses for the industrial customers are shown in Table IX-9.

Table IX-9
EXTRAPOLATED END USES FOR ACWD INDUSTRIAL CUSTOMERS

End Use	Annual Water Use*		% of Total Water Use
	(ccf)	(mgd)	
Industrial processes	536,230	1.10	37.9
Cooling	245,380	0.50	17.3
Irrigation	240,810	0.49	17.0
Washing	113,740	0.23	8.0
Domestic uses	110,320	0.23	7.8
Product	52,620	0.11	3.7
Boiler	34,270	0.07	2.4
Other	82,530	0.17	5.8
Total	1,415,900	2.90	100

*Water use does not include NUMMI.
Source: USD discharge data.

Table IX-9 shows that process equipment, cooling, and irrigation are the largest end uses for industrial customers. The District should target these end uses for conservation. Furthermore, these end uses and potential savings are site-specific. Thus, the District can best address them through customized programs.

Institutional Class

According to USD discharge data, which omit large irrigators such as City Park and Recreation, only 6% of water use in this customer class is used for irrigation. Therefore, this customer class should be targeted for indoor conservation. Most large irrigators in this customer class have separate landscape meters. Therefore, outdoor conservation measures applicable to this customer class will be included in the landscape category.

Landscape Class

Water use in the landscape sector is shown in Table IX-10.

Table IX-10
WATER USE IN THE LANDSCAPE CLASS

Category	Number of Accounts	Annual Water Use		Annual Use Per Acct (ccf/yr/acct)
		(ccf/yr)	(% of total)	
Landscape only	342	462,760	38	1,353
Institutional	464	323,620	26	697
Industrial	149	194,320	16	1,304
Business	146	249,480	20	1,709
Total	1,101	1,230,180	100	1,117
Source: ACWD water use data.				

Even though the landscape sector constitutes a small portion of the District's demand, Table IX-10 shows that per account consumption in this sector is relatively large.

Major Water Use Accounts

Many of the BMPs contained in the MOU suggest targeting the top 10% or 20% of water users. Analysis of ACWD consumption data indicates that, for the Business, Industrial, and "Other" customer classes, such targeting makes good sense. These customers account for approximately 25% of District demand. In each case, a relatively small number of large accounts constitute the bulk of this demand, as illustrated in Table IX-11.

Table IX-11
AVERAGE ANNUAL USE FOR THE TOP NONRESIDENTIAL ACCOUNTS

Customer Class	Average Annual Use (% of Total Class Use)		
	Top 5% Accounts	Top 10% Accounts	Top 20% Accounts
Business	50	65	N/A
Industrial	77	80*	N/A
"Other"	52	68	83
*Datum is for top 8% of accounts. Data for top 10% not available.			

As discussed previously, the results of the demand disaggregation were used to guide the design of the District's conservation programs, as follows:

- Because residential customers account for 68% of water use in the District, most of the conservation programs target this class.

- Indoor plumbing, i.e., showers, toilets, and faucets, constitutes a major portion of indoor water use. Together these fixtures account for over 65% of indoor water use. The economic screen showed that retrofitting toilets and showerheads with water-efficient models is clearly cost-effective. The economic screen also showed that the installation of faucet aerators is a cost-effective conservation measure. Therefore, many of the programs target these end uses.

- Although outdoor water use is a smaller component of residential water use than indoor water use, outdoor use nonetheless contributes substantially to peak seasonal demands. It has been the experience of the District that there is significant potential to increase the efficiency of its customers' outdoor water use. Moreover, a number of residential outdoor conservation measures are potentially cost-effective. Thus, outdoor residential water use retrofits are also a prime target for conservation.

- New residential construction is a logical target for water-efficient landscapes. Landscape measures for new residential construction are highly cost-effective, since the incremental cost of installing efficient outdoor irrigation equipment and water-efficient landscaping is low or

nonexistent. Programs concentrate on encouraging or requiring developers to focus on those types of installations.

- Since state legislation already requires the installation of water-efficient plumbing in new construction, no additional District programs were proposed in this area.

- Because 57% of business sector demand consists of retail stores and offices, and over 80% of the water used by these customers is indoor, business sector conservation programs targeted plumbing fixtures, notably toilets and urinals.

- The majority of the business sector customers are unlikely to have extensive landscaping. As discussed above, those that do have large landscapes have been classified as landscape accounts and are addressed by programs that target "landscape" accounts.

- Since the water savings associated with different industrial water conservation measures are highly site specific, industrial sector programs allow for the case-by-case evaluation of measures through customized audits and rebates.

- Similarly, programs that target large landscapes allow for case-by-case evaluation because the savings are again highly site specific. Because the economic screen shows that modifying landscaping material and irrigation equipment is extremely cost-effective in new construction, landscape conservation programs focus on this target segment.

- Landscape programs also include a significant focus on training because the efficiency of any irrigation system depends largely on the manner in which it is operated.

CONSERVATION PROGRAMS

After conducting the qualitative and economic screening of conservation measures, and disaggregating demand, water conservation programs were developed. These programs combine measures that pass the screening process with appropriate delivery mechanisms. The design of the programs also reflects the District's commitment to implement conservation BMPs, as set forth in the MOU. Each program is directed at

a particular customer sector and/or end use, as identified in the demand disaggregation. Twelve programs were developed as follows:

1. Residential Audits and Direct Installation (of Cost-Effective Conservation Measures)
2. Conservation Kit Distribution
3. Ultra Low Flush Toilet (ULFT) Replacement
4. Low-Income Direct Installation (of Cost-Effective Indoor Conservation Measures)
5. Student Home Water Audit Program
6. Residential New Construction: Low-Water-Use Landscaping
7. Residential Water-Efficient Landscape Design Workshops
8. Business/Industrial Audits and Customized Rebates
9. Industrial Cooling Tower Workshops
10. Nonresidential New Construction
11. Large Landscape Audits and Customized Rebates
12. Irrigation Workshops

Appendix E presents detailed descriptions of the conservation programs.

The following criteria were used to evaluate the conservation programs:

- **Utility Program Costs.** This criterion includes costs of the measure itself, marketing costs, incentive costs, and contractor costs. It does not include participant costs, utility staffing costs, or revenue losses. Estimates of staffing requirements for each program are developed separately. Cost ranges are used to capture the uncertainty regarding cost estimates.

- **Achievable Savings.** For each program, the achievable savings over the program life are estimated by combining assumptions regarding program participation rates, "freeridership," program lifetimes,[36] savings per participant, and persistence (longevity) of savings. As with program costs, ranges are used to capture uncertainty.

- **Revenue Losses.** These are a function of achievable savings and the forecasted average water rates. The assumed current water rate is $1.142 per hundred cubic feet.

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[36]This parameter is a weighted average of the measure savings.

- **Equivalent Unit Cost of Conserved Water.** This parameter combines the utility program costs and the lifetime savings estimates to compute a discounted cost per acre-foot of water saved. This quantity can be easily compared to the unit cost of supply alternatives.

- **Demand "Hardening" Impacts.** To some extent, all long-term conservation programs affect the District's ability to achieve future short-term emergency reductions in water use in response to drought or catastrophic events. This phenomenon is often referred to as "demand hardening." An attempt was made to qualitatively evaluate the extent to which each conservation program hardens demand.

  In general, programs that have long lead times, such as industrial audits and rebates or ULFT retrofits, could not have been used to achieve rapid short-term reductions in water use. Therefore, these programs have a *low* demand hardening impact. Conversely, programs such as conservation kit distribution that have short lead times and could have been used to manage shortages have *high* demand hardening impacts.

  Landscape programs that encourage replacement of turf with water-efficient landscaping may have a *high* demand hardening impact because, in event of a shortage, customers may be less willing to sacrifice a relatively expensive landscape than they would be to sacrifice a lawn.

  Programs that encourage water-efficient behaviors, such as efficient irrigation practices or showering or flushing reductions, reduce the amount of "slack" that will be available in a drought event. These programs therefore are also said to have high demand hardening impacts.

  Programs that involve the distribution of water-efficient devices (e.g., efficient showerheads and toilet retrofit devices) have a *medium* demand hardening impact. Although those devices can be distributed in response to a drought or catastrophic event, large-scale distribution networks require several months start-up time before they achieve significant penetration.

For each program, the following parameters were developed to evaluate program performance against the above criteria:

- Program lifetime
- Participation rates
- Water savings per participant

- Persistence of savings
- Program costs
- Marketing and costs
- Customer incentives
- Participant costs

Table IX-12 summarizes the estimates of the conservation program parameters. Table IX-13 summarizes the programs by target customer classes and end uses. Table IX-14 illustrates the BMPs to which each program is applicable.

CONSERVATION PROGRAM PACKAGES

To facilitate the integration of conservation options with supply options, the individual conservation programs were grouped into four different packages. Table IX-15 summarizes the packages. The packages differ in the intensity of District effort and target different end uses. Each package is implemented separately, as follows:

- Package 1 represents the minimum level of District effort
- Package 2 focuses on reducing outdoor water demands
- Package 3 focuses on reducing indoor water demands
- Package 4 is the most aggressive package; it includes all 12 conservation programs under consideration

The cost and savings estimates for these packages are not simply the sum of the estimates for the component programs. For example, two or more programs that target similar end uses in similar customer classes may be redundant if offered concurrently (e.g., the Conservation Kit Distribution Program and the Residential Audits and Direct Installation Program). Other programs, such as Large Landscape Audits and Irrigation Workshops, may have synergistic effects and may cumulatively save more than the sum of their respective program savings. They may also cost less to implement primarily due to staffing economies. Staffing costs were developed for all conservation packages. These costs are included in the utility's costs shown on Table IX-16, which summarizes the costs and savings associated with the four conservation packages.

The conservation packages were evaluated using the IRPM. Water demand for benchmark years 2000, 2010, 2020, and 2030 was decreased by potential water savings that may be realized from implementing each of the conservation packages. Packages 2, 3, and 4 were found to best reduce water demands at critical times (i.e., peak-season and drought-year demands). When compared to Packages 2 and 3,

Table IX-12
ESTIMATED CONSERVATION PROGRAM PARAMETERS

Program	Present Value of Utility Costs[a] ($)	Total Water Savings Over 35-Year Planning Horizon (mil. gal.)	Maximum Annual Savings (mil. gal.)	Equivalent Marginal Supply Cost[b] ($/af)	Present Value of Revenue Losses ($)	Demand Hardening Impact
Program 1: Residential Audits and Direct Installation						
Option A: target top 20%, two-tier landscape audit	798,000–1,614,000	2,540–5,030	75–150	163–166	2,204,000–4,366,000	Medium
Option B: target top 20%, single-tier landscape audit	798,000–1,614,000	1,980–3,928	59–117	210–213	1,720,000–3,411,000	Medium
Program 2: Conservation Kit Distribution						
Option A: district-only program	690,000	3,123	313	82	4,214,000	Medium
Option B: joint program with PG&E	233,000	3,123	313	28	4,214,000	Medium
Program 3: ULFT Replacement						
Option A: $75 rebate & CBO	2,952,000–5,849,000	7,809–12,520	388–622	180–212	3,794,000–13,675,000	Low
Option B: $75 voucher	3,177,000–6,425,000	7,095–9,855	352–683	212	7,385,000–15,023,000	Low
Program 4: Low-Income Direct Installation	485,000–731,000	1,420–2,142	79–119	148	1,632,000–2,460,000	Medium
Program 5: Student Home Water Audit Program	15,000–64,000	35–352	3.5–35	68–162	47,000–470,000	Medium
Program 6: Residential New Construction: Low-Water-Use Landscaping	102,000–557,000	197–1,949	13–77	165–246	205,000–1,444,000	Medium
Program 7: Residential Water-Efficient Landscape Design Workshops	41,000	26–53	1.8–3.5	326–637	63,000	High
Program 8: Business/Industrial Audits and Customized Rebates	707,000–2,458,000	1,665–5,803	50–177	220	1,432,000–4,976,000	Low
Program 9: Industrial Cooling Tower Workshops	11,000	111–668	5.6–33	7–41	130,000–780,000	Low
Program 10: Nonresidential New Construction	113,000–1,819,000	785–13,324	39–780	74–83	746,000–1,809,000	Low
Program 11: Large Landscape Audits and Customized Rebates	544,000–694,000	2,043–4,087	75–150	92–144	1,884,000–3,769,000	High
Program 12: Irrigation Workshops	16,000	19–97	4.5–19	61–293	27,000–131,000	High

[a] Includes incentives costs.
[b] Present value of utility costs divided by the discounted stream of water savings that are expected from the program. Does not include participant costs, utility staffing costs, or revenue losses.

Table IX-13
CONSERVATION PROGRAM CONCEPTS, TARGET CUSTOMER CLASS, AND END USES

Program	Target Customer Class						Target End Use	
	Res.	Small Bus.	Large Bus.	Ind.	Other	Landscape	Indoor	Outdoor
1. Residential Audits and Direct Installation	✓						✓	✓
2. Conservation Kit Distribution	✓	✓					✓	✓
3. ULFT Replacement	✓	✓	✓		✓		✓	
4. Low-Income Direct Installation	✓						✓	
5. Student Home Water Audit Program	✓						✓	✓
6. Residential New Construction: Low-Water-Use Landscaping	✓						✓	✓
7. Residential Water-Efficient Landscape Design Workshops	✓					✓		✓
8. Business/Industrial Audits and Customized Rebates			✓	✓			✓	✓
9. Industrial Cooling Tower Workshops				✓			✓	
10. Nonresidential New Construction		✓	✓	✓			✓	
11. Large Landscape Audits and Customized Rebates						✓		✓
12. Irrigation Workshops						✓		✓

Table IX-14
APPLICABILITY OF PROGRAM CONCEPTS TO BMPs

Program	BMP No.								
	1	2	5	6	8	9	10	12	16
1. Residential audits and direct installation	✓	✓						✓	
2. Conservation kit distribution		✓				✓		✓	
3. ULFT replacement						✓			✓
4. Low-income direct installation	✓	✓							✓
5. Student home water audit program	✓	✓			✓				
6. Residential new construction: low-water-use landscaping								✓	
7. Residential water-efficient landscape design workshops								✓	
8. Business/industrial audits and customized rebates						✓			
9. Industrial cooling tower workshops						✓			
10. Nonresidential new construction				✓			✓		
11. Large landscape audits and customized rebates			✓						
12. Irrigation workshops			✓						

Key to BMPs:
1. Interior and exterior water audits and incentive programs for single-family residential, multifamily residential, and governmental/institutional customers.
2. Plumbing, new and retrofit.
5. Large landscape water audits and incentives.
6. Landscape water conservation requirement for new and existing commercial, industrial, institutional, governmental, and multifamily developments.
8. School education.
9. Commercial and industrial water conservation.
10. New commercial and industrial water use review.
12. Landscape water conservation for single-family homes.
16. Ultra-low-flush toilet replacement.

Table IX-15
PROGRAMS CONTAINED IN CONSERVATION PACKAGES

PACKAGE 1: MINIMAL DISTRICT EFFORT	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 8. Business/Industrial Audits and Customized Rebates	10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates
PACKAGE 2: SEASONAL DEMAND REDUCTION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 6. Residential New Construction:Low-Water-Use Landscaping 7. Residential Water-Efficient Landscape Design Workshops	8. Business/Industrial Audits and Customized Rebates 9. Industrial Cooling Tower Workshops 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates
PACKAGE 3: ANNUAL DEMAND REDUCTION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 3. ULFT Replacement 4. Low-Income Direct Installation	5. Student Home Water Audit Program 8. Business/Industrial Audits and Customized Rebates 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebate
PACKAGE 4: COMPREHENSIVE CONSERVATION	
1. Residential Audits and Direct Installation 2. Conservation Kit Distribution 3. ULFT Replacement 4. Low-Income Direct Installation 5. Student Home Water Audit Program 6. Residential New Construction:Low-Water-Use Landscaping	7. Residential Water-Efficient Landscape Design Workshops 8. Business/Industrial Audits and Customized Rebates 9. Industrial Cooling Tower Workshops 10. Nonresidential New Construction 11. Large Landscape Audits and Customized Rebates 12. Irrigation Workshops

Numbers denote program numbers (see Appendix G).

Package 4—the most aggressive and costly package—did not reduce demands during critical periods enough to warrant the additional costs. Therefore, Packages 1 and 4 were eliminated. Packages 2 and 3 were passed on to the resource plan integration phase (described in Section X) and combined with supply-side alternatives to meet District planning objectives.

Table IX-16
COSTS AND SAVINGS OF THE CONSERVATION PACKAGES

	Package 1	Package 2	Package 3	Package 4
Present value of utility costs ($)[a, b]	4,218,000–5,768,000	5,101,000–11,071,000	8,866,000–17,877,000	9,742,000–19,230,000
Present value of revenue losses ($)[a, b]	13,540,000	14,113,000–34,822,000	21,965,000–42,964,000	22,424,000–46,020,000
Total water savings over 35-year planning horizon (af)[b]	27,213	43,200–116,670	65,310–135,590	66,820–145,780
Maximum annual savings (afy)[b]	1,510	1,550–4,900	2,540–4,490	2,570–4,840
Equivalent unit cost ($/af)[b, c]	290–400	340–350	370–410	400–420

[a]Includes measure costs of the measures, marketing, incentives, contractor and staffing costs. Does not include participant costs or revenue losses.
[b]A range of savings and costs is provided in most cases to account for uncertainties.
[c]Present value of utility costs divided by the discounted stream of water savings that are expected from the conservation package.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

RESOURCE PLAN INTEGRATION AND EVALUATION

ACWD Integrated Resources
Planning Study Process

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┌─────────────────────┐          ┌─────────────────────┐
│  Policy Objectives  │          │   Demand Forecast   │
└──────────┬──────────┘          └──────────┬──────────┘
           │                                │
           │                                ▼
           │                     ┌─────────────────────┐        ┌─────────────────────┐
           │                     │  Evaluate Current   │        │ Integrated Resources│
           │                     │  System Resources   │◄······ │   Planning Model    │
           │                     │   and Operations    │        └─────────────────────┘
           │                     └──────────┬──────────┘
           ▼                                │
┌─────────────────────┐                     ▼                   ┌─────────────────────┐
│ Evaluation Criteria │────────►┌─────────────────────┐         │     Resource        │
└─────────────────────┘         │    Characterize     │         │    Assessment       │
                                │  Resource Options   │◄────────│  • Supply-Side      │
┌─────────────────────┐         └──────────┬──────────┘         │  • Demand-Side      │
│Define Future        │                    │                    └─────────────────────┘
│Uncertainties        │──┐                 │
│and Potential Outcomes│ │                 ▼
└──────────┬──────────┘  │      ┌─────────────────────┐
           │             │      │   Form Potential    │
           ▼             │      │ Resource Sequences  │
┌─────────────────────┐  │      └──────────┬──────────┘
│ Define Uncertainty  │──┘              Narrow
│     Scenarios       │                    │
└─────────────────────┘                    ▼
                                ┌─────────────────────┐
                                │Test Sequences Against│◄···
                                │  Evaluation Criteria │
                                └──────────┬──────────┘
                                        Narrow
                                           │
                                           ▼
                                ┌─────────────────────┐
                                │   Form Resource     │
                                │     Strategy        │
                                └──────────┬──────────┘
                                           │
                                           ▼
                                ┌─────────────────────┐
                                │       Final         │
                                │   Recommendations   │
                                └─────────────────────┘
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X. RESOURCE PLAN INTEGRATION AND EVALUATION

The Phase 2 characterization of water system reliability under a "no action" alternative serves as the basis for developing resource sequences. The sequences allow the District to attain operational efficiency and make optimal use of its resources (e.g., increase production capacity, maximize use of surplus supplies, minimize groundwater losses). Resource sequences were developed for a range of reliability goals. Furthermore, the sequences span the range of resource development, and therefore, allow the District to evaluate trade-offs among evaluation criteria.

BASIS FOR DEVELOPMENT OF RESOURCE SEQUENCES

As described in Section VII, IRPM was used to simulate the District's current operation and coordination of existing supplies. The purpose of this analysis was to evaluate the adequacy of existing supplies and facilities to meet future water demands under a range of base case conditions. Model simulations were run for years 2000, 2010, 2020, and 2030. The resulting use and distribution of supply sources, quantity and frequency of potential water shortages and surpluses, and system capacity constraints were evaluated for each of these benchmark years to determine the mix of resources needed to meet future water demands. Key Phase 2 evaluation results used to develop resource sequences are summarized in Table X-1.

Table X-1
KEY PHASE 2 EVALUATION RESULTS

Year	Additional Required Capacity (mgd)		Range of Dry-Year Shortages (afy)	Range of Wet-Year Surpluses (afy)	Groundwater Losses When BHF is > +10 MSL (afy)
	Max. Month	Max. Day*			
2000	0	0–7	0–23,200	21,800–34,900	12,100–30,000
2010	0	4–12	0–27,500	19,900–34,200	13,400–31,500
2020	0–3	8–17	0–31,200	16,800–33,300	3,100–27,000
2030	5–13	17–27	1,900–37,400	11,500–28,700	3,000–25,900
*Estimate based on maximum day demand of 1.8 times average day demand.					

Supply-side and demand-side resource options were evaluated individually and in combination using the IRPM. Based on the above Phase 2 evaluation results, resource options were added to the existing system and supplies in order to meet additional capacity needs, water supply needs, and to better use surplus water and minimize groundwater losses.

OPERATIONAL EFFICIENCY

Resource options were combined to make optimal use of existing and future District resources. The following observations were noted in determining the most efficient combination of alternatives.

Storage

As evidenced by the extent of dry-year shortages and wet-year surpluses, a key to meeting water demands and making better use of existing supplies is increasing storage capacity. Supplemental supplies are most needed in drought years. In normal or wet years, these additional supplies may not be needed. Therefore, resource alternatives that provide additional supplies every year are not used efficiently unless additional storage capacity is available. To that end, most of the resource sequences evaluated included additional storage capacity.[37]

Groundwater Operations

As described previously, groundwater production is limited by the need to maintain groundwater elevation above sea level and by limiting the amount of higher hardness groundwater blended with lower hardness SFWD water to maintain a blended water quality of less than 175 ppm. Increasing the amount of groundwater production and drawing the basin below sea level provide only a small water supply benefit if hardness is not allowed to increase. Conversely, increasing production and raising hardness limitations provide only a small water supply benefit because the amount of production is also limited by the need to maintain groundwater levels above sea level. However when the two alternatives are combined, total supply availability and system

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[37]Storage alternatives located in the Alameda Creek Watershed could potentially store additional local runoff as well as surplus SWP entitlement. Storage alternatives outside of the Alameda Creek Watershed could only be used for storage of SWP entitlement or agricultural transfer water. In the IRPM simulations, storage alternatives were evaluated without regard to location and, therefore, assumed storage of only surplus SWP entitlement water.

X-2

production capacity is increased. Therefore, to maximize the use of groundwater resources, either hardness constraints must be relaxed or a desalination plant must be added to the system to eliminate the hardness constraint.

In addition, groundwater losses are observed when groundwater levels rise above +10 feet Mean Sea Level (MSL). In order to minimize these losses and more efficiently remediate both the Newark and Centerville-Fremont and Deep Aquifers, ARP pumping, in addition to the required amount of pumping described in Section VII, was increased by 625 acre-feet in the Newark Aquifer and by 900 acre-feet in the Centerville-Fremont and Deep aquifers in every month when groundwater elevation below the fault was above +10 feet MSL. Appendix D contains a detailed description of the ARP program analysis.

CONSIDERATION OF CONSERVATION PACKAGES

Each resource sequence was evaluated with conservation packages 2 and 3. Since Conservation Package 2 was targeted at reducing seasonal demands, this package was most effective in reducing peak month production capacity requirements. As discussed in Section VII, peak monthly shortages are expected to occur much sooner in the planning horizon than average monthly shortages. In addition, Package 2 was more cost effective than Package 3. For these reasons, package 2 was selected for incorporation into the final resource scenarios.

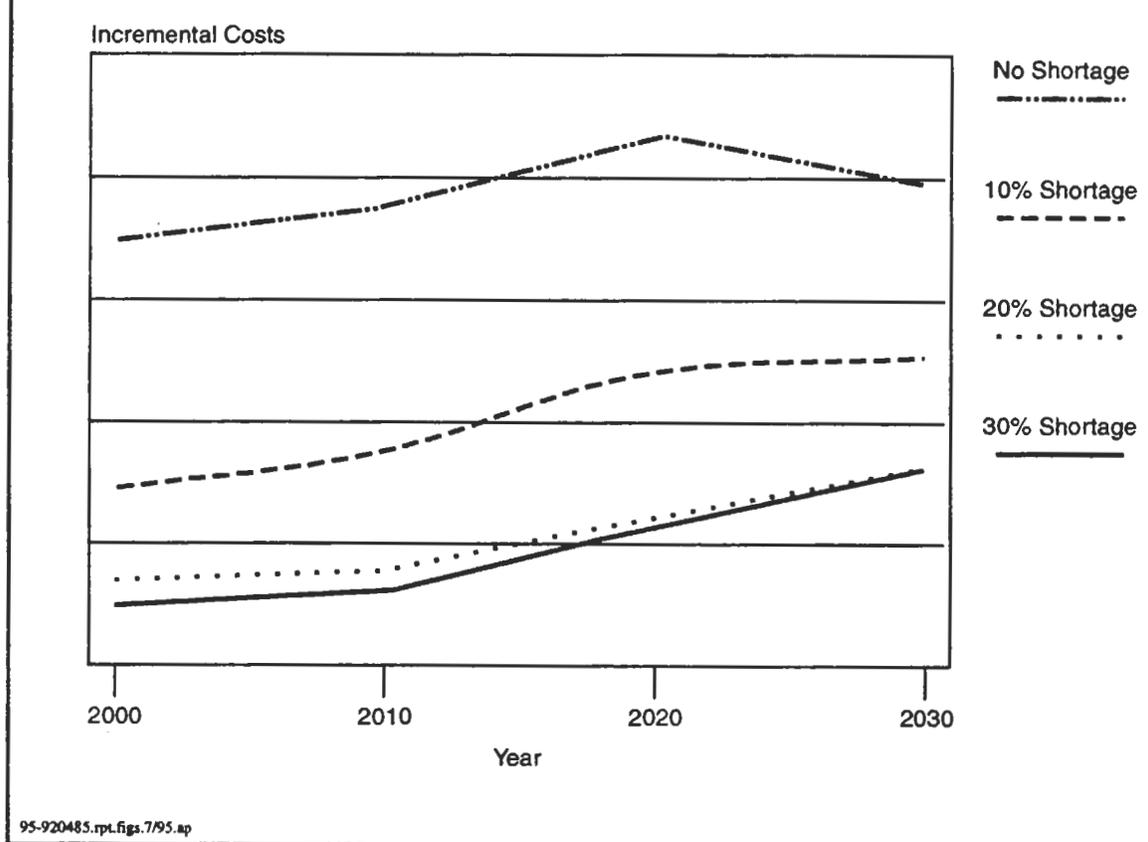## WATER SUPPLY RELIABILITY GOALS

Resources were combined to attain a range of reliability goals. The lowest level of reliability considered had a maximum annual shortage of 30% occurring once in 30 years. The highest reliability level had no shortages at all. More resources must be added to increase water supply reliability, resulting in increased cost. The incremental cost of attaining each level of reliability was evaluated to help determine the appropriate future water supply reliability goal. Figure X-1 shows the relative costs of attaining reliability goals of 30%, 20%, 10%, and 0% maximum shortage.

As part of a contingent valuation survey prepared for the California Urban Water Agencies,[38] District residential customers were surveyed and asked about their willingness to pay to avoid certain frequencies and magnitudes of shortages.

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[38]Barakat and Chamberlin. *The Value of Water Supply Reliability*. Prepared for the California Urban Water Agencies. August 1994.

Figure X-1
Relative Cost to Customers of Reducing Shortages

Incremental Costs

No Shortage
— ·· — ·· — ··

10% Shortage
— — — — ·

20% Shortage
· · · · · · ·

30% Shortage
————————

2000   2010   2020   2030

Year

95-920485.rpt.figs.7/95.ap

Responses indicated that customers would be willing to pay between $11.98 and $13.69 per month in addition to their current water bill to avoid shortages ranging from a 20% shortage once every 30 years to a 40% shortage every 10 years. In addition, customers attending each of the public presentations were asked what level of reliability they would prefer.

All resource sequences evaluated are estimated to cost less than the indicated willingness to pay. Resources sequences attaining a water supply reliability of no more than a 10% shortage once in 30 years were less than half of the amount residents claimed they were willing to pay in the CUWA survey.[39]

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[39]Based on a bi-monthly customer water use of 28 units (ccf) per household or business.

X-4

Based on the survey results and customer responses at the public presentations, a water supply reliability goal of no more than 10% shortages once in 30 years was set. Therefore, sequences were developed to attain this reliability goal, with one exception. Resource Sequence 1, which was designed to maximize use of existing resources and minimize development of new supplies and facilities, could not meet this goal. New supplies and facilities are needed to attain the water supply reliability goal.

RESOURCE SEQUENCE CHARACTERISTICS AND TRADE-OFFS

Each resource sequence was designed to focus on a type of resource or a specific evaluation criterion. Table X-2 summarizes the characteristics of each sequence and the key trade-offs evaluated.

Table X-2
RESOURCE SEQUENCES—
SUMMARY CHARACTERISTICS AND TRADE-OFFS

Sequence	Sequence Characteristics	Key Trade-Offs
1	Minimize the use of new supplies and facilities; maximize use of existing supplies and conservation.	High local control, low cost. High hardness, low reliability, lack of groundwater basin protection.
2	Maximize water quality, basin protection; develop new supplies & facilities	Higher cost Higher water quality
3	Mix of conservation, operational alternatives, new supplies and facilities	Contains a more balanced mix of trade-offs. Trade-offs are evaluated when compared to other sequences.
3A	Same as Sequence 3 except hardness at the Blending Facility is allowed to increase from 150 ppm to 175 ppm; eliminates additional WTP capacity increase.	Higher hardness and lower cost compared to Sequence 3.
4	Heavily focused on water transfers.	Lower local control, higher supply availability risk versus lower cost when compared to Sequence 3.

Sequence	Sequence Characteristics	Key Trade-Offs
5	Heavily focused on water reclamation.	Higher local control, lower supply availability risk. High cost due to reclamation.
6	Heavily focused on desalination.	Higher risk of not meeting water quality standards but lower cost when compared to sequence 6.
6A	Same as 6 without desalination. Hardness is increased at the blending facility.	Lower cost and lower water quality when compared to 6.
7	Includes all resource alternatives.	Comparison of the benefits of adding multiple, smaller size facilities & supplies

Table X-3 shows all resource alternatives included in each sequence that were added to the existing system to meet water supply needs through the year 2030. Resource alternatives were phased in over time beginning in the year 2000 and continuing to 2010, 2020, and 2030. Appendix H details the timing and sizing of alternatives included in each resource sequence.

CALCULATION OF COSTS

The addition of new resource alternatives will change the use of existing sources of supply (i.e., the quantity of water produced over time at each facility). To capture both the costs associated with the addition of new resources as well as the variable costs of existing supplies as use of those supplies changes, the IRPM was used to calculate costs.

The IRPM simulates the quantity of water produced annually from each facility through the year 2030. The cost post-processor multiplies the variable cost (dollar per acre-foot) by the quantity of water produced and calculates the total annual variable costs for each year through the year 2030. Annual variable costs were calculated for the "no action" alternative and for each resource sequence. The total net present value of existing and proposed resource alternatives was determined by discounting the annual variable costs and capital costs of new resource alternatives back to present value at a nominal discount rate of 8% less a 3% rate of inflation. To compare all

Table X-3
SUMMARY OF RESOURCE ALTERNATIVES IN EACH SEQUENCE

Sequence Number	Conser-vation	Hardness (mg/L)	BHF level (ft below MSL[a])	Agricultural Transfer		Storage/ Banking	Desali-nation	Reclamation			Additional TP Capacity
				Annual	Drought			Phase 1	Phase 2	Phase 3	
1	•	UNLTD	−40			•					•
2		150			•		•	•	•	•	
3	•	150	≥5			•	•	•	•		•
3A	•	150–175	≥5			•	•	•	•		
4	•	150--175	≥5	•		•					
5	•	150–175		•		•		•	•	•	
6	•	150		•		•	•				
6A	•	UNLTD		•		•					
7	•	150		•	•	•	•	•			

[a]MSL—Mean Sea Level

additional costs associated with proposed resource alternatives, the net present value of operating costs under the "no action" alternative was subtracted from the total new present value of costs under each resource sequence.

Table X-4 summarizes the annual capital costs of new resource alternatives and the annual variable (operating and maintenance) costs of existing resources and new resource alternatives. The net present value of additional capital and operating costs that would be incurred under each resource sequence is shown in Table X-5.

SCORING RESOURCE SEQUENCES

Based on the foregoing nine resource sequences, the final step in the resource planning process is to formulate a recommended strategy. This is accomplished by first rating the resource sequences against the evaluation criteria to select that sequence which best meets the District's objectives. The modifications in that sequence that result from different combinations of uncertainty outcomes define the resource strategy that the District will pursue.

As discussed in Section VI, IRPM calculates the following parameters:

- Annualized capital cost of new resources;

- Annual O&M cost of new resources;

- Hardness; and

- Reliability, defined as the expected unserved demand in drought years, expressed as a percentage of annual demand.

The first two parameters were used to calculate the cost of the resource sequences, expressed in net present value 1994 dollars.

The nonmodel evaluation criteria were calculated using the scores of the individual resource options presented in Section VIII. The scores discussed in Section VIII (i.e., +, ✓, –) were converted to ordinal scores, with + corresponding to a score of 1, and – corresponding to a score of 3.[40] For each criterion, the score of the sequence is the weighted average score of the individual resource options. For factors such as local control, the additional benefit of a resource is proportional to the water

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[40]Recall that a 1 is the highest rating and a 3 is the lowest.

Table X-4
SUMMARY OF RESOURCE AVOIDABLE COSTS

Existing Facilities/ Supply Sources	Item	Annual Fixed Cost ($/yr)	Reference or Acct/Job Cost ($/yr)	Ann. Var. Cost ($/afy)	Reference or ACWD Acct/Job Number
SWP [1]	Variable OMP&R Trans.	N/A	N/A	$31.57	DWR Bulletin #132-93 Table B-18
Lake Del Valle (local water only)	Storage Transportation	N/A	N/A	$3.91 $5.83	DWR trans. charges based on 1994–95 Water Cost Forecast
	Subtotal	N/A	N/A	$9.74	
San Francisco Water	Source of Supply Power Costs SCADA/Signal Channels Water Cost Est. cost for compliance w/SWT Rule	N/A	N/A	$0.87 $0.41 $357.58 $50.00	51,200 18% of 58,400 & 58,500 Estimate by Hilton, Farnkopf, & Hobson ACWD Staff
	Subtotal	N/A	N/A	$408.86	
Production Pumping (Cost of water not included)	Power Costs Well & Booster Pumps SCADA/Signal Channels Diversion Pumps	N/A	N/A	$48.56 $0.41 $0.92	58,100:58,200 (Whitfield costs not included) 35% of 58,400 + 58,500 58,310
	Subtotal	N/A	N/A	$49.89	
ARP Pumping (Cost of water not included)	Power Costs	N/A	N/A	$15.88	$0.15/KWh × 106 KWh/AF (from GW Survey Report)
	Subtotal	N/A	N/A	$15.88	
Salinity Barrier Pumping (Cost of water not included)	Power Costs	N/A	N/A	$15.88	$0.15/KWh × 106 KWh/AF (from GW Survey Report)
	Subtotal	N/A	N/A	$15.88	
MSJWTP (w/ozone)	Supervision, Labor, and Expense: Treatment Plant Maint: Treatment Plant Power Costs: SCADA TP	N/A	N/A	$25.51 $5.96 $0.41 $15.58	61,300 62,300 12% of 58,400 + 58,500 58,600
	Subtotal	N/A	N/A	$21.95	
WTP#2 (at 21 MGD—cost of water not included)	Supervision, Labor, and Expense: Treatment Plant Maint: Treatment Plant Power Costs	N/A	N/A	$23.92 $12.56 $12.66	61,400 62,400 (Includes Whitfield)
	Subtotal	N/A	N/A	$49.14	
Blending Facility	Supervision, Labor, and Expense Maintenance	N/A	N/A	$2.30 $0.61	61,100 62,100
	Subtotal	N/A	N/A	$2.91	

Table X-4
SUMMARY OF RESOURCE AVOIDABLE COSTS (continued)

New Facilities/ Supply Sources	Item	Annual Fixed Cost ($/yr)	Reference or Acct/Job Cost ($/yr)	Ann. Var. Cost ($/afy)	Reference or ACWD Acct/Job Number
Desalination [2]	Annualized Capital Operating Costs	$363,500	Desalination Feasibility Study by Dick Sudak	$380.00	Desalination Feasibility Study by Dick Sudak. ARP costs treated as separate item
	Subtotal	$363,500		$380.00	
Transfer Water Supply—Drought				$250.00	
Transfer Water Supply—Annual	SWP Transportation Chg Water Rights Transfer	$22/AF $86/AF	DWR Bulletin #132-93 KCWA fixed Trans. Chrg Total $1000/Af (amort.)	Same as SWP Variable costs	
Reclamation [3]	Annualized Capital Operating Cost	$612,700	CH2M Hill Report	$91.00	CH2M Hill report
Zone 7 Storage	Annualized Capital Operating Cost	$290/AF		$15.88	Zone 7 1993 Planning Study
Upper Del Valle	Annualized Capital Operating Cost	$6,227,900	B-E Report	$49.00	B-E Report
San Joaquin Valley Banking Program				Cost of SWP + $180/AF	
SBA Enlargement	Annualized Capital Operating Cost	$1,271,400	B-E Report	$30.00	B-E Report
WTP#2 Upgrades	Annualized Capital	$171,600/ MGD	ACWD staff based on $2 million/MGD	Included as part of WTP#2	
WTP#3	Annualized Capital Operating Cost	$171,600/ MGD	ACWD operations staff based on total $2 million/MGD	$83.04	ACWD Eng. staff est
Conservation Pkg. 1	Program Costs Staffing Costs	$124,415 $128,754	Barakat & Chamberlin		
Conservation Pkg. 2	Program Costs Staffing Costs	$218,802 $218,868			
Conservation Pkg. 3	Program Costs Staffing Costs	$501,844 $258,933			
Conservation Pkg. 4	Program Costs Staffing Costs	$516,431 $319,517			

Notes:
[1] Year 2000 fixed costs: $2,970,758.75 for 2010; $2,290,353.45 for 2020; $2,062,575.95 for 2030. Per AF variable charges: $36.60 for 2010; $38.21 for 2020; and $38.29 for 2030.
[2] Fixed costs for 3 MGD plant size: $640,419.00 for 5 MGD; $934,165.00 for 8 MGD; $1,229,054.00 for 10 MGD. Per AF variable charges: $410.00 for 5 MGD; $374.00 for 8 MGD; and $373.00 for 10 MGD.
[3] Fixed costs for Phase 1 Reclamation: $584,380.00 for Phase 2; $995,740 for Phase 3. (Assumes all costs split 50/50 with USD). Per AF variable charges: $107 for Phase 2 and $120 for Phase 3.
All costs are in 1994 dollars. Capital costs for future facilities annualized over 35 years at 8%.

Table X-5
EVALUATION OF RESOURCE SEQUENCES

Evaluation Criteria	Sequence 1	Sequence 2	Sequence 3	Sequence 3A	Sequence 4	Sequence 5	Sequence 6	Sequence 6A	Sequence 7
Cost ($ millions)[a]	$25	$104	$62	$61	$41	$54	$51	$34	$49
Capital	$14	$52	$24	$23	$18	$34	$25	$17	$25
Operating	$11	$52	$39	$39	$23	$20	$26	$17	$24
Reliability (expected unserved demand in drought years)[b]	24%	10%	10%	10%	10%	10%	10%	10%	10%
Maximum monthly hardness (mg/L)	238[b]	150	150	150–175[c]	150–175[c]	150–175[c]	150	175–238[d]	150
Environmental impact	1.3	1.8	1.3	1.4	1.3	1.2	1.2	1.0	1.4
ACWD control	1.3	1.5	1.3	1.3	2.1	1.9	1.9	1.9	1.8
Water availability risk	1.2	1.5	1.1	1.1	2.0	1.8	1.8	1.8	1.5
Financial risk	1.5	1.9	1.7	1.7	1.5	1.8	1.7	1.5	1.6
Water quality risk	2.4	2.1	2.2	2.1	2.6	2.3	2.5	2.5	2.4

Note: Lower numbers are preferable

[a]Net present value of capital and variable operating costs of new resources.

[b]1 in 30 years probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.

[c]Seasonal increases in hardness.

[d]175 mg/L annually, up to 238 mg/L during drought years.

contribution of that resource. Therefore, for these factors (i.e., ACWD control and risks), the incremental increase in water delivery attributable to each resource is used as the weighting factor.

Table X-5 also summarizes the scoring of the resource sequences.

COMPARING RESOURCE SEQUENCES

As discussed previously, the precision of the cost estimates used in this study are such that they are within 15% of actual costs. In other words, actual costs are between 85% and 115% of the estimates. Therefore, in comparing the sequences, cost differences within this ±15% range are deemed insignificant.

For qualitative criteria that were scored on an ordinal scale of 1 to 3, a difference of 0.2 or less is similarly deemed insignificant.

The following discussion focuses on individual sequences as well as comparisons of pairs of sequences.

Sequence 1. Sequence 1 has the lowest cost of all sequences under consideration. However, it also provides the least supply reliability. In addition, this sequence depends on mining the groundwater basin to −40 feet with no salinity barrier pumping. This mode of system operation may degrade the groundwater basin. Because of the low reliability and potential degradation to the groundwater basin, this sequence was determined to be unacceptable and was eliminated from further consideration.

Sequences 2 and 3. Table X-6 focuses on the pair-wise comparison of Sequences 2 and 3. The right-hand column indicates that, for all criteria, either Sequence 3 is preferred or the two sequences are equivalent.

The additional costs of Sequence 2 stems from its larger desalination and reclamation facilities. Sequence 2 also has greater environmental impacts due to its lack of conservation programs and the resulting need to utilize more supply sources. In addition, Sequence 2 has more water availability risk than Sequence 3 due to its dependence on drought-year agricultural transfer.

Based on this analysis, Sequence 2 was removed from further consideration.

Table X-6
COMPARISON OF SEQUENCES 2 AND 3

Criteria	Sequence 2	Sequence 3	Preferred Sequence
Cost ($ millions)[a]	$104	$62	3
Capital	$52	$24	
Operating	$52	$39	
Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	150	—
Environmental Issues	1.8	1.3	3
ACWD Control	1.5	1.3	—
Water Availability Risk	1.5	1.1	3
Financial Risk	1.9	1.7	—
Water Quality Risk	2.1	2.2	—

Note: Lower numbers are preferred
[a]Net present value of capital and variable operating costs for new resources.
[b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.

Sequences 3 and 3A. Sequences 3 and 3A are almost identical. The only difference is that Sequence 3 includes a treatment plant expansion near the end of the planning period (approximately in the year 2027) whereas Sequence 3A does not. This expansion permits monthly hardness to not exceed 150 mg/L (see Table X-7).

Since the plant expansion comes so late in the planning period, it adds little to the net present value of the costs. It was decided that the importance of maintaining hardness within an acceptable range is worth the little additional cost. Therefore, Sequence 3A was rejected.

Table X-7
COMPARISON OF SEQUENCES 3 AND 3A

Criteria	Sequence 3	Sequence 3A	Preferred Sequence

Cost ($ millions)[a]
    Capital
    Operating
	$62
	 $24
	 $39
		$61
		 $23
		 $39
			—

Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	150–175[c]	3
Environmental issues	1.3	1.4	—
ACWD control	1.3	1.3	—
Water availability risk	1.1	1.1	—
Financial risk	1.7	1.7	—
Water quality risk	2.2	2.1	—

Note: Lower numbers are preferred
[a] Net present value of capital and variable operating costs of new resources.
[b] 1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.
[c] Seasonal increases in hardness.

Sequences 3 and 4. The comparison between Sequences 3 and 4 is summarized in Table X-8. In Sequence 4, agricultural water purchase replaces desalination and reclamation. Sequence 3 is more expensive than Sequence 4 because of the cost to construct and operate desalination and reclamation facilities. The hardness in Sequence 4 varies seasonally from 150 to 175 mg/L between now and 2030. In 2030, hardness increases to 175 mg/L year-round. In contrast, the hardness in Sequence 3 is maintained at 150 mg/L year-round.

Sequence 4 has higher water availability and water quality risks than Sequence 3. The risks to the raw water quality of agricultural transfers is higher than the quality risks associated with desalinated or reclaimed water. Reliance on agricultural transfers also results in higher water availability risk and lower local control. It was decided that the additional cost of Sequence 3 is warranted to alleviate these risks, increase District control and reduce water hardness. Therefore, Sequence 4 was eliminated from further consideration.

Table X-8
COMPARISON OF SEQUENCES 3 AND 4

Criteria	Sequence 3	Sequence 4	Preferred Sequence
Cost ($ millions)[a]	$62	$41	4
Capital	$24	$18	
Operating	$39	$23	
Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	150-175[c]	3
Environmental issues	1.3	1.3	—
ACWD control	1.3	2.1	3
Water availability risk	1.1	2.0	3
Financial risk	1.7	1.5	—
Water quality risk	2.2	2.6	3

Note: Lower numbers are preferred
[a]Net present value of capital and variable operating costs of new resources.
[b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.
[c]Seasonal increases in hardness.

Sequences 5 and 6. Sequence 6 is similar to Sequence 5, except that reclamation is replaced with desalination. The total costs for the two sequences are similar, as shown in Table X-9. The hardness in Sequence 5 varies seasonally from 150 to 175 mg/L, whereas hardness in Sequence 6 does not exceed 150 mg/L year-round. This is because Sequence 6 contains a desalination facility which allows the District to maintain both the 10% reliability and the 150 mg/L hardness goals. Therefore, Sequence 5 was eliminated.

Table X-9
COMPARISON OF SEQUENCES 5 AND 6

Criteria	Sequence 5	Sequence 6	Preferred Sequence

Cost ($ millions)[a]
    Capital
    Operating
	$54
	 $34
	 $20
		$51
		 $25
		 $26
			—

Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150–175[c]	150	6
Environmental issues	1.2	1.2	—
ACWD control	1.9	1.9	—
Water availability risk	1.8	1.8	—
Financial risk	1.8	1.7	—
Water quality risk	2.3	2.5	—

Note: Lower numbers are preferred.
[a]Net present value of capital and variable operating costs of new resources
[b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.
[c]Seasonal increases in hardness.

Sequences 6 and 6A. In Sequence 6A, desalination is eliminated. Consequently, to maintain the 10% reliability goal, hardness in peak months during drought years can increase to 238 mg/L, shown in Table X-10. As shown in Table X-10, both sequences score the same on all criteria except hardness and cost. Sequence 6 is more expensive than Sequence 6A because of the desalination facility. The District determined that the additional expenditure is justifiable to prevent the increase in hardness. Therefore sequence 6A was eliminated.

Table X-10
COMPARISON OF SEQUENCES 6 AND 6A

Criteria	Sequence 6	Sequence 6A	Preferred Sequence

Cost ($ millions)[a]
    Capital
    Operating
	$51
	$25
	$26
		$34
		$17
		$17
			6A

Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	175-238[c]	6
Environmental issues	1.2	1.0	—
ACWD control	1.9	1.9	—
Water availability risk	1.8	1.8	—
Financial risk	1.7	1.5	—
Water quality risk	2.5	2.5	—
Note: Lower numbers are preferred [a]Net present value of capital and variable operating costs of new resources. [b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand [c]175 mg/L annually, up to 238 mg/L during drought years.			

Sequences 3 and 6. The main difference between these sequences is that Sequence 6 replaces reclamation with annual agricultural water purchases. Sequence 3 is more expensive than Sequence 6, as shown in Table X-11. However, Sequence 3 is preferred to Sequence 6 in terms of District control, and water availability and water quality risk. This reflects the difference between reclamation and agricultural purchase. Reclamation does not have any potable water quality risk because reclaimed water would be used for irrigation. In addition, the amount of reclaimed water is not expected to vary in drought years and may not be subject to contractual and transmission risks, as is the case with agricultural purchase. Furthermore, reclamation offers more local control than agricultural purchases. The Memorandum of Understanding between the District and USD will provide the District with firm water deliveries. An agricultural purchase agreement with a distant supplier does not offer similar levels of control. It was decided that these other factors outweigh the additional cost. Hence, Sequence 6 was eliminated.

Table X-11
COMPARISON OF SEQUENCES 3 AND 6

Criteria	Sequence 3	Sequence 6	Preferred Sequence
Cost ($ millions)[a]	$62	$51	6
Capital	$24	$25	
Operating	$39	$26	
Reliability (expected unserved demand in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	150	—
Environmental issues	1.3	1.2	—
ACWD control	1.3	1.9	3
Water availability risk	1.1	1.8	3
Financial risk	1.7	· 1.7	—
Water quality risk	2.2	2.5	3

Note: Lower numbers are preferred.
[a]Net present value of capital and variable operating costs of new resources.
[b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.

Sequences 3 and 7. Sequence 7 includes all potential resource alternatives considered in this study. Sequence 7 includes lower capacity facilities than those included in Sequence 3. Additionally, Sequence 7 includes drought year and annual agricultural transfers. Table X-12 shows that Sequence 7 is less expensive than Sequences 3. However, Sequence 7 offers lower District control and higher water availability risks because of increased reliance on drought year agricultural purchases. It was determined that the additional cost is justifiable for these reasons. Thus, Sequence 7 was eliminated.
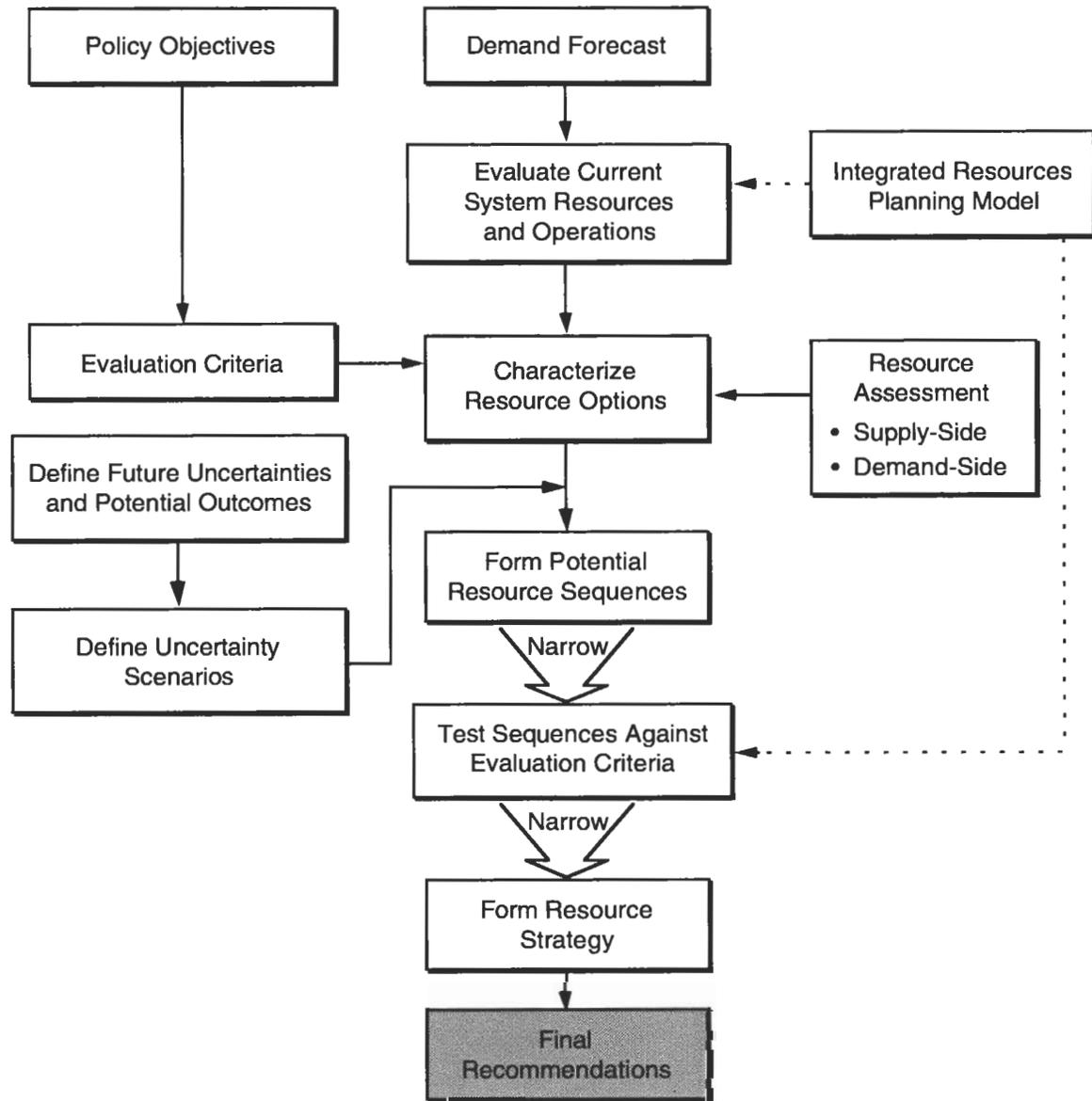
Table X-12
COMPARISON OF SEQUENCES 3 AND 7

Criteria	Sequence 3	Sequence 7	Preferred Sequence

Cost ($ millions)[a]
  Capital
  Operating
	$62
	$24
	$39
		$49
		$25
		$24
			7

Reliability (expected unserved in drought years)[b]	10%	10%	—
Maximum monthly hardness (mg/L)	150	150	—
Environmental issues	1.3	1.4	—
ACWD control	1.3	1.8	3
Water availability risk	1.1	1.5	3
Financial risk	1.7	1.6	—
Water quality risk	2.2	2.4	—

Note: Lower numbers are preferred.
[a]Net present value of capital and variable operating costs of new resources.
[b]1 in 30 probability of occurrence. Expected *annual* unserved demand expressed as a percentage of full-service *annual* demand.

ALAMEDA COUNTY WATER DISTRICT

INTEGRATED RESOURCES PLANNING STUDY

CONCLUSIONS AND RECOMMENDATIONS

ACWD Integrated Resources
Planning Study Process

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┌─────────────────────┐        ┌─────────────────────┐
│  Policy Objectives  │        │   Demand Forecast   │
└─────────────────────┘        └─────────────────────┘
           │                              │
           │                              ▼
           │                   ┌─────────────────────┐      ┌──────────────────────┐
           │                   │  Evaluate Current   │ ···· │ Integrated Resources │
           │                   │  System Resources   │      │   Planning Model     │
           │                   │   and Operations    │      └──────────────────────┘
           │                   └─────────────────────┘
           ▼                              │
┌─────────────────────┐                  ▼
│ Evaluation Criteria │ ───────► ┌─────────────────────┐      ┌──────────────────────┐
└─────────────────────┘          │    Characterize     │ ◄─── │      Resource        │
                                 │  Resource Options   │      │     Assessment       │
┌─────────────────────────┐     └─────────────────────┘      │  • Supply-Side       │
│ Define Future Uncertainties│            │                   │  • Demand-Side       │
│  and Potential Outcomes   │            │                    └──────────────────────┘
└─────────────────────────┘             ▼
           │                   ┌─────────────────────┐
           ▼                   │  Form Potential     │
┌─────────────────────┐        │ Resource Sequences  │
│  Define Uncertainty │        └─────────────────────┘
│     Scenarios       │                 │  Narrow
└─────────────────────┘                 ▼
                                ┌─────────────────────┐
                                │ Test Sequences Against │ ◄·····
                                │  Evaluation Criteria   │
                                └─────────────────────┘
                                         │  Narrow
                                         ▼
                                ┌─────────────────────┐
                                │   Form Resource     │
                                │     Strategy        │
                                └─────────────────────┘
                                         │
                                         ▼
                                ┌─────────────────────┐
                                │       Final         │
                                │  Recommendations    │
                                └─────────────────────┘
```

XI. CONCLUSIONS AND RECOMMENDATIONS

After comparing the resource sequences, Sequence 3 was determined to best meet the District's policy objectives. The implementation of the recommended strategy will meet or exceed District planning objectives in the areas of water supply reliability, economics, water quality, environmental protection, and risk. This strategy is designed to provide the flexibility needed to meet the water supply needs of existing and future customers as water supply and demand conditions continue to change.

IMPLEMENTATION STRATEGY

The timing of resource implementation for the recommended strategy is shown in Figure XI-1. This implementation schedule represents the recommended actions under the most likely (middle) scenario. Figure XI-2 shows the average yearly water production from 2000 to 2030 under the recommended resource strategy.

In addition to developing a plan for the middle scenario, this plan can be modified to accommodate a best- or worst-case scenario. Figure XI-3 shows how resource options may be added or subtracted depending on changes in future water demand, the quantity and reliability of imported water supplies, and treatment plant capacities. Actions are listed in their order of implementation for best-case, middle, and worst-case scenarios. The number and degree of the various actions increase over time to meet growing water needs. These scenarios provide the flexibility needed to respond to the different conditions that may occur.

For example, in the best-case scenario, demand by the year 2005 may be less than expected, due to low population and business growth, and the amount of imported water available may be more than expected. In this case required actions would include storage, conservation, and the first phase of desalination. In the middle scenario for 2005, increases in water demand and restrictions on imported water supplies would reflect current expectations. Required actions for this scenario would include those in the best-case scenario plus limited dry year groundwater basin mining and additional storage. In the worst-case scenario, demands may be higher and imported water supplies may be lower than expected. In this case, required actions would include all those in the best-case and middle scenarios plus water transfers and the first phase of wastewater reclamation.

Figure XI-1
Sequence 3: Resource Implementation

Latest On-Line Date: ➡	2000	2010	2020	2030
Conservation	Package 2	➡	➡	➡
Desalination (mgd)	3	3	3	8
Storage (KAF)	65	95	100	140
Minimum G/W Level (BHF, ft)	+1	-5	-5	-5
Treatment Plant Upgrades (mgd)				4
Reclamation			Phase 1	Phase 2

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Figure XI-2
Preferred Resource Sequence
Simulated Average Yearly Water Production
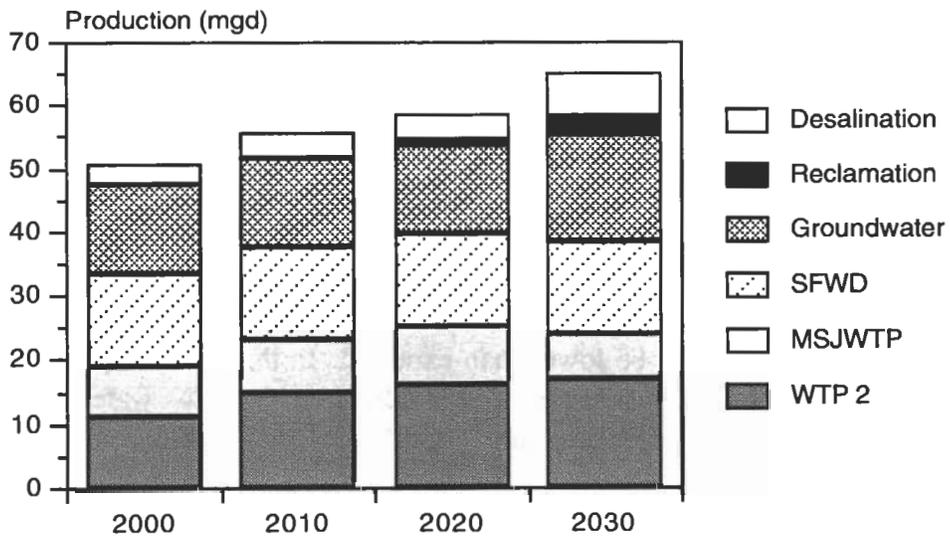
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Figure XI-3
Recommended Strategy

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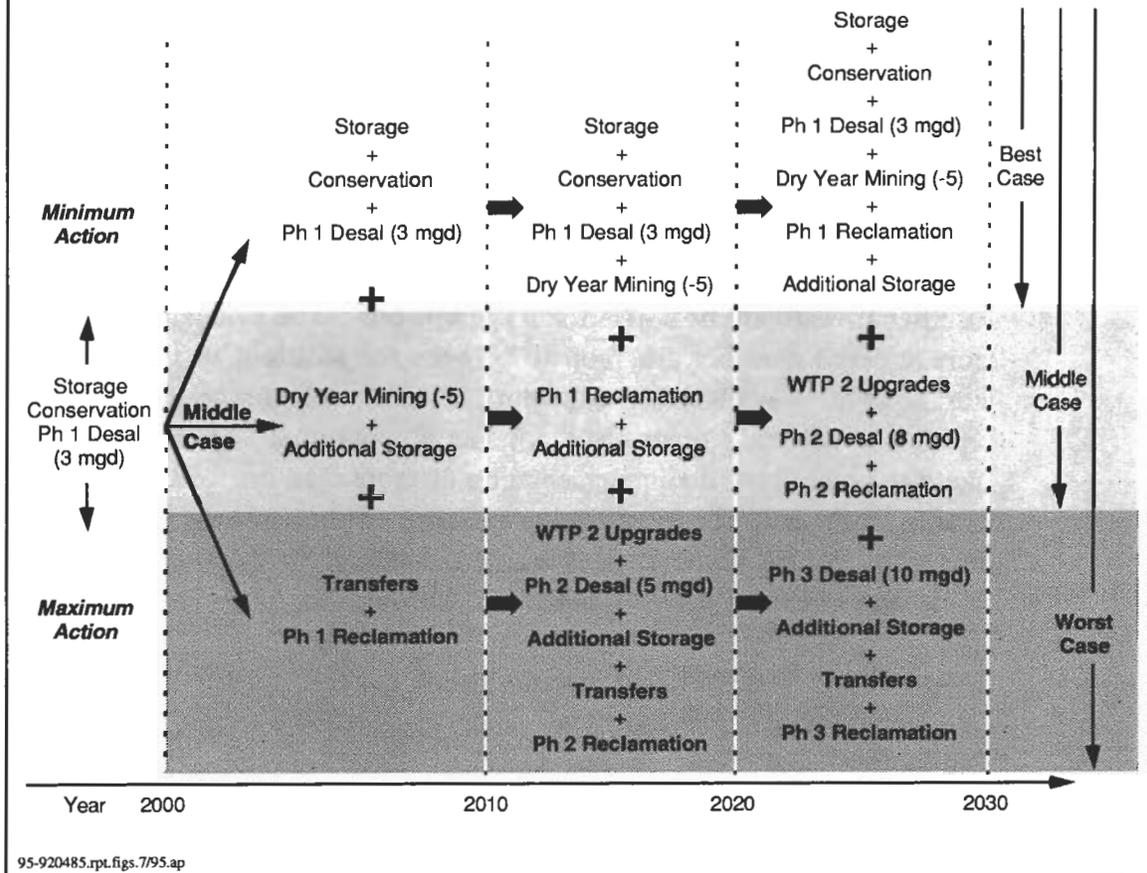
The strategy for the timing and prioritization of resource alternatives is:

- Combine the resource alternatives for each benchmark year (2000, 2010, 2020, and 2030) such that the evaluation criteria rating for each time period meets or exceeds the overall resource program rating;

- Optimize the use of existing and future resources (e.g., additional storage must be obtained before adding new sources of supply to fully utilize those sources and to carry over wet year surpluses of existing supplies; also, desalination of ARP water makes use of a supply that would otherwise be discharged to flood control channels, allows for greater use of groundwater pumped from existing production wells [more production

well water can be used when blended with very low hardness desalinated water], and makes more groundwater storage available to capture and recharge surface water); and

■ Defer more expensive options to later years.

FURTHER COURSE OF ACTION

To implement the recommended strategy, it is recommended that the District:

■ **Further investigate near-term storage options.** The evaluation of storage needs does not differentiate between the locations or types of storage options available. The quantity of additional storage identified represents the total storage required. The amount of storage required is likely to come from the implementation of more than one of the storage options evaluated. The most likely near-term options include utilizing carryover storage in the SWP system and banking SBA entitlement water in the San Joaquin Valley. The District will need to:

  • Meet with potential San Joaquin Valley banking partners to determine specific banking arrangements (e.g., cost, storage terms, and ability to "put" and "take" banked water);

  • Investigate the water supply benefits of carryover storage in the SWP system and the risk of losing stored water; and

  • Conduct additional operational studies to optimize the quantity of water diverted for storage, the timing of diversions, and the location of storage.

■ **Continue to pursue long-term storage options.** Some of the storage options considered, including storage in the Livermore Valley and storage in Sunol Valley, have either not been fully investigated or are not available in the near term. The District should continue to work with the associated agencies to further investigate future opportunities. Due to the high environmental impacts associated with raising the Calaveras Dam and constructing the Upper Del Valle Reservoir, these alternatives are not recommended for further action at this time.

- Begin a more detailed study of salt water desalination. This study should include:

  - Selecting plant location;

  - Refining distribution system configuration and cost estimates;

  - Refining well collection system configuration and cost estimates;

  - Continuing to investigate opportunities for beneficial use and/or disposal of concentrate;

  - Pursuing opportunities for a joint pilot or demonstration program; and

  - Investigating project financing options, including state and/or federal low-interest loans and grants.

- **Develop an implementation plan for the Package 2 conservation programs.** The plan would contain an implementation schedule, organizational and staffing requirements, and a marketing plan for each conservation program. In addition, the District should further evaluate the implementation of an ultra-low-flush toilet program to replace higher flow toilets for those portions of the customer base for which it would be most cost-effective to do so.

- **Implement revised ARP pumping rules.** To counteract further migration of saline water toward the District's potable well field and to remove the intruded salt water plume, ARP pumping should be increased. The amount of pumping required is a function of the quantity of water produced from the Newark, Centerville-Fremont, and Deep Aquifers and the piezometric head in the aquifers; for every 2 acre-feet of water produced below the Hayward Fault, 1 acre-foot of water must be produced from the ARP wells when operating the groundwater basin when the groundwater elevation below the Hayward fault is approximately +5 MSL. The proportion of ARP pumping required increases when the groundwater basin is operated at lower elevations and decreases when it is operated at higher elevations.

- **Increase aquifer reclamation pumping** when BHF groundwater elevation is above +10 MSL. Model analyses indicate that groundwater supplies are lost to the Bay when BHF groundwater elevation rises above +10 feet

MSL. In this situation, additional ARP production may increase the rate of basin remediation without affecting the quantity of supplies available for potable use.

- **Delay construction of the additional salinity barrier wells** recommended in the 1986 Water Supply and Facilities Planning Study. Model analyses indicate that, with the full amount of barrier pumping needed to prevent seawater intrusion, no additional water supply is obtained by drawing the basin below sea level.

- **Maintain BHF groundwater elevation** above +3 MSL. To prevent seawater intrusion without salinity barrier pumping, groundwater elevation should be maintained at above +3 MSL. Limited short-term basin mining during critically dry years should not adversely affect groundwater supplies.

- **Reevaluate the salinity barrier program and aquifer reclamation pumping requirements** when the water quality model is completed. Since the IGSM is not yet equipped with the ability to show water quality trends, this analysis did not consider the increased rate of basin remediation that may result from additional salinity barrier and aquifer reclamation pumping. Full basin remediation may result in improved water quality below the fault and increased storage capacity for potable supplies. The District is in the process of modifying the IGSM to be able to simulate the movement and remediation of the salt water plume. The salinity barrier program and aquifer reclamation pumping requirements should be revisited when the modifications are complete.

- **Place higher priority on the use of groundwater resources after securing additional storage.** Under current management of District supplies, use of groundwater supplies is the lowest priority. When additional storage is obtained, production pumping should be increased to maximize utilization of local water so that SWP water can be diverted to storage.

- **Continue to work with the USD to pursue a water reclamation project.** It is recommended that Phase 1 reclamation facilities be constructed after 2010 in the middle scenario, or after 2000 in the worst-case scenario. The District should continue cooperation with USD to develop appropriate cost-sharing arrangements, funding sources, and opportunities for the accelerated construction of a reclamation project.

- **Continue to investigate water entitlement transfer opportunities.**
  Under the recommended resource strategy, this option is included only
  under the worst-case scenario. Water transfers were not selected as a high-
  priority option due to uncertainties in the availability of transferred water.
  Since the evaluation of this option, however, an opportunity has arisen to
  purchase additional SWP entitlement water. SWP entitlement water would
  be a more reliable supply than was originally considered. As a participant
  in the urban state water contractors buyers group, the District is
  investigating opportunities for transfer of entitlement water from
  agricultural contractors in Kern County. The District should continue to
  investigate entitlement water transfers and to evaluate the benefits of
  implementing this option.

- **Continually update the Integrated Resources Plan.** This Plan is
  dynamic and should be modified as uncertainty outcomes are resolved.
  Also, the cost assumptions need to be revised periodically. The availability
  of federal and/or state low-interest loans and grants or outside agency cost
  sharing for a particular resource alternative may accelerate construction
  due to increased cost-effectiveness.

## COMPARING POLICY OBJECTIVES WITH THE RECOMMENDED STRATEGY

Implementation of the recommended strategy will allow the District to meet or exceed
planning program policy objectives for providing a high-quality, reliable water supply
for existing and future customers through 2030. The following discussion shows how
the recommended strategy compares to the policy objectives.

Reliability

Objective:

- Maintain a high level of service reliability

Figure XI-4 shows the magnitude and frequency of the shortages that may occur over
time under the recommended strategy. Water supply reliability is significantly
improved relative to the "no action" alternative—water shortages under the no action
alternative range from 0% to 13% of full-service demand in 1 of every 3 years, and

Figure XI-4
Dry Year Water Shortage Under Recommended Strategy
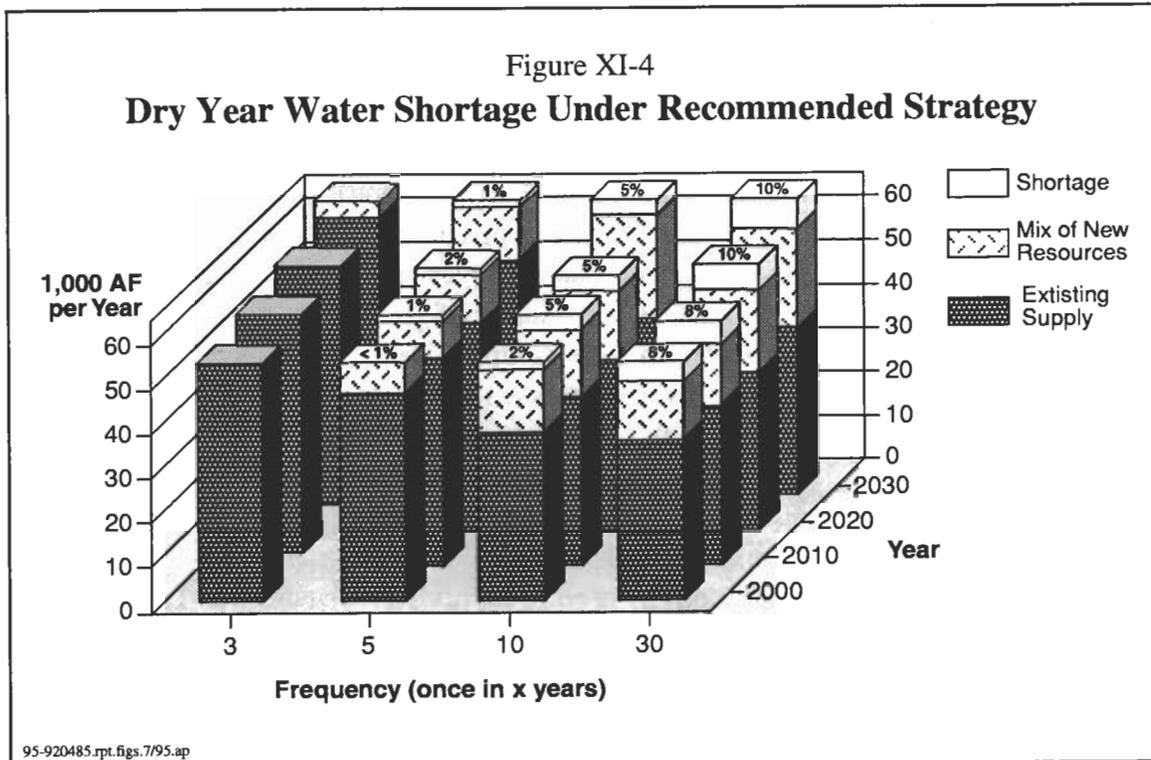
up to 29% to 53% in 1 of every 30 years. Water shortages under the recommended strategy do not exceed 10% and only approach 10% once in 30 years.

Local Control

Objective:

- Maximize District control of resources

The percentage of District supply that is under local control[41] is significantly increased under the recommended strategy. Figure XI-5 compares the percentage of supply relative to total demand that is obtained from each source in an average year under the no action alternative and under the recommended scenario. The percentage

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[41]Supplies under local control include Del Valle water, natural groundwater infiltration, desalinated water, reclaimed water, and stored SWP water.

Figure XI-5
Simulated Average Year Sources of Supply
Comparison of "No Action" Alternative and Recommended Strategy
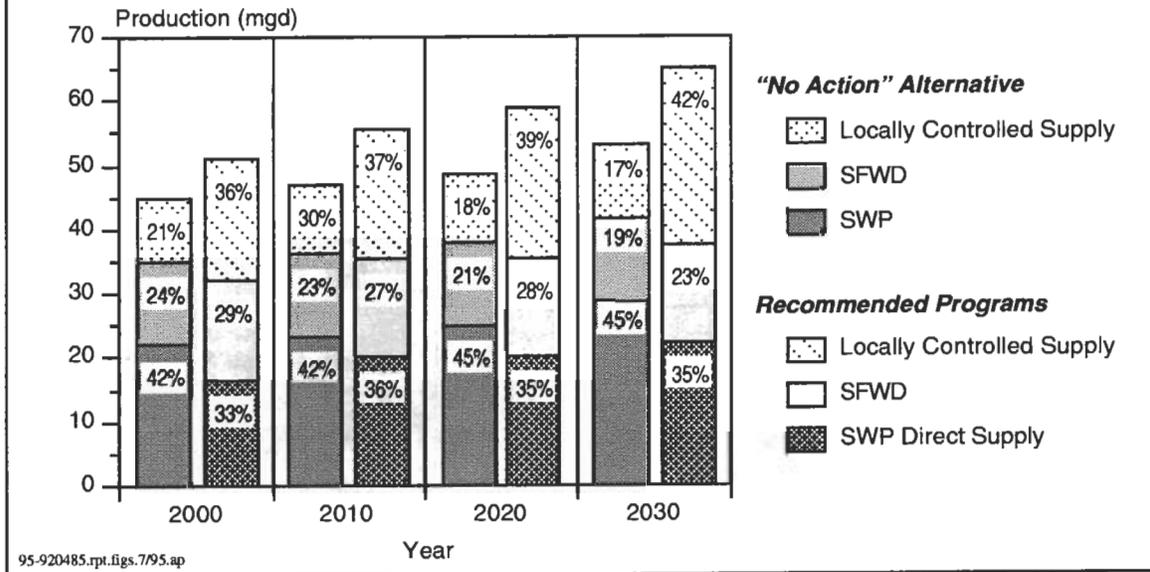
of supply under District control in the no action alternative ranges from 17% to 21%; the percentage of supply under District control under the recommended strategy increases to 37% to 42%.

As shown in Figure XI-6, the increase in District control is even more substantial when the no action alternative is compared with the recommended strategy in a dry year situation. In this case, the percentage of supply relative to total demand under District control in the no action alternative is approximately 20%, whereas it is 48% to 59% under the recommended strategy.

Costs

Objectives:

- Minimize resource costs
- Maintain low average customer bills
- Avoid rate shocks

Figure XI-6
Simulated Dry Year Sources of Supply
Comparison of "No Action" Alternative and Recommended Strategy

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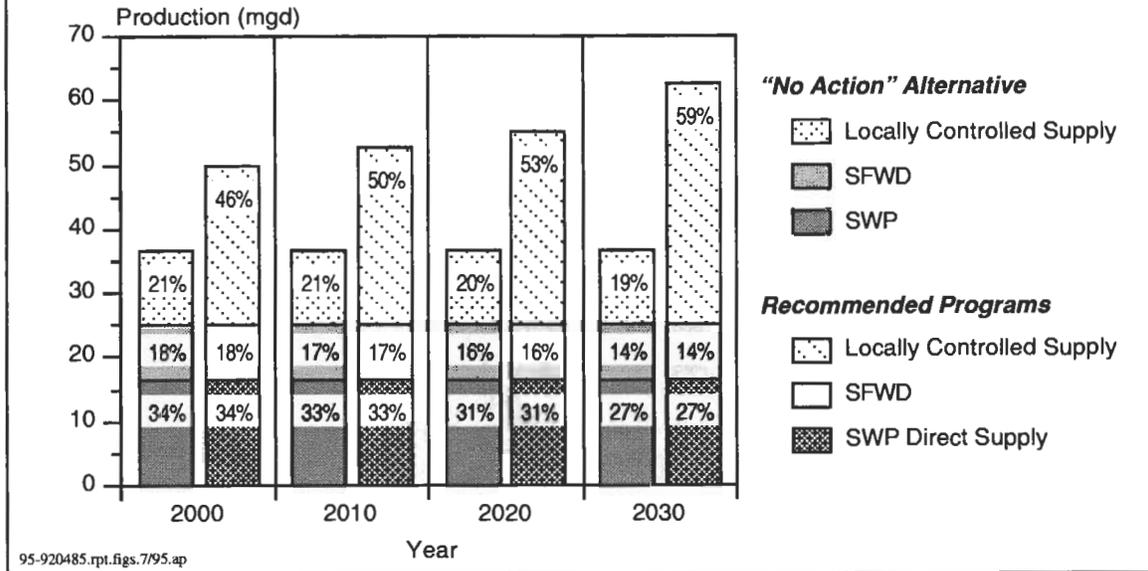
The recommended strategy was designed to meet District policy objectives while minimizing the cost of new resources. This was accomplished first by optimizing the use of existing resources and implementing the most cost-effective conservation programs, then by adding the lower cost alternatives. The higher cost alternatives are deferred to later in the planning period.

The net present value for the implementation of the recommended strategy through 2030 is estimated at $39 million. Preliminary cost analyses indicate that this amount would increase the average customer bill by approximately $7 per month over the 1995–2030 study period—approximately half of what District customers said they would be willing to pay to avoid future shortages. Costs estimates will be refined and included in the District's 25-year and 5-year Capital Improvement Program and incorporated into the financial planning model used to forecast future water rates. This process avoids rate shocks (sudden increases in water rates) and allows for a gradual increase in water rates when necessary. District water rates are among the lowest in the Bay Area, and the recommended strategy is designed to continue to meet that objective.
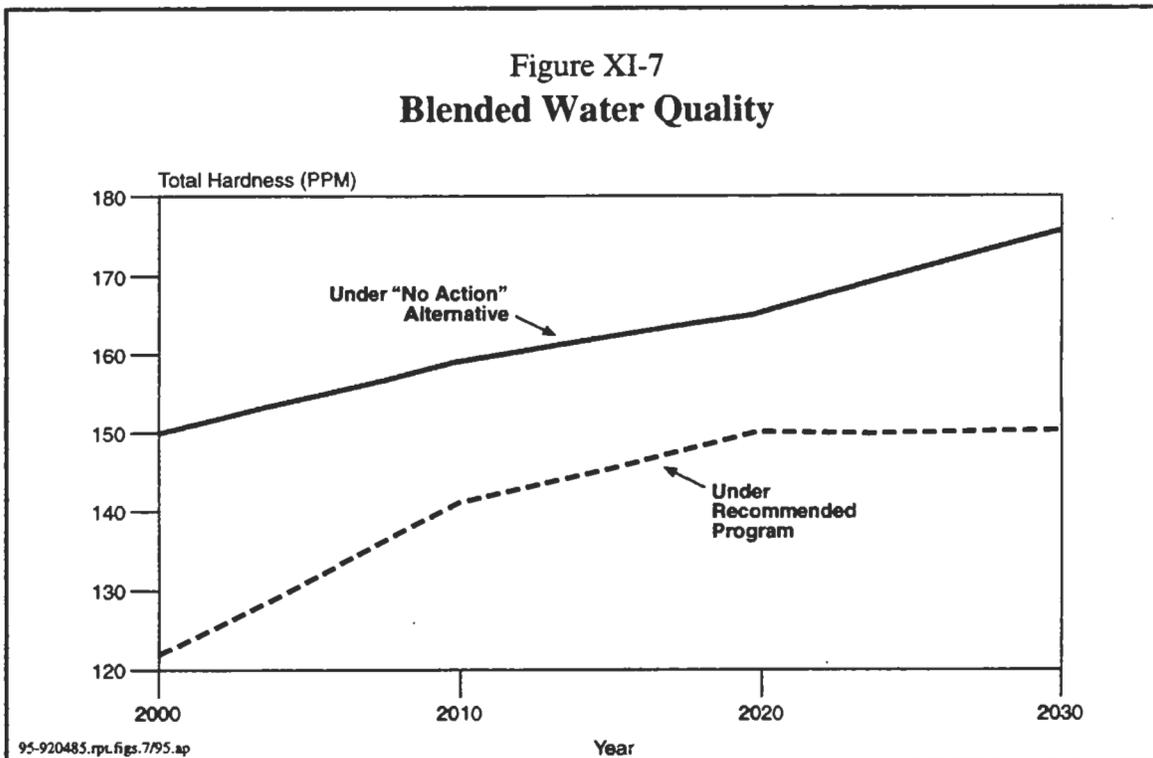
Water Quality

Objective:

- Avoid sudden changes in water taste or appearance

Health concerns are of major importance to the District. The recommended strategy continues the District's goal of meeting or exceeding all health-related water quality standards regardless of resource strategy undertaken.

Another District goal is to provide a low-hardness, uniform-aesthetic-quality water supply to its customers. Toward this end, construction of the Blending Facility was completed in 1991. Higher hardness groundwater can be blended with lower hardness SFWD water to provide a hardness level consistent with other sources of supply. The recommended strategy furthers this goal through the addition of a desalination facility. Desalinated water is a very low hardness, high-quality water supply that, when blended with groundwater, decreases the hardness of water delivered to customers. Figure XI-7 shows the blended water quality under the no action alternative relative to the blended water quality under the recommended strategy.

Figure XI-7
Blended Water Quality

Total Hardness (PPM)

Under "No Action" Alternative

Under Recommended Program

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Year

In addition, desalinated groundwater contains fewer constituents that can lead to the formation of disinfection by-products than other sources of supply.

Environmental Impacts

Objective:

- Avoid or mitigate environmental impacts

The recommended strategy was designed to minimize environmental impacts. Only resources having little or no environmental impact are recommended. In addition, the ARP pumping requirements identified in the 1986 Water Supply and Facilities Planning Study were reevaluated and revised. The implementation of the revised pumping rules will protect the groundwater basin from further movement of the salt water plume and will accelerate basin remediation without adversely affecting the availability of potable supplies. Before implementation of any alternatives, a strategy EIR and project-specific EIRs will be prepared. These reports will include detailed information regarding any environmental impacts and will include mitigation plans.

Risk

Objective:

- Minimize risks due to future uncertainty

The recommended strategy allows the District to adapt to future uncertainties. Uncertainties in future demand, water supply availability, and treatment capacity were addressed by developing alternative resource plans for best-case, middle, and worst-case scenarios.

In addition, other nonquantifiable uncertainties were addressed, including:

- Financial risk—the likelihood of overbuilding and spending more money than expected;

- Water quality risk—the likelihood of being unable to comply with future water quality regulations; and

- Water availability risk—the likelihood of supply not being available due to external legal or regulatory changes or uncertainties in the quantity of supply available.

The financial risk was minimized to the degree possible by selecting the alternatives that have lower fixed or up-front costs. This strategy minimizes the risk of building more facilities than needed and not generating enough revenue to pay for the facilities that are not being fully utilized.

All existing water sources are treated to meet or exceed current state and federal drinking water standards. Numerous future drinking water regulations may make meeting future standards more difficult and/or more costly, depending on the source of supply. Water quality risk was minimized by selecting the alternatives under which meeting the anticipated standards is expected to be less difficult and costly.

The water availability risk was minimized by including in the best-case and middle scenarios only those alternatives (e.g., desalinated water and reclaimed water) for which there is a high degree of assurance that the supply would be available for use. Supplies that may or may not be available when needed, including annual and drought year water transfers, are included in the recommended strategy only under the worst-case scenario.