Appendix y-I: San Jose Creek Water Reclamation Plan East Process Optimization Project Supporting Documents

(Please see Appendix CD for documents)

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Memorandum

Date: August 23, 2010

To: Ray Tremblay
Assistant Department Head
Technical Services

Through: Mike Sullivan
Section Head
Monitoring Section

From: Andrew Hall
Project Engineer
Monitoring Section

Subject: **Recycled Water Supply for GRIP – August 2010 Update**

The Groundwater Reliability Improvement Program (GRIP) was initially divided into two phases, with the size of Phase I based on available flow as of April 2008 and the size of Phase II based on the need for the Water Replenishment District (WRD), San Gabriel Valley Municipal Water District (SGVMWD), and the Upper San Gabriel Valley Municipal Water District (USVMWD) to displace 21,000 acre-feet per year (AFY) and 25,000 AFY of imported water in the Central (WRD) and Main (USGVMWD and SGVMWD) Basins, respectively. The capacity of Phase II also coincided with the reasonable diversions from facilities and pipelines upstream of the San Jose Creek Water Reclamation Plant (SJCWRP). However, since the feasibility of GRIP was first analyzed in April 2008, the flow within the Joint Outfall System has decreased due to increasing water conservation efforts, statewide drought conditions, and the economic recession. Additionally, previous analyses of recycled water flow tributary to the SJCWRP did not account for variations in reclaimable flow bypassing the treatment plant. As a result, the analysis of recycled water available for GRIP needs to be updated.

Since April 2008, flows bypassing the SJCWRP have been measured multiple times (November 5 through December 1, 2008; September 28 through October 5, 2009; January 5 through February 1, 2010; and April 26 through August 8, 2010). Figure 1 shows the average SJCWRP influent flow and average tributary flow (influent flow plus bypass flow) to the SJCWRP over the periods when flow bypass was measured for 2008, 2009, and 2010. While influent flows to the SJCWRP have decreased since 2008, the total flow tributary to the SJCWRP appears to have actually increased. The average tributary flow to the SJCWRP has remained fairly steady, ranging from 92,900 to 95,200 AFY (83 to 85 MGD). As a worst-case scenario for the GRIP Project, it is recommended that an average SJCWRP tributary flow of 89,600 AFY (80 MGD) and SJCWRP production of 81,200 AFY (72 MGD) be used, which is the lower bound of the error bars shown in Figure 1. Subsequent flow calculations assume that flow bypassing the SJCWRP is 89,600 AFY minus the plant influent flow.

Table 1 shows the SJCWRP flows and demands based on the lower bound estimates for SJCWRP flows, current contractual obligations, and anticipated GRIP demands. Options for increasing SJCWRP flows are presented below. Costs and water gained by implementing these options can be found in Table 2.

1. Allow the Pico Rivera contract to expire.
2. Recycle GRIP Phase I membrane filter backwash to plant influent.
3. Bring Miller Brewing Company discharge into SJCWRP.
4. Implement flow equalization (FE) at the SJCWRP that would have been constructed at GRIP regardless of the site selected and treat additional flow that is currently being bypassed.
5. Reroute SJCWRP media filter backwash to head of the SJCWRP.

6a. Increase tributary flow to the SJCWRP by diverting available flows from WN WRP drainage area.

6b. Gravity diversion from Tyler Avenue Trunk Sewer and Tyler Relief and FE to accommodate flows at the SJCWRP. These flows are a portion of the flows that would be diverted in Option 6a. Therefore, this cannot be implemented if Option 6a is implemented.

7. Divert reclaimable flow from the Pomona WRP drainage area to the SJCWRP.
8. Recycle GRIP Phase II membrane filter backwash to plant influent.

Implementing Options 1 through 5 will provide sufficient water to meet GRIP Phase I demands and contractual obligations with a 5,300 AFY margin of safety, which could be used to upsize GRIP Phase I, at a cost of $100,000. Implementing all options except 6b will provide sufficient water to meet GRIP Phase II demands and contractual obligations with a 2,100 AFY margin of safety at a total cost of $78 million. While this analysis utilizes a conservative estimate for SJCWRP influent and bypass flows, it should be noted that improvements in AWTP recoveries would also provide an additional margin of safety should flows decrease significantly in the future. Additionally, it should be noted that implementation of the options mentioned above for GRIP Phase II would require a 20 MGD expansion of the SJCWRP.

Attachments
Figure 1 - Average Influent and Tributary Flows for the SJCWRP for 2008 to 2010
Table 1 - SJCWRP Flows and Demands
Table 2 - Water Gained and Total Costs of Options for Increasing SJCWRP flows

Attachments

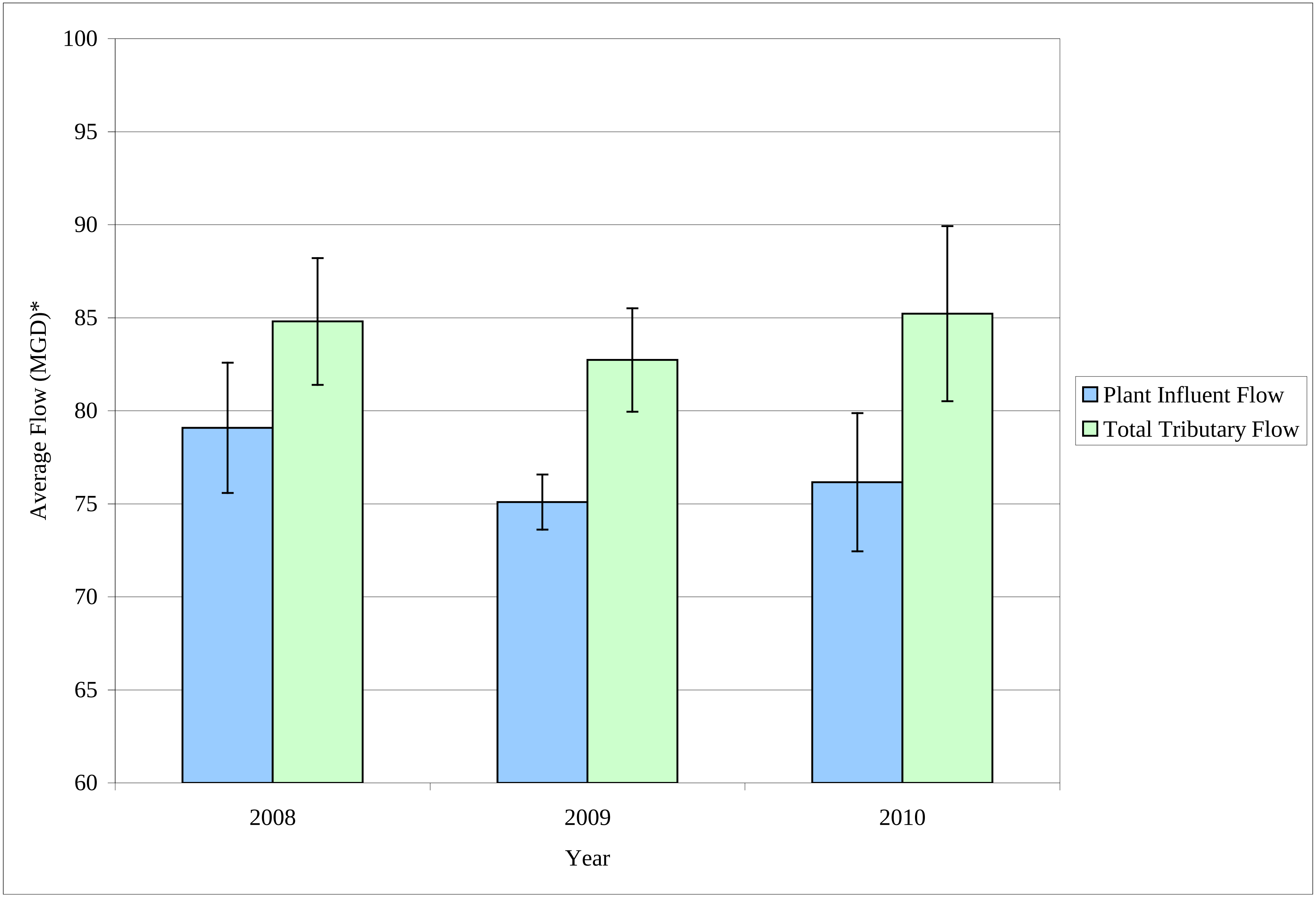

Figure 1. Average Influent and Tributary Flows for the SJCWRP for 2008 to 2010
Error Bars Represent Standard Deviations
***Average flow over periods when bypass flow was measured, (i.e., November 5 through December 1, 2008; September 28 through October 5, 2009; January 5 through February 1, 2010; and April 26 through August 8, 2010)**

Table 1. SJCWRP Flows and Demands

	Flows (AFY)
SJCWRP Production	81,200
SJCWRP Contractual Obligations	76,600
Additional Water Needed to Meet GRIP Phase I Demands[1] + Contractual Obligations	11,900
Incremental Additional Water Needed to Meet GRIP Phase II Demands[2] + Contractual Obligations	37,000
Total Additional Water Needed	48,900

1. GRIP Phase I will need 24,000 AFY of tertiary treated water, of which 10,000 AFY is already contracted to USGVMWD/SGVMWD.
2. GRIP Phase II is an expansion requiring a total of 61,000 AFY of tertiary treated water.

Table 2. Water Gained and Total Costs of Options for Increasing the SJCWRP flows

Option	Water Gained (AFY)	Total Cost
1	400	$ 0
2	1,200	$ 0
3	1,400	$ 0
4	8,400	NA[1]
5	3,300	$ 100,000
6a	27,600	$ 76,000,000
6b	4,400	$ 13,700,000[2]
7	4,400	$ 1,500,000
8	1,800	$ 0

1. Costs for implementing flow equalization for this option are already included in the GRIP project estimate.
2. Cost includes 1 MG of flow equalization that would be necessary to implement this option

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SANITATION DISTRICTS OF LOS ANGELES COUNTY

STEPHEN R. MAGUIN
Chief Engineer and General Manager

Memorandum

Date: August 9, 2010

To: Anthony Mahinda

Through: Mark McDannel

From: Andre Schmidt

Subject: **San Jose Creek WRP Process Air Compressor Efficiency Study R1**

Summary

A study was performed to evaluate the potential energy savings of replacing the process air compressors (PACs) at San Jose Creek WRP. The study included power monitoring of all eight existing PACs, analysis of plant data, determination of the energy usage of new compressors, and gathering of equipment cost estimates.

Results of the analysis are shown in Table 1. With an estimated equipment cost of $4.8 million, an annual energy savings of $1.0 million can be achieved. Excluding design and construction costs, and including the energy efficiency rebate incentive from Southern California Edison, the project has a simple payback period of less than four years.

Table 1: San Jose Creek WRP PAC Replacement Payback Period

Area of Plant	Turblex Models	Number of Duty Units	Number of Standby Units	Total Price	Annual Power Savings	SCE Rebate Incentive	Equipment Payback Period (Years)
SJC WRP East & West PACs	KA66 & KA80	4	1	$4,755,000	$1,003,289	$834,009	3.9

Background and Objectives

The PACs at San Jose Creek WRP consume 62 percent of the total plant power at a cost of $3.6 million per year. There are three sets of PACs that were installed at different stages of plant development (see Table 2). These compressors range in age from 18 years to 39 years. At the request of Wastewater Management, Energy Recovery Engineering conducted an energy efficiency study for the PACs. The objectives of the study were:

- Accurately monitor the power usage of the existing PACs
- Compare this energy usage to new high efficiency compressors
- Determine the potential financial savings associated with new equipment

Table 2: San Jose Creek WRP Existing Process Air Compressor Data

Area of Plant	Number of PACs	Duty	Standby	Horsepower Each	Capacity Each (scfm)	Age (Years)
East Stage One	3	2	1	1750	44,000	39
East Stage Two	2	2	0	900	20,000	28
West	3	1	2	1750	44,000	18

The PACs are high voltage equipment (4160 V) and therefore require specialized equipment for power monitoring. Southern California Edison (SCE) provided equipment and personnel to monitor the power of all eight compressors at no charge to the Districts. At the direction of SCE personnel, Districts staff connected the power monitoring equipment to the PAC electrical panels on December 17, 2009. Power was monitored on all eight compressors at 15-minute intervals for almost three months. The monitoring equipment was removed on February 11, 2010.

PAC Performance Data

Plant performance data for the same period of time was collected including plant flows, PAC airflow rate, and PAC discharge pressure. The data was compiled into average diurnal profiles for the entire three month test period. The diurnal profiles for power and airflow are compared in Figure 1 for each of the three sets of PACs. Power usage vs. airflow is plotted in Figure 2. The ratio of airflow to power is an energy efficiency metric that enables a direct comparison of the efficiency of each set of PACs. The diurnal profiles for airflow per kW are presented in Figure 3. Airflow per kW vs. influent flow is plotted in Figure 4.

Even though the West compressors are the newest of the three sets of PACs, they had the lowest average efficiency rate (see Figure 3). The West compressors actually have relatively good efficiencies of 34 to 37 icfm per kW between 5:00 a.m. and 10:00 a.m. when airflow is about ten percent less then peak airflow. But during the afternoon and early evening when airflow peaks at around 35,000 icfm, the efficiency rate drops to about 27 to 28 icfm per kW. This effect is also displayed in Figure 2, where the power usage of the SJC West compressors increases significantly when airflow increases just slightly. This increase is much more dramatic than the increase for the Stage 1 and Stage 2 compressors. At SJC West, it appears that the peak airflow demand is beyond the optimal range for one compressor operation (only one West PAC runs at a time). A compressor with slightly higher airflow capacity would be much more energy efficient.

The East Stage Two compressors had the opposite efficiency profile of the West compressors. During the afternoon and early evening, the compressors operated at about 33 icfm per kW. But during late night and early morning the efficiency dropped down to 24 icfm per kW. This is primarily due to the fact that only one compressor is needed at night, but rather than shutting down the second compressor, it is allowed to idle for 4 to 6 hours per night without providing any air. This is due to experience with premature mechanical coupling failure on the Stage Two compressors when they are shut down and restarted on a regular basis. The compressor idles for an average of 5 hours per night at an average power usage of 240 kW, costing approximately $50,000 in electricity per year.

Power was also compared to influent flow in Figure 5. It was found that the power usage of the PACs drops only slightly at night, while the influent flows drop much more substantially. This can be quantified by looking at the PAC energy usage per influent flow (Figure 6). For both the East and the West, the PAC energy usage was about 800 to 900 kWh per mgal during the day. But at night, the energy usage jumped to 1500 kWh per mgal for the West, and to 2000 kWh per mgal for the East. This points to the fact that the existing system has much lower efficiency during low flow periods.

The air ratios help examine the causes of the poor low flow system efficiency (see Figures 8 and 9). During the afternoon and early evening, the air ratio for both the East and West was about 1.5 icfm per gpm. But during early morning, the air ratio increased to 3.5 icfm per gpm on the East side, and 3.2 icfm per gpm on the West side. It appears that that there may be opportunity to increase the efficiency of the system by reducing the airflow during low flow periods.

Energy Savings of New PACs

The PAC performance data was analyzed to compare the energy usage of the existing equipment to new high efficiency compressors. A comparison between the existing equipment and new equipment was accomplished by breaking down the average diurnal airflow curve into four regimes based on airflow ranges (see Figures 13 thru

15). The average performance, including airflow, discharge pressure, and power was determined for each regime (see Tables 4 thru 6). The number of hours of operation per day was also determined for each regime. This established four discrete points of operation for each set of PACs that could be used to compare the existing compressors to new high efficiency compressors at the existing operating conditions.

Turblex was contacted to provide selection of new PACs, including projected energy usage and equipment costs. The various options for replacement of the existing compressors with Turblex compressors are presented in Table 3. The detailed energy usage calculations are provided in the appendix. Note that the payback periods in Table 3 are for the equipment costs only and do not take into account design, installation, or auxiliary equipment costs. The payback periods do take into account energy efficiency rebate incentives offered by SCE . Also, the equipment cost estimates include the typical features that the Districts have specified for other recent projects.

Table 3: San Jose Creek WRP PAC Replacement Payback Period

Area of Plant	Turblex Model	Number of Duty Units	Number of Standby Units	Price per Unit	Total Price	Annual Power Savings	SCE Rebate Incentive	Equipment Payback Period (Years)
East Stage One								
Option 1	KA66	2	1	$881,000	$2,643,000	$394,364	$327,825	5.9
Option 2	KA100	1	1	$1,438,000	$2,876,000	$380,969	$316,690	6.7
East Stage Two	KA66	1	1	$881,000	$1,762,000	$175,297	$145,720	9.2
East Stage One & Two Combined	KA66	3	1	$881,000	$3,524,000	$556,266	$462,410	5.5
West								
Option 1	KA80	1	0	$1,231,000	$1,231,000	$447,024	$371,599	1.9
Option 2	KA80	1	2	$1,231,000	$3,693,000	$447,024	$371,599	7.4
TOTAL - East Stage One & Two Combined and West Option 1	KA66 & KA80	4	1	n/a	$4,755,000	$1,003,289	$834,009	3.9

For Stage One, it is less expensive and more efficient to install two duty compressors with one standby than one duty and one standby, with a payback period of 5.9 years in comparison to 6.7 years. This replacement would save $394,000 per year in energy costs. Stage Two has a longer payback period of 9.2 years with $146,000 in annual energy savings. But since Stage One and Stage Two can use the same compressor model, the PACs for these could be combined for use of a common standby compressor. This combined option would require some ducting modifications, but would cut the equipment payback period for Stage One and Stage Two to 5.5 years.

For the West side, replacement of all three compressors would have a payback period of 7.4 years. However, Operations has indicated that the existing equipment is considered to be well within its useful life. Therefore, a better alternative may be to replace just one of the existing compressors, while keeping the other two as standby machines. This would have a payback period of just 1.9 years with a power savings of $447,000 per year. In total, replacement of all three sets of compressors would have an annual power savings of $1.0 million with a payback period of as low as 3.9 years.

Recommendations and Other Possible Energy Saving Measures

Operations has indicated that it does not have plans for extensive renovations to the aeration system for the West side of the plant. This being the case, it recommended to fast track installation of one duty compressor for the

West as a separate project. This separate project would provide $447,000 in annual energy savings. The equipment cost of $1.23 million would be offset by a rebate incentive from SCE of approximately $370,000, bringing the actual cost down to $860,000 and resulting in an equipment payback period of just 1.9 years. A project of this size may also be able to qualify for special financing. The California Energy Commission conducts a low interest energy efficiency financing program, which provides 3% interest loans of up to $3 million per application. This program is currently on hold due to lack of funds, but it is expected that new funding will be available in the future.

In addition to replacing the PACs, there may be other opportunities for further improvements to the energy efficiency of the aeration system. Advanced DO control could help cut down on excess aeration that may be occurring during late night and early morning low flow periods. If the average daytime air ratio of 1.5 cfm per gpm were maintained during low flow, it is estimated that with the Turblex units, the West plant could save an additional $100,000 in energy costs per year and the East plant an additional $180,000. Advanced DO control could also help optimize the amount of air being delivered to different stages of the aeration system, thereby improving the overall treatment efficiency.

Other possible energy saving measures for the aeration system include the following:

- Similar to DO control, some plants have also begun to adjust airflow based on ammonia levels, enabling the reduction of air where ammonia has already reached an acceptable level and providing further energy savings.

- The May 2010 issue of Water Environment & Technology discussed modifications that were made at the 167 mgd San Jose/Santa Clara Water Pollution Control Plant. The plant recently replaced continuous aeration in its anoxic compartments and mixed liquor channel with pulsed aeration for maintaining solids in suspension. This reduction in aeration demand has resulted in approximately $800,000 in annual energy savings.

- Some plants have optimized the performance of their primary clarifiers by providing improved baffling and hydraulics. This reduces the loading on the secondary treatment system and can cut plant energy use by as much as five percent.

- Improvements to diffuser cleaning represent another energy saving opportunity. The installation of power monitoring devices on the PACs would enable a comparison of energy use before and after diffuser cleaning to determine the impact of cleaning on energy usage. This could help optimize the methods and interval of diffuser cleaning. In addition, Sanitaire markets an in-place cleaning system that aspirates chemical into the aeration distribution system to clean the diffusers while tanks are in service. This enables uninterrupted cleaning of the diffusers at optimum intervals.

- Operations has indicated the need for higher DO levels in the first pass of the aeration system, with the possibility of converting to coarse bubble aeration in the first pass to accomplish this need. An alternative to coarse bubble aeration to provide more DO may be a FlexAir system offered by Environmental Dynamics Incorporated (represented by Pacific Process). Their MiniPanel Diffuser provides the efficiency of fine bubble diffusion, but has higher floor coverage than traditional ceramic disc diffusers, thereby providing more oxygen transfer per square foot. This system is apparently being used at Valencia WRP for side stream treatment of filtrate.

Energy Recovery Engineering is available to provide assistance with the development of a PAC replacement project at San Jose Creek WRP, including investigation into any promising related technologies that may help further improve the efficiency of the secondary treatment system. In addition, Energy Recovery Engineering can work with SCE to conduct energy efficiency analyses of the PACs at other WRPs to determine the potential savings associated with replacement of those compressors.

Figure 1: SJC WRP PAC Power □ Airflow vs. Time of Day

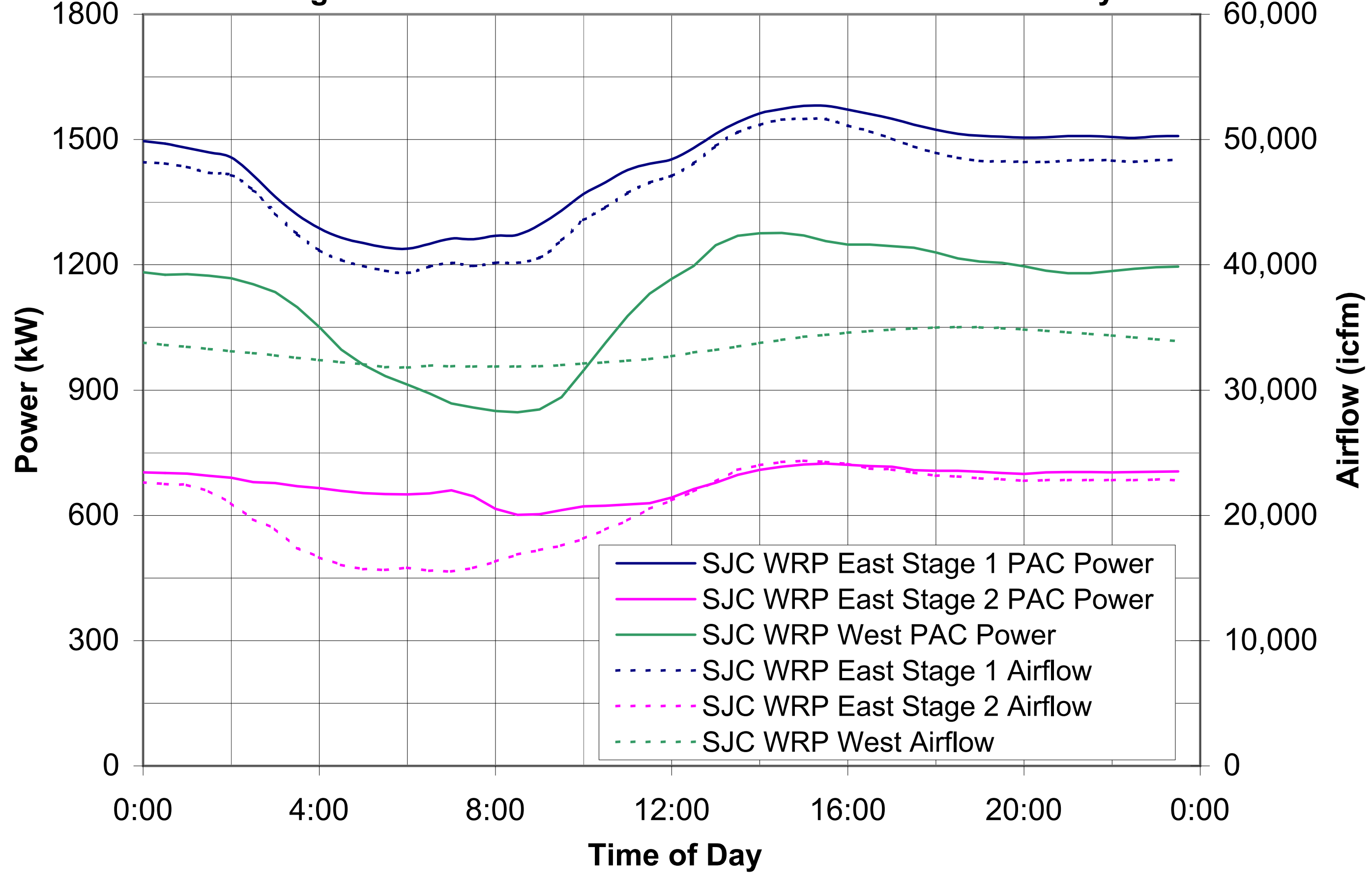


Figure 2: SJC WRP PAC Power vs. Airflow

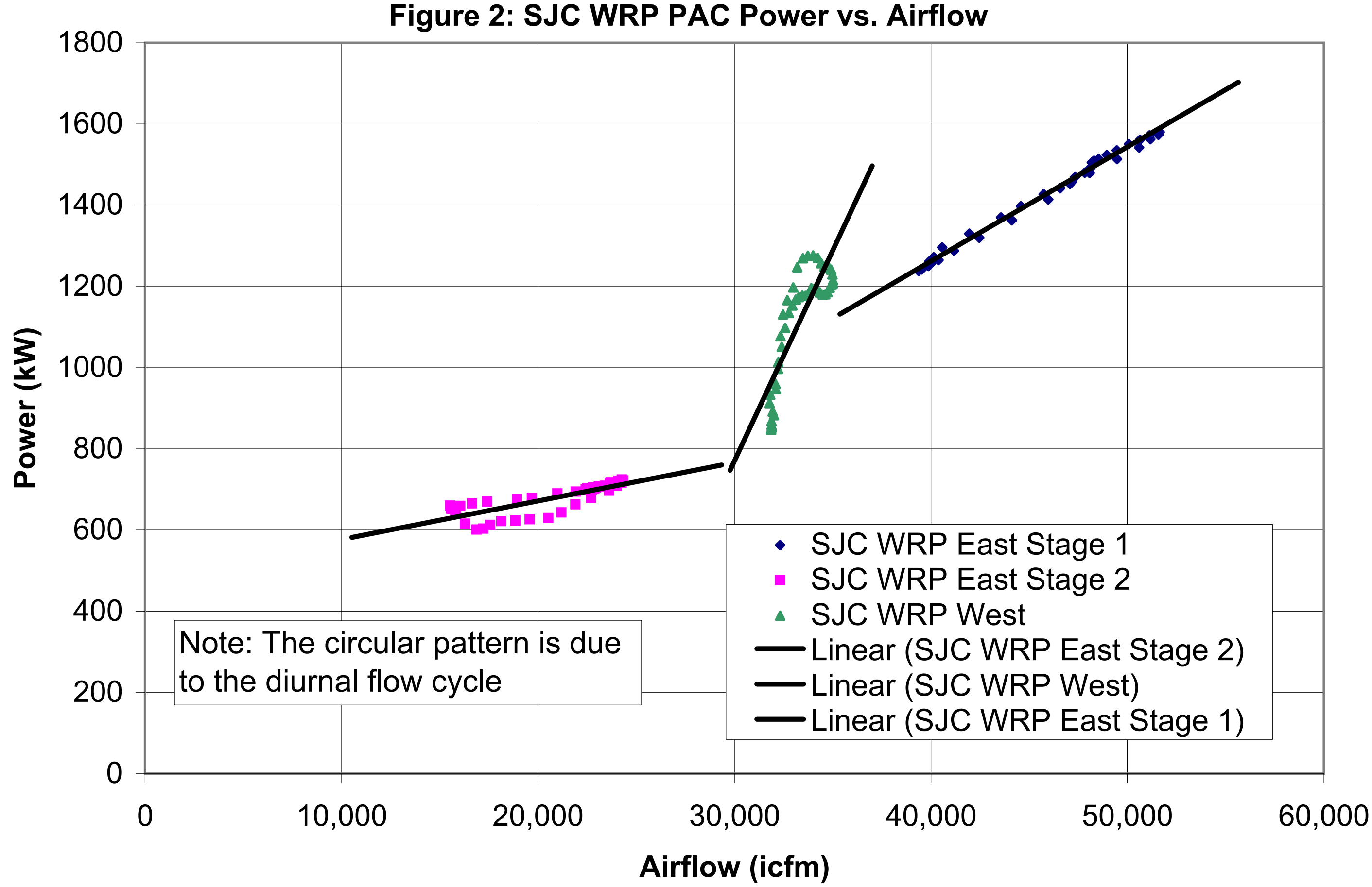


Figure 3: SJC WRP PAC Airflow Efficiency Rate

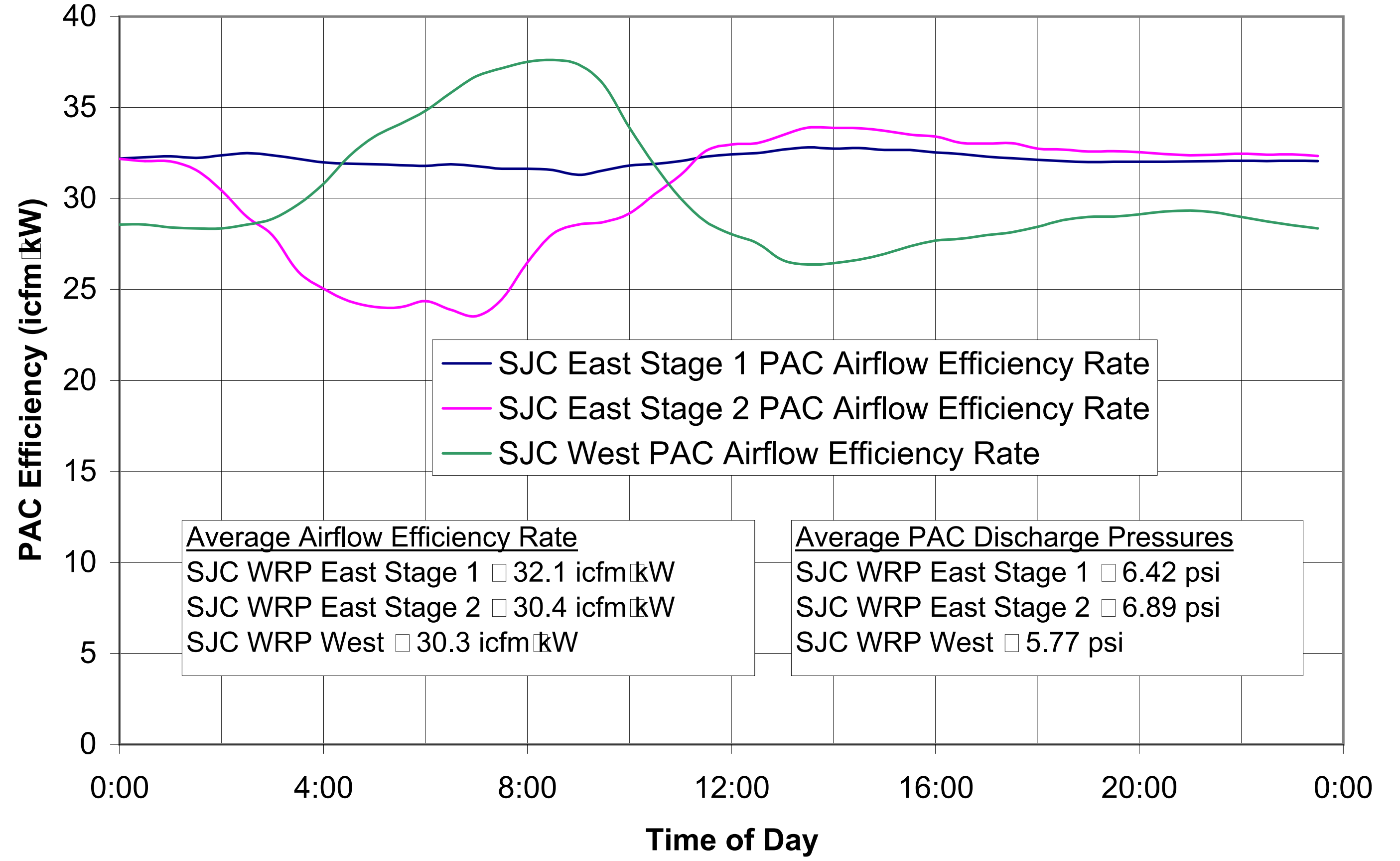


Figure 4: SJC WRP PAC Efficiency vs. Influent Flow

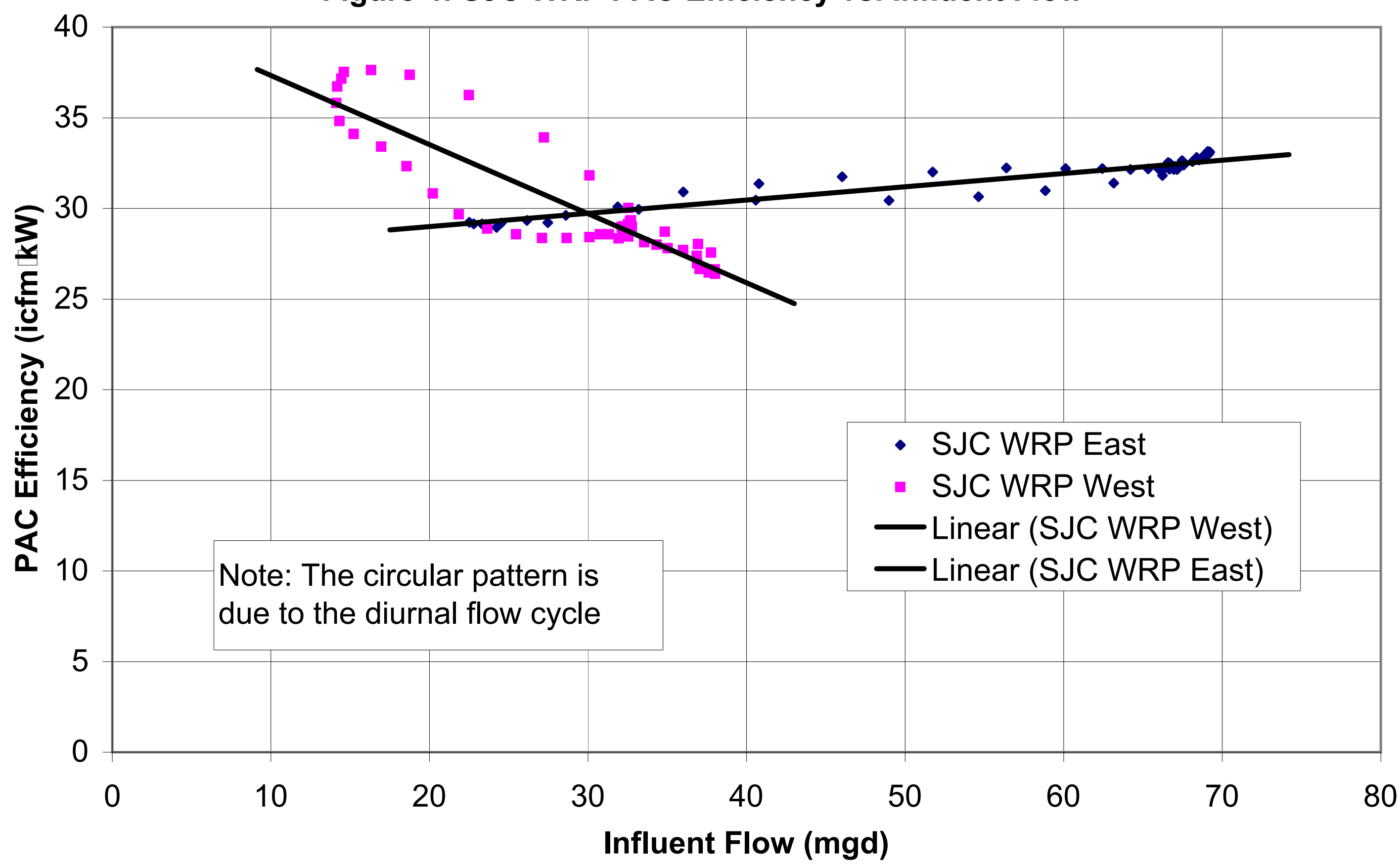


Figure 5: San Jose Creek WRP PAC Power □ Plant Flow vs. Time of Day

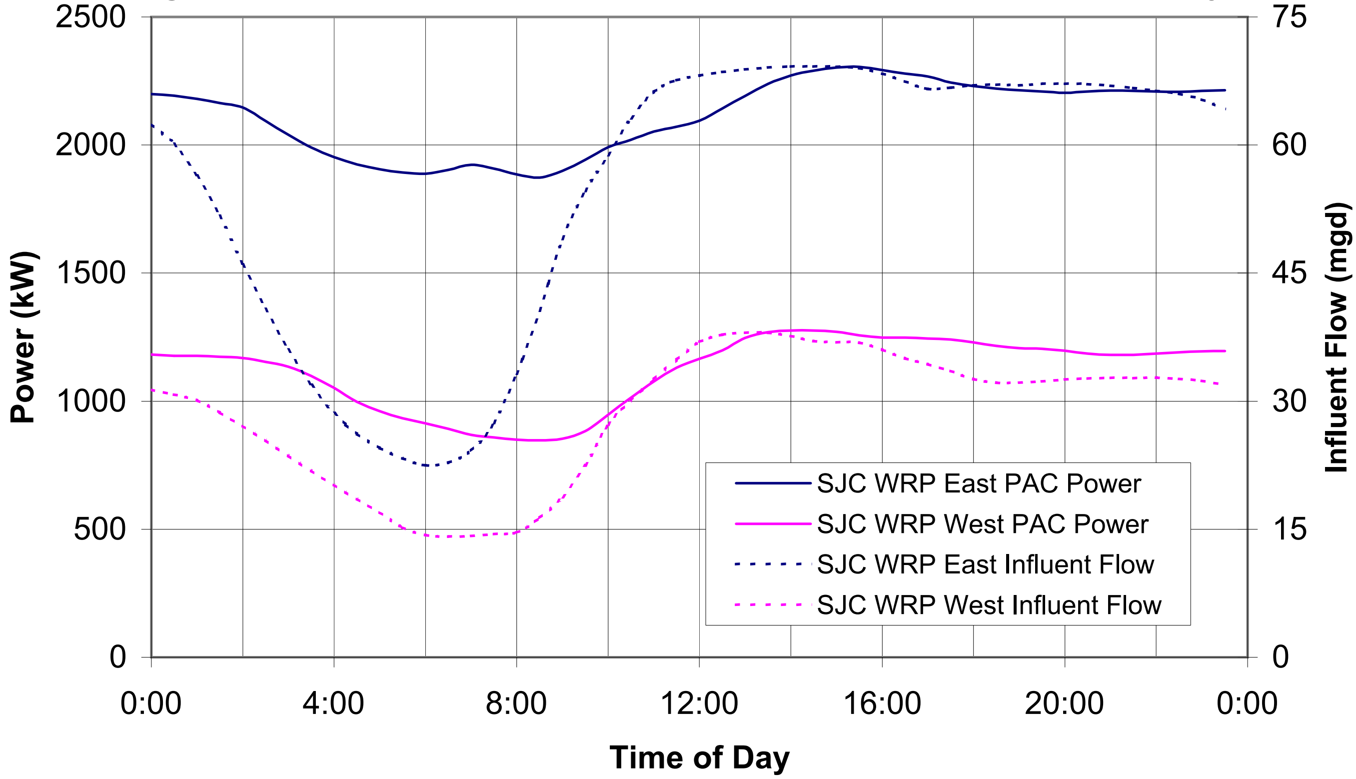
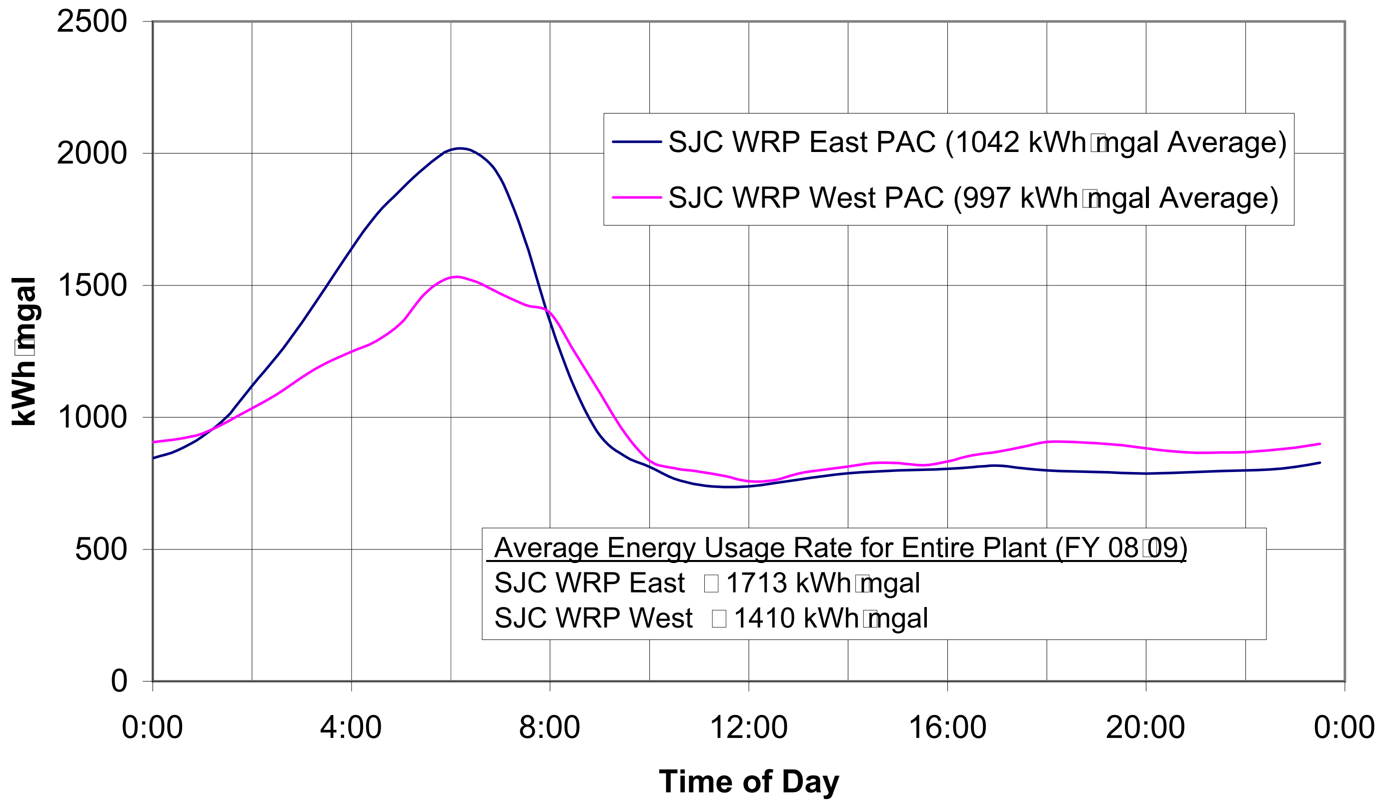


Figure 6: PAC Energy Use Per Influent Flow vs. Time of Day



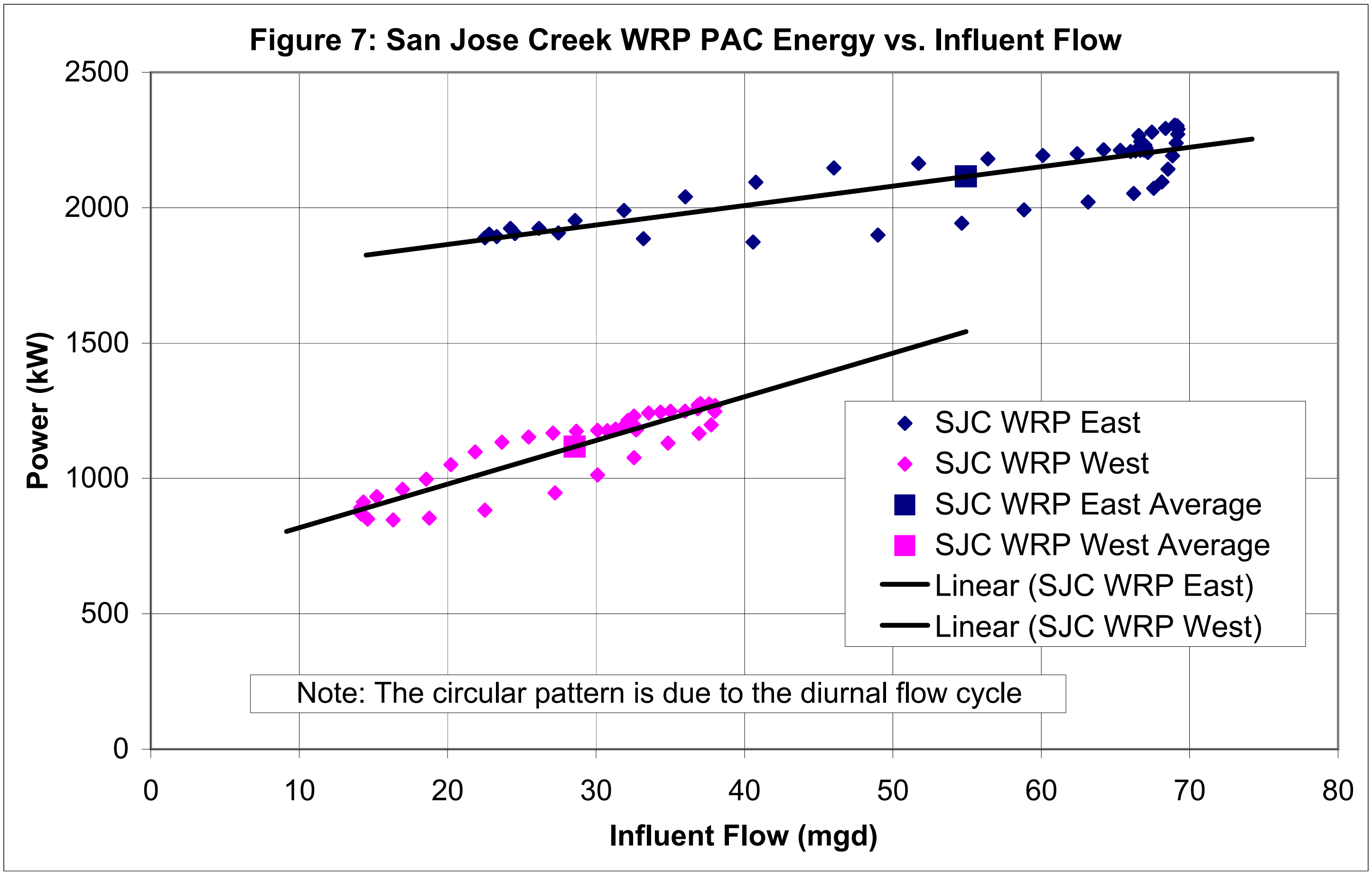


Figure 7: San Jose Creek WRP PAC Energy vs. Influent Flow
2500
2000
1500
1000
500
0
Power (kW)
0
10
20
30
40
50
60
70
80
Influent Flow (mgd)
SJC WRP East
SJC WRP West
SJC WRP East Average
SJC WRP West Average
Linear (SJC WRP East)
Linear (SJC WRP West)
Note: The circular pattern is due to the diurnal flow cycle

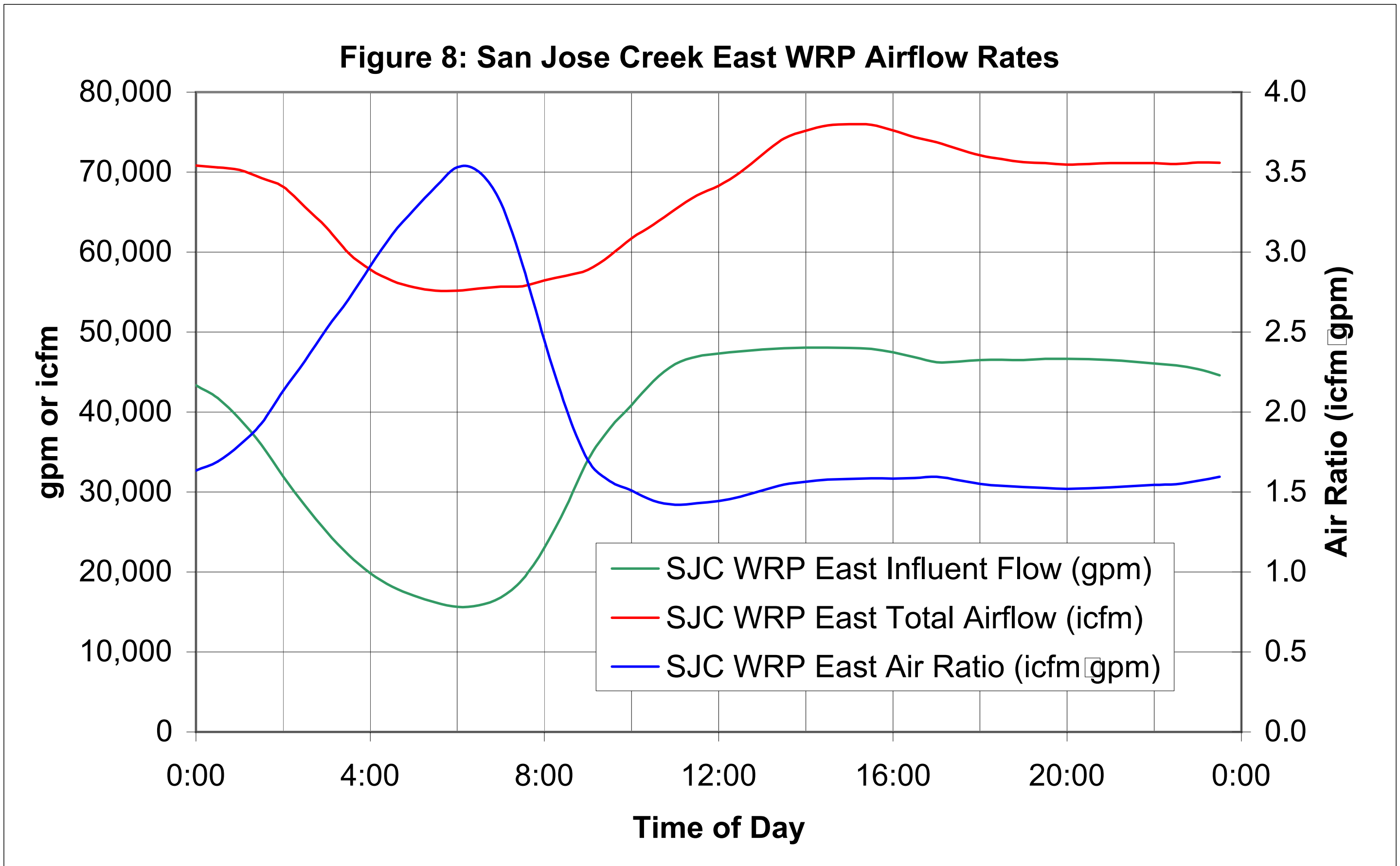


Figure 8: San Jose Creek East WRP Airflow Rates
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
gpm or icfm
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Air Ratio (icfm gpm)
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time of Day
SJC WRP East Influent Flow (gpm)
SJC WRP East Total Airflow (icfm)
SJC WRP East Air Ratio (icfm gpm)

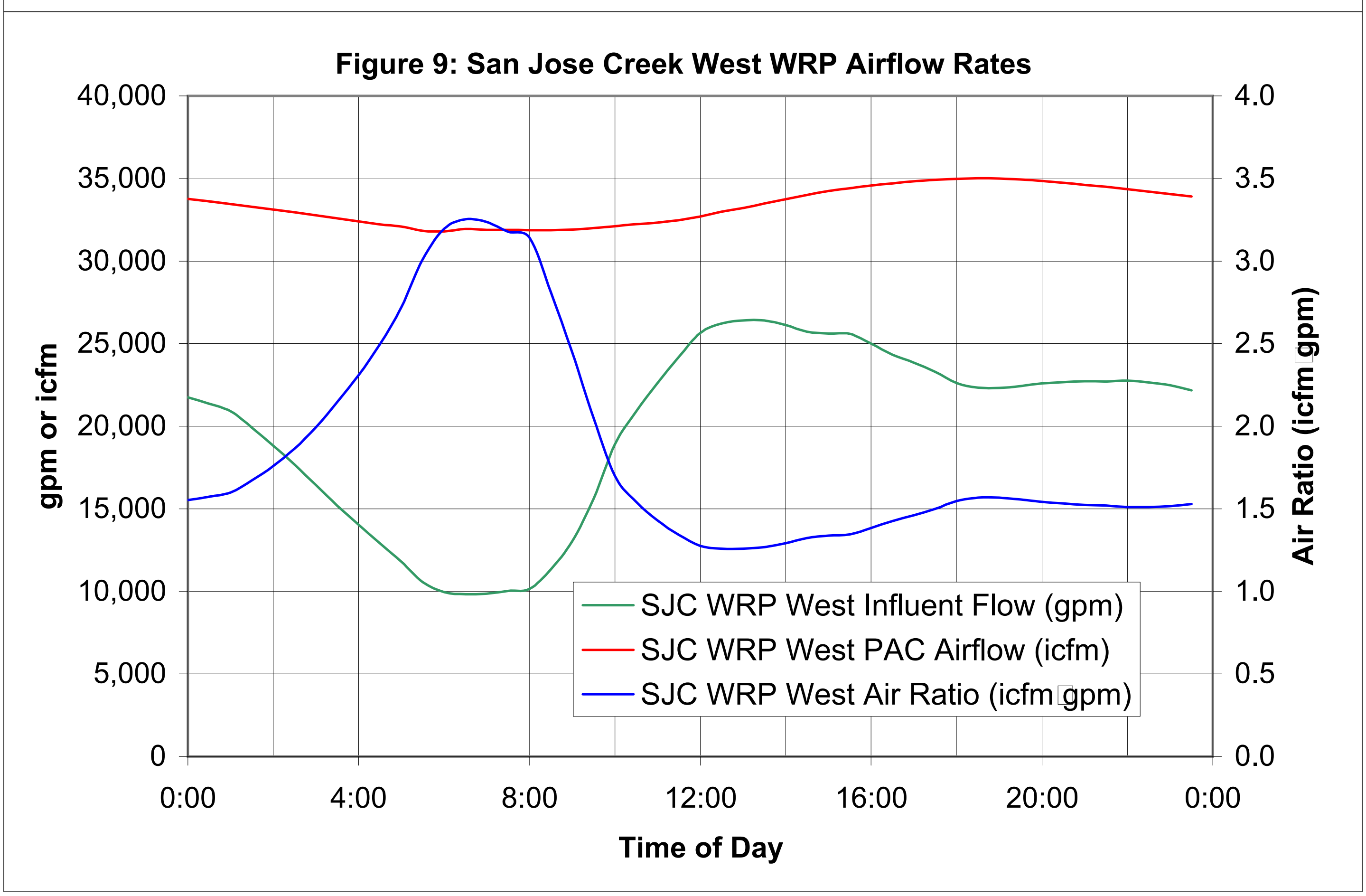


Figure 9: San Jose Creek West WRP Airflow Rates
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
gpm or icfm
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Air Ratio (icfm gpm)
0:00
4:00
8:00
12:00
16:00
20:00
0:00
Time of Day
SJC WRP West Influent Flow (gpm)
SJC WRP West PAC Airflow (icfm)
SJC WRP West Air Ratio (icfm gpm)

Figure 10: SJC East Stage One PAC Performance

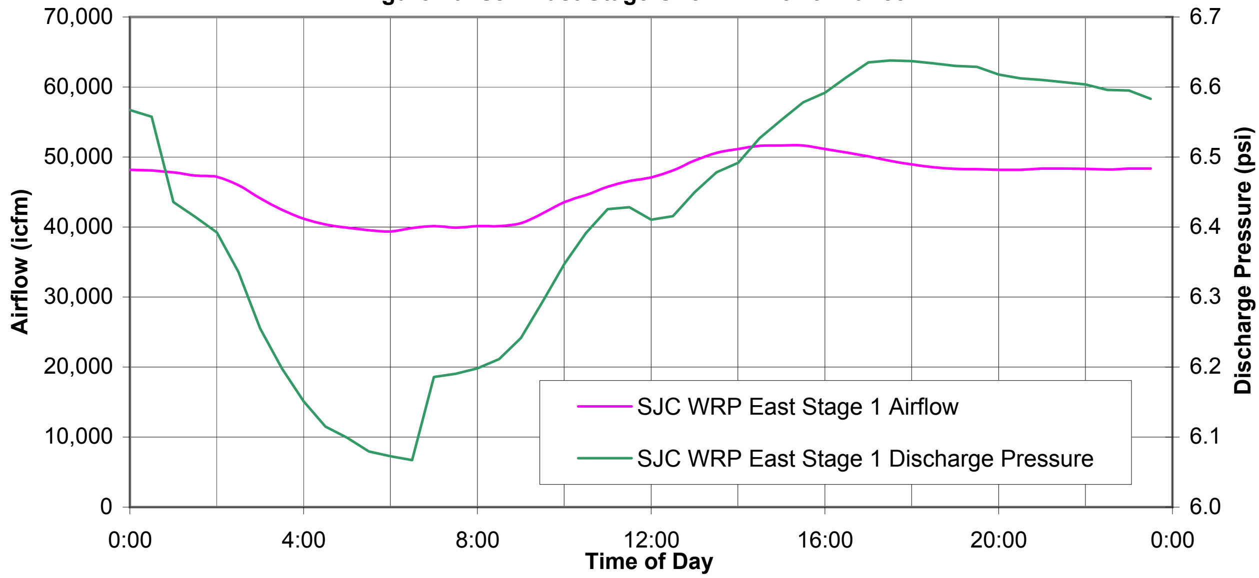


Figure 11: SJC East Stage Two PAC Performance

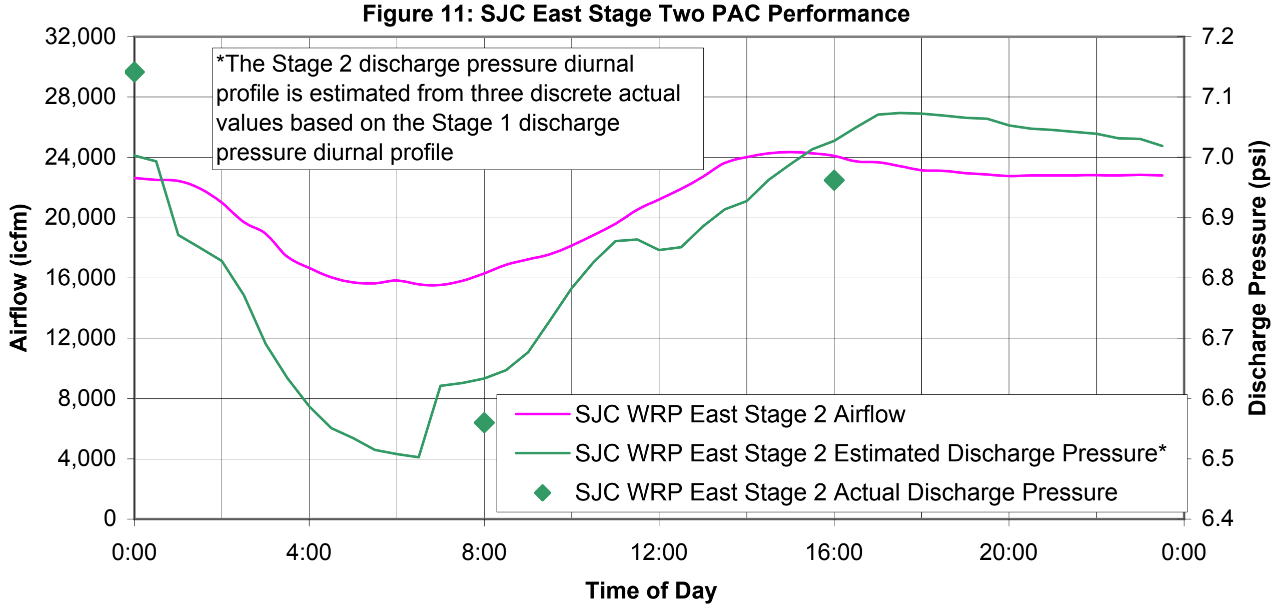


Figure 12: SJC West PAC Performance

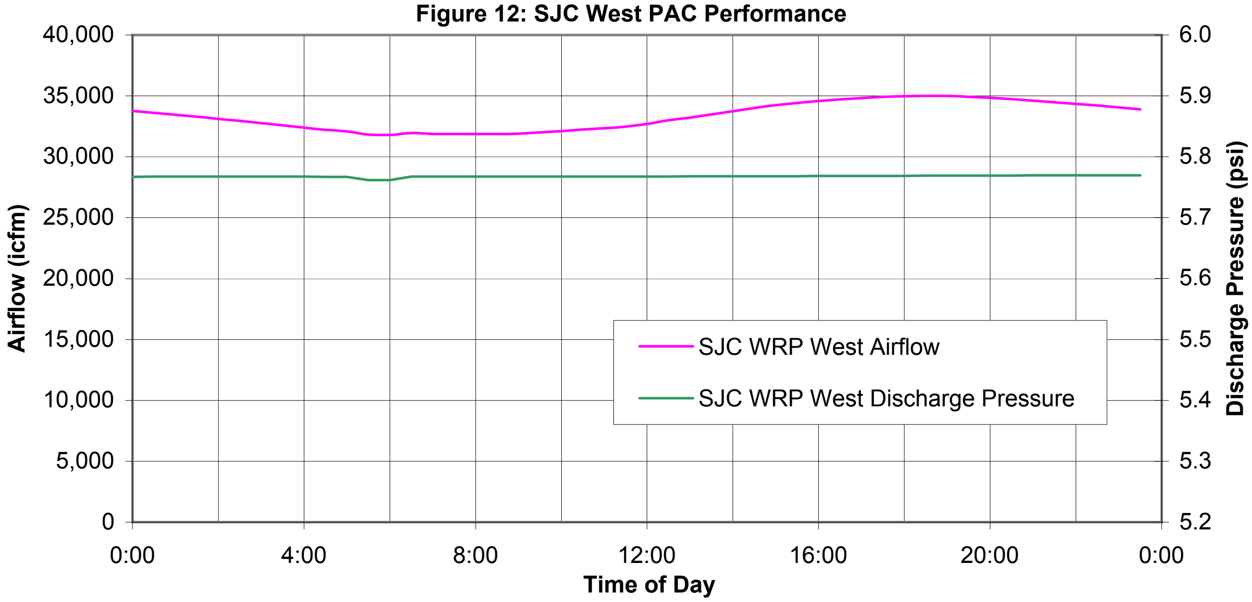


Figure 13: SJC WRP East Stage 1 Airflow Regimes

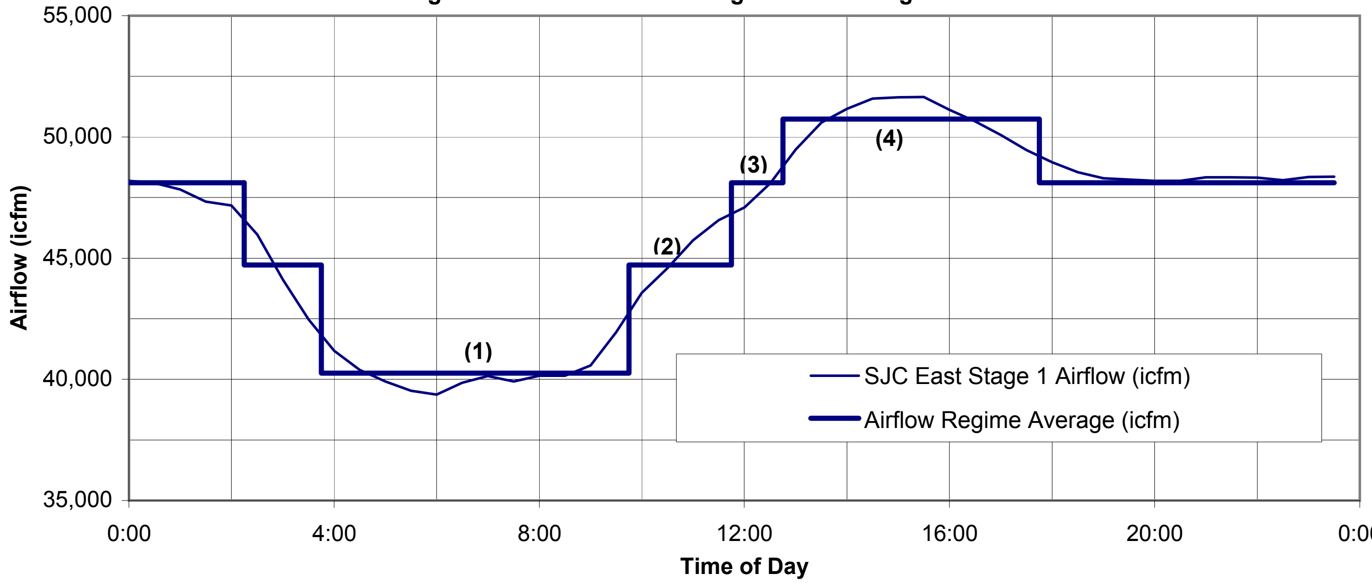


Figure 14: SJC WRP East Stage 2 Airflow Regimes

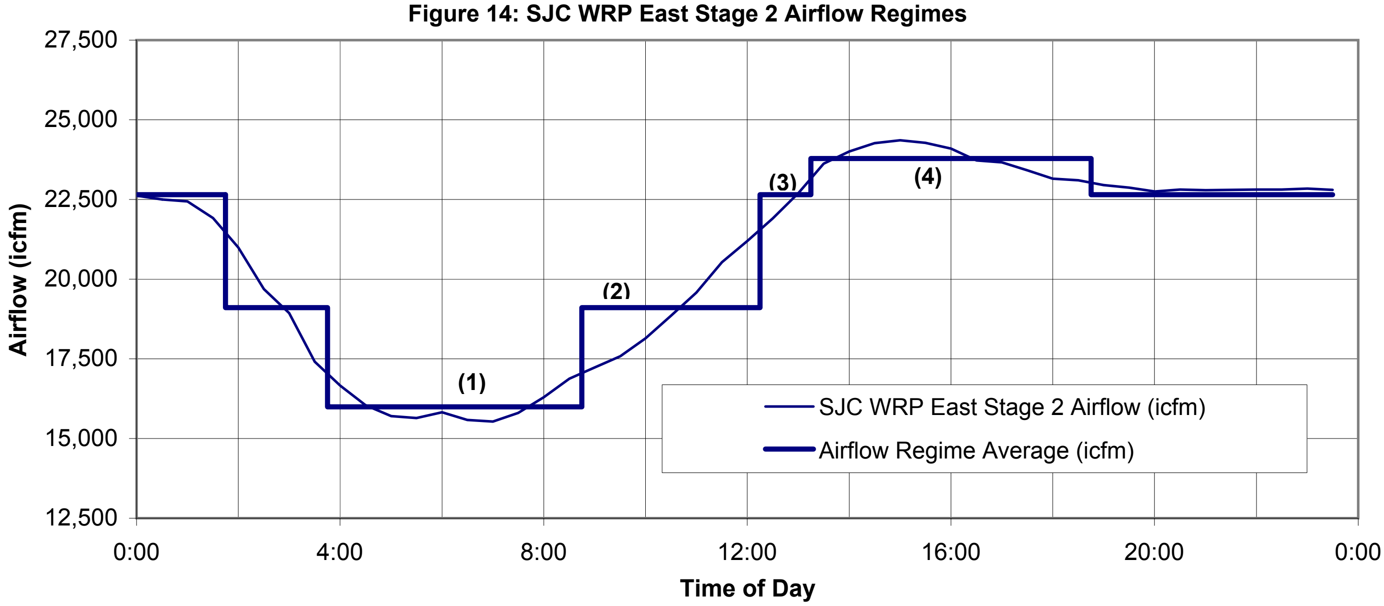


Figure 15: SJC WRP West Airflow Regimes

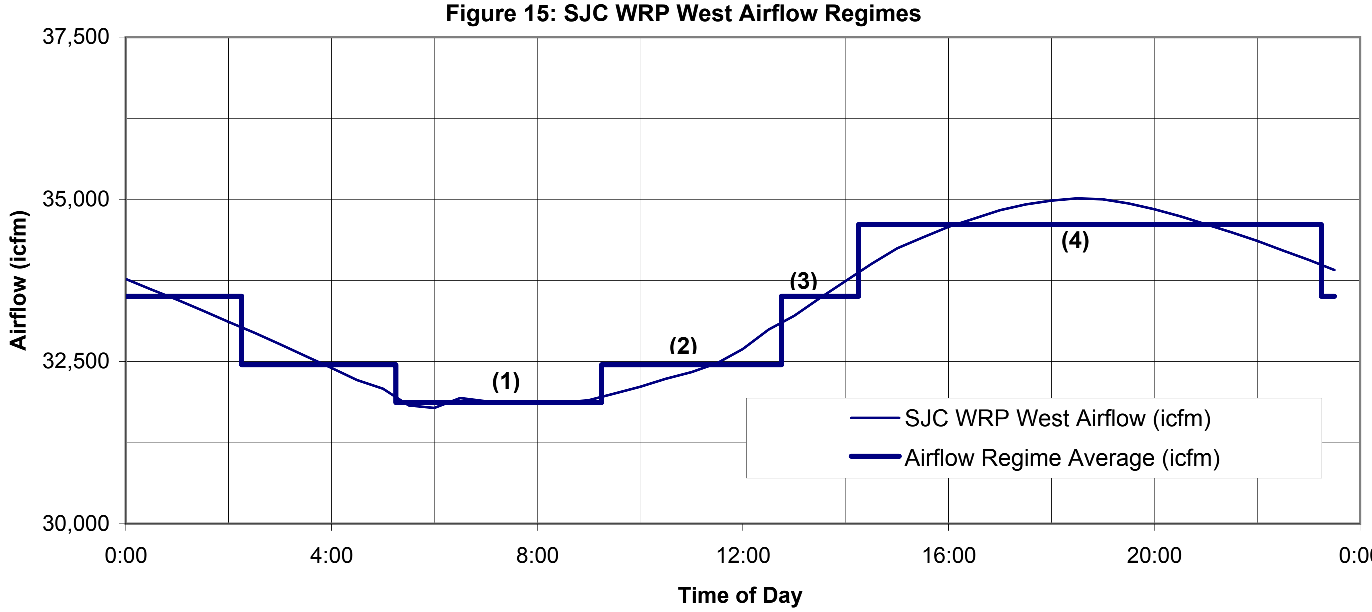


Table 4
San Jose Creek WRP East - Stage One
PAC Performance

Regime Number	Airflow Range	Hours/Day	Average Airflow within Range (icfm)	Average Discharge Pressure within Range (psi)	Average Power within Range (kW)
1	39,000 - 42,000 icfm	6.0	40,257	6.16	1269
2	42,000 - 47,000 icfm	3.5	44,715	6.34	1390
3	47,000 - 49,000 icfm	9.5	48,110	6.56	1496
4	49,000 - 52,000 icfm	5.0	50,737	6.56	1557

SJC WRP East Stage One has three 1750 hp Elliot compressors with 44,000 scfm capacity each. During the test period, two compressors normally ran at a time.

Table 5
San Jose Creek WRP East - Stage Two
PAC Performance

Regime Number	Airflow Range	Hours/Day	Average Airflow within Range (icfm)	Average Discharge Pressure within Range (psi)	Average Power within Range (kW)
1	15,000 - 17,000 icfm	5.0	15,997	6.57	645
2	17,000 - 21,500 icfm	5.5	19,104	6.77	643
3	21,500 - 23,000 icfm	8.0	22,646	6.99	698
4	23,000 - 25,000 icfm	5.5	23,790	7.02	713

SJC WRP East Stage Two has two 900 hp Roots compressors with 20,000 scfm capacity each. Both compressors ran continuously during the test period. One compressor idles for 4 to 8 hours per day without delivering any air.

Table 6
San Jose Creek WRP West
PAC Performance

Regime Number	Airflow Range	Hours/Day	Average Airflow within Range (icfm)	Average Discharge Pressure within Range (psi)	Average Power within Range (kW)
1	31,000 - 32,000 icfm	4.0	31,871	5.77	877
2	32,000 - 33,000 icfm	6.5	32,449	5.77	1062
3	33,000 - 34,000 icfm	4.5	33,507	5.77	1207
4	34,000 - 36,000 icfm	9.0	34,608	5.77	1220

SJC WRP West has three 1750 hp Roots compressors with 44,000 scfm capacity each. Only one compressor ran at a time during the test period.

Notes:
Data is for 12/17/09 through 2/11/10
Average high temperature during test period was 67 degrees
Average low termperature during test period was 47 degrees

Appendix

San Jose Creek WRP
Process Air Compressor Energy Analysis

Energy Usage Calculations for
Turblex Compressors

Data Provided by Lou Giordano
of Pacific Process

San Jose Creek WRP East - Stage 1, Option 1 (Two Duty, One Standby)

SJC WRP Power Cost □ □0.122 per kWh

Turblex Power Savings

Point No.	Yearly Hours of Opeation	Power Cost per kWh	Airflow (ICFM)	Temp (F)	Turblex Power (HP)	Turblex Power (kW)	Existing Power (kW)	Turblex Power Cost	Existing Power Cost
1a	0	$0.122	40,257	67	1226	915	1288	$0	$0
1b	2190	$0.122	40,257	47	1190	888	1250	$237,186	$334,041
2a	638.75	$0.122	44,715	67	1386	1034	1411	$80,574	$109,944
2b	638.75	$0.122	44,715	47	1342	1001	1369	$78,016	$106,718
3a	1733.75	$0.122	48,110	67	1534	1144	1518	$242,053	$321,177
3b	1733.75	$0.122	48,110	47	1476	1101	1474	$232,901	$311,754
4a	1825	$0.122	50,737	67	1628	1214	1580	$270,406	$351,866
4b	0	$0.122	50,737	47	1566	1168	1534	$0	$0

First Year Power Cost	$1,141,136	$1,535,500
First Year Power Savings	$394,364	
Annual kWh Savings	3,232,494	
Average kW Savings	369	
Turblex Model	KA66	
No. of Duty Units	1	
No. of Standby Units	1	
Price w. LACSD Features	$881,000	
Total Price w. LACSD Features	$1,762,000	
SCE Rebate Incentive	$327,825	
Equipment Payback Period	3.6	

Regime Average Performance Data

Point No.	Hrs□Day	Hrs□Yr	Temp (F)	Flow (cfm)	Disch. Pres.	Power (kW, uncorrected)
1a	0	0	67	40,257	6.16	1269
1b	6	2190	47	40,257	6.16	1269
2a	1.75	638.75	67	44,715	6.34	1390
2b	1.75	638.75	47	44,715	6.34	1390
3a	4.75	1733.75	67	48,110	6.56	1496
3b	4.75	1733.75	47	48,110	6.56	1496
4a	5	1825	67	50,737	6.56	1557
4b	0	0	47	50,737	6.56	1557

<u>Methodology of Temperature Correction for Power of Existing Equipment:</u>
Average high temperature during test period was 67F
Average low termperature during test period was 47F

From Turblex, power ratio from 47F to 67F is 97□.
Therefore multiply 67F number by 1.015 and divide 47F number by 1.015.

Point 1 (Regime □1) is during early morning, so temperature is assumed to be 47F
Point 2 (Regime □2) is very early and very late morning, so temperature is assumed to be half 47F and half 67F
Point 3 (Regime □3) is midday and midnight, so temperature is assumed to be half 47F and half 67F
Point 4 (Regime □4) is mid-afternoon, so temperature is assumed to be 67F

San Jose Creek WRP East - Stage 1, Option 2 (One Duty, One Standby)

SJC WRP Power Cost □ □0.122 per kWh

Turblex Power Savings

Point No.	Yearly Hours of Opeation	Power Cost per kWh	Airflow (ICFM)	Temp (F)	Turblex Power (HP)	Turblex Power (kW)	Existing Power (kW)	Turblex Power Cost	Existing Power Cost
1a	0	$0.122	40,257	67	1241	926	1288	$0	$0
1b	2190	$0.122	40,257	47	1210	903	1250	$241,173	$334,041
2a	638.75	$0.122	44,715	67	1402	1046	1411	$81,504	$109,944
2b	638.75	$0.122	44,715	47	1361	1015	1369	$79,120	$106,718
3a	1733.75	$0.122	48,110	67	1547	1154	1518	$244,104	$321,177
3b	1733.75	$0.122	48,110	47	1495	1115	1474	$235,899	$311,754
4a	1825	$0.122	50,737	67	1642	1225	1580	$272,731	$351,866
4b	0	$0.122	50,737	47	1585	1182	1534	$0	$0

First Year Power Cost	$1,154,531	$1,535,500
First Year Power Savings	$380,969	
Annual kWh Savings	3,122,693	
Average kW Savings	356	
Turblex Model	KA100	
No. of Duty Units	1	
No. of Standby Units	1	
Price w. LACSD Features	$1,438,000	
Total Price w. LACSD Features	$2,876,000	
SCE Rebate Incentive	$316,690	
Equipment Payback Period	6.7	

Regime Average Performance Data

Point No.	Hrs□Day	Hrs□Yr	Temp (F)	Flow (cfm)	Disch. Pres.	Power (kW, uncorrected)
1a	0	0	67	40,257	6.16	1269
1b	6	2190	47	40,257	6.16	1269
2a	1.75	638.75	67	44,715	6.34	1390
2b	1.75	638.75	47	44,715	6.34	1390
3a	4.75	1733.75	67	48,110	6.56	1496
3b	4.75	1733.75	47	48,110	6.56	1496
4a	5	1825	67	50,737	6.56	1557
4b	0	0	47	50,737	6.56	1557

Methodology of Temperature Correction for Power of Existing Equipment:
Average high temperature during test period was 67F
Average low termperature during test period was 47F

From Turblex, power ratio from 47F to 67F is 97□ .
Therefore multiply 67F number by 1.015 and divide 47F number by 1.015.

Point 1 (Regime □1) is during early morning, so temperature is assumed to be 47F
Point 2 (Regime □2) is very early and very late morning, so temperature is assumed to be half 47F and half 67F
Point 3 (Regime □3) is midday and midnight, so temperature is assumed to be half 47F and half 67F
Point 4 (Regime □4) is mid-afternoon, so temperature is assumed to be 67F

San Jose Creek WRP East - Stage 2 (One Duty, One Standby)

SJC WRP Power Cost □ □0.122 per kWh

Turblex Power Savings

Point No.	Yearly Hours of Opeation	Power Cost per kWh	Airflow (ICFM)	Temp (F)	Turblex Power (HP)	Turblex Power (kW)	Existing Power (kW)	Turblex Power Cost	Existing Power Cost
1a	0	$0.122	15,997	67	526	392	655	$0	$0
1b	1825	$0.122	15,997	47	513	383	636	$85,208	$141,605
2a	1003.75	$0.122	19,104	67	631	471	653	$57,644	$79,965
2b	1003.75	$0.122	19,104	47	613	457	634	$56,000	$77,638
3a	1460	$0.122	22,646	67	773	577	709	$102,714	$126,287
3b	1460	$0.122	22,646	47	744	555	688	$98,861	$122,547
4a	2007.5	$0.122	23,790	67	819	611	724	$149,637	$177,318
4b	0	$0.122	23,790	47	787	587	703	$0	$0

First Year Power Cost	$550,063	$725,360
First Year Power Savings	$175,297	
Annual kWh Savings	1,436,862	
Average kW Savings	164	
Turblex Model	KA66	
No. of Duty Units	1	
No. of Standby Units	1	
Price w. LACSD Features	$881,000	
Total Price w. LACSD Features	$1,762,000	
SCE Rebate Incentive	$145,720	
Equipment Payback Period	9.2	

Regime Average Performance Data

Point No.	Hrs□Day	Hrs□Yr	Temp (F)	Flow (cfm)	Disch. Pres.	Power (kW, uncorrected)
1a	0	0	67	15,997	6.57	645
1b	5	1825	47	15,997	6.57	645
2a	2.75	1003.75	67	19,104	6.77	643
2b	2.75	1003.75	47	19,104	6.77	643
3a	4	1460	67	22,646	6.99	698
3b	4	1460	47	22,646	6.99	698
4a	5.5	2007.5	67	23,790	7.02	713
4b	0	0	47	23,790	7.02	713

Methodology of Temperature Correction for Power of Existing Equipment:
Average high temperature during test period was 67F
Average low termperature during test period was 47F

From Turblex, power ratio from 47F to 67F is 97□.
Therefore multiply 67F number by 1.015 and divide 47F number by 1.015.

Point 1 (Regime □1) is during early morning, so temperature is assumed to be 47F
Point 2 (Regime □2) is very early and very late morning, so temperature is assumed to be half 47F and half 67F
Point 3 (Regime □3) is midday and midnight, so temperature is assumed to be half 47F and half 67F
Point 4 (Regime □4) is mid-afternoon, so temperature is assumed to be 67F

San Jose Creek WRP West - Option 1 (One Duty Only)

SJC WRP Power Cost = $0.122 per kWh

Turblex Power Savings

Point No.	Yearly Hours of Opeation	Power Cost per kWh	Airflow (ICFM)	Temp (F)	Turblex Power (HP)	Turblex Power (kW)	Existing Power (kW)	Turblex Power Cost	Existing Power Cost
1a	0	$0.12	31,871	67	910	679	890	$0	$0
1b	1460	$0.12	31,871	47	877	654	864	$116,534	$153,903
2a	1186.25	$0.12	32,449	67	929	693	1078	$100,298	$156,001
2b	1186.25	$0.12	32,449	47	894	667	1046	$96,519	$151,424
3a	821.25	$0.12	33,507	67	962	718	1225	$71,903	$122,746
3b	821.25	$0.12	33,507	47	925	690	1189	$69,138	$119,145
4a	3285	$0.12	34,608	67	997	744	1238	$298,077	$496,273
4b	0	$0.12	34,608	47	959	715	1202	$0	$0

First Year Power Cost	$752,469	$1,199,492
First Year Power Savings	$447,024	
Annual kWh Savings	3,664,128	
Average kW Savings	418	
Turblex Model	KA80	
No. of Duty Units	1	
No. of Standby Units	0	
Price w. LACSD Features	$1,231,000	
Total Price w. LACSD Features	$1,231,000	Years
SCE Rebate Incentive	$371,599	
Equipment Payback Period	1.9	

Regime Average Performance Data

Point No.	Hrs/Day	Hrs/Yr	Temp (F)	Flow (cfm)	Disch. Pres.	Power (kW, uncorrected)
1a	0	0	67	31,871	5.77	877
1b	4	1460	47	31,871	5.77	877
2a	3.25	1186.25	67	32,449	5.77	1062
2b	3.25	1186.25	47	32,449	5.77	1062
3a	2.25	821.25	67	33,507	5.77	1207
3b	2.25	821.25	47	33,507	5.77	1207
4a	9	3285	67	34,608	5.77	1220
4b	0	0	47	34,608	5.77	1220

Methodology of Temperature Correction for Power of Existing Equipment:

Average high temperature during test period was 67F
Average low termperature during test period was 47F

From Turblex, power ratio from 47F to 67F is 97%.
Therefore multiply 67F number by 1.015 and divide 47F number by 1.015.

Point 1 (Regime #1) is during early morning, so temperature is assumed to be 47F
Point 2 (Regime #2) is very early and very late morning, so temperature is assumed to be half 47F and half 67F
Point 3 (Regime #3) is midday and midnight, so temperature is assumed to be half 47F and half 67F
Point 4 (Regime #4) is mid-afternoon, so temperature is assumed to be 67F

San Jose Creek WRP West - Option 2 (One Duty, Two Standby)

SJC WRP Power Cost □ □0.122 per kWh

Turblex Power Savings

Point No.	Yearly Hours of Opeation	Power Cost per kWh	Airflow (ICFM)	Temp (F)	Turblex Power (HP)	Turblex Power (kW)	Existing Power (kW)	Turblex Power Cost	Existing Power Cost
1a	0	$0.12	31,871	67	910	679	890	$0	$0
1b	1460	$0.12	31,871	47	877	654	864	$116,534	$153,903
2a	1186.25	$0.12	32,449	67	929	693	1078	$100,298	$156,001
2b	1186.25	$0.12	32,449	47	894	667	1046	$96,519	$151,424
3a	821.25	$0.12	33,507	67	962	718	1225	$71,903	$122,746
3b	821.25	$0.12	33,507	47	925	690	1189	$69,138	$119,145
4a	3285	$0.12	34,608	67	997	744	1238	$298,077	$496,273
4b	0	$0.12	34,608	47	959	715	1202	$0	$0

First Year Power Cost	$752,469	$1,199,492
First Year Power Savings	$447,024	
Annual kWh Savings	3,664,128	
Average kW Savings	418	
Turblex Model	KA80	
No. of Duty Units	1	
No. of Standby Units	2	
Price w. LACSD Features	$1,231,000	
Total Price w. LACSD Features	$3,693,000	Years
SCE Rebate Incentive	$371,599	
Equipment Payback Period	7.4	

Regime Average Performance Data

Point No.	Hrs□Day	Hrs□Yr	Temp (F)	Flow (cfm)	Disch. Pres.	Power (kW, uncorrected)
1a	0	0	67	31,871	5.77	877
1b	4	1460	47	31,871	5.77	877
2a	3.25	1186.25	67	32,449	5.77	1062
2b	3.25	1186.25	47	32,449	5.77	1062
3a	2.25	821.25	67	33,507	5.77	1207
3b	2.25	821.25	47	33,507	5.77	1207
4a	9	3285	67	34,608	5.77	1220
4b	0	0	47	34,608	5.77	1220

<u>Methodology of Temperature Correction for Power of Existing Equipment:</u>
Average high temperature during test period was 67F
Average low termperature during test period was 47F

From Turblex, power ratio from 47F to 67F is 97□ .
Therefore multiply 67F number by 1.015 and divide 47F number by 1.015.

Point 1 (Regime □1) is during early morning, so temperature is assumed to be 47F
Point 2 (Regime □2) is very early and very late morning, so temperature is assumed to be half 47F and half 67F
Point 3 (Regime □3) is midday and midnight, so temperature is assumed to be half 47F and half 67F
Point 4 (Regime □4) is mid-afternoon, so temperature is assumed to be 67F

Fiscal Year 2012-2013 Budget Meetings and Documents

Budget Documents

Fiscal Year 2012-2013 Budget

Water Rates & Charges

Water Rates and Charges Table 2012-2013

Notices of Meetings

Budget Workshop – April 16, 2012

Proposed Water Rates

Imported Water Rate Per Acre Foot - Tier 1 & Tier 2

Imported Water Rate Per Acre Foot- Tier 1

	Current	7/1/12	1/1/13
MET Commodity	$794	$794	$847
MET RTS	$31	$31	$30
MET Total	**$825**	**$825**	**$877**
CB Admin Surcharge	$70	$70	$70
CB Infrastructure Surcharge	$20	$20	$20
CB Total	**$90**	**$90**	**$90**
MET & CB Total	**$915**	**$915**	**$967**

Imported Water Rate Per Acre Foot- Tier 2

	Current	7/1/12	1/1/13
MET Commodity	$920	$920	$997
MET RTS	$31	$31	$30
MET Total	**$951**	**$951**	**$1,027**
CB Admin Surcharge	$70	$70	$70
CB Infrastructure Surcharge	$20	$20	$20
CB Total	**$90**	**$90**	**$90**
MET & CB Total	**$1,041**	**$1,041**	**$1,117**

Central Basin Municipal Water District | 6252 Telegraph Road | Commerce, CA 90040-2512 | Tel: 323.201.5500 | FAX: 323.201.5550

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Using Effluent Water **On Your** Golf Course

by DR. DAVID KOPEC, DR. CHARLES MANCINO, and DOUGLAS NELSON
University of Arizona, Tucson, Arizona

YOU MIGHT CALL IT a recycler's nightmare. Every day, 365 days a year, hundreds of millions of gallons of useable treated water is dumped needlessly into the ground, rivers, and oceans of the world. Is this truly necessary, or is there an alternative method of disposal to allow the recapture of some of this water and put it through a natural filter? Actually, there is! Parks, golf courses, sports fields, and certain agricultural crops all can use effluent water for irrigation.

In addition to preventing needless dumping, a useable effluent water supply has several other advantages. These include (1) guaranteed availability, even during periods of drought, (2) a nutrient content that potentially can lessen dependence on manufactured fertilizers, (3) the freeing of limited supplies of potable water for other, more essential uses, and (4) income, from the sale of effluent water to agricultural users, to pay for the construction of public sewage treatment plants.

Before running to the faucet and turning on an effluent water supply, however, there are several points that should be considered. To begin with, a thorough understanding of effluent water and how it is produced is essential.

What is Effluent?

The source of most effluent water supplies comes from municipal sewage that is approximately 99.9% water (effluent) and

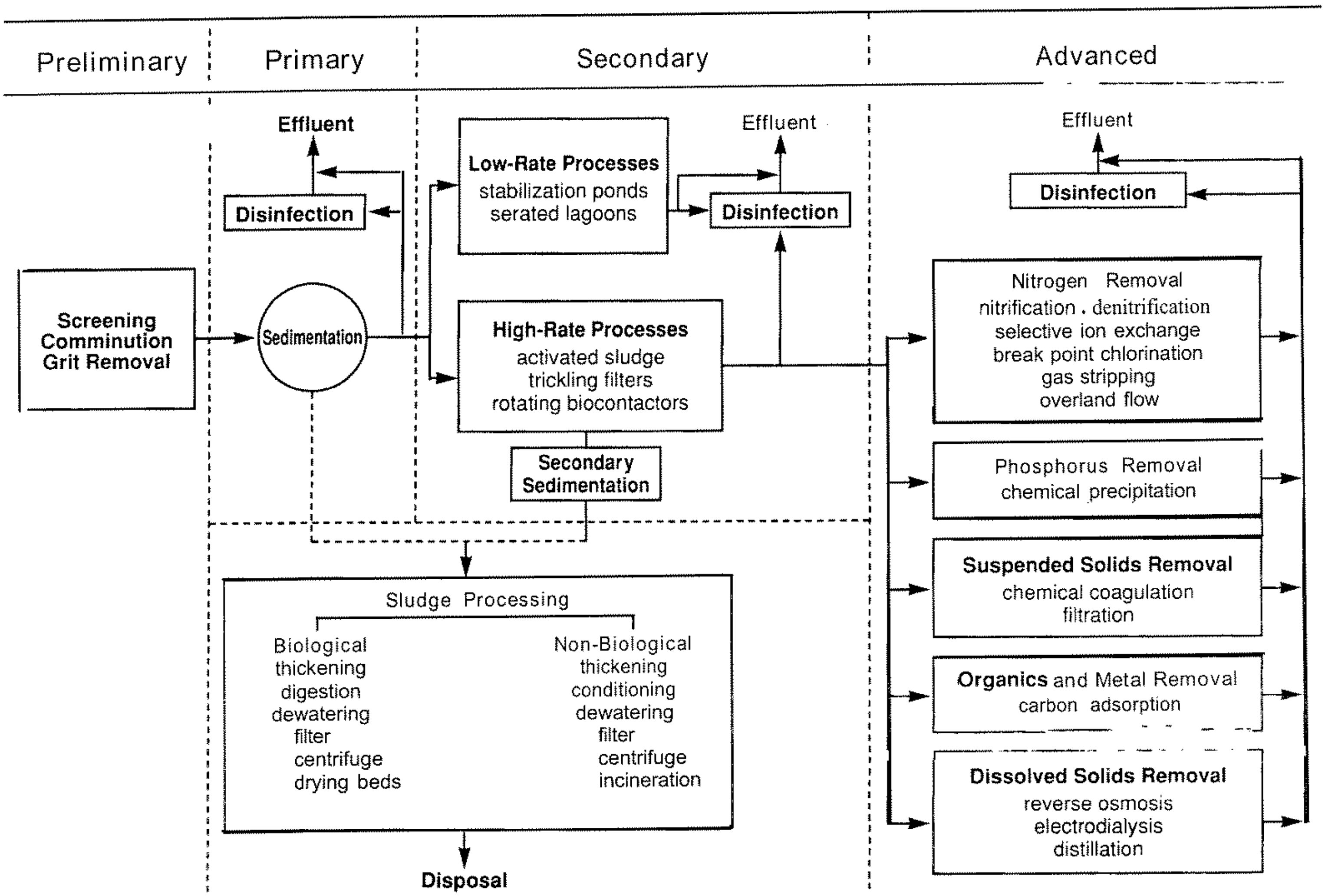

Figure 1 — Generalized Flow Sheet for Wastewater Treatment
Source: Asano, T., R. G. Smith, and G. Tschobanoglous, 1984

(Na), chlorine (Cl), magnesium (Mg), calcium (Ca), sulfate (SO_4), and bicarbonates (HCO_3). After irrigation with effluent, these salts accumulate in the soil and attract pure water molecules, preventing some of the water from being absorbed by the turfgrass plants. As a result, less "free" water is available for turfgrass uptake and symptoms of drought stress begin to occur

Sodium Hazard — Sodium hazard indicates the relative amount of sodium (Na) in relation to calcium (Ca) and magnesium (Mg). A high amount of sodium in effluent water is undesirable from a water and soil standpoint. In addition to being a component of salt stress, sodium (Na) accumulation eventually will result in displacement of calcium (Ca) and magnesium (Mg) on the exchange sites of soil particles. This in turn inhibits the abilityof the soil to aggregate and form peds necessary to maintain good soil structure.

Bicarbonate Concentration — Bicarbonate (HCO_3) concentration is important because of its ability to form precipitates of calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$). These precipitates "steal" calcium and magnesium from the soil particle exchange sites, and in turn can be replaced by sodium. Of lesser importance is that excess bicarbonate can lead to an increase in soil pH.

Toxic Ion Concentration -High concentrations of specific ions, such as chlorine and boron, can cause damage as they accumulate in plant tissue. Fortunately, turfgrasses are relatively tolerant of several toxic ions. These ions tend to accumulate in the leaf tip and are removed during mowing. Many ornamental trees and shrubs arc not as fortunate, however, and can experience disfiguring leaf bums. The type and amount of toxic ions found in effluent is a function of where the raw sewage emanates from. Generally speaking, most municipal effluent does not contain high toxic ion concentrations, whereas industrial and mining effluent does.

pH — The pH (negative logarithm of the hydrogen ion concentration) of effluent water serves as an indication that there may be some type of ion imbalance in the water. In general, it is held that the pH of the water itself is not a problem, as most soils have a great resistance to pH alteration.

What Next?

With an understanding of the chemical characteristics of effluent water, developing maintenance practices that compensate for any negative attributes is a relatively simple matter. To begin with, the highest management priority is determining the water's total salt concentration. As mentioned previously, dissolved salts can quickly accumulate in the soil and inhibit "free" moisture/nutrient uptake.

To avoid such an occurrence, periodic heavy irrigation cycles must be programmed to saturate the soil and leach the salts below the root zone. To accommodate salt leaching, the importance of good subsurface drainage cannot be overstated. This point is especially important in regard to putting greens, where excessively wet conditions would make the soil more susceptible to excessive compaction from concentrated foot traffic.

Another high priority is the sodium hazard, or the relative amount of sodium in comparison to calcium and magnesium. If the sodium hazard is high, the sodium ions will accumulate on the soil exchange sites and cause degradation of the soil structure. As a counterbalance, additional calcium should be added to the soil. In a majority of cases, this can be done by applying calcium sulfate (gypsum) in either a granular or liquid formulation.

In cases where the soil has a high pH and excess free calcium carbonate, however, sulfur should be applied. As the sulfur breaks down, it dissolves the natural calcium deposits and increases the availability of minor nutrients by lowering the

As a potential benefit, many effluent water supplies contain substantial amounts of nitrogen, phosphorus, and potassium (Table 3). However, due to daily and seasonal nutrient fluctuations, it is not possible to calculate the exact amount of these nutrients that will be deposited on the turf so that it can be subtracted from the annual fertilization program. Therefore, monitoring of both turf performance and soil test data should be done to make the necessary adjustments.

Although nutrient content is a potential benefit, toxic ions are another matter. If present, some toxic ions can lead to the deterioration of the turf and the surrounding landscape. Since the removal of toxic ions from an effluent supply would not be economically feasible in most cases, and they cannot be effectively leached through the soil, blending of the effluent with other water sources is likely to be the only real solution. For example, the concentration of boron could be reduced to a nontoxic level by blending an effluent water supply with a well water supply.

Though not directly toxic to plants, high bicarbonate levels in effluent water can contribute to sodium buildup in the soil by reacting with calcium and magnesium. To prevent this reaction, acid injection (the addition of acid to the effluent water) sometimes is used to lower the pH and nullify the bicarbonate ion. To determine the potential benefits of acid injection, water samples can be submitted for special testing.

Conclusion

As an alternative to potable water use, effluent water can in fact be a logical, safe, and economical choice for golf course and sports turf irrigation. Furthermore, it offers an environmentally responsible choice to the wholesale dumping of treated water into existing waterways. Turning on the faucet simply requires understanding both what effluent water is and what it is not!

Table 3
Potential Fertilizer Value of Irvine Ranch Water District Reclaimed Water (Per Acre-Foot)

Nutrients	Concentration mg/l	Pounds/ac.-ft.	Commercial* Value $/ac.-ft.
Nitrogen (N)	23.0	62.6	$11.27
Phosphorus (P)	2.2	6.0	2.82
Potassium (K)	13.9	38.1	6.10
Total Potential Fertilizer Value			$20.19

*Commercial value based on average fertilizer prices for the summer of 1980: N = 18¢/lb., P = 47¢/lb., K = 16¢/lb.

Source: Asano, [redacted]

REFERENCES

Asano, T. (Proj. Dir.). 1981. Evaluation of agricultural irrigation projects using reclaimed water. Agreement 8-179-215-2. Office of Water Recycling. California State Water Resources Control Board. Sacramento, CA.

Boyle Engineering

Asano, T., R. G. Smith and G. Tschobanoglous. 1984. in Pettygrove, G. S., and T. Asano (eds.). 1984. Irrigation with Reclaimed Municipal Wastewater — A Guidance Manual. Report No. 84-1 California State Water Resources Control Board. Sacramento, CA.

California Department of Health Services. 1978. Wastewater reclamation criteria. California Administrative Code.

San Diego's Water Sources: Assessing the Options

Sponsored and published by the **Equinox Center**
Researched and produced by the **Fermanian Business & Economic Institute**

July 2010

Healthy Environment

Strong Economy

Vibrant Communities

Equinox Center is pleased to partner with the Fermanian Business and Economic Institute (FBEI) to present groundbreaking, independent research on San Diego County's water supply options. Our region's imported water supply is increasingly vulnerable due to structural, environmental and legal issues and is rapidly escalating in cost. This is creating a sense of urgency to develop more local, reliable and sustainable sources of water.

"San Diego's Water Sources: Assessing the Options" is the initial publication of Equinox Center's H2Overview Project, which will provide balanced, easy-to-understand research on San Diego County's water supply to help inform the decision-making process. The Fermanian Business and Economic Institute provides a sharp and thorough economic analysis and offers a new lens with which to view our different water sources.

As the region adds 750,000 more people in the next 20 years, it is important to prepare today for the difficult decisions our region faces to properly steward our water resources well into the future. We thank the many experts that were consulted during this process for their assistance in producing this research.

About Equinox Center

To ensure a healthy environment, vibrant communities and a strong economy for the San Diego Region, Equinox Center researches and advances innovative solutions to balance regional growth with our finite natural resources. We are proponents for our region's responsible growth and we support the conscientious care-taking of the natural and economic assets that we have inherited.

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LETTER TO THE READER

The Fermanian Business & Economic Institute of PLNU

POINT LOMA NAZARENE UNIVERSITY business & economics in action

The Fermanian Business & Economic Institute is pleased to present its original research report, San Diego's Water Sources: Assessing the Options. Sponsored and published by the Equinox Center, our intention is to provide to the San Diego community a document that is in keeping with the highest levels of economic research, econometrics, modeling and analysis and yet present it in a highly readable format accessible to the widest possible audience. We have carefully considered the key issues related to the pressures associated with water as a scarce resource demanded by a growing regional population and attempted to research and address them so that all stakeholders have the information to make the critical decisions that will enhance our community and region. At the Fermanian Business & Economic Institute this is what we refer to as "actionable economics." We are grateful to the Equinox Center for its vital leadership on water issues, and look forward to additional opportunities to serve our community.

Randy M. Ataide, J.D.
Executive Director

About the Fermanian Business & Economic Institute

The Fermanian Business & Economic Institute (FBEI) is a strategic unit of Point Loma Nazarene University, providing the following services:

> Economic forecasting and events
> Expert business and economic commentary and speeches
> Professional and executive development events
> Business and economic roundtables
> Economic consulting and related services
> Economic studies and research
> Special projects

The Institute Staff

Randy M. Ataide, J.D.
Executive Director

Lynn Reaser, Ph.D.
Chief Economist

Cathy L. Gallagher
Director

Courtney Hamad
Manager

Dieter Mauerman
Research Assistant

Reka Katona
Student Assistant

Fermanian Business & Economic Institute
www.pointloma.edu/fbei
619.849.2692

EXECUTIVE SUMMARY

> Water is likely to be the most critical resource challenge that the San Diego region will face during the next two decades as it strives to achieve sustainable growth.

> Economic and environmental factors suggest that dependence on imports for the bulk of San Diego County's water is neither optimal nor sustainable. While imported water is likely to remain an important source for the region for some time, diversification into other sources will be necessary.

> Seven primary sources exist to address San Diego County's water demands: imported water, surface water, goundwater, desalinated sea water, recycled non-potable water, recycled potable water, and conservation.

> Imports from the Sacramento-San Joaquin River Delta and the Colorado River currently account for nearly 80% of San Diego County's water supply. Recycled water, only for non-potable purposes, meets about 4% of the region's demand. Desalinated sea water is not presently a source, although a desalination plant is expected to be completed in Carlsbad by 2012.

> Marginal cost estimates vary widely, but current estimates put the cost of desalinated sea water as the

Marginal Costs and Energy Intensity of San Diego County's Water Alternatives, 2010e

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost	low	875	400	375	1,800	1,600	1,200	150
($/acre foot)	high	975	800	1,100	2,800	2,600	1,800	1,000
Energy Intensity	low	2,000	500	400	4,100	600	1,500	negligible
(kWh/acre foot)	high	3,300	1,000	1,200	5,100	1,000	2,000	

e=estimated range

Source: FBEI

highest cost option at about $1,800 to $2,800 per acre foot. The cost of retrofitting the water infrastructure to a dual-pipe system also puts the estimated cost of recycled non-potable water at a relatively high level. While converting recycled water to potable levels entails additional treatment costs, the ability to use the existing water distribution system results in a somewhat more moderate marginal cost. In contrast, conservation carries a low marginal cost of $150 to $1,000 per acre foot. Surface and groundwater also have comparatively low costs, but they do not have the capacity to serve as major sources for San Diego County's water requirements.

> Concerns about the availability and cost of energy, as well as greenhouse gas emissions, make energy intensity a key issue in assessing the different water options. Desalination is the most energy intense solution, with an estimated requirement of 4,100 to 5,100 (kilowatt hours) per acre foot. In contrast, the energy intensity of recycled non-potable water is comparatively low at 600 to 1,000 kWh per acre foot. Direct energy costs for conservation are considered negligible.

> Legal, regulatory, technical, health, social, and environmental factors also are important to assessing the optimal mix of water options for San Diego County. The report presents a matrix ranking the alternatives across these various dimensions.

> Assessing marginal dollar cost, energy intensity, and the array of other major factors yields an overall ranking of the seven water alternatives. On a scale of 1 to 5, where 5 represents the most favorable/lowest-cost option, imported water and sea water desalination carry the lowest scores at 2.6 and 2.7, respectively.

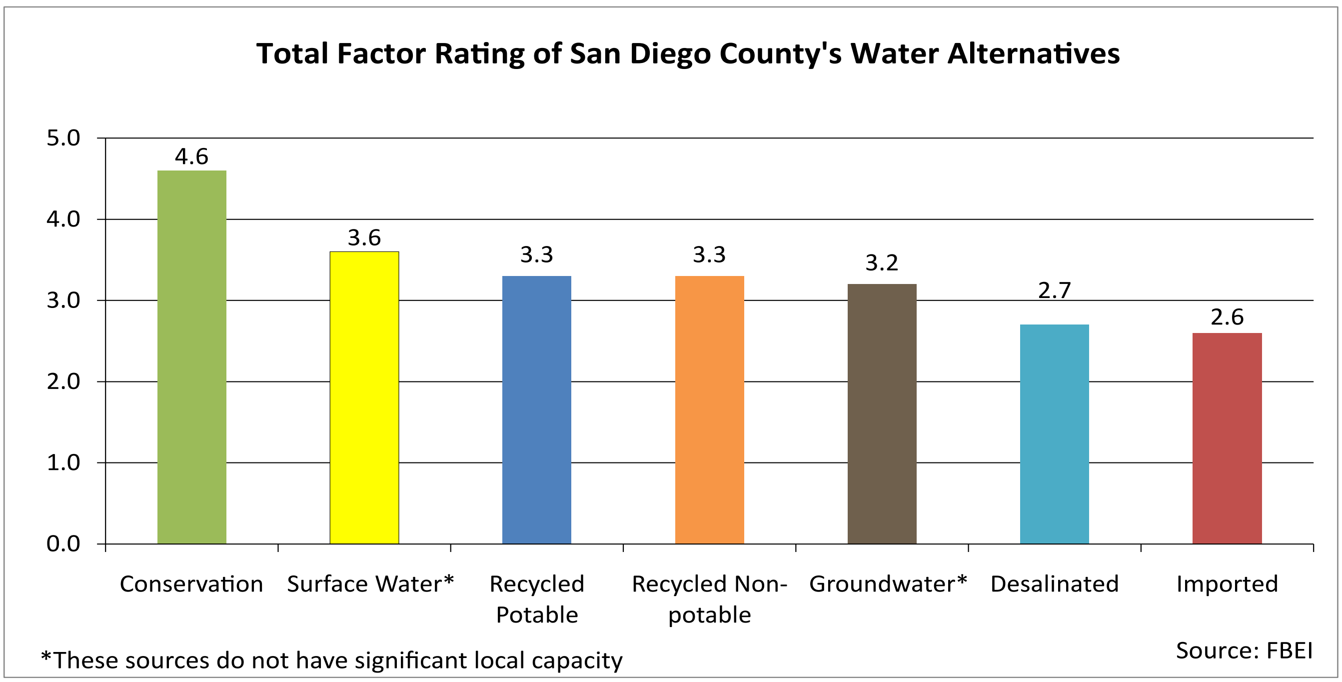
> Surface water and groundwater have relatively favorable scores of 3.6 and 3.2, respectively. However,

neither source has the capacity to supply a substantial proportion of the region's water supply over time.

> Recycled non-potable and potable water carry moderately attractive scores of 3.3 each. At $2 million/mile, the cost of the dual-pipe system poses the largest constraint to non-potable recycled water. Requirements that new residential construction incorporate dual-piping systems could help make the use of recycled non-potable water more feasible over time and locating satellite water recycling plants close to users could also help reduce water transportation costs. Public concerns over the safety of potable water pose the greatest challenge to that source, although public opinion appears to be shifting to more support.

> Conservation currently is and will remain the most favorable and least costly option over the next two decades. It carries a rating of 4.6. However, the extent to which conservation can reduce the region's water consumption as the population continues to grow over the next 20 years remains to be determined.

> These findings suggest that solving San Diego County's water challenge may also rest significantly on the demand side. Pricing water closer to its true marginal cost will be necessary to ration this most valuable and scarce resource.



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INTRODUCTION

Water is the world's most valuable commodity (*The Economist*, May 22nd-28th, 2010). As the pressures of a growing population clash with a limited resource and concerns about energy usage and the environment, it is vital that San Diego County plan strategically for its water future. Considering economic costs, energy intensity, legal, technical, social and other factors, what options should the region pursue to meet its future water demands? This report presents an analytical framework to address those questions and provides its conclusions on the optimal approach.

REPORT STRUCTURE AND METHODOLOGY

The first part of this report examines the current marginal costs of the different present or possible water sources for San Diego County. Projections for 2020 and 2030 are provided to shed light on how the relative costs of the various energy sources may change during the next ten and twenty years.

The second section analyzes the energy intensity of the different sources both to capture the impact on energy supplies and the magnitude of the "carbon footprint." The third section follows a less quantitative approach but analyzes the feasibility of the different water solutions based on legal, technical, safety, social, environmental, and other factors. The report ends with a section summarizing the rankings of the various water supply options according to these various criteria and concludes with recommendations for San Diego's water policy.

Estimates of marginal costs, energy intensity, and other factors were based on inputs from a number of different studies and water authorities from within San Diego County and elsewhere. (See Sources and References at the end of this report.) These estimates vary widely; the authors of this report used their best judgment based on the current state of knowledge in the field and projections of various economic and financial factors. Attention was paid to ensure that definitions of various concepts, such as marginal cost and energy intensity, were treated consistently across the different water source options. In most cases, estimates and forecasts are presented as ranges to portray the considerable uncertainty surrounding these issues and the different conditions that exist in the various local jurisdictions of San Diego County.

SAN DIEGO COUNTY'S WATER SUPPLY OPTIONS

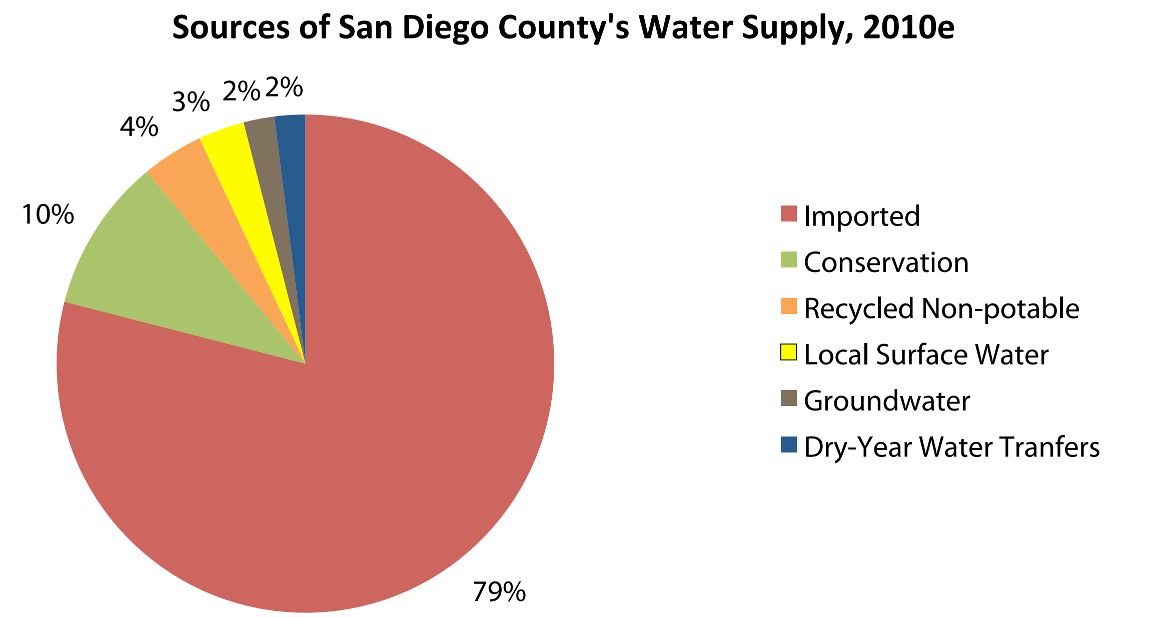
Seven solutions to meet the water demands of San Diego County are examined.

Imported Water: Water from other areas can be imported into the region if available. Currently, San Diego County receives about 80% of its water supply from this source. (See Chart 1.) In 1991, 95% of the region's water was imported. About two-thirds of San Diego County's current imports come from the Sacramento-San Joaquin River Delta; the remainder comes from the Colorado River.

Surface Water: Surface water refers to water accumulated in local streams, rivers, and lakes from precipitation in various watersheds throughout San Diego County. It will represent about 3% of the region's total water supply in 2010. Drought conditions in recent years have reduced the contribution of surface water from a more typical 5% share. Two percent of this year's total water consumption will represent "dry-year transfers," refering to water brought in from substitute sources outside the region.

Groundwater: Groundwater is water located beneath the ground surface in soil pore spaces and in the fractures of rock formations. Some of it only requires that certain minerals be extracted to obtain potable water of desired standards, while other is brackish, requiring desalination. Groundwater currently accounts for about 2% of San Diego County's water supply.

Chart 1



e=estimate

Sources: San Diego County Water Authority; FBEI

Desalinated Sea Water: Potable water can be extracted from sea water as implemented in several facilities in North America. However, this is currently not a water source in this region. In San Diego County, a water desalination plant was approved in 2009 for Carlsbad, with completion set for 2012.

Recycled Water, Non-Potable: Wastewater can be recycled, partially treated, and used for landscaping, industrial, and other uses. Currently, San Diego County relies on this source for about 4% of its total water supply.

Recycled Water, Potable: Recycled water can be treated to potable levels, although this is currently not being done in San Diego County. With advanced treatment, recycled water can be added to existing water supplies in either underground basins ("goundwater recharge") or to open reservoirs. This is referred to as Indirect Potable Reuse, or IPR.

Conservation: Conservation, achieved by using less water or by using water more efficiently, is another option to meet San Diego County's water challenge. Currently, conservation has been able to replace about 10% of the region's potential demand.

WATER MARGINAL COSTS

This section analyzes the marginal costs of the seven alternative water solutions as of 2010. (See Table 1a and Chart 2.) Marginal cost is the cost of producing an additional acre foot of water (the volume of one acre of water that is one foot deep) and includes both operating costs and amortized fixed capital costs. Subsidies are not included. Operating costs encompass various expenses involved in the extraction, treatment, transportation, and distribution of water. The allocation of fixed capital costs represents both the investment in infrastructure and financing costs over time. The ranges indicated below allow for significant variation that may exist in different areas of San Diego County arising from, among other factors, variations in distance from water sources and treatment facilities.

Imported Water: Imported water currently carries a marginal cost with a range of $875 to $975 per acre foot. This reflects a marginal cost of about $535 per acre foot for untreated water from different sources, $215 for treatment, and $175 for other expenses, including transportation, storage, customer service, and the amortized costs of expanding conveyance capacity. The total represents primarily the wholesale cost the Metropolitan Water District charges the San Diego County Water Authority, which in turn is passed on to the 24 water districts in the San Diego region.

Table 1a

Marginal Costs and Energy Intensity of San Diego County's Water Alternatives, 2010e

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost	low	875	400	375	1,800	1,600	1,200	150
($/acre foot)	high	975	800	1,100	2,800	2,600	1,800	1,000
Energy Intensity	low	2,000	500	400	4,100	600	1,500	negligible
(kWh/acre foot)	high	3,300	1,000	1,200	5,100	1,000	2,000	

e=estimated range

Source: FBEI

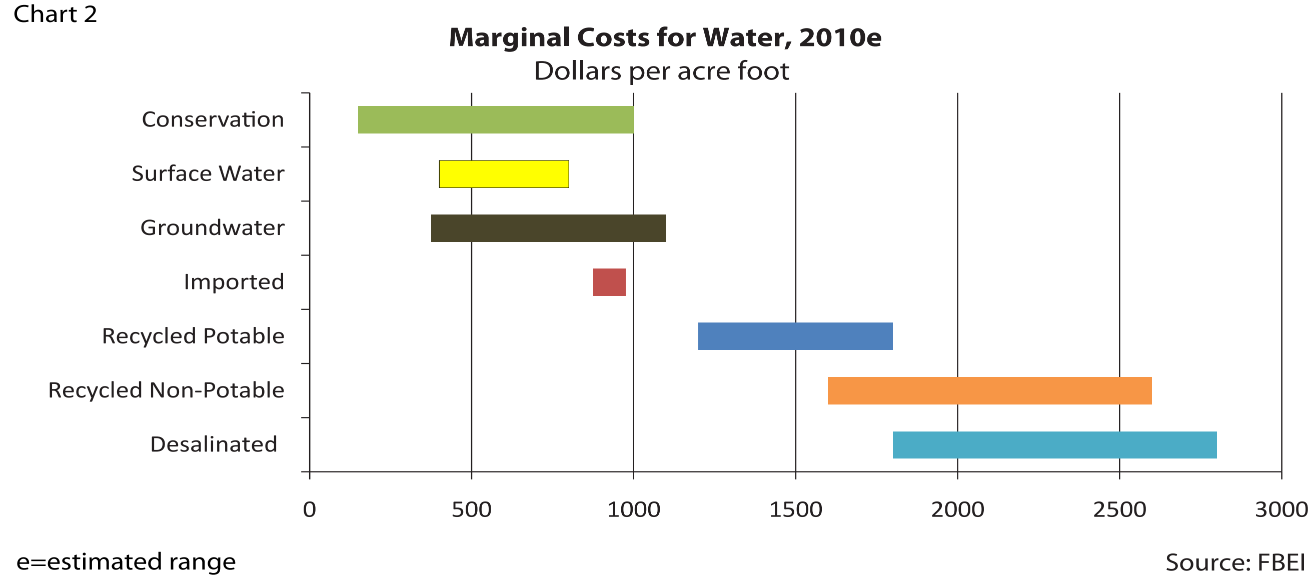
Surface Water: Surface water has a marginal cost estimated to range between $400 and $800 per acre foot. This represents treatment, pumping, distribution, and reservoir costs. Reservoir expenses encompass payments to the state for river usage rights and dam safety, brush clearance, habitat restoration, dikes to prevent contamination from diesel fuel and other elements, and dam improvements over time. The low and high ends of the range represent primarily the differences between reservoir water levels in any given year, with pumping costs per unit considerably higher when reservoir levels are low.

Groundwater: Groundwater has a marginal cost that generally ranges from about $375 to $1,100 per acre foot. Much of the cost and variation reflect differences in required treatment methods to bring the water to potable standards. Fresh water may only need to be disinfected (usually with chloramines) and can have a lower cost than surface water which may require more treatment. This is the case for some of the less expensive water supply available, for example, from the Sweetwater Authority. Demineralization, however, may be required to remove iron and manganese. Where water is brackish, reverse osmosis is necessary along with disposal costs of the brine. Distribution and transportation expense of the water to and from the treatment facility also adds both to the total cost and its variability across the region.

Desalinated Sea Water: Desalinated sea water has a marginal cost ranging from about $1,800 to $2,800 per acre foot. Although advances in technology have helped reduce the cost of desalination over the past 15 years, the high energy requirements of this source make it the most expensive of the seven energy alternatives investigated in this report. A significant part of the cost and variability in costs of this option reflects the distances that sea water and potable water must be moved. For example, if a desalination plant is connected with a power plant, it can use the outflow from the once-through cooling system of the power plant to dilute the salty brine from the desalination plant before it is discharged back to the ocean. Where dilutants for the brine need to be brought to the plant, costs are substantially higher. It should be noted that California's State Water Resources Control Board voted in May 2010 to phase out once-through cooling systems, where ocean water is cycled through the plant and then returned to the sea, because of envirnomental concerns.

The choice of intake systems is also significant in terms of both the potential environmental impact and marginal cost. Large sea water desalination plants have typically used open sea, surface water intake systems, which can trap marine organisms in the intake screens. Subsurface intake systems, involving horizontal or vertical beach wells, infiltration galleries, or seabed filtration, can eliminate much of the impact on marine life, although costs will generally be higher than those associated with open sea, surface water arrangements. Such a design to mitigate ecological damage is being incorporated in a new plant in Adelaide, Australia, and is being considered for the proposed Camp Pendleton Desalination Project.

Chart 2



Recycled Water, Non-Potable: Recycled, non-potable water carries a marginal cost estimated at $1,600 to $2,600 per acre foot for the San Diego region. The size and variation of the cost of recycled non-potable water depend on the quality of the wastewater received, the standards required by the end users (such as with varying degrees of health concerns), the cost of treatment, and the distance between the recycling facility and potential users. Although there is a large supply of wastewater available for recycling, the capital costs required to install new distribution systems in San Diego County make the marginal cost of this source relatively high. Recycled water that is not treated to potable levels must be conveyed in a separate pipe system ("purple pipes") labeled and readily distinguished from traditional water lines.

In Orange County, the ability to install the necessary pipes as new communities were initially built in the Irvine Ranch Water District has helped to contain the cost of recycled water. About 25% of this district's water supply represents recycled water. The capital costs of retrofitting much of San Diego County's water system with new piping systems would be substantial, with it costing about $2 million per mile to install these pipes. Dual-piping systems (accommodating potable and non-potable water) could be installed at much lower costs at the beginning of new property developments. Currently, the Olivenhain Water District supplies about two million gallons per day of non-potable recycled water for irrigation to several cities in North San Diego County.

Last November, California's Building Standards Commission adopted a dual-plumbing code for the state. This should help clarify the requirements for installing potable and non-potable systems in commercial, retail, office, hotel, apartment, educational, and other facilities.

Recycled Water, Potable: Recycled potable water has a marginal cost estimated at about $1,200 to $1,800 per acre foot. Although the cost of treatment to potable levels adds about 10% to 15% to the cost of non-potable recycled water, the expense of conveying recycled potable water for reservoir augmentation is less than that required to construct an entirely separate system for distribution to customers as required for non-potable systems. Conveyance costs are still a factor for this source. In the specific case of reservoir augmentation at San Vicente Dam, a large pipeline would need to be constructed to transport the water to the reservoir and pumping costs would also be considerable. For other projects that have a closer source of recycled water or that are injecting recycled water into groundwater aquifers, such as is the case with the Helix Water District's proposed project, the conveyance costs would be significantly less.

Conservation: Conservation programs carry a current marginal cost of about $150 to $1,000 per acre foot. This measure reflects the estimated expenditures on educational initiative or subsidies to promote conservation divided by the cumulative water savings of the programs. For example, the marginal cost of a program to achieve greater water efficiency of dishwashers would be calculated as the total expenditures on rebates divided by the total water savings of the dishwashers over their lifetimes. Information on or distribution of water-efficient plants for landscaping represents a lower cost option. Mandatory restrictions have also been used, with their marginal cost reflecting the expense of publicizing and enforcing the restrictions.

Marginal Costs: 2020 and 2030

Table 1b

Marginal Cost Forecasts, 2020 and 2030

Constant 2010 dollars

		Imported	Surface Water	Groundwater	Desalinated	Recycled Non-potable	Recycled Potable	Conservation
Marginal Cost ($/acre foot), 2020	low	1,479	600	530	3,391	2,861	1,929	336
	high	2,079	1,200	1,600	4,391	3,661	2,729	1,136
Marginal Cost ($/acre foot), 2030	low	2,839	875	900	4,988	4,327	3,048	608
	high	3,839	1,750	2,500	5,988	5,327	3,848	1,508

e=estimated range

Source: FBEI

Based on the estimated path of energy costs, labor, interest rates, water demands from competing users, and other factors, marginal costs for the seven different water alternatives were projected for the next ten and twenty years for the San Diego region. These numbers are presented in terms of 2010 dollars. (See Table 1b, Chart 3, and Chart 4.)

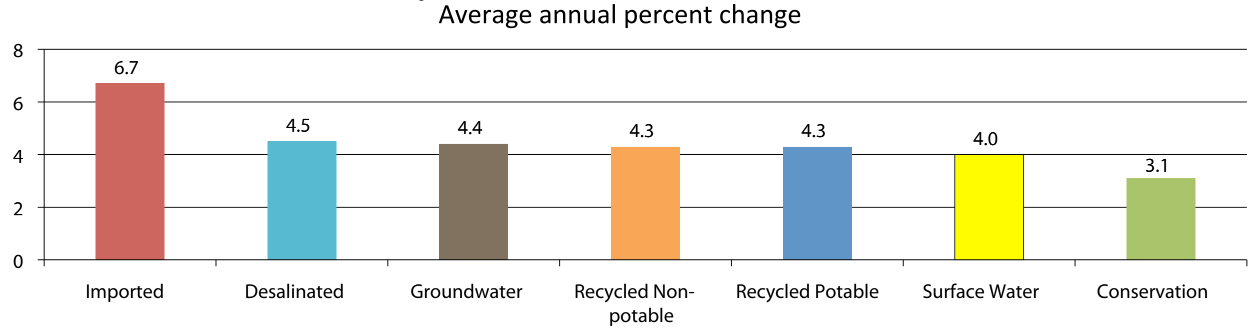
Although the relative cost rankings of the different sources do not change (with desalinated sea water still the most costly option and conservation the least expensive), there is some change in the relative dispersion of costs across the alternatives. In particular, by 2030, the marginal cost of recycled potable water could be competitive with that of imported water.

The cost of imported water is projected to rise at a real (in addition to inflation) rate averaging 6.7% over the next twenty years. The ongoing growth of California's population will continue to press supplies available from the Sacramento-San Joaquin River Delta, while continued rights to supplies from the Colorado River are challenged.

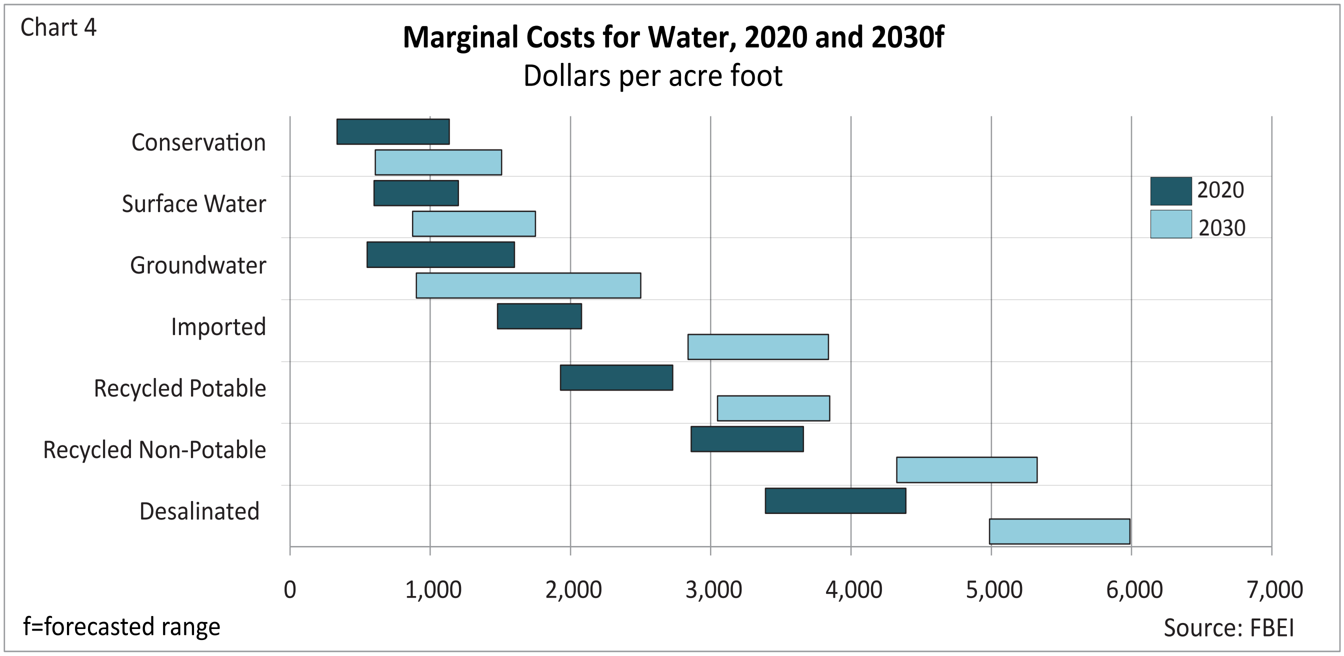
Chart 3

Projected Real Cost Increases, 2010-2030

Average annual percent change



Source: FBEI



The costs of labor, amortized expense of dam building and repair, and energy costs for pumping and treatment are forecast to push the cost of surface water up at an average rate of 4.0% over the next twenty years. Depletion of fresh goundwater could drive the cost of that source up at an average annual rate of 4.4% in the period through 2020, with greater pumping and treatment requirements.

The cost of desalinated water is forecast to rise at a relatively rapid real rate averaging 4.5% over the time period to 2030. Although technological advances could lower capital and operating costs, interest and energy expenses are expected to drive costs up at a significant pace.

The cost of recycled, potable and non-potable water is expected to increase at a 4.3% pace in real terms on average over the next twenty years. Although energy costs can be expected to continue to rise at a considerable pace, the cost increases could moderate in the second half of the twenty-year period if most of the infrastructure building and retrofitting was done earlier in the period.

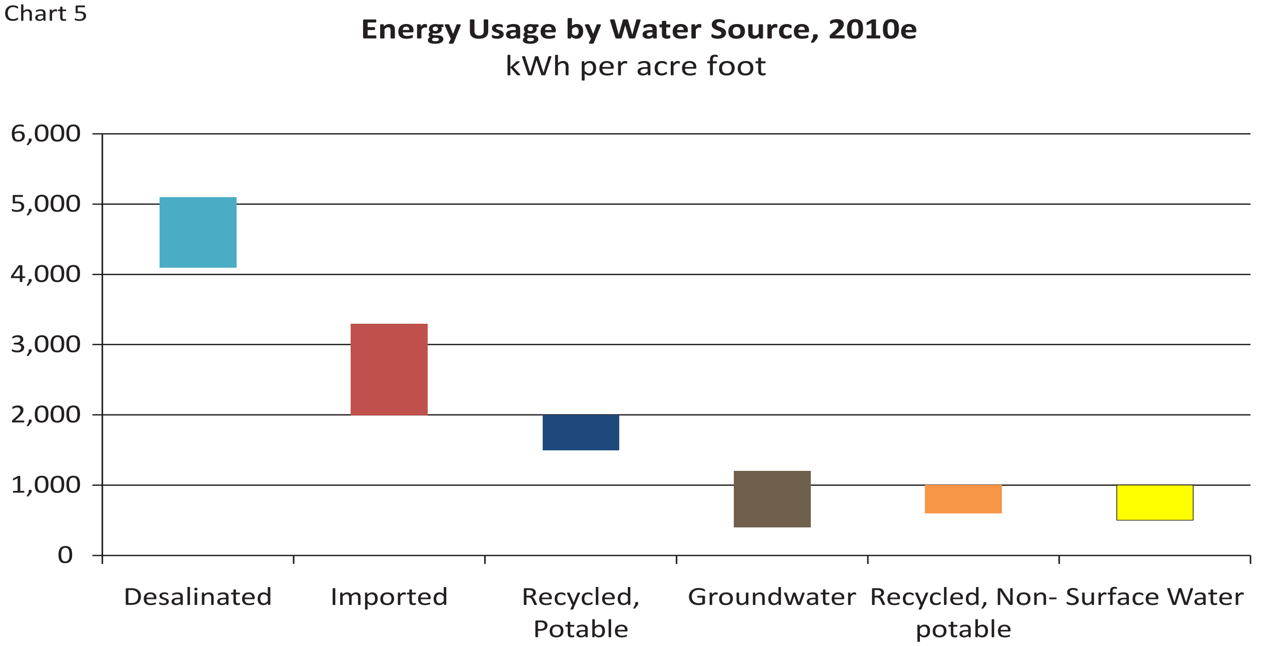
The marginal cost of conservation programs is projected to rise at a 3.1% real pace over the twenty-year period. Although new technologies could enhance water saving efforts, conservation programs could start to run into diminishing returns over the next two decades as the easiest and least costly options for water users are implemented.

ENERGY INTENSITY

According to a California Energy Commission 2005 report, water-related energy consumption accounts for nearly one-fifth of the state's total electricity usage. Energy usage for water is important to understand not only because of the implications for the state's total energy demands but also because of the implications for greenhouse gas emissions and the climate goals of the region. Estimates of the energy intensity of the different water alternatives are analyzed in this section in terms of kilowatt hours (kWh) per acre foot for 2010. (See Chart 5 and Table 1a.)

Imported Water: Imported water is quite energy intensive, requiring approximately 2,000 to 3,300 kWh per acre foot. Considerable transporatation costs keep this as a high-energy alternative.

Chart 5



e=estimated range

Source: FBEI

Surface Water: In contrast, the energy requirements of surface water are considerably lower, with a range of 500 kWh to 1,000 kWh per acre foot because of lower transportation and distribution requirements. Pumping accounts for most of the energy requirements from this water source, with treatment, transportation, and distribution responsible for the remainder.

Groundwater: The contrast of pumping fresh water to the requirements of possible demineralization and reverse osmosis take the energy range of goundwater from about 400 to 1,200 kWh per acre foot. The higher end of the range represents the energy demands from treating brackish water.

Desalinated Sea Water: Desalinated sea water carries the highest energy cost at 4,100 to 5,100 kWh per acre foot. Transportation costs and the plant energy costs involved in converting saltwater to potable water drive up the total. As noted above, "co-locating" a desalination plant with a power plant can eliminate the conveyance costs of water needed to dilute the brine, although the banning of "once-through" cooling systems could limit that advantage. Other transportation costs plus the energy intensity of the desalination process result in this water source being a high user of energy with a large "carbon footprint."

Recycled Water, Non-Potable: Recycled, non-potable, water is a relatively low energy user at 600 to 1,000 kWh per acre foot. Locating primary or satellite recycling plants relatively close to end users can help keep energy costs at the lower end of this range.

Recycled Water, Potable: Recycled potable water requires considerably more energy than its non-potable sibling because of the transportation costs necessary to convey the treated water to a storage reservoir, if this is the chosen treatment strategy. Energy costs for this source are estimated at 1,500 to 2,000 kWh per acre foot. Where significant pumping is required, such as is the case with the San Vicente Reservoir, energy expenditures could be substantial. The extent of treatment costs necessary to achieve desired quality standards for potability also adds to energy requirements.

Conservation: Conservation has no direct energy costs, although the manufacturing process of producing various energy-saving devices entails some energy usage. For the purposes of this study, the energy consumed by conservation is considered to be negligible.

OTHER FACTORS

In addition to marginal cost and energy considerations, a number of other factors are important in assessing the feasibility and desirability of different water solutions. This section discusses those factors, assessing them both as they exist currently and are expected to develop over the next twenty years. Table 2 presents a matrix which scores the seven water options on a scale of 1 (least favorable or highest cost) to 5 (most favorable or lowest cost). A wide range of sources and experts were consulted (see Sources and References) in developing these estimates.

Table 2

Factor Matrix for San Diego County Water Options*

	Conservation	Surface Water	Recyled Potable	Recycled Non-potable	Groundwater	Desalinated	Imported
Marginal Cost	5	4	3	2	4	1	4
Energy Intensity	5	4	3	4	4	1	2
Legal/Regulatory	5	3	2	3	3	2	2
Technical	4	5	3	2	4	2	3
Health/Safety	5	4	4	3	3	4	3
Social Acceptance	4	5	2	3	4	3	4
Environment	5	3	4	4	3	2	1
Availability	4	2	5	5	2	5	3
Reliability	4	2	4	4	2	4	1
Average	**4.6**	**3.6**	**3.3**	**3.3**	**3.2**	**2.7**	**2.6**

*Scale of 1 to 5, with 5 representing the most favorable/lowest cost

Source: FBEI

Legal and Regulatory: Water projects and solutions fall under the jurisdiction of local, state, and/or federal laws. Permit processes can often be lengthy with a number of legal challenges following. Desalinated sea water facilities face relatively high legal and regulatory constraints. For example, the Carlsbad desalination plant required 11 years of litigation and negotiation before the permit was received in 2009. Lawsuits have continued into 2010. Imported water also faces many legal hurdles in the period ahead as various parties dispute the rights to water from the Sacramento-San Joaquin River Delta and the Colorado River. Recycled potable water will be regulated by rigid health standards. Recycled non-potable, goundwater, and surface water are expected to face moderate legal and regulatory constraints. Conservation probably faces limited legal issues unless personal rights are disputed in the case of mandatory restrictions.

Technical: Technical factors refer to design or operational elements related to each water source alternative. Technical issues pose both upside and downside risk to some of the water options analyzed in this report. Technological advances could, for example, substantially lower costs over time for desalination and recycling. At the same time, problems can plague various water facilities, particularly as new technologies are applied or projects are moved from small-scale test facilities to large-scale operations. Desalination sea water plants are categorized with relatively high technical costs. For example, the plant in Tampa, Florida, the largest desalination sea water facility in North America, has encountered a number of design and construction problems. Non-potable recycling systems could encounter considerable technical issues. A risk for such systems is the possibility of "cross-connections" or an accidental connecting of potable and non-potable water systems, leading to contamination of potable water. Although the probability of such an event is low, the consequences could be serious.

Potable water recycling technologies also face considerable technical issues, particularly where users require that stringent standards are met, as well as possible contamination events. Imported water could face significant technical challenges in the future as the Sacramento-San Joaquin River Delta could require sophisticated redesign and construction (involving either a canal built above or tunnel below very soft substrata). Other sources face more limited technical challenges. Conservation, for example, may require the development of new technologies to achieve even greater water efficiencies than offered by the current array of available appliances. Technical issues with groundwater will primarily involve future treatment options. The technology involved in the storage and use of surface water is expected to change little in the period ahead.

Health and Safety: While all water alternatives, except conservation, carry some health risk, the extent of water treatment processes put the quality of both desalinated and recycled potable water at comparatively high levels. Recycled non-potable water is not treated to the same level of standards because of its designated applications. Possible contaminants in groundwater, surface water, and from imported sources put them at a moderate level of health and safety risks, although treatment processes generally ensure that they are safe to consume.

Social: Social factors reflect the general public attitude towards different water options based either on confidence in the quality of water or impact on local residents (the "nimby"—"not in my backyard" mentality). Incorporating potable recycled water into the general water supply could face public resistance, although attitudes appear to be changing. A 2009 public opinion poll conducted by the San Diego County Water Authority found that 63% of respondants favor augmenting our potable water supply with recycled water, compared with only 28% who endorsed that approach in 2005. Desalinated water and recycled non-potable water plants could face opposition from local residents over possible concerns related to traffic, safety, or general views of the landscape. The other options face moderate social acceptance. Some consumers may be starting to be concerned over the pollutant discharges that occur in water from the Colorado River and Northern California. In the case of conservation, while many Californians see the need to conserve water, others will need to see a compelling case before they make significant changes in their lifestyles. Groundwater probably faces relatively little public resistance although there could be some concerns over contamination of underground aquifers. Surface water probably ranks highest in terms of social acceptance because of its long history as a community's water source.

Environment: The different water alternatives can affect various aspects of the environment in addition to energy and greenhouse gas emissions. The choice of water solutions can impact wildlife, vegetation, and the general ecosystem. Particularly because of their current and potential impact on various plant and animal species, both sea water desalination and imported water have relatively high environmental costs. The tapping of groundwater supplies could also have some significant effects on the environment. Capturing of surface water has possible environmental implications because of effects on water levels and wildlife habitats. Conservation clearly has the most positive impact on the environment. Recycling (both potable and non-potable) also carries benefits by considerably reducing the amount of untreated or only partially treated effluents that otherwise might be discharged into streams, rivers, and the ocean.

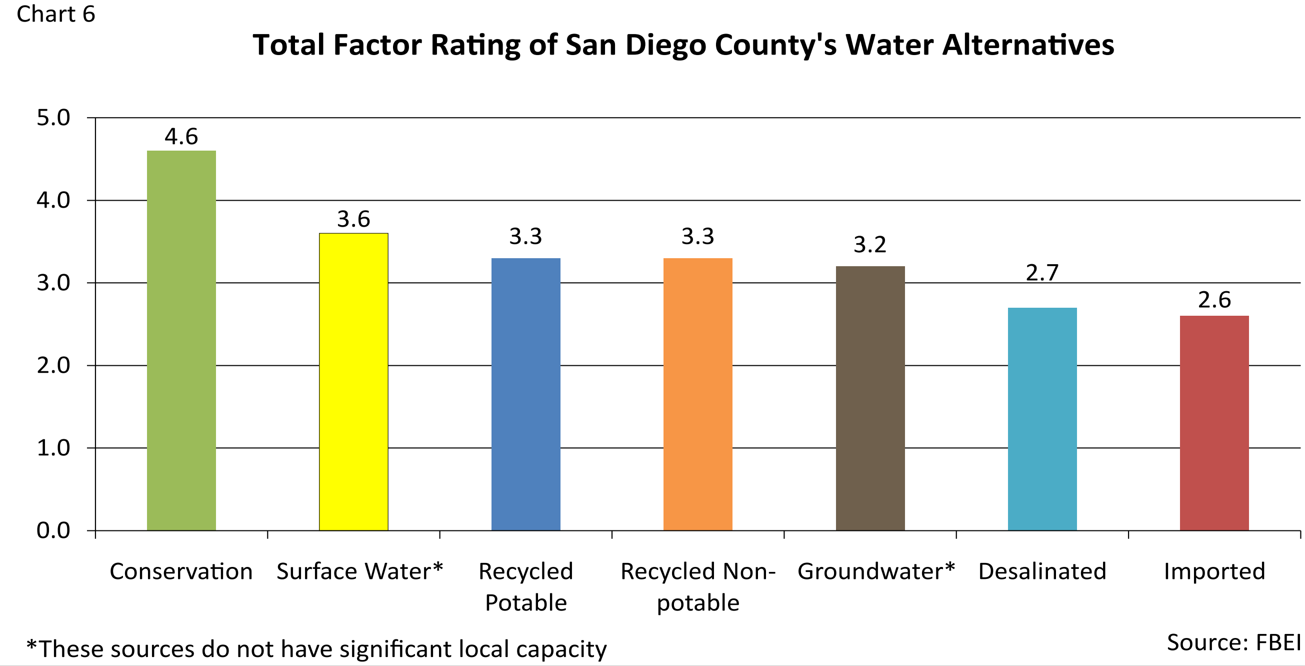
Availability: Availability refers to the amount of water that can be potentially supplied from each source. This factor measures the amount of the raw material resource assuming that the infrastructure to treat and convey it is in place. Availability is included in the scoring matrix because of the potential, or lack thereof, of the various options to play a significant role in meeting San Diego County's water demands. For example, limited supplies of both groundwater and surface water suggest that these sources will each account for only a small percentage of San Diego County's total usage on an ongoing basis. While San Diego County can be expected to continue to import large amounts of water, this source could be significantly constrained over time by global warming, climate change, and less precipitation. Reduced snow accumulations could substantially restrict the supply of water from the Sacramento-San Joaquin River Delta, while the Colorado River also faces reduced flows. In contrast, sea water and recycled water (both potable and non-potable) have abundant sources of supply. Conservation also has significant latitude to achieve changes in water consumption and practices.

Reliability: Reliability refers to the amount of possible volatility in water supply from the various options. Many businesses are concerned about the access to a reliable source of water to run their operations, while individual consumers assume a ready access to water at all times. None of the water sources can be totally guaranteed. Imported water appears to face the greatest risk because of the possibility of drought conditions and natural disasters that would result in sea water intrusion in the Sacramento-San Joaquin River Delta or destroy pipelines and canals either in Northern or Southern California, thus impeding flows to the San Diego area. Groundwater and surface water face significant swings in availability because of changes in weather, climate, and precipitation. Desalination and recycling facilities could face temporary disruptions due to power failures, earthquakes, or technical problems. Even conservation cannot be relied on totally because of the failure of consumers to adhere to water restrictions or to change their behavior substantially. The inability of one single water source or option to be completely reliable argues for the importance of a diversified approach to meeting the region's water demands.

CONSOLIDATING THE RESULTS

Different water districts may have different priorities and resources. The matrix decision tool discussed in the previous section and shown as Table 2 allows policymakers and other interested parties to place different weights on the various factors, such as marginal cost or the environment, as they see appropriate. Using an equal-weighting scheme, where a simple average is taken of the nine different factors analyzed, the following results are produced. (See Chart 6.)

Chart 6



Conservation appears as the most favorable/lowest cost option, based on this analysis, with a score of 4.6, a number substantially above that of any of the other alternatives.

Surface water has a moderately high score of 3.6. However, as noted above, it can only be counted on for a limited amount of the region's total water supply. Both potable and non-potable recycled water also have moderately favorable scores of 3.3 each. Groundwater's 3.2 score is relatively good, but like surface water, it is likely going to be able to contribute only about 5% to San Diego County's water consumption in a typical year.

Desalinated and imported water are the least favorable/highest cost options, with ratings of 2.7 and 2.6, respectively.

CONCLUSIONS

An analysis of current and projected marginal costs, energy intensity, social, health, legal, environmental, and other factors yields clear differences among the water policy options and directions San Diegan water districts may wish to pursue.

Economic and environmental factors suggest that dependence on imports for about 80% of San Diego County's water is neither optimal nor sustainable. While imported water is likely to remain an important source for the region for some time, diversification into other sources would appear to be necessary. A combination of different sources would be desirable, rather than relying on one approach. The results of this study, however, suggest that some approaches may merit more focus than others.

Although sea water desalination still might play a role in meeting our region's water demands, its high marginal cost and energy intensity, combined with a number of other considerations, render it the least favorable option along with imported water. While groundwater and surface water are moderately attractive alternatives, their limited availability will prohibit them from playing major roles in meeting San Diego County's water demands.

Recycled water, both potable and non-potable, has a moderately favorable ranking after considering the broad array of factors and would appear to have considerable potential in being part of the region's water "portfolio." The biggest constraint facing recycled water treated to potable levels is one of social acceptance. Clearly, to achieve a significantly higher use of potable recycled water a major educational drive would be necessary.

For non-potable purposes, the cost of retrofitting the region with a dual-pipe system to accommodate widespread use of recycled water poses the largest constraint to that source. Locating satellite recycling plants closer to large water users (such as agricultural entities) or to large numbers of households and commercial users could help mitigate some of the considerable transportation and distribution costs of recycled water.

Conservation appears as the most attractive of the seven water solutions analyzed for San Diego County by a wide margin. These findings suggest that solving San Diego County's water challenge may rest significantly on the demand side. For example, previous Equinox Center research revealed that appropriate water pricing (see www.equinoxcenter.org) is one tool that can spur significant water conservation. More research and modeling is needed before we can confidently project the extent to which conservation could reduce the region's demand for water as the population continues to grow over the next twenty years.

SOURCES AND REFERENCES

Escondido Water and Sewer Department

Fallbrook Public Utility District Orange County Water District

Irvine Ranch Water District

Marin Municipal Water District, http://www.marinwater.org/

Olivenhain Municipal Water District

San Diego County Water Authority

Sweetwater Authority

Water Reuse Foundation

A Special Report on Water. (May 22-28, 2010). The Economist.

California Energy Commission. (November 2005). California's Water-Energy Relationship. Sacramento: Final Staff Report CEC-700-2005-011-SF.

California Water Plan: Volume 2 - Resource Management Strategies. (2009). Retrieved from Department of Water Resources, State of California.

CCC allows city to continue pumping sewage into ocean. (2010, March 13). Retrieved April 6, 2010, from San Diego News Network: http://www.sdnn.com/sandiego/2010-03-13/environment/ccc-allows-city-to-continue-pumping-sewage-into-ocean

City of San Diego Water Department. (September 2008). Rules and Regulations for Recylced Water Use and Distribution within the City of San Diego. San Diego.

Cooley, H., Gleick, P. H., & Wolff, G. (June 2006). Desalination, With a Grain of Salt. Pacific Institute.

Fryer, J. (2010). An Investigation of the Marginal Cost of Seawater Desalination in California. Residents for Responsible Desalination.

GEI Consultants/Navigant Consulting, Inc. (2010). Embedded Energy in Water Studies, Case Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles.

Global Water Intelligence. (2009). Water Desalination Report. Houston: Media Analytics.

Jahagirdar, S. (January 2003). Down the Drain: Six Case Studies of Groundwater Contamination that are

Wasting California's Water. Los Angeles: Environment California Research and Policy Center.

Lee, M. (2008, December 11). Water-cleaning Operation Faulted. Retrieved from Sign on San Diego: http://legacy.signonsandiego.com/news/metro/20081211-9999-1m11fine.html

Natural Resources Defense Council. (October 2002). What's on Tap? Grading Drinking Water in U.S. Cities, Early Release California Edition.

Navigant Consulting, Inc. (December 2006). Refining Estimates of Water-Related Energy Use in California, Table 9. Urban water intensity matrix (kWh/MG). For the California Energy Commission.

Navigant Consulting, Inc. (May 2008). The Role of Recycled Water in Energy and Greenhouse Gas Reduction.
Pankratz, T. (n.d.). An overview of Seawater of Intake Facilities for Seawater Desalination. Retrieved from Texas A&M AgriLife: http://texaswater.tamu.edu/readings/desal/Seawaterdesal.pdf

Poseidon. (July 2008). Carlsbad Seawater Desalination Project: Energy Mitigation and Greenhouse Gas Reduction Plan. San Diego: California Coastal Commission.

QEI, Inc. (1992). Electricity Efficiency Through Water Efficiency. Report for the Southern California Edison Company.

Recycled Water Overview. (2010). Retrieved May 17, 2010, from The City of San Diego: http://www.sandiego.gov/water/recycled/overview.shtml

San Diego Coastkeeper. (2010). Securing San Diego's Water Future: The Price of Water.

Sweetwater Authority . (2006, April 26). Cost of Free Water. American Water Works Association.

The City of San Diego. (March 2006). Water Reuse Study.

The San Diego Water Challenge: Water Conservation Numerical Factoids. (2008, August 1). Retrieved April 2010, from Utility Consumers' Action Network: http://www.ucan.org/water/water_conservation_efficiency/water_conservation_efficiency_numerical_factoids

Trageserl, C. (2010, January 14). No Solutions for Rural Water Pollution Problem. Retrieved from Voice of San Diego: http://www.voiceofsandiego.org/environment/article_fc48232a-0172-11df-a839-001cc4c002e0.html

U.S. Environmental Protection Agency. (2010, January 13). How to Conserve Water and Use It Effectively. Retrieved from U.S. Environmental Protection Agency: http://www.epa.gov/nps/chap3.html

Wilkinson, R. (January 2000). Methodology for Analysis of the Energy Intensity of California's Water Systems and An Assessment of Multiple Potential Benefits through Integrated Water-Energy Efficiency Measures.

POINT LOMA
NAZARENE UNIVERSITY

3900 Lomaland Drive, San Diego, CA 92106
(619) 849-2692
www.pointloma.edu

EQUINOX CENTER

545 Second St., #3, Encinitas, CA 92024
(760) 293-2690
www.equinoxcenter.org

Survey of Professional Forecasters

Release Date: February 15, 2013

FIRST QUARTER 2013

Forecasters Predict Stronger Labor Market

The outlook for growth in the U.S. economy over the next three years looks mostly unchanged from that of three months ago, according to 46 forecasters surveyed by the Federal Reserve Bank of Philadelphia. The panel expects real GDP to grow at an annual rate of 2.1 percent this quarter and 2.3 percent next quarter and to rise to 2.7 percent in the first quarter of 2014. On an annual-average over annual-average basis, the forecasters see real GDP growing 1.9 percent in 2013, down slightly from the previous estimate of 2.0 percent. The forecasters predict real GDP will grow 2.8 percent in 2014, 2.9 percent in 2015, and 3.0 percent in 2016.

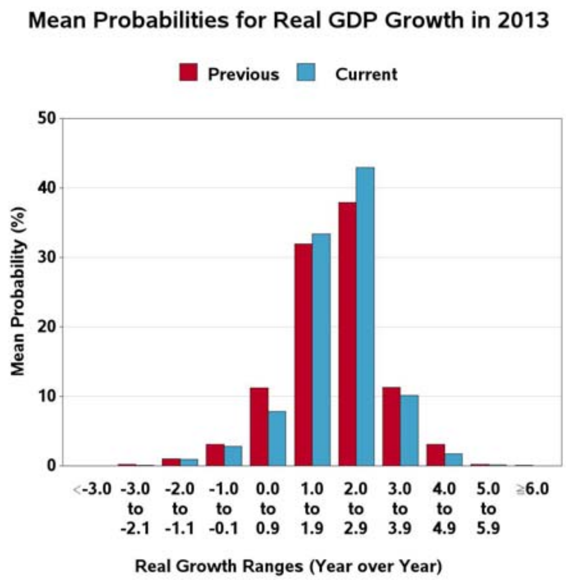
Healthier conditions in the labor market accompany the nearly stable outlook for real output. The forecasters predict that the unemployment rate will be an annual average of 7.7 percent in 2013, before falling to 7.2 percent in 2014, 6.7 percent in 2015, and 6.3 percent in 2016. These projections are below those of the last survey.

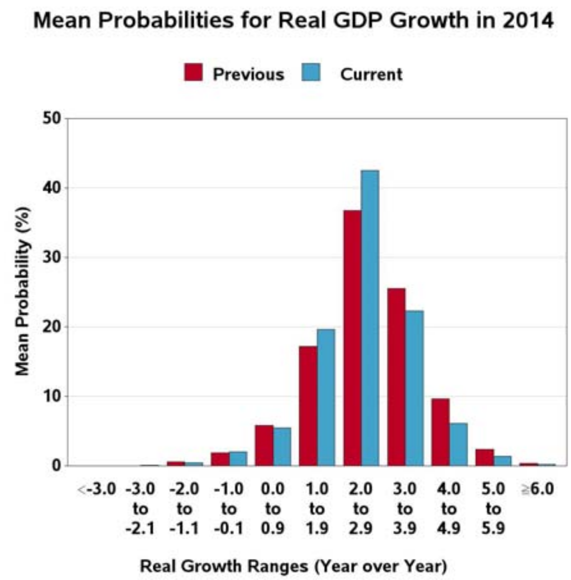
The forecasters are also more optimistic about the employment front. They have revised upward their estimates of the growth in jobs in the next four quarters. The forecasters see nonfarm payroll employment growing at a rate of 165,300 jobs per month this quarter and 154,200 jobs per month next quarter. The forecasters' projections for the annual-average level of nonfarm payroll employment suggest job gains at a monthly rate of 164,100 in 2013 and 176,800 in 2014, as the table below shows. (These annual-average estimates are computed as the year-to-year change in the annual-average level of nonfarm payroll employment, converted to a monthly rate.)

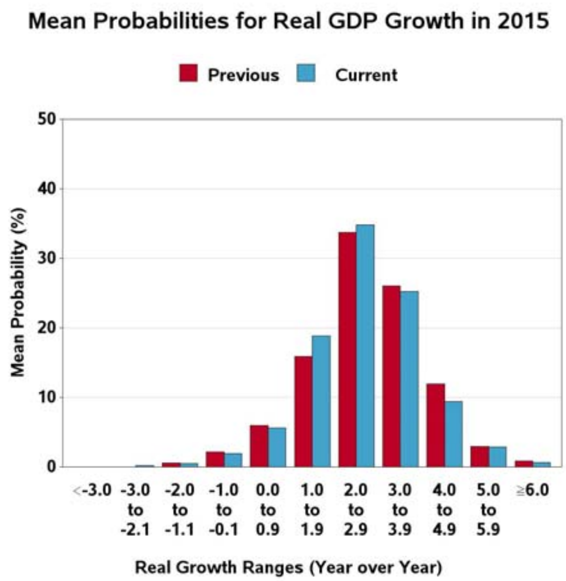
Median Forecasts for Selected Variables in the Current and Previous Surveys

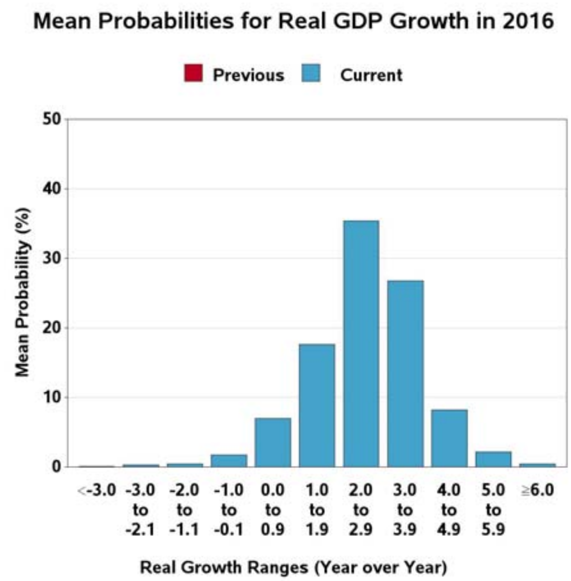
	Real GDP (%)		*Unemployment Rate (%)*		*Payrolls (000s/month)*	
	Previous	*New*	*Previous*	*New*	*Previous*	*New*
Quarterly data:						
2013:Q1	1.7	2.1	7.9	7.8	127.4	165.3
2013:Q2	2.0	2.3	7.8	7.7	146.1	154.2
2013:Q3	2.7	2.6	7.8	7.6	170.2	172.0
2013:Q4	2.8	2.5	7.6	7.5	178.3	180.4
2014:Q1	N.A.	2.7	N.A.	7.4	N.A.	171.5
Annual data (projections are based on annual-average levels):						
2013	2.0	1.9	7.8	7.7	143.3	164.1
2014	2.7	2.8	7.4	7.2	N.A.	176.8
2015	2.9	2.9	6.9	6.7	N.A.	N.A.
2016	N.A.	3.0	N.A.	6.3	N.A.	N.A.

The charts below provide some insight into the degree of uncertainty the forecasters have about their projections for the rate of growth in the annual-average level of real GDP. Each chart presents the forecasters' previous and current estimates of the probability that growth will fall into each of 11 ranges. The forecasters have revised upward their estimate of the probability that growth will fall into the range of 2.0 to 2.9 percent in 2013, 2014, and 2015.

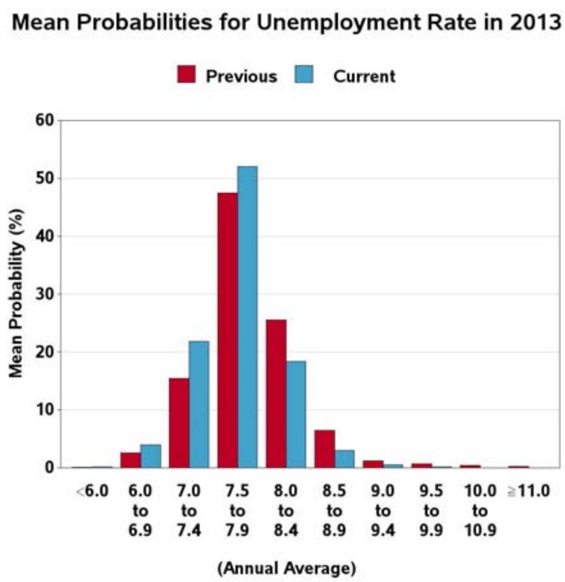


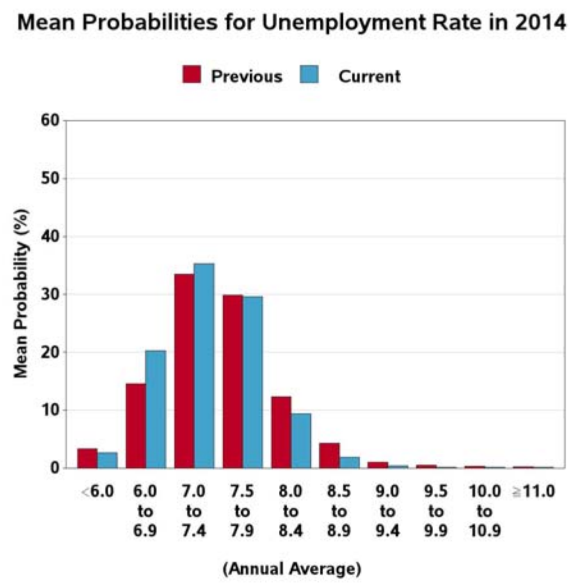


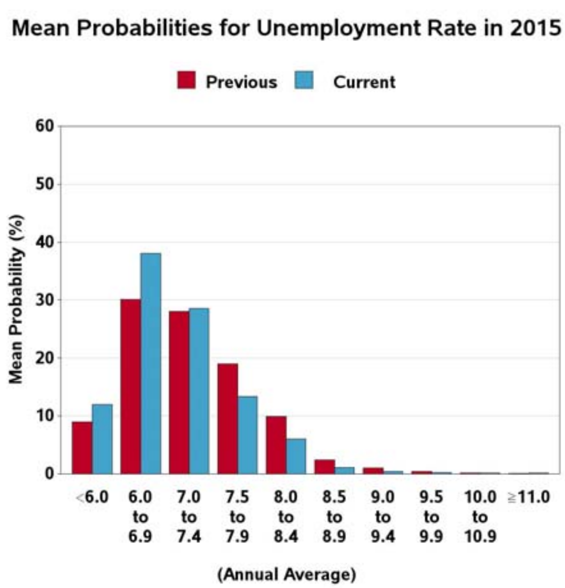


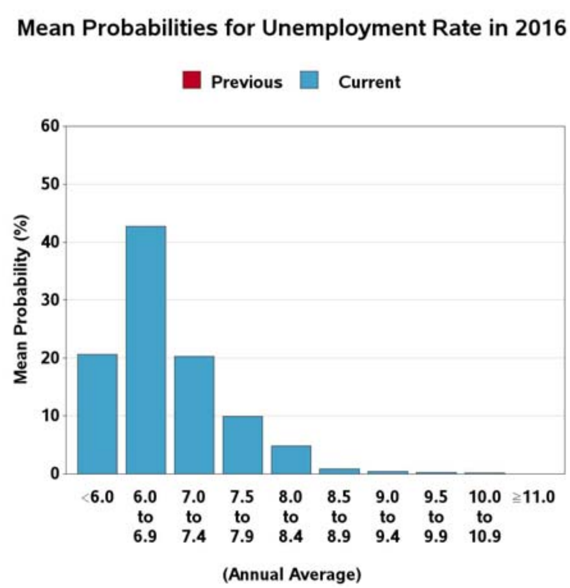


The forecasters' density projections, as shown in the charts below, shed light on the odds of a recovery in the labor market over the next four years. Each chart for unemployment presents the forecasters' previous and current estimates of the probability that unemployment will fall into each of 10 ranges. Consistent with their more optimistic point forecasts on unemployment, the forecasters have revised upward their estimate of the probability that unemployment will fall below 7.5 percent in 2013, 2014, and 2015.









Forecasters See Lower Near-Term Inflation
The forecasters expect current-quarter headline CPI inflation to average 1.8 percent, lower than the last survey's estimate of 2.1 percent. The forecasters predict current-quarter headline PCE inflation of 1.4 percent, lower than the prediction of 1.8 percent from the survey of three months ago.

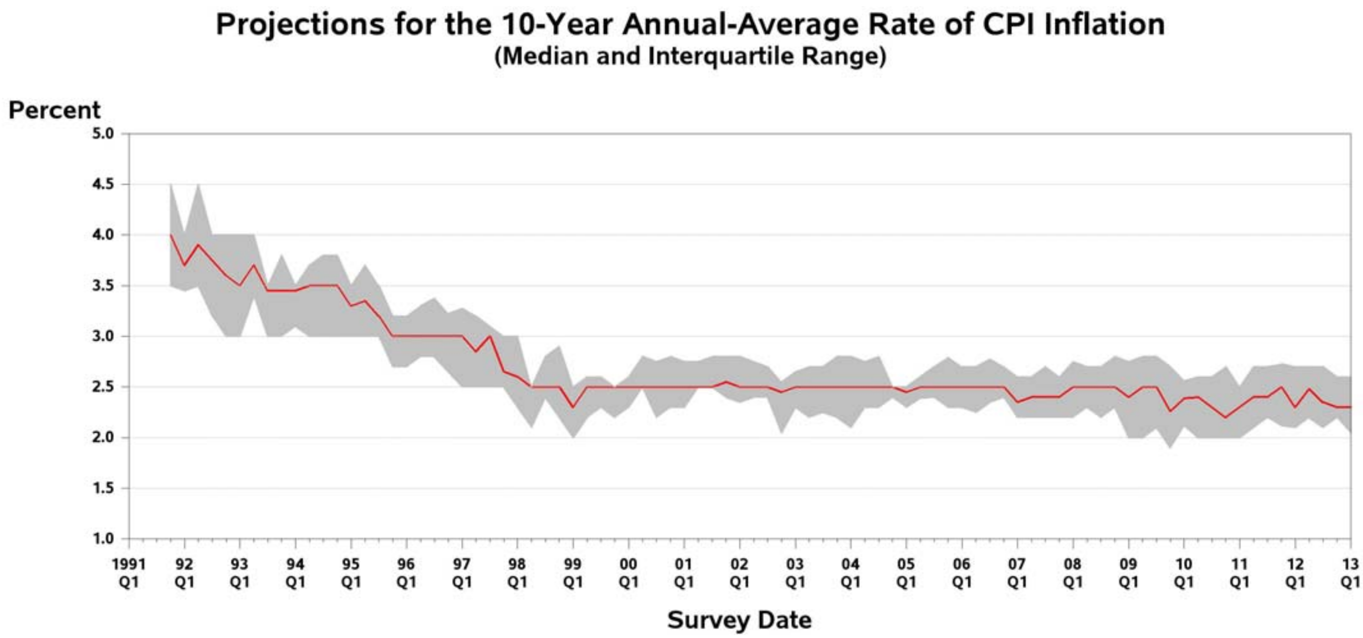
The forecasters also see lower headline and core measures of CPI and PCE inflation during the next two years. Measured on a fourth-quarter over fourth-quarter basis, headline CPI inflation is expected to average 2.0 percent in 2013, down from 2.2 percent in the last survey, and 2.2 percent in 2014, down 0.1 percentage point from the previous estimate. Forecasters expect fourth-quarter over fourth-quarter headline PCE inflation to average 1.8 percent in 2013, down from 2.0 percent in the last survey, and 2.0 percent in 2014, down 0.2 percentage point from the previous estimate.

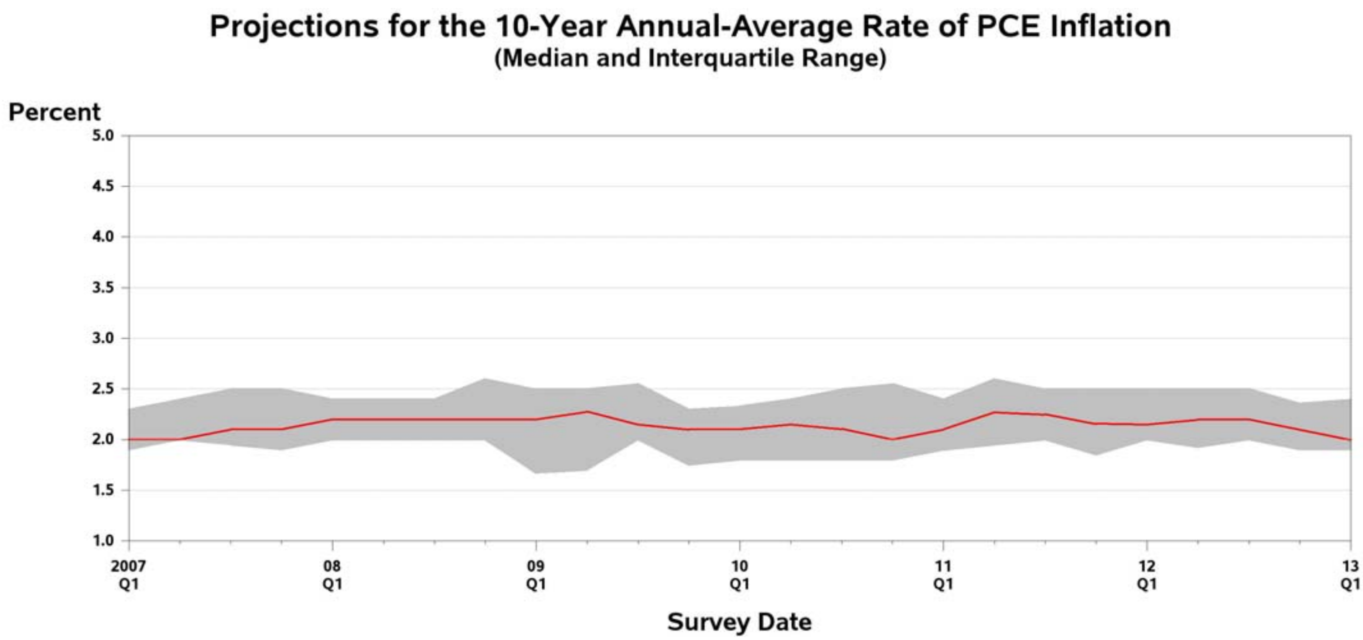
Over the next 10 years, 2013 to 2022, the forecasters expect headline CPI inflation to average 2.3 percent at an annual rate. The corresponding estimate for 10-year annual-average PCE inflation is 2.0 percent.

Median Short-Run and Long-Run Projections for Inflation (Annualized Percentage Points)

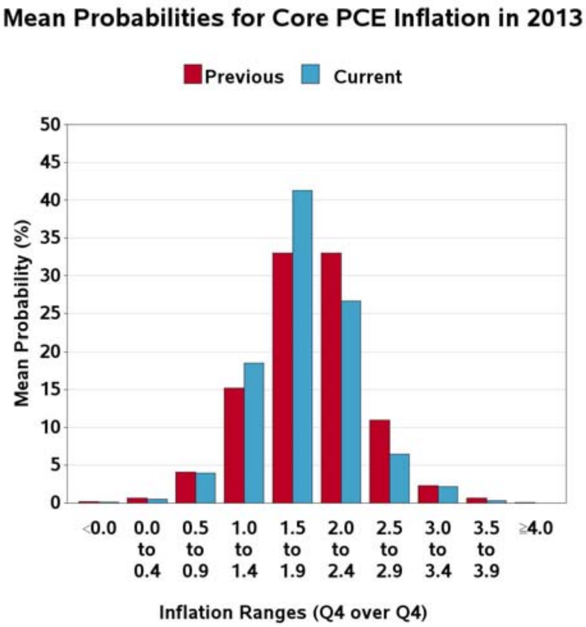
	Headline CPI		Core CPI		Headline PCE		Core PCE	
	Previous	Current	Previous	Current	Previous	Current	Previous	Current
Quarterly								
2013:Q1	2.1	1.8	1.9	1.8	1.8	1.4	1.8	1.4
2013:Q2	2.2	2.1	2.0	2.0	2.0	1.9	1.9	1.7
2013:Q3	2.2	2.1	2.0	2.0	2.0	1.9	1.9	1.8
2013:Q4	2.3	2.1	2.0	2.0	2.1	1.9	1.9	1.7
2014:Q1	N.A.	2.1	N.A.	2.0	N.A.	2.0	N.A.	1.8
Q4/Q4 Annual Averages								
2013	2.2	2.0	2.0	1.9	2.0	1.8	1.9	1.6
2014	2.3	2.2	2.2	2.1	2.2	2.0	2.0	1.9
2015	N.A.	2.3	N.A.	2.2	N.A.	2.0	N.A.	1.9
Long-Term Annual Averages								
2012-2016	2.28	N.A.	N.A.	N.A.	2.00	N.A.	N.A.	N.A.
2013-2017	N.A.	2.30	N.A.	N.A.	N.A.	2.00	N.A.	N.A.
2012-2021	2.30	N.A.	N.A.	N.A.	2.10	N.A.	N.A.	N.A.
2013-2022	N.A.	2.30	N.A.	N.A.	N.A.	2.00	N.A.	N.A.

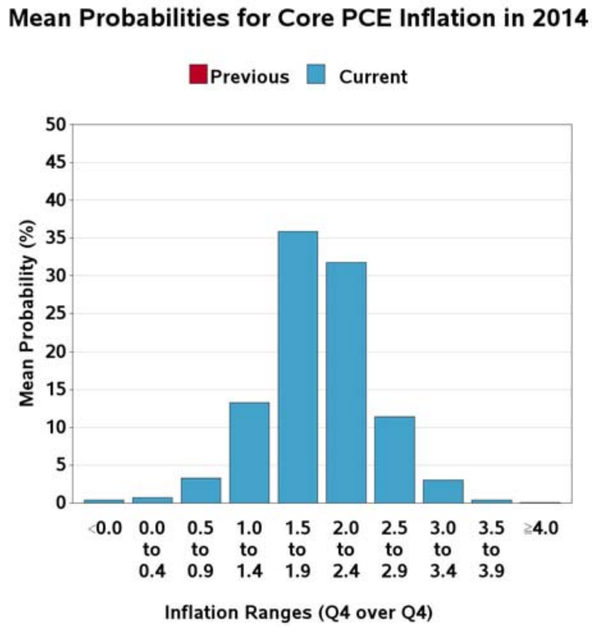
The charts below show the median projections (the red line) and the associated interquartile ranges (the gray area around the red line) for the projections for the 10-year annual-average CPI and PCE inflation. The top panel shows the unchanged long-term projection for CPI inflation, at 2.3 percent. The bottom panel highlights the slightly lower 10-year forecast for PCE inflation at 2.0 percent.





The figures below show the probabilities that the forecasters are assigning to the possibility that fourth-quarter over fourth-quarter core PCE inflation in 2013 and 2014 will fall into each of 10 ranges. For 2013, the forecasters assign a higher chance than previously that core PCE inflation will fall in the range of 1.0 to 1.9 percent (and a lower probability that inflation will exceed 1.9 percent).





Lower Risk of a Negative Quarter

The forecasters have revised downward the chance of a contraction in real GDP in any of the next four quarters. For the current quarter, they predict a 15.3 percent chance of negative growth, down from 23.0 percent in the survey of three months ago. As the table below shows, the panelists have also made downward revisions to their forecasts for the following three quarters.

Risk of a Negative Quarter (%)

Quarterly data:	*Previous*	*New*
2013: Q1	23.0	15.3
2013: Q2	21.7	18.0
2013: Q3	17.9	15.2
2013: Q4	16.4	13.6
2014: Q1	N.A.	13.2

Forecasters State Their Views on House Prices

In this survey, a special question asked panelists to provide their forecasts for fourth-quarter over fourth-quarter growth in house prices, as measured by a number of alternative indices. The panelists were allowed to choose from a provided list of indices or to write in their own index. For each index of their choosing, the panelists provided forecasts of growth in 2013 and 2014.

Thirty-one panelists answered the special question. Some panelists provided projections for more than one index. The table below provides a summary of the forecasters' responses. For some indices, the number of responses (N) is very small. The median estimates for the six house-price indices listed in the table below range from 2.0 percent to 9.2 percent in 2013 and 3.9 percent to 7.8 percent in 2014.

Projections for Growth in Various Indices of House Prices
Q4/Q4, Percentage Points

Index	2013 (Q4/Q4 Percent Change)			2014 (Q4/Q4 Percent Change)		
	N	Mean	Median	N	Mean	Median
S&P/Case-Shiller: U.S. National	15	3.5	3.3	15	3.5	4.0
S&P/Case-Shiller: Composite 20	6	4.8	4.5	6	4.6	3.9
FHFA: U.S. Total	9	2.6	2.0	9	4.4	4.0
FHFA: Purchase Only	4	2.7	2.8	4	4.1	3.9
CoreLogic: National HPI, incl Distressed Sales (Single Family Combined)	7	4.8	5.0	7	4.6	4.8
NAR Median: Total Existing	4	8.1	9.2	4	7.4	7.8

Forecasters Reduce Estimates for Long-Run Growth in Output and Productivity and Returns on Financial Assets

In first-quarter surveys, the forecasters provide their long-run projections for an expanded set of variables, including growth in output and productivity, as well as returns on financial assets.

As the table below shows, the forecasters have reduced their long-run estimates for the annual-average rate of growth in real GDP. Currently, the forecasters expect real GDP to grow 2.50 percent per year over the next 10 years, down from 2.64 percent in the survey of 2012 Q1.

Similarly, productivity growth is now expected to average 1.80 percent, down from 1.85 percent. Downward revisions to the return on financial assets accompany the current outlook. The forecasters see the S&P 500 returning an annual-average 6.13 percent per year over the next 10 years, down from 6.80 percent. The forecasters expect 10-year Treasuries to return 3.83 percent per year over the next 10 years, down from 4.00 percent. Three-month Treasury bills will return 2.40 percent, down from 2.50 percent.

Long-Term (10-year) Forecasts (%)

	First Quarter 2012	*Current Survey*
Real GDP Growth	2.64	2.50
Productivity Growth	1.85	1.80
Stock Returns (S&P 500)	6.80	6.13
Bond Returns (10-year)	4.00	3.83
Bill Returns (3-month)	2.50	2.40

The Federal Reserve Bank of Philadelphia thanks the following forecasters for their participation in recent surveys:

Scott Anderson, Bank of the West (BNP Paribas Group); **Robert J. Barbera**, Johns Hopkins University Center for Financial Economics; **Peter Bernstein**, RCF Economic and Financial Consulting, Inc.; **Christine Chmura, Ph.D.** and **Xiaobing Shuai, Ph.D.**, Chmura Economics & Analytics; **Gary Ciminero, CFA**, GLC Financial Economics; **Julia Coronado**, BNP Paribas; **David Crowe**, National Association of Home Builders; **Nathaniel Curtis**, EconLit LLC; **Rajeev Dhawan**, Georgia State University; **Shawn Dubravac**, Consumer Electronics Association; **Michael R. Englund**, Action Economics, LLC; **Timothy Gill**, NEMA; **James Glassman**, JPMorgan Chase & Co.; **Daniel Hanson**, LTZF Economics; **Keith Hembre**, Nuveen Asset Management; **Peter Hooper**, Deutsche Bank Securities, Inc.; **IHS Global Insight**; **Fred Joutz**, Benchmark Forecasts and Research Program on Forecasting, George Washington University; **N. Karp**, BBVA Compass; **Walter Kemmsies**, Moffatt & Nichol; **Jack Kleinhenz,** Kleinhenz & Associates, Inc.; **Thomas Lam**, OSK Group/DMG & Partners; **L. Douglas Lee**, Economics from Washington; **Allan R. Leslie**, Economic Consultant; **John Lonski**, Moody's Capital Markets Group; **Macroeconomic Advisers, LLC**; **Dean Maki**, Barclays Capital; **Jim Meil** and **Arun Raha**, Eaton Corporation; **Anthony Metz**, Pareto Optimal Economics; **Michael Moran**, Daiwa Capital Markets America; **Joel L. Naroff**, Naroff Economic Advisors; **Mark Nielson, Ph.D.**, MacroEcon Global Advisors; **Michael P. Niemira**, International Council of Shopping Centers; **Luca Noto**, Anima Sgr; **Brendon Ogmundson**, BC Real Estate Association; **Martin A. Regalia**, U.S. Chamber of Commerce; **Philip Rothman**, East Carolina University; **Chris Rupkey**, Bank of Tokyo-Mitsubishi UFJ; **John Silvia**, Wells Fargo; **Allen Sinai**, Decision Economics, Inc; **Tara M. Sinclair**, Research Program on Forecasting, George Washington University; **David Sloan**, Thomson Reuters; **Sean M. Snaith, Ph.D.**, University of Central Florida; **Constantine G. Soras, Ph.D.**, CGS Economic Consulting; **Neal Soss**, Credit Suisse; **Stephen Stanley**, Pierpont Securities; **Charles Steindel**, New Jersey Department of the Treasury; **Susan M. Sterne**, Economic Analysis Associates, Inc.; **Thomas Kevin Swift**, American Chemistry Council; **Andrew Tilton**, Goldman Sachs; **Lea Tyler**, Oxford Economics USA, Inc.; **Jay N. Woodworth**, Woodworth Holdings, Ltd.; **Richard Yamarone**, Bloomberg, LP; **Mark Zandi**, Moody's Analytics; **Ellen Zentner**, Nomura Securities.

This is a partial list of participants. We also thank those who wish to remain anonymous.

SUMMARY TABLE
SURVEY OF PROFESSIONAL FORECASTERS
MAJOR MACROECONOMIC INDICATORS

	2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	2013	2014	2015	2016
						(YEAR-OVER-YEAR)			
PERCENT GROWTH AT ANNUAL RATES									
1. REAL GDP (BILLIONS, CHAIN WEIGHTED)	2.1	2.3	2.6	2.5	2.7	1.9	2.8	2.9	3.0
2. GDP PRICE INDEX (PERCENT CHANGE)	1.7	1.9	2.1	1.7	2.0	1.7	2.1	N.A.	N.A.
3. NOMINAL GDP ($ BILLIONS)	4.0	4.2	4.4	4.3	5.0	3.6	4.7	N.A.	N.A.
4. NONFARM PAYROLL EMPLOYMENT									
(PERCENT CHANGE)	1.5	1.4	1.5	1.6	1.5	1.5	1.6	N.A.	N.A.
(AVG MONTHLY CHANGE)	165.3	154.2	172.0	180.4	171.5	164.1	176.8	N.A.	N.A.
VARIABLES IN LEVELS									
5. UNEMPLOYMENT RATE (PERCENT)	7.8	7.7	7.6	7.5	7.4	7.7	7.2	6.7	6.3
6. 3-MONTH TREASURY BILL (PERCENT)	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.6	1.7
7. 10-YEAR TREASURY BOND (PERCENT)	1.9	2.0	2.1	2.3	2.5	2.1	2.6	3.3	3.8

	2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	2013	2014	2015
						(Q4-OVER-Q4)		
INFLATION INDICATORS								
8. CPI (ANNUAL RATE)	1.8	2.1	2.1	2.1	2.1	2.0	2.2	2.3
9. CORE CPI (ANNUAL RATE)	1.8	2.0	2.0	2.0	2.0	1.9	2.1	2.2
10. PCE (ANNUAL RATE)	1.4	1.9	1.9	1.9	2.0	1.8	2.0	2.0
11. CORE PCE (ANNUAL RATE)	1.4	1.7	1.8	1.7	1.8	1.6	1.9	1.9

THE FIGURES ON EACH LINE ARE MEDIANS OF 46 INDIVIDUAL FORECASTERS.

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA.
SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

SURVEY OF PROFESSIONAL FORECASTERS

First Quarter 2013

Tables

Note: Data in these tables listed as "actual" are the data that were available to the forecasters when they were sent the survey questionnaire on January 30; the tables do not reflect subsequent revisions to the data. All forecasts were received on or before February 11, 2013.

TABLE ONE
MAJOR MACROECONOMIC INDICATORS
MEDIANS OF FORECASTER PREDICTIONS

	NUMBER OF FORECASTERS	ACTUAL	FORECAST					ACTUAL	FORECAST			
		2012 Q4	2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	2012 ANNUAL	2013 ANNUAL	2014 ANNUAL	2015 ANNUAL	2016 ANNUAL
1. GROSS DOMESTIC PRODUCT (GDP) ($ BILLIONS)	42	15829	15986	16150	16325	16499	16700	15676	16239	16997	N.A.	N.A.
2. GDP PRICE INDEX (2005=100)	43	115.98	116.47	117.02	117.63	118.14	118.72	115.36	117.32	119.79	N.A.	N.A.
3. CORPORATE PROFITS AFTER TAXES ($ BILLIONS)	21	N.A.	1536.0	1545.8	1577.1	1587.5	1612.1	N.A.	1570.6	1669.8	N.A.	N.A.
4. UNEMPLOYMENT RATE (PERCENT)	44	7.8	7.8	7.7	7.6	7.5	7.4	8.1	7.7	7.2	6.7	6.3
5. NONFARM PAYROLL EMPLOYMENT (THOUSANDS)	38	133864	134360	134822	135338	135879	136394	133241	135210	137332	N.A.	N.A.
6. INDUSTRIAL PRODUCTION (2007=100)	39	97.6	98.3	99.1	100.0	100.8	101.7	97.2	99.5	102.9	N.A.	N.A.
7. NEW PRIVATE HOUSING STARTS (ANNUAL RATE, MILLIONS)	41	0.90	0.92	0.95	0.98	1.03	1.09	0.78	0.97	1.17	N.A.	N.A.
8. 3-MONTH TREASURY BILL RATE (PERCENT)	42	0.09	0.10	0.10	0.10	0.10	0.11	0.09	0.10	0.16	0.55	1.69
9. AAA CORPORATE BOND YIELD (PERCENT)	34	3.54	3.73	3.80	3.90	4.04	4.15	3.67	3.85	4.30	N.A.	N.A.
10. BAA CORPORATE BOND YIELD (PERCENT)	33	4.57	4.80	4.82	4.96	5.05	5.17	4.94	4.91	5.52	N.A.	N.A.
11. 10-YEAR TREASURY BOND YIELD (PERCENT)	42	1.71	1.91	2.00	2.14	2.29	2.45	1.80	2.10	2.60	3.25	3.75
12. REAL GDP (BILLIONS, CHAIN WEIGHTED)	45	13648	13720	13799	13888	13973	14067	13589	13847	14229	14640	15072
13. TOTAL CONSUMPTION EXPENDITURE (BILLIONS, CHAIN WEIGHTED)	43	9671.9	9710.5	9757.0	9813.6	9872.7	9937.7	9605.3	9789.2	10023.5	N.A.	N.A.
14. NONRESIDENTIAL FIXED INVESTMENT (BILLIONS, CHAIN WEIGHTED)	41	1506.2	1518.9	1539.3	1564.3	1587.6	1608.1	1483.8	1553.3	1646.7	N.A.	N.A.
15. RESIDENTIAL FIXED INVESTMENT (BILLIONS, CHAIN WEIGHTED)	41	384.3	396.1	408.8	421.3	434.5	450.1	366.6	415.5	466.3	N.A.	N.A.
16. FEDERAL GOVERNMENT C & I (BILLIONS, CHAIN WEIGHTED)	40	1004.4	1004.3	1002.9	1003.0	998.0	995.3	1024.0	1001.6	992.8	N.A.	N.A.
17. STATE AND LOCAL GOVT C & I (BILLIONS, CHAIN WEIGHTED)	40	1460.2	1458.8	1458.7	1460.1	1463.1	1463.0	1462.4	1459.5	1469.0	N.A.	N.A.
18. CHANGE IN PRIVATE INVENTORIES (BILLIONS, CHAIN WEIGHTED)	40	20.0	36.9	41.1	43.7	45.0	45.0	44.6	42.5	44.5	N.A.	N.A.
19. NET EXPORTS (BILLIONS, CHAIN WEIGHTED)	41	-404.0	-404.3	-404.2	-410.0	-411.1	-409.2	-405.6	-406.3	-408.8	N.A.	N.A.

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA. SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE TWO
MAJOR MACROECONOMIC INDICATORS
PERCENTAGE CHANGES AT ANNUAL RATES

	NUMBER OF FORECASTERS	Q4 2012 TO Q1 2013	Q1 2013 TO Q2 2013	Q2 2013 TO Q3 2013	Q3 2013 TO Q4 2013	Q4 2013 TO Q1 2014	2012 TO 2013	2013 TO 2014	2014 TO 2015	2015 TO 2016
1. GROSS DOMESTIC PRODUCT (GDP) ($ BILLIONS)	42	4.0	4.2	4.4	4.3	5.0	3.6	4.7	N.A.	N.A.
2. GDP PRICE INDEX (2005=100)	43	1.7	1.9	2.1	1.7	2.0	1.7	2.1	N.A.	N.A.
3. CORPORATE PROFITS AFTER TAXES ($ BILLIONS)	21	5.7	2.6	8.4	2.7	6.3	5.3	6.3	N.A.	N.A.
4. UNEMPLOYMENT RATE (PERCENT)	44	0.0	-0.1	-0.1	-0.1	-0.1	-0.4	-0.4	-0.5	-0.5
5. NONFARM PAYROLL EMPLOYMENT										
(PERCENT CHANGE)	38	1.5	1.4	1.5	1.6	1.5	1.5	1.6	N.A.	N.A.
(AVG MONTHLY CHANGE)	38	165.3	154.2	172.0	180.4	171.5	164.1	176.8	N.A.	N.A.
6. INDUSTRIAL PRODUCTION (2007=100)	39	3.0	3.3	3.6	3.4	3.4	2.4	3.3	N.A.	N.A.
7. NEW PRIVATE HOUSING STARTS (ANNUAL RATE, MILLIONS)	41	9.2	14.7	13.2	22.0	23.2	24.6	20.2	N.A.	N.A.
8. 3-MONTH TREASURY BILL RATE (PERCENT)	42	0.01	0.00	0.00	0.00	0.01	0.01	0.06	0.39	1.14
9. AAA CORPORATE BOND YIELD (PERCENT)	34	0.19	0.07	0.10	0.15	0.11	0.18	0.45	N.A.	N.A.
10. BAA CORPORATE BOND YIELD (PERCENT)	33	0.23	0.02	0.14	0.09	0.12	-0.04	0.61	N.A.	N.A.
11. 10-YEAR TREASURY BOND YIELD (PERCENT)	42	0.19	0.10	0.14	0.16	0.16	0.30	0.50	0.65	0.50
12. REAL GDP (BILLIONS, CHAIN WEIGHTED)	45	2.1	2.3	2.6	2.5	2.7	1.9	2.8	2.9	3.0
13. TOTAL CONSUMPTION EXPENDITURE (BILLIONS, CHAIN WEIGHTED)	43	1.6	1.9	2.3	2.4	2.7	1.9	2.4	N.A.	N.A.
14. NONRESIDENTIAL FIXED INVESTMENT (BILLIONS, CHAIN WEIGHTED)	41	3.4	5.5	6.7	6.1	5.3	4.7	6.0	N.A.	N.A.
15. RESIDENTIAL FIXED INVESTMENT (BILLIONS, CHAIN WEIGHTED)	41	12.9	13.4	12.9	13.1	15.2	13.4	12.2	N.A.	N.A.
16. FEDERAL GOVERNMENT C & I (BILLIONS, CHAIN WEIGHTED)	40	-0.0	-0.6	0.0	-2.0	-1.1	-2.2	-0.9	N.A.	N.A.
17. STATE AND LOCAL GOVT C & I (BILLIONS, CHAIN WEIGHTED)	40	-0.4	-0.0	0.4	0.8	-0.0	-0.2	0.6	N.A.	N.A.
18. CHANGE IN PRIVATE INVENTORIES (BILLIONS, CHAIN WEIGHTED)	40	16.9	4.2	2.6	1.3	0.0	-2.1	2.0	N.A.	N.A.
19. NET EXPORTS (BILLIONS, CHAIN WEIGHTED)	41	-0.3	0.1	-5.8	-1.1	1.9	-0.7	-2.5	N.A.	N.A.

NOTE: FIGURES FOR UNEMPLOYMENT RATE, TREASURY BILL RATE, AAA CORPORATE BOND YIELD, BAA CORPORATE BOND YIELD, AND 10-YEAR TREASURY BOND YIELD ARE CHANGES IN THESE RATES, IN PERCENTAGE POINTS.
FIGURES FOR CHANGE IN PRIVATE INVENTORIES AND NET EXPORTS ARE CHANGES IN BILLIONS OF CHAIN-WEIGHTED DOLLARS.
ALL OTHERS ARE PERCENTAGE CHANGES AT ANNUAL RATES.

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA. SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE THREE
MAJOR PRICE INDICATORS
MEDIANS OF FORECASTER PREDICTIONS

	NUMBER OF FORECASTERS	ACTUAL 2012 Q4	FORECAST(Q/Q) 2013 Q1	2013 Q2	2013 Q3	2013 Q4	2014 Q1	ACTUAL 2012 ANNUAL	FORECAST(Q4/Q4) 2013 ANNUAL	2014 ANNUAL	2015 ANNUAL
1. CONSUMER PRICE INDEX (ANNUAL RATE)	43	2.1	1.8	2.1	2.1	2.1	2.1	1.9	2.0	2.2	2.3
2. CORE CONSUMER PRICE INDEX (ANNUAL RATE)	41	1.6	1.8	2.0	2.0	2.0	2.0	1.9	1.9	2.1	2.2
3. PCE PRICE INDEX (ANNUAL RATE)	38	1.2	1.4	1.9	1.9	1.9	2.0	1.5	1.8	2.0	2.0
4. CORE PCE PRICE INDEX (ANNUAL RATE)	39	0.9	1.4	1.7	1.8	1.7	1.8	1.5	1.6	1.9	1.9

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA. SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE FOUR
ESTIMATED PROBABILITY OF DECLINE IN REAL GDP

ESTIMATED PROBABILITY (CHANCES IN 100)	Q4 2012 TO Q1 2013	Q1 2013 TO Q2 2013	Q2 2013 TO Q3 2013	Q3 2013 TO Q4 2013	Q4 2013 TO Q1 2014
	NUMBER OF FORECASTERS				
10 OR LESS	22	12	13	21	22
11 TO 20	8	16	22	15	15
21 TO 30	8	9	5	4	2
31 TO 40	2	4	1	1	2
41 TO 50	1	0	0	0	0
51 TO 60	0	0	0	0	0
61 TO 70	0	0	0	0	0
71 TO 80	0	0	0	0	0
81 TO 90	0	0	0	0	0
91 AND OVER	0	0	0	0	0
NOT REPORTING	5	5	5	5	5
MEAN AND MEDIAN					
MEDIAN PROBABILITY	10.00	16.00	15.00	10.00	10.00
MEAN PROBABILITY	15.32	17.99	15.21	13.64	13.16

NOTE: TOTAL NUMBER OF FORECASTERS REPORTING IS 41.
SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA.
SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE FIVE
MEAN PROBABILITIES

MEAN PROBABILITY ATTACHED TO POSSIBLE
CIVILIAN UNEMPLOYMENT RATES:
(ANNUAL AVERAGE)

	2013	2014	2015	2016
11.0 PERCENT OR MORE	0.00	0.13	0.16	0.00
10.0 TO 10.9 PERCENT	0.01	0.15	0.18	0.18
9.5 TO 9.9 PERCENT	0.18	0.16	0.19	0.20
9.0 TO 9.4 PERCENT	0.50	0.44	0.42	0.41
8.5 TO 8.9 PERCENT	2.98	1.88	1.10	0.87
8.0 TO 8.4 PERCENT	18.35	9.38	6.04	4.78
7.5 TO 7.9 PERCENT	52.04	29.59	13.34	9.92
7.0 TO 7.4 PERCENT	21.85	35.30	28.55	20.28
6.0 TO 6.9 PERCENT	3.96	20.31	38.03	42.74
LESS THAN 6.0 PERCENT	0.13	2.68	11.98	20.60

MEAN PROBABILITY ATTACHED TO POSSIBLE
PERCENT CHANGES IN REAL GDP:
(ANNUAL-AVERAGE OVER ANNUAL-AVERAGE)

	2012-2013	2013-2014	2014-2015	2015-2016
6.0 OR MORE	0.02	0.21	0.62	0.45
5.0 TO 5.9	0.14	1.38	2.84	2.15
4.0 TO 4.9	1.74	6.08	9.38	8.19
3.0 TO 3.9	10.12	22.28	25.24	26.78
2.0 TO 2.9	42.98	42.50	34.83	35.38
1.0 TO 1.9	33.35	19.65	18.85	17.59
0.0 TO 0.9	7.84	5.42	5.61	6.99
-1.0 TO -0.1	2.80	2.01	1.90	1.74
-2.0 TO -1.1	0.95	0.38	0.51	0.42
-3.0 TO -2.1	0.06	0.08	0.21	0.28
LESS THAN -3.0	0.00	0.01	0.01	0.05

MEAN PROBABILITY ATTACHED TO POSSIBLE
PERCENT CHANGES IN GDP PRICE INDEX:
(ANNUAL-AVERAGE OVER ANNUAL-AVERAGE)

	2012-2013	2013-2014
8.0 OR MORE	0.00	0.00
7.0 TO 7.9	0.00	0.00
6.0 TO 6.9	0.00	0.02
5.0 TO 5.9	0.11	0.13
4.0 TO 4.9	0.82	2.00
3.0 TO 3.9	5.23	8.98
2.0 TO 2.9	35.89	44.02
1.0 TO 1.9	49.34	36.90
0.0 TO 0.9	7.84	7.07
WILL DECLINE	0.78	0.86

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA.
SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE SIX

MEAN PROBABILITY OF CORE CPI AND CORE PCE INFLATION (Q4/Q4)

MEAN PROBABILITY ATTACHED TO CORE CPI INFLATION:

	12Q4 TO 13Q4	13Q4 TO 14Q4
4 PERCENT OR MORE	0.05	0.35
3.5 TO 3.9 PERCENT	0.50	0.73
3.0 TO 3.4 PERCENT	2.86	5.60
2.5 TO 2.9 PERCENT	10.27	15.55
2.0 TO 2.4 PERCENT	30.49	32.55
1.5 TO 1.9 PERCENT	40.36	31.51
1.0 TO 1.4 PERCENT	12.94	10.29
0.5 TO 0.9 PERCENT	1.77	2.62
0.0 TO 0.4 PERCENT	0.34	0.53
WILL DECLINE	0.42	0.28

MEAN PROBABILITY ATTACHED TO CORE PCE INFLATION:

	12Q4 TO 13Q4	13Q4 TO 14Q4
4 PERCENT OR MORE	0.00	0.03
3.5 TO 3.9 PERCENT	0.29	0.37
3.0 TO 3.4 PERCENT	2.14	3.01
2.5 TO 2.9 PERCENT	6.46	11.40
2.0 TO 2.4 PERCENT	26.68	31.74
1.5 TO 1.9 PERCENT	41.32	35.88
1.0 TO 1.4 PERCENT	18.51	13.26
0.5 TO 0.9 PERCENT	3.97	3.25
0.0 TO 0.4 PERCENT	0.52	0.70
WILL DECLINE	0.10	0.36

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA.
SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

TABLE SEVEN
LONG-TERM (5-YEAR AND 10-YEAR) FORECASTS

ANNUAL AVERAGE OVER THE NEXT 5 YEARS: 2013-2017

CPI INFLATION RATE		PCE INFLATION RATE	
MINIMUM	0.60	MINIMUM	0.61
LOWER QUARTILE	2.00	LOWER QUARTILE	1.80
MEDIAN	2.30	MEDIAN	2.00
UPPER QUARTILE	2.50	UPPER QUARTILE	2.30
MAXIMUM	3.10	MAXIMUM	2.80
MEAN	2.24	MEAN	2.01
STD. DEVIATION	0.45	STD. DEVIATION	0.41
N	40	N	38
MISSING	6	MISSING	8

ANNUAL AVERAGE OVER THE NEXT 10 YEARS: 2013-2022

CPI INFLATION RATE		PCE INFLATION RATE	
MINIMUM	0.97	MINIMUM	0.99
LOWER QUARTILE	2.05	LOWER QUARTILE	1.90
MEDIAN	2.30	MEDIAN	2.00
UPPER QUARTILE	2.60	UPPER QUARTILE	2.40
MAXIMUM	3.50	MAXIMUM	3.00
MEAN	2.33	MEAN	2.12
STD. DEVIATION	0.45	STD. DEVIATION	0.40
N	39	N	37
MISSING	7	MISSING	9

REAL GDP GROWTH RATE		PRODUCTIVITY GROWTH RATE	
MINIMUM	1.75	MINIMUM	0.90
LOWER QUARTILE	2.43	LOWER QUARTILE	1.50
MEDIAN	2.50	MEDIAN	1.80
UPPER QUARTILE	2.80	UPPER QUARTILE	2.20
MAXIMUM	3.50	MAXIMUM	3.00
MEAN	2.57	MEAN	1.86
STD. DEVIATION	0.35	STD. DEVIATION	0.51
N	37	N	30
MISSING	9	MISSING	16

STOCK RETURNS (S&P 500)		BOND RETURNS (10-YEAR)		BILL RETURNS (3-MONTH)	
MINIMUM	4.00	MINIMUM	1.90	MINIMUM	0.50
LOWER QUARTILE	5.05	LOWER QUARTILE	2.75	LOWER QUARTILE	1.80
MEDIAN	6.13	MEDIAN	3.83	MEDIAN	2.40
UPPER QUARTILE	6.95	UPPER QUARTILE	4.30	UPPER QUARTILE	2.85
MAXIMUM	10.00	MAXIMUM	7.00	MAXIMUM	4.25
MEAN	6.15	MEAN	3.70	MEAN	2.46
STD. DEVIATION	1.58	STD. DEVIATION	1.32	STD. DEVIATION	0.98
N	24	N	26	N	25
MISSING	22	MISSING	20	MISSING	21

SOURCE: RESEARCH DEPARTMENT, FEDERAL RESERVE BANK OF PHILADELPHIA.
SURVEY OF PROFESSIONAL FORECASTERS, FIRST QUARTER 2013.

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Technical Support Document: -
Social Cost of Carbon for Regulatory Impact Analysis -
Under Executive Order 12866 -

Interagency Working Group on Social Cost of Carbon, United States Government

With participation by

Council of Economic Advisers
Council on Environmental Quality
Department of Agriculture
Department of Commerce
Department of Energy
Department of Transportation
Environmental Protection Agency
National Economic Council
Office of Energy and Climate Change
Office of Management and Budget
Office of Science and Technology Policy
Department of the Treasury

February 2010

Executive Summary

Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the "social cost of carbon" (SCC) estimates presented here is to allow agencies to incorporate the social benefits of reducing carbon dioxide (CO_2) emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. The estimates are presented with an acknowledgement of the many uncertainties involved and with a clear understanding that they should be updated over time to reflect increasing knowledge of the science and economics of climate impacts.

The SCC is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services due to climate change.

This document presents a summary of the interagency process that developed these SCC estimates. Technical experts from numerous agencies met on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key model inputs and assumptions. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions grounded in the existing scientific and economic literatures. In this way, key uncertainties and model differences transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC from three integrated assessment models, at discount rates of 2.5, 3, and 5 percent. The fourth value, which represents the 95^{th} percentile SCC estimate across all three models at a 3 percent discount rate, is included to represent higher-than-expected impacts from temperature change further out in the tails of the SCC distribution.

Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

I. Monetizing Carbon Dioxide Emissions

The "social cost of carbon" (SCC) is an estimate of the monetized damages associated with an incremental increase in carbon emissions in a given year. It is intended to include (but is not limited to) changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services. We report estimates of the social cost of carbon in dollars per metric ton of carbon dioxide throughout this document.[1]

When attempting to assess the incremental economic impacts of carbon dioxide emissions, the analyst faces a number of serious challenges. A recent report from the National Academies of Science (NRC 2009) points out that any assessment will suffer from uncertainty, speculation, and lack of information about (1) future emissions of greenhouse gases, (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages. As a result, any effort to quantify and monetize the harms associated with climate change will raise serious questions of science, economics, and ethics and should be viewed as provisional.

Despite the serious limits of both quantification and monetization, SCC estimates can be useful in estimating the social benefits of reducing carbon dioxide emissions. Under Executive Order 12866, agencies are required, to the extent permitted by law, "to assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs." The purpose of the SCC estimates presented here is to make it possible for agencies to incorporate the social benefits from reducing carbon dioxide emissions into cost-benefit analyses of regulatory actions that have small, or "marginal," impacts on cumulative global emissions. Most federal regulatory actions can be expected to have marginal impacts on global emissions.

For such policies, the benefits from reduced (or costs from increased) emissions in any future year can be estimated by multiplying the change in emissions in that year by the SCC value appropriate for that year. The net present value of the benefits can then be calculated by multiplying each of these future benefits by an appropriate discount factor and summing across all affected years. This approach assumes that the marginal damages from increased emissions are constant for small departures from the baseline emissions path, an approximation that is reasonable for policies that have effects on emissions that are small relative to cumulative global carbon dioxide emissions. For policies that have a large (non-marginal) impact on global cumulative emissions, there is a separate question of whether the SCC is an appropriate tool for calculating the benefits of reduced emissions; we do not attempt to answer that question here.

An interagency group convened on a regular basis to consider public comments, explore the technical literature in relevant fields, and discuss key inputs and assumptions in order to generate SCC estimates. Agencies that actively participated in the interagency process include the Environmental Protection

[1] In this document, we present all values of the SCC as the cost per metric ton of CO_2 emissions. Alternatively, one could report the SCC as the cost per metric ton of carbon emissions. The multiplier for translating between mass of CO_2 and the mass of carbon is 3.67 (the molecular weight of CO_2 divided by the molecular weight of carbon = 44/12 = 3.67).

Agency, and the Departments of Agriculture, Commerce, Energy, Transportation, and Treasury. This process was convened by the Council of Economic Advisers and the Office of Management and Budget, with active participation and regular input from the Council on Environmental Quality, National Economic Council, Office of Energy and Climate Change, and Office of Science and Technology Policy. The main objective of this process was to develop a range of SCC values using a defensible set of input assumptions that are grounded in the existing literature. In this way, key uncertainties and model differences can more transparently and consistently inform the range of SCC estimates used in the rulemaking process.

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are \$5, \$21, \$35, and \$65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to \$24 per ton of CO_2 in 2015 and \$26 per ton of CO_2 in 2020. See Appendix A for the full range of annual SCC estimates from 2010 to 2050.

It is important to emphasize that the interagency process is committed to updating these estimates as the science and economic understanding of climate change and its impacts on society improves over time. Specifically, we have set a preliminary goal of revisiting the SCC values within two years or at such time as substantially updated models become available, and to continue to support research in this area. In the meantime, we will continue to explore the issues raised in this document and consider public comments as part of the ongoing interagency process.

II. Social Cost of Carbon Values Used in Past Regulatory Analyses

To date, economic analyses for Federal regulations have used a wide range of values to estimate the benefits associated with reducing carbon dioxide emissions. In the final model year 2011 CAFE rule, the Department of Transportation (DOT) used both a "domestic" SCC value of \$2 per ton of CO_2 and a "global" SCC value of \$33 per ton of CO_2 for 2007 emission reductions (in 2007 dollars), increasing both values at 2.4 percent per year. It also included a sensitivity analysis at \$80 per ton of CO_2. A domestic SCC value is meant to reflect the value of damages in the United States resulting from a unit change in carbon dioxide emissions, while a global SCC value is meant to reflect the value of damages worldwide.

A 2008 regulation proposed by DOT assumed a domestic SCC value of \$7 per ton CO_2 (in 2006 dollars) for 2011 emission reductions (with a range of \$0-\$14 for sensitivity analysis), also increasing at 2.4 percent per year. A regulation finalized by DOE in October of 2008 used a domestic SCC range of \$0 to \$20 per ton CO_2 for 2007 emission reductions (in 2007 dollars). In addition, EPA's 2008 Advance Notice of Proposed Rulemaking for Greenhouse Gases identified what it described as "very preliminary" SCC estimates subject to revision. EPA's global mean values were \$68 and \$40 per ton CO_2 for discount rates of approximately 2 percent and 3 percent, respectively (in 2006 dollars for 2007 emissions).

In 2009, an interagency process was initiated to offer a preliminary assessment of how best to quantify the benefits from reducing carbon dioxide emissions. To ensure consistency in how benefits are evaluated across agencies, the Administration sought to develop a transparent and defensible method, specifically designed for the rulemaking process, to quantify avoided climate change damages from reduced CO_2 emissions. The interagency group did not undertake any original analysis. Instead, it combined SCC estimates from the existing literature to use as interim values until a more comprehensive analysis could be conducted.

The outcome of the preliminary assessment by the interagency group was a set of five interim values: global SCC estimates for 2007 (in 2006 dollars) of $55, $33, $19, $10, and $5 per ton of CO_2. The $33 and $5 values represented model-weighted means of the published estimates produced from the most recently available versions of three integrated assessment models—DICE, PAGE, and FUND—at approximately 3 and 5 percent discount rates. The $55 and $10 values were derived by adjusting the published estimates for uncertainty in the discount rate (using factors developed by Newell and Pizer (2003)) at 3 and 5 percent discount rates, respectively. The $19 value was chosen as a central value between the $5 and $33 per ton estimates. All of these values were assumed to increase at 3 percent annually to represent growth in incremental damages over time as the magnitude of climate change increases.

These interim values represent the first sustained interagency effort within the U.S. government to develop an SCC for use in regulatory analysis. The results of this preliminary effort were presented in several proposed and final rules and were offered for public comment in connection with proposed rules, including the joint EPA-DOT fuel economy and CO_2 tailpipe emission proposed rules.

III. Approach and Key Assumptions

Since the release of the interim values, interagency group has reconvened on a regular basis to generate improved SCC estimates. Specifically, the group has considered public comments and further explored the technical literature in relevant fields. This section details the several choices and assumptions that underlie the resulting estimates of the SCC.

It is important to recognize that a number of key uncertainties remain, and that current SCC estimates should be treated as provisional and revisable since they will evolve with improved scientific and economic understanding. The interagency group also recognizes that the existing models are imperfect and incomplete. The National Academy of Science (2009) points out that there is tension between the goal of producing quantified estimates of the economic damages from an incremental ton of carbon and the limits of existing efforts to model these effects. Throughout this document, we highlight a number of concerns and problems that should be addressed by the research community, including research programs housed in many of the agencies participating in the interagency process to estimate the SCC.

The U.S. Government will periodically review and reconsider estimates of the SCC used for cost-benefit analyses to reflect increasing knowledge of the science and economics of climate impacts, as well as improvements in modeling. In this context, statements recognizing the limitations of the analysis and calling for further research take on exceptional significance. The interagency group offers the new SCC values with all due humility about the uncertainties embedded in them and with a sincere promise to continue work to improve them.

A. Integrated Assessment Models

We rely on three integrated assessment models (IAMs) commonly used to estimate the SCC: the FUND, DICE, and PAGE models.[2] These models are frequently cited in the peer-reviewed literature and used in the IPCC assessment. Each model is given equal weight in the SCC values developed through this process, bearing in mind their different limitations (discussed below).

These models are useful because they combine climate processes, economic growth, and feedbacks between the climate and the global economy into a single modeling framework. At the same time, they gain this advantage at the expense of a more detailed representation of the underlying climatic and economic systems. DICE, PAGE, and FUND all take stylized, reduced-form approaches (see NRC 2009 for a more detailed discussion; see Nordhaus 2008 on the possible advantages of this approach). Other IAMs may better reflect the complexity of the science in their modeling frameworks but do not link physical impacts to economic damages. There is currently a limited amount of research linking climate impacts to economic damages, which makes this exercise even more difficult. Underlying the three IAMs selected for this exercise are a number of simplifying assumptions and judgments reflecting the various modelers' best attempts to synthesize the available scientific and economic research characterizing these relationships.

The three IAMs translate emissions into changes in atmospheric greenhouse concentrations, atmospheric concentrations into changes in temperature, and changes in temperature into economic damages. The emissions projections used in the models are based on specified socio-economic (GDP and population) pathways. These emissions are translated into concentrations using the carbon cycle built into each model, and concentrations are translated into warming based on each model's simplified representation of the climate and a key parameter, climate sensitivity. Each model uses a different approach to translate warming into damages. Finally, transforming the stream of economic damages over time into a single value requires judgments about how to discount them.

Each model takes a slightly different approach to model how changes in emissions result in changes in economic damages. In PAGE, for example, the consumption-equivalent damages in each period are calculated as a fraction of GDP, depending on the temperature in that period relative to the pre-industrial average temperature in each region. In FUND, damages in each period also depend on the rate of temperature change from the prior period. In DICE, temperature affects both consumption and investment. We describe each model in greater detail here. In a later section, we discuss key gaps in how the models account for various scientific and economic processes (e.g. the probability of catastrophe, and the ability to adapt to climate change and the physical changes it causes).

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[2] The DICE (Dynamic Integrated Climate and Economy) model by William Nordhaus evolved from a series of energy models and was first presented in 1990 (Nordhaus and Boyer 2000, Nordhaus 2008). The PAGE (Policy Analysis of the Greenhouse Effect) model was developed by Chris Hope in 1991 for use by European decision-makers in assessing the marginal impact of carbon emissions (Hope 2006, Hope 2008). The FUND (Climate Framework for Uncertainty, Negotiation, and Distribution) model, developed by Richard Tol in the early 1990s, originally to study international capital transfers in climate policy. is now widely used to study climate impacts (e.g., Tol 2002a, Tol 2002b, Anthoff et al. 2009, Tol 2009).

The parameters and assumptions embedded in the three models vary widely. A key objective of the interagency process was to enable a consistent exploration of the three models while respecting the different approaches to quantifying damages taken by the key modelers in the field. An extensive review of the literature was conducted to select three sets of input parameters for these models: climate sensitivity, socio-economic and emissions trajectories, and discount rates. A probability distribution for climate sensitivity was specified as an input into all three models. In addition, the interagency group used a range of scenarios for the socio-economic parameters and a range of values for the discount rate. All other model features were left unchanged, relying on the model developers' best estimates and judgments. In DICE, these parameters are handled deterministically and represented by fixed constants; in PAGE, most parameters are represented by probability distributions. FUND was also run in a mode in which parameters were treated probabilistically.

The sensitivity of the results to other aspects of the models (e.g. the carbon cycle or damage function) is also important to explore in the context of future revisions to the SCC but has not been incorporated into these estimates. Areas for future research are highlighted at the end of this document.

The DICE Model

The DICE model is an optimal growth model based on a global production function with an extra stock variable (atmospheric carbon dioxide concentrations). Emission reductions are treated as analogous to investment in "natural capital." By investing in natural capital today through reductions in emissions—implying reduced consumption—harmful effects of climate change can be avoided and future consumption thereby increased.

For purposes of estimating the SCC, carbon dioxide emissions are a function of global GDP and the carbon intensity of economic output, with the latter declining over time due to technological progress. The DICE damage function links global average temperature to the overall impact on the world economy. It varies quadratically with temperature change to capture the more rapid increase in damages expected to occur under more extreme climate change, and is calibrated to include the effects of warming on the production of market and nonmarket goods and services. It incorporates impacts on agriculture, coastal areas (due to sea level rise), "other vulnerable market sectors" (based primarily on changes in energy use), human health (based on climate-related diseases, such as malaria and dengue fever, and pollution), non-market amenities (based on outdoor recreation), and human settlements and ecosystems. The DICE damage function also includes the expected value of damages associated with low probability, high impact "catastrophic" climate change. This last component is calibrated based on a survey of experts (Nordhaus 1994). The expected value of these impacts is then added to the other market and non-market impacts mentioned above.

No structural components of the DICE model represent adaptation explicitly, though it is included implicitly through the choice of studies used to calibrate the aggregate damage function. For example, its agricultural impact estimates assume that farmers can adjust land use decisions in response to changing climate conditions, and its health impact estimates assume improvements in healthcare over time. In addition, the small impacts on forestry, water systems, construction, fisheries, and outdoor recreation imply optimistic and costless adaptation in these sectors (Nordhaus and Boyer, 2000; Warren et al., 2006). Costs of resettlement due to sea level rise are incorporated into damage estimates, but their magnitude is not clearly reported. Mastrandrea's (2009) review concludes that "in general, DICE assumes very effective adaptation, and largely ignores adaptation costs."

Note that the damage function in DICE has a somewhat different meaning from the damage functions in FUND and PAGE. Because GDP is endogenous in DICE and because damages in a given year reduce investment in that year, damages propagate forward in time and reduce GDP in future years. In contrast, GDP is exogenous in FUND and PAGE, so damages in any given year do not propagate forward.[3]

The PAGE Model

PAGE2002 (version 1.4epm) treats GDP growth as exogenous. It divides impacts into economic, non-economic, and catastrophic categories and calculates these impacts separately for eight geographic regions. Damages in each region are expressed as a fraction of output, where the fraction lost depends on the temperature change in each region. Damages are expressed as power functions of temperature change. The exponents of the damage function are the same in all regions but are treated as uncertain, with values ranging from 1 to 3 (instead of being fixed at 2 as in DICE).

PAGE2002 includes the consequences of catastrophic events in a separate damage sub-function. Unlike DICE, PAGE2002 models these events probabilistically. The probability of a "discontinuity" (i.e., a catastrophic event) is assumed to increase with temperature above a specified threshold. The threshold temperature, the rate at which the probability of experiencing a discontinuity increases above the threshold, and the magnitude of the resulting catastrophe are all modeled probabilistically.

Adaptation is explicitly included in PAGE. Impacts are assumed to occur for temperature increases above some tolerable level (2°C for developed countries and 0°C for developing countries for economic impacts, and 0°C for all regions for non-economic impacts), but adaptation is assumed to reduce these impacts. Default values in PAGE2002 assume that the developed countries can ultimately eliminate up to 90 percent of all economic impacts beyond the tolerable 2°C increase and that developing countries can eventually eliminate 50 percent of their economic impacts. All regions are assumed to be able to mitigate 25 percent of the non-economic impacts through adaptation (Hope 2006).

The FUND Model

Like PAGE, the FUND model treats GDP growth as exogenous. It includes separately calibrated damage functions for eight market and nonmarket sectors: agriculture, forestry, water, energy (based on heating and cooling demand), sea level rise (based on the value of land lost and the cost of protection),

[3] Using the default assumptions in DICE 2007, this effect generates an approximately 25 percent increase in the SCC relative to damages calculated by fixing GDP. In DICE2007, the time path of GDP is endogenous. Specifically, the path of GDP depends on the rate of saving and level of abatement in each period chosen by the optimizing representative agent in the model. We made two modifications to DICE to make it consistent with EMF GDP trajectories (see next section): we assumed a fixed rate of savings of 20%, and we re-calibrated the exogenous path of total factor productivity so that DICE would produce GDP projections in the absence of warming that exactly matched the EMF scenarios.

ecosystems, human health (diarrhea, vector-borne diseases, and cardiovascular and respiratory mortality), and extreme weather. Each impact sector has a different functional form, and is calculated separately for sixteen geographic regions. In some impact sectors, the fraction of output lost or gained due to climate change depends not only on the absolute temperature change but also on the rate of temperature change and level of regional income.[4] In the forestry and agricultural sectors, economic damages also depend on CO_2 concentrations.

Tol (2009) discusses impacts not included in FUND, noting that many are likely to have a relatively small effect on damage estimates (both positive and negative). However, he characterizes several omitted impacts as "big unknowns": for instance, extreme climate scenarios, biodiversity loss, and effects on economic development and political violence. With regard to potentially catastrophic events, he notes, "Exactly what would cause these sorts of changes or what effects they would have are not well-understood, although the chance of any one of them happening seems low. But they do have the potential to happen relatively quickly, and if they did, the costs could be substantial. Only a few studies of climate change have examined these issues."

Adaptation is included both implicitly and explicitly in FUND. Explicit adaptation is seen in the agriculture and sea level rise sectors. Implicit adaptation is included in sectors such as energy and human health, where wealthier populations are assumed to be less vulnerable to climate impacts. For example, the damages to agriculture are the sum of three effects: (1) those due to the rate of temperature change (damages are always positive); (2) those due to the level of temperature change (damages can be positive or negative depending on region and temperature); and (3) those from CO_2 fertilization (damages are generally negative but diminishing to zero).

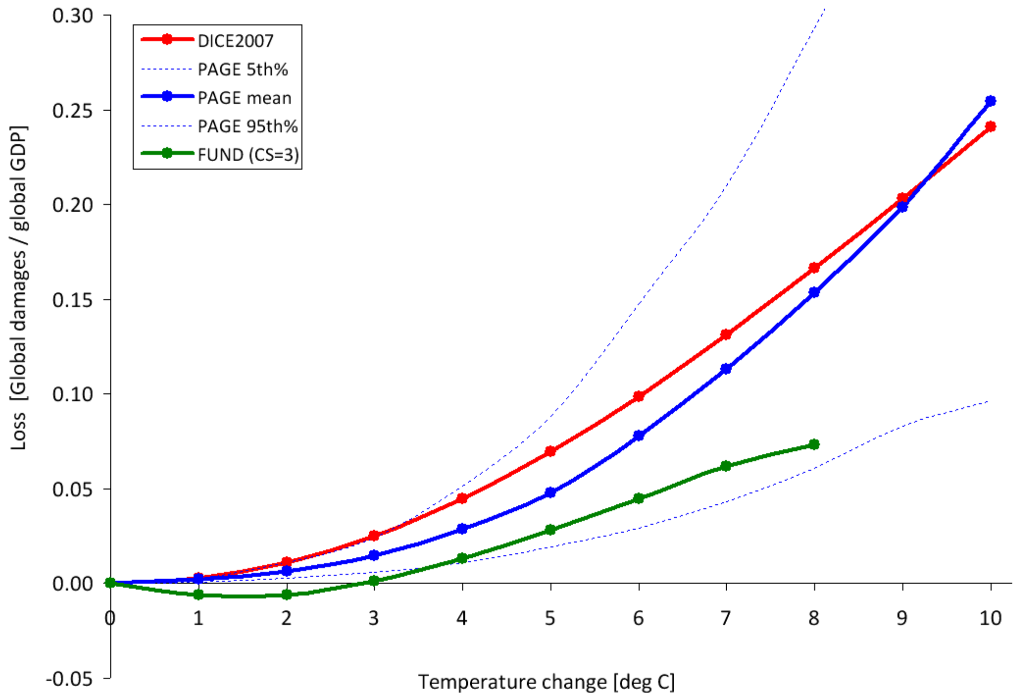
Adaptation is incorporated into FUND by allowing damages to be smaller if climate change happens more slowly. The combined effect of CO_2 fertilization in the agricultural sector, positive impacts to some regions from higher temperatures, and sufficiently slow increases in temperature across these sectors can result in negative economic damages from climate change.

Damage Functions

To generate revised SCC values, we rely on the IAM modelers' current best judgments of how to represent the effects of climate change (represented by the increase in global-average surface temperature) on the consumption-equivalent value of both market and non-market goods (represented as a fraction of global GDP). We recognize that these representations are incomplete and highly uncertain. But given the paucity of data linking the physical impacts to economic damages, we were not able to identify a better way to translate changes in climate into net economic damages, short of launching our own research program.

[4] In the deterministic version of FUND, the majority of damages are attributable to increased air conditioning demand, while reduced cold stress in Europe, North America, and Central and East Asia results in health benefits in those regions at low to moderate levels of warming (Warren et al., 2006).

Figure 1A: Annual Consumption Loss as a Fraction of Global GDP in 2100 Due to an Increase in Annual - Global Temperature in the DICE, FUND, and PAGE models[5]



The damage functions for the three IAMs are presented in Figures 1A and 1B, using the modeler's default scenarios and mean input assumptions. There are significant differences between the three models both at lower (figure 1B) and higher (figure 1A) increases in global-average temperature.

The lack of agreement among the models at lower temperature increases is underscored by the fact that the damages from FUND are well below the 5th percentile estimated by PAGE, while the damages estimated by DICE are roughly equal to the 95th percentile estimated by PAGE. This is significant because at higher discount rates we expect that a greater proportion of the SCC value is due to damages in years with lower temperature increases. For example, when the discount rate is 2.5 percent, about 45 percent of the 2010 SCC value in DICE is due to damages that occur in years when the temperature is less than or equal to 3 °C. This increases to approximately 55 percent and 80 percent at discount rates of 3 and 5 percent, respectively.

These differences underscore the need for a thorough review of damage functions—in particular, how the models incorporate adaptation, technological change, and catastrophic damages. Gaps in the literature make modifying these aspects of the models challenging, which highlights the need for additional research. As knowledge improves, the Federal government is committed to exploring how these (and other) models can be modified to incorporate more accurate estimates of damages.

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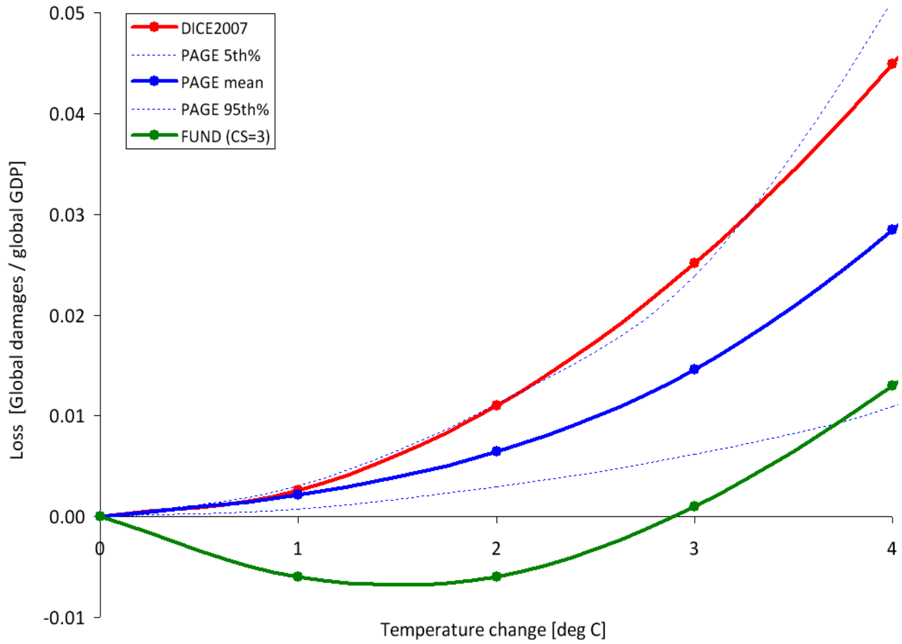
[5] The x-axis represents increases in annual, rather than equilibrium, temperature, while the y-axis represents the annual stream of benefits as a share of global GDP. Each specific combination of climate sensitivity, socio-economic, and emissions parameters will produce a different realization of damages for each IAM. The damage functions represented in Figures 1A and 1B are the outcome of default assumptions. For instance, under alternate assumptions, the damages from FUND may cross from negative to positive at less than or greater than 3 °C.

Figure 1B: Annual Consumption Loss for Lower Temperature Changes in DICE, FUND, and PAGE -



B. Global versus Domestic Measures of SCC

Because of the distinctive nature of the climate change problem, we center our current attention on a global measure of SCC. This approach is the same as that taken for the interim values, but it otherwise represents a departure from past practices, which tended to put greater emphasis on a domestic measure of SCC (limited to impacts of climate change experienced within U.S. borders). As a matter of law, consideration of both global and domestic values is generally permissible; the relevant statutory provisions are usually ambiguous and allow selection of either measure.[6]

Global SCC

Under current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional. However, the climate change problem is highly unusual in at least two respects. First, it involves a global externality: emissions of most greenhouse gases contribute to damages around the world even when they are emitted in the United States. Consequently, to address the global nature of the problem, the SCC must incorporate the full (global) damages caused by GHG emissions. Second, climate change presents a problem that the United States alone cannot solve. Even if the United States were to reduce its greenhouse gas emissions to zero, that step would be far from enough to avoid substantial climate change. Other countries would also need to take action to reduce emissions if

[6] It is true that federal statutes are presumed not to have extraterritorial effect, in part to ensure that the laws of the United States respect the interests of foreign sovereigns. But use of a global measure for the SCC does not give extraterritorial effect to federal law and hence does not intrude on such interests.

significant changes in the global climate are to be avoided. Emphasizing the need for a global solution to a global problem, the United States has been actively involved in seeking international agreements to reduce emissions and in encouraging other nations, including emerging major economies, to take significant steps to reduce emissions. When these considerations are taken as a whole, the interagency group concluded that a global measure of the benefits from reducing U.S. emissions is preferable.

When quantifying the damages associated with a change in emissions, a number of analysts (e.g., Anthoff, et al. 2009a) employ “equity weighting” to aggregate changes in consumption across regions. This weighting takes into account the relative reductions in wealth in different regions of the world. A per-capita loss of $500 in GDP, for instance, is weighted more heavily in a country with a per-capita GDP of $2,000 than in one with a per-capita GDP of $40,000. The main argument for this approach is that a loss of $500 in a poor country causes a greater reduction in utility or welfare than does the same loss in a wealthy nation. Notwithstanding the theoretical claims on behalf of equity weighting, the interagency group concluded that this approach would not be appropriate for estimating a SCC value used in domestic regulatory analysis.[7] For this reason, the group concluded that using the global (rather than domestic) value, without equity weighting, is the appropriate approach.

Domestic SCC

As an empirical matter, the development of a domestic SCC is greatly complicated by the relatively few region- or country-specific estimates of the SCC in the literature. One potential source of estimates comes from the FUND model. The resulting estimates suggest that the ratio of domestic to global benefits of emission reductions varies with key parameter assumptions. For example, with a 2.5 or 3 percent discount rate, the U.S. benefit is about 7-10 percent of the global benefit, on average, across the scenarios analyzed. Alternatively, if the fraction of GDP lost due to climate change is assumed to be similar across countries, the domestic benefit would be proportional to the U.S. share of global GDP, which is currently about 23 percent.[8]

On the basis of this evidence, the interagency workgroup determined that a range of values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic effects. Reported domestic values should use this range. It is recognized that these values are approximate, provisional, and highly speculative. There is no a priori reason why domestic benefits should be a constant fraction of net global damages over time. Further, FUND does not account for how damages in other regions could affect the United States (e.g., global migration, economic and political destabilization). If more accurate methods for calculating the domestic SCC become available, the Federal government will examine these to determine whether to update its approach.

[7] It is plausible that a loss of $X inflicts more serious harm on a poor nation than on a wealthy one, but development of the appropriate "equity weight" is challenging. Emissions reductions also impose costs, and hence a full account would have to consider that a given cost of emissions reductions imposes a greater utility or welfare loss on a poor nation than on a wealthy one. Even if equity weighting—for both the costs and benefits of emissions reductions—is appropriate when considering the utility or welfare effects of international action, the interagency group concluded that it should not be used in developing an SCC for use in regulatory policy at this time.

[8] Based on 2008 GDP (in current US dollars) from the *World Bank Development Indicators Report*.

C. Valuing Non-CO_2 Emissions

While CO_2 is the most prevalent greenhouse gas emitted into the atmosphere, the U.S. included five other greenhouse gases in its recent endangerment finding: methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. The climate impact of these gases is commonly discussed in terms of their 100-year global warming potential (GWP). GWP measures the ability of different gases to trap heat in the atmosphere (i.e., radiative forcing per unit of mass) over a particular timeframe relative to CO_2. However, because these gases differ in both radiative forcing and atmospheric lifetimes, their relative damages are not constant over time. For example, because methane has a short lifetime, its impacts occur primarily in the near term and thus are not discounted as heavily as those caused by longer-lived gases. Impacts other than temperature change also vary across gases in ways that are not captured by GWP. For instance, CO_2 emissions, unlike methane and other greenhouse gases, contribute to ocean acidification. Likewise, damages from methane emissions are not offset by the positive effect of CO_2 fertilization. Thus, transforming gases into CO_2-equivalents using GWP, and then multiplying the carbon-equivalents by the SCC, would not result in accurate estimates of the social costs of non-CO_2 gases.

In light of these limitations, and the significant contributions of non-CO_2 emissions to climate change, further research is required to link non-CO_2 emissions to economic impacts. Such work would feed into efforts to develop a monetized value of reductions in non-CO_2 greenhouse gas emissions. As part of ongoing work to further improve the SCC estimates, the interagency group hopes to develop methods to value these other greenhouse gases. The goal is to develop these estimates by the time we issue revised SCC estimates for carbon dioxide emissions.

D. Equilibrium Climate Sensitivity

Equilibrium climate sensitivity (ECS) is a key input parameter for the DICE, PAGE, and FUND models.[9] It is defined as the long-term increase in the annual global-average surface temperature from a doubling of atmospheric CO_2 concentration relative to pre-industrial levels (or stabilization at a concentration of approximately 550 parts per million (ppm)). Uncertainties in this important parameter have received substantial attention in the peer-reviewed literature.

The most authoritative statement about equilibrium climate sensitivity appears in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC):

> *Basing our assessment on a combination of several independent lines of evidence…including observed climate change and the strength of known feedbacks simulated in [global climate models], we conclude that the global mean equilibrium warming for doubling CO_2, or 'equilibrium climate*

[9] The equilibrium climate sensitivity includes the response of the climate system to increased greenhouse gas concentrations over the short to medium term (up to 100-200 years), but it does not include long-term feedback effects due to possible large-scale changes in ice sheets or the biosphere, which occur on a time scale of many hundreds to thousands of years (e.g. Hansen et al. 2007).

sensitivity', is likely to lie in the range 2 °C to 4.5 °C, with a most likely value of about 3 °C. Equilibrium climate sensitivity is very likely larger than 1.5 °C. [10]

For fundamental physical reasons as well as data limitations, values substantially higher than 4.5 °C still cannot be excluded, but agreement with observations and proxy data is generally worse for those high values than for values in the 2 °C to 4.5 °C range. (Meehl et al., 2007, p 799)

After consulting with several lead authors of this chapter of the IPCC report, the interagency workgroup selected four candidate probability distributions and calibrated them to be consistent with the above statement: Roe and Baker (2007), log-normal, gamma, and Weibull. Table 1 included below gives summary statistics for the four calibrated distributions.

Table 1: Summary Statistics for Four Calibrated Climate Sensitivity Distributions

	Roe & Baker	Log-normal	Gamma	Weibull
Pr(ECS < 1.5°C)	0.013	0.050	0.070	0.102
Pr(2°C < ECS < 4.5°C)	0.667	0.667	0.667	0.667
5th percentile	1.72	1.49	1.37	1.13
10th percentile	1.91	1.74	1.65	1.48
Mode	2.34	2.52	2.65	2.90
Median (50th percentile)	3.00	3.00	3.00	3.00
Mean	3.50	3.28	3.19	3.07
90th percentile	5.86	5.14	4.93	4.69
95th percentile	7.14	5.97	5.59	5.17

Each distribution was calibrated by applying three constraints from the IPCC:

(1) a median equal to 3°C, to reflect the judgment of "a most likely value of about 3 °C";[11]
(2) two-thirds probability that the equilibrium climate sensitivity lies between 2 and 4.5 °C; and
(3) zero probability that it is less than 0°C or greater than 10°C (see Hegerl et al. 2006, p. 721).

We selected the calibrated Roe and Baker distribution from the four candidates for two reasons. First, the Roe and Baker distribution is the only one of the four that is based on a theoretical understanding of the response of the climate system to increased greenhouse gas concentrations (Roe and Baker 2007,

[10] This is in accord with the judgment that it "is likely to lie in the range 2 °C to 4.5 °C" and the IPCC definition of "likely" as greater than 66 percent probability (Le Treut et al.2007). "Very likely" indicates a greater than 90 percent probability.

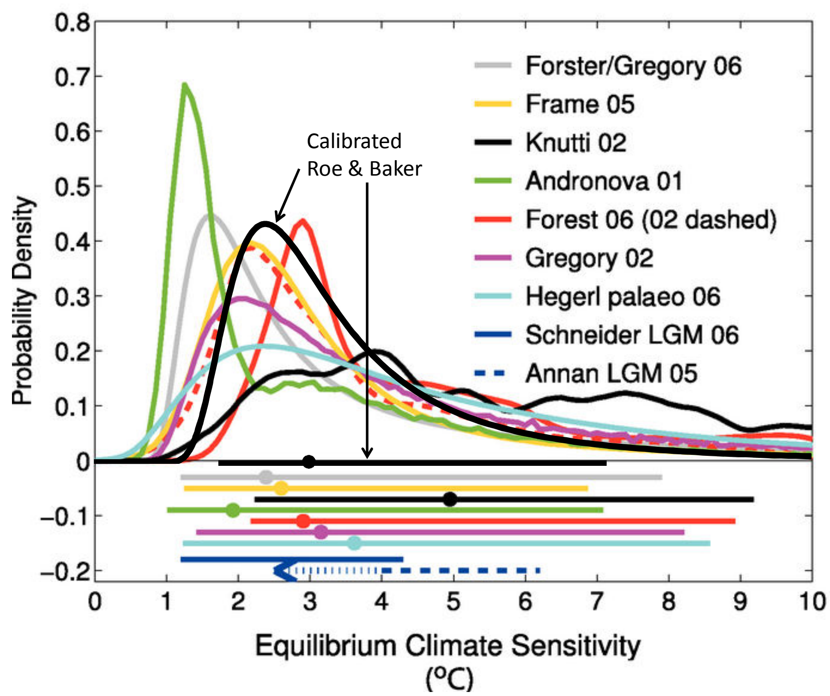
[11] Strictly speaking, "most likely" refers to the mode of a distribution rather than the median, but common usage would allow the mode, median, or mean to serve as candidates for the central or "most likely" value and the IPCC report is not specific on this point. For the distributions we considered, the median was between the mode and the mean. For the Roe and Baker distribution, setting the median equal to 3°C, rather than the mode or mean, gave a 95th percentile that is more consistent with IPCC judgments and the literature. For example, setting the mean and mode equal to 3°C produced 95th percentiles of 5.6 and 8.6 °C, respectively, which are in the lower and upper end of the range in the literature. Finally, the median is closer to 3°C than is the mode for the truncated distributions selected by the IPCC (Hegerl, et al., 2006); the average median is 3.1 °C and the average mode is 2.3 °C, which is most consistent with a Roe and Baker distribution with the median set equal to 3 °C.

Roe 2008). In contrast, the other three distributions are mathematical functions that are arbitrarily chosen based on simplicity, convenience, and general shape. The Roe and Baker distribution results from three assumptions about climate response: (1) absent feedback effects, the equilibrium climate sensitivity is equal to 1.2 °C; (2) feedback factors are proportional to the change in surface temperature; and (3) uncertainties in feedback factors are normally distributed. There is widespread agreement on the first point and the second and third points are common assumptions.

Second, the calibrated Roe and Baker distribution better reflects the IPCC judgment that "values substantially higher than 4.5°C still cannot be excluded." Although the IPCC made no quantitative judgment, the 95th percentile of the calibrated Roe & Baker distribution (7.1 °C) is much closer to the mean and the median (7.2 °C) of the 95th percentiles of 21 previous studies summarized by Newbold and Daigneault (2009). It is also closer to the mean (7.5 °C) and median (7.9 °C) of the nine truncated distributions examined by the IPCC (Hegerl, et al., 2006) than are the 95th percentiles of the three other calibrated distributions (5.2-6.0 °C).

Finally, we note the IPCC judgment that the equilibrium climate sensitivity "is very likely larger than 1.5°C." Although the calibrated Roe & Baker distribution, for which the probability of equilibrium climate sensitivity being greater than 1.5°C is almost 99 percent, is not inconsistent with the IPCC definition of "very likely" as "greater than 90 percent probability," it reflects a greater degree of certainty about very low values of ECS than was expressed by the IPCC.

Figure 2: Estimates of the Probability Density Function for Equilibrium Climate Sensitivity (°C)



To show how the calibrated Roe and Baker distribution compares to different estimates of the probability distribution function of equilibrium climate sensitivity in the empirical literature, Figure 2 (below) overlays it on Figure 9.20 from the IPCC Fourth Assessment Report. These functions are scaled to integrate to unity between 0 °C and 10 °C. The horizontal bars show the respective 5 percent to 95 percent ranges; dots indicate the median estimate.[12]

E. Socio-Economic and Emissions Trajectories

Another key issue considered by the interagency group is how to select the set of socio-economic and emissions parameters for use in PAGE, DICE, and FUND. Socio-economic pathways are closely tied to climate damages because, all else equal, more and wealthier people tend to emit more greenhouse gases and also have a higher (absolute) willingness to pay to avoid climate disruptions. For this reason, we consider how to model several input parameters in tandem: GDP, population, CO_2 emissions, and non-CO_2 radiative forcing. A wide variety of scenarios have been developed and used for climate change policy simulations (e.g., SRES 2000, CCSP 2007, EMF 2009). In determining which scenarios are appropriate for inclusion, we aimed to select scenarios that span most of the plausible ranges of outcomes for these variables.

To accomplish this task in a transparent way, we decided to rely on the recent Stanford Energy Modeling Forum exercise, EMF-22. EMF-22 uses ten well-recognized models to evaluate substantial, coordinated global action to meet specific stabilization targets. A key advantage of relying on these data is that GDP, population, and emission trajectories are internally consistent for each model and scenario evaluated. The EMF-22 modeling effort also is preferable to the IPCC SRES due to their age (SRES were developed in 1997) and the fact that 3 of 4 of the SRES scenarios are now extreme outliers in one or more variables. Although the EMF-22 scenarios have not undergone the same level of scrutiny as the SRES scenarios, they are recent, peer-reviewed, published, and publicly available.

To estimate the SCC for use in evaluating domestic policies that will have a small effect on global cumulative emissions, we use socio-economic and emission trajectories that span a range of plausible scenarios. Five trajectories were selected from EMF-22 (see Table 2 below). Four of these represent potential business-as-usual (BAU) growth in population, wealth, and emissions and are associated with CO_2 (only) concentrations ranging from 612 to 889 ppm in 2100. One represents an emissions pathway that achieves stabilization at 550 ppm CO_2e (i.e., CO_2-only concentrations of 425 – 484 ppm or a radiative forcing of 3.7 W/m^2) in 2100, a lower-than-BAU trajectory.[13] Out of the 10 models included in the EMF-22 exercise, we selected the trajectories used by MiniCAM, MESSAGE, IMAGE, and the optimistic scenario from MERGE. For the BAU pathways, we used the GDP, population, and emission trajectories from each of these four models. For the 550 ppm CO_2e scenario, we averaged the GDP, population, and emission trajectories implied by these same four models.

[12] The estimates based on instrumental data are from Andronova and Schlesinger (2001), Forest et al. (2002; dashed line, anthropogenic forcings only), Forest et al. (2006; solid line, anthropogenic and natural forcings), Gregory et al. (2002a), Knutti et al. (2002), Frame et al. (2005), and Forster and Gregory (2006). Hegerl et al. (2006) are based on multiple palaeoclimatic reconstructions of north hemisphere mean temperatures over the last 700 years. Also shown are the 5-95 percent approximate ranges for two estimates from the last glacial maximum (dashed, Annan et al. 2005; solid, Schneider von Deimling et al. 2006), which are based on models with different structural properties.

[13] Such an emissions path would be consistent with widespread action by countries to mitigate GHG emissions, though it could also result from technological advances. It was chosen because it represents the most stringent case analyzed by the EMF-22 where all the models converge: a 550 ppm, not to exceed, full participation scenario.

Table 2: Socioeconomic and Emissions Projections from Select EMF-22 Reference Scenarios -

Reference Fossil and Industrial CO_2 Emissions ($GtCO_2$/yr) -

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	26.6	31.9	36.9	40.0	45.3	60.1
MERGE Optimistic	24.6	31.5	37.6	45.1	66.5	117.9
MESSAGE	26.8	29.2	37.6	42.1	43.5	42.7
MiniCAM	26.5	31.8	38.0	45.1	57.8	80.5
550 ppm average	26.2	31.1	33.2	32.4	20.0	12.8

Reference GDP (using market exchange rates in trillion 2005$)[14]

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	38.6	53.0	73.5	97.2	156.3	396.6
MERGE Optimistic	36.3	45.9	59.7	76.8	122.7	268.0
MESSAGE	38.1	52.3	69.4	91.4	153.7	334.9
MiniCAM	36.1	47.4	60.8	78.9	125.7	369.5
550 ppm average	37.1	49.6	65.6	85.5	137.4	337.9

Global Population (billions)

EMF – 22 Based Scenarios	2000	2010	2020	2030	2050	2100
IMAGE	6.1	6.9	7.6	8.2	9.0	9.1
MERGE Optimistic	6.0	6.8	7.5	8.2	9.0	9.7
MESSAGE	6.1	6.9	7.7	8.4	9.4	10.4
MiniCAM	6.0	6.8	7.5	8.1	8.8	8.7
550 ppm average	6.1	6.8	7.6	8.2	8.7	9.1

We explore how sensitive the SCC is to various assumptions about how the future will evolve without prejudging what is likely to occur. The interagency group considered formally assigning probability weights to different states of the world, but this proved challenging to do in an analytically rigorous way given the dearth of information on the likelihood of a full range of future socio-economic pathways.

There are a number of caveats. First, EMF BAU scenarios represent the modelers' judgment of the most likely pathway absent mitigation policies to reduce greenhouse gas emissions, rather than the wider range of possible outcomes. Nevertheless, these views of the most likely outcome span a wide range,

[14] While the EMF-22 models used market exchange rates (MER) to calculate global GDP, it is also possible to use purchasing power parity (PPP). PPP takes into account the different price levels across countries, so it more accurately describes relative standards of living across countries. MERs tend to make low-income countries appear poorer than they actually are. Because many models assume convergence in per capita income over time, use of MER-adjusted GDP gives rise to projections of higher economic growth in low income countries. There is an ongoing debate about how much this will affect estimated climate impacts. Critics of the use of MER argue that it leads to overstated economic growth and hence a significant upward bias in projections of greenhouse gas emissions, and unrealistically high future temperatures (e.g., Castles and Henderson 2003). Others argue that convergence of the emissions-intensity gap across countries at least partially offset the overstated income gap so that differences in exchange rates have less of an effect on emissions (Holtsmark and Alfsen, 2005; Tol, 2006). Nordhaus (2007b) argues that the ideal approach is to use superlative PPP accounts (i.e., using cross-sectional PPP measures for relative incomes and outputs and national accounts price and quantity indexes for time-series extrapolations). However, he notes that it important to keep this debate in perspective; it is by no means clear that exchange-rate-conversion issues are as important as uncertainties about population, technological change, or the many geophysical uncertainties.

from the more optimistic (e.g. abundant low-cost, low-carbon energy) to more pessimistic (e.g. constraints on the availability of nuclear and renewables).[15] Second, the socio-economic trajectories associated with a 550 ppm CO_2e concentration scenario are not derived from an assessment of what policy is optimal from a benefit-cost standpoint. Rather, it is indicative of one possible future outcome. The emission trajectories underlying some BAU scenarios (e.g. MESSAGE's 612 ppm) also are consistent with some modest policy action to address climate change.[16] We chose not to include socio-economic trajectories that achieve even lower GHG concentrations at this time, given the difficulty many models had in converging to meet these targets.

For comparison purposes, the Energy Information Agency in its 2009 Annual Energy Outlook projected that global carbon dioxide emissions will grow to 30.8, 35.6, and 40.4 gigatons in 2010, 2020, and 2030, respectively, while world GDP is projected to be $51.8, $71.0 and $93.9 trillion (in 2005 dollars using market exchange rates) in 2010, 2020, and 2030, respectively. These projections are consistent with one or more EMF-22 scenarios. Likewise, the United Nations' 2008 Population Prospect projects population will grow from 6.1 billion people in 2000 to 9.1 billion people in 2050, which is close to the population trajectories for the IMAGE, MiniCAM, and MERGE models.

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane, nitrous oxide, fluorinated greenhouse gases, and net land use CO_2 emissions out to 2100. These assumptions also are used in the three models while retaining the default radiative forcings due to other factors (e.g. aerosols and other gases). See the Appendix for greater detail.

F. Discount Rate

The choice of a discount rate, especially over long periods of time, raises highly contested and exceedingly difficult questions of science, economics, philosophy, and law. Although it is well understood that the discount rate has a large influence on the current value of future damages, there is no consensus about what rates to use in this context. Because carbon dioxide emissions are long-lived, subsequent damages occur over many years. In calculating the SCC, we first estimate the future damages to agriculture, human health, and other market and non-market sectors from an additional unit of carbon dioxide emitted in a particular year in terms of reduced consumption (or consumption equivalents) due to the impacts of elevated temperatures, as represented in each of the three IAMs. Then we discount the stream of future damages to its present value in the year when the additional unit of emissions was released using the selected discount rate, which is intended to reflect society's marginal rate of substitution between consumption in different time periods.

For rules with both intra- and intergenerational effects, agencies traditionally employ constant discount rates of both 3 percent and 7 percent in accordance with OMB Circular A-4. As Circular A-4 acknowledges, however, the choice of discount rate for intergenerational problems raises distinctive

[15] For instance, in the MESSAGE model's reference case total primary energy production from nuclear, biomass, and non-biomass renewables is projected to increase from about 15 percent of total primary energy in 2000 to 54 percent in 2100. In comparison, the MiniCAM reference case shows 10 percent in 2000 and 21 percent in 2100.

[16] For example, MiniCAM projects if all non-US OECD countries reduce CO_2 emissions to 83 percent below 2005 levels by 2050 (per the G-8 agreement) but all other countries continue along a BAU path CO_2 concentrations in 2100 would drop from 794 ppmv in its reference case to 762 ppmv.

problems and presents considerable challenges. After reviewing those challenges, Circular A-4 states, "If your rule will have important intergenerational benefits or costs you might consider a further sensitivity analysis using a lower but positive discount rate in addition to calculating net benefits using discount rates of 3 and 7 percent." For the specific purpose of developing the SCC, we adapt and revise that approach here.

Arrow et al. (1996) outlined two main approaches to determine the discount rate for climate change analysis, which they labeled "descriptive" and "prescriptive." The descriptive approach reflects a positive (non-normative) perspective based on observations of people's actual choices—e.g., savings versus consumption decisions over time, and allocations of savings among more and less risky investments. Advocates of this approach generally call for inferring the discount rate from market rates of return "because of a lack of justification for choosing a social welfare function that is any different than what decision makers [individuals] actually use" (Arrow et al. 1996).

One theoretical foundation for the cost-benefit analyses in which the social cost of carbon will be used—the Kaldor-Hicks potential-compensation test—also suggests that market rates should be used to discount future benefits and costs, because it is the market interest rate that would govern the returns potentially set aside today to compensate future individuals for climate damages that they bear (e.g., Just et al. 2004). As some have noted, the word "potentially" is an important qualification; there is no assurance that such returns will actually be set aside to provide compensation, and the very idea of compensation is difficult to define in the intergenerational context. On the other hand, societies provide compensation to future generations through investments in human capital and the resulting increase in knowledge, as well as infrastructure and other physical capital.

The prescriptive approach specifies a social welfare function that formalizes the normative judgments that the decision-maker wants explicitly to incorporate into the policy evaluation—e.g., how inter-personal comparisons of utility should be made, and how the welfare of future generations should be weighed against that of the present generation. Ramsey (1928), for example, has argued that it is "ethically indefensible" to apply a positive pure rate of time preference to discount values across generations, and many agree with this view.

Other concerns also motivate making adjustments to descriptive discount rates. In particular, it has been noted that the preferences of future generations with regard to consumption versus environmental amenities may not be the same as those today, making the current market rate on consumption an inappropriate metric by which to discount future climate-related damages. Others argue that the discount rate should be below market rates to correct for market distortions and uncertainties or inefficiencies in intergenerational transfers of wealth, which in the Kaldor-Hicks logic are presumed to compensate future generations for damage (a potentially controversial assumption, as noted above) (Arrow et al. 1996, Weitzman 1999).

Further, a legitimate concern about both descriptive and prescriptive approaches is that they tend to obscure important heterogeneity in the population. The utility function that underlies the prescriptive approach assumes a representative agent with perfect foresight and no credit constraints. This is an artificial rendering of the real world that misses many of the frictions that characterize individuals' lives and indeed the available descriptive evidence supports this. For instance, many individuals smooth consumption by borrowing with credit cards that have relatively high rates. Some are unable to access traditional credit markets and rely on payday lending operations or other high cost forms of smoothing consumption. Whether one puts greater weight on the prescriptive or descriptive approach, the high interest rates that credit-constrained individuals accept suggest that some account should be given to the discount rates revealed by their behavior.

We draw on both approaches but rely primarily on the descriptive approach to inform the choice of discount rate. With recognition of its limitations, we find this approach to be the most defensible and transparent given its consistency with the standard contemporary theoretical foundations of benefit-cost analysis and with the approach required by OMB's existing guidance. The logic of this framework also suggests that market rates should be used for discounting future consumption-equivalent damages. Regardless of the theoretical approach used to derive the appropriate discount rate(s), we note the inherent conceptual and practical difficulties of adequately capturing consumption trade-offs over many decades or even centuries. While relying primarily on the descriptive approach in selecting specific discount rates, the interagency group has been keenly aware of the deeply normative dimensions of both the debate over discounting in the intergenerational context and the consequences of selecting one discount rate over another.

Historically Observed Interest Rates

In a market with no distortions, the return to savings would equal the private return on investment, and the market rate of interest would be the appropriate choice for the social discount rate. In the real world risk, taxes, and other market imperfections drive a wedge between the risk-free rate of return on capital and the consumption rate of interest. Thus, the literature recognizes two conceptual discount concepts—the consumption rate of interest and the opportunity cost of capital.

According to OMB's Circular A-4, it is appropriate to use the rate of return on capital when a regulation is expected to displace or alter the use of capital in the private sector. In this case, OMB recommends Agencies use a discount rate of 7 percent. When regulation is expected to primarily affect private consumption—for instance, via higher prices for goods and services—a lower discount rate of 3 percent is appropriate to reflect how private individuals trade-off current and future consumption.

The interagency group examined the economics literature and concluded that the consumption rate of interest is the correct concept to use in evaluating the benefits and costs of a marginal change in carbon emissions (see Lind 1990, Arrow et al 1996, and Arrow 2000). The consumption rate of interest also is appropriate when the impacts of a regulation are measured in consumption (-equivalent) units, as is done in the three integrated assessment models used for estimating the SCC.

Individuals use a variety of savings instruments that vary with risk level, time horizon, and tax characteristics. The standard analytic framework used to develop intuition about the discount rate typically assumes a representative agent with perfect foresight and no credit constraints. The risk-free rate is appropriate for discounting certain future benefits or costs, but the benefits calculated by IAMs are uncertain. To use the risk-free rate to discount uncertain benefits, these benefits first must be transformed into "certainty equivalents," that is the maximum certain amount that we would exchange for the uncertain amount. However, the calculation of the certainty-equivalent requires first estimating the correlation between the benefits of the policy and baseline consumption.

If the IAM projections of future impacts represent expected values (not certainty-equivalent values), then the appropriate discount rate generally does not equal the risk-free rate. If the benefits of the policy tend to be high in those states of the world in which consumption is low, then the certainty-equivalent benefits will be higher than the expected benefits (and vice versa). Since many (though not necessarily all) of the important impacts of climate change will flow through market sectors such as agriculture and energy, and since willingness to pay for environmental protections typically increases with income, we might expect a positive (though not necessarily perfect) correlation between the net benefits from climate policies and market returns. This line of reasoning suggests that the proper discount rate would exceed the riskless rate. Alternatively, a negative correlation between the returns to climate policies and market returns would imply that a discount rate below the riskless rate is appropriate.

This discussion suggests that both the post-tax riskless and risky rates can be used to capture individuals' consumption-equivalent interest rate. As a measure of the post-tax riskless rate, we calculate the average real return from Treasury notes over the longest time period available (those from Newell and Pizer 2003) and adjust for Federal taxes (the average marginal rate from tax years 2003 through 2006 is around 27 percent).[17] This calculation produces a real interest rate of about 2.7 percent, which is roughly consistent with Circular A-4's recommendation to use 3 percent to represent the consumption rate of interest.[18] A measure of the post-tax risky rate for investments whose returns are positively correlated with overall equity market returns can be obtained by adjusting pre-tax rates of household returns to risky investments (approximately 7 percent) for taxes yields a real rate of roughly 5 percent.[19]

The Ramsey Equation

Ramsey discounting also provides a useful framework to inform the choice of a discount rate. Under this approach, the analyst applies either positive or normative judgments in selecting values for the key parameters of the Ramsey equation: η (coefficient of relative risk aversion or elasticity of the marginal utility of consumption) and ρ (pure rate of time preference).[20] These are then combined with g (growth

[17] The literature argues for a risk-free rate on government bonds as an appropriate measure of the consumption rate of interest. Arrow (2000) suggests that it is roughly 3-4 percent. OMB cites evidence of a 3.1 percent pre-tax rate for 10-year Treasury notes in the A-4 guidance. Newell and Pizer (2003) find real interest rates between 3.5 and 4 percent for 30-year Treasury securities.

[18] The positive approach reflects how individuals make allocation choices across time, but it is important to keep in mind that we wish to reflect preferences for society as a whole, which generally has a longer planning horizon.

[19] Cambell et al (2001) estimates that the annual real return from stocks for 1900-1995 was about 7 percent. The annual real rate of return for the S&P 500 from 1950 – 2008 was about 6.8 percent. In the absence of a better way to population-weight the tax rates, we use the middle of the 20 – 40 percent range to derive a post-tax interest rate (Kotlikoff and Rapson 2006).

[20] The parameter ρ measures the *pure rate of time preference*: people's behavior reveals a preference for an increase in utility today versus the future. Consequently, it is standard to place a lower weight on utility in the future. The parameter η captures *diminishing marginal utility*: consumption in the future is likely to be higher than consumption today, so diminishing marginal utility of consumption implies that the same monetary damage will

rate of per-capita consumption) to equal the interest rate at which future monetized damages are discounted: $\rho + \eta \cdot g$.[21] In the simplest version of the Ramsey model, with an optimizing representative agent with perfect foresight, what we are calling the "Ramsey discount rate," $\rho + \eta \cdot g$, will be equal to the rate of return to capital, i.e., the market interest rate.

A review of the literature provides some guidance on reasonable parameter values for the Ramsey discounting equation, based on both prescriptive and descriptive approaches.

- η. Most papers in the climate change literature adopt values for η in the range of 0.5 to 3 (Weitzman cites plausible values as those ranging from 1 to 4), although not all authors articulate whether their choice is based on prescriptive or descriptive reasoning.[22] Dasgupta (2008) argues that η should be greater than 1 and may be as high as 3, since η equal to 1 suggests savings rates that do not conform to observed behavior.

- ρ. With respect to the pure rate of time preference, most papers in the climate change literature adopt values for ρ in the range of 0 to 3 percent per year. The very low rates tend to follow from moral judgments involving intergenerational neutrality. Some have argued that to use any value other than $\rho = 0$ would unjustly discriminate against future generations (e.g., Arrow et al. 1996, Stern et al. 2006). However, even in an inter-generational setting, it may make sense to use a small positive pure rate of time preference because of the small probability of unforeseen cataclysmic events (Stern et al. 2006).

- g. A commonly accepted approximation is around 2 percent per year. For the socio-economic scenarios used for this exercise, the EMF models assume that g is about 1.5-2 percent to 2100.

Some economists and non-economists have argued for constant discount rates below 2 percent based on the prescriptive approach. When grounded in the Ramsey framework, proponents of this approach have argued that a ρ of zero avoids giving preferential treatment to one generation over another. The choice of η has also been posed as an ethical choice linked to the value of an additional dollar in poorer

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cause a smaller reduction of utility for wealthier individuals, either in the future or in current generations. If $\eta = 0$, then a one dollar increase in income is equally valuable regardless of level of income; if $\eta = 1$, then a one percent increase in income is equally valuable no matter the level of income; and if $\eta > 1$, then a one percent increase in income is less valuable to wealthier individuals.

[21] In this case, g could be taken from the selected EMF socioeconomic scenarios or alternative assumptions about the rate of consumption growth.

[22] Empirical estimates of η span a wide range of values. A benchmark value of 2 is near the middle of the range of values estimated or used by Szpiro (1986), Hall and Jones (2007), Arrow (2007), Dasgupta (2006, 2008), Weitzman (2007, 2009), and Nordhaus (2008). However, Chetty (2006) developed a method of estimating η using data on labor supply behavior. He shows that existing evidence of the effects of wage changes on labor supply imposes a tight upper bound on the curvature of utility over wealth (CRRA < 2) with the mean implied value of 0.71 and concludes that the standard expected utility model cannot generate high levels of risk aversion without contradicting established facts about labor supply. Recent work has jointly estimated the components of the Ramsey equation. Evans and Sezer (2005) estimate $\eta = 1.49$ for 22 OECD countries. They also estimate $\rho = 1.08$ percent per year using data on mortality rates. Anthoff, et al. (2009b) estimate $\eta = 1.18$, and $\rho = 1.4$ percent. When they multiply the bivariate probability distributions from their work and Evans and Sezer (2005) together, they find $\eta = 1.47$, and $\rho = 1.07$.

countries compared to wealthier ones. Stern et al. (2006) applies this perspective through his choice of ρ = 0.1 percent per year, η = 1 and g = 1.3 percent per year, which yields an annual discount rate of 1.4 percent. In the context of permanent income savings behavior, however, Stern's assumptions suggest that individuals would save 93 percent of their income.[23]

Recently, Stern (2008) revisited the values used in Stern et al. (2006), stating that there is a case to be made for raising η due to the amount of weight lower values place on damages far in the future (over 90 percent of expected damages occur after 2200 with η = 1). Using Stern's assumption that ρ = 0.1 percent, combined with a η of 1.5 to 2 and his original growth rate, yields a discount rate greater 2 percent.

We conclude that arguments made under the prescriptive approach can be used to justify discount rates between roughly 1.4 and 3.1 percent. In light of concerns about the most appropriate value for η, we find it difficult to justify rates at the lower end of this range under the Ramsey framework.

Accounting for Uncertainty in the Discount Rate

While the consumption rate of interest is an important driver of the benefits estimate, it is uncertain over time. Ideally, we would formally model this uncertainty, just as we do for climate sensitivity. Weitzman (1998, 2001) showed theoretically and Newell and Pizer (2003) and Groom et al. (2006) confirm empirically that discount rate uncertainty can have a large effect on net present values. A main result from these studies is that if there is a persistent element to the uncertainty in the discount rate (e.g., the rate follows a random walk), then it will result in an effective (or certainty-equivalent) discount rate that declines over time. Consequently, lower discount rates tend to dominate over the very long term (see Weitzman 1998, 1999, 2001; Newell and Pizer 2003; Groom et al. 2006; Gollier 2008; Summers and Zeckhauser 2008; and Gollier and Weitzman 2009).

The proper way to model discount rate uncertainty remains an active area of research. Newell and Pizer (2003) employ a model of how long-term interest rates change over time to forecast future discount rates. Their model incorporates some of the basic features of how interest rates move over time, and its parameters are estimated based on historical observations of long-term rates. Subsequent work on this topic, most notably Groom et al. (2006), uses more general models of interest rate dynamics to allow for better forecasts. Specifically, the volatility of interest rates depends on whether rates are currently low or high and variation in the level of persistence over time.

While Newell and Pizer (2003) and Groom et al (2006) attempt formally to model uncertainty in the discount rate, others argue for a declining scale of discount rates applied over time (e.g., Weitzman 2001, and the UK's "Green Book" for regulatory analysis). This approach uses a higher discount rate

[23] Stern (2008) argues that building in a positive rate of exogenous technical change over time reduces the implied savings rate and that η at or above 2 are inconsistent with observed behavior with regard to equity. (At the same time, adding exogenous technical change—all else equal—would increase g as well.)

initially, but applies a graduated scale of lower discount rates further out in time.[24] A key question that has emerged with regard to both of these approaches is the trade-off between potential time inconsistency and giving greater weight to far future outcomes (see the EPA Science Advisory Board's recent comments on this topic as part of its review of their *Guidelines for Economic Analysis*).[25]

The Discount Rates Selected for Estimating SCC

In light of disagreement in the literature on the appropriate market interest rate to use in this context and uncertainty about how interest rates may change over time, we use three discount rates to span a plausible range of certainty-equivalent constant discount rates: 2.5, 3, and 5 percent per year. Based on the review in the previous sections, the interagency workgroup determined that these three rates reflect reasonable judgments under both descriptive and prescriptive approaches.

The central value, 3 percent, is consistent with estimates provided in the economics literature and OMB's Circular A-4 guidance for the consumption rate of interest. As previously mentioned, the consumption rate of interest is the correct discounting concept to use when future damages from elevated temperatures are estimated in consumption-equivalent units. Further, 3 percent roughly corresponds to the after-tax riskless interest rate. The upper value of 5 percent is included to represent the possibility that climate damages are positively correlated with market returns. Additionally, this discount rate may be justified by the high interest rates that many consumers use to smooth consumption across periods.

The low value, 2.5 percent, is included to incorporate the concern that interest rates are highly uncertain over time. It represents the average certainty-equivalent rate using the mean-reverting and random walk approaches from Newell and Pizer (2003) starting at a discount rate of 3 percent. Using this approach, the certainty equivalent is about 2.2 percent using the random walk model and 2.8 percent using the mean reverting approach.[26] Without giving preference to a particular model, the average of the two rates is 2.5 percent. Further, a rate below the riskless rate would be justified if climate investments are negatively correlated with the overall market rate of return. Use of this lower value also responds to certain judgments using the prescriptive or normative approach and to ethical objections that have been raised about rates of 3 percent or higher.

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[24] For instance, the UK applies a discount rate of 3.5 percent to the first 30 years; 3 percent for years 31 - 75; 2.5 percent for years 76 - 125; 2 percent for years 126 - 200; 1.5 percent for years 201 - 300; and 1 percent after 300 years. As a sensitivity, it recommends a discount rate of 3 percent for the first 30 years, also decreasing over time.

[25] Uncertainty in future damages is distinct from uncertainty in the discount rate. Weitzman (2008) argues that Stern's choice of a low discount rate was "right for the wrong reasons." He demonstrates how the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. Newbold and Daigneault, (2009) and Nordhaus (2009) find that Weitzman's result is sensitive to the functional forms chosen for climate sensitivity, utility, and consumption. Summers and Zeckhauser (2008) argue that uncertainty in future damages can also work in the other direction by increasing the benefits of waiting to learn the appropriate level of mitigation required.

[26] Calculations done by Pizer et al. using the original simulation program from Newell and Pizer (2003).

IV. Revised SCC Estimates

Our general approach to estimating SCC values is to run the three integrated assessment models (FUND, DICE, and PAGE) using the following inputs agreed upon by the interagency group:

- A Roe and Baker distribution for the climate sensitivity parameter bounded between 0 and 10 with a median of 3 °C and a cumulative probability between 2 and 4.5 °C of two-thirds.
- Five sets of GDP, population and carbon emissions trajectories based on EMF-22.
- Constant annual discount rates of 2.5, 3, and 5 percent.

Because the climate sensitivity parameter is modeled probabilistically, and because PAGE and FUND incorporate uncertainty in other model parameters, the final output from each model run is a distribution over the SCC in year *t*.

For each of the IAMS, the basic computational steps for calculating the SCC in a particular year *t* are:

1. Input the path of emissions, GDP, and population from the selected EMF-22 scenarios, and the extrapolations based on these scenarios for post-2100 years.

2. Calculate the temperature effects and (consumption-equivalent) damages in each year resulting from the baseline path of emissions.

    a. In PAGE, the consumption-equivalent damages in each period are calculated as a fraction of the EMF GDP forecast, depending on the temperature in that period relative to the pre-industrial average temperature in each region.
    b. In FUND, damages in each period depend on both the level and the rate of temperature change in that period.
    c. In DICE, temperature affects both consumption and investment, so we first adjust the EMF GDP paths as follows: Using the Cobb-Douglas production function with the DICE2007 parameters, we extract the path of exogenous technical change implied by the EMF GDP and population paths, then we recalculate the baseline GDP path taking into account climate damages resulting from the baseline emissions path.

3. Add an additional unit of carbon emissions in year *t.* (The exact unit varies by model.)

4. Recalculate the temperature effects and damages expected in all years beyond *t* resulting from this adjusted path of emissions, as in step 2.

5. Subtract the damages computed in step 2 from those in step 4 in each year. (DICE is run in 10 year time steps, FUND in annual time steps, while the time steps in PAGE vary.)

6. Discount the resulting path of marginal damages back to the year of emissions using the agreed upon fixed discount rates.

7. Calculate the SCC as the net present value of the discounted path of damages computed in step 6, divided by the unit of carbon emissions used to shock the models in step 3.

8. Multiply by 12/44 to convert from dollars per ton of carbon to dollars per ton of CO_2 (2007 dollars) in DICE and FUND. (All calculations are done in tons of CO_2 in PAGE).

The steps above were repeated in each model for multiple future years to cover the time horizons anticipated for upcoming rulemaking analysis. To maintain consistency across the three IAMs, climate damages are calculated as lost consumption in each future year.

It is important to note that each of the three models has a different default end year. The default time horizon is 2200 for PAGE, 2595 for DICE, and 3000 for the latest version of FUND. This is an issue for the multi-model approach because differences in SCC estimates may arise simply due to the model time horizon. Many consider 2200 too short a time horizon because it could miss a significant fraction of damages under certain assumptions about the growth of marginal damages and discounting, so each model is run here through 2300. This step required a small adjustment in the PAGE model only. This step also required assumptions about GDP, population, and greenhouse gas emission trajectories after 2100, the last year for which these data are available from the EMF-22 models. (A more detailed discussion of these assumptions is included in the Appendix.)

This exercise produces 45 separate distributions of the SCC for a given year, the product of 3 models, 3 discount rates, and 5 socioeconomic scenarios. This is clearly too many separate distributions for consideration in a regulatory impact analysis.

To produce a range of plausible estimates that still reflects the uncertainty in the estimation exercise, the distributions from each of the models and scenarios are equally weighed and combined to produce three separate probability distributions for SCC in a given year, one for each assumed discount rate. These distributions are then used to define a range of point estimates for the global SCC. In this way, no integrated assessment model or socioeconomic scenario is given greater weight than another. Because the literature shows that the SCC is quite sensitive to assumptions about the discount rate, and because no consensus exists on the appropriate rate to use in an intergenerational context, we present SCCs based on the average values across models and socioeconomic scenarios for each discount rate.

The interagency group selected four SCC values for use in regulatory analyses. Three values are based on the average SCC across models and socio-economic and emissions scenarios at the 2.5, 3, and 5 percent discount rates. The fourth value is included to represent the higher-than-expected economic impacts from climate change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. (The full set of distributions by model and scenario combination is included in the Appendix.) As noted above, the 3 percent discount rate is the central value, and so the central value that emerges is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range.

As previously discussed, low probability, high impact events are incorporated into the SCC values through explicit consideration of their effects in two of the three models as well as the use of a probability density function for equilibrium climate sensitivity. Treating climate sensitivity probabilistically results in more high temperature outcomes, which in turn lead to higher projections of damages. Although FUND does not include catastrophic damages (in contrast to the other two models), its probabilistic treatment of the equilibrium climate sensitivity parameter will directly affect the non-catastrophic damages that are a function of the rate of temperature change.

In Table 3, we begin by presenting SCC estimates for 2010 by model, scenario, and discount rate to illustrate the variability in the SCC across each of these input parameters. As expected, higher discount rates consistently result in lower SCC values, while lower discount rates result in higher SCC values for each socioeconomic trajectory. It is also evident that there are differences in the SCC estimated across the three main models. For these estimates, FUND produces the lowest estimates, while PAGE generally produces the highest estimates.

Table 3: Disaggregated Social Cost of CO_2 Values by Model, Socio-Economic Trajectory, and Discount Rate for 2010 (in 2007 dollars)

	Discount rate:	**5%**	**3%**	**2.5%**	**3%**
Model	*Scenario*	Avg	Avg	Avg	95th
DICE	IMAGE	10.8	35.8	54.2	70.8
	MERGE	7.5	22.0	31.6	42.1
	Message	9.8	29.8	43.5	58.6
	MiniCAM	8.6	28.8	44.4	57.9
	550 Average	8.2	24.9	37.4	50.8
PAGE	IMAGE	8.3	39.5	65.5	142.4
	MERGE	5.2	22.3	34.6	82.4
	Message	7.2	30.3	49.2	115.6
	MiniCAM	6.4	31.8	54.7	115.4
	550 Average	5.5	25.4	42.9	104.7
FUND	IMAGE	-1.3	8.2	19.3	39.7
	MERGE	-0.3	8.0	14.8	41.3
	Message	-1.9	3.6	8.8	32.1
	MiniCAM	-0.6	10.2	22.2	42.6
	550 Average	-2.7	-0.2	3.0	19.4

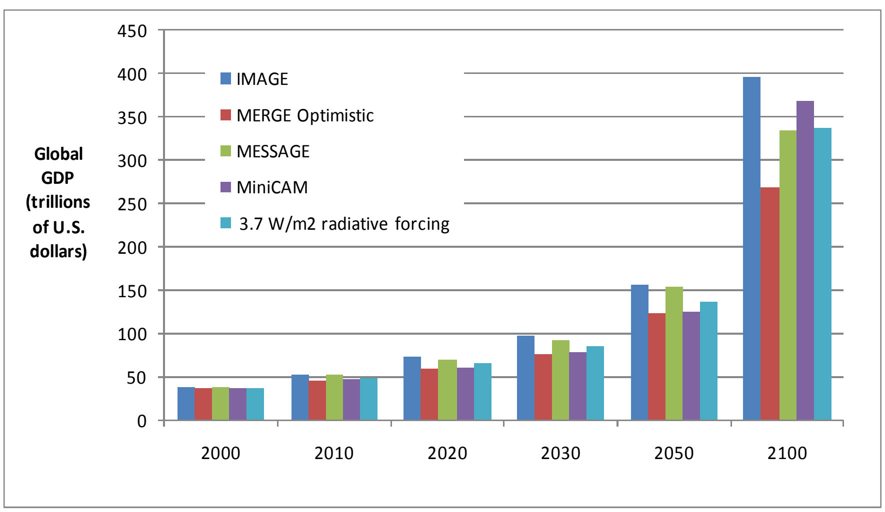
These results are not surprising when compared to the estimates in the literature for the latest versions of each model. For example, adjusting the values from the literature that were used to develop interim

SCC values to 2007 dollars for the year 2010 (assuming, as we did for the interim process, that SCC grows at 3 percent per year), FUND yields SCC estimates at or near zero for a 5 percent discount rate and around $9 per ton for a 3 percent discount rate. There are far fewer estimates using the latest versions of DICE and PAGE in the literature: Using similar adjustments to generate 2010 estimates, we calculate a SCC from DICE (based on Nordhaus 2008) of around $9 per ton for a 5 percent discount rate, and a SCC from PAGE (based on Hope 2006, 2008) close to $8 per ton for a 4 percent discount rate. Note that these comparisons are only approximate since the literature generally relies on Ramsey discounting, while we have assumed constant discount rates.[27]

The SCC estimates from FUND are sensitive to differences in emissions paths but relatively insensitive to differences in GDP paths across scenarios, while the reverse is true for DICE and PAGE. This likely occurs because of several structural differences among the models. Specifically in DICE and PAGE, the fraction of economic output lost due to climate damages increases with the level of temperature alone, whereas in FUND the fractional loss also increases with the rate of temperature change. Furthermore, in FUND increases in income over time decrease vulnerability to climate change (a form of adaptation), whereas this does not occur in DICE and PAGE. These structural differences among the models make FUND more sensitive to the path of emissions and less sensitive to GDP compared to DICE and PAGE.

Figure 3 shows that IMAGE has the highest GDP in 2100 while MERGE Optimistic has the lowest. The ordering of global GDP levels in 2100 directly corresponds to the rank ordering of SCC for PAGE and DICE. For FUND, the correspondence is less clear, a result that is to be expected given its less direct relationship between its damage function and GDP.

Figure 3: Level of Global GDP across EMF Scenarios



[27] Nordhaus (2008) runs DICE2007 with ρ = 1.5 and η = 2. The default approach in PAGE2002 (version 1.4epm) treats ρ and η as random parameters, specified using a triangular distribution such that the min, mode, and max = 0.1, 1, and 2 for ρ, and 0.5, 1, and 2 for η, respectively. The FUND default value for η is 1, and Tol generates SCC estimates for values of ρ = 0, 1, and 3 in many recent papers (e.g. Anthoff et al. 2009). The path of per-capita consumption growth, g, varies over time but is treated deterministically in two of the three models. In DICE, g is endogenous. Under Ramsey discounting, as economic growth slows in the future, the large damages from climate change that occur far out in the future are discounted at a lower rate than impacts that occur in the nearer term.

Table 4 shows the four selected SCC values in five year increments from 2010 to 2050. Values for 2010, 2020, 2040, and 2050 are calculated by first combining all outputs (10,000 estimates per model run) from all scenarios and models for a given discount rate. Values for the years in between are calculated using a simple linear interpolation.

Table 4: Social Cost of CO_2, 2010 – 2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2015	5.7	23.8	38.4	72.8
2020	6.8	26.3	41.7	80.7
2025	8.2	29.6	45.9	90.4
2030	9.7	32.8	50.0	100.0
2035	11.2	36.0	54.2	109.7
2040	12.7	39.2	58.4	119.3
2045	14.2	42.1	61.7	127.8
2050	15.7	44.9	65.0	136.2

The SCC increases over time because future emissions are expected to produce larger incremental damages as physical and economic systems become more stressed in response to greater climatic change. Note that this approach allows us to estimate the growth rate of the SCC directly using DICE, PAGE, and FUND rather than assuming a constant annual growth rate as was done for the interim estimates (using 3 percent). This helps to ensure that the estimates are internally consistent with other modeling assumptions. Table 5 illustrates how the growth rate for these four SCC estimates varies over time. The full set of annual SCC estimates between 2010 and 2050 is reported in the Appendix.

Table 5: Changes in the Average Annual Growth Rates of SCC Estimates between 2010 and 2050

Average Annual Growth Rate (%)	**5%** Avg	**3%** Avg	**2.5%** Avg	**3.0%** 95th
2010-2020	3.6%	2.1%	1.7%	2.2%
2020-2030	3.7%	2.2%	1.8%	2.2%
2030-2040	2.7%	1.8%	1.6%	1.8%
2040-2050	2.1%	1.4%	1.1%	1.3%

While the SCC estimate grows over time, the future monetized value of emissions reductions in each year (the SCC in year *t* multiplied by the change in emissions in year *t*) must be discounted to the present to determine its total net present value for use in regulatory analysis. Damages from future emissions should be discounted at the same rate as that used to calculate the SCC estimates themselves to ensure internal consistency—i.e., future damages from climate change, whether they result from emissions today or emissions in a later year, should be discounted using the same rate. For example, climate damages in the year 2020 that are calculated using a SCC based on a 5 percent discount rate also should be discounted back to the analysis year using a 5 percent discount rate.[28]

V. Limitations of the Analysis

As noted, any estimate of the SCC must be taken as provisional and subject to further refinement (and possibly significant change) in accordance with evolving scientific, economic, and ethical understandings. During the course of our modeling, it became apparent that there are several areas in particular need of additional exploration and research. These caveats, and additional observations in the following section, are necessary to consider when interpreting and applying the SCC estimates.

Incomplete treatment of non-catastrophic damages. The impacts of climate change are expected to be widespread, diverse, and heterogeneous. In addition, the exact magnitude of these impacts is uncertain because of the inherent complexity of climate processes, the economic behavior of current and future populations, and our inability to accurately forecast technological change and adaptation. Current IAMs do not assign value to all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature (some of which are discussed above) because of lack of precise information on the nature of damages and because the science incorporated into these models understandably lags behind the most recent research. Our ability to quantify and monetize impacts will undoubtedly improve with time. But it is also likely that even in future applications, a number of potentially significant damage categories will remain non-monetized. (Ocean acidification is one example of a potentially large damage from CO_2 emissions not quantified by any of the three models. Species and wildlife loss is another example that is exceedingly difficult to monetize.)

Incomplete treatment of potential catastrophic damages. There has been considerable recent discussion of the risk of catastrophic impacts and how best to account for extreme scenarios, such as the collapse of the Atlantic Meridional Overturning Circulation or the West Antarctic Ice Sheet, or large releases of methane from melting permafrost and warming oceans. Weitzman (2009) suggests that catastrophic damages are extremely large—so large, in fact, that the damages from a low probability, catastrophic event far in the future dominate the effect of the discount rate in a present value calculation and result in an infinite willingness-to-pay for mitigation today. However, Nordhaus (2009) concluded that the conditions under which Weitzman's results hold “are limited and do not apply to a wide range of potential uncertain scenarios."

Using a simplified IAM, Newbold and Daigneault (2009) confirmed the potential for large catastrophe risk premiums but also showed that the aggregate benefit estimates can be highly sensitive to the shapes of both the climate sensitivity distribution and the damage function at high temperature changes. Pindyck (2009) also used a simplified IAM to examine high-impact low-probability risks, using a right-skewed gamma distribution for climate sensitivity as well as an uncertain damage coefficient, but in most cases found only a modest risk premium. Given this difference in opinion, further research in this area is needed before its practical significance can be fully understood and a reasonable approach developed to account for such risks in regulatory analysis. (The next section discusses the scientific evidence on catastrophic impacts in greater detail.)

[28] However, it is possible that other benefits or costs of proposed regulations unrelated to CO_2 emissions will be discounted at rates that differ from those used to develop the SCC estimates.

Uncertainty in extrapolation of damages to high temperatures: The damage functions in these IAMs are typically calibrated by estimating damages at moderate temperature increases (e.g., DICE was calibrated at 2.5 °C) and extrapolated to far higher temperatures by assuming that damages increase as some power of the temperature change. Hence, estimated damages are far more uncertain under more extreme climate change scenarios.

Incomplete treatment of adaptation and technological change: Each of the three integrated assessment models used here assumes a certain degree of low- or no-cost adaptation. For instance, Tol assumes a great deal of adaptation in FUND, including widespread reliance on air conditioning ; so much so, that the largest single benefit category in FUND is the reduced electricity costs from not having to run air conditioning as intensively (NRC 2009).

Climate change also will increase returns on investment to develop technologies that allow individuals to cope with adverse climate conditions, and IAMs to do not adequately account for this directed technological change.[29] For example, scientists may develop crops that are better able to withstand higher and more variable temperatures. Although DICE and FUND have both calibrated their agricultural sectors under the assumption that farmers will change land use practices in response to climate change (Mastrandrea, 2009), they do not take into account technological changes that lower the cost of this adaptation over time. On the other hand, the calibrations do not account for increases in climate variability, pests, or diseases, which could make adaptation more difficult than assumed by the IAMs for a given temperature change. Hence, models do not adequately account for potential adaptation or technical change that might alter the emissions pathway and resulting damages. In this respect, it is difficult to determine whether the incomplete treatment of adaptation and technological change in these IAMs under or overstate the likely damages.

Risk aversion: A key question unanswered during this interagency process is what to assume about relative risk aversion with regard to high-impact outcomes. These calculations do not take into account the possibility that individuals may have a higher willingness to pay to reduce the likelihood of low-probability, high-impact damages than they do to reduce the likelihood of higher-probability but lower-impact damages with the same expected cost. (The inclusion of the 95th percentile estimate in the final set of SCC values was largely motivated by this concern.) If individuals do show such a higher willingness to pay, a further question is whether that fact should be taken into account for regulatory policy. Even if individuals are not risk-averse for such scenarios, it is possible that regulatory policy should include a degree of risk-aversion.

Assuming a risk-neutral representative agent is consistent with OMB's Circular A-4, which advises that the estimates of benefits and costs used in regulatory analysis are usually based on the average or the expected value and that "emphasis on these expected values is appropriate as long as society is 'risk neutral' with respect to the regulatory alternatives. While this may not always be the case, [analysts] should in general assume 'risk neutrality' in [their] analysis."

Nordhaus (2008) points to the need to explore the relationship between risk and income in the context of climate change across models and to explore the role of uncertainty regarding various parameters in

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[29] However these research dollars will be diverted from whatever their next best use would have been in the absence of climate change (so productivity/GDP would have been still higher).

the results. Using FUND, Anthoff et al (2009) explored the sensitivity of the SCC to Ramsey equation parameter assumptions based on observed behavior. They conclude that "the assumed rate of risk aversion is at least as important as the assumed rate of time preference in determining the social cost of carbon." Since Circular A-4 allows for a different assumption on risk preference in regulatory analysis if it is adequately justified, we plan to continue investigating this issue.

V. A Further Discussion of Catastrophic Impacts and Damage Functions

As noted above, the damage functions underlying the three IAMs used to estimate the SCC may not capture the economic effects of all possible adverse consequences of climate change and may therefore lead to underestimates of the SCC (Mastrandrea 2009). In particular, the models' functional forms may not adequately capture: (1) potentially discontinuous "tipping point" behavior in Earth systems, (2) inter-sectoral and inter-regional interactions, including global security impacts of high-end warming, and (3) limited near-term substitutability between damage to natural systems and increased consumption.

It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling. In the meantime, we discuss some of the available evidence.

Extrapolation of climate damages to high levels of warming

The damage functions in the models are calibrated at moderate levels of warming and should therefore be viewed cautiously when extrapolated to the high temperatures found in the upper end of the distribution. Recent science suggests that there are a number of potential climatic "tipping points" at which the Earth system may exhibit discontinuous behavior with potentially severe social and economic consequences (e.g., Lenton et al, 2008, Kriegler et al., 2009). These tipping points include the disruption of the Indian Summer Monsoon, dieback of the Amazon Rainforest and boreal forests, collapse of the Greenland Ice Sheet and the West Antarctic Ice Sheet, reorganization of the Atlantic Meridional Overturning Circulation, strengthening of El Niño-Southern Oscillation, and the release of methane from melting permafrost. Many of these tipping points are estimated to have thresholds between about 3 °C and 5 °C (Lenton et al., 2008). Probabilities of several of these tipping points were assessed through expert elicitation in 2005–2006 by Kriegler et al. (2009); results from this study are highlighted in Table 6. Ranges of probability are averaged across core experts on each topic.

As previously mentioned, FUND does not include potentially catastrophic effects. DICE assumes a small probability of catastrophic damages that increases with increased warming, but the damages from these risks are incorporated as expected values (i.e., ignoring potential risk aversion). PAGE models catastrophic impacts in a probabilistic framework (see Figure 1), so the high-end output from PAGE potentially offers the best insight into the SCC if the world were to experience catastrophic climate change. For instance, at the 95th percentile and a 3 percent discount rate, the SCC estimated by PAGE across the five socio-economic and emission trajectories of \$113 per ton of CO_2 is almost double the value estimated by DICE, \$58 per ton in 2010. We cannot evaluate how well the three models account for catastrophic or non-catastrophic impacts, but this estimate highlights the sensitivity of SCC values in the tails of the distribution to the assumptions made about catastrophic impacts.

Table 6: Probabilities of Various Tipping Points from Expert Elicitation -

Possible Tipping Points	Duration before effect is fully realized (in years)	Additional Warming by 2100		
		0.5-1.5 C	1.5-3.0 C	3-5 C
Reorganization of Atlantic Meridional Overturning Circulation	about 100	0-18%	6-39%	18-67%
Greenland Ice Sheet collapse	at least 300	8-39%	33-73%	67-96%
West Antarctic Ice Sheet collapse	at least 300	5-41%	10-63%	33-88%
Dieback of Amazon rainforest	about 50	2-46%	14-84%	41-94%
Strengthening of El Niño-Southern Oscillation	about 100	1-13%	6-32%	19-49%
Dieback of boreal forests	about 50	13-43%	20-81%	34-91%
Shift in Indian Summer Monsoon	about 1	Not formally assessed		
Release of methane from melting permafrost	Less than 100	Not formally assessed.		

PAGE treats the possibility of a catastrophic event probabilistically, while DICE treats it deterministically (that is, by adding the expected value of the damage from a catastrophe to the aggregate damage function). In part, this results in different probabilities being assigned to a catastrophic event across the two models. For instance, PAGE places a probability near zero on a catastrophe at 2.5 °C warming, while DICE assumes a 4 percent probability of a catastrophe at 2.5 °C. By comparison, Kriegler et al. (2009) estimate a probability of at least 16-36 percent of crossing at least one of their primary climatic tipping points in a scenario with temperatures about 2-4 °C warmer than pre-Industrial levels in 2100.

It is important to note that crossing a climatic tipping point will not necessarily lead to an economic catastrophe in the sense used in the IAMs. A tipping point is a critical threshold across which some aspect of the Earth system starts to shifts into a qualitatively different state (for instance, one with dramatically reduced ice sheet volumes and higher sea levels). In the IAMs, a catastrophe is a low-probability environmental change with high economic impact.

Failure to incorporate inter-sectoral and inter-regional interactions

The damage functions do not fully incorporate either inter-sectoral or inter-regional interactions. For instance, while damages to the agricultural sector are incorporated, the effects of changes in food supply on human health are not fully captured and depend on the modeler's choice of studies used to calibrate the IAM. Likewise, the effects of climate damages in one region of the world on another region are not included in some of the models (FUND includes the effects of migration from sea level rise). These inter-regional interactions, though difficult to quantify, are the basis for climate-induced national and economic security concerns (e.g., Campbell et al., 2007; U.S. Department of Defense 2010) and are particularly worrisome at higher levels of warming. High-end warming scenarios, for instance, project water scarcity affecting 4.3-6.9 billion people by 2050, food scarcity affecting about 120 million additional people by 2080, and the creation of millions of climate refugees (Easterling et al., 2007; Campbell et al., 2007).

Imperfect substitutability of environmental amenities

Data from the geological record of past climate changes suggests that 6 °C of warming may have severe consequences for natural systems. For instance, during the Paleocene-Eocene Thermal Maximum about 55.5 million years ago, when the Earth experienced a geologically rapid release of carbon associated with an approximately 5 °C increase in global mean temperatures, the effects included shifts of about 400-900 miles in the range of plants (Wing et al., 2005), and dwarfing of both land mammals (Gingerich, 2006) and soil fauna (Smith et al., 2009).

The three IAMs used here assume that it is possible to compensate for the economic consequences of damages to natural systems through increased consumption of non-climate goods, a common assumption in many economic models. In the context of climate change, however, it is possible that the damages to natural systems could become so great that no increase in consumption of non-climate goods would provide complete compensation (Levy et al., 2005). For instance, as water supplies become scarcer or ecosystems become more fragile and less bio-diverse, the services they provide may become increasingly more costly to replace. Uncalibrated attempts to incorporate the imperfect substitutability of such amenities into IAMs (Sterner and Persson, 2008) indicate that the optimal degree of emissions abatement can be considerably greater than is commonly recognized.

VI. Conclusion

The interagency group selected four SCC estimates for use in regulatory analyses. For 2010, these estimates are \$5, \$21, \$35, and \$65 (in 2007 dollars). The first three estimates are based on the average SCC across models and socio-economic and emissions scenarios at the 5, 3, and 2.5 percent discount rates, respectively. The fourth value is included to represent the higher-than-expected impacts from temperature change further out in the tails of the SCC distribution. For this purpose, we use the SCC value for the 95th percentile at a 3 percent discount rate. The central value is the average SCC across models at the 3 percent discount rate. For purposes of capturing the uncertainties involved in regulatory impact analysis, we emphasize the importance and value of considering the full range. These SCC estimates also grow over time. For instance, the central value increases to \$24 per ton of CO_2 in 2015 and \$26 per ton of CO_2 in 2020.

We noted a number of limitations to this analysis, including the incomplete way in which the integrated assessment models capture catastrophic and non-catastrophic impacts, their incomplete treatment of adaptation and technological change, uncertainty in the extrapolation of damages to high temperatures, and assumptions regarding risk aversion. The limited amount of research linking climate impacts to economic damages makes this modeling exercise even more difficult. It is the hope of the interagency group that over time researchers and modelers will work to fill these gaps and that the SCC estimates used for regulatory analysis by the Federal government will continue to evolve with improvements in modeling.

References

Andronova, N., and M. Schlesinger. 2001. "Objective estimation of the probability density function for climate sensitivity." *J. Geophys. Res*., 106(D19), 22605–22611.

Annan, J., et al., 2005. "Efficiently constraining climate sensitivity with paleoclimate simulations." *Scientific Online Letters on the Atmosphere*, 1, 181–184.

Anthoff D, C. Hepburn, and R. Tol. 2009a. "Equity Weighting and the Marginal Damage Costs of Climate Change." *Ecological Economics* 68:836-849.

Anthoff, D., R. Tol, and G. Yohe. 2009b. "Risk aversion, time preference, and the social cost of carbon." *Environmental Research Letters* 4: 024002 (7pp).

Arrow, K. 2007. "Global climate change: a challenge to policy." *Economist's Voice* 4(3):Article 2.

Arrow, K. 2000. "A Comment on Cooper." *The World Bank Research Observer*. vol 15, no. 2.

Arrow, K., et al. 1996. *Benefit-Cost Analysis in Environmental, Health, and Safety Regulation: A Statement of Principles*. Washington, D.C., AEI Press. pp. 13-14.

Arrow, K.J., et al. 1996. "Intertemporal equity, discounting and economic efficiency," in Climate Change 1995: Economic and Social Dimensions of Climate Change, Contribution of Working Group III to the *Second Assessment Report of the Intergovernmental Panel on Climate Change*.

Campbell, J., P. Diamond, and J. Shoven. 2001. "Estimating the Real Rate of Return on Stocks Over the Long Term." Presented to the Social Security Advisory Board. August.

Campbell, K. et al. 2007. *The age of consequences: The foreign policy and national security implications of global climate change*. Center for Strategic & International Studies, 119 pp.

Castles, I. and D. Henderson. 2003. "The IPCC Emission Scenarios: An Economic-Statistical Critique." *Energy and Environment* 14(2-3): 159-185.

Chetty, R. 2006. "A New Method of Estimating Risk Aversion." *American Economic Review* 96(5): 1821–1834.

Dasgupta P. 2006. "Comments on the Stern Review's economics of climate change." University of Cambridge working paper.

Dasgupta P. 2008. "Discounting climate change." *Journal of Risk and Uncertainty* 37:141-169.

Easterling, W., et al. 2007. *Climate Change 2007: Impacts, Adaptation, and Vulnerability*. Intergovernmental Panel on Climate Change, 976 pp. http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_wg2_report_impacts_adaptation_and_vulnerability.htm, last accessed March 25, 2010.

Evans D., and H. Sezer. 2005. "Social discount rates for member countries of the European Union." *J. Econ. Stud*. 32 47–59.

Forest, C., et al. 2002. “Quantifying uncertainties in climate system properties with the use of recent observations.” *Science* 295, 113.

Forest, D., P. Stone, and A. Sokolov. 2006. “Estimated PDFs of climate system properties including natural and anthropogenic forcings.” *Geophys. Res. Lett*., 33, L01705.

Forster, P., and J. Gregory. 2006. “The climate sensitivity and its components diagnosed from Earth radiation budget data.” *J. Clim*., 19, 39–52.

Frame, D., et al. 2005. “Constraining climate forecasts: The role of prior assumptions.” *Geophys. Res. Lett*., 32, L09702.

Gingerich, P. 2006. “Environment and evolution through the Paleocene-Eocene thermal maximum.” *Trends Ecol. Evol.* 21: 246-253.

Gollier, C. 2008. “Discounting with fat-tailed economic growth.” *Journal of Risk and Uncertainty* 37:171-186.

Gollier, C. and M. Weitzman (2009). "How Should the Distant Future be Discounted When Discount Rates are Uncertain?" Harvard University, mimeo, Nov 2009.

Gregory, J., et al. 2002a. “An observationally based estimate of the climate sensitivity.” *J. Clim*., 15(22), 3117–3121.

Groom, B., Koundouri, P., Panipoulou, E., Pantelidis, T. 2006. “An econometric approach to estimating long-run discount rates.” *Journal of Applied Econometrics.*

Hall R, and C. Jones . 2007. “The value of life and the rise in health spending.” Quarterly *Journal of Economics* 122(1):39-72.

Hansen, J.,M. Sato, P. Kharecha, G. Russell, D. W. Lea and M. Siddall. 2007. “Climate change and trace gases.” *Phil. Trans. Roy. Soc. A* 365: 1925-1954.

Hegerl G, et al. 2007. “Understanding and attributing climate change.” in Solomon S, et al. (eds) *Climate Change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, UK: Cambridge University Press. http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html

Hegerl, G., T. Crowley, W. Hyde, and D. Frame. 2006. “Constraints on climate sensitivity from temperature reconstructions of the past seven centuries.” *Nature* 440.

Holtsmark, B., and K. Alfsen. 2005. “PPP Correction of the IPCC Emission Scenarios – Does it Matter?” *Climatic Change* 68(1-2): 11-19.

Hope C. 2006. “The marginal impact of CO2 from PAGE2002: an integrated assessment model incorporating the IPCC’s five reasons for concern.” *The Integrated Assessment Journal* 6(1):19-56.

Hope C. 2008. “Optimal carbon emissions and the social cost of carbon under uncertainty.” *The Integrated Assessment Journal* 8(1):107-122.

Intergovernmental Panel on Climate Change (2007). “Summary for Policymakers.” In *Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Just, R., D. Hueth, and A. Schmitz. 2004. *The Welfare Economics of Public Policy*. Glos UK: Edward Elgar Publishing Limited.

Knutti, R., T. Stocker, F. Joos, and G. Plattner. 2002. “Constraints on radiative forcing and future climate change from observations and climate model ensembles.” *Nature*, 416, 719–723.

Kriegler, E. et al. 2009. “Imprecise probability assessment of tipping points in the climate system.” *Proc. Natl. Acad. Sci.* 106: 5041-5046.

Kotlikoff, L. and D. Rapson. 2006. “Does It Pay, at the Margin, to Work and Save? – Measuring Effective Marginal Taxes on Americans’ Labor Supply and Saving.” National Bureau of Economic Research, Working Paper, No. 12533.

Le Treut H., et al. 2007. “Historical Overview of Climate Change.” in Solomon et al., *Climate Change 2007*.

Lenton, T., et al. 2008. “Tipping elements in the Earth’s climate system.” *Proc. Natl. Acad. Sci.* 105: 1786-1793.

Levy, M., et al. 2005. “Ecosystem conditions and human well-being.” In: *Ecosystems and Human Well-being: Current State and Trends, Volume 1.* [R. Hassan, R. Scholes, and N. Ash, eds.] Washington: Island Press. pp. 123-164.

Lind, R. 1990. “Reassessing the Government’s Discount Rate Policy in Light of New Theory and Data in a World Economy with a High Degree of Capital Mobility.” *Journal of Environmental Economics and Management* 18, S-8-S-28.

Mastrandre, M. 2009. “Calculating the benefits of climate policy: Examining the assumptions of Integrated Assessment Models.” Pew Center on Global Climate Change Working Paper, 60 pp.

Meehl, G, et al. 2007. “Global Climate Projections.” in Solomon et al., *Climate Change 2007*.

National Research Council (2009). *Hidden Costs of Energy: Unpriced Consequences of Energy Production and Use*. National Academies Press.

Newbold S, Daigneault A. 2009. “Climate response uncertainty and the benefits of greenhouse gas emissions reductions.” *Environmental and Resource Economics* 44:351-377.

Newell, R., and W. Pizer. 2003. Discounting the distant future: how much do uncertain rates increase valuations? *Journal of Environmental Economics and Management* 46: 52-71.

Nordhaus, W. 1994. “Expert Opinion on Climate Change.” *American Scientist* 82: 45-51.

Nordhaus, W. 2007a. *Accompanying notes and documentation on development of DICE-2007 model: notes on DICE-2007.delta.v8 as of September 21, 2007.*

Nordhaus, W. 2007b. “Alternative measures of output in global economic-environmental models: Purchasing power parity or market exchange rates?” *Energy Economics* 29: 349-372.

Nordhaus W. 2008. *A Question of Balance: Weighing the Options on Global Warming Policies*. New Haven, CT: Yale University Press.

Nordhaus, W. 2009. “An Analysis of the Dismal Theorem. Cowles Foundation Discussion Paper. No. 1686. January.

Nordhaus W., and Boyer J. 2000. *Warming the World: Economic Models of Global Warming*. Cambridge, MA: MIT Press.

Pindyck, R. 2009. “Uncertain Outcomes and Climate Change Policy.” NBER Working Paper, No. 15259. August.

Ramsey, F. 1928. “A Mathematical Theory of Saving.” *The Economic Journal* 38(152): 543-559.

Roe, G. 2008. “Feedbacks, timescales, and seeing red.” *Annual Review of Earth and Planetary Sciences* 37:5.1-5.23.

Roe, G., and M. Baker. 2007. “Why is climate sensitivity so unpredictable?” *Science* 318:629-632.

Schneider von Deimling, T., H. Held, A. Ganopolski, and S. Rahmstorf. 2006. “Climate sensitivity estimated from ensemble simulations of glacial climate.” *Clim. Dyn*., 27, 149–163.

Smith, J. et al. 2009. “Transient dwarfism of soil fauna during the Paleocene-Eocene Thermal Maximum.” *Proc. Natl. Acad. Sci.* 106: 17665-17660.

Stern, N., et al. (2006), *Stern Review: The Economics of Climate Change*, HM Treasury, London. See http://www.hm-treasury.gov.uk/stern_review_report.htm, last accessed March 25, 2010.

Stern N. 2008. “The economics of climate change.” *American Economic Review* 98(2):1-37.

Sterner, T., and U. Persson. 2008. An even Sterner review: Introducing relative prices into the discounting debate. *Rev. Env. Econ. Pol.* 2: 61-76.

Summers, L., and R. Zeckhauser. 2008. “Policymaking for Posterity.” Journal of Risk and Uncertainty 37: 115-140.

Szpiro, G. 1986. “Measuring Risk Aversion: An Alternative Approach.” *The Review of Economics and Statistics* 68(1): 156-9.

Tol, R. 2002a. “Estimates of the damage costs of climate change. Part I: benchmark estimates.” *Environmental and Resource Economics* 21:47-73.

Tol, R. 2002b. “Estimates of the damage costs of climate change. Part II: dynamic estimates.” *Environmental and Resource Economics* 21:135-160.

Tol, R. 2006. “Exchange Rates and Climate Change: An Application of FUND.” *Climatic Change* 75(1-2): 59-80.

Tol, R. 2009. “An analysis of mitigation as a response to climate change.” Copenhagen Consensus on Climate. Discussion Paper.

U.S. Department of Defense. 2010. Quadrennial Defense Review Report. February.

Warren, R., et al. 2006. “Spotlight Impact Functions in Integrated Assessment.” Tyndall Center for Climate Change Research, Working Paper 91.

Weitzman, M. 2009. “On modeling and interpreting the economics of catastrophic climate change.” *Review of Economics and Statistics* 91:1-19.

Weitzman, M. 2007. “A review of The Stern Review of the Economics of Climate Change*.” Journal of Economic Literature* 45:703-724.

Weitzman, M. 1999. In Portney P.R. and Weyant J.P. (eds.), *Discounting and Intergenerational Equity*, Resources for the Future, Washington, D.C.

Weitzman, M. 1998. “Why the Far-Distant Future Should Be Discounted at Its Lowest Possible Rate.” *Journal of Environmental Economics and Management* 36 (3): 201-208.

Wing, S. et al. 2005. “Transient floral change and rapid global warming at the Paleocene-Eocene boundary.” *Science* 310: 993-996.

Appendix

Table A1: Annual SCC Values: 2010–2050 (in 2007 dollars)

Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	4.7	21.4	35.1	64.9
2011	4.9	21.9	35.7	66.5
2012	5.1	22.4	36.4	68.1
2013	5.3	22.8	37.0	69.6
2014	5.5	23.3	37.7	71.2
2015	5.7	23.8	38.4	72.8
2016	5.9	24.3	39.0	74.4
2017	6.1	24.8	39.7	76.0
2018	6.3	25.3	40.4	77.5
2019	6.5	25.8	41.0	79.1
2020	6.8	26.3	41.7	80.7
2021	7.1	27.0	42.5	82.6
2022	7.4	27.6	43.4	84.6
2023	7.7	28.3	44.2	86.5
2024	7.9	28.9	45.0	88.4
2025	8.2	29.6	45.9	90.4
2026	8.5	30.2	46.7	92.3
2027	8.8	30.9	47.5	94.2
2028	9.1	31.5	48.4	96.2
2029	9.4	32.1	49.2	98.1
2030	9.7	32.8	50.0	100.0
2031	10.0	33.4	50.9	102.0
2032	10.3	34.1	51.7	103.9
2033	10.6	34.7	52.5	105.8
2034	10.9	35.4	53.4	107.8
2035	11.2	36.0	54.2	109.7
2036	11.5	36.7	55.0	111.6
2037	11.8	37.3	55.9	113.6
2038	12.1	37.9	56.7	115.5
2039	12.4	38.6	57.5	117.4
2040	12.7	39.2	58.4	119.3
2041	13.0	39.8	59.0	121.0
2042	13.3	40.4	59.7	122.7
2043	13.6	40.9	60.4	124.4
2044	13.9	41.5	61.0	126.1
2045	14.2	42.1	61.7	127.8
2046	14.5	42.6	62.4	129.4
2047	14.8	43.2	63.0	131.1
2048	15.1	43.8	63.7	132.8
2049	15.4	44.4	64.4	134.5
2050	15.7	44.9	65.0	136.2

This Appendix also provides additional technical information about the non-CO_2 emission projections used in the modeling and the method for extrapolating emissions forecasts through 2300, and shows the full distribution of 2010 SCC estimates by model and scenario combination.

1. Other (non-CO_2) gases

In addition to fossil and industrial CO_2 emissions, each EMF scenario provides projections of methane (CH_4), nitrous oxide (N_2O), fluorinated gases, and net land use CO_2 emissions to 2100. These assumptions are used in all three IAMs while retaining each model's default radiative forcings (RF) due to other factors (e.g., aerosols and other gases). Specifically, to obtain the RF associated with the non-CO_2 EMF emissions only, we calculated the RF associated with the EMF atmospheric CO_2 concentrations and subtracted them from the EMF total RF.[30] This approach respects the EMF scenarios as much as possible and at the same time takes account of those components not included in the EMF projections. Since each model treats non-CO_2 gases differently (e.g., DICE lumps all other gases into one composite exogenous input), this approach was applied slightly differently in each of the models.

<u>FUND</u>: Rather than relying on RF for these gases, the actual emissions from each scenario were used in FUND. The model default trajectories for CH_4, N_20, SF_6, and the CO_2 emissions from land were replaced with the EMF values.

<u>PAGE</u>: PAGE models CO_2, CH_4, sulfur hexafluoride (SF_6), and aerosols and contains an "excess forcing" vector that includes the RF for everything else. To include the EMF values, we removed the default CH_4 and SF_6 factors[31], decomposed the excess forcing vector, and constructed a new excess forcing vector that includes the EMF RF for CH_4, N_20, and fluorinated gases, as well as the model default values for aerosols and other factors. Net land use CO_2 emissions were added to the fossil and industrial CO_2 emissions pathway.

<u>DICE</u>: DICE presents the greatest challenge because all forcing due to factors other than industrial CO_2 emissions is embedded in an exogenous non-CO_2 RF vector. To decompose this exogenous forcing path into EMF non-CO_2 gases and other gases, we relied on the references in DICE2007 to the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4) and the discussion of aerosol forecasts in the IPCC's Third Assessment Report (TAR) and in AR4, as explained below. In DICE2007, Nordhaus assumes that exogenous forcing from all non-CO_2 sources is -0.06 W/m^2 in 2005, as reported in AR4, and increases linearly to 0.3 W/m^2 in 2105, based on GISS projections, and then stays constant after that time.

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[30] Note EMF did not provide CO_2 concentrations for the IMAGE reference scenario. Thus, for this scenario, we fed the fossil, industrial and land CO_2 emissions into MAGICC (considered a "neutral arbiter" model, which is tuned to emulate the major global climate models) and the resulting CO_2 concentrations were used. Note also that MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

[31] Both the model default CH_4 emissions and the initial atmospheric CH_4 is set to zero to avoid double counting the effect of past CH_4 emissions.

According to AR4, the RF in 2005 from CH_4, N_20, and halocarbons (approximately similar to the F-gases in the EMF-22 scenarios) was 0.48 + 0.16 + 0.34 = 0.98 W/m^2 and RF from total aerosols was -1.2 W/m^2. Thus, the -.06 W/m^2 non-CO_2 forcing in DICE can be decomposed into: 0.98 W/m^2 due to the EMF non-CO_2 gases, -1.2 W/m^2 due to aerosols, and the remainder, 0.16 W/m^2, due to other residual forcing.

For subsequent years, we calculated the DICE default RF from aerosols and other non-CO_2 gases based on the following two assumptions:

(1) RF from aerosols declines linearly from 2005 to 2100 at the rate projected by the TAR and then stays constant thereafter, and
(2) With respect to RF from non-CO_2 gases not included in the EMF-22 scenarios, the share of non-aerosol RF matches the share implicit in the AR4 summary statistics cited above and remains constant over time.

Assumption (1) means that the RF from aerosols in 2100 equals 66 percent of that in 2000, which is the fraction of the TAR projection of total RF from aerosols (including sulfates, black carbon, and organic carbon) in 2100 vs. 2000 under the A1B SRES emissions scenario. Since the SRES marker scenarios were not updated for the AR4, the TAR provides the most recent IPCC projection of aerosol forcing. We rely on the A1B projection from the TAR because it provides one of the lower aerosol forecasts among the SRES marker scenarios and is more consistent with the AR4 discussion of the post-SRES literature on aerosols:

> *Aerosols have a net cooling effect and the representation of aerosol and aerosol precursor emissions, including sulphur dioxide, black carbon and organic carbon, has improved in the post-SRES scenarios. Generally, these emissions are projected to be lower than reported in SRES. {WGIII 3.2, TS.3, SPM}.*[32]

Assuming a simple linear decline in aerosols from 2000 to 2100 also is more consistent with the recent literature on these emissions. For example, Figure A1 shows that the sulfur dioxide emissions peak over the short-term of some SRES scenarios above the upper bound estimates of the more recent scenarios.[33] Recent scenarios project sulfur emissions to peak earlier and at lower levels compared to the SRES in part because of new information about present and planned sulfur legislation in some developing countries, such as India and China.[34] The lower bound projections of the recent literature have also shifted downward slightly compared to the SRES scenario (IPCC 2007).

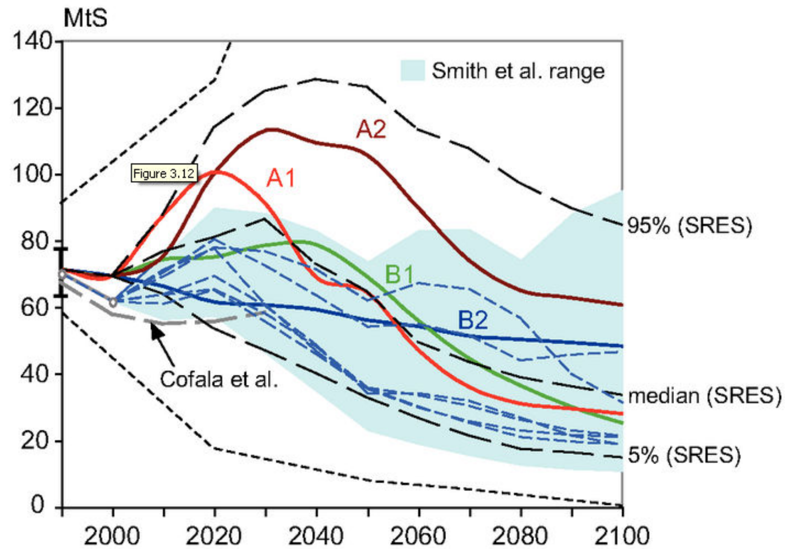
[32] AR4 Synthesis Report, p. 44, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

[33] See Smith, S.J., R. Andres, E. Conception, and J. Lurz, 2004: Historical sulfur dioxide emissions, 1850-2000: methods and results. Joint Global Research Institute, College Park, 14 pp.

[34] See Carmichael, G., D. Streets, G. Calori, M. Amann, M. Jacobson, J. Hansen, and H. Ueda, 2002: Changing trends in sulphur emissions in Asia: implications for acid deposition, air pollution, and climate. Environmental Science and Technology, 36(22):4707- 4713; Streets, D., K. Jiang, X. Hu, J. Sinton, X.-Q. Zhang, D. Xu, M. Jacobson, and J. Hansen, 2001: Recent reductions in China's greenhouse gas emissions. Science, 294(5548): 1835-1837.

With these assumptions, the DICE aerosol forcing changes from -1.2 in 2005 to -0.792 in 2105 W/m^2; forcing due to other non-CO_2 gases not included in the EMF scenarios declines from 0.160 to 0.153 W/m^2.

Figure A1: Sulphur Dioxide Emission Scenarios -



Notes: Thick colored lines depict the four SRES marker scenarios and black dashed lines show the median, 5th and 95th percentile of the frequency distribution for the full ensemble of 40 SRES scenarios. The blue area (and the thin dashed lines in blue) illustrates individual scenarios and the range of Smith et al. (2004). Dotted lines indicate the minimum and maximum of SO_2 emissions scenarios developed pre-SRES.
Source: IPCC (2007), AR4 WGIII 3.2, http://www.ipcc.ch/publications_and_data/ar4/wg3/en/ch3-ens3-2-2-4.html.

Although other approaches to decomposing the DICE exogenous forcing vector are possible, initial sensitivity analysis suggests that the differences among reasonable alternative approaches are likely to be minor. For example, adjusting the TAR aerosol projection above to assume that aerosols will be maintained at 2000 levels through 2100 reduces average SCC values (for 2010) by approximately 3 percent (or less than $2); assuming all aerosols are phased out by 2100 increases average 2010 SCC values by 6-7 percent (or $0.50-$3)–depending on the discount rate. These differences increase slightly for SCC values in later years but are still well within 10 percent of each other as far out as 2050.

Finally, as in PAGE, the EMF net land use CO_2 emissions are added to the fossil and industrial CO_2 emissions pathway.

2. - Extrapolating Emissions Projections to 2300

To run each model through 2300 requires assumptions about GDP, population, greenhouse gas emissions, and radiative forcing trajectories after 2100, the last year for which these projections are available from the EMF-22 models. These inputs were extrapolated from 2100 to 2300 as follows:

1. Population growth rate declines linearly, reaching zero in the year 2200.
2. GDP/ per capita growth rate declines linearly, reaching zero in the year 2300.
3. The decline in the fossil and industrial carbon intensity (CO_2/GDP) growth rate over 2090-2100 is maintained from 2100 through 2300.
4. Net land use CO_2 emissions decline linearly, reaching zero in the year 2200.
5. Non-CO_2 radiative forcing remains constant after 2100.

Long run stabilization of GDP per capita was viewed as a more realistic simplifying assumption than a linear or exponential extrapolation of the pre-2100 economic growth rate of each EMF scenario. This is based on the idea that increasing scarcity of natural resources and the degradation of environmental sinks available for assimilating pollution from economic production activities may eventually overtake the rate of technological progress. Thus, the overall rate of economic growth may slow over the very long run. The interagency group also considered allowing an exponential decline in the growth rate of GDP per capita. However, since this would require an additional assumption about how close to zero the growth rate would get by 2300, the group opted for the simpler and more transparent linear extrapolation to zero by 2300.

The population growth rate is also assumed to decline linearly, reaching zero by 2200. This assumption is reasonably consistent with the United Nations long run population forecast, which estimates global population to be fairly stable after 2150 in the medium scenario (UN 2004).[35] The resulting range of EMF population trajectories (Figure A2) also encompass the UN medium scenario forecasts through 2300 – global population of 8.5 billion by 2200, and 9 billion by 2300.

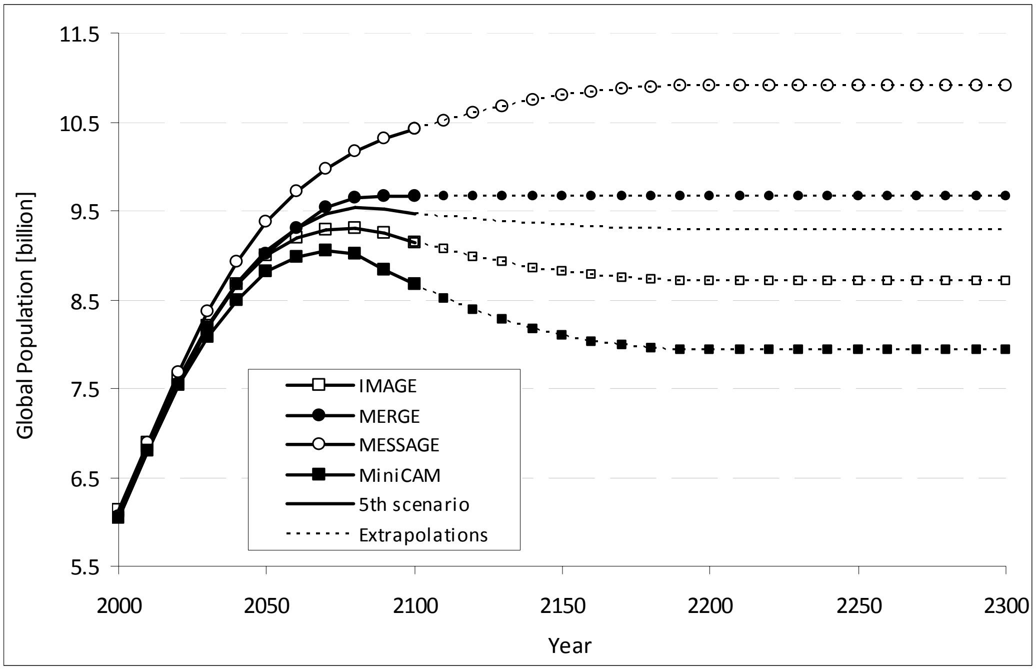
Maintaining the decline in the 2090-2100 carbon intensity growth rate (i.e., CO_2 per dollar of GDP) through 2300 assumes that technological improvements and innovations in the areas of energy efficiency and other carbon reducing technologies (possibly including currently unavailable methods) will continue to proceed at roughly the same pace that is projected to occur towards the end of the forecast period for each EMF scenario. This assumption implies that total cumulative emissions in 2300 will be between 5,000 and 12,000 GtC, which is within the range of the total potential global carbon stock estimated in the literature.

Net land use CO_2 emissions are expected to stabilize in the long run, so in the absence of any post 2100 projections, the group assumed a linear decline to zero by 2200. Given no a priori reasons for assuming a long run increase or decline in non-CO_2 radiative forcing, it is assumed to remain at the 2100 levels for each EMF scenario through 2300.

Figures A2-A7 show the paths of global population, GDP, fossil and industrial CO_2 emissions, net land CO_2 emissions, non-CO_2 radiative forcing, and CO_2 intensity (fossil and industrial CO_2 emissions/GDP) resulting from these assumptions.

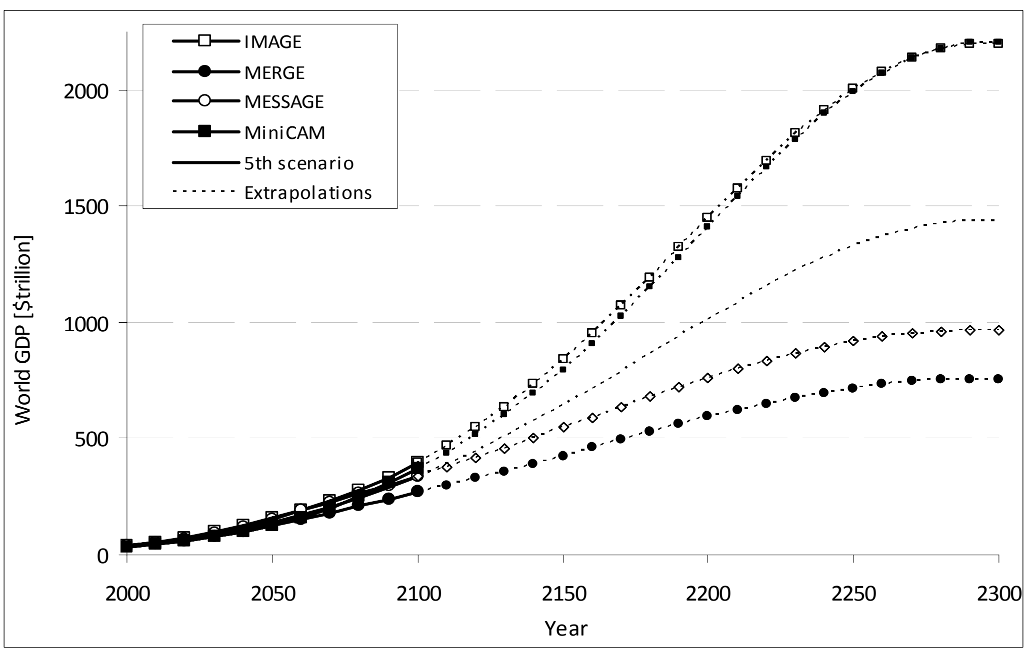
[35] United Nations. 2004. *World Population to 2300*.
http://www.un.org/esa/population/publications/longrange2/worldpop2300final.pdf

Figure A2. Global Population, 2000-2300 (Post-2100 extrapolations assume the population growth rate changes linearly to reach a zero growth rate by 2200.)



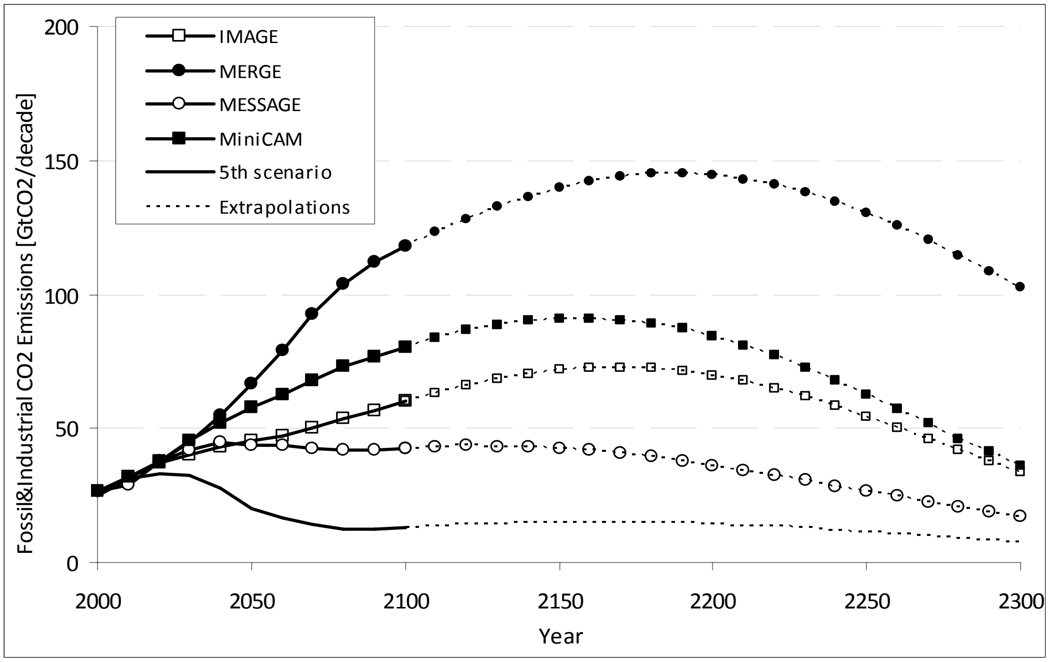
Note: In the fifth scenario, 2000-2100 population is equal to the average of the population under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A3. World GDP, 2000-2300 (Post-2100 extrapolations assume GDP per capita growth declines linearly, reaching zero in the year 2300)



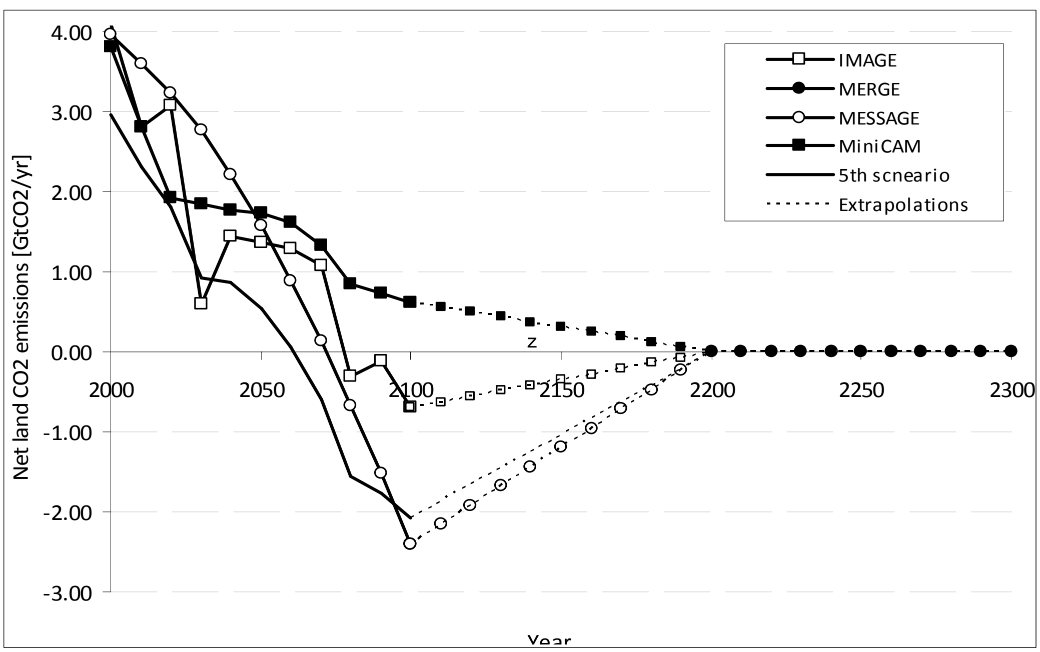
Note: In the fifth scenario, 2000-2100 GDP is equal to the average of the GDP under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A4. Global Fossil and Industrial CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume growth rate of CO_2 intensity (CO_2/GDP) over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

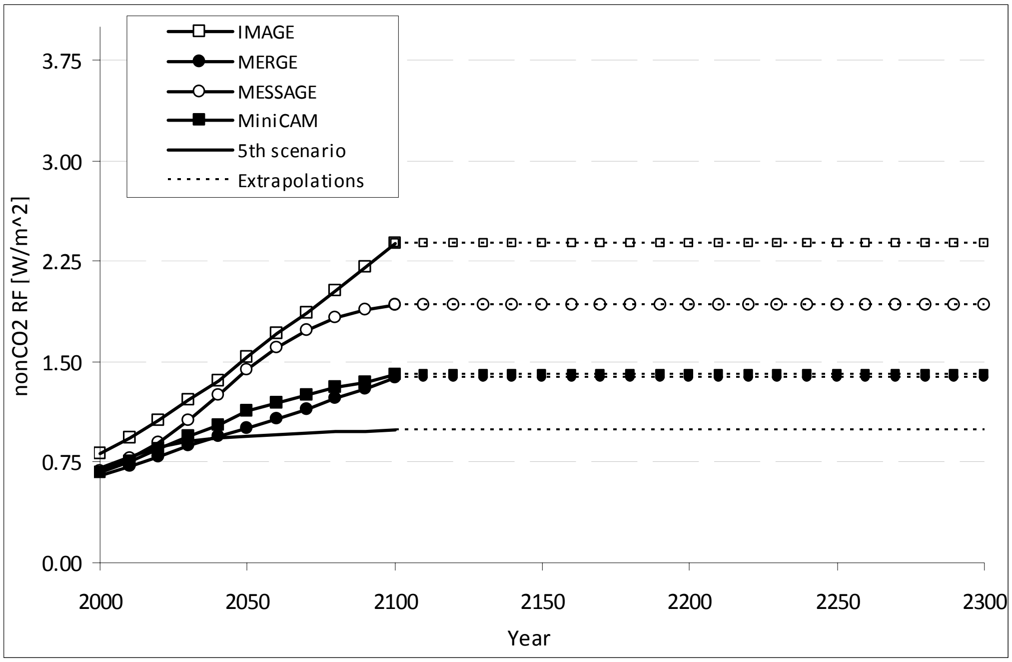
Figure A5. Global Net Land Use CO_2 Emissions, 2000-2300 (Post-2100 extrapolations assume emissions decline linearly, reaching zero in the year 2200)[36]



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

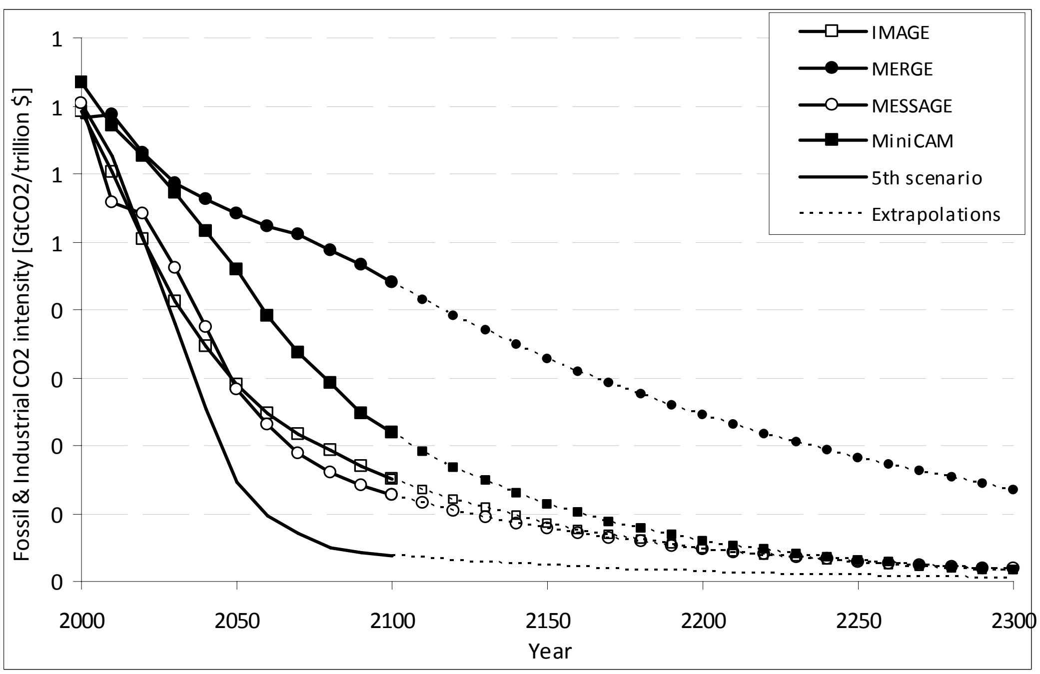
[36] MERGE assumes a neutral biosphere so net land CO_2 emissions are set to zero for all years for the MERGE Optimistic reference scenario, and for the MERGE component of the average 550 scenario (i.e., we add up the land use emissions from the other three models and divide by 4).

Figure A6. Global Non-CO_2 Radiative Forcing, 2000-2300 (Post-2100 extrapolations assume constant non-CO_2 radiative forcing after 2100.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Figure A7. Global CO_2 Intensity (fossil & industrial CO_2 emissions/GDP), 2000-2300 (Post-2100 extrapolations assume decline in CO_2/GDP growth rate over 2090-2100 is maintained through 2300.)



Note: In the fifth scenario, 2000-2100 emissions are equal to the average of the emissions under the 550 ppm CO_2e, full-participation, not-to-exceed scenarios considered by each of the four models.

Table A2. 2010 Global SCC Estimates at 2.5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	3.3	5.9	8.1	13.9	28.8	65.5	68.2	147.9	239.6	563.8
MERGE optimistic	1.9	3.2	4.3	7.2	14.6	34.6	36.2	79.8	124.8	288.3
Message	2.4	4.3	5.8	9.8	20.3	49.2	50.7	114.9	181.7	428.4
MiniCAM base	2.7	4.6	6.4	11.2	22.8	54.7	55.7	120.5	195.3	482.3
5th scenario	2.0	3.5	4.7	8.1	16.3	42.9	41.5	103.9	176.3	371.9
Scenario					DICE					
IMAGE	16.4	21.4	25	33.3	46.8	54.2	69.7	96.3	111.1	130.0
MERGE optimistic	9.7	12.6	14.9	19.7	27.9	31.6	40.7	54.5	63.5	73.3
Message	13.5	17.2	20.1	27	38.5	43.5	55.1	75.8	87.9	103.0
MiniCAM base	13.1	16.7	19.8	26.7	38.6	44.4	56.8	79.5	92.8	109.3
5th scenario	10.8	14	16.7	22.2	32	37.4	47.7	67.8	80.2	96.8
Scenario					FUND					
IMAGE	-33.1	-18.9	-13.3	-5.5	4.1	19.3	18.7	43.5	67.1	150.7
MERGE optimistic	-33.1	-14.8	-10	-3	5.9	14.8	20.4	43.9	65.4	132.9
Message	-32.5	-19.8	-14.6	-7.2	1.5	8.8	13.8	33.7	52.3	119.2
MiniCAM base	-31.0	-15.9	-10.7	-3.4	6	22.2	21	46.4	70.4	152.9
5th scenario	-32.2	-21.6	-16.7	-9.7	-2.3	3	6.7	20.5	34.2	96.8

Table A3. 2010 Global SCC Estimates at 3 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	2.0	3.5	4.8	8.1	16.5	39.5	41.6	90.3	142.4	327.4
MERGE optimistic	1.2	2.1	2.8	4.6	9.3	22.3	22.8	51.3	82.4	190.0
Message	1.6	2.7	3.6	6.2	12.5	30.3	31	71.4	115.6	263.0
MiniCAM base	1.7	2.8	3.8	6.5	13.2	31.8	32.4	72.6	115.4	287.0
5th scenario	1.3	2.3	3.1	5	9.6	25.4	23.6	62.1	104.7	222.5
Scenario					DICE					
IMAGE	11.0	14.5	17.2	22.8	31.6	35.8	45.4	61.9	70.8	82.1
MERGE optimistic	7.1	9.2	10.8	14.3	19.9	22	27.9	36.9	42.1	48.8
Message	9.7	12.5	14.7	19	26.6	29.8	37.8	51.1	58.6	67.4
MiniCAM base	8.8	11.5	13.6	18	25.2	28.8	36.9	50.4	57.9	67.8
5th scenario	7.9	10.1	11.8	15.6	21.6	24.9	31.8	43.7	50.8	60.6
Scenario					FUND					
IMAGE	-25.2	-15.3	-11.2	-5.6	0.9	8.2	10.4	25.4	39.7	90.3
MERGE optimistic	-24.0	-12.4	-8.7	-3.6	2.6	8	12.2	27	41.3	85.3
Message	-25.3	-16.2	-12.2	-6.8	-0.5	3.6	7.7	20.1	32.1	72.5
MiniCAM base	-23.1	-12.9	-9.3	-4	2.4	10.2	12.2	27.7	42.6	93.0
5th scenario	-24.1	-16.6	-13.2	-8.3	-3	-0.2	2.9	11.2	19.4	53.6

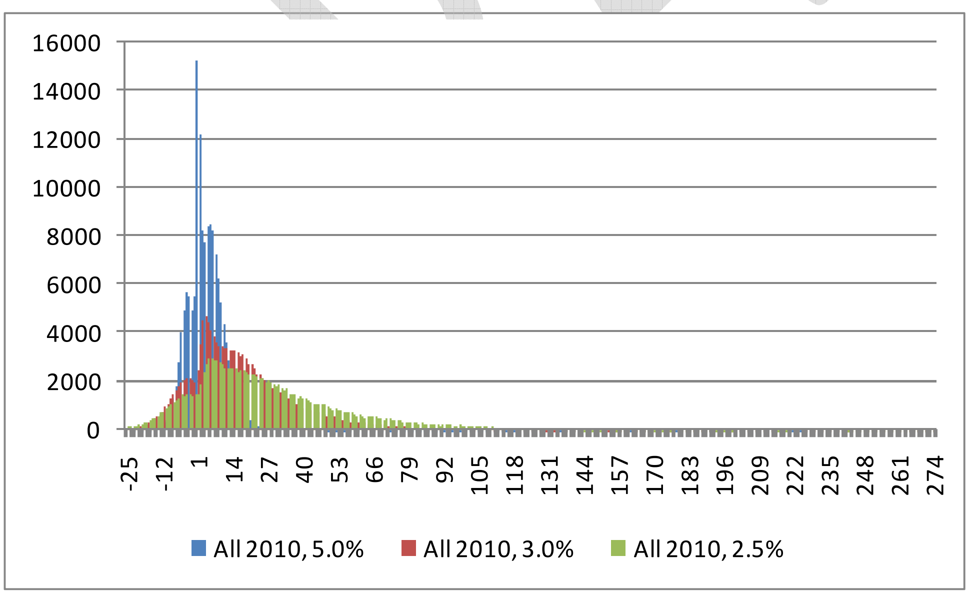
Table A4. 2010 Global SCC Estimates at 5 Percent Discount Rate (2007$/ton CO_2)

Percentile	1st	5th	10th	25th	50th	Avg	75th	90th	95th	99th
Scenario					PAGE					
IMAGE	0.5	0.8	1.1	1.8	3.5	8.3	8.5	19.5	31.4	67.2
MERGE optimistic	0.3	0.5	0.7	1.2	2.3	5.2	5.4	12.3	19.5	42.4
Message	0.4	0.7	0.9	1.6	3	7.2	7.2	17	28.2	60.8
MiniCAM base	0.3	0.6	0.8	1.4	2.7	6.4	6.6	15.9	24.9	52.6
5th scenario	0.3	0.6	0.8	1.3	2.3	5.5	5	12.9	22	48.7

Scenario					DICE					
IMAGE	4.2	5.4	6.2	7.6	10	10.8	13.4	16.8	18.7	21.1
MERGE optimistic	2.9	3.7	4.2	5.3	7	7.5	9.3	11.7	12.9	14.4
Message	3.9	4.9	5.5	7	9.2	9.8	12.2	15.4	17.1	18.8
MiniCAM base	3.4	4.2	4.7	6	7.9	8.6	10.7	13.5	15.1	16.9
5th scenario	3.2	4	4.6	5.7	7.6	8.2	10.2	12.8	14.3	16.0

Scenario					FUND					
IMAGE	-11.7	-8.4	-6.9	-4.6	-2.2	-1.3	0.7	4.1	7.4	17.4
MERGE optimistic	-10.6	-7.1	-5.6	-3.6	-1.3	-0.3	1.6	5.4	9.1	19.0
Message	-12.2	-8.9	-7.3	-4.9	-2.5	-1.9	0.3	3.5	6.5	15.6
MiniCAM base	-10.4	-7.2	-5.8	-3.8	-1.5	-0.6	1.3	4.8	8.2	18.0
5th scenario	-10.9	-8.3	-7	-5	-2.9	-2.7	-0.8	1.4	3.2	9.2

Figure A8. Histogram of Global SCC Estimates in 2010 (2007$/ton CO_2), by discount rate



* The distribution of SCC values ranges from -$5,192 to $66,116 but the X-axis has been truncated at approximately the 1st and 99th percentiles to better show the data.

Table A5. Additional Summary Statistics of 2010 Global SCC Estimates -

Discount rate:	5%				3%				2.5%			
Scenario	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis	Mean	Variance	Skewness	Kurtosis
DICE	9.0	13.1	0.8	0.2	28.3	209.8	1.1	0.9	42.2	534.9	1.2	1.1
PAGE	6.5	136.0	6.3	72.4	29.8	3,383.7	8.6	151.0	49.3	9,546.0	8.7	143.8
FUND	-1.3	70.1	28.2	1,479.0	6.0	16,382.5	128.0	18,976.5	13.6	150,732.6	149.0	23,558.3

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Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change

Summary for Policymakers

This summary, approved in detail at the Eighth Session of IPCC Working Group II (Brussels, Belgium, 2-5 April 2007), represents the formally agreed statement of the IPCC concerning the sensitivity, adaptive capacity and vulnerability of natural and human systems to climate change, and the potential consequences of climate change.

Drafting Authors:

Neil Adger, Pramod Aggarwal, Shardul Agrawala, Joseph Alcamo, Abdelkader Allali, Oleg Anisimov, Nigel Arnell, Michel Boko, Osvaldo Canziani, Timothy Carter, Gino Casassa, Ulisses Confalonieri, Rex Victor Cruz, Edmundo de Alba Alcaraz, William Easterling, Christopher Field, Andreas Fischlin, Blair Fitzharris, Carlos Gay García, Clair Hanson, Hideo Harasawa, Kevin Hennessy, Saleemul Huq, Roger Jones, Lucka Kajfež Bogataj, David Karoly, Richard Klein, Zbigniew Kundzewicz, Murari Lal, Rodel Lasco, Geoff Love, Xianfu Lu, Graciela Magrín, Luis José Mata, Roger McLean, Bettina Menne, Guy Midgley, Nobuo Mimura, Monirul Qader Mirza, José Moreno, Linda Mortsch, Isabelle Niang-Diop, Robert Nicholls, Béla Nováky, Leonard Nurse, Anthony Nyong, Michael Oppenheimer, Jean Palutikof, Martin Parry, Anand Patwardhan, Patricia Romero Lankao, Cynthia Rosenzweig, Stephen Schneider, Serguei Semenov, Joel Smith, John Stone, Jean-Pascal van Ypersele, David Vaughan, Coleen Vogel, Thomas Wilbanks, Poh Poh Wong, Shaohong Wu, Gary Yohe

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A. Introduction

This Summary sets out the key policy-relevant findings of the Fourth Assessment of Working Group II of the Intergovernmental Panel on Climate Change (IPCC).

The Assessment is of current scientific understanding of the impacts of climate change on natural, managed and human systems, the capacity of these systems to adapt and their vulnerability.[1] It builds upon past IPCC assessments and incorporates new knowledge gained since the Third Assessment.

Statements in this Summary are based on chapters in the Assessment and principal sources are given at the end of each paragraph.[2]

B. Current knowledge about observed impacts of climate change on the natural and human environment

A full consideration of observed climate change is provided in the Working Group I Fourth Assessment. This part of the Working Group II Summary concerns the relationship between observed climate change and recent observed changes in the natural and human environment.

The statements presented here are based largely on data sets that cover the period since 1970. The number of studies of observed trends in the physical and biological environment and their relationship to regional climate changes has increased greatly since the Third Assessment in 2001. The quality of the data sets has also improved. There is, however, a notable lack of geographical balance in the data and literature on observed changes, with marked scarcity in developing countries.

Recent studies have allowed a broader and more confident assessment of the relationship between observed warming and impacts than was made in the Third Assessment. That Assessment concluded that "there is high confidence[3] that recent regional changes in temperature have had discernible impacts on many physical and biological systems".

From the current Assessment we conclude the following.

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

With regard to changes in snow, ice and frozen ground (including permafrost),[4] there is high confidence that natural systems are affected. Examples are:
- enlargement and increased numbers of glacial lakes [1.3];
- increasing ground instability in permafrost regions, and rock avalanches in mountain regions [1.3];
- changes in some Arctic and Antarctic ecosystems, including those in sea-ice biomes, and also predators high in the food chain [1.3, 4.4, 15.4].

Based on growing evidence, there is high confidence that the following effects on hydrological systems are occurring:
- increased runoff and earlier spring peak discharge in many glacier- and snow-fed rivers [1.3];
- warming of lakes and rivers in many regions, with effects on thermal structure and water quality [1.3].

There is very high confidence, based on more evidence from a wider range of species, that recent warming is strongly affecting terrestrial biological systems, including such changes as:
- earlier timing of spring events, such as leaf-unfolding, bird migration and egg-laying [1.3];
- poleward and upward shifts in ranges in plant and animal species [1.3, 8.2, 14.2].

Based on satellite observations since the early 1980s, there is high confidence that there has been a trend in many regions towards earlier 'greening'[5] of vegetation in the spring linked to longer thermal growing seasons due to recent warming [1.3, 14.2].

There is high confidence, based on substantial new evidence, that observed changes in marine and freshwater biological systems are associated with rising water temperatures, as well as related changes in ice cover, salinity, oxygen levels and circulation [1.3]. These include:
- shifts in ranges and changes in algal, plankton and fish abundance in high-latitude oceans [1.3];
- increases in algal and zooplankton abundance in high-latitude and high-altitude lakes [1.3];
- range changes and earlier migrations of fish in rivers [1.3].

[1] For definitions, see Endbox 1.
[2] Sources to statements are given in square brackets. For example, [3.3] refers to Chapter 3, Section 3. In the sourcing, F = Figure, T = Table, B = Box and ES = Executive Summary.
[3] See Endbox 2.
[4] See Working Group I Fourth Assessment.
[5] Measured by the Normalised Difference Vegetation Index, which is a relative measure of the amount of green vegetation in an area based on satellite images.

The uptake of anthropogenic carbon since 1750 has led to the ocean becoming more acidic, with an average decrease in pH of 0.1 units [IPCC Working Group I Fourth Assessment]. However, the effects of observed ocean acidification on the marine biosphere are as yet undocumented [1.3].

A global assessment of data since 1970 has shown it is likely[6] that anthropogenic warming has had a discernible influence on many physical and biological systems.

Much more evidence has accumulated over the past five years to indicate that changes in many physical and biological systems are linked to anthropogenic warming. There are four sets of evidence which, taken together, support this conclusion:

1. The Working Group I Fourth Assessment concluded that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.

2. Of the more than 29,000 observational data series,[7] from 75 studies, that show significant change in many physical and biological systems, more than 89% are consistent with the direction of change expected as a response to warming (Figure SPM.1) [1.4].

3. A global synthesis of studies in this Assessment strongly demonstrates that the spatial agreement between regions of significant warming across the globe and the locations of significant observed changes in many systems consistent with warming is very unlikely to be due solely to natural variability of temperatures or natural variability of the systems (Figure SPM.1) [1.4].

4. Finally, there have been several modelling studies that have linked responses in some physical and biological systems to anthropogenic warming by comparing observed responses in these systems with modelled responses in which the natural forcings (solar activity and volcanoes) and anthropogenic forcings (greenhouse gases and aerosols) are explicitly separated. Models with combined natural and anthropogenic forcings simulate observed responses significantly better than models with natural forcing only [1.4].

Limitations and gaps prevent more complete attribution of the causes of observed system responses to anthropogenic warming. First, the available analyses are limited in the number of systems and locations considered. Second, natural temperature variability is larger at the regional than at the global scale, thus affecting identification of changes due to external forcing. Finally, at the regional scale other factors (such as land-use change, pollution, and invasive species) are influential [1.4].

Nevertheless, the consistency between observed and modelled changes in several studies and the spatial agreement between significant regional warming and consistent impacts at the global scale is sufficient to conclude with high confidence that anthropogenic warming over the last three decades has had a discernible influence on many physical and biological systems [1.4].

Other effects of regional climate changes on natural and human environments are emerging, although many are difficult to discern due to adaptation and non-climatic drivers.

Effects of temperature increases have been documented in the following (medium confidence):
- effects on agricultural and forestry management at Northern Hemisphere higher latitudes, such as earlier spring planting of crops, and alterations in disturbance regimes of forests due to fires and pests [1.3];
- some aspects of human health, such as heat-related mortality in Europe, infectious disease vectors in some areas, and allergenic pollen in Northern Hemisphere high and mid-latitudes [1.3, 8.2, 8.ES];
- some human activities in the Arctic (e.g., hunting and travel over snow and ice) and in lower-elevation alpine areas (such as mountain sports) [1.3].

Recent climate changes and climate variations are beginning to have effects on many other natural and human systems. However, based on the published literature, the impacts have not yet become established trends. Examples include:

- Settlements in mountain regions are at enhanced risk of glacier lake outburst floods caused by melting glaciers. Governmental institutions in some places have begun to respond by building dams and drainage works [1.3].

- In the Sahelian region of Africa, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops. In southern Africa, longer dry seasons and more uncertain rainfall are prompting adaptation measures [1.3].

- Sea-level rise and human development are together contributing to losses of coastal wetlands and mangroves and increasing damage from coastal flooding in many areas [1.3].

[6] See Endbox 2.
[7] A subset of about 29,000 data series was selected from about 80,000 data series from 577 studies. These met the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; and (3) showing a significant change in either direction, as assessed in individual studies.

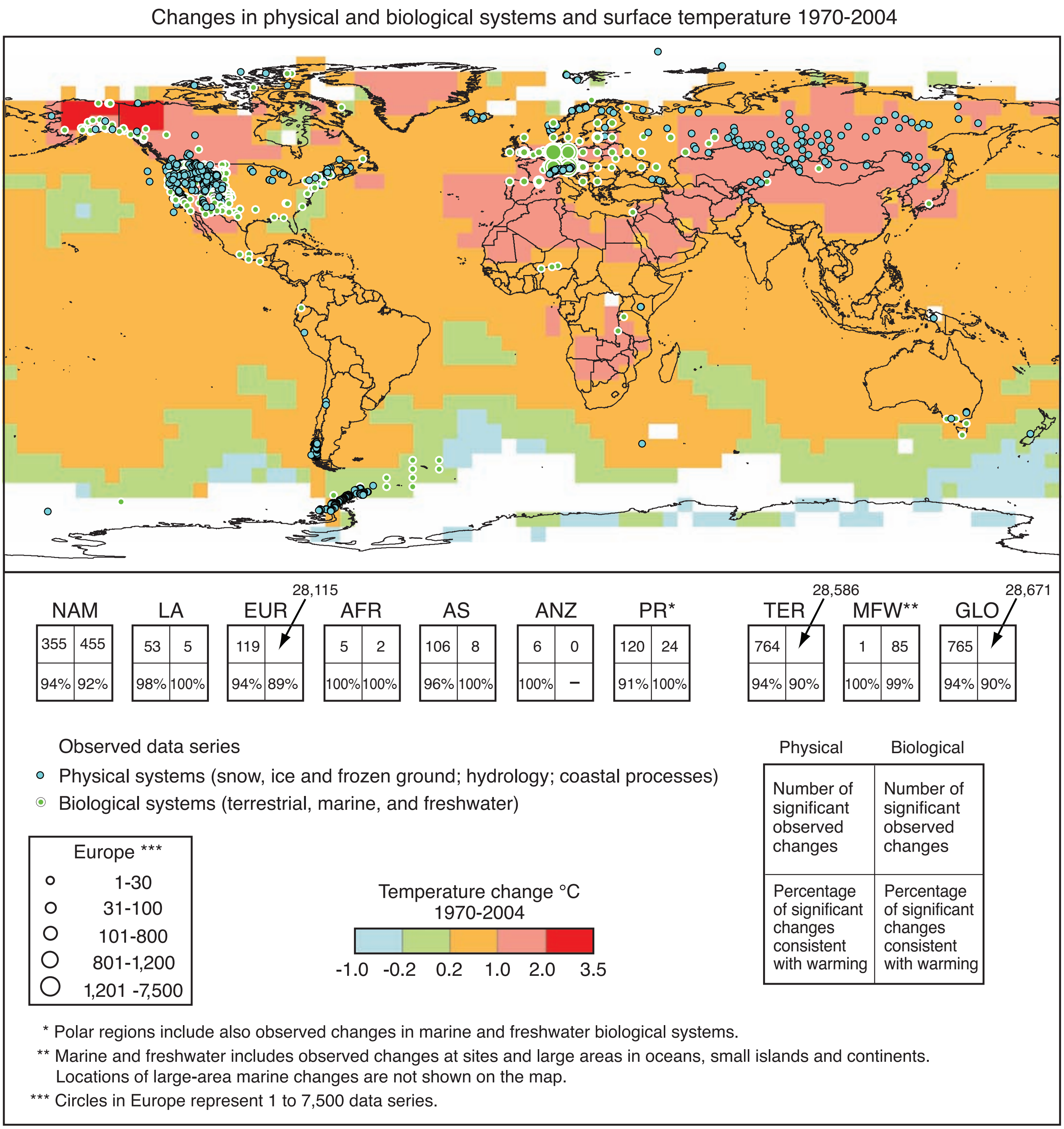

Figure SPM.1. *Locations of significant changes in data series of physical systems (snow, ice and frozen ground; hydrology; and coastal processes) and biological systems (terrestrial, marine, and freshwater biological systems), are shown together with surface air temperature changes over the period 1970-2004. A subset of about 29,000 data series was selected from about 80,000 data series from 577 studies. These met the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; and (3) showing a significant change in either direction, as assessed in individual studies. These data series are from about 75 studies (of which about 70 are new since the Third Assessment) and contain about 29,000 data series, of which about 28,000 are from European studies. White areas do not contain sufficient observational climate data to estimate a temperature trend. The 2 x 2 boxes show the total number of data series with significant changes (top row) and the percentage of those consistent with warming (bottom row) for (i) continental regions: North America (NAM), Latin America (LA), Europe (EUR), Africa (AFR), Asia (AS), Australia and New Zealand (ANZ), and Polar Regions (PR) and (ii) global-scale: Terrestrial (TER), Marine and Freshwater (MFW), and Global (GLO). The numbers of studies from the seven regional boxes (NAM, …, PR) do not add up to the global (GLO) totals because numbers from regions except Polar do not include the numbers related to Marine and Freshwater (MFW) systems. Locations of large-area marine changes are not shown on the map. [Working Group II Fourth Assessment F1.8, F1.9; Working Group I Fourth Assessment F3.9b].*

C. Current knowledge about future impacts

The following is a selection of the key findings regarding projected impacts, as well as some findings on vulnerability and adaptation, in each system, sector and region for the range of (unmitigated) climate changes projected by the IPCC over this century[8] judged to be relevant for people and the environment.[9] The impacts frequently reflect projected changes in precipitation and other climate variables in addition to temperature, sea level and concentrations of atmospheric carbon dioxide. The magnitude and timing of impacts will vary with the amount and timing of climate change and, in some cases, the capacity to adapt. These issues are discussed further in later sections of the Summary.

More specific information is now available across a wide range of systems and sectors concerning the nature of future impacts, including for some fields not covered in previous assessments.

Freshwater resources and their management

By mid-century, annual average river runoff and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, and decrease by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are presently water-stressed areas. In some places and in particular seasons, changes differ from these annual figures. ** D[10] [3.4]

Drought-affected areas will likely increase in extent. Heavy precipitation events, which are very likely to increase in frequency, will augment flood risk. ** N [Working Group I Fourth Assessment Table SPM-2, Working Group II Fourth Assessment 3.4]

In the course of the century, water supplies stored in glaciers and snow cover are projected to decline, reducing water availability in regions supplied by meltwater from major mountain ranges, where more than one-sixth of the world population currently lives. ** N [3.4]

Adaptation procedures and risk management practices for the water sector are being developed in some countries and regions that have recognised projected hydrological changes with related uncertainties. *** N [3.6]

Ecosystems

The resilience of many ecosystems is likely to be exceeded this century by an unprecedented combination of climate change, associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification), and other global change drivers (e.g., land-use change, pollution, over-exploitation of resources). ** N [4.1 to 4.6]

Over the course of this century, net carbon uptake by terrestrial ecosystems is likely to peak before mid-century and then weaken or even reverse,[11] thus amplifying climate change. ** N [4.ES, F4.2]

Approximately 20-30% of plant and animal species assessed so far are likely to be at increased risk of extinction if increases in global average temperature exceed 1.5-2.5°C. * N [4.4, T4.1]

For increases in global average temperature exceeding 1.5-2.5°C and in concomitant atmospheric carbon dioxide concentrations, there are projected to be major changes in ecosystem structure and function, species' ecological interactions, and species' geographical ranges, with predominantly negative consequences for biodiversity, and ecosystem goods and services e.g., water and food supply. ** N [4.4]

The progressive acidification of oceans due to increasing atmospheric carbon dioxide is expected to have negative impacts on marine shell-forming organisms (e.g., corals) and their dependent species. * N [B4.4, 6.4]

Food, fibre and forest products

Crop productivity is projected to increase slightly at mid- to high latitudes for local mean temperature increases of up to 1-3°C depending on the crop, and then decrease beyond that in some regions. * D [5.4]

At lower latitudes, especially seasonally dry and tropical regions, crop productivity is projected to decrease for even small local temperature increases (1-2°C), which would increase the risk of hunger. * D [5.4]

Globally, the potential for food production is projected to increase with increases in local average temperature over a range of 1-3°C, but above this it is projected to decrease. * D [5.4, 5.6]

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[8] Temperature changes are expressed as the difference from the period 1980-1999. To express the change relative to the period 1850-1899, add 0.5°C.
[9] Criteria of choice: magnitude and timing of impact, confidence in the assessment, representative coverage of the system, sector and region.
[10] In Section C, the following conventions are used:
Relationship to the Third Assessment:
D — *Further development of a conclusion in the Third Assessment*
N — *New conclusion, not in the Third Assessment*
Level of confidence in the whole statement:
*** — *Very high confidence*
** — *High confidence*
* — *Medium confidence*
[11] Assuming continued greenhouse gas emissions at or above current rates and other global changes including land-use changes.

Increases in the frequency of droughts and floods are projected to affect local crop production negatively, especially in subsistence sectors at low latitudes. ** D [5.4, 5.ES]

Adaptations such as altered cultivars and planting times allow low- and mid- to high-latitude cereal yields to be maintained at or above baseline yields for modest warming. * N [5.5]

Globally, commercial timber productivity rises modestly with climate change in the short- to medium-term, with large regional variability around the global trend. * D [5.4]

Regional changes in the distribution and production of particular fish species are expected due to continued warming, with adverse effects projected for aquaculture and fisheries. ** D [5.4]

Coastal systems and low-lying areas

Coasts are projected to be exposed to increasing risks, including coastal erosion, due to climate change and sea-level rise. The effect will be exacerbated by increasing human-induced pressures on coastal areas. *** D [6.3, 6.4]

Corals are vulnerable to thermal stress and have low adaptive capacity. Increases in sea surface temperature of about 1-3°C are projected to result in more frequent coral bleaching events and widespread mortality, unless there is thermal adaptation or acclimatisation by corals. *** D [B6.1, 6.4]

Coastal wetlands including salt marshes and mangroves are projected to be negatively affected by sea-level rise especially where they are constrained on their landward side, or starved of sediment. *** D [6.4]

Many millions more people are projected to be flooded every year due to sea-level rise by the 2080s. Those densely-populated and low-lying areas where adaptive capacity is relatively low, and which already face other challenges such as tropical storms or local coastal subsidence, are especially at risk. The numbers affected will be largest in the mega-deltas of Asia and Africa while small islands are especially vulnerable. *** D [6.4]

Adaptation for coasts will be more challenging in developing countries than in developed countries, due to constraints on adaptive capacity. ** D [6.4, 6.5, T6.11]

Industry, settlement and society

Costs and benefits of climate change for industry, settlement and society will vary widely by location and scale. In the aggregate, however, net effects will tend to be more negative the larger the change in climate. ** N [7.4, 7.6]

The most vulnerable industries, settlements and societies are generally those in coastal and river flood plains, those whose economies are closely linked with climate-sensitive resources, and those in areas prone to extreme weather events, especially where rapid urbanisation is occurring. ** D [7.1, 7.3 to 7.5]

Poor communities can be especially vulnerable, in particular those concentrated in high-risk areas. They tend to have more limited adaptive capacities, and are more dependent on climate-sensitive resources such as local water and food supplies. ** N [7.2, 7.4, 5.4]

Where extreme weather events become more intense and/or more frequent, the economic and social costs of those events will increase, and these increases will be substantial in the areas most directly affected. Climate change impacts spread from directly impacted areas and sectors to other areas and sectors through extensive and complex linkages. ** N [7.4, 7.5]

Health

Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, through:

- increases in malnutrition and consequent disorders, with implications for child growth and development;
- increased deaths, disease and injury due to heatwaves, floods, storms, fires and droughts;
- the increased burden of diarrhoeal disease;
- the increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and,
- the altered spatial distribution of some infectious disease vectors. ** D [8.4, 8.ES, 8.2]

Climate change is expected to have some mixed effects, such as a decrease or increase in the range and transmission potential of malaria in Africa. ** D [8.4]

Studies in temperate areas[12] have shown that climate change is projected to bring some benefits, such as fewer deaths from cold exposure. Overall it is expected that these benefits will be outweighed by the negative health effects of rising temperatures worldwide, especially in developing countries. ** D [8.4]

The balance of positive and negative health impacts will vary from one location to another, and will alter over time as temperatures continue to rise. Critically important will be factors that directly shape the health of populations such as education, health care, public health initiatives and infrastructure and economic development. *** N [8.3]

[12] Studies mainly in industrialised countries.

More specific information is now available across the regions of the world concerning the nature of future impacts, including for some places not covered in previous assessments.

Africa

By 2020, between 75 million and 250 million people are projected to be exposed to increased water stress due to climate change. If coupled with increased demand, this will adversely affect livelihoods and exacerbate water-related problems. ** D [9.4, 3.4, 8.2, 8.4]

Agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020. ** N [9.2, 9.4, 9.6]

Local food supplies are projected to be negatively affected by decreasing fisheries resources in large lakes due to rising water temperatures, which may be exacerbated by continued over-fishing. ** N [9.4, 5.4, 8.4]

Towards the end of the 21st century, projected sea-level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5-10% of Gross Domestic Product (GDP). Mangroves and coral reefs are projected to be further degraded, with additional consequences for fisheries and tourism. ** D [9.4]

New studies confirm that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. Some adaptation to current climate variability is taking place; however, this may be insufficient for future changes in climate. ** N [9.5]

Asia

Glacier melt in the Himalayas is projected to increase flooding, and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede. * N [10.2, 10.4]

Freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease due to climate change which, along with population growth and increasing demand arising from higher standards of living, could adversely affect more than a billion people by the 2050s. ** N [10.4]

Coastal areas, especially heavily-populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. ** D [10.4]

Climate change is projected to impinge on the sustainable development of most developing countries of Asia, as it compounds the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation, and economic development. ** D [10.5]

It is projected that crop yields could increase up to 20% in East and South-East Asia while they could decrease up to 30% in Central and South Asia by the mid-21st century. Taken together, and considering the influence of rapid population growth and urbanisation, the risk of hunger is projected to remain very high in several developing countries. * N [10.4]

Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle associated with global warming. Increases in coastal water temperature would exacerbate the abundance and/or toxicity of cholera in South Asia. **N [10.4]

Australia and New Zealand

As a result of reduced precipitation and increased evaporation, water security problems are projected to intensify by 2030 in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions. ** D [11.4]

Significant loss of biodiversity is projected to occur by 2020 in some ecologically rich sites including the Great Barrier Reef and Queensland Wet Tropics. Other sites at risk include Kakadu wetlands, south-west Australia, sub-Antarctic islands and the alpine areas of both countries. *** D [11.4]

Ongoing coastal development and population growth in areas such as Cairns and South-east Queensland (Australia) and Northland to Bay of Plenty (New Zealand), are projected to exacerbate risks from sea-level rise and increases in the severity and frequency of storms and coastal flooding by 2050. *** D [11.4, 11.6]

Production from agriculture and forestry by 2030 is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in western and southern areas and close to major rivers due to a longer growing season, less frost and increased rainfall. ** N [11.4]

The region has substantial adaptive capacity due to well-developed economies and scientific and technical capabilities, but there are considerable constraints to implementation and major challenges from changes in extreme events. Natural systems have limited adaptive capacity. ** N [11.2, 11.5]

Europe

For the first time, wide-ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to a heatwave of unprecedented magnitude. The observed changes described above are consistent with those projected for future climate change. *** N [12.2, 12.4, 12.6]

Nearly all European regions are anticipated to be negatively affected by some future impacts of climate change, and these will pose challenges to many economic sectors. Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods, and more frequent coastal flooding and increased erosion (due to storminess and sea-level rise). The great majority of organisms and ecosystems will have difficulty adapting to climate change. Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emission scenarios by 2080). *** D [12.4]

In Southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. It is also projected to increase health risks due to heat-waves, and the frequency of wildfires. ** D [12.2, 12.4, 12.7]

In Central and Eastern Europe, summer precipitation is projected to decrease, causing higher water stress. Health risks due to heatwaves are projected to increase. Forest productivity is expected to decline and the frequency of peatland fires to increase. ** D [12.4]

In Northern Europe, climate change is initially projected to bring mixed effects, including some benefits such as reduced demand for heating, increased crop yields and increased forest growth. However, as climate change continues, its negative impacts (including more frequent winter floods, endangered ecosystems and increasing ground instability) are likely to outweigh its benefits. ** D [12.4]

Adaptation to climate change is likely to benefit from experience gained in reaction to extreme climate events, specifically by implementing proactive climate change risk management adaptation plans. *** N [12.5]

Latin America

By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. ** D [13.4]

In drier areas, climate change is expected to lead to salinisation and desertification of agricultural land. Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones soybean yields are projected to increase. ** N [13.4, 13.7]

Sea-level rise is projected to cause increased risk of flooding in low-lying areas. Increases in sea surface temperature due to climate change are projected to have adverse effects on Mesoamerican coral reefs, and cause shifts in the location of south-east Pacific fish stocks. ** N [13.4, 13.7]

Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation. ** D [13.4]

Some countries have made efforts to adapt, particularly through conservation of key ecosystems, early warning systems, risk management in agriculture, strategies for flood drought and coastal management, and disease surveillance systems. However, the effectiveness of these efforts is outweighed by: lack of basic information, observation and monitoring systems; lack of capacity building and appropriate political, institutional and technological frameworks; low income; and settlements in vulnerable areas, among others. ** D [13.2]

North America

Warming in western mountains is projected to cause decreased snowpack, more winter flooding, and reduced summer flows, exacerbating competition for over-allocated water resources. *** D [14.4, B14.2]

Disturbances from pests, diseases and fire are projected to have increasing impacts on forests, with an extended period of high fire risk and large increases in area burned. *** N [14.4, B14.1]

Moderate climate change in the early decades of the century is projected to increase aggregate yields of rain-fed agriculture by 5-

20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. ** D [14.4]

Cities that currently experience heatwaves are expected to be further challenged by an increased number, intensity and duration of heatwaves during the course of the century, with potential for adverse health impacts. Elderly populations are most at risk. *** D [14.4].

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution. Population growth and the rising value of infrastructure in coastal areas increase vulnerability to climate variability and future climate change, with losses projected to increase if the intensity of tropical storms increases. Current adaptation is uneven and readiness for increased exposure is low. *** N [14.2, 14.4]

Polar Regions

In the Polar Regions, the main projected biophysical effects are reductions in thickness and extent of glaciers and ice sheets, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. In the Arctic, additional impacts include reductions in the extent of sea ice and permafrost, increased coastal erosion, and an increase in the depth of permafrost seasonal thawing. ** D [15.3, 15.4, 15.2]

For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. ** D [15.4]

Beneficial impacts would include reduced heating costs and more navigable northern sea routes. * D [15.4]

In both polar regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered. ** D [15.6, 15.4]

Arctic human communities are already adapting to climate change, but both external and internal stressors challenge their adaptive capacities. Despite the resilience shown historically by Arctic indigenous communities, some traditional ways of life are being threatened and substantial investments are needed to adapt or re-locate physical structures and communities. ** D [15.ES, 15.4, 15.5, 15.7]

Small islands

Small islands, whether located in the tropics or higher latitudes, have characteristics which make them especially vulnerable to the effects of climate change, sea-level rise and extreme events. *** D [16.1, 16.5]

Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources, e.g., fisheries, and reduce the value of these destinations for tourism. ** D [16.4]

Sea-level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. *** D [16.4]

Climate change is projected by mid-century to reduce water resources in many small islands, e.g., in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. *** D [16.4]

With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands. ** N [16.4]

Magnitudes of impact can now be estimated more systematically for a range of possible increases in global average temperature.

Since the IPCC Third Assessment, many additional studies, particularly in regions that previously had been little researched, have enabled a more systematic understanding of how the timing and magnitude of impacts may be affected by changes in climate and sea level associated with differing amounts and rates of change in global average temperature.

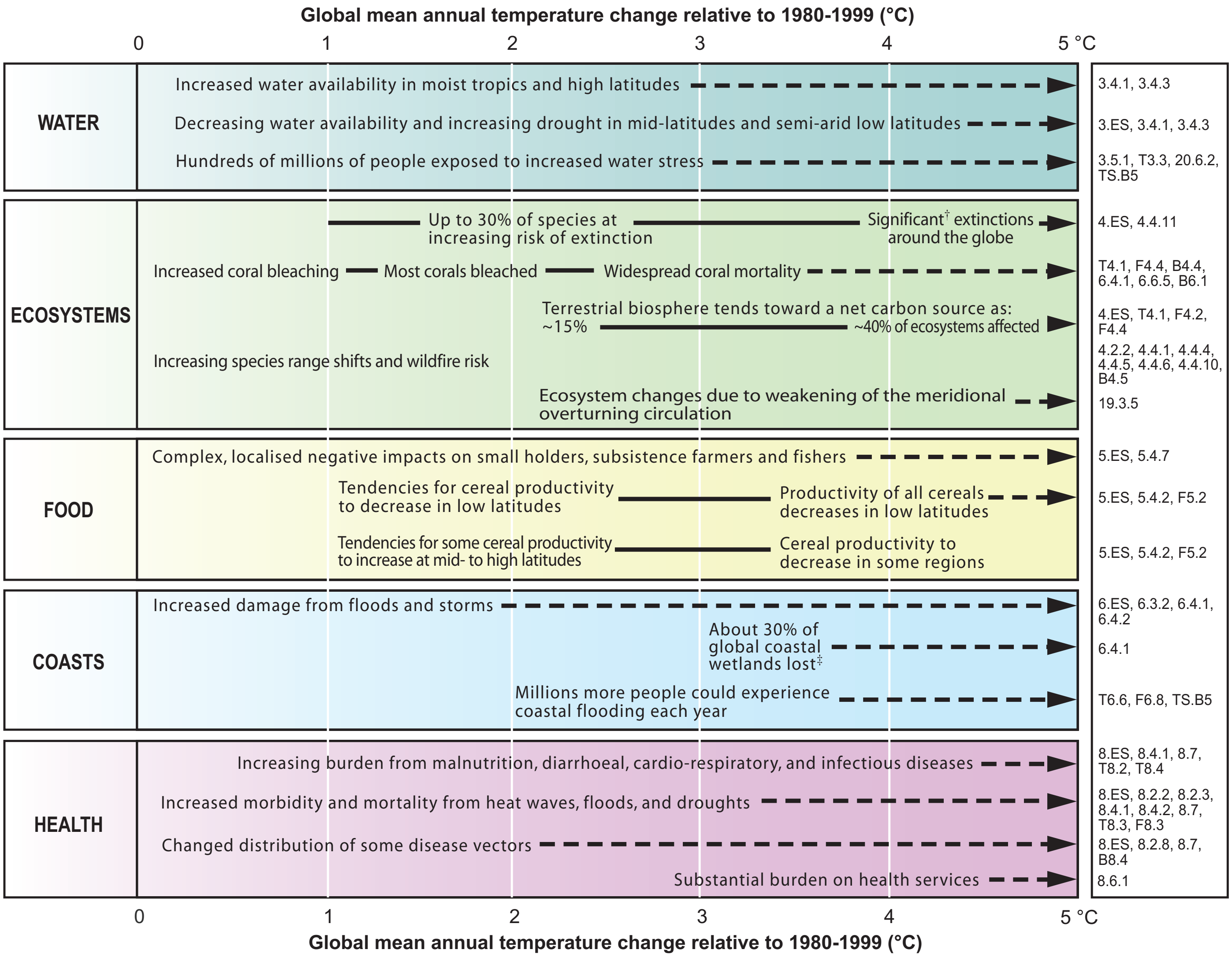
Examples of this new information are presented in Figure SPM.2. Entries have been selected which are judged to be relevant for people and the environment and for which there is high confidence in the assessment. All examples of impact are drawn from chapters of the Assessment, where more detailed information is available.

Depending on circumstances, some of these impacts could be associated with ‘key vulnerabilities’, based on a number of criteria in the literature (magnitude, timing, persistence/reversibility, the potential for adaptation, distributional aspects, likelihood and ‘importance’ of the impacts). Assessment of potential key vulnerabilities is intended to provide information on rates and levels of climate change to help decision-makers make appropriate responses to the risks of climate change [19.ES, 19.1].

The ‘reasons for concern’ identified in the Third Assessment remain a viable framework for considering key vulnerabilities. Recent research has updated some of the findings from the Third Assessment [19.3].

Key impacts as a function of increasing global average temperature change

(Impacts will vary by extent of adaptation, rate of temperature change, and socio-economic pathway)



† Significant is defined here as more than 40%.
‡ Based on average rate of sea level rise of 4.2 mm/year from 2000 to 2080.

Figure SPM.2. *Illustrative examples of global impacts projected for climate changes (and sea level and atmospheric carbon dioxide where relevant) associated with different amounts of increase in global average surface temperature in the 21st century [T20.8]. The black lines link impacts, dotted arrows indicate impacts continuing with increasing temperature. Entries are placed so that the left-hand side of the text indicates the approximate onset of a given impact. Quantitative entries for water stress and flooding represent the additional impacts of climate change relative to the conditions projected across the range of Special Report on Emissions Scenarios (SRES) scenarios A1FI, A2, B1 and B2 (see Endbox 3). Adaptation to climate change is not included in these estimations. All entries are from published studies recorded in the chapters of the Assessment. Sources are given in the right-hand column of the Table. Confidence levels for all statements are high.*

Impacts due to altered frequencies and intensities of extreme weather, climate and sea-level events are very likely to change.

Since the IPCC Third Assessment, confidence has increased that some weather events and extremes will become more frequent, more widespread and/or more intense during the 21st century; and more is known about the potential effects of such changes. A selection of these is presented in Table SPM.1.

The direction of trend and likelihood of phenomena are for IPCC SRES projections of climate change.

Some large-scale climate events have the potential to cause very large impacts, especially after the 21st century.

Very large sea-level rises that would result from widespread deglaciation of Greenland and West Antarctic ice sheets imply major changes in coastlines and ecosystems, and inundation of low-lying areas, with greatest effects in river deltas. Relocating populations, economic activity, and infrastructure would be costly and challenging. There is medium confidence that at least partial deglaciation of the Greenland ice sheet, and possibly the West Antarctic ice sheet, would occur over a period of time ranging from centuries to millennia for a global average temperature increase of 1-4°C (relative to 1990-2000), causing a contribution to sea-level rise of 4-6 m or more. The complete melting of the Greenland ice sheet and the West Antarctic ice sheet would lead to a contribution to sea-level rise of up to 7 m and about 5 m, respectively [Working Group I Fourth Assessment 6.4, 10.7; Working Group II Fourth Assessment 19.3].

Based on climate model results, it is very unlikely that the Meridional Overturning Circulation (MOC) in the North Atlantic will undergo a large abrupt transition during the 21st century. Slowing of the MOC during this century is very likely, but temperatures over the Atlantic and Europe are projected to increase nevertheless, due to global warming. Impacts of large-scale and persistent changes in the MOC are likely to include changes to marine ecosystem productivity, fisheries, ocean carbon dioxide uptake, oceanic oxygen concentrations and terrestrial vegetation [Working Group I Fourth Assessment 10.3, 10.7; Working Group II Fourth Assessment 12.6, 19.3].

Impacts of climate change will vary regionally but, aggregated and discounted to the present, they are very likely to impose net annual costs which will increase over time as global temperatures increase.

This Assessment makes it clear that the impacts of future climate change will be mixed across regions. For increases in global mean temperature of less than 1-3°C above 1990 levels, some impacts are projected to produce benefits in some places and some sectors, and produce costs in other places and other sectors. It is, however, projected that some low-latitude and polar regions will experience net costs even for small increases in temperature. It is very likely that all regions will experience either declines in net benefits or increases in net costs for increases in temperature greater than about 2-3°C [9.ES, 9.5, 10.6, T10.9, 15.3, 15.ES]. These observations confirm evidence reported in the Third Assessment that, while developing countries are expected to experience larger percentage losses, global mean losses could be 1-5% GDP for 4°C of warming [F20.3].

Many estimates of aggregate net economic costs of damages from climate change across the globe (i.e., the social cost of carbon (SCC), expressed in terms of future net benefits and costs that are discounted to the present) are now available. Peer-reviewed estimates of the SCC for 2005 have an average value of US$43 per tonne of carbon (i.e., US$12 per tonne of carbon dioxide), but the range around this mean is large. For example, in a survey of 100 estimates, the values ran from US$-10 per tonne of carbon (US$-3 per tonne of carbon dioxide) up to US$350 per tonne of carbon (US$95 per tonne of carbon dioxide) [20.6].

The large ranges of SCC are due in the large part to differences in assumptions regarding climate sensitivity, response lags, the treatment of risk and equity, economic and non-economic impacts, the inclusion of potentially catastrophic losses, and discount rates. It is very likely that globally aggregated figures underestimate the damage costs because they cannot include many non-quantifiable impacts. Taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time [T20.3, 20.6, F20.4].

It is virtually certain that aggregate estimates of costs mask significant differences in impacts across sectors, regions, countries and populations. In some locations and among some groups of people with high exposure, high sensitivity and/or low adaptive capacity, net costs will be significantly larger than the global aggregate [20.6, 20.ES, 7.4].

Phenomenon[a] and direction of trend	Likelihood of future trends based on projections for 21st century using SRES scenarios	Examples of major projected impacts by sector			
		Agriculture, forestry and ecosystems [4.4, 5.4]	Water resources [3.4]	Human health [8.2, 8.4]	Industry, settlement and society [7.4]
Over most land areas, warmer and fewer cold days and nights, warmer and more frequent hot days and nights	Virtually certain[b]	Increased yields in colder environments; decreased yields in warmer environments; increased insect outbreaks	Effects on water resources relying on snow melt; effects on some water supplies	Reduced human mortality from decreased cold exposure	Reduced energy demand for heating; increased demand for cooling; declining air quality in cities; reduced disruption to transport due to snow, ice; effects on winter tourism
Warm spells/heat waves. Frequency increases over most land areas	Very likely	Reduced yields in warmer regions due to heat stress; increased danger of wildfire	Increased water demand; water quality problems, e.g., algal blooms	Increased risk of heat-related mortality, especially for the elderly, chronically sick, very young and socially-isolated	Reduction in quality of life for people in warm areas without appropriate housing; impacts on the elderly, very young and poor
Heavy precipitation events. Frequency increases over most areas	Very likely	Damage to crops; soil erosion, inability to cultivate land due to waterlogging of soils	Adverse effects on quality of surface and groundwater; contamination of water supply; water scarcity may be relieved	Increased risk of deaths, injuries and infectious, respiratory and skin diseases	Disruption of settlements, commerce, transport and societies due to flooding; pressures on urban and rural infrastructures; loss of property
Area affected by drought increases	Likely	Land degradation; lower yields/crop damage and failure; increased livestock deaths; increased risk of wildfire	More widespread water stress	Increased risk of food and water shortage; increased risk of malnutrition; increased risk of water- and food-borne diseases	Water shortages for settlements, industry and societies; reduced hydropower generation potentials; potential for population migration
Intense tropical cyclone activity increases	Likely	Damage to crops; windthrow (uprooting) of trees; damage to coral reefs	Power outages causing disruption of public water supply	Increased risk of deaths, injuries, water- and food-borne diseases; post-traumatic stress disorders	Disruption by flood and high winds; withdrawal of risk coverage in vulnerable areas by private insurers, potential for population migrations, loss of property
Increased incidence of extreme high sea level (excludes tsunamis)[c]	Likely[d]	Salinisation of irrigation water, estuaries and freshwater systems	Decreased freshwater availability due to saltwater intrusion	Increased risk of deaths and injuries by drowning in floods; migration-related health effects	Costs of coastal protection versus costs of land-use relocation; potential for movement of populations and infrastructure; also see tropical cyclones above

[a] See Working Group I Fourth Assessment Table 3.7 for further details regarding definitions.
[b] Warming of the most extreme days and nights each year.
[c] Extreme high sea level depends on average sea level and on regional weather systems. It is defined as the highest 1% of hourly values of observed sea level at a station for a given reference period.
[d] In all scenarios, the projected global average sea level at 2100 is higher than in the reference period [Working Group I Fourth Assessment 10.6]. The effect of changes in regional weather systems on sea level extremes has not been assessed.

Table SPM.1. *Examples of possible impacts of climate change due to changes in extreme weather and climate events, based on projections to the mid- to late 21st century. These do not take into account any changes or developments in adaptive capacity. Examples of all entries are to be found in chapters in the full Assessment (see source at top of columns). The first two columns of the table (shaded yellow) are taken directly from the Working Group I Fourth Assessment (Table SPM-2). The likelihood estimates in Column 2 relate to the phenomena listed in Column 1.*

D. Current knowledge about responding to climate change

Some adaptation is occurring now, to observed and projected future climate change, but on a limited basis.

There is growing evidence since the IPCC Third Assessment of human activity to adapt to observed and anticipated climate change. For example, climate change is considered in the design of infrastructure projects such as coastal defence in the Maldives and The Netherlands, and the Confederation Bridge in Canada. Other examples include prevention of glacial lake outburst flooding in Nepal, and policies and strategies such as water management in Australia and government responses to heat-waves in, for example, some European countries [7.6, 8.2, 8.6, 17.ES, 17.2, 16.5, 11.5].

Adaptation will be necessary to address impacts resulting from the warming which is already unavoidable due to past emissions.

Past emissions are estimated to involve some unavoidable warming (about a further 0.6°C by the end of the century relative to 1980-1999) even if atmospheric greenhouse gas concentrations remain at 2000 levels (see Working Group I Fourth Assessment). There are some impacts for which adaptation is the only available and appropriate response. An indication of these impacts can be seen in Figure SPM.2.

A wide array of adaptation options is available, but more extensive adaptation than is currently occurring is required to reduce vulnerability to future climate change. There are barriers, limits and costs, but these are not fully understood.

Impacts are expected to increase with increases in global average temperature, as indicated in Figure SPM.2. Although many early impacts of climate change can be effectively addressed through adaptation, the options for successful adaptation diminish and the associated costs increase with increasing climate change. At present we do not have a clear picture of the limits to adaptation, or the cost, partly because effective adaptation measures are highly dependent on specific, geographical and climate risk factors as well as institutional, political and financial constraints [7.6, 17.2, 17.4].

The array of potential adaptive responses available to human societies is very large, ranging from purely technological (e.g., sea defences), through behavioural (e.g., altered food and recreational choices), to managerial (e.g., altered farm practices) and to policy (e.g., planning regulations). While most technologies and strategies are known and developed in some countries, the assessed literature does not indicate how effective various options[13] are at fully reducing risks, particularly at higher levels of warming and related impacts, and for vulnerable groups. In addition, there are formidable environmental, economic, informational, social, attitudinal and behavioural barriers to the implementation of adaptation. For developing countries, availability of resources and building adaptive capacity are particularly important [see Sections 5 and 6 in Chapters 3-16; also 17.2, 17.4].

Adaptation alone is not expected to cope with all the projected effects of climate change, and especially not over the long term as most impacts increase in magnitude [Figure SPM.2].

Vulnerability to climate change can be exacerbated by the presence of other stresses.

Non-climate stresses can increase vulnerability to climate change by reducing resilience and can also reduce adaptive capacity because of resource deployment to competing needs. For example, current stresses on some coral reefs include marine pollution and chemical runoff from agriculture as well as increases in water temperature and ocean acidification. Vulnerable regions face multiple stresses that affect their exposure and sensitivity as well as their capacity to adapt. These stresses arise from, for example, current climate hazards, poverty and unequal access to resources, food insecurity, trends in economic globalisation, conflict, and incidence of diseases such as HIV/AIDS [7.4, 8.3, 17.3, 20.3]. Adaptation measures are seldom undertaken in response to climate change alone but can be integrated within, for example, water resource management, coastal defence and risk-reduction strategies [17.2, 17.5].

Future vulnerability depends not only on climate change but also on development pathway.

An important advance since the IPCC Third Assessment has been the completion of impacts studies for a range of different development pathways taking into account not only projected climate change but also projected social and economic changes. Most have been based on characterisations of population and income level drawn from the IPCC Special Report on Emission Scenarios (SRES) (see Endbox 3) [2.4].

[13] A table of options is given in the Technical Summary

These studies show that the projected impacts of climate change can vary greatly due to the development pathway assumed. For example, there may be large differences in regional population, income and technological development under alternative scenarios, which are often a strong determinant of the level of vulnerability to climate change [2.4].

To illustrate, in a number of recent studies of global impacts of climate change on food supply, risk of coastal flooding and water scarcity, the projected number of people affected is considerably greater under the A2-type scenario of development (characterised by relatively low per capita income and large population growth) than under other SRES futures [T20.6]. This difference is largely explained, not by differences in changes of climate, but by differences in vulnerability [T6.6].

Sustainable development[14] can reduce vulnerability to climate change, and climate change could impede nations' abilities to achieve sustainable development pathways.

Sustainable development can reduce vulnerability to climate change by enhancing adaptive capacity and increasing resilience. At present, however, few plans for promoting sustainability have explicitly included either adapting to climate change impacts, or promoting adaptive capacity [20.3].

On the other hand, it is very likely that climate change can slow the pace of progress towards sustainable development, either directly through increased exposure to adverse impact or indirectly through erosion of the capacity to adapt. This point is clearly demonstrated in the sections of the sectoral and regional chapters of this report that discuss the implications for sustainable development [See Section 7 in Chapters 3-8, 20.3, 20.7].

The Millennium Development Goals (MDGs) are one measure of progress towards sustainable development. Over the next half-century, climate change could impede achievement of the MDGs [20.7].

Many impacts can be avoided, reduced or delayed by mitigation.

A small number of impact assessments have now been completed for scenarios in which future atmospheric concentrations of greenhouse gases are stabilised. Although these studies do not take full account of uncertainties in projected climate under stabilisation, they nevertheless provide indications of damages avoided or vulnerabilities and risks reduced for different amounts of emissions reduction [2.4, T20.6].

A portfolio of adaptation and mitigation measures can diminish the risks associated with climate change.

Even the most stringent mitigation efforts cannot avoid further impacts of climate change in the next few decades, which makes adaptation essential, particularly in addressing near-term impacts. Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt [20.7].

This suggests the value of a portfolio or mix of strategies that includes mitigation, adaptation, technological development (to enhance both adaptation and mitigation) and research (on climate science, impacts, adaptation and mitigation). Such portfolios could combine policies with incentive-based approaches, and actions at all levels from the individual citizen through to national governments and international organisations [18.1, 18.5].

One way of increasing adaptive capacity is by introducing the consideration of climate change impacts in development planning [18.7], for example, by:
- including adaptation measures in land-use planning and infrastructure design [17.2];
- including measures to reduce vulnerability in existing disaster risk reduction strategies [17.2, 20.8].

E. Systematic observing and research

Although the science to provide policymakers with information about climate change impacts and adaptation potential has improved since the Third Assessment, it still leaves many important questions to be answered. The chapters of the Working Group II Fourth Assessment include a number of judgements about priorities for further observation and research, and this advice should be considered seriously (a list of these recommendations is given in the Technical Summary Section TS-6).

[14] The Brundtland Commission definition of sustainable development is used in this Assessment: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". The same definition was used by the IPCC Working Group II Third Assessment and Third Assessment Synthesis Report.

Endbox 1. Definitions of key terms

Climate change in IPCC usage refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the Framework Convention on Climate Change, where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.

Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Endbox 2. Communication of Uncertainty in the Working Group II Fourth Assessment

A set of terms to describe uncertainties in current knowledge is common to all parts of the IPCC Fourth Assessment.

Description of confidence
Authors have assigned a confidence level to the major statements in the Summary for Policymakers on the basis of their assessment of current knowledge, as follows:

Terminology	*Degree of confidence in being correct*
Very high confidence	At least 9 out of 10 chance of being correct
High confidence	About 8 out of 10 chance
Medium confidence	About 5 out of 10 chance
Low confidence	About 2 out of 10 chance
Very low confidence	Less than a 1 out of 10 chance

Description of likelihood
Likelihood refers to a probabilistic assessment of some well-defined outcome having occurred or occurring in the future, and may be based on quantitative analysis or an elicitation of expert views. In the Summary for Policymakers, when authors evaluate the likelihood of certain outcomes, the associated meanings are:

Terminology	*Likelihood of the occurrence/ outcome*
Virtually certain	>99% probability of occurrence
Very likely	90 to 99% probability
Likely	66 to 90% probability
About as likely as not	33 to 66% probability
Unlikely	10 to 33% probability
Very unlikely	1 to 10% probability
Exceptionally unlikely	<1% probability

Endbox 3. The Emissions Scenarios of the IPCC Special Report on Emissions Scenarios (SRES)

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

An illustrative scenario was chosen for each of the six scenario groups A1B, A1FI, A1T, A2, B1 and B2. All should be considered equally sound.

The SRES scenarios do not include additional climate initiatives, which means that no scenarios are included that explicitly assume implementation of the United Nations Framework Convention on Climate Change or the emissions targets of the Kyoto Protocol.

Golden State Water Company

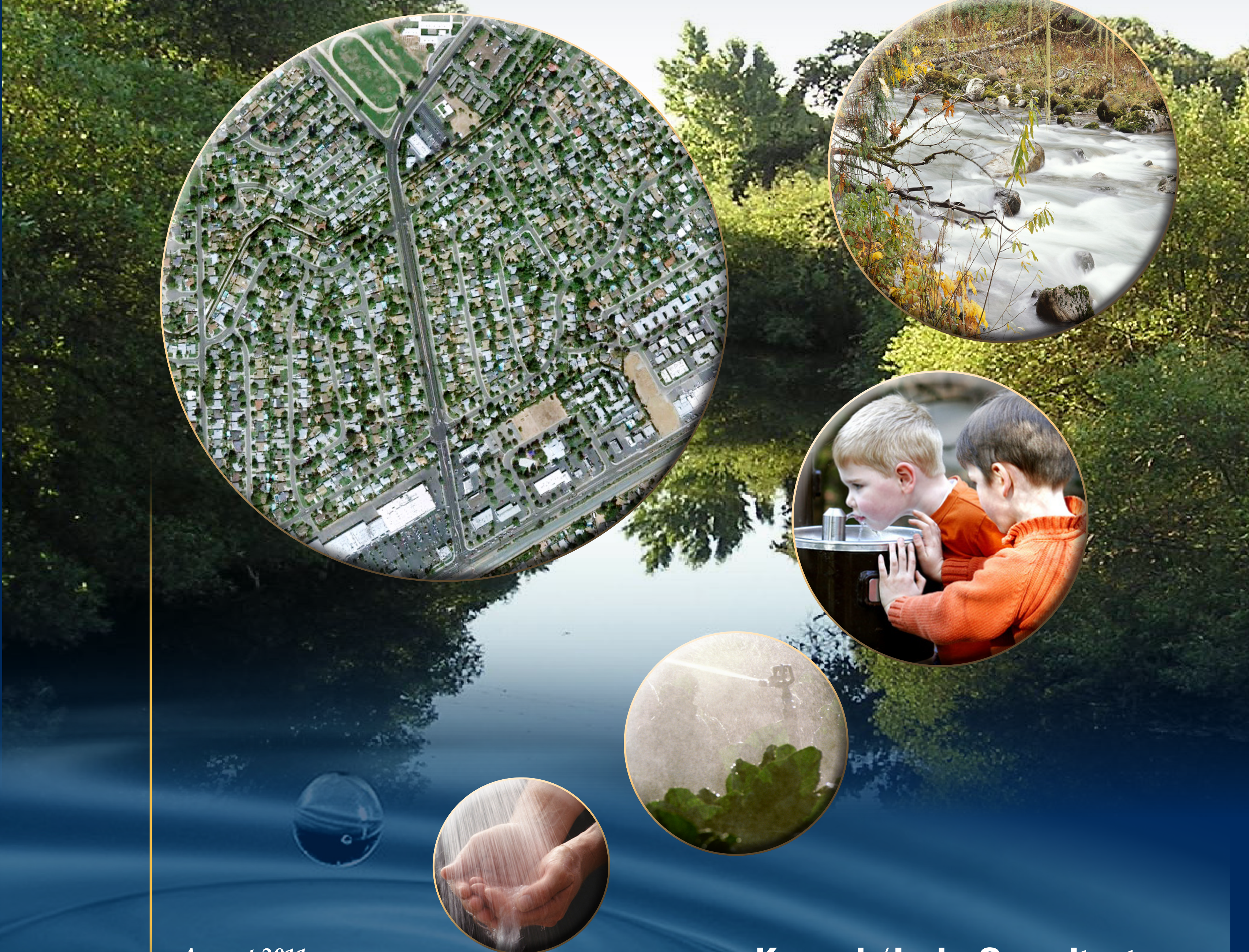
A Subsidiary of American States Water Company

Final Report

2010 Urban Water Management Plan

South San Gabriel

Corporate Office
630 E. Foothill Blvd.
San Dimas CA 91773



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10850 Gold Center Drive, Suite 350
Rancho Cordova, CA 95670

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Notice of Adoption

A meeting to solicit public comments on the 2010 Urban Water Management Plan for the Golden State Water Company South San Gabriel System was held on July 19, 2011 at 6 p.m. at the San Dimas Community Center in San Dimas, California. Notice of this meeting was published in accordance with Section 6066 of the Government Code in the San Gabriel Valley Tribune on May 17, 22, and June 15, 2011.

Copies of the Urban Water Management Plan were made available to the public at the Golden State Water Company Customer Service Office in Arcadia, California, at least one week prior to the public hearing.

Golden State Water Company, hereby, adopts the 2010 Urban Water Management Plan for the South San Gabriel System.

William C. Gedney
Vice President, Asset Management
Golden State Water Company

August 31, 2011

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Abbreviations

µg/L	micrograms per liter
ac-ft	acre-feet
ac-ft/yr or AFY	acre-feet per year
Act	Urban Water Management Planning Act
AMR	automatic meter reading
AWWA	American Water Works Association
BMPs	best management practices
Cal EMA	California Emergency Management Agency
CAL Green Code	California Green Building Standards Code
ccf	hundred cubic feet
CDPH	California Department of Public Health
CII	commercial, industrial, institutional
CIMIS	California Irrigation Management Information System
COG	Council of Governments
Council or CUWCC	California Urban Water Conservation Council
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
D/DBP	disinfectant/disinfection by-product
DMM	Demand Management Measure
DOF	Department of Finance
DSC	Discovery Science Center
DWF	dry weather flow
DWR	Department of Water Resources (California)
DWR Guidebook	Guidebook to Assist Water Suppliers in the Preparation of a 2010 Urban Water Management Plan

ERP	Emergency Response Plan
ETo	evapotranspiration
GAC	Granular Activated Carbon
GIS	Geographic Information System
gpcd	gallons per capita day
gpd	gallons per day
gpm	U.S. gallons per minute
GSWC	Golden State Water Company
HCD	Housing and Community Development
HECW	high-efficiency clothes washers
HET	high-efficiency toilets
IRP	Integrated Resources Plan
LACSD	Sanitation Districts of Los Angeles County
MAF	million acre-feet per year
MCL	maximum contaminant levels
Metropolitan	Metropolitan Water District of Southern California
MF	multi-family
mgd	million gallons per day
MOU	memorandum of understanding (regarding urban water conservation in California)
msl	mean sea level
N/A	not available, not applicable
NAICS	North American Industry Classification System
O&M	operation and maintenance
OSY	operating safe yield
pCi/L	picoCuries per liter
RAP	Resource Action Programs
RHNA	Regional Housing Needs Allocation

RTP	Regional Transportation Plan
RUWMP	Regional Urban Water Management Plan
SBX7-7	Senate Bill X7-7, The Water Conservation Act of 2009
SCAG	Southern California Association of Governments
SD	Science Discover
SDWA	Safe Drinking Water Act
SF	single-family
SWP	State Water Project
TAF	thousand acre-feet per year
ULFT	ultra-low-flush-toilet
Upper District	Upper San Gabriel Valley Municipal Water District
USEPA	U.S. Environmental Protection Agency
USGVMWD	Upper San Gabriel Valley Municipal Water District
UWMP	Urban Water Management Plan
VOCs	volatile organic compounds
WAP	Water Action Plan
WBIC	weather based irrigation controllers
WLCD	Water Loss Control Department
WRCC	Western Regional Climate Center
WRP	water reclamation plant
WSAP	Water Supply Allocation Plan
WSDM Plan	Water Surplus and Drought Management Plan
WSS	WaterSense Specification

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Definitions

Chapter 2, Part 2.6, Division 6 of the California Water Code provides definitions for the construction of the Urban Water Management Plans. Appendix A contains the full text of the Urban Water Management Planning Act.

CHAPTER 2. DEFINITIONS

Section 10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

Section 10611.5. "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

Section 10612. "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

Section 10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

Section 10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

Section 10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, and reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

Section 10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

Section 10616.5. "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

Section 10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

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Chapter 1: Plan Preparation

1.1 Background

This Urban Water Management Plan (UWMP) has been prepared for the Golden State Water Company (GSWC) South San Gabriel System in compliance with Division 6, Part 2.6, of the California Water Code, Sections 10608 through 10657 as last amended by Senate Bill No. 7 (SBX7-7), the Water Conservation Act of 2009. The original bill requiring an UWMP was enacted in 1983. SBX7-7, which became law in November 2009, requires increased emphasis on water demand management and requires the state to achieve a 20 percent reduction in urban per capita water use by December 31, 2020.

Urban water suppliers having more than 3,000 service connections or water use of more than 3,000 acre-feet per year (ac-ft/yr) for retail or wholesale uses are required to submit a UWMP every 5 years to the California Department of Water Resources (DWR). The UWMP typically must be submitted by December 31 of years ending in 0 and 5, however SBX7-7 extended the UWMP deadline to July 1, 2011 to provide for development by DWR of required evaluation methodologies for determining water demand reduction targets. GSWC prepared an UWMP for the South San Gabriel System in 1985, 1990, 1995, 2000, and 2005. This 2010 UWMP is an update to the 2005 plan.

GSWC water use targets for the South San Gabriel System were developed based on Compliance Method 3 and the Minimum Reduction requirement, as described by SBX7-7 and supplemental guidance from DWR.

The portion of the Urban Water Management Planning Act (Act) that describes the purpose and intent of the UWMP states and declares the following:

Section 10610.2.

(a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact on water management strategies and supply reliability.

(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

Section 10610.4. The Legislature finds and declares that it is the policy of the state as follows:

(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.

(b) The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions.

(c) Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies.

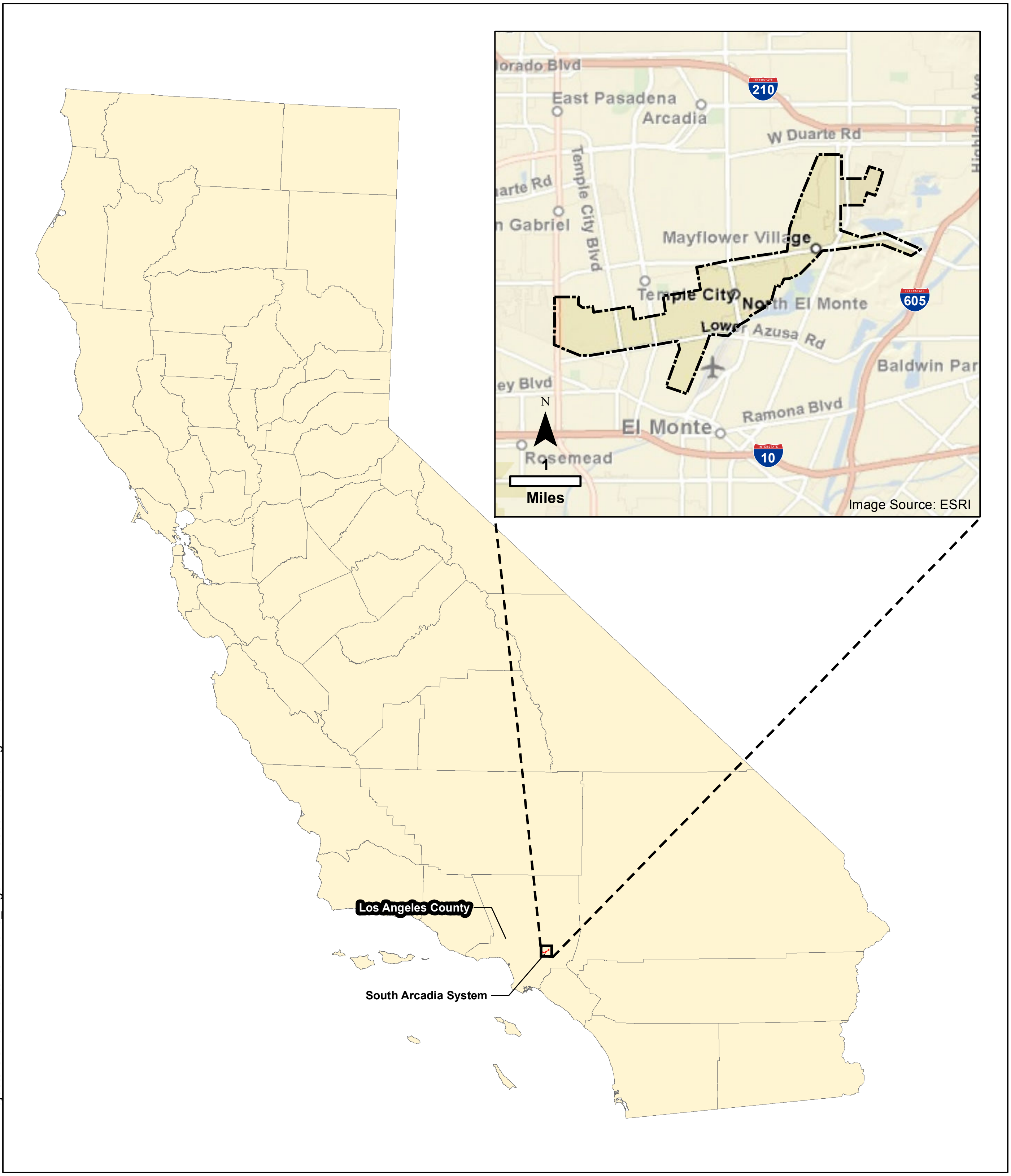
1.2 System Overview

GSWC is an investor-owned public utility company which owns 38 water systems throughout California regulated by the California Public Utilities Commission (CPUC). This UWMP has been prepared for the South San Gabriel System.

Located in Los Angeles County, the South San Gabriel System serves half of the City of Rosemead, parts of the City of San Gabriel, the City of Monterey Park, and adjacent unincorporated areas of Los Angeles County. The service area is primarily characterized by residential and commercial areas. Figure 1-1 illustrates the location of the South San Gabriel System.

1.3 Notice of Document Use

GSWC is committed to implementation of the projects, plans, and discussions provided within this document. However, it is important to note that execution of the plan is contingent upon the regulatory limitations and approval of the CPUC and other state agencies. Additionally, this document merely presents the water supply, reliability, and conservation programs known and in effect at the time of adoption of this plan.



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South Arcadia Service Area

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Kennedy/Jenks Consultants

Golden State Water Company
2010 Urban Water Management Plan

South Arcadia System
Location Map

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August 2011

Figure 1-1

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1.4 Public Utility Commission 2010 Water Action Plan

The CPUC adopted the 2005 Water Action Plan (WAP) in December 2005 and an updated 2010 WAP in October 2010. The WAP is a general policy document, and specific implementation of policies and programs, along with modifications to CPUC ratemaking policies, and other programs including conservation, long-term planning, water quality and drought management programs are ongoing.

The purpose of the 2010 WAP update was to establish renewed focus on the following elements:

1. Maintain the highest standards of water quality;
2. Promote water infrastructure investment;
3. Strengthen water conservation programs to a level comparable to those of energy utilities;
4. Streamline CPUC regulatory decision-making;
5. Set rates that balance investment, conservation, and affordability; and
6. Assist low-income ratepayers.

GSWC has been actively involved with the CPUC in suggesting optimal approaches to the WAP. In particular, the GSWC has suggested specific implementation measures and modifications to certain CPUC rate setting practices so that regulated utilities are able as a practical matter to achieve the policy objectives of the WAP. These efforts are intended to include further investment in local resource optimization, reduced reliance on imported supplies, enhanced conservation, and intensification of company-wide efforts to optimize water resource mix, including planned water supply projects and programs to meet the long-term water supply needs of GSWC's customers.

1.5 Agency Coordination

The 2010 UWMP requirements for agency coordination include specific timetables and requirements as presented in this chapter. The required elements of the Act are as follows:

Section 10620.

(d) (2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

Section 10621.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

Section 10635.

(b) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

Section 10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area.

Table 1-1 lists the agencies with which coordination occurred while preparing this 2010 UWMP. The initial coordination included the distribution of letter notification and request for information as indicated in Table 1-1 followed by telephone correspondence as necessary to obtain supporting data for the preparation of the UWMP. Table 1-1 also provides a checklist of agencies that have been provided the notifications and access to the documents.

Table 1-1: Coordination with Agencies

Agency	Contacted for Assistance	Participated in UWMP Development	Commented on the Draft	Attended Public Meetings	Received Copy of the Draft	Sent Notice of Intent to Adopt	Not Involved / No Information
Southern California Association of Governments	✓						
City of Anaheim	✓	✓				✓	
City of Monterey Park	✓					✓	
City of Rosemead	✓					✓	
City of San Gabriel	✓	✓				✓	
Covina Irrigating Company	✓	✓				✓	
County of Los Angeles	✓					✓	
Upper San Gabriel Valley Municipal Water District	✓				✓	✓	
Los Angeles County Sanitation District	✓	✓				✓	

Note:
This table is based on DWR's *Guidebook to Assist Water Suppliers in the Preparation of a 2010 Urban Water Management Plan* (DWR Guidebook) Table 1.

1.6 Plan Adoption and Submittal

Public participation and plan adoption requirements are detailed in the following sections of the Act:

> *Section 10621.*
>
> *(c) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640)*
>
> *Section 10642. After the hearing, the plan shall be adopted as prepared or as modified after the hearing.*
>
> *Section 10644.*
>
> *(a) An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption.*
>
> *Section 10645. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.*

A public hearing to review the 2010 South San Gabriel System UWMP was held on July 19, 2011 at the San Dimas Community Center in San Dimas, California. This public session was held for review and comment on the draft UWMP before approval by GSWC. Legal public notices for the public hearing and availability of the plan for review and comment were published in advance in the local newspapers in accordance with Government Code Section 6066. Notifications were also posted to GSWC’s website (www.gswater.com).

In addition, notifications of preparation of the plan were provided to cities and counties within which GSWC provides water at least 60 days in advance of the public hearing as required by the Act. Copies of the draft plan were available to the public for review at GSWC’s South San Gabriel office and posted on GSWC’s website. Appendix B contains the following:

- Copy of the public hearing notice from the local newspaper,
- Screen capture of website posting of public hearing notice,
- Notifications and follow-up correspondence provided to cities and counties, and
- Meeting minutes from the public hearing pertaining to the UWMP.

The final UWMP, as adopted by GSWC, will be submitted to DWR, the California State Library, and cities and counties within which GSWC provides water within 30 days of adoption. Likewise, copies of any amendments or changes to the plan will be provided to the aforementioned entities within 30 days. This plan includes all information necessary to meet the requirements of California Water Code Division 6, Part 2.6 (Urban Water Management Planning). Adopted copies of this plan will be made available to the public at GSWC’s South San Gabriel Customer Service Office no later than 30 days after submitting the final UWMP to DWR.

1.7 UWMP Preparation

GSWC prepared this UWMP with the assistance of its consultant, Kennedy/Jenks Consultants, as permitted by the following section of the Act:

> *Section 10620.*
>
> *(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.*

During the preparation of the UWMP, documents that have been prepared over the years by GSWC and other entities were reviewed and information from those documents incorporated, as applicable, into this UWMP. The list of references is provided in Chapter 9.

The adopted plan is available for public review at GSWC's South San Gabriel Office as required by Section 10645. Copies of the plan were submitted to DWR, cities and counties within the service area, the State Library, and other applicable institutions within 30 days of adoption as required by Section 10644. Appendix H includes copies of the transmittals included with the adopted plan as supporting documentation.

1.8 UWMP Implementation

> *Section 10643. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.*

GSWC is committed to the implementation of this UWMP concurrent with the scheduled activities identified herein as required by Section 10643 of the Act. Each system is managed through GSWC District offices and is afforded staff with appropriate regulatory approval to properly plan and implement responses identified in this document and other key planning efforts to proactively address water supply reliability challenges. Furthermore, each region of GSWC has a conservation coordinator that oversees the implementation of Demand Management Measures (DMMs) through GSWC participation in the California Urban Water Conservation Council's (Council) Memorandum of Understanding (MOU).

1.9 Content of the UWMP

This UWMP addresses all subjects required by Section 10631 of the Act as defined by Section 10630, which permits "levels of water management planning commensurate with the numbers of customers served and the volume of water supplied." All applicable sections of the Act are discussed in this UWMP, with chapters of the UWMP and DWR Guidebook Checklist cross-referenced against the corresponding provision of the Act in Table 1-2. Also, a completed copy of the 2010 Urban Water Management Plan Checklist organized by subject is included as Appendix J.

Table 1-2: Summary of UWMP Chapters and Corresponding Provisions of the California Water Code

Chapter	Corresponding Provisions of the Water Code		DWR Guidebook Checklist No.
Chapter 1: Plan Preparation	10642	Public participation	55 and 56
	10643	Plan implementation	58
	10644	Plan filing	59
	10645	Public review availability	60
	10620 (a)□(e)	Coordination with other agencies; document preparation	4
	10621 (a)□(c)	City and county notification; due date; review	6 and 54
	10621 (c)	UWMP adoption	7 and 57
	10620 (f)	Resource optimization	5
Chapter 2: System Description	10631 (a)	Area, demographics, population, and climate	8-12
Chapter 3: Water Use	10608	Urban water use targets	1
	10631 (e), (k)	Water use, data sharing	25 and 34
	10631 (k)	Data to wholesaler	33
Chapter 4: Water Supply	10631 (b)□(d), (h), (k)	Water sources, reliability of supply, transfers and exchanges, supply projects, data sharing	13-21, 24, 30, 33
	10631 (i)	Desalination	31
	10633	Recycled water	44-51
Chapter 5: Water Quality	10634	Water quality impacts on reliability	52
Chapter 6: Water Supply Reliability	10631 (c) (1)	Water supply reliability and vulnerability to seasonal or climatic shortage	22
	10631 (c) (2)	Factors resulting in inconsistency of supply	23
	10635 (a)	Reliability during normal, dry, and multiple-dry years	53
Chapter 7: Conservation Program and Demand Management Measures	10631 (f)□(g), (j),10631.5, 10608.26 (a), 10608.36	Conservation Program, DMMs, and SBX7-7 water use reduction plan	2, 26-29, 32
Chapter 8: Water Shortage Contingency Plan	10632	Water shortage contingency plan	35-43

1.10 Resource Optimization

Section 10620(f) of the Act asks urban water suppliers to evaluate water management tools and options to maximize water resources and minimize the need for purchased water from other regions. GSWC understands the limited nature of water supply in California and is committed to optimizing its available water resources. This commitment is demonstrated through GSWC's use of water management tools throughout the company to promote the efficient use of water supplies from local sources, wherever feasible. Additionally, GSWC takes efforts to procure local reliable water supplies wherever feasible and cost effective. GSWC is a regular participant in regional water resources planning efforts, has developed internal company water resource plans and robust water conservation programs.

GSWC has implemented a robust water conservation program, deployed through each region of the company. In an effort to expand the breadth of offered programs, GSWC partners with wholesale suppliers, energy utilities, and other agencies that support water conservation programs.

Chapter 2: System Description

Chapter 2 summarizes the South San Gabriel System's service area and presents an analysis of available demographics, population growth projections, and climate data to provide the basis for estimating future water requirements.

The water system description requirements are detailed in the following section of the Act:

> *Section 10631*
>
> *(a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.*

2.1 Area

The South San Gabriel System, located in Los Angeles County, serves half of the City of Rosemead, parts of City of San Gabriel, City of Monterey Park, and unincorporated area of Los Angeles County. The system is located in the westerly portion of the San Gabriel Valley and is divided by the San Bernardino Freeway. The service area is generally flat with some hills in the south part of the system. Figure 2-1 illustrates the service area of the South San Gabriel System. The service area is primarily characterized by residential and commercial areas.

2.2 Demographics

The City of Rosemead was chosen as demographically representative of the South San Gabriel System. According to 2000 U.S. Census Data, the median age of Rosemead's residents is 32.3 years. Rosemead has an average household size of 3.80 and a median household income of approximately $36,181 in 1999 dollars or $47,252 in 2010 dollars.

A General Plan or land use information is not available for the South San Gabriel System. Based on the San Gabriel System map and review of recent satellite imagery, it appears to be near build-out. There are only a few undeveloped individual parcels in the system and any growth occurring will likely be a combination of urban expansion, redevelopment, and in-fill. In a built-out or nearly built-out area, changes are typically minor and difficult to predict.

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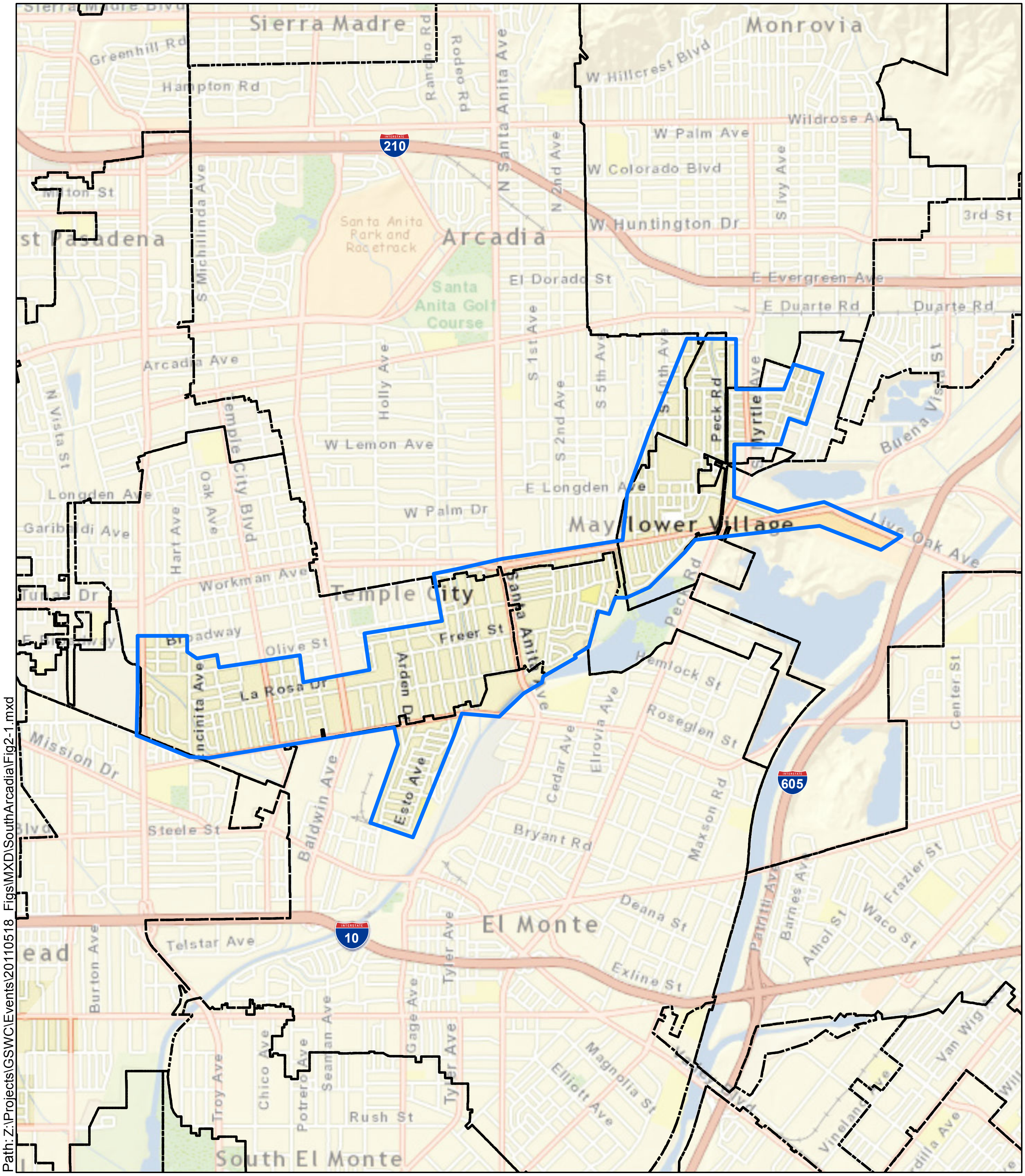

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South Arcadia System Boundary

City Boundary

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Kennedy/Jenks Consultants

Golden State Water Company
2010 Urban Water Management Plan

South Arcadia System Service Area

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August 2011

Figure 2-1

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2.3 Population, Housing and Employment

Population, housing, and employment projections were developed for the South San Gabriel System using the Southern California Association of Governments (SCAG) population, housing and employment data. SCAG last updated its projections for population, household, and employment growth through the year 2035 using the 2008 Integrated Growth Forecasting process used in the 2008 Regional Transportation Plan (2008 RTP). SCAG's methodology is described below, followed by the derivation of population projections for the South San Gabriel System. Previous and current projections utilize 2000 U.S. Census Data.

SCAG is currently in the process of developing its 2012 Regional Transportation Plan (2012 RTP) which will utilize a new population projection model based 2010 Census data. In certain cases, growth rates using these preliminary data are significantly reduced from the 2008 model. The population, household, and employment projections in this document use the adopted 2008 RTP data. Future UWMP updates will be able to utilize 2012 RTP projections as well as 2010 Census data.

2.3.1 SCAG Population Projection Development Methodology

Population, housing, and employment data are derived from the 2000 U.S. Census, which forms a baseline for local data projections. SCAG applies a statistical cohort-component model and the headship rate to the 2000 U.S. Census data for regional, county, and household demographic projections. To evaluate the South San Gabriel System, SCAG data was used in census tract form, the smallest geographic division of data that SCAG provides. SCAG projects subcounty and census tract demographic trends using the housing unit method.

The Integrated Growth Forecasting process uses a variety of estimates and projections from the federal and state governments. Sources include the U.S. Department of Labor, Internal Revenue Service (IRS), U.S. Citizenship and Immigration Services, U.S. Department of Health and Human Services, California Department of Finance (DOF), California Employment Development Department, and information received through the Intergovernmental Review process. A detailed explanation of the population projection process can be found in the adopted SCAG 2008 Regional Transportation Plan, Growth Forecast Report for SCAG.

2.3.2 Historical and Projected Population

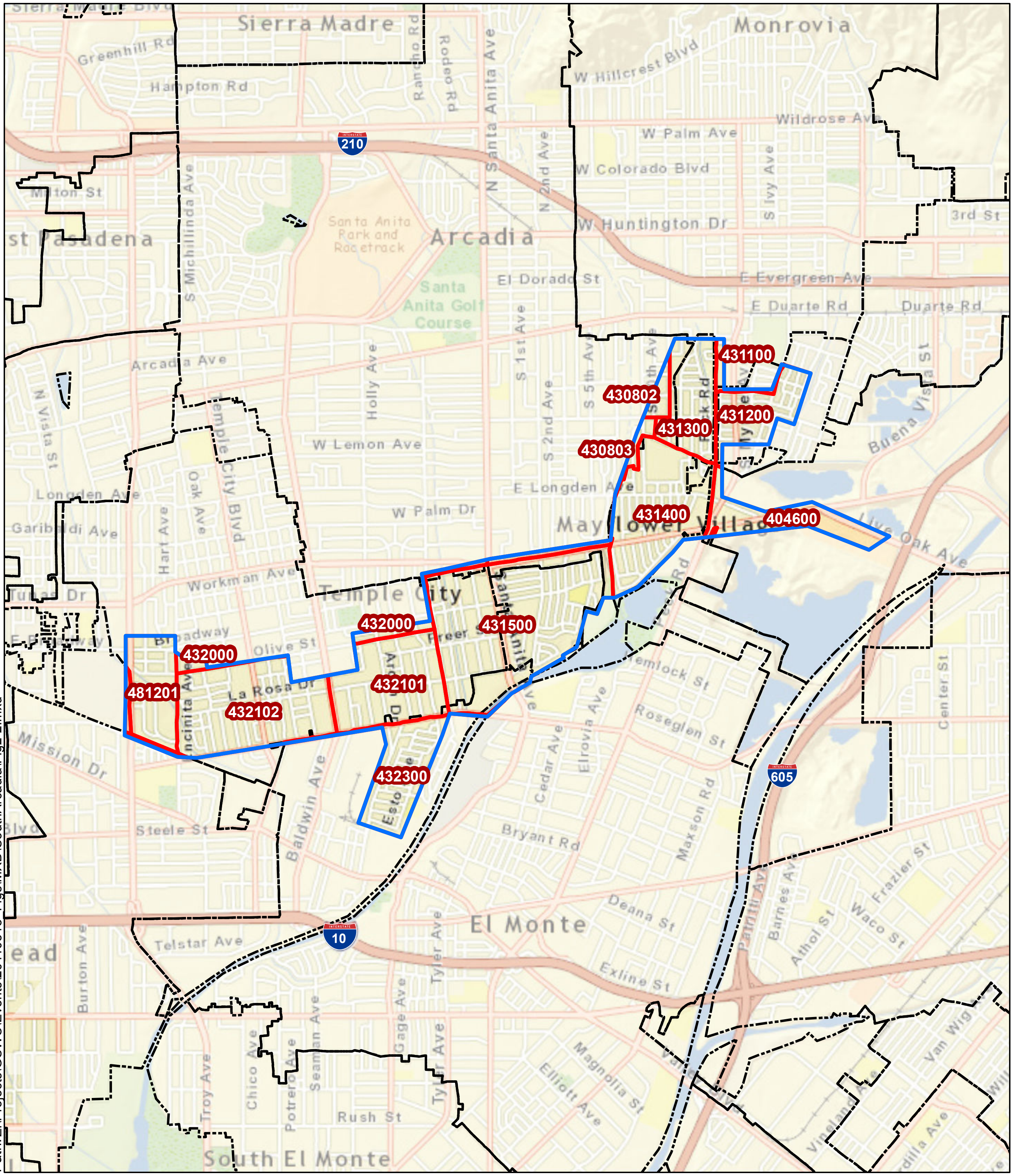
SCAG-derived census-tract projections were used to determine historical and projected population from 1997 to 2035. The South San Gabriel System service area boundaries often contain multiple census tracts, many of which have boundaries that do not coincide exactly with service area boundaries. The population projection analysis consisted of superimposing service area boundaries over census tract boundaries, identifying the applicable overlapping census tracts, and developing a percentage estimate for each overlapping area. For a census tract 100 percent within the service area boundaries, it was assumed that 100 percent of the associated census tract population data was applicable to the South San Gabriel System. For areas where the overlap was not exact, the area of overlap as a percentage was applied to the data to develop an estimate of applicable population. Appendix G, Table G-1 lists the census tracts with a corresponding estimate of what percent of each tract lies within the South San Gabriel System. It was typically assumed that the various types of housing and employment within a census tract are distributed uniformly within all parts of that census tract, unless maps indicated non-uniform concentrations. In these cases, population estimates were either increased or decreased as applicable to match the existing land use. Appendix G, Table G-2 contains all of the SCAG's historic and projected demographic data for each census tract number from 2015 through 2035. Figure 2-2 details the census tracts within the South San Gabriel System.

Annual estimates of historical population between 1997 and 2010 required for SBX7-7 are provided in Table 2-1. The population estimates were developed following DWR Technical Methodology 2: Service Area Population. GSWC is considered a Category 2 water supplier because they maintain a Geographic Information System (GIS) of their service area. The per-connection methodology described in Appendix A of *Technical Methodology 2* was used since annual estimates of direct service area population from SCAG or other local government agencies were not available. This method estimates annual population by anchoring the ratio of year 2000 residential connections to the year 2000 U.S. Census population. This ratio was then linearly scaled to active residential connections data to estimate population for the non-census years in which water supply data were available: 1997 through 2010. The residential billing category includes traditional single-family residential connections; however since GSWC does not have a specific multi-family billing category that only encompasses apartment complexes and other types of multi-family housing units, the ratio of year 2000 U.S. Census total population per residential connections was used for projecting population growth.

Table 2-1: South San Gabriel System Historical Population

Year	Service Area Population
1997	27,589
1998	27,513
1999	27,646
2000	27,545 (1)
2001	27,785
2002	27,855
2003	27,899
2004	28,038
2005	28,140
2006	28,317
2007	28,443
2008	28,608
2009	28,633
2010	28,715

Note:
1. Population for year 2000 from 2005 UWMP.



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- South Arcadia System Boundary
- Census Tract Boundary within Service Area
- City Boundary

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Kennedy/Jenks Consultants

Golden State Water Company
2010 Urban Water Management Plan

South Arcadia System Service Area with Census Tract Boundary

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August 2011

Figure 2-2

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As concluded from analysis of SCAG demographic data, the South San Gabriel System had an estimated population of 28,715 people in 2010 and is expected to reach 31,932 by 2035. A summary of historic and projected population, households, and employment within the South San Gabriel System (based on SCAG growth rate data) is presented in Table 2-2 and illustrated in Figure 2-3. To ensure consistency between the historical and projected population data required for this plan, projections for 2015 through 2035 were adjusted relative to the 2010 population benchmark using the appropriate SCAG percentage growth rates in each category. For this reason, SCAG projections after 2000 for the Census Tracts do not correlate precisely with the estimates included in this plan.

Table 2-2: South San Gabriel System Historical and Projected Population

Year	Service Area Population	Service Area Household	Service Area Employment	Data Source
2005	28,140	6,758	4,428	GSWC(3)
2010	28,715	6,945	4,610	GSWC(3)
2015	29,414	7,187	4,752	SCAG
2020	30,065	7,420	4,841	SCAG
2025	30,710	7,604	4,947	SCAG
2030	31,332	7,780	5,059	SCAG
2035	31,932	7,925	5,166	SCAG

Notes:

1. This table is based on the DWR Guidebook Table 2.
2. Dashed line represents division between historic and projected data.
3. Growth rates for population, household and employment are based on SCAG projections.

In summary, from 2005 to 2010 the South San Gabriel population increased 2 percent, which is a growth rate of approximately 0.5 percent per year. By 2035, population is expected to increase by a total of 11 percent, from 28,715 in 2010 to 31,932 in 2035, which is a 0.5 percent growth rate per year. The number of households is expected to grow 14 percent during the same period, which equates to an annual household growth rate of 0.6 percent. Employment is expected to grow 12 percent during the same period, which equates to an annual employment growth rate of 0.5 percent. Areas with the highest projected growth increases are also the areas that will see the largest increase in water use. SCAG's demographic analysis does not project any planned residential developments for future years. As discussed in demographic section, new development and redevelopment projects in the South San Gabriel System may contribute to future growth.

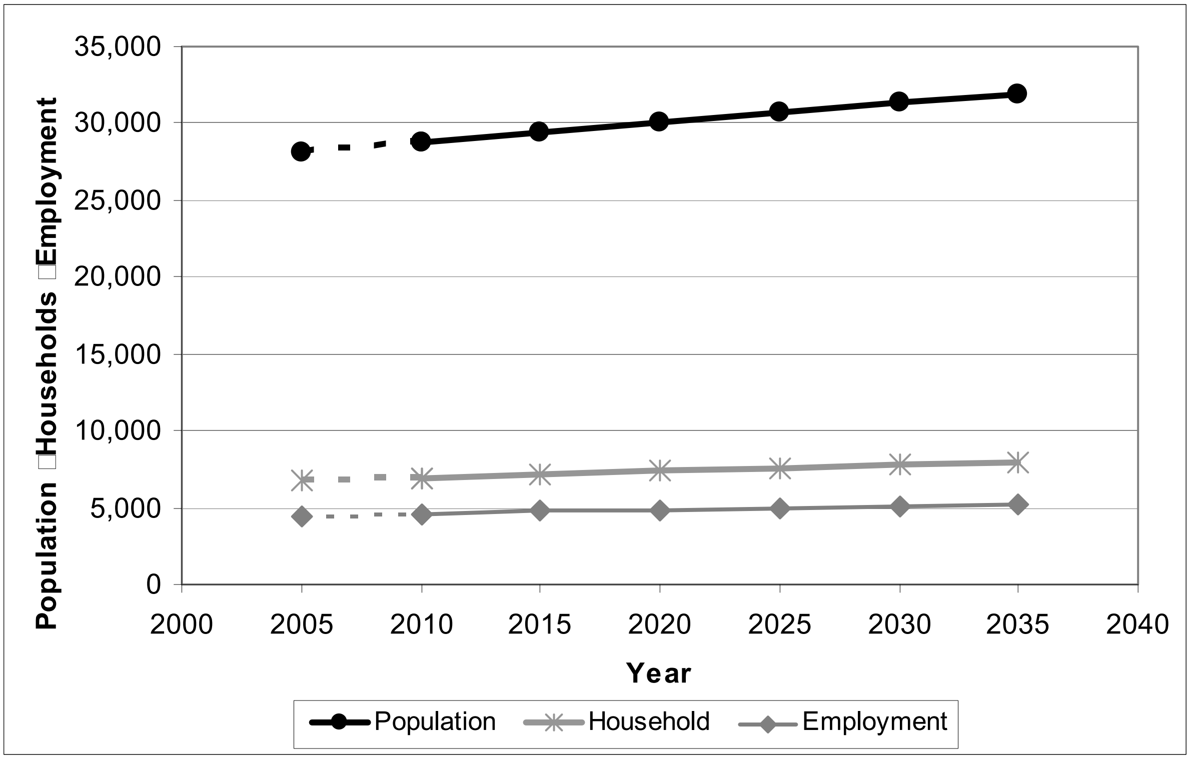

Figure 2-3: Historical and Projected Population, Household and Employment Growth within the South San Gabriel System

2.4 Climate

South San Gabriel System has cool, humid winters and warm, dry summers. Western Regional Climate Center (WRCC) has maintained 30-year historic climate data for selected cities throughout the West. The WRCC's website (www.wrcc.dri.edu) maintains climate records for the past 70 years for the San Gabriel Station. Table 2-3 presents the average climate summary based on the 70-year historical climate data for South San Gabriel System.

In the winter, the lowest average monthly temperature is approximately 42 degrees Fahrenheit. The highest average monthly temperature reaches approximately 90 degrees Fahrenheit in the summer. Figure 2-4 presents the monthly average precipitation based on 30-year historical data. The rainy season is typically from November to March. Monthly precipitation during the winter months ranges from 2 to 4 inches. Low humidity occurs in the summer months from May to October. The moderately hot and dry weather during the summer months typically results in moderately high water demand.

Similar to the WRCC in the South San Gabriel area, the California Irrigation Management Information System (CIMIS) website (http://www.cimis.water.ca.gov) tracks and maintains records of ETo for selected cities. ETo statistics used for this system come from the Monrovia station, which is the closest station (6 miles) to the South San Gabriel System. ETo is a standard measurement of environmental parameters that affect the water use of plants. ETo is given in inches per day, month, or year and is an estimate of the evapotranspiration from a large field of well-watered, cool-season grass that is 4- to 7-inches tall. The monthly average ETo is presented in inches in Table 2-3. As the table indicates, a greater quantity of water is evaporated during July and August in correlation to high temperatures and low humidity, which may result in high water demand.

Table 2-3: Monthly Average Climate Data Summary for South San Gabriel System

Month	Standard Monthly Average ETo[(1)] (inches)	Average Total Rainfall (inches)	Average Temperature (degrees Fahrenheit)	
			Max	Min
January	2.2	3.70	69.1	41.8
February	2.3	3.98	70.2	43.6
March	3.8	3.00	71.7	45.9
April	4.2	1.21	75.2	49.1
May	5.3	0.28	77.7	53.5
June	5.8	0.09	82.5	57.2
July	6.9	0.02	88.8	61.1
August	6.4	0.07	89.7	61.5
September	5.1	0.35	88.1	59.4
October	3.4	0.56	82.2	53.8
November	2.5	1.64	75.3	46.4
December	2.0	2.35	69.8	41.9

Note:
1. Evapotranspiration (ETo) from http://www.cimis.water.ca.gov/cimis/welcom.jsp.

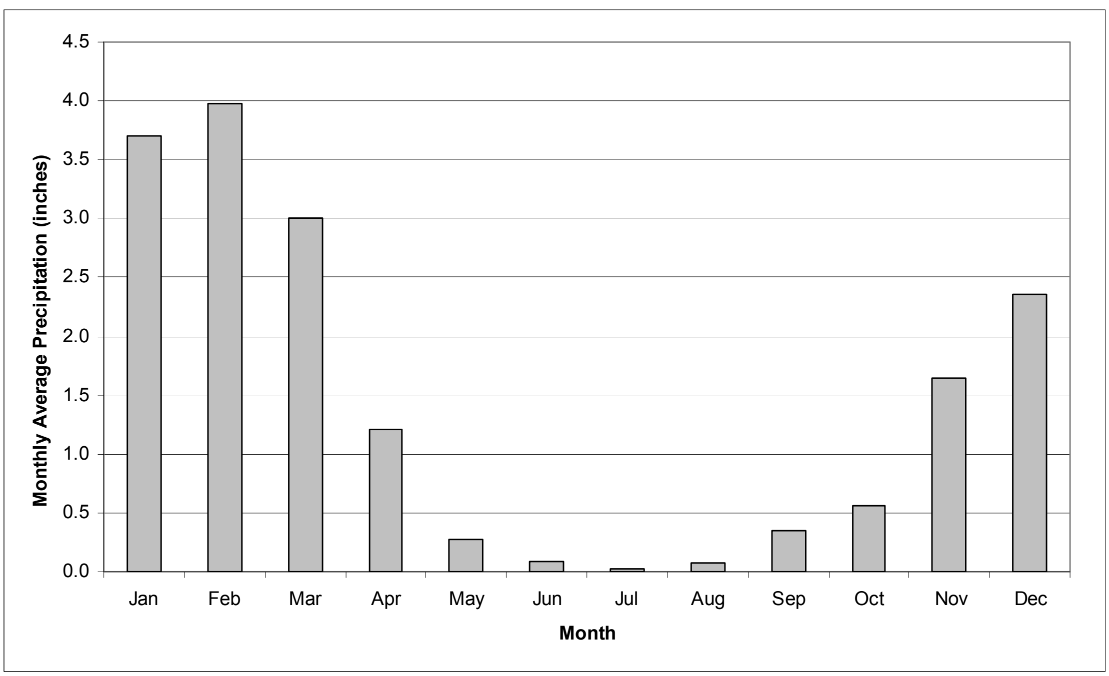

Figure 2-4: Monthly Average Precipitation in South San Gabriel System Based on 70-Year Historical Data

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Chapter 3: Water Use

Section 10631(e) of the Act requires that an evaluation of water use be performed for the South San Gabriel System. The Act states the following:

> *Section 10631.*
>
> *(e) (1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water-use sectors including, but not necessarily limited to, all of the following uses:*
>
> *(A) Single-family residential*
>
> *(B) Multifamily*
>
> *(C) Commercial*
>
> *(D) Industrial*
>
> *(E) Institutional and governmental*
>
> *(F) Landscape*
>
> *(G) Sales to other agencies*
>
> *(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof*
>
> *(I) Agricultural.*
>
> *(2) The water-use projections shall be in the same five-year increments described in subdivision (a).*

In addition, Section 10631(k) directs urban water suppliers to provide existing and projected water-use information to wholesale agencies from which water deliveries are obtained. The Act states the following:

> *Section 10631.*
>
> *(k) Urban water suppliers that rely upon a wholesale agency for a source of water, shall provide the wholesale agency with water-use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c).*

In conjunction with projecting total water demand, each urban water retail supplier must develop urban water use targets and an interim urban water use target in accordance with SBX7-7. SBX7-7 amends the Act and requires statewide urban demand reduction of 20 percent by the year 2020. The bill sets specific methods for calculating both the baseline water usage and water use targets in gallons per capita day (gpcd).

Section 10608.20(e) states the following:

Section 10608.20.

(e) An urban retail water supplier shall include in its urban water management plan required pursuant to Part 2.6 (commencing with Section 10610) due in 2010 the baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.

This chapter presents an analysis of water use data with the resulting projections for future water needs and water use targets in accordance with SBX7-7 for the South San Gabriel System.

3.1 Historical Water Use

Historical water use data from 1994 to 2010 were analyzed in order to provide an overview of historical water usage for the South San Gabriel System. Figure 3-1 shows the historical number of metered service connections and water use for the South San Gabriel System from 1994 through 2010.

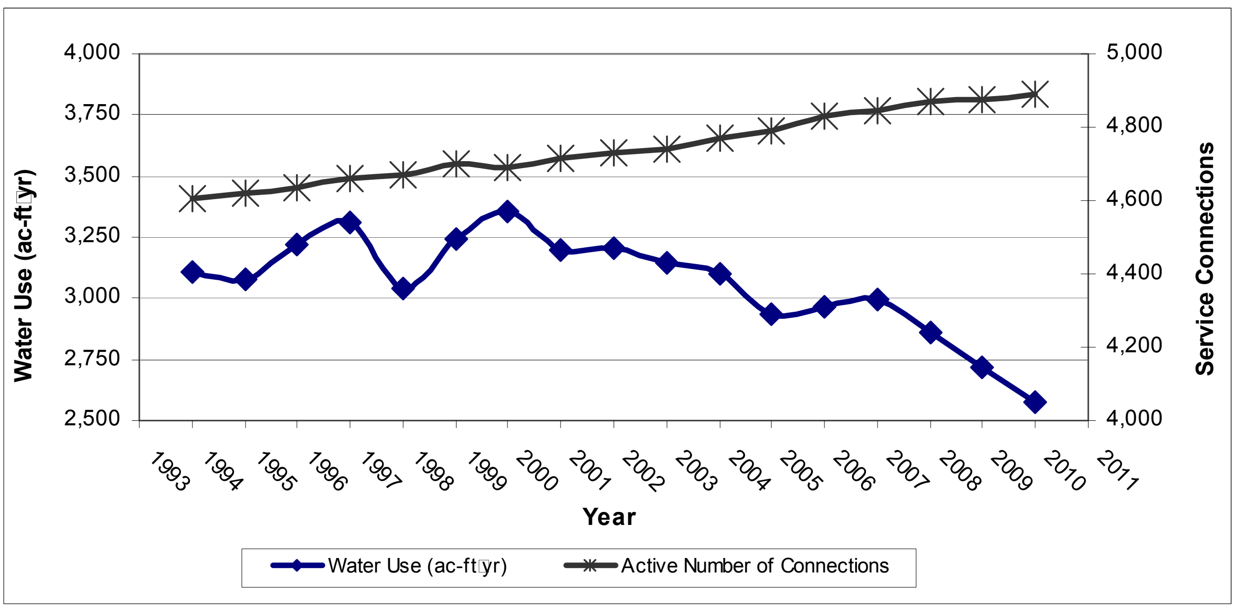

Figure 3-1: Historical Number of Metered Service Connections and Water Use

Figure 3-1 shows a decline in water use beginning in 2007 with an approximate 11 percent decline from 2008 to 2010. Review of similar data from other systems suggests the recent decline in water use has been widespread and is not isolated to the South San Gabriel System. The decline in water use is not yet fully understood, but may be a result of several factors including: several years of cool summers, a statewide drought that forced mandatory water reductions and conservation in many areas, and an economic downturn that has caused many businesses to close and increased housing vacancies.

The customer billing data for the system consists of annual water sales data. The water sales data was sorted by customer type using the assigned North American Industry Classification System (NAICS) codes. Then, the sorted water sales data were further grouped into the following seven categories: single-family, multi-family, industrial, commercial, institutional/government, landscape, and other. Table 3-1 shows the historical water use by customer type.

Table 3-1: Historical Water Use (ac-ft/yr) by Customer Type

YEAR	Commercial	Industrial	Institutional/ Government	Landscape	Multi-Family	Other	Single-Family	Total
1994	271	7	129	64	887	0	1,747	3,105
1995	305	4	96	72	927	0	1,673	3,077
1996	319	3	111	81	991	0	1,717	3,222
1997	353	5	140	86	1,007	0	1,722	3,313
1998	347	3	111	65	995	0	1,521	3,042
1999	422	2	158	114	1,058	0	1,489	3,243
2000	469	5	162	123	1,136	0	1,457	3,352
2001	451	5	162	94	1,097	4	1,387	3,200
2002	423	6	136	103	1,097	5	1,437	3,207
2003	491	6	125	74	1,062	6	1,382	3,146
2004	465	4	124	85	1,043	6	1,372	3,099
2005	429	3	114	90	978	6	1,315	2,935
2006	408	3	126	94	991	6	1,338	2,966
2007	403	4	124	87	986	5	1,385	2,994
2008	371	3	128	84	935	5	1,337	2,863
2009	368	2	105	90	887	4	1,262	2,718
2010	379	2	101	64	836	3	1,190	2,575

3.2 Water Use Targets

This section includes documentation of the water use targets commensurate with enactment of SBX7-7. The 2010 UWMP update is the first in which such targets have been required to be documented. The projected water use for each urban retail water supplier is required to be reduced by a total of up to 20 percent by the year 2020 from a calculated baseline gpcd as required by SBX7-7. The steps described throughout this section follow the guideline methodologies developed by DWR over the past year, as documented in Section D of the *Guidebook to Assist Urban Water Suppliers to Prepare a 2010 Urban Water Management Plan* (DWR Guidebook) issued March 2011. The three overall steps to determine the 2020 water use target are as follows:

- Step 1 — Calculate the baseline per capita water use, using the required methodologies.
- Step 2 — Calculate the per capita reduction using at least one of the four methodologies (including the minimum reduction target — which is a provision included to ensure all agencies achieve a minimum level of water savings).
- Step 3 — Select the target reduction methodology and set interim (2015) and compliance (2020) water use targets. The chosen methodology is the responsibility of the water supplier and may be changed in 2015.

The Act now stipulates that the state shall review the progress made towards reaching the statewide water savings targets as reported in the 2015 UWMP updates. Currently, no single urban water supplier is required to conserve more than 20 percent, however there are provisions in the law that could require additional conservation after 2015 if it is found that the program is not on track to reach 20 percent statewide water savings by 2020.

3.2.1 Baseline Per Capita Water Use

The first step in the process of determining the water use target is calculation of the baseline per capita water use (baseline gpcd). In order to calculate the baseline gpcd, service area population within the South San Gabriel System was estimated and compared to actual water use records. The following three baseline gpcd calculations identified in SBX7-7 were evaluated for the South San Gabriel System:

- Baseline Method 1 — Average water use over a continuous 10-year period ending no earlier than December 31, 2004 and no later than December 31, 2010.
- Baseline Method 2 — For retailers with at least 10 percent of 2008 demand served by recycled water (either retail-or wholesale-provided), this calculation may be extended to include an additional 5 years ending no earlier than December 31, 2004 and no later than December 31, 2010.
- Baseline Method 3 — Estimate of average gross water use reported in gpcd and calculated over a continuous 5-year period ending no earlier than December 31, 2007 and no later than December 31, 2010.

The Baseline Methods 1 and 3 were evaluated using water supply data for the years ending December 31, 1997 through December 31, 2010. The base water use was calculated for each year commencing with 1997 as this was the first year with production data records available. The South San Gabriel system does not currently receive recycled water; therefore Baseline Method 2 is not applicable. Table 3-2 below presents the base period ranges, total water deliveries and the volume of recycled water delivered in 2008; these data are used to determine the number of years that can be included in the base period range. Also shown are the actual start and end years for the selected base period range.

Table 3-2: Base Period Ranges			
Base	**Parameter**	**Value**	**Units**
10-year base period	2008 total water deliveries	3,096	Ac-ft
	2008 total volume of delivered recycled water	0	Ac-ft
	2008 recycled water as a percent of total deliveries	0	Percent
	Number of years in base period	10	Years
	Year beginning base period range	1997	
	Year ending base period range	2006	
5-year base period	Number of years in base period	5	Years
	Year beginning base period range	2003	
	Year ending base period range	2007	

Note:
Table format based on DWR Guidebook Table 13.

The average annual daily per capita water use in gpcd from 1997 through 2010 is provided in Table 3-3. The gallons per day calculation includes potable water entering the distribution system.

Table 3-3: 1997-2010 Base Daily Use Calculation			
Calendar Year	**Distribution System Population**	**Gallons □Day**	**Daily per Capita Water Use, gpcd**
1997	27,589	3,299,623	120
1998	27,513	3,091,203	112
1999	27,646	3,173,668	115
2000	27,545	3,260,774	118
2001	27,785	3,113,270	112
2002	27,855	3,080,299	111
2003	27,899	3,021,992	108
2004	28,038	3,067,966	109
2005	28,140	2,864,906	102
2006	28,317	3,023,029	107
2007	28,443	2,863,002	101
2008	28,608	2,763,565	97
2009	28,633	2,575,696	90
2010	28,715	2,400,543	84

Note:
Table format based on DWR Guidebook Tables 14 and 15.

The 10-year averages are presented in Table 3-4; and the 5-year averages are shown in Table 3-5. The 1997-2006 10-year and 2003-2007 5-year average base daily usages of 111 and 105 gpcd, respectively, were selected.

Table 3-4: 10-Year Average Base Daily Per Capita Water Use

10-Year Period	Average Base Daily Per Capita Water Use (gpcd)
1997-2006	111
1998-2007	110
1999-2008	108
2000-2009	105
2001-2010	102

Table 3-5: 5-Year Average Base Daily Per Capita Water Use

5-Year Period	Average Base Daily Per Capita Water Use (gpcd)
2003-2007	105
2004-2008	103
2005-2009	99
2006-2010	96

3.2.2 Urban Water Use Targets

Retail suppliers must identify their urban water use targets by utilizing one of four compliance methods identified in SBX7-7. The four urban water use target development methods are as follows:

- Compliance Method 1 80 percent of baseline gpcd water use.
- Compliance Method 2 The sum of the following performance standards: indoor residential use (provisional standard set at 55 gpcd); plus landscape use, including dedicated and residential meters or connections equivalent to the State Model Landscape Ordinance (70 percent of reference ETo; plus 10 percent reduction in baseline commercial, industrial institutional (CII) water use by 2020.
- Compliance Method 3 95 percent of the applicable state hydrologic region target as identified in the 2020 Conservation Plan (DWR, 2010).
- Compliance Method 4 A provisional method identified and developed by DWR through a public process released February 16, 2011, which aims to achieve a cumulative statewide 20 percent reduction. This method assumes water savings will be obtained through metering

of unmetered water connections and achieving water conservation measures in three water use categories: (1) indoor residential, (2) landscape, water loss and other water uses and (3) CII.

GSWC elected to evaluate Compliance Methods 1 and 3 for selecting urban water use targets for the 2010 plan. The following section provides an explanation of the target calculations and a summary of the interim and compliance water use targets.

Compliance Method 1 Calculation Summary

The Compliance Method 1 2020 water use target was calculated by multiplying the base daily gpcd by 80 percent. A 20 percent reduction in baseline water use would require reduction of 22 gpcd by 2020, as shown in Table 3-6. The 2015 interim target would be 100 gpcd with a 2020 water use target of 89 gpcd.

Table 3-6: 2020 Water Use Target Method 1 Calculation Summary

Description	Baseline	2015 Interim Target	2020 Compliance Target
Per Capita Water Use (gpcd)	111	100	89
Percent Reduction	N/A	10%	20%

Compliance Method 3 Calculation Summary

The Compliance Method 3 2020 water use target was calculated by multiplying the respective hydrologic region target by 95 percent. The South San Gabriel System is located in the South Coast region (Region 4), which has a hydrologic region target of 149 gpcd and a baseline water use of 180 gpcd. Ninety-five (95) percent of the Region 4 hydrologic region target results in a 2020 water use target of 142. Since the baseline of 111 gpcd is lower than 95 percent of the hydrologic regional target of 142 gpcd, a review of the minimum reduction target was triggered per the DWR methodologies to ensure minimum water conservation targets are established for the South San Gabriel System. Table 3-7 presents the results of the Method 3 calculation:

Table 3-7: 2020 Water Use Target Method 3 Calculation Summary

Description	Baseline	2015 Interim Target	2020 Compliance Target
Per Capita Water Use (gpcd)	111	126	142
Percent Reduction	N/A	N/A	N/A

Minimum Compliance Reduction Target

Systems with a 5-year baseline per capita water use of greater than 100 gpcd must calculate a minimum water use reduction, which the 2020 water use target cannot exceed. The minimum water use reduction compliance target is 95 percent of the 5-year rolling average base daily per capita water use (ending no earlier than December 31, 2007, and no later than December 31, 2010). By this method, the minimum 2020 water use target for the South San Gabriel System is 100 gpcd as presented in Table 3-8 below:

Table 3-8: Minimum 2020 Reduction

Description	5-Yr Average	2015 Interim Target	2020 Compliance Target
Minimum Allowable 2020 Target (gpcd)	105	103	100

3.2.3 Interim and Compliance Water Use Targets

The interim and compliance water use targets are provided per Section 10608.20(e) of the Act. Compliance Method 3 was selected by GSWC for the South San Gabriel System, which in turn triggered the minimum reduction target since the Method 3 hydrologic region target (142 gpcd) is greater than the Minimum 100 gpcd. As a result, Table 3-9 shows the 2020 SBX7-7 compliance target for the South San Gabriel System is 100 gpcd and the 2015 interim water use target is 103 gpcd. The implementation plan for achieving these targets is described in Section 4.8, Recycled Water and Chapter 7, Demand Management Measures.

Table 3-9: SBX7-7 Water Use Reduction Targets (gpcd)

Baseline	2015 Interim Target	2020 Compliance Target
111	103	100

3.3 Projected Water Use

Growth projections for the number of service connections and volume of water use were calculated for the year 2015 through 2035, in 5-year increments. Future water demands were estimated using two different methods, a population-based approach and a historical-trend approach, in order to present a projection range reflecting the inherent uncertainty in growth trends. Additionally, demand projections are provided showing a scenario where the South San Gabriel System fully meets water use target reductions by 2020 for comparison to current per capita water use trends. Detailed descriptions of how the population-based and historical-trend projections were calculated are provided below.

The range established between these two approaches is intended as supplemental information; all connection and demand estimates use the population-based growth rate projections which are higher and provide a more conservative estimate of future water use. The historical-trend projections are provided as ancillary information only.

Figure 3-2 shows the historical and projected number of metered service connections for the South San Gabriel System from 1994 through 2035. Figure 3-3 shows the historical and projected water use for the South San Gabriel System from 1994 until 2035.

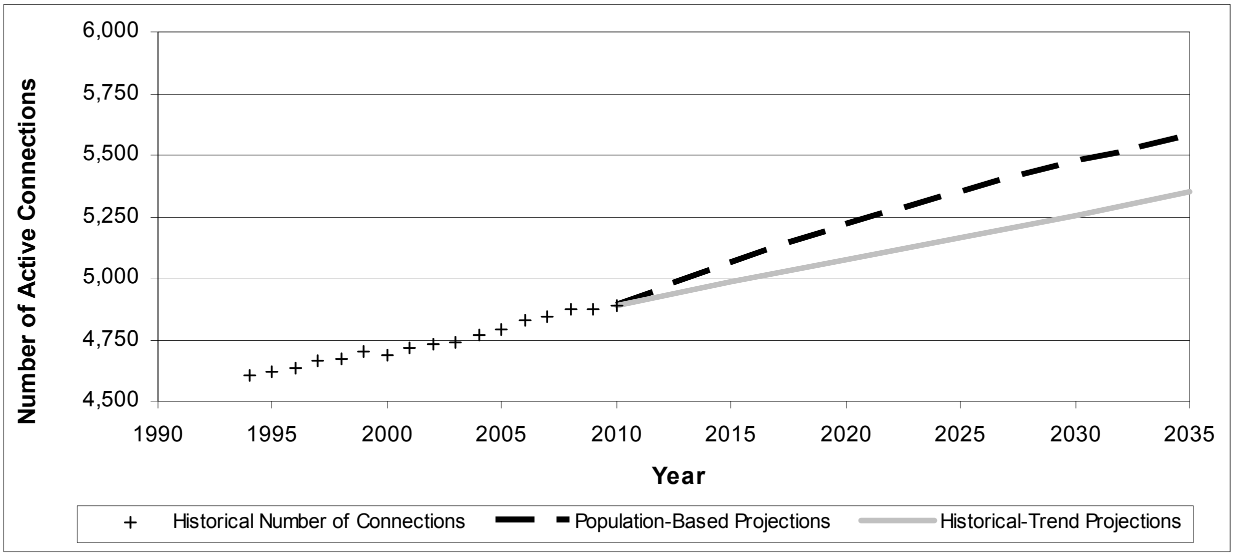

Figure 3-2: Historical and Projected Number of Metered Service Connections

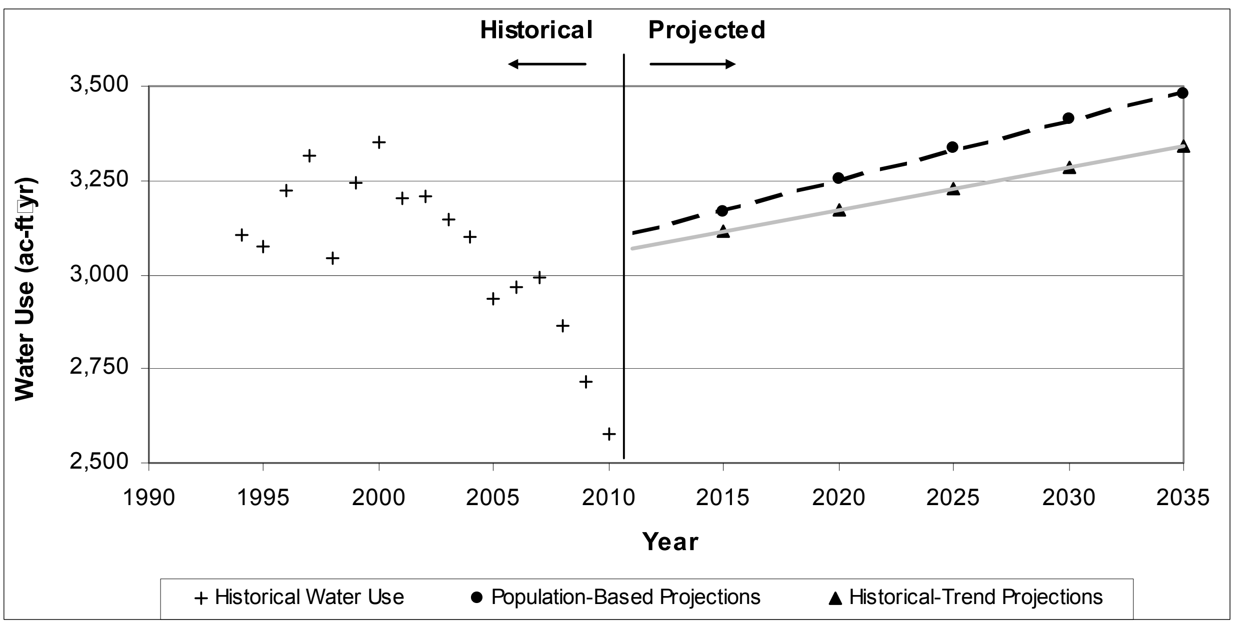

Figure 3-3: Historical Water Use and Future Water Use Projections

Historical water use records from 2000 through 2010 were analyzed to generate estimates of future water demands.

Water use factors were then developed for the projection of future water use. A water use factor was calculated for each category in order to quantify the average water used per metered connection. For a given customer type, the unit water use factor is calculated as the total water sales for the category divided by the number of active service connections for that category. The unit water use factors for each customer type were averaged over the data range from 2000 through 2010 in order to obtain a representative water use factor for determining water demand projections by customer type. Table 3-10 presents the water use factors calculated for each customer category.

Table 3-10: Water Use Factors for the South San Gabriel System

	Account Category						
	Single-Family	Multi-family	Commercial	Industrial	Institutional Government	Landscape	Other(2)
Water Use Factor(1)	0.40	0.95	1.96	0.61	1.72	2.31	1.34

Notes:
1. Based on customer water use data for calendar years 2000-2010.
2. Other accounts for any service connections not included in any other category, including idle or inactive connections.

The population-based water use projections are based on the population and housing growth rates described in Chapter 2. SCAG household projections were used to determine the growth in single-family and multi-family service connections for the years 2015, 2020, 2025, 2030, and 2035. For example, the percent growth rate in households from the year 2010 to year 2015 was multiplied by the number of residential service connections in 2000 to obtain a projection of the number of connections in the year 2015. Similarly, employment growth projections were used to determine the growth for commercial, industrial, institutional government, and landscape service connections. The population-based projected water use was then calculated by multiplying the number of projected active service connections for each customer category by the corresponding customer average water use factor calculated above.

The historical-trend water use projections are based on a linear projection of the historical number of metered service connections. The average growth rate established by this historical trend was applied to the number of connections in each customer category to project the future number of service connections. The historical-trend projected water use was then calculated by multiplying the number of projected active service connections for each customer category with the corresponding customer average water use factor calculated above.

Figure 3-4 shows the population based water use projections by customer type. The population-based projections of the number of service connections, and the resulting water demand, are provided in Table 3-11.

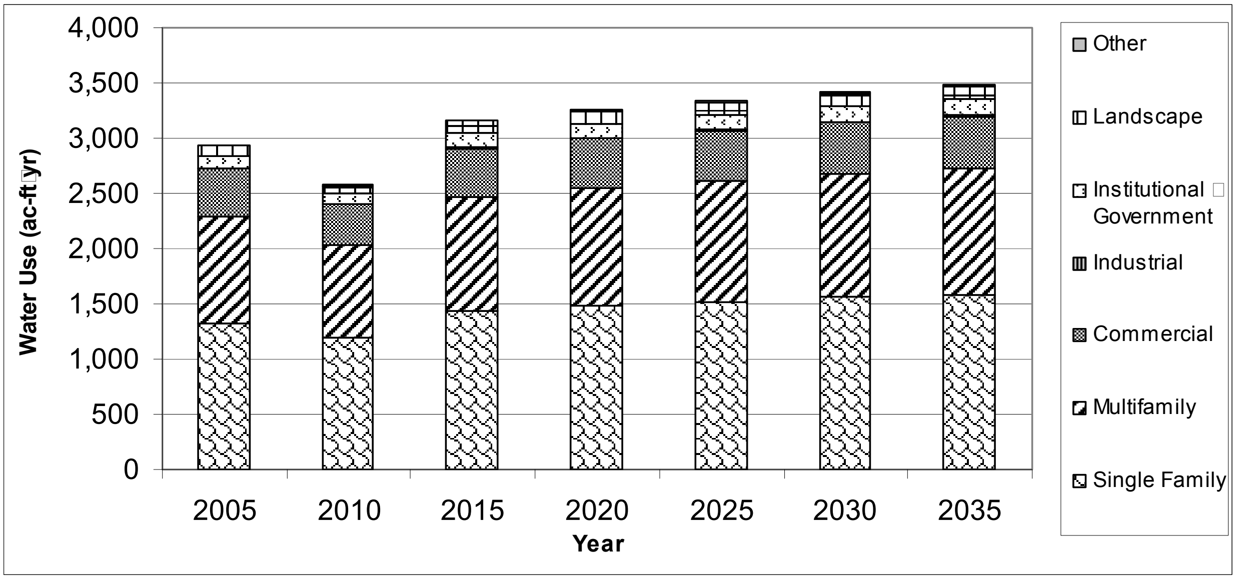

Figure 3-4: Projected Water Use by Customer Type

Table 3-11: Projections of the Number of Metered Service Connections and Water Use for the South San Gabriel System

Year	Projection Type	Accounts by Type							
		Single-Family	Multi-family	Commercial	Industrial	Institutional Government	Landscape	Other(3)	Total
2005(2)	*No. of Accounts*	3,395	1,053	220	6	75	39	4	4,792
	Water Use (ac-ft)	1,315	978	429	3	114	90	6	2,935
2010	*No. of Accounts*	3,492	1,047	218	7	75	45	5	4,889
	Water Use (ac-ft)	1,190	836	379	2	101	64	3	2,575
2015	*No. of Accounts*	3,614	1,084	225	8	78	47	6	5,062
	Water Use (ac-ft)	1,438	1,030	440	5	134	109	8	3,164
2020	*No. of Accounts*	3,731	1,119	229	8	79	48	6	5,220
	Water Use (ac-ft)	1,485	1,063	448	5	136	111	8	3,256
2025	*No. of Accounts*	3,824	1,147	234	8	81	49	6	5,349
	Water Use (ac-ft)	1,522	1,090	458	5	139	113	8	3,335
2030	*No. of Accounts*	3,912	1,173	240	8	83	50	6	5,472
	Water Use (ac-ft)	1,556	1,115	470	5	142	116	8	3,412
2035	*No. of Accounts*	3,985	1,195	245	8	85	51	6	5,575
	Water Use (ac-ft)	1,586	1,136	479	5	146	118	8	3,478

Notes:

1. This table is based on the DWR Guidebook Tables 3 through 7.
2. Based on calendar year.
3. Other accounts for any service connections not included in any other category, including idle or inactive connections.
4. All connections are metered.

3.4 Sales to Other Agencies

There are no sales to other agencies for the South San Gabriel System; therefore, Table 3-12 has intentionally been left blank.

Table 3-12: Sales to Other Agencies in ac-ft/yr

Water Distributed	2005(2)	2010	2015	2020	2025	2030	2035
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
1. This table is based on the DWR Guidebook Table 9.
2. Based on calendar year.

3.5 Other Water Uses and System Losses

In order to estimate total water demand, other water uses, as well as any water lost during conveyance, must be added to the customer demand. California regulation requires water suppliers to quantify any additional water uses not included as a part of water use by customer type. There are no other water uses in addition to those already reported in the South San Gabriel System.

System losses must be incorporated when projecting total water demand. System losses (also known as non-revenue water) are defined as the difference between annual water production and annual sales. Included are system losses due to leaks, reservoir overflows, or inaccurate meters, and other water used in operations such as system flushing and filter backwashing GSWC does not tabulate system losses separately from other water uses; such as operations. In the South San Gabriel System, from 1997 through 2010, system water losses have averaged approximately 8 percent of the total production; therefore, this rate was incorporated into water demand projections. Table 3-13 provides a summary of projected system losses in the South San Gabriel System.

Table 3-13: Additional Water Uses and Losses in ac-ft/yr

Water-Use Type	2005(2)	2010	2015	2020	2025	2030	2035
Other Water Uses	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unaccounted-for System Losses(3)	274	114	246	253	260	266	271
Total	274	114	246	253	260	266	271

Notes:
1. This table is based on the DWR Guidebook Table 10.
2. Based on calendar year.
3. Includes system losses due to leaks, reservoir overflows, and inaccurate meters, as well as water used in operations.

3.6 Total Water Demand

As described above, other water uses, as well as any water lost during conveyance, must be added to the customer demand in order to project total water demand for the South San Gabriel System. Although there are no other water uses contributing to the total water demand in the South San Gabriel System, other water uses and system water losses must be incorporated into the total water demand. Table 3-14 summarizes the projections of water sales, other water uses and system losses, and total water demand through the year 2035.

The projected water sales and system losses were added to estimate the total baseline water demand shown in Table 3-14. The baseline demand projections below do not include water use reductions due to additional implementation of future DMMs or other conservation activities. Baseline demands are used for supply reliability evaluation purposes throughout this UWMP for estimates of water supplies that may be required to meet system demands for the next 25 years. Figure 3-5 shows the projected total water demand through 2035.

Projected water demands assuming SBX7-7 compliance are also provided in Table 3-14 for reference purposes; assuming full compliance with the SBX7-7 interim and 2020 water use reduction targets. SBX7-7 compliance water demands were calculated by multiplying the projected population by the applicable water use target. Future water use that is exempt from SBX7-7, such as industrial process water or direct reuse recycled water is not included in this projection.

Table 3-14: Projected Total Water Demand and SBX7-7 Compliance Projections in ac-ft/yr

				SBX7-7 Compliance Projections	
Year[2]	Projected Water Sales	Other Water Uses and System Losses	Total Baseline Water Demand	Water Savings	Total Water Demand with Savings
2005	2,935	274	3,209	0	n/a
2010	2,575	114	2,689	0	n/a
2015	3,164	246	3,410	17	3,394
2020	3,256	253	3,509	141	3,368
2025	3,335	260	3,595	155	3,440
2030	3,412	266	3,678	168	3,510
2035	3,478	271	3,748	172	3,577

Notes:
1. This table is based on the DWR Guidebook Table 11.
2. Based on calendar year.

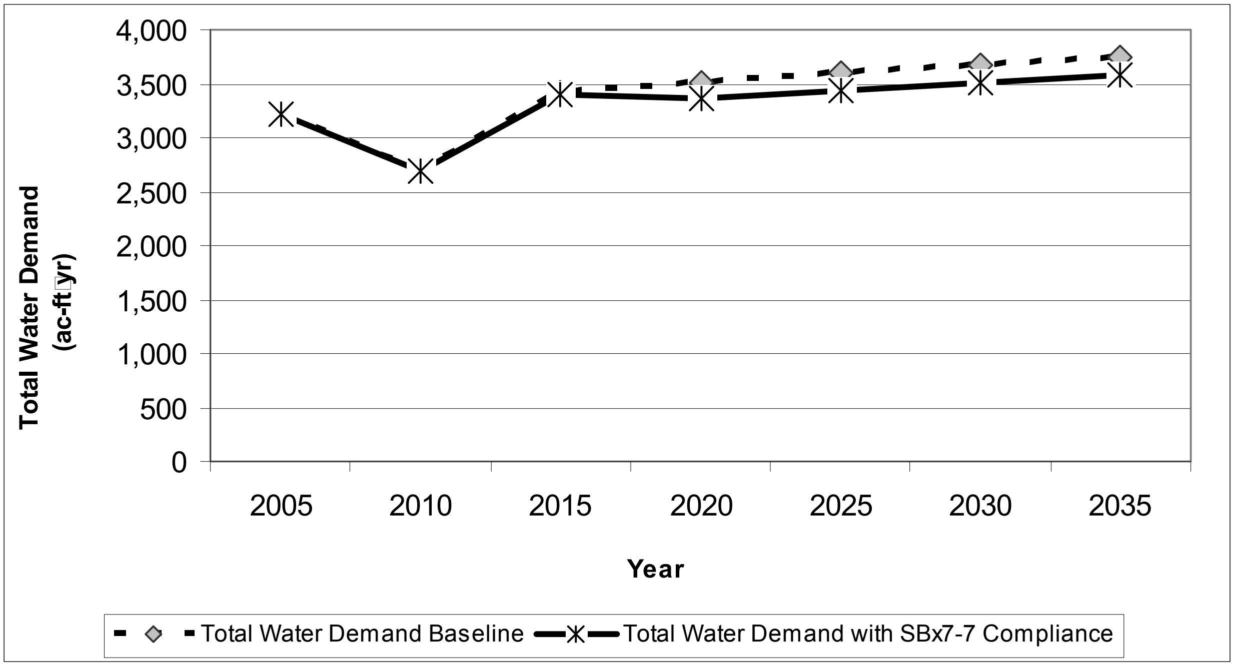

Figure 3-5: Total Water Demand

3.7 Data Provided to Wholesale Agency

GSWC provided the following projected water use data to the Upper San Gabriel Valley Municipal Water District (USGVMWD, Upper District), the wholesale water supplier for the South San Gabriel System, as summarized in Table 3-15. Since the preliminary projections were submitted in 2010, GSWC has refined projections by integrating actual 2010 water usage and supply data. As a result, the projections shown in Table 3-15 below do not agree with the demands presented in other chapters of this UWMP. As required per Section 10631(k) the supporting documentation providing the water use projections to the wholesale agency is included in Appendix I.

Table 3-15: Summary of South San Gabriel System Data Provided to USGVMWD in ac-ft/yr

Wholesaler	Contracted Volume	2010	2015	2020	2025	2030	2035
USGVMWD	N/A	2,896	3,200	3,500	3,745	3,969	4,044

Note:
This table is based on the DWR Guidebook Table 12.

3.8 Disadvantaged Community Water Use Projections

Section 10631.1 (a). Include projected water use for single-family and multi-family residential housing needed for lower income households, as identified in the housing element of any city, county, or city and county in the service area of the supplier.

Senate Bill 1087 requires that water use projections of a UWMP include the projected water use for single-family and multi-family residential housing for lower income households as identified in the housing element of any city, county, or city and county in the service area of the supplier.

Housing elements rely on the Regional Housing Needs Allocation (RHNA) generated by the State Department of Housing and Community Development (HCD) to allocate the regional need for housing to the regional Council of Governments (COG) (or a HCD for cities and counties not covered by a COG) for incorporation into housing element updates. Before the housing element is due, the HCD determines the total regional housing need for the next planning period for each region in the state and allocates that need. The COGs then allocate to each local jurisdiction its "fair share" of the RHNA, broken down by income categories; very low, low, moderate, and above moderate, over the housing element's planning period.

The County of Los Angeles last updated its housing element in 2006. A lower income house is defined as 80 percent median income, adjusted for family size. The County's housing element identifies the target number of low-income households in the County from 2006 to 2013 as 15.7 percent and very low-income households as 24.7 percent. However, it is unknown what percentage of the low-income and very low-income households are within GSWC's South San Gabriel service area. For this reason, it is not possible to project water use for lower income households separately from overall residential demand. However, to remain consistent with the intent of the SB-1087 legislation and to comply with the UWMP Act, an effort has been made to identify those water use projections for future single and multi-family households based on the aggregate percentage of both the low-income and very low-income categories. 40 percent was used to estimate the lower income demand projections as shown in Table 3-16 below.

Table 3-16: Low-Income Projected Water Demands in ac-ft/yr

	2015	2020	2025	2030	2035
Single-Family Residence	101	119	134	148	160
Multi-Family Residence	78	92	102	112	121
Total	179	211	237	261	281

Note:
This table is based on the DWR Guidebook Table 8.

GSWC will not deny or conditionally approve water services, or reduce the amount of services applied for by a proposed development that includes housing units affordable to lower income households unless one of the following occurs:

- GSWC specifically finds that it does not have sufficient water supply.
- GSWC is subject to a compliance order issued by the State Department of Public Health that prohibits new water connections.
- The applicant has failed to agree to reasonable terms and conditions relating to the provision of services.

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Chapter 4: Water Supply

A detailed evaluation of water supply is required by the Act. Sections 10631 (b) through (d) and (h) of the Act state the following:

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a). If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:

(1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management.

(2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree.

For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.

(3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(1) An average water year.

(2) A single dry water year.

(3) Multiple dry water years.

For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

(d) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single dry, and multiple dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

This chapter addresses the water supply sources of the South San Gabriel System. The following chapter provides details in response to those requirements of this portion of the Act.

4.1 Water Sources

GSWC obtains its water supply for the South San Gabriel System from two primary sources: imported water and GSWC-operated groundwater wells. Imported water is purchased from the Upper San Gabriel Valley Municipal Water District (USGVMWD), also called the Upper District. The Upper District obtains its imported water supply from the Metropolitan Water District of Southern California (Metropolitan).

As described in Section 4.3.1, below, the groundwater rights for the South Arcadia System and the South San Gabriel System are shared and are not preferential to either system. GSWC manages the allocation between the two systems. South Arcadia does not have any water supply from purchased sources, and therefore is 100 percent reliant upon groundwater supply from the Main San Gabriel Basin. If demands increase beyond the allocated OSY shared water right for the South Arcadia or South San Gabriel systems, GSWC can either find additional water rights or purchase replenishment water. Water rights may be obtained by purchasing or leasing existing rights from other producers in the basin. Groundwater pumping in excess of the OSY and any additional purchased or leased rights is permitted when replaced in kind with available replenishment water that is purchased from the Basin's responsible agency. The Upper District is the responsible agency for the portion of the Basin from which groundwater is pumped from the South Arcadia and South San Gabriel Systems.

Table 4-1, below, summarizes the approximate amount of water supplied by each source in acre-feet per year. The availability of water from each source is estimated through the year 2035, in accordance with GSWC's long-term water supply planning projections and those of its wholesale suppliers. GSWC's water supply is projected to increase by about 39 percent from 2010 to 2035 to meet the projected water demands, with most of this increased demand being met by imported water from the Upper District. Water demand projections are documented in Chapter 3.

Table 4-1: Current and Planned Water Supplies for the South San Gabriel System in ac-ft/yr

Source	2010	2015	2020	2025	2030	2035
Purchased water from USGVMWD	338	2,097	2,375	2,604	2,828	3,015
Groundwater(1)	2,352	1,313	1,134	991	850	733
Recycled water	0	0	0	0	0	0
Total	2,689	3,410	3,509	3,595	3,678	3,748

Notes:

1. Based on projected use in the Main San Gabriel Groundwater Basin. 2015-2035 groundwater projections assume a long-term average OSY of 190,000 ac-ft.
2. 2010 water supplies are based on actual production records.
3. Table format based on DWR Guidebook Table 16.

This water supply summary is based on GSWC's groundwater management strategy for the South San Gabriel and South Arcadia Systems, and data provided by the Upper District. In the future, GSWC expects to use its Main Basin groundwater rights to supply the South Arcadia System, and shift the South San Gabriel System to rely more heavily on the Upper District imported water supply.

There is no recycled water supply planned for this system. The potential for future recycled water use is described in Section 4.8. Details of the water supply are presented in the following section, while water supply reliability is discussed in Chapter 6.

4.2 Purchased Water

The Upper District is a member agency of the Metropolitan, providing treated water to several agencies, including GSWC. Additional details regarding Upper District's imported water supply can be found in the Upper District's 2010 UWMP. The South San Gabriel System has one connection through which it receives water from the Upper District, named the USG-1 connection, with a capacity of 3,375 gallons per minute (gpm).

In addition, the South San Gabriel System has an emergency connection with the City of Monterey Park, with a capacity of 1,500 gpm. Two reservoirs with a total volume of 0.52 million gallons serve as storage in the South San Gabriel System.

4.3 Groundwater

This section provides a brief description of the Main San Gabriel Groundwater Basin, including the groundwater supplies available to GSWC. More detailed information can be found in the references cited in these sections.

Groundwater supplying GSWC's South San Gabriel System is pumped from a total of three active groundwater wells in the Main San Gabriel Basin, which has a surface area of approximately 154,000 acres (241 square miles). These wells have a current total normal year active capacity of 4,356 ac-ft/yr. Between 1999 and 2010, the actual production averaged 2,836 ac-ft/yr.

The Main San Gabriel Basin is bounded by the Raymond fault and the contact between Quaternary sediments and consolidated basement rocks of the San Gabriel Mountains on the north, by the Repetto, Merced, and Puente Hills on the south and west, and by the Chino and San Jose faults on the east.

Water-bearing units in the Main San Gabriel Basin are recent alluvium and the San Pedro Formation. The alluvium consists of Pleistocene and Holocene deposits with a total thickness ranging from 40 feet to over 4,000 feet. The Holocene alluvium consists of alluvial fans and stream deposits approximately 100 feet in thickness (DWR, 2004). The Pleistocene alluvium is composed of unsorted, angular to sub-rounded sedimentary deposits ranging from gravels near the San Gabriel Mountains to sands and silts in the central and western parts of the basin. These Pleistocene alluvium deposits constitute the most of the productive water-bearing units in the basin (DWR, 2004). The Pleistocene alluvium varies in thickness from 40 feet in the north to 4,100 feet in the central portion of the basin (DWR, 2004). The San Pedro formation also bears fresh water and consists of interbedded marine sand, gravel, and silt. The maximum thickness of the San Pedro formation is approximate 2,000 feet (DWR, 2004)

Estimates of the hydraulic conductivities in the Basin range from 270 feet per day (ft/d) for gravel to 0.001 ft/d for clay (CH2M HILL, 1986). Sand and gravel units were estimated to have a hydraulic conductivity of 135 ft/d and sandy clay estimated at 10 ft/d (CH2M HILL, 1986). These values of hydraulic conductivities are an estimate based on aquifer test and boring log descriptions of the sediments.

Groundwater levels have historically fluctuated in the basin. Since 1993, the water levels for the Baldwin Park Key Well have varied about from an elevation high of 272 feet to a historic low in 2009 of 189.2 feet (Upper District, 2010). The Watermaster reported in 2010 that the groundwater levels in the Baldwin Park Key Well have been just above the lower value of the operating range of storage for the groundwater basin at 204.2 feet as of June 26, 2010. One foot of elevation change of the Key Well is roughly equal to a change in water storage of 8,000 ac-ft. The total storage capacity of the San Gabriel Basin is estimated to be about 8.6 million ac-ft (Main San Gabriel Basin Watermaster, 2011). The historic high groundwater elevation was measured in 1916 at 329.1 feet at which time the Main San Gabriel Basin storage was estimated at 8.7 million ac-ft. The historic low groundwater elevation was 189.2 feet in 2009 when the Main San Gabriel Basin storage was estimated at 7.6 million ac-ft.

4.3.1 Main San Gabriel Basin Adjudication

In 1973, the rights to use groundwater from the San Gabriel Valley Basin were adjudicated in the case *Upper San Gabriel Valley Municipal Water District vs. City of Alhambra, et al* (Superior Court, County of Los Angeles, Case No. 924128, Appendix F). During the adjudication process, the safe yield of the basin was studied to help assign prescriptive pumping rights. The total prescriptive pumping right for the Main San Gabriel Basin was established at 197,634 ac-ft. This prescriptive right was used during the adjudication to determine the baseline share of pumping rights for each water producer in the basin.

The Main San Gabriel Basin Watermaster regulates groundwater production within the basin. Each year the Watermaster determines the operating safe yield (OSY) for the basin, which may be larger or smaller than the total prescriptive right of 197,634. The Watermaster performs hydrologic balance calculations to assess the groundwater conditions in the Main San Gabriel Basin. The hydrologic assessments are based on an evaluation of groundwater levels in the Basin, determination of the previous year's recharge and extraction activities, estimates of the current year's recharges and extractions, water quality, historic and current rainfall data, and the availability of imported water. The OSY has historically fluctuated to account for wet or dry conditions in the basin and to accommodate the availability of imported water that may be needed to supplement local water supplies and recharge of the basin.

The OSY is the amount of water that can be pumped from the basin before the Watermaster imposes a "Replacement Water Assessment" to replenish the basin with imported water. Each water right holder is entitled to a set percentage of the OSY annually. Because the OSY is recalculated each fiscal year (FY), the actual amount of water GSWC has rights to pump without paying a replenishment assessment fee can fluctuate annually. Since the basin was adjudicated in 1973, the OSY has ranged from a low of 140,000 (FY 1991 – 1992) to a high of 240,000 ac-ft (FY's 2005 – 2007).

Water pumped in excess of the OSY is managed by Upper District, the applicable responsible agency, which is determined by geographic and political boundaries under terms of the Judgment. Upper District is responsible for ensuring that the basin is not overpumped in any given year, i.e. that total groundwater production equals OSY water rights plus replenishment water. Replenishment water must be available to allow pumping in excess of the OSY. For the past 2 years, replenishment water was not available when the producers over pumped in the basin. The responsible parties have implemented cyclic storage agreements to provide replenishment water supplies during periods of reduced imported water availability. Additional descriptions of groundwater supply reliability and cyclic storage are provided in Chapter 6.

GSWC has pumping rights to 2.92105 percent of the OSY for the Main San Gabriel Basin, which is shared between the South San Gabriel and South Arcadia Systems. GSWC's total pumping rights for these two Systems have varied from 4,089 ac-ft/yr to 6,718 ac-ft/yr as shown in Table 4-2. In May 2011, the Watermaster established an OSY of 210,000 ac-ft/yr for FY 2011-12, which means that GSWC's current pumping right is 6,134 ac-ft/yr. However, since the OSY is set annually by the Watermaster, it was conservatively assumed that the long-term average OSY will be equal to 190,000 ac-ft/yr, for a pumping right of 5,550 ac-ft/yr. This total could be augmented by purchasing or leasing water rights from other right-holders in the basin. Furthermore, the adjudication for the Main San Gabriel Basin permits producers to carry over water rights from previous years and to pump more than their share of the OSY, provided they pay a replenishment fee for all excess production. The historic low, high, and current operating safe yield for the Main San Gabriel Basin are shown in Table 4-2.

Table 4-2: Main San Gabriel Basin Groundwater Pumping Rights

Condition/Time Period	Operating Safe Yield (ac-ft/yr)	GSWC Pumping Rights(1) (ac-ft/yr)
Historic Low OSY (FY 1991 – 1992)	140,000	4,089
Historic High OSY (FY 2005 – 2007)	240,000	7,011
Current OSY (FY 2011 – 2012)	210,000	6,134

Notes:
1. GSWC pumping right is equal to 2.92105 percent of the OSY for the South Arcadia and South San Gabriel Systems.
2. OSY is reassessed on an annual basis.

GSWC's South San Gabriel System currently operates 3 active wells in the Main San Gabriel Groundwater Basin; they are listed in Table 4-3. Well production capacity is provided in terms of instantaneous capacity in gpm and annual yield in ac-ft/yr for the South San Gabriel System. The total normal year active well capacity for GSWC's South San Gabriel System is 2,700 gpm (4,356 ac-ft/yr).

Table 4-3: Well Name and Capacity

Well Name	Current Well Capacity (gpm)(1)	Current Well Capacity (ac-ft/yr)
Earle	0	0
Garvey No. 1	0	0
Garvey No. 2	0	0
San Gabriel No. 1	1,200	1,936
San Gabriel No. 2	0	0
Saxon No. 3	1,000	1,613
Saxon No. 4	500	807
Total Capacity	**2,700**	**4,356**

Note:
1. Estimated annual average current well production capacity is provided; actual and design instantaneous pumping capacity may be greater for each well.

Table 4-4 shows the groundwater pumping history for the South San Gabriel System for calendar years 2005 through 2010. The amount of water pumped from the Main San Gabriel Basin for the South San Gabriel System has varied through this 5 year period. From 2005 to 2010, groundwater represented between 68 and 92 percent of the total water supply for the South San Gabriel System.

Table 4-4: Groundwater Pumping History by South San Gabriel System (2005 to 2010) in ac-ft

Basin Name	Metered or Unmetered	2005	2006	2007	2008	2009	2010
Main San Gabriel	Metered	2,192	2,555	2,912	2,877	2,628	2,352
Percent of Total Water Supply		68%	74%	90%	92%	91%	87%

Notes:
1. Table format based on DWR Guidebook Table 18.
2. Years are reported in calendar years (January 1 – December 31).

The projected groundwater pumping volumes for the South San Gabriel System through 2035 are summarized in Table 4-5. If needed, the South San Gabriel System's share of the OSY could be augmented through the purchase or lease of pumping rights from other producers in the Main San Gabriel Basin. The adjudication for the Main San Gabriel Basin also permits a producer to pump more than its share of the OSY if replenishment water is available, and if the producer pays a replenishment fee for all production in excess of the allocated rights.

Table 4-5: Projected Groundwater Pumping Amounts by South San Gabriel System to 2035 in ac/ft

Basin Name	2010	2015	2020	2025	2030	2035
Main San Gabriel	2,352	1,313	1,134	991	850	733
Percent of Total Water Supply	87%	38%	32%	28%	23%	20%

Notes:
1. Table format based on DWR Guidebook Table 19.
2. Years are reported in calendar years (January 1 – December 31).

4.4 Transfers and Exchanges

GSWC has historically transferred groundwater rights for its holdings in the Main San Gabriel Basin between the San Dimas District and the San Gabriel District. Additionally, if GSWC's actual need for groundwater exceeds its share of the OSY, GSWC can lease available groundwater rights from other producers in the basin to increase their allowed pumping. GSWC has the ability to obtain leases for additional groundwater in the Main San Gabriel Basin annually, on an as-needed basis, following an evaluation of the economic benefits to their rate payers.

No specific transfer or exchange opportunities have been identified in the South San Gabriel System at this time; therefore, Table 4-6 has been left blank.

Table 4-6: Transfer and Exchange Opportunities					
Source Transfer Agency	**Transfer or Exchange**	**Short Term**	**Proposed Quantities**	**Long-Term**	**Proposed Quantities**
GSWC	N/A	N/A	N/A	N/A	N/A

Note:
Table format based on DWR Guidebook Table 20.

4.5 Planned Water Supply Projects and Programs

GSWC, as a part of its normal maintenance and operations, will construct new wells, pipelines, and treatment systems as needed as a part of its ongoing Capital Investment Program to maintain its supply and meet distribution system requirements.

Additionally, GSWC participates with the Upper District in a variety of programs intended to enhance regional water supply. These projects include surface water treatment plant improvements, groundwater replenishment and recharge studies, recycled water, and groundwater cleanup. In addition, the Upper District is currently evaluating the expanded use of recycled water for groundwater recharge. See the Upper District's 2010 UWMP for details.

A potential long-term water supply transfer opportunity that GSWC is evaluating is the Cadiz Valley Water Conservation, Recovery and Storage Project (Cadiz Project). The project is designed to capture and conserve thousands of acre-feet of native groundwater currently being lost to evaporation through an aquifer system beneath Cadiz's property in eastern San Bernardino County, California. By implementing established groundwater management practices, the project will create a new, sustainable annual water supply for project participants. In addition, the project offers storage capacity that can be used by participants to carry-over "or "bank" annual supplies, without the high rates of evaporative loss suffered by local surface reservoirs.

The Cadiz Project will produce up to 50,000 ac-ft/yr for fifty years. GSWC is one of five entities that have expressed an interest in receiving water from the project. In 2009, GSWC signed a letter of intent to purchase up to 5,000 ac-ft/yr and committed to paying a share of the cost of the project's environmental evaluation. GSWC continues to evaluate the economics and technical feasibility of this project. Table 4-7 shows the potential water supply that could be provided by the Cadiz Project.

Table 4-7: Future Water Supply Projects in ac-ft					
			Multiple-Dry Years		
Project Name	**Normal Year**	**Single-Dry Year**	**Year 1**	**Year 2**	**Year 3**
Cadiz Project	5,000	5,000	5,000	5,000	5,000

Note:
This table is based on the DWR Guidebook Table 26.

4.6 Wholesale Agency Supply Data

Table 4-8 provides the Upper District's existing and planned water sources available to the South San Gabriel System during normal years. These supplies are expected to meet the projected imported water demands.

Table 4-8: Existing and Planned Wholesale Water Supplies in ac-ft/yr

Wholesaler Sources	Contracted Volume	2010	2015	2020	2025	2030	2035
USGVMWD		338	2,097	2,375	2,604	2,828	3,015

Note:
This table is based on DWR Guidebook Table 17.

Table 4-9 demonstrates the reliability of wholesale water supply available to meet annual water demand under an average, single-dry year condition for the South San Gabriel System. The table includes single-dry year and multiple-dry year supplies for 2035. The Upper District is assured by Metropolitan of 100 percent reliability to meet the water demand through 2035 (Metropolitan RUWMP, 2010).

Table 4-9: Reliability of Wholesale Supply for Year 2035 in ac-ft/yr

			Multiple-Dry Water Years		
Wholesaler	Average / Normal Water Year Supply	Single-Dry	Year 1	Year 2	Year 3
USGVMWD	3,015	3,015	3,015	3,015	3,015
Percent Normal		100	100	100	100

Note:
Table format based on DWR Guidebook Table 31.

Table 4-10 lists factors affecting wholesale supply for the South San Gabriel System. Metropolitan intends to provide 100 percent supply reliability to the Upper District, which in turn provides 100 percent reliability of supply to the South San Gabriel System.

Table 4-10: Factors Affecting Wholesale Supply

Name of Supply	Legal	Environmental	Water Quality	Climatic
USGVMWD	N/A	N/A	N/A	N/A

Note:
Table format based on DWR Guidebook Table 29.

4.7 Desalination

This section presents a discussion of opportunities to use desalinated water as a supplemental future water supply source for the South San Gabriel System. Section 10631(i) of the Act requires an evaluation of desalination opportunities within the South San Gabriel System. The Act states the following:

Section 10631

(i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

GSWC obtains the majority of its water supply for the South San Gabriel System from local groundwater which has not been impacted by salinity issues and does not require desalination. There are currently no opportunities for using desalinated water as a source of water supply for the South San Gabriel System by GSWC or the groundwater basin responsible agency, Upper District. Therefore, Table 4-11 has been intentionally left blank.

Upper District has concluded that due to the high quality (low TDS concentration) groundwater, Upper District and its member agencies do not need to investigate the use of desalination to develop or reestablish a new long-term supply (Upper District, 2011). Likewise, while it is currently economically impractical and infeasible for GSWC to participate in a desalination program that directly benefits the South San Gabriel System, GSWC would be open to considering partnering opportunities with other water suppliers in the region who may participate in a desalination project that would provide a direct or indirect benefit through mechanisms such as groundwater replenishment.

Table 4-11: Summary of Opportunities for Water Desalination

Source of Water	Yield (ac-ft/yr)	Start Date	Type of Use	Other
None	N/A	N/A	N/A	N/A

4.8 Recycled Water Plan

This chapter covers Section 10633 which details the requirements of the Recycled Water Plan that are included in the Act. The Act states the following:

Section 10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(c) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse,

groundwater recharge, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(d) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(e) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre feet of, recycled water used per year.

(f) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

4.8.1 Coordination

Table 4-12 summarizes the role of the agencies that participate in the development of recycled water plans that affect the South San Gabriel System of the Golden State Water Company (GSWC).

Table 4-12: Role of Participating Agencies in the Development of the Recycled Water Plan

Participating Agencies	Role in Plan Development
Water agencies	GSWC works closely with the Los Angeles County Sanitation District (LACSD) in planning a potential recycled water distribution system and identifying potential recycled water customers. The Upper San Gabriel Valley Municipal Water District acting as the recycled water wholesaler, would lead the way in implementing the recycled water plan and distribution network.
Wastewater agencies	The LACSD provides a reliable supply of recycled water that meets California recycled water quality standards set forth in Title 22 of the California Code of Regulations.
Groundwater agencies	Not applicable for this System.
Planning agencies	Los Angeles County Sanitation District plays a key role in conducting data and customer assessments, as well as analyzing community and economic impacts.

4.8.2 Wastewater Quantity, Quality, and Current Uses

Wastewater in the South San Gabriel System is collected by gravity sewers and lift stations owned by the cities of Rosemead, San Gabriel, and Monterey Park, as well as by the Sanitation Districts of Los Angeles County (LACSD). The wastewater is transported through trunk sewers to LACSD's San Jose Creek and Whittier Narrows Water Reclamation Plants (WRP).

The San Jose Creek WRP provides primary, secondary, and tertiary treatment for an average dry weather flow (DWF) of 100 million gallons of wastewater per day (mgd). The plant serves a largely residential population of approximately one million people. About 35 mgd of treated effluent from San Jose Creek WRP is reused at 17 different sites. The recycled water is primarily used for groundwater recharge and agricultural and landscape irrigation. The remaining effluent (65 mgd) is discharged into the San Gabriel River (LACSD 2011).

The Whittier Narrows WRP provides primary, secondary, and tertiary treatment for an average DWF of 15 mgd. The plant serves a population of approximately 150,000 people. According to the LACSD, nearly all of the treated effluent is reused as groundwater recharge into the Rio Hondo and San Gabriel Coastal Spreading Grounds or for irrigation at an adjacent nursery. Any remaining effluent is discharged into the San Gabriel River (LACSD 2011).

Because the Whittier Narrows and San Jose Creek WRPs treat wastewater for a larger population than exists in the South San Gabriel System, an estimated per capita wastewater generation factor was used to calculate the volume of wastewater generated by GSWC's customers in South San Gabriel. Based on the populations served and the average wastewater treatment rates for the San Jose Creek and Whittier Narrows WRPs as detailed above, the average per capita wastewater generation factor for both of these WRPs is 100 gallons per person per day. This factor was used to estimate existing and projected volumes of wastewater collected and treated in the South San Gabriel System as summarized in Table 4-13.

Because all of the effluent from Whittier Narrows and San Jose Creek WRPs is treated to meet Title 22 recycled water standards, 100 percent of the treated effluent is included in Table 4-13 as meeting such standards. However, out of the combined wastewater effluent (115 mgd) from these two treatment plants, 50 mgd (43 percent) of the treated water is actively reused throughout the region. Therefore, the assumption is that 43 percent of the treated wastewater that is collected in the South San Gabriel System is recycled while the remaining 57 percent is discharged into the unlined portions of the San Gabriel River. Although the majority of the water that is discharged into the San Gabriel River will contribute to groundwater recharge through the riverbed, LACSD does not consider this an active recycled water use. Table 4-14 lists the estimates of existing and projected volumes of treated effluent collected from the South San Gabriel System that will be discharged into the San Gabriel River.

Although much of the wastewater generated in the South San Gabriel System is recycled, all of the reuse sites are elsewhere in the LACSD system, and there are no existing uses of recycled water within the boundaries of the South San Gabriel service area. Therefore, Table 4-15 has intentionally been left blank.

Table 4-13: Estimates of Existing and Projected Wastewater Collection and Treatment in ac-ft/yr (mgd) for the South San Gabriel System

	2005(3)	2010(3)	2015	2020	2025	2030	2035
Projected population in service area(2)	28,140	28,715	29,414	30,065	30,710	31,332	31,932
Wastewater collected and treated in service area(4)	3,152 (2.81 mgd)	3,216 (2.87 mgd)	3,295 (2.94 mgd)	3,368 (3.01 mgd)	3,440 (3.07 mgd)	3,510 (3.13 mgd)	3,577 (3.19 mgd)
Quantity that meets recycled water standard	3,152 (2.81 mgd)	3,216 (2.87 mgd)	3,295 (2.94 mgd)	3,368 (3.01 mgd)	3,440 (3.07 mgd)	3,510 (3.13 mgd)	3,577 (3.19 mgd)

Notes:

1. This table is based on the DWR Guidebook Table 21.
2. For population projections see Section 2.3.
3. Based on calendar year.
4. Volumes of wastewater collected and treated are estimated based on the per capita generation factor. WW = population x 100 gal/day.

Table 4-14: Estimates of Existing and Projected Disposal of Non-Recycled Wastewater in ac-ft/yr (mgd) for the South San Gabriel System								
Method of Disposal	**Treatment Level**	**2005(2)**	**2010(2)**	**2015**	**2020**	**2025**	**2030**	**2035**
River Discharge	Tertiary	1,782 (1.59)	1,818 (1.62)	1,862 (1.66)	1,904 (1.70)	1,944 (1.74)	1,984 (1.77)	2,022 (1.80)

Notes:

1. This table is based on the DWR Guidebook Table 22.
2. Based on actual year.
3. Volumes of effluent discharged are estimated. For a description of the methodology, refer to the text.

Table 4-15: Existing Recycled Water Use in the South San Gabriel System		
Type of Use	**Treatment Level**	**2010 Use (ac-ft/yr)**
N/A	N/A	N/A

4.8.3 Potential and Projected Use

Although the wastewater generated in the South San Gabriel System is treated by the San Jose Creek and Whittier Narrows WRPs, the recycled water distribution networks from these two facilities do not extend to the South San Gabriel System. It is the responsibility of LACSD, as owner and operator of these facilities, to determine the feasibility of extending the recycled water distribution network to South San Gabriel. At this time, LACSD does not have plans to extend their distribution network.

In addition to LACSD, the Upper San Gabriel Municipal Water District (Upper District), a member agency of the Metropolitan Water District of Southern California, and a water provider for the GSWC, has developed a direct reuse project located in the vicinity of the South San Gabriel System. The Direct Reuse project will supply approximately 1,800 ac-ft/yr of recycled water to irrigation customers in the Whittier Narrows area in order to replace groundwater and imported potable water that historically has been used for irrigation at these customer locations. However, this project does not include GSWC customers within the South San Gabriel System.

Since no potential or projected recycled water use has been identified for the South San Gabriel System, Table 4-16 and Table 4-17 were intentionally left blank. In the 2005 UWMP for the South San Gabriel System there were no projections of recycled water by the year 2010, so Table 4-18 has also been left blank.

Table 4-16: Potential Future Recycled Water Uses in ac-ft/yr

Type of Use	Treatment Level	Description	Feasibility	2015	2020	2025	2030	2035
N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note:
This table is based on the DWR Guidebook Table 23.

Table 4-17: Projected Future Recycled Water Use in Service Area in ac-ft/yr

Type of Use	2015	2020	2025	2030	2035
N/A	N/A	N/A	N/A	N/A	N/A

Table 4-18: Comparison of Recycled Water Uses—Year 2000 Projections versus 2005 Actual

Type of Use	2005 Projection for 2010	2010 Actual Use
N/A	N/A	N/A

Note:
This table is based on the DWR Guidebook Table 24.

4.8.4 Optimization and Incentives for Recycled Water Use

If and when the LACSD and/or Upper District decide to extend the distribution of recycled water to South San Gabriel, where feasible, GSWC will support the projects by encouraging recycled water use among its customers. However, because no plans exist to provide recycled water to the South San Gabriel System, there are no actions in place at this time by which GSWC is encouraging the use of recycled water in this system. Therefore, Table 4-19 is not applicable for this system and has been intentionally left blank.

Table 4-19: Methods to Encourage Recycled Water Use and the Resulting Projected Use in ac-ft/yr

Actions	2015	2020	2025	2030	2035
N/A	N/A	N/A	N/A	N/A	N/A

Note:
This table is based on the DWR Guidebook Table 25.

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Chapter 5: Water Quality

Section 10634 of the Act requires an analysis of water quality issues and their impact to supply reliability. The Act states as follows:

> *Section 10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631 and the manner in which water quality affects water management strategies and supply reliability.*

5.1 GSWC Measures for Water Quality Regulation Compliance

To facilitate full compliance with water quality laws and regulations, GSWC maintains an Environmental Quality Department that has independent lines of reporting authority within the organization. The Environmental Quality Department is headed by a company officer specifically assigned to oversee and manage the company's environmental and water quality programs. The Vice President of Environmental Quality has a staff of three managers, including two Water Quality Managers. The Water Quality Managers, in turn, manage a staff of Water Quality Engineers and Technicians that are assigned to district offices. Each district office is assigned one Water Quality Engineer and at least one Water Quality Technician to provide direct support to the local drinking water systems within the district.

The District Water Quality Engineer is the main point of contact for the California Department of Public Health (CDPH) as well as other regulatory agencies. The Water Quality Engineer also is responsible for coordinating compliance measures through scheduling required sample collection, preparing water quality related plans, maintaining a water quality database, providing training to operations, maintaining a cross connection control program, and preparing and submitting monitoring reports, permit applications and other regulatory related correspondence.

As a whole, the Environmental Quality Department monitors and participates in the implementation of new water quality related laws and regulations. Through routine department meetings and training, the District Water Quality Engineers are kept up to date with changing water quality regulations and related technology. These efforts contribute towards maintaining a pool of trained water quality professionals that can be utilized throughout the company. This provides the company the ability to respond to a wide variety of water quality issues or emergencies.

5.2 Water Quality Issues

The drinking water quality of the South San Gabriel System must comply with the Safe Drinking Water Act (SDWA), which is composed of primary and secondary drinking water standards regulated by the U.S. Environmental Protection Agency and CDPH. Water Quality sampling is performed at each well and within the distribution system to ensure compliance with the regulatory standards.

5.2.1 Surface Water Quality

Treated surface water purchased from the Upper San Gabriel Valley Municipal Water District (Upper District) enters the South San Gabriel System through a single inter-connection. Metropolitan and Upper District are responsible for meeting all drinking water standards as water leaves the surface water treatment plant and at all inter-connections with the South San Gabriel System.

5.2.2 Groundwater Quality Management

Significant groundwater contamination in the Main San Gabriel Basin has resulted from industrial solvents known as volatile organic compounds (VOCs) and agricultural practices which contribute nitrates to the groundwater. In an effort to create a coordinated response to the groundwater contamination issue and to minimize impacts to groundwater supply, Main Basin water agencies adopted a joint resolution in 1989. This resolution assigned the Main Basin Watermaster the responsibility of developing and maintaining a 5-Year Water Quality and Supply Plan, subject to review by the Los Angeles Regional Water Quality Control Board. The objective of the 5-Year Plan is to coordinate cleanup projects, and ensure that pumping does not lead to degradation of water quality in the Main Basin. The Upper District also maintains a basinwide groundwater quality management and remediation plan (Upper District, 2010). As a result of these coordinated efforts by the Main Basin Watermaster and Upper District, groundwater quality is carefully monitored and activities are regulated to ensure that the effect of contamination on producers, including GSWC, is minimized.

5.2.3 Groundwater Quality

Table 5-1 summarizes water quality issues and recommendations for wells within the water system. The groundwater wells in the South San Gabriel System meet all current California Title 22 drinking water standards before water is delivered to customers. The following discussion relates to contaminants with maximum contaminant levels (MCLs) that are either existing or have been proposed by the USEPA and/or CDPH.

Drinking water regulations pertaining to emerging contaminants of concern, such as chromium (VI), nitrosamines, and VOCs, and potential revisions to existing regulations are closely monitored by GSWC's Environmental Quality Department. The appropriate sampling and action will be taken on any affected water supply sources as monitoring requirements, new or revised MCLs are promulgated by the USEPA or CDPH. It is anticipated that it will take approximately 2 to 5 years from official adoption of a new or revised MCL to implement wellhead treatment or alternative approach for a source, including all steps from procuring CPUC funding approval to planning, permitting, design, and construction. There is typically adequate time allotted from regulatory approval to promulgation of a new drinking water standard to address localized treatment requirements; therefore no direct impacts to water supply reliability from future water quality regulations are anticipated at this time.

Portions of the groundwater basin are impacted by contaminants from improper waste disposal. The contaminants consist primarily of volatile organic compounds (VOCs) and perchlorate. The water system has been able to compensate for the loss of the contaminated wells and maintain its extractions from the basin by upgrading equipment at existing well sites, and making other system improvements.

The water system currently includes a total of seven wells, four of which have been taken off-line due to groundwater contamination. These wells and associated contaminants are:

- Earle Well – VOCs
- Garvey Wells No. 1 and No. 2 – VOCs
- San Gabriel Well No. 2 – VOCs, perchlorate and nitrate

Perchlorate. To date, perchlorate has impacted two wells, San Gabriel Wells Nos. 1 and 2. In 2010, perchlorate treatment was removed due to a sustained decline in perchlorate levels at San Gabriel Well No. 1. In addition, granular activated carbon treatment is being provided to remove VOCs. An expansion of the treatment process is underway to bring San Gabriel Well No. 2 on-line.

VOCs. Volatile organic compounds (VOCs) have impacted the five wells, including the San Gabriel No. 1 Well for which granular activated carbon treatment is being used. VOC monitoring and actions at the other wells include drilling replacement wells, well destruction, or installation of wellhead treatment systems.

Nitrate. Nitrate currently impacts San Gabriel Well No. 2. There is currently no treatment in place for nitrate, and the well has been taken offline.

1,4-Dioxane. Recently, 1,4-Dioxane has been detected in San Gabriel Well No. 1. The average concentration is below the Notification Limit of 1 µg/L. 1,4-Dioxane monitoring occurs on a more frequent basis.

Should additional treatment for the constituents listed above including perchlorate, VOCs, or 1,4 dioxane removal be required in the future, it is anticipated it would take approximately 2 to 5 years to implement a best available technology wellhead treatment system such as ion exchange, GAC, or advanced oxidation. Consideration will also be included for alternative water quality management strategies such as blending or supply replacement.

Radon. Radon has also been detected in many of the wells in the system. In 1999, the USEPA has proposed a radon MCL at 300 pCi/L, with an alternative standard of 4,000 pCi/L if the state has an approved Multimedia Mitigation program to reduce the indoor radon risk from soil and rocks underneath homes and buildings. While the proposed radon rule has not proceeded to promulgation, the effect of the proposed radon MCL would be widespread in groundwater wells throughout California.

Groundwater production from most of the active wells in this system will be impacted if the radon MCL is set at 300 pCi/L. Best available technologies for radon removal include Packed Tower Aeration (PTA) and Granular Activated Carbon (GAC). Due to some critical operation concerns with the use of GAC, PTA is the most common and effective method for radon removal. Installation of treatment facilities at some of the well sites in this system may be problematic due to lack of available space for treatment equipment. It is expected the state will develop an approved Multimedia Mitigation program thus allow the alternative MCL standard. If an MCL is promulgated, Multimedia mitigation would be recommended for these wells.

Table 5-1: Summary of Assessment					
Well	**Current Well Capacity (gpm)[1]**	**Status**	**Water Quality Issue□Concern**	**Existing Treatment**	**Recommendations**
Earle	0	Inactive	VOCs; Radon		Destroy
Garvey No. 1	0	Inactive	VOCs; Radon		Destroy
Garvey No. 2	0	Inactive	VOCs; Radon		Destroy
San Gabriel No. 1	1,200	Active	VOCs, Perchlorate □ 1,4-Dioxane	GAC	Continue Treatment
San Gabriel No. 2	0	Inactive	VOCs perchlorate; nitrate, Radon		Provide Treatment; Future multimedia mitigation (radon)
Saxon No. 3	1,000	Active	Radon		Future Multimedia mitigation (radon)
Saxon No. 4	500	Active	Radon		Future Multimedia mitigation (radon)

Note:

1. Estimated annual average current well production capacity is provided; actual and design instantaneous pumping capacity may be greater for each well.

5.2.4 Distribution System Water Quality

Distribution system water quality monitoring is performed for several water quality parameters in the South San Gabriel System, including general physical parameters, presence of coliform bacteria, disinfectant and disinfection by-product levels. Corrosivity of the water is monitored by measuring lead and copper levels at customer water taps. The South San Gabriel System utilizes an approved Sample Siting Plan for the collection, recording, and reporting of all bacteriological analyses. All monitoring parameters and levels currently meet drinking water standards. The ability to continue to meet these standards is not expected to change in the foreseeable future. The South San Gabriel System has also established an aggressive cross-connection control program to reduce the hazard associated with backflow and back-siphonage. These programs are required to comply with DHS regulations on Waterworks Standards and Cross Connection Control. Drinking water standard levels for disinfection by-products will be lowered in the future in accordance with the Stage 2 D□DBP Rule. It is anticipated that the system will meet the new standard without treatment or operational changes.

5.3 Projected Water Quality Impacts

As the water system loses additional wells due to groundwater contamination (Table 5-2), evaluations will be made to determine replacement water supply, treatment options and/or drilling new wells in accordance with the requirements of the Upper District's groundwater quality management policies.

Table 5-2: Summary of Projected Water Supply Changes Due to Water Quality Issues

Water Source	Projected Change (ac-ft/yr)					
	2010	2015	2020	2025	2030	2035
Earle (to be destroyed)	(261)	0	0	0	0	0
Garvey No. 1 (to be destroyed)	(149)	0	0	0	0	0
Garvey No. 2 (to be destroyed)	(217)	0	0	0	0	0
San Gabriel No. 1	0	0	0	0	0	0
San Gabriel No. 2	0	0	0	0	0	0
Saxon No. 3	0	0	0	0	0	0
Saxon No. 4	0	0	0	0	0	0

Note:
Table format based on DWR Guidebook Table 30.

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Chapter 6: Water Supply Reliability

Sections 10631 and 10635 of the Act require that an assessment of water supply reliability for various climatic conditions be undertaken. The Act states:

Section 10631.

(c) (1) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(A) An average water year.

(B) A single dry water year.

(C) Multiple dry water years.

(2) For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

Section 10635.

(a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

6.1 Reliability of Supply

The South San Gabriel System obtains its water supply from two sources: Metropolitan imported water obtained from the Upper District San Gabriel Valley Municipal Water District (Upper District), and groundwater from the Main San Gabriel Groundwater Basin. The majority of the imported water delivered from the Upper District to its sub-agencies is used for groundwater recharge (Upper District, 2011). Upper District is the agency identified in the Main Basin Judgment that is responsible for importing water into the basin for the South Arcadia and South San Gabriel Systems. The Upper District imports water from Metropolitan, therefore, conditions in local and distant areas can impact the reliability of supplies. In general, GSWC's supply is expected to be 100 percent reliable through 2035. This is a result of the projected reliability of the Upper District as a member of Metropolitan, both of which intend to provide 100 percent reliable imported water supplies. Groundwater reliability is based on GSWC's share of the projected Main San Gabriel Basin annual OSY and the numerous current and planned projects in the Main San Gabriel Basin designed to increase the reliability of the groundwater supply. The following is a summary of the basis of this reliability.

6.1.1 Metropolitan Supply Reliability

Metropolitan member agencies in the San Gabriel Valley, including Upper District, are largely pass-through entities that obtain nearly all their imported water from Metropolitan, directly or indirectly. Metropolitan's resource management plans are intended to optimize the use of its available resources during surpluses and shortages to minimize the probability of severe shortages and eliminate the possibility of extreme shortages and shortage allocations

This section presents a brief discussion of the source reliability of Metropolitan's primary water supply sources: imported water supply from the Colorado River and the State Water Project, and Metropolitan's plans to ensure a reliable water supply into the future. Metropolitan maintains a diverse portfolio of water sources including surface water supply, aquifer recharge and recovery, desalination, and recycled water. The two primary components of Metropolitan's water supplies are also the most variable:

- ***Colorado River Supply:*** Metropolitan owns and operates the Colorado River Aqueduct (CRA), which connects the Colorado River to the Metropolitan regional distribution system. The CRA has a capacity of 1.25 Million AFY (MAF) to transport Metropolitan's current contracted entitlement of 550 Thousand AFY (TAF) of Colorado River water. Metropolitan also holds a priority for an additional 662 TAF and 180 TAF when surplus flows are available.

- ***State Water Project (SWP) Supply:*** The original State Water Project Contract called for an ultimate delivery capacity of 4.2 MAF, with Metropolitan holding a contract for 1.9 MAF. Since that time there have been significant challenges to meeting those delivery goals. DWR released a Water Allocation Analysis in 2010 that has resulted in a Metropolitan estimated reduction in SWP supplies of 150 – 200 TAF for 2010 (Metropolitan Draft Regional UWMP, 2010).

As a result of the inherent uncertainty in Colorado River and SWP supplies given various hydrologic, environmental, and legal considerations, Metropolitan has undertaken several planning initiatives, summarized below, to broaden its water resources reliability. Metropolitan has documented that, consistent with Section 4202 of its Administrative Code, the agency is prepared to provide its member agencies with adequate supplies of water to meet expanding and increasing needs in the years ahead. When additional water resources are required to meet increasing needs, Metropolitan has stated that it will be prepared to deliver such supplies. In its 2010 Regional Urban Water Management Plan, Section II.4, Metropolitan also states that as a result of investments made in supply and storage, it has identified a resource management plan that should result in 100 percent reliability for non-discounted non-interruptible demands through 2035.

- **Integrated Resources Plan Updates (IRP):** Metropolitan's IRP updates completed in 1996 and updated in 2004 and 2010, included assessments of potential future regional demand projections based upon anticipated population and economic growth as well as conservation potential. The IRP also includes regional supply strategies and implementation plans to better manage resources, meet anticipated demand, and ensure overall system reliability. Metropolitan intends to implement the 2010 IRP to further support member agency local resource development as well as to investigate generating its own local resources for distribution to member agencies. The development of local resources, as well as the furthering of existing conservation goals to meet the Water Conservation Act of 2009 targets, is anticipated to provide a supply buffer for member agencies to rely upon in times of drought and long-term climatic changes.

- **1999 Water Surplus and Drought Management Plan (WSDM):** The WSDM provides the policy guidance to manage the region's water supplies to achieve the reliability goals of the IRP. This is achieved by integrating the operating activities of surplus and shortage supplies through a series of stages and principles.

- **2008 Water Supply Allocation Plan (WSAP):** The WSAP includes the specific formula for calculating member agency supply allocations and the key implementation elements needed for administering the allocation. The need for the WSAP arose after the 2008 Bay-Delta biological opinions and rulings that limited SWP supplies to its contractors including Metropolitan. The WSAP formula seeks to balance the impacts of a shortage at the retail level while maintaining equity on the wholesale level for shortages of Metropolitan supplies up to 50 percent.

  Since the 2008 Bay-Delta reductions, Metropolitan has been using the WSAP formulas to contend with the reduction in available imported supplies implementing a Stage 2 (Regional 10 percent reduction in supply allocation) of the WSAP from July 2009 to April 2011. During such allocations, Metropolitan institutes severe financial penalties should an entity request supply over their reduced allocation. This in effect, limits supply at the retail level. Although it is anticipated that the WSAP will continue to be in effect in the near term, Metropolitan states in its 2010 Draft UWMP that there will be sufficient supply to meet member agency demands in single and multiple-dry years from 2015 through 2035. However, this is assuming that Metropolitan storage levels are at or above average levels prior to those cycles, and key programs come to fruition as assumed by Metropolitan in their projections. For example, Metropolitan assumes that a Delta conveyance solution will be in place by 2022. Also, Metropolitan has indicated that there is a 50 percent probability that storage levels will be lower than the assumption used. Based on the recent WSAP allocations and regulatory restrictions in the Delta. GSWC's conservative assumption is that Metropolitan's projections in their 2010 Draft UWMP may not be 100 percent reliable in all cases.

6.1.2 The Upper District's Water Supply Reliability

In addition to Metropolitan's reliability initiatives, the Upper District and GSWC participate in a variety of programs intended to enhance the reliability of regional water supply. These projects include surface water treatment plant improvements, percolation studies, recycled water, and groundwater cleanup. In addition, the Upper District is currently evaluating the expanded use of recycled water for groundwater recharge. See the Upper District's 2010 UWMP for details.

6.1.3 South San Gabriel System's Water Supply Reliability

Supply reliability for the South San Gabriel System depends upon the reliability of imported water and local groundwater pumping, as discussed above.

Under the Main San Gabriel Basin Judgment, the Watermaster is responsible for managing withdrawals from the Basin by monitoring groundwater levels at the Baldwin Park Key Well. The Judgment states that the Watermaster shall not spread replenishment water when the groundwater level at the Key Well exceeds 250 feet above mean sea level (msl). The Judgment also states that the Watermaster shall spread replacement water necessary to maintain the water level elevation above 200 feet msl. During the period of management under the Judgment, significant drought events have occurred from 1969 to 1977, 1983 to 1991, and 1998 to 2004. In each drought cycle the Main San Gabriel Basin was managed to maintain groundwater levels. Based on historic management practices, all pumpers from the Main San Gabriel Basin will have adequate supply over the next 25 years under single year and multiple year drought periods (Upper District, 2011). The Upper District's UWMP provides basin-wide details about the reliability of the Main San Gabriel Basin.

GSWC and other water producers participate with the responsible agency, Upper District, to ensure that the OSY is available to the pumpers in the Main San Gabriel Basin. The Upper District has a cyclic storage agreement with Metropolitan and the Main Basin Watermaster. Cyclic storage accounts have been used to increase storage in the basin since 1975. Metropolitan pre-delivers replenishment water to the Basin and later sells the stored water to the water districts at a reduced rate. Metropolitan can store up to 100,000 ac-ft of water for the Upper District. Currently, Metropolitan has 22,633 ac-ft of water in storage for Upper District (Main San Gabriel Basin Watermaster 2010).

The Main San Gabriel Groundwater Basin's pumping and reliability is subject to the OSY established each fiscal year by the Watermaster and the availability of replenishment water. Long-term cyclic storage provides a mechanism that allows the responsible agency to establish a buffer during droughts and periods of reduced OSY by allowing for storage recharge waters during times of available import supplies. Recharge in the basin occurs from percolation of precipitation, return flow of applied water, some septic system discharges, and stream flow. Recharge through streams and spreading basins is generated from runoff from surrounding mountains and imported water from the State Water Project and the Colorado River.

There are also pending amendments to the Judgment that would enhance groundwater reliability in the basin. The Watermaster has determined that its 1973 Judgment may require changes to reflect the current conditions and allow the Watermaster more flexibility in securing necessary supplemental supplies. The Watermaster expects proposed changes to be finalized and submitted to the Los Angeles Superior Court for approval after FY 2010-11 (Watermaster 2010). Some of the key proposed changes that would enhance basin groundwater reliability and reduce vulnerability to droughts and uncertain imported supplies include:

- Storage and export – allow for outside water to be stored and exported by agreement with Watermaster;
- Recycled water – remove the limit on recycled water that can be recharged in 1 year;
- Key Well – eliminate the 250-foot upper limit at the Key Well for spreading imported water;
- Assessments – provide a means for the Watermaster to levy assessments to support endeavors such as pre-purchasing Replacement Water, development of new supplemental water resources (such as the recycled water recharge project), and to buy supplemental water that may become available unexpectedly or on short notice.

In part, the Main Basin reliability may also be increased through the groundwater management and replenishment efforts of the other responsible agencies in the basin. For example, the Upper San Gabriel Municipal Water District will supply approximately 15,000 ac-ft/yr of recycled water to irrigation customers through the San Gabriel Valley Water Recycling Direct Reuse Project. This project will optimize the availability of Metropolitan's imported water supply, enhancing the reliability of regional water supplies. This project replaces untreated imported water used for groundwater replenishment and irrigation. There are four phases to this project, two of which have been completed in 2007. The remaining two phases include the following:

Phase IIA-Rosemead Extension expands Phase IIA-Whittier Narrows Project to provide recycled water in the near future to the Whittier Narrows Golf Course, several schools, parks and industrial complexes. The project began construction in September 2009 and is projected to be completed by summer of 2011. Pipeline construction is complete and retrofits are being designed. The facilities for Phase IIA-Rosemead Extension include an approximate 2.5-mile long pipeline. An approximate demand of 720 acre-feet per year of high-quality water is anticipated to be supplied from the Whittier Narrows Water Reclamation Plant. The 720 acre-feet will be available during an average year, single-dry year and multiple-dry years.

Phase IIB Industry Project is separated into packages. Phase IIB includes the construction of new joint and local conveyance, storage, and distribution facilities, providing improved and extended recycled water service to potential customers in the Cities of West Covina and Walnut. Construction began in 2010 and is projected to be constructed by summer 2013. Phase IIB will supply approximately 1,600 acre-feet per year of recycled water to several landfills, parks, schools, open areas and commercial establishments from the San Jose Creek and Whittier Narrows Water Reclamation Plants. The 1,600 acre-feet will be available during an average year, single-dry year and multiple-dry years.

Table 6-1 presents 2035 water supply projections for imported and groundwater sources during a normal year, a single-dry year, and multiple-dry years for the South San Gabriel System. The normal-year supply represents the expected supply under average hydrologic conditions, the dry-year supply represents the expected supply under the single driest hydrologic year, and the multiple-dry year supply represents the expected supply during a period of three consecutive dry years.

As described above, Metropolitan, which is the source of water to the Upper District, has indicated that it will maintain 100 percent reliability through 2035. GSWC bases its reliability projections for purchased supply beyond 2025 on Metropolitan's projections. The purchased water supply projections for a normal water year, single-dry year, and multiple-dry years are taken as the 2035 projection, which is equivalent to the imported water demand projected for 2035. It is assumed that the single-dry year and multiple-dry year supplies are the same as those for the normal years because the Upper District has stated that it will meet projected demands under all anticipated hydrologic conditions.

Table 6-1: Supply Reliability for the South San Gabriel System for Year 2035 in ac-ft/yr

Source	Normal Water Year	Single-Dry Water Year	Multiple-Dry Water Years		
			Year 1	Year 2	Year 3
Purchased water from USGVMWD	3,015	3,015	3,015	3,015	3,015
Groundwater	733	733	733	733	733
Total	3,748	3,748	3,748	3,748	3,748
Percent of Normal		100%	100%	100%	100%

Note:
Table format based on DWR Guidebook Table 28.

The San Gabriel Basin Watermaster adjusts the OSY annually to account for fluctuations in groundwater availability in the Main San Gabriel Groundwater Basin. The Upper District's 2010 UWMP states that all pumpers, including GSWC, will have adequate supply to meet their demands during normal year, single-dry year, and multiple-dry year periods (Upper District, 2010). Replenishment water is used to replace the water pumped beyond a producer's share of the OSY and to maintain groundwater levels in the Key Well above 200 feet msl. The replenishment water for the Main San Gabriel Basin will be supplied from imported water through the Upper District and Metropolitan. Metropolitan has provided its member agencies with a reliability analysis for imported water supplies, which indicates Metropolitan's plan to provide 100 percent reliability through 2035 (Metropolitan, 2010). Upper District has provided projections of up to 25,000 ac-ft/yr of untreated imported water and recycled water to be used for basin replenishment through Fiscal Year 2030-31 (Upper District, 2011).

The South San Gabriel System has pumped between 2,192 ac-ft/yr and 2,912 ac-ft/yr for the past 5 years. It is projected the South San Gabriel System will decrease pumping rates annually, pumping only 733 ac-ft/yr in 2035.

Table 6-2 lists single-dry year and multiple-dry year periods for groundwater supplies. The single-dry year and multiple-dry year periods are based on Upper District's and Metropolitan's analysis on the lowest average precipitation for a single year and consecutive multiple-year period, respectively. Metropolitan's estimates, based on average rainfall between 1922 and 2004, uses the average of these years for normal water year conditions. 1977 represents the single-dry year, and the years 1990-1992 represent the driest three consecutive years. Effective management by the Main San Gabriel Basin Watermaster is expected to ensure that the Basin will have sufficient storage to meet projected water demands for these periods, so the available supply is equal to the projected demands.

Table 6-2: Basis of Water Year Data

Water Year Type	Base Year(s)	Historical Sequence
Normal Water Year[(2)]	Average of 1922 - 2004	1922 - 2004
Single-Dry Water Year	1977	1922 - 2004
Multiple-Dry Water Years	1990 - 1992	1922 - 2004

Notes:

1. Based on Metropolitan Water District 2010 RUWMP analysis of climate data.
2. Normal Water Year calculated from average precipitation for 1922-2004.
3. Table format based on DWR Guidebook Table 27.

Again, the Main San Gabriel Basin storage is used and the basin is operated to store surplus waters (storm water, recycled water, and imported water) when these waters are available and then to draw down the basin in drier years to meet the requirements of the Watermaster established under the Main San Gabriel Basin Judgment. The Basin has proven to be very reliable under extreme climate conditions over the last 30 years and is expected to remain reliable through 2035.

6.1.4 Factors Resulting in Inconsistency of Supply

Table 6-3 presents factors that could potentially result in inconsistency of supply for the South San Gabriel System.

Although there are no known factors that would results in an inconsistency in overall water supply, it should be noted that groundwater extractions in the San Gabriel Basin are regulated by the Watermaster. Annually, the Watermaster establishes basin-wide pumping limits based on local hydrologic conditions and groundwater levels within the basins. In dry years, when the operating safe yield (OSY) is low and GSWC's water right is correspondingly reduced, GSWC does have the option of leasing or purchasing water rights from other users in the basin and can thereby reliably meet all system demands. The adjudication for the Main San Gabriel Basin also permits a producer to pump more than its rights when replenishment water is available from the responsible agency. A replenishment fee is required for all production in excess of the allocated rights. As a result, GSWC does not foresee any inconsistency in its ability to supply the South San Gabriel System, and Table 6-3 is intentionally blank.

Table 6-3: Factors Resulting in Inconsistency of Supply

Name of Supply	Legal	Environmental	Water Quality	Climatic
USGVMWD	N/A	N/A	N/A	N/A
Groundwater, Main San Gabriel Groundwater Basin	N/A	N/A	N/A	N/A

Notes:

1. Table format based on DWR Guidebook Table 29.
2. N/A = Not Applicable.

6.2 Normal Water Year Analysis

Table 6-4 summarizes the service reliability assessment for a normal water year based on water supply and water demand projections.

Table 6-4: Comparison of Projected Normal Year Supply and Demand

	2015	2020	2025	2030	2035
Water Supply Total (ac-ft/yr)	3,410	3,509	3,595	3,678	3,748
Water Demand Total (ac-ft/yr)	3,410	3,509	3,595	3,678	3,748
Difference (supply minus demand)	0	0	0	0	0
Difference as Percent of Supply	0%	0%	0%	0%	0%
Difference as Percent of Demand	0%	0%	0%	0%	0%

Note:

Table format based on DWR Guidebook Table 32.

6.3 Single-Dry-Year Analysis

Table 6-5 demonstrates the reliability of water supplies to meet projected annual water demands for the South San Gabriel System in a single-dry year.

Table 6-5: Comparison of Projected Supply and Demand for Single-Dry Year

	2015	2020	2025	2030	2035
Supply Total (ac-ft/yr)	3,410	3,509	3,595	3,678	3,748
Demand Total (ac-ft/yr)	3,410	3,509	3,595	3,678	3,748
Difference (supply minus demand)	0	0	0	0	0
Difference as Percent of Supply	0%	0%	0%	0%	0%
Difference as Percent of Demand	0%	0%	0%	0%	0%

Note:
Table format based on DWR Guidebook Table 33.

6.4 Multiple-Dry-Year Analysis

Table 6-6 presents the projected multiple-dry year water supply and demand assessment. It is assumed that the multiple-dry year water supplies are the same as those for the normal years because Metropolitan (through Upper District) intends to meet projected purchased demands under all anticipated hydrologic conditions. The third year of the multiple-dry year water supply projection represents the end of each 3-year multiple-dry year period as required for the multiple-dry year analysis. Upper District has determined that they can meet projected water demands for multiple-dry years, so the water supply is projected to equal the demand.

Table 6-6 demonstrates that the water supplies are sufficient to meet the projected water demand for each multiple-dry year period because:

- Upper District determined that they can meet projected water demands for the multiple-dry year periods (see Chapter 3), and;
- Groundwater from the Main San Gabriel Groundwater Basin is expected to be 100 percent reliable in multiple-dry years.

It should be noted that the active connection capacity to deliver purchased water is significantly higher than the projected purchased water supply that is needed to meet these demands. Therefore, the purchased water supply is generally expected to be much greater than the expected projected water demands during multiple-dry years.

In summary, GSWC, Metropolitan, and Upper District have implemented and will continue to implement projects to ensure the purchased water demands can be met under normal year, single-dry year, and multiple-dry years.

Table 6-6: Projected Multiple-Dry Year Water Supply and Demand Assessment					
Year	**Supply (ac-ft/yr)**	**Demand (ac-ft/yr)**	**Difference**	**Difference as Percent of Supply**	**Difference as Percent of Demand**
2011					
2012					
2013	3,122	3,122	0	0%	0%
2014	3,266	3,266	0	0%	0%
2015	3,410	3,410	0	0%	0%
2016					
2017					
2018	3,470	3,470	0	0%	0%
2019	3,489	3,489	0	0%	0%
2020	3,509	3,509	0	0%	0%
2021					
2022					
2023	3,560	3,560	0	0%	0%
2024	3,577	3,577	0	0%	0%
2025	3,595	3,595	0	0%	0%
2026					
2027					
2028	3,644	3,644	0	0%	0%
2029	3,661	3,661	0	0%	0%
2030	3,678	3,678	0	0%	0%
2031					
2032					
2033	3,720	3,720	0	0%	0%
2034	3,734	3,734	0	0%	0%
2035	3,748	3,748	0	0%	0%

Notes:

1. This assessment is based on the 3-year multiple-dry year period ending in 2015, 2020, 2025, 2030, and 2035.
2. Table format based on DWR Guidebook Table 34.

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Chapter 7: Conservation Program and Demand Management Measures

This Chapter addresses the water conservation requirements of the Act for the South San Gabriel System and includes a summary of current and planned Demand Management Measure (DMM) implementation and an overview of the proposed program for compliance with SBX7-7, which requires 20 percent statewide reduction in urban water use by 2020. The DMM portions of the Act state the following:

Section 10631.

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:

(A) Water survey programs for single-family residential and multifamily residential customers.

(B) Residential plumbing retrofit.

(C) System water audits, leak detection, and repair.

(D) Metering with commodity rates for all new connections and retrofit of existing connections.

(E) Large landscape conservation programs and incentives.

(F) High-efficiency washing machine rebate programs.

(G) Public information programs.

(H) School education programs.

(I) Conservation programs for commercial, industrial, and institutional accounts.

(J) Wholesale agency programs.

(K) Conservation pricing.

(L) Water conservation coordinator.

(M) Water waste prohibition.

(N) Residential ultra-low-flush (ULF) toilet replacement programs.

(2) A schedule of implementation for all water demand management measures proposed or described in the plan.

(3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.

(4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(j) For purposes of this part, urban water suppliers that are members of the California Urban Water Conservation Council shall be deemed in compliance with the requirements of subdivisions (f) and (g) by

complying with all the provisions of the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated December 10, 2008, as it may be amended, and by submitting the annual reports required by Section 6.2 of that memorandum.

7.1 Conservation Program Background

In 1991, GSWC became a signatory to the MOU regarding water conservation in California and a member of the CUWCC, establishing a firm commitment to the implementation of the Best Management Practices (BMPs) or DMMs. The CUWCC is a consensus-based partnership of agencies and organizations concerned with water supply and conservation of natural resources in California. By becoming a signatory, GSWC committed to implement a specific set of locally cost-effective conservation practices in its service areas.

To facilitate efficient BMP reporting for water systems located in GSWC's three regions in California, GSWC established a number of BMP "Reporting Units" based on geographic proximity. GSWC's conservation program implementation for the San Gabriel Valley Reporting Unit includes the reporting of the South Arcadia and South San Gabriel systems. Therefore, this chapter includes the reporting for both systems.

As an investor-owned utility, GSWC's ability to obtain funding and implement conservation programs is contingent on approval of the General Rate Case by the CPUC. GSWC is currently in the process of reviewing and revising its existing conservation program as follows:

- In 2011, GSWC will be submitting a General Rate Case with the CPUC which will facilitate further development of cost-effective conservation programs, including compliance with SBX7-7.
- Subject to funding approval for each rate making area, GSWC will conduct a baseline water use efficiency assessment of each of its districts to identify the opportunities for cost-effective conservation. Results of the baseline assessment will be available by 2013 and will enable GSWC to define programs that target water savings in specific areas and meet DMM requirements.
- To the extent practicable, a companywide conservation program will then be implemented. Varying levels of program implementation will be scaled as appropriate for each district depending on funding availability, local wholesaler and regional participation levels, and SBX7-7 targets.

The MOU and associated BMPs were revised by the CUWCC in 2008, which is equated to the DMMs per Section 10631(j) of the Act. The revised BMPs now contain a category of "Foundational BMPs" that signatories are, for the first time and with few exceptions, expected to implement as a matter of their regular course of business. These include Utility Operations (metering, water loss control, pricing, conservation coordinator, wholesale agency assistance programs, and water waste ordinances) and Public Education (public outreach and school education programs). The remaining BMPs are called Programmatic BMPs and are divided into Residential, Large Landscape, and CII categories. These revisions are reflected in the CUWCC's BMP reporting database starting with reporting year 2009. The revised BMP organization is also reflected in the 2010 UWMP's DMM compliance requirements. A summary of the DMMs described in the Act and the current CUWCC BMP organization is presented in Table 7-1 for reference.

Table 7-1: CUWCC BMP and UWMP DMMs Organization and Names

CUWCC BMP Organization and Names (2009 MOU)				UWMP DMMs	
Type	**Category**	**BMP □**	**BMP name**	**DMM □**	**DMM name**
Foundational	Operations Practices	1.1.1	Conservation Coordinator	L	Water conservation coordinator
		1.1.2	Water Waste Prevention	M	Water waste prohibition
		1.1.3	Wholesale Agency Assistance Programs	J	Wholesale agency programs
		1.2	Water Loss Control	C	System water audits, leak detection, and repair
		1.3	Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections	D	Metering with commodity rates for all new connections and retrofit of existing connections
		1.4	Retail Conservation Pricing	K	Conservation pricing
	Education Programs	2.1	Public Information Programs	G	Public information programs
		2.2	School Education Programs	H	School education programs
Programmatic	Residential	3.1	Residential assistance program	A	Water survey programs for single-family residential and multi-family residential customers[1]
				B	Residential plumbing retrofit
		3.2	Landscape water survey	A	Water survey programs for single-family residential and multi-family residential customers[1]
		3.3	High-Efficiency Clothes Washing Machine Financial Incentive Programs	F	High-efficiency washing machine rebate programs
		3.4	WaterSense Specification (WSS) toilets	N	Residential ultra-low-flush toilet replacement programs
	Commercial, Industrial, and Institutional	4	Commercial, Industrial, and Institutional	I	Conservation programs for commercial, industrial, and institutional accounts
	Landscape	5	Landscape	E	Large landscape conservation programs and incentives

Note:

1. Components of DMM A (Water survey programs for single-family residential and multi-family residential customers) applies to both BMP 3.1 (Residential assistance program) and BMP 3.2 (Landscape water survey).

7.2 Implementation of BMPs/DMMs

This section provides a description of the various programs and conservation activities implemented in the San Gabriel Valley Reporting Unit water systems. Signatories to the MOU are permitted by Water Code Section 10631(j) to include their biennial CUWCC BMP reports in an UWMP to meet the requirements of the DMMs sections of the UWMP Act if the agency is meeting all provisions of the MOU. The San Gabriel Valley Reporting Unit BMP coverage report for 2009 through 2010 is attached as Appendix C and supplements the summary of BMP implementation activities provided in this chapter.

GSWC is progressing towards implementing all Foundational BMPs for these systems, as required in the revised MOU and UWMP Act. The Programmatic BMPs are currently being implemented through a BMP approach for the systems. The SBX7-7 conservation goals and proposed implementation plans are discussed further in Section 7.5.

GSWC plans to continue to implement and track conservation programs for systems in the San Gabriel Valley Reporting Unit. GSWC also partners on conservation activities with its wholesale water suppliers, including Metropolitan and Upper San Gabriel Valley Municipal Water District (Upper District). GSWC□s customers are eligible for a number of conservation programs offered by Metropolitan, providing water savings to GSWC. Examples of programs offered by wholesale suppliers that are available to customers include High-Efficiency Clothes Washers (HECW) rebates, CII programs and rebates, and High-Efficiency Toilets (HET) rebates.

7.3 Foundational DMMs

7.3.1 Utility Operations

7.3.1.1 Conservation Coordinator

This BMP is implemented. GSWC maintains a fully staffed Conservation Department with a companywide Water Use Efficiency Manager, Water Conservation Analyst and one Water Conservation Coordinator for each of the three regions to administer conservation programs and support wholesaler programs which includes the San Gabriel Valley System. GSWC also employs a number of consultants to support program development and implementation.

7.3.1.2 Water Waste Prevention

Although GSWC does not have rule-making authority, it supports member agencies and local cities in efforts to adopt ordinances that will reduce water waste. This BMP is implemented through CPUC-approved rules provided in Appendix D, including Rule No. 14.1, the Water Conservation and Rationing Plan, and Rule 11, Discontinuance and Restoration of Service.

CPUC□s methodology for water utilities to implement Rule 14.1 is documented in Standard Practice U-40-W, □Instructions for Water Conservation, Rationing, and Service Connection Moratoria.□Rule No. 14.1 sets forth water use violation fines, charges for removal of flow restrictors, and the period during which mandatory conservation and rationing measures will be in effect. Water conservation restrictions include:

- Use of potable water for more than minimal landscaping.
- Use through a broken or defective water meter.

- Use of potable water which results in flooding or runoff in gutters or streets.
- Use of potable water for washing private cars or commercial aircrafts, cars, buses, boats, or trailers, except at a fixed location where water is properly maintained to avoid wasteful use.
- Use of potable water for washing buildings, structures, driveways, street cleaning or other hard-surfaced areas.
- Use of potable water to irrigate turf, lawns, gardens or ornamental landscaping.
- Use of potable water for construction purposes.
- Use of potable water for filling or refilling of swimming pools.

Rule No. 20 (approved in 1978) discourages wasteful use of water and promotes use of water saving devices. The stated purpose of the rule is to "ensure that water resources available to the utility are put to a reasonable beneficial use and that the benefits of the utility's water supply and service extend to the largest number of persons." Together, Rules 11, 14.1 and 20 prohibit negligent or wasteful use of water, create a process for mandatory conservation and rationing, and promote the use of water saving devices.

7.3.1.3 Water Loss Control

Unaccounted for water losses are monitored by the Water Loss Control Department (WLCD) by reviewing the Water Audit program's survey results for each system. If the amount of unaccounted for water exceeds the established tolerance levels, a Leak Detection Audit is performed. This is conducted by the Water Loss Control Technician with the most current leak detection technology, a Sonic Leak Detection Sound Amplification Instrument. To pinpoint leaks, the technician conducts a comprehensive survey of the system by making physical contact with all available main line valves, hydrant valves and all service connections.

For calendar year 2009, GSWC implemented the American Water Works Association (AWWA) M36 Standard Water Audit methodology. The approach consists of a component analysis of leaks for designation into "revenue" and "non-revenue" categories and an economic analysis of recoverable loss. Results of the analysis are included in the BMP coverage report in Appendix C.

Before the AWWA Standard Water Audit M36 methodology was implemented, prescreening for water losses was conducted by comparing the total volume of water sales and other verifiable uses against the total water supply into the system. A full audit was triggered if the total sales and verifiable uses was less than 90 percent of the total supply (i.e., unaccounted-for-water exceeded 10 percent). Table 7-2 summarizes prescreening results.

Table 7-2: Water Loss Control Evaluation Summary		
Report Year	Prescreen Completed	Prescreen Result
2006	No	-
2007	No	-
2008	Yes	93.20%
2009	Yes	97.70%

Note:
2010 Data Not applicable; M36 method implemented.

<u>Implementation Steps and Schedule</u>

Effective 2010, GSWC will continue to complete the Standard Audit and Water Balance worksheets following the AWWA M36 protocol for the next 4 years, taking measurable steps to improve data accuracy while cost-effectively reducing non-revenue water through repair of leaks and other measures.

GSWC used version 3.0 of the AWWA Water Audit software for its initial evaluation, and will use the current software for 2010 and all future evaluations. The current version includes metrics for evaluating the validity of the data. GSWC already has a work order system in place that documents leak locations and repair history.

7.3.1.4 Metering with Commodity Rates for All New Connections and Retrofit of Existing Connections

All customers in San Gabriel Valley Reporting Unit are metered and billed by volume on a monthly basis. A meter maintenance and repair plan has been submitted to the CUWCC. In addition, GSWC follows the requirements of CPUC General Order 103-A which prescribes minimum water system design, operation and maintenance standards for water utilities includes requirements for calibrating, testing frequency, and replacing water meters.

7.3.1.5 Retail Conservation Pricing

All metered customers in the San Gabriel Valley Reporting Unit are billed volumetrically. In addition, effective December 2010, GSWC has implemented a third tier of a conservation pricing rate structure for residential customers, as approved by the CPUC for Region III. The current rate structure for residential customers has a fixed charge as well as volumetric escalating pricing tiers, depending on customer usage. Non-residential customers have a fixed charge and a fixed volumetric charge. Implementation of this revised pricing policy is the result of GSWC's collaboration with CPUC to implement conservation tiered rates for residential customers of investor-owned utilities. Tiered rates are consistent with the CPUC's Water Action Plan.

<u>Implementation Steps and Schedule</u>

2009 and 2010 volumetric and fixed price revenue data for the San Gabriel Valley Reporting Unit are summarized in the BMP Coverage Report located in Appendix C. Since 2010, GSWC has been adding third tier pricing structures and increasing volumetric charges. In 2010, volumetric revenue consisted of 63.1 percent of San Gabriel Valley Reporting Unit's total revenue which is on track to meet the 2012 MOU goal of 70 percent.

As previously discussed, GSWC will be submitting a General Rate Case filing to the CPUC in 2011, which includes a proposed rate increase for volumetric charges for South San Gabriel System customers. If approved, this rate increase will allow GSWC to increase volumetric revenues and progress towards fulfilling the requirements of the Retail Conservation Pricing BMP by 2015.

7.3.1.6 Education

Public Information Programs

San Gabriel Valley Reporting Unit customers are notified of various conservation programs by the Community Education Department. GSWC had a 2010 annual budget of $6,100 for public outreach in the San Gabriel Valley Reporting Unit. GSWC provides marketing and outreach materials to their customers by issuing press releases, publishing quarterly newsletters and using door tags and bill inserts. Customers can learn about rebates and other conservation programs on GSWC's website, which provides links to Metropolitan's website for detailed information. Outreach activities completed between 2006 and 2010 are summarized in Table 7-3.

In addition, the Upper District promotes water conservation through its many public information programs. The Upper District offers conservation brochures and posters, activity booklets, public outreach displays, oral presentations, and workshops to inform the public of conservation efforts. The Upper District also raises awareness about water conservation through paid advertising, press releases, news ads, media events, and through the Speaker's Bureau. Annually, Upper District hosts a water awareness festival (Water Fest) to raise public awareness about water conservation, water quality and other water-related issues.

Table 7-3: Outreach Activities

Item	2006	2007	2008	2009	2010
Paid Advertising	3	2	4	4	4
Public Service Announcement	2	1	3	4	4
Bill Inserts / Newsletters / Brochures	2	4	3	8	8
Bill showing water usage in comparison to previous year's usage	Yes	Yes	Yes	Yes	Yes
Demonstration Gardens	0	0	0	1	1
Special Events, Media Events	2	1	4	2	2
Speaker's Bureau	0	0	1	0	0
Program to coordinate with other government agencies, industry, public interest groups and media	Yes	Yes	Yes	Yes	Yes

School Education Programs

GSWC sponsors a school education program in South San Gabriel elementary schools, as implemented by The Discovery Science Center (DSC)), with a 2010 annual budget of $39,000. Students learn about conservation practices and receive a free conservation kit that includes a water survey, 1.5-gpm low-flow shower head, 1.5-gpm kitchen sink aerator and 1.0-gpm bathroom aerators, leak detection dye tablets, a watering gauge, and step-by-step instructions. The students are given homework assignments to complete a water audit form and replace inefficient showerheads and aerators with water-saving devices provided in the kit. The program has been a very effective way for GSWC to reach a large number of customers and educate students, who in turn educate their parents about water use efficiency practices and low-flow plumbing devices.

Results from the program are tracked, and a comprehensive Program Summary Report is generated at the end of each school year. This report documents the estimated reduction in water usage that was achieved through the retrofits and provides data on the percentage of students who participated in the program. Table 7-4 provides a summary of program participation results between 2006 and 2010.

Table 7-4: School Education Activities

	2006	2007	2008	2009	2010
Presentations	12	3	-	-	-
Grade	4^{th} – 6^{th}	4^{th} – 6^{th}	4 – 6^{th}	-	-
Number of students	666	591	2,234	746	1,367

In addition, Upper District directly offers school education programs in an effort to raise awareness of water issues. Upper District started its school education programs in September 1992 and the materials and presentations meet state education framework requirements. The following is a list of Upper District’s school educational programs.

- Water Awareness Art Contests
- Solar Cup Competition
- Water Education Grant Program
- Annual Art Poster Contest for grades K through 3^{rd} and 4^{th} through 6^{th}
- T-shirt Art Contest for grades 7^{th} through 12^{th}
- Water Resource Library

In addition to the DSC and partnering with wholesalers and other public agencies, GSWC implements Resource Action Programs (RAP) and the Science Discover (SD) program. During the 2009–2010 school year, GSWC conducted school conservation education programs for an estimated 15,525 students company-wide.

Implementation Steps and Schedule

GSWC recognizes the value in increased customer awareness of the various conservation programs that are available. To that end, GSWC will review opportunities to enhance its outreach program over the next two (2) years to supplement DSC’s existing public education efforts. Public information measures that will be evaluated include additional direct mail fliers, increased outreach participation at community functions, and an improved conservation website.

Going forward, GSWC plans to continue to use the RAP, DSC, and SD and internal staff to conduct its school conservation programs. RAP and DSC's school conservation education programs will continue to include annual reports, classroom education and the distribution and installation of conservation kits that are part of the school education program.

7.3.1.7 Methods Used to Evaluate Effectiveness and Water Savings from Foundational BMPs

Effective implementation of the Foundational BMPs is critical to ensuring the long-term success of GSWC's conservation efforts. GSWC will utilize quantitative methods to assess the effectiveness of each BMP, to the extent practicable. The effectiveness of the Water Waste Prevention and Water Loss Control BMPs can be measured, in part, by completing the annual M36 water loss audits and documenting the year-over-year change in unaccounted-for water as well as the number of repair projects completed. GSWC will track the impact of new conservation pricing by using its upgraded billing system to carefully monitor consumption of residential customers.

The effectiveness of implementing Public Education BMPs will be measured by tracking the number of public outreach events and education programs where customers receive information on conservation. A successful public information program should encourage customers to take advantage of conservation incentives being offered by GSWC, Upper District, and Metropolitan as Programmatic DMMs.

There are no direct estimates of water savings applicable to the Foundational BMPs; however, these measures will continue to contribute to reducing San Gabriel Valley Reporting Unit's demand.

7.4 Programmatic DMMs

GSWC intends to continue to comply with the MOU using the BMP compliance approach for the San Gabriel Valley Reporting Unit. Implementation of the programmatic BMPs will continue to be a joint effort with Metropolitan and Upper District. The wholesalers are responsible for administering most of the Residential, Landscape, and CII BMPs currently being offered to San Gabriel Valley Reporting Unit customers. Additional detailed descriptions of wholesaler DMM implementation can also be found in Metropolitan's 2010 RUWMP, as well as Upper District's 2010 UWMP where appropriate. GSWC will continue to support Metropolitan activities and will focus on improving outreach to its customers and promoting awareness of the programs available to them.

Once the pending rate case is approved by the CPUC, GSWC will develop a prioritized water use efficiency program and implementation schedule for all customer service areas in the company focusing on systems with the highest SBX7-7 water use reduction targets, and those where specific conservation activities can be implemented that are locally cost-effective. Programs that are cost-effective to implement on a companywide basis will also be considered. At this time, all of the BMPs, are cost-effective for implementation in the San Gabriel Valley Reporting Unit, where the avoided cost of water is $926 per acre-foot.

7.4.1 Residential DMMs

7.4.1.1 Residential Assistance Programs

GSWC has an audit program targeting high-use single-family (SF) and multi-family (MF) residential customers. GSWC identifies these customers based on billing data and contacts them to offer free audits. Audits are also offered to walk-in customers at the local customer service area office. Additional home audits are conducted as part of the school education program (Section 7.3.1.6). The number of residential audits performed by GSWC and the number of low-flow devices that were distributed are summarized in Table 7-5. Low-flow devices are available for free to customers at the GSWC office and are distributed to students as part of the free conservation kits they receive in the school education program.

Table 7-5: Residential Surveys and Retrofits

	2006	2007	2008	2009	2010
Single-Family Accounts					
Surveys Offered	0	0	1,251	0	0
Surveys Completed	0	0	227	0	0
Multi-Family Accounts					
Surveys Offered	0	0	1,251	0	0
Surveys Completed	0	0	227	0	0
Devices					
Showerheads	569	0	2,234	0	0
Aerators	1,300	0	2,234	0	0

Implementation Steps and Schedule

Over the next 5 years, GSWC will continue distributing low flow showerheads and aerators to customers, and offering audits to high-use SF and MF customers until saturation requirements are satisfied for this BMP. It is estimated that 175 devices per year will need to be installed in SF and MF residences. Once saturation requirements are met, GSWC will continue to offer the programs as required by the MOU.

Methods Used to Evaluate Effectiveness and Water Savings

Effectiveness of implementation of this program is evaluated by GSWC by tracking customer participation rates in surveys and distribution of low flow showerheads. The following water savings estimates were developed using data provided by the CUWCC:

- Residential Assistance Surveys: According to the CUWCC, SF surveys are estimated to save 40 gpd and MF surveys are estimated to save 20 gpd. At 174 surveys per year, it is estimated that GSWC will save more than 300 ac-ft over the next 10 years.

- Plumbing Retrofit kits: Per the CUWCC, it is estimated that 7.7 gpd per unit is conserved from installation of low flow showerheads. At 75 percent saturation, the potential total savings is approximately 54 ac-ft over the next 10 years.

Program effectiveness and per capita use will continue to be monitored based on meter readings and billing data, and follow-up calls will be made to offer audits and other assistance to high-use customers. Implementation of the residential assistance programs BMP has no anticipated impacts on GSWC's ability to further reduce demands.

7.4.1.2 Landscape Water Surveys

GSWC offers landscape water surveys to high water-use SF and MF customers throughout the company. Since residential surveys include a landscape component, participation rates are included in the residential assistance program summary above. Introduction of the third tier of metered rates in late 2010 is expected to result in higher participation rates, and funding has been designated to improving program marketing.

Implementation Steps and Schedule

Residential assistance survey programs have a landscape component to them and are being implemented concurrently. A description of the proposed implementation strategy and schedule is provided in the section describing the Residential Assistance Program BMP.

Methods Used to Evaluate Effectiveness and Water Savings

See residential assistance programs description.

7.4.1.3 High-Efficiency Clothes Washers

GSWC customers are eligible to participate in the HECW rebate program provided by Metropolitan, which has been available since 2003. Metropolitan has supplemented its HECW rebate using state or federal grants whenever possible. The water efficiency of clothes washers is represented by the "water factor," which is a measure of the amount of water used to wash a standard load of laundry. Washers with a lower water factor save more water. Metropolitan has continued to transform the market by changing its program requirement to lower water factors. The program eligibility requirement is currently set at water factor 4.0, which saves more than 10,000 gallons per year per washer over a conventional top loading washer. GSWC does not contribute funds to the HECW rebate program. The GSWC conservation webpage advertises the rebates and provides a link to the Metropolitan website for full program details. A summary of the HECW Rebates received by GSWC customers in the San Gabriel Valley Reporting Unit is provided in Table 7-6.

Table 7-6: HECW Rebates

	2006	2007	2008	2009	2010	TOTAL
Rebates	44	0	149	0	282	475

Implementation Steps and Schedule

To comply with the BMP, rebates need to be issued to 104 customers per year in the San Gabriel Valley Reporting Unit until saturation requirements are met. GSWC intends to continue to participate in the HECW rebate program administered by Metropolitan and to increase program participation will increase marketing efforts to raise customer awareness that the program is being offered. GSWC will develop an updated conservation website, and prominently include HECW rebate incentive on future bill stuffers or other direct mail campaigns.

Methods Used to Evaluate Effectiveness and Water Savings

Metropolitan tracks customer participation in the HECW rebate program and estimates that 28 gallons per day are saved for each HECW installed. At the required implementation levels, it is estimated that GSWC will save a total of approximately 142 ac-ft from 104 annual HECW installations over the next 10 years. There are no anticipated impacts on GSWC's ability to further reduce demands.

7.4.1.4 WaterSense Specification (WSS) Toilets

GSWC customers have been eligible to participate in the HET rebate program administered by Metropolitan since 2008. Metropolitan has provided incentives for toilet programs since 1988, including ultra-low-flush toilet (ULFT) rebates. Currently, Metropolitan only provides funding for high-efficiency toilets (1.28 gallons per flush or less), which use 20 percent less than ultra-low-flush toilets (1.6 gallons per flush). ULFTs are the current standard defined by the plumbing code. Metropolitan uses the EPA's WaterSense list of tested toilets in its programs as qualifying models. The GSWC webpage for South San Gabriel advertises the rebates and provides a link to the Metropolitan website for full details. The number of rebates issued by Metropolitan to GSWC San Gabriel Valley Reporting Unit customers is provided in Table 7-7.

Table 7-7: Toilet Rebates and Replacements Received by San Gabriel Valley Reporting Unit Customers

Type	2006	2007	2008	2009	2010
Single-Family					
ULFT Rebate	350	0	11	0	0
HET Rebate	0	0	0	136	44
Multi-Family					
ULFT Rebate	0	0	9	0	0
HET Rebate	0	0	0	51	0

Implementation Steps and Schedule

To comply with the BMP, rebates need to be issued to 93 SF and 23 MF customers per year in the San Gabriel Valley Reporting Unit. GSWC intends to continue to participate in the HET rebate program administered by Metropolitan as described above. GSWC will also evaluate augmenting existing public outreach efforts through direct mail and enhanced website features to inform customers about current incentive opportunities and increase program participation.

Methods Used to Evaluate Effectiveness and Water Savings

Metropolitan tracks customer participation in the HET rebate program to measure effectiveness. According to the CUWCC research and evaluation committee, it is estimated that 21.1 and 26.6 gallons per day are saved for each HECW installed in SF and MF units, respectively. It is estimated that GSWC will save approximately 141 ac-ft from HET installations completed over the next 10 years at required implementation levels of 93 SF and 23 MF installations per year. There are no anticipated impacts on GSWC's ability to further reduce demands.

7.4.1.5 WaterSense Specification for Residential Development

Integration of WSS fixtures for new development will be accelerated by the 2010 California Green Building Standards Code (CAL Green Code), which became effective in January 2011. The CAL Green Code sets mandatory green building measures, including a 20 percent reduction in indoor water use, as well as dedicated meter requirements and regulations addressing landscape irrigation and design. Local jurisdictions, at a minimum, must adopt the mandatory measures; the CAL Green Code also identifies voluntary measures that set a higher standard of efficiency for possible adoption.

Implementation Exemption

GSWC is filing an exemption on implementation of the WSS specification for new developments due to lack of legal authority. As an investor-owned utility, GSWC does not have regulatory authority and cannot adopt ordinances or regulations; however, it does support standards that will achieve a reduction in indoor water use including implementation and use of WSS fixtures as well as adoption of the CAL Green Code by local jurisdictions, including Los Angeles County. GSWC will continue to support incentive programs for water efficient devices and standards.

The cost of implementing this BMP is non-quantifiable; therefore a cost-effectiveness evaluation was not completed.

7.4.1.6 Commercial, Industrial, and Institutional DMMs

The Commercial, Industrial, and Institutional (CII) programs are implemented by Metropolitan on behalf of GSWC. Table 7-8 provides a summary of CII program participation from GSWC's San Gabriel Valley Reporting Unit customers from 2006 to 2010. GSWC customers are eligible to participate in Upper District and Metropolitan's CII Save-A-Buck Program for Southern California businesses. Those who qualify are eligible for rebates to help encourage water efficiency and conservation. Devices available for rebates include: high efficiency toilets, zero water and ultra low water urinals, connectionless food steamers, air-cooled ice machines (Tier III), cooling tower and pH conductivity controllers, water brooms, dry vacuum pumps). Additionally, the Save-A-Buck program offers rebates for outdoor landscaping equipment such as: weather based irrigation controllers, central computer irrigation controllers, rotating spray nozzles retrofits, and high efficiency large rotary nozzle retrofits.

Table 7-8: CII Programs

Program	2006	2007	2008	2009	2010
CII HET Rebates	0	0	2	0	0
CII ULFT Rebates	0	0	0	0	0
Dual Flush Toilets	0	0	0	0	0
CII Urinal Rebates	0	0	16	1	37
CII HECW Rebates	0	0	0	0	0
Cooling Tower Controllers	0	0	0	0	0
Cash for Grass	0	0	0	0	0

Implementation Steps and Schedule

GSWC's goal for the next 3 to 5 years is to focus on advertising and outreach programs, including CII rebates, as described elsewhere in this chapter. If, after additional advertising efforts it is determined that Metropolitan's program is not meeting coverage requirements, GSWC will evaluate augmenting Metropolitan's program. To meet BMP requirements for the required 10 percent water savings (about 94 ac-ft/yr) by 2020, GSWC will need to support or augment Metropolitan's program to encourage customers to participate in rebate incentive programs. GSWC will also evaluate implementing additional CII water savings programs, such as industrial process water use reductions.

Methods Used to Evaluate Effectiveness and Water Savings

Effectiveness of the CII program will be evaluated by tracking multiple parameters, including program participation, metered CII water use, high water users, and measuring water savings from of specific CII activities where practicable to show a water savings of at least 9 ac-ft per year. There are no anticipated impacts on GSWC's ability to further reduce demands.

7.4.1.7 Large Landscape

GSWC's large landscape program consists of identifying and contacting high-use customers, providing information and offering water use surveys, voluntary landscape water use budgets, and landscape training. The program is available to all large landscape customers free of charge. An increase in conservation pricing rates in 2011 is expected to prompt increased participation, and funding has been designated for improved program marketing.

Upper District's large landscape conservation program includes the Synthetic Turf Grant School Program. The Goal of the Synthetic Turf Grant Program is to assist schools with funding for retrofitting large landscaped areas with synthetic turf. Through this program, Upper District offers grants of up to $75,000 per site to assist with the cost of installing synthetic turf. Since the start of the program in fiscal year 2005-06, five schools have participated in this program. Based on an estimated service life of 10 years for synthetic turf, the total annual water savings for the 5 synthetic turf programs is estimated at 53 acre-feet.

Implementation Steps and Schedule

Implementation of this BMP will be improved by promoting existing incentive opportunities s and raising customer awareness about existing audit program offerings. For the next 4 to 5 years, GSWC will work to increase program participation at schools and other institutional accounts to establish landscape water budgets and decrease overall water use. Additionally, GSWC will discuss with Metropolitan specific measures that could be implemented to encourage broader interest in the multiple CII programs that are currently being offered.

In order to meet BMP coverage requirements, GSWC/Metropolitan/Upper District will need to develop evapotranspiration-based landscape water budgets for 9 accounts with dedicated irrigation meters per year. GSWC will also continue to offer landscape water use surveys to customers without dedicated irrigation meters. Devices such as weather based irrigation controllers (WBIC) and precision nozzles will also be distributed to mix-metered high water use customers who have been determined not to be water efficient.

Methods Used to Evaluate Effectiveness and Water Savings

GSWC will track increased customer participation in the CII large landscape water budgeting and rebate programs. At the implementation rate described above, it is estimated that as much as 279 AF could be conserved by 2020 (Table 7-9). There are no anticipated impacts on GSWC's ability to further reduce demands.

Table 7-9: Water Savings for Large Landscape Programs

Large Landscape Conservation Program	Units per Year	Water savings over next 10 Years (ac- ft)
CII WBIC Rebates	9	46
CII WBIC Direct Install	9	46
CII Precision Nozzles Distribution	1,330	85
Dedicated Irrigation Surveys	9	102
TOTAL	1,357	279

7.5 SBX7-7 Compliance Strategy

The SBX7-7 water use baseline for the South San Gabriel System is 105 gpcd, and the 2020 compliance goal is 100 gpcd, as detailed in Chapter 3. Several factors have contributed to a rapid reduction in gpcd over the past few years Including the economic recession, recent mild climate conditions, implementation of a residential tiered conservation pricing structure m and other conservation measures. Over the past 3 years, there has been a recent 13 percent decline in gpcd in the South San Gabriel System from 97 gpcd in 2008 to an estimated 84 gpcd in 2010. Therefore, the South San Gabriel System is on track to meet its SBX7-7 goals, and will remain focused on maintaining these savings over the next 10 years.

However, if the gpcd begins to increase to previous levels, GSWC's continued commitment to complying with the CUWCC MOU and implementation of all BMPs should provide sufficient water savings to meet the goal of 100 gpcd. GSWC will assess implementation of a suite of programs over the next 2 to 3 years to meet conservation targets companywide. Implementation levels and specific program offerings will vary by system depending on system goals, including existing implementation levels, demographics, and hydrologic characteristics.

GSWC is developing a companywide approach that will include assessment of options such as accelerating the current programs, and adding additional programmatic, regulatory and information-based activities to meet the requirements of SBX7-7. This systematic approach may allow GSWC to do more with less, in essence, administering overall conservation program operations from a centralized location while allowing local resources for direct implementation of BMPs and other water savings practices. Funding for all conservation activities is subject to approval by the CPUC before programs can be implemented. Some of the programs that may be considered by GSWC if needed to meet SBX7-7 requirements include financial incentives, regulatory approaches, and information elements. These efforts will be planned to build on existing programs and activities. Programs that may be implemented by 2014 on a companywide basis include the following:

Conservation Pricing

GSWC is in the process of filing a General Rate Case application to increase tiered rates in its systems for residential and CII metered customers. If approved, increased tiered rates are expected to significantly increase water savings and participation in conservation incentive programs in many of GSWC's systems.

Financial Incentives

Ongoing and/or additional financial incentives may be offered directly to customers by GSWC or in partnership with other agencies:

1. HECW rebates: Clothes washer rebates are already being implemented by Metropolitan on behalf of GSWC and will continue to provide measurable water savings.

2. Zero and low-flow urinal rebates: Rebates would include CII fixtures such as zero consumption and ultra-low volume urinals as well as CII specific HETs.

3. Expansion of fixture rebates to CII and MF customers in all systems: currently, the toilet rebate programs are only available to CII and MF customers in select systems. GSWC will evaluate expansion of the programs to all customers and there will be increased focus on marketing to large Home Owner Association accounts.

4. Larger variety of fixture rebates: This may include hot water distribution tanks, pressurized water brooms and high-pressure spray nozzles.

5. Cash-for-grass rebates: Customers will be provided with an incentive of up to $0.5 per square-foot of turf removed and replaced with landscape appropriate plants. The program is being considered for both residential and CII customers; it is currently being offered in select GSWC systems.

6. Expansion of large landscape program: GSWC will be evaluating the effectiveness of the current landscape program and making adjustments depending on the results. If the program is found to be successful at meeting reduction targets, the program may be accelerated and more devices will be offered, such as precision nozzles.

Building Code New Standards

Although it does not have regulatory authority, GSWC supports adoption of new building standards, beyond those currently in code to enhance conservation. If all current code changes that improve the efficiency of fixtures and design are implemented, it could account for up to 60 percent of the expected reduction in demand. Some of the changes proposed will be captured in the CAL Green Code, adopted January 2011 as well as SB407 (Plumbing Retrofit on Resale) and standard updates for toilets and washers that are being phased in.

Information Tracking

Information and tracking represents a new element to the existing programs focusing on collecting and processing information and ensuring that the programs are on track to meet the goals. These activities will also help in program design by providing more robust information about customers and their water use patterns. The immediate priorities include:

1. Automatic Meter Reading (AMR): GSWC currently follows the requirements of CPUC General Order 103-A, which prescribe minimum water system design, operation and maintenance standards for water utilities, and includes requirements for calibrating, testing frequency, and replacing water meters. GSWC will continue to follow this standard and consider the use of AMR in its systems as a priority to obtain real time data for water usage and identify customer-side leaks. This information can also help GSWC monitor the impacts of existing programs, make adjustments where necessary and develop new programs.

2. Water Use Tracking Tools: Another priority, GSWC will consider plans to design and develop database tracking tools for water savings associated with its conservation plans and increase flexibility in adding or changing program elements.

GSWC is developing a companywide approach that will include assessment of options such as accelerating the current programs, and adding additional programmatic, regulatory and information-based activities to meet the requirements of SBX7-7. This systematic approach may allow GSWC to do more with less, in essence, administering overall conservation program operations from a centralized location while allowing local resources for direct implementation of BMPs and other water savings practices. Funding for all conservation activities is subject to approval by the CPUC before programs can be implemented.

7.5.1 Consideration of Economic Impacts

Since funding for all conservation activities is subject to approval by the CPUC before programs can be implemented, the economic impacts of complying with SBX7-7 have not yet been fully determined. However, an economic analysis to help develop programs that avoid placing disproportionate burdens on any single sector will be prepared during development of the SBX7-7 water use efficiency program. The annual costs associated with implementing all traditional CUWCC programmatic BMPs cannot be determined because it represents the combined efforts of Metropolitan, Upper District, and GSWC, where funding levels, incentives and particular measures change from year to year. To continue benefiting customers, GSWC will take advantage of applicable partnership programs that will make conservation programs more efficient and cost effective.

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Chapter 8: Water Shortage Contingency Plan

Section 10632 of the Act details the requirements of the water-shortage contingency analysis. The Act states the following:

Section 10632. The plan shall provide an urban water-shortage contingency analysis that includes each of the following elements that are within the authority of the urban water supplier:

(a) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions, which are applicable to each stage.

(b) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.

(c) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

(d) Additional, mandatory prohibitions against specific water-use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

(e) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water-use reduction consistent with up to a 50 percent reduction in water supply.

(f) Penalties or charges for excessive use, where applicable.

(g) An analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.

(h) A draft water shortage contingency resolution or ordinance.

(i) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

This chapter documents GSWC s Water Shortage Contingency Plan for the South San Gabriel System per requirements of Section 10632 of the Act. The Water Shortage Contingency Plan is based on Rule No. 14.1 Mandatory Water Conservation, Restrictions and Ratings Program adopted by GSWC and on file with CPUC. Appendix D contains the full text of the rule.

The purpose of the Water Shortage Contingency Plan is to provide a plan of action to be followed during the various stages of a water shortage. The plan includes the following elements: action stages, estimate of minimum supply available, actions to be implemented during a catastrophic interruption of water supplies, prohibitions, penalties and consumption reduction methods, revenue impacts of reduced sales, and water use monitoring procedures.

8.1 Action Stages

The Act requires documentation of actions to be undertaken during a water shortage. GSWC has developed actions to be undertaken in response to water supply shortages, including up to a 50 percent reduction in water supply. Implementation of the actions is dependent upon approval of the CPUC, especially for implementing mandatory water use restriction. CPUC has jurisdiction over GSWC because GSWC is an investor-owned water utility. Section 357 of the California Water Code requires that suppliers subject to regulation by the CPUC secure its approval before imposing water consumption regulations and restrictions required by water supply shortage emergencies.

GSWC has grouped the actions to be taken during a water shortage into four stages, I through IV, that are based on the water supply conditions. Table 8-1 describes the water supply shortage stages and conditions. The stages will be implemented during water supply shortages according to shortage level, ranging from 5 percent shortage in Stage I to 50 percent shortage in Stage IV. A water shortage declaration will be made by the American State Water Company Board. The water shortage stage determination during a water supply shortage will be made by the Regional Vice President Customer Service.

Table 8-1: Water Supply Shortage Stages and Conditions

Stage No.	Water Shortage Supply Conditions	Shortage Percent
I	Minimum	5 - 10
II	Moderate	10 - 20
III	Severe	20 - 35
IV	Critical	35 - 50

Note:
This table is based on the DWR Guidebook Table 35.

The actions to be undertaken during each stage include, but are not limited to, the following:

Stage I (5 - 10 percent shortage) □Water alert conditions are declared and voluntary conservation is encouraged. The drought situation is explained to the public and governmental bodies. GSWC explains the possible subsequent water shortage stages in order to forecast possible future actions for the customer base. The activities performed by GSWC during this stage include, but are not limited to:

- Public information campaign consisting of distribution of literature, speaking engagements, website updates, bill inserts, and conversation messages printed in local newspapers
- Educational programs in area schools
- Conservation Hotline, a toll-free number with trained Conservation Representatives to answer customer questions about conservation and water use efficiency

Stage II (10 - 20 percent shortage) □Stage II will include actions undertaken in Stage I. In addition, GSWC may propose voluntary conservation allotments and□or require mandatory conservation rules. The severity of actions depends upon the percent shortage. The level of voluntary or mandatory water use reduction requested from the customers is also based on the severity. It needs to be noted that prior to implementation of any mandatory reductions, GSWC must obtain approval from CPUC. If necessary, GSWC may also support passage of drought ordinances by appropriate governmental agencies.

Stage III (20 - 35 percent shortage) Stage III is a severe shortage that entails or includes allotments and mandatory conservation rules. This phase becomes effective upon notification by the GSWC that water usage is to be reduced by a mandatory percentage. GSWC implements mandatory reductions after receiving approval from CPUC. Rate changes are implemented to penalize excess usage. Water use restrictions are put into effect, i.e. prohibited uses can include restrictions of daytime hours for watering, excessive watering resulting in gutter flooding, using a hose without a shutoff device, use of non-recycling fountains, washing down sidewalks or patios, unrepaired leaks, etc. GSWC monitors production weekly for compliance with necessary reductions. Use of flow restrictors is implemented if abusive practices are documented.

Stage IV (35 - 50 percent shortage) This is a critical shortage that includes all steps taken in prior stages regarding allotments and mandatory conservation. All activities are intensified and production is monitored daily by GSWC for compliance with necessary reductions.

8.2 Minimum Supply

The Act requires an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for GSWC's existing water supply sources.

Table 8-2 summarizes the minimum volume of water available from each existing source during the next three-years based on multiple-dry water years and normal water year. The driest three-year historic sequence is provided in Chapter 6. The water supply quantities for 2011 to 2013 are calculated by linearly interpolating between the projected water supplies of 2010 and 2015 for normal years. The water supplies for 2010 and 2015 are presented in Chapter 4.

It is assumed that the multiple-dry year supplies will be the same as those for the normal years because purchased water supplies will meet projected imported water demands under all anticipated hydrologic conditions.

GSWC's supply for the South San Gabriel System is expected to be 100 percent reliable from 2011 to 2013. This reliability is a result of

- Adjudicated groundwater rights in the Main San Gabriel Basin,
- anticipated benefits of groundwater replenishment provisions and conjunctive use storage programs, and
- the projected reliability of Metropolitan water supplies purchased through USGVMWD, which are expected to be 100 percent reliable.

Table 8-2: Three-Year Estimated Minimum Water Supply in ac-ft/yr				
Source	**2011**	**2012**	**2013**	**2010 Average Year**
Purchased water from USGVMWD	689	1,041	1,393	337
Groundwater	2,144	1,936	1,729	2,352
Recycled water	-	-	-	0
Total	2,833	2,978	3,122	2,689

Note:
This table is based on the DWR Guidebook Table 31.

8.3 Catastrophic Supply Interruption Plan

The Act requires documentation of actions to be undertaken by the water supplier to prepare for, and implement during, a catastrophic interruption of water supplies. A catastrophic interruption constitutes a proclamation of a water shortage and could result from any event (either natural or man-made) that causes a water shortage severe enough to classify as either a Stage III or Stage IV water supply shortage condition.

In order to prepare for catastrophic events, GSWC has prepared an Emergency Response Plan (ERP) in accordance with other state and federal regulations. The purpose of this plan is to design actions necessary to minimize the impacts of supply interruptions due to catastrophic events.

The ERP coordinates overall company response to a disaster in any and all of its districts. In addition, the ERP requires each district to have a local disaster plan that coordinates emergency responses with other agencies in the area. The ERP also provides details on actions to be undertaken during specific catastrophic events. Table 8-3 provides a summary of actions cross-referenced against specific catastrophes for three of the most common possible catastrophic events: regional power outage, earthquake, and malevolent acts.

In addition to specific actions to be undertaken during a catastrophic event, GSWC performs maintenance activities, such as annual inspections for earthquake safety, and budgets for spare items, such as auxiliary generators, to prepare for potential events.

Table 8-3: Summary of Actions for Catastrophic Events

Possible Catastrophe	Summary of Actions
Regional power outage	• Isolate areas that will take the longest to repair and/or present a public health threat. Arrange to provide emergency water. • Establish water distribution points and ration water if necessary. • If water service is restricted, attempt to provide potable water tankers or bottled water to the area. • Make arrangements to conduct bacteriological tests, in order to determine possible contamination. • Utilize backup power supply to operate pumps in conjunction with elevated storage.
Earthquake	• Assess the condition of the water supply system. • Complete the damage assessment checklist for reservoirs, water treatment plants, wells and boosters, system transmission and distribution. • Coordinate with Cal EMA utilities group or fire district to identify immediate fire fighting needs. • Isolate areas that will take the longest to repair and/or present a public health threat. Arrange to provide emergency water. • Prepare report of findings, report assessed damages, advise as to materials of immediate need and identify priorities including hospitals, schools and other emergency operation centers. • Take actions to preserve storage. • Determine any health hazard of the water supply and issue any "Boil Water Order" or "Unsafe Water Alert" notification to the customers, if necessary. • Cancel the order or alert information after completing comprehensive water quality testing. • Make arrangements to conduct bacteriological tests, in order to determine possible contamination.
Malevolent acts	• Assess threat or actual intentional contamination of the water system. • Notify local law enforcement to investigate the validity of the threat. • Get notification from public health officials if potential water contamination • Determine any health hazard of the water supply and issue any "Boil Water Order" or "Unsafe Water Alert" notification to the customers, if necessary. • Assess any structural damage from an intentional act. • Isolate areas that will take the longest to repair and or present a public health threat. Arrange to provide emergency water.

8.4 Prohibitions, Penalties, and Consumption Reduction Methods

The Act requires an analysis of mandatory prohibitions, penalties, and consumption reduction methods against specific water use practices which may be considered excessive during water shortages. Given that GSWC is an investor-owned entity, it does not have the authority to pass any ordinance enacting specific prohibitions or penalties. In order to enact or rescind any prohibitions or penalties, GSWC would seek approval from CPUC to enact or rescind Rule No. 14.1, Mandatory Conservation and Rationing, which is included in Appendix D. When Rule No. 14.1 has expired or is not in effect, mandatory conservation and rationing measures will not be in force.

Rule No. 14.1 details the various prohibitions and sets forth water use violation fines, charges for removal of flow restrictors, as well as establishes the period during which mandatory conservation and rationing measures will be in effect. The prohibitions on various wasteful water uses, include, but are not limited to, the hose washing of sidewalks and driveways using potable water, and cleaning for filling decorative fountains. Table 8-4 summarizes the various prohibitions and the stages during which the prohibition becomes mandatory.

Table 8-4: Summary of Mandatory Prohibitions

Examples of Prohibitions	Stage When Prohibition Becomes Mandatory
Uncorrected plumbing leaks	II, III, IV
Watering which results in flooding or run-off in gutters, waterways, patios, driveway, or streets	II, III, IV
Washing aircraft, cars, buses, boats, trailers, or other vehicles without a positive shut-off nozzle on the outlet end of the hose	II, III, IV
Washing buildings, structures, sidewalks, walkways, driveways, patios, parking lots, tennis courts, or other hard-surfaced areas in a manner which results in excessive run-off	II, III, IV
Irrigation of non-permanent agriculture	II, III, IV
Use of water for street watering with trucks or for construction purposes unless no other source of water or other method can be used	II, III, IV
Use of water for decorative fountains or the filling or topping off of decorative lakes or ponds	II, III, IV
Filling or refilling of swimming pools	II, III, IV

Note:
This table is based on the DWR Guidebook Table 36.

In addition to prohibitions during water supply shortage events requiring a voluntary or mandatory program, GSWC will make available to its customers water conservation kits as required by GSWC's Rule No. 20. GSWC will notify all customers of the availability of conservation kits.

In addition to prohibitions, Rule No. 14.1 provides penalties and charges for excessive water use. The enactment of these penalties and charges is contingent on approval of Rule 14.1 implementation by the CPUC. When the rule is in effect, violators receive one verbal and one written warning after which a flow-restricting device may be installed in the violator's service for a reduction of up to 50 percent of normal flow or 6 ccf per month, whichever is greater. Table 8-5 summarizes the penalties and charges and the stage during which they take effect.

Table 8-5: Summary of Penalties and Charges for Excessive Use

Penalties or Charges	Stage When Penalty Takes Effect
Penalties for not reducing consumption	III, IV
Charges for excess use	III, IV
Flat fine; Charge per unit over allotment	III, IV
Flow restriction	III, IV
Termination of service	III, IV

Note:
This table is based on the DWR Guidebook Table 38.

In addition to prohibitions and penalties, GSWC can use other consumption reduction methods to reduce water use up to 50 percent. Based on the requirements of the Act, Table 8-6 summarizes the methods that can be used by GSWC in order to enforce a reduction in consumption, where necessary.

Table 8-6: Summary of Consumption Reduction Methods		
Consumption Reduction Method	**Stage When Method Takes Effect**	**Projected Reduction Percentage**
Demand reduction program	All Stages	N/A
Reduce pressure in water lines; Flow restriction	III, IV	N/A
Restrict building permits; Restrict for only priority uses	II, III, IV	N/A
Use prohibitions	II, III, IV	N/A
Water shortage pricing; Per capita allotment by customer type	II, IV	N/A
Plumbing fixture replacement	All Stages	N/A
Voluntary rationing	II	N/A
Mandatory rationing	III, IV	N/A
Incentives to reduce water consumption; Excess use penalty	III, IV	N/A
Water conservation kits	All Stages	N/A
Education programs	All Stages	N/A
Percentage reduction by customer type	III, IV	N/A

Note:
This table is based on the DWR Guidebook Table 37.

8.5 Revenue Impacts of Reduced Sales

Section 10632(g) of the Act requires an analysis of the impacts of each of the actions taken for conservation and water restriction on the revenues and expenditures of the water supplier. Because GSWC is an investor-owned water utility and, as such, is regulated by the CPUC, the CPUC authorizes it to establish memorandum accounts to track expenses and revenue shortfalls caused by both mandatory rationing and voluntary conservation efforts. Utilities with CPUC-approved water management plans are authorized to implement a surcharge to recover revenue shortfalls recorded in their drought memorandum accounts. Table 8-7 provides a summary of actions with associated revenue reductions; while Table 8-8 provides a summary of actions and conditions that impact expenditures. Table 8-9 summarizes the proposed measures to overcome revenue impacts. Table 8-10 provides a summary of the proposed measures to overcome expenditure impacts.

Table 8-7: Summary of Actions and Conditions that Impact Revenue	
Type	**Anticipated Revenue Reduction**
Reduced sales	Reduction in revenue will be based on the decline in water sales and the corresponding quantity tariff rate
Recovery of revenues with CPUC-approved surcharge	Higher rates may result in further decline in water usage and further reduction in revenue

Table 8-8: Summary of Actions and Conditions that Impact Expenditures	
Category	**Anticipated Cost**
Increased staff cost	Salaries and benefits for new hires required to administer and implement water shortage program
Increased O□M cost	Operating and maintenance costs associated with alternative sources of water supply
Increased cost of supply and treatment	Purchase and treatment costs of new water supply

Table 8-9: Proposed Measures to Overcome Revenue Impacts	
Names of Measures	**Summary of Effects**
Obtain CPUC-approved surcharge	Allows for recovery of revenue shortfalls brought on by water shortage program
Penalties for excessive water use	Obtain CPUC approval to use penalties to offset portion of revenue shortfall

Table 8-10: Proposed Measures to Overcome Expenditure Impacts	
Names of Measures	**Summary of Effects**
Obtain CPUC-approved surcharge	Allows for recovery of increased expenditures brought on by water shortage program
Penalties for excessive water use	Obtain CPUC approval to use penalties to offset portion of increased expenditures

8.6 Water-Use Monitoring Procedures

The Act asks for an analysis of mechanisms for determining actual reduction in water use when the Water Shortage Contingency Plan is in effect. Table 8-11 lists the possible mechanisms used by GSWC to monitor water use and the quality of data expected.

Table 8-11: Water-Use Monitoring Mechanisms

Mechanisms for Determining Actual Reductions	Type and Quality of Data Expected
Customer meter readings	Hourly/daily/monthly water consumption data for a specific user depending on frequency of readings
Production meter readings	Hourly/daily/monthly water production depending on frequency of readings; correlates to water use plus system losses

In addition to the specific actions that GSWC can undertake to verify level of conservation, GSWC can monitor long-term water use through regular bi-monthly meter readings, which give GSWC the ability to flag exceptionally high usage for verification of water loss or abuse.

Chapter 9: References

California Department of Water Resources (DWR). 2011. *Guidebook to Assist Water Suppliers to Prepare of a 2010 Urban Water Management Plan*. March 2011.

California Department of Water Resources (DWR). Water Use and Efficiency Branch. Division of Statewide Integrated Water Management. *Methodologies for Calculating Baseline and Compliance Urban Per Capita Water Use*. February 2011.

California Department of Water Resources (DWR). 2010. *20x2020 Water Conservation Plan*. February 2010.

California Department of Water Resources (DWR). 2003. *California's Groundwater: Bulletin 118-2003*. <http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm>

California Urban Water Management Council (Council). 2010. *Memorandum of Understanding Regarding Urban Water Conservation in California*. As Amended June 09.

Los Angeles City. Department of City Planning. *City of Los Angeles Housing Element 2006 - 2014*. Los Angeles: 2008.

Los Angeles County Sanitation District. 2005. *Recycled Water User Manual*. February.

Metropolitan Water District of Southern California (Metropolitan). Water Resource Management Group. *2010 Regional Urban Water Management Plan.* June 2010.

Southern California Association of Governments (SCAG) Projections. 2008. *Growth Forecast*. <http://www.scag.ca.gov/rtp2008/2008draft/techappendix/Appendix_A_final.pdf>.

Upper San Gabriel Valley Municipal Water District, 2011. *FINAL DRAFT Urban Water Management Plan*. Stetson Engineers Inc.

UWMP. 2005. *Urban Water Management Plan for South San Gabriel Customer Service Area*. CH2M HILL. December 2005.

Western Regional Climate Center (WRCC). 2008. *Period of Record Monthly Climate Summary*. <http://www.wrcc.dri.edu/summary/lcdus08.html>.

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Appendix A

Urban Water Management Planning Act

CALIFORNIA WATER CODE DIVISION 6
PART 2.6. URBAN WATER MANAGEMENT PLANNING

All California Codes have been updated to include the 2010 Statutes.

WATER CODE
SECTION 10610-10610.4

10610. This part shall be known and may be cited as the "Urban Water Management Planning Act."

10610.2. (a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact

on water management strategies and supply reliability.
(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

10610.4. The Legislature finds and declares that it is the policy of the state as follows:
(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.
(b) The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions.
(c) Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies.

WATER CODE
SECTION 10611-10617

10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

10611.5. "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

10612. "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

10616.5. "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

WATER CODE
SECTION 10620-10621

10620. (a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.

(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.

(d) (1) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

(2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.

(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

10621. (a) Each urban water supplier shall update its plan at least once every five years on or before December 31, in years ending in five and zero.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

(c) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).

WATER CODE
SECTION 10630-10634

10630. It is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied.

10631. A plan shall be adopted in accordance with this chapter that shall do all of the following:

(a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a). If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:

(1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management.

(2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.

(3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) (1) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(A) An average water year.

(B) A single dry water year.

(C) Multiple dry water years.

(2) For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

(d) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(e) (1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water use sectors, including, but not necessarily limited to, all of the following uses:

(A) Single-family residential.

(B) Multifamily.

(C) Commercial.

(D) Industrial.

(E) Institutional and governmental.

(F) Landscape.

(G) Sales to other agencies.

(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.

(I) Agricultural.

(2) The water use projections shall be in the same five-year increments described in subdivision (a).

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:

(A) Water survey programs for single-family residential and multifamily residential customers.

(B) Residential plumbing retrofit.

(C) System water audits, leak detection, and repair.

(D) Metering with commodity rates for all new connections and retrofit of existing connections.

(E) Large landscape conservation programs and incentives.

(F) High-efficiency washing machine rebate programs.

(G) Public information programs.

(H) School education programs.

(I) Conservation programs for commercial, industrial, and institutional accounts.

(J) Wholesale agency programs.
(K) Conservation pricing.
(L) Water conservation coordinator.
(M) Water waste prohibition.
(N) Residential ultra-low-flush toilet replacement programs.

(2) A schedule of implementation for all water demand management measures proposed or described in the plan.

(3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.

(4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

(j) For purposes of this part, urban water suppliers that are members of the California Urban Water Conservation Council shall be deemed in compliance with the requirements of subdivisions (f) and (g) by complying with all the provisions of the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated December 10, 2008, as it may be amended, and by submitting the annual reports required by Section 6.2 of that memorandum.

(k) Urban water suppliers that rely upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c).

10631.1. (a) The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier.

(b) It is the intent of the Legislature that the identification of projected water use for single-family and multifamily residential housing for lower income households will assist a supplier in complying with the requirement under Section 65589.7 of the Government Code to grant a priority for the provision of service to housing units affordable to lower income households.

10631.5. (a) (1) Beginning January 1, 2009, the terms of, and eligibility for, a water management grant or loan made to an urban water supplier and awarded or administered by the department, state board, or California Bay-Delta Authority or its successor agency shall be conditioned on the implementation of the water demand management measures described in Section 10631, as determined by the department pursuant to subdivision (b).

(2) For the purposes of this section, water management grants and loans include funding for programs and projects for surface water or groundwater storage, recycling, desalination, water conservation, water supply reliability, and water supply augmentation. This section does not apply to water management projects funded by the federal American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

(3) Notwithstanding paragraph (1), the department shall determine that an urban water supplier is eligible for a water management grant or loan even though the supplier is not implementing all of the water demand management measures described in Section 10631, if the urban water supplier has submitted to the department for approval a schedule, financing plan, and budget, to be included in the grant or loan agreement, for implementation of the water demand management measures. The supplier may request grant or loan funds to implement the water demand management measures to the extent the request is consistent with the eligibility requirements applicable to the water management funds.

(4) (A) Notwithstanding paragraph (1), the department shall

determine that an urban water supplier is eligible for a water management grant or loan even though the supplier is not implementing all of the water demand management measures described in Section 10631, if an urban water supplier submits to the department for approval documentation demonstrating that a water demand management measure is not locally cost effective. If the department determines that the documentation submitted by the urban water supplier fails to demonstrate that a water demand management measure is not locally cost effective, the department shall notify the urban water supplier and the agency administering the grant or loan program within 120 days that the documentation does not satisfy the requirements for an exemption, and include in that notification a detailed statement to support the determination.

(B) For purposes of this paragraph, "not locally cost effective" means that the present value of the local benefits of implementing a water demand management measure is less than the present value of the local costs of implementing that measure.

(b) (1) The department, in consultation with the state board and the California Bay-Delta Authority or its successor agency, and after soliciting public comment regarding eligibility requirements, shall develop eligibility requirements to implement the requirement of paragraph (1) of subdivision (a). In establishing these eligibility requirements, the department shall do both of the following:

(A) Consider the conservation measures described in the Memorandum of Understanding Regarding Urban Water Conservation in California, and alternative conservation approaches that provide equal or greater water savings.

(B) Recognize the different legal, technical, fiscal, and practical roles and responsibilities of wholesale water suppliers and retail water suppliers.

(2) (A) For the purposes of this section, the department shall determine whether an urban water supplier is implementing all of the water demand management measures described in Section 10631 based on either, or a combination, of the following:

(i) Compliance on an individual basis.

(ii) Compliance on a regional basis. Regional compliance shall require participation in a regional conservation program consisting of two or more urban water suppliers that achieves the level of conservation or water efficiency savings equivalent to the amount of conservation or savings achieved if each of the participating urban water suppliers implemented the water demand management measures. The urban water supplier administering the regional program shall provide participating urban water suppliers and the department with data to demonstrate that the regional program is consistent with this clause. The department shall review the data to determine whether the urban water suppliers in the regional program are meeting the eligibility requirements.

(B) The department may require additional information for any determination pursuant to this section.

(3) The department shall not deny eligibility to an urban water supplier in compliance with the requirements of this section that is participating in a multiagency water project, or an integrated regional water management plan, developed pursuant to Section 75026 of the Public Resources Code, solely on the basis that one or more of

the agencies participating in the project or plan is not implementing all of the water demand management measures described in Section 10631.

(c) In establishing guidelines pursuant to the specific funding authorization for any water management grant or loan program subject to this section, the agency administering the grant or loan program shall include in the guidelines the eligibility requirements developed by the department pursuant to subdivision (b).

(d) Upon receipt of a water management grant or loan application by an agency administering a grant and loan program subject to this section, the agency shall request an eligibility determination from the department with respect to the requirements of this section. The department shall respond to the request within 60 days of the request.

(e) The urban water supplier may submit to the department copies of its annual reports and other relevant documents to assist the department in determining whether the urban water supplier is implementing or scheduling the implementation of water demand management activities. In addition, for urban water suppliers that are signatories to the Memorandum of Understanding Regarding Urban Water Conservation in California and submit biennial reports to the California Urban Water Conservation Council in accordance with the memorandum, the department may use these reports to assist in tracking the implementation of water demand management measures.

(f) This section shall remain in effect only until July 1, 2016, and as of that date is repealed, unless a later enacted statute, that is enacted before July 1, 2016, deletes or extends that date.

10631.7. The department, in consultation with the California Urban Water Conservation Council, shall convene an independent technical panel to provide information and recommendations to the department and the Legislature on new demand management measures, technologies, and approaches. The panel shall consist of no more than seven members, who shall be selected by the department to reflect a balanced representation of experts. The panel shall have at least one, but no more than two, representatives from each of the following: retail water suppliers, environmental organizations, the business community, wholesale water suppliers, and academia. The panel shall be convened by January 1, 2009, and shall report to the Legislature no later than January 1, 2010, and every five years thereafter. The department shall review the panel report and include in the final report to the Legislature the department's recommendations and comments regarding the panel process and the panel's recommendations.

10632. (a) The plan shall provide an urban water shortage contingency analysis that includes each of the following elements that are within the authority of the urban water supplier:

(1) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions that are applicable to each stage.

(2) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic

sequence for the agency's water supply.

(3) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

(4) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

(5) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.

(6) Penalties or charges for excessive use, where applicable.

(7) An analysis of the impacts of each of the actions and conditions described in paragraphs (1) to (6), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.

(8) A draft water shortage contingency resolution or ordinance.

(9) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

(b) Commencing with the urban water management plan update due December 31, 2015, for purposes of developing the water shortage contingency analysis pursuant to subdivision (a), the urban water supplier shall analyze and define water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, separately from swimming pools and spas, as defined in subdivision (a) of Section 115921 of the Health and Safety Code.

10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area, and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.

(c) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(d) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(e) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(f) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

(g) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.

WATER CODE SECTION 10635

10635. (a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

(b) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

(c) Nothing in this article is intended to create a right or entitlement to water service or any specific level of water service.

(d) Nothing in this article is intended to change existing law concerning an urban water supplier's obligation to provide water service to its existing customers or to any potential future customers.

WATER CODE
SECTION 10640-10645

10640. Every urban water supplier required to prepare a plan pursuant to this part shall prepare its plan pursuant to Article 2 (commencing with Section 10630).

The supplier shall likewise periodically review the plan as required by Section 10621, and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

10641. An urban water supplier required to prepare a plan may consult with, and obtain comments from, any public agency or state agency or any person who has special expertise with respect to water demand management methods and techniques.

10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area. After the hearing, the plan shall be adopted as prepared or as modified after the hearing.

10643. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.

10644. (a) An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption.

(b) The department shall prepare and submit to the Legislature, on or before December 31, in the years ending in six and one, a report summarizing the status of the plans adopted pursuant to this part. The report prepared by the department shall identify the exemplary elements of the individual plans. The department shall provide a copy of the report to each urban water supplier that has submitted its plan to the department. The department shall also prepare reports and provide data for any legislative hearings designed to consider the effectiveness of plans submitted pursuant to this part.

(c) (1) For the purpose of identifying the exemplary elements of the individual plans, the department shall identify in the report those water demand management measures adopted and implemented by specific urban water suppliers, and identified pursuant to Section

10631, that achieve water savings significantly above the levels established by the department to meet the requirements of Section 10631.5.

(2) The department shall distribute to the panel convened pursuant to Section 10631.7 the results achieved by the implementation of those water demand management measures described in paragraph (1).

(3) The department shall make available to the public the standard the department will use to identify exemplary water demand management measures.

10645. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

WATER CODE
SECTION 10650-10656

10650. Any actions or proceedings to attack, review, set aside, void, or annul the acts or decisions of an urban water supplier on the grounds of noncompliance with this part shall be commenced as follows:

(a) An action or proceeding alleging failure to adopt a plan shall be commenced within 18 months after that adoption is required by this part.

(b) Any action or proceeding alleging that a plan, or action taken pursuant to the plan, does not comply with this part shall be commenced within 90 days after filing of the plan or amendment thereto pursuant to Section 10644 or the taking of that action.

10651. In any action or proceeding to attack, review, set aside, void, or annul a plan, or an action taken pursuant to the plan by an urban water supplier on the grounds of noncompliance with this part, the inquiry shall extend only to whether there was a prejudicial abuse of discretion. Abuse of discretion is established if the supplier has not proceeded in a manner required by law or if the action by the water supplier is not supported by substantial evidence.

10652. The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) does not apply to the preparation and adoption of plans pursuant to this part or to the implementation of actions taken pursuant to Section 10632. Nothing in this part shall be interpreted as exempting from the California Environmental Quality Act any project that would significantly affect water supplies for fish and wildlife, or any project for implementation of the plan, other than projects implementing Section 10632, or any project for expanded or additional water supplies.

10653. The adoption of a plan shall satisfy any requirements of state law, regulation, or order, including those of the State Water Resources Control Board and the Public Utilities Commission, for the preparation of water management plans or conservation plans; provided, that if the State Water Resources Control Board or the Public Utilities Commission requires additional information concerning water conservation to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan prepared to meet federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part.

10654. An urban water supplier may recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan. Any best water management practice that is included in the plan that is identified in the

"Memorandum of Understanding Regarding Urban Water Conservation in California" is deemed to be reasonable for the purposes of this section.

10655. If any provision of this part or the application thereof to any person or circumstances is held invalid, that invalidity shall not affect other provisions or applications of this part which can be given effect without the invalid provision or application thereof, and to this end the provisions of this part are severable.

10656. An urban water supplier that does not prepare, adopt, and submit its urban water management plan to the department in accordance with this part, is ineligible to receive funding pursuant to Division 24 (commencing with Section 78500) or Division 26 (commencing with Section 79000), or receive drought assistance from the state until the urban water management plan is submitted pursuant to this article.

Appendix B

Public Hearing Notices, Notifications, and Meeting Minutes

Golden State Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Arcadia
Corkran W. Nicholson
Planning Services Manager
240 W. Huntington Drive
Arcadia, CA 91006

Subject: ***REVISED***-Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Corkran:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review prior one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011,* and take place at:

San Dimas/Senior Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Arcadia
Philip A. Wray
City Engineer
240 W. Huntington Drive
Arcadia, CA 91006

Subject: ***REVISED***- Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP)Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Phillip:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

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San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas/Senior Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Claremont
Chris Veirs
City Planner
P.O. Box 880
Claremont, CA 91711

Subject: ***REVISED***-Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Chris:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, July 19, 2011* and take place at:

San Dimas/Senior Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company
A Subsidiary of American States Water Company

May 17, 2011

City of Covina
Michael A. Marquez
Community Development Director
125 E. College Street
Covina, CA 91723

Subject: Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – San Dimas, Claremont, San Gabriel and South Arcadia Water Systems.

Dear Michael:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

San Dimas, Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review prior to the public hearing and can be reviewed during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plan at:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP will be held at 6:00 p.m., on Tuesday, July 19, 2011 and take place at:

San Dimas Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of El Monte
James Troyer
Planning Services Manager
11333 Valley Blvd.
El Monte, Ca 91732

Subject: ***REVISED***-Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear James:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP**'**s will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Irwindale
Tonya Pace
Director of Planning
5050 North Irwindale Ave.
Irwindale, CA 91706

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP)Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Tonya:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

May 17, 2011

City of La Verne
Hal Fredericksen
Community Development Director
3660 D Street
La Verne, CA 91723

Subject: Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – San Dimas, Claremont, San Gabriel and South Arcadia Water Systems.

Dear Hal:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

San Dimas, Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review prior to the public hearing and can be reviewed during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plan at:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP will be held at 6:00 p.m., on Tuesday, July 19, 2011 and take place at:

San Dimas Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Monrovia
Alice Griselle
Community Development Director
415 South Ivy Avenue
Monrovia, CA 91016

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Alice:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Montclair
Steve Lustro
Community Development Director
5111 Bento Street
Montclair, CA 91763

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Steve:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Monterey Park
Ray Hamada
Planning Manager
320 West Newmark Avenue
Monterey Park, CA 91754

Subject: ***REVISED***- Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – Claremont, San Gabriel and South Arcadia Water Systems.

Dear Ray:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Pomona
Mark Laccaretto
Planning Division
505 South Garey Avenue
Pomona, CA 91766

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – Claremont, San Gabriel and South Arcadia Water Systems.

Dear Mark:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Rosemead
Bradford Johnson
Planning Director
8838 Valley Blvd.
Rosemead, CA 91770

Subject: ***REVISED***- Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – Claremont, San Gabriel and South Arcadia Water Systems.

Dear Bradford:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

May 17, 2011

City of San Dimas
Dan Coleman
Planning Manager
245 East Bonita Avenue
San Dimas, CA 91773

Subject: Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – San Dimas, Claremont, San Gabriel and South Arcadia Water Systems.

Dear Dan:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

San Dimas, Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review prior to the public hearing and can be reviewed during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plan at:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP will be held at 6:00 p.m., on Tuesday, July 19, 2011 and take place at:

San Dimas Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of San Gabriel
Carol Banet
Planning Manager
425 South Mission Drive
San Gabriel, CA 91776

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Carol:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

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San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Temple City
Joseph Lambert
Community Development Director
9701 Las Tunas Drive
Temple City, CA 91780

Subject: ***REVISED-*** Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company –Claremont, San Gabriel and South Arcadia Water Systems.

Dear Joseph:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

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110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

July 19, 2011

City of Upland
Jeffrey Bloom
Planning Director
460 North Euclid Avenue
Upland, CA 91786

Subject: ***REVISED***-Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Jeffrey:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

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110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State Water Company

A Subsidiary of American States Water Company

May 17, 2011

City of Walnut
Tom Wiener
Director of Community Development
21201 La Puente Road
Walnut, CA 91789

Subject: Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – San Dimas, Claremont, San Gabriel and South Arcadia Water Systems.

Dear Tom:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

San Dimas, Claremont, San Gabriel and South Arcadia

The UWMP's will be available for public review prior to the public hearing and can be reviewed during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plan at:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP will be held at 6:00 p.m., on Tuesday, July 19, 2011 and take place at:

San Dimas Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Golden State
Water Company
A Subsidiary of American States Water Company

May 17, 2011

Country of Los Angeles
Richard Brudckner
Director Department of Regional Planning
320 West Temple Street
Los Angeles, CA 90012

Subject: Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company – San Dimas, Claremont, San Gabriel and South Arcadia Water Systems.

Dear Richard:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

San Dimas, Claremont, San Gabriel and South Arcadia

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San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP will be held at 6:00 p.m., on Tuesday, July 19, 2011 and take place at:

San Dimas Community Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

July 19, 2011

Country of Los Angeles
Richard Brudckner
Director Department of Regional Planning
320 West Temple Street
Los Angeles, CA 90012

Subject: ***REVISED***- Notification of Public Hearing for the 2010 Urban Water Management Plan (UWMP) Golden State Water Company **–**Claremont, San Gabriel and South Arcadia Water Systems.

Dear Richard:

Golden State Water Company (GSWC) is providing you this notice pursuant to Water Code, section 10621, subdivision (b) of the Act, which requires an urban water supplier to notify any city or county within which it provides water that it is reviewing its plan and considering changes to the plan for the following water systems:

Claremont, San Gabriel and South Arcadia

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San Gabriel Customer Service Center
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Center
689 West Foothill Blvd., Suite D
Claremont, CA 91711

A public hearing to solicit comments on the draft UWMP's will be held at 6:00 p.m., on *Thursday, August 18, 2011* and take place at:

San Dimas Community/Senior Center
201 E. Bonita Avenue
San Dimas, CA 91773

If you have any questions please contact me at (916) 853-3612.

Very truly yours,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

(Space below for use of County Clerk only)

SAN GABRIEL VALLEY TRIBUNE

Affiliated with
SGV Newspaper Group
1210 N. Azusa Canyon Road
West Covina, CA 91790

PROOF OF PUBLICATION
(2015.5 C.C.P.)

STATE OF CALIFORNIA

County of Los Angeles

I am a citizen of the United States, and a resident of the county aforesaid; I am over the age of eighteen years, and not a party to or interested in the above-entitled matter. I am the principal clerk of the printer of **SAN GABRIEL VALLEY TRIBUNE**, a newspaper of general circulation which has been adjudicated as a newspaper of general circulation by the Superior Court of the County of Los Angeles, State of California, on the date of September 10, 1957, Case Number 684891. The notice, of which the annexed is a true printed copy, has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to wit:

6/15/11, 6/22/11

I declare under penalty of perjury that the foregoing is true and correct.

Executed at West Covina, LA Co. California
This 22nd day of June, 2011

Signature

12/22/9

A000002258060

Proof of Publication of

Golden State
Water Company
A Subsidiary of American States Water Company

Notice of Public Hearing

In conformance with the California Urban Water Management Planning Act, Golden State Water Company (GSWC) is hosting a public hearing on July 19, from 6 p.m. to 7 p.m. at the San Dimas Community Center, 201 East Bonita Avenue, San Dimas, to solicit comments on the Urban Water Management Plans (UWMPs) for the company's San Dimas, Claremont, San Gabriel and South Arcadia water systems.

GSWC's San Dimas Water System serves customers in San Dimas and portions of Charter Oaks, Covina, Glendora, La Verne, and Walnut.

The company's Claremont Water System serves customers in Claremont and portions of Montclair, Pomona, and Upland.

GSWC's San Gabriel and South Arcadia Water Systems serve customers in portions of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, and Temple City.

The UWMPs are available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Office
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Office
689 West Foothill Blvd., Ste. D
Claremont, CA 91711

For more information about Golden State Water Company, visit www.gswater.com.

Published: June 15, 22, 2011
San Gabriel Valley Tribune Ad#42810

2115267

SAN GABRIEL VALLEY TRIBUNE

affiliated with
SGV Newspaper Group
1210 N. Azusa Canyon Road
West Covina, CA 91790

PROOF OF PUBLICATION
(2015.5 C.C.P.)

STATE OF CALIFORNIA

County of Los Angeles

I am a citizen of the United States, and a resident of the county aforesaid; I am over the age of eighteen years, and not a party to or interested in the above-entitled matter. I am the principal clerk of the printer of SAN GABRIEL VALLEY TRIBUNE, a newspaper of general circulation which has been adjudicated as a newspaper of general circulation by the Superior Court of the County of Los Angeles, State of California, on the date of September 10, 1957, Case Number 684891. The notice, of which the annexed is a true printed copy, has been published in each regular and entire issue of said newspaper and not in any supplement thereof on the following dates, to wit:

5/17/11

I declare under penalty of perjury that the foregoing is true and correct.

Executed at West Covina, LA Co. California
this 17 day of MAY, 20 11

signature

Proof of Publication of

Golden State
Water Company
A Subsidiary of American States Water Company

Notice of Public Hearing

In conformance with the California Urban Water Management Planning Act, Golden State Water Company (GSWC) is hosting a public hearing on July 19, from 6 p.m. to 7 p.m. at the San Dimas Community Center, 201 East Bonita Avenue, San Dimas, to solicit comments on the Urban Water Management Plans (UWMPs) for the company's San Dimas, Claremont, San Gabriel and South Arcadia water systems.

GSWC's San Dimas Water System serves customers in San Dimas and portions of Charter Oaks, Covina, Glendora, La Verne, and Walnut.

The company's Claremont Water System serves customers in Claremont and portions of Montclair, Pomona, and Upland.

GSWC's San Gabriel and South Arcadia Water Systems serve customers in portions of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, and Temple City.

The UWMPs are available for public review one week prior to the public hearing during normal business hours. Please call 1-800-999-4033 to make an appointment to view the plans at the following locations:

San Dimas Customer Service Office
121 Exchange Place
San Dimas, CA 91773

San Gabriel Customer Service Office
110 East Live Oak
Arcadia, CA 91006

Claremont Customer Service Office
689 West Foothill Blvd., Ste. D
Claremont, CA 91711

For more information about Golden State Water Company visit www.gswater.com.

CNS"2102177
Published: May 17, 2011
San Gabriel Valley Tribune
Ad#201573

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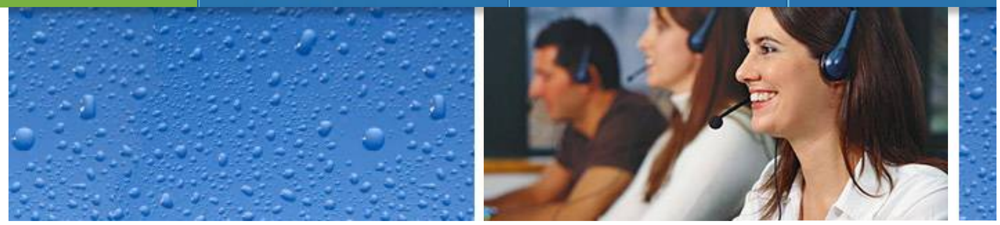

Customer Service Home Page
Find Local Office Information
Payment Options
Understanding Your Bill
How to Read Your Meter
Definitions and Terminology
Frequently Asked Questions
New Customer Brochure

For 24-hour customer service or emergency please call

1-800-999-4033
24 hours, 7 days a week

877-933-9533
TTY (hearing impaired)

Find Local Office Information » San Gabriel Valley

San Gabriel Valley Customer Service Area

WATER CONSERVATION TIPS

Don't use the toilet as a wastebasket and save up to 200 gallons of water a month.

Areas Serviced
This Customer Service Area serves approximately 12,200 customers in portions of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, and Temple City

Office Location
San Gabriel CSA
110 East Live Oak
Arcadia, CA 91006

24 hour Customer Service and Emergency
800-999-4033 (24 hours, 7 days a week)
877-933-9533 (TTY hearing impaired)
Email: customerservice@gswater.com

Urban Water Management Plan Public Meeting Notice

Golden State Water Company (GSWC) is in the process of updating its existing Urban Water Management Plan and is seeking public input. The plan is expected to be available for review one week prior to the meeting date.

See public notice for more information.

Golden State Water Company (GSWC) Files a Cost of Capital Application

A Cost of Capital application was filed May 2, 2011 with the the California Public Utilities Commission (CPUC). The CPUC regulates GSWC to ensure adequate levels of service are provided at the lowest reasonable costs.

In this filing, GSWC is requesting for the CPUC to review and authorize an increase in the cost of capital reflected in rates for 2012, 2013, and 2014. A decision is expected in December 2011.

A copy of the application is here.

New Rates Established in San Gabriel Valley Customer Service Area for 2011 and 2012

The CPUC issued a final decision on the company s 2008 General Rate Case on Nov. 19, 2010. The decision established rates for GSWC to charge customers for 2010, 2011 and 2012 in its Region III, which includes the San Gabriel Valley Customer Service Area.

Fact Sheet

RATES, SCHEDULES & TARIFFS

- Residential Metered Service
- Non-Residential Metered Service
- Mandatory Conservation-Rationing (Schedule 14.1)

CLICK HERE to view all our rates, tariffs and advice letters

Third Tier Added to Tiered Rates for San Gabriel Valley Customer Service Area to Encourage Water Use Efficiency

GSWC residential customers in the utility s San Gabriel Valley Customer Service Area (CSA) had a third tier added to their tiered rates to promote water use efficiency.

The change, approved by the California Public Utilities Commission, began in December 2010. GSWC will not exceed CPUC authorized revenues as a result of tiered rates.

Here s how tiered rates work. Customers get charged for each unit of water they use. A unit is equal to one hundred cubic feet of water, or Ccf (748 gallons). In the San Gabriel Valley CSA, residential customers will pay the lowest rate for each Ccf they use in tier one, up to 13 Ccf. For every unit of water used in tier two, which is 14-21 Ccf, customers will pay a 15 percent higher rate. In tier three, customers will pay an additional 15 percent for every unit of water from 22 Ccf and above.

The top of the first tier is based on the average winter month usage for the service area. The top of second tier is based on the midpoint between the annual average usage and the average summer month usage for the service area. The per unit price differential between each tier is approximately 15 percent, a sufficient amount to encourage water use efficiency.

For more information, see our Residential Metered Service tariff in the article above.

LOW INCOME PROGRAM
California Alternate Rates for Water (CARW)

Golden State Water Company offers a discount through the California Alternate Rates for Water (CARW) program to eligible customers. The amount of the discount is $8 per month, which is equal to 15 percent of the average bill in your customer service area.

If you qualify for a rate discount on your electricity, you may be eligible for a discount on your water bill. Qualifications are based on the number of people living in your home and your total household income, including wages, government checks and benefits, and other financial support you and members of your family receive.

For further information, see the application below or contact our CARW hotline at (866) 360-CARW (2279).

Application (English)
Application (Spanish)

Visit Golden State Water Company's Demonstration Garden

Golden State Water Company s demonstration garden which features over 25 different California-friendly plants, drought tolerant turf, and a water-wise smart irrigation system recently received the California Landscape Contractors Association (CLCA) state-wide trophy award for sustainability.

The CLCA trophy awards recognize companies, institutions, municipalities and residents for their interest in preserving and maintaining a beautiful California. The first of an inaugural award to be given by the CLCA, the award was designed to recognize those projects containing sustainable installation elements, including: water management, planting and plant selection, sustainable construction methods.

Since the completion of the project, Golden State Water Company has exceeded a 56-month return on investment goal of 40 percent water savings.

Golden State Water Company's Water Shortage Plan for San Gabriel Valley Customers

Golden State Water Company (GSWC) developed a water shortage plan (Schedule 14.1) for its San Gabriel Customer Service Area that asks customers to voluntarily reduce their usage based on historical averages. Read additional plan details here. Each water allocation is based on the customer's average historical usage in 2004, 2005, and 2006, minus 10 percent.

Additionally, water use restrictions are now in place. GSWC may issue fines to customers who are involved in water wasting activities such as using water in any manner that results in run-off in gutters, waterways, patios, driveways or streets. Repeated violations could lead to the installation of flow restrictors at the customer s cost and suspension of service. See list of restrictions.

Should a mandatory allocation stage be implemented, exception forms will be available for customers to request an allocation adjustment. For example, if a household added several people since 2006, or if customers require additional water for medical needs, they may be eligible for a higher water budget. Water conservation practices and devices may be evaluated as part of the exception evaluation process. Since the targeted reductions in the current stage for San Gabriel customers are voluntary, allocation forms will not be processed at this time.

For more information, see our list of frequently asked questions about the water shortage plan, or call 1-800-999-4033.

Golden State has Invested More Than $19.7 Million in the San Gabriel Customer Service Area Since 2000

Golden State is continually improving its water infrastructure to ensure its supply, distribution, and storage systems are adequate. From 2000 to 2009, Golden State spent more than $19.7 million on improvements in the San Gabriel Customer Service Area, which includes portions of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, and Temple City.

"To make high quality water readily available to all of our customers, we must continually invest in our water facilities, installing new infrastructure," said GSWC's Foothill District Manager Benjamin Lewis.

Golden State Water Company is regulated by the California Public Utilities Commission, which established a Water Action Plan. One of the objectives of the plan is to promote water infrastructure investment. Nationally, leaking pipes lose an estimated seven billion gallons of clean drinking water a day, according to the American Society of Civil Engineers.

WATER CONSERVATION REBATE PROGRAMS

Golden State Water Company partners with other agencies to offer various rebate programs as an incentive for customers to purchase water-efficient products. Here are some programs created for San Gabriel Valley Customer Service Area customers. Funding is limited.

High-Efficiency Clothes Washer (HECW) Rebates
For single-family homes call 1-888-376-3314 or visit www.socalwatersmart.com.
Up to $85 rebate for those who qualify.

High-Efficiency Toilet (HET) Rebates
Up to $125 for qualifying customers. Click here for application or call 1-800-999-4033.

Rotating Nozzles and Pressure Regulating Sprinkler Heads
Single-family homes, call 888-376-3314 or visit www.socalwatersmart.com.
Up to $4 per set rebate for those who qualify.

Weather-based Irrigation Controller (SmarTimer)
Single-family homes and multi-family buildings up to four units, call 888-376-3314 or visit www.socalwatersmart.com.
Up to $25 rebate per station for those who qualify.

SmarTimer rebates for multi-family buildings with more than four units are currently no longer available due to overwhelming public response.

To learn more about any of our current rebate programs, please call customer service at 800-999-4033.

WATER QUALITY ANNUAL REPORT

South Arcadia
South San Gabriel

Terms of Use | Privacy Policy

Home Page | About Golden State Water Company | Customer Service | Find Your Local Office | Understanding Your Bill
Conservation Information and Rebate Programs | Rates, Schedules and Tariffs | Water Quality | Contact Us

For 24-hour emergency and customer service, please call: 1-800-999-4033 or 877-933-9533 TTY (hearing impaired)
customerservice@gswater.com

Website design by NetPilot Web Solutions

AUGUST 18, 2011

2010 UWMP PUBLIC MEETING MINUTES FOR CLAREMONT, SOUTH ARCADIA & SOUTH SAN GABRIEL

GSWC ATTENDEES: ADRIAN COMBES, BEN LEWIS, TOM TRAFFAS, DIANE PINNICK

MEETING CALLED TO ORDER 6:02pm

SEE COMMENT CARDS FOR ALL QUESTIONS AND COMMENTS

MEETING ADJOURNED 7:06pm

Golden State Water Company
A Subsidiary of American States Water Company

Comment Card

Claremont, South Arcadia, South San Gabriel
UWMP Public Hearing
Aug. 18, 2011

Name Richard Haskell

Service Address 421 Baughman Avenue

City Claremont

Question regarding future use of reclaimed waste water:

Does GSW have a vision for the use of reclaimed water in the Claremont community? How can GSW collaborate with Three Valleys, LACSD, & the City to provide reclaimed water for landscape irrigation? The section on reclaimed water is very disappointing.

Golden State
Water Company
A Subsidiary of American States Water Company

Comment Card
Claremont, South Arcadia, South San Gabriel
UWMP Public Hearing
Aug. 18, 2011

Name Marilee Scaff

Service Address 640 Alden Rd

City Claremont

Question Read comments

Response2010 Urban Water Management Plan for CLAREMONT
Hearing at San Dimas Community Center, August 18, 2011

From: Marilee K. Scaff 640 Alden Road Apt 2, Claremont, Ca 91711
C0Chair of the Water Task Force of League of Women Voters of Claremont Area

Golden State Water Company and Kennedy/Jenks Consultants are to be commended for the 2011 Revision of their Urban Water Management Plan for Claremont. It is comprehensive and detailed, and outlines well the current situation of water supplies for Pomona Valley.

However, there are errors and omissions and important issues not addressed which if corrected might make the Plan even more useful, and improve its function as a guide for future operations. I wpu ld like to call attention to the following:

1. Page vii. First, may I point out that advance notices of this public hearing are quite inadequate for inviting comment from citizens of Claremont. A notice in a newspaper in Covina is completely inaccessible to the reading public of Claremont; *Inland Valley Daily Bulletin* published in Pomona and *Claremont Courier* are the papers people in Pomona Valley read. Also you should remember that a great many of your clientele --several thousand college students, plus all residents of retirement communities, all persons living in multi-family housing and renters in single family homes never see their water bills, as they pay for water through their rents. Yet all of them should be concerned about their water supply.

2. Chapter 2. Demographics relies entirely on year 2000 population figures and uses these for projections. By the time the period covered by the report comes to an end, your figures will be 20 years out of date, and hence inadequate for planning.

One thing is sure: The next 20 years will not be like the last 20. Global warming, population increase, diminishing water availability from Sierra snow pack, changes in State Water Plan—all these and more will need to be taken into account.

As the 2010 Census figures are already available, a really useful plan must take the extra time and effort to put those into its calculations.

3. Claremont's population, furthermore, is quite unusual for a town of its size, and depending on SCAG's population projections do not fit this population. As a small town with eight colleges enrolling something like 14,000 students a majority of whom live in Residence Halls, plus four retirement communities with another 1,500 members, nearly half of the total population does not fit the expected pattern of household and employment projections adopted from 2008 RTP data. So your methodology for 2.3. section is inappropriate and will not give you reliable data.

This same problem infects your population projection of 39,015 by the year 2015 (Table 2.2). Claremont is essentially "built out"; there is almost no open space for normal community growth. Surely there must be other communities which do not fit this paradigm of never-ending growth. It certainly will affect planning and water distribution. This same inaccuracy I note in all your longer-range water use projections. You would more reasonably revise these projections.

4. May I commend the core of this report: Chapter 3 on historical water use, the present efforts at conservation, and future targets for reduction in per capita use. Claremont's "Sustainable City " Plan is in full agreement with GSWC on this subject and we all applaud both the data and your efforts.

However, one does note the inconsistency of amounts of water used by the residents, (Table 3-3) with per capita daily use varying between 269 and 345 in the last 6 years. Therefore, I am astonished that in face of this, you can we even speak of a target reduction of 50% to 142 by the year 2020? Is thata reasonable?

5. Affordable Housing/ Disadvantages resi8dents
Section 3-18 - Disadvantaged Community Water Projections implies that Claremont has no need of provision of affordable housing. This s not accurate. Claremont City lists at least the following:

Courier Village (City sponsored) is under construction on S. College for 45 seniors and 40 families (I'm less sure of the numbers)
Access Village (City sponsored) on N. Mountain for handicapped adults
Claremont Villa (City sponsored) on Indian Hill Blvd. for seniors, some affordable units.
Bonita Terrace for seniors
Claremont Village Green for seniors
Mountain Village for seniors
Emerson Village in Pomona, (to which Claremont refers seniors.)
Plus some Section 8 voucher-accepting commercial housing.

6. Ch 4.8 - 4.15 on Recycled water: thank you for the summary of the current situation about Recycled water. The Claremont College Consortium does expect to go ahead with recycling water for their own multiple-campus irrigation, which we hope will become a model for small scale recycling and that in the next 10 years there will be others.

7.One final addition: The State Water Plan calls for Southern California to seek to improve their reliance on local water supplies. What does GSWC plan about a possible **Water Emergency**, either because of a catastrophe on the delivery system of the State Water Project, or because of extended drought or damage to the Delta? The public should hear what kinds of thinking GSWC and MWD and TVMWD are doing in preparation for this really long-range possibility.

8. Finally, The League of Women Voters has a Water Task Force working for the last six years on water issues in the Claremont Area. This public-interest group has shared all our material with Golden State Water Company and all the other component users of water in Pomona Valley. Our aim has been to improve storm water spreading in Thompson Creek. We have a Feasibility Study, funded by Prop 84 bonds through the Los Angeles and San Gabriel Rivers and Mountains Conversancy which estimates that we could increase storm water spreading there by 30% to 150%. In addition the City of Claremont is willing to add this land to the Claremont Hills Wilderness Park, and manage it for the free usage by people from all over this region. Floyd Wicks as CEO of Golden State Water offered encouragement and support to this project. We urge Golden State Water Company to continue leadership in this project which would benefit the health and welfare of citizens all over this great Valley

how

Golden State
Water Company
A Subsidiary of American States Water Company

Comment Card
Claremont, South Arcadia, South San Gabriel
UWMP Public Hearing
Aug. 18, 2011

Name Freeman Allen

Service Address 394 Blaisdell Dr,

City Claremont

Question Written

Comments on the draft 2010 urban Water Management Plan - Claremont
August 18, 2011

The Urban Water Management Plan for Claremont contains a wealth of information, and is well written. The following comments address aspects that should be strengthened

1.1 Background

Solicitation of active participation of the population within the service area was minimal, and should be enhanced in the future.

Page 1-6. According to the Urban Water Management Plan Act:

Each urban water supplier shall encourage the active involvement of diverse social, cultural and economic elements of the population within the service area prior to and during the preparation of the Plan

In fact:

- Notice of the Hearings on July 19 and August 18 were not published in Claremont. The population in this part of the service area was not encouraged to be involved.
- No notice of the Hearing was posted in the Claremont office of Golden States Water. Upon inquiry as to the time and location of the Hearing the customer representative referred to the GSW web site for the information. The Notice of public Hearing printed from the web site instructs the customer to "call 1-800-999-4033 to make an appointment to view the plan at the (Claremont office)". At that number it was difficult to find anyone who knew of the Hearing. The information provided was to "contact the local office; no appointment is necessary".
- At the local office, earlier today, the only information offered about the Plan was reference to the web site.

I attended the July 19 hearing and suggested that the August 18 Heating be publicized in the local newspaper, the Claremont Courier, and that copies of the Plan be made easily accessible at locations such as the Claremont Public Library. That was not done.

Clearly involvement of the population in the service area has not been encouraged. This appears to be contrary to the intent of the Act, and an opportunity lost to involve the public in cooperative planning for the future of their water supply.

The relevant population should be involved and encouraged to participate. Golden States Water carries out a very active and well-publicized program encouraging water conservation. I suggest a similar active program be used to encourage involvement in water management planning.

If the Plan is to be relied on by the CPUC in regulatory decision-making accuracy and completeness will be important. The following comments relate to these features.

2.2 Demographics

Affordable housing units are presently being constructed. This Plan says they "may be implemented".

2.3 Population, Housing and Employment

It was apparently not possible to use the latest census data. More accurate and up-to-date data should be used in regulatory decisions.

4.1. Water Sources

The reference to the Covina Irrigation Company does not seem relevant.

Table 4.4.

Pumping for 2006 and 2007 appears to exceed pumping rights. Are these figures correct?

4.8.3 Potential and Projected Use (of recycled water).

Planning for a scalping plant at the Claremont Colleges is correctly stated to be in the preliminary stages. However, it now seems likely this plant will be constructed and in operation within a few years. If so, the recycled water used for irrigation will amount to about 5% of Claremont's total usage and similarly reduce the need for more expensive imported water. This should be a consideration in CPUC regulatory decisions.

6.1.3 Water Supply

PVPA also owns and operates the Thompson Creek Spreading Grounds. This source of water is much smaller than the San Antonio Spreading Grounds but it does provide water for the Six Basins Aquifer from the San Gabriel River watershed.

8.3 Catastrophic Supply Interruption Plan

This section should specifically address the possibility of disruption of the State Water System for long periods of time. The Sacramento/San Joaquin river delta is notably vulnerable.

C. Freeman Allen, PhD
Professor Emeritus Chemistry, Pomona College
Co-Chair, Sustainable Claremont
Director for Sustainability, League of Women Voters of the Claremont Area

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Urban Water Management Planning Meeting
Sign-In Sheet
Claremont, South San Gabriel, South Arcadia Systems
Aug. 18, 2011

Name	Address	Phone	Email
Jim Pedroza	580 Cinderella Dr	909-864-2047	
Richard Haskell	421 Baughman Ave Claremont	909-625-2223	richard_haskell@hmc.ed
CHRIS VEIRS	PO BOX 880 CLAREMONT	(909) 399-5486	CVEIRS@ci.CLAREMONT.CA.US
Freeman Allen	394 Blaisdell Dr Claremont, CA 91711		cf1allen@aol.com
Marilee Scaff	620 Alden Rd Claremont CA 91711		marilee.scaff@verizon

Appendix C

Council Annual Reports for Demand Management Measures

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

Agency: **Golden State Water Company** **District Name:** **San Gabriel Valley** **CUWCC Unit #:** **5045**
Retail

Primary Contact John Turner **Telephone** (909) 394-3600 Ext **Email:** johnturner@gswater.com

Compliance Option Chosen By Reporting Agency:
(Traditional, Flex Track or GPCD)
GPCD if used:

GPCD in 2010	**144**
GPCD Target for 2018	152

Year	Report	Target		Highest Acceptable Bound	
		% Base	GPCD	% Base	GPCD
2010	1	96.4%	179	100%	185
2012	2	92.8%	172	96%	179
2014	3	89.2%	165	93%	172
2016	4	85.6%	159	89%	165
2018	5	82.0%	152	82%	152

Not on Track if 2010 GPCD is ≥ than target

GPCD in 201 **144**
Highest Acceptable GPCD for **185**

On Track

Agency:	Golden State Water Company	District Name:	San Gabriel Valley	CUWCC Unit #:	5045

Retail

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

Foundational BMPs

BMP 1.1 Operational Practices

		2009	2010	Conservation Coordinator provided with necessary resources to implement BMPs?
1.Conservation Coordinator provided with necessary resources to implement BMPs?	Name	Albert Frias	Albert Frias	
	Title	Water Conservation Coordinator	Water Conservation Coordinator	
	Email			
		On Track	On Track	

2. Water waste prevention documentation

Descriptive File	Rule 20 = Water Conservation. Rule 11B = Discontinuance of Service based upon Water Wastage. R
Descriptive File 2010	
URL	Where negligent or wasteful use of water exists on customer's premises, the utility may discontinue the service if such practices are not remedied within five days after it has given the customer written notice to such effect.
URL 2010	http://www.aswater.com/Organization/Rates_and_Regulations/Rates_and_Tariffs/Rule_11.pdf
Describe Ordinance Terms	

On Track (2009) — On Track (2010)

On Track if any one of the 6 ordinance actions done, plus documentation or links provided

Agency: **Golden State Water Company** **District Name:** **San Gabriel Valley** **CUWCC Unit #:** **5045**
Retail

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

BMP 1.2 Water Loss Control

	2009		
Complete a prescreening Audit			On Track if Yes
Metered Sales	**6,081**		
Verifiable Other Uses	**143**		
Total Supply	**6,511**		
(Metered Sales + System uses)/ Total Supply >0.89	0.96	**On Track**	On Track if =>.89, Not on Track if No
If ratio is less than 0.9, complete a full scale Audit in 2009?	**No**		On Track if Yes
Verify Data with Records on File?	**Yes**	**On Track**	On Track if Yes
Operate a system Leak Detection Program?	**Yes**	**On Track**	On Track if Yes

		2010		
Compile Standard Water Audit using AWWA Software?		Yes	**On Track**	On Track if Yes, Not on Track if No
AWWA file provided to CUWCC?	Yes		**On Track**	On Track if Yes, Not on Track if No
AWWA Water Audit Validity Score?		84		Info only until 2012
Completed Training in AWWA Audit Method?		Yes		
Completed Training in Component Analysis Process?		No		Info only until 2012
Complete Component Analysis?		No		Info only until 2012
Repaired all leaks and breaks to the extent cost effective?		Yes	**On Track**	On Track if Yes, Not on Track if No
Locate and repair unreported leaks to the extent cost effective.		Yes	**On Track**	On Track if Yes, Not on Track if No
Maintain a record-keeping system for the repair of reported leaks, including time of report, leak location, type of leaking pipe segment or fitting, and leak running time from report to repair.		Yes		Info only until 2012

Provided 7 types of Water Loss Control Info — Info only until 2012

Leaks Repaired	Value Real Losses	Value Apparent Losses	Miles Surveyed	Press Reduction	Cost of Interventions	Water Saved
18	$1,540.00	$1,540.00	38			41

Agency: Golden State Water Company **District Name:** San Gabriel Valley **CUWCC Unit #:** 5045
Retail

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

1.3 METERING WITH COMMODITY RATES FOR ALL NEW CONNECTIONS AND RETROFIT OF EXISTING CONNECTIONS

		2009		2010		
Exemption or 'At least as Effective As' accepted by CUWCC						If signed MOU prior to 31 Dec 1997, On Track if all connections metered; If signed after 31 Dec 1997, complete meter installations by 1 July 2012 or within 6 yrs of signing and 20% biannual reduction of unmetered connections.
Numbered Unmetered Accounts	2008	0	On Track	0	On Track	On Track if no unmetered accounts
Metered Accounts billed by volume of use		Yes	On Track	Yes	On Track	Volumetric billing required for all connections on same schedule as metering
Number of CII accounts with Mixed Use meters		120		120		Info only
Conducted a feasibility study to assess merits of a program to provide incentives to switch mixed-use accounts to dedicated landscape meters?		No		No		Info only until 2012
Feasibility Study provided to CUWCC?		No	On Track until 2012	No	On Track until 2012	On Track if Yes, Not on Track if No
Completed a written plan, policy or program to test, repair and replace meters		Yes	On Track	Yes	On Track	On Track if Yes, Not on Track if No

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

Agency: **Golden State Water Company** **District Name:** **San Gabriel Valley** **CUWCC Unit #:** **5045**

Retail

Primary Contact John Turner **Email:** johnturner@gswater.com

1.4 Retail Conservation Pricing

Metered Water Rate Structure

On Track if: Increasing Block, Uniform, Allocation, Standby Service; Not on Track if otherwise

Customer Class	2009 Rate Type	Conserving Rate?	Customer Class	2010 Rate Type	Conserving Rate?
Single-Family	Increasing Block	Yes	Single-Family	Increasing Block	Yes
Multi-Family	Increasing Block	Yes	Multi-Family	Increasing Block	Yes
Commercial	Uniform	Yes	Commercial	Uniform	Yes
Industrial	Uniform	Yes	Industrial	Uniform	Yes
Institutional	Uniform	Yes	Institutional	Uniform	Yes
	On Track			On Track	

Year Volumetric Rates began for Agencies with some Unmetered Accounts

Info only

Agencies with Partially Metered Service Areas: If signed MOU prior to 31 Dec. 1997, implementation starts no later than 1July 2010. If signed MOU after 31 Dec. 1997, implementation starts no later than 1July 2013, or within seven years of signing the MOU,

Agency: **Golden State Water Company** District Name: **San Gabriel Valley** CUWCC Unit #: **5045**
Retail

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

Adequacy of Volumetric Rates) for Agencies with No Unmetered Accounts

Customer Class	2009 Rate Type	2009 Volumetric Revenues $1000s	2010 Rate Type	2010 Volumetric Revenues $1000s
Single-Family	Increasing Block	$ 2,994	Single-Family	$ 2,930
Multi-Family	Increasing Block	$ 370	Multi-Family	$ 362
Commercial	Uniform	$ 1,791	Commercial	$ 1,753
Industrial	Uniform	$ 26	Industrial	$ 26
Institutional	Uniform	$ 375	Institutional	$ 366
Dedicated Irrigation		$ 136		$ 133
Other		$ 35		$ 34
Total Revenue Commodity Charges (V):		$ 5,728		$ 5,605
Total Revenue Fixed Charges (M):		$ 3,343		$ 3,271
Calculate: V / (V + M):		63%		63%
		Info Only untill 2011		Info Only untill 2011

Agency Choices for rates:

A) Agencies signing MOU prior to 13 June2007, implementation starts 1 July2007: On Track if (V / (V + M) ≥ 70% x .8 = **56% for 2009** and 70%x0.90 = **63% for 2010**; Not on track if (V / (V + M)) < 70%;

B) Use Canadian model. Agencies signing MOU after 13June2007, implementation starts July 1 of year following signing.

Canadian Water & Wastewater Rate Design Model Used and Provided to CUWCC — 2009: **No** (Info Only untill 2011) — 2010: **No** (Info Only untill 2011)

If Canadian Model is used, was 1 year or 3 year period applied?

Wastewater Rates

	2009	2010
Does Agency Provide Sewer Service?	**No**	**No**

If 'No', then wastewater rate info not required.

Customer Class	2009 Rate Type	Conserving Rate?	Customer Class	2010 Rate Type	Conserving Rate?
		Yes			Yes
		Yes			Yes
		Yes			Yes
		Yes			Yes
		Yes			Yes
		Yes			Yes
		Yes			Yes
		On Track			On Track

On Track if: 'Increasing Block', 'Uniform', 'based on long term marginal cost' or 'next unit of capacity'

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

BMP 2. EDUCATION PROGRAMS

BMP 2.1 Public Outreach Actions Implemented and Reported to CUWCC

	2009	2010	
Does a wholesale agency implement Public Outrach Programs for this unility's benefit?	Yes	**Yes**	Yes/No
Names of Wholesale Agencies	**Upper San Gabriel Valley Munipal Water District and MWD Los angeles**	**Upper San Gabriel Valley Munipal Water District and MWD Los angeles**	
1) Contacts with the public (minimum = 4 times per year)	18	18	
2) Water supplier contacts with media (minimum = 4 times per year, i.e., at least quarterly).	8	8	
3) An actively maintained website that is updated regularly (minimum = 4 times per year, i.e., at least quarterly).	Yes	Yes	All 6 action types implemented and reported to CUWCC to be 'On Track')
4) Description of materials used to meet minimum requirement.	Newspaper contacts Television contacts	Newspaper contacts Television contacts	
5) Annual budget for public outreach program.	$ 6,100	$ 6,100	
6) Description of all other outreach programs	Full description will be online in the BMP reporting database	Full description will be online in the BMP reporting database	
	On Track	**OnTrack**	

CUWCC BMP RETAIL COVERAGE REPORT 2009-2010

Foundation Best Management Practices for Urban Water Efficiency

2.2 School Education Programs Implemented and Reported to CUWCC

	2009	2010	
Does a wholesale agency implement School Education Programs for this unility's benefit?	No	No	
Name of Wholesale Supplier?	Description available in the online BMP reporting system when available.	Description available in the online BMP reporting system when available.	
3) Materials Distributed to K-6?	Yes	Yes	
Materials distributed to 7-12 students?	No	No	Info Only
	On Track	On Track	

Appendix D

CPUC Water Conservation and Rationing Rules and Regulations

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE

A. Customer's Request for Discontinuance of Service

1. A customer may have service discontinued by giving not less than two day's advance notice thereof to the utility. Charges for service may be required to be paid until the requested date of discontinuance or such later date as will provide not less than the required two days' advance notice.

2. When such notice is not given, the customer will be required to pay for service until two days after the utility has knowledge that the customer has vacated the premises or otherwise has discontinued water service.

B. Discontinuance of Service by Utility

1. For Nonpayment of Bills

a. Past-Due Bills. When bills are rendered monthly or bimonthly, they will be considered past due if not paid within 19 days from the date of mailing. The utility shall allow every residential customer at least 19 days from the date of mailing its bill for services, postage prepaid, to make payment of the bill. The utility may not discontinue residential service for nonpayment of a delinquent account unless the utility first gives notice of the delinquency and impeding discontinuance, at least 10 days prior to the proposed discontinuance, by means of a notice mailed, postage prepaid, to the customer to whom the service is provided if different than to whom the service is billed, not earlier than (T) 19 days from the date of mailing the utility's bill for services. The 10-day discontinuance of service notice shall not commence until five days after the mailing of the notice.

b. When a bill for water service has become past due and a 10-day discontinuance of residential service notice or a 7-day discontinuance of residential service notice for nonpayment has been issued, service may be discontinued if bill is not paid within the time required by such notice. The customer's service, however, will not be discontinued for nonpayment until the amount of any deposit made to establish credit for that service has been fully absorbed.

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

c. Any customer, residential as well as nonresidential, who has initiated a billing complaint or requested an investigation within 5 days of receiving a disputed bill or who has, before discontinuance of service made a request for extension of the payment period of a bill asserted to be beyond the means of the customer to pay in full within the normal period for payment, shall not have residential water service discontinued for nonpayment during the pendency of an investigation by the utility of such customer complaint or request and shall be given an opportunity for review of the complaint, investigation, or request by a review manager of the utility. The review shall include consideration of whether a residential customer shall be permitted to make installment payments on any unpaid balance of the delinquent account over a reasonable period of time, not to exceed 12 months. Such service shall not be discontinued for nonpayment for any customer complying with an installment payment agreement entered into with the utility, provided the customer also keeps current his account for water service as charges accrue in each subsequent billing period. If a residential customer fails to comply with an installment payment agreement, the utility will give a 10-day discontinuance of service notice before discontinuing such service, but such notice shall not entitle the customer to further investigation by the utility.

d. Any customer whose complaint or request for an investigation pursuant to subdivision (c) has resulted in an adverse determination by the utility may appeal the determination to the Commission. Any subsequent appeal of the dispute or complaint to the Commission shall be in accordance with the Commission adopted Rules of Practice and Procedure.

e. Service to a residential water customer will not be discontinued for nonpayment when the customer has previously established to the satisfaction of the utility that:

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

e. (Continued)

(1) The customer is elderly (age 62 or over) or handicapped,* or upon certification of a licensed physical or surgeon that to discontinue water will be life threatening to the customer; and

*Proof of age must be supported by certificate of birth, driver's license, passport or other reliable document. Proof of handicap must be by certification from a licensed physician, surgeon, public health nurse or social worker.

(2) The customer is temporarily unable to pay for such service in accordance with the provisions of the utility's tariffs; and

(3) The customer is willing to arrange installment payments satisfactory to the utility, over a period not to exceed 12 months, including arrangements for prompt payment of subsequent bills.

However, service may be discontinued to any customer who does not comply with an installment payment agreement or keep current his account for water service as charges accrue in each subsequent billing period.

(f) A customer's residential service may be discontinued for nonpayment of a bill for residential service previously rendered him at any location served by the utility.

A nonresidential service may be discontinued for nonpayment of a bill for residential as well as nonresidential service previously rendered him at any location served by the utility.

The discontinuance of service notice as set forth in subdivision (b) will be given in both cases stated above before discontinuance of service takes place.

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

f. (Continued)

Residential services will not, however, be discontinued for nonpayment of bills for separate nonresidential service.

g. Service will not be discontinued by reason of delinquency in payment for service on any Saturday, Sunday, legal holiday, or at any time during which the business offices of the utility are not open to the public.

h. Where water service is provided to residential users in a multi-unit residential structure, mobilehome park, or permanent residential structures in a labor camp, where the owner, manager, or operator is listed by the utility as the customer of record, the utility will make every good faith effort to inform the users, when the account is in arrears, that service will be dicontinued. Notice will be in as prescribed in subdivision (a) above, and in Rules Nos. 5 and 8. (T)

(T)

(1) Where said users are individually metered. (N)

The utility is not required to make service available to these users unless each user agrees to the terms and conditions of service and meets the requirement of the law and the utility's rules and tariffs. However, if one or more users are willing and able to assume responsibility for subsequent charges by these users to the account to the satisfaction of the utility, and if there is a practical physical means, legally available to the utility of selectively providing services to these users who have met the requirements of the utility's rules and tariffs, the utility will make service available to these users. For these selected users establishment of credit will be as prescribed in Rule No. 6, except that where prior service for a period of time is a condition for establishing credit with the utility, proof that is acceptable to the utility of residence and prompt payment of rent or other credit obligation during that period of time is a satisfactory equivalent.

(N)

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

h. (Continued)

(2) Where said users are master metered. (N)

The utility is not required to make service available to these users unless each user agrees to the terms and conditions of service, and meets the requirements of the law and the utility's rules and tariffs and the following:

The same Rule 11, item B.1.h. (1) above which applies to individually metered users also applies to master metered users, except a representative may act on the behalf of a master metered user, and the utility will not discontinue service in any of the following situations:

(a) During the pendency of an investigation by the utility of a master-meter customer dispute or complaint.

(b) When the master-metered customer has been granted an extension of the period for repayment of a bill.

(c) For an indebtedness owned by the master metered customer to any other person or corporation or when the obligation represented by the delinquent account or any other indebtedness was incurred with a person or corporation other than the utility demanding payment therefor.

(d) When a delinquent account relates to another property owned, managed, or operated by the master-metered customer.

(e) When a public health or building officer certifies that determination would result in a significant threat to the health or safety of the residential occupants or the public. Proof of age or handicap are described in Rule 11.B.1.e. (N)

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

i. A reasonable attempt must be made by the utility to personally contact an adult person on the residential customer's premises either by telephone, or in person, at hours prior to discontinuance. For elderly or (C)
handicapped residential customers, the utility shall provide at least 48 hours' notice by telephone or in person. For these customers, if telephone or personal contact cannot be made, a notice of discontinuance of service shall be posted in a conspicuous location at the service address at least 48 hours prior to discontinuance. Such notice shall be (N)
independent of and in addition to, other notices(s) as may be prescribed (N)
in the utility's tariffs. (N)

j. Residential Customer's Remedies Upon Receipt of Discontinuance Notice.

(1) If upon receipt of a 10 day discontinuance notice, a residential customer is unable to pay, he must contact the utility before discontinuance of service to make payment arrangements to avoid discontinuance of service.

(2) If, after contacting the utility, the residential customer alleges to the Commission an inability to pay and that he is unable to make payment arrangements with the utility he should write to the Commission's Consumer Affairs Branch (CAB) to make an informal complaint. This action must be taken within the 10-day discontinuance of service notice.

(3) The CAB's resolution of the matter will be reported to the utility and the residential customer within ten business days after receipt of the informal complaint. If the customer is not satisfied with such resolution, he must file, within ten business days after the date of the CAB's letter, a formal complaint with the Commission under Public Utilities Code Section 1702 on a form provided by the CAB.

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Discontinuance of Services by Utility (Continued)

1. For Nonpayment of Bills (Continued)

j. Residential Customer's Remedies Upon Receipt of Discontinuance Notice.

(4) Failure of the residential as well as the nonresidential customer to observe these time limits shall entitle the utility to insist upon payment or, upon failure to pay, to discontinue the customer's service.

k. Designation of a Third-Party Representative (Elderly or Handicapped only)

(1) Customer must inform utility if he desires that a third party receive discontinuance or other notices on his behalf.

(2) Utility must be advised of name, address and telephone number of third party with a letter from third party accepting this responsibility.

(3) Only customers who certify that they are elderly or handicapped are entitled to third-party representation.*

2. For Noncompliance with Rules

The utility may discontinue service to any customer for violation of these rules after it has given the customer at least five days' written notice of such intention. Where safety of water supply is endangered, service may be discontinued immediately without notice.

3. For Waste of Water

a. Where negligent or wasteful use of water exists on customer's premises, the utility may discontinue the service if such practices are not remedied within five days after it has given the customer written notice to such effect.

(Continued)

* Proof of age must be supported by certificate of birth, driver's license, passport or other reliable document. Proof of handicap must be by certification from a licensed physician, public health nurse or social worker.

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

B. Continuance of Services by Utility (Continued)

3. For Waste of Water (Continued)

b. In order to protect itself against serious and unnecessary waste or misuse of water, the utility may meter any flat rate service and apply the regularly established meter rates where the customer continues to misuse or waste water beyond five days after the utility has given the customer written notice to remedy such practices.

4. For Unsafe Apparatus or Where Service is Detrimental or Damaging to the Utility or its Customers

If an unsafe or hazardous condition is found to exist on the customer's premise, or if the use of water thereon by apparatus, appliances, equipment or otherwise is found to be detrimental or damaging to the utility or its customers, the service may be shutoff without notice. The utility will notify the customer immediately of the reasons for the discontinuance and the corrective action to be taken by the customer before service can be restored.

5. For Fraudulent Use of Service

When the utility has discovered that a customer has obtained service by fraudulent means, or has diverted the water service for unauthorized use, the service to that customer may be discontinued without notice. The utility will not restore service to such customer until that customer has complied with all filed rules and reasonable requirements of the utility and the utility has been reimbursed for the full amount of the service rendered and the actual cost to the utility incurred by reason of the fraudulent use.

C. Restoration of Service

1. Reconnection Charge

Where service has been discontinued for violation of these rules or for nonpayment of bills, the utility may charge $25.00 for reconnection of service during regular working hours or $37.50 (I)
for reconnection of service at other than regular working hours when the customer has requested that the reconnection be made at other than regular working hours.

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

C. Restoration of Service (Continued)

2. To be Made During Regular Working Hours

The utility will endeavor to make reconnections during regular working hours on the day of the request, if the conditions permit; otherwise reconnections will be made on the regular working day following the day the request is made.

3. To Be Made at Other Than Regular Working Hours

When a customer has requested that the reconnection be made at other than regular working hours, the utility will reasonably endeavor to so make the reconnection if practicable under the circumstances.

4. Wrongful Discontinuance

A service wrongfully discontinued by the utility, must be restored without charge for the restoration to the customer within 24 hours.

D. Refusal to Serve

1 Conditions for Refusal

The utility may refuse to serve an applicant for service under the following conditions:

a. If the applicant fails to comply with any of the rules as filed with the Public Utilities Commission.

b. If the intended use of the service is of such a nature that it will be detrimental or injurious to existing customers.

c. If, in the judgment of the utility, the applicant's installation for utilizing the service is unsafe or hazardous, or of such nature that satisfactory service cannot be rendered.

(Continued)

Rule No. 11

DISCONTINUANCE AND RESTORATION OF SERVICE
(Continued)

C. Restoration of Service (Continued)

1. Conditions for Refusal (Continued)

d. Where service has been discontinued for fraudulent use, the utility will not serve an applicant until it has determined that all conditions of fraudulent use or practice has been corrected.

2. Notification to Customers

When an applicant is refused service under the provisions of this rule, the utility will notify the applicant promptly of the reason for the refusal to service and of the right of applicant to appeal the utility's decision to the Public Utilities Commission.

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

GENERAL INFORMATION

(N)

1. If water supplies are projected to be insufficient to meet normal customer demand, and are beyond the control of the utility, the utility may elect to implement voluntary conservation using the portion of this plan set forth in Section A of this Rule, after notifying the Director of the Commission's Division of Water and Audits of its intent, via a letter in both hard-copy and e-mailed formats.

2. Prior to declaration of mandatory rationing, a utility may request authorization of a Schedule 14.1 – Staged Mandatory Water Conservation and Rationing tariff, via a Tier 2 advice letter.

3. If, in the opinion of the utility, more stringent water measures are required, the utility shall request Commission authorization to implement the staged mandatory conservation and rationing measures set forth in Sections B through E.

4. The utility shall file a Tier 1 advice letter to request activation of a particular stage of Schedule 14.1 – Staged Mandatory Water Conservation and Rationing tariff.

a. If a Declaration of Mandatory Rationing is made by utility or governing agency, or

b. If the utility is unable to address voluntary conservation levels set by itself, supplier, or governing agency, or

c. If the utility chooses to subsequently activate a different stage

5. When Schedule 14.1 is in effect and the utility determines that water supplies are again sufficient to meet normal demands, and mandatory conservation and rationing measures are no longer necessary, the utility shall seek Commission approval via a Tier 1 advice letter to de-activate the particular stage of mandatory rationing that had been authorized.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

GENERAL INFORMATION (Continued) (N)

6. In the event of a water supply shortage requiring a voluntary or mandatory program, the utility shall make available to its customers water conservation kits as required by its version of Rule 20. The utility shall notify all customers of the availability of conservation kits via a bill insert or direct mailers.

A. CONSERVATION - NON-ESSENTIAL OR UNAUTHORIZED WATER USE

No customer shall use utility-supplied water for non-essential or unauthorized uses, including but not limited to:

1. Use of potable water for more than minimal landscaping, as defined in the landscaping regulated of the jurisdiction or as described in Article 10.8 of the California Government Code in connection with new construction;
2. Use through any meter when the company has notified the customer in writing to repair a broken or defective plumbing, sprinkler, watering or irrigation system and the customer has failed to effect such repairs within five business days;
3. Use of potable water which results in flooding or runoff in gutters or streets;
4. Individual private washing of cars with a hose except with the use of a positive action shut-off nozzle. Use of potable water for washing commercial aircraft, cars, buses, boats, trailers, or other commercial vehicles at any time, except at commercial or fleet vehicle or boat washing facilities operated at a fixed location where equipment using water is properly maintained to avoid wasteful use;
5. Use of potable water washing buildings, structures, , driveways, patios, parking lots, tennis courts, or other hard-surfaced areas, except in the cases where health and safety are at risk;
6. Use of potable water to irrigate turf, lawns, gardens, or ornamental landscaping by means other than drip irrigation, or hand watering without quick acting positive action shut-off nozzles, on a specific schedule, for example: 1) before 8:00 a.m. and after 7:00 p.m.; 2) every other day; or 3) selected days of the week; (N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

GENERAL INFORMATION (Continued)

(N)

7. Use of potable water for watering streets with trucks, except for initial wash-down for construction purposes (if street sweeping is not feasible), or to protect the health and safety of the public;
8. Use of potable water for construction purposes, such as consolidation of backfill, dust control, or other uses unless no other source of water or other method can be used.
9. Use of potable water for construction purposes unless no other source of water or other method can be used;
10. Use of potable water for street cleaning;
11. Operation of commercial car washes without recycling at least 50% of the potable water used per cycle;
12. Use of potable water for watering outside plants, lawn, landscape and turf areas during certain hours if and when specified in Schedule No. 14.1 when the schedule is in effect;
13. Use of potable water for decorative fountains or the filling or topping off of decorative lakes or ponds. Exceptions are made for those decorative fountains, lakes, or ponds which utilize recycled water;
14. Use of potable water for the filling or refilling of swimming pools.
15. Service of water by any restaurant except upon the request of a patron; and
16. Use of potable water to flush hydrants, except where required for public health or safety.

B. STAGED MANDATORY RATIONING OF WATER USAGE

1. Prior to declaration of mandatory rationing, a utility may request authorization of a Schedule 14.1 – Staged Mandatory Water Conservation and Rationing tariff, via a Tier 2 advice letter, with full justification. The utility may not institute Schedule 14.1 until it has been authorized to do so by the Commission.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

(N)

STAGED MANDATORY RATIONING OF WATER USAGE (Continued)

a. A staged Schedule 14.1 that has been authorized by the Commission shall remain dormant until triggered by specific conditions detailed in the Schedule 14.1 tariff and utility has requested and received authorization for activating a stage by Commission.

b. Notice of the Tier 2 advice letter (example shown in Appendix C) and associated public participation hearing shall be provided to customers under General Order (GO) 96-B rules.

c. Utility shall comply with all requirements of Sections 350-358 of the California Water Code.

d. The Tier 2 advice letter requesting institution of a Schedule 14.1 shall include but not be limited to:

   i. Proposed Schedule 14.1 tariff, which shall include but not be limited to:

      1. Applicability,
      2. Territory applicable to,
      3. A detailed description of each Stage of Rationing,
      4. A detailed description of the Trigger that Activates each Stage of Rationing,
      5. A detailed description of each water use restriction for each stage of rationing.
      6. Water use violation levels, written warning levels, associated fines, and exception procedures,

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

STAGED MANDATORY RATIONING OF WATER USAGE (Continued) Page 5

7. Conditions for installation of a flow restrictor, (N)

8. Charges for removal of flow restrictors, and

9. Special Conditions

ii. Justification for, and documentation and calculations in support of plan, including but not limited to each item in B.1.d.i above.

2. Number of Stages requested by each utility/district may vary, depending on specifics of water shortage event.

3. The utility shall file a Tier 1 advice letter to request activation of a particular stage of Schedule 14.1 – Staged Mandatory Water Conservation and Rationing tariff.

   a. If a Declaration of Mandatory Rationing is made by utility or governing agency,

   b. If the utility is unable to address voluntary conservation levels set by itself or governing agency, or

   c. If the utility chooses to subsequently activate a different stage.

   d. The Tier 1 advice letter requesting activation of a Schedule 14.1 shall include but not be limited to:

      i. Justification for activating this particular stage of mandatory rationing, as well as period during which this particular stage of mandatory conservation and rationing measures will be in effect.

      ii. When the utility requests activation of a particular Stage, it shall notify its customers as detailed in Section E, below.

4. All monies collected by the utility through water use violation fines shall not be accounted for as income.

5. All expenses incurred by utility to implement Rule 14.1 and Schedule 14.1 that have not been considered in a General Rate Case or other proceeding, shall be recoverable by utility if determined to be reasonable by Commission.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

(N)

a. These monies shall be accumulated by the utility in a separate memorandum account for disposition as directed or authorized from time to time by the Commission.

C. ENFORCEMENT OF STAGED MANDATORY CONSERVATION AND RATIONING

1. The water use restrictions of the conservation program, in Section A of this rule, become mandatory when the authorized Schedule 14.1-Staged Mandatory Rationing Program is triggered, the utility files a Tier 1 advice letter requesting activation of a particular stage, and authorization is received from the Commission.
   a. In the event a customer is observed to be using water for any nonessential or unauthorized use as defined in Section A of this rule, the utility may charge a water use violation fine in accordance with Schedule No. 14.1.

2. The utility may, after one written warning and one non-essential or unauthorized use violation notice , install a flow-restricting device on the service line of any customer observed by utility personnel to be using water for any non-essential or unauthorized use as defined in Section A above.

3. A flow restrictor shall not restrict water delivery by greater than 50% of normal flow. The restricting device may be removed only by the utility, only after a three-day period has elapsed, and only upon payment of the appropriate removal charge as set forth in Schedule No. 14.1.

4. After the removal of the restricting device, if any non-essential or unauthorized use of water shall continue, the utility may install another flow-restricting device. This device shall remain in place until water supply conditions warrant its removal and until the appropriate charge for removal has been paid to the utility.

5. Any tampering with flow restricting device by customer can result in fines or discontinuation of water use at the utility's discretion.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

ENFORCEMENT OF STAGED MANDATORY CONSERVATION AND RATIONING (Continued)

(N)

6. If, despite installation of such flow-restricting device pursuant to the provisions of the previous enforcement conditions, any such non-essential or unauthorized use of water shall continue, then the utility may discontinue water service to such customer. In such latter event, a charge as provided in Rule No. 11 shall be paid to the utility as a condition to restoration of service.

7. All monies collected by the utility through water use violation fines shall not be accounted for as income. All expenses incurred by utility to implement Rule 14.1 and Schedule 14.1 that have not been considered in a General Rate Case or other proceeding, shall be recoverable by utility if determined to be reasonable by Commission. These additional monies shall be accumulated by the utility in a separate memorandum account for disposition as directed or authorized from time to time by the Commission.

8. The charge for removal of a flow-restricting device shall be in accordance with Schedule No. 14.1.

D. APPEAL PROCEDURE

1. Any customer who seeks a variance from any of the provisions of this water conservation and rationing plan shall notify the utility in writing, explaining in detail the reason for such a variation. The utility shall respond to each such request in writing.

2. Any customer not satisfied with the utility's response may file an appeal with the staff of the Commission. The customer and the utility will be notified of the disposition of such appeal by letter from the Executive Director of the Commission.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

APPEAL PROCEDURE (Continued)

(N)

3. If the customer disagrees with such disposition, the customer shall have the right to file a formal complaint with the Commission. Except as set forth in this Section, no person shall have any right or claim in law or in equity, against the utility because of, or as a result of, any matter or thing done or threatened to be done pursuant to the provisions of this water conservation and rationing plan.

E. PUBLICITY

1. As stated under Section B.1.b and c, when a utility requests authorization of a Schedule 14.1 – Staged Mandatory Water Conservation and Rationing tariff, via a Tier 2 advice letter, it shall provide notice of the Tier 2 advice letter (example shown in Attachment C) and associated public meeting provided to customers, under General Order (GO) 96-B rules, and shall comply with all requirements of Sections 350-358 of the California Water Code (CWC), including but not limited to the following:
   a. In order to be in compliance with both the GO and CWC, the utility shall provide notice via both newspaper and bill insert/direct mailing.
   b. Utility shall file one notice for each advice letter filed, that includes both notice of the filing of the Tier 2 advice letter as well as the details of the public meeting (date, time, place, etc).
   c. The public meeting shall be held after the utility files the Tier 2 advice letter, and before the Commission authorizes implementation of the tariff.
   d. Utility shall consult with Division of Water and Audits staff prior to filing advice letter, in order to determine details of public meeting.
2. In the event that a Schedule 14.1-Staged Mandatory Rationing Plan is triggered, and an utility requests activation through the filing of a Tier 1 advice letter, the utility shall notify its customers and provide each customer with a copy of Schedule 14.1 by means of bill insert or direct mailing. Notification shall take place prior to imposing any fines associated with this plan.

(N)

(Continued)

RULE 14.1
WATER CONSERVATION AND RATIONING PLAN

PUBLICITY (Continued)

(N)

3. During the period that a stage of Schedule 14.1 is activated, the utility shall provide customers with updates in at least every other bill, regarding its water supply status and the results of customers' conservation efforts.

(N)

Rule No. 20

WATER CONSERVATION (N)

A. Purpose

The purpose of this rule is to ensure that water resources available to the utility are put to a reasonable beneficial use and that the benefits of the utility's water water supply and service extend to the largest number of persons.

B. Waste of Water Discouraged

Refer to Rule 11 B. (3).

C. Use of Water-Saving Devices and Practices

Each customer of the utility is urged to install devices to reduce the quantity of water to flush toilets and to reduce the flow rate of showers.
Each customer is further urged to adopt such other water usage and reusage practices and procedures as are feasible and reasonable.

D. Water-Saving Kits

The utility will make available, without initial cost to the customer, for use in each residence receiving water service from the utility, a water-saving kit containing the following:

(1) A device or devices for reducing toilet flush water requirements;

(2) A device or devices for reducing shower flow rates;

(3) A dye tablet or tablets for determining if a toilet tank leaks;

(4) Other devices from time to time approved by the utility;

(5) Installation and other instructions and information pertinent to conservation of water. (N)

Appendix E

DMM Supporting Documents

Schedule No. R3-1-R
Region 3 Customer Service Areas
RESIDENTIAL METERED SERVICE

APPLICABILITY

Applicable to all residential metered water services provided to single-family residential customers.

TERRITORY

Barstow and vicinity, San Bernardino County, the City of Claremont, portions of Montclair, Pomona, Upland, within the area north of Thompson Creek and the Padua Hills Service Area, and adjacent unincorporated territory in Los Angeles and San Bernardino Counties, the City of Calipatria and community of Niland, and the adjacent territory in Imperial County, the vicinity of Victorville and Lucerne, San Bernardino County, all or portions of the Cities of Cypress, La Palma, Los Alamitos, Placentia, Seal Beach, Stanton, Yorba-Linda and vicinity, Cowan Heights, Orange County; San Dimas, Charter Oak and vicinity, Los Angeles County; and portions of the Cities of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, Temple City and vicinity, Los Angeles County.

RATES

Quantity Rate:

First 1,300 cu. Ft., per 100 cu. ft.	$ 2.673
Next 800 cu. Ft., per 100 cu. ft.	$ 3.074
Over 2,100 cu. Ft., per 100 cu. ft.	$ 3.535

Service Charges:	Per Meter Per Month
For 5/8 x 3/4-inch meter	$ 15.15
For 3/4-inch meter	22.70
For 1-inch meter	37.80
For 1 1/2 inch meter	75.65
For 2-inch meter	121.00
For 3-inch meter	227.00
For 4-inch meter	378.00
For 6-inch meter	756.00
For 8-inch meter	1,210.00
For 10-inch meter	1,739.00
Sprinkler System Services	$16.65

The Service Charge is a readiness-to-serve charge applicable to all metered service and to which is added the charge for water used computed at the Quantity Rate.

SPECIAL CONDITIONS

1. All bills are subject to the reimbursement fee set forth on Schedule No. UF.
2. Residential customers are defined as all single family customers with one dwelling unit that are individually metered.
3. As authorized by the California Public Utilities Commission, an amount of $0.156 per Ccf for Tier 1, $0.180 per Ccf for Tier 2 and $0.207 per Ccf for Tier 3 is to be added to the Quantity Rate for a period of 24 months, beginning on the effective date of Advice Letter 1381-W, which is March 21, 2010. This surcharge will apply to all customers covered by the WRAM in 2009 which includes metered customers in Barstow, Claremont, San Gabriel, Los Alamitos, Placentia, San Dimas and Calipatria customers who were billed at the metered rate as of December 31, 2009
4. As authorized by the California Public Utilities Commission, an amount of $0.0735 per Ccf for Tier 1, $0.0845 per Ccf for Tier 2 and $0.0972 per Ccf for Tier 3 is to be added to the Quantity Rate for a period of 12 months, beginning on the effective date of Advice Letter 1401-W, which is June 7, 2010. This surcharge will recover the undercollection in the CARW Balancing Account, as of December 31, 2009.
5. Pursuant to Decision 10-11-035, a surcharge of $0.0035 per Ccf will be applied to all metered customers bills excluding customers that are receiving the CARW credit, beginning on the effective date of Advice Letter 1417-W. This surcharge will offset the CARW credits and CARW administrative program costs recorded in the CARW Balancing Account.
6. As authorized by the California Public Utilities Commission in D. 10-11-035, an amount of $0.20214 per Ccf is to be added to the Quantity Rate for a period of 24 months, beginning on January 1, 2011. This surcharge recovers the difference between the interim rates and final rates for the period of January 1, 2010 through December 1, 2010.
7. As authorized by the California Public Utilities Commission, an amount of $0.0053 per Ccf for Tier 1 and $0.0061 per Ccf (N)
for Tier 2 is to be added to the Quantity Rate for a period of 12 months, beginning on the effective date of Advice Letter (N)
1408-WA. This surcharge will recover the undercollection in the Orange County Annexation Memorandum Account, as of March (N)
31, 2010. (N)

Schedule No. R3-1-NR
Region 3 Customer Service Areas
NON-RESIDENTIAL METERED SERVICE

APPLICABILITY
Applicable to all metered water service except those covered under R3-1-R.

TERRITORY
Barstow and vicinity, San Bernardino County, the City of Claremont, portions of Montclair, Pomona, Upland, within the area north of Thompson Creek and the Padua Hills Service Area, and adjacent unincorporated territory in Los Angeles and San Bernardino Counties, the City of Calipatria and community of Niland, and the adjacent territory in Imperial County, the vicinity of Victorville and Lucerne, San Bernardino County, all or portions of the Cities of Cypress, La Palma, Los Alamitos, Placentia, Seal Beach, Stanton, Yorba-Linda and vicinity, Cowan Heights, Orange County; San Dimas, Charter Oak and vicinity, Los Angeles County; and portions of the Cities of Arcadia, El Monte, Irwindale, Monrovia, Monterey Park, Rosemead, San Gabriel, Temple City and vicinity, Los Angeles County.

RATES

Quantity Rate:

For all water delivered, per 100 cu. ft.. $ 2.489

Service Charges:	Per Meter Per Month
For 5/8 x 3/4-inch meter	$ 21.45
For 3/4-inch meter	32.15
For 1-inch meter	53.55
For 1 1/2 inch meter	107.00
For 2-inch meter	171.00
For 3-inch meter	321.00
For 4-inch meter	536.00
For 6-inch meter	1,071.00
For 8-inch meter	1,714.00
For 10-inch meter	2,464.00

The Service Charge is a readiness-to-serve charge applicable to all metered service and to which is added the charge for water used computed at the Quantity Rate.

SPECIAL CONDITIONS

1. All bills are subject to the reimbursement fee set forth on Schedule No. UF.
2. As authorized by the California Public Utilities Commission, an amount of $0.154 per Ccf is to be added to the Quantity Rate for a period of 24 months, beginning on the effective date of Advice Letter 1381-W, which is March 21, 2010. This surcharge will apply to all customers covered by the WRAM in 2009 which includes metered customers in Barstow, Claremont, San Gabriel, Los Alamitos, Placentia, San Dimas and Calipatria customers who were billed at the metered rate as of December 31, 2009.
3. As authorized by the California Public Utilities Commission, an amount of $0.06879 per Ccf is to be added to the Quantity Rate for a period of 12 months, beginning on the effective date of Advice Letter 1401-W, which is June 7, 2010. This surcharge will recover the undercollection in the CARW Balancing Account, as of December 31, 2009.
4. Pursuant to Decision 10-11-035, a surcharge of $0.0035 per Ccf will be applied to all metered customers bills excluding customers that are receiving the CARW credit, beginning on the effective date of Advice Letter 1417-W. This surcharge will offset the CARW credits and CARW administrative program costs recorded in the CARW Balancing Account.
5. As authorized by the California Public Utilities Commission in D. 10-11-035, an amount of $0.20214 per Ccf is to be added to the Quantity Rate for a period of 24 months, beginning on January 1, 2011. This surcharge recovers the difference between the interim rates and final rates for the period of January 1, 2010 through December 1, 2010.
6. As authorized by the California Public Utilities Commission, an amount of $0.0047 per Ccf is to be added to the Quantity Rate (N)
for a period of 12 months, beginning on the effective date of Advice Letter 1408-WA. This surcharge will recover the (N)
undercollection in the Orange County Annexation Memorandum Account, as of March 31, 2010. (N)

AWWA WLCC Water Audit Software: Reporting Worksheet

WASv3.0

Back to Instructions

? Click to access definition

Water Audit Report for: Golden State Water Company - South San Gabriel
Reporting Year: 2008

Please enter data in the white cells below. Where possible, metered values should be used; if metered values are unavailable please estimate a value. Indicate this by selecting a choice from the gray box to the left, where M = measured (or accurately known value) and E = estimated.

All volumes to be entered as: ACRE-FEET PER YEAR

WATER SUPPLIED

Volume from own sources:	M	2,866.000	acre-ft/yr
Master meter error adjustment:		0.000	under-registered acre-ft/yr
Water imported:	M	295.000	acre-ft/yr
Water exported:		0.000	acre-ft/yr
WATER SUPPLIED:		3,161.000	acre-ft/yr

AUTHORIZED CONSUMPTION

Click here: ? for help using option buttons below

				Pcnt:	Value:
Billed metered:	M	2,982.000	acre-ft/yr		
Billed unmetered:		0.000	acre-ft/yr		
Unbilled metered:	M	76.600	acre-ft/yr		
Unbilled unmetered:		39.513	acre-ft/yr	1.25%	
AUTHORIZED CONSUMPTION:		3,098.113	acre-ft/yr		

Use buttons to select percentage OR value

WATER LOSSES (Water Supplied - Authorized Consumption) 62.888 acre-ft/yr

Apparent Losses

				Pcnt:	Value:
Unauthorized consumption:		7.903	acre-ft/yr	0.25%	
Customer metering inaccuracies:		62.420	acre-ft/yr	2.00%	
Systematic data handling errors:		0.000	acre-ft/yr		
Apparent Losses:		70.323	acre-ft/yr		

Check above input values; APPARENT LOSSES should be less than WATER LOSSES

Real Losses

Real Losses = (Water Losses - Apparent Losses):	-7.435	acre-ft/yr
WATER LOSSES:	62.888	acre-ft/yr

NON-REVENUE WATER

NON-REVENUE WATER: 179.000 acre-ft/yr

SYSTEM DATA

Length of mains:	M	35.0	miles
Number of active AND inactive service connections:	M	5,054	
Connection density:		144	conn./mile main
Average length of customer service line:	E	30.0	ft (pipe length between curbstop and customer meter or property boundary)
Average operating pressure:	M	62.8	psi

COST DATA

Total annual cost of operating water system:	$1,988,855	$/Year
Customer retail unit cost (applied to Apparent Losses):	$25.44	$/100 cubic feet (ccf)
Variable production cost (applied to Real Losses):	$549.00	$/acre-ft/yr

DATA REVIEW - Please review the following information and make changes above if necessary:

- Input values should be indicated as either measured or estimated. You have entered:
  - **7 as measured values**
  - **1 as estimated values**
  - **2 as default values**
  - **7 without specifying measured, estimated or default**
- Water Supplied Data: No problems identified
- Unbilled unmetered consumption: No problems identified
- Unauthorized consumption: No problems identified
- It is important to accurately measure the master meter - you have entered the measurement type as: measured
- Cost Data: No problems identified

PERFORMANCE INDICATORS

Financial Indicators

Non-revenue water as percent by volume:	5.7%	
Non-revenue water as percent by cost:	42.2%	
Annual cost of Apparent Losses:	$779,295	
Annual cost of Real Losses:	-$4,082	

Operational Efficiency Indicators

Apparent Losses per service connection per day:	12.42	gallons/connection/day
Real Losses per service connection per day*:	-1.31	gallons/connection/day
Real Losses per length of main per day*:	N/A	
Real Losses per service connection per day per psi pressure:	-0.02	gallons/connection/day/psi
Unavoidable Annual Real Losses (UARL):	26.65	million gallons/year
Infrastructure Leakage Index (ILI) [Real Losses/UARL]:	-0.09	

* only the most applicable of these two indicators will be calculated

Appendix F

Groundwater Basin Water Rights Stipulation/Judgment

SUPERIOR COURT OF THE STATE OF CALIFORNIA

FOR THE COUNTY OF LOS ANGELES

UPPER SAN GABRIEL VALLEY
MUNICIPAL WATER DISTRICT

Plaintiff,

vs.

CITY OF ALHAMBRA, et al,

Defendants.

No. 924128

AMENDED JUDGMENT
(and Exhibits Thereto),

Honorable Florence T. Pickard
Assigned Judge Presiding

Original Judgment
Signed and Filed: December 29, 1972;
Entered: January 4, 1973
Book 6741, Page 197

JUDGMENT AS AMENDED AUGUST 24, 1989

Ralph B. Helm
Suite 214
4605 Lankershim Boulevard
North Hollywood, CA 91602
Telephone (818) 769-2002

Attorney for Watermaster

SUPERIOR COURT OF CALIFORNIA, COUNTY OF LOS ANGELES

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT, Plaintiff, vs. CITY OF ALHAMBRA, et al., Defendants.	No. 924128 AMENDED JUDGMENT (And Exhibits Thereto)

HONORABLE FLORENCE T. PICKARD

Assigned Judge Presiding

DEPARTMENT 38

August 24, 1989

AMENDED JUDGMENT
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And
Amended Judgment Sections
Identified With Prior Judgment
Section Numbers

EXHIBITS

Exhibits Continued

Ralph B. Helm
Suite 214
4605 Lankershim Boulevard
North Hollywood, CA 91602
Telephone (818) 769-2002

Attorney for Watermaster

SUPERIOR COURT OF CALIFORNIA, COUNTY OF LOS ANGELES

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT,	)	No. 924128
Plaintiff,	)	AMENDED JUDGMENT
vs.	)	
CITY OF ALHAMBRA, et al.,	)	
Defendants.	)	Hearing: August 24, 1989 Department 38, 9:00 A.M.

The Petition of the MAIN SAN GABRIEL BASIN WATERMASTER for this AMENDED JUDGMENT herein, came on regularly for hearing in this Court before the HONORABLE FLORENCE T. PICKARD, ASSIGNED JUDGE PRESIDING, on August 24, 1989; Ralph B. Helm appeared as attorney for Watermaster - Petitioner; and good cause appearing, the following ORDER and AMENDED JUDGMENT are, hereby, made:

I. INTRODUCTION

1. Pleadings, Parties, and Jurisdiction. The complaint herein was filed on January 2, 1968, seeking an adjudication of water rights. By amendment of said complaint and dismissals of certain parties, said adjudication was limited to the Main San Gabriel Basin and its Relevant Watershed. Substantially all

defendants and the cross-defendant have appeared herein, certain defaults have been entered, and other defendants dismissed. By the pleadings herein and by Order of this Court, the issues have been made those of a full <u>inter se</u> adjudication of water rights as between each and all of the parties. This Court has jurisdiction of the subject matter of this action and of the parties herein.

2. <u>Stipulation for Entry of Judgment.</u> A substantial majority of the parties, by number and by quantity of rights herein Adjudicated, Stipulated for entry of a Judgment in substantially the form of the original Judgment herein.

3. <u>Lis Pendens.</u> (New) A <u>Lis Pendens</u> was recorded August 20, 1970, as Document 2650, in Official Records of Los Angeles County, California, in Book M 3554, Page 866.

4. <u>Findings and Conclusions.</u> (Prior Judgment Section 3) Trial was had before the Court, sitting without a jury, John Shea, Judge Presiding, commencing on October 30, 1972, and Findings of Fact and Conclusions of Law have been entered herein.

5. <u>Judgment.</u> (New) Judgment (and Exhibits Thereto), Findings of Fact and Conclusions of Law (and Exhibits thereto), Order Appointing Watermaster, and Initial Watermaster Order were signed and filed December 29, 1972, and Judgment was entered January 4, 1973, in Book 6791, Page 197.

6. <u>Intervention After Judgment.</u> (New) Certain defendants have, pursuant to the Judgment herein and the Court's continuing jurisdiction, intervened and appeared herein after entry of Judgment.

7. Amendments to Judgment. (New) The original Judgment herein was previously amended on March 29, 1979, by: (1) adding definition (r [1]) thereto, (2) amending definition (bb) therein, (3) adding Exhibit "K" thereto, (4) adding Sections 14.5 and 16.5 thereto, and (5) amending Sections 37(b), 37(c), 37(d), and Section 47 therein; it was again amended on December 21, 1979, by amending Section 38(c) thereof; again amended on February 21, 1980, by amending Section 24 thereof; again amended on September 12, 1980, by amending Sections 35(a), 37(a), and 38(a); again amended on December 22, 1987, by adding Section 37(e) thereto; and last amended on July 22, 1988 by amending Section 37(e) thereof and Ordering an Amended Judgment herein.

8. Transfers. (New) Since the entry of Judgment herein there have been numerous transfers of Adjudicated water rights. To the date hereof, said transfers are reflected in Exhibits "C", "D", and "E".

9. Producers and Their Designees. (New) The current status of Producers and their Designees is shown on Exhibit "L".

10. Definitions. (Prior Judgment Section 4) As used in this Judgment, the following terms shall have the meanings herein set forth:

(a) Base Annual Diversion Right -- The average annual quantity of water which a Diverter is herein found to have the right to Divert for Direct Use.

(b) Direct Use --Beneficial use of water other than for spreading or Ground Water recharge.

(c) Divert or Diverting -- To take waters of any surface stream within the Relevant Watershed.

(d) Diverter -- Any party who Diverts.

(e) Elevation -- Feet above mean sea level.

(f) Fiscal Year -- A period July 1 through June 30, following.

(g) Ground Water -- Water beneath the surface of the ground and within the zone of saturation.

(h) Ground Water Basin -- An interconnected permeable geologic formation capable of storing a substantial Ground Water supply.

(i) Integrated Producer -- Any party that is both a Pumper and a Diverter, and has elected to have its rights adjudicated under the optional formula provided in Section 18 of this Judgment.

(j) In-Lieu Water Cost -- The differential between a Producer's non-capital cost of direct delivery of Supplemental Water and the cost of Production of Ground Water (including depreciation on Production facilities) to a particular Producer who has been required by Watermaster to take direct delivery of Supplemental Water in lieu of Ground Water.

(k) Key Well -- Baldwin Park Key Well, being elsewhere designated as State Well No. 1S/10W-7R2, or Los Angeles County Flood Control District Well No. 3030-F. Said well has a ground surface Elevation of 386.7.

(l) Long Beach Case -- Los Angeles Superior Court Civil Action No. 722647, entitled, "Long Beach, et al., v. San Gabriel Valley Water Company, et al."

(m) Main San Gabriel Basin or Basin -- The Ground Water Basin underlying the area shown as such on Exhibit "A".

(n) Make-up Obligation -- The total cost of meeting the obligation of the Basin to the area at or below Whittier Narrows, pursuant to the Judgment in the Long Beach Case.

(o) Minimal Producer -- Any party whose Production in any Fiscal Year does not exceed five (5) acre feet.

(p) Natural Safe Yield -- The quantity of natural water supply which can be extracted annually from the Basin under conditions of long term average annual supply, net of the requirement to meet downstream rights as determined in the Long Beach Case (exclusive of Pumped export), and under cultural conditions as of a particular year.

(q) Operating Safe Yield -- The quantity of water which the Watermaster determines hereunder may be Pumped from the Basin in a particular Fiscal Year, free of the Replacement Water Assessment under the Physical Solution herein.

(r) Overdraft -- A condition wherein the total annual Production from the Basin exceeds the Natural Safe Yield thereof.

(s) Overlying Rights -- (Prior Judgment Section 4 (r) [1]) The right to Produce water from the Basin for use on Overlying Lands, which rights are exercisable only on specifically defined Overlying Lands and which cannot be separately conveyed or transferred apart therefrom.

(t) Physical Solution -- (Prior Judgment Section 4 (s)) The Court decreed method of managing the waters of the Basin so as to achieve the maximum utilization of the Basin and its water supply, consistent with the rights herein declared.

(u) Prescriptive Pumping Right -- (Prior Judgment

Section 4 (t)) The highest continuous extractions of water by a Pumper from the Basin for beneficial use in any five (5) consecutive years after commencement of Overdraft and prior to filing of this action, as to which there has been no cessation of use by that Pumper during any subsequent period of five (5) consecutive years, prior to the said filing of this action.

(v) Produce or Producing -- (Prior Judgment Section 4 (u)) To Pump or Divert water.

(w) Producer -- (Prior Judgment Section 4 (v)) A party who Produces water.

(x) Production -- (Prior Judgment Section 4 (w)) The annual quantity of water Produced, stated in acre feet.

(y) Pump or Pumping -- (Prior Judgment Section 4 (x)) To extract Ground Water from the Basin by Pumping or any other method.

(z) Pumper -- (Prior Judgment Section 4 (y)) Any party who Pumps water.

(aa) Pumper's Share -- (Prior Judgment Section 4 (z)) A Pumper's right to a percentage of the entire Natural Safe Yield, Operating Safe Yield and appurtenant Ground Water storage.

(bb) Relevant Watershed -- (Prior Judgment Section 4(aa)) That portion of the San Gabriel River watershed tributary to Whittier Narrows which is shown as such on Exhibit "A", and the exterior boundaries of which are described in Exhibit "B".

(cc) Replacement Water -- (Prior Judgment Section 4 (bb)) Water purchased by Watermaster to replace:

(1) Production in excess of a Pumper's Share of Operating Safe Yield; (2) The consumptive use portion resulting from the exercise of an Overlying Right; and (3) Production in excess of a Diverter's right to Divert for Direct Use.

(dd) <u>Responsible Agency</u> -- (Prior Judgment Section 4 (cc)) The municipal water district which is the normal and appropriate source from whom Watermaster shall purchase Supplemental Water for replacement purposes under the Physical Solution, being one of the following:

(1) <u>Upper District</u> -- Upper San Gabriel Valley Municipal Water District, a member public agency of The Metropolitan Water District of Southern California (MWD).

(2) <u>San Gabriel District</u> -- San Gabriel Valley Municipal Water District, which has a direct contract with the State of California for State Project Water.

(3) <u>Three Valleys District</u> -- Three Valleys Municipal Water District, formerly, "Pomona Valley Municipal Water District", a member public agency of MWD.

(ee) <u>Stored Water</u> -- (Prior Judgment Section 4 (dd)) Supplemental Water stored in the Basin pursuant to a contract with Watermaster as authorized by Section 34(m).

(ff) <u>Supplemental Water</u> -- (Prior Judgment Section 4 (ee)) Nontributary water imported through a Responsible Agency.

(gg) <u>Transporting Parties</u> -- (Prior Judgment Section 4 (ff)) Any party presently transporting water (i.e., during the 12 months immediately preceding the making of the findings herein) from the Relevant Watershed or Basin to an area outside thereof, and any party presently or hereafter having an interest in lands or having a service area outside the Basin or Relevant Watershed contiguous to lands in which it has an interest or a service area within the Basin or Relevant Watershed. Division by a road, highway, or easement shall not interrupt contiguity. Said term shall also include the City of Sierra Madre, or any party supplying water thereto, so long as the corporate limits of said City are included within one of the Responsible Agencies and if said City, in order to supply water to its corporate area from the Basin, becomes a party to this action bound by this Judgment.

(hh) Water Level -- (Prior Judgment Section 4 (gg)) The measured Elevation of water in the Key Well, corrected for any temporary effects of mounding caused by replenishment or local depressions caused by Pumping.

(ii) Year -- (Prior Judgment Section 4 (hh)) A calendar year, unless the context clearly indicates a contrary meaning.

11. Exhibits. (Prior Judgment Section 5) The following exhibits are attached to this Judgment and incorporated herein by this reference:

Exhibit "A" -- Map entitled "San Gabriel River Watershed Tributary to Whittier Narrows", showing the boundaries and relevant geologic and hydrologic features in the portion of the watershed of the San Gabriel River lying upstream from Whittier Narrows.

Exhibit "B" -- Boundaries of Relevant Watershed.

Exhibit "C" -- Table Showing Base Annual Diversion

Rights of Certain Diverters.

Exhibit "D" -- Table Showing Prescriptive Pumping Rights and Pumper's Share of Each Pumper.

Exhibit "E" -- Table Showing Production Rights of Each Integrated Producer.

Exhibit "F" -- Table Showing Special Category Rights.

Exhibit "G" -- Table Showing Non-consumptive Users.

Exhibit "H" -- Watermaster Operating Criteria.

Exhibit "J" -- Puente Narrows Agreement.

Exhibit "K" -- Overlying Rights, Nature of Overlying Right, Description of Overlying Lands to which Overlying Rights are Appurtenant, Producers Entitled to Exercise Overlying Rights and their Respective Consumptive Use Portions, and Map of Overlying Lands.

Exhibit "L" -- (New) List of Producers And Their Designees, as of June 1988.

Exhibit "M" -- (New) Watermaster Members, Officers and Staff, Including Calendar Year 1989.

II. <u>DECREE</u>

NOW, THEREFORE, IT IS HEREBY DECLARED, ORDERED, ADJUDGED AND DECREED:

A. <u>DECLARATION OF HYDROLOGIC CONDITIONS</u>

12. <u>Basin as Common Source of Supply.</u> (Prior Judgment Section 6) The area shown on Exhibit "A" as Main San Gabriel Basin overlies a Ground Water basin. The Relevant Watershed is the watershed area within which rights are herein adjudicated. The waters of the Basin and Relevant Watershed constitute a common source of natural water supply to the parties herein.

13. <u>Determination of Natural Safe Yield.</u> (Prior Judgment Section 7) The Natural Safe Yield of the Main San Gabriel Basin is found and declared to be one hundred fifty-two thousand seven-hundred (152,700) acre feet under Calendar Year 1967 cultural conditions.

14. <u>Existence of Overdraft.</u> (Prior Judgment Section 8) In each and every Calendar Year commencing with 1953, the Basin has been and is in Overdraft.

B. <u>DECLARATION OF RIGHTS</u>

15. <u>Prescription.</u> (Prior Judgment Section 9) The use of water by each and all parties and their predecessors in interest has been open, notorious, hostile, adverse, under claim of right, and with notice of said overdraft continuously from January 1, 1953 to January 4, 1973. The rights of each party herein declared are prescriptive in nature. The following aggregate consequences of said prescription within the Basin and Relevant Watershed are hereby declared:

(a) <u>Prior Prescription.</u> Diversions within the Relevant Watershed have created rights for direct consumptive use within the Basin, as declared and determined in Sections 16 and 18 hereof, which are of equal priority <u>inter se</u>, but which are prior and paramount to Pumping Rights in the Basin.

(b) <u>Mutual Prescription.</u> The aggregate Prescriptive Pumping Rights of the parties who are Pumpers now exceed, and for many years prior to filing of this action, have exceeded, the Natural Safe Yield of the Basin. By reason of said condition, all rights of said Pumpers are declared to be mutually prescriptive and of equal priority, inter se.

(c) Common Ownership of Safe Yield and Incidents Thereto. By reason of said Overdraft and mutual Prescription, the entire Natural Safe Yield of the Basin, the Operating Safe Yield thereof and the appurtenant rights to Ground Water storage capacity of the Basin are owned by Pumpers in undivided Pumpers' Shares as hereinafter individually declared, subject to the control of Watermaster, pursuant to the Physical Solution herein decreed. Nothing herein shall be deemed in derogation of the rights to spread water pursuant to rights set forth in Exhibit "G".

16. Surface Rights. (Prior Judgment Section 10) Certain of the aforesaid prior and paramount prescriptive water rights of Diverters to Divert for Direct Use stream flow within the Relevant Watershed are hereby declared and found in terms of Base Annual Diversion Right as set forth in Exhibit "C". Each Diverter shown on Exhibit "C" shall be entitled to Divert for Direct Use up to two hundred percent (200%) of said Base Annual Diversion Right in any one (1) Fiscal Year; provided that the aggregate quantities of water Diverted in any consecutive ten (10) Fiscal Year period shall not exceed ten (10) times such Diverter's Base Annual Diversion Right.

17. Ground Water Rights. (Prior Judgment Section 11) The Prescriptive Pumping Right of each Pumper, who is not an Integrated Producer, and his Pumper's Share are declared as set forth in Exhibit "D".

18. Optional Integrated Production Rights. (Prior Judgment Section 12) Those parties listed on Exhibit "E" have elected to be treated as Integrated Producers. Integrated Production Rights have two (2) historical components:

(1) a fixed component based upon historic Diversions for Direct Use; and

(2) a mutually prescriptive Pumper's Share component based upon Pumping during the period 1953 through 1967.

Assessment and other Watermaster regulation of the rights of such parties shall relate to and be based upon each such component. So far as future exercise of such rights is concerned, however, the gross quantity of the aggregate right in any Fiscal Year may be exercised, in the sole discretion of such party, by either Diversion or Pumping or any combination or apportionment thereof; provided, that for Assessment purposes the first water Produced in any Fiscal Year (other than "carry-over", under Section 49 hereof) shall be deemed an exercise of the Diversion component, and any Production over said quantity shall be deemed Pumped water, regardless of the actual method of Production.

19. Special Category Rights. (Prior Judgment Section 13) The parties listed on Exhibit "F" have water rights in the Relevant Watershed which are not ordinary Production rights. The nature of each such right is as described in Exhibit "F".

20. Non-consumptive Practices. (Prior Judgment Section 14) Certain Producers have engaged in Water Diversion and spreading practices which have caused such Diversions to have a

non-consumptive or beneficial impact upon the aggregate water supply available in the Basin. Said parties, and a statement of the nature of their rights, uses and practices, are set forth in Exhibit "G". The Physical Solution decreed herein, and particularly its provisions for Assessments, shall not apply to such non-consumptive uses. Watermaster may require reports on the operations of said parties.

21. <u>Overlying Rights.</u> (Prior Judgment Section 14.5) Producers listed in Exhibit "K" hereto were not parties herein at the time of the original entry of Judgment herein. They have exercised in good faith Overlying Rights to Produce water from the Basin during the periods subsequent to the entry of Judgment herein and have by self-help initiated or maintained appurtenant Overlying Rights. Such rights are exercisable without quantitative limit only on specifically described Overlying Land and cannot be separately conveyed or transferred apart therefrom. As to such rights and their exercise, the owners thereof shall become parties to this action and be subject to Watermaster Replacement Water Assessments under Section 45 (b) hereof, sufficient to purchase Replenishment Water to offset the net consumptive use of such Production and practices. In addition, the gross amount of such Production for such overlying use shall be subject to Watermaster Administrative Assessments under Section 45 (a) hereof and the consumptive use portion of such Production for overlying use shall be subject to Watermaster's In-Lieu Water Cost Assessments under Section 45 (d) hereof. The Producers presently entitled to exercise Overlying Rights, a description of the Overlying Land to which

Overlying Rights are appurtenant, the nature of use and the consumptive use portion thereof are set forth in Exhibit "K" hereto. Watermaster may require reports and make inspections of the operations of said parties for purposes of verifying the uses set forth in said Exhibit "K", and, in the event of a material change, to redetermine the net amount of consumptive use by such parties as changed in the exercise of such Overlying Rights. Annually, during the first two (2) weeks of June in each Calendar Year, such Overlying Rights Producers shall submit to Watermaster a verified statement as to the nature of the then current uses of said Overlying Rights on said Overlying Lands for the next ensuing Fiscal Year, whereupon Watermaster shall either affirm the prior determination or redetermine the net amount of the consumptive use portion of the exercise of such Overlying Right by said Overlying Rights Producer.

C. INJUNCTION

22. Injunction Against Unauthorized Production. (Prior Judgment Section 15) Effective July 1, 1973, each and every party, its officers, agents, employees, successors and assigns, to whom rights to waters of the Basin or Relevant Watershed have been declared and decreed herein is ENJOINED AND RESTRAINED from Producing water for Direct Use from the Basin or the Relevant Watershed except pursuant to rights and Pumpers' Shares herein decreed or which may hereafter be acquired by transfer pursuant to Section 55, or under the provisions of the Physical Solution in this Judgment and the Court's continuing jurisdiction, provided that no party is enjoined from Producing up to five (5) acre feet per Fiscal Year.

23. <u>Injunction re Non-consumptive Uses.</u> (Prior Judgment Section 16) Each party listed in Exhibit "G", its officers, agents, employees, successors and assigns, is ENJOINED AND RESTRAINED from materially changing said non-consumptive method of use.

24. <u>Injunction Re Change in Overlying Use Without Notice Thereof To Watermaster.</u> (Prior Judgment Section 16.5) Each party listed in Exhibit "K", its officers, agents, employees, successors and assigns, is ENJOINED AND RESTRAINED from materially changing said overlying uses at any time without first notifying Watermaster of the intended change of use, in which event Watermaster shall promptly redetermine the consumptive use portion thereof to be effective after such change.

25. <u>Injunction Against Unauthorized Recharge.</u> (Prior Judgment Section 17) Each party, its officers, agents, employees, successors and assigns, is ENJOINED AND RESTRAINED from spreading, injecting or otherwise recharging water in the Basin <u>except</u> pursuant to: (a) an adjudicated non-consumptive use, or (b) consent and approval of or Cyclic Storage Agreement with Watermaster, or (c) subsequent order of this Court.

26. <u>Injunction Against Transportation From Basin or Relevant Watershed.</u> (Prior Judgment Section 18) Except upon further order of Court, all parties, other than Transporting Parties and MWD in its exercise of its Special Category Rights, to the extent authorized therein, are ENJOINED AND RESTRAINED from transporting water hereafter Produced from the Relevant Watershed or Basin outside the areas thereof. For purposes of

this Section, water supplied through a city water system which lies chiefly within the Basin shall be deemed entirely used within the Basin. Transporting Parties are entitled to continue to transport water to the extent that any Production of water by any such party does not violate the injunctive provisions contained in Section 22 hereof; provided that said water shall be used within the present service areas or corporate or other boundaries and additions thereto so long as such additions are contiguous to the then existing service area or corporate or other boundaries; except that a maximum of ten percent (10%) of use in any Fiscal Year may be outside said then existing service areas or corporate or other boundaries.

D. CONTINUING JURISDICTION

27. Jurisdiction Reserved. (Prior Judgment Section 19) Full jurisdiction, power and authority are retained by and reserved to the Court for purposes of enabling the Court upon application of any party or of the Watermaster, by motion and upon at least thirty (30) days notice thereof, and after hearing thereon, to make such further or supplemental orders or directions as may be necessary or appropriate for interim operation before the Physical Solution is fully operative, or for interpretation, enforcement or carrying out of this Judgment, and to modify, amend or amplify any of the provisions of this Judgment or to add to the provisions thereof consistent with the rights herein decreed. Provided, that nothing in this paragraph shall authorize:

(1) modification or amendment of the quantities specified in the declared rights of any party;

(2) modification or amendment of the manner of exercise of the Base Annual Diversion Right or Integrated Production Right of any party; or

(3) the imposition of an injunction prohibiting transportation outside the Relevant Watershed or Basin as against any Transporting Party transporting in accordance with the provisions of this Judgment or against MWD as to its Special Category Rights.

E. WATERMASTER

28. Watermaster to Administer Judgment. (Prior Judgment Section 20) A Watermaster comprised of nine (9) persons, to be nominated as hereinafter provided and appointed by the Court, shall administer and enforce the provisions of this Judgment and any subsequent instructions or orders of the Court thereunder.

29. Qualification, Nomination and Appointment. (Prior Judgment Section 21) The nine (9) member Watermaster shall be composed of six (6) Producer representatives and three (3) public representatives qualified, nominated and appointed as follows:

(a) Qualification. Any adult citizen of the State of California shall be eligible to serve on Watermaster; provided, however, that no officer, director, employee or agent of Upper District or San Gabriel District shall be qualified as a Producer member of Watermaster.

(b) Nomination of Producer Representatives. A meeting of all parties shall be held at the regular meeting of Watermaster in November of each year, at the offices of Watermaster. Nomination of the six (6) Producer representatives shall be by cumulative voting, in person or by proxy, with each Producer entitled to one (1) vote for each one hundred (100) acre feet, or portion thereof, of Base Annual Diversion Right or Prescriptive Pumping Right or Integrated Production Right.

(c) Nomination of Public Representatives. On or before the regular meeting of Watermaster in November of each year, the three (3) public representatives shall be nominated by the boards of directors of Upper District (which shall select two [2]) and San Gabriel District (which shall select one [1]). Said nominees shall be members of the board of directors of said public districts.

(d) Appointment. All Watermaster nominations shall be promptly certified to the Court, which will in ordinary course confirm the same by an appropriate order appointing said Watermaster; provided, however, that the Court at all times reserves the right and power to refuse to appoint, or to remove, any member of Watermaster.

30. Term and Vacancies. (Prior Judgment Section 22) Each member of Watermaster shall serve for a one (1) year term commencing on January 1, following his appointment, or until his successor is appointed. In the event of a vacancy on Watermaster, a successor shall be nominated at a special meeting to be called by Watermaster within ninety (90) days (in the case of a Producer representative) or by action of the appropriate district board of directors (in the case of a public representative).

31. Quorum. (Prior Judgment Section 23) Five (5) members

of the Watermaster shall constitute a quorum for the transaction of affairs of the Watermaster. Action by the affirmative vote of five (5) members shall constitute action by Watermaster, except that the affirmative vote of six (6) members shall be required:

(a) to approve the purchase, spreading or injection of water for Ground Water recharge, or

(b) to enter in any Agreement pursuant to Section 34 (m) hereof.

32. Compensation. (Prior Judgment Section 24) Each Watermaster member shall receive compensation of One Hundred Dollars ($100.00) per day for each day's attendance at meetings of Watermaster or for each day's service rendered as a Watermaster member at the request of Watermaster, together with any expenses incurred in the performance of his duties required or authorized by Watermaster. No member of the Watermaster shall be employed by or compensated for professional services rendered by him to Watermaster, other than the compensation herein provided, and any authorized travel or related expense.

33. Organization. (Prior Judgment Section 25) At its first meeting in each year, Watermaster shall elect a chairman and a vice chairman from its membership. It shall also select a secretary, a treasurer and such assistant secretaries and assistant treasurers as may be appropriate, any of whom may, but need not be, members of Watermaster.

(a) Minutes. Minutes of all Watermaster meetings shall be kept which shall reflect all actions taken by Watermaster. Draft copies thereof shall be furnished to any party who files a request therefor in writing with Watermaster. Said draft copies of minutes shall constitute notice of any Watermaster action therein reported; failure to request copies thereof shall constitute waiver of notice.

(b) Regular Meetings. Watermaster shall hold regular meetings at places and times to be specified in Watermaster's rules and regulations to be adopted by Watermaster. Notice of the scheduled or regular meetings of Watermaster and of any changes in the time or place thereof shall be mailed to all parties who shall have filed a request therefor in writing with Watermaster.

(c) Special Meetings. Special meetings of Watermaster may be called at any time by the chairman or vice chairman or by any three (3) members of Watermaster by written notice delivered personally or mailed to each member of Watermaster and to each party requesting notice, at least twenty-four (24) hours before the time of each such meeting in the case of personal delivery, and forty-eight (48) hours prior to such meeting in the case of mail. The calling notice shall specify the time and place of the special meeting and the business to be transacted at such meeting. No other business shall be considered at such meeting.

(d) Adjournments. Any meeting of Watermaster may be adjourned to a time and place specified in the order of adjournment. Less than a quorum may so adjourn from time to time. A copy of the order or notice of adjournment shall be conspicuously posted on or near the door of the place where the meeting was held within twenty-four (24) hours after adoption of the order of adjournment.

34. <u>Powers and Duties.</u> (Prior Judgment Section 26) Subject to the continuing supervision and control of the Court, Watermaster shall have and may exercise the following express powers, and shall perform the following duties, together with any specific powers, authority and duties granted or imposed elsewhere in this Judgment or hereafter ordered or authorized by the Court in the exercise of its continuing jurisdiction.

(a) <u>Rules and Regulations</u>. To make and adopt any and all appropriate rules and regulations for conduct of Watermaster affairs. A copy of said rules and regulations and any amendments thereof shall be mailed to all parties.

(b) <u>Acquisition of Facilities</u>. To purchase, lease, acquire and hold all necessary property and equipment; provided, however, that Watermaster shall not acquire any interest in real property in excess of year-to-year tenancy for necessary quarters and facilities.

(c) <u>Employment of Experts and Agents</u>. To employ such administrative personnel, engineering, geologic, accounting, legal or other specialized services and consulting assistants as may be deemed appropriate in the carrying out of its powers and to require appropriate bonds from all officers and employees handling Watermaster funds.

(d) <u>Measuring Devices, etc</u>. To cause parties, pursuant to uniform rules, to install and maintain in good operating condition, at the cost of each party, such necessary measuring devices or meters as may be appropriate; and to inspect and test any such measuring device as may be necessary.

(e) Assessments. To levy and collect all Assessments specified in the Physical Solution.

(f) Investment of Funds. To hold and invest any and all funds which Watermaster may possess in investments authorized from time to time for public agencies in the State of California.

(g) Borrowing. To borrow in anticipation of receipt of Assessment proceeds an amount not to exceed the annual amount of Assessments levied but uncollected.

(h) Purchase of and Recharge with Supplemental Water. To purchase Supplemental Water and to introduce the same into the Basin for replacement or cyclic storage purposes, subject to the affirmative vote of six (6) members of Watermaster.

(i) Contracts. To enter into contracts for the performance of any administrative powers herein granted, subject to approval of the Court.

(j) Cooperation With Existing Agencies. To act jointly or cooperate with agencies of the United States and the State of California or any political subdivision, municipality or district to the end that the purposes of the Physical Solution may be fully and economically carried out. Specifically, in the event Upper District has facilities available and adequate to accomplish any of the administrative functions of Watermaster, consideration shall be given to performing said functions under contract with Upper District in order to avoid duplication of facilities.

(k) <u>Assumption of Make-up Obligation</u>. Watermaster shall assume the Make-up Obligation for and on behalf of the Basin.

(m) <u>Water Quality</u>. Water quality in the Basin shall be a concern of Watermaster, and all reasonable steps shall be taken to assist and encourage appropriate regulatory agencies to enforce reasonable water quality regulations affecting the Basin, including regulation of solid and liquid waste disposal.

(n) <u>Cyclic Storage Agreements</u>. To enter into appropriate contracts, to be approved by the Court, for utilization of Ground Water storage capacity of the Basin for cyclic or regulatory storage of Supplemental Water by parties and non-parties, for subsequent recovery or Watermaster credit by the storing entity, pursuant to uniform rules and conditions, which shall include provision for:

(1) Watermaster control of all spreading or injection and extraction scheduling and procedures for such stored water;

(2) calculation by Watermaster of any special costs, damages or burdens resulting from such operations;

(3) determination by Watermaster of, and

accounting for, all losses in stored water, assuming that such stored water floats on top of the Ground Water supplies, and accounting for all losses of water which otherwise would have replenished the Basin, with priorities being established as between two or more such contractors giving preference to parties over non-parties; and

(4) payment to Watermaster for the benefit of the parties hereto of all special costs, damages or burdens incurred (without any charge, rent, assessment or expense as to parties hereto by reason of the adjudicated proprietary character of said storage rights, nor credit or offset for benefits resulting from such storage); provided, that no party shall have any direct interest in or control over such contracts or the operation thereof by reason of the adjudicated right of such party, the Watermaster having sole custody and control of all Ground Water storage rights in the Basin pursuant to the Physical Solution herein, and subject to review of the Court.

(o) Notice List. Maintain a current list of party designees to receive notice hereunder, in accordance with Section 54 hereof.

35. Policy Decisions -- Procedure. (Prior Judgment Section 27) It is contemplated that Watermaster will exercise discretion in making policy decisions relating to Basin management under the Physical Solution decreed herein. In order to assure full participation and opportunity to be heard for

those affected, no policy decision shall be made by Watermaster until thirty (30) days after the question involved has been raised for discussion at a Watermaster meeting and noted in the draft of minutes thereof.

36. Reports. (Prior Judgment Section 28) Watermaster shall annually file with the Court and mail to the parties a report of all Watermaster activities during the preceding year, including an audited statement of all accounts and financial activities of Watermaster, summary reports of Diversions and Pumping, and all other pertinent information. To the extent practical, said report shall be mailed to all parties on or before November 1.

37. Review Procedures. (Prior Judgment Section 29) Any action, decision, rule or procedure of Watermaster (other than a decision establishing Operating Safe Yield, see Section 43[c]) shall be subject to review by the Court on its own motion or on timely motion for an Order to Show Cause by any party, as follows:

(a) Effective Date of Watermaster Action. Any order, decision or action of Watermaster shall be deemed to have occurred on the date that written notice thereof is mailed. Mailing of draft copies of Watermaster minutes to the parties requesting the same shall constitute notice to all such parties.

(b) Notice of Motion. Any party may, by a regularly noticed motion, petition the Court for review of said Watermaster's action or decision. Notice of such motion shall be mailed to Watermaster and all parties. Unless so ordered by the Court, such petition shall not operate to stay the effect of such Watermaster action.

(c) Time for Motion. Notice of motion to review any Watermaster action or decision shall be served and filed within ninety (90) days after such Watermaster action or decision.

(d) De Novo Nature of Proceeding. Upon filing of such motion for hearing, the Court shall notify the parties of a date for taking evidence and argument, and shall review de novo the question at issue on the date designated. The Watermaster decision or action shall have no evidentiary weight in such proceeding.

(e) Decision. The decision of the Court in such proceeding shall be an appealable Supplemental Order in this case. When the same is final, it shall be binding upon the Watermaster and the parties.

F. PHYSICAL SOLUTION

38. Purpose and Objective. (Prior Judgment Section 30) Consistent with the California Constitution and the decisions of the Supreme Court, the Court hereby adopts and Orders the parties to comply with this Physical Solution. The purpose and objective of these provisions is to provide a legal and practical means for accomplishing the most economic, long term, conjunctive utilization of surface, Ground Water, Supplemental Water and Ground Water storage capacity to meet the needs and requirements of the water users dependent upon the Basin and Relevant Watershed, while preserving existing equities.

39. Need for Flexibility. (Prior Judgment Section 31) In

order that Watermaster may be free to utilize both existing and new and developing technological, social and economic concepts for the fullest benefit of all those dependent upon the Basin, it is essential that the Physical Solution hereunder provide for maximum flexibility and adaptability. To that end, the Court has retained continuing jurisdiction to supplement the broad discretion herein granted to the Watermaster.

40. Watermaster Control. (Prior Judgment Section 32) In order to develop an adequate and effective program of Basin management, it is essential that Watermaster have broad discretion in the making of Basin management decisions within the ambit hereinafter set forth. Withdrawal and replenishment of supplies of the Basin and Relevant Watershed and the utilization of the water resources thereof, and of available Ground Water storage capacity, must be subject to procedures established by Watermaster in implementation of the provisions of this Judgment. Both the quantity and quality of said water resource are thereby preserved and its beneficial utilization maximized.

41. General Pattern of Contemplated Operation. (Prior Judgment Section 33) In general outline (subject to the specific provisions hereafter and to Watermaster Operating Criteria set forth in Exhibit "H"), Watermaster will determine annually the Operating Safe Yield of the Basin and will notify each Pumper of his share thereof, stated in acre feet per Fiscal Year. Thereafter, no party may Produce in any Fiscal Year an amount in excess of the sum of his Diversion Right, if any, plus his Pumper's Share of such Operating Safe Yield, or his

Integrated Production Right, or the terms of any Cyclic Storage Agreement, without being subject to Assessment for the purpose of purchasing Replacement Water. In establishing the Operating Safe Yield, Watermaster shall follow all physical, economic, and other relevant parameters provided in the Watermaster Operating Criteria. Watermaster shall have Assessment powers to raise funds essential to implement the management plan in any of the several special circumstances herein described in more detail.

42. Basin Operating Criteria. (Prior Judgment Section 34) Until further order of the Court and in accordance with the Watermaster Operating Criteria, Watermaster shall not spread Replacement Water when the water level at the Key Well exceeds Elevation two hundred fifty (250), and Watermaster shall spread Replacement Water, insofar as practicable, to maintain the water level at the Key Well above Elevation two hundred (200).

43. Determination of Operating Safe Yield. (Prior Judgment Section 35) Watermaster shall annually determine the Operating Safe Yield applicable to the succeeding Fiscal Year and estimate the same for the next succeeding four (4) Fiscal Years. In making such determination, Watermaster shall be governed in the exercise of its discretion by the Watermaster Operating Criteria. The procedures with reference to said determination shall be as follows:

(a) Preliminary Determination. On or before Watermaster's first meeting in April of each year, Watermaster shall make a Preliminary Determination of the Operating Safe Yield of the Basin for each of the succeeding five Fiscal Years. Said determination shall be made in the form of a report containing a summary statement of the considerations, calculations and factors used by Watermaster in arriving at said Operating Safe Yield.

(b) Notice and Hearing. A copy of said Preliminary Determination and report shall be mailed to each Pumper and Integrated Producer at least ten (10) days prior to a hearing to be held at Watermaster's regular meeting in May, of each year, at which time objections or suggested corrections or modifications of said determinations shall be considered. Said hearing shall be held pursuant to procedures adopted by Watermaster.

(c) Watermaster Determination and Review Thereof. Within thirty (30) days after completion of said hearing, Watermaster shall mail to each Pumper and Integrated Producer a final report and determination of said Operating Safe Yield for each such Fiscal Year, together with a statement of the Producer's entitlement in each such Fiscal Year stated in acre feet. Any affected party, within thirty (30) days of mailing of notice of said Watermaster determination, may, by a regularly noticed motion, petition the Court for an Order to Show Cause for review of said Watermaster finding, and thereupon the Court shall hear such objections and settle such dispute. Unless so ordered by the Court, such petition shall not operate to stay the effect of said report and determination. In the absence of such review proceedings, the Watermaster determination shall be final.

44. Reports of Pumping and Diversion. (Prior Judgment

Section 36) Each party (other than Minimal Producers) shall file with the Watermaster quarterly, on or before the last day of January, April, July and October, a report on a form to be prescribed by Watermaster showing the total Pumping and Diversion (separately for Direct Use and for non-consumptive use, if any,) of such party during the preceding calendar quarter.

45. Assessments -- Purpose. (Prior Judgment Section 37) Watermaster shall have the power to levy and collect Assessments from the parties (other than Minimal Producers, non-consumptive users, or Production under Special Category Rights or Cyclic Storage Agreements) based upon Production during the preceding Fiscal Year. Said Assessments may be for one or more of the following purposes:

(a) Watermaster Administration Costs. Within thirty (30) days after completion of the hearing on the Preliminary Determination of the Operating Safe Yield of the Basin and Watermaster's determination thereof, pursuant to Section 43 hereof, Watermaster shall adopt a proposed budget for the succeeding Fiscal Year and shall mail a copy thereof to each party, together with a statement of the level of Administration Assessment levied by Watermaster which will be collected for purposes of raising funds for said budget. Said Assessment shall be uniformly applicable to each acre foot of Production.

(b) Replacement Water Costs. Replacement Water Assessments shall be collected from each party on account of such party's Production in excess of its Diversion

Rights, Pumper's Share or Integrated Production Right, and on account of the consumptive use portion of Overlying Rights, computed at the applicable rate established by Watermaster consistent with the Watermaster Operating Criteria.

(c) Make-Up Obligation. An Assessment shall be collected equally on account of each acre foot of Production, which does not bear a Replacement Assessment hereunder, to pay all necessary costs of Administration and satisfaction of the Make-Up Obligation. Such Assessment shall not be applicable to water Production for an Overlying Right.

(d) In-Lieu Water Cost. Watermaster may levy an Assessment against all Pumping to pay reimbursement for In-Lieu Water Costs except that such Assessment shall not be applicable to the non-consumptive use portion of an Overlying Right.

(e) Basin Water Quality Improvement. For purposes of testing, protecting or improving the water quality in the Basin, Watermaster may, after a noticed hearing thereon, fix terms and conditions under which it may waive all or any part of its Assessments on such ground water Production and if such Production, in addition to his other Production, does not exceed such Producer's Share or entitlement for that Fiscal Year, such stated Production shall be allowed to be carried over for a part of such Producer's next Fiscal Year's Producer's Share or entitlement. In connection therewith, Watermaster may also waive the provisions of Sections 25, 26 and 57 hereof, relating to Injunction Against Unauthorized Recharge, Injunction Against Transportation From Basin or Relevant Watershed, and Intervention After Judgment, respectively. Nothing in this Judgment is intended to allow an increase in any Producer's annual entitlement nor to prevent Watermaster, after hearing thereon, from entering into contracts to encourage, assist and accomplish the clean up and improvement of degraded water quality in the Basin by non-parties herein. Such contracts may include the exemption of the Production of such Basin water therefor from Watermaster Assessments and, in connection therewith, the waiver of the provisions of Judgment Sections 25, 26, and 57 hereof.

46. Assessments -- Procedure. (Prior Judgment Section 38) Assessments herein provided for shall be levied and collected as follows:

(a) Levy and Notice of Assessment. Within thirty (30) days of Watermaster's annual determination of Operating Safe Yield of the Basin for each Fiscal Year and succeeding four (4) Fiscal Years, Watermaster shall levy applicable Administration Assessments, Replacement Water Assessments, Make-up Water Assessments and In-Lieu Water Assessments, if any. Watermaster shall give written notice of all applicable Assessments to each party on or before August 15, of each year.

(b) Payment. Each Assessment shall be payable, and each party is Ordered to pay the same, on or before

September 20, following such Assessment, subject to the rights reserved in Section 37 hereof.

(c) Delinquency. Any Assessment which becomes delinquent after January 1, 1980, shall bear interest at the annual prime rate plus one percent (1%) in effect on the first business day of August of each year. Said prime interest rate shall be that fixed by the Bank of America NT&SA for its preferred borrowing customers on said date. Said prime interest rate plus one percent (1%) shall be applicable to any said delinquent Assessment from the due date thereof until paid. Provided, however, in no event shall any said delinquent Assessment bear interest at a rate of less than ten percent (10%) per annum. Such delinquent Assessment and interest may be collected in a Show Cause proceeding herein or any other legal proceeding instituted by Watermaster, and in such proceeding the Court may allow Watermaster its reasonable costs of collection, including attorney's fees.

47. Availability of Supplemental Water From Responsible Agencies. (Prior Judgment Section 39) If any Responsible Agency shall, for any reason, be unable to deliver Supplemental Water to Watermaster when needed, Watermaster shall collect funds at an appropriate level and hold them in trust, together with interest accrued thereon, for purchase of such water when available.

48. Accumulation of Replacement Water Assessment Proceeds. (Prior Judgment Section 40) In order to minimize fluctuation in Assessments and to give Watermaster flexibility in Basin

management, Watermaster may make reasonable accumulations of Replacement Water Assessments. Such moneys and any interest accrued thereon shall only be used for the purchase of Replacement Water.

49. Carry-over of Unused Rights. (Prior Judgment Section 41) Any Pumper's Share of Operating Safe Yield, and the Production right of any Integrated Producer, which is not Produced in a given Fiscal Year may be carried over and accumulated for one Fiscal Year, pursuant to reasonable rules and procedures for notice and accounting which shall be adopted by Watermaster. The first water Produced in the succeeding Fiscal Year shall be deemed Produced pursuant to such Carry-over Rights.

50. Minimal Producers. (Prior Judgment Section 42) In the interest of Justice, Minimal Producers are exempted from the operation of this Physical Solution, so long as such party's annual Production does not exceed five (5) acre feet. Quarterly Production reports by such parties shall not be required, but Watermaster may require, and Minimal Producers shall furnish, specific periodic reports. In addition, Watermaster may conduct such investigation of future operations of any Minimal Producer as may be appropriate.

51. Effective Date. (Prior Judgment Section 43) The effective date for commencing accounting and operation under this Physical Solution, other than for Replacement Water Assessments, shall be July 1, 1972. The first Assessment for Replacement Water shall be payable on September 20, 1974, on account of Fiscal Year 1973-74 Production.

G. MISCELLANEOUS PROVISIONS

52. Puente Narrows Flow. (Prior Judgment Section 44) The Puente Basin is tributary to the Main San Gabriel Basin. All Producers within said Puente Basin have been dismissed herein, based upon the Puente Narrows Agreement (Exhibit "J"), whereby Puente Basin Water Agency agreed not to interfere with surface inflow and to assure continuance of historic subsurface contribution of water to Main San Gabriel Basin. The Court declares said Agreement to be reasonable and fair and in full satisfaction of claims by Main San Gabriel Basin for natural water from Puente Basin.

53. San Gabriel District - Interim Order. (Prior Judgment Section 45) San Gabriel District has a contract with the State of California for State Project Water, delivered at Devil Canyon in San Bernardino County. San Gabriel District is HEREBY ORDERED to proceed with and complete necessary pipeline facilities as soon as practical.

Until said pipeline is built and capable of delivering a minimum of twenty-eight thousand eight-hundred (28,800) acre feet of State Project water per year, defendant cities of Alhambra, Azusa, and Monterey Park shall pay to Watermaster each Fiscal Year a Replacement Assessment at a uniform rate sufficient to purchase Replenishment Water when available, which rate shall be declared by San Gabriel District. When water is available through said pipeline, San Gabriel District shall make the same available to Watermaster, on his reasonable demand, at said specified rate per acre foot. Interest accrued on such funds shall be paid to San Gabriel

District.

54. Service Upon and Delivery to Parties of Various Papers. (Prior Judgment Section 46) Service of the Judgment on those parties who have executed the Stipulation for Judgment shall be made by first class mail, postage prepaid, addressed to the Designee and at the address designated for that purpose in the executed and filed counterpart of the Stipulation for Judgment, or in any substitute designation filed with the Court.

Each party who has not heretofore made such a designation shall, within thirty (30) days after the Judgment shall have been served upon that party, file with the Court, with proof of service of a copy thereof upon Watermaster, a written designation of the person to whom and the address at which all future notices, determinations, requests, demands, objections, reports and other papers and processes to be served upon that party or delivered to that party are to be so served or delivered.

A later substitute designation filed and served in the same manner by any party shall be effective from the date of filing as to the then future notices, determinations, requests, demands, objections, reports and other papers and processes to be served upon or delivered to that party.

Delivery to or service upon any party by Watermaster, by any other party, or by the Court, of any item required to be served upon or delivered to a party under or pursuant to the Judgment may be made by deposit thereof (or by copy thereof) in the mail, first class, postage prepaid, addressed to the Designee of the party and at the address shown in the latest designation filed by that party.

55. Assignment, Transfer, etc., of Rights. (Prior Judgment Section 47) Any rights Adjudicated herein except Overlying Rights, may be assigned, transferred, licensed or leased by the owners thereof; provided however, that no such assignment shall be complete until the appropriate notice procedures established by Watermaster have been complied with. No water Produced pursuant to rights assigned, transferred, licensed, or leased may be transported outside the Relevant Watershed except by:

(1) a Transporting Party, or

(2) a successor in interest immediate or mediate to a water system on lands or portion thereof, theretofore served by such a Transporting Party, for use by such successor in accordance with limitations applicable to Transporting Parties, or

(3) a successor in interest to the Special Category rights of MWD.

The transfer and use of Overlying Rights shall be limited, as provided in Section 21 hereof, as exercisable only on the specifically defined Overlying Lands and they cannot be separately conveyed or transferred apart therefrom.

56. Abandonment of Rights. (Prior Judgment Section 48) It is in the interest of reasonable beneficial use of the Basin and its water supply that no party be encouraged to take and use more water in any Fiscal Year than is actually required. Failure to Produce all of the water to which a party is entitled hereunder shall not, in and of itself, be deemed or constitute

an abandonment of such party's right, in whole or in part. Abandonment and extinction of any right herein Adjudicated shall be accomplished only by:

(1) a written election by the party, filed in this case, or

(2) upon noticed motion of Watermaster, and after hearing.

In either case, such abandonment shall be confirmed by express subsequent order of this Court.

57. Intervention After Judgment. (Prior Judgment Section 49) Any person who is not a party or successor to a party and who proposes to Produce Water from the Basin or Relevant Watershed, may seek to become a party to this Judgment through a Stipulation For Intervention entered into with Watermaster. Watermaster may execute said Stipulation on behalf of the other parties herein but such Stipulation shall not preclude a party from opposing such Intervention at the time of the Court hearing thereon. Said Stipulation For Intervention must thereupon be filed with the Court, which will consider an order confirming said Intervention following thirty (30) days' notice to the parties. Thereafter, if approved by the Court, such Intervenor shall be a party bound by this Judgment and entitled to the rights and privileges accorded under the Physical Solution herein.

58. Judgment Binding on Successors, etc. (Prior Judgment Section 50) Subject to specific provisions hereinbefore contained, this Judgment and all provisions thereof are applicable to and binding upon and inure to the benefit of not

only the parties to this action, but as well to their respective heirs, executors, administrators, successors, assigns, lessees, licensees and to the agents, employees and attorneys in fact of any such persons.

59. Water Rights Permits. (Prior Judgment Section 51) Nothing herein shall be construed as affecting the relative rights and priorities between MWD and San Gabriel Valley Protective Association under State Water Rights Permits Nos. 7174 and 7175, respectively.

60. Costs. (Prior Judgment Section 52) No party shall recover any costs in this proceeding from any other party.

61. Entry of Judgment. (New) The Clerk shall enter this Judgment.

DATED: August 24, 1989.

s/ Florence T. Pickard
Florence T. Pickard, Judge
Specially Assigned

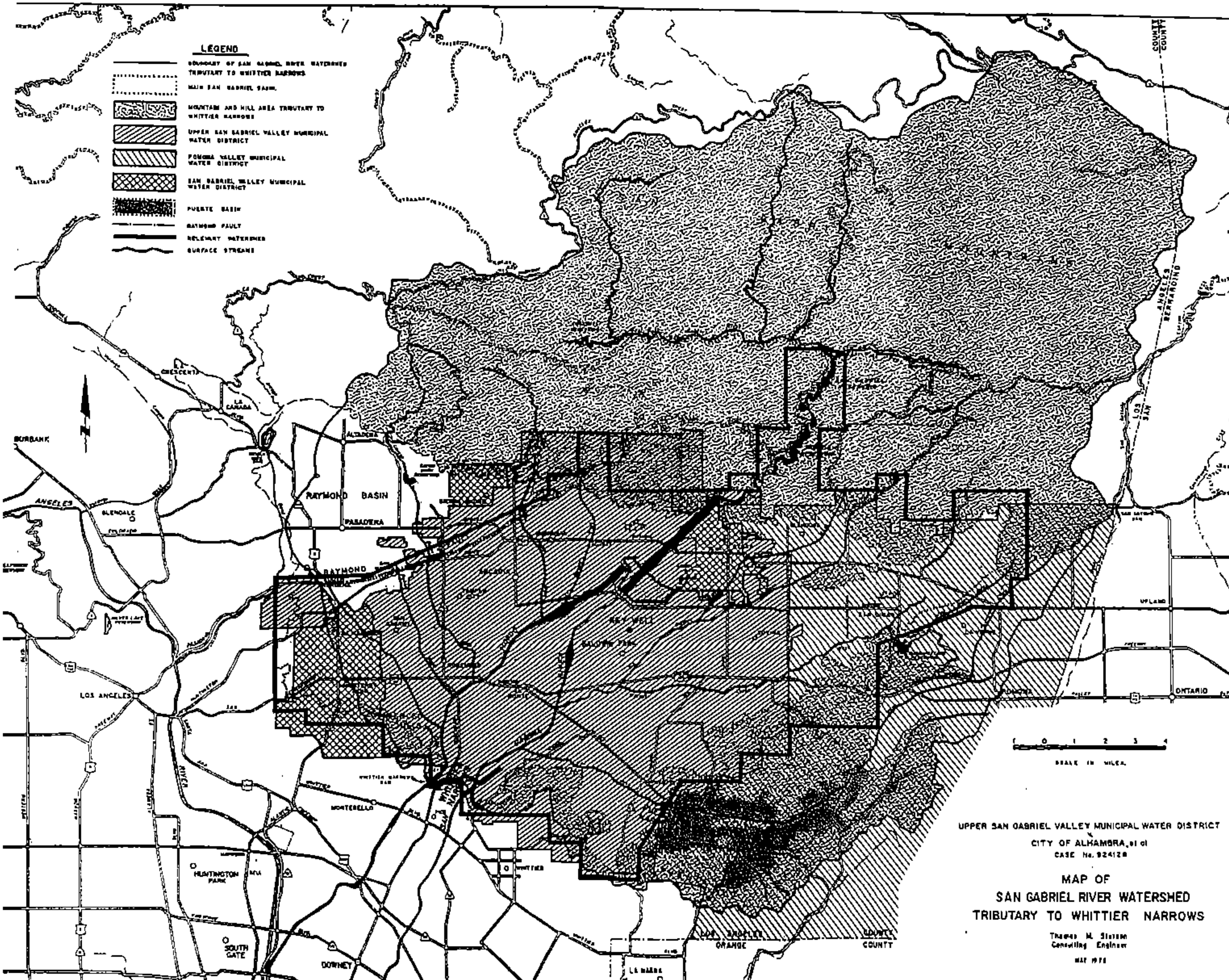

LEGEND
BOUNDARY OF SAN GABRIEL RIVER WATERSHED TRIBUTARY TO WHITTIER NARROWS
MAIN SAN GABRIEL BASIN
MOUNTAIN AND HILL AREA TRIBUTARY TO WHITTIER NARROWS
UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT
POMONA VALLEY MUNICIPAL WATER DISTRICT
SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT
PUENTE BASIN
RAYMOND FAULT
SURFACE STREAMS
BURBANK
GLENDALE
CRESCENTA
LA CANADA
ALTADENA
PASADENA
RAYMOND BASIN
RAYMOND
ANGELES
LOS ANGELES
RIVER
MONTEBELLO
HUNTINGTON PARK
SOUTH GATE
DOWNEY
WHITTIER
LA HABRA
ONTARIO
UPLAND
LOS ANGELES COUNTY
ORANGE COUNTY
SAN BERNARDINO COUNTY
0 1 2 3 4
SCALE IN MILES
UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT
v.
CITY OF ALHAMBRA, et al
CASE No. 924128
MAP OF
SAN GABRIEL RIVER WATERSHED
TRIBUTARY TO WHITTIER NARROWS
Consulting Engineer

Exhibit "B"

BOUNDARIES OF RELEVANT WATERSHED

The following described property is located in Los Angeles County, State of California:

Beginning at the Southwest corner of Section 14, Township 1 North, Range 11 West, San Bernardino Base and Meridian;

Thence Northerly along the West line of said Section 14 to the Northwest corner of the South half of said Section 14;

Thence Easterly along the North line of the South half of Section 14 to the East line of said Section 14;

Thence Northerly along the East line of said Section 14, Township 1 North, Range 11 West and continuing Northerly along the East line of Section 11 to the Northeast corner of said Section 11;

Thence Easterly along the North line of Section 12 to the Northeast corner of said Section 12;

Thence Southerly along the East line of said Section 12 and continuing Southerly along the East line of Section 13 to the Southeast corner of said Section 13, said corner being also the Southwest corner of Section 18, Township 1 North, Range 10 West;

Thence Easterly along the South line of Sections 18, 17, 16 and 15 of said Township 1 North, Range 10 West to the Southwest corner of Section 14;

Thence Northerly along the West line of Section 14 to the Northwest corner of the South half of Section 14;

Thence Easterly along the North line of the South half of Section 14 to the East line of said section;

Thence Northerly along the East line of said Section 14, and continuing Northerly along the West line of Section 12 of said Township 1 North, Range 10 West to the North line of said Section 12;

Thence Easterly along the North line of said Section 12, to the Northeast corner of said Section 12, said corner being also the Southwest corner of Section 6, Township 1 North, Range 9 West;

Thence Northerly along the West line of said Section 6 and continuing Northerly along West line of Sections 31 and 30, Township 2 North, Range 9 West to the Westerly prolongation of the North line of said Section 30;

Thence Easterly along said Westerly prolongation of the North line of said Section 30 and continuing Easterly along the North line of Section 29 to the Northeast corner of said Section 29;

Thence Southerly along the East line of said Section 29 and continuing Southerly along the East line of Section 32, Township 2 North, Range 9 West, and thence continuing Southerly along the East line of Section 5, Township 1 North, Range 9 West to the Southeast corner of said Section 5;

Thence Westerly along the South line of said Section 5 to the Southwest corner of said Section 5, said point being also the Northwest corner of Section 8;

Thence Southerly along the West line of said Section 8 and continuing Southerly along the West line of Section 17, to the Southwest corner of said Section 17, said corner being also the Northwest corner of Section 20;

Thence Easterly along the North line of Sections 20 and 21 to the Northwest corner of Section 22, said corner being also the Southwest corner of Section 15;

Thence Northerly along the West line of said Section 15 to the Northwest corner of the South half of said Section 15;

Thence Easterly along the North line of said South half of Section 15 to the Northeast corner of said South half of Section 15;

Thence Southerly along the East line of Section 15 and continuing Southerly along the East line of Section 22 to the Southeast corner of said Section 22, said point being also the Southwest corner of Section 23;

Thence Easterly along the South line of Sections 23 and 24 to the East line of the West half of said Section 24;

Thence Northerly along said East line of the West half of Section 24 to the North line thereof;

Thence Easterly along said North line of Section 24 to the Northeast corner thereof, said point also being the Northwest corner of Section 19, Township 1 North, Range 8 West;

Thence continuing Easterly along the North line of Section 19 and Section 20 of said Township 1 North, Range 8 West to the Northeast corner of said Section 20;

Thence Southerly along the East line of Sections 20, 29 and 32 of said Township 1 North, Range 8 West to the Southeast corner of said Section 32;

Thence Westerly along the South line of Section 32 to the Northwest corner of the East half of Section 5, Township 1 South, Range 8 West;

Thence Southerly along the West line of the East half of said Section 5 to the South line of said Section 5;

Thence West to the East line of the Northerly prolongation of Range 9 West;

Thence South 67° 30' West to an intersection with the Northerly prolongation of the West line of Section 27, Township 1 South, Range 9 West;

Thence Southerly along the Northerly prolongation of said West line of Section 27 and continuing Southerly along the West line of Section 27 to the Southwest corner of said Section 27, said point being also the Southeast corner of Section 28;

Thence Westerly along the South line and Westerly projection of the South line of said Section 28 to the Northerly prolongation of the West line of Range 9 West;

Thence Southerly along said prolongation of the West line of Range 9 West to the Westerly prolongation of the North line of Township 2 South;

Thence Westerly along said Westerly prolongation of the North line of Township 2 South, a distance of 8,500 feet;

Thence South a distance of 4,500 feet;

Thence West a distance of 10,700 feet;

Thence South 29° West to an intersection with the Northerly prolongation of the West line of Section 20, Township 2 South, Range 10 West;

Thence Southerly along said Northerly prolongation of the West line of said Section 20 and continuing Southerly along the West line of Section 20 to the Southwest corner of said Section 20;

Thence South a distance of 2,000 feet;

Thence West a distance of two miles, more or less, to an intersection with the East line of Section 26, Township 2 South, Range 11 West;

Thence Northerly along said East line of Section 26 and continuing Northerly along the East line of Section 23, Township 2 South, Range 11 West to the Northeast corner of said Section 23;

Thence Westerly along the North line of said Section 23 to the Northwest corner thereof, said point being also the Southeast corner of Section 15, Township 2 South, Range 11 West;

Thence Northerly and Westerly along the East and North lines, respectively, of said Section 15, Township 2 South, Range 11 West, to the Northwest corner thereof;

Thence continuing Westerly along the Westerly prolongation of said North line of Section 15, Township 2 South, Range 11 West to an intersection with a line parallel to and one mile East of the West line of Range 11 West;

Thence Northerly along said parallel line to an intersection with the Northerly boundary of the City of Pico Rivera as said City of Pico Rivera existed on July 17, 1970;

Thence Westerly along said City boundary to an intersection with the East line of Range 12 West;

Thence Northerly along said East line of Range 12 West to the North line of Township 2 South;

Thence Westerly along the North line of Township 2 South to an intersection with the Southerly prolongation of the East line of the West half of Section 26, Township 1 South, Range 12 West;

Thence Northerly along said Southerly prolongation of said East line of the West half of said Section 26 to the Southeast corner of said West half;

Thence Westerly along the South line of Sections 26, 27 and 28, Township 1 South, Range 12 West, to the Southeast corner of Section 29, Township 1 South, Range 12 West;

Thence Northerly along the East line of said Section 29 to the Northeast corner of the South half of said Section 29;

Thence Westerly along the North line of the South half of said Section 29 to the Northwest corner thereof;

Thence Northerly along the West line of Sections 29, 20, 17 and 8, Township 1 South, Range 12 West;

Thence continuing Northerly along the Northerly prolongation of the West line of Section 8, Township 1 South, Range 12 West to an intersection with the North line of Township 1 South;

Thence Easterly along said North line of Township 1 South to the Northeast corner of Section 3, Township 1 South, Range 12 West;

Thence North 64° 30′ East to an intersection with the West line of Section 23, Township 1 North, Range 11 West;

Thence Northerly along the West line of said Section 23 to the Northwest corner thereof, said point being the Southwest corner of Section 14, Township 1 North, Range 11 West and said point being also the point of beginning.

Exhibit "C"

TABLE
SHOWING BASE
ANNUAL DIVERSION
RIGHTS OF CERTAIN
DIVERTERS

	Base Annual Diversion Right Acre-Feet
Covell, Ralph (Successor to Rittenhouse, Catherine and Rittenhouse, James)	2.12
Maddock, A. G.	3.40
Rittenhouse, Catherine (Transferred to Covell, Ralph)	0
Rittenhouse, James (Transferred to Covell, Ralph)	0
Ruebhausen, Arline (Held in common with Ruebhausen, Victor) (Transferred to City of Glendale)	0
Ruebhausen, Victor (See Ruebhausen, Arline, above)	0
TOTAL	5.52

Exhibit "D"

TABLE
SHOWING PRESCRIPTIVE PUMPING RIGHTS
AND PUMPER'S SHARE OF EACH PUMPER
AS OF JUNE, 1988

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share Percent (%)
Adams Ranch Mutual Water Company	100.00	0.05060
A & E Plastik Pak Co., Inc. (Transferred to Industry Properties, Ltd.)	0	0
Alhambra, City of	8,812.05	4.45876
Amarillo Mutual Water Company	709.00	0.35874
Anchor Plating Co., Inc. (Successor to Bodger & Sons) (Transferred to Crown City Plating Co.)	0	0
Anderson, Ray L. and Helen T., Trustees (Successor to Covina-Valley Unified School District)	50.16	0.02538
Andrade, Marcario and Consuelo; and Andrade, Robert and Jayne (Successor to J. F. Isbell Estate, Inc.)	8.36	0.00423
Arcardia, City of	9,252.00	4.68137
(Successor to First National Finance Corporation)	60.90	0.03081
(Transferred to City of Monrovia)	951.00	0.48119
	8,361.90	4.23099
Associated Southern Investment Company (Transferred to Southern California Edison Company)	0	0
AZ-Two, Inc. (Lessee of Southwestern Portland Cement Co.)	0	0
Azusa, City	3,655.99	1.84988
Azusa-Western Inc. (Transferred to Southwestern Portland Cement Co.)	0	0
Bahnsen & Beckman Ind., Inc. (Transferred to Woodland, Richard)	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Bahnsen, Betty M. (Transferred to Dawes, Mary Kay)	0	0
Baldwin Park County Water District (See Valley County Water District)	-	-
Banks, Gale C. (Successor to Doyle, Mr. and Mrs.; and Madruga, Mr. and Mrs.)	50.00	0.02530
Base Line Water Company	430.20	0.21767
Beverly Acres Mutual Water Company	93.00	0.04706
Birenbaum, Max (Held in common with Birenbaum, Sylvia; Schneiderman, Alan; Schneiderman, Lydia; Wigodsky, Bernard; Wigodsky, Estera) (Transferred to City of Whittier)	0	0
Birenbaum, Sylvia (See Birenbaum, Max)	-	-
Blue Diamond Concrete Materials Div., The Flintkote Company (Transferred to Sully-Miller Contracting Co.)	0	0
Bodger & Sons DBA Bodger Seeds Ltd. (Transferred to Anchor Plating Co., Inc.)	0	0
Botello Water Company	0	0
Burbank Development Company	50.65	0.02563
Cadway, Inc. (Successor to:		
Corcoran, Jack S. and R. L.)	100.00	0.05060
Corcoran, Jack S. and R. L.)	100.00	0.05060
	200.00	0.10120
Cal Fin (Transferred to Suburban Water Systems)	0	0
California-American Water Company (San Marino System)	7,868.70	3.98144
California Country Club	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
California Domestic Water Company	11,024.82	5.57839
(Successor to:		
Cantrill Mutual Water Company	42.50	0.02150
Industry Properties, Ltd.	73.50	0.03719
Modern Accent Corporation	256.86	0.12997
Fisher, Russell)	19.00	0.00961
	11,416.68	5.77666
California Materials Company	0	0
Cantrill Mutual Water Company (Transferred to California Domestic Water Co.)	0	0
Cedar Avenue Mutual Water Company	121.10	0.06127
Champion Mutual Water Company	147.68	0.07472
Chronis, Christine (See Polopolus, et al)	-	-
Clayton Manufacturing Company	511.80	0.25896
Collison, E. O.	0	0
Comby, Erma M. (See Wilmott, Erma M.)	-	-
Conrock Company		
(Formerly Consolidated Rock Products Co.)	1,465.35	0.74144
(Successor to Manning Bros. Rock & Sand Co.)	328.00	0.16596
	1,793.35	0.90740
Consolidated Rock Products Co. (See Conrock Company)	-	-
Corcoran, Jack S.		
(Held in common with Corcoran, R. L.)		
(Transferred to:	747.00	0.37797
Cadway, Inc.	100.00	0.05060
Cadway, Inc.)	100.00	0.05060
	547.00	0.27677
Corcoran, R. L. (See Corcoran, Jack S.)	-	-
County Sanitation District No. 18 of Los Angeles County	4.50	0.00228

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Covell, et al. (Successor to Rittenhouse, Catherine and Rittenhouse, James) (Held in common with Jobe, Darr; Goedert, Lillian E.; Goedert, Marion W.; Lakin, Kendall R.; Lakin, Kelly R.; Snyder, Harry)	111.05	0.05619
Covina, City of	2,507.89	1.26895
(Transferred to Covina Irrigating Company)	1,734.00	0.87737
(Transferred to Covina Irrigating Company)	300.00	0.15179
	473.89	0.23979
Covina-Valley Unified School District (Transferred to Anderson, Ray)	0	0
Crevolin, A. J.	2.25	0.00114
Crocker National Bank, Executor of the Estate of A. V. Handorf (Transferred to Modern Accent Corp.)	0	0
Cross Water Company (Transferred to City of Industry)	0	0
Crown City Plating Company	190.00	0.09614
(Successor to Anchor Plating Co., Inc.)	10.00	0.00506
	200.00	0.10120
Davidson Optronics, Inc.	22.00	0.01113
Dawes, Mary Kay (Successor to Bahnsen, Betty M.)	441.90	0.22359
Del Rio Mutual Water Company	199.00	0.10069
Denton, Kathryn W., Trustee for San Jose Ranch Company (Transferred to White, June G., Trustee of the June G. White Share of the Garnier Trust)	0	0
Doyle, Mr. and Mrs.; and Madruga, Mr. and Mrs. (Successor to Sawpit Farms, Ltd.) (Transferred to Banks, Gale C.)	0	0
Driftwood Dairy	163.80	0.08288
Duhalde, L. (Transferred to El Monte Union High School District)	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Dunning, George (Held in common with Dunning, Vera H.) (Successor to Vera H. Dunning)	324.00	0.16394
Dunning, Vera H. (Transferred to George Dunning)	-	-
East Pasadena Water Company, Ltd.	1,407.69	0.71227
Eckis, Rollin (Successor to Sawpit Farms, Ltd.) (Transferred to City of Monrovia)	0	0
El Encanto Properties (Transferred to La Puente Valley County Water District)	0	0
El Monte, City of	2,784.23	1.40878
El Monte Cemetary Association	18.50	0.00936
El Monte Union High School District (Successor to Duhalde, L.) (Transferred to City of Whittier)	0	0
Everett, Mrs. Alda B. (Held in common with Everett, W. B., Executor of the Estate of I. Worth Everett)	0	0
Everett, W. B., Executor of the Estate of I. Worth Everett (See Everett, Mrs. Alda B.)	-	-
Faix, Inc. (Successor to Frank F. Pellissier & Sons, Inc.) (Transferred to Faix, Ltd.)	0	0
Faix, Ltd. (Successor to Faix, Inc.)	6,490.00	3.28384
First National Finance Corporation (Transferred to City of Arcadia)	0	0
Fisher, Russell (Held in common with Hauch, Edward and Warren, Clyde) (Transferred to California Domestic Water Company)	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Frank F. Pellissier & Sons, Inc. (Transferred to Faix, Inc.)	0	0
Fruit Street Water Company (Transferred to: Gifford, Brooks, Jr. City of La Verne)	0	0
Gifford, Brooks, Jr. (Successor to: Fruit Street Water Co., Mission Gardens Mutual Water Company) (Transferred to City of Whittier)	0	0
Gilkerson, Frank B. (Transferred to Jobe, Darr)	-	-
Glendora Unified High School District (Transferred to City of Glendora)	0	0
Goedert, Lillian E. (See Covell, et al)	-	-
Goedert, Marion W. (See Covell, et al)	-	-
Graham, William (Transferred to Darr Jobe)	-	-
Green, Walter	71.70	0.03628
Grizzle, Lissa B. (Held in common with Grizzle, Mervin A.; Wilson, Harold R.; Wilson, Sarah C.) (Transferred to City of Whittier)	0	0
Grizzle, Mervin A. (See Grizzle, Lissa B.)	0	0
Hansen, Alice	0.75	0.00038
Hartley, David	0	0
Hauch, Edward (See Fisher, Russell)	0	0
Hemlock Mutual Water Company	166.00	0.08399

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Hollenbeck Street Water Company (Transferred to Suburban Water Systems)	0	0
Hunter, Lloyd F. (Successor to R. Wade)	4.40	0.00223
Hydro-Conduit Corporation	0	0
Industry Waterworks System, City of (Successor to Cross Water Company)	1,103.00	0.55810
Industry Properties, Ltd. (Successor to A & E Plastik Pak Co., Inc.) (Transferred to California Domestic Water Co.)	0	0
J. F. Isbell Estate, Inc. (Transferred to Andrade, Macario and Consuelo; and Andrade, Robert and Jayne)	0	0
Jerris, Helen (See Polopolus, et al)	-	-
Jobe, Darr (See Covell, et al)	-	-
Kirklen Family Trust (Formerly Kirklen, Dawn L.)		
(Held in common with Kirklen, William R.)	375.00	0.18974
(Successor to San Dimas-La Verne	62.50	0.03162
Recreational Facilities Authority)	437.50	0.22136
Kirklen, Dawn L. (See Kirklen Family Trust)	-	-
Kirklen, William R. (See Kirklen, Dawn L.)	-	-
Kiyan, Hideo (Held in common with Kiyan, Hiro)	30.00	0.01518
Kiyan, Hiro (See Kiyan, Hideo)	-	-
Knight, Kathryn M. (Successor to William Knight)	227.88	0.11530
Knight, William (Transferred to Kathryn M. Knight)	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Lakin, Kelly R. (See Covell, et al)	-	-
Lakin, Kendall R. (See Covell, et al)	-	-
Landeros, John	0.75	0.00038
La Grande Source Water Company (Transferred to Suburban Water Systems)	0	0
Lang, Frank (Transferred to San Dimas-La Verne Recreational Facilities Authority)	0	0
La Puente Cooperative Water Company (Transferred to Suburban Water Systems)	0	0
La Puente Valley County Water District (Successor to El Encanto Properties)	1,097.00 33.40 1,130.40	0.55507 0.01690 0.57197
La Verne, City of (Successor to Fruit Street Water Co.)	250.00 105.71 355.71	0.12650 0.05349 0.17999
Lee, Paul M. and Ruth A.; Nasmyth, Virrginia; Nasmyth, John	0	0
Little John Dairy	0	0
Livingston-Graham, Inc.	1,824.40	0.92312
Los Flores Mutual Water Company (Transferred to City of Monterey Park)	0	0
Loucks, David	3.00	0.00152
Manning Bros. Rock & Sand Co. (Transferred to Conrock Company)	0	0
Maple Water Company	118.50	0.05996
Martinez, Frances Mercy (Held in common with Martinez, Jaime)	0.75	0.00038
Martinez, Jaime (See Martinez, Frances Mercy)	-	-
Massey-Ferguson Company	0	0

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Miller Brewing Company	111.01	0.05617
(Successor to:		
Maechtlen, Estate of J. J.	151.50	0.07666
Phillips, Alice B., et al)	50.00	0.02530
	312.51	0.15813
Mission Gardens Mutual Water Company (Transferred to Gifford, Brooks, Jr.)	0	0
Modern Accent Corporation (Successor to Crocker National Bank, Executor of the Estate of A. V. Handorf) (Transferred to California Domestic Water Co.)	0	0
Monterey Park, City of	6,677.48	3.37870
(Successor to Los Flores Mutual Water Co.)	26.60	0.01346
	6,704.08	3.39216
Murphy Ranch Mutual Water Company (Transferred to Southwest Suburban Water)	0	0
Namimatsu Farms (Transferred to California Cities Water Company)	0	0
Nick Tomovich & Sons	0.02	0.00001
No. 17 Walnut Place Mutual Water Co. (Transferred to San Gabriel Valley Water Company)	0	0
Orange Production Credit Association	0	0
Owl Rock Products Co.	715.60	0.36208
Pacific Rock & Gravel Co. (Transferred to: City of Whittier Rose Hills Memorial Park Association)	0	0
Park Water Company (Transferred to Valley County Water District)	0	0
Penn, Margaret (See Polopolus, et al)	-	-
Pico County Water District	0.75	0.00038
Polopolus, John (See Polopolus, et al)	-	-

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Polopolus, et al (Successor to Polopolus, Steve) (Held in common with Chronis, Christine; Jerris, Helen; Penn, Margaret; Polopolus, John)	22.50	0.01138
Polopolus, Steve (Transferred to Polopolus, et al)	-	-
Rados, Alexander (Held in common with Rados, Stephen and Rados, Walter)	43.00	0.02176
Rados, Stephen (See Rados, Alexander)	-	-
Rados, Walter (See Rados, Alexander)	-	-
Richwood Mutual Water Company	192.60	0.09745
Rincon Ditch Company	628.00	0.31776
Rincon Irrigation Company	314.00	0.15888
Rittenhouse, Catherine (Transferred to Covell, Ralph)	0	0
Rittenhouse, James (Transferred to Covell, Ralph)	0	0
Rose Hills Memorial Park Association	594.00	0.30055
(Successor to Pacific Rock & Gravel Co.)	200.00	0.10120
	794.00	0.40175
Rosemead Development, Ltd. (Successor to Thompson, Earl W.)	1.00	0.00051
Rurban Homes Mutual Water Company	217.76	0.11018
Ruth, Roy	0.75	0.00038
San Dimas-La Verne Recreational Facilities Authority (Successor to Lang, Frank) (Transferred to Kirklen, Dawn L. and William R.)	0	0
San Gabriel Country Club	286.10	0.14476
San Gabriel County Water District	4,250.00	2.15044

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
San Gabriel Valley Municipal Water District	0	0
San Gabriel Valley Water Company	16,659.00	8.42920
(Successor to:		
Vallecito Water Co.	2,867.00	1.45066
No. 17 Walnut Place Mutual Water Co.)	21.50	0.01088
	19,547.50	9.89074
Sawpit Farms, Limited (Transferred to: Eckis, Rollin Doyle and Madruga)	0	0
Schneiderman, Alan (See Birenbaum, Max)	-	-
Schneiderman, Lydia (See Birenbaum, Max)	-	-
Security Pacific National Bank, Co-Trustee for the Estate of Winston F. Stoody (See Stoody, Virginia A.) (Transferred to City of Whittier)	0	0
Sierra Madre, City of	0	0
Sloan Ranches	129.60	0.06558
Smith, Charles	0	0
Snyder, Harry (See Covell, et al)	-	-
Sonoco Products Company	311.60	0.15766
South Covina Water Service	992.30	0.50209
Southern California Edison Company	155.25	0.07855
(Successor to: Associated Southern Investment Company)	16.50	0.00835
	171.75	0.08690
Southern California Water Company, San Gabriel Valley District	5,773.00	2.92105
South Pasadena, City of	3,567.70	1.80520
Southwest Suburban Water (See Suburban Water Systems)	-	-

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Southwestern Portland Cement Company (Successor to Azusa Western, Inc.)	742.00	0.37544
Speedway 605, Inc.	0	0
Standard Oil Company of California	2.00	0.00101
Sterling Mutual Water Company	120.00	0.06072
Stoody, Virginia A., Co-Trustee for the Estate of Winston F. Stoody (See Security Pacific National Bank, Co-Trustee)	-	-
Suburban Water Systems (Formerly Southwest Suburban Water) (Successor to:	20,462.47	10.35370
Hollenbeck Street Water Company	646.39	0.32706
La Grande Source Water Company	1,078.00	0.54545
La Puente Cooperative Water Co.	1,210.90	0.61270
Valencia Valley Water Company	651.50	0.32965
Victoria Mutual Water Company	469.60	0.23761
Cal Fin	118.10	0.05976
Murphy Ranch Mutual Water Co.	223.23	0.11295
	24,860.19	12.57888
Sully-Miller Contracting Company (Successor to Blue Diamond Concrete Materials Division, The Flintkote Co.)	1,399.33	0.70804
Sunny Slope Water Company	2,228.72	1.12770
Taylor Herb Garden (Transferred to Covina Irrigating Company)	0	0
Texaco, Inc.	50.00	0.02530
Thompson, Earl W. (Held in common with Thompson, Mary) (Transferred to Rosemead Development, Ltd.)	0	0
Thompson, Mary (See Thompson, Earl W.)	-	-
Tyler Nursery	3.21	0.00162
United Concrete Pipe Corporation (See U. S. Pipe & Foundry Company)	-	-

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
U. S. Pipe & Foundry Company (Formerly United Concrete Pipe Corporation)	376.00	0.19025
Valencia Heights Water Company	861.00	0.43565
Valencia Valley Water Company (Transferred to Suburban Water Systems)	0	0
Vallecito Water Company (Transferred to San Gabriel Valley Water Company)	0	0
Valley County Water District (Formerly Baldwin Park County Water District) (Successor to Park Water Company)	5,775.00 184.01 5,959.01	2.92206 0.09311 3.01517
Valley Crating Company	0	0
Valley View Mutual Water Company	616.00	0.31169
Via, H. (See Via, H., Trust of)	-	-
Via, H., Trust of (Formerly Via, H.)	46.20	0.02338
Victoria Mutual Water Company (Transferred to Suburban Water Systems)	0	0
Wade, R. (Transferred to Lloyd F. Hunter)	0	0
Ward Duck Company	1,217.40	0.61599
Warren, Clyde (See Fisher, Russell)	-	-
W. E. Hall Company	0.20	0.00010
White, June G., Trustee of the June G. White Share of the Garnier Trust (Successor to Denton, Kathryn W., Trustee for the San Jose Ranch Company)	185.50	0.09386

Pumper	Prescriptive Pumping Right Acre-feet	Pumper's Share %
Whittier, City of	7,620.23	3.85572
(Successor to:		
Grizzle, Lissa B.	184.00	0.09310
Pacific Rock and Gravel Co.)	208.00	0.10524
Security Pacific National Bank,		
Co-Trustee for the Estate of Winston F. Stoody	38.70	0.01958
El Monte Union High School District	16.20	0.00820
Gifford, Brooks, Jr.	198.25	0.10031
Birenbaum, Max)	6.00	0.00304
	8,271.38	4.18519
Wigodsky, Bernard (See Birenbaum, Max)	-	-
Wigodsky, Estera (See Birenbaum, Max)	-	-
Wilmott, Erma M. (Formerly Comby, Erma M.)	0.75	0.00038
Wilson, Harold R. (See Grizzle, Lissa B.)	-	-
Wilson, Sarah C. (See Grizzle, Lissa B.)	-	-
Woodland, Frederick G.	-	-
Woodland, Richard (Successor to: Bahnsen and Beckman Ind., Inc.)	840.50	0.42528
Totals for Exhibit "D"	**155,800.68**	**78.83276**
Totals from Exhibit "E"	41 833.75 ~~38,026.25~~	21.16724 ~~19.54431~~
GRAND TOTALS	**197,634.43**	**100.00000**

TABLE
SHOWING PRODUCTION RIGHTS
OF EACH
INTEGRATED PRODUCER
AS OF JUNE 1988

Party	Diversion Component Acre-feet	Prescriptive Pumping Component Acre-feet	Pumping Component Share Percent (%)
Azusa Agricultural Water Company	1,000.00	1,732.20	0.87647
Azusa Foot-Hill Citrus Water Company (Transfered to Monrovia Nursery Company)	0	0	0
Azusa Valley Water Company	2,422.00	8,274.00	4.18652
California-American Water Company (Duarte System)	1,672.00	3,649.00	1.84634
California Cities Water Company (See Southern California Water Company, San Dimas District)	-	-	-
Covina Irrigating Company	2,514.00	4,140.00	2.09478
(Successor to:			
City of Covina,		1,734.00	0.87737
City of Covina, and		300.00	0.15179
Taylor Herb Garden)		6.00	0.00304
	2,514.00	6,180.00	3.12698
Glendora, City of	17.00	8,258.00	4.17842
(Successor to:			
Maechtlen, Estate of J. J.,		150.00	0.07590
Maechtlen, Trust of P. A.,		50.00	0.02530
Ruebhausen, Arline, and	18.34		
Glendora Unified High School District)		9.00	0.05009
	35.34	8,557.00	4.32971
Los Angeles, County of	310.00	3,721.30	1.88292
Maechtlen, Estate of J. J.	0	301.50	0.15256
(Transferred to:			
City of Glendora		-150.00	-0.07590
Miller Brewing Company)		-151.50	-0.07666
	0	0	0

Party	Diversion Componet Acre-feet	Prescriptive Pumping Component Acre-feet	Pumping Component Share %
Maechtlen, Estate of J. J.	1.49	0	0
Maechtlen, Trust of P. A.	0.50	100.50	0.05085
(Transferred to:			
City of Glendora		-50.00	-0.02530
Alice B. Phillips, et al)	-0.50	-50.50	-0.02555
	0	0	0
The Metropolitan Water District of Southern California	9.59	165.00	0.08349
Monrovia, City of	1,098.00	5,042.22	2.55129
(Sucessor to:			
Eckis, Rollin		123.00	0.06224
City of Arcadia)		951.00	0.48119
	1,098.00	6,116.22	3.09472
Monrovia, Nursery Company	239.50	0	0
(Successor to:			
Azusa Foot-Hill Citrus Co.)	718.50	0	
Phillips, Alice B., et al			
(Successor to:			
Maechtlen, Trust of P. A.)	0.50	50.50	0.02530
(Transferred to:			
Miller Brewing Company)		-50.00	-0.02530
	0.50	0.50	0.00025
Southern California Water Company (San Dimas Dist.)	500.00	3,242.53	1.64076
(Formerly California Cities Water Company)			
(Successor to:			
Namimatsu Farms)		196.00	0.09917
	500.00	3,438.53	1.73984
TOTAL for Exhibit "E"	10,520.92	41,833.75	21.16724

Exhibit "F"

TABLE SHOWING
SPECIAL CATAGORY RIGHTS

PARTY	Nature of Right
The Metropolitan Water District of Southern California	Morris Reservoir Storage and Withdrawal (a) A right to divert, store and use San Gabriel River Water, pursuant to Permit No. 7174. (b) Prior and paramount right to divert 72 acre-feet annually to offset Morris Reservoir evaporation and seepage losses and to provide the water supply necessary for presently existing incidential Morris Dam facilities.
Los Angeles County Flood Control District (Now Los Angeles County Department of Public Works)	Puddingstone Reservoir Prior Prescriptive right to divert water from San Dimas Wash for storage in Puddingstone Reservoir in quantities sufficient to offset annual evaporation and seepage losses of the reservoir at approximate elevation 942.

Exhibit "G"

TABLE SHOWING
NON-CONSUMPTIVE USERS

Party	Nature of Right
Covina Irrigating Company Azusa Valley Water Company Azusa Agricultural Water Co. Azusa Foot-Hill Citrus Co. Monrovia Nursery Company	"Committee-of-Nine" Spreading Right To continue to divert water from the San Gabriel River pursuant to the 1888 Settlement, and to spread in spreading grounds within the Basin all water thus diverted without the right to recapture water in excess of said parties' rights as adjudicated in Exhibit "E".
California-American Water Company (Duarte System)	Spreading Right To continue to divert water from the San Gabriel River pursuant to the 1888 Settlement, and to continue to divert water from Fish Canyon and to spread said waters in its spreading grounds in the Basin without the right to recapture water in excess of said party's rights as adjudicated in Exhibit "E".
City of Glendora	Spreading Right To continue to spread the water of Big and Little Dalton Washes, pursuant to License No. 2592 without the right to recapture water in excess of said party's rights as adjudicated in Exhibit "E".
San Gabriel Valley Protective Association	Spreading Right To continue to spread San Gabriel River water pursuant to License Nos. 9991 and 12,209, without the right to recapture said water.
California Cities Water Company	Spreading Right To continue to spread waters from San Dimas Wash without the right to recapture water in excess of said party's rights as adjudicated in Exhibit "E".
Los Angeles County Flood Control District	Temporary storage of storm flow for regulatory purposes; Spreading and conservation for general benefit in streambeds, reservoirs and spreading grounds without the right to recapture said water. Maintenance and operation of dams and other flood control works.

EXHIBIT "H"

WATERMASTER OPERATING CRITERIA

1. Basin Storage Capacity. The highest water level at the end of a water year during the past 40 years was reached at the Key Well on September 30, 1944 (elevation 316). The State of California, Department of Water Resources, estimates that as of that date, the quantity of fresh water in storage in the Basin was approximately 8,600,000 acre-feet. It is also estimated by said Department that by September 30, 1960, the quantity of fresh water in storage had decreased to approximately 7,900,000 acre-feet (elevation 237) at the Key Well).

The lowest water level at the end of a water year during the past 40 years was reached at the Key Well on September 30, 1965 (elevation 209). It is estimated that the quantity of fresh water in storage in the Basin on that date was approximately 7,700,000 acre-feet.

Thus, the maximum utilization of Basin storage was approximately 900,000 acre-feet, occurring between September 30, 1944, and September 30, 1965 (between elevations 316 and 209 at the Key Well). This is not to say that more than 900,000 acre-feet of storage space below the September 30, 1944 water levels cannot be utilized. However, it demonstrates that pumpers have deepened their wells and lowered their pumps so that such 900,000 acre-feet of storage can be safely and economically utilized.

The storage capacity of the Basin between elevations of 200 and 250 at the Key Well represents a usable volume of approximately 400,000 acre-feet of water.

2. Operating Safe Yield and Spreading. Watermaster in determining Operating Safe Yield and the importation of Replacement Water shall be guided by water level elevations in the Basin. He shall give recognition to, and base his operations on, the following general objectives insofar as practicable:

(a) The replenishment of ground water from sources of supplemental water should not cause excessively high levels of ground water and such replenishment should not cause undue waste of local water supplies.

(b) Certain areas within the Basin are not at the present time capable of being recharged with supplemental water. Efforts should be made to provide protection to such areas from excessive ground water lowering either through the "in lieu" provisions of the Judgment or by other means.

(c) Watermaster shall consider and evaluate the long-term consequences on ground water quality, as well as quantity, in determining and establishing Operating Safe Yield. Recognition shall be given to the enhancement of ground water quality insofar as practicable, especially in the area immediately upstream of Whittier Narrows where degradation of water quality may occur when water levels at the Key Well are maintained at or below elevation 200.

(d) Watermaster shall take into consideration the comparative costs of supplemental and Make-up Water in determining the savings on a present value basis of temporary or permanent lowering or raising of water levels and other economic data and analyses indicating both the short-term and long-term propriety of adjusting Operating Safe Yield in order to derive optimum water levels during any period. Watermaster shall utilize the provisions in the Long Beach Judgment which will result in the least cost of delivering Make-up Water.

3. Replacement Water -- Sources and Recharge Criteria. The following criteria shall control purchase of Replacement Water and Recharge of the Basin by Watermaster.

(a) Responsible Agency From Which to Purchase. Watermaster, in determining the Responsible Agency from which to purchase supplemental water for replacement purposes, shall be governed by the following:

(1) Place of Use of Water which is used primarily within the Basin or by cities within San Gabriel District in areas within or outside the Basin shall control in determining the Responsible Agency. For purposes of this subparagraph, water supplied through a municipal water system which lies chiefly within the Basin shall be deemed entirely used within the Basin; and

(2) Place of production of water shall control in determining the Responsible Agency as to water exported from the Basin, except as to use within San Gabriel District.

Any Responsible Agency may, at the request of Watermaster, waive its right to act as the source for such supplemental water, in which case Watermaster shall be free to purchase such water from the remaining Responsible Agencies which are the most beneficial and appropriate sources; provided, however, that a Responsible Agency shall not authorize any sale of water in violation of the California Constitution.

(b) Water Quality. Watermaster shall purchase the best quality of supplemental water available for replenishment of the Basin, pursuant to subsection (a) hereof.

(c) Reclaimed Water. It is recognized that the technology and economic and physical necessity for utilization of reclaimed water is increasing. The purchase of reclaimed water in accordance with the Long Beach Judgment to satisfy the Make-up Obligation is expressly authorized. At the same time, water quality problems involved in the reuse of water within the Basin pose serious questions of increased costs and other problems to the pumpers, their customers and all water users. Accordingly, Watermaster is authorized to gather information, make and review studies, and make recommendations on the feasibility of the use of reclaimed water for replacement purposes; provided that no reclaimed water shall be recharged in the Basin by Watermaster without the prior approval of the court, after notice to all parties and hearing thereon.

4. Replacement Assessment Rates. The Replacement Assessment rates shall be in an amount calculated to allow Watermaster to purchase one acre-foot of supplemental water for each acre-foot of excess Production to which such Assessment applies.

EXHIBIT "J"

PUENTE NARROWS AGREEMENT

THIS AGREEMENT is made and entered into as of the 8th day of May, 1972, by and between PUENTE BASIN WATER AGENCY, herein called "Puente Agency", and UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT, herein called "Upper District".

A. RECITALS

1. Puente Agency. Puente Agency is a joint powers agency composed of Walnut Valley Water District, herein called "Walnut District", and Rowland Area County Water District, herein called "Rowland District". Puente Agency is formed for the purpose of developing and implementing a ground water basin management program for Puente Basin. Pursuant to said purpose, said Agency is acting as a representative of its member districts and of the water users and water right claimants therein in the defense and maintenance of their water rights within Puente Basin.

2. Upper District. Upper District is a municipal water district overlying a major portion of the Main San Gabriel Basin. Upper District is plaintiff in the San Gabriel Basin Case, wherein it seeks to adjudicate rights and implement a basin management plan for the Main San Gabriel Basin.

3. Puente Basin is a ground water basin tributary to the Main San Gabriel Basin. Said area was included within the scope of the San Gabriel Basin Case and substantially

all water rights claimants within Puente Basin were joined as defendants therein. The surface contribution to the Main San Gabriel Basin from Puente Basin is by way of the paved flood control channel of San Jose Creek, which passes through Puente Basin from the Pomona Valley area. Subsurface outflow is relatively limited and moves from the Puente Basin to the Main San Gabriel Basin through Puente Narrows.

4. Intent of Agreement. Puente Agency is prepared to assure Upper District that no activity within Puente Basin will hereafter be undertaken which will (1) interfere with surface flows in San Jose Creek, or (2) impair the subsurface flow from Puente Basin to the Main San Gabriel Basin. Walnut District and Rowland District, by operation of law and by express assumption endorsed hereon, assume the covenants of this agreement as a joint and several obligation. Based upon such assurances and the covenants hereinafter contained in support thereof, Upper District consents to the dismissal of all Puente Basin parties from the San Gabriel Basin Case. By reason of said dismissals, Puente Agency will be free to formulate a separate water management program for Puente Basin.

B. DEFINITIONS AND EXHIBITS

5. Definitions. As used in this Agreement, the following terms shall have the meanings herein set forth:

(a) Annual or Year refers to the fiscal year July 1 through June 30.

(b) Base Underflow. The underflow through

Puente Narrows which Puente Agency agrees to maintain, and on which accrued debits and credits shall be calculated.

(c) Make-up Payment. Make-up payments shall be an amount of money payable to the Watermaster appointed in the San Gabriel Basin Case, sufficient to allow said Watermaster to purchase replacement water on account of any accumulated deficit as provided in Paragraph 9 hereof.

(d) Puente Narrows. The subsurface geologic constriction at the downstream boundary of Puente Basin, located as shown on Appendix "B".

(e) Main San Gabriel Basin, the ground water basin shown and defined as such in Exhibit "A" to the Judgment in the San Gabriel Basin Case.

(f) San Gabriel Basin Case. *Upper San Gabriel Valley Municipal Water District v. City of Alhambra, et al.*, L. A. Sup. Ct. No. 924128, filed January 2, 1968.

6. Appendices. Attached hereto and by this reference made a part hereof are the following appendices:

"A" -- Location Map of Puente Basin, showing major geographic, geologic, and hydrologic features.

"B" -- Map of Cross-Section Through Puente Narrows, showing major physical features and location of key wells.

"C" -- Engineering Criteria, being a description of a method of measurement of subsurface outflow to be utilized for Watermaster purposes.

C. COVENANTS

7. Watermaster. There is hereby created a two member Watermaster service to which each of the parties to this agreement shall select one consulting engineer. The respective representatives on said Watermaster shall serve at the pleasure of the governing body of each appointing party and each party shall bear its own Watermaster expense.

a. Organization. Watermaster shall perform the duties specified herein on an informal basis, by unanimous agreement. In the event the two representatives are unable to agree upon any finding or decision, they shall select a third member to act, pursuant to the applicable laws of the State of California. Thereafter, until said issue is resolved, said three shall sit formally as a board of arbitration. Upon resolution of the issue in dispute, the third member shall cease to function further.

b. Availability of Information. Each party hereto shall, for itself and its residents and water users, use its best efforts to furnish all appropriate information to the Watermaster in order that the required determination can be made.

c. Cooperation With Other Watermasters. Watermaster hereunder shall cooperate and coordinate activities with the Watermasters appointed in the San Gabriel Basin Case and in Long Beach v. San Gabriel Valley Water Company, et al.

d. Determination of Underflow. Watermaster shall annually determine the amount of underflow from Puente Basin to the San Gabriel Basin, pursuant to Engineering Criteria.

e. Perpetual Accounting. Watermaster shall maintain a perpetual account of accumulated base underflow, accumulated subsurface flow, any deficiencies by reason of interference with surface flows, and the offsetting credit for any make-up payments. Said account shall annually show the accumulated credit or debit in the obligation of Puente Agency to Upper District.

f. Report. Watermaster findings shall be incorporated in a brief written report to be filed with the parties and with the Watermaster in the San Gabriel Basin Case. Said report shall contain a statement of the perpetual account heretofore specified.

8. Base Underflow. On the basis of a study and review of historic underflow from Puente Basin to the Main San Gabriel Basin, adjusted for the effect of the paved flood control channel and other relevant considerations, it is

mutually agreed by the parties that the base underflow is and shall be 580 acre feet per year, calculated pursuant to Engineering Criteria.

9. Puente Agency's Obligation. Puente Agency covenants, agrees and assumes the following obligation hereunder:

a. Noninterference with Surface Flow. Neither Puente Agency nor any persons or entities within the corporate boundaries of Walnut District or Rowland District will divert or otherwise interfere with or utilize natural surface runoff now or hereafter flowing in the storm channel of San Jose Creek; provided, however, that this covenant shall not prevent the use, under Watermaster supervision, of said storm channel by the Puente Agency or Walnut District or Rowland District for transmission within Puente Agency of supplemental or reclaimed water owned by said entities and introduced into said channel solely for transmission purposes. In the event any unauthorized use of surface flow in said channel is made contrary to the covenant herein provided, Puente Agency shall compensate Upper District by utilizing any accumulated credit or by make-up payment in the same manner as is provided for deficiencies in subsurface outflow from Puente Basin.

b. Subsurface Outflow. To the extent that the accumulated subsurface outflow falls below the accumulated base underflow and the result thereof is an accumulated deficit in the Watermaster's annual accounting, Puente Agency agrees to provide make-up payments during the next year in an amount not less than one-third of the accumulated deficit.

c. Purchase of Reclaimed Water. To the extent that Puente Agency or Walnut District or Rowland District may hereafter purchase reclaimed water from the facilities of Sanitation District 21 of Los Angeles County, such purchaser shall use its best efforts to obtain waters originating within San Gabriel River Watershed.

10. Puente Basin Parties Dismissal. In consideration of the assumption of the obligation hereinabove provided by Puente Agency, Upper District consents to entry of dismissals as to all Puente Basin parties in San Gabriel Basin Case. This agreement shall be submitted for specific approval by the Court and a finding that it shall operate as full satisfaction of any and all claims by the parties within Main San Gabriel Basin against Puente Basin parties by reason of historic surface and subsurface flow.

IN WITNESS WHEREOF the parties hereto have caused this Agreement to be executed as of the day and date first above written.

Approved as to form:
CLAYSON, STARK, ROTHROCK & MANN

By ______________________
Attorneys for Puente Agency

PUENTE BASIN AGENCY

By ______________________
EDMUND M. BIEDERMAN
President

Approved as to form:

By ______________________
Attorney for Upper District

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT

By ______________________
Howard H. Hawkins
President

The foregoing agreement is approved and accepted, and the same is acknowledged as the joint and several obligation of the undersigned.

Approved as to form:

____
Attorney for Walnut District

WALNUT VALLEY WATER DISTRICT

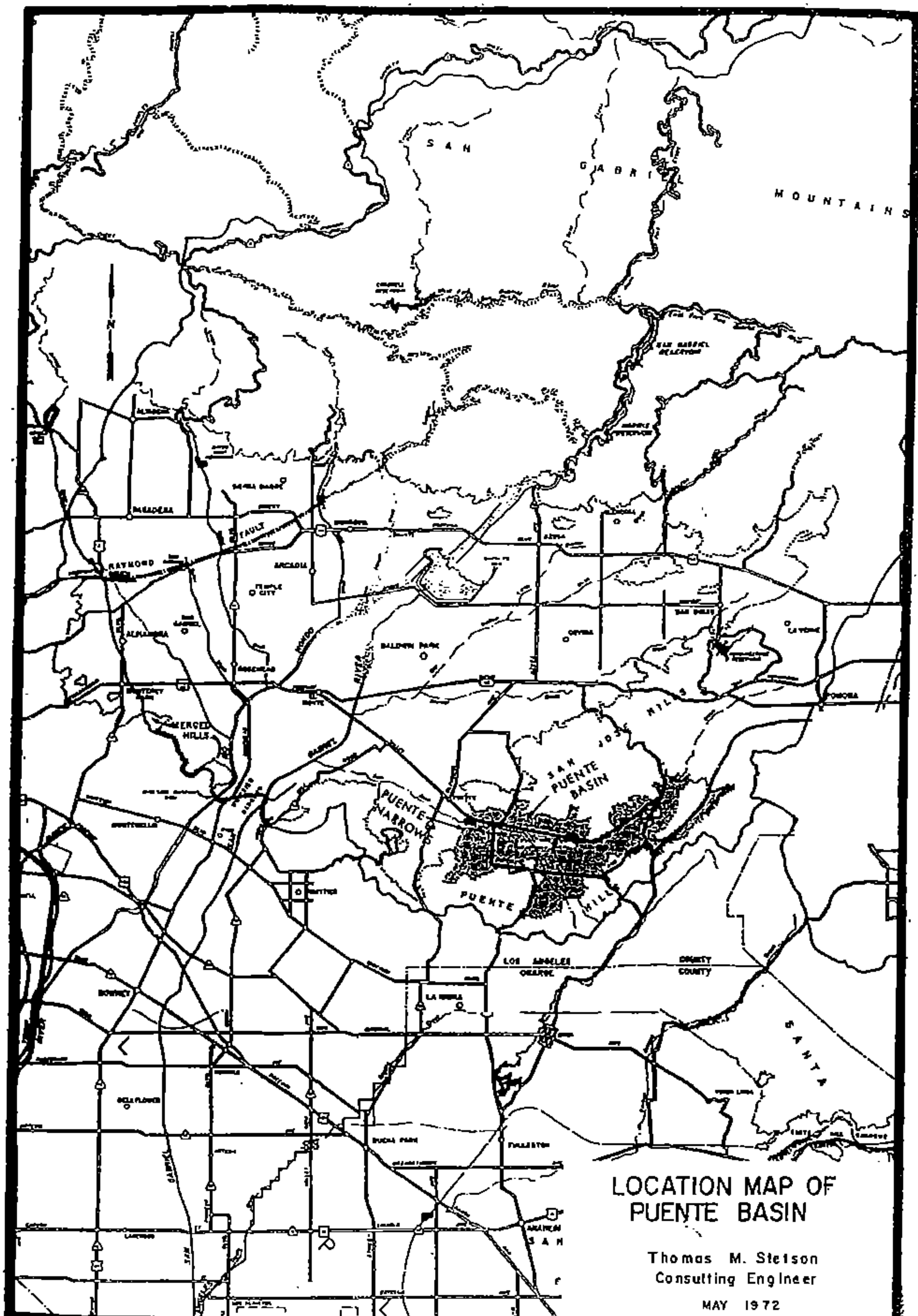
By ______________________
J. P. BOURDET
Vice President

Approved as to form:

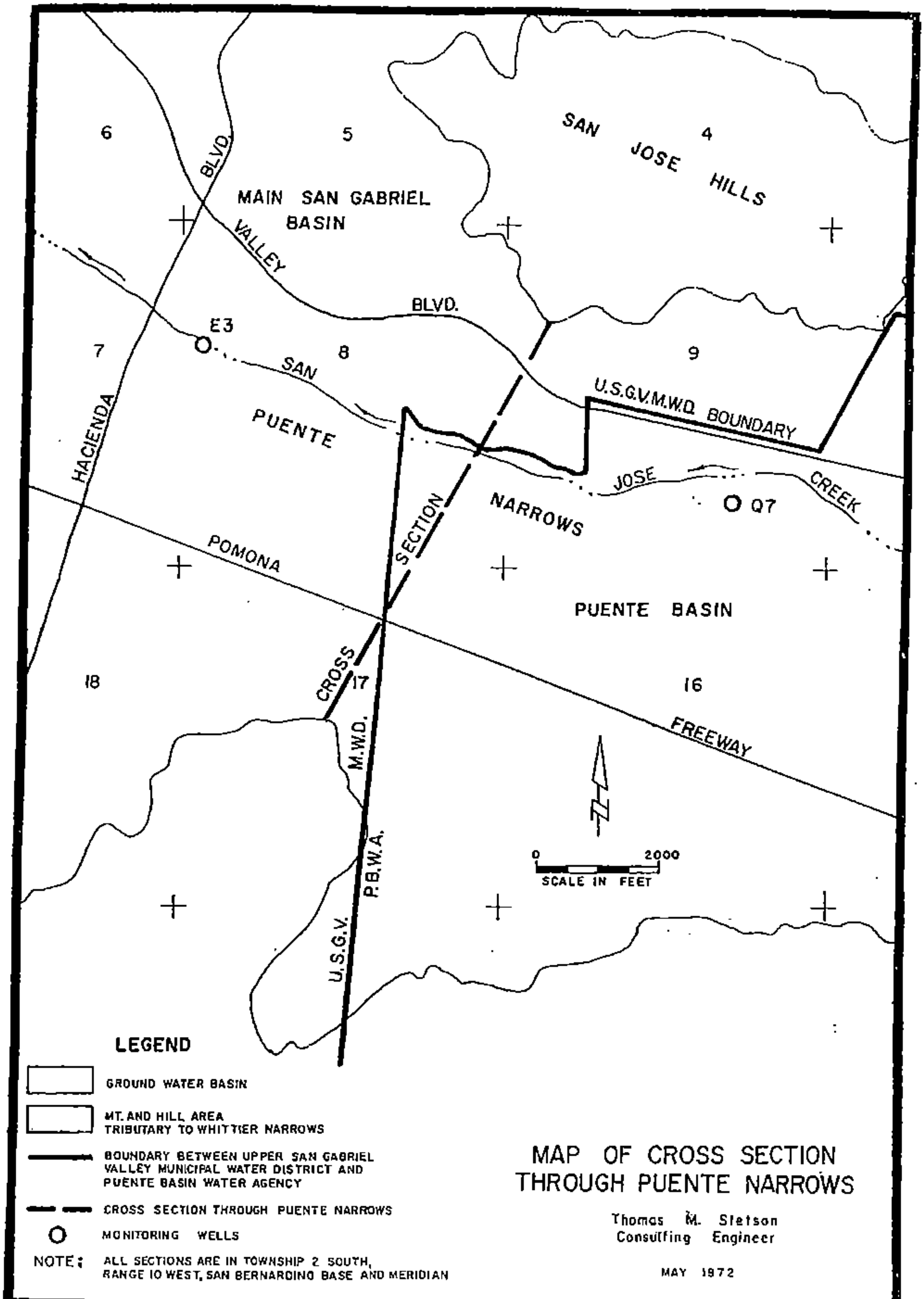
____
Attorneys for Rowland District

ROWLAND AREA COUNTY WATER DISTRICT

By ______________________
President
Wm. A. Simmons



APPENDIX "A"
EXHIBIT "J"



APPENDIX "B"
EXHIBIT "J"

ENGINEERING CRITERIA

APPENDIX "C"

1. Monitoring Wells. The wells designated as State Wells No. 2S/10W-9Q7 and 2S/10W-8E3 and Los Angeles County Flood Control District Nos. 3079M and 3048B, respectively, shall be used to measure applicable ground water elevations. In the event either monitoring well should fail or become unrepresentative, a substitute well shall be selected or drilled by Watermaster. The cost of drilling a replacement well shall be the obligation of the Puente Agency.

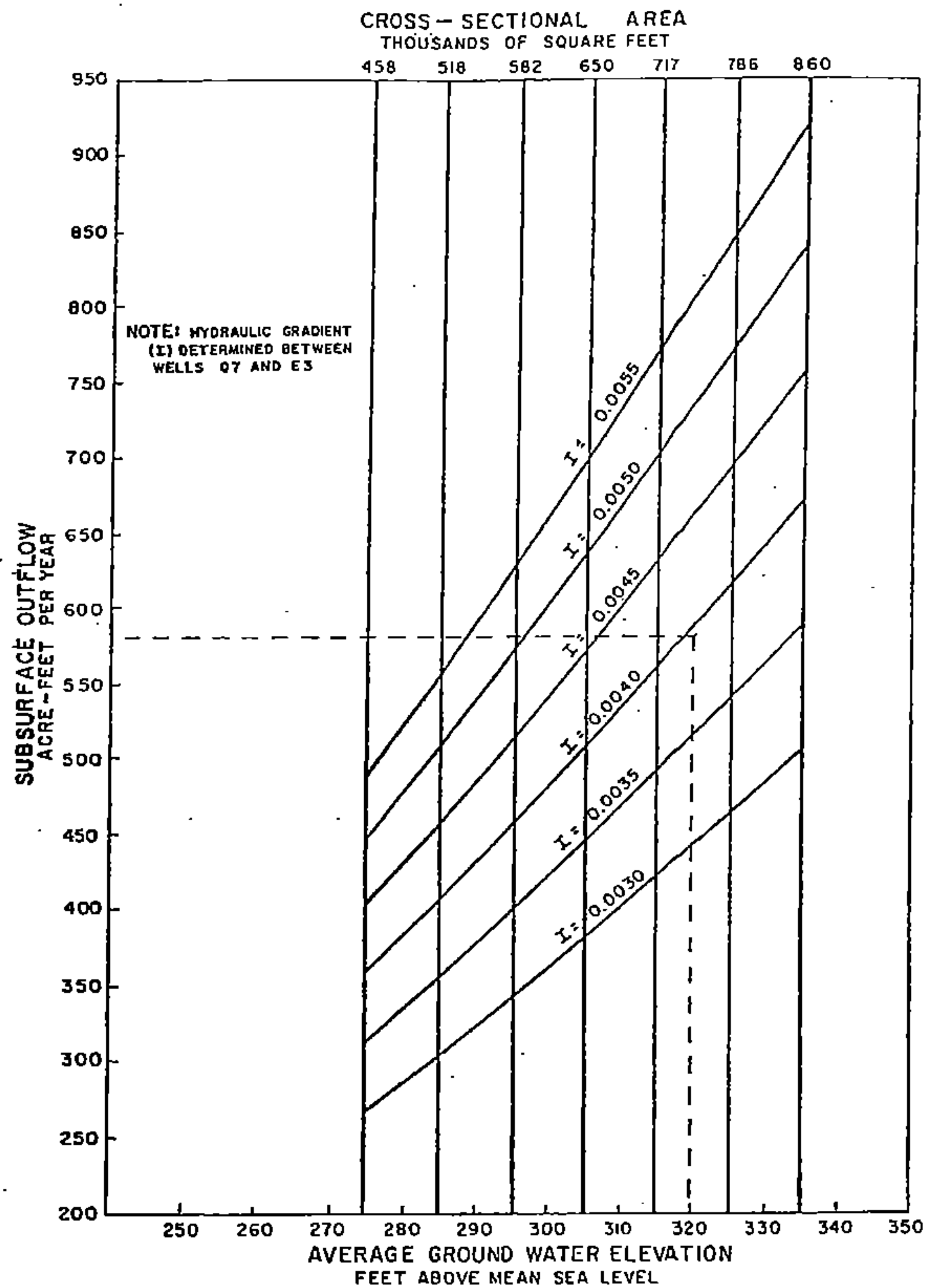
2. Measurement. Each monitoring well shall be measured and the ground water elevation determined semi-annually on or about April 1 and October 1 of each year. Prior to each measurement, the pump shall be turned off for a sufficient period to insure that the water table has recovered to a static or near equilibrium condition.

3. Hydraulic Gradient. The hydraulic gradient, or slope of the water surface through Puente Narrows, shall be calculated between the monitoring wells as the difference in water surface elevation divided by the distance, approximately 9,000 feet, between the wells. The hydraulic gradient shall be determined for the spring and fall and the average hydraulic gradient calculated for the year.

4. Ground Water Elevation at Puente Narrows Cross Section. The ground water elevation at the Puente Narrows

cross section midway between the monitoring wells shall be the average of the ground water elevation at the two wells. This shall be determined for the spring and fall and the average annual ground water elevation calculated for the year.

5. <u>Determination of Underflow</u>. The chart attached is a photo-reduction of a full scale chart on file with the Watermaster. By applying the appropriate average annual hydraulic gradient (I) to the average annual ground water elevation at the Puente Narrows cross section (involving the appropriate cross-sectional area [A]), it is possible to read on the vertical scale the annual acre feet of underflow.



RELATIONSHIP OF AVERAGE GROUND WATER ELEVATION AT PUENTE NARROWS AND APPLICABLE CROSS-SECTIONAL AREA WITH SUBSURFACE OUTFLOW THROUGH PUENTE NARROWS FOR VARIOUS HYDRAULIC GRADIENTS

Thomas M. Stetson
Consulting Engineer
MAY 1972

EXHIBIT "K"

OVERLYING RIGHTS

I. NATURE OF OVERLYING RIGHT

An "Overlying Right" is the right to Produce water from the Main San Gabriel Basin for use on the overlying lands hereinafter described. Such rights are exercisable without quantitative limit only on said overlying land and cannot be separately conveyed or transferred apart therefrom. The exerciser of such right is assessable by Watermaster as provided in Paragraph 21 of the Amended Judgment herein (prior Paragraph 14.5 of the Judgment herein) and is subject to the other provisions of said Paragraph.

II. OVERLYING LANDS (Description)

The overlying lands to which Overlying Rights are appurtenant are described as follows:

> "Those portions of Lots 1 and 2 of the lands formerly owned by W.A. Church, in the Rancho San Francisquito, in the City of Irwindale, County of Los Angeles, State of California, as shown on recorder's filed map No. 509, in the office of the County Recorder of said County, lying northeasterly of the northeasterly line and its southeasterly prolongation of Tract 1888, as shown on map recorded in Book 21 page 183 of Maps, in the office of the County Recorder of said County.
>
> "EXCEPT the portions thereof lying northerly and northwesterly of the center line of Arrow Highway described 'Sixth' and the center line of Live Oak Avenue described 'Third' in a final decree of condemnation, a certified copy of which was recorded August 18, 1933 as Instrument No. 354, in Book 12289, Page 277, Official Records.
>
> "ALSO EXCEPT that portion of said land described in the final decree of condemnation entered in Los Angeles County Superior Court Case No. 805008, a certified copy of which was recorded September 21, 1964, as Instrument No. 3730, in Book D-2634, Page 648, Official Records."

III. PRODUCERS ENTITLED TO EXERCISE OVERLYING RIGHTS AND THEIR RESPECTIVE CONSUMPTIVE USE PORTIONS

The persons entitled to exercise Overlying Rights are both the owners of Overlying Rights and persons and entities licensed by such owners to exercise such Overlying Rights. The persons entitled to exercise Overlying Rights and their respective Consumptive Use portions are as follows:

OWNER PRODUCERS	CONSUMPTIVE USE PORTION
BROOKS GIFFORD, SR. BROOKS GIFFORD, JR. PAUL MNOIAN JOHN MGRDICHIAN J. EARL GARRETT	3.5 acre-feet per year
Present User: Nu-Way Industries	
PRODUCERS UNDER LICENSE	
A. WILLIAM C. THOMAS and EVELYN F. THOMAS, husband and wife, and MALCOLM K. GATHERER and JACQUELINE GATHERER, husband and wife, doing business by and through B & B REDI-I-MIX CONCRETE, INC., a corporation	45.6 acre-feet per year
B. PRE-STRESS CRANE RIGGING & TRUCK CO., INC., a corporation	1.0 acre-foot per year
Present Users: Pre-Stress Crane Rigging & Truck Co., Inc., a corporation	
Total	50.1 acre-feet per year

IV. ANNUAL GROSS AMOUNT OF PRODUCTION FROM WHICH CONSUMPTIVE USE PORTIONS WERE DERIVED

183.65 acre-feet

Exhibit "L"

LIST OF PRODUCERS AND THEIR DESIGNEES
June, 1989

Producer Name	Designee
A	
Adams Ranch Mutual Water Company	Goji Iwakiri
Alhambra, City of	T. E. Shollenberger
Amarillo Mutual Water Company	Ester Guadagnolo
Anderson, Ray	Ray Anderson
Andrade, Macario, et al.	Macario R. Andrade
Arcadia, City of	Eldon Davidson
AZ-Two, Inc.	R. S. Chamberlain
Azusa, City of	William H. Redcay
Azusa Ag. Water Company	Robert E. Talley
Azusa Valley Water Company	Edward Heck
B	
Baldwin Park County Water District (See Valley County Water District)	-
Banks, Gale C.	Gale C. Banks
Base Line Water Company	Everett W. Hughes, Jr.
Beverly Acres Mutual Water User's Assn. (Formerly Beverly Acres Mutual Water Co.)	Eloise A. Moore
Burbank Development Company	Darrell A. Wright
C	
Cadway, Inc.	P. Geoffrey Nunn
California-American Water Company (San Marino System)	Andrew A. Krueger
California-American Water Company (Duarte System)	Andrew A. Krueger
California Country Club	Henri F. Pellissier
California Domestic Water Company	P. Geoffrey Nunn
Cedar Avenue Mutual Water Company	Austin L. Knapp

Exhibit "L"

Producer Name	Designee
Champion Mutual Water Company	Margaret Bauwens
Chevron, USA, Inc.	Ms. Margo Bart
Clayton Manufacturing Company	Don Jones
Conrock Company	Gene R.Block
Corcoran Brothers	Ray Corcoran
County Sanitation District No. 18	Charles W. Curry
Covell, et al.	Darr Jobe
Covell, Ralph	Ralph Covell
Covina, City of	Wayne B. Dowdey
Covina Irrigating Company	William R. Temple
Crevolin, A. J.	A. J. Crevolin
Crown City Plating Company	N. G. Gardner
D	
Davidson Optronics, Inc.	James McBride
Dawes, Mary Kay	Mary Kay Dawes
Del Rio Mutual Water Company	Gonzalo Galindo
Driftwood Dairy	James E. Dolan
Dunning, George	George Dunning
E	
East Pasadena Water Company	Robert D. Mraz
El Monte, City of	Robert J. Pinniger
El Monte Cemetery Association	Linn E. Magoffin
F	
Faix, Ltd.	Henri F. Pellissier
G	
Glendora, City of	Arthur E. Cook
Green, Walter	Dr. Walter Green
H	
Hansen, Alice	Alice Hansen

Exhibit "L"

Producer Name	Designee
Hartley, David	David Hartley
Hemlock Mutual Water Company	Bud Selander
Hunter, Lloyd F.	Lloyd F. Hunter
I	
Industry Waterworks System, City of	Mary L. Jaureguy
K	
Kiyan Farm Kiyan, Hideo	Mrs. Hideo Kiyan
Kirklen Family Trust	Dawn Kirklen
Knight, Kathryn M.	William J. Knight
L	
Landeros, John	John Landeros
La Puente Valley County Water District	Mary L. Jaureguy
La Verne, City of	N. Kathleen Hamm
Livingston-Graham	Gary O. Tompkins
Los Angeles, County of	Robert L. Larson
Loucks, David	David Loucks
M	
Maddock, A. G.	Ranney Draper, Esq.
Maechtlen, Trust of J. J.	Jack F. Maechtlen
Maple Water Company, Inc.	Charles King
Martinez, Francis Mercy	Francis Mercy Martinez
Metropolitan Water District of Southern California	Fred Vendig, Esq.
Miller Brewing Company	Dennis B. Puffer
Mnoian, Paul, et al.	Mal Gatherer
Monrovia, City of	Robert K. Sandwick
Monrovia Nursery	Miles R. Rosedale
Monterey Park, City of	Nels Palm

Producer Name	Designee
N	
Nick Tomovich & Sons	Nick Tomovich
O	
Owl Rock Products Company	Peter L. Chiu
P	
Phillips, Alice B., et al.	Jack F. Maechtlen
Pico County Water District	Robert P. Fuller
Polopolus, et al.	Christine Chronis
R	
Rados Brothers	Alexander S. Rados
Richwood Mutual Water Company	Bonnie Pool
Rincon Ditch Company	K. E. Nungesser
Rincon Irrigation Company	K. E. Nungesser
Rose Hills Memorial Park Association	Allan D. Smith
Rosemead Development, Ltd.	John W. Lloyd
Rurban Homes Mutual Water Company	George W. Bucey
Ruth, Roy	Roy Ruth
S	
San Dimas - La Verne Recreational Facilities Authority	R. F. Griszka
San Gabriel Country Club	Fran Wolfe
San Gabriel County Water District	Philip G. Crocker
San Gabriel Valley Municipal Water District	Bob Stallings
San Gabriel Valley Water Company	Robert H. Nicholson, Jr.
Sloan Ranches	Larry R. Sloan
Sonoco Products Company	Elaine Corboy
South Covina Water Service	Anton C. Garnier
Southern California Edison Company	S. R. Shermoen

Producer Name	Designee
Southern California Water Company -San Dimas District	J. F. Young
Southern California Water Company -San Gabriel Valley District	J. F. Young
South Pasadena, City of	John Bernardi
Southwestern Portland Cement Company	Dale W. Heineck
Standard Oil Company of California	John A. Wild
Sterling Mutual Water Company	Bennie L. Prowett
Suburban Water Systems	Anton C. Garnier
Sully-Miller Contracting Company	R. R. Munro
Sunny Slope Water Company	Michael J. Hart
T	
Taylor Herb Garden	Paul S. Taylor
Texaco, Inc.	E. O. Wakefield
Tyler Nursery	James K. Mitsumori, Esq.
U	
United Concrete Pipe Corporation	Doyle H. Wadley
United Rock Products Corporation	William S. Capps, Esq.
V	
Valencia Heights Water Company	Herman Weskamp
Valley County Water District (Formerly Baldwin Park County Water District)	Stanley D. Yarbrough
Valley View Mutual Water Company	Robert T. Navarre
Via, H., Trust of	Marverna Parton
W	
Ward Duck Company	Richard J. Woodland
W. E. Hall Company	Thomas S. Bunn, Jr., Esq.
White, June G., Trustee	June G. Lovelady
Whittier, City of	Neil Hudson
Wilmott, Erma M.	Erma M. Wilmott

Exhibit "M"

WATERMASTER MEMBERS

FOR CALENDAR YEAR 1973

ROBERT T. BALCH (Producer Member), Chairman

LINN E. MAGOFFIN (Producer Member), Vice Chairman

RICHARD L. ROWLAND (Producer Member), Secretary

BOYD KERN (Public Member), Treasurer

WALKER HANNON (Producer Member)

HOWARD H. HAWKINS (Public Member)

M. E. MOSLEY (Producer Member)

CONRAD T. REIBOLD (Public Member)

HARRY C. WILLS (Producer Member)

STAFF

Carl Fossette, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1974

ROBERT T. BALCH (Producer Member), Chairman

LINN E. MAGOFFIN (Producer Member), Vice Chairman

RICHARD L. ROWLAND (Producer Member), Secretary

BOYD KERN (Public Member), Treasurer

WALKER HANNON (Producer Member)

BURTON E. JONES (Public Member)

M. E. MOSLEY (Producer Member)

CONRAD T. REIBOLD (Public Member)

HARRY C. WILLS (Producer Member)

STAFF

Carl Fossette, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1975

ROBERT T. BALCH (Producer Member), Chairman

LINN E. MAGOFFIN (Producer Member), Vice Chairman

HARRY C. WILLS (Producer Member), Secretary

BOYD KERN (Public Member), Treasurer

WALKER HANNON (Producer Member)

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M. E. MOSLEY (Producer Member)

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Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1976

ROBERT T. BALCH (Producer Member), Chairman

LINN E. MAGOFFIN (Producer Member), Vice Chairman

HARRY C. WILLS (Producer Member), Secretary

BOYD KERN (Public Member), Treasurer

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CONRAD T. REIBOLD (Public Member)

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ROBERT G. BERLIEN (Producer Member)

ANTON C. GARNIER (Producer Member)

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CONRAD T. REIBOLD (Public Member), Treasurer

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L. E. MOELLER (Producer Member)

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Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1982

LINN E. MAGOFFIN (Producer Member), Chairman

R. H. NICHOLSON, JR. (Producer Member), Vice Chairman

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CONRAD T. REIBOLD (Public Member), Treasurer

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FOR CALENDAR YEAR 1983

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ROBERT G. BERLIEN (Producer Member), Secretary

CONRAD T. REIBOLD (Public Member), Treasurer

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FOR CALENDAR YEAR 1984

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CONRAD T. REIBOLD (Public Member), Treasurer

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Jane M. Bray, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1985

LINN E. MAGOFFIN (Producer Member), Chairman

R. H. NICHOLSON, JR. (Producer Member), Vice Chairman

ROBERT G. BERLIEN (Producer Member), Secretary

CONRAD T. REIBOLD (Public Member), Treasurer

ROBERT T. BALCH (Producr Member)

DONALD F. CLARK (Public Member)

ANTON C. GARNIER (Producer Member)

L. E. MOELLER (Producer Member)

ALFRED R. WITTIG (Public Member)

STAFF

Jane M. Bray, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1986

LINN E. MAGOFFIN (Producer Member), Chairman

R. H. NICHOLSON, JR. (Producer Member), Vice Chairman

ROBERT G. BERLIEN (Producer Member), Secretary

CONRAD T. REIBOLD (Public Member), Treasurer

ROBERT T. BALCH (Producer Member)

DONALD F. CLARK (Public Member)

L. E. MOELLER (Producer Member)

REGINOLD A. STONE (Producer Member)

ALFRED R. WITTIG (Public Member)

STAFF

Jane M. Bray, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1987

LINN E. MAGOFFIN (Producer Member), Chairman

REGINALD A. STONE (Producer Member), Vice Chairman

L. E. MOELLER (Producer Member), Secretary

ALFRED R. WITTIG (Public Member), Treasurer

ROBERT T. BALCH (Producer Member)

GERALD J. BLACK (Producer Member)

DONALD F. CLARK (Public Member)

EDWARD R. HECK (Producer Member)

JOHN E. MAULDING (Public Member)

STAFF

Robert G. Berlien, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1988

LINN E. MAGOFFIN (Producer Member), Chairman

REGINALD A. STONE (Producer Member), Vice Chairman

L. E. MOELLER (Producer Member), Secretary

ALFRED R. WITTIG (Public Member), Treasurer

ROBERT T. BALCH (Producer Member)

GERALD J. BLACK (Producer Member)

DONALD F. CLARK (Public Member)

EDWARD R. HECK (Producer Member)

JOHN E. MAULDING (Public Member)

STAFF

Robert G. Berlien, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

FOR CALENDAR YEAR 1989

LINN E. MAGOFFIN (Producer Member), Chairman

REGINALD A. STONE (Producer Member), Vice Chairman

GERALD G. BLACK (Producer Member), Secretary

ALFRED R. WITTIG (Public Member), Treasurer

ROBERT T. BALCH (Producer Member) *

DONALD F. CLARK (Public Member)

EDWARD R. HECK (Producer Member)

BURTON E. JONES (Public Member)

NELS PALM (Producer Member) **

THOMAS E. SCHOLLENBERGER (Producer Member)

STAFF

Robert G. Berlien, Assistant Secretary-Assistant Treasurer
Ralph B. Helm, Attorney
Thomas M. Stetson, Engineer

* DECEASED APRIL 25, 1989

** Appointed August 24, 1989, for the balance of the calendar year term, to replace deceased member, Robert T. Balch.

Ralph B. Helm - Bar No. 022004
4605 Lankershim Boulevard, #214
North Hollywood, CA 91602

Telephone (818) 769-2002

Attorney for Watermaster - Petitioner

SUPERIOR COURT OF CALIFORNIA, COUNTY OF LOS ANGELES

UPPER SAN GABRIEL VALLEY MUNICIPAL WATER DISTRICT, Plaintiff, vs. CITY OF ALHAMBRA, et al., Defendants.	No. 924129 ORDER AMENDING JUDGMENT TO EXPAND WATERMASTER'S POWERS TO INCLUDE MAINTENANCE, IMPROVEMENT, AND CONTROL OF BASIN WATER QUALITY WITH ALLOWABLE FUNDING THROUGH IN-LIEU ASSESSMENTS Hearing: August 7, 1990 Department 38, 9:15 A. M.

The Petition of the Main San Gabriel Basin Watermaster (Watermaster) for Amendment to Judgment herein to expand its powers to include maintenance, improvement, and control of Basin water quality by controlling pumping in the Basin, with allowable funding for associated costs to be paid through its In-Lieu Assessments, was continued on July 31, 1990, to August 7, 1990, when it duly and regularly came on for hearing, at 9:15 o'clock A. M. in Department 38 of the above entitled Court, the Honorable FLORENCE T. PICKARD, Assigned Judge Presiding. Ralph B. Helm appeared as Attorney for Watermaster - Petitioner; Wayne K. Lemieux appeared for Defendant, San Gabriel Valley Municipal Water District, in support of the Petition; Fred Vendig, General

Counsel, Karen L. Tachiki, Assistant General Counsel, and Victor E. Gleason, Senior Deputy General Counsel, by Victor E. Gleason, appeared for Defendant, The Metropolitan Water District of Southern California, in support of the Petition; Timothy J. Ryan appeared for Defendant, San Gabriel Valley Water Company, in opposition to the Petition; Lagerlof, Senecal, Drescher & Swift, by H. Jess Senecal, appeared for Defendants, Calmat Company, Livingston-Graham, Owl Rock Products, AZ-Two, Inc., and Sully-Miller Contracting Company, in opposition to the Petition; Ira Reiner, Los Angeles County District Attorney, by Jan Chatten-Brown, Special Assistant to the District Attorney, appeared in opposition to the Petition; and Sarah F. Bates and Laurens H. Silver, by Sarah F. Bates, appeared on behalf of Amicus Curiae Sierra Club, in opposition to the Petition.

The Court acknowledged receipt and consideration of: letters in support of the Petition by the California Regional Water Quality Control Board - Los Angeles Region and by the State Water Resources Control Board; a copy of a letter addressed to the Attorney for Petitioner, from the US Environmental Protection Agency - Region IX, by Mark J. Klaiman, Assistant Regional Counsel, regarding several matters of federal law which EPA believed might ultimately affect the subject Petition; a letter in opposition to the Petition by East Valleys Organization; and a FAX communication to the Court, in opposition to the Petition, from Congressman Esteban E. Torres, which was not communicated to nor seen by the parties.

Members of the public, present in Court, were invited to, and did, present oral testimony during the hearing.

Under date of December 10, 1990 the Court entered its Intended Decision Re Amendment To Judgment and, by minute order duly entered and mailed to Counsel for Petitioner, ordered copies thereof mailed forthwith to all appearing parties, including those appearing as friends of the court, and to all other affected parties on the case's current mailing list.

A Proof Of Service by mail on December 13, 1990, Of Intended Decision Re Amendment To Judgment, as ordered, has been filed with the Court.

Opposition to Petitioner's Proposed Order were filed by Amicus Curiae Sierra Club, Amicus Curiae Los Angeles District Attorney, and by Producer Parties Calmat Co., Livingston-Graham, Owl Rock Products Company, AZ-Two, Inc., and Sully-Miller Contracting Company.

Proof being made to the satisfaction of the Court and good cause appearing:

IT IS, HEREBY, ORDERED:

1. That the Amended Judgment herein be further amended by amending Subsection (j) of Section 10 thereof, Definitions, and Section 40 thereof, Division F, Physical Solution, to read as follows:

"10 (j) In-Lieu Water Cost - - The differential between a particular Producer's cost of Watermaster directed produced, treated, blended, substituted, or Supplemental Water delivered or substituted to, for, or taken by, such Producer in-lieu of his cost of otherwise normally Producing a like amount of Ground Water from the Basin.

"40. Watermaster Control. (Prior Judgment Section 32)

In order to develop an adequate and effective program of Basin management, it is essential that Watermaster have broad discretion in the making of Basin management decisions within the ambit hereinafter set forth. The maintenance, improvement, and control of the water quality and quantity of the Basin, withdrawal and replenishment of supplies of the Basin and Relevant Watershed, and the utilization of the water resources thereof, must be subject to procedures established by Watermaster in implementation of the Physical Solution provisions of this Judgment. Both the quantity and quality of said water resource are thereby preserved and its beneficial utilization maximized.

"(a) Watermaster shall develop an adequate and effective program of Basin management. The maintenance, improvement, and control of the water quality and quantity of the Basin, withdrawal and replenishment of supplies of the Basin and Relevant Watershed, and the utilization of the water resources thereof, must be subject to procedures established by Watermaster in implementation of the Physical Solution provisions of this Judgment. All Watermaster programs and procedures shall be adopted only after a duly noticed public hearing pursuant to Sections 37 and 40 of the Amended Judgment herein.

"(b) Watermaster shall have the power to control pumping in the Basin by water Producers therein for Basin cleanup and water quality control so that specific well production can be directed as to a lesser amount, to total cessation, as to an increased amount, and even to require pumping in a new location in the

Basin. Watermaster's right to regulate pumping activities of Producers shall be subordinate to any conflicting Basin cleanup plan established by the EPA or other public governmental agency with responsibility for ground water management or clean up.

"(c) Watermaster may act individually or participate with others to carry on technical and other necessary investigations of all kinds and collect data necessary to carry out the herein stated purposes. It may engage in contractual relations with the EPA or other agencies in furtherance of the clean up of the Basin and enter into contracts with agencies of the United States, the State of California, or any political subdivision, municipality, or district thereof, to the extent allowed under applicable federal or state statutes. Any cooperative agreement between the Watermaster and EPA shall require the approval of the appropriate Agency(s) of the State of California.

"(d) For regulation and control of pumping activity in the Basin, Watermaster shall adopt Rules and Regulations and programs to promote, manage and accomplish clean up of the Basin and its waters, including, but not limited to, measures to confine, move, and remove contaminants and pollutants. Such Rules and Regulations and programs shall be adopted only after a duly Noticed Public Hearing by Watermaster and shall be subject to Court review pursuant to Section 37 of the Amended Judgment herein.

"(e) Watermaster shall determine whether funds from local, regional, state or federal agencies are available for regulating pumping and the various costs associated with, or arising from such activities. If no public funds are available from local, regional, state, or federal agencies, the costs shall be obtained and paid by way of an In-Lieu Assessment by Watermaster pursuant to Section 10 (j) of the Amended Judgment herein. Provided such In-Lieu Assessments become necessary, the costs shall be borne by all Basin Producers.

"(f) Watermaster is a Court empowered entity with limited powers, created pursuant to the Court's Physical Solution Jurisdiction under Article X, Section 2 of the California Constitution. None of the Powers granted herein to Watermaster shall be construed as designating Watermaster a political subdivision of the State of California or authorizing Watermaster to act as 'lead agency' to administer the federal Superfund for clean up of the Basin."

2. This Amended Judgment shall continue in full force and effect as hereby Ordered and Amended.

Dated: January 29, 1991.

/s/Florence T. Pickard
FLORENCE T. PICKARD
Judge of the Superior Court,
Specially Assigned

Appendix G

Summary of Population Based on Census Data

Appendix G-1: Census Tracts within the South San Gabriel System

County	Subregion	City	Census Tract	Percentage of Tract in System
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	433602	4%
Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	481401	4%
Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	482301	61%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482303	88%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482304	100%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482401	25%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482402	60%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482502	100%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482503	100%
Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	482521	100%
Los Angeles	San Gabriel Valley Assoc. of Cities	Unincorporated	482521	45%
Los Angeles	San Gabriel Valley Assoc. of Cities	Monterey Park city	482600	4%

Table G-2: Population, Household and Employment Projections for South San Gabriel System

Census Tract	County	Subregion	City	Population 2005	2010	2015	2020	2025	2030	2035	Percentage of Tract in System
433602	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	2,992	3,064	3,109	3,159	3,206	3,252	3,296	4%
481401	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	6,382	6,411	6,649	6,782	6,932	7,076	7,221	4%
482301	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	5,525	5,560	5,850	6,016	6,204	6,385	6,565	61%
482303	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	6,141	6,276	6,361	6,456	6,547	6,634	6,718	88%
482304	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	4,142	4,232	4,289	4,352	4,413	4,473	4,530	100%
482401	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	4,178	4,278	4,342	4,411	4,477	4,540	4,601	25%
482402	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	5,519	5,637	5,713	5,796	5,876	5,953	6,026	60%
482502	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	3,638	3,713	3,761	3,816	3,868	3,919	3,967	100%
482503	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	4,603	4,697	4,757	4,824	4,889	4,952	5,012	100%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	122	127	132	137	142	146	150	100%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Unincorporated	6,064	6,475	6,944	7,412	7,864	8,303	8,723	45%
482600	Los Angeles	San Gabriel Valley Assoc. of Cities	Monterey Park city	7,202	7,684	8,127	8,517	8,872	9,186	9,504	4%
Total Population Based on SCAG				29,021	29,729	30,452	31,127	31,795	32,439	33,060	
SCAG Growth Rate						2%	2%	2%	2%	2%	

Census Tract	County	Subregion	City	Households 2005	2010	2015	2020	2025	2030	2035	Percentage of Tract in System
433602	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	724	746	765	786	802	818	831	0%
481401	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	1,877	1,886	1,989	2,055	2,107	2,157	2,196	0%
482301	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	1,333	1,340	1,422	1,476	1,518	1,558	1,590	0%
482303	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	1,473	1,517	1,559	1,603	1,638	1,671	1,699	0%
482304	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	1,006	1,030	1,053	1,077	1,096	1,114	1,129	0%
482401	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	947	974	999	1,026	1,046	1,066	1,083	0%
482402	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	1,488	1,531	1,571	1,614	1,647	1,680	1,706	0%
482502	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	830	850	868	887	903	917	930	0%
482503	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	1,028	1,053	1,076	1,100	1,119	1,138	1,153	0%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	11	11	11	11	12	12	12	0%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Unincorporated	1,486	1,588	1,723	1,865	1,976	2,084	2,172	0%
482600	Los Angeles	San Gabriel Valley Assoc. of Cities	Monterey Park city	2,283	2,325	2,392	2,429	2,455	2,484	2,504	0%
Total Population Based on SCAG				6,976	7,169	7,419	7,659	7,849	8,031	8,180	
SCAG Growth Rate						3%	3%	2%	2%	2%	

Census Tract	County	Subregion	City	Employment 2005	2010	2015	2020	2025	2030	2035	Percentage of Tract in System
433602	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	4,464	4,535	4,592	4,627	4,669	4,713	4,756	0%
481401	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	1,730	1,754	1,774	1,787	1,802	1,819	1,834	0%
482301	Los Angeles	San Gabriel Valley Assoc. of Cities	San Gabriel city	280	351	408	443	484	529	571	0%
482303	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	419	422	425	427	429	431	434	0%
482304	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	671	691	708	718	731	744	757	0%
482401	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	540	558	573	582	593	605	617	0%
482402	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	1,613	1,714	1,793	1,841	1,898	1,958	2,016	0%
482502	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	551	563	572	578	585	592	599	0%
482503	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	989	1,000	1,008	1,013	1,020	1,027	1,033	0%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Rosemead city	295	312	325	334	345	357	368	0%
482521	Los Angeles	San Gabriel Valley Assoc. of Cities	Unincorporated	322	345	361	370	380	390	400	0%
482600	Los Angeles	San Gabriel Valley Assoc. of Cities	Monterey Park city	449	485	507	525	548	567	585	0%
Total Population Based on SCAG				4,559	4,745	4,892	4,983	5,092	5,207	5,318	
SCAG Growth Rate						3%	2%	2%	2%	2%	

Appendix H

Documentation of submittal to Library, Cities and Counties

Golden State
Water Company
A Subsidiary of American States Water Company

September 1, 2011

City of Monterey Park
Ray Hamada
Planning Manager
320 West Newmark Avenue
Monterey Park, CA 91754

Dear: Ray Hamada

RE: Golden State Water Company- 2010 Urban Water Management Plan

Golden State Water Company (GSWC) adopted the 2010 Urban Water Management Plan (UWMP) following a public hearing on August 18, 2011. The 2010 UWMP was adopted in accordance with the Urban Water Management Planning Act and filed with DWR and the California Sate Library.

Pursuant to Section 10644(a) of the California Water Code, GSWC is required to file a copy of the adopted 2010 UWMP with any city or county within which GSWC provided water. Enclosed for your files is one copy of GSWC's adopted 2010 UWMP. It is also on our website at www.gswater.com.

If you have any questions you can contact me at (916) 853-3612.

Sincerely,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Enclosure

Golden State
Water Company
A Subsidiary of American States Water Company

September 1, 2011

City of Rosemead
Bradford Johnson
Planning Director
8838 Valley Boulevard
Rosemead, CA 91770

Dear: Bradford Johnson

RE: Golden State Water Company- 2010 Urban Water Management Plan

Golden State Water Company (GSWC) adopted the 2010 Urban Water Management Plan (UWMP) following a public hearing on August 18, 2011. The 2010 UWMP was adopted in accordance with the Urban Water Management Planning Act and filed with DWR and the California Sate Library.

Pursuant to Section 10644(a) of the California Water Code, GSWC is required to file a copy of the adopted 2010 UWMP with any city or county within which GSWC provided water. Enclosed for your files is one copy of GSWC's adopted 2010 UWMP. It is also on our website at www.gswater.com.

If you have any questions you can contact me at (916) 853-3612.

Sincerely,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Enclosure

Golden State
Water Company
A Subsidiary of American States Water Company

September 1, 2011

City of San Gabriel
Carol Banet
Planning Manager
425 South Mission Drive
San Gabriel, CA 91776

Dear: Carol Banet

RE: Golden State Water Company- 2010 Urban Water Management Plan

Golden State Water Company (GSWC) adopted the 2010 Urban Water Management Plan (UWMP) following a public hearing on August 18, 2011. The 2010 UWMP was adopted in accordance with the Urban Water Management Planning Act and filed with DWR and the California Sate Library.

Pursuant to Section 10644(a) of the California Water Code, GSWC is required to file a copy of the adopted 2010 UWMP with any city or county within which GSWC provided water. Enclosed for your files is one copy of GSWC's adopted 2010 UWMP. It is also on our website at www.gswater.com.

If you have any questions you can contact me at (916) 853-3612.

Sincerely,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Enclosure

Golden State
Water Company
A Subsidiary of American States Water Company

September 1, 2011

County of Los Angeles
Richard Brudckner
Director Department of Regional Planning
320 West Temple Street
Los Angeles, CA 90012

Dear: Richard Brudckner

RE: Golden State Water Company- 2010 Urban Water Management Plan

Golden State Water Company (GSWC) adopted the 2010 Urban Water Management Plan (UWMP) following a public hearing on August 18, 2011. The 2010 UWMP was adopted in accordance with the Urban Water Management Planning Act and filed with DWR and the California Sate Library.

Pursuant to Section 10644(a) of the California Water Code, GSWC is required to file a copy of the adopted 2010 UWMP with any city or county within which GSWC provided water. Enclosed for your files is one copy of GSWC's adopted 2010 UWMP. It is also on our website at www.gswater.com.

If you have any questions you can contact me at (916) 853-3612.

Sincerely,
GOLDEN STATE WATER COMPANY

Ernest A. Gisler
Planning Manager

Enclosure

Appendix I

Documentation of Water Use Projections Submittal

Golden State
Water Company
A Subsidiary of American States Water Company

11 February 2011

Mr. Steve Sherman
Field Operations Superintendent
Covina Irrigating Company
146 E College Street
Covina, CA 91723

Subject: Golden State Water Company - Claremont, San Dimas, South Arcadia, and South San Gabriel System
2010 Urban Water Management Plan Preparation Notification and Supply Reliability Information Request

Dear Mr. Sherman:

Golden State Water Company (GSWC) is currently preparing its 2010 Urban Water Management Plan (UWMP) for the Claremont, San Dimas, South Arcadia, and South San Gabriel System as required by the Urban Water Management Planning Act (Act). Since Covina Irrigating Company is a wholesale water supplier to GSWC, water use projections through 2035 are enclosed (Table 1) pursuant to §10631(k) of the Act. We would like to request confirmation of the anticipated water supply reliability, water supply sources, and other information as described below. This information may be provided by either (a) providing a copy of your Draft UWMP if all requested information is included or, (b) completing the enclosed tables and providing any additional documents as required.

1. Supply projections to 2035 (Table 2)
2. Single Dry Year Reliability to 2035 (Table 3)
3. Normal, single dry, and multiple dry year reliability (Table 4)
4. Basis of water year data (Table 5)
5. Factors resulting in inconsistency of supply (Table 6)
6. Assumptions used to determine retail agency supply projections, including conservation.
7. Recycled water projections to the Claremont, San Dimas, South Arcadia, and South San Gabriel service area (if applicable) (Table 7)
8. Describe any regional desalination opportunities, if any for the Claremont, San Dimas, South Arcadia, and South San Gabriel system (if applicable)

We appreciate your timely attention to the information requested above and ask you provide a response no later than **18 February 2011**. Kennedy/Jenks Consultants is assisting GSWC with preparation of the 2010 UWMP and will be contacting you directly within the next week to follow up on this request. In the meantime, should you have any questions or concerns please feel free to contact me at (916) 853-3612.

Very truly yours,

GOLDEN STATE WATER COMPANY

Ernest Gisler
Planning Manager

Enclosures

cc: Sean Maguire, Kennedy/Jenks Consultants

Golden State
Water Company
A Subsidiary of American States Water Company

11 February 2011

Mr. Timothy C. Jochem
General Manager
Upper San Gabriel Valley Municipal Water District
11310 Valley Blvd.
El Monte, CA 91731

Subject: Golden State Water Company - South San Gabriel System
2010 Urban Water Management Plan Preparation Notification and Supply Reliability Information Request

Dear Mr. Jochem:

Golden State Water Company (GSWC) is currently preparing its 2010 Urban Water Management Plan (UWMP) for the South San Gabriel System as required by the Urban Water Management Planning Act (Act). Since Upper San Gabriel Valley Municipal Water District is a wholesale water supplier to GSWC, water use projections through 2035 are enclosed (Table 1) pursuant to §10631(k) of the Act. We would like to request confirmation of the anticipated water supply reliability, water supply sources, and other information as described below. This information may be provided by either (a) providing a copy of your Draft UWMP if all requested information is included or, (b) completing the enclosed tables and providing any additional documents as required.

1. Supply projections to 2035 (Table 2)
2. Single Dry Year Reliability to 2035 (Table 3)
3. Normal, single dry, and multiple dry year reliability (Table 4)
4. Basis of water year data (Table 5)
5. Factors resulting in inconsistency of supply (Table 6)
6. Assumptions used to determine retail agency supply projections, including conservation.
7. Recycled water projections to the South San Gabriel service area (if applicable) (Table 7)
8. Describe any regional desalination opportunities, if any for the South San Gabriel system (if applicable)

We appreciate your timely attention to the information requested above and ask you provide a response no later than **18 February 2011**. Kennedy/Jenks Consultants is assisting GSWC with preparation of the 2010 UWMP and will be contacting you directly within the next week to follow up on this request. In the meantime, should you have any questions or concerns please feel free to contact me at (916) 853-3612.

Very truly yours,

GOLDEN STATE WATER COMPANY

Ernest Gisler
Planning Manager

Enclosures

cc: Sean Maguire, Kennedy/Jenks Consultants

Appendix J

Urban Water Management Plan Checklist

Table I-2 Urban Water Management Plan checklist, organized by subject

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
PLAN PREPARATION					
4	Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	10620(d)(2)		1.6	1-7
6	Notify, at least 60 days prior to the public hearing on the plan required by Section 10642, any city or county within which the supplier provides water that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. Any city or county receiving the notice may be consulted and provide comments.	10621(b)		1.6	1-7
7	Provide supporting documentation that the UWMP or any amendments to, or changes in, have been adopted as described in Section 10640 et seq.	10621(c)		1.6	1-7
54	Provide supporting documentation that the urban water management plan has been or will be provided to any city or county within which it provides water, no later than 60 days after the submission of this urban water management plan.	10635(b)		Appendix H	
55	Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	10642		1.6	1-7
56	Provide supporting documentation that the urban water supplier made the plan available for public inspection and held a public hearing about the plan. For public agencies, the hearing notice is to be provided pursuant to Section 6066 of the Government Code. The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water. Privately-owned water suppliers shall provide an equivalent notice within its service area.	10642		Page vii	Vii
57	Provide supporting documentation that the plan has been adopted as prepared or modified.	10642		1.6	1-7
58	Provide supporting documentation as to how the water supplier plans to implement its plan.	10643		1.8	1-8

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
59	Provide supporting documentation that, in addition to submittal to DWR, the urban water supplier has submitted this UWMP to the California State Library and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. This also includes amendments or changes.	10644(a)		1.7 Appendix H	1-8
60	Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the urban water supplier has or will make the plan available for public review during normal business hours	10645		1.7	1-8
SYSTEM DESCRIPTION					
8	Describe the water supplier service area.	10631(a)		2.1	2-1
9	Describe the climate and other demographic factors of the service area of the supplier	10631(a)		2.2 & 2.4	2-1 & 2-10
10	Indicate the current population of the service area	10631(a)	Provide the most recent population data possible. Use the method described in Baseline Daily Per Capita Water Use. See Section M.	2.3	2-5
11	Provide population projections for 2015, 2020, 2025, and 2030, based on data from State, regional, or local service area population projections.	10631(a)	2035 and 2040 can also be provided to support consistency with Water Supply Assessments and Written Verification of Water Supply documents.	2.3.2	2-5
12	Describe other demographic factors affecting the supplier's water management planning.	10631(a)		2.2 & 2.4	2-1 & 2-10
SYSTEM DEMANDS					
1	Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	10608.20(e)		3.2	3-3

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
2	*Wholesalers:* Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions. *Retailers:* Conduct at least one public hearing that includes general discussion of the urban retail water supplier's implementation plan for complying with the Water Conservation Bill of 2009.	10608.36 10608.26(a)	Retailers and wholesalers have slightly different requirements	4.6	4-8
3	Report progress in meeting urban water use targets using the standardized form.	10608.40		Not Applicable	
25	Quantify past, current, and projected water use, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use, and (I) agriculture.	10631(e)(1)	Consider past' to be 2005, present to be 2010, and projected to be 2015, 2020, 2025, and 2030. Provide numbers for each category for each of these years.	3.3	3-8
33	Provide documentation that either the retail agency provided the wholesale agency with water use projections for at least 20 years, if the UWMP agency is a retail agency, OR, if a wholesale agency, it provided its urban retail customers with future planned and existing water source available to it from the wholesale agency during the required water-year types	10631(k)	Average year, single dry year, multiple dry years for 2015, 2020, 2025, and 2030.	3.7 Appendix I	3-15
34	Include projected water use for single-family and multifamily residential housing needed for lower income households, as identified in the housing element of any city, county, or city and county in the service area of the supplier.	10631.1(a)		3.8	3-16
SYSTEM SUPPLIES					
13	Identify and quantify the existing and planned sources of water available for 2015, 2020, 2025, and 2030.	10631(b)	The existing' water sources should be for the same year as the current population in line 10. 2035 and 2040 can also be provided.	4.1	4-2

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
14	Indicate whether groundwater is an existing or planned source of water available to the supplier. If yes, then complete 15 through 21 of the UWMP Checklist. If no, then indicate not applicable in lines 15 through 21 under the UWMP location column.	10631(b)	Source classifications are: surface water, groundwater, recycled water, storm water, desalinated sea water, desalinated brackish groundwater, and other.	4.3	4-3
15	Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	10631(b)(1)		4.3	4-3
16	Describe the groundwater basin.	10631(b)(2)		4.3	4-3
17	Indicate whether the groundwater basin is adjudicated? Include a copy of the court order or decree.	10631(b)(2)		4.3 & Appendix F	4-3
18	Describe the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. If the basin is not adjudicated, indicate not applicable in the UWMP location column.	10631(b)(2)		4.3	4-3
19	For groundwater basins that are not adjudicated, provide information as to whether DWR has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition. If the basin is adjudicated, indicate not applicable in the UWMP location column.	10631(b)(2)		Not Applicable	
20	Provide a detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years	10631(b)(3)		4.3	4-3
21	Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped.	10631(b)(4)	Provide projections for 2015, 2020, 2025, and 2030.	4.3	4-3
24	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	10631(d)		4.4	4-7

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
30	Include a detailed description of all water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and multiple-dry years, excluding demand management programs addressed in (f)(1). Include specific projects, describe water supply impacts, and provide a timeline for each project.	10631(h)		4.5	4-7
31	Describe desalinated water project opportunities for long-term supply, including, but not limited to, ocean water, brackish water, and groundwater.	10631(i)		4.7	4-9
44	Provide information on recycled water and its potential for use as a water source in the service area of the urban water supplier. Coordinate with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area.	10633		4.8	4-9
45	Describe the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	10633(a)		4.8.2	4-11
46	Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	10633(b)		4.8.2	4-11
47	Describe the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.	10633(c)		4.8.2	4-11
48	Describe and quantify the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.	10633(d)		4.8.3	4-12
49	The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected.	10633(e)		4.8	4-9
50	Describe the actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.	10633(f)		4.8.4	4-13

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
51	Provide a plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.	10633(g)		4.8.4	4-13
WATER SHORTAGE RELIABILITY AND WATER SHORTAGE CONTINGENCY PLANNING [b]					
5	Describe water management tools and options to maximize resources and minimize the need to import water from other regions.	10620(f)		1.10	1-10
22	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage and provide data for (A) an average water year, (B) a single dry water year, and (C) multiple dry water years.	10631(c)(1)		6.1	6-1
23	For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.	10631(c)(2)		6.1.4	6-6
35	Provide an urban water shortage contingency analysis that specifies stages of action, including up to a 50-percent water supply reduction, and an outline of specific water supply conditions at each stage	10632(a)		8.1	8-1
36	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.	10632(b)		8.2	8-3
37	Identify actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.	10632(c)		8.3	8-4
38	Identify additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.	10632(d)		8.4	8-6
39	Specify consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.	10632(e)		8.4	8-6
40	Indicated penalties or charges for excessive use, where applicable.	10632(f)		8.4	8-6

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
41	Provide an analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.	10632(g)		8.5	8-8
42	Provide a draft water shortage contingency resolution or ordinance.	10632(h)		8.4 & Appendix D	8-6
43	Indicate a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.	10632(i)		8.6	8-10
52	Provide information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments, and the manner in which water quality affects water management strategies and supply reliability	10634	For years 2010, 2015, 2020, 2025, and 2030	5	5-1
53	Assess the water supply reliability during normal, dry, and multiple dry water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. Base the assessment on the information compiled under Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.	10635(a)		6.2 – 6.4	6-7
DEMAND MANAGEMENT MEASURES					
26	Describe how each water demand management measures is being implemented or scheduled for implementation. Use the list provided.	10631(f)(1)	Discuss each DMM, even if it is not currently or planned for implementation. Provide any appropriate schedules.	7.1	7-2
27	Describe the methods the supplier uses to evaluate the effectiveness of DMMs implemented or described in the UWMP.	10631(f)(3)		7.1	7-2
28	Provide an estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the ability to further reduce demand.	10631(f)(4)		7.2	7-4

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location	Page Number
29	Evaluate each water demand management measure that is not currently being implemented or scheduled for implementation. The evaluation should include economic and non-economic factors, cost-benefit analysis, available funding, and the water suppliers' legal authority to implement the work.	10631(g)	See 10631(g) for additional wording.	7.2	7-4
32	Include the annual reports submitted to meet the Section 6.2 requirements, if a member of the CUWCC and signer of the December 10, 2008 MOU.	10631(j)	Signers of the MOU that submit the annual reports are deemed compliant with Items 28 and 29.	N/A	

a The UWMP Requirement descriptions are general summaries of what is provided in the legislation. Urban water suppliers should review the exact legislative wording prior to submitting its UWMP.

b The Subject classification is provided for clarification only. It is aligned with the organization presented in Part I of this guidebook. A water supplier is free to address the UWMP Requirement anywhere with its UWMP, but is urged to provide clarification to DWR to facilitate review.

Bay-Delta Water Quality Evaluation Draft Final Report

California Urban Water Agencies

Expert Panel:

Douglas M. Owen, P.E., Chair
Vice President
Malcolm Pirnie, Inc.

Phillippe A. Daniel, P.E.
Associate
Camp, Dresser and McKee

R. Scott Summers, PhD
Associate Professor
University of Cincinnati

Preface by California Urban Water Agencies

One objective of the CALFED Bay-Delta Program is to provide good water quality in water diverted from the Delta to meet drinking water needs. To accomplish this, CALFED must select a long-term solution that provides a quality of source water that urban water providers can treat with reasonable cost to meet current and future federal and state health-based drinking water standards. To enable a quantitative assessment of the impact of alternative Bay-Delta solutions, specific water quality criteria must be chosen for analysis. Although there are numerous water quality constituents of concern in meeting drinking water standards, the major constituents of health concern in Delta water are pathogens (*Giardia* and *Cryptosporidium*) and disinfection by-product (DBP) precursors (bromide and total organic carbon). The quality of water diverted from the Delta will bear heavily on the treatment technology which needs to be employed to meet increasingly stringent drinking water standards. Municipal water providers are already investing hundreds of millions of dollars in advanced treatment processes to meet more restrictive treatment standards. Without a higher quality of source water, probable future standards could make these investments obsolete and force technology which can neither be guaranteed to perform, be feasible due to market constraints or environmental regulation constraints, or be realistically affordable to the end users.

Setting water quality criteria requires knowledge about both the future regulatory setting under the Safe Drinking Water Act and the relative performance characteristics of currently available treatment technologies under a variety of actual conditions. Rather than asking its treatment experts to make this assessment, CUWA convened a panel of nationally recognized drinking water quality experts to determine the required criteria for total organic carbon (TOC) and bromide that will allow utilities treating Delta water to comply with current and probable future drinking water regulations utilizing available advanced technology. The expert panel consists of Douglas Owen, P.E. Vice President at Malcolm Pirnie, Inc., Phillippe Daniel, P.E. Associate at Camp Dresser & McKee and R. Scott Summers, PhD, Associate Professor at the University of Cincinnati. The purpose of the expert panel report is to recommend Delta drinking water quality criteria with which CALFED staff can evaluate Bay-Delta alternative's relative performance in meeting program objectives. These criteria have been developed in recognition of the interaction between source water quality, treatment efficacy and probable regulatory outcomes, as developed by the panel. This report, however, does not represent CUWA's or any of its members endorsement of a specific regulatory outcome.

This report concludes that for currently available advanced water treatment technology (i.e., enhanced coagulation and ozone disinfection) to be able to meet potential long-term drinking water quality standards for water diverted from the Delta, the source water quality should have concentrations less than 3.0 mg/L for TOC and less than 50 μg/L for bromide (<20 mg/L chloride concentration). Although using granular activated carbon or membranes allows upward flexibility in these values, the feasibility of these processes in terms of cost,

residual disposal, and construction is uncertain (there are only one or two facilities in the United States of the size applicable to CUWA member facilities which use GAC or membranes for drinking water treatment). Source water quality with concentrations higher than 3.0 mg/L TOC and 50 μg/L bromide could still meet a near-term regulatory scenario, but the long-term scenario is more appropriate for planning eventual CALFED Bay-Delta solution.

CUWA recognizes that based upon historic concentrations of these constituents measured at Clifton Court Forebay in the Delta, it is unlikely that the above criterion for bromide could be met by all urban water agencies using ozonation under existing conditions, even in wet years. Therefore, CALFED must carefully analyze a variety of actions within its alternatives analysis to determine which combination of actions can assure the achievement of the program's drinking water quality objective in concert with other important objectives. These actions should include at least the following:

- The capability of in-Delta hydraulic modifications to limit seawater intrusion and resulting increase in bromide concentration
- Pollutant source control programs for TOC and pathogens (actions should include areas where water is degraded after diversion from the Delta as well as the Bay-Delta watershed itself.)
- Water storage and storage management
- Increased outflow
- An isolated facility

These actions must be assessed in appropriate combinations designed to meet CALFED's multiple program objectives.

CUWA also recognizes that CALFED should assess the environmental and economic impact and the practical feasibility of **not** providing a water quality for Delta diversions which would allow future standards to be met with currently available advanced technology. CUWA does not believe such technology, including membrane technologies and granulated activated carbon filtration, are either affordable or feasible on the scale needed for municipal treatment in California and are not likely to be in the foreseeable future.

Public water agencies have a unique public trust responsibility to provide the highest quality of water reasonably achievable. This approach to public health protection is one that is balanced by combining (1) source selection to enhance water quality, (2) source protection to preserve water quality, and (3) effective and reliable treatment technology. CUWA believes the CALFED Bay-Delta Program solution should be consistent with the following principles.

- Maintenance and improvement of existing high quality urban water supplies and in-Delta supplies as the most effective means to protect public health

- A strong program of water pollutant source control is required to assure public health and environmental quality

- Provision for the highest quality drinking water quality reasonably available. This will assure the greatest likelihood that available treatment technologies will meet future drinking water standards.

California Urban Water Agencies
June 1998

EXECUTIVE SUMMARY

The California Urban Water Agencies (CUWA) retained the assistance of three water quality and treatment specialists who have specific expertise in the formation of disinfection by-products (DBPs). These three individuals -- the expert panel -- evaluated specific source water quality characteristics which would be necessary to permit diverted water from the San Francisco Bay/Sacramento-San Joaquin River Delta (Delta) to be used for meeting potential public health related water quality standards under defined treatment conditions. Specifically, the expert panel was charged with 1) developing potential future regulatory scenarios, 2) defining appropriate process criteria for coagulation, ozonation, granular activated carbon and membrane treatment processes, and 3) estimating source water quality diverted from the Delta which would allow users implementing the defined treatment technologies to comply with the regulatory scenario. The source water quality characteristics were framed in the context of total organic carbon (TOC) and bromide concentrations, both constituents which have the potential to be controlled by different management strategies for the Delta.

Two potential regulatory scenarios were projected based upon regulatory negotiations conducted in 1992-93 and 1997. The near-term scenario focuses on Stage 1 of the Disinfectant/Disinfection By-Product (D/DBP) Rule and the Interim Enhanced Surface Water Treatment Rule. The long-term scenario focuses on Stage 2 of the D/DBP Rule and the Long Term Enhanced Surface Water Treatment Rule. The potential regulatory scenarios include specific limits for two organic classifications of DBPs recently proposed in rulemaking by EPA; total trihalomethanes (TTHMs) and the sum of five haloacetic acids (HAA5). In addition, a potential limit was projected for bromate, an inorganic by-product formed by the ozonation of bromide-containing waters; a standard has been proposed by EPA for this DBP, as well. These DBP limits were coupled with various potential requirements for microbial removal and inactivation.

The treatment criteria specified by the expert panel for the near-term regulatory scenario included: 1) the use of 40 mg/L of alum at a pH of 7.0 and possibly as low as 6.5 in the coagulation process, followed by chlorine disinfection with a chloramine residual in the distribution system, and 2) the use of ozone at specific ozone:TOC ratios followed by a chloramine residual. The chlorine and ozone disinfection criteria were proposed to meet potential 1 or 2 log *Giardia* inactivation requirements. For the long-term regulatory scenario, the use of post-filter GAC adsorbers, GAC in combination with ozone, membrane filtration in combination with ozone, and nanofiltration with free chlorine were considered. The long-term scenario included inactivation for *Giardia* and *Cryptosporidium*, the latter of which could only be achieved by ozone disinfection or the "absolute barrier" of membrane treatment.

The expert panel used data submitted by CUWA members, available literature and ongoing research, as well as their own experience and best professional judgement to arrive at potential source water quality requirements. Available models for DBP formation were evaluated to investigate threshold DBP formation behavior and to support the initial conclusions reached by the expert panel.

Specific combinations for TOC and bromide necessary in the water diverted from the Delta can vary depending upon the treatment technology implemented and microbiological inactivation required. Further, the selected bromate level of 5 μg/L in the long-term regulatory scenario is significant in establishing limiting bromide levels in this evaluation. The rationale for this level in this analysis ultimately may be modified by a variety of factors including allowing for trade-offs for disinfection and the formation of organically-based brominated DBPs (e.g., THMs or HAAs) or evidence of a cancer threshold for bromate (investigations underway). On the other hand, there are other potential regulatory outcomes involving 1) further lowering the MCLs for DBPs, 2) the regulation of individual DBP species (rather than the groups of compounds represented by TTHM and HAA5 due to the potentially more severe health effects associated with brominated compounds), 3) regulating other DBPs beyond TTHMs and HAA5, including the addition of other regulated HAAs (there are nine total) as analytical methods are developed and refined, 4) a comparative risk framework which balances all of the risk attributable to the DBPs formed, rather than providing specific MCLs for each group, and 5) concerns over reproductive and developmental effects that may be associated with DBPs, which may lower the regulatory levels and/or the permissible maximum concentration (i.e., annual averaging may no longer be the basis for determining compliance).

In summary, it was the opinion of the panel that < 3 mg/L of TOC and < 50 μg/L of bromide would be necessary to allow users the flexibility to incorporate either enhanced coagulation or ozone disinfection to meet the potential long-term regulatory scenario in this evaluation. The TOC value is constrained by the formation of total trihalomethanes when using enhanced coagulation for TOC removal and free chlorine to inactivate *Giardia*. The bromide value is constrained by the formation of bromate when using ozone to inactivate *Cryptosporidium*. Looking only at the potential near-term regulatory scenario provides significantly more source water flexibility when using enhanced coagulation or ozone, with source water TOC concentrations ranging between 4 and up to 7 mg/L (the 90th percentile value for waters diverted from the south Delta) and bromide ranging between 100 and 300 μg/L, depending upon the extent of *Giardia* inactivation required (the near-term scenario does not include *Cryptosporidium* inactivation).

Similarly, the use of either GAC or membrane treatment in the long-term regulatory scenario broadens the allowable source water quality. For GAC, a source water TOC value of 5 mg/L is acceptable with bromide of 150 μg/L or 50 μg/L, depending upon *Giardia* inactivation. GAC alone is not applicable to instances in which *Cryptosporidium* inactivation is required, and must be coupled with ozone disinfection. This allows the source water TOC concentration to increase to at least 7 mg/L, although bromide is constrained to < 50 μg/L even at an ozone pH of 6.5.

The use of microfiltration or ultrafiltration, coupled with ozone for primary disinfection and chloramines for secondary disinfection, is an "absolute barrier" for protozoan (*Giardia* and *Cryptosporidium*) removal. Viruses, however, must still be inactivated. This treatment scheme allows source water TOC concentrations to increase to at least 7 mg/L. The bromide concentration is again limited by bromate formation under ozone addition for virus inactivation, and is < 150 μg/L for microfiltration and < 300 μg/L for ultrafiltration (less virus inactivation is required for ultrafiltration). If nanofiltration is used with free chlorination, TOC concentration can be up to 10 mg/L for all bromide concentrations evaluated (< 300 μg/L).

It is important to note that when ozone disinfection is used for treatment, the allowable TOC is not unlimited. There are concerns regarding the ability of biological filters or GAC to remove biodegradable organic carbon to adequate levels as TOC approaches 7 mg/L (the 90th percentile for water diverted from the south Delta). In general, ozone disinfection is more effective and reliable as TOC decreases.

The feasibility of implementing either GAC or NF/RO membranes in California, given cost considerations, environmental permitting constraints, and limited residual disposal options, is uncertain. The use of MF/UF membranes address some residual disposal issues, but large system design issues affect feasibility on a site-specific basis.

1.0 INTRODUCTION

The California Urban Water Agencies (CUWA) engaged the services of three water quality experts to assist in providing input to the CALFED process regarding potential management alternatives in the San Francisco Bay/Sacramento-San Joaquin River Delta (Delta). The expert panel was charged with determining the required raw water quality diverted from the Delta which would permit the effective implementation of specific drinking water treatment processes to meet potential future drinking water quality standards. The expert panel was comprised of Douglas M. Owen, P.E., Vice President at Malcolm Pirnie, Inc., Phillippe A. Daniel, P.E., Associate at Camp, Dresser & McKee, and R. Scott Summers, PhD, Associate Professor at the University of Cincinnati.

The expert panel used data submitted by CUWA members, available literature and ongoing research, as well as their own experience and best professional judgement to arrive at potential source water quality requirements. Available models for DBP formation were evaluated to investigate threshold DBP formation behavior and to support the preliminary conclusions reached by the expert panel. This report presents the best professional judgement from this expert panel.

This report is subdivided into the following chapters:

Chapter 2 - Potential Regulatory Scenario and Schedule

Chapter 3 - Treatment Processes to Meet Regulatory Requirements

Chapter 4 - Evaluation of Source Water Quality and Treatment Efficiency

In Chapter 2, the general trends in drinking water regulations are discussed and plausible, future regulatory criteria are presented. Treatment processes relevant to users of water diverted from the Delta are presented in Chapter 3, together with general assumptions regarding the design and application of these processes. In Chapter 4, source water quality is projected which allows the treatment processes defined in Chapter 3 to be used to meet the potential regulatory scenario presented in Chapter 2.

2.0 POTENTIAL REGULATORY SCENARIO AND SCHEDULE

2.1 REGULATORY SCENARIO

2.1.1 Introduction

From a perspective of water quality parameters which can be controlled through management strategies in the Delta [e.g., total organic carbon (TOC) and bromide], the most critical present and future human health-related regulations affecting the implementation and performance of drinking water treatment processes for agencies using Delta water are:

1. Microbiological control - The focus for disinfection and microbial control currently pivots around the removal and inactivation of *Giardia* and *Cryptosporidium*. Currently, 3 log (99.9 percent) removal and inactivation of *Giardia* is required in the Surface Water Treatment Rule (SWTR). The EPA began considering an Enhanced SWTR (ESWTR) starting in late 1992, which would address the ability of systems to maintain microbiological control as disinfection practices were scrutinized. This rule would also address the removal/ inactivation of *Cryptosporidium*, through either removal or inactivation. The ESWTR has been proposed in two stages (USEPA, 1994) and is currently being re-evaluated, as discussed below.

2. Disinfection By-Product Control - The disinfectant residual concentration and the organic and inorganic compounds formed by the disinfection process (termed disinfection by-products or DBPs) will be regulated under the Disinfectants/Disinfection By-Products (D/DBP) Rule. This rule also was proposed in two stages (USEPA, 1994) and is currently being re-evaluated.

Other water quality contaminants, such as pesticides, herbicides, and metals, are of concern but are not likely to constrain treatment requirements as significantly as the microbial and DBP regulations, based upon their occurrence in water currently diverted from the Delta.

Both stages of the ESWTR and D/DBP Rule will impact the CUWA members and will affect the quality of water diverted from the Delta to meet regulatory requirements using an array of treatment technologies. Although a longer-term view of the regulations (i.e., second stage) is more appropriate to coordinate with the ultimate Delta management solutions, these future regulations are still relatively uncertain. The initial regulations -- Stage 1 of the D/DBP Rule and the Interim ESWTR — have been agreed to in principle through a Federal Advisory Committee Act (FACA) process involving stakeholder meetings held in the Spring and Summer of 1997. Consequently, the expert panel evaluated potential future source water quality requirements using the specified technologies for both the near-term and long-term regulations.

The following sections discuss potential regulatory scenarios for both the near-term (i.e., Stage 1 D/DBP Rule and Interim ESWTR) and the long-term (i.e., Stage 2 D/DBP Rule and Long Term 2 ESWTR) regulations. Source water quality requirements are developed in Chapter 4, using the defined technologies in Chapter 3, to meet both the near-term and long-term potential regulatory outcomes.

2.1.2 Potential Near-Term Regulatory Scenario

Stage 1 D/DBP Rule

The requirements for the Stage 1 D/DBP Rule have been agreed to in principle through the FACA process. The requirements most significantly impacting treatment technologies and source water quality requirements include maximum contaminant levels (MCLs) and a treatment technique. Relevant MCLs include an 80 $\mu g/L$ standard for total trihalomethanes (TTHMs) and 60 $\mu g/L$ value for the sum of five haloacetic acids (HAA5). In addition, a 10 $\mu g/L$ MCL has been proposed for bromate (a compound formed in bromide-containing waters, particularly with ozone treatment).

The treatment technique is enhanced coagulation and enhanced precipitative softening. For the CUWA members, the requirements of enhanced coagulation are more relevant than those for softening. With a few exceptions based upon treated water quality, enhanced coagulation must be implemented at existing conventional treatment facilities. It will not be enforced for direct filtration facilities. The treatment requirements for enhanced coagulation, as they apply to this evaluation, are discussed in Chapter 3.

Interim ESWTR

The Interim ESWTR (IESWTR), also agreed to in principle at the FACA negotiations, is designed to provide microbial protection as systems are potentially modifying treatment practices to comply with Stage 1 of the D/DBP Rule. In summary, the IESWTR focuses on maintaining the level of chemical disinfection currently provided at existing facilities, while requiring a higher standard of particle removal. Briefly, the standard for combined filtered water turbidity will be reduced to <0.3 NTU at least 95% of the time. Individual filter turbidities must be monitored and there is a series of evaluations which must be performed if individual filter water turbidities exceed 1 or 2 NTU for consecutive 15 minute measurements.

The chemical disinfection requirements are based upon a microbial "backstop." In concept, the backstop focuses on maintaining the minimum level of disinfection that existing facilities have historically been providing. If a system modifies disinfection practices to meet the requirements of Stage 1 of the D/DBP Rule, they must either 1) meet or exceed the "backstop" disinfection practice, or 2) discuss their proposed disinfection modifications with the primacy agency (e.g., California Department of Health Services). The backstop is calculated through profiling existing disinfection practices as follows:

1. The monthly average of daily *Giardia* inactivation is calculated for three consecutive calendar years.

2. The minimum monthly average inactivation is identified for each calendar year.

3. The three minimum monthly average inactivations are averaged to calculate a single, "backstop" value.

This backstop is only applicable if a significant change in disinfection (e.g., disinfectant type, dosage) is implemented by the system which results in an inactivation that is less than the backstop value. It is important to note that the backstop triggers a discussion with the primacy agency. It is possible that the utility may be allowed to reduce the level of disinfection below the backstop level, depending upon the backstop value, disinfectant type, and other site-specific issues. The final disinfection requirements, if less than the backstop, are determined by the primacy agency together with the utility.

Historical disinfection data submitted by the Metropolitan Water District of Southern California and the Alameda County Water District were reviewed to determine a "central tendency" backstop for the CUWA members. The evaluation indicated that the backstop value could vary between 90 percent (1 log) and 99 percent (2 log) inactivation of *Giardia*.

Therefore, the expert panel considered both of these backstop values in determining source water quality requirements.

Potential Near-Term Regulatory Scenario

Based upon the above discussion, the potential near-term regulatory scenario is summarized in Table 2.1:

TABLE 2.1

POTENTIAL NEAR-TERM REGULATORY SCENARIO

Regulation	Parameter	Treatment Requirement or MCL
Interim ESWTR	*Giardia*	Additional 1 or 2 log inactivation by disinfection, after treatment removal credit
Stage 1 D/DBP Rule	TTHMs	80 μg/L
	HAA5	60 μg/L
	Bromate	10 μg/L

2.1.3 Potential Long-Term Regulatory Scenario

Stage 2 D/DBP Rule

Stage 2 DBP levels which were proposed in 1994, while acknowledged to be "placeholder" values until additional data can be collected and reviewed, were assumed to be reasonable targets for this analysis (i.e., TTHM of 40 μg/L, HAA5 of 30 μg/L). Further, a bromate MCL of 5 μg/L was considered for the long-term. The rational for this level is based upon a host of factors. First, the 10^{-4}, 10^{-5}, and 10^{-6} excess cancer risk levels for bromate are 5 μg/L, 0.5 μg/L and 0.05 μg/L, respectively. These levels were confirmed in EPA's recent Notice of Data Availability for Disinfectants and Disinfection By-Products in March 1998 (USEPA, 1998). Although a 5 μg/L limit was considered during the regulatory negotiation in 1992-1993, a value of 10 μg/L was established based upon practical quantitation levels (PQLs) for this compound at that time. Since 1994, however, many improvements have been made in the analytical technique for bromate thereby providing an excellent potential for reducing the PQL in future rulemaking. Because of EPA's reaffirmation of the carcinogenicity of bromate in recent studies and the improvement in analytical techniques, a bromate target of 5 μg/L was selected for the long-term scenario.

Long-Term ESWTR

The final outcome for a Long Term 2 ESWTR (LT2ESWTR) is uncertain, but many alternatives in the ESWTR proposed by EPA require treatment based on pathogen density in source waters (USEPA, 1994). Based upon 1) a review of pathogen data collected at various locations in the Delta by the Metropolitan Water District of Southern California, and 2) regulatory alternatives proposed in the ESWTR, plausible requirements identified by the expert panel for Delta water range from 1 log and 2 log inactivation of *Giardia* to 1 log inactivation of *Cryptosporidium*. This level of inactivation would be required after treatment removal credit is achieved. These criteria assume that higher log inactivations will be required as the concentration of pathogens in the source water increases. For every log increase in source water concentration, an additional log increase in removal/inactivation is required to achieve a constant finished water quality. This concept was proposed in the SWTR Guidance Manual and was furthered in several proposals published by EPA for the ESWTR.

Potential Long-Term Regulatory Scenario

Based upon the above discussion, the potential long-term regulatory scenario is summarized in Table 2.2:

TABLE 2.2

POTENTIAL LONG-TERM REGULATORY SCENARIO

Regulation	Parameter	Treatment Requirement or MCL
Long-Term 2 ESWTR	*Giardia*	Additional 1 or 2 log inactivation by disinfection, after treatment removal credit
	Cryptosporidium	Additional 1 log inactivation by disinfection, after treatment removal credit
Stage 2 D/DBP Rule	TTHMs	40 μg/L
	HAA5	30 μg/L
	Bromate	5 μg/L

While there are many factors that contribute to the uncertainty surrounding the projected regulatory scenario in Table 2.2, it is the selected bromate level of 5 μg/L that most keenly influences the analysis. The rationale for this level (i.e., advances in detection limit, the weight of the carcinogenic evidence, the precedence for THM and HAA5 limits in Stage 2 at half the Stage 1 levels) in this analysis could ultimately be modified by a variety of factors. Nevertheless, in the absence of more definitive direction, the panel considers a 5 μg/L value to be both prudent and plausible.

There are other potential regulatory outcomes involving 1) further lowering the MCLs for DBPs, 2) the regulation of individual DBP species (rather than the groups of compounds represented by TTHM and HAA5 due to the potentially more severe health effects associated with brominated compounds), 3) regulating other DBPs beyond TTHMs and HAA5, including the addition of other HAAs (there are nine total) as analytical methods are developed and refined, 4) a comparative risk framework which balances all of the risk attributable to the DBPs formed, rather than providing specific MCLs for each group, and 5) concerns over reproductive and developmental effects that may be associated with DBPs, which may lower the regulatory levels and/or the permissible maximum concentration (i.e., annual averaging may no longer be the basis for determining compliance). The potential implications of such regulatory outcomes is briefly discussed in Section 4.4.

2.2 REGULATORY SCHEDULE

The recently-enacted 1996 Amendments to the Safe Drinking Water Act (SDWA) have caused EPA to adopt a more ambitious schedule than EPA presented in June 1996 (see Table 2.3). The June 1996 dates were based upon a scenario in which EPA would not be "pushed" to develop an Interim ESWTR, and promulgate Stage 1 of the D/DBP Rule and the Interim ESWTR, until pathogen data were available from the Information Collection Rule (ICR).

TABLE 2.3

COMPARISON OF OLD AND NEW REGULATORY SCHEDULE

Regulation	Promulgation Date	
	Initial (June 1996)	Revised (August 1996)
Interim ESWTR	June 2000	November 1998
Long Term 2 ESWTR	NA [1]	November 2000
Stage 1 D/DBP Rule	June 2000	November 1998
Stage 2 D/DBP Rule	June 2003	May 2002

Notes:
(1) NA = Not available

EPA understands, however, that the LT2ESWTR and Stage 2 of the D/DBP Rule, at a minimum, are linked to data availability through the ICR. Monitoring for the 18-month ICR began in July 1997. Consequently, EPA was pressed between the statutory requirements and the recognition that a longer time frame would be required to promulgate Stage 1 of the D/DBP Rule and the IESWTR if the ICR data were to be considered. Therefore, EPA proceeded with interim regulations for microbial and DBP control based upon the existing knowledge base rather than waiting for the ICR data. The FACA process for the agreement in principle concluded in June 1997 to allow EPA to meet the schedule in Table 2.3 for the near-term regulations. Nevertheless, both the LT2ESWTR and Stage 2 of the D/DBP Rule will ultimately need to be finalized and become effective by the dates given in the reauthorized SDWA (November 2000 and May 2002, respectively) and take the ICR data into account. Even though the ICR monitoring has begun, the schedule will remain tight as a result of the time needed to analyze the data and to perform treatability studies to support compliance forecasts for the Stage 2 D/DBP Rule.

3.0 TREATMENT PROCESSES REQUIRED TO MEET FUTURE REGULATIONS

In this chapter, general process criteria are defined to characterize specific treatment processes relevant to users of water diverted from the Delta. Source water quality is determined in Chapter 4 which permits these treatment processes to meet the potential regulatory scenarios discussed in Chapter 2.

3.1 SELECTION OF TREATMENT PROCESSES TO BE EVALUATED

As a part of this effort, CUWA requested that the expert panel initially focus on those treatment processes which were considered to be the most cost-effective for simultaneously meeting the requirements of the D/DBP Rule and the ESWTR when treating water diverted from the Delta. These processes were defined as enhanced coagulation, a treatment technique proposed for Stage 1 of the D/DBP Rule, and ozone disinfection. These two processes are also relevant for Stage 2 of the D/DBP Rule and were considered appropriate because they can be implemented into facilities currently owned and operated by the CUWA agencies (as well as a majority of conventional filtration facilities across the country). For example, the majority of filtration systems across the country use conventional treatment including sedimentation, which allows for increased coagulation dosages to meet proposed enhanced coagulation requirements. In addition, some CUWA facilities already use ozone disinfection. The most cost-effective option(s) for meeting potential future regulations is specific for each water purveyor, depending upon water source and quality.

Based upon comments received from the Natural Resources Defense Council (NRDC), CUWA also directed the expert panel to evaluate the impact of implementing post-filter granular activated carbon (GAC) adsorbers and membranes on the potential allowable source water quality characteristics. Neither of these processes are currently used by any of the CUWA members and their feasibility for large scale water treatment facilities in California is uncertain. Post-filter GAC adsorbers and membranes can be at least an order of magnitude more expensive than ozone and the feasibility of these technologies is much more uncertain based upon cost, environmental permitting constraints, and availability of residual handling alternatives. This view is shared by much of the water industry. For reference, only one or two treatment plants in the country at the size comparable to many of the CUWA members use post-filter GAC or membranes for drinking water treatment.

There are CUWA members who now treat much higher quality water than that currently diverted from the Delta. These entities are able to use in-line filtration or simply disinfection without filtration to produce high quality drinking water. It should be emphasized that the determination of feasible treatment processes is dependent upon the existing source and that this evaluation is based only upon those entities currently using water diverted from the Delta.

3.2 GENERAL ASSUMPTIONS FOR SELECTED TREATMENT PROCESSES

3.2.1 Enhanced Coagulation

Enhanced coagulation offers the advantages of removing naturally-occurring organic material, thereby removing DBP precursors which, upon disinfection, form DBPs. As such, MCLs for TTHMs and HAA5 can be addressed by enhanced coagulation, when followed by chlorine disinfection. Upon review of the potential for DBP formation, it was determined that enhanced coagulation would only be required under conditions in which free chlorine is used for primary disinfection (pathogen inactivation), followed by chloramines for secondary disinfection to maintain a distribution system residual. Further, this treatment option is only applicable to instances in which either 1 or 2 log *Giardia* inactivation is required to demonstrate microbial control, as discussed in Chapter 2. It was assumed that *Cryptosporidium* inactivation could not be achieved by free chlorine disinfection under treatment conditions feasible for drinking water systems.

The conditions for enhanced coagulation were defined according to the specific percent removal requirements for Total Organic Carbon (TOC) -- as proposed in Stage 1 of the D/DBP Rule (USEPA, 1994) and amended through the FACA process -- by raw water TOC and alkalinity. Given the specific TOC removal percentages in the proposed D/DBP Rule, this translated to a projected 40 mg/L dosage of alum at a coagulation pH of 7.0, and possibly as low as 6.5. Consequently, acid addition may be required since the 40 mg/L dosage will likely only lower the pH to a value between 7.0 and 7.2. These coagulant dosages are not atypical of those currently being used by some CUWA members (e.g., Alameda County, Contra Costa, and Santa Clara Valley Water Districts), although these systems do not reduce pH with acid to improve precursor removal. It was assumed that a chlorine: TOC ratio of 1:1 and 60 minutes of free chlorine contact (t_{50}) would be required to achieve 1 log inactivation of *Giardia*. For 2 log *Giardia* inactivation, 120 minutes of free chlorine contact would be required. The above criteria for chlorine dose and contact time assume a chlorine residual of approximately 1 to 1.5 mg/L after the associated contact time, with a t_{10}:t_{50} ratio of between 0.5 and 0.6 in a moderately well-baffled contactor. This allows for the appropriate CT values to be met at the limiting case of a temperature between 10 and 15° C and a chlorination pH of 7.0 to 7.5. The 1 and 2 log *Giardia* inactivation targets are applicable to both the backstop for the IESWTR and some of the microbial requirements for the LT2ESWTR in the potential regulatory scenarios in Chapter 2.

In the above definition, it is assumed that chlorination would be postponed until after coagulation, flocculation and sedimentation is complete. It is recognized that during the latest round of regulatory deliberations, the USEPA accepted that utilities may need to provide raw water chlorination -- and receive credit for microbial inactivation -- simultaneously with removing organic material to reduce DBP formation. Recent enhanced coagulation research (Summers, 1997) indicates that the DBPs formed when chlorination is delayed until after sedimentation may be only 75 to 80 percent of those formed when prechlorination is practiced. Consequently, the definition of enhanced coagulation used in this evaluation represents the best that systems could achieve in terms of DBP production. This translates to a larger allowable range for source water quality. In addition, the above definition assumes that the systems can and will construct additional dedicated contact chambers to meet inactivation requirements, if required. There are costs associated with providing additional clearwell contact time beyond that currently available.

In the evaluation in Chapter 4, regions of "uncertainty" are illustrated to delineate those source water conditions under which the selection of specific treatment technologies will be highly system-specific. For enhanced coagulation, these regions will include the uncertainty associated with potential differences in DBP formation based upon whether or not prechlorination is practiced under enhanced coagulation conditions.

3.2.2 Ozone Disinfection

The use of ozone disinfection offers the opportunity to meet the MCLs for TTHM and HAA5 in the potential regulatory scenario by again using chloramines as the secondary disinfectant. Therefore, additional removal of naturally-occurring organic matter may not be necessary. That is, enhanced coagulation may not have to be coupled with ozone disinfection, as long as the source water TOC is ≤ 4.0 mg/L and alkalinity is > 60 mg/L as $CaCO_3$. Implementing ozone and chloramines under the Stage 1 timeframe to meet both Stage 1 and Stage 2 MCLs is one strategy for water utilities to avoid implementing enhanced coagulation when treating source waters with TOC concentrations ≤ 4.0 mg/L and alkalinity > 60 mg/L as $CaCO_3$. Many entities using water diverted from the Delta, however, treat source water TOC concentrations > 4 mg/L.

Based upon the ozone dosage and inactivation data from the CUWA members, the expert panel's experience, and recent research, possible ozone: TOC ratios which may be required to achieve pathogen inactivation were evaluated. These ratios take into consideration a host of factors, including 1) CT requirements for 1 log *Cryptosporidium* inactivation may be up to 10 times that required for 1 log *Giardia* inactivation, 2) ozone residuals increase as dosages increase for a fixed contact time once the initial ozone demand has been satisfied, and 3) pH affects the persistence of ozone residuals. The ratios were adjusted for pH effects (i.e., greater ozone residual persistence as pH decreases resulting in lower ozone requirements). For example, to meet 1 log *Giardia* inactivation at ambient pH, Alameda County Water District routinely requires an ozone to TOC ratio of 0.8 (ambient pH for entities using water diverted from the Delta can range from 7.5 to 9.5, a "typical" value of 7.8 is used in this analysis). At pH 7, MWD's demonstration plant results indicated roughly a 0.7 ozone: TOC ratio for achieving 2 log *Giardia* inactivation. It is important to note that CT compliance needs to be achieved continuously, and therefore an approximate

20 percent safety factor was applied to the CUWA member data. This also partially accounts for EPA's approach in setting CT values based upon 90 percentile values versus median (50 percentile values) which are represented by the CUWA member data. The selection of ozone: TOC ratios also considered operational issues, for which it was assumed that there would be a certain "overshoot" of specific dosage targets to ensure continual CT compliance. Based upon these assumptions, bromate formation was evaluated at a range of ozone: TOC ratios and pH values, as summarized in Table 3.1.

TABLE 3.1

OZONE: TOC RATIO AND PH CONDITIONS FOR BROMATE EVALUATION

pH	Ozone: TOC Ratios
7.8	0.8, 1.2, 1.5
7.2	0.7, 1.0, 1.3
6.8	0.6, 0.9, 1.1
6.5	0.5, 0.75, 1.0

The ozone: TOC ratios at each pH were considered to inactivate 1 log *Giardia*, 2 log *Giardia*, and 1 log *Cryptosporidium*. The 1 and 2 log *Giardia* inactivation is relevant to both the potential near and long-term regulatory scenarios presented in Chapter 2. The 1 log *Cryptosporidium* inactivation is only relevant to the LT2ESWTR in the potential regulatory scenario in Chapter 2.

It is recognized that the above ozone:TOC ratios are dependent upon other ozone design criteria proposed, such as a 12 minute contact time in a single, multi-chamber contactor. Other facility configurations, such as two-stage ozonation (e.g., ozone added at raw and settled water) and longer ozone contact times may yield different source water quality constraints for a fixed water quality target (e.g., bromate MCL). The criteria proposed here are based upon typical ozone system designs throughout the country.

The expert panel was also requested to evaluate bromate formation at pH 6.0. Relatively fewer data are available at this pH, and this value is outside the boundary conditions of available models (Ozekin, 1994) that were used to assist in validating the expert panel's initial opinions. Further, very few systems with moderate to high alkalinity

(> 60 to 80 mg/L as $CaCO_3$) would consider providing treatment at a pH of 6.0. It has a significant impact on chemical (acid) feed requirements to reduce pH which, in turn, have secondary impacts. For example, total dissolved solids (TDS) levels can increase significantly as a result of acid addition to achieve a pH of 6.0 in moderate to high alkalinity waters. A pH of 6.0 is also very aggressive to basin and pipe surfaces, and special precautions should be implemented in the design and construction of facilities to accommodate this pH.

It is the relative lack of data, however, that led the expert panel to not predict bromate production at a pH of 6.0. Any bromate concentration predicted at this pH would be speculative in nature, and would have a much greater uncertainty than other values presented in this report. Consequently, predictions of bromate formation at pH 6.0 are not presented.

3.2.3 Granular Activated Carbon Adsorption

Post-Filter GAC

Like enhanced coagulation, granular activated carbon controls the formation of DBPs through the removal of DBP precursors. Initially, GAC can remove over 80 percent of the organic DBP precursors. It is an unsteady-state process, however, in which the effluent concentration increases with time and the GAC has a finite adsorption capacity. Thus, when the effluent treatment objective is exceeded the GAC must be removed from the adsorbers and reactivated or replaced. The critical design parameter is the empty bed contact time (EBCT), which is the ratio of the volume of GAC to the volumetric flow rate. The critical operational parameter is the reactivation time or run time to the controlling effluent treatment objective. For the control of DBP precursors, typically measured as TOC, design EBCTs of 15 to 30 minutes are used and the GAC is operated until the effluent concentration (C) reaches 30 to 70 percent of that in the influent (C_0). The EBCTs are chosen so that the reactivation periods are at least 60 days. More frequent removal/reactivation of the GAC is expensive and limits feasibility from an operational perspective.

GAC is normally applied after the coagulation/sedimentation process and was assumed to follow rapid media filtration for this evaluation (post-filter adsorption mode). A GAC influent TOC range of 3 to 7 mg/L was evaluated and Table 3.2 lists the resulting effluent TOC concentration values for a range of breakthrough ratios (C/C_0).

TABLE 3.2

PREDICTED GAC EFFLUENT QUALITY FOR A RANGE OF INFLUENT TOC CONCENTRATIONS

Influent TOC (mg/L)	Effluent TOC (mg/L)		
	$C/C_0 = 0.3$	$C/C_0 = 0.5$	$C/C_0 = 0.7$
3	0.9	1.5	2.0
4	1.2	2.0	2.8
5	1.5	2.5	3.5
6	2.8	3.0	4.2
7	2.1	3.5	4.9

The same disinfection assumptions that applied to enhanced coagulation are also applicable to post-GAC microbial inactivation (i.e., a 1:1 chlorine to TOC dose ratio, 60 and 120 minutes of free chlorine contact to yield 1 and 2 log *Giardia* inactivation, respectively; free chlorine followed by chloramines for distribution system residual; no *Cryptosporidium* inactivation with this chlorine/chloramine combination).

Ozone and GAC Treatment

It is important to note that GAC, by itself, will not remove pathogens. Therefore, some systems, particularly in Europe, use GAC following ozone disinfection. In this configuration, ozone provides a strong disinfectant and the GAC is used to control biodegradable ozonation by-products through biological activity and to remove precursors of chlorination/chloramination by-products through adsorption. Many of the biodegradable ozonation by-products can be completely removed, and depending on the EBCT and water quality conditions, the biodegradable organic carbon (BDOC) can be decreased to the levels in the water prior to ozonation. GAC has not been shown to be efficient, however, for removing bromate using feasible design criteria in full-scale applications. This is discussed in greater detail in Section 4.2.2.

Following ozone, GAC can be used in a steady-state mode where the GAC is replaced at a very low frequency (once every 3 to 10 years) and a 20 to 30 percent removal of DBP precursors can be expected. In an unsteady state mode, as described above, the GAC is replaced more often (more than once per year) in which higher removal (30 to 70 percent) of DBP precursors can be expected. In this evaluation of ozone and GAC, ozone is expected to provide inactivation of *Cryptosporidium*, and chloramines will be applied after the GAC to provide a distribution system residual. A free chlorine contact time of 5 minutes was assumed sufficient to provide post-GAC inactivation of heterotrophic plate count bacteria, prior to the application of ammonia.

In this evaluation, it was assumed that the ozone and GAC act somewhat independently for the inactivation and removal of water quality contaminants. For example, ozone can be used to inactivate *Cryptosporidium*; GAC does not appreciably remove microbial contaminants. Ozone forms bromate; GAC does not adsorb bromate in feasible full-scale applications. Ozone does not remove precursors for organically-based DBP compounds (THMs and HAAs); GAC adsorbs these compounds. It is recognized, however, that ozone creates biodegradable organic components which can be adsorbed by GAC, thereby reducing the DBP formation potential through biodegradation. The amount of this removal compared to direct adsorption of organic material is relatively small and within the error of the estimates projected by the expert panel for GAC adsorption, alone.

3.2.4 Membrane Treatment

For simplicity, membrane treatment is divided into two categories in this evaluation:

1. Membrane filtration (e.g., microfiltration, ultrafiltration), which removes particles, protozoan cysts (*Giardia* and *Cryptosporidium*), and some viruses. Membrane filtration does not remove dissolved organic material, hardness, or ionic compounds (e.g., bromide) to any significant degree.

2. Membrane softening (e.g., nanofiltration, reverse osmosis), which removes particles, protozoan cysts, dissolved organic carbon, hardness, viruses and some ions (e.g., bromide). These "tighter" membranes must be preceded by particle removal to reduce fouling. Recently, the use of nanofiltration and reverse osmosis for dissolved organic carbon removal is challenging the traditional use for softening. RO membranes provide more complete rejection of salt (e.g., chloride bromide) than NF membranes.

Membrane filtration and membrane softening differ in many aspects. In general, capital costs for membrane softening are at least twice those for membrane filtration and much higher operating pressures are required for membrane softening (80 to 200 psi) as compared to membrane filters (15 to 30 psi). Therefore, the higher quality water produced by membrane softening comes at a price.

Membrane Filtration

Membrane filtration is being evaluated in a wide array of drinking water applications. The largest facility with an operating history in the United States is a 5 mgd facility in San Jose, CA. Larger facilities are under design, construction, and are being put on-line. Design of a 28 mgd facility is underway with planned operation in 2000 in Del Rio, Texas. Nevertheless, the use of membrane filtration for large plants (> 40 to 50 mgd) has not been demonstrated and the feasibility is uncertain. Most MF/UF installations showing demonstrated performance have modular units in the 1 to 1.5 mgd capacity range. Therefore, large plants require a large number of treatment modules, which significantly increases facility complexity.

The major advantage of membrane filtration is that, in the absence of coagulation, it does not produce a chemically-treated waste product. Consequently waste disposal is simpler. Further, the cost of membrane filtration is competitive with complete conventional treatment. The feasibility of membrane filtration, however, is dependent upon the source water. It performs best on low turbidity waters and waters low in TOC. Because membrane filters do not remove dissolved compounds, additional pretreatment (i.e., coagulation, flocculation and possibly sedimentation or flotation) must precede this technology if removal of organic carbon is necessary. This may reduce the cost efficiency of membrane filtration compared to conventional treatment.

Because membrane filters do not remove TOC or bromide, and because some virus inactivation still is required after treatment, the use of ozone disinfection followed by a chloramine residual in the distribution system will allow for the maximum flexibility in source water quality diverted from the Delta. In this evaluation, it was assumed that microfilter (MF) or ultrafilter (UF) membranes would follow existing, conventional sedimentation. Assuming 1 log and 2 log virus removal credits for sedimentation coupled with MF and UF, respectively, additional 3 log (MF) and 2 log (UF) virus inactivations will be required by ozone to meet regulatory requirements. The CT requirements for 1 and 2 log virus inactivation by ozone are similar to that required for 0.5 log and 1.5 log *Giardia* inactivation, respectively. Therefore, bromate formation still is a concern using a membrane filtration/ozone/chloramine treatment strategy. Consequently, it was assumed that an ozonation pH of 6.5 would be required to maximize the flexibility in source water bromide concentrations diverted from the Delta.

Instead of using ozone, it is possible to use free chlorine following MF or UF to provide virus inactivation. The use of chlorine, however, introduces source water limitations based upon TTHM and HAA5 concentrations. Consequently, ozone was evaluated for disinfection rather than free chlorination following membranes. In addition, it may be possible to demonstrate a 4 log virus removal using UF, thereby eliminating any need for supplemental primary disinfection. This would have to be demonstrated to the satisfaction of the primacy agency.

Membrane Softening for DOC and Bromide Removal

There are a few membrane softening plants used for potable water treatment throughout the country, mostly in Florida. The largest membrane softening application for drinking water in the United States is 12 mgd. Slightly larger facilities have been constructed for groundwater recharge in California.

NF/RO membrane provides distinct advantages compared to MF/UF in that microbial contaminants (*Giardia, Cryptosporidium* and some viruses), dissolved organic carbon and bromide are all removed. There are two major issues which affect the feasibility of NF/RO membrane treatment in California. One is the disposal of membrane concentrate and the other is the volume of concentrate "wasted" from the system, which is much larger than that "wasted" by MF/UF systems. In a water-short regions such as California, the reject of 15 percent of the source water volume may be considered unacceptable. Further, this reject is highly concentrated with dissolved ions, and therefore disposal options, other than the ocean (if this can be environmentally permitted) are limited. Consequently, these considerations must be carefully weighed when determining whether it is feasible to implement NF/RO treatment.

For softening membranes, it is assumed that existing conventional treatment available at the CUWA treatment facilities, followed by cartridge filters, will provide sufficient pretreatment. Research and full-scale operations suggest that NF treatment can achieve at least 90 and 50 percent removal of TOC and bromide, respectively. It is recognized that RO could provide even higher levels of bromide removal (up to 90 percent), but NF was used as the limiting case in this evaluation. Further, it was assumed that membranes would be treating the entire flow. It is recognized that many facilities by-pass a portion of the membrane influent to achieve a target value for specific parameters (e.g., total dissolved solids) to lower costs and reduce corrosivity. This refinement, however, is beyond the scope of this effort as the extent of blending desired is site-specific.

Application of NF/RO is considered in combination with post-membrane chlorination for both primary and secondary disinfection in this evaluation because of the generally good quality (low TOC and TDS) of the treated water. Uniform formation conditions (UFC) were used to simulate the distribution system conditions (Summers et al., 1996); 24 hour contact time, pH 8.0, temperature of 20° C and a free chlorine residual of 1 mg/L after 24 hours.

3.3 CONCEPTUAL UNIT COSTS FOR TECHNOLOGIES

The technologies presented in this chapter have unique capital and operation and maintenance (O & M) costs. In this section, conceptual unit costs for specific technologies are provided. The estimates show a range of incremental costs, on a $/acre-ft (AF) basis (e.g., the increased unit cost for water treatment), for enhanced coagulation, ozone disinfection, granular activated carbon (GAC), membrane filtration (MF/UF), and membrane softening (NF/RO).

A range is provided to demonstrate that there is a spectrum of costs associated with a given technology, which is highly dependent upon factors such as design criteria, system size, and other site-specific factors. It must be emphasized that the costs presented here are incremental costs, and do not include costs for other aspects of treatment. For example, the membrane treatment costs do not include pretreatment, which will be considerable for NF/RO treatment. It is possible that conventional treatment including filtration can provide adequate pretreatment for NF/RO, but the consistency of the pretreated water is critical for the success of the NF/RO technology.

The range of costs presented are based upon the expert panel's experience with systems around the country and are consistent with costs prepared for the USEPA during their development of the D/DBP Rule. These technology costs were peer-reviewed during the regulatory negotiation in 1992-1993 and were deemed acceptable by water industry representatives. Further, the costs were updated for the 1997 deliberations, and membrane costs were modified to reflect the substantial improvements in technology since 1992.

The expert panel did not generate independent cost estimates for CUWA members, as such costs are extremely site-specific and such an evaluation is not with the scope of this effort. The costs presented in this Section were compared to costs developed by the Metropolitan Water District of Southern California for all technologies, with the exception of membrane filtration. When Metropolitan's estimates are converted to unit costs ($/AF), the values fall within the range of costs presented here.

Table 3.3 provides unit costs for the technologies on a $/AF basis. These conceptual costs include amortized capital costs (e.g., 20 year design period, 8 percent interest) added to annual O & M costs. Again, these costs assume treatment of the entire facility flow, without bypassing and blending.

Table 3.3

Conceptual Incremental Unit Cost Treatment

Treatment	Incremental Cost $/Ac-Ft
Enhanced Coagulation	16-34
Ozone	26-42
Granular Activated Carbon	100-210
MF/UF Membranes	140-250
NF/RO Membranes	340-650

It is important to note that costs for controlling pH are not provided in the above table. These costs are highly site-specific but can add $5 to $10/Ac-Ft to incremental costs. In addition, it is important to reemphasize that all incremental costs are highly dependent upon many site-specific factors. A sample of potential factors affecting costs is presented in Table 3.4.

Table 3.4

Some Factors Affecting Incremental Treatment Costs

Technology	Example Factors Affecting Incremental Costs
Enhanced Coagulation	1. System size 2. Existing coagulant dosage 3. Required Coagulant dosage/pH 4. Existing and feasible sludge disposal method
Ozonation	1. System size 2. Oxygen feed source 3. Ozone dosage and pH conditions 4. Energy costs
Granular Activated Carbon	1. System size 2. GAC reactivation frequency 3. Method of reactivation/replacement 4. Energy costs
MF/UF Treatment	1. System size 2. Operating philosophy 3. System configuration 4. Backwash disposal
NF/RO Treatment	1. System size 2. Operating philosophy 3. Energy costs 4. Concentrate disposal option

4.0 EVALUATION OF SOURCE WATER QUALITY AND TREATMENT EFFICIENCY

4.1 WATER QUALITY IMPACTS AND VARIABILITY

In this section, water quality constraints are described which will allow implementation of specific treatment processes to meet potential regulatory goals. In general, the water quality constraints will be described in terms of two measurable surrogate parameters which affect DBP formation; TOC and bromide. In evaluating these water quality variables and interpreting the results, it is important to recognize that:

1. TOC is a heterogeneous mixture, and is comprised of humic and fulvic acids and other naturally-occurring organic material which varies from source to source and from location to location within a source. Consequently, TOC from different regions of the Delta will not have an identical impact on DBP formation. In this effort, it was necessary to assume that TOC could be a unifying variable for organic DBP precursor material, even given the inherent variability in the material which comprises this parameter.

2. The extent to which bromide participates in DBP reactions is dependent upon its oxidation state as well as its relative concentration with other competing oxidants (e.g., chlorine). The following analysis is not stoichiometrically-based, but rather is empirical in nature based upon measured formation rates and other data available to the expert panel.

3. The formation of DBPs is dependent upon many other water quality parameters beyond TOC and bromide, alone. Some of these include temperature and pH. The expert panel focused on TOC and bromide because it was assumed that management alternatives for the Delta had the opportunity to affect these variables, and therefore their control will influence subsequent DBP formation through treatment processes.

In the following presentation, bromide concentrations are provided in μg/L. It is recognized that bromide is often related to chloride concentration, as both are present in salt water which can intrude into the Delta system. If chloride concentrations relevant to stated bromide concentrations are of interest, the following conversion (Krasner et.al. 1994) can be used:

$$Cl^{-}\ (\text{mg/L}) = \frac{Br^{-}\ (\mu\text{g/L}) + 4.96}{3.27}$$

4.2 DISINFECTION BY-PRODUCT FORMATION

4.2.1 Halogenated Organic By-Products

To assist in assessing the formation of DBPs from treated water from the Delta, a TTHM formation model developed for the Metropolitan Water District of Southern California was used (Malcolm Pirnie Inc., 1993). The model was developed from 648 data observations under bench-scale conditions using various blends of water diverted from the Delta. A chlorine-to-TOC dose ratio of 1:1 and free chlorine contact times of 60 and 120 minutes (to yield 1 and 2 log *Giardia* inactivation, respectively) were used in the analysis. A pH of 7.0, a temperature of 20° C and bromide concentration values of 50, 100, 150, 200 and 300 μg/L were also used. These conditions were within the experimental boundaries of the model. A more detailed description of the model is provided in Appendix A. The predicted TTHM values are summarized in Table 4.1.

The TTHM values were compared to the data supplied by the CUWA members, those in the open literature, and with the experience of the expert panel. A summary of the data provided by the CUWA members is included in Appendix B. The available data and the expert panel's experience agreed well with values in Table 4.1.

HAAs are also formed under these reaction conditions. The Stage 1 and Stage 2 proposed TTHM MCLs of 80 and 40 μg/L, and HAA5 MCLs of 60 and 30 μg/L, respectively, yield a mass concentration TTHM-to-HAA5 ratio of 1:0.75. The DBP data supplied to the expert panel by the CUWA members indicate that the TTHM values exceed the HAA5 concentrations by greater than this ratio of 1:0.75 in 84% of the 160 cases where paired TTHM and HAA5 data were available. Other data from both research and full-scale applications in waters containing at least 50 μg/L of bromide confirm these findings (Summers, et. al., 1996, Cheng, et. al., 1995, Shukairy, et.al., 1994). Thus, it was concluded that TTHMs are the DBP of regulatory concern for this evaluation of organic DBP precursor removal. It is important to note, however, that HAA5 represents only five of the nine HAA compounds and three of the four remaining are mixed bromo-chloro compounds which have been shown to have significant levels of formation in bromide containing waters (Cowman and Singer, 1996). If HAA6 or even HAA9 were to become regulated, then the controlling parameters and values could be affected. Further, for source water bromide levels

TABLE 4.1

PROJECTED TTHM FORMATION FROM TREATED WATER

		TTHM Formation ($\mu g/L$)	
Treated TOC (mg/L)	**Bromide ($\mu g/L$)**	**1 hr. contact**	**2 hr. contact**
2.0	50	23	28
	100	26	31
	150	28	33
	200	31	36
	300	36	43
2.25	50	26	31
	100	29	34
	150	31	38
	200	34	41
	300	40	48
3.0	50	34	41
	100	38	45
	150	41	49
	200	45	54
	300	53	63
3.25	50	37	44
	100	40	48
	150	44	53
	200	48	57
	300	57	68
3.9	50	43	52
	100	47	57
	150	52	62
	200	56	67
	300	66	79
4.55	50	49	59
	100	54	65
	150	59	71
	200	64	77
	300	76	90
5.2	50	55	66
	100	61	72
	150	66	79
	200	72	86
	300	85	101
5.4	50	57	68
	100	62	75
	150	68	82
	200	75	89
	300	87	104
6.0	50	62	74
	100	68	81
	150	75	89
	200	81	97
	300	95	114

considerably lower than 50 μg/L, it is recognized that HAA5 may control over TTHM (Cowman and Singer, 1996). These low bromide values were not considered relevant for this study.

A 20 percent safety factor on THM and HAA5 production was used in determining the source water conditions which would result in the target DBP concentrations following treatment. Thus a target TTHM concentration value of 64 μg/L (80% of 80 μg/L) was used for Stage 1 evaluations and 32 μg/L (80% of 40 μg/L) was used for Stage 2 evaluations.

4.2.2 Bromate Formation and Removal

<u>Bromate Formation</u>

The formation of bromate by ozone has come into focus only recently. The ultimate MCL for this compound is of critical importance to facilities which have bromide in their source water and are currently using, or anticipating the use of, ozone for drinking water treatment. Even small concentrations of bromide (< 50 μg/L) can result in measurable concentrations of bromate after ozonation. Therefore, the expert panel carefully evaluated available data from the CUWA members, other available literature, and ongoing research on bromate formation to evaluate potential source water constraints. Based upon these data, the expert panel arrived at initial conclusions regarding potential source water bromide concentrations which would be required to limit bromate formation within the potential regulatory scenarios in Chapter 2.

Unfortunately, bromate formation is strongly dependent upon the nature of the experimental system design (e.g., bench versus pilot or full-scale). In addition, bromate formation depends upon ozone dosage and residual, which is often specific for full-scale facilities, making the direct comparison of these data difficult. Therefore, a bromate model (Ozekin, 1994) was utilized to systematically evaluate the impact of ozone dose, bromide, TOC and pH on the formation of bromate and thereby supplement the available literature (Shukairy et.al., 1994), data supplied by the Alameda County Water District, Contra Costa Water District, Santa Clara Valley Water District, and Metropolitan Water District of Southern California, and the expert panel's experience. The model was developed from data from several source waters including water diverted from the Delta, including results from source waters containing bromide concentrations between 70 μg/L and 440 μg/L. A contact time of 12 minutes was chosen and the concentrations of TOC, bromide, ozone dose and pH were varied over representative ranges as discussed in Chapter 3. At each pH, three ozone: TOC ratios were estimated to provide the following levels of inactivation; 1 log *Giardia,* 2 log *Giardia* and 1 log *Cryptosporidium.* The dose of ozone estimated for these inactivations decreases with decreasing pH as a higher ozone residual is maintained at the lower pHs. The results of the modeling supported the initial conclusions reached by the Panel based upon the available literature and review of the CUWA data. A more detailed description of the model is provided in Appendix A.

Figure 4.1 illustrates bromate formation as a function of source water bromide and ozonation pH. Relationships are shown for 1 and 2 log *Giardia* inactivation for both 5 and 10 μg/L bromate standards, and 1 log *Cryptosporidium* inactivation for a 5 μg/L bromate requirement.

<u>Bromate Removal</u>

Bromate removal after ozonation has been studied for the following technologies:

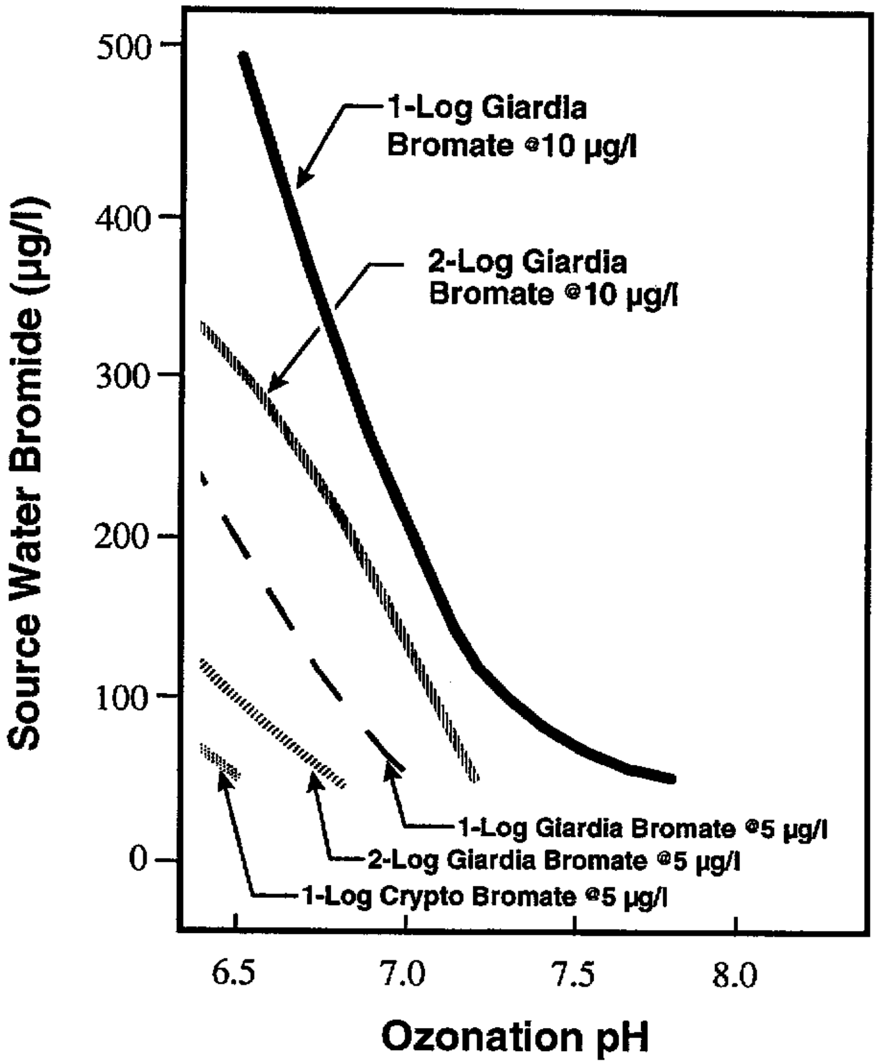
- Ferrous salt coagulation
- Reduction on a GAC surface
- UV Irradiation

It is important to recognize that research on bromate removal mechanisms is relatively new and has only been conducted for about the last five years. Consequently, the technologies presented below have been evaluated on a laboratory scale and published literature on full-scale applications is not available. It is premature to consider that these bromate removal technologies could be implemented reliably and cost-effectively on a full-scale basis.

Ferrous Salt Coagulation

Based on results of an AWWARF project conducted at the University of Colorado and currently in press, ferrous salts have been evaluated as a bromate removal technique with pre-ozonation. Up to 50 to 70 percent removal was reported though filterability problems (turbidity and particle breakthrough) were experienced. Ferric addition in conjunction with ferrous salts somewhat circumvented these filterability problems, though the issue has not yet been sufficiently evaluated. Bromate levels after ozonation ranging

Figure 4.1
Projected Bromide & Ozonation pH Requirements
to Meet Potential Regulatory Scenarios
for Microbial Inactivation and Bromate



Notes
1. Partially based on modeling equations of ozonation *(Ozekin, 1994)*.
2. Approximate value only.

from 20 to 50 μg/L were reduced to below 10 μg/L. Consequently, it is not certain whether a 5 μg/L limit could be met (this depends, in part, on levels exiting the ozone contactor).

Reduction on a GAC Surface

Bromate removal in a GAC contactor is expected to be a two step process in which the bromate is first adsorbed onto the GAC and subsequently is reduced to bromide. Almost complete bromate removal can be expected on a fresh GAC bed. The adsorption and chemical reduction, however, rapidly reaches a steady state with a reduction in removal percentage of bromate from the influent water. The time to reach a steady state varies as a function of empty bed contact time (EBCT). In general, the rapid breakthrough shown to date would result in very short reactivation frequencies that would be difficult to implement on full-scale.

Expected bromate removals are based upon rapid small-scale column test (RSSCT) experiments without biological activity. The effect of biological activity on bromate removal is not known. Additional research is being currently conducted to study these effects.

UV Irradiation

UV irradiation from medium pressure mercury lamps has been found to be effective in the removal of bromate. Limited bench top continuous flow experiments have been performed thus far (Siddiqui and Amy, 1994). A contact time of less than 10 minutes combined with at a UV dose of 600 mW-sec/cm^2 was found to reduce 50 to 100 μg/L of bromate to less than 2 μg/L. Although this technology has been effective on a bench scale, the cost-effectiveness and reliability of UV in large scale application has not been demonstrated or completely evaluated. This technology has not been applied for any purposes at drinking water facilities the size of those operated by the CUWA members.

4.3 SOURCE WATER QUALITY FOR REGULATORY SCENARIOS

In the following discussion, source water quality in terms of TOC and bromide is estimated based upon the implementation of specific treatment technology (defined in Chapter 3) and the potential regulatory outcome (described in Chapter 2). Source water concentrations of TOC were evaluated between 2 and 7 mg/L. The 7 mg/L value represents the 90th percentile for TOC concentrations diverted from the Delta. Bromide concentrations were evaluated up to 300 $\mu g/L$, as this was also considered a practical maximum in this evaluation. The data presented here are summarized in Section 4.5 both in tabular and graphical form.

4.3.1 Stage 1 D/DBP Rule and IESWTR

Enhanced Coagulation

For enhanced coagulation, source water TOC concentrations in the range of 3 to 7 mg/L and bromide concentrations of 50, 100, 150, 200 and 300 $\mu g/L$ were evaluated. As discussed in Chapter 3, an alum dose of 40 mg/L at a coagulation pH of 7.0, and possibly as low as 6.5, was projected to be required to meet the TOC removal requirements. These TOC removal requirements, which are a function of influent alkalinity and TOC concentrations, and the resulting effluent TOC concentrations are shown in Table 4.2.

TABLE 4.2

DETERMINATION OF TREATED WATER TOC FOR ENHANCED COAGULATION

Influent TOC (mg/L)	Required Removal (%)	Treated TOC (mg/L)
3	25	2.25
4	25	3.0
5	35	3.25
6	35	3.9
7	35	4.55

To assess the TTHMs formed from the chlorination of effluents with this TOC range, the results in Table 4.1 can be utilized to draw the following projections:

1. For a 1 log *Giardia* inactivation using free chlorine for 60 minutes following enhanced coagulation, it was projected that the following water quality conditions would permit compliance with the stage 1 TTHM target of 64 $\mu g/L$ in the regulatory scenario:

Raw Water TOC Concentration, mg/L	Bromide Concentration, $\mu g/L$
<7	<150-200
<6	<200
<5	<300

2. For a 2 log *Giardia* inactivation using free chlorine for 120 minutes following enhanced coagulation, it was projected that the following water quality conditions would permit compliance with the stage 1 TTHM target of 64 μg/L in the regulatory scenario:

Raw Water TOC Concentration, mg/L	Bromide Concentration, μg/L
<7	<50-100
<6	<150
<5	<200
<4	<300

For both of the above scenarios, certain combinations of raw water TOC and bromide concentrations that lie between the bounded concentration ranges are also projected to meet the target DBP values. For example, raw TOC concentrations between 6 and 5 mg/L and bromide concentrations between 200 and 300 μg/L, are projected to meet the DBP target values under a 1 log *Giardia* inactivation.

Ozone Disinfection

Bromate formation is the limiting DBP (as opposed to TTHM and HAA5) for the ozone treatment and disinfection strategy specified in this evaluation. It is the opinion of the expert panel that the controlling source water quality parameter for the formation of bromate, in the context of this evaluation, is bromide. It is recognized that higher concentrations of TOC will result in higher ozone dosages to achieve a given CT, and, as a result, may increase the concentration of bromate formed depending upon ozone residual, bromide concentration and potentially other parameters such as contactor design. Higher ozone dosages as a result of higher TOC also result in increased capital and operational costs for ozone treatment. Further, TOC can also be limiting to the extent that the biodegradable material, formed by the reaction between ozone and naturally-occurring organic matter (NOM), is not completely controlled through biofiltration, thereby creating an undesirable regrowth potential in the distribution system. The extent to which regrowth will be a problem is a function of the distribution system design, as well as disinfectant residuals maintained and other water quality parameters which are agency-specific. Nevertheless, sufficient data were not available to isolate the impact of TOC on bromate formation, in the absence of variation in bromide, pH and other water quality factors.

Based upon the data supplied by the CUWA members and other bromate formation studies and the model results, the expert panel concluded:

1. A bromate standard of 10 μg/L is restrictive at ambient pH values. At pH 7.8 (ambient for some pre-ozonated waters) it is projected that a bromide level of 50 μg/L or less would be needed to meet a bromate standard of 10 μg/L for 1 log *Giardia* inactivation. This bromate standard could not be met for ozone dosages providing 2 log *Giardia* inactivation at ambient pH.

2. Lowering the pH of ozonation is an effective means of reducing bromate formation. If the ozonation pH were lowered to 6.5, then a 10 μg/L level of bromate may be achievable with:

   - 1 log *Giardia* inactivation in the bromide range of less than 500 μg/L.
   - 2 log *Giardia* inactivation in the bromide range of less than 300 μg/L.

3. The potential for reliably meeting bromate standards using the bromate removal technologies currently being evaluated is unknown at this time. Although some technologies show promise, many have been demonstrated only on bench scale and the understanding of full-scale feasibility is limited. Consequently, the expert panel does not propose the use of bromate removal techniques as a well-understood and currently feasible and reliable method for increasing the allowable source water concentrations for bromide.

4. Limiting TOC concentrations were not estimated because of the limited availability and robustness of the data illustrating the impact of TOC on bromate formation, in the presence of bromide. It should be recognized, however, that higher TOC concentrations translate to higher ozone dosages to meet a given disinfection criterion and thereby can result in higher bromate formation. This is empirically validated in reviewing bromate formed during settled water ozonation as opposed to raw water ozonation. In general, when TOC concentrations are lower at a given facility, ozone dosages to achieve a given disinfection requirement are lower, and measured bromate concentrations are lower. Lower pH in settled water also helps reduce bromate concentrations.

The expert panel recognizes that there are variations in bromate production data and therefore looked for indications relating to threshold behavior. That is, evaluating source water bromide concentrations which result in a clear increase in bromate concentrations for a given set of ozonation conditions. Given some variation in the formation of bromate reported at lower source water bromide concentrations (< 50 μg/L), the expert panel took a position of plausible conservatism.

GAC and Membrane Treatment

It was the opinion of the expert panel that, given the relative flexibility that enhanced coagulation and ozone disinfection provided to meet the near-term regulatory scenario, CUWA members would not implement GAC or membrane treatment for this potential regulatory outcome. Consequently, source water quality limitations were not developed for these technologies in the near-term regulatory scenario.

4.3.2 Stage 2 D/DBP Rule and LT2SEWTR

Enhanced Coagulation

Using the same approach taken for the stage 1 D/DBP Rule and IESWTR, the following projections can be made for source water quality when using enhanced coagulation to achieve the potential long-term regulatory outcome:

1. For a 1 log *Giardia* inactivation using free chlorine for 60 minutes following enhanced coagulation, it was projected a raw water TOC concentration < 3.0 mg/L and a bromide concentration < 150 μg/L would permit compliance with the Stage 2 TTHM target of 32 μg/L in the regulatory scenario.

2. For a 2 log *Giardia* inactivation using free chlorine for 120 minutes following enhanced coagulation, it was projected that a raw water TOC concentration < 3.0 mg/L and a bromide concentration <50 μg/L would permit compliance with the TTHM target concentration of 32 μg/L in the regulatory scenario.

Ozone Disinfection

The estimates illustrated in Figure 4.1 were again used to evaluate potential source water limitations using ozone disinfection in the long-term regulatory scenario. The expert panel arrived at the following conclusions:

1. A bromate standard of 5 μg/L is very restrictive at pH values above 7. At pH 7.8 (ambient for some pre-ozonated waters) it is projected that this standard will not be met for any of the potential microbial inactivation requirements.

2. If the ozonation pH were lowered to 6.5, then a 5 μg/L level of bromate may be achievable with:

    - 1 log *Giardia* inactivation in the bromide range of less than 200 μg/L.

    - 2 log *Giardia* inactivation in the bromide range of 100 to 150 μg/L.

- 1 log *Cryptosporidium* inactivation with a bromide concentration of less than 50 μg/L.

3. The potential for reliably meeting bromate standard using the bromate removal technologies currently being evaluated is unknown at this time. Although some technologies show promise, many have been demonstrated only on bench scale and the understanding of full-scale feasibility is limited. Consequently, the expert panel did not propose the use of bromate removal techniques as a well-understood and currently feasible and reliable method for increasing the allowable source water concentrations for bromide.

4. Limiting TOC concentrations were not estimated because of the limited availability and robustness of the data illustrating the impact of TOC on bromate formation, in the presence of bromide. It should be recognized, however, that higher TOC concentrations translate to higher ozone dosages to meet a given disinfection criterion and thereby can result in higher bromate formation. This is empirically validated in reviewing bromate formed during settled water ozonation as opposed to raw water ozonation. In general, when TOC concentrations are lower at a given facility, ozone dosages to achieve a given disinfection requirement are lower, and measured bromate concentrations are lower. Lower pH in settled water also helps reduce bromate concentrations.

GAC Treatment

In assessing the use of GAC to meet the Stage 2 TTHM target of 32 μg/L, several constraints were used. The values in Table 4.1 suggest that the treated water TOC concentration must be below about 2.5 mg/L to approach this TTHM target within the range of bromide concentrations evaluated. To achieve this level of TOC in the finished water then the GAC influent TOC must be below 5.0 mg/L at a breakthrough (C/C_0) of 0.5, (see Table 3.2). As shown in Table 4.3, an EBCT of 20 minutes or greater is needed to achieve this effluent concentration while maintaining run times greater than 60 days (Summers et al., 1994, Hooper et al., 1996).

TABLE 4.3

ESTIMATED TIME TO 50 PERCENT BREAKTHROUGH AT DIFFERENT GAC EMPTY BED CONTACT TIMES

Influent TOC	Effluent TOC	Time to 50% Breakthrough (days)		
		EBCT (min) 15	EBCT (min) 20	EBCT (min) 30
3	1.5	62	83	124
4	2.0	47	68	93
5	2.5	38	50	75
6	3.0	32	42	63
7	3.5	27	36	54

The assumption of 10 to 15 percent TOC removal by the coagulation process prior to GAC yields a maximum raw water TOC of 5 mg/L for the GAC use scenario.

Using the results in Table 4.1 the following projections can be made based on the above analysis:

1. For a 1 log *Giardia* inactivation using free chlorine for 60 minutes following conventional coagulation and GAC, it was projected that a raw water TOC concentration of < 5 mg/L and a bromide concentration of < 150 μg/L would permit compliance with the Stage 2 TTHM target of 32 μg/L in the regulatory scenario.

2. For a 2 log *Giardia* inactivation using free chlorine for 120 minutes following coagulation and GAC, it was projected that a raw water TOC concentration of < 5 mg/L and a bromide concentration of <50 μg/L would permit compliance with the stage 2 TTHM target of 32 μg/L in the regulatory scenario.

Higher GAC influent TOC concentrations can be used with breakthroughs (C/C_0) lower than 0.5 to achieve effluent TOCs lower than 2.5 mg/L. For example an influent TOC of 6 mg/L and a C/C_0 of 0.4 yields a GAC effluent of 2.4 mg/L. The run times are below 60 days, however, even at an EBCT of 30 minutes. The run time at a C/C_0 of 0.4 is about 20 percent shorter than that at 0.5 (Summers and Hooper, 1997 unpublished data).

As discussed in Section 3.2.3, ozone can be used in combination with GAC to enhance disinfection and provide a good medium to remove biodegradable organic carbon (BDOC) formed by the application of ozone. Because of the particular constituents of concern in this evaluation, it was assumed that ozone and GAC operate somewhat independently for microbial inactivation and removal of water quality contaminants. This particular treatment scenario allows GAC to be used when *Cryptosporidium* inactivation is required.

For GAC in combination with ozone, source water TOC can increase up to at least 7 mg/L (the 90th percentile for water diverted from the south Delta). Bromide concentrations using

ozone at a pH of 6.5 are limited to <200, 100 to <150, and <50 μg/L for 1 log *Giardia*, 2 log *Giardia*, and 1 log *Cryptosporidium* inactivations, respectively.

The source water for this combined treatment is limited by the ozonation process for bromide. For TOC values approaching 7 mg/L there is a concern that the TTHMs formed in the five minutes of contact with free chlorine will exceed the Stage 2 target. However, there are few TTHM formation data available at contact times as short as this. In addition there is concern that the GAC will be able to adequately control BDOC. High levels of ozonation by-products in the distribution system can lead to microbial regrowth, although currently these compounds are not regulated.

Membrane Treatment

As discussed in Chapter 3, two types of membrane treatment can be considered; membrane filtration and membrane softening. Because both of these processes represent "absolute barriers" to *Giardia* and *Cryptosporidium*, the source water quality does not vary based upon the extent of protozoan removal required. Based upon this understanding, the following projections were made:

1. For microfiltration, ozone, and chloramine treatment, it was assumed that ozone would be required to provide 3 log virus inactivation. This corresponds to CT values which are similar to 1.5 log *Giardia* inactivation. To provide the greatest degree of flexibility for source water bromide concentrations, it was assumed that ozonation would be conducted at pH 6.5. Referring to Figure 4.1, this results in a limiting source water bromide concentration of < 150 μg/L. A specific limit for source water TOC was not estimated for this treatment scheme. For TOC values approaching 7 mg/L (the 90th percentile for water diverted from the south Delta) there is a concern that biological filtration will be able to adequately control BDOC. High levels of ozonation by-products in the distribution system can lead to microbial regrowth, although currently these compounds are not regulated.

2. For ultrafiltration, ozone, and chloramine treatment, it was assumed that ozone would be required to provide 2 log virus inactivation. This corresponds to CT values which are similar to 0.5 log *Giardia* inactivation. To provide the greatest degree of flexibility for source water bromide concentrations, it was assumed that ozonation would be conducted at pH 6.5. This results in a limiting source water bromide concentration of < 300 μg/L. A specific limit for source water TOC was not estimated for this treatment scheme. For TOC values approaching 7 mg/L (the 90th percentile for water diverted from the south Delta) there is a concern that biological filtration will be able to adequately control BDOC. High levels of ozonation by-products in the distribution system can lead to microbial regrowth, although currently these compounds are not regulated.

3. For the application of nanofiltration followed by free chlorine addition for distribution system residual maintenance, TOC is limited by the extent to which TTHMs are formed in the distribution system. Under these conditions, the treated water TOC should be below 1 mg/L and the bromide level below 0.15 mg/L, as predicted by uniform formation conditions (Summers et. al., 1996). Assuming a 90 percent TOC removal and a 50 percent bromide removal by nanofiltration, a source water TOC of up to 10 mg/L is estimated at all source water bromide levels examined (< 300 μg/L).

4.4 IMPACT OF OTHER POTENTIAL REGULATORY OUTCOMES

4.4.1 Introduction

This section describes the impact of other potential regulatory outcomes on treatment requirements and/or allowable source water quality. It was not possible for the expert panel to evaluate all of the potential scenarios and the most plausible were discussed in Chapter 2. This section discusses broad trends based upon regulatory outcomes that were conceived during the regulatory negotiations, as affected by recent developments.

4.4.2 Lower MCLs and/or Maximum MCLs for Halogenated Organic Compounds

Plausibility: The current placeholder values could possibly go lower based on new health effects research. First, THM and HAA levels might be lowered. EPA has been conducting research on reproductive effects that may be associated with various THM and HAA species. Given the intense concern expressed during reg-neg over the New Jersey epidemiology studies and the potential associations with neural tube defects, lower MCLs than the 40 μg/L and 30 μg/L would be plausible. In addition, a recently released study based in California developed an association between TTHM, individual THM compounds, and spontaneous abortion. Because this is considered an acute affect, this increases emphasis for considering a maximum value for DBPs, rather than a running annual average. Second, the current bromate MCL is based on what was considered to be the Practical Quantitation Level (PQL). Much effort is being focused on improving the method which could lead to a lower MCL, especially given the toxicology which suggests the high carcinogenic potency of bromate. Third, HAA regulatory levels are currently based on five species. There are, however, four other species that can form in the presence of bromide. Such compounds could dramatically increase the total HAA. Due to the apparently greater potency, it is possible that the MCL for total HAAs may decrease, though they may increase.

Impacts: Lower MCLs, or maximum rather than running annual average values, for THM or HAA will require either TOC or bromide to be reduced. A lower bromate PQL would require lower ozonation pH, depending on the actual level. But a very low level (e.g., less than 1 μg/L) could make use of ozone prohibitive.

4.4.3 MCLs For Individual DBP Species

Plausibility: A wide variation in relative potency of individual species within a given class has been observed. For example, bromodichloromethane is much more potent than chloroform, and has been associated with spontaneous abortion in a California based study. Its metabolism is more rapid leading to higher tissue concentrations, it has a greater capacity for binding proteins and lipids and the mutagenic response is much greater. These types of observations, particularly associated with bromine substitution in the place of chlorine-intensifying toxicity, lends credence to regulating individual species rather than broad chemical classes. Further, EPA recently proposed increasing the MCLG for chloroform from zero to 300 μg/L, thereby recognizing threshold behavior for carcinogens. These differences provide emphasis to regulating individual DBPs.

Implications: Low MCLs for species such as bromodichloromethane could preclude the use of chlorine for primary disinfection in waters containing measurable amounts of bromide. Membrane filtration, which requires some inactivation of virus, would require an alternative disinfectant to chlorine (e.g., ozone). Enhanced coagulation would be of marginal benefit. GAC would still be relevant though it would need to be evaluated in light of the proposed levels.

4.4.4 DBPs Other Than THMs and HAAs Are Regulated

Plausibility: While there are a variety of DBPs, resources for health effects research are currently directed on the brominated analogues of the haloacids and trihalomethanes, not new compounds. Regulations for DBPs such as chloral hydrate, chloropicrin, haloketones or halocetonitriles are not anticipated.

Implications: It is not possible to evaluate the impacts of what appear to be less plausible regulatory outcomes, based upon the likelihood of health effects data supporting such regulation. In general, the more DBPs that are regulated, the greater the constraints on treatment technology and source water quality.

4.4.5 Regulating for a Minimum Total Risk; the "Risk Bubble"

Plausibility: Each technology results in a different mixture of DBPs in terms of relative concentrations. An individual MCL approach does not recognize this and does not allow for DBP - DBP tradeoffs. For example, chlorine will produce greater concentration of chlorinated, brominated and mixed bromo-chloro organics than ozone. Ozone, however, will produce more bromate and oxygenated compounds (e.g., aldehydes, ketones, carboxylic acids). In order to determine the lowest risk associated with the treatment options, it has been argued that a more comprehensive approach is needed, one that considers the wide array of by-products produced, not simply focused on THMs or HAAs. To this end, various approaches have been proposed and have recently been re-discussed in the stakeholder meetings. It has also emerged as part of the comparative risk framework currently being considered by EPA.

Implications: A mixtures approach may allow for greater flexibility in technology choice.

4.4.6 Implication of a Reproductive Endpoint

Plausibility: As there are some indications that reproductive health effects are associated with certain DBPs and that the exposures of interest (e.g., spontaneous abortion) are short-term rather than long-term (i.e., cancer). The current practice of running annual averages of quarterly samples for calculating compliance may not be appropriate. More frequent monitoring and enforcing of maximum levels could be required. Individual MCLs may also be prompted.

Implication: Going from running averages to maximum acute levels may decrease the range and variability of source water quality permissible. This would provide greater restrictions on the ability of all unit processes to meet water quality requirements and would lower the allowable TOC and bromide concentrations, and the allowable variability, depending upon the maximum values established.

4.4.7 Summary of Alternative Regulatory Scenarios

As with the wide array of issues being addressed as part of the overall Delta process, there is no single 'best' solution in formulation of future drinking water regulations -- there are a variety of trade-offs which need to be considered. It will be important that CUWA continue to keep these issues before the negotiated rulemaking committee.

4.5 SUMMARY

4.5.1 Summary of Source Water Quality Constraints

Table 4.4 summarizes projected source water quality requirements for TOC and bromide, depending upon the technology applied. In reviewing the values presented in this table, it is evident that there are various water quality constraints for TOC and bromide depending upon the technology used, the DBP concentrations allowed, and the level of microbiological inactivation required. As stated previously, which technology is implemented is agency-specific, and is dependent upon a host of constraints related to cost, permitting issues and residual disposal.

TABLE 4.4

SUMMARY OF SOURCE WATER QUALITY CONSTRAINTS[1]

TREATMENT SCENARIO/ DISINFECTION STRATEGY		MICROBIAL INACTIVATION REQUIRED					
		1 Log *Giardia* Inactivation		2 Log *Giardia* Inactivation		1 Log *Cryptosporidium* Inactivation[2]	
		TOC (mg/L)	Bromide (μg/L)	TOC (mg/L)	Bromide (μg/L)	TOC (mg/L)	Bromide (μg/L)
Potential Near-Term Regulatory Scenario							
Enhanced coagulation with free chlorine/chloramines		<7	<150-200	<7	<50-100		
		<6	<200	<6	<150		
		<5	<300	<5	<200		
				<4	<300		
Ozonation with Chloramines	at pH 7.8	N/E[3]	<50	N/E[3]	N/A[4]		
	at pH 6.5	N/E[3]	<500	N/E[3]	<300		
Potential Long-Term Regulatory Scenario							
Enhanced coagulation with free chlorine/chloramines		<3.0	<150	<3.0	<50	N/A[5]	N/A[5]
Ozonation with chloramines	at pH 7.8	N/E[3]	N/A[4]	N/E[3]	N/A[4]	N/E[3]	N/A[4]
	at pH 6.5	N/E[3]	<200	N/E[3]	<100 to 150	N/E[3]	<50
Granular Activated Carbon (GAC)		<5	<150	<5	<50	N/A[5]	N/A[5]
GAC With Ozone at pH 6.5		N/E[3]	<200	N/E[3]	<100-150	N/E[3]	<50
Membrane Treatment	MF with Ozone	N/E[3]	<150	N/E[3]	<150	N/E[3]	<150
	UF with Ozone	N/E[3]	<300	N/E[3]	<300	N/E[3]	<300
	Nanofiltration	<10 mg/L	<300	<10 mg/L	<300	<10 mg/L	<300

Notes:

1. Source water quality constraints are based upon achieving: 80 μg/L of TTHM, 60 μg/L of HAA5, and 10 μg/L of bromate for Stage 1 and 40 μg/L of TTHM, 30 μg/L of HAA5, and 5 μg/L of bromate for Stage 2, using the treatment and disinfection conditions presented in Chapter 3.
2. 1 log *Cryptosporidium* inactivation is not a part of the potential near-term regulatory scenario.
3. N/E = Not estimated. Limiting TOC concentrations were not estimated because of the availability and robustness of the data illustrating the impact of TOC on bromate formation, in the presence of bromide. It should be recognized, however, that higher TOC concentrations translate to higher ozone dosages to meet a given disinfection criterion and thereby can result in higher bromate formation. It is important to note that when ozone disinfection is used for treatment, the allowable TOC is not unlimited. There are concerns regarding the ability of biological filters or GAC to remove BDOC to adequate levels as TOC approaches 7 mg/L (the 90th percentile for water diverted from the Delta). In general, ozone disinfection is more effective and reliable as TOC decreases.
4. N/A = Not achievable. Bromide concentrations would have to be considerably less than 50 μg/L to achieve a bromate concentration of 5 or 10 μg/L. Data to determine the necessary bromide concentration relevant to this study were not available.
5. N/A = Not achievable. At this time, it is considered that free chlorine can not inactivate *Cryptosporidium* at dosages practical in water treatment.

4.5.2 Summary of Compliance Choices

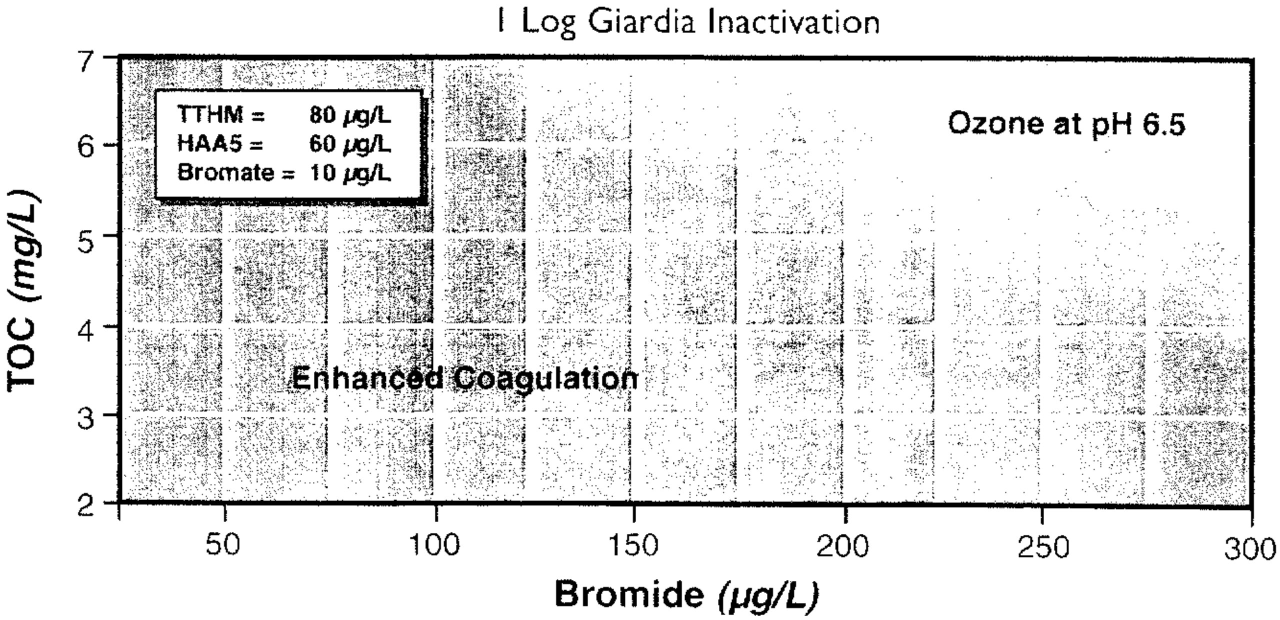
Instead of presenting the data in a table which summarizes the allowable TOC and bromide concentrations as a function of different treatment processes for a given regulatory scenario, it is often helpful to graphically illustrate the technology that can be implemented, as a function of source water TOC and bromide, for a given regulatory scenario. That is, illustrate the area in which a given technology will allow compliance with a regulatory outcome, using a two-dimensional graphic illustrating bromide on the X-axis and TOC on the Y-axis. Therefore, the applicability of technologies in a given regulatory scenario as TOC or bromide increase can be visualized. A comparison of relationships for different regulatory scenarios illustrates how this "compliance forecast" changes when regulations change. It is important to note that the boundaries between technologies are not hard lines, but rather "transitional" regions. The absolute water quality boundaries which trigger the need for a different technology are extremely utility specific, and also are variable within a utility, itself, as criteria which effect technology selection other than water quality change.

Figure 4.2 illustrates the compliance forecast for the Stage 1 D/DBP Rule and IESWTR, for 1 and 2 log inactivations of *Giardia*. This figure illustrates that enhanced coagulation and ozone treatment can be used to meet the requirements up to TOC and bromide concentrations of 7 mg/L and 300 μg/L, respectively. In this figure, the colored area represents the region in which it is feasible to use the associated technology for combinations of TOC and bromide. For example, the yellow area describes the region in which ozone at pH 6.5 would be used for specific combinations of TOC and bromide, as opposed to enhanced coagulation. The gradual transition, and region of uncertainty, for combinations of TOC and bromide which require different technologies are also illustrated. The regulatory allowance to provide prechlorination with enhanced coagulation, which increases DBP production, has the impact of reducing the feasible region for enhanced coagulation. Which technology is selected in this transition zone is highly utility specific.

Figure 4.3 illustrates the compliance forecast for the potential Stage 2 D/DBP Rule and LT2ESWTR, for inactivations of 1 log *Giardia*, 2 log *Giardia*, and 1 log *Cryptosporidium*. In this figure, regions of technology application for enhanced coagulation, GAC, ozone and membranes (recall that the maximum bromide concentration for

Figure 4.2

Compliance Forecast for Stage I D/DBP Rule



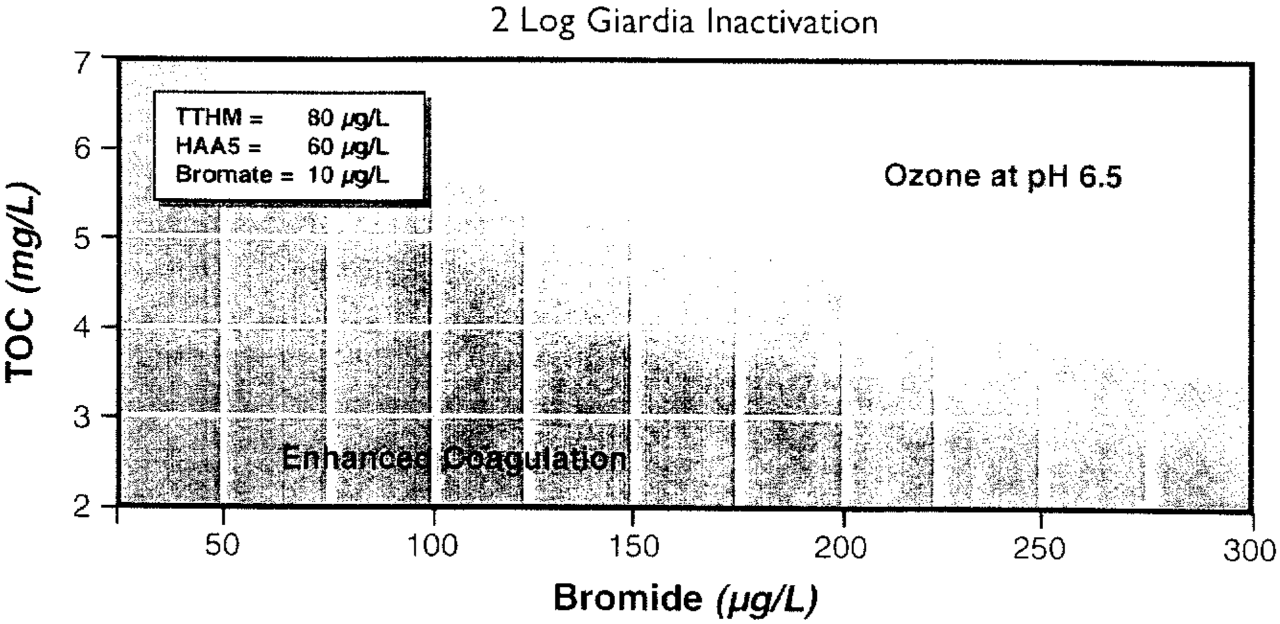
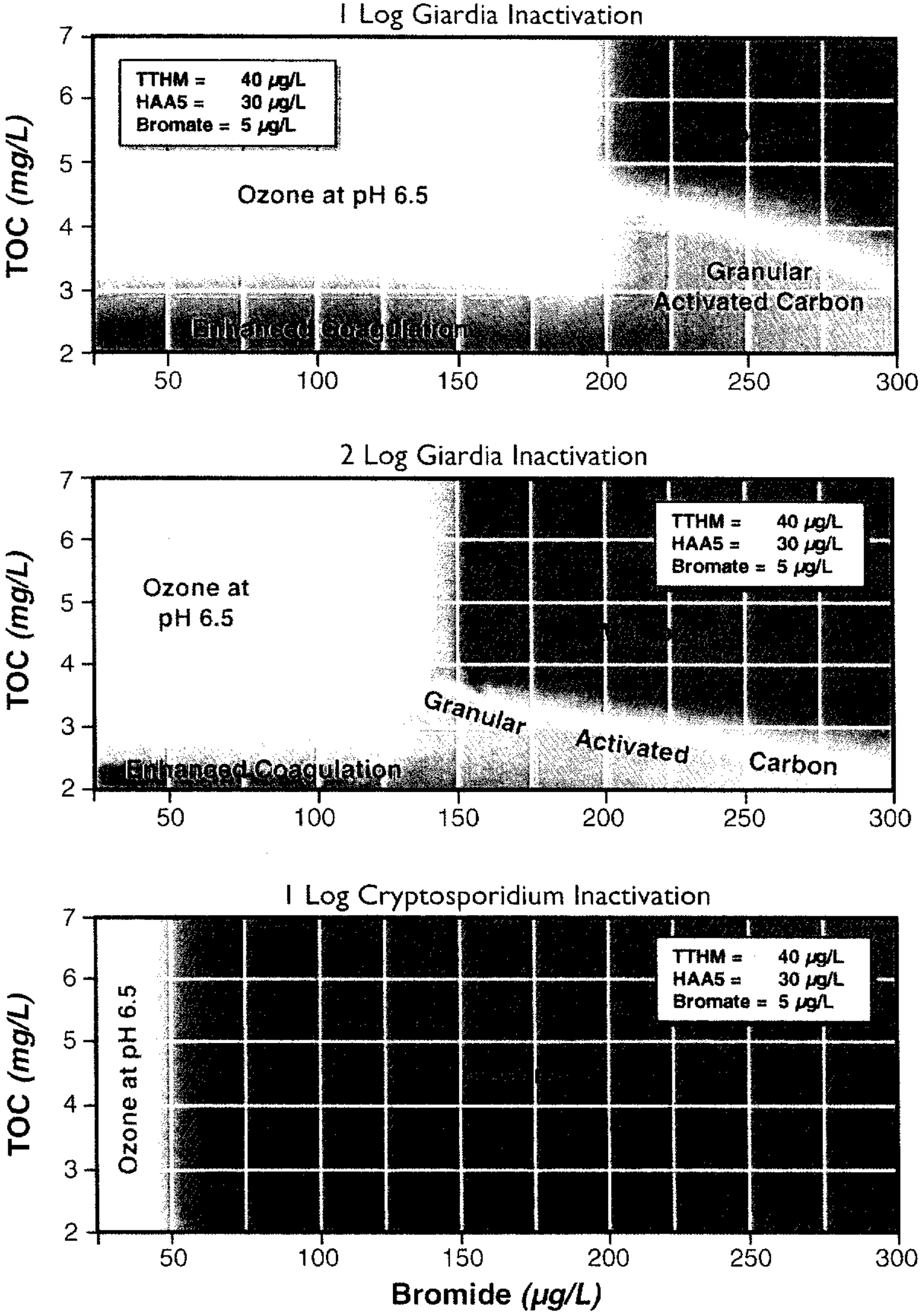


Figure 4.3

Compliance Forecast for Stage 2 D/DBP Rule



microfiltration coupled with ozone is 150 μg/L) are illustrated. Individual systems may determine that other water quality benefits merit the use of more expensive technologies for certain water quality regions that are shown with less expensive technologies (e.g., ozone as opposed to enhanced coagulation; membranes as opposed to GAC). The figure was prepared to show "least cost" technology application, based upon the range of conceptual costs presented in Section 3.3. It is important to note that the region of feasibility for membranes in Figure 4.3 does not differentiate among MF/UF or NF/RO membranes. In general, only MF is somewhat limited for bromide when using ozone for virus inactivation. Table 4.4 summarizes these source water bromide limitations for MF.

It is evident that as the level of microbial inactivation increases, the technologies which may be used to meet the applicable regulation decreases. Of particular interest is that for a Stage 2 D/DBP Rule and LT2ESWTR which requires 1 log inactivation of *Cryptosporidium*, membrane technology plays a significant role in compliance choices.

As stated in Chapter 3, it is recognized that the above source water quality constraints are based upon the design criteria proposed, such as ozone:TOC dose ratios, ozone contact time, and single, multi-chamber contactor configuration. Other facility configurations, such as two-stage ozonation (e.g., ozone added at raw and settled water) and longer ozone contact times may yield different, and possibly more liberal, source water quality constraints. The source water quality constraints presented here are based upon typical ozone system designs throughout the country.

4.5.3 Concluding Remarks

The expert panel is aware of the significance of bromate in establishing limiting bromide levels in this evaluation. There are many factors that contribute to the uncertainty surrounding the projected numbers, including relatively few studies which have evaluated bromate formation in low bromide waters (< 50 μg/L), variations in treatment conditions which may reduce bromate formation (e.g., using both pre- and post-ozonation to reduce ozone dosages at any single location), and potentially lower CT values for ozone. It is the selected level of 5 μg/L in the long-term regulatory scenario, however, that most keenly influences the analysis. The rationale for this level (i.e., advances in detection limit, the weight of the carcinogenic evidence, the precedence for THM and HAA5 limits in Stage 2 at half the Stage 1 levels) in this analysis may be modified by a variety of factors including:

- A bromate versus brominated organic compound trade-off (i.e., addressing the difference between DBPs formed with ozone versus those formed with chlorine).
- Evidence of a cancer threshold for bromate (investigations underway).

On the other hand, there are other potential regulatory outcomes involving 1) further lowering the MCLs for DBPs, 2) the regulation of individual DBP species (rather than the groups of compounds represented by TTHM and HAA5 due to the potentially more severe health effects associated with brominated compounds), 3) regulating other DBPs beyond TTHMs and HAA5, including the addition of other HAAs (there are nine total) as analytical methods are developed and refined, 4) a comparative risk framework which balances all of the risk attributable to the DBPs formed, rather than providing specific MCLs for each group, and 5) concerns over reproductive and developmental effects that may be associated with DBPs, which may lower the regulatory levels and/or the permissible maximum concentration (i.e., annual averaging may no longer be the basis for determining compliance).

Given this understanding, if flexibility were provided to all agencies to implement either enhanced coagulation or ozone to meet the potential long-term regulatory scenario, then it is projected that a TOC of < 3.0 mg/L and a bromide of < 50 μg/L in water diverted from the Delta would be necessary. The TOC value is constrained by the formation of total trihalomethanes when using enhanced coagulation for TOC removal and free chlorine to inactivate *Giardia*. The bromide value is constrained by the formation of bromate when using ozone to inactivate *Cryptosporidium*. Looking only at the potential near-term regulatory scenario provides significantly more flexibility, with source water TOC concentrations ranging between 4 and 7 mg/L (the 90th percentile value in water diverted from the Delta) and bromide ranging between 50-100 and 300 μg/L, depending upon the extent of *Giardia* inactivation required (the near-term scenario does not include *Cryptosporidium* inactivation).

Similarly, the use of either GAC or membrane treatment in the long-term regulatory scenario broadens the allowable source water quality. For GAC, a source water TOC value of 5 mg/L is acceptable with bromide ranging between 50 and 150 μg/L, depending upon *Giardia* inactivation.

If *Cryptosporidium* inactivation is required, however, ozone must be coupled with GAC. This allows the source water TOC concentration to increase to at least 7 mg/L (the 90th percentile value for waters diverted from the Delta), although bromide is constrained to < 50 μg/L even at an ozone pH of 6.5.

The use of microfiltration or ultrafiltration, coupled with ozone for primary disinfection and chloramines for secondary disinfection, is an "absolute barrier" for protozoan (*Giardia* and *Cryptosporidium*) removal. Viruses, however, must still be inactivated. This treatment scheme allows source water TOC concentrations to increase to at least 7 mg/L. The bromide concentration is again limited by bromate formation under ozone addition for virus inactivation, and is < 150 μg/L microfiltration and < 300 μg/L for ultrafiltration (less virus inactivation is required for ultrafiltration). If nanofiltration is used with free chlorination, source water quality can range up to 10 mg/L for TOC for all bromide concentrations evaluated (< 300 μg/L).

It is important to note that when ozone disinfection is used for treatment, the allowable TOC is not unlimited. There are concerns regarding the ability of biological filters or GAC to remove BDOC to adequate levels as TOC approaches 7 mg/L (the 90th percentile for water diverted from the Delta). In general, ozone disinfection is more effective and reliable as TOC decreases.

Finally, the feasibility of implementing either GAC or membranes in California, given cost considerations, environmental permitting constraints, and limited residual disposal options, is uncertain.

REFERENCES

Cheng, R. C. et. al., 1995. "Enhanced Coagulation : A Preliminary Evaluation," *Journal AWWA*, 87:2:91 (February, 1995).

Cowman, G.A. and P.C. Singer, 1996. Effect of Bromide Ion on Haloacetic Acid Specification Resulting From Chlorination and Chloramination of Aquatic Humic Substances. *Environmental Science and Technology,* 30:1:16 (January, 1996).

Hooper S.M., Summers R.S., Solarik G., Hong S.: "GAC Performance for DBP Control: Effect of Influent Concentration, Seasonal Variation, and Pretreatment," *Proc. Amer. Water Works Assoc. Conference,* Toronto, Ontario, Canada (1996).

Krasner et. al., 1994. "Quality Degradation: Implications for DBP Formation," *Journal AWWA*, 86:6:34 (June 1994).

Malcolm Pirnie, Inc., 1993. *Bay-Delta Water Quality Modeling*, prepared for the Metropolitan Water District of Southern California, December 1993.

Ozekin, K., 1994. *Modeling Bromate Formation During Ozonation and Assisting Its Control*. PhD Thesis, University of Colorado, 1994.

Shukairy, H. M. et. al., 1994. "Bromide Impact on Disinfection By-Product Formation and Control: Part 1 Ozonation," *Journal AWWA*, 86:6:72 (June, 1994).

Siddiqui, M. and G.L. Amy, 1994. "Strategies for Removing Bromate from Drinking Water." A report prepared for the California Urban Water Agencies, October, 1994.

Summers, R.S. 1997. Enhanced coagulation data with prechlorination prepared for USEPA, 1997 FACA process. Unpublished data.

Summers, R.S. and S. Hooper, 1997. Unpublished data.

Summers, R.S. et. al., 1996. "Assessing DBP Yield: Uniform Formation Conditions," *Journal AWWA*, 88:6:80 (June 1996).

Summers R.S., Hong S., Hooper S., Solarik G., 1994: "Adsorption of Natural Organic Matter and Disinfection By-Product Precursors," *Proc. Amer. Water Works Assoc. Annual Conference, New York, NY* (1994).

USEPA, 1998. National Primary Drinking Water Regulations: Disinfectants and Disinfection By-Products: Notice of Data Availability: Proposed Rule. *Fed. Reg.*, 63: 31: 15674 (March 31, 1998).

USEPA, 1994. National Primary Drinking Water Regulations; Disinfectants and Disinfection Byproducts; Proposed Rule. *Fed. Reg.*, 59:145:38668 (July 29, 1994).

APPENDIX A
PREDICTIVE MODELS FOR DISINFECTION BY-PRODUCTS

A.1 THM PREDICTIVE EQUATIONS

Malcolm Pirnie, Inc. (1993) undertook a study on the formation of DBPs in chlorinated waters over a wide range of TOC and bromide concentrations for the Metropolitan Water District of Southern California. A 5 by 5 matrix of discrete samples containing incremental increases in TOC and bromide concentrations were prepared and evaluated. For this study, water was synthesized using low-TOC, low bromide Sacramento River water and high-TOC agricultural drainage water. High-bromide concentrations were achieved by adding sodium bromide.

The database used in this study, consisting of more than 900 observations, was constructed based upon the results of the source water quality monitoring program and the chlorination experiments from the 5 by 5 matrix. One portion of the database represented THM formation in jar-treated waters and another portion represented THM formation in 0.45 μm membrane filtered raw water.

Three sets of THM predictive equations were developed during this study using a non-linear power function format including total organic carbon (TOC), ultraviolet absorbance at 254 nm (UV-254), chlorine dose, bromide concentration, reaction time, temperature and pH as independent variables. The final TTHM predictive equation was based upon a portion of the database representing THM formation in 0.45 μm membrane filtered raw water (approximately 650 observations). Predictive capabilities of this equation were compared with THM formation in the jar-treated water (approximately 250 observations). The final TTHM equation developed was:

$$\begin{aligned} TTHM = \; & 7.21\ TOC^{0.004}\ UV254^{0.534}\ (C1DOSE\text{-}7.6{*}NH_3\text{-}N)^{0.224}\ TIME^{0.255} \\ & (Br+1)^{2.01} \\ & (pH-2.6)^{0.719}\ TEMP^{0.480} \end{aligned}$$

$[r^2 = 0.96, F = 2010, p < 0.001]$

This equation was developed at TOC concentrations ranging between 1.1 and 7.6 mg/L, bromide between 10 and 800 $\mu g/L$, contact times between 1 and 48 hours, and chlorine doses between 1.0 and 16.4 mg/L. The values for UV-254 to be input into the TTHM equation were predicted using a relationship between TOC and UV-254 developed in the study as follows:

$$\text{UV-254} = -0.0224 + (0.0374)(\text{TOC})$$
$$(r^2 = 0.92)$$

Using free chlorine as a disinfectant, a chlorine-to-TOC ratio of 1:1 and contact times of 1 and 2 hours were projected to yield 1 and 2 log *Giardia* inactivation, respectively. A temperature of 20 ° C and pH of 7 was also input to this equation to yield the values in Table 4.1 in the body of this report.

A.2 BROMATE PREDICTIVE EQUATION

The bromate model of Ozekin and Amy (Ozekin, 1994) was utilized to systematically evaluate the impact of ozone dose, bromide, DOC and pH on the formation of bromate. The model was developed from data from several source waters including waters diverted from the Delta. Source water bromide concentrations ranged between 70 and 440 $\mu g/L$ with bromate concentrations ranging between 2 and 314 $\mu g/L$.

The model used has the following form:

$$BrO_3 = 1.63\text{x}10^{-6}\ DOC^{-1.26}\ pH^{5.82}\ (O_3\ \text{dose})^{1.57}\ Br^{0.73}\ \text{time}^{0.28}$$

A contact time of 12 minutes was chosen and the concentrations of DOC, bromide, ozone dose and pH were varied over a representative range as input to the above equation. Temperature was held constant at 20 ° C.

It is important to note that the model was only used to support conclusions reached by the expert panel prior to using the model. The bromate model was evaluated to investigate threshold behavior regarding formation at specific levels and to support the initial conclusions reached by the expert panel. The results of the modeling should not be overemphasized. The results of the modeling supported the initial conclusions reached by the Panel based upon the available literature and review of the CUWA data.

APPENDIX B

CUWA MEMBER TREATMENT DATA

Data was provided by the CUWA members, including those resulting from the operation of their treatment facilities as well as bench and pilot studies. There are variations in these data which are unique to each treatment system. For example, some systems supplied data representing ozonation of only raw water, while others supplied data with both pre- and post-ozonation. The expert panel recognizes that there are unique aspects of process operation which can affect the ultimate formation of DBPs. For this study, however, the expert panel defined "unifying criteria" in Chapter 3 for enhanced coagulation and ozone which allow a comparison of these processes and a systematic method by which to evaluate the impact of water quality constraints on DBP formation. This appendix contains the data supplied by the CUWA members.

Utility ID: ACWD (ACWD, CCWD, EBMUD, MWD, SCVWD)

1. Study ID: (Optimization Study 9/95, etc.)

2. Source water: (River, lake, groundwater, etc.)

3. Source water ID: (State Project water, blend of...., etc.)

5. Describe level of study: (Indicate with an "X") — Bench-scale / Pilot-scale / Full-scale

In this data sheet, "Filt." refers to data collected after coagulation, flocculation, sedimentation, and filtration.

6. Indicate with an "X" if data reported as "Filt." are from samples collected after sedimentation only:

or after sedimentation and filtration:

WATER QUALITY DATA: CONVENTIONAL

Date	Time	TOC (mg/L)		UV-254 (1/cm)		Bromide (µg/L)		Turbidity (NTU)		Temperature (deg. C)		Disinfection By-products: TTHM (µg/L)		HAA5 (µg/L)		HAA6 (µg/L)	
		Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.
5/30/95		4.3	2.7					16.2		66.4							
6/6/95		4.3	2.0			40.0		29.0		65.9			28.9				
6/13/95		3.6	1.8			42.0		14.1		67.3			40.2				
6/20/95		3.5	1.9			60.0		15.6		66.3			44.0		48.0		
6/27/95		3.8	2.0			80.0		13.4		76.7			49.6				
7/4/95		4.2	2.3					17.4		73.3			45.2				
7/11/95		4.1	2.1			68.0		23.0		72.3			43.0				
7/18/95		3.8	1.9			50.0		19.5		73.5			45.9				
7/25/95			2.4			72.0		21.2		72.6			48.0				
8/1/95		4.1	2.2			65.0		13.3		78.3			48.0				
8/8/95		3.6	1.9			60.0		11.5		76.2			49.8				
8/15/95		3.1	2.0			60.0		11.4		77.0			58.9				
8/22/95		3.2	2.2			55.0		10.6		75.6			58.9				
8/29/95						50.0		11.5		71.2							
9/5/95		3.4	2.0			81.0	<20	12.5		70.5			61.1		37.0		44.0
9/12/95		4.1	3.3			42.0	12.0	2.3		68.9			66.9				
9/19/95		4.0	3.2			50.0	<20	2.2		68.4			85.9		58.0		65.0
9/26/95		4.0	2.8			53.0	10.0	8.3		67.9							
10/3/95		4.1	2.8			49.0	17.0	5.0		64.1			55.4		43.0		49.0
10/10/95		4.3	3.0			44.0	<40	4.4		62.6			72.0				
10/17/95		4.2				43.0		6.6		63.0							
10/24/95		3.9	2.8			47.0	14.0	4.3		61.9							
10/31/95		3.8	2.5			45.0	12.0	6.5		61.7			58.6		35.0		40.0
11/7/95		3.8	2.6	0.19	0.07	47.0	13.0	5.3		59.9			72.1				
11/14/95		4.3	3.1	0.18		39.0	12.0								46.0		52.0
11/21/95		3.4	3.3	0.19	0.10	42.0	16.0										
11/28/95				0.14	0.10	86.0	18.0						55.5		23.0		28.0
12/5/95		4.4	3.4	0.13	0.09			1.6		58.5			73.1				
12/12/95		4.6	4.0	0.12	0.08	39.0	<20	2.2		58.0					56.0		62.0
12/19/95		4.7	3.7	0.14	0.10	38.0	<20	3.9		55.8			73.3				
12/26/95		3.1	2.0	0.12	0.09	97.0	24.0	7.6		52.5					31.0		38.0
1/2/96		3.3	2.1	0.13	0.09	150	36.0	3.6		53.8			64.6				
1/9/96		6.4	3.7	0.24	0.10	110	31.0	4.8		52.7			75.2		54.0		63.0
1/16/96		6.4	3.5	0.27	0.11	87	24.0	4.0		51.4			80.0				
1/23/96		3.0	2.4	0.18	0.16			9.3		50.7							
1/30/96		3.5	3.2	0.20	0.10			20.0		51.4			77.8				
2/6/96		5.6	3.6	0.20	0.11								75.0				
2/13/96		5.6	3.6	0.17	0.08								76.1				
2/20/96		5.8	3.6	0.13	0.31								86.0				
2/27/96		5.8	3.0	0.20	0.11								72.8				
3/5/96		0.0	3.1	0.22	0.09		14.0						80.7		54.0		57.0
3/12/96		5.6	3.1	0.21	0.10		<20										
3/19/96		5.5	3.4	0.22	0.10		<20						61.3		49.0		52.0
3/26/96		5.3	3.1	0.21	0.09		14.0						81.3				
4/2/96				0.20	0.08								57.2		31.0		38.0
4/9/96				0.21	0.08								94.7				
4/16/96		4.4	3.0	0.20	0.10		<10.0								59.0		68.0
4/23/96		4.2	2.8	0.21	0.09		29.0						71.4				
4/30/96			2.4		0.09		34.0						76.7		41.0		52.0
5/7/96		3.7	2.6	0.20	0.09		41.0						73.3				
5/14/96		3.6	2.8	0.21	0.09		45.0						85.0		43.0		55.0
5/21/96					0.09												
5/28/96		3.8	2.1	0.22			20.4						52.3		34.0		41.0
6/4/96		3.6	2.3	0.22	0.08		24.6						70.4				
6/11/96			1.9		0.08		17.2						80.1		38.0		43.0
6/18/96			1.8	0.19	0.08		10.6						53.9				
6/25/96			1.9		0.08		25.2						43.9				
7/2/96		3.2	2.0				20.4						64.8				
7/9/96							13.7										

Utility ID:	ACWD	(ACWD, CCWD, EBMUD, MWD, SCWD)				
1. Study ID:	Routine Monitoring	(Optimization Study 8/95, etc.)		4. If blended source water indicate sources and proportions:		
2. Source water:	River	(River, lake, groundwater, etc.)		Source	%	
3. Source water ID:	South Bay Aqueduct	(State Project water, blend of..., etc.)				
5. Describe level of study:		Bench-scale	In this data sheet, "Filt." refers to data collected after coagulation, flocculation, sedimentation, and filtration.			
(Indicate with an "X")		Pilot-scale				
	X	Full-scale				
6. Indicate with an "X" if data reported as "Filt." are from samples collected after sedimentation only:						
or after sedimentation and filtration:						

WATER QUALITY DATA: PRE-OZONE

Date	Time	TOC (mg/L) Raw	TOC Ozon.	TOC Filt.	UV-254 (1/cm) Raw	UV-254 Ozon.	UV-254 Filt.	Alkalinity (mg/L as CaCO3) Raw	Alkalinity Ozon.	Alkalinity Filt.	Hardness (mg/L as CaCO3) Total Raw	Total Ozon.	Total Filt.	Calcium Raw	Calcium Ozon.	Calcium Filt.	Bromide (ug/L) Raw	Bromide Ozon.	Bromide Filt.	Chloride (mg Cl-/L) Raw	Chloride Ozon.	Chloride Filt.	Turbidity (NTU) Raw	Turbidity Ozon.	Turbidity Filt.
1/3/95		5.8	5.4	3.4				82		84	132									108.0			8.77		0.05
1/10/95		5.8		2.9				74		80	104									70.0			30.00		0.06
1/17/95		5.9	5.7	3.3				139		136	162						100.0			41.0			68.80		0.04
1/24/95		5.9	5.9	3.6				140		162	168						80.0			33.0			60.70		0.05
1/31/95		6.0	6.4	3.5				170		158	154						70.0			25.0			56.00		0.04
2/7/95		5.6	5.6	3.3				152		92	160									26.0			38.50		0.04
2/14/95		5.7	5.4	3.4				158		160	140						71.0			61.0			29.70		0.05
2/21/95		5.8	5.3	3.6				152		188	142						72.0			40.0			24.30		0.05
2/28/95		5.6	5.4	3.7				158		180	144						56.0			42.0			10.80		0.03
3/7/95		5.6	5.4	3.7				122		120	138						83.0			61.0			6.20		0.05
3/14/95		6.1	5.8	3.1				110		128	144						50.0			34.0			17.10		0.06
3/21/95		5.8	5.1	3.2				102		98	120						90.0			45.0			21.20		0.06
3/28/95		6.1	6.3	3.2				128		130	136						40.0			41.0			61.50		0.06
4/4/95			5.4	3.3				94		94	110						170.0			90.0			9.00		0.06
4/11/95		5.9	5.7	3.7				96		112	120						200.0			75.0			17.00		0.04
4/18/95		5.6	5.3	3.2				106		112	128						110.0			41.0			16.80		0.04
4/25/95		5.8	5.7	3.4				90		94	140						120.0			82.0			12.17		0.06
5/2/95		5.3	5.1	3.2				112		106	128						87.0			144.0			10.78		0.03
5/9/95		5.1	5.0	2.8				78		88	108						90.0			47.0			8.65		0.04
5/16/95		4.7	4.3	2.4				70		72	84						60.0			34.0			11.23		0.05
5/23/95		5.0	4.7	2.2				64		72	80						40.0			35.0			23.00		0.04
5/30/95		4.3	3.8	1.9				56		58	82									30.0			15.95		0.06
6/6/95		4.8	4.4	1.8				44		44	62						40.0			24.0			28.67		0.04
6/13/95		3.9	3.4	1.6				44		44	50						42.0			26.0			13.17		0.03
6/20/95		3.7	3.3	1.8				38		46	66						60.0			60.0			14.93		0.06
6/27/95		3.9	3.7	1.8				48		52	66						80.0			58.0			14.10		0.08
7/4/95		4.0	2.7	1.9				42		50	56									40.0			16.47		0.02
7/11/95		3.7	3.2	1.6				44		48	60						66.0			28.0			20.62		0.04
7/18/95		3.6	2.4	1.5				40		44	47						50.0			25.0			17.78		0.04
7/25/95		4.0	3.1	1.9				45		53	56						72.0			19.0			18.32		0.05
8/1/95		4.6	2.6	1.6				49		51	54						65.0			18.0			14.20		0.06
8/8/95				1.5				50		52	48						60.0			26.0			12.73		0.07
8/15/95		3.2	1.3	1.5				48		50	52						60.0			25.0			12.13		0.05
8/22/95		3.1	1.8	1.6				54		59	60						55.0			47.0			10.67		0.06
8/29/95		3.1	2.6	1.4				55		61	54						50.0			23.0			10.62		0.05
9/5/95		3.7	3.6	1.5				58		66	60						61.0	<5	<20	25.0			12.37		0.06
9/12/95		4.4	2.2	2.3				108		132	127						42.0		<40	28.0			1.94		0.05
9/19/95		4.5	2.7	2.1				112		128	114						50.0		<20	31.0			1.88		0.06
9/26/95		4.2	4.2	2.3				96		106	100						53.0		<20	30.0			8.40		0.08
10/3/95		4.1	4.4	2.4				89		94	110						48.0		<40	52.0			4.91		0.07
10/10/95		4.5	3.7	2.8				103		108	104						44.0		<40	38.0			3.88		0.06
10/17/95		4.2	3.1	2.5				102		109	111						43.0		<20	129.0			6.65		0.06
10/24/95		3.9	3.7	2.3				94		104	102						47.0		12.0	18.0			3.77		0.07
10/31/95			2.9	2.1				90		94	96						45.0		<20	21.0			4.36		0.07
11/7/95			2.6	2.2			0.09	88		92	98						47.0		<20	20.0			4.70		0.07
11/14/95		4.2	2.6	2.5			0.07	114		120	130						39.0		10.0	5.0			3.15		0.06
11/21/95		4.4	3.2	2.8			0.07	108		124	124						42.0		<20	12.0			2.83		0.07
11/28/95							0.09	54		58	88						86.0		<20	37.0			8.81		0.08
12/12/95		4.6	4.3	3.3			0.07	156		168	172						39.0		<20	14.0			2.64		0.06
12/19/95		4.8	3.7	3.3			0.07	137		141	160						38.0		<20	13.0			4.22		0.08
12/26/95		3.3	3.3	1.7			0.08	84		90	90						97.0		<20	26.0			5.85		0.08
1/2/96		3.4	4.0	1.9			0.07	66		70	82						150.0		<20	50.0			4.83		0.07
1/9/96		6.4	4.6	2.9			0.07	79		82	104						110.0		47.0	44.0			5.37		0.07
1/16/96		6.2	4.0	2.8			0.13	72		90	140						87.0		<20	50.0			4.48		0.07
1/23/96		5.8	6.6	3.5			0.08	76		89	82									40.0			10.10		0.08
1/30/96		5.8	4.3	2.7			0.07	110		122	130									28.0			21.00		0.08
2/6/96		5.6	3.3	3.4			0.08	147		153	160									21.0			13.79		0.07
2/13/96		5.4	3.8	3.4			0.03	80		82	168									11.0			13.00		0.06
3/12/96		5.5	5.0	3.0			0.09	68		86	134						21.0		<20	10.0			33.20		0.08
3/19/96		5.4	5.2	2.8			0.10	96		100	142						17.0		<20	14.0			17.10		0.07
3/26/96		5.2	4.8	2.6			0.08	88		89	122						41.0		<20	13.0			14.00		0.07
4/2/96		3.3	3.2				0.09	54		59	74						84.0		<20	37.0			16.20		0.05
4/9/96		3.6	3.7	2.2			0.09	58		62	96									54.0			5.90		0.06
4/16/96		4.0	3.7	2.4			0.10	62		68	102						95.0		11.0	30.0			5.70		0.07
4/23/96		4.0	4.1	2.2			0.09	70		76	100						110.0		<10	54.0			7.00		0.06
4/30/96		3.7	3.9	1.9			0.09	60		54	98						120.0		<10.0	60.0			13.50		0.08
5/7/96		3.7	3.7	1.9			0.09	50		52	90						140.0		27.0	60.0			7.30		0.05
5/14/96		3.7	3.6	1.9			0.09	42		51	84						130.0		<20	61.0			7.10		0.06
5/21/96								52		55	102									48.0			5.90		0.07
5/28/96		3.8	3.0	1.7			0.09	68		64	106						79.0		<1	28.0			21.70		0.08
6/4/96		3.5	3.4	1.6			0.08	50		54	76						75.2		<1	18.0			15.80		0.07
6/11/96		3.4	3.3	1.5			0.09	54		66	56						58.0		<3	81.0			19.60		0.07
6/18/96		3.8	3.7	1.6			0.08	58		73	82						59.6		<3	32.0			39.00		0.07
6/25/96		3.2	3.0	1.6				63		74	102						52.7		13.6	13.0			19.70		0.08

Utility ID:

1. Study ID:

2. Source w

3. Source w

5. Describe

(indicate w

6. Indicate

WATER QU

TREATMENT CONDITIONS

Date	pH ()			Temperature (deg. C)			Bromate (ug/L)			Disinfection By-products: TTHM (ug/L)			HAA5 (ug/L)			HAA6 (ug/L)			Ozonation Conditions: Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min)	Ozone pH ()	Ozone temp. (deg. C)
	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.					
1/3/95	7.7		7.0	8.6								7.9			9			14	2.2	0.49		8.1	8.8
1/10/95	7.8		6.7	10.4								7.7						6	2.3	0.64		8.2	10.8
1/17/95	8.0		7.0	11.3								4.2			6			5	1.7	0.44		8.0	11.3
1/24/95	8.0		7.0	11.6								4.8						4	1.8	0.40		8.5	11.6
1/31/95	7.9		6.9	11.6								4.4						5	2.0	0.37		8.6	11.6
2/7/95	7.9		6.8	12.3								4.8						5	3.6	0.91		8.3	12.3
2/14/95	8.0		6.9	10.2								5.1			5			6	4.8	0.83		8.4	10.2
2/21/95	7.9		7.1	10.0								4.8						3	3.2	0.68		8.2	10.0
2/28/95	8.4		7.4	11.2								5.1			6			7	3.8	0.49		8.2	11.2
3/7/95	8.1		7.2	12.0														18	3.8	0.66		7.6	12.0
3/14/95	8.1		7.1	11.5								3.6			3			8	3.7	0.74		7.7	11.5
3/21/95	8.2		7.1	12.0					8.0			4.8						4	3.7	0.69		7.3	12.0
3/28/95	8.0		7.0	11.2								3.6			4			3	3.8	0.62		6.9	11.2
4/4/95	8.5		7.0	16.0					12.0			82.8						4	3.9	0.38		7.4	16.0
4/11/95	8.6		7.1	15.3								8.3			6			3	3.5	0.73		7.5	15.3
4/18/95	8.3		7.0	14.1					9.0			4.9						3	4.7	0.59		7.8	14.1
4/25/95	8.4		7.1	15.5					8.0			6.9						2	3.8	0.62		7.4	15.5
5/2/95	8.2		7.2	15.7								5.4							3.5	0.55		7.2	15.7
5/9/95	8.2		6.9	16.1								13.3							4.0	0.60		7.4	16.1
5/16/95	7.6		6.8	16.5								8.4							3.9	0.77		7.5	16.5
5/23/95	7.7		6.8	18.0								5.1							3.6	0.83		7.6	18.0
5/30/95	7.3		6.6	19.3								5.0							4.2	0.52		7.7	19.3
6/6/95	6.9		6.2	19.0								6.1							3.3	0.59		7.4	19.0
6/13/95	7.4		6.5	19.2								5.0							3.8	0.60		7.7	19.2
6/20/95	7.5		6.6	19.1					6.0			4.7			3				3.8	0.69		7.6	19.1
6/27/95	7.8		6.6	24.9					8.0			6.1							3.3	0.81		7.3	24.9
7/4/95	7.4		6.4	22.9					4.0			5.6							4.0	0.47		8.0	22.9
7/11/95	7.2		6.3	22.7								6.3			2				4.2	0.61		6.0	22.7
7/18/95	7.4		6.3	23.2					10.0			4.1							4.1	0.52		7.5	23.2
7/25/95	7.5		6.4	21.6					5.0			4.3			3				4.2	0.42		6.9	21.6
8/1/95	7.6		6.2	25.9					9.0			6.2							2.0	0.30		6.9	25.9
8/8/95	7.7		6.5	24.5					6.0			3.8			3				3.8	0.83		7.6	24.6
8/15/95	7.4		6.1	25.4					7.0			3.8							4.1	0.52		7.4	25.4
8/22/95	7.7		6.3	24.4					10.0						11				2.2	0.28		7.5	24.4
8/29/95	7.6		6.8	22.0					10.0													7.6	22.0
9/5/95	7.3		6.8	21.6				<5	11.0			3.3			10			14	2.2	0.94		7.7	21.6
9/12/95	8.0		6.9	19.4				8.0	15.0			32.8							4.1	1.20		7.8	19.4
9/19/95	8.0		7.0	21.1				21.0	14.0			13.8			4			6	6.5	0.65		8.1	21.1
9/26/95	7.5		6.8	19.9				<5	23.0										3.1	1.00		7.7	19.9
10/3/95	6.9		6.9	17.8				<5	5.0			6.1			4			5	2.7	0.82		7.8	17.8
10/10/95	6.9		6.9	16.8				<5	<5			5.8							2.6	0.78		7.7	16.8
10/17/95	7.6		6.9	17.1				8.0	<5										2.8	0.56		8.1	17.1
10/24/95	7.4		6.9	16.7				<5	<5										3.0	0.77		7.6	16.7
10/31/95	7.5		6.9	16.6				<5	<5			3.7			3			4	2.9	0.67		7.5	16.6
11/7/95	7.6		6.9	15.4				<5	<5			6.2							3.0	0.82		7.6	15.4
11/14/95	7.7		6.8	15.0				<5	<5						4			5	3.0	0.78		7.7	15.0
11/21/95	7.6		6.9	15.0				<5	<5										2.9	0.81		7.8	15.0
11/28/95	8.1		6.7	14.6				14.0	<5			3.8			4			5	3.5	0.68		7.8	14.6
12/12/95	7.7		7.0	14.6				<5							5			6	2.4	0.63		7.9	14.5
12/19/95	7.8		7.2	13.6				<5	<5			6.2							2.3	0.77		7.9	13.5
12/26/95	7.7		6.9	11.8				<5	<5						2			3	2.1	0.50		7.9	11.8
1/2/96	8.1		6.9	12.6				<5	6.0			4.6							2.1	0.48		7.7	12.6
1/9/96	7.5		6.6	11.2				<5	6.0			5.8			5			7	3.5	0.46		8.2	11.2
1/16/96	7.5		6.8	10.8				<5	<5			12.2							3.6	0.50		7.8	10.8
1/23/96	7.6		6.4	10.2					5.0										3.7	0.79		8.1	10.2
1/30/96	7.7		6.3	10.8								32.9							3.5	0.84		8.2	10.8
2/6/96	7.8		7.0	11.6								5.8							3.1	0.54		8.5	11.6
2/13/96	7.8		7.0	11.8								8.2							2.5	0.50		8.1	11.6
3/12/96	7.9		6.9	12.3				<5											4.1	0.86		8.3	12.3
3/19/96	7.9		7.0	12.7				<5	<5			8.7			5			6	3.0	0.66		7.5	12.7
3/26/96	7.9		6.8	13.2				<5	<5			5.4							4.1	0.61		7.6	13.2
4/2/96	7.7		6.4	15.3					<5			8.8			3			4	3.4	0.95		7.4	15.3
4/9/96	8.2		6.6	16.3					15.0			2.9							4.0	0.79		7.5	16.3
4/16/96	7.8		7.0	16.3				8.5							2			3	3.8	0.83		7.7	16.3
4/23/96	8.1		6.9	17.0				8.0	9.0			2.8							3.8	0.66			17.0
4/30/96	8.2		6.7	19.1				15.0	12.0			1.3			3			4	3.6	0.75			19.1
5/7/96	8.5		6.9	19.3				16.5	14.0			2.6							3.8	0.54			19.3
5/14/96	8.1		6.6	19.6				13.5	25.0			5.8			2			3	3.3	0.90			19.6
5/21/96	8.3		7.0	17.7					22.0										3.0	0.69			17.7
5/28/96	7.5		6.7	17.8				<4.5				3.1			2			3	2.7	0.61			17.8
6/4/96	7.6		6.4	24.0				12.57	<4.5			2.3							2.8	0.54			24.0
6/11/96	7.4		6.5	22.6				<4.5	<4.5			2.4			1			2	2.5	0.31			22.6
6/18/96	7.5		6.7	21.4				<4.5	<4.5			2.6							2.8	0.35			21.4
6/25/96	7.7		7.0	20.7				<4.5	<4.5			1.6							2.7	0.45			20.7

Utility ID:	ACWD	(ACWD, CCWD, EBMUD, MWD, SCVWD)	
1. Study ID:	Enh. Coagulation (from EC study data)	(Optimization Study 9/95, etc.)	
2. Source water:	River	(River, lake, groundwater, etc.)	
3. Source water ID:	South Bay Aqueduct	(State Project water, blend of...., etc.)	
5. Describe level of study:		Bench-scale	In this data sheet, "Filt." refers to data collected
(indicate with an 'X')		Pilot-scale	after coagulation, flocculation, sedimentation, and
	x	Full-scale	filtration.

6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only: x

or after sedimentation and filtration: x

WATER QUALITY DATA: CONVENTIONAL

Date	Time	TOC (mg/L)			Alkalinity (mg/L as CaCO3)		Hardness (mg/L as CaCO3)				Turbidity (NTU)		pH ()		Temperature (deg. C)	
		Raw	Filt.	Filt.	Raw	Filt.	Total		Calcium		Raw	Filt.	Raw	Filt.	Raw	Filt.
							Raw	Filt.	Raw	Filt.						
			(settled)	(filt)								(settled)				
		3.2	1.9		104		132				11.5	2.2	7.7		21.2	
		3.1	2.1		105		118				6.0167	1.1	8.1		20.3	
		3.7	2.8	2.4	112		120				4.65	1.7	7.6		17.3	
		4.0	2.7	2.8	127		150				2.1667	0.8	7.9		19.1	
		3.6	2.6	2.5	128		144				2.1167	2.3	7.9		19.9	
		5.8	4.0	3.4	152		142				24.333	6.9	7.9		10	
		5.6	4.2	3.7	158		144				11.933	4.4	8.4		11.1	
		5.8	4.1	3.7	127		134				8.2833	2.4	8.1		11.3	
		6.1	3.8	3.2	110		144				17.117	3.9	8.2		12.5	
		5.8	3.6	2.9	102		120				21.233	2.6	8.3		12.4	
		6.1	3.3		117		134				76.667	13.4	8		11.9	
		5.9	4.3	3.6	96		116				13.633	2.7	8.6		15	
		5.6	4.0	3.1	87		124				8.9667	2.6	8.7		14.6	
		5.8	4.2	3.5	98		118				11.55	3.4	8.5		15.5	
		5.3	3.7	3.4	105		126				10.783	3.3	8.3		15.7	
		5.1	3.7	2.8	78		108				8.6833	2.5	7.9		16.1	
		3.2	2.00		104		132				11.5	2.97	7.7		21.2	
		3.1	2.40		105		118				6.0167	1.53	8.1		20.3	
		3.7	3.10	2.40	112		120				4.65	1.88	7.6		17.3	
		4.0	2.80	2.80	127		150				2.1667	1.09	7.9		19.1	
		3.6	2.60	2.60	128		144				2.1167	1.00	7.9		19.9	
		5.8	3.70	3.40	152		142				24.333	3.02	7.9		10	
		5.6	4.20	3.50	158		144				11.933	2.98	8.4		11.1	
		5.8	4.10	3.50	127		134				8.2833	2.18	8.1		11.3	
		6.1	3.50	3.00	110		144				17.117	2.68	8.2		12.5	
		5.8	3.30	2.80	102		120				21.233	3.65	8.3		12.4	
		6.1	3.30		117		134				76.667	4.98	8		11.9	
		5.9	4.00	3.50	96		116				13.633	2.39	8.6		15	
		5.6	3.60	2.90	87		124				8.9667	2.18	8.7		14.6	
		5.8	3.70	3.10	98		118				11.55	2.92	8.5		15.5	
		5.3	3.50	3.20	105		126				10.783	2.30	8.3		15.7	
		5.1	3.40	2.70	78		108				8.6833	2.02	7.9		16.1	

indicate coagulants studied:

ID	Coagulant	Chemical formula	Units
1	Alum	$Al_2(SO_4)_3 \cdot 14\ H_2O$	mg/L
2	Ferric	$FeCl_3 \cdot 6\ H_2O$	mg/L
3			
4			

TREATMENT CONDITIONS

Cl2 Conditions	Disinfection By-products				Coagulation Conditions					
Chlorine dose (mg Cl2/L)	TTHM (µg/L) Raw	TTHM (µg/L) Filt.	HAA5 (µg/L) Raw	HAA5 (µg/L) Filt.	Coagulant ID (see above)	Dose	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)
2.34		9		6	1	25.1				
2.40		8		6	1	11.8				
2.60		8		4	1	11.6				
2.35		9		5	1	12.8				
2.20		8		6	1	12.5				
1.43		5		5	1	28				
1.57		5		6	1	21.3				
1.49		5		5	1	18.8				
1.32		4		3	1	40				
1.10		5		4	1	31.1				
1.47		4		4	1	29.4				
1.47		8		6	1	24				
1.54		5		4	1	25				
1.60		7		7	1	23.1				
1.90		5		5	1	21.2				
2.00		13		4	1	21				
2.34		9.0		6.0	2	11.2				
2.40		7.6		6.0	2	11.1				
2.60		8.0		4.0	2	8.1				
2.35		8.7		5.0	2	15.9				
2.20		7.8		6.0	2	9.2				
1.43		4.8		5.0	2	16				
1.57		5.1		6.0	2	13.5				
1.49		5.0		5.0	2	10.2				
1.32		3.6		3.0	2	23.8				
1.10		4.8		4.0	2	13.6				
1.47		3.8		4.0	2	26.1				
1.47		8.3		6.0	2	16.7				
1.54		4.9		4.0	2	18.5				
1.60		6.9		7.0	2	18				
1.90		5.4		5.0	2	16.7				
2.00		13.3		4.0	2	18				

Utility ID: CCWD: Bollman WTP (ACWD, CCWD, EBMUD, MWD, SCVWD)

1. Study ID: Historical data 7/1/95-6/30/96 (Optimization Study 9/95, etc.)

2. Source water: Delta - Mallard Slough/Rock Slough (River, lake, groundwater, etc.)

3. Source water ID: Central Valley Project Water (State Project water, blend of...., etc.)

4. If blended source water indicate sources and proportions:

Source	%

5. Describe level of study: (indicate with an 'X')

	Bench-scale
	Pilot-scale
X	Full-scale

In this data sheet, "Filt." refers to data collected after coagulation, flocculation, sedimentation, and filtration.

6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only: [ ]
or after sedimentation and filtration: X

WATER QUALITY DATA: CONVENTIONAL

Date	Time	TOC (mg/L)		UV-254 (1/cm)		Alkalinity (mg/L as CaCO3)		Hardness (mg/L as CaCO3)				Bromide (mg/L)		Ammonia (mg NH3-N/L)		Chloride (mg Cl-/L)		TDS (mg/L)		Turbidity (NTU)		pH ()	
								Total		Calcium													
		Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.
Jul-95						43.9	44.4	47.8	47.9			<0.1	<0.1	<0.1	0.32	21.3	21.3	90	120	3	0.05	7.8	8.8
Aug-95						42.3	42	47.1	46.6				<0.1			20.3	21.3		115	2.4	0.05	8.1	8.9
Sep-95						47.2	48.3	48.4	47.9				<0.1			16.1	16.3		110	2.4	0.05	8	9
Oct-95						52.4	54.2	53.1	54.8			<0.1	<0.1	<0.1	0.25	17.7	18	90	113	3.1	0.05	8.2	9
Nov-95						52.3	51.7	55.1	55.4				<0.1			20	20.4		120	5	0.05	8.4	8.9
Dec-95						54.7	55.5	62	61.3				<0.1			22.3	22.4		130	5.7	0.05	8	8.9
Jan-96						63.2	60.5	71.8	71.5			<0.1	<0.1	<0.1	0.28	29.6	29.8	130	160	6.8	0.05	8.5	9
Feb-96						67.7	67.4	78	75.7				<0.1			33.5	32		195	5.1	0.05	7.8	8.7
Mar-96						64.5	63.8	77.5	76.3				<0.1			34.3	34.3		195	5.5	0.05	8	8.9
Apr-96						63.8	64.3	84.3	82			<0.1	<0.1	<0.1	0.18	36.9	37.5	160	193	5	0.05	8	8.9
May-96						62.5	62.4	88.2	88.8				<0.1			44.8	45.7		210	5.4	0.05	8.2	8.8
Jun-96						54.6	55.8	71.5	73.8				<0.1			35.6	36.5		170	6.4	0.05	8.1	8.9

Temperature (deg. C)		Bromate (µg/L)		Microbial Parameters												Raw					
				Coliforms				Giardia		Crypto.		Viruses		HPC							
Raw	Filt.	Raw	Filt.	Total (#/100mL)		Fecal (#/100mL)		Giardia (cysts/100L)		Crypto. (oocysts/100L)		Viruses (#/mL)		HPC (CFU/mL)		Indicate disinfectant(s) used with an 'X'		Chlorine dose (mg Cl2/L)	Ammonia dose (mg NH3-N/L)	Incububation time (h)	
				Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	chlorine	chloramine			chlorine	chloramine
	24.8			44	0	7		0	0	0	0			960	0						
	25.2			6	0	3								1750	0						
	23.7			8	0	14								410	0						
	20.8			42	0	5								480	0						
	18.1			29	0	27								3600	0						
	14.3			21	0	3		0	0	0	0			13700	0						
	12.1			26	0	5		0	0	0	0			2100	0						
	14			31	0	16		<5.3		<5.3				160	0						
	15.1			700	0	10		0		0				63700	0						
	17.8			33	0	5		0		0				880	0						
	20.5			37	0	9		0	0	0	<1			1500	0						
	21.8			7	0	1								20400	10						

Chlorination conditions												Disinfection By-products							
			Filtered									TTHM		HAA5		HAA6		TOX	
Incub. temp. (deg. C)	pH ()	Residual (mg Cl2/L)	Indicate disinfectant(s) used with an 'X' chlorine	chloramine	Chlorine dose (mg Cl2/L)	Ammonia dose (mg NH3-N/L)	Incububation time (h) chlorine	chloramine	Incub. temp. (deg. C)	pH ()	Residual (mg Cl2/L)	(μg/L) Raw	Filt.	(μg/L) Raw	Filt.	(μg/L) Raw	Filt.	(μg Cl-/L) Raw	Filt.
			X	X	1.7	0.37	0.24		24.8	7.2	1.2	<0.5	14.1				7.1		
			X	X	1.6	0.36	0.23		25.2	7.1	1.1		7.8				11.9		
			X	X	1.5	0.3	0.26		23.7	7.3	1.06		8.1				3.9		
			X	X	1.6	0.3	0.3		20.8	7.4	1.07	<0.5	9.8				5.4		
			X	X	1.6	0.33	0.26		18.1	7.4	1.07		14.7				5.1		
			X	X	1.7	0.33	0.54		14.3	7.3	1.07		12.6				6.7		
			X	X	1.8	0.33	0.58		12.1	7.2	1.1	<0.5	16				8.6		
			X	X	1.9	0.31	0.58		14	7.2	1.1		17				7.5		
			X	X	2	0.33	0.52		15.1	7.1	1.12		24.6				6.3		
			X	X	1.9	0.33	0.41		17.8	7.1	1.11	<0.5	24.3				9.8		
			X	X	1.8	0.33	0.31		20.5	7.2	1.17		20.3				12.6		
			X	X	1.8	0.29	0.24		21.8	7.2	0.95		19.3				13.7		

Note: Disinfection at Bollman is accomplished by a limited free chlorine contact time (see Filtered Incubation Time) followed by chloramination.
Typically 90-95% of the CT credit is achieved with free chlorine, the remainder being provided by chloramines

Indicate coagulants studied:

ID	Coagulant	Chemical formula	Units
1	Alum	$Al_2(SO_4)_3$	mg/L
2			
3			
4			

TREATMENT CONDITIONS

Coagulation Conditions					
Coagulant ID (see above)	Dose	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)
1	31.2	Y	N		
1	33.7	Y	N		
1	31.8	Y	N		
1	31.6	Y	N		
1	31.1	Y	N		
1	35.6	Y	N		
1	47.4	Y	N		
1	42.2	Y	N		
1	49.9	Y	N		
1	42.9	Y	N		
1	36.7	Y	N		
1	35.7	Y	N		

Contra Costa WD							
Randall-Bold WTP							
Sample	Bromate	Chloride	Bromide				
Date	(measured)	(daily avg)	(estimated)				
	(µg/L)	(mg/L)	(mg/L)				
2/23/93	<0.5	72	0.22				
4/6/93	<1.4	89	0.27				
5/21/93	10	55	0.17				
6/15/93	6	30	<0.1				
8/18/93	6	25	<0.1				
10/5/93	10.3	60	0.18				
11/17/93	30.4	142	0.43				
1/4/94	1.5	70	0.21				
2/9/94	4.6	70	0.21				
3/1/94	2.6	55	0.17				
4/5/94	7.3	77	0.23				
5/10/94	<3	57	0.17				
7/12/94	<5	112	0.34				
8/9/94	<5	133	0.4				
10/4/94	51	158	0.48				
10/10/94	33	118	0.36				
11/1/94	15	150	0.45				
12/6/94	13	162	0.49				
1/10/95	5.7	94	0.28				
2/14/95	17	60	0.18				
3/14/95	7.6	35	0.11				
4/4/95	18	105	0.32				
6/13/95	<5	40	0.12				
7/11/95	21	32	0.1				
8/8/95	7.8	32	0.1				
9/19/95	<5	16	<0.1				
10/3/95	<5	14	<0.1				
11/7/95	<5	16	<0.1				
12/12/95	<5	23	<0.1				
2/6/96	<5	40	0.12				
3/5/96	<5	117	0.35				
Note:	Ozone	dose	currently	optimized	for	coagulation,	
	not	bromate	production.				
Conservative	ozone	doses:	pre-ozone	2.5-3 ppm	(raw water		
			post-ozone	1ppm	(filtered)		
Plant CT operating	from 2-5						

Utility ID:	CCWD: Randall-Bold WTP	(ACWD, CCWD, EBMUD, MWD, SCVWD)		
1. Study ID:	Historical data 7/1/95-6/30/96	(Optimization Study 9/95, etc.)	4. If blended source water indicate sources and proportions:	
2. Source water:	Delta (Rock Slough)	(River, lake, groundwater, etc.)	Source	%
3. Source water ID:	Central Valley Project Water	(State Project water, blend of...., etc.)		
	5. Describe level of study: (indicate with an 'X')		Bench-scale	
			Pilot-scale	
		x	Full-scale	

WATER QUALITY DATA: CONVENTIONAL+OZONE

Date	Time	TOC (mg/L)				UV-254 (1/cm)				Alkalinity (mg/L as CaCO3)				Hardness (mg/L as CaCO3)								Bromide (mg/L)				Ammonia (mg NH3-N/L)				Chl (mg	
														Total				Calcium													
		Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.
7/10/95		5.7								37			21	42			43					<0.1			<0.1	0.11			0.35	15	
8/7/95		3.6								36			20	39			46					<0.1			<0.1	<0.1			0.28	12	
9/11/95		7.7								65			48	61			56					<0.1			<0.1	<0.1			0.32	16	
10/2/95		3								58			49	63			49					<0.1			<0.1	<0.1			0.45	15	
11/6/95		2.8								52			43	50			42					<0.1			<0.1	<0.1			0.33	17	
12/4/95		3								55			35	57			55					<0.1			<0.1	0.15			0.44	19	
1/8/96		5.5								62			40	73			76					<0.1			<0.1	<0.1			0.46	28	
2/5/96		6.9								71			36	89			90					0.12			0.11	<0.1			0.51	42	
3/4/96		5.1								107			87	190			181					0.31			0.16	<0.1			0.41	92	
4/1/96		7.8								83			63	129			131					<0.1			0.13	<0.1			0.40	70	
5/6/96										69			51	110			115					0.22			0.19	0.15				60	
6/3/96		4.1								47			35	67			65					0.12			<0.1	<0.1			0.45	25	

Note: Form is set up for conventional filtration and intermediate ozone.
CCWD's Randall-Bold WTP has pre & post ozone and direct filtration.
Raw = Pre-oz
Filt = Post-oz
Settl. = Applied
N/A - not applicable (chlorination is only done after post-ozone process (after filtration))

Utility ID:

1. Study

2. Source

3. Source

WATER

Date	ride (-/L) Ozon.	ride (-/L) Filt.	TDS (mg/L) Raw	TDS (mg/L) Settl.	TDS (mg/L) Ozon.	TDS (mg/L) Filt.	Turbidity (NTU) Raw	Turbidity (NTU) Settl.	Turbidity (NTU) Ozon.	Turbidity (NTU) Filt.	pH () Raw	pH () Settl.	pH () Ozon.	pH () Filt.	Temperature (deg. C) Raw	Temperature (deg. C) Settl.	Temperature (deg. C) Ozon.	Temperature (deg. C) Filt.
7/10/95		12	80			110	9.68	6.78		0.032	7.45	6.74		6.56	24.1			23.9
8/7/95		12	70			110	10.87	3.14		0.022	7.43	7.21		6.48	25.2			25.0
9/11/95		14	110			90	4.59	2.19		0.025	7.57	7.14		6.81	23.7			23.0
10/2/95		17	100			120	3.60	2.40		0.027	7.68	7.28		7.03	22.7			22.0
11/6/95		21	90			120	2.52	4.46		0.015	7.73	7.21		7.31	18.0			17.0
12/4/95		21	100			130	2.67	2.79		0.022	7.62	7.46		7.36	16.5			15.2
1/8/96		33	140			180	5.20	6.20		0.028	7.52	7.05		6.81	13.0			12.0
2/5/96		61	200			300	6.25	17.25		0.020	7.6	7.12		7.04	14.0			12.8
3/4/96		110	390			390	4.06	6.23		0.082	7.88	7.14		7.01	14.0			13.0
4/1/96			260			330	3.83	3.08		0.019	6.93	7.24		7.36	16.8			16.0
5/6/96		62	250			290	9.25	10.30		0.018	7.83	6.81		6.71	21.0			21.0
6/3/96		73	120			140	9.55	5.74		0.020	7.59	7.09		7.18	23.5			23.5

Date	Bromate (µg/L) Raw	Bromate (µg/L) Settl.	Bromate (µg/L) Ozon.	Bromate (µg/L) Filt.	Coliforms Total (#/100mL) Raw	Coliforms Total (#/100mL) Settl.	Coliforms Total (#/100mL) Ozon.	Coliforms Total (#/100mL) Filt.	Coliforms Fecal (#/100mL) Raw	Coliforms Fecal (#/100mL) Settl.	Coliforms Fecal (#/100mL) Ozon.	Coliforms Fecal (#/100mL) Filt.	Gi (cyst Raw	Gi (cyst Settl.
7/10/95				21	190			0	7					
8/7/95				7.8	65			0	9				0	
9/11/95				<5	77			0	8					
10/2/95				<5	41			0	5					
11/6/95				<5	48			0	2					
12/4/95				<5	65			0	8					
1/8/96				<5	61			0	1				0	
2/5/96				<5	22			0	3				<1.6	
3/4/96				<5	40			0	0					
4/1/96				<5	36			0	4				0	
5/6/96				<5	42			0	16				0	
6/3/96				<5	28			0	0					

Utility ID:

1. Study

2. Source

3. Source

WATER

Date	Microbial Parameters														Chlorination conditions												
	dia (/100L)		Crypto. (oocysts/100L)				Viruses (#/mL)				HPC (CFU/mL)				Filtered									TTHM (µg/L)			
															Indicate disinfectant(s) used with an 'X'		Chlorine dose	Ammonia dose	Incububation time (h)		Incub. temp.	pH	Residual				
	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	chlorine	chloramine	(mg Cl2/L)	(mg NH3-N/L)	chlorine	chloramine	(deg. C)	( )	(mg Cl2/L)	Raw	Settl.	Ozon.	Filt.
7/10/95		0				0					2100			1		X				3.07	22	9.07	1.00				0.9
8/7/95			0								680			4		X				3.97	23.2	9.00	0.97				<0.5
9/11/95											290			3		X	1.66	0.55		21.7	25	9.08	1.04				<0.5
10/2/95											510			0		X	1.79	0.60		27.1	23.8	9.41	1.06				<0.5
11/6/95											1350			0		X	1.71	0.56		20.3	17	9.05	0.96				<0.5
12/4/95		0				0					810			1		X	1.76	0.58		27.1	15.8	9.34	1.23				<0.5
1/8/96		0	0			0					520			2		X	1.82	0.68		32.5	12.5	8.89	1.10				<0.5
2/5/96			<1.6								660			0		X	1.92	0.67		32.5	12.2	8.92	1.04				<0.5
3/4/96											290			6		X	1.99	0.65		46.5	12.8	8.54	1.08				<0.5
4/1/96		0	0			0					510			1		X	1.77	0.64		20.3	15.6	8.68	1.08				<0.5
5/6/96		0	0			0					430			0		X	1.39	0.47		8.13	20.5	8.56	1.12				<0.5
6/3/96											2950			2		X	1.48	0.49		7.4	22.2	8.76	1.19				<0.5

Utility ID:

1. Study

2. Source

3. Source

WATER

Indicate coagulants studied:

ID	Coagulant	Chemical formula	Units
1	Alum		
2	Cat Poly		
3	Non-Ionic		
4			

TREATMENT CONDITIONS

Date	Disinfection By-products: HAA5 (µg/L) Raw	HAA5 Settl.	HAA5 Ozon.	HAA5 Filt.	HAA6 (µg/L) Raw	HAA6 Settl.	HAA6 Ozon.	HAA6 Filt.	TOX (µg Cl-/L) Raw	TOX Settl.	TOX Ozon.	TOX Filt.
7/10/95								<2				
8/7/95								<1				
9/11/95								5				
10/2/95								<1				
11/6/95								<1				
12/4/95								<1				
1/8/96								2				
2/5/96								<2				
3/4/96								<2				
4/1/96								15.8				
5/6/96								2.5				
6/3/96								<2				

Date	Coagulation Conditions: Coagulant ID (see above)	Dose	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)	Ozonation Conditions: Ozone dose (mg/L) [Pre/Post]	Ozone residual (mg/L) [Post-Ozone Stages 1/2/3]	Contact time (min) [Per Stage]	Ozone pH ()	Ozone temp. (deg. C)
7/10/95	1/2/3		N	N	6.74	24.1		.36/.23/.3	1.41	7.31	16.2
8/7/95	1/2/3	35/1.0/0.1	N	N	7.21	25.2	2.5/0.5	.34/.27/.3	1.83	6.56	23.9
9/11/95	1/2/3	35/1.0/0.0	N	N	7.14	23.7	1.81/0.3	.06/.05/.0	9.98	6.48	25.0
10/2/95	1/2/3	5.7/1.2/0.0	N	N	7.25	22.7	1.8/0.29	.07/.03/.0	12.48	6.81	23.0
11/6/95	1/2/3	9.5/1.03/0.0	N	N	7.21	18.0	1.55/0.3	.10/.09/.0	9.36	7.03	21.5
12/4/95	1/2/3	9.9/1.05/0.0	N	N	7.46	16.5	1.9/0.4	.14/.10/.0	12.48	7.36	15.2
1/8/96	1/2/3	44.7/1.0/0.2	N	N	7.05	13.0	2.85/0.3	.12/.04/.0	14.98	6.81	12.0
2/5/96	1/2/3	49.8/1.0/0.2	N	N	7.12	14.0	3.12/0.4	.26/.18/.1	14.98	7.04	12.8
3/4/96	1/2/3	77.9/3.0/0.49	N	N	7.14	14.0	3.25/1.1	.19/.06/.0	21.39	7.01	13.0
4/1/96	1/2/3	5.5/0.93/0.1	N	N	7.24	18.8	2.9/0.54	.23/.14/.1	9.36	7.36	16.0
5/6/96	1/2/3	40/0.50/0.0	N	N	6.81	21.0	2.40/0.4	.36/.24/.2	3.74	6.71	21.0
6/3/96	1/2/3	27/0.48/0.0	N	N	7.09	23.5	1.53/0.4	.26/.13/.1	3.40	7.18	23.5

Utility ID:			CCWD, Randall-Bold WTP		(ACWD, CCWD, EBMUD, MWD, SCVWD)		
1. Study ID:			Historical data 7/1/95-6/30/96		(Optimization Study 8/95, etc.)		
2. Source water:			Delta (Rock Slough)		(River, lake, groundwater, etc.)		
3. Source water ID:			Central Valley Project Water		(State Project water, blend of..., etc.)		
			4. Describe level of study:		Bench-scale		
			(indicate with an "X")		Pilot-scale		
				X	Full-scale	(see footnotes)	

WATER QUALITY DATA: CONVENTIONAL+OZONE

Date	Time	TOC (mg/L)	Alkalinity (mg/L as CaCO3)				Hardness (mg/L as CaCO3) Total				Bromide (mg/L)			
		Raw	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.
2/23/93			76				127			106	0.22			
4/6/93			98				177			180	0.27			
5/21/93			75				104			100	0.17			
6/15/93			65				66			55	<0.1			
8/10/93			50				51			51	<0.1			
10/5/93			83				85			72	0.18			
11/17/93			56				103			104	0.43			
12/8/93			68				89			80				
1/4/94			60				81			88	0.21			
2/9/94			66				96			89	0.21			
3/1/94			75				105			103	0.12			
4/5/94			86				135			131	0.23			
5/10/94			81				115			105	0.17			
7/12/94			72				109			105	0.30			
8/9/94			59				99			95	0.4			
10/4/94			74				124			122	0.40			
10/10/94			75				104			106	0.36			
11/1/94			72				107			106	0.45			
12/6/94			77				128			134	0.49			
1/10/95			89				105			102	0.28			
2/14/95			70				118			138	0.18			
3/14/95			84				103			104	0.11			
4/4/95			100				170			165	0.32			
6/13/95			40				52			46	0.12			
7/10/95		5.7	37			21	42			43	0.1			<0.1
8/7/95		3.8	36			20	39			45	0.1			<0.1
9/11/95		7.7	55			46	61			56	<0.1			<0.1
10/2/95		3	56			49	63			48	<0.1			<0.1
11/6/95		2.8	52			43	90			42	<0.1			<0.1
12/4/95		3	55			35	97			65	<0.1			<0.1
1/8/96		5.3	62			40	73			73	<0.1			<0.1
2/5/96		6.9	71			36	86			90	0.12			0.11
3/4/96		5.1	107			87	180			161	0.31			0.16
4/1/96		7.8	83			63	129			131	<0.1			0.13
5/6/96			69			51	110			115	0.22			0.19
6/3/96		4.1	47			35	67			85	0.12			<0.1

Date	Ammonia (mg NH3-N/L)				Chloride (mg Cl-/L)				TDS (mg/L)			
	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.
2/23/93	0.024			0.342	72							
4/6/93	0			0.232	80							
5/21/93	0.024			0.232	55							
6/15/93	0.024			0.378	30							
8/10/93	0.024			0.402	25							
10/5/93	0.02			0.4	60							
11/17/93	0			0.45	142							
12/8/93	0.012			0.293								
1/4/94	0.085			0.476	70							
2/9/94	0.012			0.439	70							
3/1/94	0			0.427	68							
4/5/94	0			-	77							
5/10/94	-			-	87							
7/12/94	0.024			0.41	112							
8/9/94	0.012			0.33	133							
10/4/94	0.024			0.38	156							
10/10/94	0.012			0.451	116							
11/1/94	0.01			0.34	150							
12/6/94	0.01			0.44	162							
1/10/95	0.024			0.378	84							
2/14/95	-			-	40							
3/14/95	0.012			0.573	35							
4/4/95	-			-	105							
6/13/95	-			-	40							
7/10/95	0.11			0.35	32			12	90			110
8/7/95	<0.1			0.28	32			12	70			110
9/11/95	<0.1			0.32	18			14	110			90
10/2/95	<0.1			0.45	14			17	100			120
11/6/95	<0.1			0.33	18			21	60			120
12/4/95	0.15			0.44	23			21	100			130
1/8/96	<0.1			0.46	28			33	140			180
2/5/96	<0.1			0.51	42			61	200			300
3/4/96	<0.1			0.41	92			110	390			390
4/1/96	<0.1			0.40	70				280			330
5/6/96	0.15				60			62	260			290
6/3/96	<0.1			0.45	25			73	120			140

Date	Turbidity (NTU)				pH ()				Temperature (deg. C)				Bromate (µg/L)				
	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.	Raw	Settl.	Ozon.	Fltr.	Raw
2/23/93	17.5	27.5		0.03	7.5	7.3		6.8	12.9							<5	
4/6/93	6.7	12.2		0.066	8.1	7.4		7	17.3							<1.4	
5/21/93	12	25.5		0.05	8.6	7.4		6.9	20.2							10	
6/15/93	15.8	18.12		0.044	7.5	7.4		6.75	23.5							6	
8/10/93	4.6	11.6		0.02	8.65	7.38		6.90	25.4							6	
10/5/93	4.57	7.15		0.066	9.1	7.19		6.63	23.4							10.3	
11/17/93	1.31	4.52		0.034	7.83	6.66		6.65	17.7							[illegible]	
12/8/93	1.36	2.7		0.046	7			7.3	12.8			14.3				6.9	
1/4/94	2.7	6		0.057	7.2			6.7	11.7			11.8				1.8	
2/9/94	1.7	6		0.053	7			6.3	12.4			12.2				4.8	
3/1/94	3.6	10.17		0.063	7	6.8		6.6	14.1			13.8				2.8	
4/5/94	2.6	11.4		0.071	7.87	7		6.9	17.8			17.6				7.3	
5/10/94	1.48	4.18		0.046	7.8	7.14		6.7	20.1			20.7				<3	
7/12/94	5.95	14		0.037	7.7	6.86		6.80	26.7			26.1				<5	
8/9/94	3	1.97		0.066	7.54	7.3		6.7	26			26.6				<5	
10/4/94	6.1	8.3		0.06	7.6	7.3		6.9	22.7			23.3				51	
10/10/94	4.8	4.3		0.052	7.6	7.3		6.9	22.4			22.7				33	
11/1/94	2.13	2.43		0.051	8.12	7.17		6.96	20.1			19.9				15	
12/6/94	2.38	3.01		0.031	7.8	7.4		7.2	13.4			13.4				13	
1/10/95	4.7	19		0.038	7.68	7.1		7	12			12				8.7	
2/14/95	10.7	22.7		0.036	7.36	6.78		6.66	12.8			12.9				17	
3/14/95	6.52	23.8		0.024	7.78	6.93		6.93	14			14.2				7.8	
4/4/95	7.22	2.93		0.031	7.60	6.94		6.65	18.3			18.0				18	
6/13/95	20			0.1	7.56			6.60	24.0			22.2				<5	
7/10/95	9.60	8.78		0.032	7.46	6.74		6.56	24.1			23.9				21	190
8/7/95	10.87	3.14		0.022	7.43	7.21		6.40	25.2			25.0				7.8	65
9/11/95	4.58	2.18		0.025	7.57	7.14		6.81	23.7			23.0				<5	77
10/2/95	3.60	2.40		0.027	7.56	7.26		7.03	22.7			22.0				<5	41
11/6/95	2.52	4.46		0.015	7.73	7.21		7.31	18.0			17.0				<5	46
12/4/95	2.87	2.78		0.022	7.82	7.40		7.36	16.5			15.2				<5	65
1/8/96	6.20	6.90		0.036	7.52	7.05		6.81	13.0			12.0				<5	61
2/5/96	6.25	17.25		0.020	7.8	7.12		7.04	14.0			12.9				<5	22
3/4/96	4.06	6.23		0.062	7.86	7.14		7.01	14.0			13.0				<5	40
4/1/96	3.43	3.08		0.018	8.03	7.24		7.34	18.8			18.0				<5	36
5/6/96	9.25	10.33		0.018	7.63	6.81		6.71	21.0			21.8				<5	42
6/3/96	9.65	8.74		0.020	7.59	7.09		7.18	23.6			23.5				<5	28

Note: Form is set up for conventional filtration and intermediate ozone.
- CCWD's Randall-Bold WTP has pre & post ozone and direct filtration
- Raw = Pre-oz
- Fltr = Post-oz
- Settl = Applied
- N/A - not applicable (chlorination is only done after post-ozone process (after filtration))
- At times, the plant has been operated in start-stop manner resulting in higher ozone doses (and bromate) than would have occurred if the plant were operated in a continuous manner (these periods are not marked but could be made available)

Utility ID	
1. Study	
2. Sourc	
3. Sourc	
WATE	

Microbial Parameters

Date	Coliforms Total (#/100mL) Settl.	Coliforms Total (#/100mL) Ozon.	Coliforms Total (#/100mL) Filt.	Coliforms Fecal (#/100mL) Raw	Coliforms Fecal (#/100mL) Settl.	Coliforms Fecal (#/100mL) Ozon.	Coliforms Fecal (#/100mL) Filt.	Giardia (cysts/100L) Raw	Giardia (cysts/100L) Settl.	Giardia (cysts/100L) Ozon.	Giardia (cysts/100L) Filt.	Crypto. (oocysts/100L) Raw	Crypto. (oocysts/100L) Settl.	Crypto. (oocysts/100L) Ozon.	Crypto. (oocysts/100L) Filt.	Viruses (#/mL) Raw	Viruses (#/mL) Settl.	Viruses (#/mL) Ozon.	Viruses (#/mL) Filt.	HPC (CFU/mL) Raw	HPC (CFU/mL) Settl.	HPC (CFU/mL) Ozon.	HPC (CFU/mL) Filt.
2/23/93																							
4/6/93																							
5/21/93																							
6/15/93																							
8/18/93																							
10/5/93																							
11/17/93																							
12/8/93																							
1/4/94																							
2/9/94																							
3/1/94																							
4/5/94																							
5/10/94																							
7/12/94																							
8/9/94																							
10/4/94																							
10/10/94																							
11/1/94																							
12/6/94																							
1/10/95																							
2/14/95																							
3/14/95																							
4/4/95																							
6/13/95																							
7/10/95			0	7							0				0					2100			1
8/7/95			0	9				0				0								880			4
9/11/95			0	8																290			3
10/2/95			0	5																510			6
11/6/95			0	2																1350			0
12/4/95			0	0							0				0					810			1
1/8/96			0	1				0			0	0			0					820			2
2/5/96			0	3				<1.6				<1.0								880			0
3/4/96			0	6																290			6
4/1/96			0	4				0			0	0			0					510			1
5/6/96			0	16				0			0	0			0					430			0
6/3/96			0	0																2950			2

Chlorination conditions — Filtered

Date	Indicate disinfectant(s) used with an 'X' chlorine	Indicate disinfectant(s) used with an 'X' chloramine	Chlorine dose (mg Cl2/L)	Ammonia dose (mg NH3-N/L)	Incubation time (h) chlorine	Incubation time (h) chloramine	Incub. temp. (deg. C)	pH ()	Residual (mg Cl2/L)	TTHM (µg/L) Raw	TTHM (µg/L) Settl.	TTHM (µg/L) Ozon.
2/23/93		X	1.3	0.43		6.1	12.7	8.5	0.84			
4/6/93		X	1.3	0.43		4.6	16.6	8.6	0.77			
5/21/93		X	1.3	0.43		6.3	20.1	8.4	1.35			
6/15/93		X	1.1	0.37		3.7	22.8	8	1.17			
8/18/93		X	1.6	0.53		13.2	25.2	8.68	1.31			
10/5/93		X	1.3	0.433		4.1	23	8.01	1.18			
11/17/93		X	1.3	0.433		5.3	15.9	8.84	1.12			
12/8/93		X	1.3	0.6		27.1	13	8.9	1.18			
1/4/94		X	1.5	0.48		28.1	11.1	8.9	1.14			
2/9/94		X	1.5	0.53		28.1	11.8	8.9	1.1			
3/1/94		X	1.6	0.53		31.3	13.1	8.8	1.08			
4/5/94		X	1.5	0.51		18.3	17.4	8.7	1.13			
5/10/94		X	1.2	0.38		8.0	19.8	8.68	1.06			
7/12/94		X	1.8	0.5		24.7	25.7	8.68	1.29			
8/9/94		X	1.8	0.6		18.7	26.1	8.57	1.06			
10/4/94		X	1.35	0.45		5.1	23	8.5	1.18			
10/10/94		X	1.35	0.45		5.1	22.2	8.7	1.15			
11/1/94		X	1.35	0.45		5.1	18.3	8.76	1.03			
12/6/94		X	1.4	0.47		13.8	13.4	8.6	1.16			
1/10/95		X	1.4	0.47		27.1	11.1	8.8	1.18			
2/14/95		X	1.5	0.52		20.3	12	8.82	1.34			
3/14/95		X	1.6	0.52		36.2	13.3	8.74	1.08			
4/4/95		X	1.6	0.57		18.3	18.1	8.38	0.86			
6/13/95		X	1.6	0.47		4.5	21.3	8.66	1.25			
7/10/95		X				3.07	22	8.87	1.00			
8/7/95		X				3.87	23.2	9.00	0.97			
9/11/95		X	1.88	0.65		21.7	25	9.08	1.04			
10/2/95		X	1.70	0.60		27.1	23.8	9.41	1.08			
11/6/95		X	1.71	0.56		20.3	17	9.05	0.88			
12/4/95		X	1.76	0.58		27.1	15.8	9.34	1.23			
1/8/96		X	1.82	0.68		32.6	12.6	9.00	1.10			
2/5/96		X	1.92	0.67		32.5	12.2	8.92	1.04			
3/4/96		X	1.80	0.65		45.5	12.6	8.64	1.08			
4/1/96		X	1.77	0.64		20.3	15.6	8.86	1.06			
5/6/96		X	1.30	0.47		8.13	20.8	8.58	1.12			
6/3/96		X	1.48	0.49		7.4	22.2	8.78	1.18			

Note.
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Utility ID	
1. Study	
2. Source	
3. Source	

Indicate coagulants studied:

ID	Coagulant	Chemical formula	Units
1	Alum		
2	Cat Poly		
3	Non-Ionic		
4			

WATE

TREATMENT CONDITIONS

Pre/Post | 1/2/3 | Stage | Post-Ozone Stages | Per

Date	Disinfection By-products Filt.	HAA6 (µg/L) Raw	HAA6 Settl.	HAA6 Ozon.	HAA6 Filt.	TOX (µg Cl-/L) Raw	TOX Settl.	TOX Ozon.	TOX Filt.	Coagulation Conditions: Coagulant ID (see above)	Dose 1	Dose 2	Dose 3	Acid adjusted (Y/N)	Base adjusted (Y/N)	Coag. pH ()	Coag. temp. (deg. C)	Ozonation Conditions: Ozone dose (mg/L) Pre	Ozone dose Post	Ozone residual (mg/L) 1	Ozone residual 2	Ozone residual 3	Contact time (min)	Ozone pH ()	Ozone temp. (deg. C)
2/23/93										1/2/3	55	3	0.1	N	N	7.3	12.9	0.00	0.70	0.3	0.29	0.29	2.79	6.9	
4/6/93										1/2/3	37		0.14	N	N	7.4	17.3	2.00	1.00	0.51	0.28	0.28	2.05	7	
5/21/93										1/2/3	45	4		N	N	7.4	20.2	2.75	1.10	0.28	0.2	0.2	2.42	6.9	
6/15/93										1/2/3	24		0.12	N	N	7.4	23.5	2.00	0.90	0.79	0.16	0.19	1.09	6.75	
8/18/93										1/2/3	37	2	0.2	N	N	7.38	24.4			0.59	0.15	0.15	1.14	6.98	
10/5/93										1/2/3	26		0.2	N	N	7.18	23.4	1.76	0.60	0.35	0.1	0.1	1.86	6.83	
11/17/93										1/2/3	24		0.2	N	N	6.96	17.7	1.50	0.45		0.48	0.45	2.42	6.86	
12/8/93										1/2/3	20		0.93	N	N		12.9	1.50	0.40		0.26	0.14	12.48	7.3	14.3
1/4/94										1/2/3	23.8		0.2	N	N		11.7	1.50	0.35		0.18	0.18	13.37	8.7	11.6
2/9/94										1/2/3	30	2		N	N		12.4	1.50	0.35	0.13	0.05	0.03	12.91	8.3	12.2
3/1/94										1/2/3	30	2.1	0.073	N	N	6.6	14.1	2.60	0.45	0.18	0.09	0.04	14.4	6.8	13.6
4/5/94										1/2/3	38	1	0.08	N	N	7	17.8	2.50	0.65	0.13	0.09	0.08	7.49	8.9	17.8
5/10/94										1/2/3	34	0.7	0.09	N	N	7.14	20.1	1.75	0.30	0.36	0.15	0.12	4.18	8.7	20.7
7/12/94										1/2/3	31	0.8	0.073	N	N	6.96	25.7	3.60	0.35	0.18	0.05	0.04	11.35	6.88	26.1
8/9/94										1/2/3	23	0.68	0.08	N	N	7.3	26	2.60	0.40	0.12	0.04	0.02	8.01	6.7	28.4
10/4/94										1/2/3	14	1.7	0.075	N	N	7.3	22.7	2.58	0.40	0.27	0.23	0.18	2.34	6.9	23.3
10/10/94										1/2/3	14	1.7	0.075	N	N	7.3	22.4	1.70	0.40	0.27	0.26	0.19	2.34	6.8	22.7
11/1/94										1/2/3	14	1.7	0.075	N	N	7.17	20.3	1.50	0.40	0.1	0.15	0.16	2.34	6.96	19.8
12/6/94										1/2/3	18	1	0.075	N	N	7.4	13.4	2.00	0.40	0.33	0.21	0.14	4.24	7.2	13.4
1/10/95										1/2/3	30	1	0.1	N	N	7.1	12	2.00	0.43	0.22	0.08	0.06	12.48	7	12
2/14/95										1/2/3	71	3.36	0.26	N	N	6.78	12.5	3.00	0.65	0.1	0.07	0.06	9.36	6.54	12.6
3/14/95										1/2/3	40	1.13	0.11	N	N	6.83	14	2.00	0.40	0.18	0.1	0.07	16.64	6.93	14.2
4/4/95										1/2/3	67	1	0.11	N	N	6.84	16.3	2.50	0.60	0.27	0.09	0.09	7.46	6.65	16.9
6/13/95										1/2/3	30	1	0.1	N	N		24.6	2.50	0.60	0.32	0.12	0.24	1.97	6.30	22.2
7/10/95	0.6				<2					1/2/3				N	N	6.74	24.1			0.36	0.35	0.37	1.41	7.31	18.2
8/7/95	<0.5				<1					1/2/3	38	1	.1	N	N	7.21	25.2	2.50	0.50	0.34	0.27	0.3	1.83	6.56	23.9
9/11/95	<0.5				6					1/2/3	35	1	.05	N	N	7.14	23.7	1.81	0.31	0.06	0.05	0.04	9.86	6.46	25.0
10/2/95	<0.5				<1					1/2/3	18	1.2	.08	N	N	7.25	22.7	1.40	0.29	0.07	0.03	0.02	12.48	6.91	23.8
11/6/95	<0.5				<1					1/2/3	19.5	1.03	.05	N	N	7.21	16.8	1.55	0.30	0.16	0.08	0.08	9.36	7.03	21.5
12/4/95	<0.5				<1					1/2/3	19.0	1.09	.05	N	N	7.46	16.5	1.80	0.40	0.14	0.1	0.08	12.48	7.36	16.2
1/8/96	<0.5				3					1/2/3	44.2	1	.3	N	N	7.05	13.0	2.65	0.38	0.12	0.04	0.03	14.98	6.81	12.0
2/5/96	<0.5				<2					1/2/3	49.6	1	.2	N	N	7.12	14.8	3.12	0.45	0.28	0.18	0.13	14.08	7.04	12.8
3/4/96	<0.5				<2					1/2/3	77.9	3	.48	N	N	7.14	14.0	3.25	1.19	0.18	0.08	0.01	21.39	7.01	13.0
4/1/96	<0.5				15.6					1/2/3	49.6	.83	.10	N	N	7.24	19.6	2.80	0.54	0.23	0.14	0.13	8.34	7.36	18.8
5/6/96	<0.5				2.5					1/2/3	40	0.3	0.02	N	N	6.81	21.0	2.40	0.43	0.38	0.34	0.26	3.74	6.71	21.9
6/3/96	<0.5				<2					1/2/3	27	.46	.01	N	N	7.08	23.5	1.53	0.43	0.28	0.13	0.18	3.40	7.18	23.5

Note:
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Utility ID:		EBMUD	(ACWD, CCWD, EBMUD, MWD, SCVWD)
1. Study ID:		EBMUD Alternate Source Study	(Optimization Study 9/95, etc.)
2. Source water:		(American) River	(River, lake, groundwater, etc.)
3. Source water ID:			(State Project water, etc.)

5. Describe point of reference for which water quality data are being supplied, i.e. upstream and downstream of City of Sacramento combined sewage discharge, etc.

Nimbus Dam, American River

If entering data on seasonal changes in plant raw source water quality, use upstream column.

WATER QUALITY DATA: RAW

Date	Time	TOC (mg/L)		Alkalinity (mg/L as CaCO)		Hardness (mg/L as CaCO3) Total		Bromide ~~(mg/L)~~ (ug/L)		Ammonia (mg NH3-N/L)		Chloride (mg Cl/L)		TDS (mg/L)		Turbidity (NTU)		pH ()		Temperature (deg. C)		Microbial Parameters Coliforms Total (#/100mL)		Fecal (#/100mL)	
		Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.	Upstr.	Down.
1/17/89		2.4		32		33		<0.005		0.009		4		59		1.8		7.7		8		28		11	
2/14/89		1.8		31		32		<0.03		0.01		5		60		0.88		7.8		8		50		11	
3/13/89		2.8		33		35		<0.02		0.01		4		64		3.5		7.8		11		430		140	
4/17/89		1.6		27		28		<0.05		0.016		3		53		2.3		8.1		15		800		500	
5/15/89		1.9		24		25		<0.05		<0.005		3		50		1.5		7.6		18		210		30	
6/19/89		1.9		24		22		<0.05		0.04		2		45		1.1		7.8		18		170		30	
6/19/89		2.3		25		120						13		47		1.2						170		80	
6/19/89				120																		500		130	
7/17/89		1.4		21		22		<0.03		<0.005		2		48		0.7		7.5		24		1300		300	
8/14/89		35		24		21		<0.05		0.005		6		44		0.82		7.4		24.5		300		80	
9/25/89		1.4		21		20		<0.01				4		44		0.45		7.5		20		220		130	
11/13/89		1.7		21		21		0.01		<0.005		2		44		1.1		7.4		18		80		80	
12/11/89		1.3		29		24		<0.01		0.01		2		47		2.5		7.4		11		1100		800	
12/11/89																						2200		2200	
1/22/90		1.3		23		24		<0.01		<0.005		2		49		1.3		7.6		9		110		110	
2/20/90		1.8		25		28		<0.02		0.007		4		50		5.5		7.7		8		800		300	
3/5/90		1.3		36		32		0.01				5		57		1.8		7.8		11.5		17		4	
4/6/90		1.2		31		29		<0.01		<0.005		4		53		0.57		7.8		17.5		80		50	
5/21/90		1.4						0.01				3		54		0.64						280			
6/25/90		1.3		27		27		<0.05		0.03		3		51		0.38		7.5		17.5		80		80	
7/16/90		1.3						<0.01				4		48		0.5						11			
8/20/90		1.4						0.02				2		43		2.5									
9/17/90		1.4						0.01				2		39		0.95						80			
10/15/90		1.3		21		18		0.11				2		40		0.77		7.4		20		50		30	
10/15/90		1.8		22		20		<0.01								0.8						170		70	
11/26/90		1.5						<0.01				4		43		0.94						500			
12/17/90		1.5						<0.01				4		47		3.1						70			
1/7/91		1.2		25		21		<0.01				3		34		1.3		7.8				50		50	
1/7/91		1.3		27								4				1.6						110		110	
2/11/91		1.7		30		25		0.02				6		50		4.1		7.2		13		130		50	
3/11/91		2.3		27		32		0.01		0.01		4		58		3.4		7.8		12		1700		500	
3/11/91										0.08															
4/8/91		3.2		36		38		0.01		0.01		4		68				6.8		16		50		23	
5/20/91		1.9		32		32		0.01		<0.02		2		59		1.6		8.2		19.5		800		500	
6/17/91		1.9		28		28		<0.01				3		61		1.8		7.6		21.5		70		11	
6/17/91																								23	
7/8/91		1.3		28		25		<0.01				2		50		1.2		7.8		20.5		90		30	
7/8/91		1.7		32		31						3		51		1.8		8.4				500		80	
7/8/91												13				1.6									
8/19/91		1.5		27		23		<0.01				2		46		1.1		7.6		23.5		50		17	
8/19/91		1.6		28		24						3		49								80		23	
9/16/91				24		22		<0.01				4		55		0.6		7.6		24		350		30	
9/16/91												14													
10/15/91		1.6		25		21		0.07		0.02		3		45		1.1		7.4		20.5		110		80	
10/15/91								<0.01																	
11/18/91		1.4		27		25		0.02		0.01		3		48		1.2		7.6		15		130		23	
11/18/91								0.1																	
12/16/91		1.7		26		23		<0.05				2		44		0.79		7.6		11		70		70	

Utility ID:	MWD	(ACWD, CCWD, EBMUD, MWD, SCVWD)			
1. Study ID:	Jar Tests--range of %SPW/%CRW	(Optimization Study 9/95, etc.)	Indicate coagulants studied:		
			ID / Coagulant	Chemical formula	Units
2. Source water:	Surface	(River, lake, groundwater, etc.)	1 Alum	$Al_2(SO_4)_3{*}14\ H_2O$	mg/L
			2 Polymer	Cationic	mg/L
3. Source water ID:	SPW, CRW	(State Project water, blend of...., etc.)	3		
			4		
5. Describe level of study: (indicate with an 'X')	X	Bench-scale	In this data sheet, "Filt." refers to data collected after coagulation, flocculation, sedimentation, and filtration.	Doses include usually 3 (sometimes 2) mg/L polymer	
		Pilot-scale			
		Full-scale			
6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only:				X	60 min settling time
or after sedimentation and filtration:					

WATER QUALITY DATA: CONVENTIONAL

TREATMENT CONDITIONS

Study ID	Water % CRW	Water % SPW	TOC (mg/L) Raw	TOC (mg/L) Filt.	UV-254 (1/cm) Raw	UV-254 (1/cm) Filt.	Alkalinity (mg/L as CaCO3) Raw	Alkalinity (mg/L as CaCO3) Filt.	Turbidity (NTU) Raw	Turbidity (NTU) Filt.	pH () Raw	pH () Filt.	Coagulation Conditions: Coagulant ID (see above)	Dose	Acid adjusted? (Y/N) blank=N	Base adjusted? (Y/N) blank=N	Coag. pH ()
MWDJAR01	100		2.42	2.43	0.025		123		0.74	0.74	8.03		1	0			8.06
MWDJAR01	100		2.42	2.32	0.025	0.039	123		0.74	0.43	8.03		1	10			7.71
MWDJAR01	100		2.42	2.27	0.025	0.036	123		0.74	0.54	8.03		1	20			7.44
MWDJAR01	100		2.42	2.17	0.025	0.035	123		0.74	0.68	8.03		1	30			7.30
MWDJAR01	100		2.42	2.02	0.025	0.013	123		0.74		8.03		1	40			7.24
MWDJAR01	100		2.42	1.95	0.025	0.038	123		0.74	0.90	8.03		1	50			6.89
MWDJAR01	100		2.42	1.86	0.025	0.034	123		0.74	0.82	8.03		1	60			6.81
MWDJAR01	100		2.42	1.88	0.025	0.036	123		0.74	0.27	8.03		1	70			6.72
MWDJAR06	100		2.25	2.20	0.019	0.019	132		0.65	0.62	8.29		1	0			8.29
MWDJAR06	100		2.25	2.12	0.019	0.013	132		0.65	0.56	8.29		1	10			7.88
MWDJAR06	100		2.25	1.97	0.019	0.011	132		0.65	0.51	8.29		1	20			7.67
MWDJAR06	100		2.25	1.95	0.019	0.009	132		0.65	0.43	8.29		1	30			7.49
MWDJAR06	100		2.25	1.83	0.019	0.007	132		0.65	0.62	8.29		1	40			7.33
MWDJAR06	100		2.25	1.67	0.019	0.004	132		0.65	0.79	8.29		1	50			7.24
MWDJAR06	100		2.25	1.88	0.019	0.004	132		0.65	0.74	8.29		1	60			7.00
MWDJAR06	100		2.25	1.67	0.019	0.003	132		0.65	0.90	8.29		1	70			6.93
MWDJAR06	100		2.25	1.61	0.019	0.002	132		0.65	1.00	8.29		1	80			6.84
MWDJAR06	100		2.25	1.56	0.019	0.001	132		0.65	1.30	8.29		1	90			6.75
MWDJAR06	100		2.25	1.52	0.019	0.001	132		0.65	1.40	8.29		1	100			6.67
MWDJAR06	100		2.25	1.47	0.019	0.001	132		0.65	1.30	8.29		1	110			6.57
MWDJAR07	100		2.39	2.41	0.036	0.038	132		0.42	0.34	8.34		1	0			8.15
MWDJAR07	100		2.39	2.28	0.036	0.033	132		0.42	0.34	8.34		1	10			7.88
MWDJAR07	100		2.39	2.11	0.036	0.032	132		0.42	0.36	8.34		1	20			7.71
MWDJAR07	100		2.39	1.99	0.036	0.028	132		0.42	0.32	8.34		1	30			7.56
MWDJAR07	100		2.39	1.94	0.036	0.025	132		0.42	0.34	8.34		1	40			7.46
MWDJAR07	100		2.39	1.78	0.036	0.023	132		0.42	0.42	8.34		1	50			7.38
MWDJAR07	100		2.39	1.76	0.036	0.023	132		0.42	0.49	8.34		1	60			7.25
MWDJAR07	100		2.39	1.60	0.036	0.023	132		0.42	0.57	8.34		1	70			7.22
MWDJAR07	100		2.39	1.68	0.036	0.027	132		0.42	0.59	8.34		1	80			7.10
MWDJAR07	100		2.39	1.63	0.036	0.021	132		0.42	0.60	8.34		1	90			7.06
MWDJAR07	100		2.39	1.65	0.036	0.019	132		0.42	0.67	8.34		1	100			6.98
MWDJAR08	100		2.45	2.56	0.030	0.033	122		0.40	0.40	8.18		1	0			7.98
MWDJAR08	100		2.45	2.44	0.030	0.031	122		0.40	0.32	8.18		1	10			7.85
MWDJAR08	100		2.45	2.26	0.030	0.031	122		0.40	0.25	8.18		1	20			7.72
MWDJAR08	100		2.45	2.14	0.030	0.026	122		0.40	0.28	8.18		1	30			7.61
MWDJAR08	100		2.45	2.06	0.030	0.025	122		0.40	0.68	8.18		1	40			7.52
MWDJAR08	100		2.45	2.03	0.030	0.026	122		0.40	0.33	8.18		1	50			7.45
MWDJAR08	100		2.45	2.01	0.030	0.024	122		0.40	0.34	8.18		1	60			7.35
MWDJAR08	100		2.45	2.00	0.030	0.031	122		0.40	0.35	8.18		1	70			7.26
MWDJAR08	100		2.45	1.87	0.030	0.020	122		0.40	0.50	8.18		1	80			7.17
MWDJAR08	100		2.45	1.79	0.030	0.020	122		0.40	0.48	8.18		1	90			7.06
MWDJAR08	100		2.45	1.78	0.030	0.019	122		0.40	0.55	8.18		1	100			6.98
MWDJAR09	90		2.55	2.55	0.055		119		0.71	0.62	7.97		1	0			7.97
MWDJAR09	90		2.55	2.51	0.055	0.046	119		0.71	0.40	7.97		1	10			7.66
MWDJAR09	90		2.55	2.46	0.055	0.036	119		0.71	0.34	7.97		1	20			7.48
MWDJAR09	90		2.55	2.23	0.055	0.041	119		0.71	0.41	7.97		1	30			7.34
MWDJAR09	90		2.55	2.19	0.055	0.031	119		0.71	0.33	7.97		1	40			7.21
MWDJAR09	90		2.55	2.00	0.055	0.034	119		0.71	0.42	7.97		1	50			6.89
MWDJAR09	90		2.55	1.92	0.055	0.032	119		0.71	0.42	7.97		1	60			6.85
MWDJAR09	90		2.55	2.01	0.055		119		0.71		7.97		1	70			6.79
MWDJAR09	90		2.55	1.98	0.055		119		0.71		7.97		1	80			6.62
MWDJAR09	90		2.55	1.87	0.055		119		0.71		7.97		1	90			6.58
MWDJAR09	90		2.55	1.95	0.055		119		0.71		7.97		1	100			6.50
MWDJAR09	90		2.55	1.84	0.055		119		0.71		7.97		1	110			6.41
MWDJAR09	90		2.55	1.87	0.055		119		0.71		7.97		1	120			6.18
MWDJAR10	90		2.58	2.52	0.055	0.046	125		0.64	0.55	8.22		1	0			8.26
MWDJAR10	90		2.58	2.42	0.055	0.036	125		0.64	0.60	8.22		1	10			7.74
MWDJAR10	90		2.58	2.23	0.055	0.041	125		0.64	0.66	8.22		1	20			7.49
MWDJAR10	90		2.58	2.04	0.055	0.031	125		0.64	0.48	8.22		1	30			7.28
MWDJAR10	90		2.58	2.12	0.055	0.034	125		0.64	0.78	8.22		1	40			7.15
MWDJAR10	90		2.58	1.83	0.055	0.032	125		0.64	0.86	8.22		1	50			6.98
MWDJAR10	90		2.58	2.01	0.055	0.027	125		0.64	0.75	8.22		1	60			7.15
MWDJAR10	90		2.58	2.03	0.055	0.030	125		0.64	0.63	8.22		1	70			7.04
MWDJAR10	90		2.58	1.95	0.055	0.026	125		0.64	0.68	8.22		1	80			6.88
MWDJAR10	90		2.58	1.92	0.055	0.027	125		0.64	0.88	8.22		1	90			6.82
MWDJAR10	90		2.58	1.76	0.055	0.036	125		0.64	1.30	8.22		1	100			6.75
MWDJAR10	90		2.58	1.83	0.055	0.028	125		0.64	1.30	8.22		1	110			6.77
MWDJAR11	90		2.67	2.63	0.053	0.048	128		0.49	0.45	8.33		1	0			8.40
MWDJAR11	90		2.67	2.60	0.053	0.037	128		0.49	0.56	8.33		1	10			7.89
MWDJAR11	90		2.67	2.44	0.053	0.039	128		0.49	0.60	8.33		1	20			7.64
MWDJAR11	90		2.67	2.21	0.053	0.025	128		0.49	0.46	8.33		1	30			7.41
MWDJAR11	90		2.67	2.22	0.053	0.026	128		0.49	0.72	8.33		1	40			7.21
MWDJAR11	90		2.67	2.00	0.053	0.024	128		0.49	0.70	8.33		1	50			7.08
MWDJAR11	90		2.67	1.77	0.053	0.022	128		0.49	0.78	8.33		1	60			6.93
MWDJAR11	90		2.67	1.72	0.053	0.023	128		0.49	0.78	8.33		1	70			6.83

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR11	90		2.67	1.66	0.053	0.026	128		0.49	0.85	8.33		1	80			6.72
MWDJAR11	90		2.67	1.67	0.053	0.022	128		0.49	1.10	8.33		1	90			6.62
MWDJAR12	90		2.95	3.00	0.042	0.043	120		0.67	0.30	8.23		1	0			8.20
MWDJAR12	90		2.95	2.76	0.042	0.032	120		0.67	0.28	8.23		1	10			7.80
MWDJAR12	90		2.95	2.63	0.042	0.032	120		0.67	0.22	8.23		1	20			7.66
MWDJAR12	90		2.95	2.50	0.042	0.031	120		0.67	0.21	8.23		1	30			7.44
MWDJAR12	90		2.95	2.35	0.042	0.029	120		0.67	0.23	8.23		1	40			7.26
MWDJAR12	90		2.95	2.33	0.042	0.029	120		0.67	0.23	8.23		1	50			7.23
MWDJAR12	90		2.95	2.12	0.042	0.032	120		0.67	0.24	8.23		1	60			7.16
MWDJAR12	90		2.95	2.01	0.042	0.029	120		0.67	0.20	8.23		1	70			7.08
MWDJAR12	90		2.95	1.95	0.042	0.029	120		0.67	0.25	8.23		1	80			7.01
MWDJAR12	90		2.95	1.90	0.042	0.027	120		0.67	0.23	8.23		1	90			6.88
MWDJAR12	90		2.95	1.86	0.042	0.028	120		0.67	0.29	8.23		1	100			6.82
MWDJAR12	90		2.95	1.82	0.042	0.027	120		0.67	0.27	8.23		1	110			6.79
MWDJAR12	90		2.95	1.74	0.042	0.028	120		0.67	0.47	8.23		1	120			6.76
MWDJAR12	90		2.95	1.70	0.042	0.028	120		0.67	0.56	8.23		1	130			6.67
MWDJAR12	90		2.95	1.71	0.042	0.026	120		0.67	0.52	8.23		1	140			6.61
MWDJAR12	90		2.95	1.62	0.042	0.026	120		0.67	0.45	8.23		1	150			6.47
MWDJAR12	90		2.95	1.61	0.042	0.027	120		0.67	0.49	8.23		1	160			6.40
MWDJAR12	90		2.95	1.54	0.042	0.027	120		0.67	0.55	8.23		1	170			6.37
MWDJAR12	90		2.95	1.62	0.042	0.028	120		0.67	1.30	8.23		1	180			6.23
MWDJAR12	90		2.95	1.57	0.042	0.026	120		0.67	1.30	8.23		1	190			6.18
MWDJAR12	90		2.95	1.69	0.042	0.052	120		0.67	3.80	8.23		1	200			6.12
MWDJAR13	90		2.25	2.26	0.034	0.035	126		0.77	0.77	8.30		1	0			8.28
MWDJAR13	90		2.25	2.08	0.034	0.023	126		0.77	0.48	8.30		1	10			7.90
MWDJAR13	90		2.25	1.86	0.034	0.021	126		0.77	0.40	8.30		1	20			7.72
MWDJAR13	90		2.25	2.00	0.034	0.019	126		0.77	0.38	8.30		1	30			7.56
MWDJAR13	90		2.25	1.92	0.034	0.018	126		0.77	0.46	8.30		1	40			7.43
MWDJAR13	90		2.25	1.86	0.034	0.018	126		0.77	0.45	8.30		1	50			7.33
MWDJAR13	90		2.25	1.80	0.034	0.018	126		0.77	0.58	8.30		1	60			7.20
MWDJAR13	90		2.25	1.76	0.034	0.015	126		0.77	0.57	8.30		1	70			7.14
MWDJAR13	90		2.25	1.66	0.034	0.013	126		0.77	0.58	8.30		1	80			7.06
MWDJAR13	90		2.25	1.62	0.034	0.013	126		0.77	0.53	8.30		1	90			6.98
MWDJAR13	90		2.25	1.52	0.034	0.012	126		0.77	0.67	8.30		1	100			6.94
MWDJAR13	90		2.25	1.51	0.034	0.012	126		0.77	0.78	8.30		1	110			6.88
MWDJAR14	90		2.31	2.48	0.033	0.033	127		0.58	0.54	8.20		1	0			8.22
MWDJAR14	90		2.31	2.45	0.033	0.025	127		0.58	0.55	8.20		1	10			7.95
MWDJAR14	90		2.31	2.38	0.033	0.023	127		0.58	0.44	8.20		1	20			7.71
MWDJAR14	90		2.31	2.21	0.033	0.021	127		0.58	0.48	8.20		1	30			7.52
MWDJAR14	90		2.31	2.09	0.033	0.020	127		0.58	0.67	8.20		1	40			7.40
MWDJAR14	90		2.31	1.98	0.033	0.018	127		0.58	0.39	8.20		1	50			7.31
MWDJAR14	90		2.31	1.77	0.033	0.017	127		0.58	0.68	8.20		1	60			7.27
MWDJAR14	90		2.31	1.74	0.033	0.015	127		0.58	0.77	8.20		1	70			7.13
MWDJAR14	90		2.31	1.67	0.033	0.017	127		0.58	0.82	8.20		1	80			7.06
MWDJAR14	90		2.31	1.60	0.033	0.015	127		0.58	0.70	8.20		1	90			6.93
MWDJAR14	90		2.31	1.55	0.033	0.015	127		0.58	0.95	8.20		1	100			6.84
MWDJAR14	90		2.31	1.52	0.033	0.014	127		0.58	1.00	8.20		1	110			6.77
MWDJAR14	90		2.31	1.49	0.033	0.015	127		0.58	1.00	8.20		1	120			6.60
MWDJAR14	90		2.31	1.46	0.033	0.016	127		0.58	1.00	8.20		1	130			6.53
MWDJAR14	90		2.31	1.48	0.033		127		0.58		8.20		1	140			
MWDJAR14	90		2.31	1.42	0.033		127		0.58		8.20		1	150			
MWDJAR14	90		2.31	1.33	0.033		127		0.58		8.20		1	160			
MWDJAR15	90		3.17	2.51	0.036	0.041	127		0.47	0.35	8.29		1	0			8.30
MWDJAR15	90		3.17	2.37	0.036	0.034	127		0.47	0.54	8.29		1	10			7.96
MWDJAR15	90		3.17	2.24	0.036	0.031	127		0.47	0.39	8.29		1	20			7.74
MWDJAR15	90		3.17	2.06	0.036	0.028	127		0.47	0.27	8.29		1	30			7.52
MWDJAR15	90		3.17	2.01	0.036	0.026	127		0.47	0.59	8.29		1	40			7.39
MWDJAR15	90		3.17	1.86	0.036	0.028	127		0.47	0.56	8.29		1	50			7.32
MWDJAR15	90		3.17	1.76	0.036	0.025	127		0.47	0.58	8.29		1	60			7.23
MWDJAR15	90		3.17	1.72	0.036	0.024	127		0.47	0.65	8.29		1	70			7.15
MWDJAR15	90		3.17	1.66	0.036	0.024	127		0.47	0.77	8.29		1	80			7.06
MWDJAR15	90		3.17	1.54	0.036	0.024	127		0.47	0.63	8.29		1	90			7.03
MWDJAR15	90		3.17	1.58	0.036	0.022	127		0.47	0.78	8.29		1	100			6.95
MWDJAR16	90		2.43	2.52	0.041	0.042	117		0.42	0.32	8.25		1	0			8.28
MWDJAR16	90		2.43	2.50	0.041	0.031	117		0.42	0.35	8.25		1	10			8.01
MWDJAR16	90		2.43	2.32	0.041	0.026	117		0.42	0.28	8.25		1	20			7.80
MWDJAR16	90		2.43	2.19	0.041	0.025	117		0.42	0.24	8.25		1	30			7.68
MWDJAR16	90		2.43	2.05	0.041	0.024	117		0.42	0.27	8.25		1	40			7.55
MWDJAR16	90		2.43	2.06	0.041	0.024	117		0.42	0.30	8.25		1	50			7.44
MWDJAR16	90		2.43	1.99	0.041	0.022	117		0.42	0.30	8.25		1	60			7.36
MWDJAR16	90		2.43	1.92	0.041	0.021	117		0.42	0.35	8.25		1	70			7.27
MWDJAR16	90		2.43	1.87	0.041	0.021	117		0.42	0.33	8.25		1	80			7.16
MWDJAR16	90		2.43	1.82	0.041	0.021	117		0.42	0.36	8.25		1	90			7.07
MWDJAR16	90		2.43	1.85	0.041	0.021	117		0.42	0.36	8.25		1	100			7.00
MWDJAR16	90		2.43	1.75	0.041	0.020	117		0.42	0.39	8.25		1	110			6.84
MWDJAR16	90		2.43	1.73	0.041	0.019	117		0.42	0.46	8.25		1	120			6.77
MWDJAR16	90		2.43	1.76	0.041	0.018	117		0.42	0.55	8.25		1	130			6.65
MWDJAR16	90		2.43	1.65	0.041	0.018	117		0.42	0.53	8.25		1	140			6.61
MWDJAR16	90		2.43	1.68	0.041	0.017	117		0.42	0.62	8.25		1	150			6.51
MWDJAR16	90		2.43	1.60	0.041	0.016	117		0.42	0.80	8.25		1	160			6.50
MWDJAR16	90		2.43	1.49	0.041	0.015	117		0.42	0.91	8.25		1	170			6.61
MWDJAR16	90		2.43	1.63	0.041	0.014	117		0.42	1.10	8.25		1	180			6.48
MWDJAR16	90		2.43	1.64	0.041	0.013	117		0.42	1.10	8.25		1	190			6.38
MWDJAR16	90		2.43	1.55	0.041	0.014	117		0.42	1.40	8.25		1	200			6.26
MWDJAR16	90		2.43	1.52	0.041	0.013	117		0.42	0.93	8.25		1	210			6.18
MWDJAR16	90		2.43	1.58	0.041	0.013	117		0.42	1.10	8.25		1	220			6.12
MWDJAR17	80		2.55	2.55	0.061		114		1.20	1.20	8.09		1	0			8.04
MWDJAR17	80		2.55	2.61	0.061	0.048	114		1.20	0.49	8.09		1	10			7.68
MWDJAR17	80		2.55	2.55	0.061	0.042	114		1.20	0.41	8.09		1	20			7.46
MWDJAR17	80		2.55	2.39	0.061	0.041	114		1.20	0.34	8.09		1	30			7.24
MWDJAR17	80		2.55	2.39	0.061	0.034	114		1.20	0.61	8.09		1	40			7.15
MWDJAR17	80		2.55	2.13	0.061	0.033	114		1.20	0.39	8.09		1	50			7.01

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR17	80		2.55	2.02	0.061	0.034	114		1.20	0.44	8.09		1	60			6.95
MWDJAR17	80		2.55	1.96	0.061	0.042	114		1.20	1.10	8.09		1	70			6.60
MWDJAR17	80		2.55	1.84	0.061	0.032	114		1.20	0.95	8.09		1	80			6.51
MWDJAR17	80		2.55	1.74	0.061	0.031	114		1.20	0.85	8.09		1	90			6.43
MWDJAR17	80		2.55	1.64	0.061	0.033	114		1.20	1.40	8.09		1	100			6.27
MWDJAR17	80		2.55	1.67	0.061	0.033	114		1.20	1.20	8.09		1	110			6.17
MWDJAR17	80		2.55	1.62	0.061	0.033	114		1.20	1.30	8.09		1	120			6.14
MWDJAR18	80		2.45	2.59	0.054	0.061	121		0.78	0.68	8.22		1	0			8.23
MWDJAR18	80		2.45	2.66	0.054	0.045	121		0.78	0.66	8.22		1	10			7.85
MWDJAR18	80		2.45	2.54	0.054	0.039	121		0.78	0.60	8.22		1	20			7.61
MWDJAR18	80		2.45	2.32	0.054	0.036	121		0.78	0.65	8.22		1	30			7.45
MWDJAR18	80		2.45	2.35	0.054	0.041	121		0.78	0.54	8.22		1	40			7.35
MWDJAR18	80		2.45	2.22	0.054	0.032	121		0.78	0.67	8.22		1	50			7.23
MWDJAR18	80		2.45	1.95	0.054	0.034	121		0.78	0.82	8.22		1	60			6.97
MWDJAR18	80		2.45	1.97	0.054	0.032	121		0.78	0.76	8.22		1	70			7.00
MWDJAR18	80		2.45	1.77	0.054	0.031	121		0.78	0.78	8.22		1	80			6.90
MWDJAR18	80		2.45	1.83	0.054	0.034	121		0.78	0.75	8.22		1	90			6.88
MWDJAR18	80		2.45	1.76	0.054	0.035	121		0.78	0.73	8.22		1	100			6.82
MWDJAR18	80		2.45	1.75	0.054	0.037	121		0.78	1.00	8.22		1	110			6.77
MWDJAR19	80		2.70	2.87	0.049	0.048	122		0.57	0.55	8.38		1	0			8.46
MWDJAR19	80		2.70	2.65	0.049	0.031	122		0.57	0.69	8.38		1	10			7.85
MWDJAR19	80		2.70	2.44	0.049	0.027	122		0.57	0.60	8.38		1	20			7.64
MWDJAR19	80		2.70	2.22	0.049	0.025	122		0.57	0.56	8.38		1	30			7.32
MWDJAR19	80		2.70	2.04	0.049	0.023	122		0.57	0.59	8.38		1	40			7.18
MWDJAR19	80		2.70	2.02	0.049	0.021	122		0.57	0.78	8.38		1	50			7.13
MWDJAR19	80		2.70	1.97	0.049	0.021	122		0.57	0.75	8.38		1	60			6.80
MWDJAR19	80		2.70	1.85	0.049	0.018	122		0.57	0.81	8.38		1	70			6.79
MWDJAR19	80		2.70	1.78	0.049	0.018	122		0.57	0.97	8.38		1	80			6.71
MWDJAR19	80		2.70	1.88	0.049	0.015	122		0.57	0.89	8.38		1	90			6.67
MWDJAR19	80		2.70	1.77	0.049	0.015	122		0.57	0.84	8.38		1	100			6.56
MWDJAR19	80		2.70	1.88	0.049	0.016	122		0.57	1.50	8.38		1	110			6.53
MWDJAR2	100		2.53	2.90	0.042	0.045	133		0.85	0.90	8.38		1	0			8.45
MWDJAR2	100		2.53	2.89	0.042	0.036	133		0.85	0.71	8.38		1	10			8.02
MWDJAR2	100		2.53	2.68	0.042	0.030	133		0.85	0.53	8.38		1	20			7.72
MWDJAR2	100		2.53	2.51	0.042	0.027	133		0.85	0.40	8.38		1	30			7.46
MWDJAR2	100		2.53	2.19	0.042	0.029	133		0.85	0.64	8.38		1	40			7.34
MWDJAR2	100		2.53	2.30	0.042	0.028	133		0.85	0.57	8.38		1	50			7.26
MWDJAR2	100		2.53	2.03	0.042	0.017	133		0.85	0.78	8.38		1	60			6.96
MWDJAR2	100		2.53	1.99	0.042	0.018	133		0.85	1.10	8.38		1	70			6.85
MWDJAR2	100		2.53	1.90	0.042	0.018	133		0.85	1.20	8.38		1	80			6.84
MWDJAR2	100		2.53	1.90	0.042	0.020	133		0.85	1.30	8.38		1	90			6.81
MWDJAR20	80		2.79	2.87	0.053	0.055	114		0.54	0.38	8.21		1	0			8.15
MWDJAR20	80		2.79	2.46	0.053	0.040	114		0.54	0.37	8.21		1	10			7.45
MWDJAR20	80		2.79	2.60	0.053	0.044	114		0.54	0.25	8.21		1	20			7.58
MWDJAR20	80		2.79	2.39	0.053	0.038	114		0.54	0.26	8.21		1	30			7.42
MWDJAR20	80		2.79	2.28	0.053	0.035	114		0.54	0.34	8.21		1	40			7.30
MWDJAR20	80		2.79	2.20	0.053	0.036	114		0.54	0.20	8.21		1	50			7.21
MWDJAR20	80		2.79	2.13	0.053	0.036	114		0.54	0.20	8.21		1	60			7.19
MWDJAR20	80		2.79	2.03	0.053	0.032	114		0.54	0.23	8.21		1	70			7.10
MWDJAR20	80		2.79	1.97	0.053	0.034	114		0.54	0.26	8.21		1	80			7.01
MWDJAR20	80		2.79	1.95	0.053	0.033	114		0.54	0.37	8.21		1	90			6.97
MWDJAR20	80		2.79	1.83	0.053	0.032	114		0.54	0.27	8.21		1	100			6.82
MWDJAR20	80		2.79	1.79	0.053	0.031	114		0.54	0.63	8.21		1	110			6.80
MWDJAR20	80		2.79	1.74	0.053	0.031	114		0.54	0.39	8.21		1	120			6.74
MWDJAR20	80		2.79	1.70	0.053	0.027	114		0.54	0.43	8.21		1	130			6.62
MWDJAR20	80		2.79	1.62	0.053	0.032	114		0.54	0.53	8.21		1	140			6.48
MWDJAR20	80		2.79	1.61	0.053	0.030	114		0.54	0.58	8.21		1	150			6.53
MWDJAR20	80		2.79	1.61	0.053	0.030	114		0.54	0.53	8.21		1	160			6.42
MWDJAR20	80		2.79	1.63	0.053	0.048	114		0.54	0.60	8.21		1	170			4.33
MWDJAR20	80		2.79	1.47	0.053	0.032	114		0.54	1.20	8.21		1	180			6.19
MWDJAR20	80		2.79	1.55	0.053	0.032	114		0.54	1.40	8.21		1	190			6.10
MWDJAR20	80		2.79	1.52	0.053	0.027	114		0.54	1.50	8.21		1	200			6.08
MWDJAR21	80		2.43	2.42	0.036	0.028	121		0.83	0.73	8.22		1	0			8.23
MWDJAR21	80		2.43	2.42	0.036	0.028	121		0.83	0.69	8.22		1	10			7.94
MWDJAR21	80		2.43	2.29	0.036	0.025	121		0.83	0.52	8.22		1	20			7.60
MWDJAR21	80		2.43	2.09	0.036	0.023	121		0.83	0.32	8.22		1	30			7.47
MWDJAR21	80		2.43	2.04	0.036	0.021	121		0.83	0.46	8.22		1	40			7.35
MWDJAR21	80		2.43	1.97	0.036	0.019	121		0.83	0.57	8.22		1	50			7.28
MWDJAR21	80		2.43	1.80	0.036	0.017	121		0.83	0.51	8.22		1	60			7.30
MWDJAR21	80		2.43	1.77	0.036	0.017	121		0.83	0.57	8.22		1	70			7.28
MWDJAR21	80		2.43	1.73	0.036	0.015	121		0.83	0.67	8.22		1	80			7.13
MWDJAR21	80		2.43	1.72	0.036	0.014	121		0.83	0.71	8.22		1	90			7.06
MWDJAR21	80		2.43	1.70	0.036	0.014	121		0.83	0.72	8.22		1	100			6.96
MWDJAR21	80		2.43	1.69	0.036	0.013	121		0.83	0.98	8.22		1	110			6.95
MWDJAR22	80		2.41	2.53	0.038	0.038	121		0.78	0.71	8.15		1	0			8.25
MWDJAR22	80		2.41	2.31	0.038	0.029	121		0.78	0.50	8.15		1	10			7.92
MWDJAR22	80		2.41	2.23	0.038	0.027	121		0.78	0.68	8.15		1	20			7.71
MWDJAR22	80		2.41	2.04	0.038	0.021	121		0.78	0.55	8.15		1	30			7.52
MWDJAR22	80		2.41	1.96	0.038	0.019	121		0.78	0.50	8.15		1	40			7.43
MWDJAR22	80		2.41	1.90	0.038	0.018	121		0.78	0.38	8.15		1	50			7.30
MWDJAR22	80		2.41	1.81	0.038	0.018	121		0.78	0.73	8.15		1	60			7.03
MWDJAR22	80		2.41	1.74	0.038	0.017	121		0.78	0.85	8.15		1	70			6.90
MWDJAR22	80		2.41	1.68	0.038	0.016	121		0.78	0.80	8.15		1	80			6.83
MWDJAR22	80		2.41	1.64	0.038	0.016	121		0.78	0.76	8.15		1	90			6.76
MWDJAR22	80		2.41	1.58	0.038	0.015	121		0.78	0.81	8.15		1	100			6.72
MWDJAR22	80		2.41	1.56	0.038	0.015	121		0.78	0.93	8.15		1	110			6.70
MWDJAR22	80		2.41	1.42	0.038	0.015	121		0.78	0.95	8.15		1	120			6.55
MWDJAR22	80		2.41	1.33	0.038	0.016	121		0.78	0.95	8.15		1	130			6.50
MWDJAR23	80		2.51	2.56	0.050	0.055	121		0.43	0.45	8.32		1	0			8.33
MWDJAR23	80		2.51	2.43	0.050	0.042	121		0.43	0.58	8.32		1	10			7.92
MWDJAR23	80		2.51	2.25	0.050	0.035	121		0.43	0.44	8.32		1	20			7.65
MWDJAR23	80		2.51	2.12	0.050	0.030	121		0.43	0.50	8.32		1	30			7.49

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR23	80		2.51	2.00	0.050	0.021	121		0.43	0.36	8.32		1	40			7.39
MWDJAR23	80		2.51	1.92	0.050	0.024	121		0.43	0.40	8.32		1	50			7.28
MWDJAR23	80		2.51	1.79	0.050	0.023	121		0.43	0.42	8.32		1	60			7.21
MWDJAR23	80		2.51	1.75	0.050	0.018	121		0.43	0.45	8.32		1	70			7.16
MWDJAR23	80		2.51	1.62	0.050	0.022	121		0.43	0.48	8.32		1	80			7.07
MWDJAR23	80		2.51	1.56	0.050	0.019	121		0.43	0.55	8.32		1	90			7.00
MWDJAR23	80		2.51	1.56	0.050	0.022	121		0.43	0.58	8.32		1	100			6.95
MWDJAR24	80		2.57	2.45	0.045	0.046	113		0.65	0.59	8.11		1	0			8.20
MWDJAR24	80		2.57	2.49	0.045	0.035	113		0.65	0.33	8.11		1	10			7.95
MWDJAR24	80		2.57	2.32	0.045	0.031	113		0.65	0.29	8.11		1	20			7.80
MWDJAR24	80		2.57	2.09	0.045	0.027	113		0.65	0.28	8.11		1	30			7.62
MWDJAR24	80		2.57	2.05	0.045	0.027	113		0.65	0.28	8.11		1	40			7.50
MWDJAR24	80		2.57	1.90	0.045	0.026	113		0.65	0.27	8.11		1	50			7.39
MWDJAR24	80		2.57	1.90	0.045	0.025	113		0.65	0.27	8.11		1	60			7.19
MWDJAR24	80		2.57	2.03	0.045	0.023	113		0.65	0.27	8.11		1	70			7.11
MWDJAR24	80		2.57	1.92	0.045	0.021	113		0.65	0.28	8.11		1	80			7.03
MWDJAR24	80		2.57	1.80	0.045	0.021	113		0.65	0.40	8.11		1	90			6.93
MWDJAR24	80		2.57	1.69	0.045	0.021	113		0.65	0.44	8.11		1	100			6.90
MWDJAR24	80		2.57	1.61	0.045	0.020	113		0.65	0.45	8.11		1	110			6.86
MWDJAR24	80		2.57	1.61	0.045	0.020	113		0.65	0.54	8.11		1	120			6.78
MWDJAR24	80		2.57	1.64	0.045	0.020	113		0.65	0.62	8.11		1	130			6.67
MWDJAR24	80		2.57	1.55	0.045	0.019	113		0.65	0.80	8.11		1	140			6.58
MWDJAR24	80		2.57	1.69	0.045	0.018	113		0.65	1.20	8.11		1	150			6.53
MWDJAR24	80		2.57	1.57	0.045	0.018	113		0.65	1.20	8.11		1	160			6.45
MWDJAR24	80		2.57	1.44	0.045	0.017	113		0.65	0.89	8.11		1	170			6.37
MWDJAR24	80		2.57	1.46	0.045	0.017	113		0.65	1.53	8.11		1	180			6.30
MWDJAR24	80		2.57	1.36	0.045	0.016	113		0.65	0.76	8.11		1	190			6.22
MWDJAR24	80		2.57	1.35	0.045	0.015	113		0.65	0.77	8.11		1	200			6.13
MWDJAR24	80		2.57	1.40	0.045	0.015	113		0.65	0.75	8.11		1	210			6.04
MWDJAR24	80		2.57	1.29	0.045	0.015	113		0.65	0.95	8.11		1	220			5.91
MWDJAR25	70		2.67	2.67	0.065		109		0.84	0.75	7.84		1	0			7.92
MWDJAR25	70		2.67	2.59	0.065	0.054	109		0.84	0.65	7.84		1	10			7.64
MWDJAR25	70		2.67	2.49	0.065	0.049	109		0.84	0.65	7.84		1	20			7.41
MWDJAR25	70		2.67	2.20	0.065	0.039	109		0.84	0.43	7.84		1	30			7.13
MWDJAR25	70		2.67	2.10	0.065	0.037	109		0.84	0.50	7.84		1	40			6.98
MWDJAR25	70		2.67	1.97	0.065	0.037	109		0.84	0.76	7.84		1	50			6.85
MWDJAR25	70		2.67	1.92	0.065	0.035	109		0.84	0.77	7.84		1	60			6.72
MWDJAR25	70		2.67	1.82	0.065	0.028	109		0.84	0.90	7.84		1	70			6.58
MWDJAR25	70		2.67	1.82	0.065	0.026	109		0.84	0.85	7.84		1	80			6.50
MWDJAR25	70		2.67	1.66	0.065	0.026	109		0.84	0.87	7.84		1	90			6.42
MWDJAR25	70		2.67	1.68	0.065	0.024	109		0.84	0.95	7.84		1	100			6.22
MWDJAR26	70		2.50	2.56	0.055	0.058	115		0.68	0.82	8.22		1	0			8.22
MWDJAR26	70		2.50	2.53	0.055	0.046	115		0.68	0.76	8.22		1	10			7.79
MWDJAR26	70		2.50	2.39	0.055	0.041	115		0.68	0.78	8.22		1	20			7.57
MWDJAR26	70		2.50	2.29	0.055	0.038	115		0.68	0.75	8.22		1	30			7.43
MWDJAR26	70		2.50	2.01	0.055	0.035	115		0.68	0.73	8.22		1	40			7.28
MWDJAR26	70		2.50	2.02	0.055	0.035	115		0.68	1.00	8.22		1	50			7.18
MWDJAR26	70		2.50	1.96	0.055	0.033	115		0.68	0.67	8.22		1	60			6.97
MWDJAR26	70		2.50	1.75	0.055	0.034	115		0.68	0.70	8.22		1	70			7.00
MWDJAR26	70		2.50	1.75	0.055	0.036	115		0.68	0.70	8.22		1	80			6.81
MWDJAR26	70		2.50	1.71	0.055	0.031	115		0.68	0.41	8.22		1	90			6.78
MWDJAR26	70		2.50	1.62	0.055	0.034	115		0.68	0.57	8.22		1	100			6.77
MWDJAR26	70		2.50	1.72	0.055	0.031	115		0.68	0.72	8.22		1	110			6.56
MWDJAR26	70		2.50	1.63	0.055	0.032	115		0.68	1.20	8.22		1	120			6.46
MWDJAR26	70		2.50	1.56	0.055	0.033	115		0.68	1.40	8.22		1	130			6.39
MWDJAR26	70		2.50	1.53	0.055	0.035	115		0.68	1.70	8.22		1	140			6.33
MWDJAR27	70		3.14	2.94	0.064	0.061	115		0.69	0.62	8.32		1	0			8.29
MWDJAR27	70		3.14	2.38	0.064	0.027	115		0.69	0.48	8.32		1	10			7.34
MWDJAR27	70		3.14	2.62	0.064	0.030	115		0.69	0.43	8.32		1	20			7.33
MWDJAR27	70		3.14	2.48	0.064	0.029	115		0.69	0.41	8.32		1	30			7.25
MWDJAR27	70		3.14	2.44	0.064	0.027	115		0.69	0.52	8.32		1	40			7.05
MWDJAR27	70		3.14	2.14	0.064	0.024	115		0.69	0.55	8.32		1	50			6.99
MWDJAR27	70		3.14	3.87	0.064	0.029	115		0.69	0.61	8.32		1	60			6.78
MWDJAR27	70		3.14	2.81	0.064	0.020	115		0.69	0.71	8.32		1	70			6.67
MWDJAR27	70		3.14	1.93	0.064	0.020	115		0.69	0.62	8.32		1	80			6.63
MWDJAR27	70		3.14	1.83	0.064	0.018	115		0.69	0.74	8.32		1	90			6.56
MWDJAR27	70		3.14	1.72	0.064	0.029	115		0.69	0.84	8.32		1	100			6.42
MWDJAR27	70		3.14	1.96	0.064		115		0.69	1.00	8.32		1	110			6.33
MWDJAR27	70		3.14	1.72	0.064	0.025	115		0.69	1.70	8.32		1	120			6.19
MWDJAR27	70		3.14	1.92	0.064	0.019	115		0.69	2.10	8.32		1	130			6.15
MWDJAR27	70		3.14	1.76	0.064	0.017	115		0.69	1.70	8.32		1	140			6.05
MWDJAR27	70		3.14	1.75	0.064	0.016	115		0.69	3.10	8.32		1	150			5.85
MWDJAR28	70		2.74	2.82	0.058	0.057	111		0.47	0.37	8.12		1	0			8.17
MWDJAR28	70		2.74	2.61	0.058	0.047	111		0.47	0.22	8.12		1	10			7.91
MWDJAR28	70		2.74	2.45	0.058	0.042	111		0.47	0.20	8.12		1	20			7.80
MWDJAR28	70		2.74	2.39	0.058	0.039	111		0.47	0.17	8.12		1	30			7.59
MWDJAR28	70		2.74	2.27	0.058	0.033	111		0.47	0.16	8.12		1	40			7.47
MWDJAR28	70		2.74	2.17	0.058	0.039	111		0.47	0.21	8.12		1	50			7.37
MWDJAR28	70		2.74	2.04	0.058	0.032	111		0.47	0.22	8.12		1	60			7.25
MWDJAR28	70		2.74	2.02	0.058	0.030	111		0.47	0.22	8.12		1	70			7.09
MWDJAR28	70		2.74	1.96	0.058	0.027	111		0.47	0.24	8.12		1	80			7.04
MWDJAR28	70		2.74	1.88	0.058	0.027	111		0.47	0.21	8.12		1	90			6.89
MWDJAR28	70		2.74	1.82	0.058	0.028	111		0.47	0.28	8.12		1	100			6.89
MWDJAR28	70		2.74	1.82	0.058	0.030	111		0.47	0.27	8.12		1	110			6.71
MWDJAR28	70		2.74	1.71	0.058	0.025	111		0.47	0.33	8.12		1	120			6.73
MWDJAR28	70		2.74	1.63	0.058	0.029	111		0.47	0.50	8.12		1	130			6.63
MWDJAR28	70		2.74	1.70	0.058	0.030	111		0.47	0.53	8.12		1	140			6.55
MWDJAR28	70		2.74	1.74	0.058	0.027	111		0.47	0.45	8.12		1	150			6.41
MWDJAR28	70		2.74	1.58	0.058	0.026	111		0.47	0.45	8.12		1	160			6.35
MWDJAR28	70		2.74	1.81	0.058	0.044	111		0.47	0.58	8.12		1	170			6.40
MWDJAR28	70		2.74	1.68	0.058	0.023	111		0.47	0.63	8.12		1	180			6.33
MWDJAR28	70		2.74	1.67	0.058	0.041	111		0.47	0.67	8.12		1	190			6.33

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR29	70		2.50	2.55	0.040	0.040	115		0.68	0.68	8.20		1	0			8.20
MWDJAR29	70		2.50	2.44	0.040	0.030	115		0.68	0.58	8.20		1	10			7.92
MWDJAR29	70		2.50	2.25	0.040	0.026	115		0.68	0.52	8.29		1	20			7.69
MWDJAR29	70		2.50	2.12	0.040	0.023	115		0.68	0.44	8.20		1	30			7.51
MWDJAR29	70		2.50	1.97	0.040	0.020	115		0.68	0.54	8.20		1	40			7.48
MWDJAR29	70		2.50	1.91	0.040	0.020	115		0.68	0.72	8.20		1	50			7.39
MWDJAR29	70		2.50	1.80	0.040	0.019	115		0.68	0.77	8.20		1	60			7.06
MWDJAR29	70		2.50	1.76	0.040	0.018	115		0.68	0.86	8.20		1	70			6.99
MWDJAR29	70		2.50	1.76	0.040	0.018	115		0.68	0.61	8.20		1	80			6.93
MWDJAR29	70		2.50	1.67	0.040	0.017	115		0.68	0.50	8.20		1	90			6.90
MWDJAR29	70		2.50	1.62	0.040	0.016	115		0.68	0.60	8.20		1	100			6.87
MWDJAR29	70		2.50	1.60	0.040	0.015	115		0.68	0.78	8.20		1	110			6.80
MWDJAR29	70		2.50	1.49	0.040	0.015	115		0.68	1.00	8.20		1	120			6.72
MWDJAR29	70		2.50	1.47	0.040	0.017	115		0.68	1.10	8.20		1	130			6.63
MWDJAR29	70		2.50	1.47	0.040	0.016	115		0.68	1.00	8.20		1	140			6.58
MWDJAR29	70		2.50	1.41	0.040	0.018	115		0.68	1.10	8.20		1	150			6.40
MWDJAR29	70		2.50	1.39	0.040	0.014	115		0.68	1.20	8.20		1	160			6.33
MWDJAR29	70		2.50	1.37	0.040	0.014	115		0.68	1.20	8.20		1	170			6.27
MWDJAR3	100		2.50	2.55	0.040	0.037	134		0.42	0.35	8.41		1	0			8.40
MWDJAR3	100		2.50	2.30	0.040	0.029	134		0.42	0.49	8.41		1	10			7.84
MWDJAR3	100		2.50	2.10	0.040	0.029	134		0.42	0.49	8.41		1	20			7.63
MWDJAR3	100		2.50	2.00	0.040	0.025	134		0.42	0.41	8.41		1	30			7.39
MWDJAR3	100		2.50	1.94	0.040	0.023	134		0.42	0.60	8.41		1	40			7.32
MWDJAR3	100		2.50	1.85	0.040	0.022	134		0.42	0.61	8.41		1	50			7.13
MWDJAR3	100		2.50	1.78	0.040	0.022	134		0.42	0.78	8.41		1	60			6.93
MWDJAR3	100		2.50	1.65	0.040	0.019	134		0.42	0.86	8.41		1	70			6.90
MWDJAR3	100		2.50	1.60	0.040	0.020	134		0.42	1.10	8.41		1	80			6.84
MWDJAR30	70		2.44	2.51	0.042	0.042	116		0.8	0.58	8.14		1	0			8.12
MWDJAR30	70		2.44	2.36	0.042	0.032	116		0.8	0.61	8.14		1	10			7.81
MWDJAR30	70		2.44	2.20	0.042	0.027	116		0.8	0.50	8.14		1	20			7.53
MWDJAR30	70		2.44	2.04	0.042	0.024	116		0.8	0.50	8.14		1	30			7.36
MWDJAR30	70		2.44	1.96	0.042	0.022	116		0.8	0.70	8.14		1	40			7.29
MWDJAR30	70		2.44	1.83	0.042	0.021	116		0.8	0.52	8.14		1	50			7.23
MWDJAR30	70		2.44	1.92	0.042	0.019	116		0.8	0.58	8.14		1	60			7.00
MWDJAR30	70		2.44	1.86	0.042	0.019	116		0.8	0.64	8.14		1	70			6.86
MWDJAR30	70		2.44	1.88	0.042	0.017	116		0.8	0.72	8.14		1	80			6.82
MWDJAR30	70		2.44	1.84	0.042	0.016	116		0.8	0.84	8.14		1	90			6.79
MWDJAR30	70		2.44	1.83	0.042	0.015	116		0.8	1.10	8.14		1	100			6.74
MWDJAR30	70		2.44	1.79	0.042	0.015	116		0.8	0.95	8.14		1	110			6.70
MWDJAR30	70		2.44	1.27	0.042	0.019	116		0.8	0.75	8.14		1	120			6.51
MWDJAR30	70		2.44	1.26	0.042	0.018	116		0.8	1.10	8.14		1	130			6.43
MWDJAR30	70		2.44	1.24	0.042	0.017	116		0.8	0.87	8.14		1	140			6.36
MWDJAR30	70		2.44	1.24	0.042	0.016	116		0.8	1.30	8.14		1	150			6.31
MWDJAR30	70		2.44	1.13	0.042	0.015	116		0.8	1.20	8.14		1	160			6.27
MWDJAR31	70		2.60	2.56	0.053	0.053	114		0.45	0.40	8.29		1	0			8.30
MWDJAR31	70		2.60	2.44	0.053	0.052	114		0.45	0.55	8.29		1	10			7.91
MWDJAR31	70		2.60	2.22	0.053	0.036	114		0.45	0.50	8.29		1	20			7.66
MWDJAR31	70		2.60	2.10	0.053	0.033	114		0.45	0.35	8.29		1	30			7.52
MWDJAR31	70		2.60	2.00	0.053	0.031	114		0.45	0.33	8.29		1	40			7.32
MWDJAR31	70		2.60	1.94	0.053	0.029	114		0.45	0.53	8.29		1	50			7.27
MWDJAR31	70		2.60	1.87	0.053	0.028	114		0.45	0.42	8.29		1	60			7.20
MWDJAR31	70		2.60	1.81	0.053	0.026	114		0.45	0.48	8.29		1	70			7.08
MWDJAR31	70		2.60	1.72	0.053	0.024	114		0.45	0.48	8.29		1	80			7.00
MWDJAR31	70		2.60	1.62	0.053	0.023	114		0.45	0.48	8.29		1	90			6.96
MWDJAR31	70		2.60	1.62	0.053	0.023	114		0.45	0.52	8.29		1	100			6.86
MWDJAR31	70		2.60	1.58	0.053	0.021	114		0.45	0.50	8.29		1	110			6.72
MWDJAR31	70		2.60	1.52	0.053	0.021	114		0.45	0.67	8.29		1	120			6.68
MWDJAR31	70		2.60	1.47	0.053	0.020	114		0.45	0.63	8.29		1	130			6.59
MWDJAR31	70		2.60	1.50	0.053	0.020	114		0.45	0.73	8.29		1	140			6.52
MWDJAR31	70		2.60	1.46	0.053	0.019	114		0.45	0.77	8.29		1	150			6.46
MWDJAR31	70		2.60	1.40	0.053	0.018	114		0.45	0.71	8.29		1	160			6.39
MWDJAR31	70		2.60	1.26	0.053	0.018	114		0.45	1.00	8.29		1	170			6.55
MWDJAR31	70		2.60	1.30	0.053	0.017	114		0.45	1.10	8.29		1	180			6.43
MWDJAR31	70		2.60	1.17	0.053	0.017	114		0.45	1.10	8.29		1	190			6.34
MWDJAR31	70		2.60	1.12	0.053	0.016	114		0.45	1.40	8.29		1	200			6.23
MWDJAR32	70		2.49	2.51	0.048	0.047	106		0.52	0.44	8.06		1	0			8.07
MWDJAR32	70		2.49	2.36	0.048	0.047	106		0.52	0.37	8.06		1	10			7.90
MWDJAR32	70		2.49	2.18	0.048	0.040	106		0.52	0.26	8.06		1	20			7.73
MWDJAR32	70		2.49	1.96	0.048	0.042	106		0.52	0.32	8.06		1	30			7.51
MWDJAR32	70		2.49	2.09	0.048	0.035	106		0.52	0.29	8.06		1	40			7.48
MWDJAR32	70		2.49	2.04	0.048	0.030	106		0.52	0.29	8.06		1	50			7.41
MWDJAR32	70		2.49	1.81	0.048	0.027	106		0.52	0.25	8.06		1	60			7.27
MWDJAR32	70		2.49	1.80	0.048	0.022	106		0.52	0.30	8.06		1	70			7.14
MWDJAR32	70		2.49	1.74	0.048	0.022	106		0.52	0.33	8.06		1	80			7.04
MWDJAR32	70		2.49	1.73	0.048	0.022	106		0.52	0.30	8.06		1	90			6.97
MWDJAR32	70		2.49	1.67	0.048	0.023	106		0.52	0.37	8.06		1	100			6.86
MWDJAR32	70		2.49	1.67	0.048	0.023	106		0.52	0.42	8.06		1	110			6.83
MWDJAR32	70		2.49	1.60	0.048	0.021	106		0.52	0.39	8.06		1	120			6.80
MWDJAR32	70		2.49	1.59	0.048	0.019	106		0.52	0.49	8.06		1	130			6.75
MWDJAR32	70		2.49	1.62	0.048	0.018	106		0.52	0.53	8.06		1	140			6.66
MWDJAR32	70		2.49	1.52	0.048	0.018	106		0.52	0.56	8.06		1	150			6.65
MWDJAR32	70		2.49	1.55	0.048	0.018	106		0.52	0.70	8.06		1	160			6.51
MWDJAR32	70		2.49	1.56	0.048	0.017	106		0.52	0.61	8.06		1	170			6.41
MWDJAR32	70		2.49	1.41	0.048	0.017	106		0.52	0.65	8.06		1	180			6.34
MWDJAR32	70		2.49	1.39	0.048	0.017	106		0.52	0.78	8.06		1	190			6.13
MWDJAR32	70		2.49	1.50	0.048	0.015	106		0.52	0.85	8.06		1	200			6.06
MWDJAR32	70		2.49	1.37	0.048	0.015	106		0.52	0.85	8.06		1	210			5.90
MWDJAR32	70		2.49	1.33	0.048	0.015	106		0.52	1.10	8.06		1	220			5.86
MWDJAR33	60		2.72	2.69	0.074		104		1.70		8.03		1	0			7.91
MWDJAR33	60		2.72	2.62	0.074	0.062	104		1.70	0.53	8.03		1	10			7.59
MWDJAR33	60		2.72	2.50	0.074	0.055	104		1.70	0.64	8.03		1	20			7.38
MWDJAR33	60		2.72	2.40	0.074	0.048	104		1.70	0.64	8.03		1	30			7.17

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDIAR33	60		2.72	2.15	0.074	0.043	104		1.70	0.75	8.03		1	40			6.98
MWDIAR33	60		2.72	2.09	0.074	0.042	104		1.70	0.84	8.03		1	50			6.92
MWDIAR33	60		2.72	2.04	0.074	0.041	104		1.70	0.86	8.03		1	60			6.77
MWDIAR33	60		2.72	1.92	0.074	0.039	104		1.70	0.81	8.03		1	70			6.49
MWDIAR33	60		2.72	1.86	0.074	0.038	104		1.70	1.10	8.03		1	80			6.33
MWDIAR33	60		2.72	1.75	0.074	0.035	104		1.70	0.97	8.03		1	90			6.26
MWDIAR33	60		2.72	1.67	0.074	0.037	104		1.70	2.00	8.03		1	100			6.11
MWDIAR34	60		2.51	2.67	0.048	0.043	109		0.77	0.67	8.27		1	0			8.27
MWDIAR34	60		2.51	2.57	0.048	0.035	109		0.77	0.70	8.27		1	10			7.79
MWDIAR34	60		2.51	2.46	0.048	0.031	109		0.77	0.70	8.27		1	20			7.57
MWDIAR34	60		2.51	2.32	0.048	0.025	109		0.77	0.41	8.27		1	30			7.43
MWDIAR34	60		2.51	2.24	0.048	0.025	109		0.77	0.57	8.27		1	40			7.28
MWDIAR34	60		2.51	2.22	0.048	0.024	109		0.77	0.72	8.27		1	50			7.18
MWDIAR34	60		2.51	1.91	0.048	0.021	109		0.77	0.57	8.27		1	60			7.09
MWDIAR34	60		2.51	1.99	0.048	0.020	109		0.77	0.81	8.27		1	70			6.98
MWDIAR34	60		2.51	1.82	0.048	0.019	109		0.77	0.66	8.27		1	80			6.91
MWDIAR34	60		2.51	1.76	0.048	0.027	109		0.77	0.73	8.27		1	90			6.81
MWDIAR34	60		2.51	1.69	0.048	0.023	109		0.77	0.78	8.27		1	100			6.76
MWDIAR34	60		2.51	1.64	0.048	0.022	109		0.77	0.88	8.27		1	110			6.68
MWDIAR34	60		2.51	1.48	0.048	0.035	109		0.77	1.40	8.27		1	120			6.45
MWDIAR34	60		2.51	1.47	0.048	0.036	109		0.77	1.50	8.27		1	130			6.41
MWDIAR35	60		3.44	3.13	0.081	0.077	111		0.74	0.65	8.36		1	0			8.34
MWDIAR35	60		3.44	3.27	0.081	0.054	111		0.74	0.58	8.36		1	10			7.86
MWDIAR35	60		3.44	2.92	0.081	0.044	111		0.74	0.58	8.36		1	20			7.57
MWDIAR35	60		3.44	2.66	0.081	0.038	111		0.74	0.56	8.36		1	30			7.39
MWDIAR35	60		3.44	2.49	0.081	0.036	111		0.74	0.47	8.36		1	40			7.25
MWDIAR35	60		3.44	2.33	0.081	0.031	111		0.74	0.43	8.36		1	50			7.10
MWDIAR35	60		3.44	2.27	0.081	0.043	111		0.74	0.67	8.36		1	60			6.83
MWDIAR35	60		3.44	2.15	0.081	0.034	111		0.74	0.72	8.36		1	70			6.78
MWDIAR35	60		3.44	2.02	0.081	0.028	111		0.74	0.84	8.36		1	80			6.69
MWDIAR35	60		3.44	2.08	0.081	0.028	111		0.74	0.70	8.36		1	90			6.61
MWDIAR35	60		3.44	1.88	0.081	0.026	111		0.74	0.58	8.36		1	100			6.54
MWDIAR35	60		3.44	1.81	0.081	0.028	111		0.74	0.68	8.36		1	110			6.38
MWDIAR35	60		3.44	1.77	0.081	0.028	111		0.74	1.10	8.36		1	120			6.17
MWDIAR35	60		3.44	1.64	0.081	0.027	111		0.74	1.10	8.36		1	130			6.06
MWDIAR35	60		3.44	1.65	0.081	0.031	111		0.74	1.30	8.36		1	140			6.00
MWDIAR35	60		3.44	1.64	0.081	0.028	111		0.74	1.58	8.36		1	150			5.93
MWDIAR36	60		3.22	3.20	0.064	0.063	107		0.43	0.48	8.10		1	0			8.13
MWDIAR36	60		3.22	2.98	0.064	0.051	107		0.43	0.27	8.10		1	10			7.78
MWDIAR36	60		3.22	2.80	0.064	0.047	107		0.43	0.38	8.10		1	20			7.58
MWDIAR36	60		3.22	2.69	0.064	0.044	107		0.43	0.27	8.10		1	30			7.43
MWDIAR36	60		3.22	2.52	0.064	0.040	107		0.43	0.18	8.10		1	40			7.31
MWDIAR36	60		3.22	2.38	0.064	0.038	107		0.43	0.32	8.10		1	50			7.19
MWDIAR36	60		3.22	2.34	0.064	0.037	107		0.43	0.26	8.10		1	60			7.46
MWDIAR36	60		3.22	2.24	0.064	0.035	107		0.43	0.25	8.10		1	70			7.25
MWDIAR36	60		3.22	2.17	0.064	0.034	107		0.43	0.27	8.10		1	80			7.06
MWDIAR36	60		3.22	2.07	0.064	0.033	107		0.43	0.26	8.10		1	90			6.95
MWDIAR36	60		3.22	2.02	0.064	0.030	107		0.43	0.27	8.10		1	100			6.86
MWDIAR36	60		3.22	1.98	0.064	0.037	107		0.43	0.45	8.10		1	110			6.78
MWDIAR36	60		3.22	1.75	0.064	0.026	107		0.43	0.36	8.10		1	120			6.77
MWDIAR36	60		3.22	1.74	0.064	0.026	107		0.43	0.36	8.10		1	130			6.66
MWDIAR36	60		3.22	1.72	0.064	0.027	107		0.43	0.38	8.10		1	140			6.58
MWDIAR36	60		3.22	1.75	0.064	0.026	107		0.43	0.42	8.10		1	150			6.49
MWDIAR36	60		3.22	1.81	0.064	0.025	107		0.43	0.35	8.10		1	160			6.51
MWDIAR36	60		3.22	1.70	0.064	0.039	107		0.43	0.95	8.10		1	170			6.34
MWDIAR36	60		3.22	1.71	0.064	0.037	107		0.43	0.87	8.10		1	180			6.21
MWDIAR36	60		3.22	1.64	0.064	0.050	107		0.43	1.13	8.10		1	190			6.13
MWDIAR37	60		2.56	2.68	0.039	0.038	109		0.88	0.70	8.15		1	0			8.35
MWDIAR37	60		2.56	2.49	0.039	0.036	109		0.88	0.56	8.15		1	10			7.95
MWDIAR37	60		2.56	2.35	0.039	0.030	109		0.88	0.52	8.15		1	20			7.78
MWDIAR37	60		2.56	2.23	0.039	0.026	109		0.88	0.30	8.15		1	30			7.57
MWDIAR37	60		2.56	2.22	0.039	0.024	109		0.88	0.58	8.15		1	40			7.40
MWDIAR37	60		2.56	2.07	0.039	0.023	109		0.88	0.54	8.15		1	50			7.29
MWDIAR37	60		2.56	1.84	0.039	0.021	109		0.88	0.56	8.15		1	60			7.25
MWDIAR37	60		2.56	1.81	0.039	0.019	109		0.88	0.65	8.15		1	70			7.12
MWDIAR37	60		2.56	1.76	0.039	0.017	109		0.88	0.65	8.15		1	80			7.01
MWDIAR37	60		2.56	1.63	0.039	0.015	109		0.88	0.87	8.15		1	90			6.96
MWDIAR37	60		2.56	1.62	0.039	0.016	109		0.88	0.86	8.15		1	100			6.88
MWDIAR37	60		2.56	1.58	0.039	0.015	109		0.88	0.86	8.15		1	110			6.81
MWDIAR37	60		2.56	1.42	0.039	0.018	109		0.88	0.97	8.15		1	120			6.76
MWDIAR37	60		2.56	1.42	0.039	0.017	109		0.88	0.95	8.15		1	130			6.56
MWDIAR37	60		2.56	1.38	0.039	0.015	109		0.88	0.87	8.15		1	140			6.39
MWDIAR37	60		2.56	1.37	0.039	0.015	109		0.88	1.00	8.15		1	150			6.36
MWDIAR37	60		2.56	1.39	0.039	0.015	109		0.88	1.00	8.15		1	160			6.28
MWDIAR37	60		2.56	1.33	0.039	0.014	109		0.88	1.20	8.15		1	170			6.23
MWDIAR38	60		2.49	2.47	0.049	0.049	110		0.84	0.76	8.13		1	0			8.14
MWDIAR38	60		2.49	2.35	0.049	0.035	110		0.84	0.53	8.13		1	10			7.74
MWDIAR38	60		2.49	2.12	0.049	0.027	110		0.84	0.39	8.13		1	20			7.44
MWDIAR38	60		2.49	1.92	0.049	0.023	110		0.84	0.33	8.13		1	30			7.29
MWDIAR38	60		2.49	1.86	0.049	0.020	110		0.84	0.45	8.13		1	40			7.18
MWDIAR38	60		2.49	1.80	0.049	0.020	110		0.84	0.48	8.13		1	50			7.11
MWDIAR38	60		2.49	1.56	0.049	0.020	110		0.84	0.60	8.13		1	60			6.95
MWDIAR38	60		2.49	1.62	0.049	0.018	110		0.84	0.63	8.13		1	70			6.87
MWDIAR38	60		2.49	1.51	0.049	0.017	110		0.84	0.49	8.13		1	80			6.85
MWDIAR38	60		2.49	1.47	0.049	0.017	110		0.84	0.54	8.13		1	90			6.79
MWDIAR38	60		2.49	1.38	0.049	0.014	110		0.84	0.84	8.13		1	100			6.71
MWDIAR38	60		2.49	1.39	0.049	0.014	111		0.84	0.83	8.13		1	110			6.59
MWDIAR38	60		2.49	1.34	0.049	0.020	110		0.84	0.97	8.13		1	120			6.53
MWDIAR38	60		2.49	1.35	0.049	0.021	110		0.84	0.95	8.13		1	130			6.48
MWDIAR38	60		2.49	1.34	0.049	0.020	110		0.84	1.10	8.13		1	140			6.39
MWDIAR38	60		2.49	1.29	0.049	0.019	110		0.84	1.20	8.13		1	150			6.33
MWDIAR38	60		2.49	1.31	0.049	0.018	110		0.84	1.20	8.13		1	160			6.21

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR39	60		2.68	2.69	0.059	0.057	109		0.48	0.45	8.26		1	0			8.22
MWDJAR39	60		2.68	2.48	0.059	0.042	109		0.48	0.51	8.26		1	10			7.87
MWDJAR39	60		2.68	2.31	0.059	0.039	109		0.48	0.37	8.26		1	20			7.65
MWDJAR39	60		2.68	2.15	0.059	0.035	109		0.48	0.32	8.26		1	30			7.52
MWDJAR39	60		2.68	1.98	0.059	0.031	109		0.48	0.38	8.26		1	40			7.36
MWDJAR39	60		2.68	1.87	0.059	0.030	109		0.48	0.37	8.26		1	50			7.29
MWDJAR39	60		2.68	1.80	0.059	0.026	109		0.48	0.42	8.26		1	60			7.12
MWDJAR39	60		2.68	1.74	0.059	0.026	109		0.48	0.54	8.26		1	70			7.02
MWDJAR39	60		2.68	1.66	0.059	0.025	109		0.48	0.48	8.26		1	80			6.95
MWDJAR39	60		2.68	1.61	0.059	0.023	109		0.48	0.58	8.26		1	90			6.88
MWDJAR39	60		2.68	1.60	0.059	0.022	109		0.48	0.68	8.26		1	100			6.79
MWDJAR39	60		2.68	1.60	0.059	0.025	109		0.48	0.77	8.26		1	110			6.83
MWDJAR39	60		2.68	1.50	0.059	0.023	109		0.48	0.76	8.26		1	120			6.75
MWDJAR39	60		2.68	1.57	0.059	0.023	109		0.48	1.00	8.26		1	130			6.62
MWDJAR39	60		2.68	1.43	0.059	0.021	109		0.48	0.80	8.26		1	140			6.42
MWDJAR39	60		2.68	1.41	0.059	0.021	109		0.48	0.92	8.26		1	150			6.38
MWDJAR39	60		2.68	1.34	0.059	0.021	109		0.48	0.92	8.26		1	160			6.27
MWDJAR4	100		2.55	2.67	0.043	0.040	123		0.85	0.20	8.23		1	0			8.08
MWDJAR4	100		2.55	2.68	0.043	0.038	123		0.85	0.40	8.23		1	10			7.83
MWDJAR4	100		2.55	2.54	0.043	0.034	123		0.85	0.30	8.23		1	20			7.60
MWDJAR4	100		2.55	2.44	0.043	0.031	123		0.85	0.26	8.23		1	30			7.49
MWDJAR4	100		2.55	2.31	0.043	0.029	123		0.85	0.21	8.23		1	40			7.37
MWDJAR4	100		2.55	2.26	0.043	0.029	123		0.85	0.33	8.23		1	50			7.27
MWDJAR4	100		2.55	2.09	0.043	0.027	123		0.85	0.21	8.23		1	60			7.21
MWDJAR4	100		2.55	2.04	0.043	0.030	123		0.85	0.22	8.23		1	70			7.05
MWDJAR4	100		2.55	1.95	0.043	0.026	123		0.85	0.25	8.23		1	80			6.97
MWDJAR4	100		2.55	1.92	0.043	0.027	123		0.85	0.31	8.23		1	90			6.91
MWDJAR4	100		2.55	1.84	0.043	0.025	123		0.85	0.25	8.23		1	100			6.82
MWDJAR4	100		2.55	1.85	0.043	0.027	123		0.85	0.55	8.23		1	110			6.75
MWDJAR40	60		2.57	2.53	0.042	0.046	101		3.10	0.52	8.05		1	0			8.03
MWDJAR40	60		2.57	2.41	0.042	0.042	101		3.10	0.33	8.05		1	10			7.85
MWDJAR40	60		2.57	3.35	0.042	0.035	101		3.10	0.34	8.05		1	20			7.68
MWDJAR40	60		2.57	2.16	0.042	0.032	101		3.10	0.24	8.05		1	30			7.54
MWDJAR40	60		2.57	2.04	0.042	0.030	101		3.10	0.27	8.05		1	40			7.33
MWDJAR40	60		2.57	1.80	0.042	0.028	101		3.10	0.24	8.05		1	50			7.26
MWDJAR40	60		2.57	1.76	0.042	0.026	101		3.10	0.20	8.05		1	60			7.13
MWDJAR40	60		2.57	1.66	0.042	0.024	101		3.10	0.32	8.05		1	70			7.02
MWDJAR40	60		2.57	1.66	0.042	0.022	101		3.10	0.38	8.05		1	80			6.96
MWDJAR40	60		2.57	1.59	0.042	0.021	101		3.10	0.33	8.05		1	90			6.89
MWDJAR40	60		2.57	1.57	0.042	0.021	101		3.10	0.38	8.05		1	100			6.75
MWDJAR40	60		2.57	1.49	0.042	0.022	101		3.10	0.45	8.05		1	110			6.74
MWDJAR40	60		2.57	1.48	0.042	0.021	101		3.10	0.54	8.05		1	120			6.70
MWDJAR40	60		2.57	1.47	0.042	0.020	101		3.10	0.61	8.05		1	130			6.65
MWDJAR40	60		2.57	1.39	0.042	0.019	101		3.10	0.69	8.05		1	140			6.54
MWDJAR40	60		2.57	1.39	0.042	0.019	101		3.10	0.70	8.05		1	150			6.46
MWDJAR40	60		2.57	1.36	0.042	0.018	101		3.10	0.75	8.05		1	160			6.39
MWDJAR40	60		2.57	1.53	0.042	0.017	101		3.10	0.80	8.05		1	170			6.30
MWDJAR40	60		2.57	1.61	0.042	0.017	101		3.10	1.20	8.05		1	180			6.19
MWDJAR40	60		2.57	1.50	0.042	0.016	101		3.10	1.20	8.05		1	190			6.13
MWDJAR41	50		2.64	2.78	0.079		94		0.85		8.13		1	0			7.98
MWDJAR41	50		2.64	2.69	0.079	0.065	94		0.85	0.56	8.13		1	10			7.47
MWDJAR41	50		2.64	2.50	0.079	0.058	94		0.85	0.65	8.13		1	20			7.25
MWDJAR41	50		2.64	2.40	0.079		94		0.85	0.50	8.13		1	30			7.05
MWDJAR41	50		2.64	2.23	0.079	0.040	94		0.85	0.50	8.13		1	40			6.93
MWDJAR41	50		2.64	2.13	0.079	0.041	94		0.85	0.70	8.13		1	50			6.82
MWDJAR41	50		2.64	2.15	0.079	0.040	94		0.85	0.58	8.13		1	60			6.73
MWDJAR41	50		2.64	1.97	0.079	0.031	94		0.85	0.80	8.13		1	70			6.61
MWDJAR41	50		2.64	1.96	0.079	0.031	94		0.85	1.00	8.13		1	80			6.44
MWDJAR41	50		2.64	1.85	0.079	0.030	94		0.85	0.98	8.13		1	90			6.19
MWDJAR42	50		2.37	2.52	0.061	0.054	103		0.75	0.78	8.17		1	0			8.15
MWDJAR42	50		2.37	2.32	0.061	0.034	103		0.75	0.57	8.17		1	10			7.49
MWDJAR42	50		2.37	2.19	0.061	0.031	103		0.75	0.68	8.17		1	20			7.32
MWDJAR42	50		2.37	2.00	0.061	0.027	103		0.75	0.51	8.17		1	30			7.12
MWDJAR42	50		2.37	1.91	0.061	0.025	103		0.75	0.86	8.17		1	40			7.03
MWDJAR42	50		2.37	1.79	0.061	0.028	103		0.75	0.85	8.17		1	50			6.88
MWDJAR42	50		2.37	1.77	0.061	0.024	103		0.75	1.10	8.17		1	60			6.69
MWDJAR42	50		2.37	1.83	0.061	0.028	103		0.75	1.30	8.17		1	70			6.60
MWDJAR42	50		2.37	1.80	0.061	0.028	103		0.75	1.50	8.17		1	80			6.51
MWDJAR42	50		2.37	1.66	0.061	0.024	103		0.75	1.40	8.17		1	90			6.49
MWDJAR42	50		2.37	1.72	0.061	0.026	103		0.75	1.50	8.17		1	100			6.41
MWDJAR42	50		2.37	1.58	0.061	0.028	103		0.75	1.50	8.17		1	110			6.26
MWDJAR43	50		3.18	3.41	0.081	0.079	106		0.87	0.74	8.32		1	0			8.37
MWDJAR43	50		3.18	3.03	0.081	0.058	106		0.87	0.86	8.32		1	10			7.82
MWDJAR43	50		3.18	2.78	0.081	0.046	106		0.87	0.72	8.32		1	20			7.58
MWDJAR43	50		3.18	2.50	0.081	0.039	106		0.87	0.66	8.32		1	30			7.36
MWDJAR43	50		3.18	2.26	0.081	0.036	106		0.87	0.51	8.32		1	40			7.22
MWDJAR43	50		3.18	2.29	0.081	0.036	106		0.87	0.51	8.32		1	50			7.13
MWDJAR43	50		3.18	2.28	0.081	0.038	106		0.87	0.61	8.32		1	60			6.71
MWDJAR43	50		3.18	2.10	0.081	0.036	106		0.87	0.67	8.32		1	70			6.70
MWDJAR43	50		3.18	2.02	0.081	0.032	106		0.87	0.76	8.32		1	80			6.58
MWDJAR43	50		3.18	2.08	0.081	0.034	106		0.87	0.73	8.32		1	90			6.54
MWDJAR43	50		3.18	2.05	0.081	0.032	106		0.87	0.76	8.32		1	100			6.49
MWDJAR43	50		3.18	2.07	0.081	0.030	106		0.87	1.20	8.32		1	110			6.33
MWDJAR43	50		3.18	1.92	0.082	0.030	106		0.87	1.10	8.32		1	120			6.24
MWDJAR43	50		3.18	2.11	0.081	0.027	106		0.87	1.40	8.32		1	130			6.13
MWDJAR43	50		3.18	1.77	0.081	0.026	106		0.87	2.00	8.32		1	140			5.99
MWDJAR43	50		3.18	2.02	0.081	0.025	106		0.87	1.40	8.32		1	150			5.93
MWDJAR44	50		3.11	3.17	0.066	0.070	103		1.30	0.51	7.99		1	0			8.14
MWDJAR44	50		3.11	2.20	0.066	0.049	103		1.30	0.28	7.99		1	10			7.76
MWDJAR44	50		3.11	2.78	0.066	0.045	103		1.30	0.27	7.99		1	20			7.50
MWDJAR44	50		3.11	2.64	0.066	0.041	103		1.30	0.24	7.99		1	30			7.36
MWDJAR44	50		3.11	2.42	0.066	0.036	103		1.30	0.25	7.99		1	40			7.20

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR44	50		3.11	2.32	0.066	0.035	103		1.30	0.21	7.99		1	50			7.14
MWDJAR44	50		3.11	2.25	0.066	0.032	103		1.30	0.19	7.99		1	60			7.07
MWDJAR44	50		3.11	2.14	0.066	0.033	103		1.30	0.25	7.99		1	70			6.93
MWDJAR44	50		3.11	2.07	0.066	0.033	103		1.30	0.29	7.99		1	80			6.87
MWDJAR44	50		3.11	2.02	0.066	0.030	103		1.30	0.33	7.99		1	90			6.78
MWDJAR44	50		3.11	1.97	0.066	0.028	103		1.30	0.35	7.99		1	100			6.68
MWDJAR44	50		3.11	1.85	0.066	0.027	103		1.30	0.28	7.99		1	110			6.65
MWDJAR44	50		3.11	1.83	0.064	0.030	103		1.30	0.46	7.99		1	120			6.52
MWDJAR44	50		3.11	1.83	0.066	0.030	103		1.30	0.56	7.99		1	130			6.51
MWDJAR44	50		3.11	1.78	0.066	0.028	103		1.30	0.52	7.99		1	140			6.44
MWDJAR44	50		3.11	1.69	0.066	0.028	103		1.30	0.44	7.99		1	150			6.34
MWDJAR44	50		3.11	1.66	0.066	0.030	103		1.30	0.45	7.99		1	160			6.34
MWDJAR45	50		2.46	2.63		0.061	105		0.87	0.78	8.14		1	0			8.27
MWDJAR45	50		2.46	2.30		0.047	105		0.87	0.55	8.14		1	10			7.91
MWDJAR45	50		2.46	2.26		0.042	105		0.87	0.50	8.14		1	20			7.52
MWDJAR45	50		2.46	2.07		0.036	105		0.87	0.52	8.14		1	30			7.55
MWDJAR45	50		2.46	1.96		0.034	105		0.87	0.33	8.14		1	40			7.31
MWDJAR45	50		2.46	1.84		0.032	105		0.87	0.40	8.14		1	50			7.26
MWDJAR45	50		2.46	1.82		0.029	105		0.87	0.52	8.14		1	60			7.16
MWDJAR45	50		2.46	1.72		0.028	105		0.87	0.44	8.14		1	70			7.12
MWDJAR45	50		2.46	1.76		0.027	105		0.87	0.62	8.14		1	80			7.02
MWDJAR45	50		2.46	1.69		0.026	105		0.87	0.64	8.14		1	90			6.80
MWDJAR45	50		2.46	1.59		0.025	105		0.87	0.72	8.14		1	100			6.76
MWDJAR45	50		2.46	1.56		0.024	105		0.87	0.94	8.14		1	110			6.71
MWDJAR45	50		2.46	1.52		0.023	105		0.87	0.65	8.14		1	120			6.62
MWDJAR45	50		2.46	1.46		0.022	105		0.87	0.80	8.14		1	130			6.50
MWDJAR45	50		2.46	1.45		0.021	105		0.87	1.00	8.14		1	140			6.48
MWDJAR45	50		2.46	1.48		0.016	105		0.87	1.10	8.14		1	150			6.52
MWDJAR45	50		2.46	1.38		0.015	105		0.87	1.20	8.14		1	160			6.39
MWDJAR45	50		2.46	1.36		0.014	105		0.87	1.30	8.14		1	170			6.37
MWDJAR45	50		2.46	1.31		0.015	105		0.87	1.50	8.14		1	180			6.18
MWDJAR46	50		2.46	2.56	0.040	0.040	105		0.73	0.60	8.13		1	0			8.20
MWDJAR46	50		2.46	2.54	0.040	0.028	105		0.73	0.70	8.13		1	10			7.86
MWDJAR46	50		2.46	2.43	0.040	0.019	105		0.73	0.44	8.13		1	20			7.63
MWDJAR46	50		2.46	2.13	0.040	0.013	105		0.73	0.29	8.13		1	30			7.45
MWDJAR46	50		2.46	2.05	0.040	0.011	105		0.73	0.52	8.13		1	40			7.31
MWDJAR46	50		2.46	2.00	0.040	0.010	105		0.73	0.67	8.13		1	50			7.19
MWDJAR46	50		2.46	1.86	0.040	0.010	105		0.73	0.66	8.13		1	60			7.17
MWDJAR46	50		2.46	1.73	0.040	0.010	105		0.73	0.71	8.13		1	70			7.04
MWDJAR46	50		2.46	1.75	0.040	0.010	105		0.73	0.83	8.13		1	80			6.93
MWDJAR46	50		2.46	1.62	0.040	0.007	105		0.73	0.75	8.13		1	90			6.84
MWDJAR46	50		2.46	1.59	0.040	0.004	105		0.73	0.95	8.13		1	100			6.75
MWDJAR46	50		2.46	1.59	0.040	0.004	105		0.73	1.50	8.13		1	110			6.66
MWDJAR46	50		2.46	1.26	0.040	0.023	105		0.73	1.00	8.13		1	120			6.50
MWDJAR46	50		2.46	1.32	0.040	0.019	105		0.73	1.10	8.13		1	130			6.46
MWDJAR46	50		2.46	1.18	0.040	0.017	105		0.73	0.25	8.13		1	140			6.31
MWDJAR46	50		2.46	1.17	0.040	0.016	105		0.73	1.10	8.13		1	150			6.27
MWDJAR46	50		2.46	1.15	0.040	0.021	105		0.73	1.30	8.13		1	160			6.15
MWDJAR47	50		2.79	2.79	0.063	0.062	102		0.42	0.40	8.23		1	0			8.27
MWDJAR47	50		2.79	2.70	0.063	0.049	102		0.42	0.50	8.23		1	10			7.85
MWDJAR47	50		2.79	2.39	0.063	0.041	102		0.42	0.48	8.23		1	20			7.56
MWDJAR47	50		2.79	2.20	0.063	0.036	102		0.42	0.39	8.23		1	30			7.38
MWDJAR47	50		2.79	2.15	0.063	0.032	102		0.42	0.42	8.23		1	40			7.23
MWDJAR47	50		2.79	1.94	0.063	0.028	102		0.42	0.45	8.23		1	50			7.18
MWDJAR47	50		2.79	1.84	0.063	0.026	102		0.42	0.50	8.23		1	60			7.13
MWDJAR47	50		2.79	1.76	0.063	0.025	102		0.42	0.50	8.23		1	70			7.03
MWDJAR47	50		2.79	1.69	0.063	0.024	102		0.41	0.43	8.23		1	80			6.92
MWDJAR47	50		2.79	1.60	0.063	0.024	102		0.42	0.54	8.23		1	90			6.87
MWDJAR47	50		2.79	1.58	0.063	0.022	102		0.42	0.58	8.23		1	100			6.77
MWDJAR47	50		2.79	1.61	0.063	0.023	102		0.41	0.68	8.23		1	110			6.61
MWDJAR47	50		2.79	1.53	0.063	0.021	102		0.41	0.84	8.23		1	120			6.46
MWDJAR47	50		2.79	1.50	0.063	0.021	102		0.41	0.82	8.23		1	130			6.38
MWDJAR47	50		2.79	1.49	0.063	0.020	102		0.42	0.86	8.23		1	140			6.34
MWDJAR47	50		2.79	1.44	0.063	0.019	102		0.42	0.90	8.23		1	150			6.20
MWDJAR47	50		2.79	1.45	0.063	0.020	102		0.42	1.30	8.23		1	160			6.11
MWDJAR48		100	3.31	3.31	0.126		73		2.40	1.30	7.91		1	0			7.87
MWDJAR48		100	3.31	3.21	0.126	0.103	73		2.40	0.88	7.91		1	10			7.57
MWDJAR48		100	3.31	3.05	0.126	0.081	73		2.40	0.53	7.91		1	20			7.32
MWDJAR48		100	3.31	2.68	0.126	0.066	73		2.40	0.54	7.91		1	30			7.14
MWDJAR48		100	3.31	2.36	0.126	0.061	73		2.40	0.52	7.91		1	40			6.83
MWDJAR48		100	3.31	2.22	0.126	0.054	73		2.40	0.45	7.91		1	50			6.79
MWDJAR48		100	3.31	2.12	0.126	0.049	73		2.40	0.50	7.91		1	60			6.64
MWDJAR48		100	3.31	1.89	0.126	0.049	73		2.40	0.95	7.91		1	70			6.15
MWDJAR48		100	3.31	1.83	0.126	0.050	73		2.40	0.83	7.91		1	80			6.09
MWDJAR48		100	3.31	1.78	0.126	0.049	73		2.40	1.10	7.91		1	90			5.80
MWDJAR48	50		2.55	2.55	0.057	0.057	94		0.34	0.36	7.93		1	0			7.95
MWDJAR48	50		2.55	2.32	0.057	0.051	94		0.34	0.17	7.93		1	10			7.86
MWDJAR48	50		2.55	2.30	0.057	0.045	94		0.34	0.17	7.93		1	20			7.71
MWDJAR48	50		2.55	2.14	0.057	0.041	94		0.34	0.19	7.93		1	30			7.59
MWDJAR48	50		2.55	1.97	0.057	0.033	94		0.34	0.20	7.93		1	40			7.48
MWDJAR48	50		2.55	1.86	0.057	0.032	94		0.34	0.20	7.93		1	50			7.39
MWDJAR48	50		2.55	1.74	0.057	0.030	94		0.34	0.20	7.93		1	60			7.34
MWDJAR48	50		2.55	1.68	0.057	0.028	94		0.34	0.19	7.93		1	70			7.27
MWDJAR48	50		2.55	1.67	0.057	0.026	94		0.34	0.20	7.93		1	80			7.15
MWDJAR48	50		2.55	1.61	0.057	0.024	94		0.34	0.22	7.93		1	90			7.13
MWDJAR48	50		2.55	1.49	0.057	0.023	94		0.34	0.40	7.93		1	100			7.02
MWDJAR48	50		2.55	1.55	0.057	0.023	94		0.34	0.38	7.93		1	110			6.95
MWDJAR48	50		2.55	1.58	0.057	0.022	94		0.34	0.42	7.93		1	120			6.80
MWDJAR48	50		2.55	1.56	0.057	0.021	94		0.34	0.42	7.93		1	130			6.63
MWDJAR48	50		2.55	1.49	0.057	0.020	94		0.34	0.44	7.93		1	140			6.55
MWDJAR48	50		2.55	1.47	0.057	0.020	94		0.34	0.70	7.93		1	150			6.44
MWDJAR48	50		2.55	1.41	0.057	0.024	94		0.34	1.20	7.93		1	160			6.32

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDJAR49		100	2.33	2.36	0.077	0.074	73			0.85	8.07		1	0			8.07
MWDJAR49		100	2.33	2.20	0.077	0.064	73			0.57	8.07		1	10			7.65
MWDJAR49		100	2.33	2.19	0.077	0.050	73			0.75	8.07		1	20			7.41
MWDJAR49		100	2.33	2.03	0.077	0.046	73			0.56	8.07		1	30			7.24
MWDJAR49		100	2.33	1.84	0.077	0.043	73			0.72	8.07		1	40			7.15
MWDJAR49		100	2.33	1.75	0.077	0.040	73			0.75	8.07		1	50			7.05
MWDJAR49		100	2.33	1.72	0.077	0.040	73			0.53	8.07		1	60			7.00
MWDJAR49		100	2.33	1.78	0.077	0.037	73			0.47	8.07		1	70			6.87
MWDJAR49		100	2.33	1.42	0.077	0.035	73			0.47	8.07		1	80			6.73
MWDJAR49		100	2.33	1.41	0.077	0.035	73			0.57	8.07		1	90			6.66
MWDJAR49		100	2.33	1.54	0.077	0.030	73			0.56	8.07		1	100			6.58
MWDJAR49		100	2.33	1.31	0.077	0.028	73			0.60	8.07		1	110			6.45
MWDJAR49		100	2.33	1.30	0.077	0.031	73			0.45	8.07		1	120			6.38
MWDJAR49		100	2.33	1.25	0.077	0.029	73			0.60	8.07		1	130			6.23
MWDJAR49		100	2.33	1.20	0.077	0.028	73			0.65	8.07		1	140			6.14
MWDJAR5	100		2.37	2.40	0.048	0.048	131		0.76	0.58	8.23		1	0			8.23
MWDJAR5	100		2.37	2.27	0.048	0.045	131		0.76	0.57	8.23		1	10			7.58
MWDJAR5	100		2.37	2.19	0.048	0.038	131		0.76	0.47	8.23		1	20			7.77
MWDJAR5	100		2.37	2.32	0.048	0.036	131		0.76	0.59	8.23		1	30			7.66
MWDJAR5	100		2.37	2.07	0.048	0.033	131		0.76	0.61	8.23		1	40			7.52
MWDJAR5	100		2.37	1.96	0.048	0.029	131		0.76	0.46	8.23		1	50			7.44
MWDJAR5	100		2.37	1.94	0.048	0.028	131		0.76	0.78	8.23		1	60			7.36
MWDJAR5	100		2.37	1.84	0.048	0.026	131		0.76	0.77	8.23		1	70			7.25
MWDJAR5	100		2.37	1.77	0.048	0.025	131		0.76	0.82	8.23		1	80			7.16
MWDJAR5	100		2.37	1.75	0.048	0.024	131		0.76	0.85	8.23		1	90			7.05
MWDJAR5	100		2.37	1.68	0.048	0.015	131		0.76	0.86	8.23		1	100			7.06
MWDJAR5	100		2.37	1.65	0.048	0.015	131		0.76	1.30	8.23		1	110			6.97
MWDJAR50		100	3.90	4.45	0.110	0.109	77		1.7	1.50	8.00		1	0			8.00
MWDJAR50		100	3.90	3.69	0.110	0.072	77		1.7	0.79	8.00		1	10			7.44
MWDJAR50		100	3.90	3.17	0.110	0.049	77		1.7	0.39	8.00		1	20			7.15
MWDJAR50		100	3.90	2.81	0.110	0.037	77		1.7	0.38	8.00		1	30			6.99
MWDJAR50		100	3.90	2.38	0.110	0.032	77		1.7	0.31	8.00		1	40			6.92
MWDJAR50		100	3.90	2.25	0.110	0.029	77		1.7	0.66	8.00		1	50			6.89
MWDJAR50		100	3.90	2.16	0.110	0.024	77		1.7	0.60	8.00		1	60			6.66
MWDJAR50		100	3.90	2.06	0.110	0.020	77		1.7	0.58	8.00		1	70			6.45
MWDJAR50		100	3.90	1.99	0.110	0.020	77		1.7	0.63	8.00		1	80			6.31
MWDJAR50		100	3.90	2.00	0.110	0.021	77		1.7	0.67	8.00		1	90			6.14
MWDJAR50		100	3.90	2.03	0.110	0.018	77		1.7	1.10	8.00		1	100			5.93
MWDJAR50		100	3.90	1.80	0.110	0.020	77		1.7	0.90	8.00		1	110			5.70
MWDJAR51		100	3.09	3.17	0.097	0.103	81		0.85	2.30	7.80		1	0			7.86
MWDJAR51		100	3.09	2.94	0.097	0.077	81		0.85	0.33	7.80		1	10			7.58
MWDJAR51		100	3.09	3.28	0.097	0.072	81		0.85	0.36	7.80		1	20			7.38
MWDJAR51		100	3.09	2.97	0.097	0.066	81		0.85	0.40	7.80		1	30			7.14
MWDJAR51		100	3.09	2.42	0.097	0.054	81		0.85	0.29	7.80		1	40			7.06
MWDJAR51		100	3.09	2.35	0.097	0.049	81		0.85	0.45	7.80		1	50			7.00
MWDJAR51		100	3.09	2.15	0.097	0.051	81		0.85	0.30	7.80		1	60			6.97
MWDJAR51		100	3.09	2.32	0.097	0.044	81		0.85	0.36	7.80		1	70			6.77
MWDJAR51		100	3.09	2.31	0.097	0.040	81		0.85	0.31	7.80		1	80			6.66
MWDJAR51		100	3.09	2.33	0.097	0.039	81		0.85	0.38	7.80		1	90			6.57
MWDJAR51		100	3.09	2.68	0.097	0.036	81		0.85	0.32	7.80		1	100			6.43
MWDJAR51		100	3.09	1.94	0.097	0.040	81		0.85	0.62	7.80		1	110			6.35
MWDJAR51		100	3.09	1.74	0.097	0.038	81		0.85	0.35	7.80		1	120			6.33
MWDJAR51		100	3.09	1.91	0.097	0.035	81		0.85	0.30	7.80		1	130			6.25
MWDJAR52		100	2.78	2.94		0.060			0.78	0.77	7.72		1	0			7.91
MWDJAR52		100	2.78	2.58		0.061			0.78	0.40	7.72		1	10			7.70
MWDJAR52		100	2.78	2.40		0.051			0.78	0.36	7.72		1	20			7.33
MWDJAR52		100	2.78	2.09		0.048			0.78	0.31	7.72		1	30			7.14
MWDJAR52		100	2.78	1.95		0.040			0.78	0.33	7.72		1	40			7.11
MWDJAR52		100	2.78	1.88		0.034			0.78	0.32	7.72		1	50			6.92
MWDJAR52		100	2.78	1.75		0.031			0.78	0.37	7.72		1	60			6.88
MWDJAR52		100	2.78	1.64		0.028			0.78	0.47	7.72		1	70			6.84
MWDJAR52		100	2.78	1.52		0.026			0.78	0.64	7.72		1	80			6.71
MWDJAR52		100	2.78	1.49		0.025			0.78	0.50	7.72		1	90			6.65
MWDJAR52		100	2.78	1.47		0.025			0.78	0.54	7.72		1	100			6.58
MWDJAR52		100	2.78	1.43		0.024			0.78	0.50	7.72		1	110			6.45
MWDJAR52		100	2.78	1.36		0.023			0.78	0.52	7.72		1	120			6.34
MWDJAR52		100	2.78	1.29		0.023			0.78	0.65	7.72		1	130			6.25
MWDJAR52		100	2.78	1.34		0.024			0.78	1.00	7.72		1	140			6.07
MWDJAR53		100	2.25	2.40	0.065	0.066	79		1.10	0.38	7.98		1	0			7.98
MWDJAR53		100	2.25	2.24	0.065	0.046	79		1.10	0.48	7.98		1	10			7.58
MWDJAR53		100	2.25	1.98	0.065	0.031	79		1.10	0.40	7.98		1	20			7.33
MWDJAR53		100	2.25	2.06	0.065	0.021	79		1.10	0.38	7.98		1	30			7.13
MWDJAR53		100	2.25	1.59	0.065	0.017	79		1.10	0.42	7.98		1	40			7.07
MWDJAR53		100	2.25	1.75	0.065	0.016	79		1.10	0.46	7.98		1	50			6.97
MWDJAR53		100	2.25	1.45	0.065	0.013	79		1.10	0.59	7.98		1	60			6.69
MWDJAR53		100	2.25	1.38	0.065	0.009	79		1.10	0.74	7.98		1	70			6.61
MWDJAR53		100	2.25	1.29	0.065	0.008	79		1.10	0.69	7.98		1	80			6.54
MWDJAR53		100	2.25	1.43	0.065	0.007	79		1.10	0.69	7.98		1	90			6.46
MWDJAR53		100	2.25	1.21	0.065	0.006	79		1.10	0.90	7.98		1	100			6.33
MWDJAR53		100	2.25	1.19	0.065	0.006	79		1.10	0.90	7.98		1	110			6.29
MWDJAR54		100	2.92	3.21	0.087	0.092	72		0.52	0.55	7.87		1	0			7.90
MWDJAR54		100	2.92	2.91	0.087	0.070	72		0.52	0.78	7.87		1	10			7.64
MWDJAR54		100	2.92	1.33	0.087	0.051	72		0.52	0.39	7.87		1	20			7.54
MWDJAR54		100	2.92	1.55	0.087	0.043	72		0.52	0.52	7.87		1	30			7.35
MWDJAR54		100	2.92	2.05	0.087	0.039	72		0.52	0.47	7.87		1	40			7.15
MWDJAR54		100	2.92	1.91	0.087	0.037	72		0.52	0.45	7.87		1	50			7.11
MWDJAR54		100	2.92	1.63	0.087	0.030	72		0.52	0.52	7.87		1	60			6.87
MWDJAR54		100	2.92	1.49	0.087	0.025	72		0.52	0.49	7.87		1	70			6.85
MWDJAR54		100	2.92	1.55	0.087	0.022	72		0.52	0.45	7.87		1	80			6.72
MWDJAR54		100	2.92	1.42	0.087	0.018	72		0.52	0.57	7.87		1	90			6.55
MWDJAR54		100	2.92	1.44	0.087	0.015	72		0.52	0.64	7.87		1	100			6.49
MWDJAR54		100	2.92	1.38	0.087	0.014	72		0.52	0.56	7.87		1	110			6.37

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Coagulation Conditions				
	% CRW	% SPW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		Coagulant	Dose	Acid	Base	Coag.
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	ID		adjusted?	adjusted?	pH
													(see above)		(Y/N)	(Y/N)	()
															blank=N	blank=N	
MWDIARS4		100	2.92	1.30	0.087	0.014	72		0.52	0.63	7.87		1	120			6.12
MWDIARS4		100	2.92	1.27	0.087	0.013	72		0.52	0.68	7.87		1	130			6.08
MWDIARS4		100	2.92	1.22	0.087	0.014	72		0.52	0.81	7.87		1	140			5.93
MWDIARS4		100	2.92	1.25	0.087	0.014	72		0.52	0.98	7.87		1	150			5.69
MWDIARS4		100	2.92	1.23	0.087	0.021	72		0.52	1.30	7.87		1	160			5.51
MWDIARS5		100	2.68	2.65	0.086	0.083	62		0.72	0.55	7.82		1	0			7.77
MWDIARS5		100	2.68	2.43	0.086	0.061	62		0.72	0.42	7.82		1	10			7.52
MWDIARS5		100	2.68	2.24	0.086	0.051	62		0.72	0.74	7.82		1	20			7.35
MWDIARS5		100	2.68	2.00	0.086	0.040	62		0.72	0.24	7.82		1	30			7.18
MWDIARS5		100	2.68	1.76	0.086	0.036	62		0.72	0.29	7.82		1	40			7.12
MWDIARS5		100	2.68	1.76	0.086	0.032	62		0.72	0.30	7.82		1	50			7.20
MWDIARS5		100	2.68	1.58	0.086	0.030	62		0.72	0.28	7.82		1	60			7.08
MWDIARS5		100	2.68	1.40	0.086	0.029	62		0.72	0.24	7.82		1	70			6.97
MWDIARS5		100	2.68	1.45	0.086	0.027	62		0.72	0.25	7.82		1	80			6.84
MWDIARS5		100	2.68	1.40	0.086	0.024	62		0.72	0.31	7.82		1	90			6.67
MWDIARS5		100	2.68	1.34	0.086	0.023	62		0.72	0.25	7.82		1	100			6.50
MWDIARS5		100	2.68	1.47	0.086	0.024	62		0.72	0.74	7.82		1	110			6.45
MWDIARS5		100	2.68	1.31	0.086	0.024	62		0.72	0.44	7.82		1	120			6.30
MWDIARS5		100	2.68	1.34	0.086	0.021	62		0.72	0.63	7.82		1	130			5.95
MWDIARS5		100	2.68	1.33	0.086	0.022	62		0.72	0.50	7.82		1	140			5.83
MWDIARS5		100	2.68	1.30	0.086	0.022	62		0.72	0.72	7.82		1	150			5.52
MWDIARS5		100	2.68	1.32	0.086	0.021	62		0.72	0.72	7.82		1	160			5.30

Utility ID:	MWD	(ACWD, CCWD, EBMUD, MWD, SCVWD)
1. Study ID:	EC Study Data	(Optimization Study 9/95, etc.)
2. Source water:	SPW / CRW	(River, lake, groundwater, etc.)
3. Source water ID:		(State Project water, blend of...., etc.)

5. Describe level of study:		Bench-scale	In this data sheet, "Filt." refers to data collected
(indicate with an 'X')		Pilot-scale	after coagulation, flocculation, sedimentation, and
	X	Full-scale	filtration.

6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation <u>only</u>:

or after sedimentation <u>and</u> filtration:

WATER QUALITY DATA: CONVENTIONAL

Study ID	Water		TOC (mg/L)		UV-254 (1/cm)		Alkalinity (mg/L as CaCO3)		Turbidity (NTU)		pH ()		Temperature (deg. C)		Fi dicate disinfectant used with an 'X'		Chlorine dose
	SPW	CRW	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	chlorine	hloramin	(mg Cl2/L
MWDODP1	X		2.45	1.88	0.073	0.026	74		2.10		8.90		11.2		0.5 mg/L Cl2 thru floc basin; 1.7 mg/		
MWDODP1	X		2.41	1.86	0.069	0.020	74		2.10		8.20		10.3		0.5 mg/L Cl2 thru floc basin; 1.7 mg/		
MWDODP1	X		2.33	1.71	0.068	0.026	74		2.30		8.10		10.1		0.5 mg/L Cl2 thru floc basin; 1.7 mg/		
MWDODP1	X		2.28	1.70	0.064	0.024	74		2.00		8.00		10.9		0.5 mg/L Cl2 thru floc basin; 1.7 mg/		
MWDODP1	X		2.48	1.80	0.073	0.026	74		1.80		8.50		10.8		0.5 mg/L Cl2 thru floc basin; 1.7 mg/		
MWDODP2	X		2.26	1.35	0.070	0.027	78		0.93		7.95		11.5		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP2	X		2.31	1.43	0.068	0.028	78		1.60		7.96		10.8		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP2	X		2.34	1.59	0.065	0.030	78		1.50		8.03		11.0		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP2	X		2.21	1.42	0.069	0.028	78		1.20		7.92		11.2		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP3	X		2.47	2.31	0.036	0.036	131		0.98		8.30		12.0		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP3	X		2.51	2.08	0.036	0.027	131		0.80		8.41		12.0		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP3	X		2.31	1.90	0.033	0.024	131		0.88		8.34		11.5		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP4	X		2.05	1.10	0.033	0.014	131		0.76		8.33		12.0		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.27	2.24	0.076	0.071	81		1.40		8.60		11.7		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.42	1.98	0.078	0.070	81		1.30		8.63		11.7		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.78	1.95	0.087	0.044	70		1.90		7.97		9.3		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.43	1.82	0.074	0.044	81		1.40		8.69		11.7		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.71	1.81	0.079	0.036	75		1.48		8.46		10.9		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.64	1.65	0.074	0.028	75		1.20		8.41		11.2		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.76	1.63	0.083	0.023	70		1.80		7.91		9.1		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.28	1.59	0.068	0.039	81		1.60		8.70		11.8		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP5	X		2.62	1.62	0.077	0.027	75		1.30		8.53		11.1		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDODP6	X		2.65	1.88	0.072	0.030	76		2.10		8.44		11.0		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.62	1.68	0.080	0.024	76		2.00		8.37		10.9		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.67	1.51	0.078	0.018	70		2.10		8.01		9.2		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.70	1.25	0.066	0.012	76		1.90		8.37		11.0		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.62	1.38	0.074	0.019	75		1.20		8.46		11.1		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.76	1.24	0.076	0.014	70		2.20		7.97		9.2		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDODP6	X		2.67	1.19	0.080	0.022	76		1.80		8.31		10.9		1.0 mg/L Cl2, residual, 1 hr @ 25oC		
MWDOP1	92-99%		2.94	2.71	0.084	0.064	76		0.55		7.90		11.7		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.77	2.55	0.086	0.082			0.50		7.83		12.1		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.79	2.37	0.088	0.062	71		2.20		8.05		9.2		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.59	2.17	0.083	0.060			1.50		7.96		10.2		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.84	1.46	0.084	0.022	71		1.60		8.27		10.6		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.60	1.42	0.083	0.027	72		1.50		8.14		11.3		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.74	1.53	0.078	0.022			1.80		8.55		12.6		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		3.30	2.02	0.091	0.036			3.10		9.22		14.9		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		3.20	1.99	0.099	0.035	75		2.10		8.60		13.5		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		3.43	2.03	0.103	0.039	77		1.75		8.51		14.3		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP1	92-99%		2.78	1.58	0.072	0.029	73		0.72		7.83		11.3		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP2	92-100%		3.46	3.01	0.108	0.099	80		1.60		8.36		17.4		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP2	92-100%		3.37	2.99	0.088	0.063			2.00		8.14		17.5		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.26	1.93	0.111	0.036			1.55		8.34		16.6		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.49	2.07	0.120	0.043	78		1.60		8.24		16.1		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.53	2.07	0.111	0.040	79		1.80		8.18		16.6		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.67	2.12	0.115	0.040			1.60		8.24		16.2		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.05	1.85	0.100	0.036			2.10		7.99		21.1		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.29	1.81	0.104	0.043	80		2.70		8.03		18.9		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.20	1.85	0.102	0.033			2.90		8.09		18.8		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP3	92-100%		3.17	1.85	0.103	0.032	81		2.70		8.11		17.8		1.0 mg/L Cl2, 1 hr @ 25oC		
MWDOP4	X		3.54	3.60	0.106	0.097	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	3.80	0.106	0.100	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	3.50	0.106	0.091	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.86	0.106	0.067	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	3.01	0.106	0.073	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	3.01	0.106	0.082	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		

Study ID	Water		TOC		UV-254		Alkalinity		Turbidity		pH		Temperature				
	SPW	CRW	(mg/L)		(1/cm)		(mg/L as CaCO3)		(NTU)		()		(deg. C)				Fi
			Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	dicate disinfectant		Chlorine
															used with an 'X'		dose
															chlorine	hloramin	(mg Cl2/L
MWDOP4	X		3.54	3.07	0.106	0.077	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	3.02	0.106	0.069	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.55	0.106	0.055	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.50	0.106	0.052	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.37	0.106	0.051	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.23	0.106	0.045	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.74	0.106	0.059	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.82	0.106	0.060	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.31	0.106	0.048	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.51	0.106	0.048	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.12	0.106	0.042	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.14	0.106	0.037	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.88	0.106	0.059	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.57	0.106	0.052	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.20	0.106	0.046	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.05	0.106	0.037	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	2.01	0.106	0.041	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	1.92	0.106	0.046	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP4	X		3.54	1.78	0.106	0.033	85		1.49		7.85		21.7		1 mg/L resid, 1 hr, 25 oC		
MWDOP5		X	2.44	2.12	0.039	0.031	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	2.16	0.039	0.028	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.97	0.039	0.024	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.85	0.039	0.021	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.80	0.039	0.023	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.81	0.039	0.020	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.99	0.039	0.024	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		
MWDOP5		X	2.44	1.73	0.039	0.020	131.5		0.65		7.7		24.6		1 mg/L resid, 1 hr, 25 °C		

Utility ID:													
1. Study ID:													
2. Source wat													
3. Source wat													
								Indicate coagulants studied:					
5. Describe le								ID	oagula	Chemical formula		Units	
(indicate with								1	Alum	$Al_2(SO_4)_3 \cdot 14\,H_2O$		mg/L	
								2	Ferric	$FeCl_3 \cdot 6\,H_2O$		mg/L	
								3					
6. Indicate wit								4					
									Polymer added: 2, 3, 0.5 mg/L				
WATER QU								TREATMENT CONDITIONS					
Study ID				Disinfection By-products				Coagulation Conditions					
	ered			TTHM		HAA5		Coagulant	Dose	Acid	Base	Coag.	Coag.
	mmoni	bubation t	Residual	(µg/L)		(µg/L)		ID		adjusted?	adjusted?	pH	temp.
	dose	(h)		Raw	Filt.	Raw	Filt.	(see above)		(Y/N)	(Y/N)	()	(deg. C)
	g NH3-N	chlorine	(mg Cl2/L)										
MWDODP1	Cl2 thru filters				40.6			1	40			7.00	
MWDODP1	Cl2 thru filters							1	40			7.00	
MWDODP1	Cl2 thru filters				35.1		30.1	1	40			7.00	
MWDODP1	Cl2 thru filters							1	40			7.00	
MWDODP1	Cl2 thru filters				37.2		31.7	1	40			6.90	
MWDODP2					30.7		12.4	1	30	Y		6.40	
MWDODP2					32.9		12.0	1	35	Y		6.46	
MWDODP2					35.8		14.4	1	40	Y		7.03	
MWDODP2					29.9		12.2	1	40	Y		6.56	
MWDODP3					29.0		12.4	2	5			7.91	
MWDODP3					24.8		11.0	2	10			7.97	
MWDODP3					20.5		10.6	2	25			7.14	
MWDODP4					14.0		7.7	2	25	Y		5.59	
MWDODP5					45.5		19.3	2	5			7.90	
MWDODP5					40.9		15.4	2	10			7.54	
MWDODP5					35.4		16.1	2	15			7.13	
MWDODP5					33.9		14.0	2	20			7.23	
MWDODP5					31.7		19.3	2	20			7.20	
MWDODP5					29.4		20.2	2	25			6.97	
MWDODP5					28.4		15.6	2	25			6.95	
MWDODP5					33.8		14.6	2	30			7.18	
MWDODP5					26.1		15.3	2	30			6.86	
MWDODP6					33.2		17.8	2	10	Y		6.98	
MWDODP6					28.4		12.2	2	10	Y		6.24	
MWDODP6					27.7		12.7	2	15	Y		6.25	
MWDODP6					21.2		8.9	2	20	Y		6.25	
MWDODP6					24.1		15.6	2	20	Y		6.15	
MWDODP6					22.3		11.8	2	25	Y		6.15	
MWDODP6					20.3		9.0	2	30	Y		6.22	
MWDOP1					50.8		25.9	2	3			7.60	
MWDOP1					49.8		29.2	2	3			7.53	
MWDOP1								2	5			7.56	
MWDOP1					48.6		22.8	2	5			7.53	
MWDOP1					28.3		16.2	2	30			6.86	
MWDOP1					28.2		14.5	2	30			6.80	
MWDOP1					32.0		16.1	2	30			6.77	
MWDOP1					37.8		16.9	2	30			7.09	
MWDOP1					36.1		17.1	2	30			6.94	
MWDOP1					36.0		17.8	2	30			6.92	
MWDOP1					31.4		14.3	2	30			6.88	
MWDOP2					68.2		30.3	1	12			7.71	
MWDOP2					66.5		29.5	1	12			7.65	
MWDOP3					43.0		16.9	1	40	Y		6.41	
MWDOP3					38.3		17.9	1	40	Y		6.41	
MWDOP3					41.4		17.0	1	40	Y		6.37	
MWDOP3					38.0		17.1	1	40	Y		6.33	
MWDOP3					41.6		16.5	1	40	Y		6.43	
MWDOP3					39.4		16.4	1	40	Y		6.34	
MWDOP3					39.9		18.2	1	40	Y		6.33	
MWDOP3					36.7		16.4	1	40	Y		6.31	
MWDOP4					77.9		34.0	1	10	Y		7.82	
MWDOP4					75.7		33.7	1	10	Y		7.71	
MWDOP4					71.1		31.6	1	10	Y		7.00	
MWDOP4					59.6		25.1	1	10	Y		6.23	
MWDOP4					67.7		26.7	1	10	Y		5.41	
MWDOP4					70.8		< 32.5	1	20	Y		7.65	

Study ID				Disinfection By-products				Coagulation Conditions					
	ered			TTHM		HAA5		Coagulant	Dose	Acid	Base	Coag.	Coag.
	mmoni	bubation t	Residual	(µg/L)		(µg/L)		ID		adjusted?	adjusted?	pH	temp.
	dose	(h)		Raw	Filt.	Raw	Filt.	(see above)		(Y/N)	(Y/N)	()	(deg. C)
	g NH3-N	chlorine	(mg Cl2/L)										
MWDOP4					67.4		29.4	1	20	Y		7.17	
MWDOP4					62.7		< 28.9	1	20	Y		7.11	
MWDOP4					54.9		< 22.3	1	20	Y		6.34	
MWDOP4					49.9		21.0	1	20	Y		6.40	
MWDOP4					53.1		20.9	1	20	Y		5.52	
MWDOP4					52.2		22.4	1	20	Y		5.71	
MWDOP4					62.1		23.8	1	30	Y		7.26	
MWDOP4					63.5		<24.7	1	30	Y		7.05	
MWDOP4					53.0		< 21.1	1	30	Y		6.26	
MWDOP4					53.8		<20.3	1	30	Y		6.50	
MWDOP4					48.1		<17.8	1	30	Y		6.23	
MWDOP4					46.7		<21.5	1	30	Y		5.43	
MWDOP4					56.4		24.9	1	40	Y		6.97	
MWDOP4					57.1		25.3	1	40	Y		7.24	
MWDOP4					52.4		< 21.5	1	40	Y		6.30	
MWDOP4					43.9		<18.7	1	40	Y		6.19	
MWDOP4					45.9		< 18.0	1	40	Y		5.65	
MWDOP4					46.1		< 18.6	1	40	Y		5.74	
MWDOP4					43.6		<15.8	1	40	Y		5.42	
MWDOP5					22.2		11.7	1	10	Y		5.88	
MWDOP5					22.0		14.7	1	20	Y		7.58	
MWDOP5					18.7		11.1	1	20	Y		6.89	
MWDOP5					16.6		9.5	1	20	Y		6.50	
MWDOP5					17.4		9.2	1	20	Y		5.75	
MWDOP5					17.5		< 10.6	1	20	Y		5.31	
MWDOP5					18.7		9.8	1	40	Y		6.90	
MWDOP5					16.3		9.2	1	40	Y		5.53	

Utility ID: MWDSC (ACWD, CCWD, EBMUD, MWD, SCVWD)

1. Study ID: Oxidation Demonstration Project (Optimization Study 9/93, etc.)

2. Source water: River (River, lake, groundwater, etc.)

3. Source water ID: California State Project Water (State Project water, blend of ..., etc.)

4. If blended source water indicate sources and proportions: Source %

5. Describe level of study: (indicate with an 'X') Bench-scale; Pilot-scale; X Full-scale

In this data sheet, "Filt." refers to data collected after coagulation, flocculation, sedimentation, and filtration.

6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only: or after sedimentation and filtration: X

WATER QUALITY DATA: PRE-OZONE

Date	TOC (mg/L) Raw	TOC Ozon.	TOC Filt.	UV-254 (1/cm) Raw	UV-254 Ozon.	UV-254 Filt.	Alkalinity (mg/L as CaCO3) Raw	Alkalinity Ozon.	Alkalinity Filt.	Bromide (mg/L) Raw	Bromide Ozon.	Bromide Filt.	Turbidity (NTU) Raw	Turbidity Ozon.	Turbidity Filt.	pH Raw	pH Ozon.	pH Filt.	Temperature (deg. C) Raw	Temperature Ozon.	Temperature Filt.
09/08/92	3.86			0.116	0.089		87				0.31		1.8			8.07	8.07		26.7		
09/08/92	3.86	3.82		0.116	0.081		87				0.31		1.5			7.96	7.90		25.6		
09/09/92				0.114	0.084						0.31		2.3			7.89	7.89		25.0		
09/09/92				0.112	0.088						0.31		2.4			7.89	7.89		25.0		
09/10/92				0.113	0.085						0.30		1.6			7.91	7.91		24.4		
09/10/92				0.114	0.081						0.30		1.5			8.00	8.00		24.4		
09/10/92				0.118	0.078						0.30		1.5			8.01	8.01		25.6		
09/18/92				0.108	0.078								1.6				8.07		22.3		
09/21/92				0.110												7.98	7.33		23.2		
09/21/92				0.110	0.084								1.6			7.90	7.90		23.3		
09/22/92																	7.34		23.2		
09/22/92																	7.18		23.2		
09/23/92	3.32			0.109	0.079		87				0.31		1.6			8.02	8.02		23.1		
09/24/92					0.072								1.8			8.02	8.20		23.3		
09/24/92					0.079								1.6			8.02	8.18		23.3		
09/24/92					0.087								1.6			8.02	8.08		23.3		
10/05/92	3.27			0.106			85				0.34		1.8			7.81	8.17		21.7		
10/05/92	3.27			0.109			85				0.34		1.5			7.81	8.20		21.7		
10/12/92																	8.06		21.0		
10/12/92																	8.02		21.0		
10/12/92																	8.03		21.8		
10/13/92																	7.32		20.9		
10/13/92																	7.09		20.8		
10/14/92																	7.18		20.8		
10/14/92																	7.08		20.8		
10/14/92																	7.06		20.8		
10/20/92																7.87	7.87		19.9		
10/20/92																7.87	7.87		19.9		
10/20/92																7.87	7.87		18.9		
10/26/92																7.92	7.92		18.5		
10/26/92																7.92	7.92		19.5		
10/26/92																7.92	7.92		19.5		
01/21/93	3.50						73				0.34		3.1			7.81	7.81		10.0		
01/21/93	3.50						73				0.34		3.1			7.81	7.81		10.0		
01/21/93	3.50						73				0.34		3.1			7.81	7.81		10.0		
03/16/93	2.84			0.089							0.19					7.72	7.72		12.0		
03/16/93	2.84			0.089							0.19					7.72	7.72		12.0		
03/16/93	2.84			0.089							0.19					7.72	7.72		12.0		
04/01/93													2.2			7.88	8.01		12.0		
04/01/93													2.2			7.88	8.11		12.0		
04/01/93													2.2			7.88	8.89		12.0		
04/01/93													2.2			7.88	8.90		12.0		
04/01/93													2.2			7.88	8.07		12.0		
04/02/93													2.3			7.88	7.88		12.0		
04/02/93													2.3			7.88	7.88		12.0		
04/02/93													2.3			7.88	7.88		12.0		
04/02/93													2.3			7.88	7.88		12.0		
04/02/93													2.3			7.88	7.88		12.0		
04/05/93	2.78			0.098			72				0.19					7.50	7.50		12.2		
04/05/93	2.78			0.098			72				0.19					7.50	7.50		12.2		
04/06/93																	6.93		12.3		
04/06/93																	8.05		12.3		
04/07/93											0.18		1.3			7.58	8.13		12.1		
04/07/93											0.18		1.3			7.58	8.18		12.1		
04/07/93											0.18		1.3			7.58	6.98		12.1		
04/07/93											0.34		1.3			7.58	6.82		12.1		
04/07/93											0.28		1.3			7.58	6.63		12.1		
04/08/93											0.33		1.3			7.60	7.60		12.1		
04/08/93											0.19		1.3			7.60	7.80		12.1		
04/08/93											0.21		1.3			7.80	7.80		12.1		
04/08/93											0.27		1.3			7.60	7.60		12.1		
04/08/93											0.17		1.3			7.60	7.60		12.1		
04/12/93	2.76			0.095			73				0.47					7.57	7.57		12.1		
04/21/93																	6.15		13.0		

TREATMENT CONDITIONS

Date	Bromate (µg/L) Raw	Bromate Ozon.	Bromate Filt.	Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min) (full contactor)	Ozone pH 0	Ozone temp. (deg. C)	Ozone residual (mg/L) Ch. 1A	Ozone residual (mg/L) Ch. 1B	Ozone residual (mg/L) Ch. 2A	Ozone residual (mg/L) Ch. 2B	Ozone residual (mg/L) Ch. 3A	Ozone residual (mg/L) Ch. 3B
09/08/92		9.0		1.9		12.1			0.32	<.01	<.01	<.01	<.01	<.01
09/08/92		12.0		2.0		12.1			0.42	0.02	0.01	<.01	<.01	0.01
09/09/92		10.0		1.9		12.2			0.31	0.04	0.04	0.04	0.05	0.04
09/09/92		11.8		1.9		12.0			0.32	0.02	0.01	0.01	0.08	0.01
09/10/92		7.0		1.6		12.3			0.18	<.01	<.01	<.01	<.01	<.01
09/10/92		11.9		1.9		12.3			0.32	0.01	0.01	<.01	<.01	<.01
09/10/92		13.0		2.2		12.2			0.44	0.03	0.03	0.03	0.02	0.02
09/18/92		6.0		1.7		12.1			0.40	0.11	0.03	0.03	0.02	0.02
09/21/92		8.0		1.5		12.2			0.34	0.08	0.05	0.04	0.03	0.04
09/21/92		7.0		1.6		12.2			0.25	0.04	0.03	0.04	0.03	0.03
09/22/92		6.0		1.3		12.1			0.20	0.03	0.03	0.03	0.02	0.02
09/22/92		7.0		1.4		12.2			0.27	0.04	0.03	0.03	0.03	0.03
09/23/92		8.0		1.7		12.3			0.36	0.03	0.03	0.03	0.03	0.03
09/24/92		3.0		1.2		12.2			0.30	0.04	0.04	0.04	0.03	0.04
09/24/92		4.5		1.5		12.3			0.51	0.09	0.04	0.04	0.03	0.03
09/24/92		8.5		1.7		12.2			0.75	0.18	0.10	0.04	0.04	0.04
10/05/92		1.5		1.0		12.1			0.20	0.02	0.02	0.02	0.02	0.01
10/05/92		8.0		1.2		12.3			0.34	0.04	0.02	0.02	0.02	0.02
10/12/92		1.5		1.0		12.2			0.20	0.02	0.01	0.01	<0.010	0.01
10/12/92		1.5		1.1		12.1			0.24	0.02	0.02	0.02	0.02	0.02
10/12/92		1.5		1.1		12.1			0.33	0.03	0.02	0.02	0.02	0.01
10/13/92		1.5		1.1		12.2			0.23	0.03	0.02	0.02	0.02	0.02
10/13/92		5.0		1.1		12.2			0.32	0.01	0.02	0.02	0.01	0.01
10/14/92		6.0		1.0		12.3			0.22	0.02	0.01	0.01	<0.010	<0.010
10/14/92		7.0		1.2		12.3			0.34	0.01	<0.010	<0.010	<0.010	<0.010
10/14/92		7.5		1.4		12.5			0.42	0.05	0.02	0.01	0.01	<0.010
10/20/92		13.0		1.6		6.1			0.58	0.11	0.04	<0.010	<0.010	<0.010
10/20/92		15.5		1.8		6.1			0.66	0.11	0.14	0.02	<0.010	<0.010
10/20/92		23.5		2.1		6.1			0.72	0.29	0.28	0.11	0.06	0.03
10/26/92		13.0		1.4		12.2			0.42	0.08	0.04	0.04	0.04	0.04
10/26/92		18.5		1.7		12.2			0.43	0.04	0.03	0.03	0.03	0.03
10/26/92		18.0		2.0		12.2			0.67	0.10	0.08	0.03	0.03	0.03
01/21/93		9.5		1.6		11.9			0.58	0.19	0.05	<0.010	<0.010	<0.010
01/21/93		15.5		1.9		12.2			0.76	0.23	0.11	0.08	<0.010	<0.010
01/21/93		23.0		2.2		12.1			0.88	0.47	0.22	0.09	0.06	0.01
03/16/93		3.0		1.0		12.3			0.21	<0.010	<0.010	<0.010	<0.010	<0.010
03/16/93		6.5		1.5		12.3			0.58	0.27	0.05	0.04	0.03	0.03
03/16/93		8.5		2.0		12.2			0.78	0.31	0.21	0.09	0.06	0.03
04/01/93		1.5		0.8		12.2			0.11	<0.010	0.01	0.01	0.02	<0.010
04/01/93		1.8		1.0		12.2			0.39	0.02	0.01	<0.010	0.01	0.01
04/01/93		1.5		1.3		12.2			0.45	0.10	0.08	0.03	0.03	0.03
04/01/93		1.8		1.6		12.2			0.70	0.38	0.24	0.13	0.08	0.05
04/01/93		5.0		1.8		12.2			0.88	0.44	0.38	0.31	0.23	0.18
04/02/93		1.5		1.0		12.2			0.23	0.02	0.02	0.01	0.02	0.02
04/02/93		3.5		1.3		12.2			0.44	0.07	0.02	0.02	0.02	0.02
04/02/93		4.5		1.5		12.2			0.46	0.09	0.05	0.02	0.02	0.02
04/02/93		1.5		1.7		12.1			0.83	0.33	0.19	0.08	0.03	0.02
04/02/93		13.0		2.0		12.1			1.07	0.44	0.31	0.17	0.10	0.04
04/05/93		8.0		1.8		12.2			0.74	0.18	0.11	0.02	0.02	0.02
04/05/93		43.5		4.0		12.2			2.01	1.71	1.56	1.30	1.09	0.97
04/06/93		3.0		1.2		12.2			0.54	0.15	0.09	0.04	0.04	0.06
04/06/93		6.0		1.6		12.2			0.75	0.30	0.25	0.18	0.12	0.08
04/07/93		3.5		1.2		12.2			0.41	0.06	0.01	0.01	0.02	0.02
04/07/93		1.5		1.2		12.2			0.39	0.06	0.05	0.04	0.03	0.04
04/07/93		3.5		1.2		12.2			0.38	0.07	0.04	0.01	0.02	0.01
04/07/93		3.8		1.2		12.1			0.47	0.10	0.08	0.02	0.02	0.02
04/07/93		1.5		1.2		12.1			0.40	0.11	0.08	0.02	0.02	0.02
04/08/93		8.0		1.5		12.1			0.52	0.18	0.09	0.03	0.04	0.04
04/08/93		8.0		1.6		12.2			0.48	0.10	0.08	0.03	0.03	0.03
04/08/93		8.0		1.8		12.2			0.57	0.16	0.08	0.03	0.03	0.02
04/08/93		7.5		1.8		12.1			0.61	0.14	0.03	0.02	0.02	0.02
04/08/93		6.0		1.5		12.2			0.63	0.08	0.03	0.01	0.02	0.01
04/12/93		3.5		1.0		12.2			0.23	0.01	<0.010	<0.010	<0.010	<0.010
04/21/93		1.5		0.7		12.1			0.13	0.03	0.03	0.03	0.02	0.02

Date	TOC (mg/L) Raw	TOC Ozon.	TOC Fil.	UV-254 (1/cm) Raw	UV-254 Ozon.	UV-254 Fil.	Alkalinity (mg/L as CaCO3) Raw	Alkalinity Ozon.	Alkalinity Fil.	Bromide (mg/L) Raw	Bromide Ozon.	Bromide Fil.	Turbidity (NTU) Raw	Turbidity Ozon.	Turbidity Fil.	pH Raw	pH Ozon.	pH Fil.	Temperature (deg. C) Raw	Temperature Ozon.	Temperature Fil.	Bromate (µg/L) Raw	Bromate Ozon.	Bromate Fil.	Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min) (full contactor)	Ozone pH	Ozone temp. (deg. C)	Ozone residual (mg/L) Ch. 1A	Ozone residual (mg/L) Ch. 1B	Ozone residual (mg/L) Ch. 2A	Ozone residual (mg/L) Ch. 2B	Ozone residual (mg/L) Ch. 3A	Ozone residual (mg/L) Ch. 3B
04/21/93																	8.11		13.0				1.5		1.8		12.1			0.18	0.02	0.01	0.02	0.03	0.02
04/21/93																	5.98		13.0				1.5		1.3		12.2			0.36	0.09	0.09	0.02	0.02	0.03
04/21/93																	6.06		13.0				3.0		1.5		12.3			0.59	0.15	0.09	0.02	0.02	0.02
04/21/93																	5.99		13.0				3.5		1.7		12.2			0.77	0.20	0.17	0.12	0.07	0.04
04/22/93																	7.30		13.2				1.5		1.0		12.3			0.19	<0.010	<0.010	<0.010	<0.010	<0.010
04/22/93																	7.30		13.2				1.5		1.2		12.3			0.25	0.04	0.01	0.01	0.01	<0.010
04/22/93																	7.30		13.2				1.5		1.5		12.3			0.49	0.01	0.01	<0.010	<0.010	<0.010
04/22/93																	7.30		13.2				1.5		1.7		12.2			0.60	0.19	0.08	0.03	0.01	0.02
04/22/93																	7.30		13.2				6.6		2.0		12.2			0.97	0.29	0.14	0.07	0.04	0.02
04/26/93	3.87			0.100			70				0.10						7.29		13.5				3.5		1.8		12.3			0.40	0.08	0.01	<0.010	0.02	<0.010
04/26/93	3.87			0.100			78				0.10						7.29		13.5				32.0		4.0		12.2			1.80	1.82	1.32	1.03	0.86	0.72
04/27/93																	8.09		13.8				1.5		1.2		12.2			0.33	0.01	0.01	0.01	0.01	0.01
04/27/93																	8.10		13.8				1.8		1.8		12.3			0.51	0.12	0.03	<0.010	0.02	0.01
04/28/93											0.63						8.09		14.2				1.5		1.2		12.2			0.18	<0.010	<0.010	<0.010	<0.010	<0.010
04/28/93											0.10						8.09		14.2				1.5		1.2		12.2			0.17	<0.010	<0.010	<0.010	<0.010	<0.010
04/28/93											0.30						8.13		14.2				1.5		1.2		12.1			0.10	<0.010	<0.010	<0.010	<0.010	<0.010
04/28/93											0.46						5.90		14.2				1.5		1.2		12.1			0.15	<0.010	<0.010	<0.010	<0.010	<0.010
04/28/93											0.25						8.11		14.2				1.5		1.2		12.2			0.06	<0.010	<0.010	0.01	<0.010	<0.010
04/29/93											0.56					8.41	8.41		17.2				1.5		1.5		12.2			0.03	<0.010	<0.010	<0.010	<0.010	<0.010
04/29/93											0.22					8.37	8.37		17.2				1.5		1.5		12.2			0.68	<0.010	<0.010	<0.010	<0.010	<0.010
04/29/93											0.59					8.27	8.27		17.2				27.5		4.1		12.2			0.35	0.03	0.03	0.01	<0.010	0.01
05/03/93	3.18			0.108			77				0.56					8.30	8.30		16.3				8.0		1.5		12.2			0.33	0.04	0.03	0.03	0.03	0.03
05/03/93	3.18			0.108			77				0.58					8.30	8.30		16.3				12.0		1.7		12.3			0.48	0.03	0.02	0.02	0.02	0.02
05/03/93	3.18			0.108			77				0.44					8.30	8.30		16.3				14.8		2.0		12.2			0.50	0.02	0.02	0.02	0.02	0.03
05/03/93	3.18			0.108			77				0.57					8.30	8.30		16.3				22.5		2.3		12.2			0.72	0.13	0.02	0.01	0.02	0.01
05/04/93											0.47						8.08		18.0				6.0		3.0		12.2			1.07	0.40	0.21	0.13	0.09	0.05
05/12/93											0.33						8.07		18.0				1.5		1.0		12.1			0.15	<0.010	<0.010	<0.010	0.04	0.02
05/12/93											0.32						8.03		18.0				1.5		1.2		12.1			0.30	0.01	<0.010	0.01	0.01	<0.010
05/12/93											0.32						8.02		18.0				1.6		1.5		12.1			0.40	0.10	0.03	0.02	0.02	0.02
05/12/93											0.32						8.10		18.0				3.0		1.7		12.1			0.06	0.18	0.12	0.02	0.02	0.01
05/12/93											0.32						8.04		18.0				1.6		2.0		12.1			0.71	0.41	0.20	0.08	0.04	0.01
05/13/93											0.33					8.08	8.08		18.0				3.5		1.2		12.2			0.14	0.01	0.01	0.01	0.01	0.02
05/13/93											0.32					8.08	8.06		18.0				5.5		1.5		12.1			0.27	0.02	0.02	0.01	0.02	0.02
05/13/93											0.33					8.08	8.06		18.0				7.0		1.7		12.2			0.44	0.02	0.02	0.02	0.02	0.02
05/13/93											0.32					8.06	8.08		18.0				10.0		2.0		12.1			0.65	0.06	0.02	0.03	0.02	0.03
05/13/93											0.33					8.06	8.06		18.0				13.0		2.2		12.2			0.73	0.11	0.08	0.02	0.02	0.02
06/14/93							82				0.51					7.78	7.78		19.2				14.5		2.0		12.2			0.47	0.05	0.00	0.00	0.00	0.00
06/14/93	3.34	3.83					82				0.50					7.78	7.78		19.2				20.5		2.4		12.1			0.87	0.20	0.08	0.00	0.00	0.00
06/14/93							82				0.52					7.78	7.78		19.2				31.0		2.7		12.2			0.97	0.20	0.16	0.02	0.00	0.00
06/21/93	3.53						86				0.49					7.89	7.89		20.5				4.5		1.5		12.3			0.17	<0.010	<0.010	0.00	0.00	0.00
06/21/93	3.63						85				0.49					7.89	7.89		20.5				8.5		2.0		12.3			0.44	0.01	<0.010	0.00	0.00	0.00
06/21/93	3.63	2.73					85				0.48					7.89	7.89		20.5				18.0		2.5		12.2			0.63	0.13	0.04	0.00	0.00	0.00
06/28/93	3.58						84				0.54					7.87	7.87		20.8				12.8		1.5		12.2			0.17	0.02	0.01	0.00	0.00	0.00
06/28/93	3.59						84				0.50					7.87	7.87		20.8				6.0		2.0		12.2			0.44	0.02	0.01	0.00	0.00	0.00
06/28/93	3.56	3.78					84				0.53					7.87	7.87		20.8				23.8		2.5		12.2			0.55	0.14	0.09	0.02	0.00	0.00
07/06/93				0.116			88				0.61					7.93	7.93		21.7				4.6		1.5		12.2			0.16	0.01	0.00	0.00	0.00	0.00
07/06/93				0.116			88				0.46					7.93	7.93		21.7				9.0		2.0		12.2			0.38	0.02	0.02	0.00	0.00	0.00
07/06/93				0.116	0.068		88				0.49					7.93	7.93		21.7				18.8		2.4		12.3			0.39	0.06	0.02	0.00	0.00	0.00
07/28/93											0.53					8.07	8.07		21.2				13.0		2.0		12.3			0.42	0.03	0.04	0.00	0.00	0.00
07/28/93											0.50					8.07	8.07		21.2				12.6		7.0		6.1			0.45	0.11	0.05	0.00	0.00	0.00
07/28/93											0.52					8.07	8.07		21.2				12.0		2.1		17.0			0.24	0.03	0.03	0.00	0.00	0.00
07/19/94	3.38 (d)	3.18 (d)	3.02 (d)	0.097	0.092	0.047	80				0.21		1.56			8.13	8.13	7.80	23.2				1.5		1.8		6.5			0.43	0.04	0.03	0.00	0.00	0.00
07/25/94	3.19 (d)	3.11 (d)	2.75 (d)	0.081	0.085	0.041	80				0.22		1.1			8.26	8.26	7.87	23.4				9.9		1.7		6.5			0.52	0.09	0.06	0.00	0.00	0.00
08/01/94	3.43 (d)	3.30 (d)	2.85 (d)	0.081							0.22		1.3			8.14	8.14	7.71	23.7				8.0		2.0		6.0			0.78	0.13	0.19	0.00	0.00	0.00
08/16/94													0.8			8.10	6.28	7.65	24.8				3.0		1.4		6.5			0.35	0.11	0.11	0.03	0.00	0.00
08/17/94													1.4			6.70	6.15	6.29	24.9				1.5		1.4		6.5			0.48	0.23	0.17	0.08	0.00	0.00
08/17/94																6.70	7.16		24.9				5.0		1.5		6.4			0.39	0.10	0.10	0.03	0.00	0.00
08/18/94	3.52 (d)	3.52 (d)	2.87 (d)	0.084	0.058	0.041							1.8			8.58	7.16	7.14	24.8				4.8		1.5		6.5			0.46	0.14	0.13	0.04	0.00	0.00
08/29/94	3.50 (d)	3.66 (d)	2.89 (d)	0.093	0.058	0.042	82				0.22		0.9			8.86	7.58	7.30	24.2				1.5		1.4		6.5			0.39	0.00	0.05	0.00	0.00	0.00
10/24/94	3.19 (d)	3.17 (d)	2.74 (d)	0.088	0.050	0.038	77				0.38		0.74			7.93	7.92	7.70	18.8				11.0		1.7		6.6			0.55	0.23	0.22	0.10	0.00	0.00
10/25/94																7.94	7.00		18.8				3.0		1.0		6.4			0.20	0.05	0.06	0.02	0.00	0.00
10/26/94																7.94	7.08		18.6				7.5		1.5		6.5			0.53	0.25	0.28	0.23	0.10	0.06
10/26/94																7.90	7.90		18.6				7.0		1.5		6.5			0.45	0.20	0.11	0.01	0.00	0.00
10/26/94																7.94	7.08		18.6				13.0		2.0		6.4			0.95	0.58	0.51	0.36	0.32	0.24
10/26/94																7.81	7.81		18.6				15.5		2.0		6.5			0.48	0.31	0.28	0.14	0.09	0.04
10/26/94																7.94	7.94		18.6				26.0		2.5		6.5			1.06	0.63	0.57	0.33	0.27	0.19
10/27/94																	6.39		18.4				1.5		1.0		6.4			0.33	0.11	0.11	0.05	0.02	0.02
10/27/94																	6.36		18.4				1.5		1.3		6.4			0.60	0.30	0.29	0.17	0.13	0.09
10/27/94																	6.40		18.4				3.0		1.5		6.4			0.88	0.38	0.42	0.29	0.20	0.20
10/28/94																	5.90		18.3				1.5		1.0		6.4			0.42	0.14	0.14	0.07	0.05	0.04
10/28/94																	5.97		18.3				1.6		1.2		6.4			0.64	0.28	0.30	0.20	0.16	0.12
10/28/94																	5.90		18.3				1.8		1.5		6.4			0.80	0.44	0.47	0.35	0.29	0.23
10/31/94	3.02 (d)	2.76 (d)	2.17 (d)	0.083	0.048	0.038	76				0.28		0.75			8.01	7.93	7.82	18.2				10.0		1.5		6.5			0.52	0.23	0.19	0.07	0.00	0.00
11/01/94											0.40					7.98	6.98		18.2				4.0		1.0		6.4			0.42	0.17	0.15	0.07	0.08	0.04
11/01/94											0.35					7.98	6.62		18.2				4.5		1.5		6.4			0.90	0.62	0.46	0.26	0.23	0.16
11/01/94											0.40					7.98	7.88		18.2				14.0		1.5		6.4			0.68	0.33	0.25	0.10	0.08	0.02
11/01/94											0.41					7.98	6.82		18.2				11.0		2.0		6.4			1.11	1.21	0.78	0.63	0.63	0.47
11/01/94											0.40					7.98	7.98		18.2				26.0		2.0		6.4			0.87	0.48	0.46	0.29	0.21	0.13
11/01/94											0.40					7.99	7.98		18.2				30.0		2.5		6.4			1.38	0.90	0.74	0.52	0.40	0.33
11/02/94											0.43						8.43		17.8				1.5		1.6		6.4			0.31	0.10	0.08	0.04	0.02	0.01
11/02/94											0.36						8.05		17.8				1.5		1.0		6.4			0.34	0.12	0.12	0.05	0.04	<0.010

Date	TOC			UV-254			Alkalinity			Bromide			Turbidity			pH			Temperature			Bromate			Ozonation Conditions										
	(mg/L)			(1/cm)			(mg/L as CaCO3)			[illegible] (mg/L)			(NTU)			( )			(deg. C)			(µg/L)			Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min) (full contactor)	Ozone pH ( )	Ozone temp. (deg. C)	Ozone residual (mg/L) Ch. 1A	Ozone residual (mg/L) Ch. 1B	Ozone residual (mg/L) Ch. 2A	Ozone residual (mg/L) Ch. 2B	Ozone residual (mg/L) Ch. 3A	Ozone residual (mg/L) Ch. 3B
	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.	Raw	Ozon.	Filt.											
11/02/94											0.42						8.41		17.6				4.0		1.2		6.4			0.53	0.34	0.29	0.18	0.13	0.09
11/02/94											0.41						8.05		17.6				4.0		1.3		6.4			0.51	0.29	0.28	0.18	0.14	0.09
11/02/94											0.41						8.41		17.6				5.0		1.5		6.4			0.80	0.31	0.36	0.27	0.23	0.18
11/02/94											0.42						8.05		17.6				3.5		1.5		6.4			0.82	0.46	0.50	0.33	0.30	0.23
11/07/94	2.78 (d)	2.61 (d)	2.29 (d)	0.080	0.046	0.033	78				0.26		0.7			7.87	7.97	7.63	16.4				15.0		1.7		6.5			0.76	0.49	0.36	0.20	0.00	0.00
11/08/94											0.53					7.80	8.92		16.2				6.0		1.0		6.4			0.43	0.18	0.18	0.08	0.07	0.03
11/08/94											0.55					7.80	7.90		16.2				12.5		1.2		6.4			0.52	0.17	0.18	0.08	0.06	0.04
11/08/94											0.54					7.90	8.87		16.2				9.5		1.5		6.4			0.89	0.58	0.55	0.40	0.35	0.31
11/08/94											0.55					7.90	7.90		16.2				21.0		1.5		6.4			0.70	0.37	0.33	0.17	0.11	0.07
11/08/94											0.55					7.90	8.87		16.2				12.0		2.0		6.4			1.23	0.84	0.88	0.74	0.65	0.58
11/08/94											0.54					7.95	7.90		16.2				34.5		2.0		6.4			0.98	0.55	0.57	0.45	0.37	0.29
11/10/94											0.54						8.44		15.9				3.0		1.0		6.4			0.39	0.14	0.15	0.08	0.06	0.02
11/10/94											0.64						8.05		15.9				1.5		1.0		6.4			0.40	0.18	0.21	0.11	0.19	0.08
11/10/94											0.64						8.10		15.9				3.0		1.2		6.4			0.48	0.33	0.32	0.24	0.21	0.17
11/10/94											0.53						8.44		15.9				5.0		1.3		6.4			0.60	0.37	0.33	0.22	0.17	0.12
11/10/94											0.63						8.05		15.9				4.0		1.5		6.4			0.89	0.45	0.52	0.41	0.38	0.31
11/10/94											0.58						8.44		15.9				5.0		1.5		6.4			0.77	0.40	0.62	0.30	0.33	0.26
11/14/94	2.76 (d)	2.89 (d)	2.39 (d)	0.080	0.049	0.033	75				0.29		0.64			8.31	8.29	7.86	16.1				6.0		1.6		6.5			0.84	0.13	0.18	0.08	0.00	0.08
11/28/94	2.74 (d)	2.82 (d)	2.39 (d)				80				0.30		1.05			8.33	8.37	7.70	12.7				7.0		1.5		6.4			0.51	0.23	0.21	0.06	0.05	0.00
12/08/94	2.81 (d)	2.64 (d)	2.22 (d)								0.33		1.5			8.02	8.03	7.63	11.3				10.0		1.3		6.5			0.63	0.31	0.30	0.16	0.12	0.07
12/14/94													1.9			8.08	8.08	7.70	11.9				6.0		1.2		6.6			0.56	0.32	0.26	0.15	0.10	0.07
12/20/94	2.67 (d)	2.73 (d)	2.38 (d)	0.078	0.045	0.038	82						1.2			8.06	8.08	7.78	10.1				9.0		1.2		6.4			0.62	0.35	0.27	0.15	0.12	0.06
12/28/94	2.65 (d)	2.65 (d)	2.41 (d)	0.078	0.063	0.038	82				0.34		1.1			8.11	8.11	7.97	9.8				7.0		1.2		6.5			0.46	0.30	0.27	0.15	0.12	0.07
01/05/95	2.48 (d)	2.56 (d)	2.08 (d)	0.077	0.047	0.031							0.85			8.16	8.16	7.76	10.0				6.0		1.2		6.4			0.44	0.26	0.25	0.14	0.10	0.05
01/10/95	2.42 (d)	2.46 (d)	2.15 (d)	0.078	0.050	0.032	78				0.31		1.4			8.22	8.22	7.63	10.4				8.0		1.2		6.4			0.54	0.23	0.23	0.13	0.08	0.05
01/18/95	2.48 (d)	2.48 (d)	2.10 (d)	0.073	0.047	0.038	78				0.31		2.2			8.07	8.07	7.71	10.2				6.0		1.2		6.5			0.49	0.21	0.24	0.10	0.06	0.04
01/24/95	2.73 (d)	2.70 (d)	2.32 (d)	0.076	0.045	0.033	78				0.31		1.3			8.12	8.12	7.70	10.3				6.0		1.3		6.5			0.56	0.28	0.25	0.11	0.08	0.05
01/31/95	2.68 (d)	2.59 (d)	2.22 (d)	0.072	0.041	0.032	78				0.29		0.77			8.51	8.51	8.00	11.1				9.0		1.5		6.5			0.54	0.22	0.22	0.09	0.05	0.01
02/01/95	2.23						78				0.50					8.56	7.06		11.7				14.0		1.6		6.6			0.78	0.43	0.48	0.36	0.30	0.23
02/02/95	2.50										0.50					8.36	7.80		11.3				21.5		2.0		4.5			1.25	0.70	0.74	0.58	0.52	0.43
02/07/95	2.78 (d)	2.83 (d)	2.38 (d)	0.082	0.047	0.035	78				0.26		0.85			8.26	8.36	7.76	11.6				12.0		1.6		6.5			0.58	0.25	0.27	0.13	0.09	0.03
02/14/95	2.82 (d)	2.90 (d)	2.61 (d)	0.085	0.046	0.036	80				0.28		0.9			8.37	8.37	8.00	11.4				12.0		1.6		6.4			0.84	0.29	0.28	0.14	0.08	0.03
02/28/95	3.12 (d)	3.31 (d)	2.68 (d)	0.089	0.056	0.038					0.27		1.8			8.00	7.76	7.58	12.9				6.0		1.6		6.6			0.47	0.19	0.19	0.07	0.03	<.01
08/13/95	3.37			0.110			68			0.14			4.2			8.60	8.50		19.4				4.0		3.0		6.5			0.70	0.15	0.07	0.03	0.02	0.02
08/14/95	3.27			0.104			68			0.14	0.34		3.5			8.62	8.52		19.4				21.0		3.5		6.6			0.65	0.18	0.18	0.01	0.01	0.01
08/15/95	3.40			0.108			68				0.40		5.6			8.82	7.43		19.4				18.0		3.0		6.5			0.72	0.47	0.49	0.20	0.18	0.08

Utility ID:	SCWWD	(ACWD, CCWD, EBMUD, MWD, SCWWD)
1. Study ID:	Pilot Study 93-94	(Optimization Study 8/95, etc.)
2. Source water:	South Bay Aqueduct	(River, lake, groundwater, etc.)
3. Source water ID:	State Project Water	(State Project water, blend of..., etc.)

4. If blended source water indicate sources and proportions:

Source	%

5. Describe level of study:			In this data sheet, "Filt." refers to data collected
(indicate with an 'X')		Bench-scale	after coagulation, flocculation, sedimentation, and
	X	Pilot-scale	filtration.
		Full-scale	

6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only:	
or after sedimentation and filtration:	X

WATER QUALITY DATA: CONVENTIONAL

Date	TOC (mg/L)		UV-254 (1/cm)		Alkalinity (mg/L as CaCO3)		Hardness (mg/L as CaCO3)				Bromide (µg/L)		Chloride (mg Cl-/L)		TDS (mg/L)		Turbidity (NTU)		pH ()		Temperature (deg. C)	
	Raw	Filt.	Raw	Filt.	Raw	Filt.	Total		Calcium		Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.	Raw	Filt.
							Raw	Filt.	Raw	Filt.												
11/3/93	3.46	2.46	0.127	0.0532	83	81	117	117			170		61		232	237	2.9	0.071	8.1	7.98	18.7	21
11/4/93	3.32	2.14	0.113	0.0346	86	70	122	122			150		57		230	234	2.09	0.054	7.58	6.98	18.7	20.9
11/16/93	2.81	1.52	0.112	0.0238	60	8	103	103			230		75		235	253	7.19	0.098	7.40	5.52	18.8	17.5
11/17/93	3.05	0.78	0.116	0.011	62	21	105	105			220		71		238	255	10.13	3.17	7.42	5.53	18.4	18.1
11/18/93	2.94	0.92	0.114	0.013	70	26	105	105			220		74		241	251	4.68	0.048	7.24	6.24	17.5	18.2
11/3/93	3.46	2.46	0.127	0.049	83	67	117	117			170		61		232	240	2.9	0.066	7.6	8.8	18.7	21
11/3/93	3.46	1.22	0.127	0.023	83	66	117	117			170		61		232	242	2.9	0.06	7.6	6.49	18.7	21.3
11/4/93	3.32	2.16	0.113	0.039	85	66	122	122			150		57		230	240	2.09	0.063	7.58	7	18.7	20
11/4/93	3.32	0.7	0.113	0.010	85	39	122	122			150		57		230	250	2.09	0.041	7.58	6.44	18.7	21.3
11/15/93	2.96	1.05	0.123	0.016	71	12	108	108			170		72		237	260	4.76	0.048	7.75	5.49	17.7	18.7
11/15/93	2.96	1.63	0.123	0.026	71	13	108	108			170		72		237	253	4.76	0.098	7.75	5.52	17.7	17.5
11/16/93	2.81	0.94	0.112	0.016	60	7	103	103			230		75		235	257	7.19	0.061	7.48	5.58	18.8	17.8
2/15/94	4.82	2.74	0.215	0.057	83	55	115	115			160				219	234	7.37	0.101	7.59	6.4	12.8	13.3
4/25/94	4.6	2.57	0.181	0.046	61	56	124	124			550	290	70		272	283	5.94	0.07	7.87	6.71	16.9	17.2
4/27/94	4.67	2.49	0.168	0.041	62	57	127	127			530		73		274	291	7.97	0.067	7.64	6.78	17.1	17.8
4/28/94	4.58	2.4	0.193	0.040	61	59	126	126			558		74		280	293	8.69	0.09	7.5	6.77	18	18.3
5/2/94	4.58	2.53	0.161	0.041	81	60	127	127			560		72		281	292	6.34	0.085	8.13	6.71	17.6	17.9
5/16/94	3.97	2.57	0.142	0.053	95	80	129	129			450		50		241	246	5.57	0.104	8.04	7.06	18.2	18.1
5/16/94	3.97	2.57	0.142	0.053	95	80	129	129			460		50		241	246	5.57	0.104	8.04	7.06	18.2	18.1
5/16/94	3.97	2.57	0.142	0.053	95	80	129	129			450		50		241	246	5.57	0.104	8.04	7.06	18.2	18.1
5/16/94	3.97	2.57	0.142	0.053	95	80	129	129			460		50		241	246	5.57	0.104	8.04	7.06	18.2	18.1
5/17/94	3.79	2.66	0.155	0.056	81	69	120	120			630		89		266	259	4.92	0.087	8.71	7.28	18.5	18.5
5/19/94	3.86	2.57	0.141	0.050	85	71	120	120			600		89		261	273	5.4	0.063	8.56	7.06	18.5	18.9
5/24/94	3.89	2.73	0.136	0.050	89	82	128	128			670		54		238	242	6.84	0.083	8.12	6.99	16.8	20
3/1/94	5.57	2.31	0.262	0.045	70	53	113	113			170	120			235	250	9.86	0.099	7.6	6.23	14.5	15.8
3/1/94	5.57	2.31	0.262	0.045	70	53	113	113			170	120			235	250	9.86	0.099	7.8	6.23	14.5	15.8
3/1/94	5.57	2.31	0.262	0.045	70	53	113	113			170	120			235	250	9.86	0.099	7.8	6.23	14.5	15.8
3/1/94	5.57	2.31	0.262	0.045	70	53	113	113			170	120			235	250	9.86	0.099	7.8	6.23	14.5	15.8
6/13/94	3.2	2.08	0.121	0.048	77	68	115	115			660		71		263	266	4.5	0.072	8.1	7.16	19	20.2
6/14/94	3.22	2.48	0.114	0.054	78	65	117	117			600				283	278	4.53	0.117	8.29	7.32	19.9	21.2
6/15/94	3.25	2.8	0.118	0.059	78	75	113	113			608	290	73		287	275	4.88	0.098	8.2	7.45	18.2	20.1
6/16/94	3.15	1.87	0.118	0.027	79	43	114	114			1000	560	73		266	282	4.25	0.073	7.98	6.55	17.3	19.7

Utility ID:

1. Study ID:

2. Source wa

3. Source wa

5. Describe I

(indicate wi

6. Indicate w

WATER Q

Indicate coagulants studied:

ID	oagulan	Chemical formula	Units
1	Alum	Al2(SO4)3	mg/L
2	erric Chl	FeCl3	mg/L
3			
4			

TREATMENT CONDITIONS

Date	Chlorination conditions: Filtered, Indicate disinfectant(s) used with an 'X': chlorine	chloramine	Chlorine dose (mg Cl2/L)	Ammonia dose (mg NH3-N/L)	Incububation time (h): chlorine	chloramine	Incub. temp. (deg. C)	pH ()	Residual FREE (mg Cl2/L)	Disinfection By-products: TTHM (µg/L) Raw	TTHM Filt.	HAA5 (µg/L) Raw	HAA5 Filt.	HAA6 (µg/L) Raw	HAA6 Filt.	Coagulation Conditions: Coagulant ID (see above)	Dose	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)
11/3/93	X	X	2.4	0.58	0.25	72	20 to 25	7.98	1.60		38		25.7		29.6	1	20	N	N	7.98	20
11/4/93	X	X	2.4	0.60	0.25	72	20 to 25	8.05	1.8		31		25.4		29.3	1	28	N	N	6.96	19.4
11/16/93	X	X	2.4	0.33	0.25	72	20 to 25	8.02	1		23		22.5		25.9	1	40	Y	N	5.52	17.1
11/17/93	X	X	2.4	0.39	0.25	72	20 to 25	8.05	1.17		14		18.5		20	1	40	Y	N	5.53	18.8
11/18/93	X	X	2.4	0.35	0.25	72	20 to 25	8.05	1.06		14		18.5		20	1	40	Y	N	6.24	18.6
11/3/93	X	X	2.3	0.69	0.17	72	20 to 25	6.8	2.07		34		24.7		29.3	2	15	N	N	6.73	19.6
11/3/93	X	X	2.3	0.57	0.17	72	20 to 25	6.8	1.72		21		13.5		15	2	15	N	N	6.59	20.3
11/4/93	X	X		0.55	0.17	72	20 to 25	7	1.65		35		19.7		23.8	2	15	N	N	7.09	19.5
11/4/93	X	X		0.69	0.17	72	20 to 25	6.48	2.07		11		13.5		15	2	45	N	N	6.3	19.3
11/15/93	X	X		0.36	0.25	72	20 to 25	5.61	1.07		18		15.4		16.9	2	30	Y	N	5.48	16.9
11/15/93	X	X		0.35	0.25	72	20 to 25	5.68	1.05		23		16.5		20.3	2	40	Y	N	5.49	18.6
11/16/93	X	X		0.35	0.25	72	20 to 25	5.67	1.05		20		13.5		15	2	30	Y	N	5.6	17.2
2/15/94	X	X	2	0.67	0.08	72	20 to 25	6.4	2		45		33.2		39.2	2	37	N	N	6.3	12.9
4/25/94	X	X	2	0.39	0.25	72	20 to 25	6.71	1.16		66		18.6		20.3	2	22	N	N	6.60	17.5
4/27/94	X	X	2	0.32	0.50	72	20 to 25	6.78	0.97		74		20.4		23.7	2	23	N	N	6.77	17.1
4/28/94	X	X	2	0.33	0.50	72	20 to 25	6.77	1		78		16.8		22.1	2	23	N	N	6.84	16.5
5/2/94	X	X	2	0.33	0.50	72	20 to 25	6.71	0.99		79		23		24.5	2	23	N	N	6.76	17.4
5/16/94	X	X	2	0.33	0.25	72	20 to 25	7.06	1		82		23		28.6	2	23	N	N	7.08	17.3
5/16/94	X	X	2	0.31	0.50	72	20 to 25	7.06	0.93		70		23		28.6	2	23	N	N	7.08	17.3
5/16/94	X	X	2	0.18	1.00	72	20 to 25	7.06	0.54		75		23		28.8	2	23	N	N	7.08	17.3
5/16/94	X	X	2	0.10	2.00	72	20 to 25	7.06	0.3		80		25		28.7	2	23	N	N	7.08	17.3
5/17/94	X	X	2	0.27	0.50	72	20 to 25	7.28	0.82		86		21.3		25.1	2	23	N	N	7.39	18.9
5/19/94	X	X	2	0.28	0.50	72	20 to 25	7.00	0.85		85		24		25.5	2	23	N	N	7.14	18.7
5/24/94	X	X	2	0.24	0.50	72	20 to 25	6.99	0.72		73		20.4		24.5	2	28	N	N	6.99	19.9
3/1/94	X	X	2	0.38	0.25	72	20 to 25	6.23	1.15		43		13.5		15	2	43	N	N	6.54	15.1
3/1/94	X	X	2	0.33	0.50	72	20 to 25	6.23	1		38		15.2		19.1	2	43	N	N	6.54	15.1
3/1/94	X	X	2	0.27	1.00	72	20 to 25	6.23	0.8		38		15.2		16.7	2	43	N	N	6.54	15.1
3/1/94	X	X	2	0.22	2.00	72	20 to 25	6.23	0.65		39		18		22.3	2	43	N	N	6.54	15.1
6/13/94	X	X	2	0.30	0.25	72	20 to 25	7.10	0.89		55		25		30	2	30	N	N	7.07	19.7
6/14/94	X	X	2	0.29	0.50	72	20 to 25	7.32	0.87				31.3		40.7	2	30	N	N	7.37	20.5
6/15/94	X	X	2	0.25	0.50	72	20 to 25	7.45	0.74				28		35.3	2	30	N	N	7.16	19.6
6/18/94	X	X	2	0.17	0.50	72	20 to 25	6.55	0.51				63.9		93.7	2	32	N	N	6.62	19.6

Utility ID:		SCVWD	(ACWD, CCWD, EBMUD, MWD, SCVWD)
1. Study ID:		Pilot Study 93-94	(Optimization Study 9/95, etc.)
2. Source water:		South Bay Aqueduct - San luis Reservoir	(River, lake, groundwater, etc.)
3. Source water ID:		State and Federal Water Projects	(State Project water, blend of...., etc.)
		5. Describe level of study:	Bench-scale
		(indicate with an 'X') X	Pilot-scale
			Full-scale

WATER QUALITY DATA: CONVENTIONAL+OZONE

Date	Time	TOC (mg/L)				UV-254 (1/cm)				Alkalinity (mg/L as CaCO3)				Hardness (mg/L as CaCO3) Total				Bromide (µg/L)				Ammonia (mg NH3-N/L)				Chloride (mg Cl-/L)				TDS (mg/L)				
		Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw
5/11/93		3.51	2.59		2					68	44			110	110			170			110									236	254			11
5/18/93		3.58	2.37		1.64	0.027	0.034			62	49		41	105	110		107	160			140									234	233		220	10
5/25/93		5.86	3.09		2.17	0.041				79	58		52	130	130		130	230			190									270	282		290	8
2/15/94		4.42	2.66		1.73	0.215	0.293		0.026	83	50		57	116	115		115	160			100									219	230		233	7.37
3/1/94		5.57	2.99		2.27	0.262	0.023		0.029	70	44		43	113	113		113	170			140									235	248		242	9.66
3/14/94		3.09	2.18		1.67	0.114			0.023	70	53		56	107	107		107	200			130									243	245		249	1.429
4/25/94		4.6	3.06		2.32	0.181	0.209		0.033	81	59		59	124	124		124	650		550	370					70				272	283		284	5.94
4/25/94		4.6	3.06		1.55	0.181	0.208		0.023	81	59		56	124	124		124	650		550	320					70				272	283		284	5.94
5/16/94		3.97	3		2.24	0.142	0.218		0.031	95	79		79	129	129		129	454		480	320					50				241	245		246	5.57
5/16/94		3.97	3		1.85	0.142	0.218		0.025	95			74	129			129	460		480	330					50				241			246	5.57
6/13/94		3.2	2.17		1.69	0.121	0.123		0.028	77	59		56	115	115		115	560		360	390					71				263	267		269	4.5
6/13/94		3.2	2.17		1.32	0.121	0.123		0.021	77	59		56	115	115		115	560		360	370					71				263	267		269	4.5
	Bromate Data																																	
5/11/93		3.51	2.59		2					68	44			110	110			170			110									236				11
5/18/93		3.58	2.37		1.64	0.027	0.034			62	49		41	105	110		107	160			140									234			220	10
5/25/93		5.85	3.09		2.17	0.041				79	58		62	130	130		130	230			190									270			290	6
5/26/93		6.56	3.19			0.043				79	68		6.5	131				220												285			290	6
8/18/93		2.78	1.33			0.136	0.146			45	15			45												16				88.6			51	21
8/25/93		4.13								38	17			38	38			170								32				46.8				15
8/26/93		2.34	1.06			0.128	0.115			40	18		17	41	41											16				52.7			69	13
9/1/93		2.52	1.2			0.128	0.151			43	12		15	48	48			80	740							16				58.2			78	22.8
10/4/93		3.62	2.23			0.107	0.146			87	59		67	105	105		105	80	200				0.5			30				166			179	7.16
10/5/93		3.56	2.69			0.109	0.180			95	56		70	110	110		110	80	580				0.5			31				173			182	7.2
10/6/93		3.6	1.97			0.098	0.147			92	61		51	109	109		109	90					0.5			32				180			197	8.73
10/7/93		3.48	2.37			0.102	0.160			93	68		64	102	102		102	90	460				0.5			33				177			191	9.79
10/7/93		3.48				0.102				93	68		64	102	102		102	90	460				0.5			33				177			191	8.79
10/12/93		3.67				0.106				98	79		62	116	116		116	90	250				0.5			32				178			200	5.42
10/12/93		3.67	3.03			0.106	0.182			96	79		62	116	116		116	90	250				0.5			32				178			200	5.42
10/13/93		3.42	3.89			0.096	0.256			96	82		33	112	112		112	90	730				0.5			32				179			220	5.68
10/13/93		3.42	3.89			0.096	0.256			98	82		33	112	112		112	90	730				0.5			32				179			220	5.68
10/14/93		5.02	4.02			0.150	0.273			65	66		56	107	107		107	120	720							62				228			217	3.4
10/14/93		5.02	2.84			0.150	0.174			65	51		29	107	107		107	120	720							62				228			233	3.4
10/14/93		6.02				0.150				65	51		29	107	107		107	120	720							62				228			233	3.4
1/27/94										71	46		50	112	112		112	200												241			251	11.07
2/15/94		4.82	2.86		1.73	0.215	0.293			83	60		57	115	116		115	160			180									219			233	7.37
3/1/94		5.57	2.99		2.27	0.262	0.023			70	44		43	113	113		113	170			140									235			242	9.66
3/14/94		3.09	2.18		1.67	0.114				70	53		56	107	107		107	200			130									243			249	1.429
4/25/94		4.6	3.06		2.32	0.181	0.209			81	59		59	124	124		124	210	550		370					70				272			284	5.94
4/27/94		4.67	3.08			0.168	0.226			82	61		60	127	127		127	190	530		520					73				274			288	7.87
4/28/94		4.58	3.09			0.193	0.217			81	63		61	126	126		126	190	550		490					74				280			285	8.69
5/2/94		4.56	3.06			0.161	0.224			81	58		62	127	126		127	200	550		550					72				281			290	5.34
5/16/94		3.97	3		2.24	0.142	0.218			85	79		79	129	129		129	180	450		3					50				241			246	5.57
5/17/94		3.79	2.96			0.155	0.210			81	66		68	120	120		120	180	530		320					69				266			277	4.92
5/19/94		3.86	2.79			0.141	0.190			85	71		70	120	120		120	180	500							69				261			274	5.4
5/24/94		3.69	2.73			0.136	0.232			89	71		78	128	120		128	160	670		510					54				236			247	6.84
6/13/94		3.2	2.17		1.69	0.121	0.123			77	59		58	115	115		115	200	560		390					71				263			269	4.5
6/14/94		3.22	2.06			0.114	0.101			78	58		58	117	117		117	180	600		570									263			277	4.53
6/15/94		3.25	2.24			0.118	0.116			78	62		58	113	113		113	220	600		600					73				267			273	4.88
6/16/94		3.15	2.19			0.118	0.157			79	60		61	114	114		114	200	1000		1000					73				266			273	4.25

Utility ID:			
1. Study			
2. Source			
3. Source			
WATER			

Date	Turbidity (NTU)			pH ()				Temperature (deg. C)				Bromate (µg/L)				HPC (CFU/mL)				Chlorination conditions Filtered: Indicate disinfectant(s) used with an 'X'		Chlorine dose	Ammonia dose	Incububation time (h)		Incub. temp.	pH	Residual	T	
	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	chlorine	chloramine	(mg Cl2/L)	(mg NH3-N/L)	chlorine	chloramine	(deg. C)	()	(mg Cl2/L)	Raw	Settl.
5/11/93	2		0.08	7.8	6.43	6.43		20	19.2			2			1				3933	X	X	2.5	0.73	0.083	168	20-25	6.6	2.18		
5/18/93	1.7		0.1	7.8	6.56	6.56	6.56	21	21.5		21.8	11.6							108	X	X	2.5	0.66	0.083	168	20-26	6.66	1.97		
5/25/93	3			6.8	6.33	6.33		18.7	17.8			18.5			13.5				3100	X	X	2.5	0.73	0.083	168	20-27	6.41	2.2		
2/15/94	2.32		0.164	7.59	6.24	6.24	6.34	12.5	12.8		14.8	1			2	820			1900	X	X	2	0.49	0.083	168	20-28	6.34	1.46		
3/1/94	3.05		0.077	7.6	6.4	6.4	6.52	14.5	14.1		16.6	1			2	2100			1300	X	X	2	0.45	0.083	168	20-29	6.52	1.35		
3/14/94	1.499		0.087	7.28	6.76	6.76	6.58	12.9	14.2		18	2.2			2.6				2800	X	X	2	0.56	0.083	168	20-30	6.58	1.67		
4/25/94	2.02		0.05	7.87	6.69	6.69	6.92	16.9	17.2		17.9	2			2	81			570	X	X	2	0.50	0.083	168	20-31	6.92	1.49		
4/25/94	2.02		0.053	7.87	6.69	6.69	6.79	16.9	17.2		18.2	2			2	81			2100	X	X	2	0.47	0.083	168	20-32	6.79	1.42		
5/16/94	2.14		0.066	8.04	7.04	7.04	6.98	16.2	17.7		18.6	2.4			2.9	1500			1300	X	X	2	0.53	0.083	168	20-33	6.98	1.59		
5/16/94	2.14		0.067	8.04	7.04	7.04	6.9	16.2	17.7		18.4	2.4			2	1500			3100	X	X	2	0.51	0.083	168	20-34	6.9	1.52		
6/13/94	1.14		0.041	8.1	6.8	6.8	6.87	19	19.5		20.8	3.5			3.2	690			860	X	X	2	0.47	0.083	168	20-35	6.87	1.41		
6/13/94	1.14		0.029	8.1	6.8	6.8	6.97	19	19.5		21	3.5			2.4	690			3100	X	X	2	0.47	0.083	168	20-36	6.97	1.42		

Date	Turb. Settl.	Turb. Ozon.	Turb. Filt.	pH Raw	pH Settl.	pH Ozon.	pH Filt.	Temp. Raw	Temp. Settl.	Temp. Ozon.	Temp. Filt.	Bromate Raw	Bromate Settl.	Bromate Ozon.	Bromate Filt.
5/11/93	2		0.08	7.8	6.43	6.43		20	19.2		.			2	1
5/18/93	1.7		0.1	7.8	6.56	6.56	6.56	21	21.5		21.8			11.5	
5/25/93	3			6.8	6.33	6.33		18.7	17.8					16.5	13.5
5/26/93	4.2		0.28	6.8	6.8	6.8	6.49	17.3	16.7		18			23	
8/18/93	2		0.097	7.4	6.103	6.103	6.21	22.9	23.9		25.8				1
8/25/93	1.7		0.05	7.3	6.11	6.11		23	28.3						2.2
8/26/93	1.5		0.1	7.6	6.21	6.21	6.35	22.8	28.3		27.4				4.1
9/1/93	2		0.02	7.47	5.93	5.93	6.06	23.7	25		26.5				1
10/4/93	1.27		0.04	7.74	6.52	6.52	6.44	19	19.8		20.5				1
10/5/93	1.14		0.058	7.81	6.62	6.62	7	18.2	18.6		18.9				4.2
10/6/93	1.28		0.083	7.81	6.77	6.77	6.64	17.7	17.8		19.7				4.7
10/7/93	1.81		0.058	7.94	6.89	6.89	6.9	18.4	19.3		22				4.7
10/7/93	1.81		0.058	7.94	6.89	6.89	6.9	18.4	19.3		22				4.3
10/12/93	2.9		0.085	7.6	6.88	6.88	6.75	18.5	19		20.9				12.4
10/12/93	2.9		0.085	7.6	6.88	6.88	6.75	18.5	19		20.9				1
10/13/93	2.18		0.128	7.93	7.16	7.16	6.1	18.8	19.4		20				1
10/13/93	2.18		0.128	7.93	7.16	7.16	6.1	18.8	19.4		20				1
10/14/93	3.4		0.26	7	7	7	6.53	18	19		20.3				9.1
10/14/93	1.34		0.09	7	6.67	6.67	6.15	19	18.2		20.2				6.4
10/14/93	1.34		0.09	7	6.67	6.67	6.16	19	19.2		20.2				2.7
1/27/94	3.36		0.415	7.15	6.28	6.28	6.33	11.9	13		15.4				2
2/15/94	2.32		0.164	7.99	6.24	6.24	6.34	12.5	12.8		14.8			1	2
3/1/94	3.05		0.077	7.6	6.4	6.4	6.52	14.5	14.1		16.6			1	2
3/14/94	1.499		0.087	7.28	6.76	6.76	6.58	12.9	14.2		18			2.2	2.6
4/25/94	2.02		0.05	7.87	6.69	6.69	6.92	16.9	17.2		17.9			2	2
4/27/94	2.73		0.056	7.64	6.89	6.89	6.89	17.1	17.1		18.5			2	2
4/28/94	2.72		0.071	7.6	6.91	6.91	6.84	16	16.8		18.3			2	2
5/2/94	1.89		0.074	8.13	6.74	6.74	6.8	17.6	17.4		18.5			2	2
5/16/94	2.14		0.066	8.04	7.04	7.04	6.98	16.2	17.7		18.6			2.4	2.9
5/17/94	1.79		0.054	8.71	7.16	7.16	7.12	18.5	18.9		19.6			2.7	2.8
5/19/94	2.16		0.058	8.56	7.12	7.12	6.99	18.5	18.4		19.7			2.1	2.1
5/24/94	2.04		0.056	8.12	6.83	6.83	6.87	16.8	19.3		20.9			2	2
6/13/94	1.14		0.041	8.1	6.8	6.8	6.87	19	19.5		20.8			3.5	3.2
6/14/94	1.94		0.044	8.29	7	7	6.92	19.9	20.1		21.9			4	3.2
6/15/94	0.97		0.037	8.2	6.79	6.79	7.04	18.2	18.8		20.5			2.2	2.1
6/16/94	1.58		0.032	7.98	6.93	6.83	6.97	17.3	18.6		20.4			2.9	2.6

Utility ID:

1. Study

2. Source

3. Source

Indicate coagulants studied:

ID	Coagulant	Chemical formula	Units
1	Alum	Al2(SO4)3	mg/L
2	Ferric Chlo.	FeCl3	mg/L
3			
4			

WATER

TREATMENT CONDITIONS

Date	Disinfection By-products														Coagulation Conditions						Ozonation Conditions				
	/L)		HAA5 (µg/L)				HAA6 (µg/L)				TOX (µg Cl-/L)				Coagulant ID (see above)	Dose	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)	Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min)	Ozone pH ()	Ozone temp. (deg. C)
	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.	Raw	Settl.	Ozon.	Filt.											
5/11/93		12				60.3				61.8					2	20	N		6.43	19.2	1.6	0.7	12	6.4	19.2
5/18/93		7				18				17.6					2	20	N		6.56	21.5	2.1	1.3	12	6.56	21.5
5/25/93		11				25				37					2	30	N		6.33	17.8	3.4	1.33	12	6.22	19.7
2/15/94		23				15.2				16.7					2	30	N		6.24	12.8	1.2	0.28	12	6.24	13.3
3/1/94		20				13.5				15					2	30	N		6.4	14.1	0.9	0.12	12	6.36	15.7
3/14/94		14				13.5				15					2	22	N		6.78	14.2	0.9	0.15	12	6.51	18.8
4/25/94		48				17.4				18.9					2	20	N		6.69	17.2	0.7	0.15	12	6.7	17.3
4/25/94		30				15.2				16.7					2	20	N		6.69	17.2	0.7	0.15	12	6.7	17.3
5/16/94		30				17.9				19.4					2	20	N		7.04	17.7	0.9	0.18	12	7.04	17.7
5/16/94		29				15.9				17.4					2	20	N		7.04	17.7	0.9	0.16	12	7.04	17.7
6/13/94		28				17.4				18.9					2	20	N		6.8	19.5	0.9	0.18	12	6.91	19.6
6/13/94		42				15.7				17.2					2	20			6.8	19.5	0.8	0.18	12	6.91	19.6
5/11/93																					1.6	0.7	12	6.4	19.2
5/18/93																					2.1	1.3	12	6.56	21.5
5/25/93																					3.4	1.33	12	6.22	19.7
5/26/93																					4	1.06	12	6.8	16.7
8/18/93																					0.7	0.16	12	6.21	25.8
8/25/93																					1.6	0.27	12	6.3	23
8/26/93																					2.7	1.13	12	6.1	26.8
9/1/93																					0.8	0.26	12	5.96	25.1
10/4/93																					0.8	0.22	12	6.48	19.8
10/5/93																					1.7	0.74	12		
10/6/93																					2.7	1.65	12		
10/7/93																					0.8	0.16	12	6.9	20
10/7/93																					1.7	0.83	12		
10/12/93																					2.7	1.35	12	6.99	19.8
10/12/93																					0.7	0.2	12		
10/13/93																					1.6	0.78	12	6.05	19.7
10/13/93																					2.6	1.31	12	5.98	19.3
10/14/93																					2.2	0.63	12		
10/14/93																					2.8	1.28	12		
10/14/93																					2.2	0.63	12		
1/27/94																					1	0.23	12	6.28	13
2/15/94																					1.2	0.28	12	6.24	13.3
3/1/94																					0.9	0.12	12	6.36	15.7
3/14/94																					0.9	0.15	12	6.51	18.8
4/25/94																					0.7	0.15	12	6.7	17.3
4/27/94																					1	0.2	12	6.84	18
4/28/94																					1	0.25	12	6.94	16.9
5/2/94																					1	0.18	12	6.8	18.5
5/16/94																					0.9	0.16	12	7.04	17.7
5/17/94																					1.05	0.26	12	7.12	16.7
5/19/94																					1.05	0.27	12	7.05	19
5/24/94																					0.9	0.18	12	6.8	19.8
6/13/94																					0.9	0.18	12	6.91	19.6
6/14/94																					0.9	0.24	12	7.06	19.1
6/15/94																					0.9	0.24	12	7	19
6/16/94																					0.9	0.19	12	7	18.4

Utility ID:		SCVWD		(ACWD, CCWD, EBMUD, MWD, SCVWD)			
1. Study ID:		Pilot Study		(Optimization Study 9/95, etc.)			
2. Source water:		South Bay Aqueduct - San Luis Reservoir		(River, lake, groundwater, etc.)			
3. Source water ID:		State and Federal Water Projects		(State Project water, blend of...., etc.)			
5. Describe level of study:			Bench-scale	In this data sheet, "Filt." refers to data collected			
(indicate with an 'X')		X	Pilot-scale	after coagulation, flocculation, sedimentation, and			
			Full-scale	filtration.			
6. Indicate with an 'X' if data reported as "Filt." are from samples collected after sedimentation only:							
			or after sedimentation and filtration:			X	

WATER QUALITY DATA: PRE-OZONE

Date	Time	TOC (mg/L) Raw	TOC Ozon.	TOC Filt.	UV-254 (1/cm) Raw	UV-254 Ozon.	UV-254 Filt.	Alkalinity (mg/L as CaCO3) Raw	Alkalinity Ozon.	Alkalinity Filt.	Hardness (mg/L as CaCO3) Total Raw	Hardness Total Ozon	Hardness Total Filt.	Bromide (mg/L) Raw	Bromide Ozon.	Bromide Filt.	Ammonia (mg NH3-N/L) Raw	Ammonia Ozon.	Ammonia Filt.	Chloride (mg Cl-/L) Raw	Chloride Ozon.	Chloride Filt.	TDS (mg/L) Raw	TDS Ozon.	TDS Filt.	Turbidity (NTU) Raw	Turbidity Ozon.	Turbidity Filt.	pH () Raw	pH Ozon.	pH Filt.	Tempera (deg. Raw	Tempera Ozon.
5/11/93		3.51		2.13				68			110			0.17		0.16							236			11		0.05	7.8	7.8	6.64	20	20
5/18/93		3.58		1.85				62		48	105		108	0.16		0.16							234		220	10		0.05	7.8	7.8	6.66	21	21
5/25/93		5.86		2.97				79		52	130		131	0.23		0.22							270		292	6			6.8	6.8		18.7	18.1
11/17/93		3.05		2.06	0.118		0.029	62		69	105		105	0.22		0.23				71			238		282	10.13		0.074	7.42		7.86	16.4	
1/4/94		3.44		1.91	0.120		0.028	64		53	103		103	0.23		0.14							235		223	2.9		0.17	7.7		6.7	13.5	
1/5/94		3.27		1.83	0.119		0.030	69		47	102		102	0.89									236		243	2.46		0.092	7.48		6.75	12.8	
1/5/94		3.27		1.09	0.119		0.018	69		56	102			0.89		0.88							236		243	2.46		0.085	7.48		6.61	12.8	
2/15/94		4.82		2.05	0.215		0.033	83			115		115	0.16		0.12							219			7.37			7.59	7.02		12.5	12.5
3/1/94		5.57		2.46	0.262		0.032	70		42	113		113	0.17		0.14							235		248	9.66		0.134	7.6	7.15	6.48	14.5	14.1
3/14/94		3.09		1.49	0.114		0.018	70		53	107		107	0.2		0.14							243		250	1.429		0.083	7.28	7.23	6.43	12.9	14.3
4/25/94		4.6		2.19	0.181		0.027	81		59	124		124	0.55	0.55	0.37				70			272		283	5.94		0.047	7.87	7.16	6.59	16.9	17
4/25/94		4.6		1.39	0.181		0.022	81		51	124		124	0.55	0.56	0.31				70			272		286	5.94		0.071	7.87	7.16	6.53	16.9	17
5/16/94		3.87		2.1	0.142		0.028	95		75	129		129	0.45	0.46	0.32				50			241		247	5.57		0.071	8.04	7.85	6.85	16.2	17.2
5/16/94		3.97		1.79	0.142		0.023	95		7	129		129	0.45	0.46	0.24				60			241		248	5.57		0.069	8.04	7.85	6.6	16.2	17.2
	Bromate Data																																
5/11/93		3.51		2.13				68			110			170		180							236			11		0.05	7.8	20	7.87	20	
5/13/93		4.17			0.028			70			113			170									241			11		0.06	7.8	20	6.3	20	
5/18/93		3.58		1.85				62		48	105		108	160		160							234		220	10		0.05	7.8	21	6.08	21	
5/19/93		3.55						63		37	111			180									233			9		0.09	7.3		6.03	22	
5/25/93		5.86		2.97				79		52	130		131	230		220							270		292	6			6.8	16.1		18.7	
5/26/93		6.56			0.043			70		5.3	131			220									285		298	6		0.1	6.8	16.2	6.7	17.3	
8/18/93		2.78			0.136			45			45									16			88.8		53	21		0.178	7.4	23.8	5.3	22.9	
8/25/93		4.13						38			38			170		140				32			46.8			15		0.05	7.3	21.5		23	
8/26/93		2.34			0.128			40		5	41			100		110				16			52.7		68.2	13		0.041	7.6	24.6	5.44	22.5	
9/1/93		2.52			0.120			43		18	48			740		530				18			58.2		66	22.6		0.02	7.47	23.7	6.07	23.7	
10/4/93		3.62			0.107			87			105			200		180		0.6		30			166		184	7.16		0.069	7.74	20	6.34	19	
10/5/93		3.56			0.109			85		54	110		110	880		540		0.5		31			173		186	7.2		0.075	7.61	18.8	6.6	18.2	
10/7/93		3.48			0.102			93		60	102		102	460		0.46		0.5		33			177		197	9.79		0.052	7.94	19.6	6.5	18.4	
10/12/93		3.67			0.106			96		22	116		116	260		250		0.5		32			178		204	5.42		0.063	7.8	18.6	5.7	18.5	
11/17/93		3.05		2.06	0.118			62		69	105		105	220		230				71			238		282	10.13		0.074	7.42		7.86	16.4	
12/8/93		3.27		1.95	0.115			66		85	103		103			180				69			244		252	1.6		0.06	7.5	16.8	6.68	16	
1/4/94		3.44		1.91	0.120			64		53	103		103	230		140							235		223	2.9		0.17	7.7		6.7	13.5	
1/5/94		3.27		1.83	0.119			69		47	102		102	690									236		243	2.46		0.092	7.48		6.75	12.8	
1/5/94		3.27		1.09	0.119			69		58	102			890		680							236		243	2.46		0.085	7.48		6.61	12.8	
1/27/94								71		45	112		112	200									241		248	11.07		0.202	7.15	12.3	6.25	11.9	
2/15/94		4.82		2.05	0.215			83			115		115	180		120							219			7.37			7.59	12.5		12.5	
3/1/94		5.57		2.46	0.262			70		42	113		113	170		140							235		248	9.66		0.134	7.6	14.1	6.46	14.5	
3/14/94		3.09		1.49	0.114			70		53	107		107	200		140							243		250	1.429		0.083	7.28	14.3	6.43	12.9	
4/25/94		4.6		2.19	0.181			81		59	124		124	550	650	370				70			272		283	5.94		0.047	7.87	17	6.59	16.9	
4/25/94		4.6		1.39	0.181			61		51	124		124	550	550	310				70			272		286	5.94		0.071	7.87	17	6.53	16.9	
4/27/94		4.67			0.168			62		58	127		127	530	540	430				73			274		287	7.97		0.056	7.64	16.9	6.77	17.1	
4/27/94		4.67			0.168			62		50	127		127	530	540	470				73			274		290	7.97		0.06	7.64	16.9	6.6	17.1	
4/28/94		4.58			0.193			61		57	126		126	550	550	533				74			280		281	6.69		0.076	7.5	16.4	6.78	16	
4/28/94		4.58			0.193			61		61	126		126	550	550	420				74			280		286	6.69		0.06	7.5	16.4	6.77	16	
5/2/94		4.58			0.161			61		63	127		127	560	570	570				72			281		289	5.34		0.081	8.13		6.67	17.6	
5/2/94		4.58			0.161			61		60	127		127	560	570	480				72			281		288	5.34		0.080	8.13		6.6	17.6	
5/16/94		3.97		2.1	0.142			95		75	129		129	450	460	0.32				50			241		247	5.57		0.071	8.04	17.2	6.85	16.2	
5/16/94		3.97		1.79	0.142			95		7	129		129	450	460	0.24				50			241		248	5.57		0.069	8.04	17.2	6.6	16.2	
5/17/94		3.79			0.155			81		61	120		120	530	560	0.52				69			266		277	4.92		0.042	8.71	18.3	6.97	18.5	
5/17/94		3.79			0.155			81		62	120		120	530	560	0.47				69			266		277	4.92		0.053	8.71	18.3	7.03	18.5	
5/19/94		3.88			0.141			85		71	120		120	500						69			281		271	5.4		0.092	8.56	18.7	7.05	18.5	
5/19/94		3.88			0.141			85		70	120		120	500						69			281		271	5.4		0.089	8.56	18.7	6.98	18.5	
5/24/94		3.89			0.136			89		75	128		128	670	550	0.5				54			236		246	6.84		0.051	8.12	19	6.82	16.8	
5/24/94		3.89			0.136			89		75	128		128	670	550	0.43				54			236		247	6.84		0.054	8.12	19	6.89	16.8	

Utility ID:

1. Study ID:

2. Source wa

3. Source wa

5. Describe t
(indicate wi

6. Indicate w

Indicate coagulants stu	
ID	Coagulant
1	Alum
2	Ferric Chlo.
3	
4	

WATER Q

TREATMENT COND

Date	re Filt.	Bromate (µg/L) Raw	Bromate (µg/L) Ozon.	Bromate (µg/L) Filt.	HPC (CFU/mL) Raw	HPC (CFU/mL) Ozon.	HPC (CFU/mL) Filt.	Chlorination conditions, Filtered: Indicate disinfectant(s) used with an "X" chlorine	Indicate disinfectant(s) used with an "X" chloramine	Chlorine dose (mg Cl2/L)	Ammonia dose (mg NH3-N/L)	Incubation time (h) chlorine	Incubation time (h) chloramine	Incub. temp. (deg. C)	pH ()	Residual (mg Cl2/L)	Disinfection By-products: TTHM (µg/L) Raw	TTHM Ozon.	TTHM Filt.	HAA5 (µg/L) Raw	HAA5 Ozon.	HAA5 Filt.	HAA6 (µg/L) Raw	HAA6 Ozon.	HAA6 Filt.	Coagulant ID (see above)	Coagu Dose
5/11/93	21.5		4.1	5.3			13851	X	X	2.5	0.67	0.083	168	20-25	6.94	2.01			19			21.01			40.01	2	20
5/18/93	22.2		16.3	13.5			192	X	X	2.5	0.69	0.083	168	20-25	6.84	2.07			9			11.07			20.07	2	20
5/25/93			18.7	13.3			5700	X	X	2.5	0.70	0.083	168	20-25	6.4	2.1			16			16.1			34.1	2	30
11/17/93	17.8			13.7				X	X		0.00	0.000	168	20-25	6	0			1			1			2	2	25
1/4/94	16.1			5.8			1400	X	X		0.33	0.083	168	20-25	6.7	1						1			1	2	15
1/5/94	15.5			14.5			15390	X	X		0.33	0.083	168	20-25	6.8	1			56.5			57.6			114	2	
1/5/94	15.5			14.4			14250	X	X		0.33	0.083	168	20-25	6.7	1			38.5			39.5			78	2	
2/15/94			2.4	5.3	620		5700	X	X	2	0.50	0.083	168	20-25	6.3	1.6			23			24.5			47.5	2	30
3/1/94	16.7		2	2.4	2100		1900	X	X	2	0.78	0.083	168	20-25	6.48	2.35			23			25.35			48.35	2	40
3/14/94	20.2		7.5	6.6			4200	X	X	2	0.53	0.083	168	20-25	6.43	1.6			21			22.6			43.6	2	26
4/25/94	17.6		10.5	9.64	61		860	X	X	2	0.52	0.083	168	20-25	6.59	1.55			46			47.55			93.55	2	21.5
4/25/94	17.5		10.5	6	81		3100	X	X	2	0.43	0.083	168	20-25	6.53	1.3			30			31.3			61.3	2	21.5
5/16/94	18.7		16.5	13.6	1500		1900	X	X	2	0.51	0.083	168	20-25	6.85	1.52			37			38.52			75.52	2	21
5/18/94	18.2		16.5	7.1	1500		2400	X	X	2	0.62	0.083	168	20-25	6.6	1.55			32			33.55			65.55	2	21

Date	re Filt.	Bromate Raw	Bromate Ozon.	Bromate Filt.	Coagulant ID	Dose
5/11/93	21.5		4.1	5.3	2	20
5/13/93	20		12.1		2	20
5/18/93	22.2		16.3	13.5	2	20
5/19/93	22.9		20		2	20
5/25/93			18.7	13.3	2	30
5/26/93	17.3		18		2	5.3
8/18/93	24.9			1	2	20
8/25/93				4.2	2	10
8/20/93	27.5			3.8	2	10
9/1/93	28.5			13.8	2	20
10/4/93	19.7			2.4	2	20
10/5/93	19.5			11.1	2	20
10/7/93	20.9			12	2	20
10/12/93	20.7			1	2	20
11/17/93	17.8			13.7	2	25
12/6/93	17.4			69.7	2	15
1/4/94	16.1			5.8	2	15
1/5/94	15.5			14.5	2	
1/5/94	15.5			14.4	2	
1/27/94	15			3.3	2	25
2/15/94			2.4	5.3	2	30
3/1/94	16.7		2	2.4	2	40
3/14/94	20.2		7.5	6.6	2	26
4/25/94	17.6		10.5	9.64	2	21.5
4/25/94	17.5		10.5	6	2	21.5
4/27/94	18.3		8.8	8.9	2	21
4/27/94	18.4		8.6	6.2	2	21
4/28/94	18.1		7.8	6.5	2	22
4/28/94	18.2		7.8	3.3	2	22
5/2/94	18.8		5.4	5	2	22
5/2/94	18.7		5.4	2	2	22
5/16/94	18.7		16.5	13.6	2	21
5/16/94	18.2		16.5	7.1	2	21
5/17/94	19.5		8.3	4.3	2	21
5/17/94	19.5		8.3	3.3	2	21
5/19/94	19.7		20.4	16.8	2	21
5/19/94	19.6		20.4	17.5	2	21
5/24/94	20.9		7.3	6.1	2	25
5/24/94	20.6		7.3	3.1	2	25

Utility ID:									
1. Study ID:									
2. Source wa									
3. Source wa									
	ed:								
5. Describe t	Chemical formula		Units						
(Indicate wit	Al2(SO4)3		mg/L						
	FeCl3		mg/L						
6. Indicate w									
WATER Q	IONS								

Date	tion Conditions				Ozonation Conditions				
	Acid adjusted? (Y/N)	Base adjusted? (Y/N)	Coag. pH ()	Coag. temp. (deg. C)	Ozone dose (mg/L)	Ozone residual (mg/L)	Contact time (min)	Ozone pH ()	Ozone temp. (deg. C)
5/11/93			6.64	19.7	3	0.43		7.8	20
5/18/93			6.73	22.2	4	0.52		7.8	21
5/25/93					5.3	0.71	18.36	6.8	18.1
11/17/93			7.68	17.7	3	0.43	12.24		
1/4/94			7.15	14.5	1.5	0.18	12.24		
1/5/94			6.78	14.2			12.24		
1/5/94			6.72	14.4	1.8	0.36	12.24		
2/15/94			6.3	12.7	3.1	0.32	12.24	7.02	12.5
3/1/94			6.36	15.2	3.4	0.48	12.24	7.15	14.1
3/14/94			6.51	15.7	2.3	0.45	12.24	7.23	14.3
4/25/94			6.63	17.3	3.5	0.57	12.24	7.18	17
4/25/94			6.63	17.3	3.5	0.57	12.24	7.18	17
5/16/94			7	17.5	2.5	0.4	12.24	7.85	17.2
5/16/94			7	17.5	2.5	0.4	12.24	7.85	17.2
5/11/93			6.64	19.7	3	0.43	18.36	7.8	20
5/13/93			6.29	20	3.1	0.65	18.36	6.5	20
5/18/93			6.73	22.2	4	0.52	18.36	7.8	21
5/19/93			6.04	23	4.7	1.3	12.24		
5/25/93					5.3	0.71	18.36	6.8	18.1
5/26/93			6.65	17.2	6.5	0.45	18.36	7	16.2
8/18/93			5.43	24.5	1.9	0.3	12.24	5.94	23.8
8/25/93			5.4	25.9	2.8	0.45	12.24	6.3	21.5
8/26/93			4.21	28.1	3.8	1.31	12.24	5.85	24.8
9/1/93			6.32	25.4	2.4	0.48	12.24	7.47	23.7
10/4/93			6.45	19.8	1.6	0.24	12.24	6.45	20
10/5/93			6.56	19.2	1.5	0.23	18.36	7.04	18.8
10/7/93			5.67	19.8	3.1	1.07	12.24	6.99	19.6
10/12/93			5.52	18.9	1.2	0.12	12.24	6.01	18.6
11/17/93			7.68	17.7	3	0.43	12.24		
12/6/93			6.6	17	5	1.29	12.24	7.56	16.6
1/4/94			7.15	14.5	1.5	0.18	12.24		
1/5/94			6.78	14.2			12.24		
1/5/94			6.72	14.4	1.8	0.36			
1/27/94			6.16	13.4	3.2	0.47	12.24	7.18	12.3
2/15/94			6.3	12.7	3.1	0.32		7.02	12.8
3/1/94			6.36	15.2	3.4	0.48	12.24	7.15	14.1
3/14/94			6.51	15.7	2.3	0.45	12.24	7.23	14.3
4/25/94			6.63	17.3	3.6	0.67	12.24	7.18	17
4/25/94			6.63	17.3	3.5	0.57	12.24	7.18	17
4/27/94			6.82	17.1	4.85	0.5	12.24	7.32	16.9
4/27/94			6.82	17.1	4.85	0.5	12.24	7.32	16.9
4/28/94			6.85	17	3	0.62	12.24	7.63	19.4
4/28/94			6.85	17	3	0.62	12.24	7.63	19.4
5/2/94			6.65	18.1	2.9	0.27	12.24		
5/2/94			6.65	18.1	2.9	0.27	12.24		
5/16/94			7	17.5	2.5	0.4		7.85	17.2
5/16/94			7	17.5	2.5	0.4	12.24	7.85	17.2
5/17/94			18.6	6.97	2.5	0.36	12.24	8.4	18.3
5/17/94			18.6	6.97	2.5	0.36	12.24	8.4	18.3
5/19/94			7.19	19.1	2.6	0.27	12.24	8.35	18.7
5/19/94			7.19	19.1	2.6	0.27	12.24	8.35	18.7
5/24/94			6.88	19.8	2.2	0.27	12.24	7.5	19
5/24/94			6.88	19.8	2.2	0.27	12.24	7.5	19
							12.24		

<u>Recycled Water Policy</u>

1. *Preamble*

California is facing an unprecedented water crisis.

The collapse of the Bay-Delta ecosystem, climate change, and continuing population growth have combined with a severe drought on the Colorado River and failing levees in the Delta to create a new reality that challenges California's ability to provide the clean water needed for a healthy environment, a healthy population and a healthy economy, both now and in the future.

These challenges also present an unparalleled opportunity for California to move aggressively towards a sustainable water future. The State Water Resources Control Board (State Water Board) declares that we will achieve our mission to "preserve, enhance and restore the quality of California's water resources to the benefit of present and future generations." To achieve that mission, we support and encourage every region in California to develop a salt/nutrient management plan by 2014 that is sustainable on a long-term basis and that provides California with clean, abundant water. These plans shall be consistent with the Department of Water Resources' Bulletin 160, as appropriate, and shall be locally developed, locally controlled and recognize the variability of California's water supplies and the diversity of its waterways. We strongly encourage local and regional water agencies to move toward clean, abundant, local water for California by emphasizing appropriate water recycling, water conservation, and maintenance of supply infrastructure and the use of stormwater (including dry-weather urban runoff) in these plans; these sources of supply are drought-proof, reliable, and minimize our carbon footprint and can be sustained over the long-term.

We declare our independence from relying on the vagaries of annual precipitation and move towards sustainable management of surface waters and groundwater, together with enhanced water conservation, water reuse and the use of stormwater. To this end, we adopt the following goals for California:

- Increase the use of recycled water over 2002 levels by at least one million acre-feet per year (afy) by 2020 and by at least two million afy by 2030.
- Increase the use of stormwater over use in 2007 by at least 500,000 afy by 2020 and by at least one million afy by 2030.
- Increase the amount of water conserved in urban and industrial uses by comparison to 2007 by at least 20 percent by 2020.
- Included in these goals is the substitution of as much recycled water for potable water as possible by 2030.

The purpose of this Policy is to increase the use of recycled water from municipal wastewater sources that meets the definition in Water Code section 13050(n), in a manner that implements state and federal water quality laws. The State Water Board expects to develop additional policies to encourage the use of stormwater, encourage water conservation, encourage the conjunctive use of surface and groundwater, and improve the use of local water supplies.

When used in compliance with this Policy, Title 22 and all applicable state and federal water quality laws, the State Water Board finds that recycled water is safe for approved uses, and strongly supports recycled water as a safe alternative to potable water for such approved uses.

2. *Purpose of the Policy*

a. The purpose of this Policy is to provide direction to the Regional Water Quality Control Boards (Regional Water Boards), proponents of recycled water projects, and the public regarding the appropriate criteria to be used by the State Water Board and the Regional Water Boards in issuing permits for recycled water projects.

b. It is the intent of the State Water Board that all elements of this Policy are to be interpreted in a manner that fully implements state and federal water quality laws and regulations in order to enhance the environment and put the waters of the state to the fullest use of which they are capable.

c. This Policy describes permitting criteria that are intended to streamline the permitting of the vast majority of recycled water projects. The intent of this streamlined permit process is to expedite the implementation of recycled water projects in a manner that implements state and federal water quality laws while allowing the Regional Water Boards to focus their limited resources on projects that require substantial regulatory review due to unique site-specific conditions.

d. By prescribing permitting criteria that apply to the vast majority of recycled water projects, it is the State Water Board's intent to maximize consistency in the permitting of recycled water projects in California while also reserving to the Regional Water Boards sufficient authority and flexibility to address site-specific conditions.

e. The State Water Board will establish additional policies that are intended to assist the State of California in meeting the goals established in the preamble to this Policy for water conservation and the use of stormwater.

f. For purposes of this Policy, the term "permit" means an order adopted by a Regional Water Board or the State Water Board prescribing requirements for a recycled water project, including but not limited to water recycling requirements, master reclamation permits, and waste discharge requirements.

3. *Benefits of Recycled Water*

The State Water Board finds that the use of recycled water in accordance with this Policy, that is, which supports the sustainable use of groundwater and/or surface water, which is sufficiently treated so as not to adversely impact public health or the environment and which ideally substitutes for use of potable water, is presumed to have a beneficial impact. Other public agencies are encouraged to use this presumption in evaluating the impacts of recycled water projects on the environment as required by the California Environmental Quality Act (CEQA).

4. *Mandate for the Use of Recycled Water*

a. The State Water Board and Regional Water Boards will exercise the authority granted to them by the Legislature to the fullest extent possible to encourage the use of recycled water, consistent with state and federal water quality laws.

(1) The State Water Board hereby establishes a mandate to increase the use of recycled water in California by 200,000 afy by 2020 and by an additional 300,000 afy by 2030. These mandates shall be achieved through the cooperation and collaboration of the State Water Board, the Regional Water Boards, the environmental community, water purveyors and the operators of publicly owned treatment works. The State Water Board will evaluate progress toward these mandates biennially and review and revise as necessary the implementation provisions of this Policy in 2012 and 2016.

(2) Agencies producing recycled water that is available for reuse and not being put to beneficial use shall make that recycled water available to water purveyors for reuse on reasonable terms and conditions. Such terms and conditions may include payment by the water purveyor of a fair and reasonable share of the cost of the recycled water supply and facilities.

(3) The State Water Board hereby declares that, pursuant to Water Code sections 13550 *et seq*., it is a waste and unreasonable use of water for water agencies not to use recycled water when recycled water of adequate quality is available and is not being put to beneficial use, subject to the conditions established in sections 13550 *et seq*. The State Water Board shall exercise its authority pursuant to Water Code section 275 to the fullest extent possible to enforce the mandates of this subparagraph.

b. These mandates are contingent on the availability of sufficient capital funding for the construction of recycled water projects from private, local, state, and federal sources and assume that the Regional Water Boards will effectively implement regulatory streamlining in accordance with this Policy.

c. The water industry and the environmental community have agreed jointly to advocate for $1 billion in state and federal funds over the next five years to fund projects needed to meet the goals and mandates for the use of recycled water established in this Policy.

d. The State Water Board requests the California Department of Public Health (CDPH), the California Public Utilities Commission (CPUC), and the California Department of Water Resources (CDWR) to use their respective authorities to the fullest extent practicable to assist the State Water Board and the Regional Water Boards in increasing the use of recycled water in California.

5. *Roles of the State Water Board, Regional Water Boards, CDPH and CDWR*

The State Water Board recognizes that it shares jurisdiction over the use of recycled water with the Regional Water Boards and with CDPH. In addition, the State Water Board recognizes that CDWR and the CPUC have important roles to play in encouraging the use of recycled water. The State Water Board believes that it is important to clarify the respective roles of each of these agencies in connection with recycled water projects, as follows:

a. The State Water Board establishes general policies governing the permitting of recycled water projects consistent with its role of protecting water quality and sustaining water supplies. The State Water Board exercises general oversight over recycled water projects, including review of Regional Water Board permitting practices, and shall lead the effort to meet the recycled water use goals set forth in the Preamble to this Policy. The State Water Board is also charged by statute with developing a general permit for irrigation uses of recycled water.

b. The CDPH is charged with protection of public health and drinking water supplies and with the development of uniform water recycling criteria appropriate to particular uses of water. Regional Water Boards shall appropriately rely on the expertise of CDPH for the establishment of permit conditions needed to protect human health.

c. The Regional Water Boards are charged with protection of surface and groundwater resources and with the issuance of permits that implement CDPH recommendations, this Policy, and applicable law and will, pursuant to paragraph 4 of this Policy, use their authority to the fullest extent possible to encourage the use of recycled water.

d. CDWR is charged with reviewing and, every five years, updating the California Water Plan, including evaluating the quantity of recycled water presently being used and planning for the potential for future uses of recycled water. In undertaking these tasks, CDWR may appropriately rely on urban water management plans and may share the data from those plans with the State Water Board and the Regional Water Boards. CDWR also shares with the State Water Board the authority to allocate and distribute bond funding, which can provide incentives for the use of recycled water.

e. The CPUC is charged with approving rates and terms of service for the use of recycled water by investor-owned utilities.

6. *Salt/Nutrient Management Plans*

a. *Introduction.*

(1) Some groundwater basins in the state contain salts and nutrients that exceed or threaten to exceed water quality objectives established in the applicable Water Quality Control Plans (Basin Plans), and not all Basin Plans include adequate implementation procedures for achieving or ensuring compliance with the water quality objectives for salt or nutrients. These conditions can be caused by natural soils/conditions, discharges of waste, irrigation using surface water, groundwater or recycled water and water supply augmentation using surface or recycled water. Regulation of recycled water alone will not address these conditions.

(2) It is the intent of this Policy that salts and nutrients from all sources be managed on a basin-wide or watershed-wide basis in a manner that ensures attainment of water quality objectives and protection of beneficial uses. The State Water Board finds that the appropriate way to address salt and nutrient issues is through the development of regional or subregional salt and nutrient management plans rather than through imposing requirements solely on individual recycled water projects.

b. *Adoption of Salt/ Nutrient Management Plans.*

(1) The State Water Board recognizes that, pursuant to the letter dated December 19, 2008 and attached to the Resolution adopting this Policy, the local water and wastewater entities, together with local salt/nutrient contributing stakeholders, will fund locally driven and controlled, collaborative processes open to all stakeholders that will prepare salt and nutrient management plans for each basin/sub-basin in California, including compliance with CEQA and participation by Regional Water Board staff.

(a) It is the intent of this Policy for every groundwater basin/sub-basin in California to have a consistent salt/nutrient management plan. The degree of specificity within these plans and the length of these plans will be dependent on a variety of site-specific factors, including but not limited to size and complexity of a basin, source water quality, stormwater recharge, hydrogeology, and aquifer water quality. It is also the intent of the State Water Board that because stormwater is typically lower in nutrients and salts and can augment local water supplies, inclusion of a significant stormwater use and recharge component within the salt/nutrient management plans is critical to the long-term sustainable use of water in California. Inclusion of stormwater recharge is consistent with State Water Board Resolution No. 2005-06, which establishes sustainability as a core value for State Water Board programs and also assists in implementing Resolution No. 2008-30, which requires sustainable water resources management and is consistent with Objective 3.2 of the State Water Board Strategic Plan Update dated September 2, 2008.

(b) Salt and nutrient plans shall be tailored to address the water quality concerns in each basin/sub-basin and may include constituents other than salt and nutrients that impact water quality in the basin/sub-basin. Such plans shall address and implement provisions, as appropriate, for all sources of salt and/or nutrients to groundwater basins, including recycled water irrigation projects and groundwater recharge reuse projects.

(c) Such plans may be developed or funded pursuant to the provisions of Water Code sections 10750 *et seq.* or other appropriate authority.

(d) Salt and nutrient plans shall be completed and proposed to the Regional Water Board within five years from the date of this Policy unless a Regional Water Board finds that the stakeholders are making substantial progress towards completion of a plan. In no case shall the period for the completion of a plan exceed seven years.

(e) The requirements of this paragraph shall not apply to areas that have already completed a Regional Water Board approved salt and nutrient plan for a basin, sub-basin, or other regional planning area that is functionally equivalent to paragraph 6(b)3.

(f) The plans may, depending upon the local situation, address constituents other than salt and nutrients that adversely affect groundwater quality.

(2) Within one year of the receipt of a proposed salt and nutrient management plan, the Regional Water Boards shall consider for adoption revised implementation plans, consistent with Water Code section 13242, for those groundwater basins within their regions where water quality objectives for salts or nutrients are being, or are threatening to be, exceeded. The implementation plans shall be based on the salt and nutrient plans required by this Policy.

(3) Each salt and nutrient management plan shall include the following components:

(a) A basin/sub-basin wide monitoring plan that includes an appropriate network of monitoring locations. The scale of the basin/sub-basin monitoring plan is dependent upon the site-specific conditions and shall be adequate to provide a reasonable, cost-effective means of determining whether the concentrations of salt, nutrients, and other constituents of concern as identified in the salt and nutrient plans are consistent with applicable water quality objectives. Salts, nutrients, and the constituents identified in paragraph 6(b)(1)(f) shall be monitored. The frequency of monitoring shall be determined in the salt/nutrient management plan and approved by the Regional Water Board pursuant to paragraph 6(b)(2).

(i) The monitoring plan must be designed to determine water quality in the basin. The plan must focus on basin water quality near water supply wells and areas proximate to large water recycling projects, particularly groundwater recharge projects. Also, monitoring locations shall, where appropriate, target groundwater and surface waters where groundwater has connectivity with adjacent surface waters.

(ii) The preferred approach to monitoring plan development is to collect samples from existing wells if feasible as long as the existing wells are located appropriately to determine water quality throughout the most critical areas of the basin.

(iii) The monitoring plan shall identify those stakeholders responsible for conducting, compiling, and reporting the monitoring data. The data shall be reported to the Regional Water Board at least every three years.

(b) A provision for annual monitoring of Emerging Constituents/ Constituents of Emerging Concern (e.g., endocrine disrupters, personal care products or pharmaceuticals) (CECs) consistent with recommendations by CDPH and consistent with any actions by the State Water Board taken pursuant to paragraph 10(b) of this Policy.

(c) Water recycling and stormwater recharge/use goals and objectives.

(d) Salt and nutrient source identification, basin/sub-basin assimilative capacity and loading estimates, together with fate and transport of salts and nutrients.

(e) Implementation measures to manage salt and nutrient loading in the basin on a sustainable basis.

(f) An antidegradation analysis demonstrating that the projects included within the plan will, collectively, satisfy the requirements of Resolution No. 68-16.

(4) Nothing in this Policy shall prevent stakeholders from developing a plan that is more protective of water quality than applicable standards in the Basin Plan. No Regional Water Board, however, shall seek to modify Basin Plan objectives without full compliance with the process for such modification as established by existing law.

7. *Landscape Irrigation Projects*

a. *Control of incidental runoff.* Incidental runoff is defined as unintended small amounts (volume) of runoff from recycled water use areas, such as unintended, minimal over-spray from sprinklers that escapes the recycled water use area. Water leaving a recycled water use area is not considered incidental if it is part of the facility design, if it is due to excessive application, if it is due to intentional overflow or application, or if it is due to negligence. Incidental runoff may be regulated by waste discharge requirements or, where necessary, waste discharge requirements that serve as a National Pollutant Discharge Elimination System (NPDES) permit, including municipal separate storm water system permits, but regardless of the regulatory instrument, the project shall include, but is not limited to, the following practices:

(1) Implementation of an operations and management plan that may apply to multiple sites and provides for detection of leaks, (for example, from broken sprinkler heads), and correction either within 72 hours of learning of the runoff, or prior to the release of 1,000 gallons, whichever occurs first,

(2) Proper design and aim of sprinkler heads,

(3) Refraining from application during precipitation events, and

(4) Management of any ponds containing recycled water such that no discharge occurs unless the discharge is a result of a 25-year, 24-hour storm event or greater, and there is notification of the appropriate Regional Water Board Executive Officer of the discharge.

b. *Streamlined Permitting*

(1) The Regional Water Boards shall, absent unusual circumstances (i.e., unique, site-specific conditions such as where recycled water is proposed to be used for irrigation over high transmissivity soils over a shallow (5' or less) high quality groundwater aquifer), permit recycled water projects that meet the criteria set forth in this Policy, consistent with the provisions of this paragraph.

(2) If the Regional Water Board determines that unusual circumstances apply, the Regional Water Board shall make a finding of unusual circumstances based on substantial evidence in the record, after public notice and hearing.

(3) Projects meeting the criteria set forth below and eligible for enrollment under requirements established in a general order shall be enrolled by the State or Regional Water Board within 60 days from the date on which an application is deemed complete by the State or Regional Water Board. For projects that are not enrolled in a general order, the Regional Water Board shall consider permit adoption within 120 days from the date on which the application is deemed complete by the Regional Water Board.

(4) Landscape irrigation projects that qualify for streamlined permitting shall not be required to include a project specific receiving water and groundwater monitoring component unless such project specific monitoring is required under the adopted salt/nutrient management plan. During the interim while the salt management plan is under development, a landscape irrigation project proponent can either perform project specific monitoring, or actively participate in the development and implementation of a salt/nutrient management plan, including basin/sub-basin monitoring. Permits or requirements for landscape irrigation projects shall include, in addition to any other appropriate recycled water monitoring requirements, recycled water monitoring for CECs on an annual basis and priority pollutants on a twice annual basis. Except as requested by CDPH, State and Regional Water Board monitoring requirements for CECs shall not take effect until 18 months after the effective date of this Policy. In addition, any permits shall include a permit reopener to allow incorporation of appropriate monitoring requirements for CECs after State Water Board action under paragraph 10(b)(2).

(5) It is the intent of the State Water Board that the general permit for landscape irrigation projects be consistent with the terms of this Policy.

c. *Criteria for streamlined permitting*. Irrigation projects using recycled water that meet the following criteria are eligible for streamlined permitting, and, if otherwise in compliance with applicable laws, shall be approved absent unusual circumstances:

(1) Compliance with the requirements for recycled water established in Title 22 of the California Code of Regulations, including the requirements for treatment and use area restrictions, together with any other recommendations by CDPH pursuant to Water Code section 13523.

(2) Application in amounts and at rates as needed for the landscape (i.e., at agronomic rates and not when the soil is saturated). Each irrigation project shall be subject to an operations and management plan, that may apply to multiple sites, provided to the Regional Water Board that specifies the agronomic rate(s) and describes a set of reasonably practicable measures to ensure compliance with this requirement, which may include the development of water budgets for use areas, site

supervisor training, periodic inspections, tiered rate structures, the use of smart controllers, or other appropriate measures.

(3) Compliance with any applicable salt and nutrient management plan.

(4) Appropriate use of fertilizers that takes into account the nutrient levels in the recycled water. Recycled water producers shall monitor and communicate to the users the nutrient levels in their recycled water.

8. *Recycled Water Groundwater Recharge Projects*

a. The State Water Board acknowledges that all recycled water groundwater recharge projects must be reviewed and permitted on a site-specific basis, and so such projects will require project-by-project review.

b. Approved groundwater recharge projects will meet the following criteria:

(1) Compliance with regulations adopted by CDPH for groundwater recharge projects or, in the interim until such regulations are approved, CDPH's recommendations pursuant to Water Code section 13523 for the project (e.g., level of treatment, retention time, setback distance, source control, monitoring program, etc.).

(2) Implementation of a monitoring program for constituents of concern and a monitoring program for CECs that is consistent with any actions by the State Water Board taken pursuant to paragraph 10(b) of this Policy and that takes into account site-specific conditions. Groundwater recharge projects shall include monitoring of recycled water for CECs on an annual basis and priority pollutants on a twice annual basis.

c. Nothing in this paragraph shall be construed to limit the authority of a Regional Water Board to protect designated beneficial uses, *provided* that any proposed limitations for the protection of public health may only be imposed following regular consultation by the Regional Water Board with CDPH, consistent with State Water Board Orders WQ 2005-0007 and 2006-0001.

d. Nothing in this Policy shall be construed to prevent a Regional Water Board from imposing additional requirements for a proposed recharge project that has a substantial adverse effect on the fate and transport of a contaminant plume or changes the geochemistry of an aquifer thereby causing the dissolution of constituents, such as arsenic, from the geologic formation into groundwater.

e. Projects that utilize surface spreading to recharge groundwater with recycled water treated by reverse osmosis shall be permitted by a Regional Water Board within one year of receipt of recommendations from CDPH. Furthermore, the Regional Water Board shall give a high priority to review and approval of such projects.

9. *Antidegradation*

a. The State Water Board adopted Resolution No. 68-16 as a policy statement to implement the Legislature's intent that waters of the state shall be regulated to achieve the highest water quality consistent with the maximum benefit to the people of the state.

b. Activities involving the disposal of waste that could impact high quality waters are required to implement best practicable treatment or control of the discharge necessary to ensure that pollution or nuisance will not occur, and the highest water quality consistent with the maximum benefit to the people of the state will be maintained.

c. Groundwater recharge with recycled water for later extraction and use in accordance with this Policy and state and federal water quality law is to the benefit of the people of the state of California. Nonetheless, the State Water Board finds that groundwater recharge projects using recycled water have the potential to lower water quality within a basin. The proponent of a groundwater recharge project must demonstrate compliance with Resolution No. 68-16. Until such time as a salt/nutrient management plan is in effect, such compliance may be demonstrated as follows:

(1) A project that utilizes less than 10 percent of the available assimilative capacity in a basin/sub-basin (or multiple projects utilizing less than 20 percent of the available assimilative capacity in a basin/sub-basin) need only conduct an antidegradation analysis verifying the use of the assimilative capacity. For those basins/sub-basins where the Regional Water Boards have not determined the baseline assimilative capacity, the baseline assimilative capacity shall be calculated by the initial project proponent, with review and approval by the Regional Water Board, until such time as the salt/nutrient plan is approved by the Regional Water Board and is in effect. For compliance with this subparagraph, the available assimilative capacity shall be calculated by comparing the mineral water quality objective with the average concentration of the basin/sub-basin, either over the most recent five years of data available or using a data set approved by the Regional Water Board Executive Officer. In determining whether the available assimilative capacity will be exceeded by the project or projects, the Regional Water Board shall calculate the impacts of the project or projects over at least a ten year time frame.

(2) In the event a project or multiple projects utilize more than the fraction of the assimilative capacity designated in subparagraph (1), then a Regional Water Board-deemed acceptable antidegradation analysis shall be performed to comply with Resolution No. 68-16. The project proponent shall provide sufficient information for the Regional Water Board to make this determination. An example of an approved method is the method used by the State Water Board in connection with Resolution No. 2004-0060 and the Regional Water Board in connection with Resolution No. R8-2004-0001. An integrated approach (using surface water, groundwater, recycled water, stormwater, pollution prevention, water conservation, etc.) to the implementation of Resolution No. 68-16 is encouraged.

d. Landscape irrigation with recycled water in accordance with this Policy is to the benefit of the people of the State of California. Nonetheless, the State Water Board finds that the use of water for irrigation may, regardless of its source, collectively affect groundwater quality over time. The State Water Board intends to address these impacts in part through the development of salt/nutrient management plans described in paragraph 6.

(1) A project that meets the criteria for a streamlined irrigation permit and is within a basin where a salt/nutrient management plan satisfying the provisions of paragraph 6(b) is in place may be approved without further antidegradation analysis, provided that the project is consistent with that plan.

(2) A project that meets the criteria for a streamlined irrigation permit and is within a basin where a salt/nutrient management plan satisfying the provisions of paragraph 6(b) is being prepared may be approved by the Regional Water Board by demonstrating through a salt/nutrient mass balance or similar analysis that the project uses less than 10 percent of the available assimilative capacity as estimated by the project proponent in a basin/sub-basin (or multiple projects using less than 20 percent of the available assimilative capacity as estimated by the project proponent in a groundwater basin).

10. *Emerging Constituents/Chemicals of Emerging Concern*

a. *General Provisions*

(1) Regulatory requirements for recycled water shall be based on the best available peer-reviewed science. In addition, all uses of recycled water must meet conditions set by CDPH.

(2) Knowledge of risks will change over time and recycled water projects must meet legally applicable criteria. However, when standards change, projects should be allowed time to comply through a compliance schedule.

(3) The state of knowledge regarding CECs is incomplete. There needs to be additional research and development of analytical methods and surrogates to determine potential environmental and public health impacts. Agencies should minimize the likelihood of CECs impacting human health and the environment by means of source control and/or pollution prevention programs.

(4) Regulating most CECs will require significant work to develop test methods and more specific determinations as to how and at what level CECs impact public health or our environment.

b. *Research Program.* The State Water Board, in consultation with CDPH and within 90 days of the adoption of this Policy, shall convene a "blue-ribbon" advisory panel to guide future actions relating to constituents of emerging concern.

(1) The panel shall be actively managed by the State Water Board and shall be composed of at least the following: one human health toxicologist, one environmental toxicologist, one epidemiologist, one biochemist, one civil engineer familiar with the design and construction of recycled water treatment facilities, and one chemist familiar with the design and operation of advanced laboratory methods for the detection of emerging constituents. Each of these panelists shall have extensive experience as a principal investigator in their respective areas of expertise.

(2) The panel shall review the scientific literature and, within one year from its appointment, shall submit a report to the State Water Board and CDPH describing the current state of scientific knowledge regarding the risks of emerging constituents to public health and the environment. Within six months of receipt of the panel's report the State Water Board, in coordination with CDPH, shall hold a public hearing to consider recommendations from staff and shall endorse the recommendations, as appropriate, after making any necessary modifications. The panel or a similarly constituted panel shall update this report every five years.

(3) Each report shall recommend actions that the State of California should take to improve our understanding of emerging constituents and, as may be appropriate, to protect public health and the environment.

(4) The panel report shall answer the following questions: What are the appropriate constituents to be monitored in recycled water, including analytical methods and method detection limits? What is the known toxicological information for the above constituents? Would the above lists change based on level of treatment and use? If so, how? What are possible indicators that represent a suite of CECs? What levels of CECs should trigger enhanced monitoring of CECs in recycled water, groundwater and/or surface waters?

c. *Permit Provisions.* Permits for recycled water projects shall be consistent both with any CDPH recommendations to protect public health and with any actions by the State Water Board taken pursuant to paragraph 10(b)(2).

11. *Incentives for the Use of Recycled Water*

a. *Funding*

The State Water Board will request CDWR to provide funding ($20M) for the development of salt and nutrient management plans during the next three years (i.e., before FY 2010/2011). The State Water Board will also request CDWR to provide priority funding for projects that have major recycling components; particularly those that decrease demand on potable water supplies. The State Water Board will also request priority funding for stormwater recharge projects that augment local water supplies. The State Water Board shall promote the use of the State Revolving Fund (SRF) for water purveyor, stormwater agencies, and water recyclers to use for water reuse and stormwater use and recharge projects.

b. *Stormwater*

The State Water Board strongly encourages all water purveyors to provide financial incentives for water recycling and stormwater recharge and reuse projects. The State Water Board also encourages the Regional Water Boards to require less stringent monitoring and regulatory requirements for stormwater treatment and use projects than for projects involving untreated stormwater discharges.

c. TMDLs

Water recycling reduces mass loadings from municipal wastewater sources to impaired waters. As such, waste load allocations shall be assigned as appropriate by the Regional Water Boards in a manner that provides an incentive for greater water recycling.

West Basin Municipal Water District

Urban Water Management Plan



2010

MESSAGE FROM THE BOARD OF DIRECTORS

Since its formation in 1947, West Basin has remained steadfast in its commitment to ensure a safe and reliable water supply for the region. Through the years, West Basin has grown and transformed seeking innovative and viable solutions to meet the changing needs of its communities. All of us at West Basin continue to expand our efforts to meet the growing water demand while preserving our limited and precious water resources. Through our Water Reliability 2020 Program, including recycling, conservation and desalination, West Basin will continue to diversify its local water supplies to ensure a reliable supply of water for future generations.

We are proud to submit this 2010 Urban Water Management Plan to the State Department of Water Resources. The Plan reports all current and projected water supplies and demands within West Basin's service area, demonstrates water reliability for the next 25 years and provides a comprehensive overview of West Basin's various programs.

Value Statement:
"Through various programs and projects, West Basin ensures that its customer agencies have a safe and reliable supply of water to provide to the residents, businesses and industries within its service area."

Directors

Division 1 (Director Ronald C. (Ron) Smith): Cities of Carson, Palos Verdes Estates, Rancho Palos Verdes, Rolling Hills Estates, Rolling Hills and portions of San Pedro ;

Division 2 (Director Gloria D. Gray): Cities of Inglewood, South Ladera Heights, a portion of Lennox and Athens, Howard and Ross-Sexton;

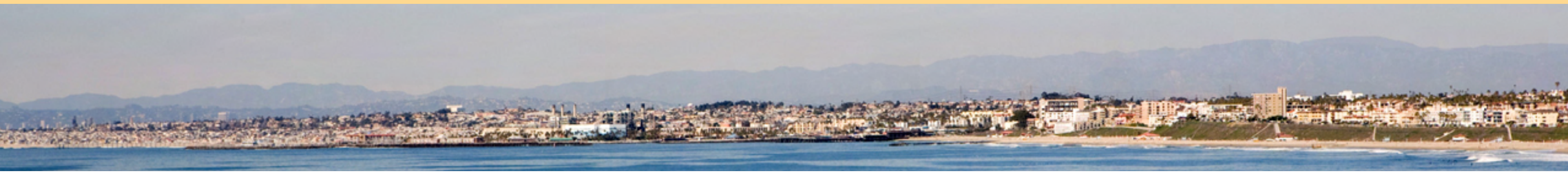
Division 3 (Director Carol W. Kwan): Cities of Hermosa Beach, Lomita, Manhattan Beach, Redondo Beach and a portion of Torrance;

Division 4 (Director Edward C. Little): Cities of Culver City, El Segundo, Malibu, and West Hollywood, Lennox, North Ladera Heights, Del Aire, Topanga, View Park and Windsor Hills; and

Division 5 (Director Donald L. Dear): Cities of Gardena, Hawthorne, Lawndale and portions of El Camino Village.

Mission Statement

"To provide a safe and reliable supply of high-quality water to the communities we serve."



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West Basin Municipal Water District
2010 Urban Water Management Plan

Prepared by:

RMC
Water and Environment

May 2011

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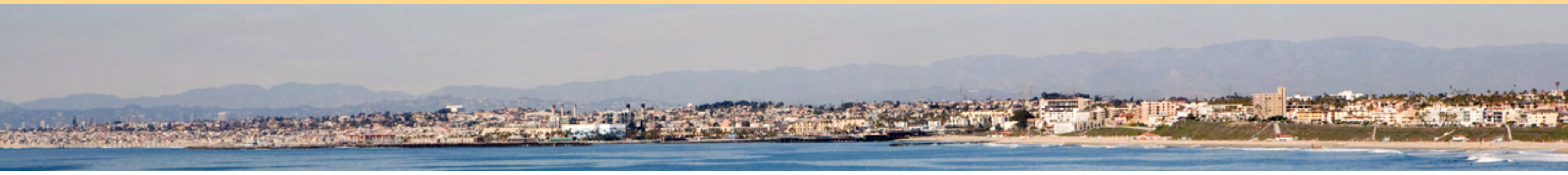

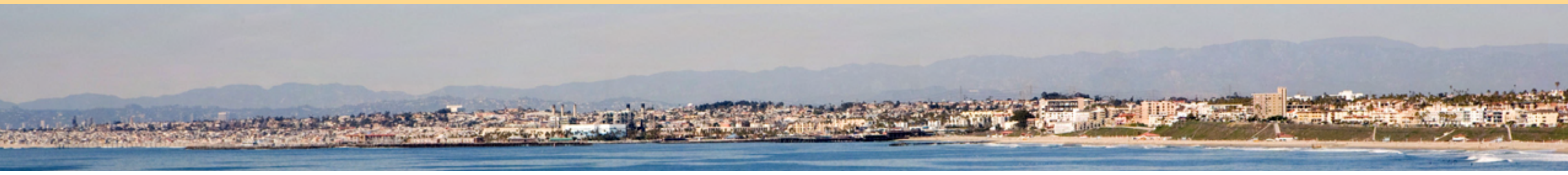

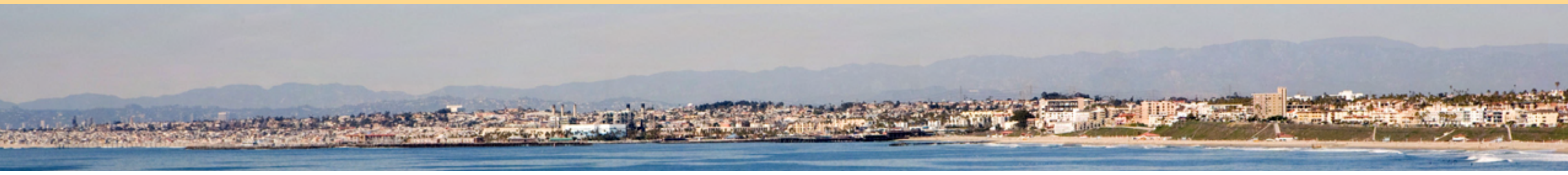

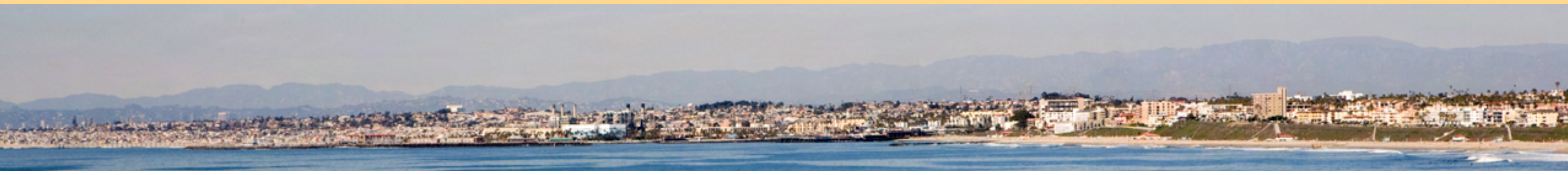

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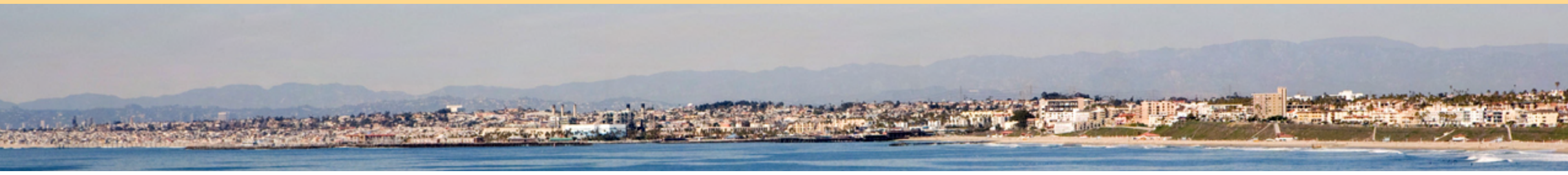

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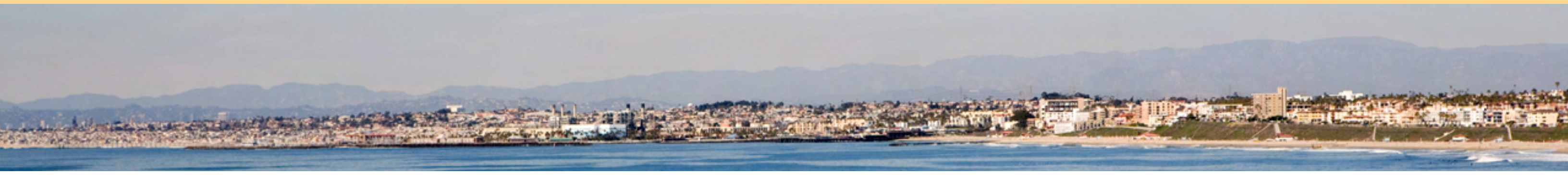


Executive Summary



2010

EXECUTIVE SUMMARY

1 West Basin's Mission

West Basin Municipal Water District (West Basin) was established in 1947 to help mitigate the over pumping of groundwater by providing imported water from the Metropolitan Water District of Southern California (MWD) as replenishment supplies. Today, this imported water is also provided to supplement local supplies including groundwater, desalination, and recycled supplies developed by West Basin or by retailer agencies operating within West Basin's service area. In addition, a combination of recycled water and imported water is introduced into local aquifers through the West Coast Seawater Barrier to both protect the groundwater supplies from seawater contamination and replace, or replenish, what is pumped.

In January 2008, the West Basin Board adopted a Strategic Business Plan to address water supply issues that plague Southern California by focusing on producing new sources of local water, improving its environmentally-sound and innovative technologies, and emphasizing customer service and satisfaction. With a goal to decrease its service area's dependence on imported water by 50 percent between now and 2020, West Basin is expanding its recycled water customer base, exploring the feasibility of taking its ocean-water desalination project to the next level, and broadening its water use efficiency programs and outreach. Through various programs and projects, West Basin ensures that its customer agencies have a safe and reliable supply of water to provide to the residents, businesses and industries within its service area.

2 West Basin's 2010 Urban Water Management Plan

West Basin's 2010 Urban Water Management Plan (UWMP) revises the 2005 UWMP prepared by West Basin and incorporates changes enacted by legislation since 2005. Since 2005, several amendments have been added to the Urban Water Management Act. The most significant being the requirements mandated through the passing of Senate Bill (SB) X7-7 that seeks a 20 percent statewide reduction in urban per capita water use in California by December 31, 2020 and for agencies to calculate individual water use reduction targets to help achieve this goal.

As a water wholesaler, West Basin is not required to provide these targets. However, given its' role as a regional water provider, West Basin has elected, in cooperation with a portion of its customer agencies, to use its 2010 UWMP as a regional alliance UWMP. Although each of West Basin's customer agencies must prepare individual 2010 UWMPs, West Basin's 2010 UWMP provides a regional target that will allow these retailers and West Basin to collaborate on the most effective and efficient programs that will ensure the targeted reductions in demand can be met.

3 West Basin Service Area Demands

While demand in the West Basin service area has historically increased due to increased population growth, recent years have shown a decrease in overall system demand. This decrease has been attributed to aggressive conservation program implementation due to drought conditions in 2007-8, an economic downturn resulting in less consumption beginning in 2009, and subsequent wet seasons in 2009 and 2010.

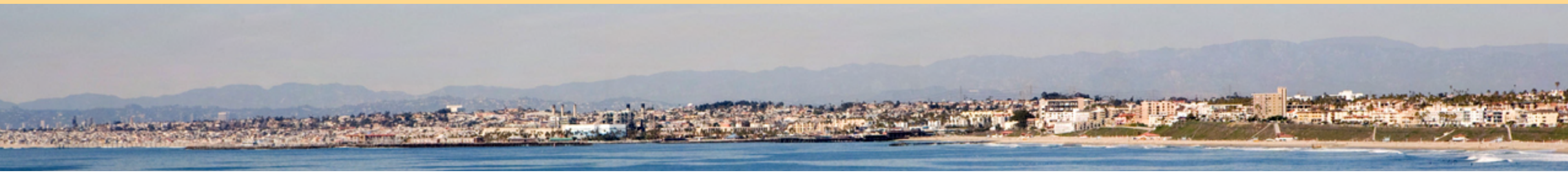


Table ES-1 and indicates that although West Basin's service area population is projected to increase, the overall potable demand in acre-feet per year (AFY) is expected to decrease given further water use efficiency and recycled water program implementation.

Table ES-1: Projected West Basin Service Area Demand (AFY)

Year	2010	2015	2020	2025	2030	2035
Baseline Demand[1]	170,527	192,134	198,218	197,408	197,451	197,275
Planned Conservation[2]	14,000	15,119	21,039	21,640	22,971	23,632
Final Total Retail Demand	**156,527**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Recycled Water Demand[3]	14,182	16,368	33,882	33,882	37,382	37,382
Final Potable Demand	**142,345**	**160,647**	**143,297**	**141,886**	**137,098**	**136,261**

[1] Projections based on Water Demand Forecasting Model, 2010
[2] Water Use Efficiency Plan, Alliance for Water Efficiency Model, 2010
[3] Projections based on the Capital Implementation Master Plan, 2009

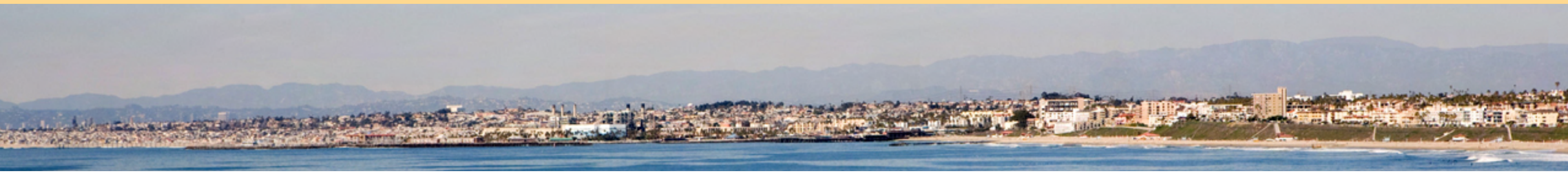
In terms of per capita use (in gallons per capita day (gpcd)), the West Basin Regional Alliance baseline and targeted water use for 2015 and 2020 are shown in table ES-2.

TableES-2: Regional Alliance 2015 Interim and 2020 Targets (gpcd)

Member	10-Year Base Water Use	Calculated Water Use Targets		Maximum Allowable Target	Final Targets	
		Method	Target		2015	2020
California Water Service Company Hawthorne	96.5	3	141.6	N/A	119.0	141.6
City of El Segundo	220.6	1	176.5	182.2	198.6	176.5
City of Inglewood	105.3	3	141.6	N/A	123.4	141.6
City of Lomita	123.4	3	141.6	116.2	119.8	116.2
City of Manhattan Beach	175.7	3	141.6	144.9	158.6	141.6
Los Angeles County Waterworks District #29	319.4	1	255.5	298.2	287.5	255.5
Regional Alliance	**227.7**	**1**	**182.2**	**160.5**	**194.1**	**160.5**

4 Reducing Demand through Water Use Efficiency Planning

Since the severe drought of the early 1990s, West Basin has been a leader implementing aggressive water conservation programs to help limit water demand within its service area. West Basin programs have included a strong emphasis on education and the distribution of rebate incentives and plumbing retrofit hardware. The results of these programs, in conjunction with passive conservation measures such as modifications to city ordinances, have resulted in significant reductions in retail water use within

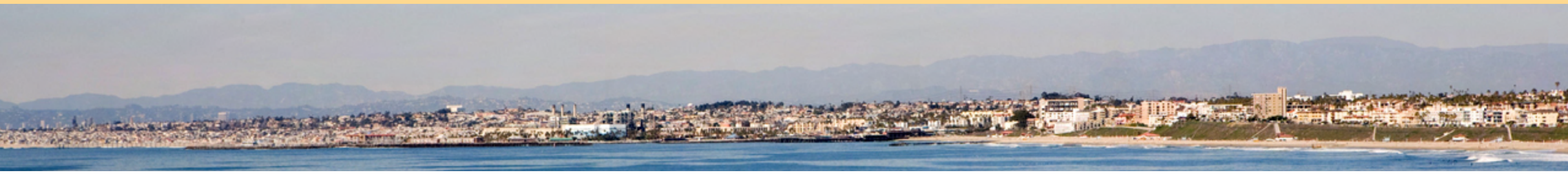


West Basin's service area. By current estimates, demand management from West Basin's active and passive conservation efforts have saved over 3 billion gallons of imported water (10,000 AF) since 1991, which is equivalent to the average annual water use of almost 20,000 households.

In order further increase conservation and meet the 2020 and interim 2015 water use targets, West Basin has recently collaborated with its Regional Alliance agencies to develop and implement the future water use efficiency measures shown in Table ES-3.

Table ES-3: West Basin and Retailer Program Participation

Programs	West Basin	Los Angeles County Water-works District #29	City of El Segundo	City of Manhattan Beach	City of Hawthorne	City of Lomita	City of Inglewood
MWD							
Residential Rebate Program	X	X	X	X	X	X	X
Save A Buck Rebate Program	X	X	X	X	X	X	X
West Basin							
High-Efficiency Toilet (HET) Distribution Events	X	X	X	X	X	X	X
Green Living for Apartments and Condos (Direct HET Installations)	X	X	X	X	X	X	X
Ocean Friendly Landscape Program	X	X	X	X	X	X	X
Complete Restroom Retrofit Program	X	X	X	X	X	X	X
Recirc & Save Program	X	X	X	X	X	X	X
Cash for Kitchens	X	X	X	X	X	X	X
Education Programs	X	X	X	X	X	X	X
West Basin Programs (Funding Pending)							
High-Efficiency Nozzle Program	X	X	X	X	X	X	X
Water Star Schools Pilot Program	X	X	X	X	X	X	X
Water & Energy Efficiency in the Motel/Hotel and Schools Sectors	X	X	X	X	X	X	X
Other Water Retailer							
Turf Removal Program	N/A	X	-	-	-	-	-
HET Rebates (CII)	N/A	X	-	-	-	-	-
Landscape Surveys	N/A	X	-	-	-	-	-
Education Programs	N/A	X					
Landscape Incentives	N/A	X	-	-	-	-	-



5 West Basin Service Area Supplies

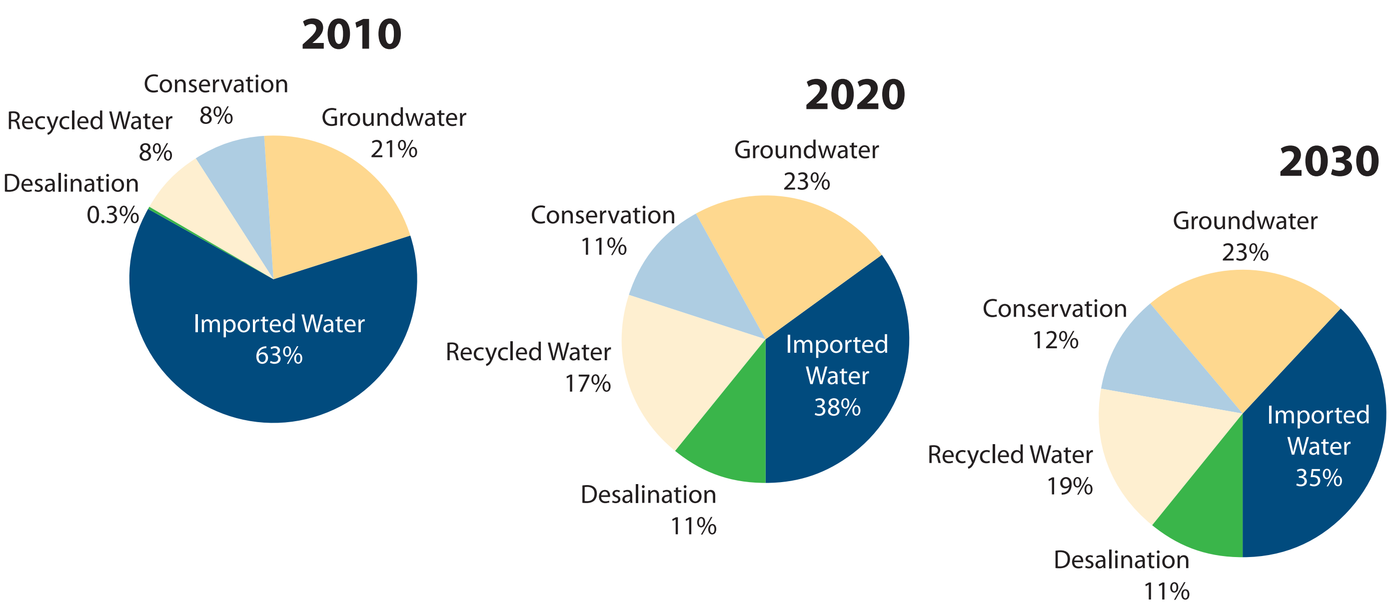
West Basin has been able to support the diversification of supplies available to its customer agencies by providing access to imported water supplies from MWD as well as through the development of recycled water supplies. These supplies are served directly to its customer agencies and indirectly as the replenishment supplies necessary to maximize groundwater production. Table ES-4 shows, West Basin is projecting to more than double current recycled water supplies as well as invest in over 20,000 AFY of ocean-water desalination supply. Coupled with an additional doubling of conserved supply through water use efficiency programs, the overall imported water use is expected to be cut nearly in half by 2035 as shown in Figure ES-1.

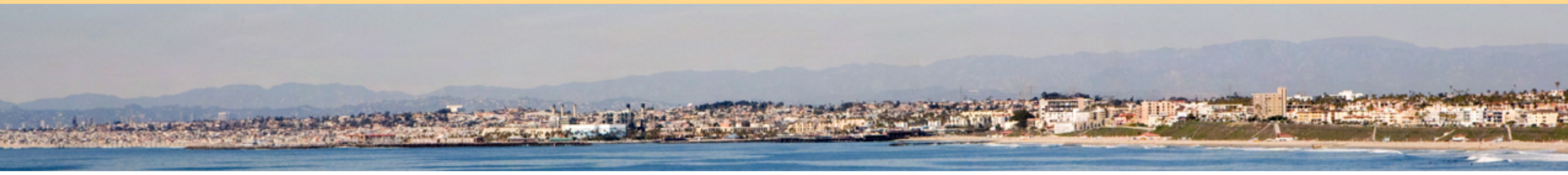
Table ES-4 West Basin's Service Area Projected Water Supply (AFY)

Supplies	2010	2015	2020	2025	2030	2035
Groundwater[1]	36,360	45,000	45,000	45,000	45,000	45,000
Imported Water[2]	104,985	114,647	76,797	75,386	70,598	69,761
Recycled Water[3]	14,182	16,368	33,882	33,882	37,382	37,382
Desalination[4]	500	1,000	21,500	21,500	21,500	21,500
Total	**156,027**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Conservation[5]	14,000	15,119	21,039	21,640	22,971	23,632
Total	**170,027**	**192,134**	**198,218**	**197,408**	**197,451**	**197,275**

[1] Groundwater production within West Basin service area only.
[2] Imported retail use only; does not include replenishment deliveries (i.e. Barrier).
[3] Recycled water does not include replenishment deliveries (i.e. Barrier).and deliveries outside the service area.
[4] Desalination includes both brackish and ocean-water.
[5] Conservation consists of Active and Passive savings according to West Basin's projected estimates.

Figure ES-1: West Basin Service Area Projected Water Supplies





6 **Recycled Water Development**

Since planning and constructing its recycled water system in the early 1990s, West Basin has become an industry leader in water reuse. West Basin's recycled water supply is sold to customers for non-potable applications such as landscape irrigation, commercial and industrial processes, and indirect potable uses through groundwater replenishment. While serving to offset imported water supplies, recycled water use also results in less ocean discharge of lesser-treated wastewater into the Santa Monica Bay.

In fiscal year 2009-10, West Basin delivered about 30,400 AF of recycled water to sites inside and outside its service area, saving enough potable water to serve roughly 61,000 households. Within West Basin's service area, municipal and industrial recycled water use totaled about 15,500 AF and seawater barrier about 7,796 AF, which is about 13 percent of the District's current total water supplies. It is projected that recycled water sales could represent 19 percent of total water supplies by 2035.

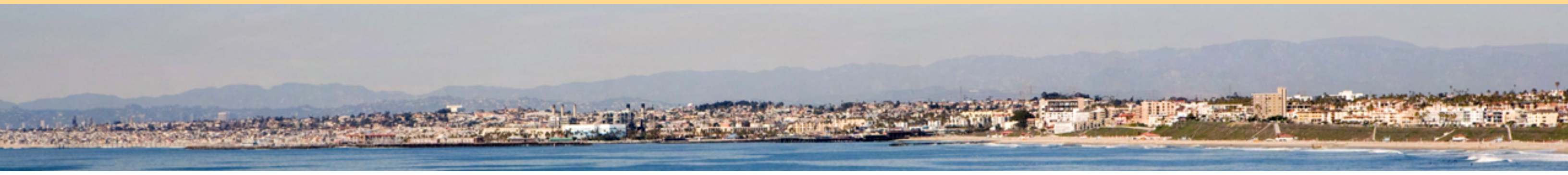
7 **Ocean-Water Desalination Development**

In early 2011, West Basin dedicated its Ocean-Water Desalination Demonstration Facility and Water Education Center. West Basin used the data acquired from the pilot project in the planning and development of the demonstration facility that produces 50,000 gallons per day of drinking water. This Ocean-Water Desalination Demonstration Facility will test the viability of a future, full-scale Ocean-Water Desalination Facility capable of providing up to 20,000 AFY, or enough to supply 40,000 families for a year, in the initial phase.

West Basin will perform a Desalination Program Master Plan in 2011 that will evaluate potential siting opportunities within West Basin's service area that could accommodate a full-scale facility. Pending the findings from the demonstration facility, the Master Plan, and subsequent environmental review process, West Basin anticipates permitting, financing, and constructing a full-scale facility by 2017.

8 **Maintaining the Quality of Water Supplies**

Compliance with water quality regulations is a regional water management priority and a shared responsibility. West Basin is responsible for the quality of the desalination and recycled water supplies generated at the C. Marvin Brewer Desalter and Edward C. Little Water Recycling Facility (ECLWRF) and its satellite facilities: Carson Water Recycling Facility, Chevron Nitrification Plant and Exxon-Mobil Nitrification Plant. MWD is responsible for complying with State and Federal drinking water regulations on its imported potable water sold to West Basin. West Basin's retail customer agencies are responsible for ensuring compliance in their individual distribution systems and at the customer tap.



West Basin has a dedicated program and budget to constantly engage in research projects that evaluate water quality, efficient operations and new pollution prevention technology and methods. Research projects close the environmental loop by addressing both final product water as well as source control issues to prevent pollution and the need for cleanup technology. West Basin leverages its research dollars by participating on the Boards of water industry research organizations such as WateReuse, American Water Works Associations, National Water Research Institute, Salinity Management Coalition as well as participating with academic institutions in water quality research.

9 Water Rates and Charges

As a water wholesale agency, West Basin does not directly charge residential and other end-use customers for supplies. Instead, West Basin's customer agencies purchase water from West Basin and then combine it with other supplies to deliver to their retail customers at a variety of rates.

West Basin's current potable water rates are primarily based upon the costs of imported supplies purchased from MWD. Imported water purchased by West Basin from MWD carries not only the cost of acquiring, importing, treating and distributing the water throughout the region, but also these costs associated with maintaining MWD reliability and "readiness to serve". The total West Basin rate structure must include the value-added costs associated with distributing to customer agencies the MWD and locally-produced recycled and desalinated groundwater supplies.

SECTION ONE

Plan Preparation



2010

SECTION 1 Plan Preparation

An Urban Water Management Plan (UWMP) is prepared by a water purveyor to ensure an appropriate level of water service reliability sufficient to meet the needs of its customers during normal, single dry or multiple dry years. The California Urban Water Management Planning Act of 1983 (Act), as amended, requires urban water suppliers to develop an UWMP every five years in the years ending in zero and five.

In describing the importance of the Act, the legislature declared that waters of the State are a limited and renewable resource, subject to ever increasing demands as well as the following tenants:

- That the conservation and efficient use of urban water supplies are of statewide concern;
- That successful implementation of plans is best accomplished at the local level;
- That conservation and efficient use of water shall be actively pursued to protect both the people of the State and their water resources;
- That conservation and efficient use of urban water supplies shall be a guiding criterion in public decisions; and
- That urban water suppliers shall be required to develop water management plans to achieve conservation and efficient use.

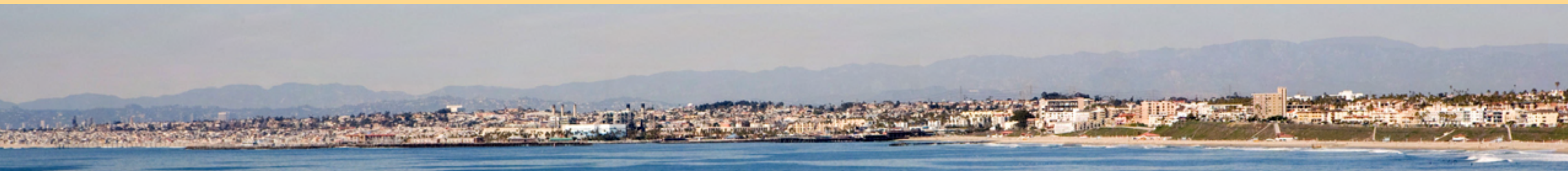
West Basin Municipal Water District's (West Basin) 2010 UWMP has been prepared in compliance with the requirements of the Act, as amended to 2009 (Appendix A), and includes the following:

- West Basin's Service Area
- Water Demand
- Water Supply
- Water Reliability
- Water Quality
- Water Use Efficiency
- Water Rates & Charges
- Water Recycling
- Desalination

1.1 Urban Water Management Planning Requirements

West Basin's 2010 UWMP revises the 2005 UWMP prepared by West Basin and incorporates changes enacted by legislation since 2005. The UWMP also incorporates water use efficiency efforts West Basin has implemented or is considering implementing pursuant to the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU)[1]. West Basin was one of the first agencies to became signatory to the MOU in September 1991.

1 The Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) was adopted in September 1991 by a large number of water suppliers, public advocacy organizations and other interested groups. It created the California Urban Water Conservation Council and established 16 Best Management Practices (BMPs) for urban water conservation, recently refined to 14 BMPs. West Basin became signatory to the MOU in September 1991.



The sections in this UWMP correspond to the outline of the Act, specifically Article 2, Contents of Plans, Sections 10631, 10632, and 10633. The sequence used for the required information, however, differs slightly in order to present information in a manner reflecting the unique characteristics of West Basin. The most recent version of the Department of Water Resources' (DWR) UWMP Checklist has been completed, which identifies the location of Act requirements in this UWMP and is included as Appendix B.

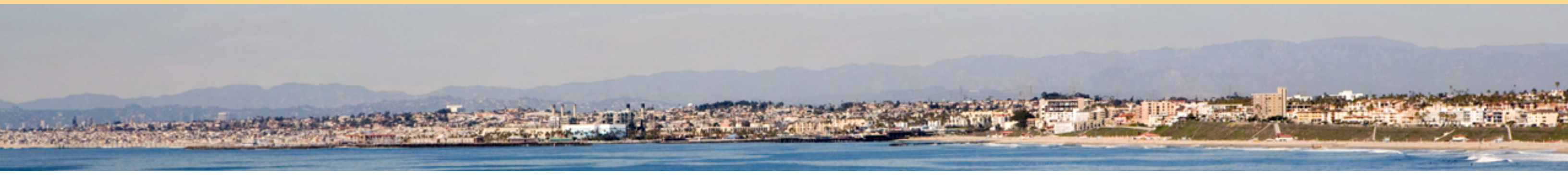
Since 2005, several amendments have been added to the Urban Water Management Act. The major changes to the Act impacting preparation of the 2010 UWMPs include the following:

- Requirement of at least 60 days advance public notice to city or county prior to public hearing on UWMP;
- Requirement that the UWMP includes water use projects for single-family and multi-family residential housing needed for low income and affordable households (retailers only); and
- Requirement that "indirect potable reuse" of recycled water be described and quantified in the UWMP, including a determination with regard to the technical and economic feasibility of serving those uses.

The most significant impact on 2010 UWMPs was the requirements mandated through the passing of Senate Bill (SB) X7-7. On November 10, 2009, the state legislature passed SB X7-7 (or the Water Conservation Bill of 2009) as a water conservation component to the Delta legislative package that seeks a 20 percent statewide reduction in urban per capita water use in California by December 31, 2020. SB X7-7 requires that each retail agency preparing a 2010 UWMP must calculate a baseline water use as well as an interim (for 2015) and final (for 2020) water use reduction target. The methodologies used to calculate both the baseline and targets were outlined in the Draft and Final UWMP guidelines published by DWR in December 2010 and March 2011. Since final guidelines were not released until March 2011, the deadline for retailer UWMP adoption and submittal has been extended to July 1, 2011. In September 2010, SB 1478 was signed by the Governor of California to extend the 2010 UWMP deadline to July 1, 2011 for wholesale agencies as well as retailers.

1.2 Regional Alliance UWMP

As a water wholesaler, West Basin is not required to provide SB X7-7 water use reduction targets. However, given its role as a regional water provider, West Basin has elected, in cooperation with a portion of its customer agencies, to use its 2010 UWMP as a regional alliance UWMP. According to DWR's 2010 UWMP guidelines, a regional demand reduction target can be developed by a regional alliance of multiple agencies to show compliance with SB X7-7. Although each of West Basin's customer agencies must prepare individual 2010 UWMPs with individual baseline and target calculations, West Basin's 2010 UWMP provides a regional target that will allow these



retailers and West Basin to collaborate on the most effective and efficient programs that will ensure that the targeted reductions in demand can be met. Additional information is described in Section 2: Water Demand.

1.3 Plan Adoption

The draft 2010 UWMP was completed in April 2011 and available for a 45 day-public review. The draft UWMP was available at local libraries and on West Basin's web site to facilitate the involvement of various social, cultural and economic elements of the population. Once finalized, the UWMP was adopted by a Resolution of the West Basin Board of Directors in May 2011, following a public hearing. The UWMP was then submitted to DWR within 30 days of Board approval. Copies of the Notice of Public Hearing and the Resolution of Plan Adoption are included in Appendices C and D, respectively.

The UWMP is intended to serve as a general, flexible, and open-ended document that periodically can be updated to reflect changes in the region's water supply trends, and conservation and water use efficiency policies. This UWMP, along with West Basin's other planning documents, will be used by West Basin staff to guide it's service area's water use and management efforts through the year 2015, when the UWMP is required to be updated next.

1.4 Agency Coordination

To facilitate the preparation of the draft UWMP, West Basin concurrently developed the West Basin Water Demand Forecasting Model as well as a Water Use Efficiency Master Plan for use by West Basin as well as its customer agencies. During this process, West Basin staff met with all of its customer agencies to discuss the demand model, calculation of SB X7-7 baseline and targets and the 2010 UWMP and offered to provide assistance when requested. West Basin also hosted a stakeholder workshop during the draft UWMP public review period. At the workshop, West Basin provided its customer agencies with consistent information for use in the development of their 2010 UWMPs.

West Basin is a water wholesaler and is fully dependent on the Metropolitan Water District of Southern California (MWD) for its imported water supplies. Therefore, West Basin provided comments and information during development of MWD's Draft Regional Urban Water Management Plan (RUWMP) which was distributed on June 4, 2010. West Basin staff also attended a June 2010 information meeting for stakeholders and the public from within MWD's service area.

As a summary of West Basin's agency coordination, Table 1-1 describes the coordination among West Basin, its customer agencies, the County of Los Angeles and MWD during the review of the draft UWMP.

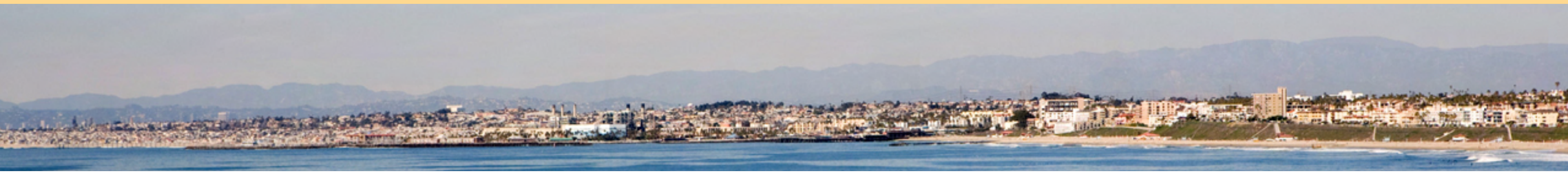


Table 1-1: Coordination with Appropriate Agencies

Agency	Participation in Regional Alliance	Received Copy of Draft	Attended Customer Workshop	Commented on Draft	Sent Notice of Intention to Adopt
County of Los Angeles - Water Resources		X			X
Metropolitan Water District of Southern California		X		X	X
California American Water Company		X	X		X
California Water Service Company		X			X
City of El Segundo	X	X	X		X
City of Inglewood	X	X			X
City of Lomita	X	X			X
City of Manhattan Beach	X	X	X		X
Golden State Water Company		X	X		X
LA County Waterworks District #29	X	X	X	X	X
Water Replenishment District of Southern California		X			X

SECTION TWO

Service Area

2010

SECTION 2 West Basin's Service Area

Today, West Basin's service area covers approximately 185-square miles and wholesale potable water is distributed to 17 cities, investor-owned utilities and water districts in Los Angeles County.

In addition, West Basin supplies recycled water to over 300 customer sites for municipal, commercial and industrial use as well as for injection into the West Coast Basin Seawater Barrier to halt seawater intrusion and replenish the aquifers.

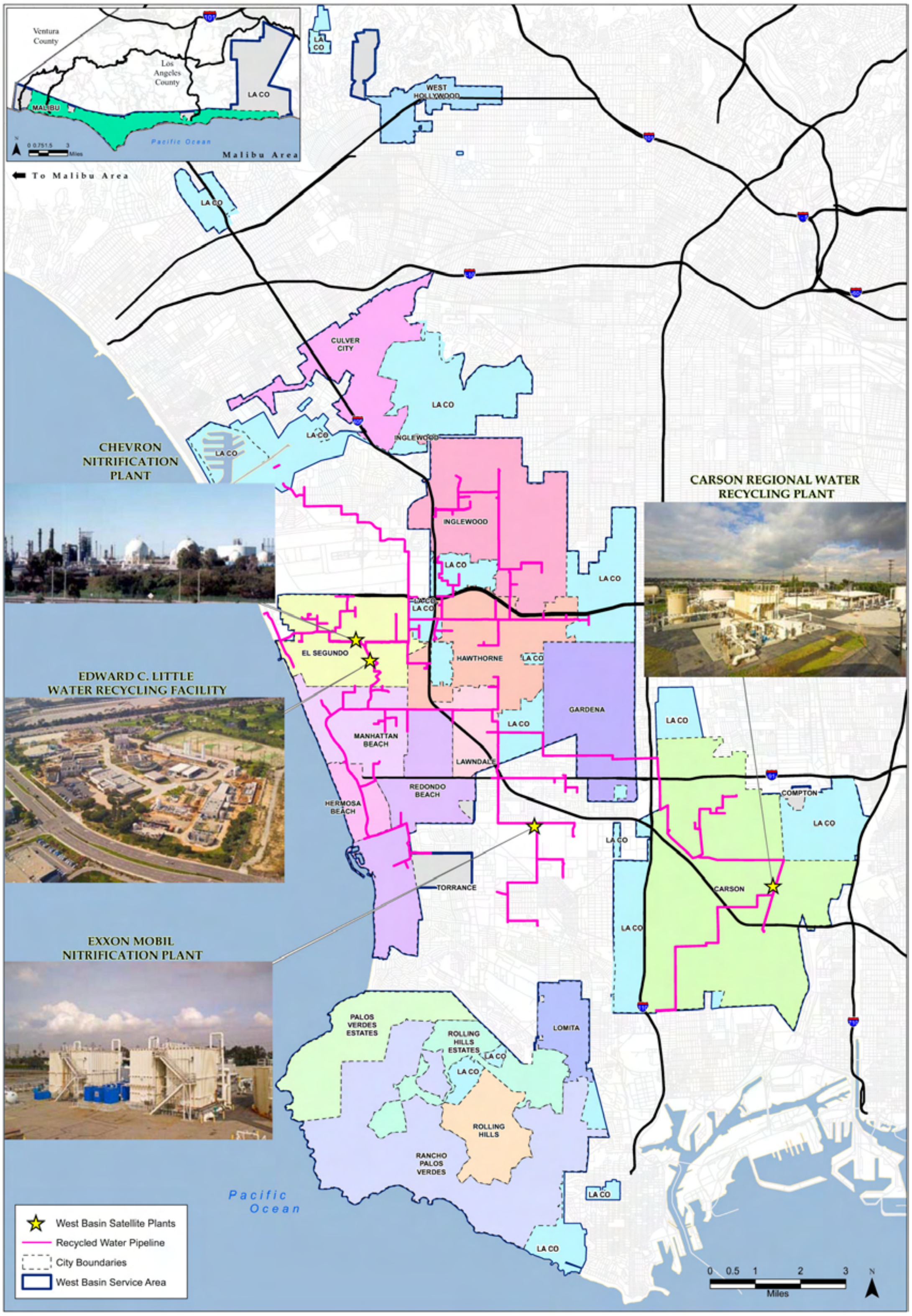
These facilities and West Basin's service are shown in Figure 2-1. Several of West Basin's customer agencies also pump groundwater supplies from the underlying West Coast Groundwater Basin to help meet their demands. A small amount of water is also used in the California Water Service Company's service area from West Basin's C. Marvin Brewer Desalter, which treats brackish groundwater from the West Coast Groundwater Basin for drinking water use.

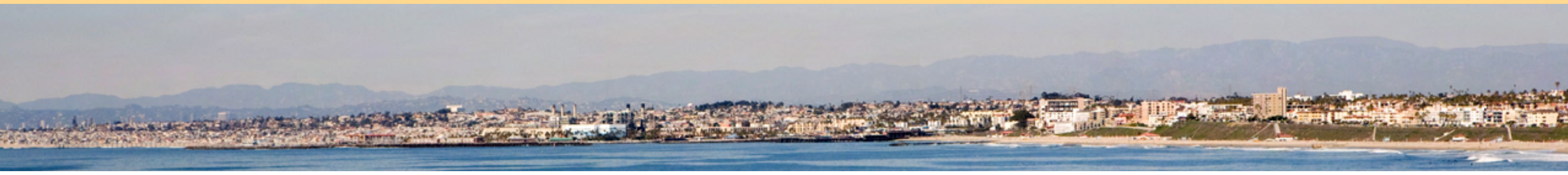
Approximately 1 million people are served within West Basin's service area which is governed by a five member elected Board of Directors. The Board of Directors guides the mission and policy of West Basin and each director serves a four-year term once elected.

2.1 West Basin's Regional Relationship

West Basin was established by a vote of the people in 1947 to help mitigate the over pumping in the West Coast Groundwater Basin (WCGB). West Basin's founders realized they would have to curtail the use of groundwater by providing the growing region with imported water. Therefore, West Basin also became a member agency of the MWD in 1947 to purchase, on a wholesale level, potable water imported from the Colorado River and the State Water Project to sell to local municipalities, investor-owned utilities and smaller water districts.

Figure 2-1: West Basin Service Area and Recycled Water Facilities





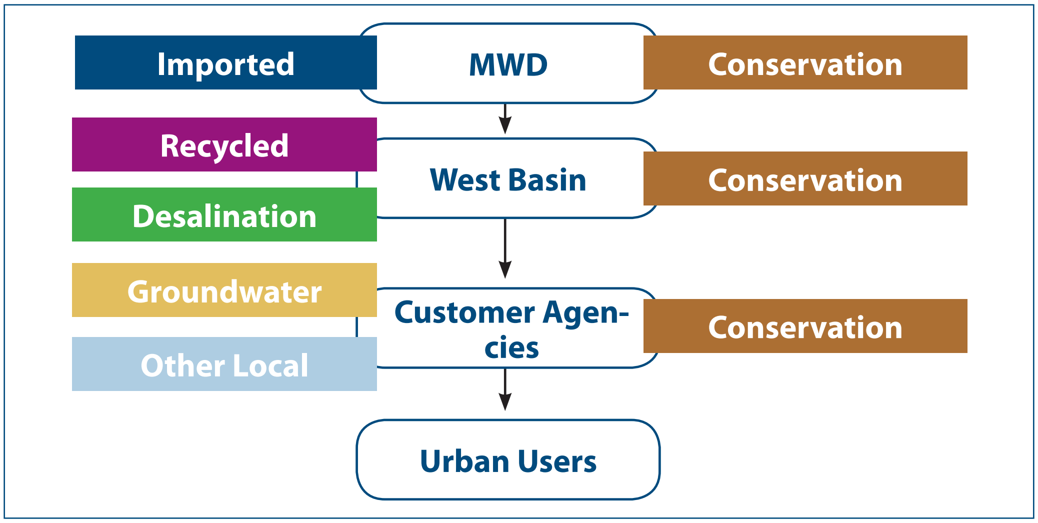
Today, West Basin imports water to supplement local supplies including groundwater, brackish desalination, and recycled water developed by both West Basin and its retail agencies operating within West Basin's service area. In addition, a blend of recycled and imported water is injected into the West Coast Basin Seawater Barrier to both protect the groundwater supplies from seawater contamination and replenish the aquifers. West Basin remains one of the largest member agencies in MWD's family of water agencies and representation on the MWD Board is critical to making West Basin's customer's voices heard at MWD to shape favorable outcomes on regional water issues. West Basin's Board of Directors appoints two representatives to serve on the 37-member MWD Board of Directors.

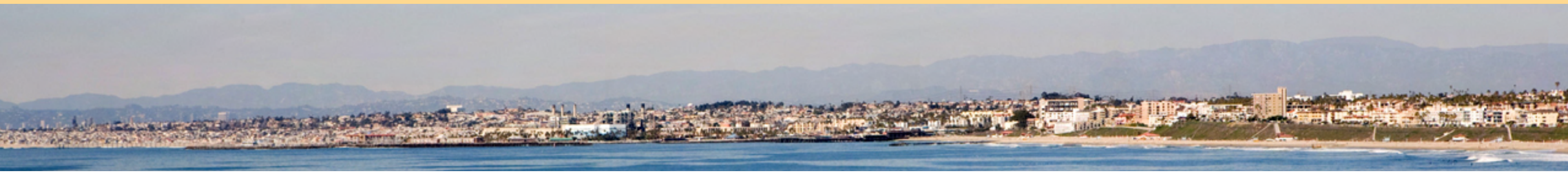
In January 2008, the West Basin Board adopted a Strategic Business Plan to address water supply issues that plague Southern California by focusing on producing new sources of local water, improving its environmentally-sound and innovative technologies, and emphasizing customer service and satisfaction. West Basin affirmed this new vision as an independent agency after concluding its joint operating agreement with Central Basin Municipal Water District, allowing West Basin to focus on the unique needs of its service area.

With a goal to decrease its service area's dependence on imported water by 50 percent between now and 2020, West Basin is implementing a Water Reliability 2020 Program (WR 2020) that will double its recycled water customer base, explore the feasibility of taking its ocean-water desalination demonstration project to the next level, and double its water use efficiency programs and outreach. Through WR 2020, West Basin ensures that its customer agencies have a safe and reliable supply of water to provide to the residents, businesses and industries within its service area.

Figure 2-2 illustrates the relationship West Basin has between MWD and its customer agencies to provide the region with diversified and integrated water supplies.

Figure 2-2: West Basin Service Area Water Supplies





2.2 Climate Characteristics

West Basin's service area lies in the heart of Southern California's coastal plain. The climate is Mediterranean, characterized by typically warm, dry summers and wet, cool winters with an average precipitation level of approximately 12.23 inches per year. The combination of mild climate and low rainfall makes the area a popular residential destination, which creates challenges for water agencies to provide for increased water demands with a tight water supply.

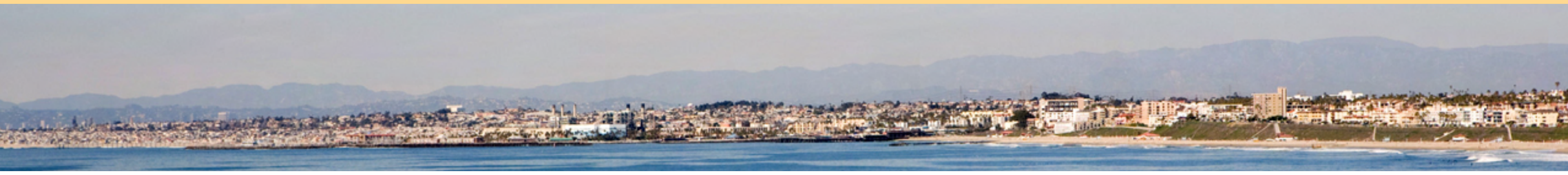
Areas with low precipitation, such as Southern California, are typically vulnerable to droughts. Historically, West Basin has experienced patterns of multiple dry years that have resulted in severe drought periods as was experienced in 1977-78, 1989-92, 1999-2004, and most recently 2007-2009. Excessively dry conditions increase the local demand given that less natural precipitation is available to meet landscaping irrigation needs. Drought conditions typically result in shortages given that this increase in demand is coupled with a decrease in natural supply.

Table 2-1 illustrates the historical average climate conditions for the overall Los Angeles and West Basin region. The potential for changes to the local climate and the resulting impacts are further discussed in Section 4: Water Supply.

Table 2-1: West Basin Average Climate Characteristics

	Standard Monthly Average Eto (inches)	Average Rainfall (inches)	Average Temperature (Fahrenheit)
January	1.83	2.72	65.1
February	2.03	2.75	65.4
March	3.48	1.93	65.2
April	4.21	0.78	67.5
May	4.62	0.17	69.2
June	4.54	0.05	72
July	5.37	0.02	75.2
August	5.06	0.08	76.4
September	4.21	0.16	76.1
October	2.94	0.37	73.6
November	1.83	1.46	70.3
December	1.46	1.74	66.1
Annual	3.47	12.23	70.2

Sources: Temperature and Precipitation: Western Climate Center's web site at the Los Angeles WSO Airport Station between 1/1/1914 and 12/31/2005 http://wrcc.dri.edu/cgi-bin/cliMAIN.pl?calosa. Eto data: California Irrigation Management Information System (CIMIS) at the Long Beach Station for the Los Angeles Region between 1/1/2000 and 12/31/2010. http://wwwcimis.water.ca.gov/cimis/welcome.jsp



2.3 Demographics

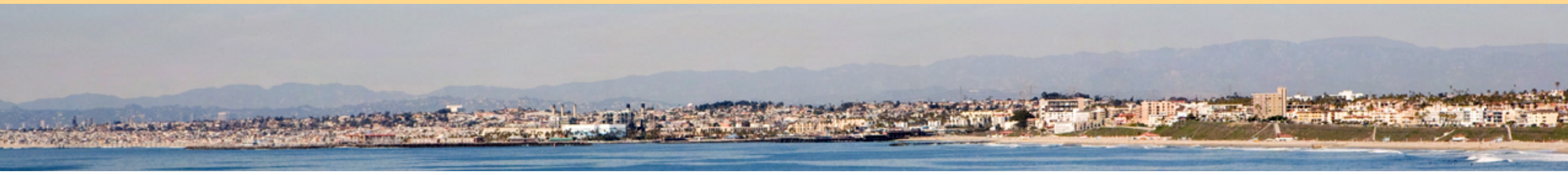
West Basin's service area encompasses 185 square miles in southwest Los Angeles County and includes 17 cities and several unincorporated areas. Given the dense urban nature of West Basin's service area, population has and was expected to rise over time. However, current projections show that population is expected to increase minimally through 2035.

Table 2-2 displays the current and projected population within West Basin's service area over the next 25 years. This population projection shows a more conservative increase in population relative to the projection provided in West Basin's 2005 UWMP.

Table 2-2: West Basin Service Area Current and Projected Population

Year (FY)	2010	2015	2020	2025	2030	2035
Total Population (# of persons)	**853,377**	**874,219**	**892,116**	**909,498**	**926,592**	**942,893**
Single Family (# of households)	169,843	172,738	175,181	176,760	178,248	179,274
Multi-Family (# of households)	117,020	121,023	124,544	127,360	130,222	132,678
Total Household	286,863	293,761	299,725	304,120	308,470	311,952
Persons Per Household	2.95	2.95	2.95	2.96	2.97	2.99
Employment	386,070	392,203	396,123	400,471	405,666	410,341

Source: Population data from the Department of Finance and Southern California Association of Governments (SCAG) and West Basin Demand Forecasting Model, 2010



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SECTION THREE

Water Demand

2010

SECTION 3 Water Demand

With an estimated current population of approximately 850,000 as well as dense commercial and industrial areas, the total retail water demand within West Basin's service area is currently about 157,000 AFY. West Basin is responsible for meeting both the direct retail demand from its customer agencies through imported (potable) and recycled water, as well as groundwater replenishment / seawater intrusion barrier demand from the Water Replenishment District of Southern California (WRD).

While demand in the West Basin service area has historically increased due to increased population growth, recent years have shown a decrease in overall system demand. West Basins' 2005 UWMP projected a 2010 demand of nearly 40,000 AFY more than what was experienced this past year. This decrease has been attributed to aggressive conservation program implementation due to drought conditions in 2007-09, an economic downturn resulting in less consumption beginning in 2009, and subsequent wet seasons in 2009 and 2010.

These decreases have been experienced throughout Southern California and have come at a time when California has implemented new legislation calling for an overall 20 percent decrease in per capita water use by the year 2020. West Basin's 2010 UWMP provides a regional alliance target for per capita water use reductions by 2020 with an interim target for 2015 that is in compliance with the State's Water Conservation Bill of 2009.

This section will explore in greater detail West Basin's historical, current and projected water demands. As a water wholesaler in the region, West Basin will also provide a regional baseline and demand reduction targets for its customer agencies that are part of the regional alliance.

3.1 Historical Water Demands

Total water use within West Basin's service area includes retail demand for potable and recycled water, and groundwater replenishment. Retail demand is defined as a population's direct consumption - or all municipal (residential, firefighting, parks, etc.) and industrial uses. Replenishment demand is the supply needed to maintain the groundwater operations in the basin and are not used directly by residences, municipalities or industries.

3.1.1 Historical Retail Demand

Historically, within the West Basin service area, increases in population have not resulted in increases in overall water demand as shown in Figure 3-1. In fact, within the last five years, demand has decreased relative to population increases. This is because other factors such as climate, economics/water rates and conservation programming also impact demand. Water use efficiency is more aggressive in drought years and resulting in decreases in demand during those periods. Once severe droughts have passed, demand will often begin to slightly rise again. While these patterns may represent a fluctuation in per capita usage, the fact that total demand has not risen along with the overall population indicates increases in water use efficiency in average or wet years.

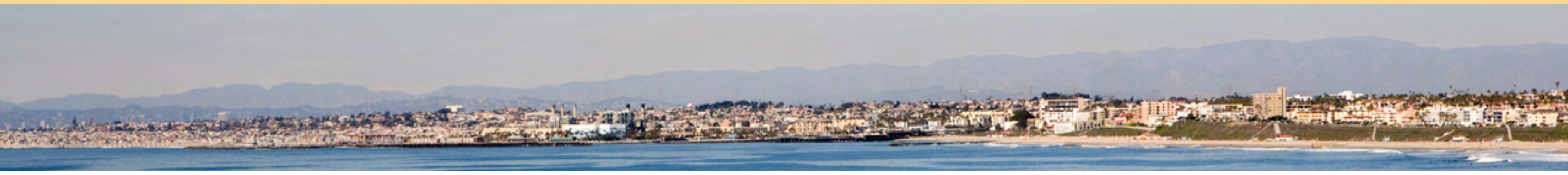
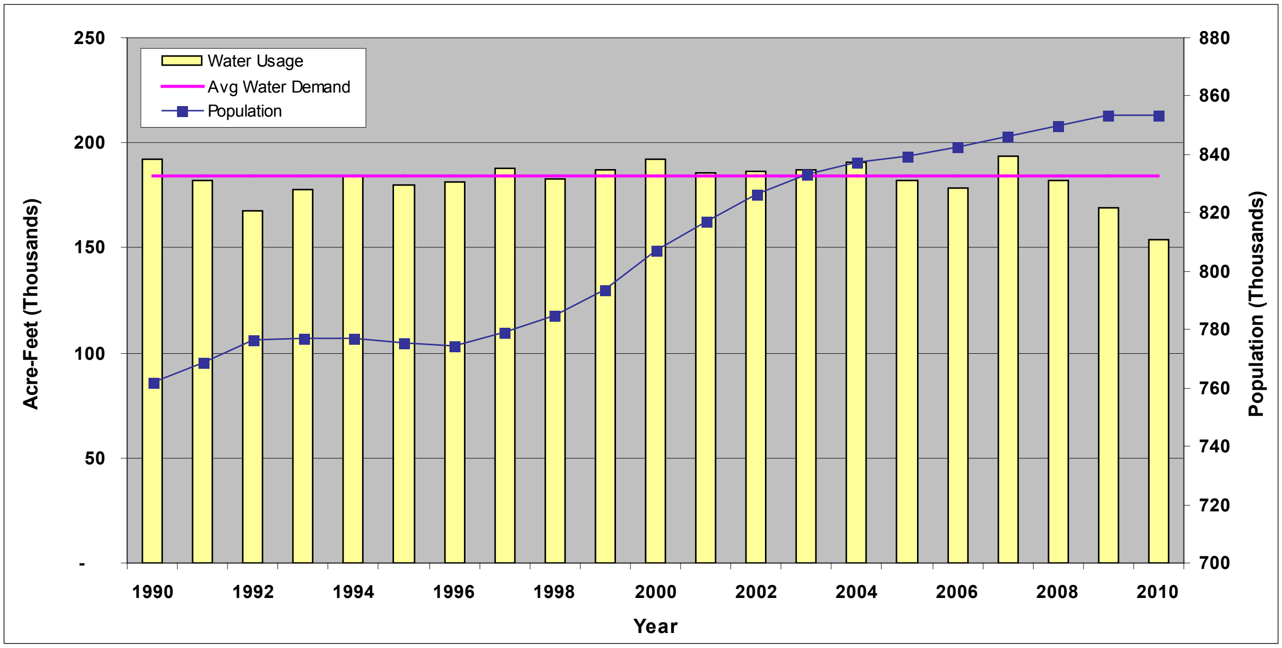


Figure 3-1: West Basin Service Area Historical Retail Water Demand vs. Population



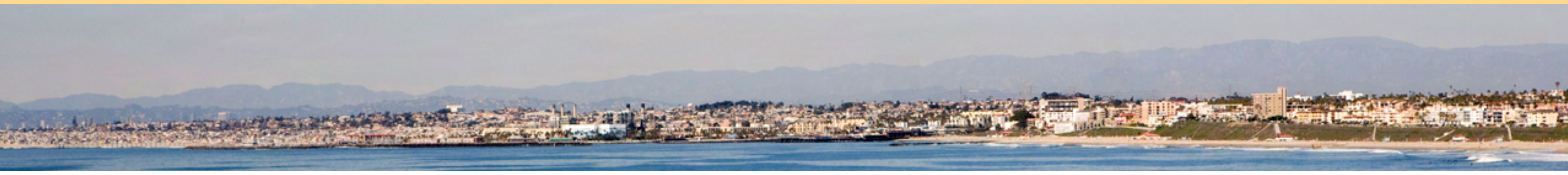
Source: Population data from the Department of Finance and Southern California Association of Governments (SCAG). Water usage data from actual water sales.

Table 3-1 shows the historical demand of each of West Basin's retail agencies as reported to West Basin by those agencies. Although some agencies have seen some dramatic shifts in water demand, there is an overall decrease of retail agency demand by 3 percent in the last five years relative to 2001-2005.

Table 3-1: Historical Water Demand per West Basin Customer Agency

Retail Agency	2001-2005	2006-2010	% Change
California American Water Co.	3,601	4,063	13%
Cal Water Service Co.- Dominguez	36,636	38,167	4%
Cal Water Service Co. - Hermosa/Redondo	16,022	14,450	-10%
Cal Water Service Co.- Palos Verdes	20,536	21,524	5%
Cal Water Service Co.- Hawthorne	5,216	4,616	-12%
City of El Segundo	17,354	17,577	1%
City of Inglewood	11,899	11,496	-3%
City of Lomita	2,729	2,459	-10%
City of Manhattan Beach	8,547	6,188	-28%
L.A. County Waterworks District #29	11,924	9,738	-18%
Golden State Water	35,657	34,185	-4%
Total	**170,121**	**164,463**	**-3%**

Source: Based upon actual water use sales.
Note: California American Water Co. and California Water Service Co - Dominguez include pumping from the Central Groundwater Basin into the West Basin service area.



3.1.2 Historical Replenishment Demand

The West Coast Groundwater Basin is reliant upon replenishment supplies to not only meet demand but also to maintain water quality levels. Groundwater in this basin is annually extracted beyond the natural level of replenishment, and as a result, seawater begins to intrude into the basin along the coast. The current method in preventing seawater from contaminating the groundwater basin is by injecting freshwater supplies into the West Coast and Dominguez Gap Seawater Intrusion Barriers.

While the Los Angeles County Department of Public Works (LACDPW) maintains these barriers, WRD is responsible for acquiring the supply necessary to meet the protection and replenishment demands. As the wholesaler in the region, West Basin sells treated imported and recycled water to WRD to inject into the seawater barriers. As Table 3-2 shows, WRD's demands over the last five years average about 19,000 annually from West Basin. Water demands at the barriers usually do not shift dramatically due to the limited groundwater production each customer is allowed annually. The LACDPW determines the quantity of injection based on the need to maintain protective elevations along the barrier system. Generally however, less groundwater production from the aquifers translates into less demand for barrier injection.

Table 3-2: Historical Replenishment Demand (AFY)

Retailer	2001-2005	2006-2010
Water Replenishment District	22,295	19,011

Source: Based upon actual water use sales.

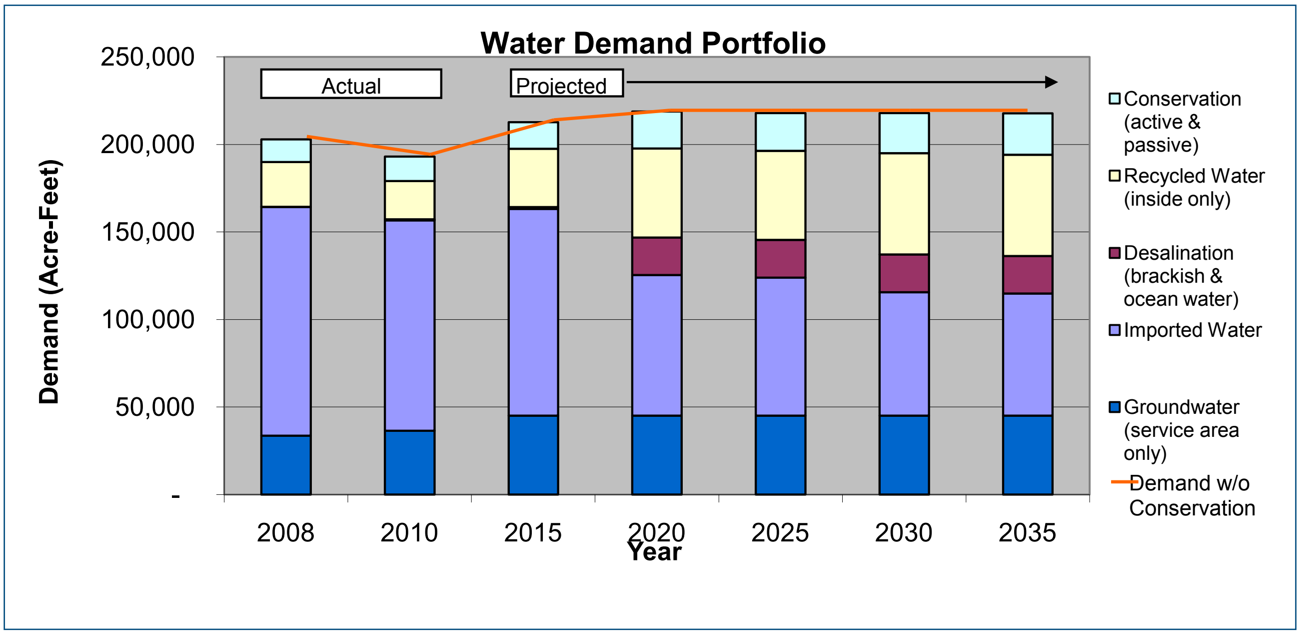
3.2 Current and Projected Water Demands

One of the objectives of this plan is to provide some insight into West Basin's expected water demands for the next 25 years. The predictability of water usage is an important element in planning future water supplies. In 2010, West Basin completed the Water Demand Forecasting Model that was used to project demand through 2035 for West Basin's entire service area. The water demand forecasting model produces various scenarios depending on the level of conservation activities anticipated, change in the cost of water, economic recovery and weather changes. These scenarios can be adjusted to determine different projected demand outcomes based on the change in conditions described above.

For example, the model was also used to show the anticipated decrease in demand that could be achieved as a result of the implementation of planned conservation programs by both West Basin and its retail customer agencies. West Basin then used the Alliance for Water Efficiency tracking tool to calculate the gallons per capita per day baseline usage and conservation targets. This per capita analysis for the regional alliance members follows the guidelines for the Water Conservation Bill of 2009 compliance.

Figure 3-2 provides an overview of the anticipated demands divided into supply sources (including conservation as a means to meet the anticipated demand). This figure also reflects the recent decrease in demand since 2008 and the anticipated future increase in natural demand as the economy improves. However, given planned conservation activities as described at the close of this section, conserved supply will actually offset this demand, maintaining a static level of overall demand of less than 200,000 AFY from 2015 through 2035.

Figure 3-2: Historical and Projected West Basin Demands for Each Supply Resource (AFY)



3.2.1 Current and Projected Retail Demand

Table 3-3 provides the projected total retail demand and potable retail demands net recycled water within West Basin's service area. This table reflects both the baseline demand anticipated if no additional conservation were implemented as well as the final total demand after planned conservation is implemented. A final potable demand is provided that removes the portion of the total demand that is to be met with recycled water supplies as planned and described in Section 4.

Table 3-3 does not include groundwater basin replenishment demands so as not to double count groundwater extraction by West Basin customer agencies. These replenishment demands are captured in Table 3-5. The demand projections shown in Table 3-3 and Table 3-4 include projected water use for lower income single-family and multifamily residential housing within West Basin's service area. As these household demands are served through West Basin's retail customer agencies, the details about those demands are contained within the individual customer agency UWMPs.

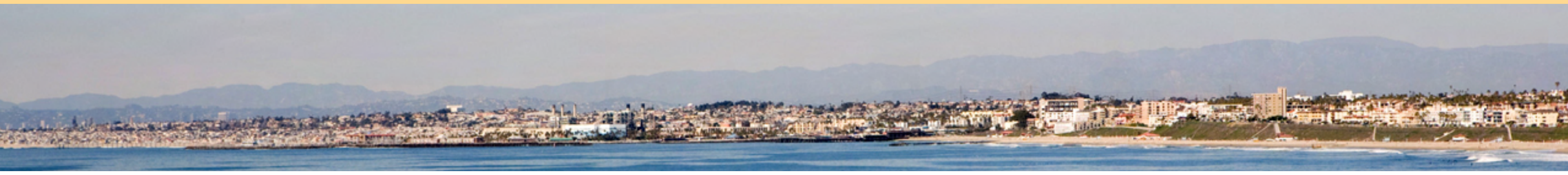


Table 3-3: Projected West Basin Service Area Demand (AFY)

Year	2010	2015	2020	2025	2030	2035
Baseline Demand[1]	170,527	192,134	198,218	197,408	197,451	197,275
Planned Conservation[2]	14,000	15,119	21,039	21,640	22,971	23,632
Final Total Retail Demand	**156,527**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Recycled Water Demand[3]	14,182	16,368	33,882	33,882	37,382	37,382
Final Potable Demand	**142,345**	**160,647**	**143,297**	**141,886**	**137,098**	**136,261**

[1] Projections based on Water Demand Forecasting Model, 2010 [2] Water Use Efficiency Master Plan, Alliance for Water Efficiency Model, 2010 [3] Projections based on the Capital Implementation Master Plan, 2009

Table 3-4 lists the water use projections for each of West Basin's retail customer agencies net of conservation. These projected demands were estimated by analyzing historical water use for each customer agency and then pro-rated for each projected total demand for their service areas. They may not coincide with the individual retail agency UWMPs.

Table 3-4: Projected Retail Water Demand by West Basin Customer Agency (AFY)

Retail Agency	2010	2015	2020	2025	2030	2035
California American Water Co.	3,737	4,226	4,230	4,196	4,165	4,145
Cal Water Service Co.- Dominguez	35,372	40,002	40,039	39,720	39,429	39,240
Cal Water Service Co.- Hawthorne	4,539	5,134	5,138	5,097	5,060	5,036
Cal Water Service Co. - Hermosa/Redondo	14,188	16,045	16,059	15,932	15,815	15,739
Cal Water Service Co.- Palos Verdes	20,681	23,388	23,410	23,223	23,053	22,942
City of El Segundo	16,739	18,930	18,948	18,797	18,659	18,569
City of Inglewood	10,853	12,273	12,285	12,187	12,097	12,039
City of Lomita	2,411	2,727	2,729	2,707	2,688	2,675
City of Manhattan Beach	6,083	6,879	6,885	6,831	6,781	6,748
L.A. County Waterworks District #29[2]	8,289	11,293	11,220	11,922	12,608	13,266
Golden State Water Company	32,515	36,770	36,805	36,511	36,244	36,070
Total[1]	**156,527**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**

[1] Total projects based on water demand forecasting model [2] Provided by L.A. County Waterworks District #29

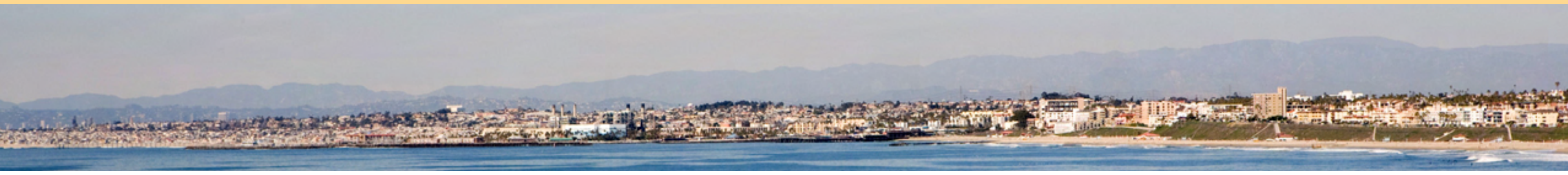
3.2.2 Current and Projected Additional Water Uses and Losses

West Basin's replenishment demands (the same as seawater intrusion barrier demands) are captured in Table 3-5. Water system losses and other factors are not included in West Basin's UWMP but are instead described by the retail customer agencies.

Table 3-5: West Basin Additional Water Uses: Replenishment (AFY)

	2010	2015	2020	2025	2030	2035
Imported Water	15,274	3,500	3,500	3,500	-	-
Recycled Water	7,706	16,980	16,980	16,980	20,480	20,480
Total	**22,980**	**20,480**	**20,480**	**20,480**	**20,480**	**20,480**

Source: Projections based on the Capital Implementation Master Plan, 2009.



3.2.3 Projected Sales to Other Agencies

West Basin also sells recycled water supplies to agencies outside of its service area to meet external non-potable demands. These demands are summarized in Table 3-6.

Table 3-6: West Basin Water Sales to External Agencies (AFY)

	2010	2015	2020	2025	2030	2035
City of Los Angeles	719	6,650	6,650	6,650	6,650	6,650
City of Torrance	6,248	10,700	10,700	10,700	10,700	10,700
Total	**6,967**	**17,350**	**17,350**	**17,350**	**17,350**	**17,350**

Source: West Basin Water Demand Forecasting Model, 2010
Note: Sales are only recycled water

3.3 Regional Alliance Baseline and Target Demands

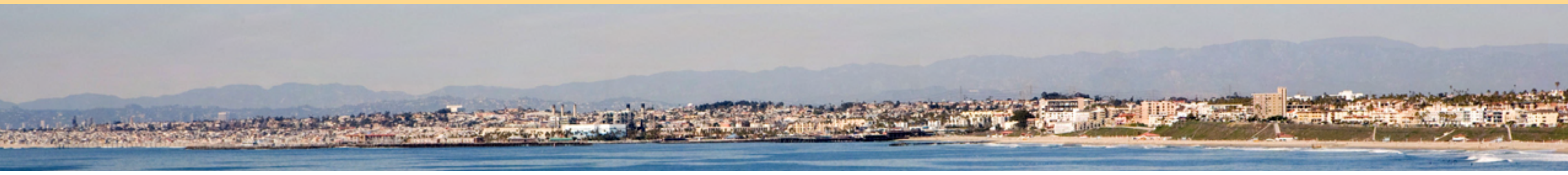
The Water Conservation Bill of 2009 (often referred to as SB X7-7 legislation) requires individual retail water suppliers to set water conservation targets for 2015 and 2020 to support an overall state goal of reducing urban potable per capita water use by 20 percent by 2020. Individual supplier conservation targets must be determined using one of four methods that are based upon a baseline of use that is calculated using the specific guidelines described in DWR's Guidebook to Assist Water Suppliers to Prepare a 2010 Urban Water Management Plan (DWR Guidebook).

As a regional water supply wholesale agency, West Basin is not required to report baseline or target demands in keeping with the Water Conservation Act of 2009. However, as a regional supplier, West Basin has elected to use its 2010 UWMP as the reporting mechanism for a regional alliance formed by some of its retail customer agencies to meet the per capita baseline and target reporting requirements of the Water Conservation Bill of 2009. Since not all of West Basin's retail agencies elected to participate in the regional alliance, the overall historical and projected demand within West Basin's service area described in Section 3.1 and 3.2 will be greater than the regional alliance per capita baseline described in this Section 3.3.

The decision for the investor-owned companies (California American Water Company, California Water Service Company, and Golden State Water Company) to not participate in the regional alliance is because much of their jurisdictions are outside West Basin's service area. Therefore, they each elected to comply as their own agency including their respective service areas across the State.

3.3.1 Regional Alliance Membership

The West Basin regional alliance members include the following West Basin retail customer agencies:



- California Water Service Company (Hawthorne region)
- City of El Segundo
- City of Inglewood
- City of Lomita
- City of Manhattan Beach
- Los Angeles County Waterworks District #29

As a regional alliance, these agencies worked with West Basin to establish a regional baseline of water use and conservation targets for 2015 and 2020. They will also collaborate on implementing the recycled water and conservation programs and projects that will be required to meet these targets.

3.3.2 Regional Alliance Base Use

The regional alliance members used the step by step process called out in the DWR Guidebook to determine the base daily water use for each member. That process and the resulting calculations are described in this section.

Step 1: Determine Supplier Base Period Year Ranges

Table 3-7 provides the recycled water deliveries in 2008 for each member of the regional alliance. The resulting analysis shows that the cities of El Segundo, Inglewood and Manhattan Beach meet over 10 percent of their demand through recycled water deliveries. Therefore these cities are allowed to use a range of 10 to 15 years from which to calculate their baseline water use. Since California Water Service Company (Hawthorne), City of Lomita and Los Angeles County Waterworks District #29 have less than 10 percent of their supply met with recycled water deliveries; they can only use a 10 year range to calculate their baseline use.

Table 3-7: Regional Alliance Recycled Water Deliveries (2008)

Regional Alliance Members	Total Water Deliveries	Total Recycled Water Deliveries	% Recycled Water Deliveries
California Water Service Company - Hawthorne	4,682	94	2%
City of El Segundo	12,765	8,986	70%
City of Inglewood	11,716	2,621	22%
City of Lomita	2,501	7	0%
City of Manhattan Beach	6,697	848	13%
Los Angeles County Waterworks District #29	10,310	0	0%
Regional Alliance Total	**57,394**	**12,556**	**22%**

Table 3-8 shows the resulting 10- to 15-year base period and Table 3-9 shows the five-year base period that will be used for each regional alliance member. The base periods were selected by determining the most appropriate set of years to represent each regional alliance member's baseline use given the methodologies available through DWR.

Table 3-8: Regional Alliance 10- to 15-Year Base Periods

Regional Alliance Members	Number of Years in Base Period	Beginning Year	Ending Year
California Water Service Company - Hawthorne	10	1995	2004
City of El Segundo	10	1995	2004
City of Inglewood	10	1995	2004
City of Lomita	10	1998	2007
City of Manhattan Beach	10	1995	2004
Los Angeles County Waterworks District #29	10	1999	2008

Table 3-9: Regional Alliance 5-Year Base Period

Regional Alliance Members	Number of Years in Base Period	Beginning Year	Ending Year
California Water Service Company - Hawthorne	5	2003	2007
City of El Segundo	5	2005	2009
City of Inglewood	5	2003	2007
City of Lomita	5	2003	2007
City of Manhattan Beach	5	2003	2007
Los Angeles County Waterworks District #29	5	2005	2009

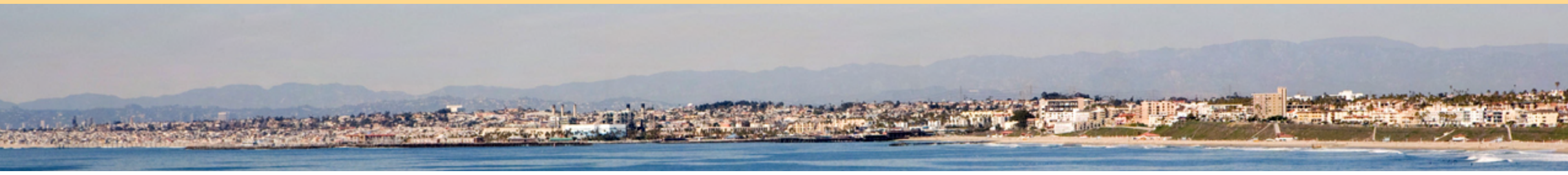
Step 2: Estimate Distribution System Area and Population

The composition of the regional alliance member distribution system boundaries does not match the West Basin service area. Therefore, the distribution service area descriptions and maps for each member of the regional alliance are provided as part of their individual agency 2010 UWMPs and not within West Basin's 2010 UWMP.

The service area population for each agency was determined independently as part of the demand forecasting model development. The service area populations used came from the Southern California Association of Government and Department of Finance projections based upon 2000 census data and predicted economic growth. The population for each regional alliance member for each of the base years is provided in Table 3-10 through Table 3-17.

Step 3: Calculate Gross Water Use

Gross water use for each year within the base year range was provided by each agency. The gross water use for each alliance member was calculated using DWR's Methodology 1 and is described in more detail within each of the alliance member 2010 UWMPs.



Step 4: Calculate Base Per Capita Demand

An annual per capita use was determined by dividing the actual potable water produced for each regional alliance member by the corresponding service area populations that were determined in Step 3 for each of the base year ranges. A final base gross water use is calculated by taking the average per capita use for all years within the selected 10-year range. These calculations are shown in Table 3-10 through Table 3-17.

The five-year base range was used to calculate average gross water use more recently to determine if any regional alliance members are already below the DWR 100 gpcd threshold. Those members with use lower than 100 gpcd, would not be required to meet any further demand reductions.

Table 3-10: California Water Service Company (Hawthorne)
Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd*)	Per Capita Use (gpcd**)
1	1995	42,503	4.2	99.9
2	1996	42,784	4.1	95.4
3	1997	43,065	4.4	101.6
4	1998	42,980	4.3	99.4
5	1999	42,957	4.1	96.0
6	2000	43,088	4.3	98.9
7	2001	46,217	4.2	91.2
8	2002	46,175	4.2	91.4
9	2003	45,147	4.3	95.4
10	2004	46,175	4.4	95.7
10 Year Base Daily Per Capita Use				**96.5**
1	2003	45,147	4.3	96.0
2	2004	46,175	4.6	98.9
3	2005	46,190	4.2	91.2
4	2006	46,174	4.2	91.4
5	2007	46,199	4.4	95.4
5 Year Base Daily Per Capita Use				**94.6**

* mgd = millions of gallons per day
** gpcd = gallons per capita per day

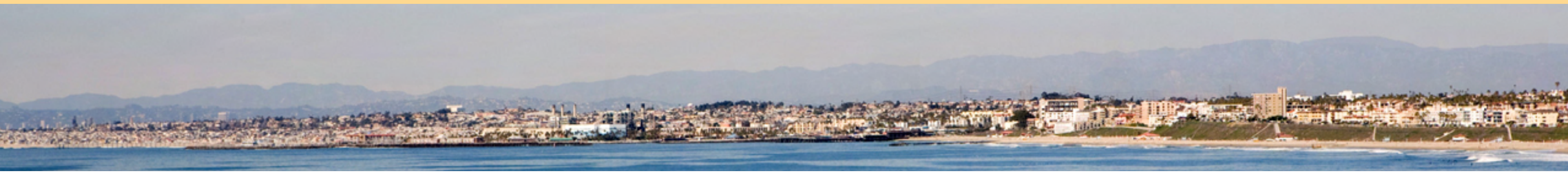


Table 3-11: City of El Segundo -Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1995	15,525	3.8	241.9
2	1996	15,497	3.7	238.0
3	1997	15,543	3.8	241.5
4	1998	15,636	3.7	236.0
5	1999	15,766	3.7	233.9
6	2000	16,033	3.7	228.3
7	2001	16,292	3.4	209.2
8	2002	16,475	3.2	195.6
9	2003	16,663	3.2	191.5
10	2004	16,810	3.2	190.5
10 Year Base Daily Per Capita Use				**220.6**
1	2005	16,904	3.0	178.5
2	2006	16,901	3.1	186.2
3	2007	16,912	3.2	188.4
4	2008	16,877	3.4	199.9
5	2009	16,937	3.5	206.3
5 Year Base Daily Per Capita Use				**191.8**

Table 3-12: City of Inglewood - Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1995	89,156	11.1	124.8
2	1996	89,432	10.2	114.0
3	1997	89,709	10.1	112.2
4	1998	89,987	8.3	92.0
5	1999	90,266	8.6	95.7
6	2000	90,545	9.4	103.6
7	2001	90,545	8.8	97.1
8	2002	90,545	9.1	100.2
9	2003	90,545	9.6	106.4
10	2004	90,545	9.7	106.7
10 Year Base Daily Per Capita Use				**105.3**
1	2003	90,545	9.6	106.4
2	2004	90,545	9.7	106.7
3	2005	94,212	9.4	100.2
4	2006	94,704	9.0	94.7
5	2007	95,199	8.2	86.2
5 Year Base Daily Per Capita Use				**98.8**

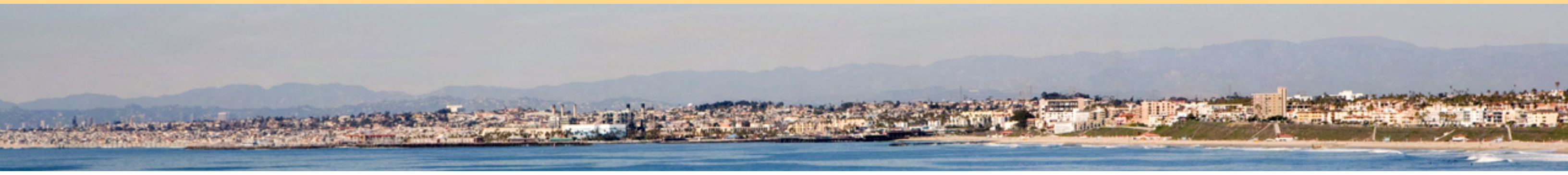


Table 3-13: City of Lomita - Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1998	19,416	2.3	119.0
2	1999	19,477	2.4	125.7
3	2000	19,538	2.5	126.5
4	2001	19,538	2.4	122.5
5	2002	19,538	2.5	129.2
6	2003	19,538	2.5	128.1
7	2004	19,538	2.5	127.5
8	2005	19,830	2.4	119.0
9	2006	19,867	2.3	116.6
10	2007	19,905	2.4	120.3
10 Year Base Daily Per Capita Use				**123.4**
1	2003	19,538	2.5	128.1
2	2004	19,538	2.5	127.5
3	2005	19,830	2.4	119.0
4	2006	19,867	2.3	116.6
5	2007	19,905	2.4	120.3
5 Year Base Daily Per Capita Use				122.3

Table 3-14: City of Manhattan Beach - Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1995	32,516	5.7	175.6
2	1996	32,399	7.6	233.1
3	1997	32,656	5.9	179.6
4	1998	32,806	5.5	166.9
5	1999	32,981	5.9	179.1
6	2000	33,852	5.8	172.3
7	2001	34,557	5.6	163.2
8	2002	35,427	5.8	163.1
9	2003	36,198	5.8	160.0
10	2004	36,464	6.0	164.2
10 Year Base Daily Per Capita Use				**175.7**
1	2003	36,198	5.8	160.0
2	2004	36,464	6.0	164.2
3	2005	36,581	5.5	151.5
4	2006	36,364	5.3	144.6
5	2007	36,240	5.2	142.1
5 Year Base Daily Per Capita Use				**152.5**

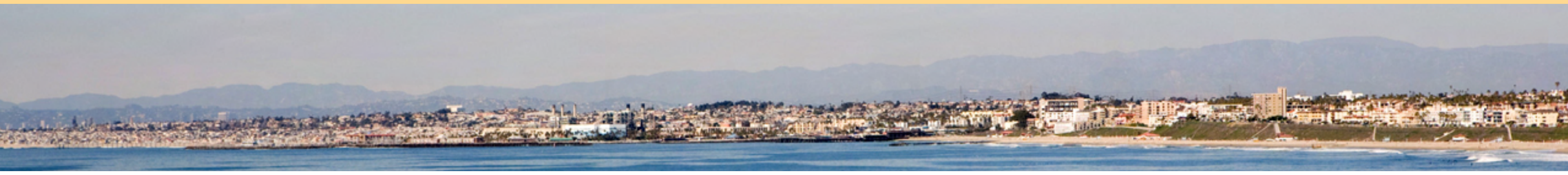
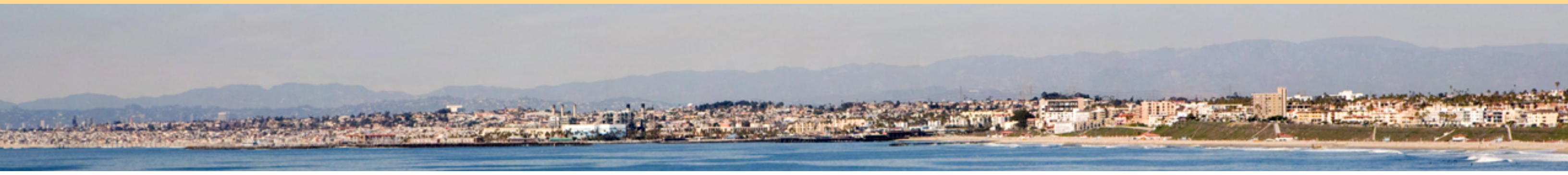


Table 3-15: Los Angeles County Waterworks District #29 - Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1999	27,200	8.3	306.6
2	2000	27,473	8.4	307.1
3	2001	27,473	8.2	298.3
4	2002	27,473	9.0	327.4
5	2003	27,473	9.0	328.3
6	2004	27,473	9.4	341.4
7	2005	27,650	8.6	310.5
8	2006	28,056	8.8	315.1
9	2007	28,467	9.7	340.8
10	2008	28,885	9.2	318.6
10 Year Base Daily Per Capita Use				**319.4**
1	2005	27,650	8.6	310.5
2	2006	28,056	8.8	315.1
3	2007	28,467	9.7	340.8
4	2008	28,885	9.2	318.6
5	2009	29,308	8.3	284.7
5 Year Base Daily Per Capita Use				**313.9**

Table 3-16: Combined West Basin Regional Alliance - Base Daily Per Capita Water Use

Year	Calendar Year	Population	Gross Water Use (mgd)	Per Capita Use (gpcd)
1	1995	225,069	56.2	249.6
2	1996	225,804	59.7	264.5
3	1997	226,990	57.1	251.5
4	1998	227,755	53.8	236.4
5	1999	228,647	54.8	239.6
6	2000	230,529	54.0	234.2
7	2001	234,622	51.1	217.7
8	2002	235,633	49.9	211.8
9	2003	235,564	43.2	183.5
10	2004	237,005	44.6	188.2
10 Year Base Daily Per Capita Use				**227.7**
1	2003	235,564	43.2	183.5
2	2004	237,005	44.6	188.2
3	2005	241,367	43.0	178.3
4	2006	242,067	41.7	172.2
5	2007	242,923	42.5	175.1
5 Year Base Daily Per Capita Use				**179.5**



3.3.3 Regional Alliance Water Use Targets

The regional alliance water use targets were calculated by first determining which of the four allowable target calculation methods would be used for each member of the regional alliance. These methods are:

- Method 1: 80 percent of ten-year baseline per capita use
- Method 2: Applying performance standards
- Method 3: 95 percent of the DWR South Coast Region target of 149
- Method 4: Applying savings by water sector

These selected methods were applied to the 10-year base per capita water use calculated in Tables 3-10 through 3-16 to determine a target per capita water use level for 2020. Once these targets were determined, they were confirmed by comparing them against DWR's maximum allowable target. The maximum allowable target is equivalent to 95 percent of each alliance member's five-year base per capita use calculated in Tables 3-10 through Table 3-16.

If the five-year base per capita use was less than 100 gpcd, then there is no maximum target for that supplier since they would be considered by DWR to be sufficiently efficient in water use. If the 2020 calculated target is greater than the maximum allowable target, then the maximum allowable target must be used instead of the calculated 10-year base targets.

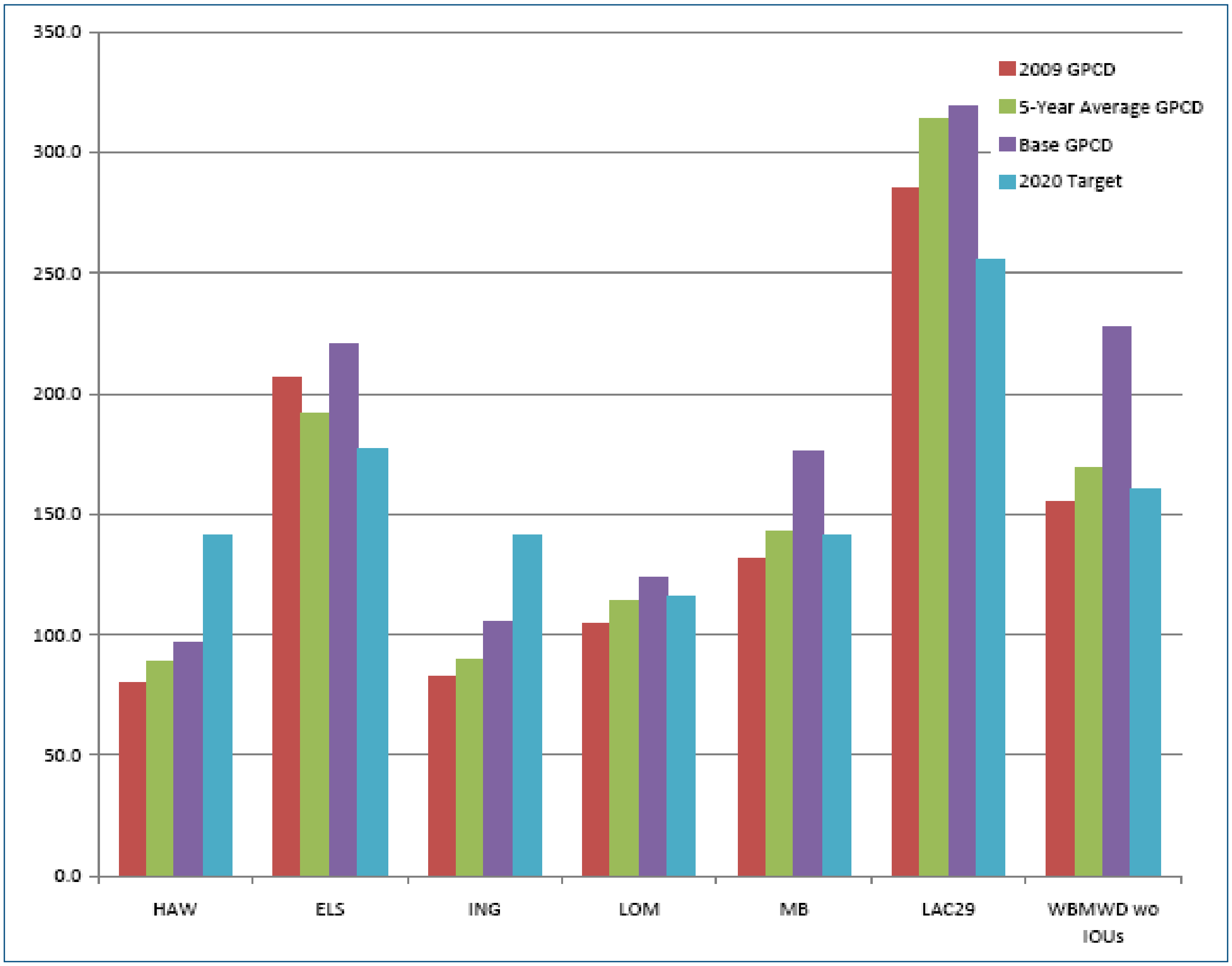
Table 3-17 provides the final per capita targets for each member of the Regional Alliance as well as the overall targets for the combined Regional Alliance. Cells highlighted in gold indicate whether the calculated or maximum allowable target was used to determine the final 2020 target. Once the final 2020 water use target has been calculated, then an interim target is created by calculating the median between the 10-year base per capita use and the final 2020 target.

Table 3-17: Regional Alliance 2015 Interim and 2020 Targets (gpcd)

Member	10-Year Base Water Use	Calculated Water Use Targets		Maximum Allowable Target	Final Targets	
		Method	Target		2015	2020
California Water Service Company Hawthorne	96.5	3	141.6	N/A	119.0	141.6
City of El Segundo	220.6	1	176.5	182.2	198.6	176.5
City of Inglewood	105.3	3	141.6	N/A	123.4	141.6
City of Lomita	123.4	3	141.6	116.2	119.8	116.2
City of Manhattan Beach	175.7	3	141.6	144.9	158.6	141.6
Los Angeles County Waterworks District #29	319.4	1	255.5	298.2	287.5	255.5
Regional Alliance	**227.7**	**1**	**182.2**	**160.5**	**194.1**	**160.5**

Figure 3-3 represents a comparison of the 2009, 5-year base, 10-year base and 2020 target water use for each regional alliance member.

Figure 3-3: Regional Alliance Base and Target Use Summary



3.4 Water Use Reduction Plan

In order to meet the 2020 and interim 2015 water use targets calculated in Table 3-17, West Basin has collaborated with its regional alliance agencies to develop individual Water Use Efficiency Master Plans. These plans are anticipated to be completed in May 2011. Table 3-18 identifies several key programs already identified for implementation that will help the regional alliance achieve or even go beyond the required water use targets.

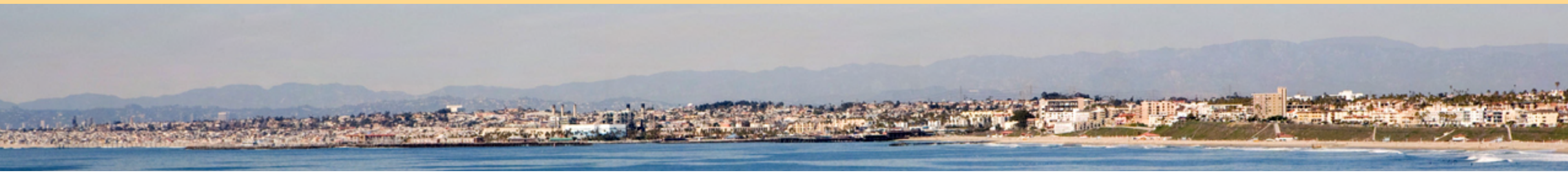
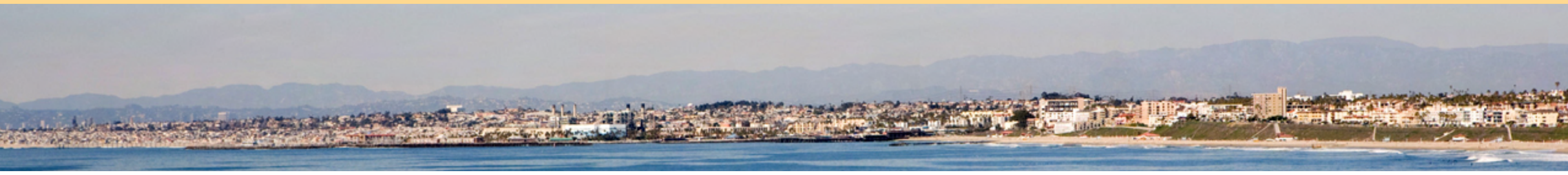


Table 3-18: West Basin and Retailer Conservation Program Participation

Programs	West Basin	Los Angeles County Waterworks District #29	City of El Segundo	City of Manhattan Beach	City of Hawthorne	City of Lomita	City of Inglewood
MWD							
Residential Rebate Program	X	X	X	X	X	X	X
Save A Buck Rebate Program	X	X	X	X	X	X	X
West Basin							
High-Efficiency Toilet (HET) Distribution Events	X	X	X	X	X	X	X
Green Living for Apartments and Condos (Direct HET Installations)	X	X	X	X	X	X	X
Ocean Friendly Landscape Program	X	X	X	X	X	X	X
Complete Restroom Retrofit Program	X	X	X	X	X	X	X
Recirc & Save Program	X	X	X	X	X	X	X
Cash for Kitchens	X	X	X	X	X	X	X
Education Programs	X	X	X	X	X	X	X
West Basin Programs (Funding Pending)							
High-Efficiency Nozzle Program	X	X	X	X	X	X	X
Water Star Schools Pilot Program	X	X	X	X	X	X	X
Water & Energy Efficiency in the Motel/Hotel and Schools Sectors	X	X	X	X	X	X	X
Other Water Retailer							
Turf Removal Program	N/A	X	-	-	-	-	-
HET Rebates (CII)	N/A	X	-	-	-	-	-
Landscape Surveys	N/A	X	-	-	-	-	-
Education Programs	N/A	X	-	-	-	-	-
Landscape Incentives	N/A	X	-	-	-	-	-



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SECTION FOUR

Water Supply

2010

SECTION 4 Water Supply

It is West Basin's mission to ensure a safe, adequate and reliable supply of water for the communities it serves. An increasing population and recent restrictions on imported supplies, have challenged West Basin to continue to diversify its supply portfolio to meet new demands through expanded recycled water production and distribution, new ocean-water desalination supply development, and increased conservation programming through its WR 2020 Program.

This section provides an overview of the current and future water supplies needed to meet the expected demands within the West Basin service area. Although West Basin does not provide all of the supplies needed to meet these demands, this 2010 UWMP provides a complete picture of all of the historical and projected supplies to be used by its customer agencies to meet the overall demand within West Basin's service area.

While this section provides a discussion of the more traditional imported and groundwater supplies, alternative supplies such as recycled water and desalination are discussed within Sections 9 and 10 respectively. Water quality for all supplies is discussed in Section 6.

4.1 West Basin Service Area Water Supply Portfolio

Since its formation in 1947, West Basin has fulfilled its responsibility of providing its customer agencies with supplemental imported and recycled water supplies to meet increasing regional demands. Prior to West Basin, the average customer agency operating within the area relied completely on groundwater.

Today, these agencies rely on an increasingly diverse mix of water resources: 22% groundwater, 62% imported, 8% non-potable recycled water, and 8% conserved supply through water use efficiency measures. It is projected that by 2030, the resource mix on average will be 23% groundwater, 36% imported, 19% non-potable recycled water, 10% ocean water desalination and 12% conservation as shown in Figure 4-1.

Table 4-1 provides West Basin's historical annual water supply in its service area from 2005 to 2009.

Table 4-1: West Basin Service Area Historical Retail Water Supply (AFY)

Supplies	2005	2006	2007	2008	2009
Groundwater[1]	34,304	31,469	31,773	33,849	38,307
Imported Water[2]	130,782	129,060	132,209	122,520	108,145
Recycled Water[3]	16,971	17,859	28,956	25,651	21,897
Desalination[4]	0	89	461	158	620
Total	**182,057**	**178,477**	**193,399**	**182,178**	**168,969**

[1] Groundwater production within West Basin service area only (includes West Coast Groundwater Basin and pumping from the Central Groundwater Basin into the West basin service area). [2] Imported retail use only; does not include replenishment deliveries (i.e. Barrier). [3] Recycled water does not include replenishment deliveries (i.e. Barrier) [4] Desalination includes brackish only.

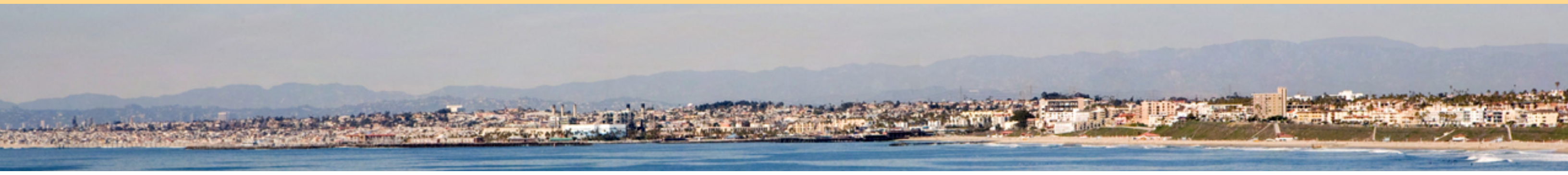
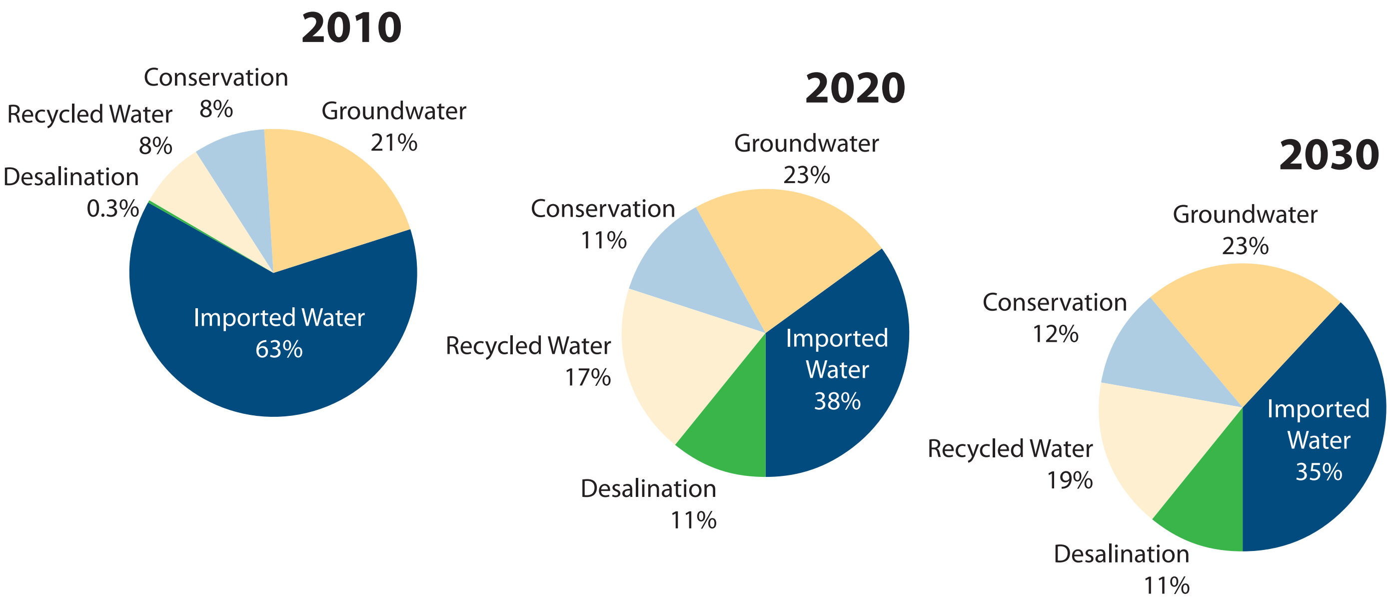


Figure 4-1: West Basin Service Area Projected Water Supplies



West Basin has been able to support the diversification of supplies available to its customer agencies by providing access to imported water supplies from MWD as well as through the development of recycled and conserved water supplies. These supplies are served directly to its customer agencies and indirectly as the replenishment supplies necessary to maximize groundwater production. Historically, West Basin's primary supply source was imported water from MWD. However, given recent concerns over future reliability of these imported supplies, West Basin has been increasing its development of local supplies.

As Table 4-2 shows, West Basin is projecting to more than double current recycled water supplies as well as invest in over 20,000 AFY of ocean-water desalination supply. Coupled with an additional doubling of conserved supply through water use efficiency programs, the overall imported water use is expected to be cut nearly in half from the start of West Basin's WR 2020 Program in 2008, by 2020.

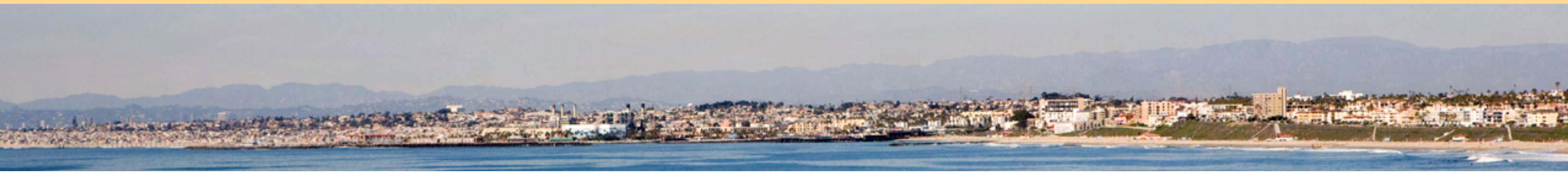


Table 4-2 West Basin's Service Area Projected Water Supply (AFY)

Supplies	2010	2015	2020	2025	2030	2035
Groundwater[1]	36,360	45,000	45,000	45,000	45,000	45,000
Imported Water[2]	104,985	114,647	76,797	75,386	70,598	69,761
Recycled Water[3]	14,182	16,368	33,882	33,882	37,382	37,382
Desalination[4]	500	1,000	21,500	21,500	21,500	21,500
Total	**156,027**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Conservation[5]	14,000	15,119	21,039	21,640	22,971	23,632
Total	**170,027**	**192,134**	**198,218**	**197,408**	**197,451**	**197,275**

[1] Groundwater production within West Basin service area only.
[2] Imported retail use only; does not include replenishment deliveries (i.e. Barrier).
[3] Recycled water does not include replenishment deliveries (i.e. Barrier).and deliveries outside the service area.
[4] Desalination includes both brackish and ocean-water.
[5] Conservation consists of Active and Passive savings according to West Basin's projected estimates.

4.2 Imported Water Supply

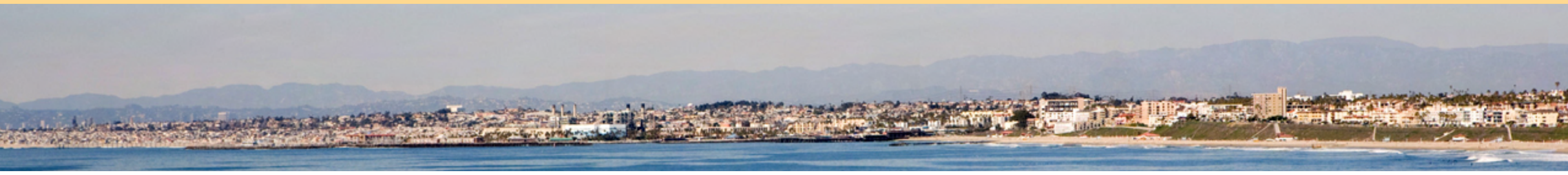
West Basin has historically relied on approximately 150,000 AFY of imported water from MWD to meet customer demand. MWD supplies originate from the Colorado River and State Water Project (SWP) to meet West Basin's retail and replenishment demands. In recent years, MWD's imported supplies have become increasingly restricted given protracted droughts and recent environmental rulings and restrictions that limited the amount of SWP water available for use.

These restrictions have resulted in partial allotments for West Basin and the unavailability of lower cost surplus water for in-lieu basin replenishment use. As a result, West Basin has been challenged to maximize the efficient use of this supply as well as explore ways to develop alternative supplies. This challenge has resulted in West Basin's goal of reducing its projected need for imported water supplies in half by 2020 through the development of local and conserved supplies.

4.2.1 Colorado River Resources

MWD owns and operates the Colorado River Aqueduct (CRA), which connects the Colorado River to MWD's regional distribution system. The CRA has a capacity of 1.25 Million AFY (MAF) to transport MWD's current contracted entitlement of 550 Thousand AFY (TAF) of Colorado River water. MWD also holds a priority for an additional 662 TAF and 180 TAF when surplus flows are available.

MWD and the State of California have acknowledged that they could obtain less water from the Colorado River in the future. The U.S. Secretary of Interior asserted that California had to limit its use of Colorado River supplies to 4.4 MAF per year, plus any available surplus water. California's Colorado River Water Use Plan characterizes how California would develop a combination of programs to meet this limit as well as how to use any available surplus water. In 2003, the Quantification Settlement Agreement



Lake Mead

(QSA) among California agencies with Colorado River rights established the baseline water use for each of the agencies and facilitates the transfer of water from agricultural agencies to urban uses. The QSA is currently ruled as invalid due to multiple legal proceedings that have taken place over the past eight years. MWD has filed appeals that will stay the ruling until the outcome of the appeal. If the ruling stands, it could delay and potentially increase the cost of the QSA's supply development programs.

An extended drought from 2000-2007 within the Colorado River Basin has also decreased supply reserves to 50 percent capacity. Even in light of these challenges, according to MWD's 2010 Draft Regional Urban Water Management Plan, MWD intends to maximize the use of the California Aqueduct by obtaining a full 1.25 MAFY through the use of exchanging water rights purchases from agricultural and other holders.

Colorado River Aqueduct

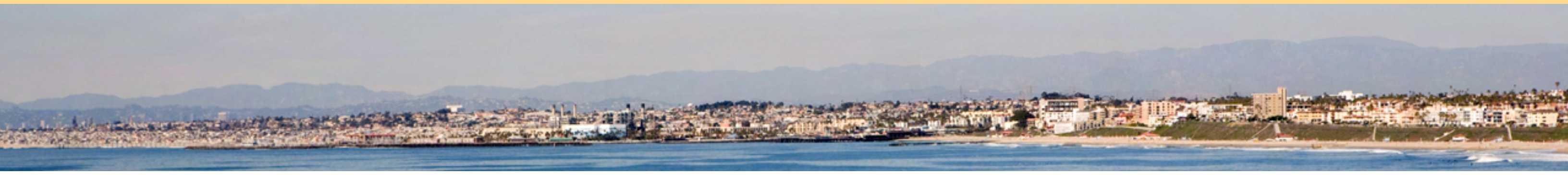
4.2.2 State Water Project Resources

California's SWP is MWD's second main source of imported water and is the nation's largest state-built water and power development and conveyance system. It includes facilities, such as pumping and power plants; reservoirs, lakes, and storage tanks; and canals, tunnels, and pipelines, that capture, store, and convey water from Northern California to 29 water agencies in Central and Southern California.

Operated and maintained by DWR, the SWP provides water supplies for 25 million Californians and for 750,000 acres of irrigated farmland. The original State Water Contract called for an ultimate delivery capacity of 4.2 MAF, with MWD holding a contract for 1.9 MAF. Since that time there have been significant challenges to meeting those delivery goals.

More than two-thirds of California's drinking water, including all of the water supplied by SWP, passes through the San Francisco-San Joaquin Bay-Delta (Bay-Delta). For decades, the Bay-Delta system has experienced water quality and supply reliability challenges and conflicts due to variable hydrology and environmental standards that limit pumping operations.

Most recently, the State experienced a critically dry period from 2008 to 2009 (including the driest ever spring in 2008) that produced some of the lowest reservoir levels recorded for SWP facilities. During this drought period, a biological opinion regarding the dwindling populations of Bay-Delta Smelt (2008) and salmonid species (2009) resulted in legal rulings that have been estimated to reduce average SWP deliveries from approximately 3.3 MAF to 2.3 MAF. DWR released a Water Allocation Analysis in 2010 that has resulted in an MWD estimated reduction in SWP supplies of 150 – 200 TAF for 2010 MWD UWMP 2010.



Although challenges to the SWP exist, MWD has developed plans to meet imported water needs for West Basin and other member agencies though the implementation of several exchange and storage programs as well as working towards a project that will fix the Bay-Delta issues and resume normal deliveries. These supply development programs will be implemented in concert with MWD's ongoing collaboration with member agencies to more efficiently use the supplies to meet increasing demands and potential climate change impacts.

State Water Project System

4.2.3 Types of MWD Supply

MWD offers different types of imported water to its member agencies depending on the ultimate use. Among them, West Basin has delivered Non-Interruptible Water (treated full-service) and Seasonal Treated Replenishment Water (in-lieu replenishment).

Non-Interruptible Water is the treated firm supply that is available all year and not subject to interruption. Historically, West Basin has delivered an average of about 150,000 AFY of non-interruptible water. It is used as the main supplemental supply to cities and water agencies, and the Dominguez Gap Seawater Barrier and 25% of the supply for the West Coast Basin Seawater Barrier.

Seasonal Treated Replenishment Water, when available, is delivered to customer agencies that are eligible to offset groundwater production with imported water. This program incentivizes customer agencies to take imported surplus water when available, which indirectly replenishes the groundwater basin. This surplus water is purchased at a discount rate in exchange for leaving groundwater in the basin for no less than a year so that it can be used subsequently during dry years.

4.3 Groundwater Supply

West Basin does not supply groundwater to retail agencies. However, retail agencies operating within West Basin's service area rely on groundwater production to meet just over 20 percent of retail demand and this is expected to continue through 2035. There are, however, a few jurisdictions within the West Basin's service area that rely exclusively on imported water to meet all their current water needs.

West Basin overlies nearly all of the adjudicated WCGB. In the early 1940s, extensive over pumping of the WCGB had led to critically low groundwater levels, which resulted in seawater intrusion along the coast. This situation precipitated an adjudication that limits the allowable extraction that could occur in any given year and assigned water rights to basin pumpers. The adjudicated water rights (as shown in Table 4-3) that were developed are, however, in excess of the safe operating basin yield.

Table 4-3: West Coast Groundwater Basin Pumping Rights (AFY)

Retail Agencies	2009-2010 Pumping Rights
Cal Water Service Co. (Dominguez)	10,417
Cal Water Service Co. (Hawthorne)	1,882
Cal Water Service Co.(Hermosa/Redondo)	4,070
City of Inglewood	4,450
City of El Segundo	953
City of Lomita	1,352
City of Manhattan Beach	1,131
Golden State Water Company	7,502
Non-Retail Water Pumpers[1]	32,711
Total	**64,468**

Source: West Basin Watermaster Report, DWR: 2009-2010
[1] Water right holders that are not water retail agencies: i.e. Nurseries, Cemeteries, Industries, and Refineries

To allow full WCGB rights to be pumped while limiting seawater intrusion, WRD purchases non-interruptible imported and recycled water supplies from West Basin for injection by the Los Angeles County Department of Public Works at the West Coast and Dominguez Gap Seawater Intrusion Barriers. WRD is the entity responsible for maintaining and replenishing the WCGB. WRD is a special district created by the State and governed by a 5-member elected body to replenish and protect the groundwater basin with imported water and recycled water.

Two of West Basin's customer retailers also import groundwater from outside the West Basin service area from the adjacent Central Groundwater Basin to meet their demand (California American Water Co. and California Water Service Co. – Dominguez). Although rights have been bought, sold, exchanged, or transferred through the years, the total amount of groundwater projected to be extracted over the next 25 years will be fairly consistent due to the adjudication of both the West Coast and Central basins. The financial costs to pump groundwater have been and are projected to remain less than the cost to purchase imported water so it can safely be assumed that water retailers will continue to maximize their groundwater rights.

Table 4-4 shows the historical amounts of Central Basin Groundwater Basin groundwater supplies that were purchased by West Basin's retail customer agencies.

Table 4-4: Historical Central Basin Groundwater Retail Imported Supply (AF)

Retail Agency	2005	2006	2007	2008	2009
California American Water Co.	3,042	2,708	1,977	1,787	3,537
Cal Water Service (Dominguez)	1,242	2,374	2,815	2,344	1,647
Total	**4,284**	**5,082**	**4,792**	**4,131**	**5,184**

Source: DWR Watermaster Reports, 2004-2009

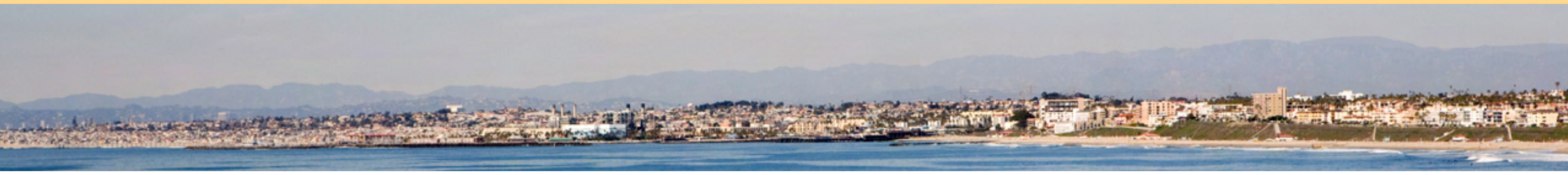


Table 4-5 shows the historical groundwater supplies for West Basin's retail customer agencies (not including the non-retail or private rights holders) from both basins.

Table 4-5: Historical Groundwater Retail Supply (AF)

Basin name(s)	2005	2006	2007	2008	2009
West Coast Basin	30,020	26,387	26,981	29,717	33,123
Central Basin	4,284	5,082	4,792	4,132	5,184
Total	**34,304**	**31,469**	**31,773**	**33,849**	**38,307**

Source: DWR Watermaster Reports, 2004-2009

Table 4-6 shows the historical groundwater replenishment supplies for the West Coast and Dominguez Gap Barriers.

Table 4-6: Historical Groundwater Replenishment Supply

	2005	2006	2007	2008	2009
West Coast Barrier Supplies	8,555	6,035	4,228	3,978	4,231
Dominguez Gap Barrier Supplies	5,327	5,828	4,027	4,049	7,927
Total	**13,882**	**11,863**	**8,255**	**8,027**	**12,158**

Source: DWR Watermaster Reports, 2004-2009

Table 4-7 shows the projected retail groundwater production to meet West Basin service demands through 2035.

Table 4-7: Current and Projected Retail Groundwater Supply (AF)

Basin name(s)	2010	2015	2020	2025	2030	2035
West Coast Basin	28,993	40,000	40,000	40,000	40,000	40,000
Central Basin	5,256	5,000	5,000	5,000	5,000	5,000
Total	**34,249**	**45,000**	**45,000**	**45,000**	**45,000**	**45,000**

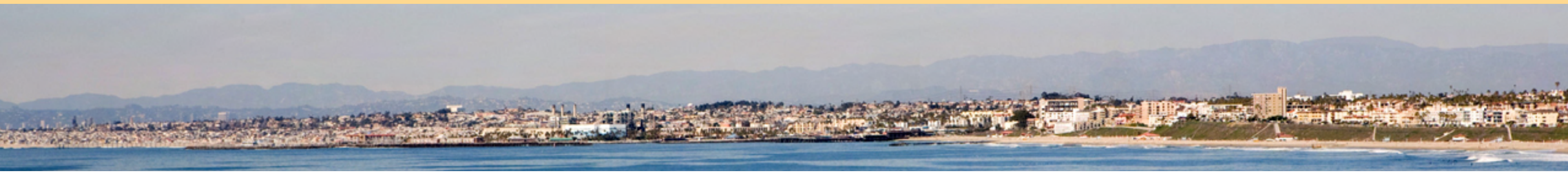
Source: [1] Based upon actual water use sales.

Table 4-8 shows the projected replenishment (or seawater intrusion barrier) supplies to be met by West Basin's retail agencies through 2035.

Table 4-8: Current and Projected Replenishment Groundwater Supply

	2010	2015	2020	2025	2030	2035
Imported Water	15,274	3,500	3,500	3,500	-	-
Recycled Water	7,706	16,980	16,980	16,980	20,480	20,480
Total	**22,980**	**20,480**	**20,480**	**20,480**	**20,480**	**20,480**

[1] Barrier water deliveries to both the West Coast and Dominguez Gap Barriers



4.4 Water Transfers and Exchanges

Water transfers and exchanges are management tools to address increased water needs in areas of limited supply. Although transfers and exchanges of water do not generate new supply, these management tools distribute water where it is abundant to where it is limited.

MWD has played an active role statewide in securing water transfers and exchanges as part of their planning goals. Although West Basin is a member of MWD, there has not been a compelling reason or opportunity to pursue transfers directly.

4.5 Alternative Sources of Supply

As shown in Figure 4-1, West Basin is planning on increasing the diversity of its water supply portfolio through the further development of alternatives to the more traditional imported water and groundwater supplies. This 2010 UWMP has dedicated entire sections to discuss the planned projects and programs to develop alternative supplies such as Recycled Water (Section 9) and Desalination (Section 10) as well as the increased water use efficiency programs discussed in Section 7. West Basin is pursuing these alternative supplies as part of its WR2020 initiative.

SECTION FIVE

Water Reliability

2010

SECTION 5 Water Reliability

West Basin's supply reliability can be greatly impacted by many factors including changes in the availability of supplies due to climatic or infrastructure changes as well as the ability to use those supplies more efficiently in both average and dry periods. These factors can result in immediate (facility failures), near-term (SWP limitations), or long-term (climate change) impacts to reliability and must therefore be considered in future planning.

The impacts of these factors on reliability increase under single dry and multiple dry year hydrologic patterns. Historically, dry years result in increases in demands as well as decreases in surface supplies that result in shortages if not managed effectively. Although not all shortages can be prevented, West Basin's WR 2020 goal to expand and further diversify its supply portfolio is the most important step toward improving the immediate, near- and long-term reliability of supplies. If shortages do occur, West Basin has completed comprehensive water shortage contingency planning to provide reliability during these situations.

5.1 Potential Impacts to Reliability

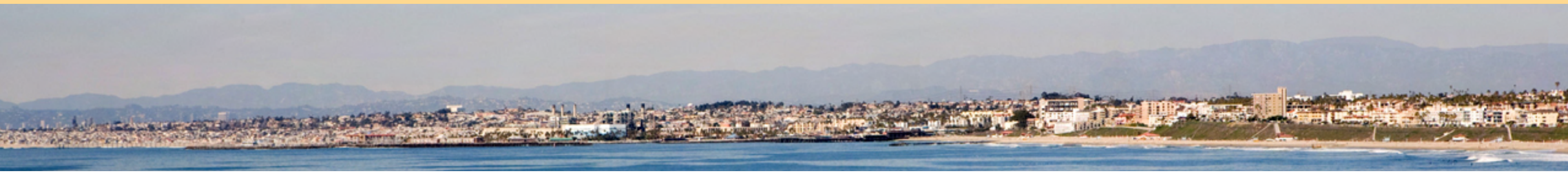
Reliability within the West Basin service area is a composite of the reliability of each source of supply. Table 5-1 summarizes the factors that impact each resource's supply reliability. Of all of the supplies shown in Table 5-1, imported supply has the greatest number of factors that will impact its reliability. It is because of this, that West Basin is moving forward with its plans to expand water use efficiency, further develop recycled water and add ocean-desalination supplies. Further explanation of each impact category on reliability is described in the subsections below.

Table 5-1: Factors Resulting in Impacts to Reliability

Water Sources	Legal	Environmental	Water Quality	Climatic
Imported Water	X	X	X	X
Groundwater	X		X	X
Recycled Water			X	
Ocean Water Desalination			X	

5.1.1 Imported Water Reliability

As discussed in Section 4, MWD has and will continue to contend with considerable challenges to maintaining a reliable source of imported supply for its member agencies. After learning from the droughts of 1977-78 and 1989-92, MWD instituted a resources planning process that has resulted in the following documents:

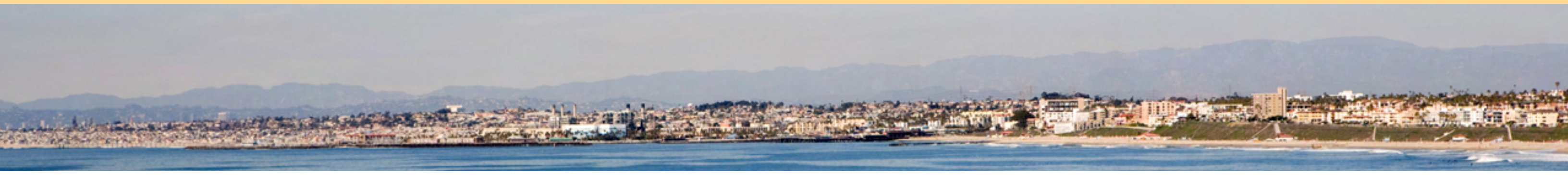


- **1996, 2004 and 2010 Integrated Resources Plans (IRP):** MWD's IRP process assessed potential future regional demand projections based upon anticipated population and economic growth as well as conservation potential. The IRP also includes regional supply strategies and implementation plans to better manage resources, meet anticipated demand, and increase overall system reliability.
- **1999 Water Surplus and Drought Management Plan (WSDM):** The WSDM provides the policy guidance to manage the region's water supplies to achieve the reliability goals of the IRP. This is achieved by integrating the operating activities of surplus and shortage supplies through a series of stages and principles.
- **2008 Water Supply Allocation Plan (WSAP):** The WSAP includes the specific formula for calculating member agency supply allocations and the key implementation elements needed for administering the allocation. The need for the WSAP arose after the 2008 Bay-Delta biological opinions and rulings that limited SWP supplies to its contractors including MWD. The WSAP formula seeks to balance the impacts of a shortage at the retail level while maintaining equity on the wholesale level for shortages of MWD supplies up to 50%.

Since the 2008 Bay-Delta reductions, MWD has been using the WSAP formulas to contend with the reduction in available imported supplies. Although it is anticipated that the WSAP will continue to be in effect in the near–term, MWD states in its 2010 Draft UWMP that there will be sufficient supply to meet member agency demands in single and multiple dry years from 2015 through 2035. This is assuming that MWD storage levels are at or above average levels prior to those cycles.

MWD also is planning as part of the 2010 IRP to further support member agency local resource development as well as investigate potentially generating its own local resources for distribution to member agencies. The development of local resources as well as furthering existing conservation goals to meet the Water Conservation Act of 2009 targets are anticipated to provide a supply buffer for member agencies to rely upon in times of drought and longer-term climatic changes.

The factors affecting reliability for imported water supplies include legal, environmental, water quality and climactic. The legal factor includes policies and contracts on the SWP with the Department of Water Resources and on the Colorado River system with the Department of the Interior and other Colorado River basin states. Legal actions can impact supplies from these two sources in various ways as experienced recently with a federal district court decision limiting SWP supplies due to perceived impacts on specific fish in the Delta estuary. This example also shows how environmental factors such as endangered species, their habitat, and other related concerns must be taken into account in decisions that can curtail supplies. Likewise, the quality of these imported source waters can impact availability of supplies due to treatment, remediation or otherwise to ensure drinking water standards are fully met. In terms of impacts from climatic factors, imported water supplies rely heavily on runoff from rainfall and



snowpack in the State Water Project and Colorado River watersheds. If the amount of snowpack and rainfall changes significantly in these two water supply systems, the quantity of water in any given year is subject to fluctuations. With the uncertainty of the impacts from long-term climate changes, imported water supplies may become more or less reliable in the future, depending on the availability of storage.

5.1.2 Groundwater Reliability

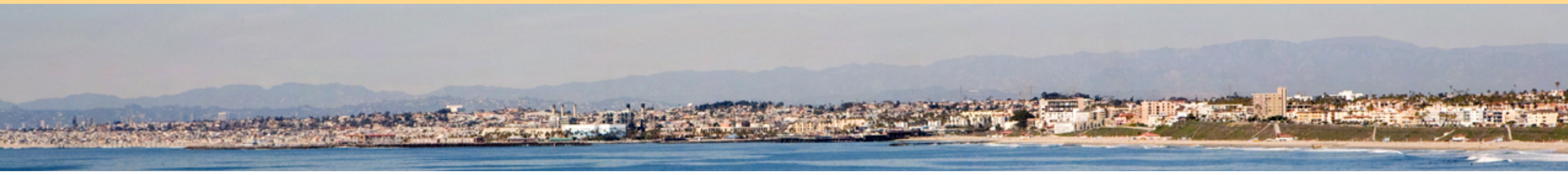
The reliability of groundwater supplies dictates how much supplemental supply West Basin will need to provide its customer agencies to meet their demands. Groundwater is traditionally considered a highly reliable supply since it is not immediately susceptible to changes in climate and surface flows. However, the two main factors that impact the reliability of groundwater supplies are legal and water quality.

Because the WCGB is an adjudicated basin, pumping rights are established for particular entities. However, changes to basin operation including allocation of pumping rights, opportunities to utilize the basin in other ways including storage, remediation of contaminated plumes, and pumping expansion for further extraction, are all considered legal impacts because it would require addressing the existing court-ordered judgment.

The LACDPW owns and maintains the seawater barrier system. They also monitor and work with WRD to determine how much barrier injection water is required in order to maintain protective levels to protect the aquifer from seawater intrusion. WRD also determines how much water is needed to replenish the WCGB to support pumping and orders this amount of water from West Basin who then delivers a combination of recycled and imported water.

The water quality of groundwater supplies is a factor in its reliability because the water needs to meet drinking water standards and sometimes requires expensive treatment at each pumping location.

During the time in which groundwater pumping was exceeding recharge and replenishment, seawater intruded into the WCGB. Once the intrusion barriers were brought on-line, the intrusion was stopped, but a large plume of saline water has remained trapped within the basin. The groundwater supply projections have already considered the presence of the plume and therefore anticipate no change in supply reliability as a result of its existence. The saline plume and the methods being employed by West Basin and its customer and neighboring agencies to manage the plume are further discussed in Section 6: Water Quality.



5.1.3 Recycled Water and Ocean-Water Desalination Reliability

Edward C. Little Water Recycling Facility

Recycled water is often considered as having one of the highest reliabilities of any supply given that there is a consistent source of supply for treatment. Ocean-water desalination is a newer form of supply in California but is also considered highly reliable given the abundance of ocean-water adjacent to West Basin's service area. West Basin has completed a pilot study and is now operating a demonstration facility to further determine environmental safeguards, energy and cost savings possible prior to a full scale program slated for completion by 2017. The planned recycled water and ocean-water desalination projects that West Basin is intending to use to meet future demand are further detailed in Sections 9 and 10 respectively.

5.1.4 Climate Change

Climate change adds its own new uncertainties to the challenges of planning. As a MWD member agency, West Basin is contributing to MWD's activities to better understand and plan for potential long-term climate change impacts.

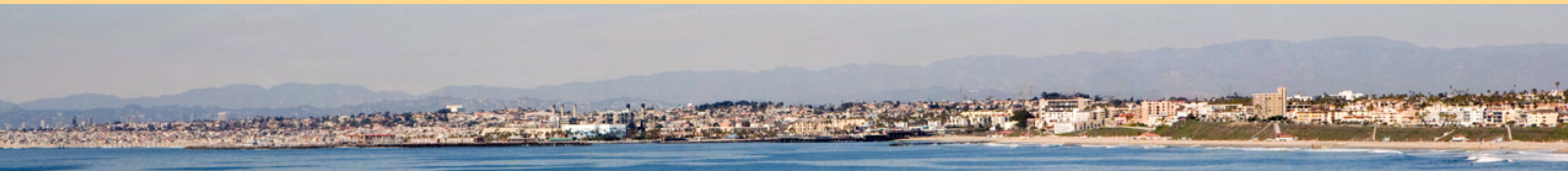
According to the MWD RUWMP, MWD uses historical hydrological data to forecast both the frequency and the severity of future drought conditions, as well as the frequency and abundance of above-normal rainfall. However, weather patterns can be expected to shift dramatically and unpredictably in a climate driven by increased concentrations of carbon dioxide in the atmosphere. MWD is committed to performing its due diligence with respect to climate change.

While uncertainties remain regarding the exact timing, magnitude, and regional impacts of these temperature and precipitation changes, researchers have identified several areas of concern for California water planners. These include:

- Reduction in Sierra Nevada snowpack
- Increased intensity and frequency of extreme weather events
- Rising sea levels resulting in:
    - Increased risk of damage from storms, high-tide events, and the erosion of levees
    - Potential pumping cutbacks on the SWP and Central Valley Project
    - Increased threats to coastal groundwater basins

Other important issues of concern due to global climate change include:

- Changes in urban and agricultural demand levels and patterns
- Impacts to human health from water-borne pathogens and water quality degradation
- Declines in ecosystem health and function
- Alterations to power generation and pumping regimes



In March 2002, the MWD Board adopted policy principles on global climate change as related to water resource planning. The Principles stated in part that MWD supports further research into the potential water resource and quality effects of global climate change, and supports flexible "no regret" solutions that provide water supply and quality benefits while increasing the ability to manage future climate change impacts. To date MWD has completed the following actions to meet these Principles:

- Membership in the Water Utility Climate Alliance that has resulted in completion of several activities including:
    - Letter of support for Western Water Assessment's continued funding as a Regional Integrated Sciences and Assessments team under the National Oceanic and Atmospheric Administration (NOAA)
    - Letter of support for the 2009 Kerry-Boxer Water Utilities Mitigation and Adaptation Partnerships congressional bill addendum
    - Regular communication and consultations with federal agencies on the U.S. Environmental Protection Agency's Climate Ready Water Utility Working Group
    - NOAA Climate Service and January 2010 International Climate Change Forum
    - Released "Options for Improving Climate Modeling to Assist Water Utility Planning for Climate Change"
- Working with local water supply agencies, state and federal agencies and non-governmental organizations to collaborate on climate change related planning issues.
- Using MWD's IRP process to incorporate climate change science into regional plans by providing adaptive management strategies, creating buffer supplies, and encouraging the more efficient use of existing supplies.

5.2 Projected Supply Reliability

West Basin has experienced several examples of single dry and multiple dry year cycles within its historical hydrologic record. For the purposes of this UWMP, West Basin will use the years called out in Table 5-2 as the best representative examples of the single and multiple dry years. Table 5-3 provides an estimate of current (2010) water supply reliability from all four of West Basin's water sources. The table estimates supply reliability for 2011 if it were a single dry year and through a multiple dry period from 2011 to 2013. The average year supply projections shown in Table 5-4 are the average of all years within the 100 year hydrologic record and were previously reported in Section 4: Water Supply.

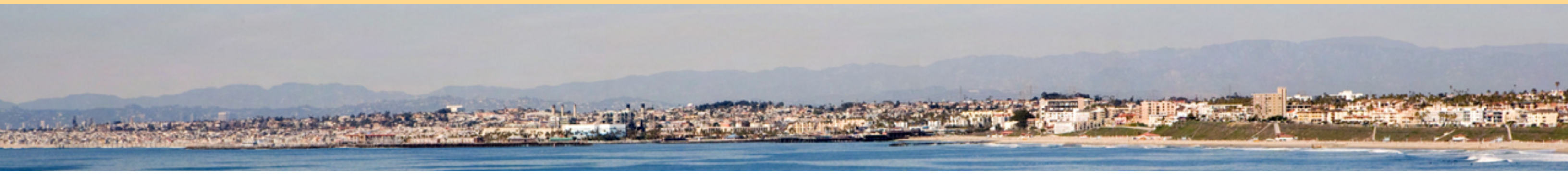


Table 5-2: Basis of Water Years and Historic Conditions

	Single Dry Water Year	Normal Water Year	Multiple Dry Water Years		
	Year 1		Year 1	Year 2	Year 3
	2001	1999	2001	2002	2003
Percent of Normal Year	4%	0%	4%	4.5%	5.0%

Table 5-3: Supply Reliability- Current Water Sources

Water Supply Sources[1]	Average/Normal Water Year Supply (2010)	Single Dry Water Year Supply (2011)	Multiple Dry Water Years Supply		
			2011	2012	2013
Groundwater	36,360	36,360	38,088	39,816	41,544
Imported Water	104,985	111,246	113,342	116,262	119,223
Recycled Water	14,182	14,182	14,619	15,056	15,494
Desalination	1,000	1,000	1,000	1,000	1,000
Total Supply	156,527	162,788	167,050	172,135	177,261
Percent of Normal Year	0%	4%	4%	4.5%	5%

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.

Table 5-4: Projected Average Year Supply and Demand

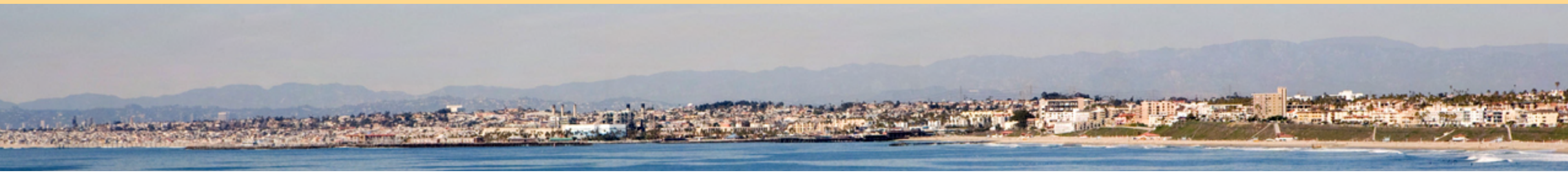
Supplies[1]	2010	2015	2020	2025	2030	2035
Groundwater[1]	36,360	45,000	45,000	45,000	45,000	45,000
Imported Water[2]	104,985	114,647	76,797	75,386	70,598	69,761
Recycled Water[3]	14,182	16,368	33,882	33,882	37,382	37,382
Desalination[4]	1,000	1,000	21,500	21,500	21,500	21,500
Total Supply	**156,527**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Total Demand	**156,527**	**177,015**	**177,179**	**175,768**	**174,480**	**173,643**
Surplus/(Shortage)	0	0	0	0	0	0

[1] Groundwater production within West Basin service area only.
[2] Imported retail use only; does not include replenishment deliveries (i.e. Barrier).
[3] Recycled water does not include replenishment deliveries (i.e. Barrier) and deliveries outside the service area.
[4] Desalination includes both brackish and ocean-water.

5.2.1 Single Dry Year

Table 5-5 shows the projected reliability of water supplies under single dry year conditions for five year increments between 2010 and 2035.

The overall demand is estimated to increase by 4 percent over average year to account for increases in irrigation needs. The scenario selected in the demand forecasting model projects that demands will increase by 4 percent in a single dry year based on the following set of assumptions:



- Economic cycle and restrictions (4-year rebound)
- Growth in connections (normal)
- Population (normal)
- Effects of price of water (MWD projected increases)
- Long-term climate change conditions (normal)
- Water use efficiency (doubling current efforts)
- Short-term weather changes (hot and dry)

The extra demand can readily be met with slight increase to imported water purchases given that West Basin is gradually reducing its dependence on imported supplies in average year and therefore should have imported water allocations available to meet these slight increases in demand.

Table 5-5: Projected Single-Dry Year Supply and Demand (AF)

Supplies[1]	2010	2015	2020	2025	2030	2035
Groundwater	36,360	45,000	45,000	45,000	45,000	45,000
Imported Water	111,246	121,728	83,884	82,417	77,577	76,707
Recycled Water	14,182	16,368	33,882	33,882	37,382	37,382
Desalination	1,000	1,000	21,500	21,500	21,500	21,500
Total Supply	**162,788**	**184,096**	**184,266**	**182,799**	**181,459**	**180,589**
Total Demand[2]	**162,788**	**184,096**	**184,266**	**182,799**	**181,459**	**180,589**
Surplus/(Shortage)	0	0	0	0	0	0

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries
[2] Reflects demand after planned conservation and assumes a 4% increase in demand from average year

5.2.2 Multiple Dry Years

Table 5-6 through 5-10 show the projected reliability of supplies under multiple (three-year) dry year conditions for five year increments between 2010 and 2035. It was assumed in all tables that demand will increase by 5 percent over the average year in the third year of multiple dry year conditions. This projected increase was determined through the assumptions used in the demand forecasting model process and in previous dry-year conditions.

As under single dry year conditions, imported supplies will be purchased to meet any annual increase in demand. As a result, there are no anticipated shortages under any multiple dry year scenarios. Any shortfall in supplies will be met through imported water so long as MWD manages its supply and demand balance through its Water Surplus and Drought Management Plan, which includes specific actions such as storage withdrawals and implications of their WSAP. This is discussed in further detail in section 5.3.1.

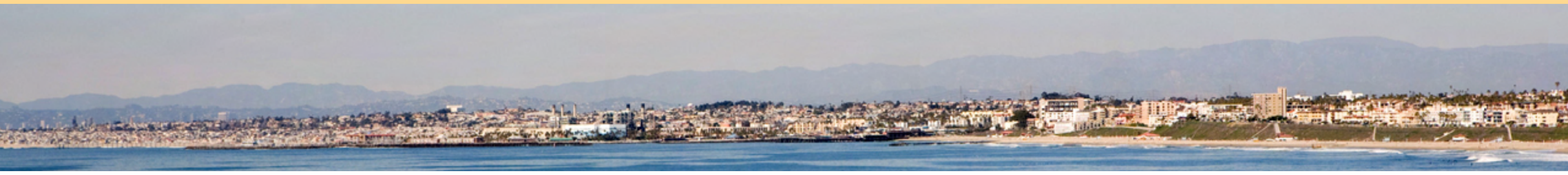


Table 5-6: Projected Multiple Dry-Year (2013-2015) Water Supply and Demand (AF)

Supplies	2013	2014	2015
Groundwater	40,700	42,850	45,000
Imported Water	117,501	115,788	114,078
Recycled Water	15,494	15,931	16,368
Desalination	1,000	1,000	1,000
Total Supply[1]	**174,695**	**175,569**	**176,446**
Total Demand[2]	**174,695**	**175,569**	**176,446**
Surplus/(Shortage)	0	0	0

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.
[2] Reflects demand after conservation and assumes a 5% increase from average to dry year 3.

Table 5-7: Projected Water Multiple Dry-Year (2018-2020) Supply and Demand (AF)

Supplies	2018	2019	2020
Groundwater	45,000	45,000	45,000
Imported Water	99,022	92,340	85,662
Recycled Water	26,876	30,379	33,882
Desalination	13,300	17,400	21,500
Total Supply[1]	**184,198**	**185,119**	**186,044**
Total Demand[2]	**184,198**	**185,119**	**186,044**
Surplus/(Shortage)	0	0	0

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.
[2] Reflects demand after conservation and assumes a 5% increase from average to dry year 3.

Table 5-8: Projected Water Multiple Dry-Year (2023-2025) Supply and Demand (AF)

Supplies	2023	2024	2025
Groundwater	45,000	45,000	45,000
Imported Water	83,003	83,920	84,842
Recycled Water	33,882	33,882	33,882
Desalination	21,500	21,500	21,500
Total Supply[1]	**183,385**	**184,302**	**185,224**
Total Demand[2]	**183,385**	**184,302**	**185,224**
Surplus/(Shortage)	0	0	0

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.
[2] Reflects demand after conservation and assumes a 5% increase from average to dry year 3.

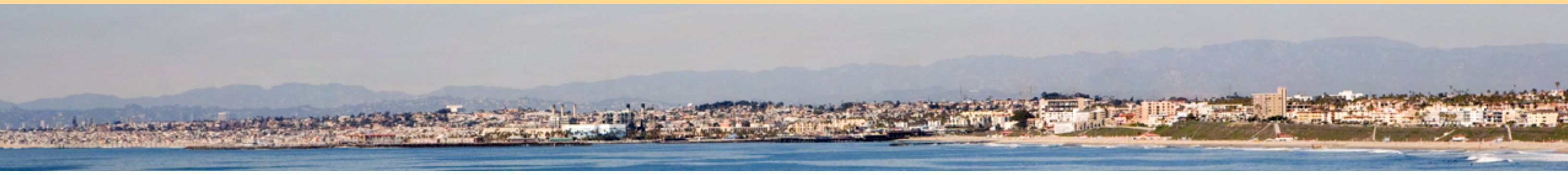


Table 5-9: Projected Water Multiple Dry-Year (2028-2030) Supply and Demand (AF)

Supplies	2028	2029	2030
Groundwater	45,000	45,000	45,000
Imported Water	79,513	79,723	79,937
Recycled Water	35,982	36,682	37,382
Desalination	21,500	21,500	21,500
Total Supply[1]	**181,995**	**182,905**	**183,819**
Total Demand[2]	**181,995**	**182,905**	**183,819**
Surplus/(Shortage)	0	0	0

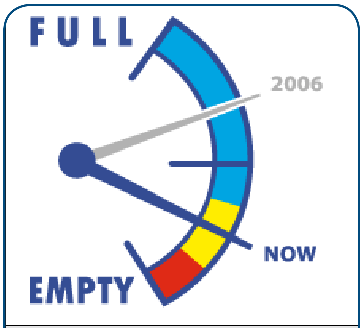
[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.
[2] Reflects demand after conservation and assumes a 5% increase from average to dry year 3.

Table 5-10: Projected Water Multiple Dry-Year (2033-2035) Supply and Demand (AF)

Supplies	2033	2034	2035
Groundwater	45,000	45,000	45,000
Imported Water	77,055	77,960	78,869
Recycled Water	37,382	37,382	37,382
Desalination	21,500	21,500	21,500
Total Supply[1]	**180,937**	**181,842**	**182,751**
Total Demand[2]	**180,937**	**181,842**	**182,751**
Surplus/(Shortage)	0	0	0

[1]Supply reliability covers only retail water demand; does not include replenishment/barrier deliveries.
[2] Reflects demand after conservation and assumes a 5% increase from average to dry year 3.

5.3 Water Shortage Contingency Plan

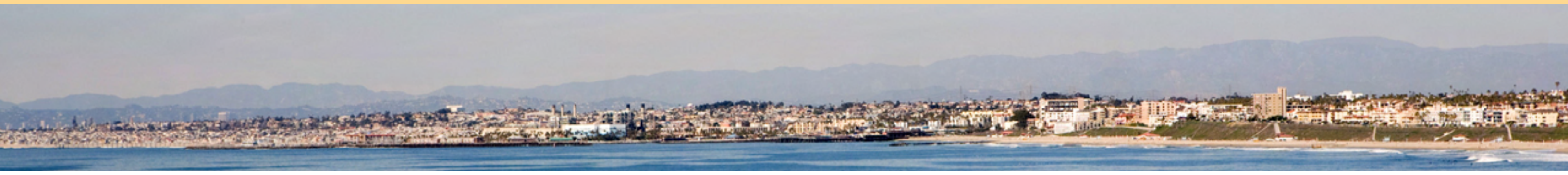


Provided Courtesy of
The Metropolitan Water District
of Southern California

DWR requires that each urban water supplier provide a water shortage contingency analysis within its UWMP. West Basin completed its WSAP in 2008 as a result of MWD's WSAP. West Basin's WSAP is only implemented after MWD reaches the appropriate stage. MWD has captured this planning in its WSDM Plan which guides MWD's planning and operations during both shortage and surplus conditions. Furthermore, MWD developed their WSAP which provides a standardized methodology for allocating supplies during times of shortage.

5.3.1 MWD Water Surplus and Drought Management Plan

In April 1999, MWD's Board adopted the WSDM Plan. It provides policy guidance for managing regional water supplies to achieve the reliability goals of the IRP and identifies the expected sequence of resource management actions that MWD will execute during surpluses and shortages to minimize the probability of severe shortages and reduce the possibility of extreme shortages and shortage allocations. Unlike MWD's previous shortage management plans, the WSDM Plan recognizes the link between surpluses and shortages, and it integrates planned operational actions with respect to both conditions.



WSDM Plan Implementation

Each year, MWD evaluates the level of supplies available and existing levels of water in storage to determine the appropriate management stage. Each stage is associated with specific resource management actions designed to (1) avoid an Extreme Shortage to the maximum extent possible and (2) minimize adverse impacts to retail customers if an Extreme Shortage occurs. The current sequencing outlined in the WSDM Plan reflects anticipated responses based on detailed modeling of MWD's existing and expected resource mix.

Surplus Stages

MWD's supply situation under the WSDM Plan is considered to be in surplus as long as net annual deliveries can be made to water storage programs. The WSDM Plan further defines five surplus management stages that guide the storage of surplus supplies in MWD's storage portfolio. Deliveries for storage in the Diamond Valley Lake and in the State Water Project terminal reservoirs continue through each surplus stage provided there is available storage capacity. Withdrawals from Diamond Valley Lake for regulatory purposes or to meet seasonal demands may occur in any stage. Deliveries to other storage facilities may be interrupted, depending on the amount of the surplus.

Shortage Stages

The WSDM Plan distinguishes between Shortages, Severe Shortages, and Extreme Shortages. Within the WSDM Plan, these terms have specific meaning relating to Metropolitan's ability to deliver water to its customers.

Shortage**:** MWD can meet full-service demands and partially meet or fully meet interruptible demands, using stored water or water transfers as necessary.

Severe Shortage**:** MWD can meet full service demands only by using stored water, transfers, and possibly calling for extraordinary conservation. In a Severe Shortage, Metropolitan may have to curtail Interim Agricultural Water Program deliveries.

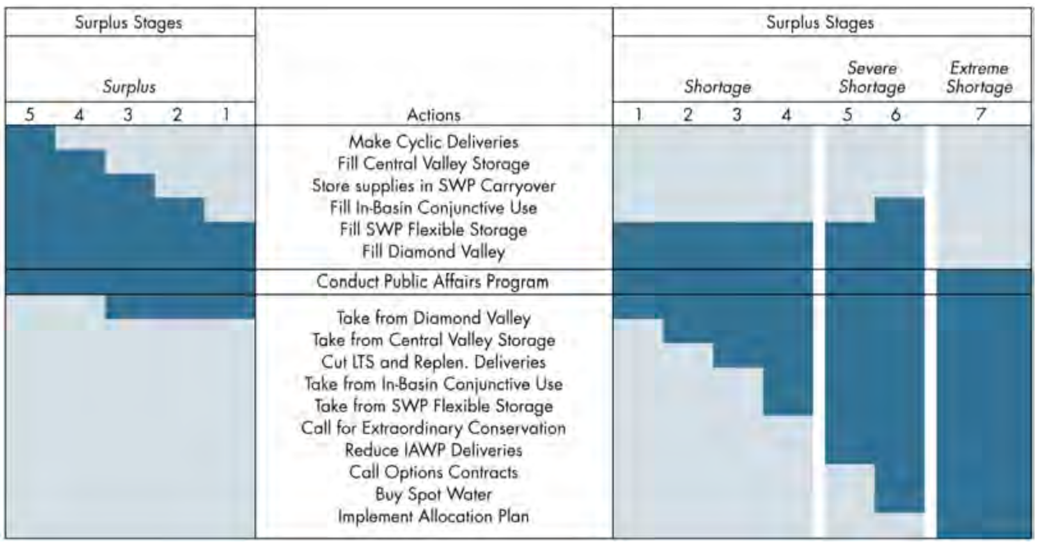
Extreme Shortage**:** MWD must allocate available supply to full-service customers.

The WSDM Plan also defines seven shortage management stages to guide resource management activities. These stages are not defined merely by shortfalls in imported water supply, but also by the water balances in MWD's storage programs. Thus, a ten percent shortfall in imported supplies could be a stage one shortage if storage levels are high. If storage levels are already depleted, the same shortfall in imported supplies could potentially be defined as a more severe shortage.

When MWD must make net withdrawals from storage to meet demands, it is considered to be in a shortage condition. Under most of these stages, it is still able to meet all end-use demands for water. For shortage stages 1 through 4, MWD will meet demands by withdrawing water from storage. At shortage stages 5 through 7, MWD may undertake additional shortage management steps, including issuing public calls for extraordinary conservation, considering curtailment of Interim Agricultural Water Program deliveries in accordance with their discounted rates, exercising water transfer options, or purchasing water on the open market.

Figure 5-1 shows the actions under surplus and shortage stages when a Water Supply Allocation Plan would be necessary to enforce mandatory cutbacks. The overriding goal of the WSDM Plan is to never reach Shortage Stage 7, an Extreme Shortage. At shortage stage 7 MWD will implement its Water Supply Allocation Plan to allocate available supply fairly and efficiently to full-service customers.

Figure 5-1: MWD Surplus and Shortage Stages



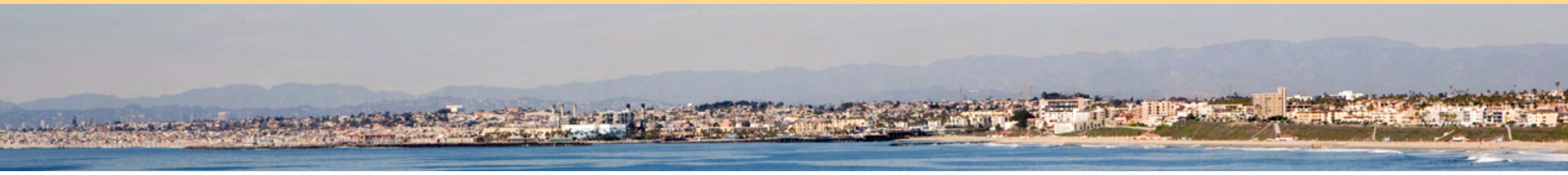
5.3.2 Drought Management Plan

When MWD is operating under a shortage stage, West Basin would take the following stages of action:

***Stage 1*:** West Basin would request for a voluntary effort among its customers to reduce imported water deliveries. In addition, West Basin would pursue an aggressive Public Awareness Campaign to encourage residents and industries to reduce their usage of water.

Stage 2: In addition to the stage above, West Basin would work with its customer agencies to review and update as needed water waste prohibitions and ordinances to discourage unnecessary water usage.

***Stage 3*:** In addition to all the stages above, West Basin would implement its adopted Water Shortage Allocation Plan which calls for a curtailment of imported water for each of its customer agencies. This plan includes an adopted allocation methodology and is enforced by a penalty structure. A draft resolution is included in Appendix F.



5.3.3 West Basin's Water Shortage Allocation Plan

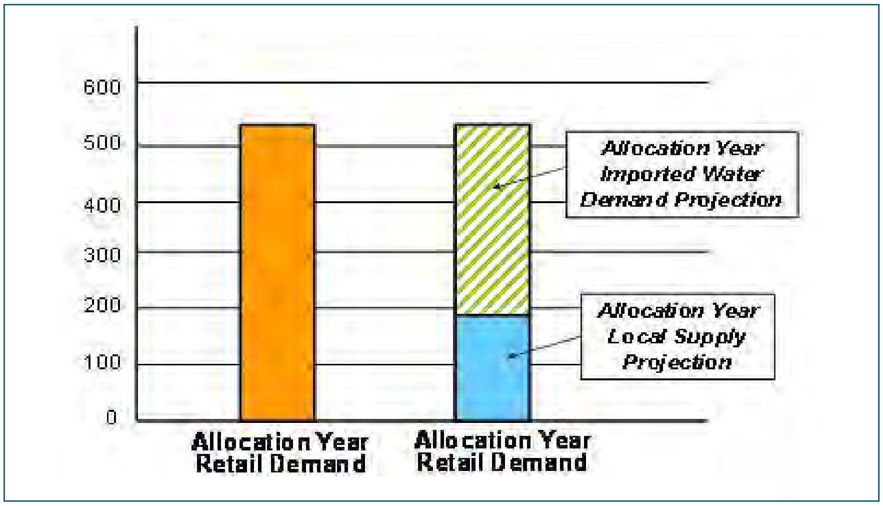
The purpose of West Basins' WSAP is to provide a method for determining allocations for its member agencies relative to the amount of supplies available when MWD has implemented its WSAP to determine West Basin's imported supply allocation. Like MWD, West Basin is a regional wholesaler and can't enforce end user restrictions – it can only impose allocations relative to its supply. Each of West Basin's member agencies must then determine how to meets its WSAP allocation of imported water to avoid over-use penalties.

This section provides an overview of West Basins' allocation formula and the requirements contained within its 2010 WSAP. The full 2010 WSAP is attached as Appendix B.

Establishing Retail Customer Agency Allocations

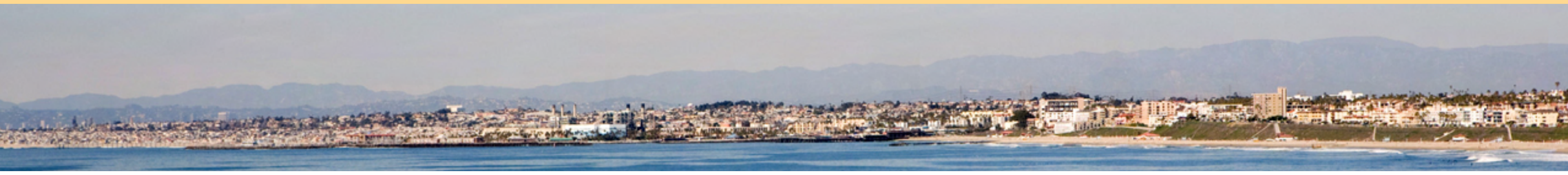
West Basin first calculates each customer agencies' baseline use by taking the average of total supply use (including both local and imported supplies) over a longer period of 1997-2007 (prior to the implementation of the Plan). The baseline is then projected forward to reflect changes in demand from population trends. This becomes the agency's allocation year demand and is shown in Figure 5-2.

Figure 5-2: Example of Allocation Year Imported Water Demand Projection



As shown in Table 5-11 and Figure 5-3, the projected imported water demand is what is allocated according to the declared MWD regional shortage level (Level 2 for the FY 2010-11 Allocation). The following concepts help explain the allocation further:

- **Regional Shortage Levels:** Each level from one to ten represents a five percent increment of Regional Shortage Percentage from 5 to 50 percent.
- **Regional Shortage Percentage:** The percentage difference between available supplies and allocation year demands, in 5 percent increments from 5 to 50.

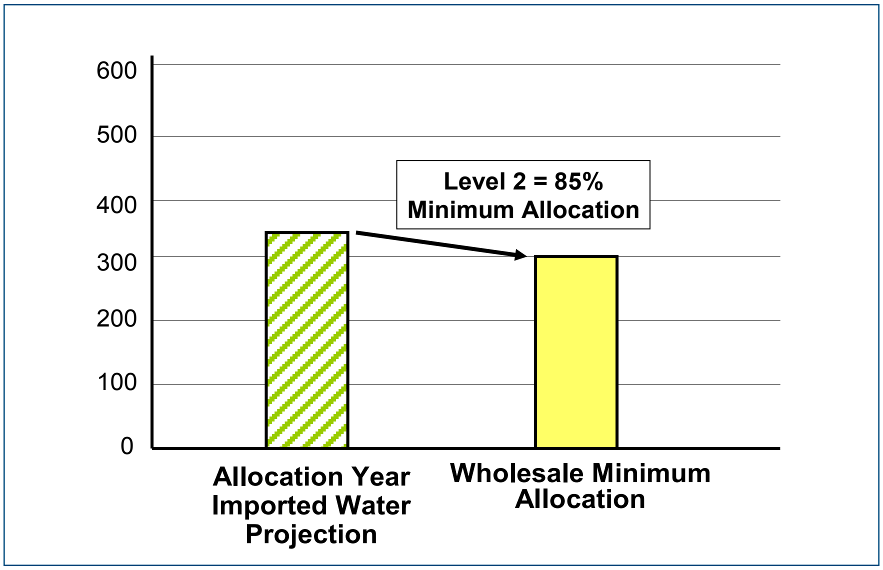


- **Wholesale Minimum Allocation:** ensures that customer agencies will not experience shortages on the wholesale level (from West Basin) that are greater than one-and-a-half times the Regional Shortage Percentage, according to Table 5-11.

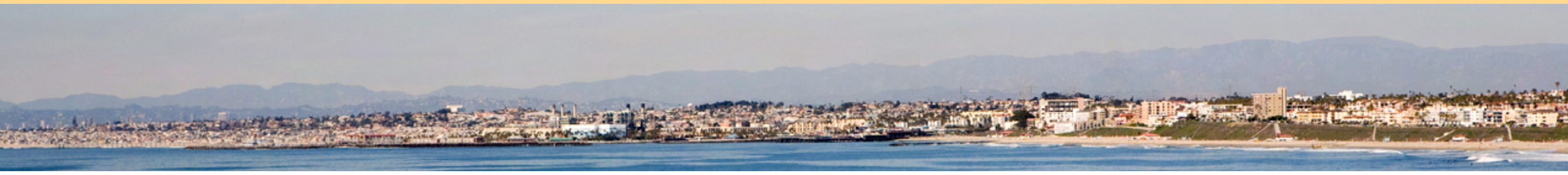
Table 5-11: Example of Initial Minimum Allocation

Regional Shortage Level	Regional Shortage Percentage	Wholesale Minimum Allocation
1	5%	92.5%
2	10%	85.0%
3	15%	77.5%
4	20%	70.0%
5	25%	62.5%
6	30%	55.0%
7	35%	47.5%
8	40%	40.0%
9	45%	32.5%
10	50%	25.0%

Figure 5-3: Example of Initial Minimum Allocation



Unequal impacts of an across-the-board allocation at the retail level can be dramatic depending primarily on the amount of local supplies, if any, held by each customer agency. That is why the allocation methodology assigns additional water supplies based on the following adjustments and credits:



- **Retail Impact Adjustment:** Previously used only in Regional Shortage Level 3 and above, the addition of this adjustment to Levels 1 and 2 was made, to ensure that customer agencies with a high level of dependence on imported water do not experience disparate shortages at the retail level compared to other agencies. Agencies that are 100% dependent on imported water, for example, are allocated at the Regional Shortage Percentage instead of the Wholesale Minimum Percentage.
- **Conservation:** Based on each customer agency's pro-rated share of MWD's modeled estimate of West Basin's conservation in 2006, including active, passive and avoided system losses. It is preferable to use the most recent year, rather than a three-year average, for demand hardening considerations.
- **Qualifying Conservation Rate Structure:** Additional credit added to those customer agencies that have a conservation rate structure. To qualify, a retail customer agency's rate structure must have at least two tiers of volumetric rates, with a price differential between the top and bottom tiers of at least 10 percent. Upon verification of the retail rate structures by MWD, West Basin is given a credit of 0.5% for the total volume subject to these rate structures.

As a member agency of MWD, West Basin is provided the opportunity to request changes to its allocation through an appeals process. Likewise, customer agencies of West Basin are provided the opportunity to appeal to their individual allocations from West Basin based on new or corrected information. Grounds for requesting a change can include, but are not limited to:

- Errors in historical data used in base period calculations
- Unforeseen losses or gains in local supplies
- Extraordinary increases in local supplies
- Adjustments in credits for conservation, including qualifying conservation water rates

In some cases, West Basin has no flexibility to change a customer agency's allocation unless it results in a change to West Basin's total allocation with MWD. West Basin staff will, however, work with customer agencies to determine whether appeals to MWD are warranted, and if so, to prepare an appeal for review by MWD.

Allocation Penalty Rates

West Basin will enforce customer agency allocations through a penalty rate structure similar to what West Basin is subject to in MWD's allocation plan. Penalty rates will only be assessed to the extent that an agency's total annual usage exceeds its total annual allocation. No billing or assessment of penalty rates will take place until the end of the twelve-month allocation period. Penalty rates are in addition to the base rate of the water purchased. The most recent change to the fiscal year 2010-11 WSAP is that there are two penalty rate scenarios.

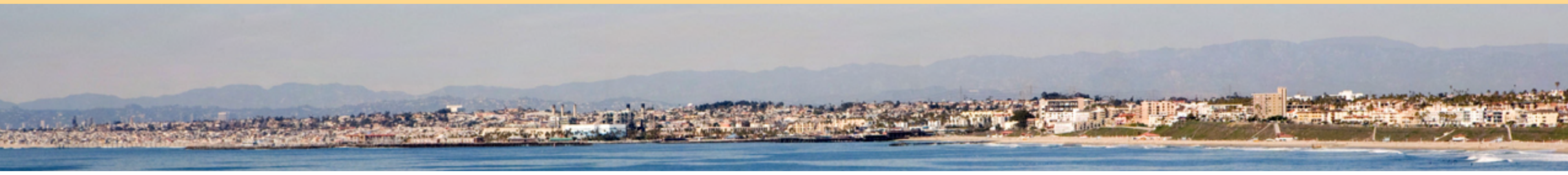


Table 5-12 demonstrates the two penalty rate structure scenarios. If West Basin is under its MWD allocation but a customer agency is over its individual allocation, it will be assessed the penalty structure reflected in Column B. However, if West Basin is over its allocation to MWD, West Basin will assess penalties reflected in Column C to those customer agencies that exceed their individual allocation.

Table 5-12: West Basin Allocation Penalty Rates

A	B	C
	Customer Agency Penalties*	
	West Basin Under Allocation to MWD	**West Basin Over Allocation to MWD**
Customer Agency up to 15% above allocation	1 x Tier 2	1 x Tier 2
Customer Agency over 15% above allocation	1 x Tier 2	3 x Tier 2

* The Tier 2 penalty rate excludes the Treatment Surcharge ("Full Service Untreated Tier 2 Rate")

The actual penalty rates shall be based on the official MWD Untreated Tier 2 water rate in effect the last day in June of the twelve-month allocation period.

Use of Penalty Revenues

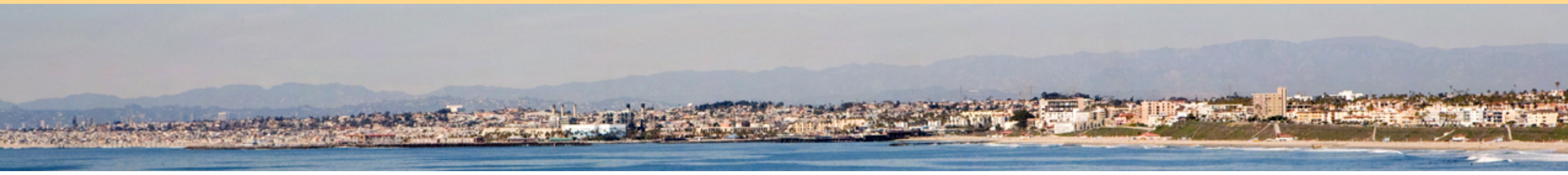
According to the WSAP policy adopted by the West Basin Board, any penalty funds collected by West Basin from customer agencies will first be applied to any penalty owed to MWD. Any "net penalty revenues" remaining can then be applied towards investments in water reliability projects and programs that benefit the West Basin service area as a whole, as approved by the board.

5.3.4 Catastrophic Supply Interruption

In the event imported water supplies are interrupted from a catastrophic event, West Basin, through coordination with MWD, can respond at both a regional and a local level.

In the event that an emergency such as an earthquake, system failure, or regional power outage, etc. affected the entire southern California region, MWD would take the lead and activate its Emergency Operation Center (EOC). The EOC coordinates MWD's and West Basin's responses to the emergency and concentrate efforts to ensure the system can begin distributing potable water in a timely manner.

If circumstances render the Southern California's aqueducts to be out of service, MWD's Diamond Valley Lake can provide emergency storage supplies for its entire service area's firm demand for up to six months. With few exceptions, MWD can deliver this emergency supply throughout its service area via gravity, thereby eliminating dependence on power sources that could also be disrupted. Furthermore, should additional



supplies be needed, MWD also has surface reservoirs and groundwater conjunctive use storage accounts that can be drawn upon to meet additional demands. The WSDM plan guides MWD's management of available supplies and resources during an emergency to minimize the impacts of a catastrophic event.

Locally, the District has the Member Agency Response System (MARS) to immediately contact its customer agencies and MWD during an emergency about potential interruption of services and the coordination of critical resources to respond to the emergency, also known as mutual aid. The MARS is a radio communication system developed by MWD and its member agencies to provide an alternative means of communication in extreme circumstances. The District is currently in the process of enhancing its communication system in order to provide a more rapid response. Additionally, a contingency plan has been developed for both planned and unplanned electrical outages which includes back-up generation for all water treatment plants, transporting mobile generators to key locations, and maintaining water supply through gravity feed in regional reservoirs (i.e. Lake Mathews, Castaic Lake, and Silverwood Lake).

SECTION SIX

Water Quality

2010

SECTION 6 Water Quality

Providing a safe drinking water supply to consumers is a task of paramount importance to West Basin. All prudent actions are taken to ensure that water delivered throughout its service area meets or surpasses drinking water standards set by the California Department of Public Health (CDPH).

Compliance with water quality regulations is a regional water management priority and a shared responsibility. West Basin is responsible for the quality of the desalination and recycled water supplies generated at the C. Marvin Brewer Desalter and Edward C. Little Water Recycling Facility (ECLWRF) and its satellite facilities: Carson Water Recycling Facility, Chevron Nitrification Plant and Exxon-Mobil Nitrification Plant. MWD is responsible for complying with State and Federal drinking water regulations on its imported potable water sold to West Basin. West Basin's retail customer agencies are responsible for ensuring compliance in their individual distribution systems and at the customer tap. As a result of these measures, there are no anticipated water quality impacts that will decrease the supply available for use.

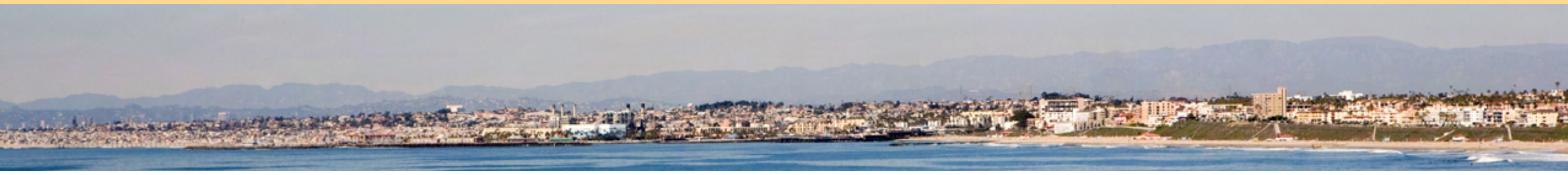
6.1 Imported Water

West Basin's imported water comes from the SWP and Colorado River via MWD pipelines and aqueducts. MWD is proactive in its water quality efforts, protecting its water quality interests through active participation in the regulatory arena and in treatment processes that provide the highest water quality from both sources. MWD has one of the most advanced laboratories in the country where water quality staff can examine the efficacy of existing treatment by performing tests and reviewing results as well as researching new treatment technologies. MWD tests its water for microbial, organic, inorganic, and radioactive contaminants as well as pesticides, herbicides and emerging contaminants of concern. Although not required, MWD also monitors for constituents that are not yet regulated but have captured scientific and/or public interest.

MWD has a strong record of identifying water quality issues early on and developing the water management strategies to minimize their impact on water supplies through their involvement in the following programs as described in MWD's 2010 Regional UWMP.

6.1.1 Source Water Protection

Source water protection is the first step in a multi-barrier approach to provide safe and reliable drinking water. In accordance with California's Surface Water Treatment Rule, Title 22 of the California Code of Regulations, CDPH requires large utilities delivering surface water to complete a Watershed Sanitary Survey every five years to identify possible sources of drinking water contamination, evaluate source and treated water quality, and recommend watershed management activities that will protect and improve source water quality. The most recent sanitary surveys for MWD's water sources were completed in 2005 and 2006.



The next Sanitary Surveys for the watersheds of the Colorado River and the SWP will report on water quality issues and monitoring data through 2010. MWD has an active source water protection program and continues to advocate on behalf of numerous SWP and Colorado River water quality protection issues.

6.1.2 DWR SWP Water Quality Programs

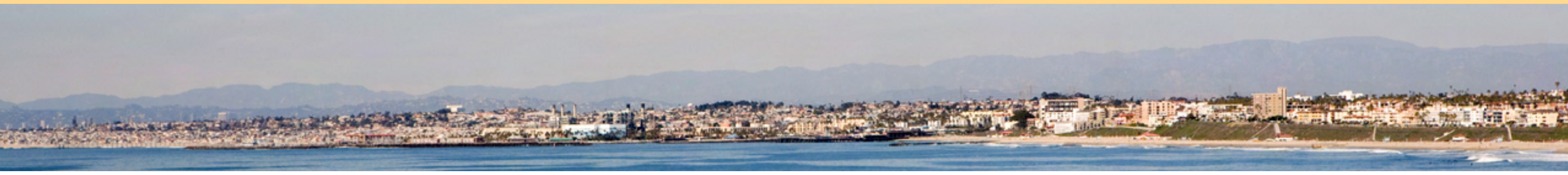
MWD supports DWR's policies and programs aimed at maintaining or improving the quality of SWP water delivered to MWD. In particular, MWD supported the DWR policy to govern the quality of non-project water conveyed by the California Aqueduct. In addition, MWD has supported the expansion of DWR's Municipal Water Quality Investigations Program beyond its Bay-Delta core water quality monitoring and studies to include enhanced water quality monitoring and forecasting of the Delta and SWP. These programs are designed to provide early warning of water quality changes that will affect treatment plant operations both in the short-term (hours to weeks) as well as seasonally. The forecasting model is currently suitable for use in a planning mode. It is expected that with experience and model refinement, it will be suitable to use as a tool in operational decision making.

6.1.3 Water Quality Exchanges

MWD has implemented selective withdrawals from the Arvin-Edison storage program and exchanges with the Kern Water Bank to improve water quality. Although these programs were initially designed to provide dry-year supply reliability, they can also be used to store SWP water at periods of better water quality so the stored water may be withdrawn at times of lower water quality, thus diluting SWP water deliveries. Although elevated arsenic levels have been a particular concern in one groundwater banking program, there are also short-term water quality benefits that can be realized through other storage programs, such as groundwater pump-ins into the California Aqueduct with lower total organic carbon (TOC) levels, as well as lower bromide and total dissolved solids (TDS), in some programs.

6.1.4 Water Supply Security

Changes in national and international security have led to increased concerns about protecting the nation's water supply. In coordination with its member agencies, MWD added new security measures in 2001 and continues to upgrade and refine procedures. Changes have included an increase in the number of water quality tests conducted each year (MWD now conducts over 300,000 analytical tests on samples collected within its service area and source waters), as well as the development of contingency plans that coordinate with the Homeland Security Office's multicolored tiered risk alert system.



6.2 Groundwater

Although West Basin does not serve traditional groundwater supplies, it works to support its customer agencies and WRD to protect and promote the quality of groundwater supplies within its service area.

6.2.1 West Basin and Customer Retail Agency Programs

As part of West Basin's customer service, the Water Quality Department works closely with regulatory agencies to assist retail agencies in meeting State and Federal drinking water regulations through the *Cooperative Basin-Wide Title 22 Groundwater Quality Monitoring Program*. Title 22 refers to the section of the California Code of Regulations pertaining to both domestic drinking water and recycled water standards.

This voluntary program offers water quality testing to customer agencies and is funded through an annual assessment. Three agencies in West Basin's service area participate in the monitoring program. West Basin's water quality staff coordinates wellhead and reservoir water quality testing at approximately eight groundwater wells in the service area to ensure high quality of the local supply of drinking water. Under the program, a contract laboratory provides sampling as well as analytical and reporting services. Laboratory results are reported to West Basin, retail agencies, and the CDPH. The program helps retail agencies save time and expense while providing a valuable service for public health.

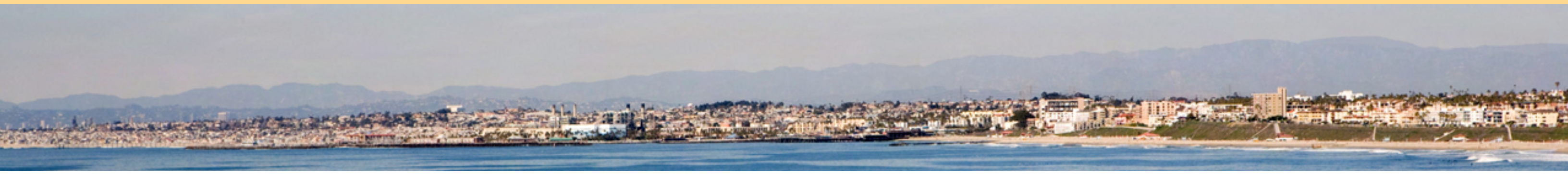
Another service provided under the program is the production of an annual Customer Water Quality report if requested by a customer agency. The Customer Water Quality Report is required by State and Federal law and West Basin's water quality staff has prepared them for several agencies for over 15 years.

6.2.2 Water Replenishment District Programs

As the regional groundwater management agency for the Central and West Coast Groundwater Basins, WRD has several active programs to monitor, evaluate and mitigate water quality issues.

Groundwater Quality Program: WRD continually evaluates current and proposed water quality compliance in agency production wells, monitoring wells, and recharge/injection waters of the groundwater basins. If non-compliance is identified, WRD staff develops a recommended course of action and associated cost estimates to address the problem and to achieve compliance. WRD also monitors and evaluates the impacts of pending drinking water regulations and proposed legislation.

Regional Groundwater Monitoring Program: This program has a network of over 250 WRD and USGS-installed monitoring wells at nearly 50 locations throughout West Basin's service area. Monitoring well data is supplemented with information from production wells to capture the most accurate information available. WRD staff, comprised



of certified hydrogeologists and registered engineers, provides the in-house capability to collect, analyze and report groundwater data. This information is stored in WRD's GIS database and provides the basis to better understand the characteristics of the Central and WCGB.

Safe Drinking Water Program: This program is intended to promote the cleanup of groundwater resources at specific well locations. Through the installation of wellhead treatment facilities at existing production wells, WRD hopes to remove contaminants from the underground supply and deliver the extracted water for potable purposes. Projects implemented through the program are accomplished through direct input and coordination with well owners. The current program focuses on the removal of volatile organic compounds (VOCs) and offers financial assistance for the design and equipment of the selected treatment facility.

WRD provides extensive information on groundwater quality in its Engineering and Survey Reports as well as Regional Groundwater Monitoring Reports. Both reports have a section devoted solely to groundwater quality management, and can be accessed through WRD's website, www.wrd.org.

6.3 Brackish Desalination

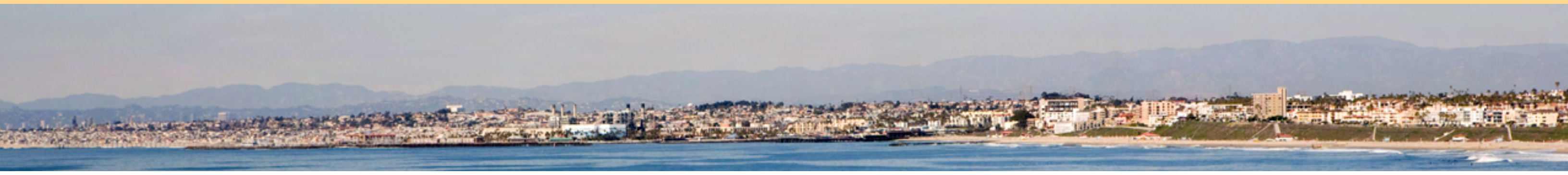
Although construction of seawater barriers was effective in halting the intrusion of seawater into the WCGB, historic plumes of brackish water still remain in the WCGB behind the barriers. In the early 1990s, West Basin completed the C. Marvin Brewer Desalter facility as a demonstration project for removing and treating the brackish water using two existing drinking water wells that were impacted by the seawater intrusion. In 2005, enhancements were made to the desalter program that replaced the two wells with a new, more productive well. This well has the capability to pump 1,600 to 2,400 AFY of brackish ground water to be treated at the desalting facility for use by West Basin's customers.

Since 2002, WRD has also been operating the Robert W. Goldsworthy Desalter, located adjacent to West Basin's desalter. Product water from the Goldsworthy Desalter is delivered for potable use to the City of Torrance's water distribution system.

6.4 Recycled Water

West Basin's ECLWRF, located in El Segundo, has been in continuous operation since 1995 and has conserved over 120 billion gallons of imported water by serving reliable supplies of recycled water for a wide variety of non-potable uses. A full description of West Basin's recycled water program is provided in the Water Recycling section of this report.

West Basin is committed to monitoring and maintaining the high quality of recycled water produced for injection at the West Coast Seawater Barrier and the surrounding groundwater from migrating contamination sources. In addition, groundwater quality



within the aquifer is monitored through more than a dozen monitoring wells inland of the Barrier. These wells represent the quality of the groundwater down-gradient of the Barrier, are essential in providing critical water quality data for the surrounding groundwater. Annual water quality data reports and groundwater modeling are submitted to both the CDPH and the Los Angeles Regional Water Quality Control Board to ensure compliance and security.

6.5 Ocean-Water Desalination

West Basin has been actively researching the feasibility of an ocean water desalination program as part of the drinking water supply. From 2002 to 2009, West Basin operated the Desalination Pilot Project, which marked the first use of microfiltration as a pretreatment to reverse osmosis for ocean-water desalination.

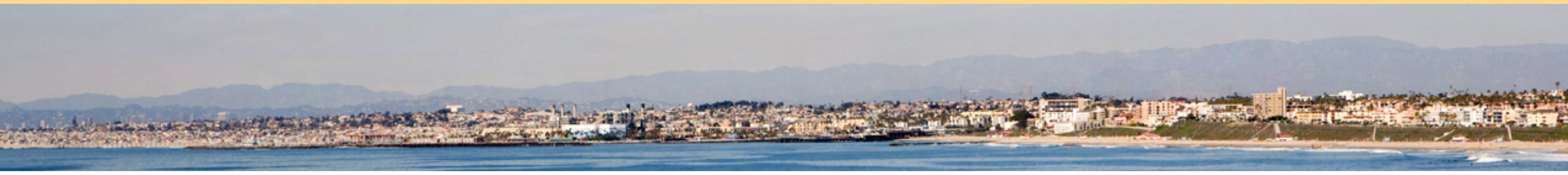
To ensure that this process was effectively treating the ocean water, West Basin performed extensive water quality research at the pilot plant. The water produced at the pilot project consisted of approximately 350 parts per million (ppm) of salt, lower than typical tap water in southern California. The pilot project's analytical test results indicated that the quality of the desalinated ocean water meets current State and Federal drinking water standards set by CDPH and the Environmental Protection Agency (EPA). Along with 500 analytical tests that were performed monthly, additional water quality studies were completed under the auspices of the American Water Works Association Research Foundation.

The research and testing conducted at the Pilot Project informed the design of the Ocean-Water Desalination Demonstration Facility, dedicated in November 2010. The Demonstration Facility will be operational for a minimum of two years while West Basin evaluates the feasibility of permitting and siting of a full-scale desalination plant capable of providing 20,000 AFY of potable water, enough to supply 40,000 families for a year.

While the Demonstration Facility is operational, West Basin will pursue a program master plan in partnership with MWD. The master plan effort will evaluate all water quality and other aspects necessary to develop a full-scale desalination facility with the option of integrating product water into the MWD distribution system. More information on West Basin's ocean-water desalination efforts is included in Section 10.

6.6 Research and Development

West Basin has a dedicated program and budget to constantly engage in research projects that evaluate water quality, efficient operations and new pollution prevention technology and methods. Research projects close the environmental loop by addressing both final product water as well as source control issues to prevent pollution and the need for cleanup technology. West Basin leverages its research dollars by participating on the Boards of water industry research organizations such as WateReuse, American Water Works Associations, National Water Research Institute, Salinity Management Coalition as well as participating with academic institutions in water quality research.



6.7 Effects on Water Management Strategies

Retail water agencies in densely populated southern California are acutely aware of the economic impact of water quality on a public water system. Management strategies must be developed to maintain a safe, reliable supply at reasonable cost without jeopardizing water quality and public health. Water quality, pressure, and supply are maintained through operational practices that can include wellhead treatment for contaminated groundwater sources, or blending down contaminated groundwater with purchased imported surface water from MWD or high quality groundwater from adjacent purveyors.

6.8 Effects on Supply Reliability

Poor water quality makes a water source unreliable, affects overall supply and increases the cost of serving water to the public. More importantly, it results in a loss of customer confidence, which can be very difficult to overcome, even after water quality is restored. A water source that fails drinking water regulations must be taken out of service. The source can be restored through treatment or other management strategies.

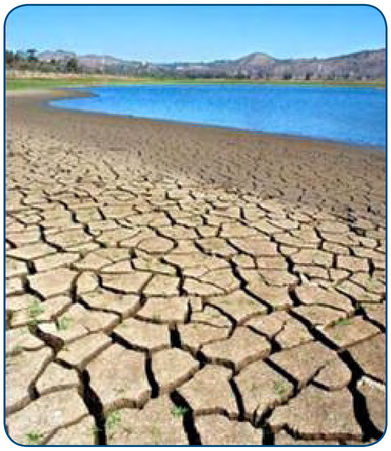
Groundwater can become impaired through leaching of contaminants into an aquifer, or by excessive concentrations of naturally-occurring constituents that impact quality, such as arsenic. Surface water sources become contaminated from human activities in the watershed or through deliberate contamination.

SECTION SEVEN

Water Use Efficiency

2010

SECTION 7 Water Use Efficiency



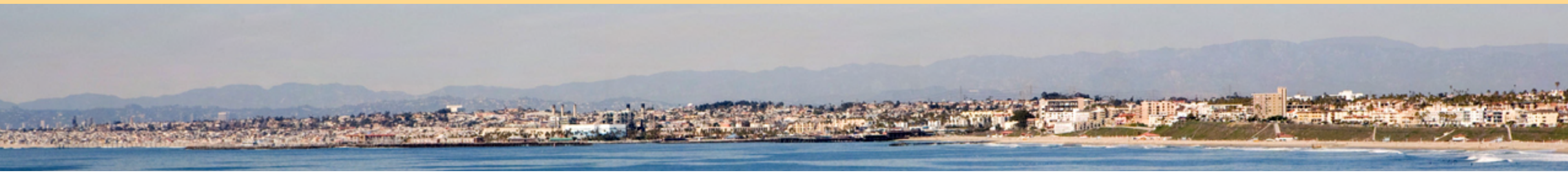
Water Use Efficiency (WUE), or conservation, continues to play an important role in West Basin's water supply portfolio. Between 2005 and 2010, there were several new key developments that occurred in the area of water use efficiency policy.

- In 2008, as a result of State Water Project supply limitations and multiple year drought conditions, MWD instituted water supply allocations (or imposed conservation) that sought to reduce member agencies' imported water demand.
- In 2008, the California Urban Water Conservation Council (CUWCC) began restructuring its 14 BMPs and reporting process.
- In 2009, AB 1420 came into effect requiring agencies to provide up-to-date information on CUWCC BMP compliance as part of grant or loan applications to the State DWR.
- In 2009, the Governor of the State of California signed into law SBX 7-7, which calls for a state-wide 20 percent reduction in per capita water use by 2020. Individual agencies are required to provide water use reduction targets of gallons per capita per day as part of the 2010 UWMP update.
- In 2009, a key piece of water efficiency legislation called AB 1881 was entered into law that updated the Model Landscape Ordinance AB 325 of 1990. This new law stated that as of January 1, 2010, all local cities were required to adopt the new Model Landscape Ordinance or stricter versions of it. West Basin, along with other stakeholders, provided input to DWR for the development of the new ordinance.

At the local level, in 2008 West Basin launched a new program to help meet these challenges, called WR 2020 Program. The main goal of this program is to increase local water supplies by doubling recycled water production, doubling water conservation savings and by bringing responsible ocean-water desalination on-line.

7.1 Historical Water Conservation Efforts

Since the severe drought of the early 1990s, West Basin has been a leader implementing aggressive water conservation programs to help limit water demand within its service area. West Basin programs have included a strong emphasis on plumbing retrofit hardware, education and the distribution of rebate incentives. The results of these programs, in conjunction with passive conservation measures such as modifications to city ordinances, have resulted in significant reductions in retail water use within West Basin's service area. By current estimates, demand management from West Basin's active and passive conservation efforts have saved over 3 billion gallons of imported water (10,000 AF) since 1991, which is equivalent to the average annual water use of almost 20,000 households. This section will present the past and current water conservation efforts West Basin has undertaken since the last update to this plan in 2005.



West Basin's conservation efforts have been comprised of a wide array of cost-effective programs that contribute to conserving water, improving water quality, reducing imported water needs and increasing the region's water supply reliability.

West Basin prides itself in the partnerships it has created with Federal, State, and local entities to offer water efficiency programs. By developing integrated programs with its partners, West Basin has been able to leverage funding and resources to provide effective programs throughout its region. As a result, West Basin has been successful in obtaining more than $4 million in local, state and federal grant funds for conservation program implementation since 2005. Due to its successes with acquiring grants, West Basin has leveraged its funding and today provides $7 worth of programs to the public for every $1 it invests.

The effect of Water Conservation is defined by two main elements: *Active* and *Passive*. Below is a brief description of these two.

Active Conservation: Water savings produced from incentive based programs: rebates, giveaways, retrofits, etc.

Passive Conservation: Water savings produced from building and plumbing codes, consumer behavioral changes, and respones to price shifts.

West Basin's current conservation programs target water conservation efforts in the residential, commercial, industrial, institutional and large landscape areas. These programs were identified as part of the 2006 Conservation Master Plan and are available to residents, businesses, and institutional customers within West Basin's service area. Below is a list of the conservation programs that were launched over the last five years:

- Region-wide Residential Rebate Program
- Ocean Friendly Landscape Program
- Green Living for Apartments & Condos
- Green Garden Program
- Complete Restroom Retrofit Program
- Region Wide Commercial Rebates
- High-Efficiency Toilet Distribution Events
- Cash for Kitchens Program
- Recirc & Save Program
- School Kit Program
- Zero Run-off Street Median Program
- School Education Programs
- Public Outreach Program
- Water Star Program

It is estimated that West Basin has distributed and installed over 300,000 devices from 1990 to 2010. As a result, it is estimated that West Basin currently saves, from active and passive (code-based) conservation combined, over 10,000 AF (three billion gallons), or five percent annually, of West Basin's total water demand. Figure 7-1 shows the total Active and Passive Savings from 1990- to 2010 on an annual basis.

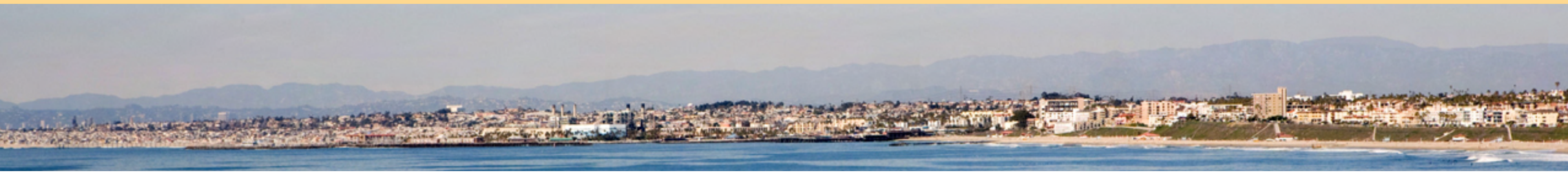
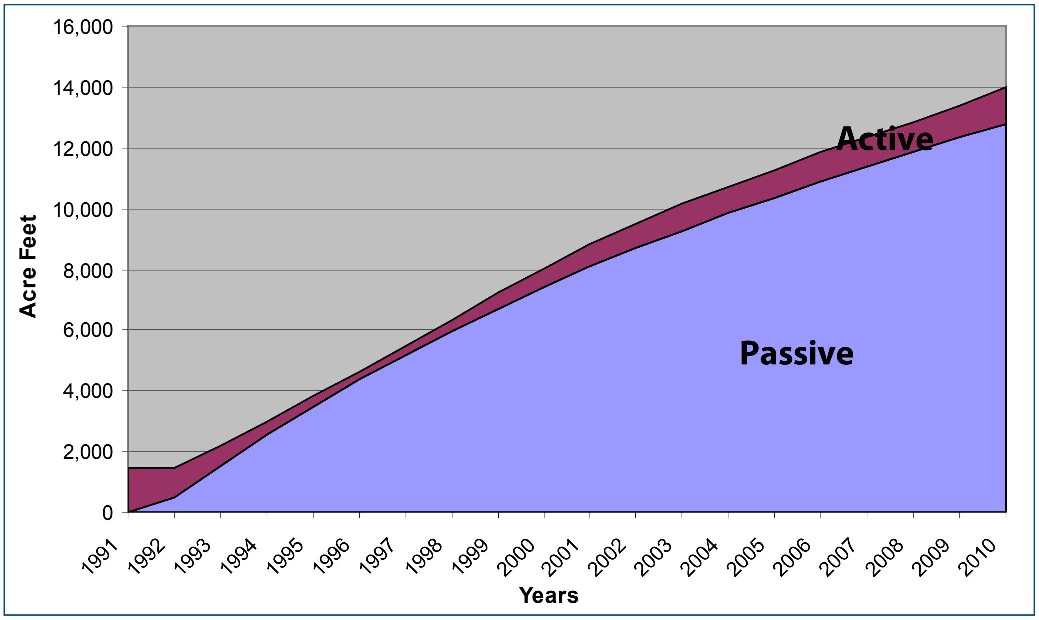


Figure 7-1: West Basin Conservation Water Savings (1990 – 2010)



Source: Estimated total active and passive water savings from West Basin's Alliance for Water Efficiency Tracking Tool, 2011.

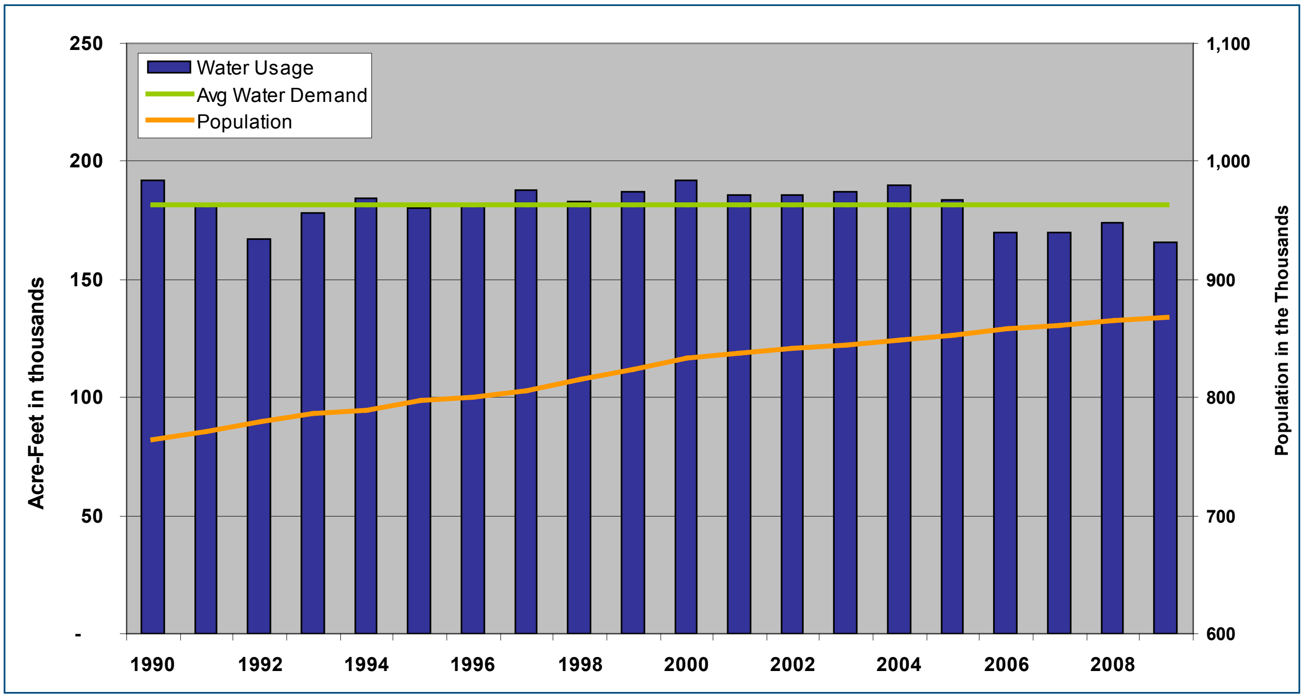
Conservation savings can further be verified by comparing West Basin's water usage versus population. As shown in Figure 7-2, average water demand has remained relatively consistent while population has escalated by an annual average of 1%.

7.2 West Basin and Customer Agency Water Conservation Master Plans

In 2006, West Basin developed its first Conservation Master Plan (CMP). In developing the CMP, West Basin worked closely with its water retailers, local cities, environmental groups and others to develop meaningful programs that were targeted and effective. The CMP included a five year timeline for cost-effective program implementation. Since adoption of the CMP, West Basin has been successfully implementing programs described in this section below.

As the regional water wholesaler, West Basin spear-headed an effort to ensure the region is working together to meet the State's goal of a 20 percent reduction in water demand by the year 2020. Begun in 2009, it was a unique program that allowed West Basin to work with its local water retailers to update the water conservation master planning efforts that were completed in 2006. West Basin (on behalf of its retailers) applied for and was awarded a $100,000 grant by the USBR to develop eight Local Water Use Efficiency Plans and to update West Basin's 2006 CMP. In addition to the grant, the retailers and West Basin provided a cost-share of $130,000. In 2010, West Basin began this project with the intent to help the agencies develop water use baselines and conservation targets to help meet the SBX 7-7 targets in 2015 and 2020.

Figure 7-2: Total Retail Water Demand vs. Population Growth (1990 – 2010)



Source: Information based on MWD Demographic Data, 2005

Note: Total retail demand includes groundwater production but not replenishment demands for use at seawater barriers.

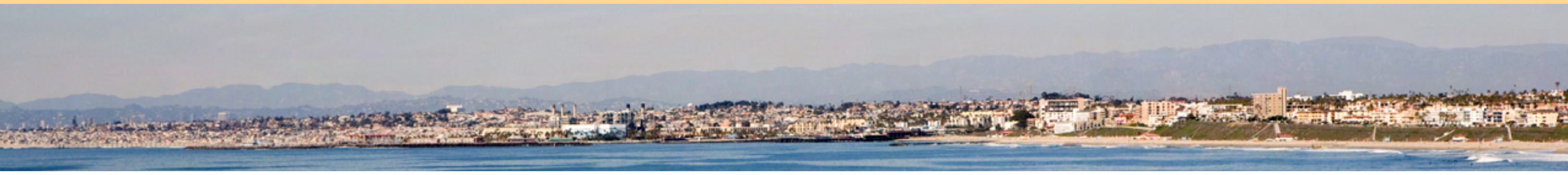
West Basin and its partners used a GPCD target calculator and the Alliance for Water Use Efficiency Water Conservation Tracking Tool to develop the information for the Conservation Master Plans. West Basin worked closely with each water retailer through bi-monthly meetings to collaborate, share ideas and discuss challenges. The plans will be completed by May 2011 and include a five year and a ten year timeline for implementation of various programs. The retailers will be able to use the information from their individual plans to report their conservation targets in their UWMPs.

7.3 External Agency Coordination

As a part of conservation planning and implementation, West Basin also works with other regional and statewide agencies and groups such as MWD, and the CUWCC.

7.3.1 Metropolitan Water District

In 2010, MWD adopted an updated Integrated Resources Plan (IRP) that includes a strong commitment to water conservation. MWD's 2010 IRP establishes water supply targets for Southern California through 2035, specifically a potable demand reduction of 1.7 MAF. This target represents MWD's goal of achieving a 20% reduction in per capita water use across its service area. MWD is currently developing a long-term conservation plan to implement the IRP conservation target. This plan focuses on conducting more research, providing device incentives and funding, assisting with market transformation and legislation and helping to support its member agencies with conservation efforts.



As a member agency of MWD, West Basin actively participated in both the IRP Working Group and the Long Term Conservation Plan development, and will benefit from the conservation implementation strategies outlined in the plan.

7.3.2 California Urban Water Conservation Council

In 1991, the CUWCC was created to increase water use efficiency by integrating urban water conservation BMPs into the planning and management of California water agencies. It is a partnership of agencies and organizations concerned with water supply and conservation of natural resources in California.

To encourage water use efficiency, the CUWCC asked water agencies and organizations to sign a MOU regarding urban water conservation in California, which committed participating urban water suppliers to use their "good faith efforts" to implement the CUWCC's 14 BMPs.

West Basin was one of the first urban water suppliers to become signatory to the CUWCC's MOU. Every two years, water agency signatories, including West Basin, must submit their BMP reports to the CUWCC. West Basin has submitted BMP Wholesaler Water Agency Reports to the CUWCC that detail West Basin's progress in implementing the 14 BMPs as currently specified in the MOU. In Appendix F, West Basin has attached its most recent 2007-08 CUWCC Report.

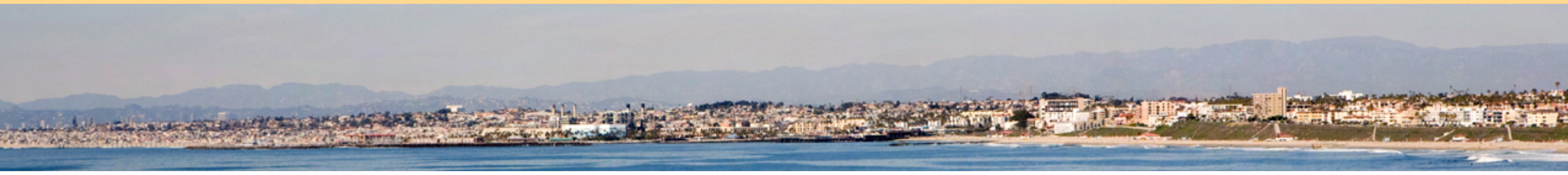
7.4 CUWCC – New BMPs and Reporting Options

In 2008/09, the CUWCC completed an ambitious project to revamp, streamline and improve the 14 BMPs and to develop several ways that an agency can report their water conservation targets and savings. Along with this process, the CUWCC created a new reporting database that agencies can use to report their achievements. Agencies must report to the CUWCC every two years, and the next reporting period will take place in 2011, when the new reporting database has been completed.

The CUWCC 14 BMPs are now organized into five categories. Two of the categories, Utility Operations and Education, are called Foundational BMPs because they are essential water conservation activities for any utility and therefore must be adopted by all signatories to the CUWCC MOU. The Residential, Commercial, Industrial, and Institutional (CII), and Landscape BMP categories are now called Programmatic BMPs.

Foundational

- Utility Operations
  - **BMP 3 System Water Audits:** Unaccounted for water calculated annually, and distribution system audits as required
  - **BMP 4 Metering with Commodity Rates:** Metering of consumption and billing by volume



- BMP 10 Wholesale Agency Assistance: Support by wholesalers for conservation programs of retail water suppliers
- **BMP 11 Conservation Pricing:** Uniform or increasing block rate structure, volume related water charges, and service cost recovery
- **BMP 12 Conservation Coordinator:** Designation of staff coordination of agency conservation programs
- **BMP 13 Water Waste Prohibition:** Enforced prohibition of wasteful use of water

- Education
    - **BMP 7 Public Information:** Public information to promote water conservation
    - **BMP 8 School Education:** Provision of education materials and services to schools

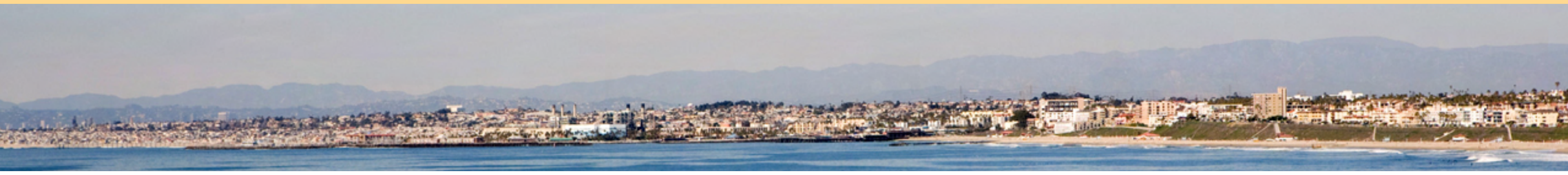
Programmatic

- Residential
    - **BMP 1 Residential Water Surveys:** Indoor and outdoor audits of residential water use and distribution of water-saving devices
    - **BMP 2 Residential Plumbing Retrofits:** Distribution or installation of water-saving devices in pre-1992 residences
    - **BMP 6 High Efficiency Clothes Washers:** Rebates for efficient washing machines
    - **BMP 14 Residential Ultra-Low Flush Toilet Replacement:** Programs promoting replacement of high-water-using toilets with ultra-low flush toilets
- Landscape
    - **BMP 5 Large-Landscape Conservation:** ET-based water budget for large landscape irrigators
- Commercial, Industrial, and Institutional
    - **BMP 9 Commercial, Industrial, and Institutional Conservation:** Programs to increase water use efficiency in CII sectors

7.5 Current Water Conservation Programs

As the water wholesaler for 8 water retail agencies and one groundwater agency, West Basin has collaborated with many important stakeholders and leveraged funding to develop and implement cost-effective programs that conserve water and energy, reduce runoff and provide other important environmental benefits.

All of these programs combined are being used to help West Basin and its retailers meet the 14 BMPs. West Basin has provided programs and activities that have assisted its retailers to help meet the BMPs listed here.



7.5.1 BMP #1 - Water Survey Programs for Single-Family Residential and Multi-Family Customers

Water surveys provide residents with valuable information about their water use. Trained conservation professionals test the water flow rates using devices inside the home, such as showerheads, toilets, and sink aerators to make sure they are water efficient. They also check for leaks and teach the resident how to read the water meter correctly. A comprehensive evaluation is conducted on the outdoor landscape to identify inefficiencies and recommend ways the resident can save water outdoors.

Several of West Basin's water retailers have hired companies to provide this service to their customers. As the regional water wholesaler, West Basin supports these efforts and provides further resources as necessary.

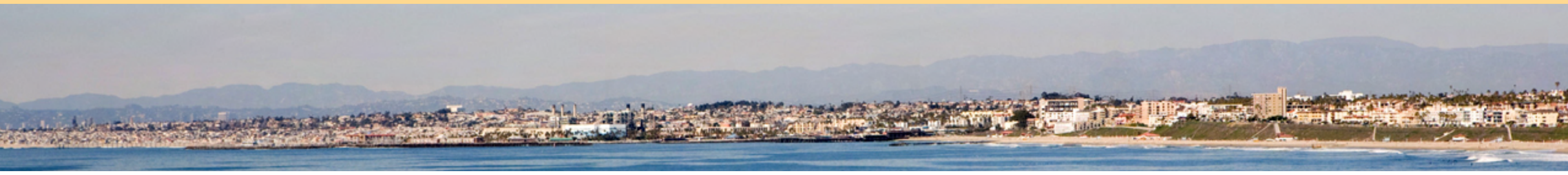
In 2007, West Basin designed a residential landscape program called the Green Garden Program and received a grant for $231,000 from USBR. In addition, West Basin received local funding through a partnership with MWD and several of its local retail water agencies. The Green Garden Program focused on providing qualified residents with free landscape surveys, "smart" irrigation controllers and rotating sprinkler nozzles. The program contained three steps:

- **Step 1:** Residents first contacted West Basin's Program vendor to pre-qualify.
- **Step 2:** West Basin's vendor provided a free landscape survey and if the resident had an older, inefficient irrigation controller, they were invited to a free sprinkler controller exchange event.
- **Step 3:** Residents brought their old irrigation controllers to the exchange event, and at the event the resident would be provided with a "smart" irrigation controller and rotating sprinkler nozzles. They would also receive one hour of training on how to install and program the controller.

Upon completion of the program in September 2010, West Basin conducted a water use study to compare the pre-controller installation water use with the post-installation water use and found an overall water savings of 14 percent. This percentage translates to about 47 gallons saved per day. Table 7-1 shows the total conserved savings from the Green Garden Program.

Table 7-1: Green Garden Program

	Number Completed	Water Use Saved (AF)
Landscape Surveys	958	N/A
Controllers Distributed	580	30
Rotating Sprinkler Nozzles	4,845	32
Total	**6,383**	**62**



7.5.2 BMP #2 - Residential Plumbing Retrofit

This BMP recommends the distribution and retrofit of low-flow showerheads, toilet displacement devices, and faucet aerators, as well as the adoption of enforceable ordinances. As Table 7-2 shows, it is estimated that since 1990, West Basin has distributed over 2,000 faucet aerators and over 220,000 low-flow showerheads.

In mid 2000, several of West Basin's retail water agencies began working with a company called Resource Action Program. This company developed a water and energy conservation kit geared for elementary school kids. As a way to provide local support and increase the program, West Basin partnered with several local water agencies and was awarded a DWR grant of $261,000 to be used for the purchase and implementation of 20,000 school kits. Through the use of these kits, a total of 588 acre-feet of water and 62 million kilowatts of electricity will be saved.

Table 7-2: Residential Plumbing Retrofits

Devices	1990-2000		2000-2005		2005-2010		Total	
	# of Units	AF Saved	# of Units	AF Saved	# of Units	AF Saved	# of Units	AF Saved
Faucet Aerators	954	3	0	0	1,133	3	2,087	6
Low-Flow Showerheads	215,563	1,014	7,500	35	152	.68	223,215	1,049

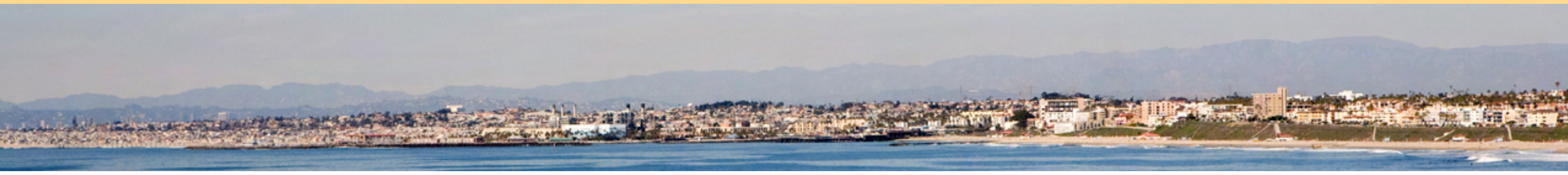
7.5.3 BMP #3 - System Water Audits, Leak Detection, and Repair

In May 2009, the American Water Works Association published the 3rd Edition *M36: Manual Water Audits and Loss Control Programs*. Included, was a new BMP 1.2 to replace the old BMP 3 and incorporated new water loss management procedures as they apply to California.

As a result, retail water agencies are expected to use the AWWA Free Water Audit Software to complete their standard water audit and water balance. Implementation shall consist of actions such as standard water audit and water balance, validation, and economic values, among others. While West Basin is required to comply with BMP 3 as a wholesale water agency, the agency is exempt due to the fact that the agency neither owns nor operates a potable water distribution system.

7.5.4 BMP #4 - Metering with Commodity Rates for all New Connections and Retrofit of Existing Connections

Since West Basin is a water wholesaler, this BMP does not directly apply. However, every water agency within West Basin's service area bills their retail customers according to meter consumption. By encouraging the installation of dedicated landscape meters, agencies will be able to recommend the appropriate irrigation schedules through future landscape programs.



This BMP requires that agencies identify barriers that make it difficult to retrofit commercial accounts with dedicated landscape meters as well as incentives to encourage such retrofits.

7.5.5 BMP #5 - Large Landscape Conservation Programs and Incentives

This BMP requires that agencies provide non-residential customers with support and incentives to improve their landscape water efficiency. Several of the local water retailers provide free large landscape surveys and MWD provides incentives for devices such as smart irrigation controllers and rotating sprinkler nozzles.

The large landscape sector was identified in West Basin's 2006 Conservation Master Plan as an area where a considerable amount of water could be saved. Recent data shows that irrigation system and landscape inefficiencies can be as high as 50 percent. Many landscapes are poorly maintained and overwatered, therefore additional training, education and resources are needed to reduce water use. As a result, West Basin and its water retailers partnered to develop several programs with grant funds.

Ocean Friendly Landscape Program

In 2005, West Basin formed a partnership with the Surfrider Foundation to develop the Ocean Friendly Landscape Program. This program contained several water conservation and education components including:

- Facilitation of 40 Ocean Friendly Garden workshops
- Distribution of 1,350 residential "smart" irrigation controller rebates
- Distribution of 1,117 large landscape irrigation controllers,
- Development of 10 Ocean Friendly demonstration gardens
- Implementation of a study that would test the success of the irrigation controllers at reducing dry-weather runoff.

As part of the Greater Los Angeles County Region Integrated Regional Water Management Program, Proposition 50 Implementation Grant Application, this program was awarded a $1.2 million grant. Since the implementation of this program began in 2010, West Basin has been working with cities, parks, school districts, Homeowner Associations, and other qualified sites to install "smart" controllers. Table 7-3 shows the estimated conserved savings to date of this program. Once all 1,117 controllers are installed by the end of the year 2012, the total annual water savings is estimated to be 332 AF per year.

Due to the State bond freeze in 2008 and 2009, the residential rebate and demonstration garden components of the program were put on hold. They both resumed implementation in late 2010.

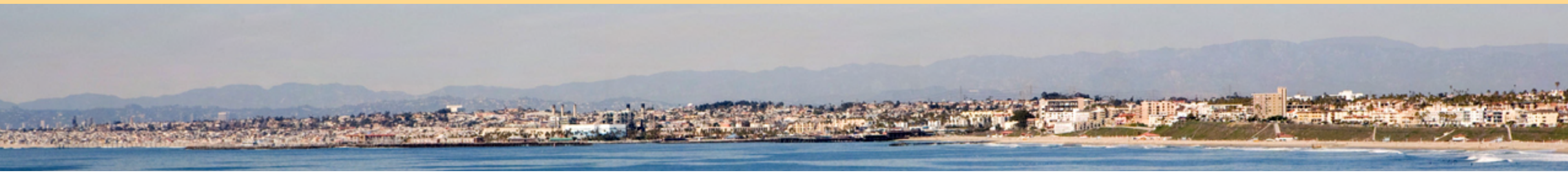


Table 7-3: Ocean-Friendly Landscape Program since Inception

Program Component	Units Completed	Annual Savings (AF)
Irrigation Controllers Installed	100	30
Classes Conducted	19	N/A
Residential Rebates Provided	5	.26
Demonstration Gardens Installed	0	N/A

Comprehensive Landscape Survey Program

In 2006, West Basin developed a Large Landscape Survey Program and was awarded funding through MWD's Enhanced Conservation Program. This program provided the services of a qualified landscape surveyor to conduct comprehensive surveys on large landscapes and provide a detailed audit report along with recommendations. Fifteen sites were audited with a resulting 55.6 percent of average irrigation efficiency due to broken and mismatched sprinkler heads, over-watering, no hydro-zoning, puddling of water, dry spots, incorrect water scheduling and various other problems.

Figure 7-3: Example Audit Report

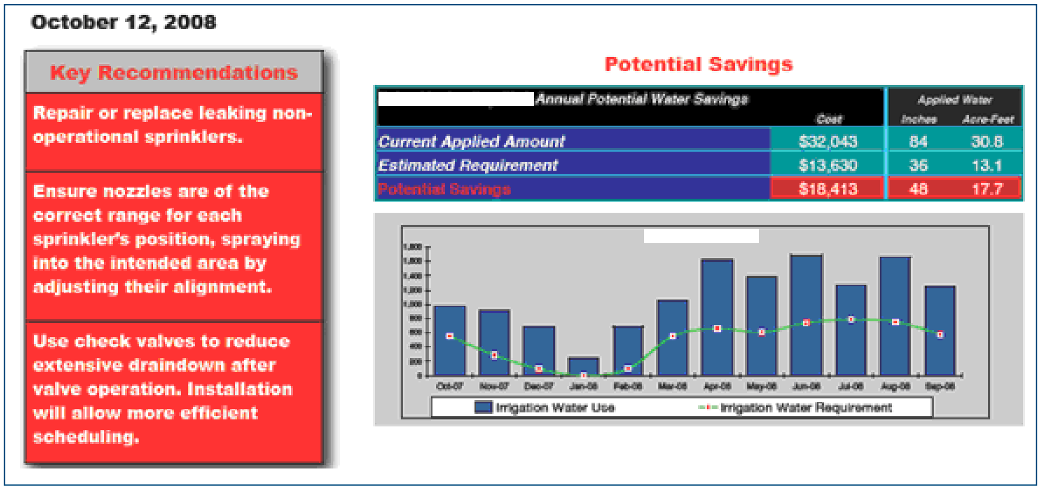
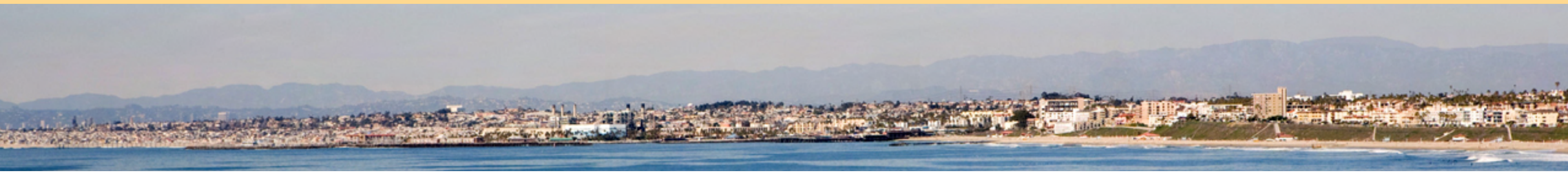


Table 7-4 is an example of the front cover of the audit report. Within the report, the water usage was analyzed and compared to the recommended water usage using the local weather or evapotranspiration potential. Key recommendations were also provided to the customer.

Table 7-4: Comprehensive Landscape Survey Program Savings

Number of Site Surveys	Annual Savings (AF)
15	51



Landscape Training to Professional Landscapers

In order to better educate the landscape community about water conservation practices, West Basin held a workshop in 2009 in the City of Malibu. West Basin partnered with the City of Malibu, Los Angeles County Waterworks District #29 (the local water retailer) and a professional landscape company to conduct a training session. The class was taught in Spanish and provided information about water-efficiency practices, the local ordinance requirements, and overall best management practices.

Model Landscape Ordinance Compliance

The landscape programs mentioned above will help West Basin and its retailers abide by the requirements of the new State's Model Landscape Ordinance. For example the ordinance contains the following requirements and provisions:

- Encouragement of the use of recycled water
- Landscape water budget component
- Provision to minimize landscape irrigation overspray and runoff
- Provisions for appropriate use and groupings of plants
- Provisions for use of automatic irrigation systems and irrigation schedules based on climate conditions

West Basin's programs are aligned with the new ordinance. For example, West Basin continues to identify and connect new customers to its water recycling system. West Basin also encourages the use of water budgets as mentioned above in the Comprehensive Landscape Program. During the last few years, several of West Basin's water retailers have developed new tiered rates and developed water budgets. Through its Ocean Friendly Garden Classes, West Basin teaches residents how to develop a water efficient and sustainable garden. Some of the topics covered include: reducing turf, installing native plants, installing drip irrigation and using weather-based irrigation controllers, all of which are mentioned in the state's new ordinance.

7.5.6 BMP #6 - High-Efficiency Washing Machine Rebate Programs

Since 2005, the MWD has provided rebates for high-efficiency clothes washers to its member agencies. MWD has branded the term BeWaterWise to develop market recognition. During the 2006–10 period, MWD conducted many radio and television commercials to promote the rebates as well as promoted the program on its *www.bewaterwise.com* website.

MWD testing found that many of the high-efficiency machines had a Water Factor of 6.0 or less. In order to motivate the public to purchase the most efficient washers possible, MWD develops a rebate that allowed only washers with a Water Factor of 4.0 or less to qualify for a $100 washer rebate. The washer rebate incentive continues to be an effective tool to achieve water conservation. Table 7-5 shows the annual water savings within West Basin's service area as a result of the use of higher efficient machines.

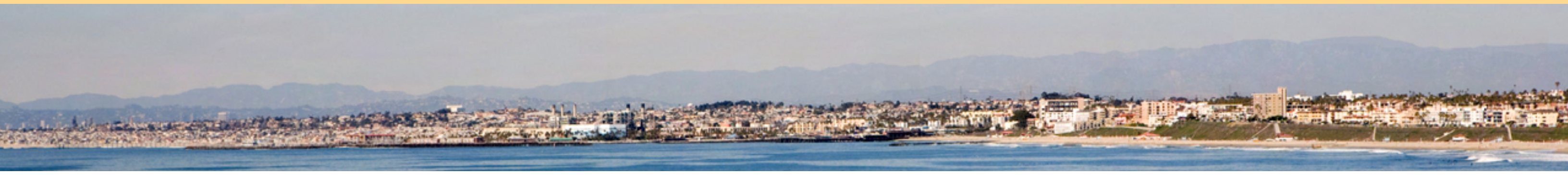


Table 7-5: High-Efficiency Washing Machine Rebate Program Savings (2003-2010)

Number of Rebates	Annual Savings (AF)
2,821	44

7.5.7 BMP #7 - Public Information Programs

West Basin uses many strategies to help promote its programs to the public. It coordinates with local and regional agencies to promote water conservation messaging as well as developing its own public information programs. Community support for WR2020 is strong based on letters of support received from City Councils, Chambers of Commerce, community groups and more than 4,000 individual supporters.

In 2009, West Basin developed and launched its WR2020 Program. The goal of this program is to communicate to the public West Basin's goal of increasing local water reliability by doubling recycled water production, doubling its water conservation efforts and introducing ocean-water desalination to its water portfolio. All of West Basin's supply development programs fall under the umbrella of the WR2020 Program. As part of WR2020, West Basin offers the specific conservation related programs described below.

WR2020 Program – Speakers Bureau

West Basin staff provides presentations on its WR2020 Program. In 2009/10, West Basin conducted over 100 presentations to local community groups that included city councils, service clubs, chambers of commerce and others. The presentations provided information on current water supply challenges and the programs that West Basin launched to help meet those challenges. Through outreach efforts more than 3,500 local residents and 100 cities/community groups pledged their support for the WR2020 Program.

Imported Water Supply Tours

West Basin, in cooperation with MWD, also provides inspection tours of the Colorado River Aqueduct and the State Water Project to legislators, local elected officials, retail agency staff, and the general public at various times throughout the year. The purpose of the three-day trips is to give local decision-makers a better understanding and appreciation of the water supply issues impacting the region.

Water Harvest Festival

Water Harvest Festival

In October 1999, West Basin began its first annual Water Harvest Festival located at the ECLWRF in El Segundo. West Basin invites the public to participate in a variety of games, shows, tours and contests to learn from informational stations about water recycling and conservation. In 2010, West Basin conducted its 12th annual Water Harvest Event that had over 3,000 people in attendance. The event features local agencies and water conservation product vendors that provide the public with information about water conserving devices, rebates and programs. West Basin also provides free tours of its facility and demonstrates to the public how waste water is turned into usable recycled water.

Smart Landscape Expo

There has been an increased desire by the public recently to learn more about native plants, drip irrigation and other landscape conservation devices and measures. In response, West Basin developed the Smart Landscape Expo, where the public can visit irrigation vendors and purchase native plants from local nurseries. At the initial expo, conducted in 2009, West Basin provided free 30-minute workshops taught by landscape designers. West Basin filmed several outdoor landscape demonstrations and placed the clips on its web site for the public to view. For the second annual Expo, West Basin will incorporate energy efficiency awareness into the event to give the public a more holistic view of green living both outdoors and indoors. It will be renamed the Water and Energy Smart Expo.

Water Recycling and Ocean-Water Desalination Tours

Once a month, West Basin offers free tours of its ECLWRF to the public to share the WR2020 Program, educate visitors about water supply issues, and show how water is purified in 20 minutes. The ocean-water desalination facility will open to the public in May 2011, and will soon offer tours three days a week. Both facilities will also be open for school tours for grades 3-12.

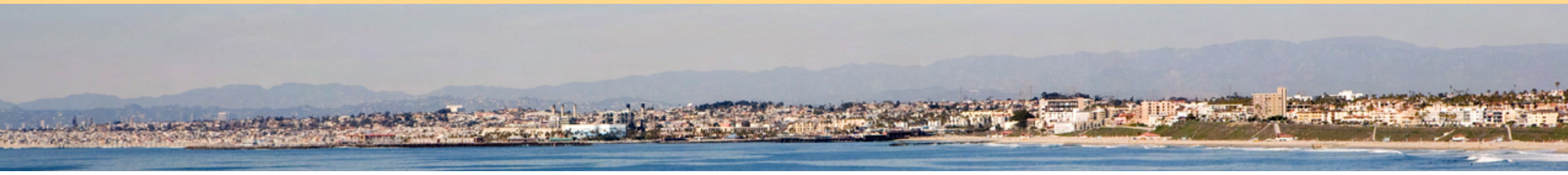
ECLWRF School Tours

Ocean Friendly Garden Classes

In 2008, West Basin began offering free Ocean Friendly Garden (OFG) Classes as part of its larger Ocean Friendly Landscape Program. In 2010, West Basin, in partnership with the Surfrider Foundation, conducted 19 classes throughout its service area. Classes are one-day, three-hour sessions that teach residents how to build an Ocean Friendly Garden of their own, reduce runoff, landscape with drought-tolerant plants, and keep water on their property. These classes were well attended with as many as 60 residents participating per class.

Zero Runoff Street Median Water Conservation Program

For this West Basin sponsored program, water efficient street medians and parkways were designed to reduce water use by at least 50 percent and water runoff by 100 percent. This program included projects that replaced existing street medians and parkways with a combination of artificial turf, porous cover, native and/or drought tolerant plants, drip irrigation, or Smart Irrigation Controllers. Several cities took advantage of this program and retrofitted street medians to reduce water use, reduce runoff and educate the public about water conservation.



Native Plant Demonstration Garden

New Native Plant Demonstration Gardens

In 2009, West Basin built a new Native Plant Demonstration Garden at ECLWRF in El Segundo. As a part of this project, West Basin held two hands-on workshops where the public assisted with the installation of the plants, drip irrigation and the permeable walkway. In 2010, West Basin also renovated the landscape at its headquarters in Carson with two hands-on workshops to install and maintain the native plants and a drip irrigation system.

California Water Awareness Campaign

West Basin is also active with the California Water Awareness Campaign (CWAC), which is an association formed several years ago to coordinate efforts throughout the State during its *May is Water Awareness Month* campaign. With this effort, water agencies throughout the State, large and small, can tap into a large pool of knowledge and materials to promote a water awareness message not only in May, but throughout the year.

Media Outreach

West Basin maintains a strong link with the local news media through press releases, one-on-one tours and talks, and small group briefings to share West basin's ongoing achievements in making water supply more reliable. Recently, West Basin conservation staff was included on the cover of a Palos Verdes gardening supplement highlighting native water efficiency plants.

7.5.8 BMP #8 - School Education Programs

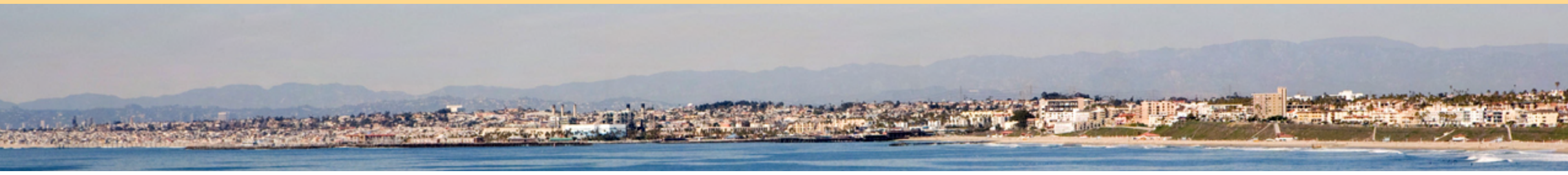
Water and environmental education continue to be critical components of West Basin's outreach strategy. Therefore, West Basin offers a variety of elementary through high school programs free of charge to all schools within its service area. Descriptions of each program can be found in Section 7.7.

7.5.9 BMP #9 - Conservation Programs for Commercial, Industrial, and Institutional (CII) Accounts

West Basin has increased its participation and involvement with the CII sector over the past few years. Since 2007, West Basin has implemented, designed and participated in a number of successful CII programs partnering with local water agencies and their purveyors as well as with governmental organizations for increased outreach opportunities, described further below.

Complete Restroom Retrofit Program

This program provides businesses using older restroom devices with high-efficiency toilets, urinals and sink faucets. This program was initially funded through a grant and has been ongoing since 2007. This program has been successful for both small businesses and larger businesses alike. Phase 2 of the program was implemented in 2010 and will focus more on larger commercial customers such as high-rise buildings and hotels.



Recirc and Save Program

This program incentivizes large commercial and industrial customers to implement water-use efficiency projects as identified by West Basin. Increased incentives are offered for cooling tower efficiency upgrades and process water efficiency improvements such as water supply recirculation and on-site treatment. This program also offers technical assistance and audits to assist these customers in making changes to their processes that will result in water use reductions.

Cash for Kitchens Program

During its pilot phase in 2009, this program initially targeted large (greater than 1,000 square feet) commercial kitchens but has now been expanded to also include smaller restaurants. Food service facilities can benefit greatly from the use of efficient devices as well as through behavioral changes. In order to address both, the program includes a quick audit, a session with the facility's management as well as device replacements for qualifying equipment.

Public Sector Program

This program was designed and implemented by MWD to assist public and institutional facilities in making water-efficiency upgrades. It was offered as a limited-time only program providing up-front funding for these public sites to make changes to their indoor and outdoor water-using systems.

Save Water, Save a Buck

In 2005, West Basin entered into a 10-year agreement with MWD to help support the on-going regional marketing efforts of this CII rebate program. As a way to increase the success of this program, West Basin offers its cities and water purveyors an opportunity to contribute additional funding to Save Water, Save a Buck to increase the rebate amounts available to their commercial customers. Over the years, agencies have partnered to provide higher rebate amounts in an effort to increase conservation participation from their customers. Rebates are offered for commercial clothes washers, water brooms, cooling tower conductivity controllers, pre-rinse spray nozzles, x-ray machine recirculating devices and commercial toilets and urinals.

7.5.10 BMP #10 - Wholesale Agency Programs

The programs provided by West Basin as a regional wholesaler are done in partnership with its retail agencies to benefit the 17 cities that are located within West Basin's service area as shown in Table 7-7.

Since 2005, West Basin has acquired more than $4 million from State, Federal and local grant funding sources for program development and implementation. Furthermore, West Basin markets, designs and implements a majority of the BMPs within its service area. West Basin has also invested over $2 million over the last five years to provide conservation and education programs that help increase water supply reliability for the region.

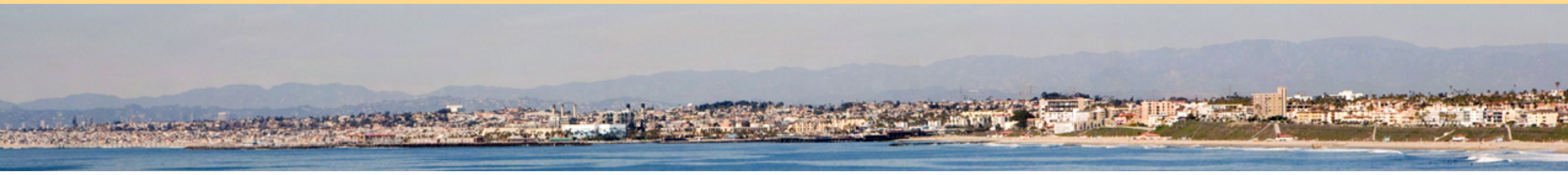


Table 7-6: Summary of CII Programs

Program	Devices Distributed	Number of Units	AF Savings*	Agency Partnerships
Complete Restroom Retrofit	High-Efficiency Toilets, Zero-Water and Ultra-Low Flush Urinals, Self-Closing Sensor Faucets	1,164	804	California Water Service Company and Golden State Water Company, Metropolitan Water District, Department of Water Resources, Water Replenishment District
Recirc and Save	pH Conductivity Controllers, Various process improve-ments	3	29	California Water Service Company and Golden State Water Company, Metropolitan Water District, Department of Water Resources, United States Bureau of Reclamation
Cash for Kitchens	Faucet Aerators, Flow Restrictors, Pre-Rinse Spray Valves, Waterbrooms	162	14.7	California Water Service Company, Golden State Water Company, Water Replenishment District, Metropolitan Water District
Public Sector Program	High-Efficiency Toilets, Zero-Water and Ultra-Low Flush Urinals, Waterbrooms, Centralized Irrigation Controllers, Synthetic Turf	265	978	Metropolitan Water District
Save Water, Save a Buck	Various	11,320	12,857	Metropolitan Water District, California Water Service Company, and Golden State Water Company
TOTAL		**12,914**	**14,683**	

*Over the Lifetime of the Devices

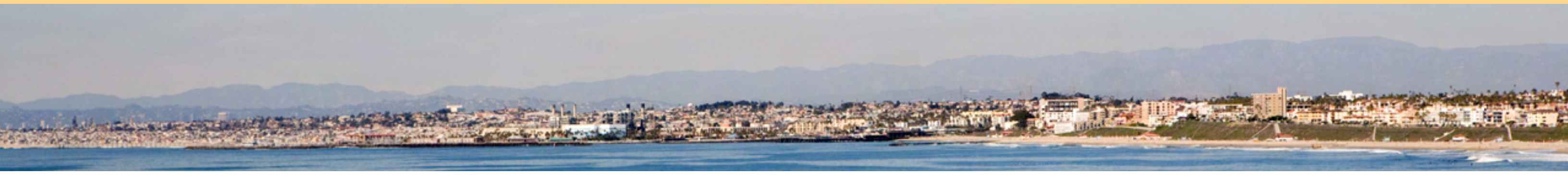


Table 7-7 West Basin Wholesale Agency Program Support

Retail Agencies that West Basin Supports	BMPs that West Basin Supports
California American Water Company	BMP #3 - System Audits
California Water Service Company	BMP #5 - Landscape Programs
City of El Segundo	BMP #6 - Washing Machines
City of Inglewood	BMP #7 - Public Information
City of Lomita	BMP #8 - School Education
Los Angeles County Waterworks District #29	BMP #9 - CII Rebates and Programs
City of Manhattan Beach	BMP #10 - Wholesaler Incentives
Golden State Water Company	BMP #12 - Water Conservation Coordinator
	BMP #14 - ULFT Replacement

As part of West Basin's WR2020 Program, conservation programs will be further enhanced to provide even greater support to city and water retailer conservation program efforts.

7.5.11 BMP #11 - Conservation Pricing

In 2003, West Basin passed-through MWD's two-tiered rate structure to its customer agencies to promote water conservation and regional water supply reliability. This rate structure called for customer agencies, in coordination with West Basin, to develop a reasonable budget for their Tier 1 annual maximum limit for imported water. Through voluntary purchase agreements, these customers will pay a higher price (Tier 2) for purchases that exceed their Tier 1 allotment. To assist them in not exceeding their Tier 1 allocation limits, West Basin works with agencies to enhance conservation, education and expand recycled water use.

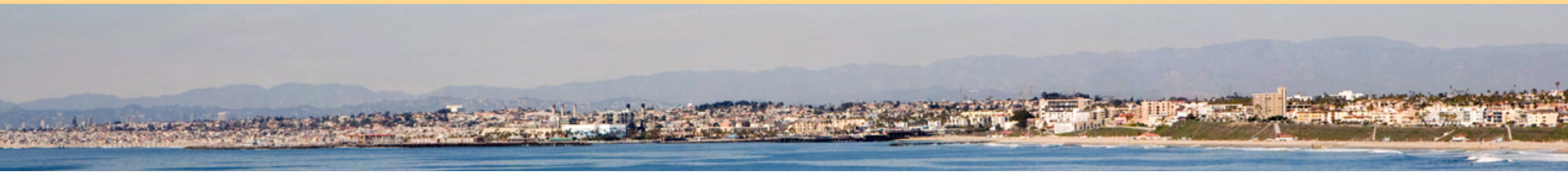
7.5.12 BMP #12 - Water Conservation Coordinator

In 2007, West Basin added an additional full time employee, which was identified in the 2006 Conservation Master Plan, to assist with the development of West Basin CII Programs. West Basin's Conservation Department now employs both a Senior Water Use Efficiency Specialist and a CII Specialist.

7.5.13 BMP #13 - Water Waste Prohibition

West Basin helped to promote MWD's *Its Time to Get Serious* media campaign by developing a campaign to increase our cities' awareness of the current water situation by requesting that they adopt a resolution. The resolution stated that the city would be willing to review their current ordinances and policies as they related to water conservation. With West Basin's effort, many cities adopted the resolution and seven cities actually passed stricter water efficiency ordinances.

In 2008/09, MWD launched the Public Sector Program. This program provided upfront incentives to motivate the public including cities, counties, agencies, schools, and others, to purchase and install water-use efficiency devices. In order to participate in this program, MWD required each city to pass a Water Waste Prohibition Ordinance.



These ordinances feature provisions regarding water waste ranging from outdoor watering restrictions and requirements for water features and pools to requiring eating establishments to provide drinking water upon request only and requiring new car washes be equipped with recirculation systems. To date, the cities within West Basin's service territory that have passed these ordinances include: Rolling Hills Estates, West Hollywood, Lomita, Manhattan Beach, Culver City, El Segundo, and Malibu. Each city's ordinance may differ slightly.

7.5.14 BMP #14 - Residential Ultra-Low-Flush Toilet (ULFT) Replacement Programs

Since early 2000, MWD, West Basin and its local water retailers have been providing the public with ULFT rebates and programs. These successful programs have evolved through the steps listed below to provide the increasing water savings shown in Table 7-8.

- 2000 – 2010: MWD, West Basin, and local retailers provided rebates
- 2000 – 2010: West Basin provided free ULFTs and High-Efficiency Toilet (HET) to the public through its one-day toilet distributions
- 2008: West Basin received a grant from MWD to directly install HETs in the multi-family sector
- 2010: MWD, due to high ULFT saturation levels (in specific areas of its region), stopped providing residential toilet rebates

Table 7-8: ULFT / HET Rebate Program

	2000-2004	2005-2010	Total
$ per Rebate	$100	$50	N/A
# of Rebates	2,822	1,271	4,093
Water Savings (AF)	113	51	164

Over the last five years, there have been several new technological advancements with the ULFTs. In 2006-07, the 1.28 gallon per flush HET was introduced and began gaining greater acceptance in the market.

In 2009, MWD conducted a region-wide saturation study, as part of its *SoCalWaterSmart* Program and found a water efficient saturation level of over 70 percent. Therefore, in 2010, MWD phased-out the rebate for the HET. In 2004, West Basin had estimated a 40% saturation level and in 2009, estimated 60% saturation. West Basin's portion of MWD's service area has older communities and opportunities still remain for replacement of older 3 - 5 gallon toilets. Since opportunities still exist in West Basin's service area, West Basin along with several of its retail water agencies has continued conducting its free one-day HET distribution events. The results of this program are shown in Table 7-9.

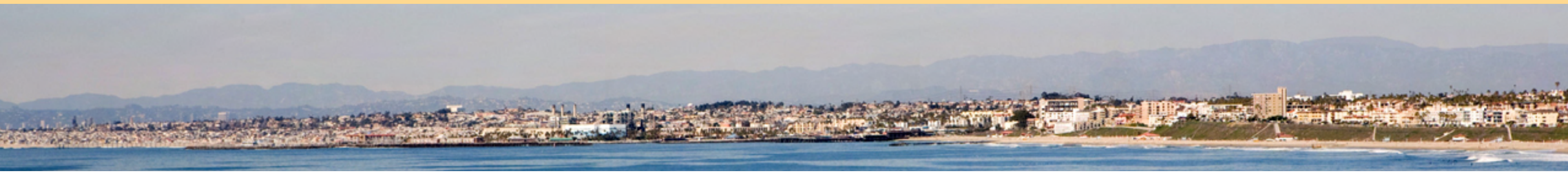


Table 7-9: One Day Free HET Replacement Program Savings

	2000-2004	2005	2006*	2007*	2008	2009	Total
# of Devices	13,172	2,742	0	0	2,593	1,500	20,007
Water Savings (AF)	381	110	0	0	104	60	655

*Temporary stop in program

In 2006, West Basin and its sister agency Central Basin Municipal Water District separated and became two distinct agencies so there was a halt of this program from 2006 -2007. Also during this time period, West Basin's toilet vendor went out of business but was able to restart toilet distributions in 2008.

Multi-Family Program

In 2008, West Basin developed a unique water/energy direct installation program called Green Living for Apartments & Condos. In collaboration with Southern California Edison (Edison) and the Southern California Gas Company (Gas Company), West Basin received a MWD grant to provide apartment and condominium owners with free installations of HETs, showerheads, bathroom aerators and compact fluorescent light bulbs. A total of 2,000 HETs were installed, conserving an estimated 80 AF per year. During this period, West Basin also provided an additional 1,000 toilets to the Multi-family sector, for a total of 3,000 toilets.

Table 7-10: Multi-Family Residential Device Replacements

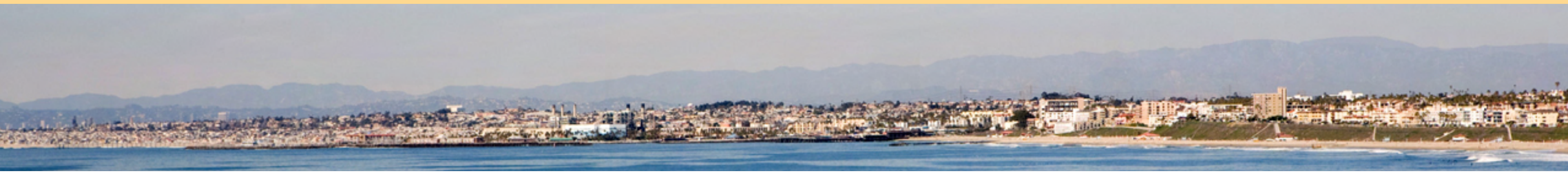
	2008	2009	Total	Annual Savings (AF)
HETs	2,500	1,500	4,000	161
Showerheads	214	214	428	3
Aerators	230	230	460	1.2
CFLs	500	500	1,000	N/A
Water Savings (AF)	104	60	655	165

7.5.15 Additional Conservation Programs

West Basin is very active in working with MWD to develop new conservation programs that are included in the CUWCC BMPs. In 2005, MWD implemented two new programs that are described below.

Water and Energy Implementation Program (WEIP)

West Basin is designing the WEIP to lay out both near-term and long-term goals working toward program integration between ourselves, Edison, the Gas Company and the water purveyors. Potential integration includes coordinated visits with the Gas Company for the *Cash for Kitchens* program, to acknowledge the strong connection between kitchens and natural gas use, and coordinated efforts to market and



implement water-efficiency programs along with Edison's well established Small Business Direct Install programs.

Community Partnering Program

MWD, in cooperation with its member agencies, accepts applications from non-profit organizations and public agencies that promote discussions and educational activities for regional water quality, conservation and reliability issues. This program provides support for the following types of activities:

- After-school water education
- Community water festivals
- Watershed education outreach
- Environmental museum exhibits
- Library water resources education book drives
- Public policy water conferences
- Other projects that directly support water conservation or water quality education

7.6 Current and Future Education Programs

West Basin is particularly dedicated to working with MWD and its customer agencies to provide water conservation educational opportunities for the communities they serve. West Basin manages and supports several programs and has also developed new program ideas for future implementation.

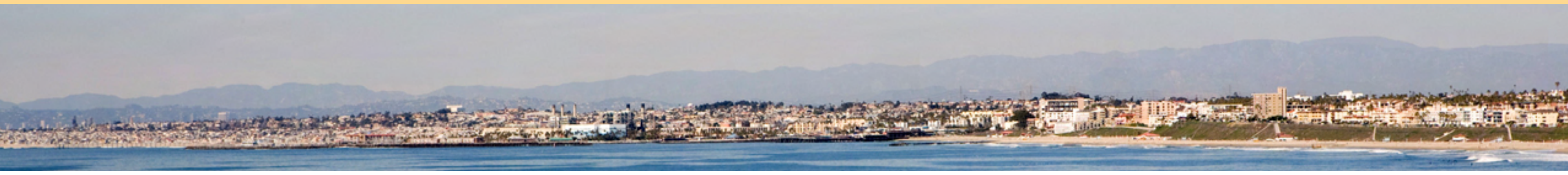
Solar Cup

7.6.1 Current Programs

Solar Cup

Solar Cup is an annual solar-power boat building and racing competition held for high school students in Southern California. The goal of the 7-month program is to encourage students to learn about science, mathematics, water quality issues, conservation, and alternative energy and fuel sources. This year, MWD, the lead sponsor of the program, allowed member agencies, including West Basin, to sponsor up to four teams. In 2010, the West Basin sponsored teams were divided into veteran and rookie teams.

- Veteran Teams
  - Palos Verdes Peninsula High School, Rolling Hills Estates
  - City Honors High School, Inglewood
- Rookie Teams
  - Environmental Charter High School, Lawndale
  - West High School, Torrance



Water is Life Student Art Contest

This program encourages 3rd -12th grade students to learn about their water supply and design a water conservation slogan illustrated with original artwork. Grand prize winners in the elementary, middle and high school categories receive a MacBook laptop through the generous support of United Water Services and the Law Offices of Lemieux and O'Neill.

Board of Directors Scholarship Program

The West Basin Board offers an annual Scholarship Award of up to $1,000 per qualified student with an interest in pursuing studies or a career in the water industry. Commencing in 2009, this program awarded eight scholarships to graduating high school seniors in West Basin's service area who have been accepted to a college, university or trade school. In 2010, this program awarded seven scholarships.

Water Educators Newsletter

West Basin keeps in touch with educators and administrators regarding our programs through our quarterly newsletter *Waterworks*.

Water Educators Newsletter

Water Explorations School Tours

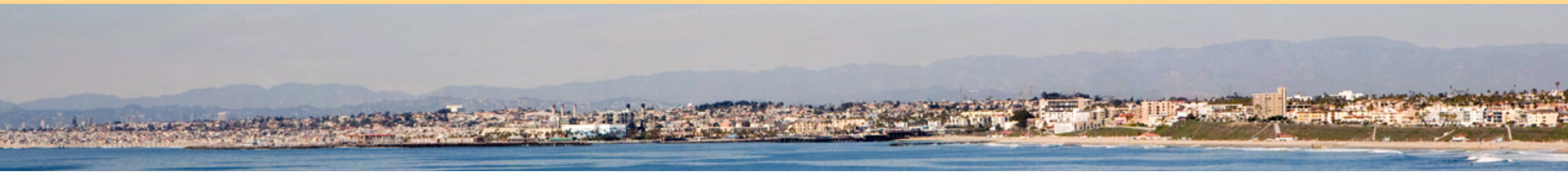
West Basin offers a free field trip experience for 3rd – 12th grade students (including a complimentary school bus) to visit the ECLWRF in El Segundo. During the field trip, students interact with a conservation exhibit that teaches the students about how changing their behavior can save water. The students are then taken to visit the SEA Lab aquarium to learn about local marine life. Also located at the SEA Lab facility is West Basin's new Water Education Center where students again get to experience another interactive conservation exhibit and learn about ocean-water desalination.

Table 7-11: School Tours at ELCWRP

Grade Level	FY 2005-06	FY 2006-07	FY 2007-08	FY 2008-09	FY 2009-10	Total
Grades K-3rd	475	958	1,012	1,939	1,033	5,417
Grades 4th-6th	590	1,061	1,534	2,893	2,467	8,545
Grades 7th-8th	35	332	150	542	196	1,255
High School	0	25	145	344	167	681
Total	**1,100**	**2,376**	**2,841**	**5,718**	**3,863**	**15,898**

Water Star Program

West Basin's new WR 2020 Water Star Program encourages elementary aged school children to sign up to save 20 gallons a day, reducing our dependence on imported water and reducing runoff to the ocean. Children receive a water star conservation kit



Water Star Program

complete with fix-it tickets, a water star badge, shower timer, faucet aerator, and other water-saving reminders. More than 700 students pledged to save 20 gallons per day during the 2010 pilot program.

Surfrider Foundation Teach and Test Program

The Surfrider Foundation South Bay Chapter's Teach and Test Program is an exciting project pairing high school students with graduate students from Loyola Marymount University to study the water quality of our South Bay beaches. West Basin sponsors this on-going effort to improve the water quality of Santa Monica Bay and introduce youth to water quality research and careers.

Teams volunteer to collect water samples from 12 local beaches to then analyze and publish their results in an on-going database. Students have participated from several schools within West Basin's service area including Chadwick School, Westchester, El Segundo, Redondo Union, and South high schools.

Splash Science

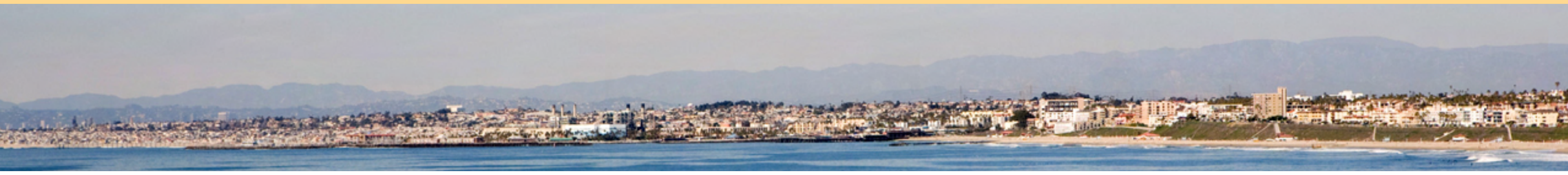
In 2011, Splash Science will be morphed into a program to bring students to the Ocean-Desalination Demonstration Facility.

Career Training Programs

Every February, West Basin partners with United Water Services, Inc. to participate in the Inglewood/Airport Chamber of Commerce's Annual Youth Business and Industry Job Shadow Day. West Basin serves as a business host and conducts a 5-hour water careers program and facility tour that accommodates 10 students. Students are introduced to West Basin's mission, water sustainability projects, agency organization and variety of job positions. Students then go on a tour of the ECLWRF to see the result of the public/private partnership with United Water. Students are exposed to a wide range of careers in chemistry, biology, engineering, human resources, finance, water resource planning, public affairs, operations and maintenance. West Basin also hosts high school summer internships in partnership with the South Bay Workforce Investment Board.

7.6.2 Future Programs

In addition to the programs listed above, in 2010 West Basin will be completing an Education Master Plan that outlines the programs best suited for the students within our service area. These programs will be considered for implementation over the next five years.



7.7 Conservation Program Partnerships

By partnering with various entities, West Basin is able to leverage its funding and resources in order to develop targeted programs that have been identified in its CMP.

Over the last five years, West Basin has partnered with local, state and federal agencies and has received several grants. These grants have allowed West Basin to develop and offer the public free water conservation programs. For every $1 that West Basin invests, it provides $6 worth of programs to the public. West Basin's funding partners have included the following:

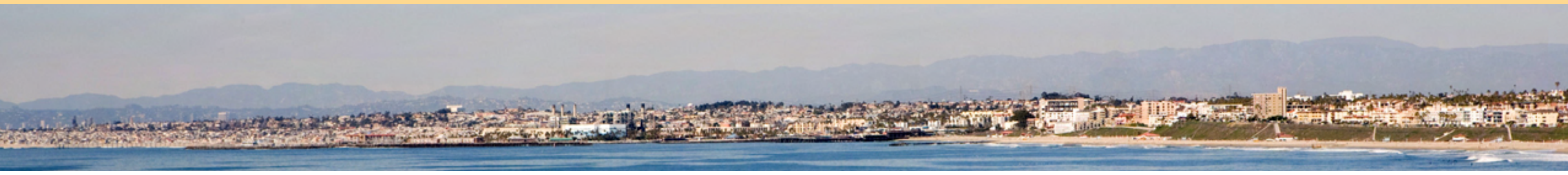
- United States Bureau of Reclamation (USBR)
- California Department of Water Resources
- Metropolitan Water District
- Retail Water Agencies
- Southern California Edison
- Southern California Gas Company

Over the last several years, West Basin has also developed new and important partnerships that help expand West Basin's conservation programs and messages including:

- **South Bay Environmental Services Center (South Bay Center):** In 2006, West Basin formed a partnership with the South Bay Center. The South Bay Center is a program of the South Bay Cities Council of Governments (South Bay COG) that promotes programs provided by Edison, the Gas Company, Los Angeles County Sanitation District and LA Metro as well as West Basin's water conservation programs throughout 16 cities in the South Bay.

- **Surfrider Foundation:** In 2006, West Basin formed a partnership with Surfrider for the purpose of creating the Ocean Friendly Landscape Program. Since that time, West Basin has also helped to sponsor Surfrider's Teach & Test Program. Surfrider works with high school students to teach them about water runoff issues and pollution to the ocean.

- **Southern California Edison and Southern California Gas Company:** Efforts to work more closely with the energy utilities have been made through West Basin's partnership with the South Bay Environmental Services Center. Residents and businesses interested in saving energy are more likely to be interested in saving water as well. Leveraging the efforts of the energy utilities allows for more cost-effective programs as well as enhanced offering for residential and business customers alike. Successful integration of water-use efficiency and energy efficiency programs is happening on a small scale with the real possibility of further and larger scale integration in the near future.



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SECTION EIGHT

Rates and Charges

SECTION 8 Water Rates & Charges

West Basin Water Purchases

As a water wholesale agency, West Basin does not directly charge residential and other end-use customers for supplies. Instead, West Basin's customer agencies purchase water from West Basin and then combine it with other supplies to deliver to their retail customers at a variety of rates.

West Basin's current potable water rates are primarily based upon the costs of imported supplies purchased from MWD. Imported water purchased by West Basin from MWD carries not only the cost of acquiring, importing, treating and distributing the water throughout the region, but also these costs associated with maintaining MWD reliability and "readiness to serve'. The total West Basin rate structure must include the value-added costs associated with representing customer agencies at MWD, and distributing locally-produced recycled and desalinated groundwater supplies.

8.1 MWD Rate Structure

In 2002, the MWD Board adopted a new rate structure to support its strategic planning vision to encourage the development of local supplies like recycled water and conservation, and ensure a reliable supply of imported water. To achieve these objectives, MWD called for voluntary purchase orders from its member agencies, unbundled its water rates, established a tiered supply rate system, and added a capacity charge. The new rate structure components provide a better opportunity for MWD and its member agencies to manage their water supplies and proactively plan for future demands.

8.1.1 Purchase Orders

The Purchase Order is an agreement between MWD and a member agency, whereby the member agency agrees to purchase a minimum amount of non-interruptible water over a ten-year Purchase period. The Annual Maximum is the amount of lower cost (Tier 1) non-interruptible water that a member agency is entitled to purchase annually as a result of that Purchase Order.

Table 8-1 shows how both the current annual maximum and purchase commitment were calculated for West Basin. West Basin's highest delivery of non-Order interruptible water was 174,304 AF in 1990. Therefore, West Basin's Tier 1 annual maximum is calculated as 90 percent of 174,304 AF – or 156,874 AF. The total purchase commitment is 60 percent of 174,304 AF multiplied by the 10 year Purchase Order period - or 1,045,824 AF to be purchased by the end of 2013. Since signing a Purchase Order with MWD in 2002 West Basin has remained below its Tier 1 annual maximum and has been on track to meet its Purchase Commitment by the year 2012.

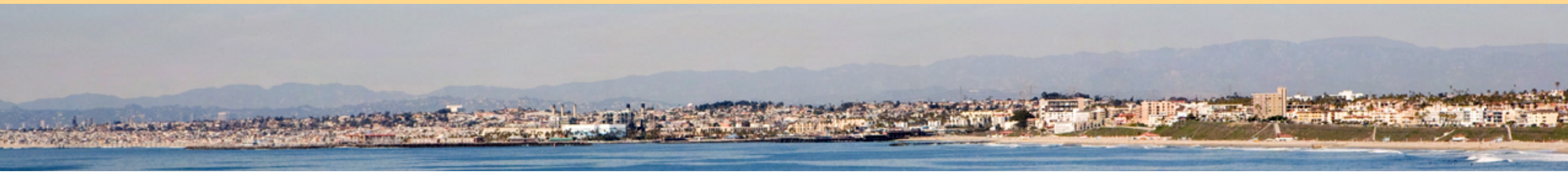


Table 8-1: West Basin Purchase Order Terms

Initial Base Allocation (AF)	Tier 1 Annual Maximum (90% of Base) (AF)	Purchase Order (60% of Base x 10) (AF)
174,304	156,874	1,045,825

8.1.2 Unbundled Rates and Tier 1& 2

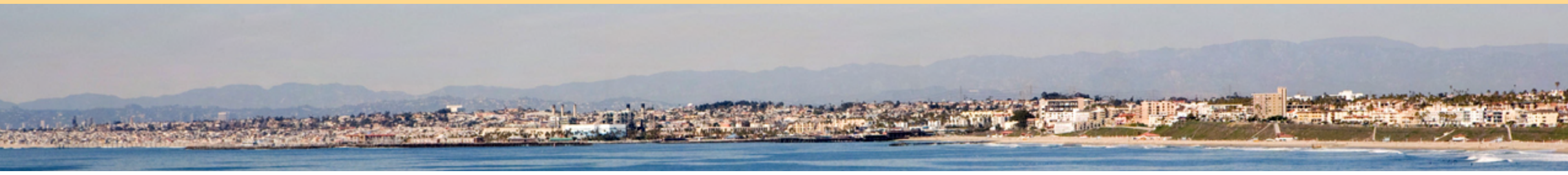
To justify the different components of the costs of water on a per acre foot basis, MWD rates are comprised of the following components:

- **Supply Rate Tier 1:** Reflects the average supply cost of water from the Colorado River and State Water Project.
- **Supply Rate Tier 2:** Reflects the MWD costs associated with developing new supplies, which is assessed when an agency exceeds its Tier 1 limit of firm deliveries.
- **System Access Rate:** Recovers a portion of the costs associated with the conveyance and distribution system, including capital and operating and maintenance costs.
- **Water Stewardship Rate:** Recovers MWD's cost of providing incentives to member agencies for conservation, water recycling, groundwater recovery, and other water management programs approved by the MWD Board.
- **Delta Supply Surcharge:** Reflects the additional supply costs that Metropolitan faces along with other costs due to the pumping restrictions on the State Water Project. The Delta Supply Surcharge replaced the Water Supply Surcharge effective with the FY 2009/10 rates.
- **System Power Rate:** Recovers MWD's electricity-related costs, such as the pumping of water through the conveyance and distribution system.
- **Treatment Surcharge:** Recovers the treatment cost and is assessed only for treated water deliveries, whether firm or non-firm.

The MWD water rates for calendar year 2011 are displayed in Table 8-2.

Table 8-2: MWD Rates Adopted for 2011

Category of Water	$/AF
Supply Rate Tier 1	$104
Supply Rate Tier 2	$280
System Access Rate	$204
Water Stewardship Rate	$41
Water Supply Surcharge	$0
Delta Supply Surcharge	$51
Power Rate	$127
Treatment Rate	$217
Total Tier 1 Treated Rate	**$744**
Total Tier 2 Treated Rate	**$869**



8.1.3 Replenishment Service

Although the great majority of the MWD water supplies are sold as uninterruptible Tier 1 or Tier 2 supply, there are times when excess supply is available for storage replenishment purposes. Since these excess supplies are only as available (or interruptible), they are typically bought at a discounted rate by agencies to recharge groundwater supplies or fill surface storage. This Replenishment Service Water is offered by MWD as either untreated or treated (that can be used as "in-lieu," where a retail agency will curtail pumping and instead take direct deliveries from MWD). Replenishment Service Water rates are not tied to the uninterruptible rate structure illustrated in Table 8-2 These rates are established by MWD to provide the best incentive to replenish the groundwater basins. Replenishment Service rates effective January 1, 2011 are shown in Table 8-3.

Table 8-3: MWD Replenishment Service Rate Adopted for 2011

Category of Water	$/AF
Replenishment Water Rate Untreated	$409
Treated Replenishment Water Rate	$601

8.1.4 MWD Capacity Charge

The MWD capacity charge was developed to recover the costs of providing distribution capacity use during peak summer demands. The aim of this charge is to encourage member agencies to reduce peak day demands during the summer months (May 1 thru September 30) and shift usages to the winter months (October 1 thru April 30), which will result in more efficient utilization of MWD's existing infrastructure and defers capacity expansion costs. Currently, MWD's capacity charge for FY 2010 and 2011 are set at $7,200/cubic feet per second (cfs).

The capacity charge is applied to an agency's maximum usage rate, which is the highest daily average usage (per cfs) for the past three summer periods. Table 8-4 shows the maximum usage rate for West Basin.

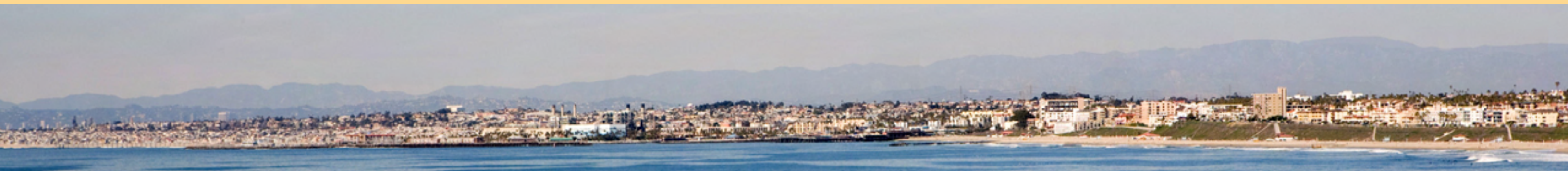
Table 8-4: Metropolitan Water District Capacity Charge for 2010

Peak Flow 2007 (cfs)	Peak Flow 2008 (cfs)	Peak Flow 2009 (cfs)	3-Year Max (cfs)	Capacity Charge
262	243	221	262	$1,663,700

Note: These peak flows are based upon West Basin's coincident peak of all its MWD connections.

8.1.5 Readiness-to-Serve Charge

MWD's readiness-to-serve charge recovers a portion of MWD's debt service costs associated with regional infrastructure improvements and is determined by the member agencies' firm imported deliveries for the past ten years. West Basin meets this obligation through its commodity rates.



8.2 West Basin's Imported Water Rates

To deliver water from MWD to its customer agencies, West Basin must pass along the MWD costs as well as an additional administrative surcharge. Described below are elements of the rate structure that West Basin applies to the delivery of imported water for its customer agencies.

8.2.1 Purchase Agreements

In order to meet the Purchase Order commitment with MWD, West Basin established its own purchase contract policy with its customer agencies. West Basin's Imported Water Purchase Agreement also calculates an annual maximum and total purchase commitment, but offers more flexibility to the customer. West Basin requires only a five-year commitment, as opposed to the ten-year MWD term. Furthermore, customer agencies have the option to adjust their annual maximum and purchase commitment amounts annually by offsetting imported water demand with recycled water purchased from West Basin. For purchases above the Tier 1 limit, or in the absence of a Purchase Agreement, the customer agency pays the Tier 2 rate.

8.2.2 Reliability Service Charge

One of the main revenue sources for West Basin is the reliability service charge applied to all imported water sold. Revenue from this charge recovers West Basin's administrative costs including planning, outreach and education, and conservation efforts, as well as a portion of the recycled water system operating costs. As of July 1, 2010, West Basin's reliability service charge is at $66/AF.

8.2.3 Readiness-to-Serve Surcharge

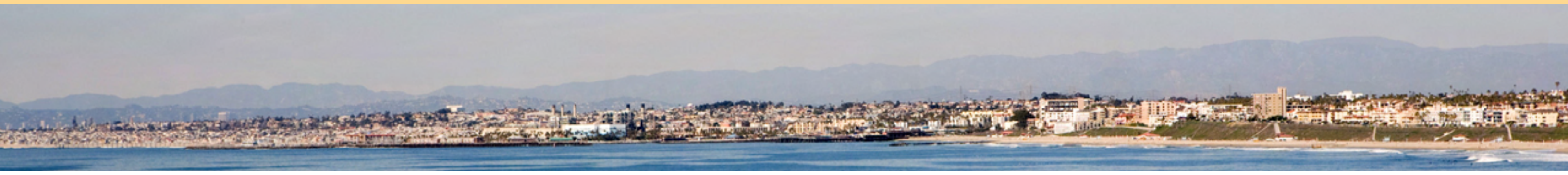
West Basin passes along MWD's readiness-to-serve charge within its commodity rates for non-interruptible and Barrier water supplies to cover this charge. As of January 1, 2011, West Basin's surcharge will be $125/AF.

8.2.4 Water Service Charge

Water utility revenue structures benefit from a mix of fixed and variable sources. West Basin's water service charge recovers a portion of the agency's fixed administrative costs, but is a relatively small portion of its overall revenue from water rates. As of July 1, 2010, the water service charge is $34/cfs of a customer agency's meter capacity for imported water meters.

8.2.5 West Basin's Capacity Charge

MWD's capacity charge is intended to encourage customers to reduce peak day demands during the summer months, which will result in more efficient utilization of MWD's existing infrastructure. West Basin has passed through MWD's capacity charge to its customer agencies based upon their highest daily average usage (per cfs) for the past three summer periods. The capacity charge that West Basin is assessed by MWD is $6,350/cfs for FY 2011.



8.2.6 Desalter Water Charges

West Basin also sells water produced by the Brewer Desalter at the effective MWD rate. This includes the MWD non-interruptible base rate and an acre-foot equivalent for the Capacity Charge. Currently, the rate for Desalter water is $767/AF as of January 2011.

8.3 Recycled Water Rates

West Basin's ECLWRF provides five different qualities of water to meet the needs of landscape irrigation, cooling towers, refineries, and industries within and outside its service area. Since 1995, West Basin has encouraged the maximum use of recycled water by providing an economic incentive through specialized rates and charges.

Recycled water use for irrigation

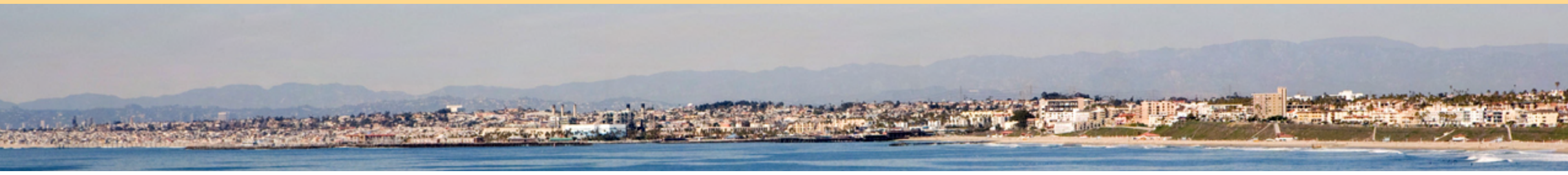
8.3.1 Recycled Water Rates

West Basin uses seven different rates for recycled water to account for differing treatment quality, power requirements, and customer location. All rates are assessed to include the operation and maintenance costs, and labor and power costs associated with the delivery of recycled water. A majority of these rates are set up in a declining tiered structure to further encourage the use of recycled water, while the others are set up to service one or more customers at a uniform rate. Most of the recycled water rates are set lower than potable water rates except for highly treated recycled water for use by refineries. Fiscal year 2010 – 2011 rates are shown in Table 8-5.

Table 8-5: 2010-2011 Recycled Water Rates

	Within West Basin Service Area					Torrance/ LADWP Service Area	Palos Verdes Zone
AF	**Basic**	**West Coast Barrier**	**Indus-trial R/O**	**AF**	**Basic**	**West Coast Barrier**	**Indus-trial R/O**
0-25	$686/AF	$540/AF	$914/AF	0-25	$686/AF	$540/AF	$914/AF
25-50	$676/AF	$540AF	$914/AF	25-50	$676/AF	$540AF	$914/AF
50-100	$666/AF	$540/AF	$914/AF	50-100	$666/AF	$540/AF	$914/AF
100-200	$656/AF	$540/AF	$914/AF	100-200	$656/AF	$540/AF	$914/AF
200+	$646/AF	$540/AF	$914/AF	200+	$646/AF	$540/AF	$914/AF

Customers outside of West Basin's service area boundaries pay an additional $42/AF per tier. This additional charge is applied to make up for the recycled water standby charge that is not levied on their parcels.



8.3.2 Recycled Water Standby Charge

The recycled water standby charge is levied by West Basin to each parcel within the service area. A rate of $24 per parcel (up to one acre for residential) is administered by West Basin to provide a source of non-potable water completely independent of drought-sensitive supplies. The revenue collected from this charge is used to pay the debt service obligations on the West Basin water recycling facilities. Each year West Basin holds a public hearing where they adopt West Basin's Engineer's Report and Resolution to assess this charge.

8.4 Future Water Rate Projections

As the demand for water increases in southern California so does the cost to administer, treat, and distribute imported and recycled water. However, West Basin has worked diligently to ensure that stable and predictable rates are managed for the future. This section discusses projections of imported and recycled water rate trends for the next ten years.

8.4.1 Imported Water Rate Projections

In 2004, the MWD Board adopted its Long Range Financial Plan. This plan was developed to forecast future costs and revenues necessary to support its operations and capital investments. Furthermore, it lays out the financial policy MWD will pursue over the next ten years. According to projected MWD sales, with investments into local resources, MWD estimates imported water rates will increase 4-6 percent annually. As a result, West Basin's water reliability service charge is projected to increase at an annual average rate of 7 percent. This increase is determined by West Basin's own Long Range Financial analysis and revenue requirements.

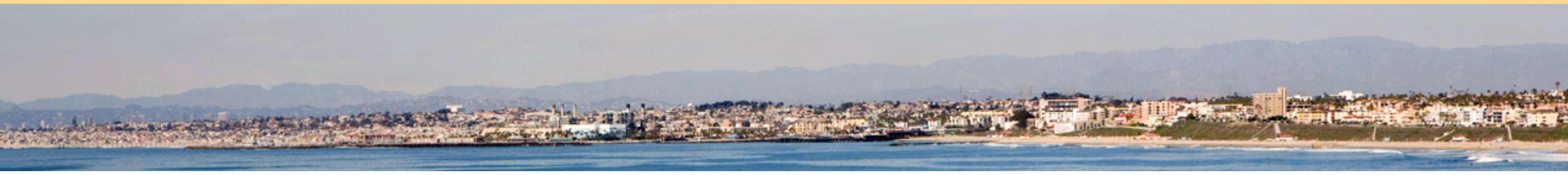
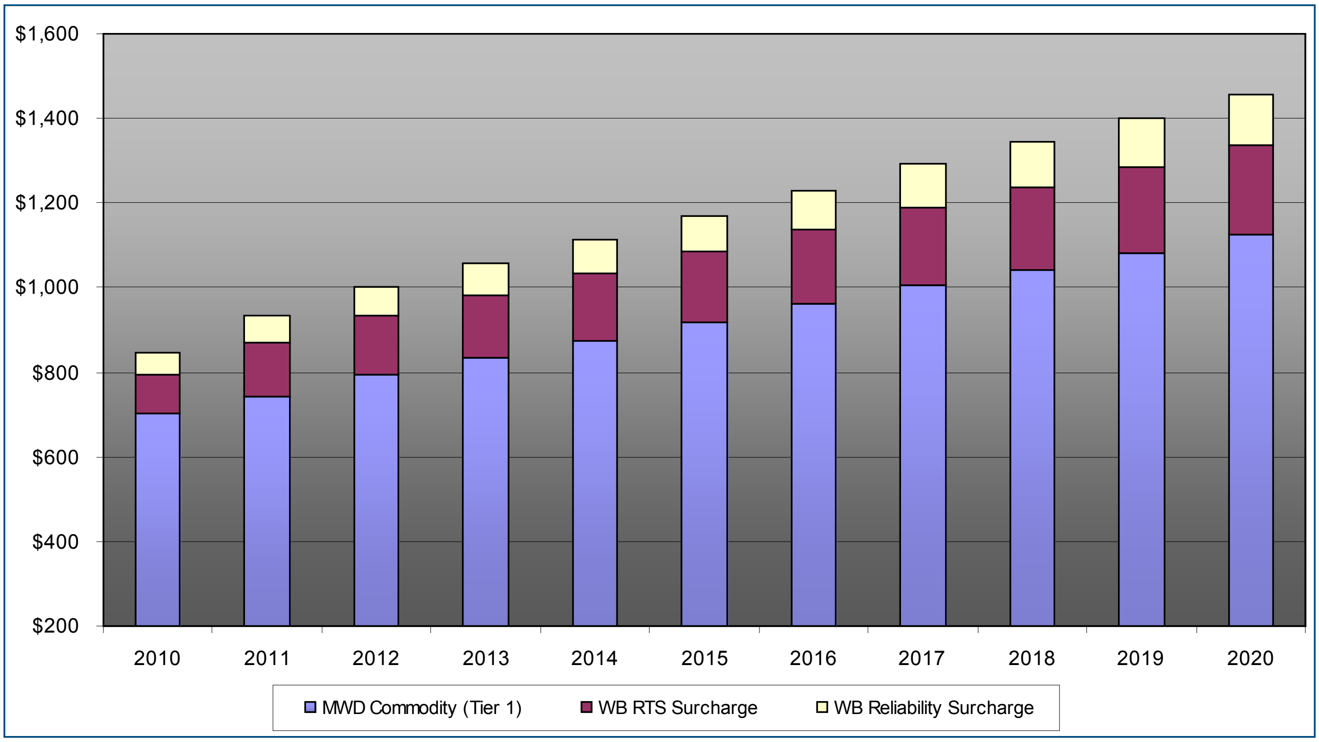


Figure 8-1: Projected Imported Water Rates displays West Basin's imported water rate projections for the next ten years.

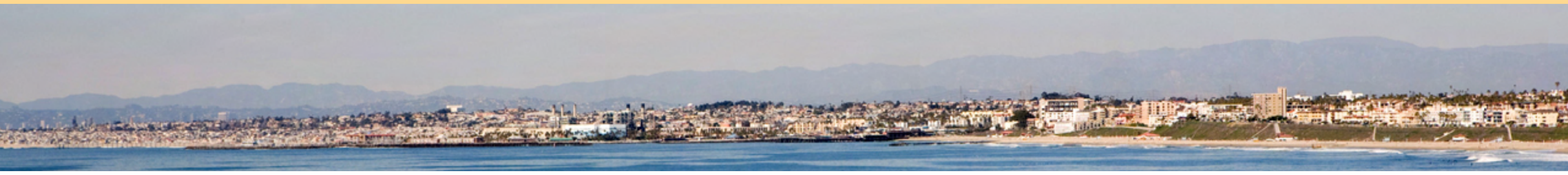
Figure 8-1: Projected Imported Water Rates



Source: MWD Long Range Financial Plan & West Basin's Financial Plan.

8.4.2 Recycled Water Rate Projections

Similar to imported water rates, recycled water rates are expected to increase due to higher treatment, maintenance, and power costs. However, West Basin believes in setting recycled water rates at a competitive level to help offset the use of imported water. To achieve this economic incentive, recycled water rates have been projected to increase at a slightly lower level than imported water. Rates are projected to increase for all types of recycled water, by an average of 5 percent annually. However, these rates may vary depending upon energy and chemical costs.



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SECTION NINE

Recycled Water

2010

SECTION 9 Recycled Water

Recycled water is the cornerstone of West Basin's efforts to increase water reliability by augmenting local supplies and reducing dependence on imported water. Since planning and constructing its recycled water system in the early 1990s, West Basin has become an industry leader in water reuse. West Basin's recycled water supply is sold to customers for non-potable applications such as landscape irrigation, commercial and industrial processes, and indirect potable uses through groundwater replenishment. While serving to offset imported water supplies, recycled water use also results in less ocean discharge of lesser-treated wastewater into the Santa Monica Bay.

In FY 2009-10, West Basin delivered about 30,400 AF of recycled water to sites inside and outside its service area, saving enough potable water to serve roughly 61,000 households. Within West Basin's service area, municipal and industrial recycled water use totaled about 15,500 AF and seawater barrier about 7,796 AF, which is about 13 percent of West Basin's current total water supplies. It is projected that recycled water sales could represent 27 percent of total water supplies by 2035.

9.1 Recycled Water Supply and Treatment

West Basin's recycled water source of supply is treated wastewater effluent from the City of Los Angeles's Hyperion Wastewater Treatment Plant (Hyperion). The City of Los Angeles has operated Hyperion, located adjacent to West Basin's service area, since 1894. Initially built as a raw sewage discharge plant into the Santa Monica Bay, Hyperion has been upgraded over the years to secondary and full secondary treatment. Hyperion's full treatment capacity is 450-850 mgd and secondary treatment capacity is 450 mgd.

Although the City of Los Angeles strives to provide West Basin with a consistent quality of secondary treated wastewater, the ECLWRF has to accommodate inevitable fluctuations in influent quality. Table 9-1 illustrates the amount of historical, current and projected wastewater collected and treated at Hyperion and the amount of recycled water that West Basin treats to at least tertiary recycled water standards.

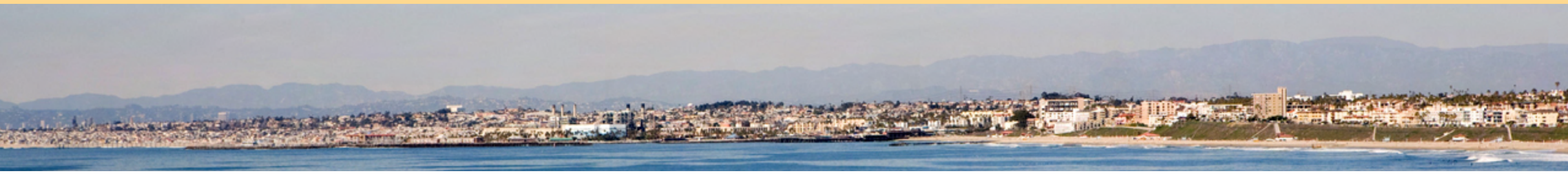


Table 9-1: Hyperion Wastewater Collected and Treated (AFY)

	2005	2010	2015	2020	2025	2030	2035
Wastewater collected & treated in Los Angeles' service area[1]	390,000	425,000	465,000	500,000	535,000	570,000	605,000
Quantity treated to meet recycled water standard[2]	24,160	30,000	58,100	62,000	66,000	70,000	70,000

[1] Data supplied by the Hyperion Wastewater Treatment Plant.
[2] Data supplied by West Basin.

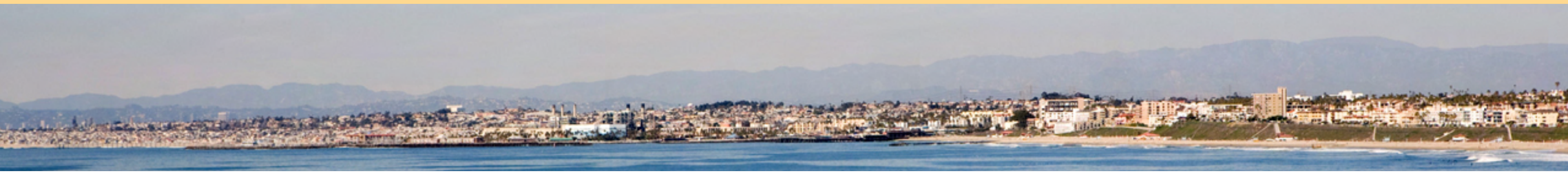
West Basin purchases approximately 37,600 AF, or roughly 9 percent of Hyperion's secondary effluent for treatment at the ECLWRF. West Basin opened ECLWRF in 1995, which is still one of the largest recycled water plants of its kind in the nation. This facility has a current capacity of 62,700 AF with its fourth expansion expected to be complete in 2012.

Most of West Basin's recycled water is treated to meet California Code of Regulations Title 22 (Title 22) tertiary standards. Title 22 addresses specific treatment requirements for recycled water and lists approved uses. Approximately 2,000 tests are performed monthly at the West Basin ECLWRF to ensure water quality meets or exceed all State and Federal requirements.

In 2002, West Basin's ECLWRF was recognized by the National Water Research Institute as one of the six National Centers for Water Treatment Technologies in the country. West Basin's recycled water program is unique in that it provides a variety of recycled water qualities beyond basic tertiary Title 22 levels. These five different water products, including Tertiary, are developed to meet specific customer specifications and are as follows:

- **Tertiary Water:** Secondary treated wastewater meeting Title 22 regulations is produced for non-potable irrigation through a conventional treatment process of coagulation, flocculation, clarification, filtration and disinfection.
- **Nitrified Water:** Tertiary water that is nitrified to remove ammonia is produced for use in refinery cooling towers.
- **Reverse Osmosis Water:** Secondary treated wastewater pretreated by microfiltration followed by reverse osmosis (RO), disinfection with ultra-violet and peroxide treatment for groundwater recharge.
- **Pure Reverse Osmosis Water:** Secondary treated wastewater that has undergone micro-filtration and RO for low-pressure boiler feed water.
- **Ultra-Pure Reverse Osmosis Water:** Secondary treated water that has undergone micro-filtration and two passes through RO for high-pressure boiler feed water.

In addition to providing recycled water for commercial and industrial uses, the reverse osmosis water produced by West Basin is purchased by the WRD and blended with potable water for injection into the West Coast Basin Seawater Barrier. This injected



water has the dual benefit of not only preventing seawater intrusion into the aquifers of the West Coast Groundwater Basin, but also providing replenishment to replace the water that is extracted by drinking water wells.

Seawater barriers are a series of injection wells that form a barrier to ensure that the groundwater level near the ocean stays high enough to keep seawater from seeping into a basin. Currently, the West Coast Basin Barrier receives approximatelty 75 percent RO recycled water mixed with 25 percent potable water. In April 2009, West Basin and WRD signed an agreement to increase the amount of RO recycled water supplied to the barrier to 100 percent by 2012 — saving 5.5 billion gallons of potable imported water a year.

In order to supply the variety of recycled water products to large customers that are often a long distance from the ECLWRF, West Basin also operates three satellite facilities that provide further treatment to tertiary water after passing through the ECLWRF.

Figure 9-1 shows the location of the ECLWRF, in the City of El Segundo, as well as these satellite treatment facilities including the Exxon-Mobil Nitrification Plant in Torrance, the Chevron Nitrification Plant in El Segundo and the Carson Regional Water Recycling Plant in Carson.

9.2 Recycled Water Use

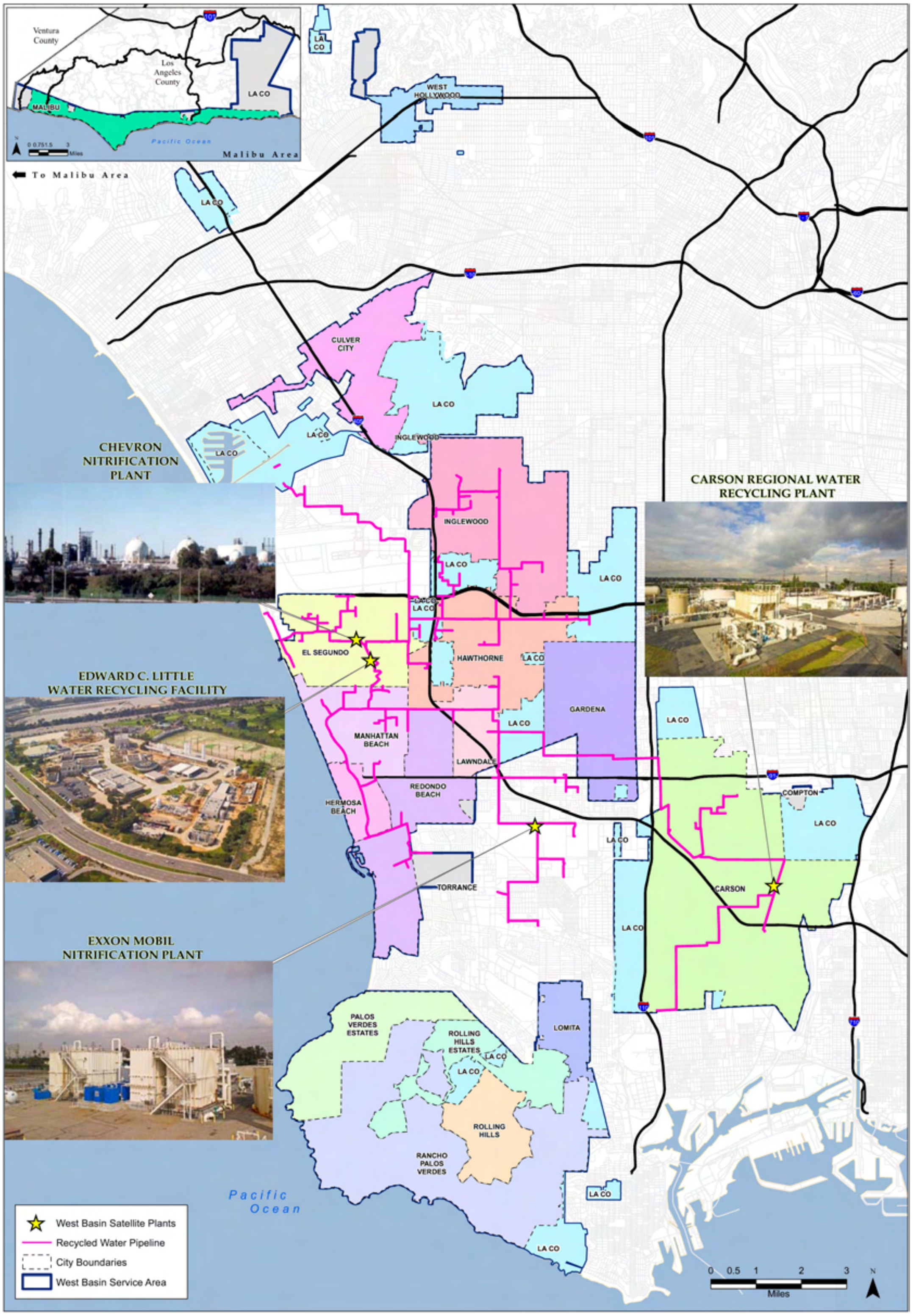
9.2.1 Existing System

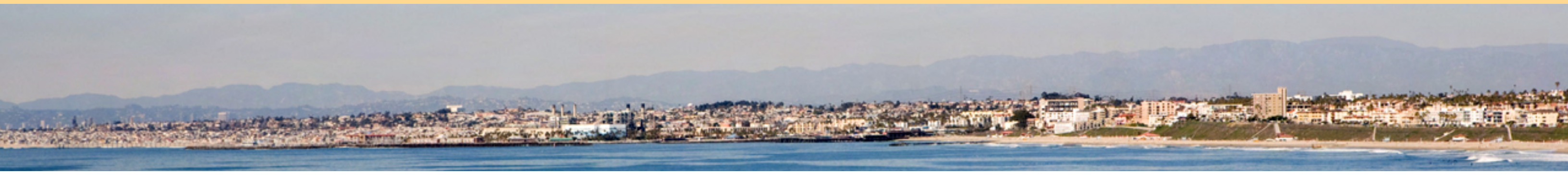
To date, West Basin has saved over 100 billion gallons of potable water imported from Northern California and the Colorado River which would have otherwise been used for non-potable applications. All recycled water is produced initially at the ECLWRF where it is distributed to either end-use sites or one of several satellite facilities. In all, more than 350 sites currently use more than 9.7 billion gallons annually.

As Figure 9-1 shows, West Basin's recycled water system serves the cities of Carson, El Segundo, Gardena, Hawthorne, Hermosa Beach, Inglewood, Manhattan Beach, Lawndale, Redondo Beach, and unincorporated areas of Los Angeles County within its service area, as well as the cities of Torrance and Los Angeles, which are outside of its service area.

The recycled water distribution infrastructure is separate from the potable drinking water system. All pipes, pumps and other equipment used to transport recycled water are clearly identified as recycled water to distinguish them from the potable drinking water system.

Figure 9-1: West Basin's Water Recycling Facilities



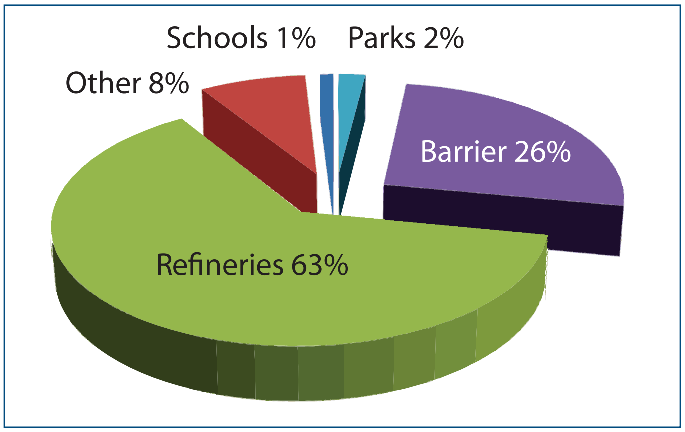


9.2.2 Recycled Water Use by Type

West Basin supplies recycled water for a wide-variety of customer uses such as:

- Seawater barriers
- Construction
- Industrial: Multi-Use
- Industrial: Nitrified
- Street Sweeping
- Irrigation: Cal-Trans
- Irrigation: Cemetery
- Irrigation: College
- Golf Course
- Irrigation: Landscape
- Irrigation: Medians
- Irrigation: Multi-Use
- Irrigation: Park
- Irrigation: School

Figure 9-2: Recycled Water Use by Type



9.2.3 Historical and Current Sales

West Basin's recycled water sales over the past ten years are illustrated in Figure 9-3. Sales increased until 2002-03, then declined due to a change in the source water from Hyperion. Sales have increased slightly in subsequent years and have remained steady at around 30,000 AF for the past two years. Table 9-3 provides a more detailed breakdown of historical sales by showing each retail customer agency's annual purchases for the past ten years.

West Basin has been able to deliver over 270, 500 AF over the last ten years to customers both inside and outside of its service area. This recycled water use has replaced enough potable water to supply the needs of approximately 135,250 families of four for an entire year. West Basin anticipates recycled water production and use to increase in the future due to system expansions, new applications, increasing public acceptance and economic incentives.

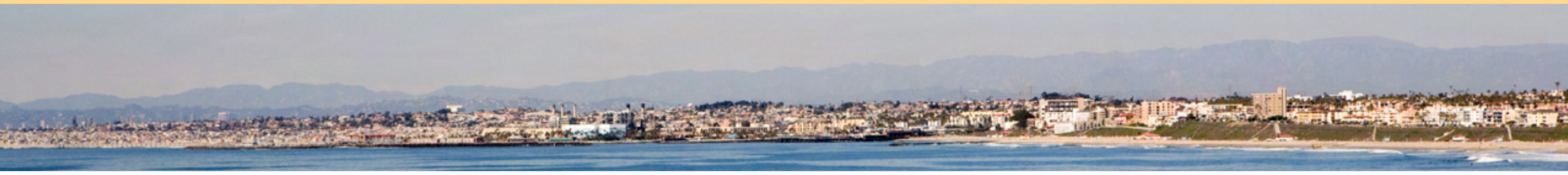
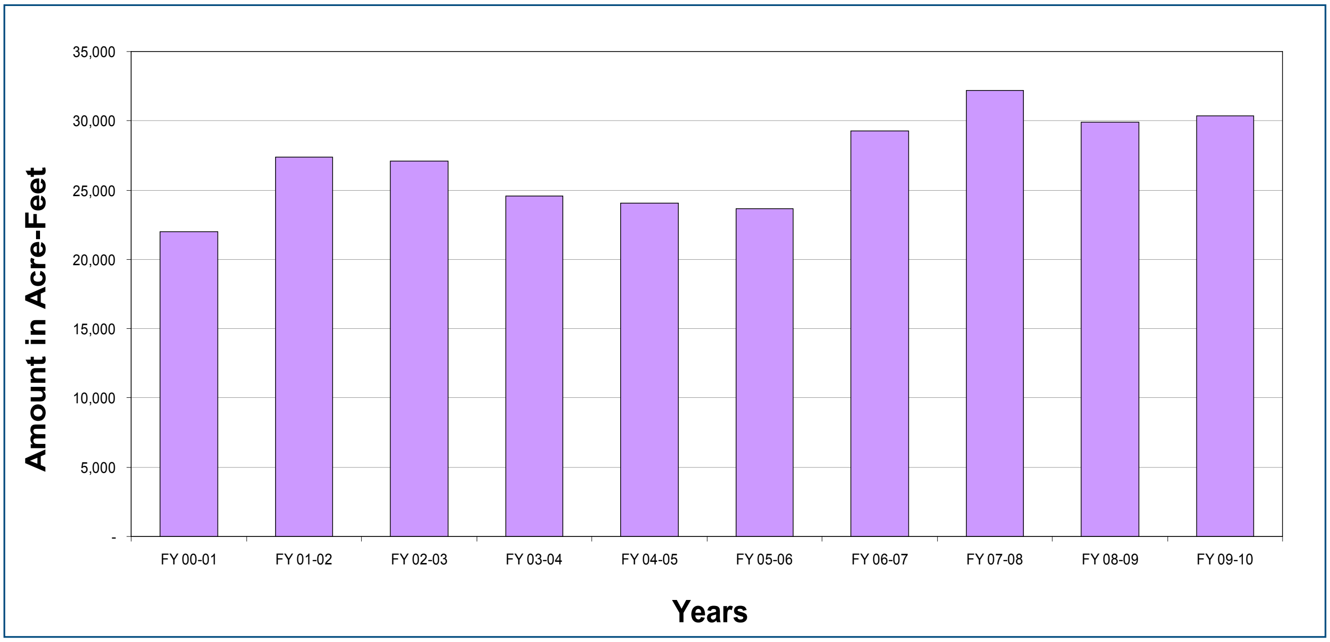


Figure 9-3: Historical Recycled Water Sales (FY 2000-2010)



West Basin's recycled water system also services the Cities of Torrance and Los Angeles, which are located outside of the District's boundaries. Therefore, although the total usage within West Basin's service area was 23,331 AF in 2009-2010, the total amount of recycled water delivered by West Basin was 30,384 AF

According to West Basin's 2005 UWMP, deliveries of recycled water within the service area were projected to reach over 39,000 by 2010. As shown in Table 9-2, actual sales in 2009/2010 fell significantly below this target. This was mainly due to setbacks in expanding the recycled water program in the southern portion of West Basin's service area which resulted in many large industrial customers not connecting to the system. In addition, water quality problems at Hyperion impacted deliveries to the West Coast Seawater Barrier significantly.

Table 9-2: Comparison of Recycled Water Use Project

Type of Use	2005 Projection for 2010	2009/2010 Actual Use
Irrigation/Industrial	21,848	22,588
West Coast Barrier	17,500	7,797
Total	**39,348**	**30,384**

9.2.4 Projected System Expansions

In 2009, West Basin completed a Capital Implementation Master Program (CIMP). The CIMP includes all of the planned projects for recycled water and desalination through the year 2030. The major recycled water capital projects are explained in further detail below.

ECLWRF Phase V Expansion: With the completion of the ECLWRF Phase V Expansion in 2012, West Basin is looking toward increasing its ability to provide enough recycled water to meet 100 percent of the West Coast Seawater Barrier's needs. The Phase V Expansion Project will increase barrier water production at the ECLWRF by up to an additional 5 mgd and serve the El Segundo Energy Center with 0.5 mgd of single-pass RO water. The Phase V Expansion will also expand ECLWRF's tertiary treatment system by an additional 10 mgd.

Edward C Little Water Recycling Facility

Hyperion Secondary Effluent Pump Station Expansion: As West Basin's recycled water production continues to increase, the demand for Hyperion's effluent will eventually exceed the capacity of the Hyperion Secondary Effluent Pump Station. A pump station expansion would be able provide a capacity of up to 70 mgd for ECLWRF. West Basin is working closely with Los Angeles Department of Water & Power, the provider of electrical power to the pump station, to also construct a second electrical feeder to the pump station that will also increase the reliability of the pumping facilities.

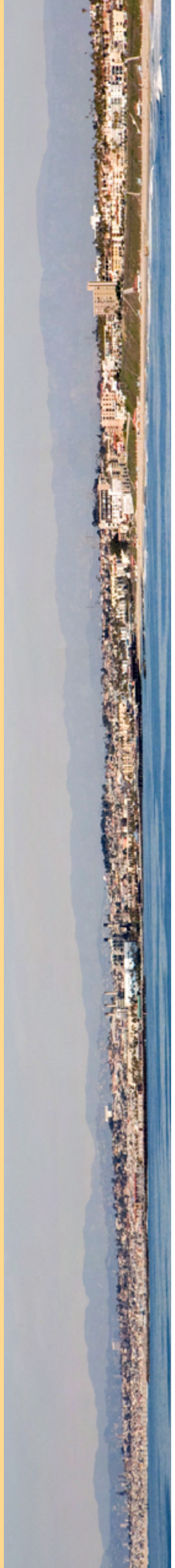


Table 9-3: West Basin Recycled Water Sales FY 2000-2010 (AFY)

West Basin	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	Total
California Water Service Co. Dominguez	3,297	3,165	3,101	3,639	3,616	3,665	3,610	4,690	5,293	4,959	39,035
California Water Service Co. Hawthorne	90	116	101	112	111	111	118	85	99	90	1,032
California Water Service Co. Hermosa/ Redondo	133	130	130	144	107	119	141	145	163	150	1,361
City of El Segundo	3,542	7,632	8,103	8,310	7,868	7,405	8,201	7,865	8,978	9,035	76,937
City of Inglewood	622	707	577	638	595	568	797	650	680	621	6,455
City of Manhattan Beach	272	307	254	301	274	249	316	288	251	264	2,777
Inglewood Unified School District	24	31	30	67	60	57	68	56	62	56	510
Golden State Water Company	237	282	315	432	435	429	523	552	410	360	3,975
M&I	8,216	12,371	12,610	13,643	13,064	12,604	13,774	14,330	15,936	15,535	132,082
WRD (Barrier)	6,753	7,290	6,754	3,935	3,799	4,383	9,104	11,129	7,652	7,797	68,596
Within Service Area	**14,969**	**19,660**	**19,364**	**17,578**	**16,863**	**16,987**	**22,878**	**25,459**	**23,588**	**23,331**	**200,677**
City of Torrance	91	117	144	196	186	253	285	311	277	272	2,134
City of Torrance - Mobil	6,558	7,212	7,328	6,385	6,735	6,156	5,774	6,078	5,599	6,173	63,998
LA DWP	357	398	277	394	283	257	313	360	444	608	3,692
Outside of Service Area	**7,006**	**7,727**	**7,750**	**6,975**	**7,205**	**6,666**	**6,372**	**6,750**	**6,320**	**7,053**	**69,823**
TOTAL	**21,974**	**27,387**	**27,113**	**24,552**	**24,067**	**23,652**	**29,250**	**32,208**	**29,908**	**30,384**	**270,500**

Harbor-South Bay Recycled Water Expansion Project: The Harbor-South Bay Recycled Water Expansion Project is a partnership between West Basin and the United States Army Corps of Engineers (USACE) to both expand West Basin's current recycled water distribution system as well as to provide an improvement in overall system reliability. This expansion will be able to bring additional recycled water supplies to the cities of Carson, Torrance, Palos Verdes, Gardena, and unincorporated areas of Los Angeles County.

Treatment/Conveyance Facility Repair, Replacement, and Improvements: Multiple improvements are under consideration for West Basin's treatment and conveyance system facilities. These improvements will enhance the safety, operability and efficiency of both the distribution system and treatment facilities. Some improvements will be made to comply with safety, water quality or other regulatory requirements or will be done to lower operating costs or improve equipment life.

Conveyance Facility Corrosion Protection Improvements: As a result of a study completed by West Basin, various cathodic protection improvements were identified that would ensure the integrity of West Basin's recycled water facilities. These improvements will be implemented periodically to ensure system integrity over the duration of the system's useful service life.

9.2.5 Projected Recycled Water Use

The 2009 CIMP identified and prioritized areas where recycled water has the potential to expand based upon potential future customers. Converting fabric and carpet dying industrial users to recycled water use are examples of significant opportunities for increased use.

The CIMP projects described in Section 9.2.4 are expected to result in at least an additional 40,900 AF of use within West Basin's service area by 2035. West Basin is also projecting to expand its export of recycled water within the City of Los Angeles' service area. Oil refineries within the harbor area of Los Angeles are proximal to West Basin's existing system and represent a large untapped potential for high-quality recycled water sales. West Basin will continue to pursue new cost-effective projects both within and outside its service area.

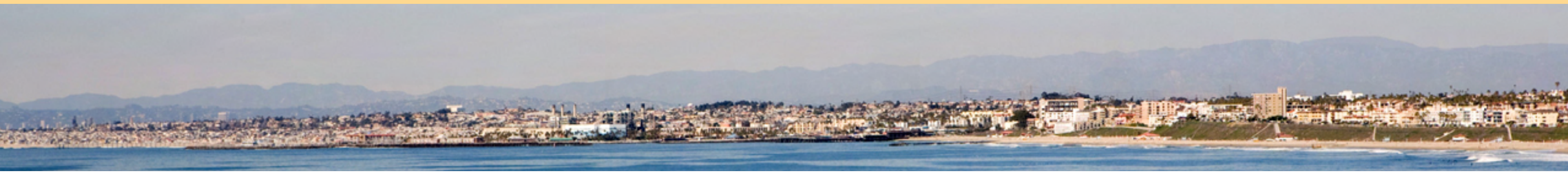


Table 9-4 illustrates the projected increase of recycled water over the next 25 years.

Table 9-4: Projected Recycled Water Use (AFY)

	2015	2020	2025	2030	2035
Industrial & Irrigation	16,368	33,882	33,882	37,382	37,382
Indirect Potable Reuse	16,980	16,980	16,980	20,480	20,480
Within Service Area	**33,348**	**50,862**	**50,862**	**57,862**	**57,862**
City Torrance	6,650	6,650	6,650	6,650	6,650
City of Los Angeles	10,700	10,700	10,700	10,700	10,700
Outside of Service Area	**17,350**	**17,350**	**17,350**	**17,350**	**17,350**
Total	**50,698**	**68,212**	**68,212**	**75,212**	**75,212**

9.2.6 Encouraging Recycled Water Use

West Basin generates interest in recycled water by contacting potential customers and cities with sites that are located near an existing main pipeline, have a high water use potential in which a line can be constructed, are mandated to use recycled water, and/or express interest. For commercial and industrial customers, West Basin emphasizes the benefit of recycled water as a tool for profitability for businesses that goes beyond the benefits of water conservation. West Basin markets recycled water as a resource that:

- Is less expensive than potable water;
- Is more reliable than imported water in a drought; and
- Is consistent with statewide goals for water supply and ecosystem improvement on both the State Water Project and Colorado River systems.

The target customer is expanding from traditional irrigation users such as golf courses and parks to unconventional commercial and industrial users. Through innovative marketing, recycled water is now being used by oil refineries and for cooling towers. In addition, West Basin is investigating recycled water use in fabric dye houses, co-generating plants, and commercial laundries.

In addition to West Basin wholesaling recycled water at a rate lower than potable water, other financial incentives are used to encourage recycled water use. Some potential recycled water customers do not have the financial capability to pay for the onsite plumbing retrofits necessary to accept recycled water. Therefore, West Basin advances funds for retrofit expenses, which can later be reimbursed through the water bills. Table 9-5 illustrates West Basin's coordinated effort with key stakeholders during the development of the CIMP.

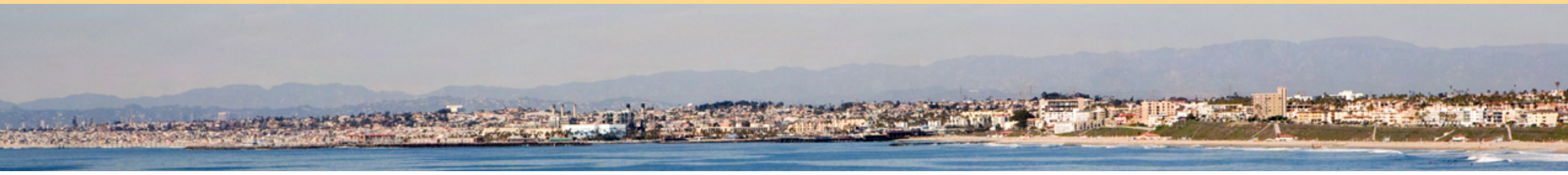


Table 9-5: CIMP Coordination

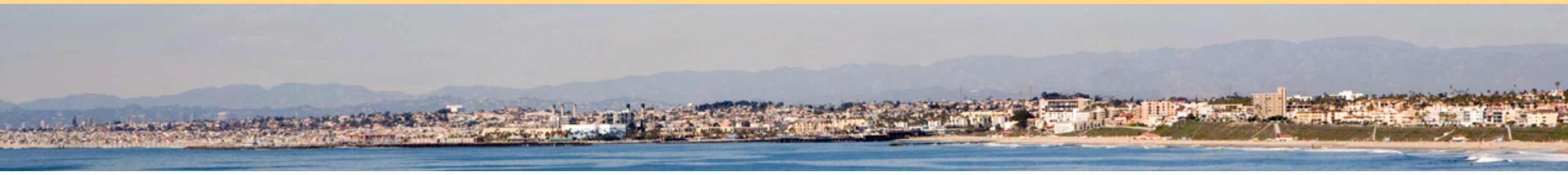
Participating Agencies	Role in Plan Development
Water Purveyors	Customer Development, Facilities, Impacts, Rates
Wastewater Agencies	Recycled Water Supply, Water Quality, Reliability
Groundwater Agencies	Rates and Customer Involvement
Planning Agencies	Economic Analysis, Rates, Data Assessment, Customer Assessment, Rates, Community Impacts, Customer Involvement, Conceptual Pipeline Routes, Cost Estimates

Funding

Capital costs for projects planned over the next five years have been budgeted to average approximately $30 million a year. These costs will be covered by the sources identified here and other sources as they become available.

MWD Local Resources Program Incentive: To qualify, proposed recycled water projects by member agencies must cost more than projected MWD treated non-interruptible water rates and reduce potable water needs. As a member agency of MWD, West Basin is eligible to receive an incentive for up to $250/AF of produced recycled water. It is competitive and requires an application and review process by MWD in coordination with West Basin staff.

Grant Funding: West Basin often applies for Federal and State grant funding for recycled water projects including through the USACE, which affords qualified programs 75 percent project funding. West Basin has utilized this funding arrangement for several of our previous water recycling projects.



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Section 10
Desalination

SECTION TEN

Desalination

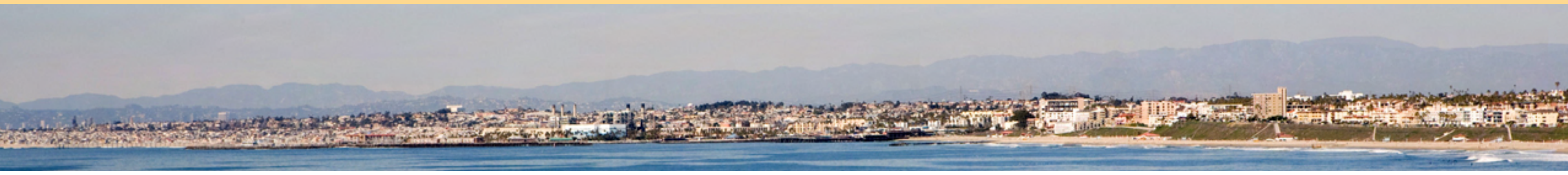
SECTION 10 Desalination

West Basin's experience in recycled water treatment includes substantial knowledge on methods used for the removal of salt from water supplies. This experience has proved useful to West Basin in pursuing both groundwater and ocean-water desalination programs to further develop local water supplies. Since 1993, West Basin has operated the C. Marvin Brewer Desalter Facility to treat brackish groundwater that remains on the inland side of the West Coast Seawater Barrier. In 2001 West Basin also began a multi-phase program to explore the systematic development of a full scale ocean-water desalination facility. This multi-phase approach has been based on deliberate scientific research and testing, beginning with a small pilot facility to test the basic treatment technology, and followed by West Basin's recently dedicated Ocean Water Desalination Demonstration Facility and Water Education Center in order to evaluate and demonstrate ocean protection, energy recovery and cost reduction technologies. These facilities have been developed to ensure a full scale ocean water desalination facility will be done in a cost and energy efficient manner and with a goal to protect the ocean. Research results from the Demonstration Facility will be shared throughout the water industry worldwide via the web site.

10.1 Ocean Desalting Process

Desalination or desalting is the process of converting highly salty, or brackish, water into a drinkable supply. Today's ocean-water desalting process removes salt, minerals and impurities from ocean water with cutting edge membrane technologies such as ultrafiltration or microfiltration and reverse osmosis. Using these methods, raw ocean water first passes through an ultrafiltration or microfiltration membrane which has thousands of hollow strands with pores on the walls that are 5,000 times smaller than a pinhole. The water then continues on to reverse osmosis membranes for the final purification process. Reverse osmosis is a pressure driven process whereby water passes through the molecular structure of a thin membrane that filters out salts, minerals, and impurities. Figure 10-1 shows a diagram of the typical desalting process.

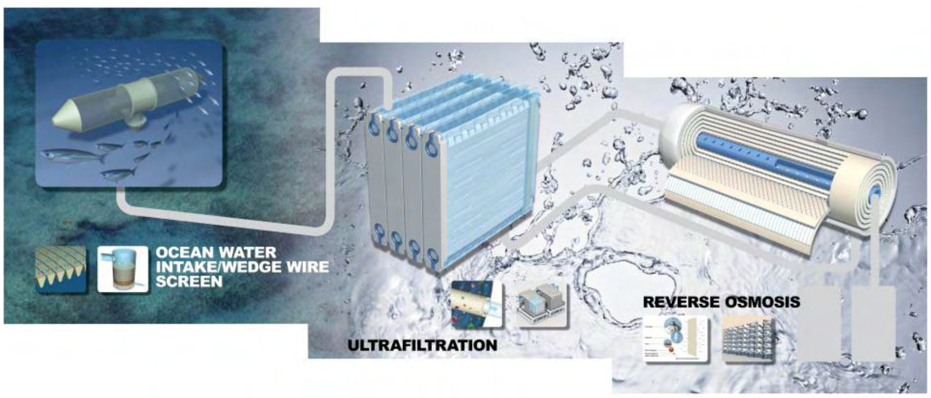
Traditionally, ocean-water desalination has been considered too expensive for a large-scale project, and for many years it was cost prohibitive compared to other sources of potable water in the West Basin service area. However, due to recent advancements in membrane technologies and energy recovery systems, and the increasing cost of existing sources of water, ocean-water desalination is now a financially viable new water source that is cost competitive with other sources of drinking water.



10.2 West Basin's Ocean Water Desalination Pilot Project

In May 2002, West Basin initiated piloting efforts to desalinate ocean water and evaluate the potential for developing a viable, new future drinking water supply for the region. This pilot project was located at the El Segundo Power Plant in the City of El Segundo and marked the first use of microfiltration pretreatment and reverse osmosis as a treatment process for ocean-water desalination. The pilot project was in operation for over seven years, and desalted approximately 20 gallons per minute (gpm) of raw ocean-water. The goal of the project was two-fold: 1) identify optimal performance conditions and 2) evaluate the water quality characteristics. The research findings are being shared among industry partners.

Figure 10-1: Desalting Process

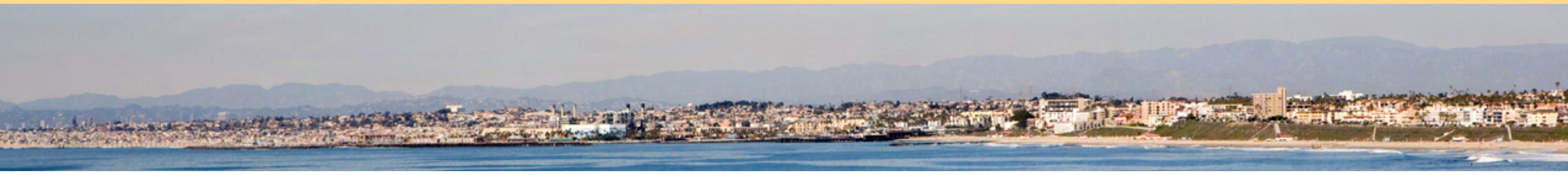


The process combination of microfiltration pretreatment and reverse osmosis treatment was to evaluate whether this process was effectively treating ocean-water and so West Basin performed extensive water quality research. Tens of thousands of water quality test results indicated that the treatment approach of utilizing microfiltration pretreatment and reverse osmosis treatment provides a reliable and consistent water quality that meets all State and Federal drinking water standards. The water produced at the pilot project consisted of approximately 300 parts per million (ppm) of total dissolved solids, lower than typical tap water in southern California. Figure 10-2 shows the microfiltration and reverse osmosis membranes used in the pilot demonstration project.

Figure 10-2: Treatment Technologies Used at West Basin's Pilot Plant

Example of Reverse Osmosis Units

Microfiltration Unit



West Basin's ocean-water desalination pilot project was designed to be a regional and national asset, and it was an open, collaborative effort that has benefited the entire water industry. To fund the $7 million combined cost of the pilot project, West Basin partnered with major agencies within and related to the water industry, including the American Water Works Association Research Foundation, California Avocado Commission, City of Tampa Bay, DWR, East Bay Municipal Utility District, Long Beach Water Department, Los Angeles Department of Water and Power, MWD, National Water Research Institute, San Diego County Water Authority, South Florida Water Management District, and United States Bureau of Reclamation.

10.3 Ocean Water Desalination Demonstration Facility Projects

Following in the pilot project, West Basin's next objective was to evaluate several critical components of the ocean-water desalination process through a small full-scale desalination demonstration project. In early 2009, West Basin received all necessary permits to proceed with the construction of the West Basin Ocean Water Desalination Demonstration Facility and Water Education Center. West Basin used the data acquired from the pilot project in the planning and development of the demonstration facility that is co-located at the SEA Lab Marine Educational Facility in Redondo Beach, California.

The Demonstration Facility draws in 500,000 gallons of seawater a day to perform various research and testing activities. Of the total intake volume, 100,000 gal/day is treated to produce 50,000 gal/day of drinking water (although the product water meets all drinking water standards, that is by permit required to re-combine the water and return it to the ocean). This process will develop a basis of design for a future full-scale desalination plant by accomplishing the following goals:

- Evaluating environmentally safe intake and concentrate discharge technologies and impacts
- Optimizing operation and maintenance procedures using full-scale elements
- Optimizing performance of energy recovery devices
- Analyzing water quality (as a continuation of the pilot plant testing)
- Providing opportunities for public and stakeholder education

Figure 10-3 shows the construction of the Demonstration Facility and Water Education Center within the facility.

10.4 Future Ocean Water Desalination Projects

10.4.1 Ocean Water Desalination Full-Scale Facility

This Ocean Water Desalination Demonstration Facility will test the viability of a future, full-scale Ocean Water Desalination Facility capable of providing up to 20,000 AFY, or enough to supply 40,000 families for a year, in the initial phase. Pending the findings from the demonstration facility and the environmental review process, West Basin anticipates permitting, financing, and constructing a full-scale facility by 2017. West Basin will perform a Desalination Program Master Plan in 2011 that will evaluate potential siting opportunities within West Basin's service area that could accommodate a full-scale facility. Potable water produced by the future ocean water desalination facility will be supplied to local and/or regional drinking water distribution systems.

Figure 10-3: West Basin's New Desalination Demonstration Facility

Construction of Demonstration Facility

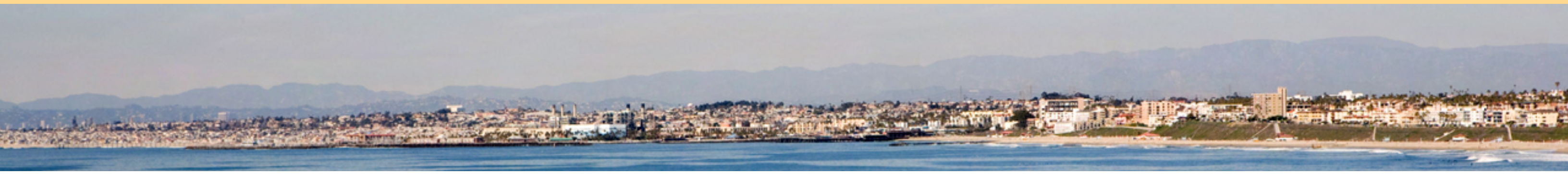
Water Education Center

Water Education Center

Water Education Center

Table 10-1: Opportunities for Desalinated Water

Sources of Water	Yield AFY	Start Date	Type of Use
Ocean Water	20,000	June 2015	Potable



10.5 Brewer Desalter Treatment Facility

West Basin owns the C. Marvin Brewer Desalter Facility which began operating in July 1993. The Desalter was built on a site owned by California Water Service Company (CWSC) in the City of Torrance where it removes chloride from groundwater impacted by seawater intrusion in the WCGB. The Desalter was initially conceived as a five-year pilot program to see if brackish water could be economically treated to drinking water standards.

The Desalter originally used two wells to pump brackish water from a saline plume remaining within the WCGB. It treats the water using cartridge filters and reverse osmosis, and the treated water is then blended with other potable water. CWSC stores the treated water blend on-site in a 5-million gallon storage reservoir, and ultimately delivers it to consumers through their distribution system. Under the terms of an agreement with CWSC, West Basin reimburses CWSC to operate and maintain the Desalter.

In 2005, enhancements were made to the Desalter program that replaced the two wells with a new, more productive well. This well has the capability to pump 1,600 to 2,400 AFY of brackish groundwater to be treated at the Desalter.

Figure 10-4: Brewer Desalter Facility Equipment

Brewer Extraction Well Site

Brewer Desalter RO Treatment

Appendices



2010

Appendices

APPENDIX A

Urban Water Management Planning Act

CALIFORNIA WATER CODE DIVISION 6
PART 2.6. URBAN WATER MANAGEMENT PLANNING

All California Codes have been updated to include the 2010 Statutes.

WATER CODE
SECTION 10610-10610.4

10610. This part shall be known and may be cited as the "Urban Water Management Planning Act."

10610.2. (a) The Legislature finds and declares all of the following:

(1) The waters of the state are a limited and renewable resource subject to ever-increasing demands.

(2) The conservation and efficient use of urban water supplies are of statewide concern; however, the planning for that use and the implementation of those plans can best be accomplished at the local level.

(3) A long-term, reliable supply of water is essential to protect the productivity of California's businesses and economic climate.

(4) As part of its long-range planning activities, every urban water supplier should make every effort to ensure the appropriate level of reliability in its water service sufficient to meet the needs of its various categories of customers during normal, dry, and multiple dry water years.

(5) Public health issues have been raised over a number of contaminants that have been identified in certain local and imported water supplies.

(6) Implementing effective water management strategies, including groundwater storage projects and recycled water projects, may require specific water quality and salinity targets for meeting groundwater basins water quality objectives and promoting beneficial use of recycled water.

(7) Water quality regulations are becoming an increasingly important factor in water agencies' selection of raw water sources, treatment alternatives, and modifications to existing treatment facilities.

(8) Changes in drinking water quality standards may also impact the usefulness of water supplies and may ultimately impact supply reliability.

(9) The quality of source supplies can have a significant impact

on water management strategies and supply reliability.
(b) This part is intended to provide assistance to water agencies in carrying out their long-term resource planning responsibilities to ensure adequate water supplies to meet existing and future demands for water.

10610.4. The Legislature finds and declares that it is the policy of the state as follows:
(a) The management of urban water demands and efficient use of water shall be actively pursued to protect both the people of the state and their water resources.
(b) The management of urban water demands and efficient use of urban water supplies shall be a guiding criterion in public decisions.
(c) Urban water suppliers shall be required to develop water management plans to actively pursue the efficient use of available supplies.

WATER CODE
SECTION 10611-10617

10611. Unless the context otherwise requires, the definitions of this chapter govern the construction of this part.

10611.5. "Demand management" means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies.

10612. "Customer" means a purchaser of water from a water supplier who uses the water for municipal purposes, including residential, commercial, governmental, and industrial uses.

10613. "Efficient use" means those management measures that result in the most effective use of water so as to prevent its waste or unreasonable use or unreasonable method of use.

10614. "Person" means any individual, firm, association, organization, partnership, business, trust, corporation, company, public agency, or any agency of such an entity.

10615. "Plan" means an urban water management plan prepared pursuant to this part. A plan shall describe and evaluate sources of supply, reasonable and practical efficient uses, reclamation and demand management activities. The components of the plan may vary according to an individual community or area's characteristics and its capabilities to efficiently use and conserve water. The plan shall address measures for residential, commercial, governmental, and industrial water demand management as set forth in Article 2 (commencing with Section 10630) of Chapter 3. In addition, a strategy and time schedule for implementation shall be included in the plan.

10616. "Public agency" means any board, commission, county, city and county, city, regional agency, district, or other public entity.

10616.5. "Recycled water" means the reclamation and reuse of wastewater for beneficial use.

10617. "Urban water supplier" means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers or supplying more than 3,000 acre-feet of water annually. An urban water supplier includes a supplier or contractor for water, regardless of the basis of right, which distributes or sells for ultimate resale to customers. This part applies only to water supplied from public water systems subject to Chapter 4 (commencing with Section 116275) of Part 12 of Division 104 of the Health and Safety Code.

WATER CODE
SECTION 10620-10621

10620. (a) Every urban water supplier shall prepare and adopt an urban water management plan in the manner set forth in Article 3 (commencing with Section 10640).

(b) Every person that becomes an urban water supplier shall adopt an urban water management plan within one year after it has become an urban water supplier.

(c) An urban water supplier indirectly providing water shall not include planning elements in its water management plan as provided in Article 2 (commencing with Section 10630) that would be applicable to urban water suppliers or public agencies directly providing water, or to their customers, without the consent of those suppliers or public agencies.

(d) (1) An urban water supplier may satisfy the requirements of this part by participation in areawide, regional, watershed, or basinwide urban water management planning where those plans will reduce preparation costs and contribute to the achievement of conservation and efficient water use.

(2) Each urban water supplier shall coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.

(e) The urban water supplier may prepare the plan with its own staff, by contract, or in cooperation with other governmental agencies.

(f) An urban water supplier shall describe in the plan water management tools and options used by that entity that will maximize resources and minimize the need to import water from other regions.

10621. (a) Each urban water supplier shall update its plan at least once every five years on or before December 31, in years ending in five and zero.

(b) Every urban water supplier required to prepare a plan pursuant to this part shall, at least 60 days prior to the public hearing on the plan required by Section 10642, notify any city or county within which the supplier provides water supplies that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. The urban water supplier may consult with, and obtain comments from, any city or county that receives notice pursuant to this subdivision.

(c) The amendments to, or changes in, the plan shall be adopted and filed in the manner set forth in Article 3 (commencing with Section 10640).

WATER CODE
SECTION 10630-10634

10630. It is the intention of the Legislature, in enacting this part, to permit levels of water management planning commensurate with the numbers of customers served and the volume of water supplied.

10631. A plan shall be adopted in accordance with this chapter that shall do all of the following:

(a) Describe the service area of the supplier, including current and projected population, climate, and other demographic factors affecting the supplier's water management planning. The projected population estimates shall be based upon data from the state, regional, or local service agency population projections within the service area of the urban water supplier and shall be in five-year increments to 20 years or as far as data is available.

(b) Identify and quantify, to the extent practicable, the existing and planned sources of water available to the supplier over the same five-year increments described in subdivision (a). If groundwater is identified as an existing or planned source of water available to the supplier, all of the following information shall be included in the plan:

(1) A copy of any groundwater management plan adopted by the urban water supplier, including plans adopted pursuant to Part 2.75 (commencing with Section 10750), or any other specific authorization for groundwater management.

(2) A description of any groundwater basin or basins from which the urban water supplier pumps groundwater. For those basins for which a court or the board has adjudicated the rights to pump groundwater, a copy of the order or decree adopted by the court or the board and a description of the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. For basins that have not been adjudicated, information as to whether the department has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition.

(3) A detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(4) A detailed description and analysis of the amount and location of groundwater that is projected to be pumped by the urban water supplier. The description and analysis shall be based on information that is reasonably available, including, but not limited to, historic use records.

(c) (1) Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage, to the extent practicable, and provide data for each of the following:

(A) An average water year.

(B) A single dry water year.

(C) Multiple dry water years.

(2) For any water source that may not be available at a consistent level of use, given specific legal, environmental, water quality, or climatic factors, describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.

(d) Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.

(e) (1) Quantify, to the extent records are available, past and current water use, over the same five-year increments described in subdivision (a), and projected water use, identifying the uses among water use sectors, including, but not necessarily limited to, all of the following uses:

(A) Single-family residential.

(B) Multifamily.

(C) Commercial.

(D) Industrial.

(E) Institutional and governmental.

(F) Landscape.

(G) Sales to other agencies.

(H) Saline water intrusion barriers, groundwater recharge, or conjunctive use, or any combination thereof.

(I) Agricultural.

(2) The water use projections shall be in the same five-year increments described in subdivision (a).

(f) Provide a description of the supplier's water demand management measures. This description shall include all of the following:

(1) A description of each water demand management measure that is currently being implemented, or scheduled for implementation, including the steps necessary to implement any proposed measures, including, but not limited to, all of the following:

(A) Water survey programs for single-family residential and multifamily residential customers.

(B) Residential plumbing retrofit.

(C) System water audits, leak detection, and repair.

(D) Metering with commodity rates for all new connections and retrofit of existing connections.

(E) Large landscape conservation programs and incentives.

(F) High-efficiency washing machine rebate programs.

(G) Public information programs.

(H) School education programs.

(I) Conservation programs for commercial, industrial, and institutional accounts.

(J) Wholesale agency programs.
(K) Conservation pricing.
(L) Water conservation coordinator.
(M) Water waste prohibition.
(N) Residential ultra-low-flush toilet replacement programs.

(2) A schedule of implementation for all water demand management measures proposed or described in the plan.

(3) A description of the methods, if any, that the supplier will use to evaluate the effectiveness of water demand management measures implemented or described under the plan.

(4) An estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the supplier's ability to further reduce demand.

(g) An evaluation of each water demand management measure listed in paragraph (1) of subdivision (f) that is not currently being implemented or scheduled for implementation. In the course of the evaluation, first consideration shall be given to water demand management measures, or combination of measures, that offer lower incremental costs than expanded or additional water supplies. This evaluation shall do all of the following:

(1) Take into account economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors.

(2) Include a cost-benefit analysis, identifying total benefits and total costs.

(3) Include a description of funding available to implement any planned water supply project that would provide water at a higher unit cost.

(4) Include a description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of implementation.

(h) Include a description of all water supply projects and water supply programs that may be undertaken by the urban water supplier to meet the total projected water use as established pursuant to subdivision (a) of Section 10635. The urban water supplier shall include a detailed description of expected future projects and programs, other than the demand management programs identified pursuant to paragraph (1) of subdivision (f), that the urban water supplier may implement to increase the amount of the water supply available to the urban water supplier in average, single-dry, and multiple-dry water years. The description shall identify specific projects and include a description of the increase in water supply that is expected to be available from each project. The description shall include an estimate with regard to the implementation timeline for each project or program.

(i) Describe the opportunities for development of desalinated water, including, but not limited to, ocean water, brackish water, and groundwater, as a long-term supply.

(j) For purposes of this part, urban water suppliers that are members of the California Urban Water Conservation Council shall be deemed in compliance with the requirements of subdivisions (f) and (g) by complying with all the provisions of the "Memorandum of Understanding Regarding Urban Water Conservation in California," dated December 10, 2008, as it may be amended, and by submitting the annual reports required by Section 6.2 of that memorandum.

(k) Urban water suppliers that rely upon a wholesale agency for a source of water shall provide the wholesale agency with water use projections from that agency for that source of water in five-year increments to 20 years or as far as data is available. The wholesale agency shall provide information to the urban water supplier for inclusion in the urban water supplier's plan that identifies and quantifies, to the extent practicable, the existing and planned sources of water as required by subdivision (b), available from the wholesale agency to the urban water supplier over the same five-year increments, and during various water-year types in accordance with subdivision (c). An urban water supplier may rely upon water supply information provided by the wholesale agency in fulfilling the plan informational requirements of subdivisions (b) and (c).

10631.1. (a) The water use projections required by Section 10631 shall include projected water use for single-family and multifamily residential housing needed for lower income households, as defined in Section 50079.5 of the Health and Safety Code, as identified in the housing element of any city, county, or city and county in the service area of the supplier.

(b) It is the intent of the Legislature that the identification of projected water use for single-family and multifamily residential housing for lower income households will assist a supplier in complying with the requirement under Section 65589.7 of the Government Code to grant a priority for the provision of service to housing units affordable to lower income households.

10631.5. (a) (1) Beginning January 1, 2009, the terms of, and eligibility for, a water management grant or loan made to an urban water supplier and awarded or administered by the department, state board, or California Bay-Delta Authority or its successor agency shall be conditioned on the implementation of the water demand management measures described in Section 10631, as determined by the department pursuant to subdivision (b).

(2) For the purposes of this section, water management grants and loans include funding for programs and projects for surface water or groundwater storage, recycling, desalination, water conservation, water supply reliability, and water supply augmentation. This section does not apply to water management projects funded by the federal American Recovery and Reinvestment Act of 2009 (Public Law 111-5).

(3) Notwithstanding paragraph (1), the department shall determine that an urban water supplier is eligible for a water management grant or loan even though the supplier is not implementing all of the water demand management measures described in Section 10631, if the urban water supplier has submitted to the department for approval a schedule, financing plan, and budget, to be included in the grant or loan agreement, for implementation of the water demand management measures. The supplier may request grant or loan funds to implement the water demand management measures to the extent the request is consistent with the eligibility requirements applicable to the water management funds.

(4) (A) Notwithstanding paragraph (1), the department shall

determine that an urban water supplier is eligible for a water management grant or loan even though the supplier is not implementing all of the water demand management measures described in Section 10631, if an urban water supplier submits to the department for approval documentation demonstrating that a water demand management measure is not locally cost effective. If the department determines that the documentation submitted by the urban water supplier fails to demonstrate that a water demand management measure is not locally cost effective, the department shall notify the urban water supplier and the agency administering the grant or loan program within 120 days that the documentation does not satisfy the requirements for an exemption, and include in that notification a detailed statement to support the determination.

(B) For purposes of this paragraph, "not locally cost effective" means that the present value of the local benefits of implementing a water demand management measure is less than the present value of the local costs of implementing that measure.

(b) (1) The department, in consultation with the state board and the California Bay-Delta Authority or its successor agency, and after soliciting public comment regarding eligibility requirements, shall develop eligibility requirements to implement the requirement of paragraph (1) of subdivision (a). In establishing these eligibility requirements, the department shall do both of the following:

(A) Consider the conservation measures described in the Memorandum of Understanding Regarding Urban Water Conservation in California, and alternative conservation approaches that provide equal or greater water savings.

(B) Recognize the different legal, technical, fiscal, and practical roles and responsibilities of wholesale water suppliers and retail water suppliers.

(2) (A) For the purposes of this section, the department shall determine whether an urban water supplier is implementing all of the water demand management measures described in Section 10631 based on either, or a combination, of the following:

(i) Compliance on an individual basis.

(ii) Compliance on a regional basis. Regional compliance shall require participation in a regional conservation program consisting of two or more urban water suppliers that achieves the level of conservation or water efficiency savings equivalent to the amount of conservation or savings achieved if each of the participating urban water suppliers implemented the water demand management measures. The urban water supplier administering the regional program shall provide participating urban water suppliers and the department with data to demonstrate that the regional program is consistent with this clause. The department shall review the data to determine whether the urban water suppliers in the regional program are meeting the eligibility requirements.

(B) The department may require additional information for any determination pursuant to this section.

(3) The department shall not deny eligibility to an urban water supplier in compliance with the requirements of this section that is participating in a multiagency water project, or an integrated regional water management plan, developed pursuant to Section 75026 of the Public Resources Code, solely on the basis that one or more of

the agencies participating in the project or plan is not implementing all of the water demand management measures described in Section 10631.

(c) In establishing guidelines pursuant to the specific funding authorization for any water management grant or loan program subject to this section, the agency administering the grant or loan program shall include in the guidelines the eligibility requirements developed by the department pursuant to subdivision (b).

(d) Upon receipt of a water management grant or loan application by an agency administering a grant and loan program subject to this section, the agency shall request an eligibility determination from the department with respect to the requirements of this section. The department shall respond to the request within 60 days of the request.

(e) The urban water supplier may submit to the department copies of its annual reports and other relevant documents to assist the department in determining whether the urban water supplier is implementing or scheduling the implementation of water demand management activities. In addition, for urban water suppliers that are signatories to the Memorandum of Understanding Regarding Urban Water Conservation in California and submit biennial reports to the California Urban Water Conservation Council in accordance with the memorandum, the department may use these reports to assist in tracking the implementation of water demand management measures.

(f) This section shall remain in effect only until July 1, 2016, and as of that date is repealed, unless a later enacted statute, that is enacted before July 1, 2016, deletes or extends that date.

10631.7. The department, in consultation with the California Urban Water Conservation Council, shall convene an independent technical panel to provide information and recommendations to the department and the Legislature on new demand management measures, technologies, and approaches. The panel shall consist of no more than seven members, who shall be selected by the department to reflect a balanced representation of experts. The panel shall have at least one, but no more than two, representatives from each of the following: retail water suppliers, environmental organizations, the business community, wholesale water suppliers, and academia. The panel shall be convened by January 1, 2009, and shall report to the Legislature no later than January 1, 2010, and every five years thereafter. The department shall review the panel report and include in the final report to the Legislature the department's recommendations and comments regarding the panel process and the panel's recommendations.

10632. (a) The plan shall provide an urban water shortage contingency analysis that includes each of the following elements that are within the authority of the urban water supplier:

(1) Stages of action to be undertaken by the urban water supplier in response to water supply shortages, including up to a 50 percent reduction in water supply, and an outline of specific water supply conditions that are applicable to each stage.

(2) An estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic

sequence for the agency's water supply.

(3) Actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.

(4) Additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.

(5) Consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.

(6) Penalties or charges for excessive use, where applicable.

(7) An analysis of the impacts of each of the actions and conditions described in paragraphs (1) to (6), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.

(8) A draft water shortage contingency resolution or ordinance.

(9) A mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.

(b) Commencing with the urban water management plan update due December 31, 2015, for purposes of developing the water shortage contingency analysis pursuant to subdivision (a), the urban water supplier shall analyze and define water features that are artificially supplied with water, including ponds, lakes, waterfalls, and fountains, separately from swimming pools and spas, as defined in subdivision (a) of Section 115921 of the Health and Safety Code.

10633. The plan shall provide, to the extent available, information on recycled water and its potential for use as a water source in the service area of the urban water supplier. The preparation of the plan shall be coordinated with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area, and shall include all of the following:

(a) A description of the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.

(b) A description of the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.

(c) A description of the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.

(d) A description and quantification of the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.

(e) The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected pursuant to this subdivision.

(f) A description of actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.

(g) A plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.

10634. The plan shall include information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments as described in subdivision (a) of Section 10631, and the manner in which water quality affects water management strategies and supply reliability.

WATER CODE SECTION 10635

10635. (a) Every urban water supplier shall include, as part of its urban water management plan, an assessment of the reliability of its water service to its customers during normal, dry, and multiple dry water years. This water supply and demand assessment shall compare the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. The water service reliability assessment shall be based upon the information compiled pursuant to Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.

(b) The urban water supplier shall provide that portion of its urban water management plan prepared pursuant to this article to any city or county within which it provides water supplies no later than 60 days after the submission of its urban water management plan.

(c) Nothing in this article is intended to create a right or entitlement to water service or any specific level of water service.

(d) Nothing in this article is intended to change existing law concerning an urban water supplier's obligation to provide water service to its existing customers or to any potential future customers.

WATER CODE
SECTION 10640-10645

10640. Every urban water supplier required to prepare a plan pursuant to this part shall prepare its plan pursuant to Article 2 (commencing with Section 10630).

The supplier shall likewise periodically review the plan as required by Section 10621, and any amendments or changes required as a result of that review shall be adopted pursuant to this article.

10641. An urban water supplier required to prepare a plan may consult with, and obtain comments from, any public agency or state agency or any person who has special expertise with respect to water demand management methods and techniques.

10642. Each urban water supplier shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan. Prior to adopting a plan, the urban water supplier shall make the plan available for public inspection and shall hold a public hearing thereon. Prior to the hearing, notice of the time and place of hearing shall be published within the jurisdiction of the publicly owned water supplier pursuant to Section 6066 of the Government Code. The urban water supplier shall provide notice of the time and place of hearing to any city or county within which the supplier provides water supplies. A privately owned water supplier shall provide an equivalent notice within its service area. After the hearing, the plan shall be adopted as prepared or as modified after the hearing.

10643. An urban water supplier shall implement its plan adopted pursuant to this chapter in accordance with the schedule set forth in its plan.

10644. (a) An urban water supplier shall submit to the department, the California State Library, and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. Copies of amendments or changes to the plans shall be submitted to the department, the California State Library, and any city or county within which the supplier provides water supplies within 30 days after adoption.

(b) The department shall prepare and submit to the Legislature, on or before December 31, in the years ending in six and one, a report summarizing the status of the plans adopted pursuant to this part. The report prepared by the department shall identify the exemplary elements of the individual plans. The department shall provide a copy of the report to each urban water supplier that has submitted its plan to the department. The department shall also prepare reports and provide data for any legislative hearings designed to consider the effectiveness of plans submitted pursuant to this part.

(c) (1) For the purpose of identifying the exemplary elements of the individual plans, the department shall identify in the report those water demand management measures adopted and implemented by specific urban water suppliers, and identified pursuant to Section

10631, that achieve water savings significantly above the levels established by the department to meet the requirements of Section 10631.5.

(2) The department shall distribute to the panel convened pursuant to Section 10631.7 the results achieved by the implementation of those water demand management measures described in paragraph (1).

(3) The department shall make available to the public the standard the department will use to identify exemplary water demand management measures.

10645. Not later than 30 days after filing a copy of its plan with the department, the urban water supplier and the department shall make the plan available for public review during normal business hours.

WATER CODE
SECTION 10650-10656

10650. Any actions or proceedings to attack, review, set aside, void, or annul the acts or decisions of an urban water supplier on the grounds of noncompliance with this part shall be commenced as follows:

(a) An action or proceeding alleging failure to adopt a plan shall be commenced within 18 months after that adoption is required by this part.

(b) Any action or proceeding alleging that a plan, or action taken pursuant to the plan, does not comply with this part shall be commenced within 90 days after filing of the plan or amendment thereto pursuant to Section 10644 or the taking of that action.

10651. In any action or proceeding to attack, review, set aside, void, or annul a plan, or an action taken pursuant to the plan by an urban water supplier on the grounds of noncompliance with this part, the inquiry shall extend only to whether there was a prejudicial abuse of discretion. Abuse of discretion is established if the supplier has not proceeded in a manner required by law or if the action by the water supplier is not supported by substantial evidence.

10652. The California Environmental Quality Act (Division 13 (commencing with Section 21000) of the Public Resources Code) does not apply to the preparation and adoption of plans pursuant to this part or to the implementation of actions taken pursuant to Section 10632. Nothing in this part shall be interpreted as exempting from the California Environmental Quality Act any project that would significantly affect water supplies for fish and wildlife, or any project for implementation of the plan, other than projects implementing Section 10632, or any project for expanded or additional water supplies.

10653. The adoption of a plan shall satisfy any requirements of state law, regulation, or order, including those of the State Water Resources Control Board and the Public Utilities Commission, for the preparation of water management plans or conservation plans; provided, that if the State Water Resources Control Board or the Public Utilities Commission requires additional information concerning water conservation to implement its existing authority, nothing in this part shall be deemed to limit the board or the commission in obtaining that information. The requirements of this part shall be satisfied by any urban water demand management plan prepared to meet federal laws or regulations after the effective date of this part, and which substantially meets the requirements of this part, or by any existing urban water management plan which includes the contents of a plan required under this part.

10654. An urban water supplier may recover in its rates the costs incurred in preparing its plan and implementing the reasonable water conservation measures included in the plan. Any best water management practice that is included in the plan that is identified in the

"Memorandum of Understanding Regarding Urban Water Conservation in California" is deemed to be reasonable for the purposes of this section.

10655. If any provision of this part or the application thereof to any person or circumstances is held invalid, that invalidity shall not affect other provisions or applications of this part which can be given effect without the invalid provision or application thereof, and to this end the provisions of this part are severable.

10656. An urban water supplier that does not prepare, adopt, and submit its urban water management plan to the department in accordance with this part, is ineligible to receive funding pursuant to Division 24 (commencing with Section 78500) or Division 26 (commencing with Section 79000), or receive drought assistance from the state until the urban water management plan is submitted pursuant to this article.

APPENDIX B

2010 Urban Water Management Plan Checklist

Table I-2 Urban Water Management Plan checklist, organized by subject

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
PLAN PREPARATION				
4	Coordinate the preparation of its plan with other appropriate agencies in the area, including other water suppliers that share a common source, water management agencies, and relevant public agencies, to the extent practicable.	10620(d)(2)		Section 1.1.4
6	Notify, at least 60 days prior to the public hearing on the plan required by Section 10642, any city or county within which the supplier provides water that the urban water supplier will be reviewing the plan and considering amendments or changes to the plan. Any city or county receiving the notice may be consulted and provide comments.	10621(b)		Section 1.1.1
7	Provide supporting documentation that the UWMP or any amendments to, or changes in, have been adopted as described in Section 10640 et seq.	10621(c)		N/A
54	Provide supporting documentation that the urban water management plan has been or will be provided to any city or county within which it provides water, no later than 60 days after the submission of this urban water management plan.	10635(b)		Appendix E
55	Provide supporting documentation that the water supplier has encouraged active involvement of diverse social, cultural, and economic elements of the population within the service area prior to and during the preparation of the plan.	10642		Section 1.1.3
56	Provide supporting documentation that the urban water supplier made the plan available for public inspection and held a public hearing about the plan. For public agencies, the hearing notice is to be provided pursuant to Section 6066 of the Government Code. The water supplier is to provide the time and place of the hearing to any city or county within which the supplier provides water. Privately-owned water suppliers shall provide an equivalent notice within its service area.	10642		Appendix C
57	Provide supporting documentation that the plan has been adopted as prepared or modified.	10642		Appendix D
58	Provide supporting documentation as to how the water supplier plans to implement its plan.	10643		Throughout All Sections of Document

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
59	Provide supporting documentation that, in addition to submittal to DWR, the urban water supplier has submitted this UWMP to the California State Library and any city or county within which the supplier provides water supplies a copy of its plan no later than 30 days after adoption. This also includes amendments or changes.	10644(a)		Appendix D
60	Provide supporting documentation that, not later than 30 days after filing a copy of its plan with the department, the urban water supplier has or will make the plan available for public review during normal business hours	10645		Appendix D
SYSTEM DESCRIPTION				
8	Describe the water supplier service area.	10631(a)		Section 2
9	Describe the climate and other demographic factors of the service area of the supplier	10631(a)		Section 2.2
10	Indicate the current population of the service area	10631(a)	Provide the most recent population data possible. Use the method described in Baseline Daily Per Capita Water Use. See Section M.	Section 2.3
11	Provide population projections for 2015, 2020, 2025, and 2030, based on data from State, regional, or local service area population projections.	10631(a)	2035 and 2040 can also be provided to support consistency with Water Supply Assessments and Written Verification of Water Supply documents.	Section 2.3
12	Describe other demographic factors affecting the supplier's water management planning.	10631(a)		Section 2.3
SYSTEM DEMANDS				
1	Provide baseline daily per capita water use, urban water use target, interim urban water use target, and compliance daily per capita water use, along with the bases for determining those estimates, including references to supporting data.	10608.20(e)		Section 3.3
2	*Wholesalers:* Include an assessment of present and proposed future measures, programs, and policies to help achieve the water use reductions. *Retailers:* Conduct at least one public hearing that includes general discussion of the urban retail water supplier's implementation plan for complying with the Water Conservation Bill of 2009.	10608.36 10608.26(a)	Retailers and wholesalers have slightly different requirements	Section 3.4

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
3	Report progress in meeting urban water use targets using the standardized form.	10608.40		N/A
25	Quantify past, current, and projected water use, identifying the uses among water use sectors, for the following: (A) single-family residential, (B) multifamily, (C) commercial, (D) industrial, (E) institutional and governmental, (F) landscape, (G) sales to other agencies, (H) saline water intrusion barriers, groundwater recharge, conjunctive use, and (I) agriculture.	10631(e)(1)	Consider "past" to be 2005, present to be 2010, and projected to be 2015, 2020, 2025, and 2030. Provide numbers for each category for each of these years.	N/A
33	Provide documentation that either the retail agency provided the wholesale agency with water use projections for at least 20 years, if the UWMP agency is a retail agency, OR, if a wholesale agency, it provided its urban retail customers with future planned and existing water source available to it from the wholesale agency during the required water-year types	10631(k)	Average year, single dry year, multiple dry years for 2015, 2020, 2025, and 2030.	Section 1.4
34	Include projected water use for single-family and multifamily residential housing needed for lower income households, as identified in the housing element of any city, county, or city and county in the service area of the supplier.	10631.1(a)		N/A
SYSTEM SUPPLIES				
13	Identify and quantify the existing and planned sources of water available for 2015, 2020, 2025, and 2030.	10631(b)	The "existing" water sources should be for the same year as the "current population" in line 10. 2035 and 2040 can also be provided.	Section 4.1
14	Indicate whether groundwater is an existing or planned source of water available to the supplier. If yes, then complete 15 through 21 of the UWMP Checklist. If no, then indicate "not applicable" in lines 15 through 21 under the UWMP location column.	10631(b)	Source classifications are: surface water, groundwater, recycled water, storm water, desalinated sea water, desalinated brackish groundwater, and other.	Section
15	Indicate whether a groundwater management plan been adopted by the water supplier or if there is any other specific authorization for groundwater management. Include a copy of the plan or authorization.	10631(b)(1)		N/A
16	Describe the groundwater basin.	10631(b)(2)		N/A
17	Indicate whether the groundwater basin is adjudicated? Include a copy of the court order or decree.	10631(b)(2)		N/A

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
18	Describe the amount of groundwater the urban water supplier has the legal right to pump under the order or decree. If the basin is not adjudicated, indicate "not applicable" in the UWMP location column.	10631(b)(2)		Section 4.3
19	For groundwater basins that are not adjudicated, provide information as to whether DWR has identified the basin or basins as overdrafted or has projected that the basin will become overdrafted if present management conditions continue, in the most current official departmental bulletin that characterizes the condition of the groundwater basin, and a detailed description of the efforts being undertaken by the urban water supplier to eliminate the long-term overdraft condition. If the basin is adjudicated, indicate "not applicable" in the UWMP location column.	10631(b)(2)		N/A
20	Provide a detailed description and analysis of the location, amount, and sufficiency of groundwater pumped by the urban water supplier for the past five years	10631(b)(3)		Section 4.3
21	Provide a detailed description and analysis of the amount and location of groundwater that is projected to be pumped.	10631(b)(4)	Provide projections for 2015, 2020, 2025, and 2030.	Section 4.3
24	Describe the opportunities for exchanges or transfers of water on a short-term or long-term basis.	10631(d)		Section 4.4
30	Include a detailed description of all water supply projects and programs that may be undertaken by the water supplier to address water supply reliability in average, single-dry, and multiple-dry years, excluding demand management programs addressed in (f)(1). Include specific projects, describe water supply impacts, and provide a timeline for each project.	10631(h)		Section 4.5
31	Describe desalinated water project opportunities for long-term supply, including, but not limited to, ocean water, brackish water, and groundwater.	10631(i)		Section 10
44	Provide information on recycled water and its potential for use as a water source in the service area of the urban water supplier. Coordinate with local water, wastewater, groundwater, and planning agencies that operate within the supplier's service area.	10633		Section 9
45	Describe the wastewater collection and treatment systems in the supplier's service area, including a quantification of the amount of wastewater collected and treated and the methods of wastewater disposal.	10633(a)		Section 9.2

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
46	Describe the quantity of treated wastewater that meets recycled water standards, is being discharged, and is otherwise available for use in a recycled water project.	10633(b)		Section 9.2
47	Describe the recycled water currently being used in the supplier's service area, including, but not limited to, the type, place, and quantity of use.	10633(c)		Section 9.3
48	Describe and quantify the potential uses of recycled water, including, but not limited to, agricultural irrigation, landscape irrigation, wildlife habitat enhancement, wetlands, industrial reuse, groundwater recharge, indirect potable reuse, and other appropriate uses, and a determination with regard to the technical and economic feasibility of serving those uses.	10633(d)		Section 9.3.2
49	The projected use of recycled water within the supplier's service area at the end of 5, 10, 15, and 20 years, and a description of the actual use of recycled water in comparison to uses previously projected.	10633(e)		Section 9.3.4
50	Describe the actions, including financial incentives, which may be taken to encourage the use of recycled water, and the projected results of these actions in terms of acre-feet of recycled water used per year.	10633(f)		Section 9.3.7
51	Provide a plan for optimizing the use of recycled water in the supplier's service area, including actions to facilitate the installation of dual distribution systems, to promote recirculating uses, to facilitate the increased use of treated wastewater that meets recycled water standards, and to overcome any obstacles to achieving that increased use.	10633(g)		Section 9.3.6
WATER SHORTAGE RELIABILITY AND WATER SHORTAGE CONTINGENCY PLANNING [b]				
5	Describe water management tools and options to maximize resources and minimize the need to import water from other regions.	10620(f)		Throughout All Sections of Document
22	Describe the reliability of the water supply and vulnerability to seasonal or climatic shortage and provide data for (A) an average water year, (B) a single dry water year, and (C) multiple dry water years.	10631(c)(1)		Section 5.2
23	For any water source that may not be available at a consistent level of use - given specific legal, environmental, water quality, or climatic factors - describe plans to supplement or replace that source with alternative sources or water demand management measures, to the extent practicable.	10631(c)(2)		Section 5.1
35	Provide an urban water shortage contingency analysis that specifies stages of action, including up to a 50-percent water supply reduction, and an outline of specific water supply conditions at each stage	10632(a)		Section 5.3

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
36	Provide an estimate of the minimum water supply available during each of the next three water years based on the driest three-year historic sequence for the agency's water supply.	10632(b)		Section 5.2
37	Identify actions to be undertaken by the urban water supplier to prepare for, and implement during, a catastrophic interruption of water supplies including, but not limited to, a regional power outage, an earthquake, or other disaster.	10632(c)		Section 5.3.6
38	Identify additional, mandatory prohibitions against specific water use practices during water shortages, including, but not limited to, prohibiting the use of potable water for street cleaning.	10632(d)		Section 5.3.1
39	Specify consumption reduction methods in the most restrictive stages. Each urban water supplier may use any type of consumption reduction methods in its water shortage contingency analysis that would reduce water use, are appropriate for its area, and have the ability to achieve a water use reduction consistent with up to a 50 percent reduction in water supply.	10632(e)		Section 5.3.2
40	Indicated penalties or charges for excessive use, where applicable.	10632(f)		Section 5.3.4
41	Provide an analysis of the impacts of each of the actions and conditions described in subdivisions (a) to (f), inclusive, on the revenues and expenditures of the urban water supplier, and proposed measures to overcome those impacts, such as the development of reserves and rate adjustments.	10632(g)		Section 5.3.3-5.3.5
42	Provide a draft water shortage contingency resolution or ordinance.	10632(h)		Appendix C
43	Indicate a mechanism for determining actual reductions in water use pursuant to the urban water shortage contingency analysis.	10632(i)		Section 5.3.1
52	Provide information, to the extent practicable, relating to the quality of existing sources of water available to the supplier over the same five-year increments, and the manner in which water quality affects water management strategies and supply reliability	10634	For years 2010, 2015, 2020, 2025, and 2030	Section 6

No.	UWMP requirement [a]	Calif. Water Code reference	Additional clarification	UWMP location
53	Assess the water supply reliability during normal, dry, and multiple dry water years by comparing the total water supply sources available to the water supplier with the total projected water use over the next 20 years, in five-year increments, for a normal water year, a single dry water year, and multiple dry water years. Base the assessment on the information compiled under Section 10631, including available data from state, regional, or local agency population projections within the service area of the urban water supplier.	10635(a)		Section 5.2
DEMAND MANAGEMENT MEASURES				
26	Describe how each water demand management measures is being implemented or scheduled for implementation. Use the list provided.	10631(f)(1)	Discuss each DMM, even if it is not currently or planned for implementation. Provide any appropriate schedules.	Section 7.6
27	Describe the methods the supplier uses to evaluate the effectiveness of DMMs implemented or described in the UWMP.	10631(f)(3)		Section 7.6
28	Provide an estimate, if available, of existing conservation savings on water use within the supplier's service area, and the effect of the savings on the ability to further reduce demand.	10631(f)(4)		Section 7.2
29	Evaluate each water demand management measure that is not currently being implemented or scheduled for implementation. The evaluation should include economic and non-economic factors, cost-benefit analysis, available funding, and the water suppliers' legal authority to implement the work.	10631(g)	See 10631(g) for additional wording.	Section 7.6
32	Include the annual reports submitted to meet the Section 6.2 requirements, if a member of the CUWCC and signer of the December 10, 2008 MOU.	10631(j)	Signers of the MOU that submit the annual reports are deemed compliant with Items 28 and 29.	Appendix G

a The UWMP Requirement descriptions are general summaries of what is provided in the legislation. Urban water suppliers should review the exact legislative wording prior to submitting its UWMP.

b The Subject classification is provided for clarification only. It is aligned with the organization presented in Part I of this guidebook. A water supplier is free to address the UWMP Requirement anywhere with its UWMP, but is urged to provide clarification to DWR to facilitate review.

APPENDIX C

Notice of Public Hearing

APPENDIX D

Resolution of Urban Water Management Plan Adoption

APPENDIX E

Notice of Urban Water Management Plan Preparation

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Garry Hofer
Operations Manager
California American Water Company
8657 Grand Ave.
Rosemead, CA 91770

Dear Mr. Hofer:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

A workshop for West Basin's retail water agencies will be held in early April at the West Basin headquarters to provide a summary of the draft UWMP including water supply and demand projections. The Public Hearing on the final 2010 UWMP will take place at the West Basin Board of Directors Meeting on May 23, 2011 at 1:00 p.m. Subsequent to the Public Hearing, the Board will consider adoption of the UWMP. West Basin will send a CD of the adopted UWMP in June 2011 to your agency.

If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Henry Wind
District Manager
California Water Service Company
2632 West 237th Street
Torrance, CA 90505

Dear Mr. Wind:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

James Turner
Water Supervisor
City of El Segundo
350 Main St.
El Segundo, CA 90245

Dear Mr. Turner:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Glen Kau
Public Works Director
City of Inglewood
One Manchester Blvd.
Inglewood, CA 90301

Dear Mr. Kau:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Vince DeMarco
Interim Director of Public Works
City of Lomita
P.O. Box 340
Lomita, CA 90717

Dear Mr. DeMarco:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Jim Arndt
Director of Public Works
City of Manhattan Beach
3621 Bell Avenue
Manhattan Beach, CA 90266

Dear Mr. Arndt:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Shad Rezai
Central District Manager
Golden State Water Company
1600 W. Redondo Beach Blvd, #101
Gardena, CA 90247-3226

Dear Mr. Rezai:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

David Rydman
Water Resources Manager
LA County Waterworks District #29
900 S. Freemont Ave.
Alhambra, CA 91803

Dear Mr. Rydman:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Robb Whitaker
General Manager
Water Replenishment District
4040 Paramount Blvd.
Lakewood, CA 90712

Dear Mr. Whitaker:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Tom Erb
Water Resources Manager
Los Angeles Department of Water and Power
P.O. Box 51111, Rm. 1315
Los Angeles, CA 90051

Dear Mr. Erb:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Rob Beste
Public Works Director
City of Torrance
20500 Madronna Ave.
Torrance, CA 90503

Dear Mr. Beste:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jk

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Grace Chan
Metropolitan Water District of Southern California
P.O. Box 54153
Los Angeles, CA 90054

Dear Ms. Chan:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

West Basin Municipal Water District (West Basin) is currently preparing the 2010 Urban Water Management Plan (UWMP) for its service area as required by the Urban Water Management Planning Act (Act) in California Water Code section 10610. The final draft of the 2010 UWMP will be available for review on West Basin's website at www.westbasin.org and will be sent to your agency in hard copy form at the end of March 2011. This final draft UWMP will include information that is required under the Act and will meet all of the requirements in the 2011 Guidebook issued by the California Department of Water Resources.

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Sincerely,

Rich Nagel
General Manager

LK:jks

17140 S. Avalon Blvd., Suite 210, Carson CA 90746 310-217-2411 www.westbasin.org

March 16, 2011

Water Resources Department
Los Angeles County Department of Public Works
900 S. Fremont Ave
Alhambra, CA 91803

Dear Water Resources Department:

Notice of Preparation
West Basin 2010 Urban Water Management Plan

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If you have any concerns, please contact Fernando Paludi, Water Policy and Resources Development Manager at (310) 660-6214.

Sincerely,

Rich Nagel
General Manager

LK:jks

APPENDIX F

Water Shortage Contingency Resolution

RESOLUTION NO. 4-09-902

A RESOLUTION OF THE BOARD OF DIRECTORS OF WEST BASIN MUNICIPAL WATER DISTRICT ESTABLISHING A WATER SHORTAGE ALLOCATION PLAN FOR CONSERVATION PURPOSES

BE IT RESOLVED BY THE BOARD OF DIRECTORS OF WEST BASIN MUNICIPAL WATER DISTRICT as follows:

WHEREAS, the State of California is now in its third consecutive year of drought, with the annual rainfall and the water content in the Sierra Nevada Snowpack being significantly below the amounts needed to fill California's storage reservoir system; and

WHEREAS, local rainfall levels for the 2008-2009 water year are 66% of average as of the April 1, 2009, measurement; and

WHEREAS, storage in the State's reservoir system is at below normal levels; and

WHEREAS, recent legal decisions issued to protect delta smelt and other species have further reduced water supplies available for delivery from the State Water Project; and

WHEREAS, Governor Schwarzenegger issued water emergency proclamations on June 12, 2008, and February 27, 2009, both ordering his administration begin taking action to address the water shortage; and

WHEREAS, the State Department of Water Resources' allocation of State Water Project water available to Southern California State Water Contractors is only 20% of the contracted supply amount; and

WHEREAS, on April 14, 2009, the Metropolitan Water District of Southern California declared that a regional shortage exists and implemented its Water Supply Allocation Plan at a Regional Shortage Level 2, including allocation penalty rates for water use in excess of a member agency's annual allocation; and

NOW, THEREFORE, THE BOARD OF DIRECTORS OF THE WEST BASIN MUNICIPAL WATER DISTRICT DOES HEREBY RESOLVE, DETERMINE AND ORDER AS FOLLOWS:

1. The West Basin Municipal Water District Board of Directors declare that there currently is a regional water shortage in the West Basin service area; and

2. The West Basin Water Shortage Allocation Plan, adopted by the West Basin Board on October 27, 2008 shall be implemented by the District's General Manager, effective July 1, 2009 through June 30, 2010, at Level 2 – the level equivalent to the Regional Shortage Level declared by the Metropolitan Water District; and

3. The West Basin Municipal Water District General Manager is hereby authorized and directed to take all necessary action to implement the West Basin Water Shortage Allocation Plan, consistent with its terms.

PASSED, APPROVED AND ADOPTED on ________________, 2009.

____
President

I hereby certify that the foregoing is a full, true and correct copy of the Resolution adopted by the Board of Directors of the West Basin Municipal Water District at its meeting held on April ____, 2009.

ATTEST:

____
Secretary

[SEAL]

w:\westbasinboard\resos\wb902

APPENDIX G

Demand Management Measures Annual Reports

Prepared by:
West Basin Municipal Water District
17140 South Avalon Boulevard, Suite 210
Carson, CA 90746
www.westbasin.org

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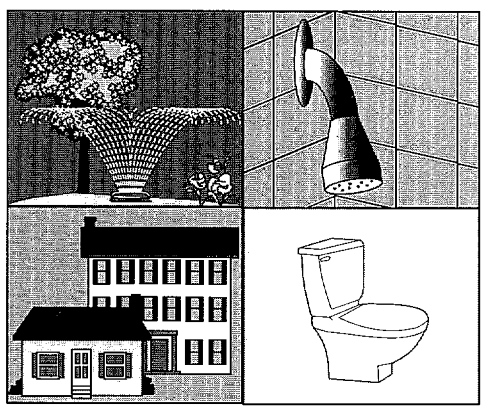
Summary

The Value of Water Supply Reliability:

Results of a Contingent Valuation Survey of Residential Customers



California Urban Water Agencies

Prepared by:
Barakat & Chamberlin, Inc.

August 1994

Summary

THE VALUE OF WATER SUPPLY RELIABILITY:
Results of a Contingent Valuation Survey of Residential Customers

CALIFORNIA URBAN WATER AGENCIES

Participating Agencies:

Alameda County Water District
Contra Costa Water District
Los Angeles Department of Water and Power
Metropolitan Water District of Southern California
Municipal Water District of Orange County
Orange County Water District
San Diego County Water Authority
San Diego Water Utilities Department
San Francisco Public Utilities Commission
Santa Clara Valley Water District

Prepared by:

BARAKAT & CHAMBERLIN, INC.
Oakland, California

August 1994

ACKNOWLEDGEMENTS

The authors would like to thank California Urban Water Agencies for sponsoring this study. The study greatly benefitted from the expertise of Dr. Michael Hanemann of the University of California, Berkeley, who served as special consultant to the project. We also are grateful for the assistance and the sustained interest of the Project Advisory Committee. Committee members included:

Dr. Richard Berk, Department of Sociology, U.C.L.A.
Mr. Arthur Bruington, Municipal Water District of Orange County
Mr. Byron Buck, San Diego County Water Authority
Mr. Norman Buehring, Los Angeles Department of Water and Power
Mr. Shane Chapman, Metropolitan Water District of Southern California
Ms. Leasa Cleland, Alameda County Water District
Mr. Merv De Haas, U.S. Bureau of Reclamation
Dr. Richard Denton, Contra Costa Water District
Mr. Jim Fiedler, Santa Clara Valley Water District
Mr. David Fullerton, Natural Heritage Institute
Mr. Jerry Harrell, California Municipal Utilities Assn.
Mr. Gordon Hess, San Diego County Water Authority
Mr. Ray Hoagland, Department of Water Resources
Mr. Morris Israel, University of California, Davis
Mr. Steve Kasover, Department of Water Resources
Dr. Jay Lund, University of California, Davis
Ms. Debra Mann, Metropolitan Water District of Southern California
Ms. Christine Morioka, San Francisco Water Department
Mr. Dan Rodrigo, Metropolitan Water District of Southern California
Mr. Richard Rogers, Pacific Earth Resources
Mr. Jim Simunovich, California Water Service Company
Mr. Karl Stinson, Alameda County Water District
Mr. Leo Thompson, Contra Costa Water District
Mr. Peter Vorster, Consultant
Mr. Richard West, Los Angeles Department of Water and Power
Mr. Lyle Hoag, ex officio, California Urban Water Agencies

Consultant staff:

Gary Fiske
Ronnie Weiner
Sami Khawaja
Scott Dimetrosky
Helen Arrick

FOREWORD

California Urban Water Agencies (CUWA) is an organization of the largest urban water providers in California. Its member agencies serve water to metropolitan areas comprising about two-thirds of the state's 32 million population. CUWA was formed to work on water supply issues of common concern to its members. Paramount among these concerns is the reliability of our urban water supplies. Statewide surveys show that California citizens rank water shortages close to crime, taxes, and traffic in listing their concerns about current problems in our society.

CUWA has an ongoing program to improve understanding of all aspects of urban water supply reliability. One important component of planning for supply reliability is being able to estimate the economic impact of water shortages so that an appropriate balance between costs and benefits of water management improvements can be found. CUWA and its member agencies sponsored earlier work on the cost of water shortages in California's manufacturing industries and the urban horticulture industry. However, the largest shortage cost component in some communities is in the residential sector, and this factor has proven difficult to quantify. CUWA and its consultant, Barakat & Chamberlin, Inc., determined that contingent valuation (CV) is the best available method for studying residential water shortage losses, and so undertook this survey—the most comprehensive and informative survey of its type conducted in the urban water supply industry.

This report detailed results of the CV surveys which shows that, on average, California residents are willing to pay \$12 to \$17 more per month per household on their water bills to avoid the kinds of water shortages which they or their regional neighbors have incurred in recent memory. The statewide magnitude of such additional consumer payments would be well over \$1 billion per year. This customer value can be considered in planning for various demand- and supply-related options to meet reliability goals. While environmental and social impacts were not assessed in the CV survey, this report points out that they must be considered in water resource planning. CUWA is planning an additional phase of its Water Supply Reliability Program which will help water managers integrate all aspects of reliability planning.

California Urban Water Agencies

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Summary

INTRODUCTION

California Urban Water Agencies (CUWA) is conducting ongoing research on issues of water supply reliability. The goal of the CUWA reliability project is to provide the framework and tools with which each water agency can better incorporate reliability issues into its overall resource planning. One of the key pieces of information needed to do this is the *value* that customers place on reliability.

To address this question, CUWA engaged the consulting firm of Barakat & Chamberlin, Inc., to design, conduct, and analyze the results of a *contingent valuation* survey to estimate the value to residential customers of water supply reliability. The survey was conducted within the service areas of ten CUWA member agencies. This summary discusses combined results for the ten participating agencies. The individual results for each agency are included as appendices to the full report.

As will be discussed below, estimates and patterns of willingness to pay (WTP) for increased water supply reliability are remarkably consistent across participating agencies. This consistency supports the integrity of the results and general findings of the study. However, contingent valuation is not an exact science, and dollar figures should be used with caution.

THE CUWA CONTINGENT VALUATION SURVEY

The primary purpose of the CUWA contingent valuation (CV) survey is to estimate the value residential customers place on water supply reliability, specifically how much they are willing to pay to avoid water shortages of varying magnitude and frequency.

The CUWA CV survey asked participants whether they would vote "yes" or "no" in a hypothetical referendum. Participants were told that if a majority votes "yes," water bills would be increased by a designated amount, and there would be no future water shortages; if a majority votes "no," respondents were told that water bills would remain the same as they otherwise would have been, but water shortages of a specified magnitude and frequency would occur. Of course, individual customers differ in their willingness to pay to avoid different shortages.

The survey purposely did not tell customers where additional supply would come from, but rather indicated that it could come from any of a number of different sources. The intent was to avoid responses that were unduly influenced by preferences for or against particular resource types.

The CV questions are preceded by a series of questions that address a number of experiential and attitudinal issues, which help to place the CV questions in context and are also used in the analysis. The actual CV questions include a carefully worded description of the hypothetical "scenario" that will form the basis of a "yes" or "no" vote. The CV questions are followed by several "debriefing" questions that provide information on the reasons why respondents voted as they did. The survey concludes with a series of demographic questions.

Respondents are distributed randomly across a range of shortage scenarios. Shortage magnitudes range from 10% to 50%. Frequencies range from once every 3 years to once every 30 years. Bid amounts range from $1 to $50 increments to monthly water bills.[1]

Magnitudes and frequencies were combined to accomplish three objectives:

- To cover a wide range of shortage severity;
- To present shortage scenarios that would be perceived by respondents as realistic possibilities; and
- To avoid shortage scenarios that are too mild to elicit reliable WTP responses.

There are some critical concerns that are intentionally not addressed by the survey. The amount that some customers are willing to pay to avoid shortages will likely depend on one or more "external" impacts associated with the resource(s) added. These might include environmental or various social impacts. The CUWA Project

[1]Initial bid amounts ranged from $5 to $20. However, the follow-up portion of the double-bounded question accommodated values as low as $1 or as high as $50, if necessary.

Advisory Committee (PAC) and the consultants determined that, in the context of an agency's resource planning process, these issues would be best treated as costs associated with particular resource additions. Pretests and focus groups conducted during the survey design process indicated that, through proper wording of the survey questions, respondents could, in fact, give answers that were not influenced by such matters.

Because of the complexity of a survey of this type, it was decided to use a combination mail/telephone survey. A package of information was mailed to potential respondents. The mail package contained material that explained the purpose of the survey and helped customers understand the impacts of various shortage magnitudes. Interviewers called several days after the mail material was received.

The survey was conducted from August 1993 through February 1994. The total number of completions across all participating agencies was 3,769.

ANALYTICAL APPROACH

As described earlier, the contingent valuation (CV) survey uses the referendum approach. The referendum approach "bounds" the maximum willingness to pay (WTP) by asking the respondent whether he or she would be willing to pay a specified amount. A "yes" response indicates that the respondent would be willing to pay that amount or more, i.e, it gives a lower bound to the maximum WTP; a "no" response gives an upper bound. The mean WTP to avoid particular shortage scenario can be estimated statistically from responses of different residential customers to different shortage descriptions.

An extension of this approach, and one which is more statistically reliable, is the "double-bounded" technique. The CUWA contingent valuation survey asked respondents whether they would pay an additional monthly amount (or bid) to avoid a particular percentage shortage occurring with a specified frequency. A second choice question, whose bid depended on the answer to the first question, was then asked. If the response to the first question was "yes," then the second bid was an amount greater than the first bid, and if it was "no," the second bid was an amount smaller.

The superior statistical efficiency of the "double-bounded" approach makes intuitive sense given that the "double-bounded" approach yields more information than the "single-bounded" approach about each respondent's preferences. The solution to the double-bounded model used maximum likelihood techniques, applying a program that was written in GAUSS, a statistical software package widely used by economists and statisticians.

Specification of the Statistical Model

As described above, many questions pertaining to sociodemographic, attitudinal, and perceptual variables were included in the survey. Responses to many of these questions were included as explanatory variables in the statistical model. By doing this, we can see how these factors affect WTP. Figure S-1 describes the key explanatory variables included in the model.

Two statistical models were estimated. The so-called "detailed" model included all of the key explanatory variables discussed above. A "simplified" model included only those variables that can be obtained from census or agency billing records. These include:

- Age
- Household income
- Education level
- Dwelling type
- Household size

To the extent that this simplified model is statistically valid, it will enable agencies to reestimate willingness to pay in the future without resurveying residential customers.

The approach results in the following expression for the mean WTP for each shortage frequency (FREQ) and magnitude (REDUCE) combination:

$$WTP(REDUCE,FREQ) = \frac{\log(1+\exp(\alpha+\beta_1(REDUCE)+\beta_2(FREQ)+\sum\gamma_n X_{mean_n}+\sum\delta_t Z_{prop_t}))}{-\beta_3}$$

Figure S-1
KEY EXPLANATORY VARIABLES

- **Number of years living in area**
- **Household size**†
- **Age**†
- **Income**†
- **Education**†
- **Housing type**†
- **Concern for other public issues**
- **Perception of drought severity**
- **Perception of water shortages as a long-term problem**
- **Awareness of agency mandates to cut back on water use**
- **Home ownership/rental status and water bill responsibility**
- **Amount and type (private or shared) of external landscaping**
- **Population growth preferences**
- **Average residential water rate for respondent's water agency**
- **Northern California or Southern California agency**

†Included in simplified model.

where:

X_{mean} = the mean of those explanatory variables that are not binary (i.e., either zero or one)

Z_{prop} = the proportion of customers for which each of the binary explanatory variables takes on a value of one.

This expression enables us to derive *customer loss functions* that express average customer willingness to pay as a function of shortage magnitude and frequency. Such functions can be a key tool for agency resource planners.

ANALYTICAL RESULTS

Willingness to pay (WTP) can be interpreted as the losses that residential customers incur as a result of particular shortage scenarios. The amount that a customer is willing to pay to avoid an event is a measure of the losses that customer would incur if that event were to occur. Therefore, we refer to these willingness to pay results as a "loss function."

Tables S-1A and S-1B present the mean WTP for the detailed model and the simplified model for each magnitude and frequency of shortage. WTP figures represent increments to monthly water bills.

WTP for the detailed model varies from a low of approximately $11.60/month to avoid either a 10% shortage every 10 years or a 20% shortage once every 30 years, to a high of about $16.90/month to avoid a 50% shortage every 20 years. The results of the simplified model are almost identical to the results of the detailed model. While results for individual agencies do exhibit some differences, the range of WTP estimates is remarkably consistent across all participating agencies.

Table S-1A
MEAN MONTHLY WILLINGNESS TO PAY, DETAILED MODEL
(Additional $/Month)

Shortage (Percent Reduction From Full Service)	Frequency (Occurrences/Years)				
	1/30	1/20	1/10	1/5	1/3
10%			$11.63	$11.98	$12.12
20%	$11.62	$12.33	$13.06		
30%	$13.05	$13.80	$14.57		
40%	$14.56	$15.34	$16.13		
50%	$16.12	$16.92			
Blank cells in the table reflect scenarios that were not part of the survey.					

Table S-1B
MEAN MONTHLY WILLINGNESS TO PAY, SIMPLIFIED MODEL
(Additional $/Month)

Shortage (Percent Reduction From Full Service)	Frequency (Occurrences/Years)				
	1/30	1/20	1/10	1/5	1/3
10%			$11.67	$12.00	$12.14
20%	$11.71	$12.39	$13.08		
30%	$13.13	$13.84	$14.56		
40%	$14.61	$15.35	$16.10		
50%	$16.15	$16.92			
Blank cells in the table reflect scenarios that were not part of the survey.					

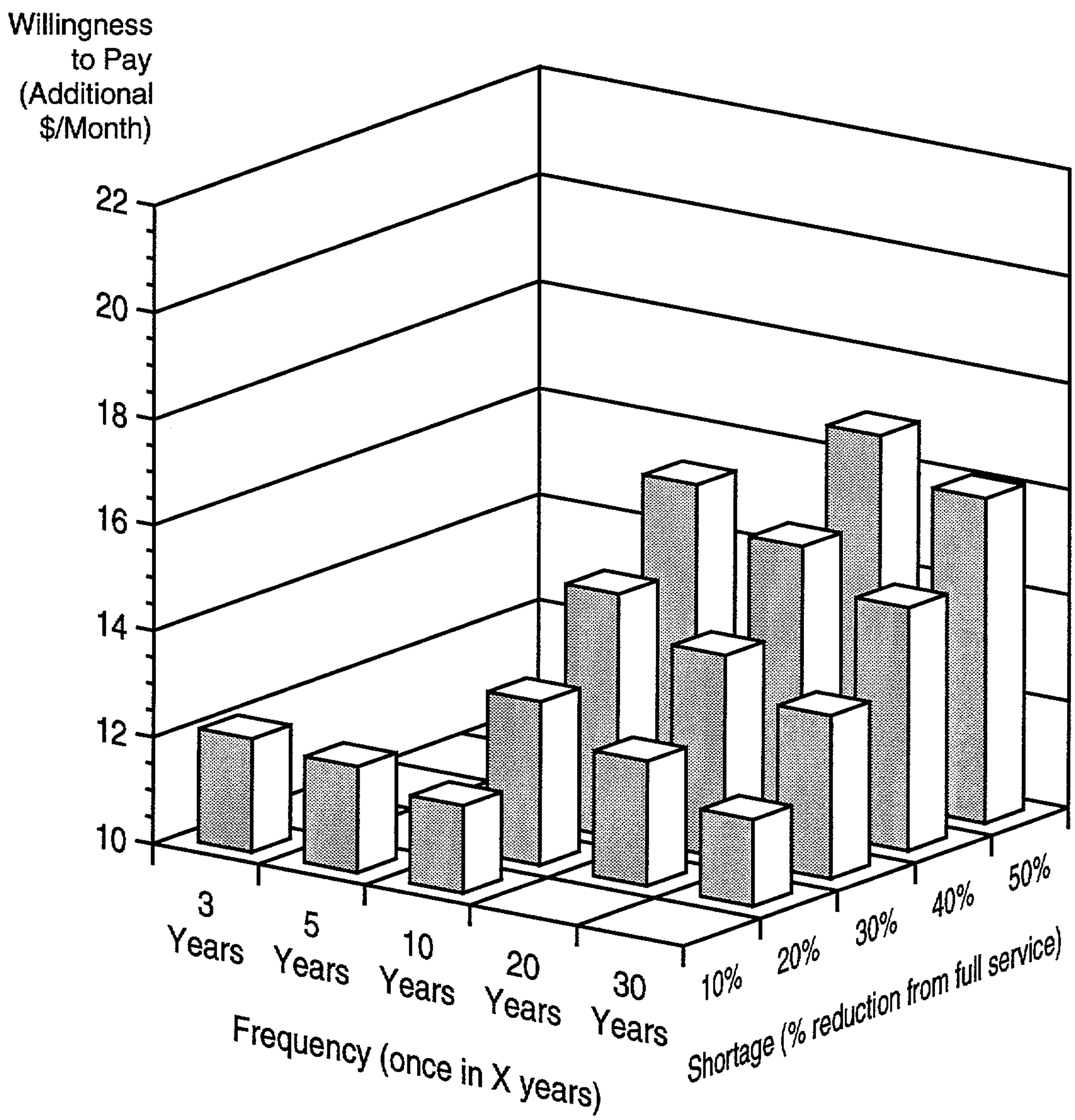
The "loss function" is shown graphically in Figure S-2. In examining the tabular and graphical results, two major conclusions can be drawn:

- As expected, respondents are willing to pay more to avoid larger shortages and for shortages that occur with higher frequency. However, the impact of frequency variations is considerably smaller than the impact of shortage magnitude on consumers' responses.

  Put another way, it appears that residential customers believe that infrequent large shortages impose higher losses than more frequent small shortages. This result is also consistent across all of the individual agencies. This type of conclusion may be important to agencies as they plan supply-side or demand-side resource additions and make system operations decisions.

- To avoid even apparently minor shortage scenarios (e.g., 10% once every 10 years), respondents are willing to pay substantial amounts. This type of "threshold" response is not uncommon in surveys of this type and may indicate that respondents regard even a mild shortage scenario as an inconvenience that they want to avoid. They may make a greater distinction between "shortage" and "no shortage" than between different magnitude or frequencies of shortages. Again, this pattern of responses holds for all participating agencies.

Figure S-2
Mean Monthly Willingness to Pay to Avoid Particular Shortage Frequencies and Magnitudes



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Impact of Key Explanatory Variables on Willingness to Pay

As described previously, the statistical model includes many variables that could potentially explain the variation in willingness to pay. For example, the variable "RATE" was included to determine if the average residential rate charged by the respondent's water agency affected WTP. The impact of this variable was not statistically distinguishable from zero. The following discussion selects three explanatory variables that are statistically significant and illustrates their impact on WTP.

Figures S-3 to S-5 show the variation of WTP at various shortage magnitudes when all other variables, other than the one in question, are held constant.

Landscape Area

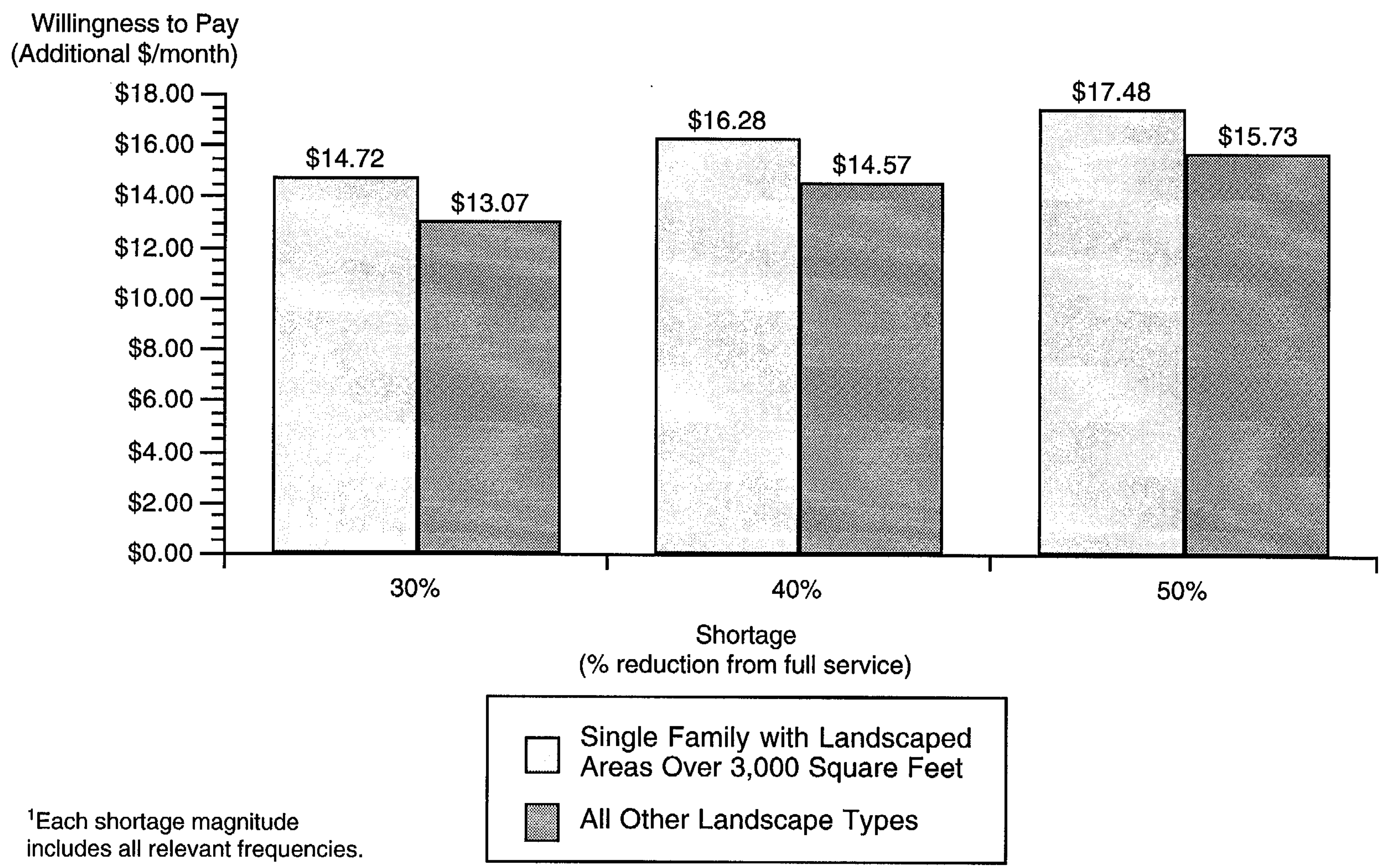
Not unexpectedly, the quantity and type of outdoor landscaping has a statistically significant influence on respondents' willingness to pay to avoid future shortages. Figure S-3 illustrates this by using the variables in the model that capture variations in landscaped area. The results show that respondents who have private lots with landscapes larger than 3,000 square feet have higher WTP than families with other types of landscaping.

Growth Preferences

Another interesting relationship is demonstrated in Figure S-4, which shows the relationship between participant feelings about community growth and their willingness to pay to avoid water shortages. Individuals who indicate a desire for their communities to grow in size have a higher WTP than do people who want their communities to stay the same size or to get smaller. Many in the latter group may perceive a relationship between water resource development and growth and are therefore more likely to prefer enduring more severe and/or frequent water shortages rather than adding to the resource base.

Figure S–3

Effect of Landscape Characteristics on Willingness to Pay[1]



[1]Each shortage magnitude includes all relevant frequencies.

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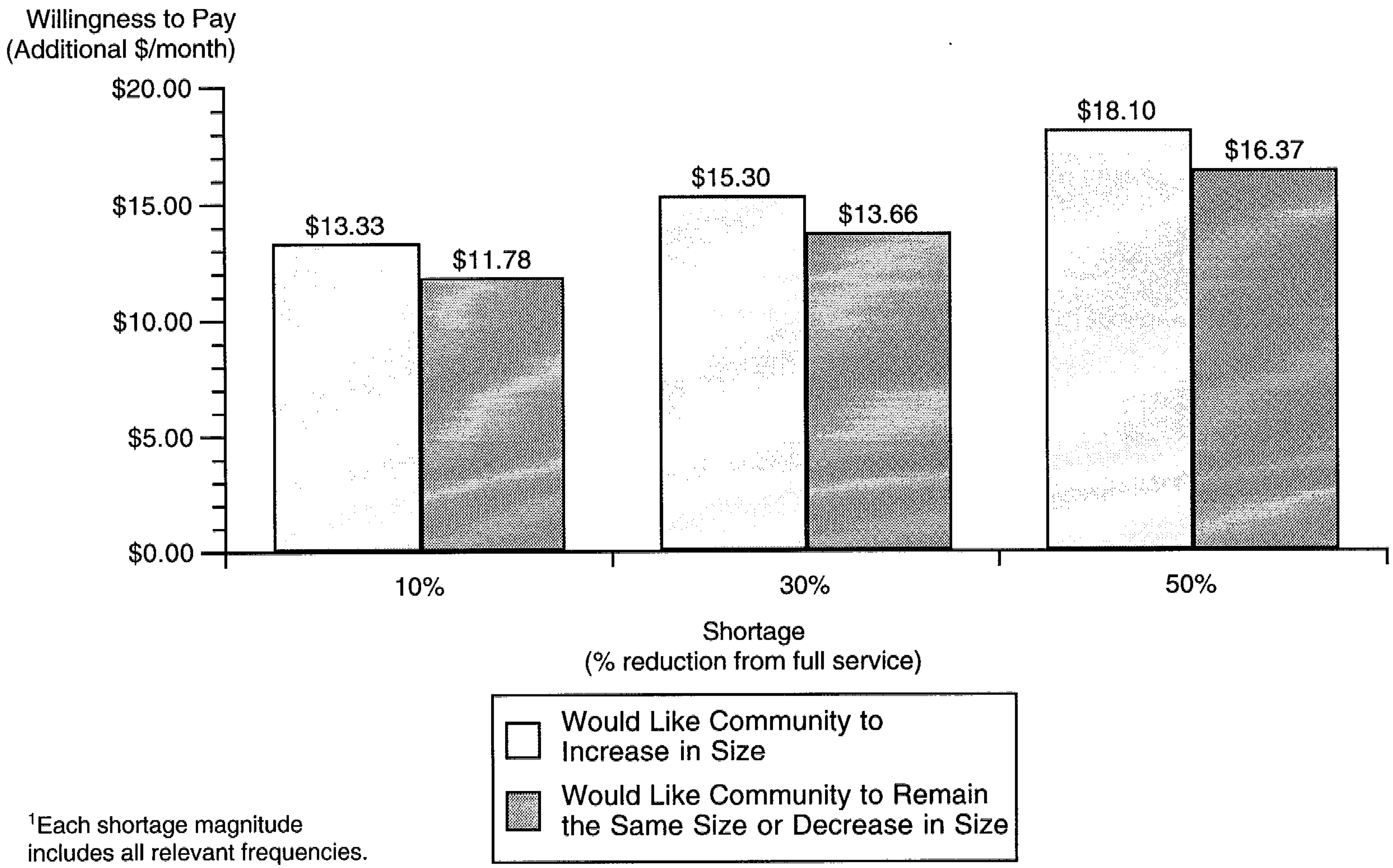
Figure S–4

Effect of Population Growth Preferences on Willingness to Pay[1]



[1]Each shortage magnitude includes all relevant frequencies.

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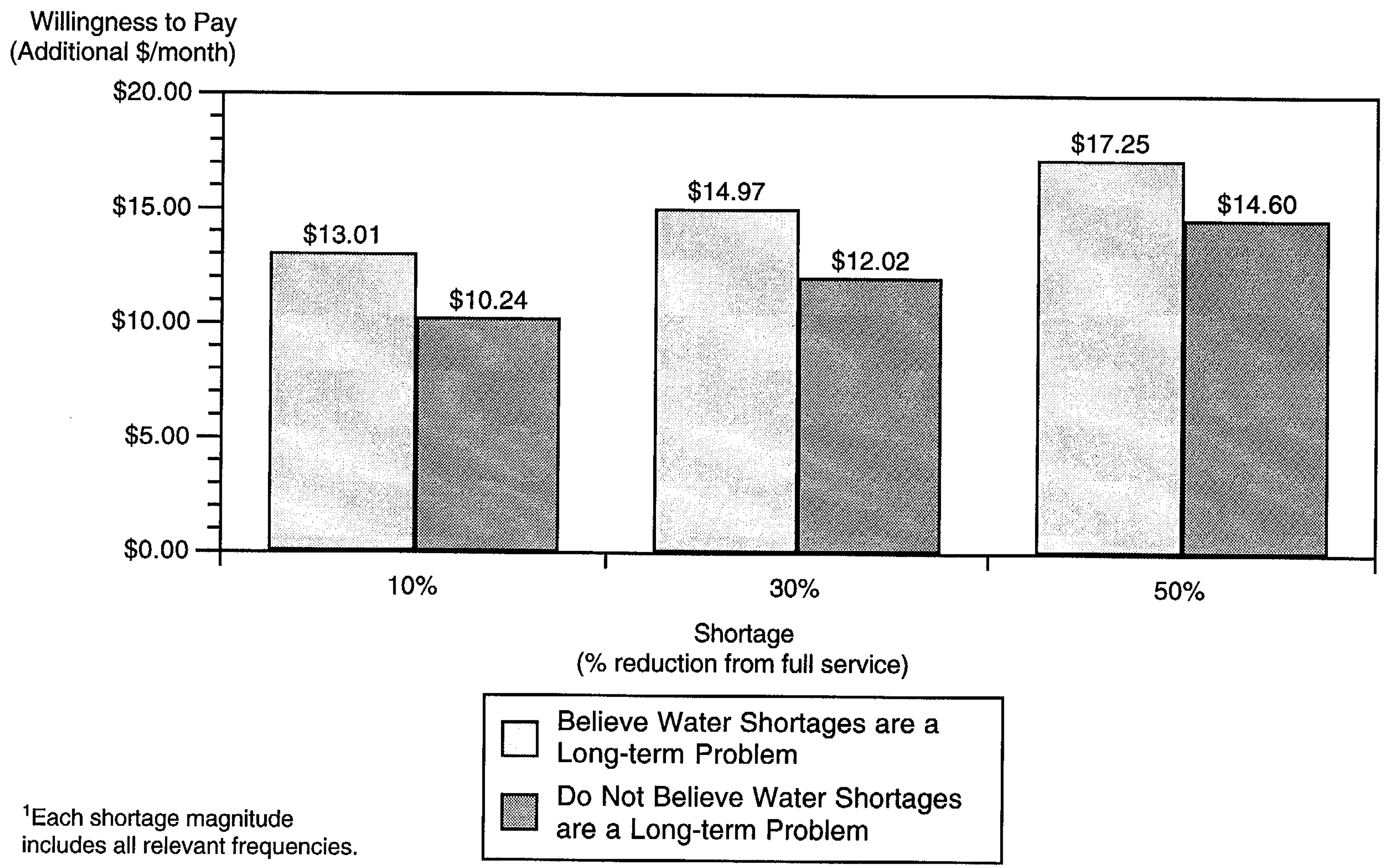
Figure S–5

Effect of Perception of Water Shortages as a Long-term Problem on Willingness to Pay



[1]Each shortage magnitude includes all relevant frequencies.

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Perception of Water Shortages as a Long-Term Problem

Survey respondents were asked to what extent they considered water shortages to be a long-term problem in their area. Those who considered the water shortages to be a long-term problem have higher WTP than those who do not. WTP for these two groups is illustrated in Figure S-5.

Regional Comparisons

An analysis was done to determine whether Northern California respondents had different WTP than Southern California respondents. To isolate the variation that is due to regional differences, a variable NORTH was included in the model. The variable was set equal to 1 if the respondent was in the service area of:

- Alameda County Water District
- Contra Costa Water District
- San Francisco Public Utilities Commission
- Santa Clara Valley Water District

The variable was set to 0 if the respondent was in the service area of:

- Los Angeles Department of Water and Power
- Metropolitan Water District of Southern California
- Municipal Water District of Orange County
- Orange County Water District
- San Diego County Water Authority
- City of San Diego

Although all Southern California mean values are slightly lower than the corresponding Northern California mean values, the variable "North" was not statistically different from zero.

Separate models were then run for the Northern California and Southern California agencies to determine whether, apart from a difference that could be attributed to living in Northern or Southern California, there were demographic and attitudinal differences that were captured in other model variables and that resulted in different estimates of WTP for the two populations. The results, illustrated in Table S-2, indicate no significant differences in WTP.

Table S-2
MEAN MONTHLY WILLINGNESS TO PAY, BY REGION
(Additional $/Month)

Shortage (% Reduction from Full Service)	Frequency (One Occurrence in X Years)	Northern California	Southern California
10%	10	$12.32	$11.13
10%	5	$12.70	$11.50
10%	3	$12.85	$11.64
20%	30	$12.10	$11.19
20%	20	$12.85	$11.93
20%	10	$13.63	$12.68
30%	30	$13.40	$12.75
30%	20	$14.19	$13.52
30%	10	$14.99	$14.32
40%	30	$14.75	$14.38
40%	20	$15.57	$15.20
40%	10	$16.40	$16.02
50%	30	$16.15	$16.09
50%	20	$16.99	$16.93

The confidence interval for the Southern California model is +/- $0.51; the confidence interval for the Northern California model is +/-$0.63. Except at the 10% shortage magnitude, the differences all fall within the overlapping confidence intervals. Given that the confidence interval is underestimated at that level because there are fewer observations, it is likely that the actual confidence intervals overlap at the 10% shortage as well and that there is therefore no statistically significant difference in WTP between Northern and Southern California respondents.

Water Shortages as a Public Concern

In the survey, respondents were asked to rate the importance of various public problems, including water shortages, as "not at all important," "somewhat important," or "very important." There were three reasons for asking this question:

- To analyze the extent to which concern with any given set of issues (e.g., financial issues) affected willingness to pay.

- To test the perceived importance of water shortages relative to other public issues.

- To see how respondents categorized water shortages. With what other issues are water shortages associated?

Overall, the mean response for each issue is illustrated in Table S-3.

Water shortages fall in the middle of the list of concerns.[2]

The factor analysis showed that respondents grouped issues as illustrated in Table S-4. Water shortages fall into the category that includes issues that can best be described as having public service components. The factors are ranked within each category according to the strength of their rating in the factor analysis.

Each of the four factors was included in the model as a binary variable to test its explanatory impact on WTP.[3] Each of these variables was assigned the value of 1 if the mean value of all of a respondent's ratings for the issues included in that factor exceeded the value assigned to the water shortage issue, and zero otherwise. For the combined CUWA results, the social concerns, quality of life, and financial factors are statistically significant in explaining WTP. Respondents who placed any of those concerns above their concern for water shortages had lower WTP.

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[2]It is possible that had this survey been conducted a year earlier, when the state was still in the grip of a serious drought, water shortages would have been viewed as much more of a concern.

[3]The "public services/environmental" factor included in the model excluded the water shortages variable.

Table S-3
ISSUE RANKING AND MEAN RESPONSE

Issue	Mean Rating	Standard Error
Economy	2.66	.0095
Drug abuse	2.38	.0126
Education	2.35	.0136
Housing costs	2.32	.0122
Taxes	2.31	.0123
Traffic	2.29	.0122
Crime	2.26	.0122
Drinking water quality	2.18	.0138
Water shortages	**2.17**	**.0129**
Air pollution	2.08	.0124
Homelessness	1.98	.0130
Overcrowding	1.92	.0129
Trash disposal	1.88	.0138
Racial issues	1.73	.0126

Table S-4
FACTOR ANALYSIS OF PUBLIC ISSUES

Public Services Concerns	Social Concerns	Quality of Life Concerns	Financial Concerns
Trash disposal	Crime	Overcrowding	Taxes
Education	Racial issues	Traffic	Economy
Water shortages	Drug abuse	Air pollution	
Homelessness			
Drinking water quality			

SUMMARY OF KEY CONCLUSIONS

The important conclusions that can be drawn from the analysis are as follows:

- Monthly willingness to pay higher residential water bills to avoid shortages ranged from $11.60 to $16.90. Individual agency results, while exhibiting some variation, are generally consistent with this range.

- As expected, respondents' willingness to pay increases with increasing magnitude and frequency of shortages.

- To avoid even apparently minor shortage scenarios (e.g. 10% once every 10 years), respondents are willing to pay substantial amounts. This type of "threshold" may indicate that respondents regard even a mild shortage scenario as an inconvenience that they want to avoid. They may make a greater distinction between "shortage" and "no shortage" than between different sizes or frequencies of shortages.

- Shortage frequency is not as important a determinant of willingness to pay as shortage magnitude. Residential customers appear to be more willing to tolerate frequent small shortages than infrequent large ones.

- There are no significant differences in willingness to pay between Northern California and Southern California respondents.

- The simplified model has virtually the same predictive power as the detailed model. Participating agencies who wish to replicate this type of analysis in the future can therefore use the simplified model rather than resurveying their customers to gather data on the remaining variables required for the detailed model.

VALUING WATER SUPPLY RELIABILITY

RONALD C. GRIFFIN AND JAMES W. MJELDE

Instead of creating water supply systems that fully insulate mankind from climate-imposed water deficiencies, it is possible that for municipal water systems a nonzero probability of water supply shortfall is efficient. Perfect water supply reliability, meaning no chance of future shortfall, is not optimal when water development costs are high. Designing an efficient strategy requires an assessment of consumer preferences pertaining to the reliability of water supply. Contingent valuations of both current and future shortfalls are reported. The consistency of these measures is gauged using an expected utility model.

Key words: reliability, water demand, water policy.

An important dimension of the water scarcity problem is the management of water supply risk, especially as it relates to drought. The traditional management practice for controlling urban water supply risk has been one of avoidance, that is, to develop a sufficiently large water supply that the probability of any tangible shortfall is very small. In light of the high and growing costs of water development, it may be sensible to revise the water planning paradigm, so that periodic shortfalls are regarded as acceptable, even planned, events.

In the municipal water use sector, there is an innate tendency to size the water supply system for severe droughts of low probability (Howe and Smith). Water is usually supplied by an entity that faces no competition and has the legal ability to pass all reasonable costs to consumers. Moreover, water supply systems are operated by people whose performance is gauged by their ability to deliver a dependable, steady, and problem-free water supply. They are not judged by their ability to deliver water that has value in excess of its costs. Consequently, the reliability[1] of water systems may be too high, water supplies dedicated to municipal use may be too great, and infrastructure costs may be too large.

Given that available water is physically limited in many regions, when municipalities increase water system reliability, they are shifting risk to nonmunicipal sectors. Obviously, some water users must incur the shortfall during drought situations. Traditionally, risk has been progressively shifted to the riparian and estuary habitat systems. These natural resource systems have become the residual claimants, possessing only what is left after man has diverted water to satisfy his wants. Recently, public policy emphasis on streamflow protection has begun to reverse this tradition (MacDonnell and Rice). One result may be the redistribution of water supply risk back toward municipalities, thereby increasing the importance of risk-attentive water supply planning.

Three dimensions of reliability analysis are addressed here. First, policy options and consumer behavior relevant to water system reliability are discussed. Second, the theory of optimizing water system reliability is briefly restated and refined. This basic theory outlines a method for optimizing reliability and identifies informational needs. Finally and primarily, contingent valuation analyses of modified reliability are presented.

Reliability Policy and Consumer Behavior

To affect water system reliability, managers can (*a*) adjust the long-run supply of water, (*b*) enhance the short-run supply of water during a shortfall event, (*c*) influence the long-run demand for water by consumers, and (*d*) lessen water demand during a shortfall. Rather than being viewed as substitute approaches, the appropriate planning goal is to develop an efficient package of all options.

The authors are professors in the Department of Agricultural Economics at Texas A&M University.

Appreciation is expressed to Mike Bowker for his advice and critiques of our survey instrument and to the Texas Water Development Board for funding support.

[1] The reliability of a water supply system is commonly regarded as inversely related to the probability of a system shortfall (demand > supply).

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On the supply side, both physical and paper components of a water supply can be adjusted. While the physical components are generally well acknowledged, various paper components (such as water rights, storage permits, contracts with other water suppliers, and dry-year options) represent an increasingly important dimension of planning tools. Either physical or paper components can be modified to adjust long-run water supply reliability, but these supply-side tools are limited for short-run water supply adjustments. Only rapidly executable leases with water right holders or contracts with other water suppliers are practical short-run tools.

Demand management tools have substantial relevance as both long- and short-term measures. Long-run policy options include regulations (e.g., plumbing codes requiring the installation of water-conserving fixtures), education programs, and water pricing. Short-run demand tools involve contingency policies such as water use regulations (e.g., alternate day watering), prohibitions, and pricing. Because of the relative impracticality of most supply policies during shortfall events, demand-based options have enhanced relevance in the short run.

In response to both long-run and short-run policies, consumers make decisions that are broader than merely how much water to consume. Households choose additions to and replacements of their water-using durables. The major durables of consequence are plumbing fixtures, appliances, pools, sprinklers, and lawn/landscaping. These durables are available in different sizes, models, and properties that influence water use and the ability of consumers to continue using durables during water supply shortfalls. Water use associated with a given durable is largely a fixed multiple of its operating time, so important determinants of household water use become less flexible when the household commits to the purchase/installation of each water-using durable. Long-run demand management policies influence these commitments (Dubin, Wirl).

Lawns and landscape plants are unique with respect to their interrelationship with water supply reliability. Lawns and landscaping are durables established for visual and aesthetic satisfaction. This satisfaction flows to residents continually, rising or falling according to the condition of the lawn/landscape. Long water supply shortfalls can depreciate or extinguish lawns and landscaping, thereby lowering their future net benefits. This implies that there may be instances in which consumers attach high value to avoiding a severe, yet transitory shortfall, because they wish to avoid diminished present and future net benefits.

These simple observations disclose important interrelationships among water supply reliability, the value of reliability, water-using durables, and the value of these durables. When making commitments to specific durables, the consumer is implicitly mindful of water price and supply policy. Consumers likely form expectations of future price and reliability based on recent experience and, perhaps, trends. Once a set of durables is acquired by the household, prospective increases in reliability offer little short-run value because the durable base is fixed. On the other hand, decreased reliability constrains the satisfaction available from the accumulated durable base. Thus, consumers have asymmetric attitudes toward increases and decreases in reliability. The change in value for an increase in reliability can be expected to be less, in absolute value, than the change in value for an equivalently measured reliability fall. This asymmetry is likely to be more pronounced in the short run where, by definition, the durable base is fixed. For this reason, as well as the wealth effect, it should be expected that equivalent surplus exceeds compensating surplus for reliability improvements.

Optimizing Reliability

Although interest in water supply reliability is increasing (Lund), there are few empirical studies of the value households associate with the reliability of their water supply. Using a mailed survey in three Colorado cities, Howe et al. asked open-ended willingness-to-pay (WTP) and willingness-to-accept (WTA) questions about modifications to the frequency of a standard annual shortage event (SASE). They define a SASE to be a supply shortfall sufficient to cause the temporary use of a specific lawn watering restriction. An advantage of this approach is that the SASE offers a very tangible and known situation for the surveyed population.

Barakat & Chamberlin, Inc. report a WTP analysis of increased reliability performed for ten California water utilities. This contingent valuation study uses a combination mail–telephone survey to obtain double-bounded dichotomous choice data. Households are asked if they would pay a specified amount per month to eliminate future shortfalls of a specified strength and frequency. Because the elimination of shortfalls is not a realistic planning scenario, the Barakat & Chamberlin, Inc. findings should be interpreted as upper bounds for consumer valuations pertaining to modified shortfall scenarios.

Howe and Smith et al. present some basic theory outlining the optimal selection of water supply level. A noteworthy observation about their theory, which distinguishes it from leading theory regarding optimal energy supply reliability, is that it sets aside the potential role of price in managing excess demand during shortfall events (Crew and Kleindorfer 1976, 1978, Marino, Meyer). The energy research on optimal reliability addresses the collaborative role of pricing and investment for achieving an optimal policy. The absence of price control in the Howe and Smith et al. theory can be criticized, but water managers remain far more concerned about appropriate concrete and pipe solutions than they are about establishing proper prices. Moreover, for stochastic settings, resource allocation by price may be economically inferior to quantity-based policy such as rationing rules (Weitzman).

A theoretical model offered by Howe and Smith et al. focuses on the concept of SASE. This model posits that the probability of occurrence for the SASE in period t is a decreasing function of supply-side investment I:

$$(1)\quad \text{Prob}\{\text{SASE}_t\} = P_t(I).$$

The objective is to determine a level of investment that minimizes investment costs plus the expected losses caused by the occurrence of the SASE. Let $A(I)$ denote annualized investment costs and let $E[L(P_t)]$ be the expected loss due to excess demand in period t. The expected value of L is an increasing function of $P_t(I)$. The optimization problem is then

$$(2)\quad \min_I [A(I) + E[L(P_t(I))]].$$

This problem yields the first order condition

$$(3)\quad \frac{dA}{dI} = -\frac{dE[L]}{dI}$$

indicating that the marginal cost of investment should equal the negative of the marginal expected losses. Howe and Smith et al. do not optimize I, but they do compare changes in A and in $E[L]$ where the changes are accomplished by sales or purchases of surface water rights.

A deficiency of this theory is its emphasis of a single type of shortage, the SASE (Lund). Nothing is conveyed about the selection of water supply capacity for addressing more moderate or extreme shortage events. Because supply investments alter the frequencies of all degrees of shortage, not just the SASE, this omission is important. To obtain a more broadly applicable theory (also initiated by Howe and Smith et al.), suppose that aggregate water demand D is an increasing function of some short-term climate index which we will call aridity "a." Water supply S is a decreasing function of aridity and an increasing function of investment I. Water price is assumed to be fixed.

When demand exceeds supply for a given aridity level in period t, the loss suffered is $\ell_t(D_t - S_t)$. Otherwise, the loss is zero. The overall loss function can be stated as

$$(4)\quad L_t(I, a_t) = \begin{cases} 0 & \text{if } D_t(a_t) \le S_t(I, a_t) \\ \ell_t(D_t(a_t) - S_t(I, a_t)) & \\ & \text{if } D_t(a_t) > S_t(I, a_t). \end{cases}$$

If f_t is the probability distribution function for the random variable a_t, then expected losses are

$$(5)\quad E[L_t(I, a_t)] = \int_{a_t^0}^{\infty} L_t(I, a_t) f_t(a_t)\, da_t$$

where a_t^0 is the level of aridity for which $D_t(a_t) = S_t(I, a_t)$.

Assuming the social problem is to minimize the sum of investment costs and the expected welfare loss due to water supply shortfall, the following criterion for investment choice is obtained:

$$(6)\quad \min_I \left[I + \sum_t \int_{a_t^0}^{\infty} L_t(I, a_t) f_t(a_t)\, da_t \right].$$

Discounting may be added explicitly to this model or it may be viewed as implicit in the definition of L_t. After differentiating the objective function with respect to I and simplifying, the first order condition becomes

$$(7)\quad 1 = \sum_t \int_{a_t^0}^{\infty} \ell_t'(\cdots) \frac{\partial S_t}{\partial I} f_t(a_t)\, da_t.$$

The left hand side of this condition is the marginal cost of investment. The right hand side is investment's marginal benefit.

This basic theory has four informational requirements that must be met prior to application. First, an aridity index must be constructed for which a probability distribution function can be determined and which can be used as an argument of demand and supply functions. Second and third, $D(a)$ and $S(I, a)$ are needed. Finally, the function giving the value of loss due to shortfall, $\ell_t(D_t - S_t)$, must be obtained. The latter requirement is the focus of the research reported here.

Survey Design and Procedures

Two lines of inquiry are pursued here using contingent valuation methods. First, the value of current water supply shortfalls—existing shortages of known strength and duration—is addressed. Second, an inquiry into the value of future shortfalls is presented. The latter are probabilistic shortages of differing frequency, strength, and duration.

A questionnaire was mailed to 4,856 households in seven Texas cities.[2] For two of the seven surveyed cities, there were a priori indications of experience with water supply shortfalls. There may be some bias in reliability valuation if assessments are sought solely from shortfall-inexperienced households. Experienced households may attach lower values to reliability for three general reasons. First, inexperience with water supply shortfalls may support an artificially high, physiological objection to an unfamiliar event. Once this unknown is removed, the consumer may have a "that wasn't so bad" reaction. Second, the learning of new water use behaviors is likely to be pronounced during shortfalls. As the consumer becomes more proficient with coping strategies, the value of shortfall-created inconveniences may decline. Third, as discussed previously, if households are accustomed to a highly dependable water supply, they are more likely to have assembled a water-intensive set of water-using durables.

Each questionnaire includes two contingent valuation questions. Paired with each of these questions is a question designed to ferret out protest responses. The first contingent valuation question is a closed-ended WTP question concerning a hypothetical current shortfall. This question establishes an "immediate and known" water supply shortfall of $X\%$ of the community's water demand expected to have a duration of Y summer days. The respondent is then asked if he/she would pay a one-time fee of $\$Z$ to be exempt from the outdoor water use restrictions the city would impose during this shortfall. Thirty-six different X-Y-Z combinations are used, and a logit model is fitted with the resulting data.

The second contingent valuation question is an open-ended WTP or WTA question concerning a hypothetical increase or decrease in future water supply reliability. This question poses an initial situation in which approximately once every U years a shortfall of $V\%$ would occur with a duration of W days. The question then poses a potential improvement or decline in one of the U or V parameters with the other being unchanged. Shortfall duration W varies among questionnaires, but it is constant in a given questionnaire. In the case of reliability improvements, the respondent is asked for a maximum WTP where this amount is expressed as a permanent increase in monthly water bills. In the case of reliability declines, the respondent is asked for a similarly expressed minimum WTA. Thirty-six distinct before and after regimes (U-V-W combinations) are used. Thus, there are thirty-six WTP questions and, by reversing the before and after components, thirty-six WTA questions. Each survey contains only one of these seventy-two variants. Respondents therefore answer either a WTP or WTA question concerning future shortfalls, but not both. Resulting data are used to estimate two tobit models, one for WTP and one for WTA.

Because there are thirty-six different constructions for the current shortfall question and seventy-two different constructions for the future shortfall questions, each of the current shortfall question variants are employed with two of the future shortfall question's scenarios. These assignments were made randomly.

The future shortfall question is more definitive in that it incorporates frequency information regarding prospective supply shortfalls, and it involves both WTP and WTA formats. However, it also presents a more perplexing proposition to respondents,

[2] Each mailing included a preaddressed and postage-paid return envelope. After two weeks, nonrespondents were mailed a reminder postcard. After three to four additional weeks, individualized surveys were again prepared for nonrespondents and were mailed with a new cover letter and a return envelope.

and there is justifiable concern that this question might overwhelm people. In the health risk valuation literature, it has been observed that probabilistic risk information is difficult to communicate to respondents and that many people may have difficulty processing this information (Loomis and duVair, Smith and Desvousges). The survey's current shortfall question poses a simpler, more comprehensible, and less challenging query for surveyed households. Inclusion of two general question styles offers the possibility of checking the consistency of survey results with expected utility theory.

A WTA version of the current shortfall question is not investigated because of the reduced information provided by close-ended questions (thereby necessitating larger datasets to achieve a given level of explanatory power). Moreover, the normative, status quo foundation of the reliability issue is closer to one where consumers do not possess entitlements to particular reliability positions.

Because water supply reliability is an unusual item for individuals to value, it is important to provide households with a solid informational context. Therefore, the individual questionnaire relayed summary information about the household's own water use patterns and bills. Because water supply shortfalls generally occur during summer months, the survey also includes information regarding the cyclical nature of the household's water use. To accomplish this, monthly 1995 information from city utilities was obtained for every household in the survey sample, and these data were used to calculate personalized information provided on each survey. The calculated information could have been electronically merged into the survey instrument prior to printing, but hand writing of this information into surveys was selected to emphasize the customized nature of the entries.[3] On the questionnaire the customized personal information is preceded and followed by additional contextual information regarding the importance and meaning of water supply reliability. The contextual information is replicated in the Appendix of this paper.

[3] The personalized information includes: total 1995 water use (gallons), peak water use month, water use in peak month (gallons), water and wastewater bill for peak month ($), low water use month, water use in low month (gallons), water and wastewater bill for low month ($), total bill for 1995 water use ($), total bill for 1995 wastewater service ($), and average monthly water and wastewater bill ($).

Overall, 30% of the survey recipients had responded prior to remailing of the survey. The overall survey response is 43%. Across the seven cities, the response rate varies from a low of 32% to a high of 45.8%. These percentages include all surveys returned with at least one question answered. Respondent and nonrespondent water use characteristics are similar, and none of the differences in the water use characteristics are statistically significant.

WTP to Avoid a Current Shortfall

A representative sample of the thirty-six editions of the current shortfall WTP question is as follows:

> Suppose that a community in which you live is facing an immediate and known shortfall of 10% that is expected to last for the next 14 *summer* days. This means that water supply is 10% less than demand. To correct this shortfall, the community is planning to restrict outdoor water use until the problem has passed. The Survey Residence can get a one-time exception from these water-use restrictions if you pay a one-time fee of $10.00.

Would you pay this one-time fee for this one-time exemption at the Survey Residence?

☐ Yes ☐ No ☐ Don't Know

Over all thirty-six scenarios, 437 respondents indicated they would be willing to pay the fee, whereas 1,595 indicated they would not be willing to pay the additional fee or did not know. Of these 1,595 respondents, 171 constituted nonprotest bids. Nonprotest bids are defined to be those meeting one of the following criteria: (*a*) any respondent answering yes to this question, or (*b*) any respondent answering no or don't know to the question *and* indicating the fee was too high to justify the payment in the subsequent protest filtering question. More than one-fourth of the 1,595 selected "Don't Know." The large number of protest bids appears to be partly a consequence of the good being valued. Some respondents indicated in hand-written notes something to the effect that "water is a god-given right and should not be valued economically." Such public perspectives often confound water policy research because "access to water is regarded as a moral right, and discriminating among claimants to water on the basis of wealth or position is in many places regarded as immoral" (Martin et al., p. 28).

Current Shortfall Model

Because of the structure of the current shortfall question, the following logistic model is estimated using maximum likelihood techniques:

$$(8)\quad F[\beta'\mathbf{x}] = \frac{e^{\beta'\mathbf{x}}}{1 + e^{\beta'\mathbf{x}}}$$

where $F[\beta'\mathbf{x}]$ is the cumulative density function associated with the logistic function, $\mathbf{x}$ is a matrix of explanatory variables, and β is a vector of associated coefficients to be estimated (Judge et al., p. 591). Explanatory variables are:

- rain — mean annual rainfall by city (National Climatic Data Center),
- summer — mean July plus August rainfall divided by the mean annual rainfall for each city,
- price — respondent's total annual water bill divided by total water use,
- fee — fee the respondent must pay to avoid the water use restrictions,
- shortfall — percent shortfall the respondent's community is facing,
- duration — number of days the shortfall will last,
- income — income level of the respondent (five categorical levels correspond to the categories on the survey; the first level is dropped to avoid a singular matrix),
- activities — respondent's preferences toward water use activities[4] (this variable is the sum of a linear index of the importance attached by the respondent to lawn and landscaping, fruit and vegetable gardening, and car washing),
- people — total number of people living at the residence,
- rent — 0/1 dummy variable with a 1 indicating the respondent rents the survey residence from another person or business,
- live — 0/1 dummy variable with a 1 indicating the respondent lives at the survey residence, and
- experience — 0/1 dummy variable with a 1 indicating the respondent has experienced water use restrictions in the past five years.

Surveys from all cities are combined into a single dataset for estimation purposes. City-by-city examinations of the data are available in an expanded report (Griffin and Mjelde). Estimation of the logit model with dummy variables for each city indicated no statistical differences in the probabilities of paying the fee between respondents in different cities. Further, simple correlation coefficients and auxiliary regression equations indicate multicollinearity is not a problem in the dataset.

Estimated coefficients for the logit model are presented in table 1. A chi-squared value of 161 is obtained for the statistical test that

Table 1. Current Shortfall Value Logit Model Coefficients, 508 Observations

Variable	Estimated Coefficient	Standard Error	p-value
Intercept	−2.12	2.36	0.37
Summer	5.99	7.34	0.41
Rain	0.0325	0.0382	0.39
Price	−0.132	0.0594	0.03
Fee	−0.104	0.0135	< 0.01
Shortfall	0.0221	0.0168	0.19
Duration	0.0358	0.0237	0.13
Inc2	0.997	0.325	< 0.01
Inc3	1.81	0.347	< 0.01
Inc4	1.80	0.443	< 0.01
Inc5	2.80	0.567	< 0.01
Activities	0.0126	0.0494	0.80
People	−0.0626	0.0679	0.36
Rent	0.201	0.408	0.62
Live	1.07	0.729	0.14
Experience	0.255	0.323	0.43

[4] Instead of asking respondents for an inventory of their water-using durables, they were asked to select one of five levels of "importance" for each of three water activity categories. This preference-based approach avoids the impracticality of obtaining water consumption features of individual durables (e.g., area, condition, species of grass lawns), but it does not enable a testing of the role of durables in determining reliability values.

all coefficients are equal to zero. For this level, the null hypothesis is rejected at a p-value < 0.01, indicating the variables help to explain the probability of choosing to pay the fee to avoid water use restrictions. As the fee increases, respondents are less likely to pay to avoid the restrictions. Respondents are more likely to pay to avoid the restrictions as the duration and/or strength increases. All three coefficients associated with these variables are significant at p-values of 0.20 or less with fee being significant at the 0.01 level. As the respondent's average water price increases, the respondent is less likely to pay to avoid the restrictions. The coefficient associated with water price is significant at the 0.03 level.

Of the variables associated with the respondent's individual characteristics, income is highly significant with respondents in higher income categories generally more likely to pay the fee than respondents with lower incomes. The one exception to this observation is that the fourth income category's estimated coefficient is slightly less than the third income category's coefficient. Respondents who live at the survey residences are more likely to pay the fee than respondent landlords who do not live at the residence. The remaining variables are insignificant at the 0.20 level of significance.

Current Shortfall Valuation

The typical approach to obtaining valuations from such models is to determine the fee amount corresponding to a Prob[Yes] = 0.5, that is, the fee level that the average respondent would find agreeable (Hanemann). Here, this fee level is the value the average household is willing to pay to avoid a current shortfall. Using mean levels of exogenous variables, a low income household would be willing to pay a one-time fee of $17.19 to avoid a current shortfall, and a high income household would be willing to pay $44.04. If shortfall parameters are varied across the questionnaire scenarios and income is varied across the five groupings, the predicted WTPs range from $12.99 to $48.88.

WTPs to avoid current shortfalls of various strengths and durations are presented in table 2. All other variables, including income class binary variables, are set at their means in the calculation of these values. As indicated earlier, WTP to avoid current water supply shortfalls increases with the anticipated strength and duration of the shortfall. For the average respondent, $29.86 is the avoidance value for a three-week current shortfall of 20%. Changes in shortfall parameters affect this value as follows. A one-week increase (decrease) in shortfall duration increases (decreases) this value by $2.41. Every 10% increase (decrease) in shortfall strength increases (decreases) this value by $2.12.

Table 2. Current Shortfall Values (WTP)

		Shortfall Duration		
		14 days	21 days	28 days
	10%	$25.34	$27.75	$30.15
Shortfall	20%	$27.46	$29.86	$32.27
strength	30%	$29.58	$31.98	$34.39

WTP/WTA to Modify Future Reliability

An example of the thirty-six future shortfall WTP questions is as follows:

Current: For your community, suppose that water demand will exceed supply once every 10 years. This shortfall will have an average length of 14 days. Typically, water restrictions will be used in the years of shortfall to decrease demand 20% as needed to manage this shortfall.
Future: Suppose that your community is considering an expansion of its water supply system to improve reliability. Subsequently, water demand will exceed supply once every 15 years. This shortfall will have an average length of 14 days. Typically, water restrictions will be used in times of shortfall to decrease demand 20% as needed to manage this shortfall.

To Summarize:	*Current*	*Future*	
Shortfall Frequency is once every	*10*	*15*	years.
Shortfall Length will average	*14*	*14*	days.
Shortfall Amount is	*20*	*20*	% of the city's demand.

Please consider the next questions carefully.

What is the largest increase in your average water bill of $ __ per month that you would be willing to pay each and every month to obtain this reliability improvement at the Survey Residence?

$__ per month

The first blank was precompleted with the respondent's average monthly water bill, so the respondent only needed to state WTP. Bids of \$0 for this question may be protests. A nonprotest \$0 bid is defined here as one in which the respondent either (*a*) checked "the reliability improvement wouldn't help me much" in the accompanying protest filter question or (*b*) did not provide any responses to the protest filter.

Households receiving a future shortfall WTA survey encountered a boxed summary nearly identical to that above followed by this question:

> **What reduction in your average water bill of \$___ per month is the minimum you would be willing to accept each and every month in exchange for this reliability reduction at the Survey Residence?**
>
> **\$___ per month**

Nonprotest bids are defined to be those who selected the following response to the paired protest filtering question: "My answer is about right for the added inconvenience."

Future Shortfall Estimation Procedures

Both the WTP and WTA open-ended questions result in a censored sample; that is "... some observations on the dependent variable corresponding to known sets of independent variables are not observed" (Judge et al., p. 609). In the WTP and WTA samples, the observable range of WTP and WTA range from zero to the highest bid. In such cases, ordinary least squares estimators are biased and inconsistent (Judge et al., p. 615). Consequently, tobit analysis is used here.

The underlying tobit model for this study is

$$(9)\quad y_i^* = \beta'\mathbf{x}_i + \varepsilon_i$$

where $\mathbf{x}_i$ are the independent variables for observation i, y_i is the dependent variable, β's are coefficients to be estimated, and ε_i is an error term. Also, $\varepsilon_i \sim N[0, \sigma^2]$; if $y_i^* \leq 0$, then $y_i = 0$; and if $y_i^* > 0$, then, $y_i = \beta'\mathbf{x}_i + \varepsilon_i$. This model is estimated using maximum likelihood techniques (Greene). Conditional means (prediction) from the tobit model are

$$(10)\quad E[y|\mathbf{x}_i] = \Phi(\hat{\beta}'\mathbf{x}_i/\hat{\sigma})\hat{\beta}'\mathbf{x}_i + \hat{\sigma}\phi(\hat{\beta}'\mathbf{x}_i/\hat{\sigma})$$

where Φ represents the cumulative standard normal distribution function, ϕ represents the standard normal density function, $\hat{\sigma}$ is the estimated standard error for the error term, and $\hat{\beta}$ is the vector of estimated coefficients.

Independent variables used in the estimation procedure for both the WTP and WTA models are the same. These variables are defined equivalently to those used in the current shortfall logit model previously presented with the exception of new variables defining water reliability. The two new variables are:

- severity — the initial severity of the water shortfall, defined as probability of shortfall occurring in any given year times shortfall strength, and
- shortype — a binary variable which equals zero if the proposed change affects the probability of a shortfall occurring and equals one if the proposed change affects shortfall strength.

By design, the number of usable responses for the WTP and WTA questions will be less than the value of current shortfall question. Four hundred and sixty-six usable observations are available for estimation of the WTP model, whereas 240 observations are usable from the WTA surveys. The difference between WTP and WTA usable responses may pertain to two factors. First, water is better understood as a good for which one pays rather than as a good for which one might receive a payment. The unfamiliar WTA perspective may have caused some confusion. Second, the wording of the WTA question is more confusing than the WTP question. A large number of respondents checked "I don't understand the question" in the protest filter.

Of the 466 usable responses in the WTP data set, 21.4% (100/466) of the respondents indicated a monthly WTP equal to zero. Using dollar intervals of 0.01–1, 1–5, 5–10, 10–15, and 15 +, the percent of responses in each interval are 1.7%, 22.1%, 21.7%, 17.8%, and 15.2%. The WTA sample is less censored, with only 5.4% (13/240) of the respondents indicating a WTA equal to zero. Also, 0%, 12.9%, 25.4%, 23.8%, and 32.5% of the respondents lie in the dollar intervals 0.01–1, 1–5, 5–10, 10–15, and 15+.

WTP for Reliability Enhancements

Presented in table 3 are the estimated coefficients and statistics for the WTP model.

Table 3. Future Shortfall Value Tobit Model Coefficients

	WTP Model 466 Observations		WTA Model 240 Observations	
Variable	Estimated Coefficient	p-value	Estimated Coefficient	p-value
Intercept	47.8	0.00	27.3	0.08
Summer	−42.5	0.32	5.97	0.90
Rain	−0.751	< 0.01	−0.643	0.01
Price	−0.113	0.78	−1.09	0.09
Severity	−0.527	0.23	−0.178	0.83
Shortype	0.618	0.67	2.18	0.13
Duration	−0.0711	0.57	0.0222	0.86
Inc2	5.03	0.01	−2.50	0.22
Inc3	3.70	0.10	−4.79	0.02
Inc4	4.17	0.11	−2.76	0.34
Inc5	8.45	< 0.01	0.207	0.94
People	1.22	0.05	0.716	0.19
Activities	−0.104	0.73	0.946	< 0.01
Rent	2.23	0.37	−0.684	0.78
Live	−8.28	0.03	3.08	0.49
Experience	−6.18	< 0.01	−0.882	0.65
σ	14.7		10.8	

The Wald chi-squared test that all coefficients are jointly significantly different from zero is rejected at a p-value below 0.01. The water reliability variables are all insignificant at p-values less than 0.23. Insignificance of the severity variable suggests that consumer valuations are unaffected by dimensions of the initially posed shortfall. The insignificance of the shortype variable indicates respondents did not value improvements in shortfall frequency or shortfall strength differently. These results corroborate the "threshold" nature of valuations suggested by Barakat & Chamberlin, Inc.:

> ...respondents regard even a mild shortage scenario as an inconvenience that they want to avoid. They may make a greater distinction between "shortage" and "no shortage" than between different sizes or frequencies of shortages (p. 15).

Individual income levels are significant at p-values of 0.11 or less. Respondents in income categories two through five (inc2–inc5) are willing to pay more for reliability increases than respondents in income category one (inc1—the base which is omitted from the model). Rain is significant at the 0.01 level with respondents in cities with higher rainfall willing to pay less than respondents in drier cities.

In contrast to the value of a current shortfall, individual characteristics appear to help explain WTP bid levels. Live, experience, and people are highly significant. As the number of people living at a residence increases, the respondent is willing to pay more for the reliability enhancement. Respondents who have experienced water shortfalls in the last five years are on average willing to pay less for the reliability increase than those who have not experienced a shortfall. The signs associated with the live variable are different than prior expectations. It was expected that respondents who do not live at the survey residence would be willing to pay less than respondents who do. One possible explanation for this discrepancy is that the variables are not picking up the desired impact. By far the majority of respondents live at and own the survey residence. In the usable dataset only sixteen observations fall into the "don't live at the residence" category; mean WTP for these sixteen is $14.56, whereas the mean WTP for the remaining observations is $8.25. Remaining variables are insignificant at p-values below 0.20.

WTA for Reliability Declines

Also presented in table 3 are the estimated coefficients and standard errors from the WTA estimation. The Wald chi-squared test that all coefficients are jointly equal to zero is rejected. The magnitudes, signs, and significance of the estimated coefficients differ between the WTA and WTP models. As in the WTP model, rain's impact is negative and significant at the 0.01 level. Summer and rent are insignificant in both the WTP and WTA models. In contrast to the WTP model, both water price and water activities are significant in the WTA model. The signs and significance of the income categories change, weakening results relative to the WTP model. Similarly, variables for experience and live are insignificant in the WTA model.

As with the WTP model, the coefficients associated with initial severity and duration are insignificant. The coefficient associated with shortype is, however, significant at a p-value of 0.13. The coefficient implies that mean WTA is approximately $2.00 higher for an increase in shortfall strength than an increase in shortfall frequency.

Future Shortfall Valuations

WTP and WTA measures can be obtained as means from survey responses, or they can be calculated as means of the in-sample predicted values from the tobit models using the conditional means equation presented earlier. Both methods are employed here. Presented in table 4 are summary statistics associated with the monthly WTP and WTA measures. Mean data WTP is $8.47, whereas the predicted WTP is $9.76. These WTP measures constitute 22.2% and 25.6% of the respondents' mean monthly water bills. These values compare with means of $11.63 to $16.92 (depending on initial shortfall frequency) reported by Barakat & Chamberlin, Inc. for the complete elimination of future Californian shortfalls. Consistent with earlier discussion regarding consumer behavior, both the predicted and data mean WTA are larger than the WTP mean values. Mean WTA is $12.66 and $13.20 for the raw data and predicted values, respectively. These mean WTAs are 32.4% and 33.8% of mean monthly water bills.

Consistency of Results

A useful inquiry pertains to whether obtained future shortfall valuations are consistent with the current shortfall valuations reported earlier. That is, are consumer valuations of modified shortfall probabilities compatible with the values they assign to avoiding current shortfalls?

The future shortfall WTP question asks respondents to state a payment p to accompany a lowered shortfall frequency such that the new state would be viewed indifferently to the initial state. Adopting the expected utility model, this means that initial expected utility must equal subsequent expected utility. Therefore,

$$(11) \quad b \cdot U(y-v) + (1-b) \cdot U(y) = c \cdot U(y-v-p) + (1-c) \cdot U(y-p)$$

where b is initial shortfall probability, c is subsequent shortfall probability, $U()$ is the utility function, y is income, and v is the value of a known (current) shortfall. This equality implicitly relates future shortfall value p to current shortfall value v.

The utility function is assumed to be locally given by the constant absolute risk aversion form $U(w) = n - me^{-rw}$, where n, m, and r are constant preference parameters. With this assumption, an explicit function can be obtained for p:

$$(12) \quad p = \frac{1}{r} \ln \left[\frac{be^{rv} + 1 - b}{ce^{rv} + 1 - c} \right]$$

where r is the Arrow–Pratt risk aversion coefficient. For demonstrative purposes, we employ two coefficients, $r = 0.01$ and $r = 0.05$. Both of these values lie at the high end

Table 4. Summary Statistics on Willingness-to-Pay and Willingness-to-Accept Using Individual Observations ($/Month).

	Data				Predicted			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
WTP	8.47	12.90	0.00	100.00	9.76	2.90	2.77	28.41
WTA	12.66	11.12	0.00	60.00	13.20	3.53	2.20	24.19

of empirically estimated ranges—indicative of a high degree of risk aversion (Raskin and Cochran). For before and after shortfall probabilities, we use the two scenarios posed in the WTP versions of the survey: $\langle b = 1/10, c = 1/5\rangle$ and $\langle b = 1/5, c = 1/10\rangle$.

Table 5 contains the results of calculating future shortfall values based on current shortfall values and the above methodology. For example, a household willing to pay \$30 to avoid a current shortfall and having a risk aversion coefficient of 0.05 should be willing to pay a one-time fee of \$1.80 to support a project that alters shortfall frequency from 1/10 to 1/15. The same household should be willing to pay \$4.59 for a project that alters shortfall frequency from 1/5 to 1/10. Our respondents provided average indications of being willing to pay larger amounts than these each and every month. Consequently, the future shortfall values reported here appear inconsistent with the reported current shortfall values.

One is inclined to look to the future shortfall valuation work for the source of the discrepancy because (a) the context of the current shortfall valuation offers a firm and well understood platform for respondents, (b) this platform is not confused by the added dimension of frequencies or probabilities, and (c) the resulting logit model performs well. Several potential reasons for the incompatible current and future shortfall valuations can be hypothesized. First, respondents may not have understood the future shortfall query well. Even though only one parameter was altered, we may have parameterized shortfalls beyond common comprehension. Second, using frequency to convey probabilistic information may be a bad idea because of scaling problems. When shortfall frequency is altered from one out of ten years to one out of fifteen, the change in probability is quite minor (0.033). In retrospect, we wonder whether respondents could grasp the smallness of this change. Third, perhaps respondents place some value on the convenience or social fairness of regular payments to achieve high system reliability as opposed to one-time payments to sidestep temporary shortfall policies. These hypotheses may be useful suggestions for the conduct of future research in this arena.

Conclusions

If economists are to contribute policy advice concerning water system reliability, we must establish and refine a guiding theory, understand the behavior and reactions of managers and consumers, and investigate the values associated with probabilistic shortfalls. The research reported here builds upon prior contributions in each of these areas.

The theoretical development offers modest improvements and questions the use of a "standardized shortage event" in theoretical or applied research. Given the range of potential water shortfalls, in terms of probability, strength, and duration, it is important to examine empirical options for obtaining shortfall values as a function of shortfall parameters. Such pursuits promise to be a challenging departure from the valuation of a standardized shortfall.

Whereas prior research has acknowledged the attitudes of water managers toward system shortfall, important features of consumer behavior have not been examined. When consumers are considered, it becomes evident that their accumulated bundles of water-using durables influence their actions as well as the values they assign to shortfalls. There is noteworthy feedback here too. The potential for shortfalls affects the selection of durables

Table 5. Consistent Future Shortfall Values (p).

	Δ Frequency: $b \to c \equiv \frac{1}{10} \to \frac{1}{15}$		Δ Frequency: $b \to c \equiv \frac{1}{5} \to \frac{1}{10}$	
Current Value (v)	$r = 0.01$	$r = 0.05$	$r = 0.01$	$r = 0.05$
\$10	\$0.35	\$0.41	\$1.04	\$1.18
\$20	\$0.72	\$1.00	\$2.14	\$2.74
\$30	\$1.14	\$1.80	\$3.32	\$4.59
\$40	\$1.57	\$2.78	\$4.58	\$6.58
\$50	\$2.05	\$3.87	\$5.91	\$8.48

by consumers. Another crucial observation is that durable fixity in the short run gives rise to asymmetric values for reliability improvements and reliability declines.

When contingent valuation methods are employed to assess consumer losses due to shortfall, the contingent valuation analysis can address either the value of avoiding a current shortfall or the value of changing the character of probabilistically defined future shortfalls. The probabilistic information necessary for future shortfall surveys confounds respondents and reduces data quantity and quality. A demonstrated option is to employ expected utility theory in conjunction with assessments of current shortfalls to calculate implied future shortfall values. This alternative eliminates the need to convey probabilistic information to respondents but requires additional assumptions regarding consumer risk preferences. Moreover, current shortfall values can be directly used to specify the loss function, $l_t(D_t - S_t)$, needed to ascertain optimal water supply. Given these findings, future research should concentrate on refining the value of current shortfalls rather than pursuing contingent valuation of probabilistically specified future shortfalls.

Even in the absence of probabilistically defined contingent valuation scenarios, there are pitfalls for the nonmarket valuation of shortfall losses. Two such pitfalls can be encountered in other arenas, but they are certainly pronounced for water issues. These are the "birthright" perspective and consumers' lack of personal consumption information. With respect to birthright, water is popularly thought of as a public good to which people have some inalienable entitlement. Many see water bills as a tax rather than as an invoice for the on-demand delivery of treated, pressurized tap water. Consequently, there is a strong tendency for respondents to protest proposed WTP scenarios. Overcoming this pitfall appears extremely difficult at this time, but some redress may be achieved through very carefully worded survey prefaces. The analyst's burden is high here.

With respect to the second pitfall, most households are not aware of their actual water use or their water bills. Not only is water a low budget share item for most households, thus failing to motivate much attention, but water bills are lumped into utility bills that may include electricity, natural gas, and solid waste components. This lack of consumer information also raises the burden for survey instruments. Our instrument's inclusion of consumer-specific data is a novel approach worthy of use, and perhaps testing, by future research.

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References

Barakat & Chamberlin, Inc. *The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers*. Sacramento CA: California Urban Water Agencies, 1994.

Crew, M.A., and P.R. Kleindorfer. "Peak Load Pricing with a Diverse Technology." *Bell J. Econ*. 7(Spring 1976):207–31.

——. "Reliability and Public Utility Pricing." *Amer. Econ. Rev*. 68(March 1978):31–40.

Dubin, J.A. *Consumer Durable Choice and the Demand for Electricity*. New York: Elsevier Science Publishing, 1985.

Greene, W.H. *LIMDEP Version 7.0 User's Manual*. Plainview NY: Econometric Software, Inc., 1995.

Griffin, R.C., and J.W. Mjelde. *Valuing and Managing Water Supply Reliability*. Final Research Report for The Texas Water Development Board, Texas A&M University, 1997.

Hanemann, M.W. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Responses." *Amer. J. Agr. Econ*. 66(August 1984):332–41.

Howe, C.W., and M.G. Smith. "Incorporating Public Preferences in Planning Urban Water Supply Reliability." *Water Resour. Res*. **29**(October 1993):3363–69.

Howe, C.W., and M. G. Smith, L. Bennett, C.M. Brendecke, J.E. Flack, R.M. Hamm, R. Mann, L. Rozaklis, and K. Wunderlich. "The Value of Water Supply Reliability in Urban Water Systems." *J. Environ. Econ. and Manage*. 26(January 1994): 19–30.

Judge, G.G., W.E. Griffiths, R.C. Hill, and T.C. Lee. *The Theory and Practice of Econometrics*. New York: John Wiley & Sons, 1980.

Loomis, J.B., and P.H. duVair. "Evaluating the Effect of Alternative Risk Communication Devices on Willingness to Pay: Results from a Dichotomous Choice Contingent Valuation Experiment." *Land Econ*. 69(August 1993): 287–98.

Lund, J.R. "Derived Estimation of Willingness to Pay to Avoid Probabilistic Shortage." *Water Resour. Res.* 31(May 1995):1367–72.

MacDonnell, L.J., and T.A. Rice. *Instream Flow Protection in the West.* Revised ed. Boulder: Natural Resources Law Center, University of Colorado School of Law, 1993.

Marino, A.M. "Peak Load Pricing in a Neoclassical Model with Bounds on Variable Input Utilization." *Bell J. Econ.* 9(Spring 1978):249–59.

Martin, W.E., H.M. Ingram, N.K. Laney, and A.H. Griffin. *Saving Water in a Desert City.* Washington DC: Resources for the Future, 1984.

Meyer, R.A. "Monopoly Pricing and Capacity Choice Under Uncertainty." *Amer. Econ. Rev.* 65(June 1975):326–37.

National Climatic Data Center. *Climatography of the United States, Texas Volume.* Asheville NC: National Climatic Data Center, 1992.

Raskin, R., and M.J. Cochran. "Interpretations and Transformations of Scale for the Pratt-Arrow Absolute Risk Aversion Coefficient: Implications for Generalized Stochastic Dominance." *W. J. Agr. Econ.* 11(December 1986):204–10.

Smith, V.K., and W.H. Desvousges. "An Empirical Analysis of the Economic Value of Risk Changes." *J. Polit. Econ.* 95(February 1987): 89–114.

Weitzman, M.L. "Prices vs. Quantities." *Rev. Econ. Stud.* 41(October 1974):471–91.

Wirl, F. *The Economics of Conservation Programs.* Boston: Kluwer Academic Publishers, 1997.

Appendix: Background Information

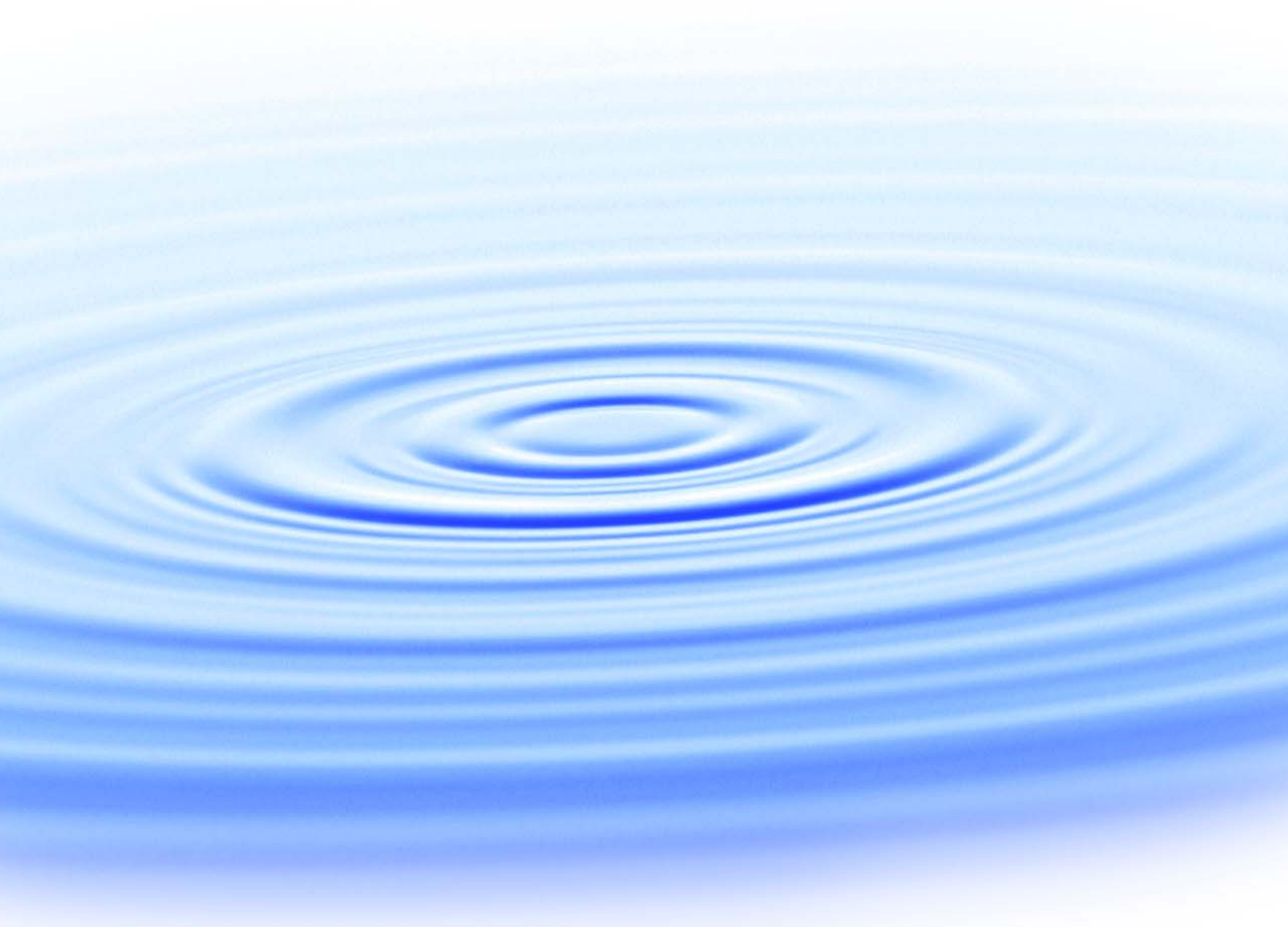
The questionnaire's introduction included contextual information highlighting four key points:

- A temporary water supply shortfall is when water supply is less than water demand. During a temporary water supply shortfall, households usually experience a drop in water pressure, NOT the loss of all water.
- A water pressure drop causes water to flow more slowly through pipes. Sinks and bathtubs take longer to fill. Water-using appliances such as washing machines take longer to operate. Outdoor sprinklers operate more slowly, and the sprinklers will not spray as far.
- Usually, water supply shortfalls occur during the summer months. Average Texas households use 40% less water in December/January than in July/August.
- During a shortfall, your community may employ voluntary or mandatory outdoor water use restrictions (such as restrictions on lawn watering or car washing) to reduce use.

After the customized household data, the questionnaire includes two short paragraphs containing basic details about why shortages tend to occur during the summer and about the important tradeoffs this creates.

> In Texas, water use and water supply change seasonally. Water demand is highest during the summer because of outdoor uses like lawn watering. This is also the season when water supply may be the lowest.
>
> Texas water utilities have traditionally designed their water supply systems to reliably provide peak summertime needs. The full capacity of these systems may be utilized only a few days a year. A portion of water supply systems costs and the rates you pay are therefore for capacity which is used only part of the year. On the other hand, this service capacity also offers Texas communities some insurance against short-term droughts and unexpected water system failures.

The Value of Water Supply Reliability in the Residential Sector



WateReuse Research Foundation

The Value of Water Supply Reliability in the Residential Sector

About the WateReuse Research Foundation

The mission of the WateReuse Research Foundation is to conduct and promote applied research on the reclamation, recycling, reuse, and desalination of water. The Foundation's research advances the science of water reuse and supports communities across the United States and abroad in their efforts to create new sources of high-quality water through reclamation, recycling, reuse, and desalination while protecting public health and the environment.

The Foundation sponsors research on all aspects of water reuse, including emerging chemical contaminants, microbiological agents, treatment technologies, salinity management and desalination, public perception and acceptance, economics, and marketing. The Foundation's research informs the public of the safety of reclaimed water and provides water professionals with the tools and knowledge to meet their commitment of increasing reliability and quality.

The Foundation's funding partners include the Bureau of Reclamation, the California State Water Resources Control Board, the California Energy Commission, and the California Department of Water Resources. Funding is also provided by the Foundation's Subscribers, water and wastewater agencies, and other interested organizations.

The Value of Water Supply Reliability in the Residential Sector

Robert S. Raucher, Janet Clements, Colleen Donovan, David Chapman, and Richard Bishop
Stratus Consulting Inc.

Grace Johns
Hazen and Sawyer

Michael Hanemann
University of California, Berkeley

Sergei Rodkin and Joe Garrett
Knowledge Networks

Cosponsors

Bureau of Reclamation
San Francisco Public Utilities Commission

WateReuse Research Foundation
Alexandria, VA

Disclaimer

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For more information, contact:

WateReuse Research Foundation
1199 North Fairfax Street, Suite 410
Alexandria, VA 22314
703-548-0880
703-548-5085 (fax)
www.WateReuse.org/Foundation

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Contents

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Acronyms

ABM	attribute-based method
ASR	aquifer storage and retrieval
BT	benefits transfer
CII	commercial, industrial, and institutional
CPI	Consumer Price Index
CUWA	California Urban Water Agencies
desal	desalination
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
GWRS	Groundwater Replenishment System
IPR	indirect potable reuse
KN	Knowledge Networks
LBWD	Long Beach Water Department
MWD	Metropolitan Water District of Southern California
NED	National Economic Development
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
OMB	Office of Management and Budget
OUC	Orlando Utilities Commission
RUM	random utility maximization
SASE	standard annual shortage event
SFPUC	San Francisco Public Utilities Commission
SWP	State Water Project
WTA	willingness to accept
WTP	willingness to pay

Foreword

The WateReuse Research Foundation, a nonprofit corporation, sponsors research that advances the science of water reclamation, recycling, reuse, and desalination. The Foundation funds projects that meet the water reuse and desalination research needs of water and wastewater agencies and the public. The goal of the Foundation's research is to ensure that water reuse and desalination projects provide high-quality water, protect public health, and improve the environment.

An Operating Plan guides the Foundation's research program. Under the plan, a research agenda of high-priority topics is maintained. The agenda is developed in cooperation with the water reuse and desalination communities including water professionals, academics, and Foundation subscribers. The Foundation's research focuses on a broad range of water reuse research topics including:

- Defining and addressing emerging contaminants
- Public perceptions of the benefits and risks of water reuse
- Management practices related to indirect potable reuse
- Groundwater recharge and aquifer storage and recovery
- Evaluation and methods for managing salinity and desalination
- Economics and marketing of water reuse

The Operating Plan outlines the role of the Foundation's Research Advisory Committee (RAC), Project Advisory Committees (PACs), and Foundation staff. The RAC sets priorities, recommends projects for funding, and provides advice and recommendations on the Foundation's research agenda and other related efforts. PACs are convened for each project and provide technical review and oversight. The Foundation's RAC and PACs consist of experts in their fields and provide the Foundation with an independent review, which ensures the credibility of the Foundation's research results. The Foundation's Project Managers facilitate the efforts of the RAC and PACs and provide overall management of projects.

This report describes original stated preference survey research, using a choice experiment approach to assess the willingness to pay (WTP) of residential customers for more reliable water supplies in their communities. Residential customers consistently revealed a statistically significant WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions. Households also expressed a clear and strong preference for expanding water recycling as a top option for enhancing water supply reliability.

Richard Nagel
Chair
WateReuse Research Foundation

G. Wade Miller
Executive Director
WateReuse Research Foundation

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Principal Investigator
Robert Raucher, PhD, *Stratus Consulting Inc*.

Project Team
Janet Clements, *Stratus Consulting Inc.*
Colleen Donovan, *Stratus Consulting Inc.*
Eric Horsch*, Stratus Consulting Inc.*
David Chapman, *Stratus Consulting Inc.*
Richard Bishop, *University of Wisconsin (retired), Stratus Consulting Inc.*
Sergei Rodkin and Joe Garrett, *Knowledge Networks*
Grace Johns, *Hazen and Sawyer*
Michael Hanemann, *University of California, Berkeley*

Participating Agencies
Austin Water Utility (TX)
El Paso Water Utilities (TX)
Inland Empire Utilities Agency (CA)
Irvine Ranch Water District (CA)
Long Beach Water Department (CA)
Las Vegas Valley Water District (NV)
Orlando Utilities Commission (FL)
Phoenix Water Services Department (AZ)
San Diego County Water Authority (CA)
San Francisco Public Utilities Commission (CA)

Project Advisory Committee
Jorge Arroyo, *Texas Water Development Board*
Mark Beuhler, *Consultant*
Steve Piper, *Bureau of Reclamation*
Dave Requa, *Dublin San Ramon Services District*

Executive Summary

Water reuse and desalination (desal) offer reliable and locally controlled yields when drought, climate change, or other factors (e.g., court orders curtailing freshwater extraction) limit other water supply options. Utility managers and others recognize that this yield reliability is likely to be highly valued by their communities. However, the absence of suitable customer valuation data has made these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes the implementation of reuse and desal and adds a challenge to securing state, federal, or other funding.

This project addresses this critical gap by developing estimates of the economic value of drought-resistant water yield reliability, such as that associated with reuse and desal projects. For the purposes of this research, we focus on reliability within the context of long-term water supply planning. This primarily includes planning for periodic (drought) events through the development of new supply sources.

The research team developed and implemented state-of-the-art “stated preference” surveys and statistical analyses to develop robust estimates of household willingness to pay (WTP) for water supply reliability. In this context, values for reliability were determined based on household WTP to avoid future water use restrictions (e.g., limitations on outdoor watering). These estimates can be used by water utilities when they evaluate and compare the benefits of future water supply options.

In addition to providing insight into how water utility customers value reliability, the stated preference surveys and subsequent analyses include information on the types of water supply options (including reuse and desal) that customers think their water utilities should pursue in the future to increase supply reliability.

The survey developed in this research effort was applied (with minor modifications to tailor it to local circumstances) to five water utility service areas across the United States: one anonymous North American utility (referred to throughout as “Utility X” or “City X”); Austin, TX; Long Beach, southern CA; Orlando, FL; and San Francisco, northern CA. The surveys were administered in the latter half of 2010 and the first half of 2011. Over 400 completed surveys were collected in each region, for a total sample size of over 2000 households.

Several empirical findings were consistently observed across the utility service areas in which customers were surveyed. Although these findings may not necessarily apply to customers in a specific utility, the consistency of findings across the five regions suggests that the preferences expressed may be consistently held in many geographical areas.

1. Residential customers consistently reveal a positive WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions.

   The estimated WTP to avoid relatively severe (“Stage 2”) water use restrictions was statistically significant in all five regions and ranged from $20.20 per household per year (Orlando) to $37.16 per household per year (San Francisco). These values reflect the WTP by households each year to avoid one year of Stage 2 restrictions at some point over the next 20 years. Given that the scenario evaluated in the survey reduced the projected number of Stage 2 restrictions by up to 3 years, the WTP to avoid all Stage 2 restrictions over the 20-year period ranged from \$60.60 to \$111.48 per household per year. These per household annual WTP values are consistent with the year-adjusted values derived by earlier WTP studies developed in the 1980s and 1990s.

2. Residential customers tend to view low-level ("Stage 1") water use restrictions as an acceptable inconvenience and generally express a low WTP to avoid such water supply shortages.

   The estimated WTP to avoid relatively minor ("Stage 1") water use restrictions was typically quite low and was not statistically significant (in terms of being statistically different from zero) in four of the five regions (San Francisco being the one exception, which produced a statistically significant WTP of \$12.25 per household per year to avoid a future year of Stage 1 restrictions). This suggests that customers generally are willing to accept periodic imposition of low-level Stage 1 restrictions, seeing them as a periodic inconvenience rather than an event necessitating significant financial investment in supply enhancements.

3. Water reuse options, including indirect potable reuse (IPR), received a very high level of customer support.

   In each service area, survey respondents were provided an opportunity to review a list of 9 or 10 water supply enhancement options and to rank their top five preferences. In all five of the surveyed service areas, the option to expand water reuse for outdoor irrigation and industrial use was the choice most frequently selected by customers as one of the top three alternatives. Hence, expanded use of recycled water for nonpotable uses was amongst the most popular choices in each region.

   The use of recycled water to replenish local groundwaters (i.e., IPR) also was considered very favorably in all regions. It was the second most popular option in one region, and was ranked third, fourth, and fifth (out of 10 options) in the other regions.

4. Desal options were moderately supported by customers in the three regions where it was an option under consideration, and ranked above the other options that added "new" water to the local portfolio.

   Ocean desal was ranked fourth among the water supply enhancement options selected as one of the top three choices of survey respondents in San Francisco, and ranked fifth amongst the 10 options offered in Long Beach and Orlando. In each location, ocean desalting ranked behind nonpotable water reuse and the conservation options and, in all but San Francisco, ocean desalting ranked below indirect potable reuse as well. However, although recycling and conservation options were consistently ranked ahead of desal, ocean desalting did rank higher than any of the other supply-adding alternatives in the three applicable locations (e.g., adding desal was consistently preferred over importing more freshwater from outside the region, or transferring water from agriculture).

Chapter 1

Introduction

1.1 Background

The extraction of freshwater from traditional sources such as rivers and aquifers is becoming more difficult because of tightening physical and institutional limits. At the same time, demand for clean water continues to grow. Faced with these issues, more water managers are considering water reuse and/or desalination (desal) options as part of their long-term supply plans. However, these new technologies typically are more expensive than traditional water supply sources, which makes reuse and desal difficult to justify to governing boards, customers, economic regulators, and potential funding agencies.

Although reuse and desal may appear relatively expensive, they do provide a range of important benefits not generated by most traditional supply options. Both desal and reuse offer reliable and locally controlled yields when drought, climate change, or other factors (e.g., court orders curtailing freshwater extraction) limit other options. Utility managers and others recognize that this yield reliability is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes the implementation of reuse and desal and poses a challenge to securing state and federal funding.

1.2 Objectives and Approach

This project addresses this critical gap by developing estimates of the economic value of drought-resistant water yield reliability, such as that associated with reuse and desal projects. To meet this objective, Stratus Consulting developed and implemented state-of-the-art “stated preference” surveys and statistical analyses in order to provide useful and robust estimates of household willingness to pay (WTP) for water supply reliability. In this context, values for reliability were determined based on household WTP to avoid future water use restrictions (e.g., limitations on outdoor watering). These estimates can be used by water utilities to evaluate and compare the benefits of future water supply options.

In addition to providing insight into how water utility customers value reliability, the stated preference surveys and subsequent analyses include information and data on the types of water supply options (including reuse and desal) that customers think their water utilities should pursue in the future to increase supply reliability.

The survey developed as part of this research effort was applied (with minor modifications to tailor it to local circumstances) to five water utility service areas across the United States. The five study sites included Austin, TX; Long Beach, CA; Orlando, FL; San Francisco, CA; and one other North American utility that preferred to remain anonymous (referred to throughout as “Utility X” or “City X”). The surveys were administered in the latter half of 2010 and the former half of 2011.

To ensure that all relevant issues were addressed, including the most recent advances in survey methodology and WTP analysis, and specific water-supply-related issues within each of the five utility service areas, our general methodology was as follows:

- Review the literature and knowledge on reliability measures and values
- Exchange information with participating utilities and other relevant entities to help shape the research (and surveys) so that it would be directly relevant and applicable to practical utility contexts
- Develop initial survey questions and designs using a stated preference choice set (conjoint analysis) approach to derive estimates of household WTP for supply reliability
- Conduct focus groups with customers of participating utilities and meet with participating water utilities to help design and refine the survey instrument to ensure that respondents will properly understand it
- Administer the final survey to water agency customers within the five water utility service areas (with an average of 423 completed surveys within a service area)
- Conduct statistical analyses of the survey data to generate useful and technically robust interpretations of WTP for added water supply reliability for residential customers and evaluate water supply preferences across the five service areas

1.3 Report Organization

The remainder of this report is organized as follows:

- Chapter 2 provides a background discussion of what supply reliability entails and describes approaches to estimating reliability values. Also included is a review of the literature on efforts to develop empirical estimates of household WTP for supply reliability.
- Chapter 3 describes the methods deployed in this research effort to develop empirical estimates of the value of water supply reliability to members of the residential sector (i.e., households served by water supply agencies). This chapter describes the development of the stated preference surveys deployed in this study.
- Chapter 4 summarizes the empirical findings derived from this research effort. Estimates of household WTP for increased supply reliability are described. In addition, the preferences expressed by the surveyed public for different water supply enhancement options are presented.
- Chapter 5 discusses the interpretation and use of the empirical information derived in this study, including key caveats. Guidance is provided on how utilities may apply or develop WTP estimates from surveys of their own customers.
- Chapter 6 provides conclusions and a suggested agenda for future research.

Appendices are also provided to offer interested readers more detailed information:

- Appendix A provides a detailed review of the empirical literature on reliability values. This supplements the more focused discussion provided in Chapter 2.
- Appendix B provides examples of the focus group materials developed and used in this study.

- Appendix C provides the survey instruments deployed in the research effort (a slightly modified version of the Internet-based survey instrument was developed for each of the surveyed service areas in order to tailor the survey to local circumstances).
- Appendices D through H provide detailed analyses of the data for each service area surveyed and empirical analyses of the data obtained.

Chapter 2

Defining and Measuring Water Supply Reliability

This chapter provides a summary of the issues and literature related to valuing water supply reliability enhancement projects. First, we address key conceptual issues associated with the reliability topic, including[1]

- Defining what reliability means, including how reliability might be measured (quantified), who receives the benefits of reliability, and how reliability measures apply within the context of water supply options
- Exploring the dimensions of reliability, with a focus on the different potential sources of variability and uncertainty in water supply yields
- Articulating the difference between WTP estimates derived from this research (which focuses on the value of increasing or maintaining a target level of reliability) and water supply "portfolio theory" (which provides a basis for adjusting the cost of maintaining a given reliability target)

The second part of this chapter provides a review of the literature related to the value of water supply reliability. Given the nature of this research, we focus primarily on studies that have attempted to value WTP for improved reliability [or willingness to accept (WTA) a decrease in the level of reliability], using stated preference techniques.

2.1 Defining Reliability

The goal of any water supplier is to deliver a reliable water supply. The term "reliability," as used here, refers to the ability of a water supply option to produce a given yield (e.g., in million gallons per day, acre-feet per year) on a reasonably stable, continuous basis, whenever the utility wishes to tap and operate that given source. In other words, a reliable water supply option is one that produces a predictable and reasonably stable target yield, without much variability in or uncertainty about how much water will be produced over a given time interval. The following sections provide further insight into the different types and dimensions of reliability.

2.1.1 Types of Reliability

One complication in describing or monetizing the benefits of enhanced water supply reliability is that the term "reliability" can apply to a wide range of circumstances or sources

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[1]This material is based in large measure on related prior work prepared for the Awwa Research Foundation (now named the Water Research Foundation, WaterRF) (Raucher et al., 2005), the WateReuse Research Foundation (or the Foundation), and the Federal Bureau of Reclamation (Kasower et al., 2007).

of uncertainty in supply. For our purposes, there are three general types of reliability enhancement contexts that apply to regional water supply projects:

- *Periodic adverse events, such as droughts* (moderate-probability, moderate-consequence risk). Droughts are fairly common events, occurring periodically over a span of several decades. The frequency and severity of droughts may vary considerably over time and across locations, but most water customers (e.g., residential users) have some direct experience with periodic drought years and their associated impacts, such as the imposition of water use restrictions. As described in subsequent sections, there is a reasonable amount of published research on household WTP to avoid drought-related water use restrictions.
- *Episodic, catastrophic events, such as earthquakes* (low-probability, high-consequence risk). Water supply reliability also can be enhanced in the context of what might happen in the aftermath of a somewhat extreme event such as a major earthquake, flood, levee failure, or terrorist attack. This kind of reliability issue—which may also be labeled “resiliency”—can be especially pertinent when a community relies predominantly on a water supply imported from a distant source. In an import-reliant community, if and when an extreme event such as an earthquake occurs, local water projects may be able to provide some level of water service if the usual imported supplies are cut off, perhaps for extended periods of time. In such cases, the value of reliability to the region’s residents would be extremely high because the local supply would be meeting the most highly valued, essential human needs. However, monetizing such values is challenging empirically, given that existing research has focused on the lower-consequence but more frequent event of periodic drought, rather than the value of water in a large-scale, long-lasting emergency situation.
- *Quasi-routine inconvenient events, such as infrastructure repair* (moderate-probability, low-consequence risk). The infrastructure conveying water to customers, such as finished water transmission mains between a water treatment plant and the customer, are another source of reliability risk. Water main breaks create unscheduled disruptions in service to some customers, and even scheduled efforts to replace or rehabilitate distribution lines may result in some temporary disruption of water service. Most water users periodically experience these events, and impacts are typically limited to temporary inconveniences associated with having no water on tap for several hours (or perhaps up to a few days) and street and parking disruptions because of flooding or water main repair work. There is some evidence that households have a positive WTP for less frequent, shorter-duration events and, in particular, value efforts to have scheduled events (e.g., announced, planned repairs) rather than unscheduled events (e.g., an emergency response to a main break) (Damodaran et al., 2004, 2005).

The previous discussion describes a broad range of contexts in which residential water supply reliability issues arise. Table 2.1 provides a listing of specific factors that can affect residential water supply reliability (including some of the topics previously mentioned).

For the purposes of this research, we focus on reliability within the context of long-term supply planning. This primarily includes planning for periodic (drought) events through the development of new supply sources. Our research does not focus on the aspects of reliability related to technological (e.g., water quality, technology performance, availability of power) or delivery infrastructure issues (e.g., service interruptions).

Table 2.1. Dimensions of Reliability in Water Supply

The dimensions of reliability (i.e., the factors that can impact the reliability of obtaining targeted yields) include 1. Weather and climate—such as periodic drought cycles, as well as longer-term potential changes in climatic regimes (e.g., those that reduce snow pack or longer-term precipitation patterns) 2. Emergency events—such as seismic or terrorist activities that may disrupt the availability or access to traditional water sources (e.g., damage to conveyance systems needed to import distant waters to local water supply agencies) 3. Nonlocal political and institutional factors—such as the activities or policies of state, federal, or other entities outside of the immediate community that can create uncertainty about how much nonlocal (i.e., imported) water can be acquired by and delivered to the local utility 4. Energy availability and cost—such as issues related to power grid capacity and the price volatility for power that may inhibit the reliability and escalate the cost of energy-intensive treatment techniques and long-distance water conveyance systems 5. Technology performance—such as the actual field performance of full-scale pretreatment, membranes, beach wells, and/or other components of desal or reuse that remain somewhat novel or highly influenced by site-specific (e.g., water quality) conditions, making long-term yield reliability hard to predict 6. Water quality—such as how influent water quality and/or the result of post-desal or recycled water blending affect the cost or usability of product water (e.g., failure to meet drinking water standards) 7. Delivery infrastructure—such as how distribution system conditions may preclude reliable delivery of product water to customers

2.1.2 How Water Projects May Provide Benefits by Improving Reliability

Water supply projects can improve reliability in different ways, depending on the type of water supply and local circumstances. The extent to which a water supply project enhances reliability depends on site- and project-specific circumstances. However, a few general observations often apply to various classes or types of water supply enhancement projects, including the following:

- *Projects that generate local water*, especially in regions that rely exclusively or predominantly on imported supplies, are likely to provide reliability benefits for periodic risks such as droughts, as well as infrequent but catastrophic events such as earthquakes. Drought protection may arise because the additional local supplies diversify the water supply portfolio (e.g., the drought impacts may be more severe for the imported source than for the newly developed local source), and because the added local source provides additional total capacity. The impacts of catastrophic risks are likely to be reduced because when the imported supply is cut off or severely curtailed by a seismic or other event, the local source remains available (and may be the only water available for local basic needs).
- *Projects that enable importation of water*, especially in regions that rely exclusively or predominantly on local supplies, also provide reliability benefits for both periodic drought and potential catastrophic events. As in the case previously discussed—which is the other side of the same coin—the diversification and overall expansion of the water supply portfolio provide value in several circumstances.

- *Projects that include reclamation or desal*, or otherwise make productive use of waters previously considered unsuitable for use (e.g., by using advanced treatments to render low-quality waters potable or fit for irrigation use), also tend to provide reliability benefits for both drought and catastrophic events. This is true regardless of whether other water sources tapped in the area are local or imported. Drought protection arises because the new sources are not drought-sensitive and thus their yields have low or zero covariance with yields from traditional water supplies (see the following portfolio theory discussion). In addition, because desal and reuse projects provide added capacity and may be developed as local (or regional) sources, they provide reliability benefits in the event of catastrophic events that might curtail delivery of nonlocal water.
- *Projects that replace or upgrade treatment or distribution infrastructure* tend to generate reliability value by reducing the risk of unscheduled short-term service disruptions. They also may provide some drought protection insofar as infrastructure renewal probably reduces the volume of water lost to leaks, thereby enabling more end use from the existing supplies (in effect, increasing overall system capacity in terms of delivered water).
- *Projects that add water storage* also provide a buffer against seasonal or interannual fluctuations in the available yields from traditional water supply sources. For example, aquifer storage and retrieval (ASR) programs can make use of excess water in wet periods and store that water for use in dry periods. These and other relatively large-scale (i.e., more than a day or two of supply) projects increase reliability during periodic drought events and also can help improve intra-annual reliability by enabling more water availability in dry months (which also tend to be periods of high water demand).

2.1.3 Who Receives Reliability Benefits?

Another important aspect of reliability is the consideration of who receives the benefits (e.g., fewer water use restrictions) and who pays any cost premiums associated with providing added water supply options. These distributional aspects can be viewed across types of water users (e.g., customer class) and also across income or other demographic characteristics within a service area.

In terms of customer classes or types of water users, reliability benefits can accrue to

- *Residential customers* who may be affected by periodic impacts on lawn and garden irrigation and other possible water use restrictions in drought periods. Residential customers benefit from additional overall supply reliability in dry periods.
- *Recreational users* who benefit from sports fields and parkland areas irrigated with reclaimed water or whose outdoor irrigation of such facilities in dry periods is enabled by the availability of additional supplies for other applications.
- *Commercial, industrial, and institutional (CII) customers* for whom reliable water service (quality and quantity) can have significant financial and other business impacts, including overall community economic vitality.
- *Agricultural and other potential large-scale water users* for whom water is a key input into production and income.

Throughout this report, our research is focused on reliability value within the context of residential water users and recreational users of irrigated green spaces. An important point regarding these customers is that, in some cases, they may not be directly receiving the water supplies made available through reliability-enhancement projects (this may be the case with desalinated or recycled water projects). However, if they are located in communities or regions where additional supplies are made available to other customers, then they will still benefit—albeit indirectly—from the increased overall supply and drought resistance of the broader community portfolio.

2.2 Valuing Reliability of Water Supply

Utility managers and others recognize that maintaining or improving the reliability of their water supply yield is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes decision making for long-term water supply investments because these investments are increasingly expensive. Thus, utility managers (and their governing boards) typically desire credible information to assess whether the value (benefit) of water supply reliability investments are high enough for their customers to warrant the potential rate increases needed to pay for them.

Two distinct methods can be used to investigate the value of reliability:

1. The portfolio theory approach, as developed initially for managing financial assets, provides a framework for comparing water supply options using a reliability-based cost adjustment for attaining a given reliability target.
2. The WTP approach (the focus of this research) uses economic valuation techniques to directly estimate the values (i.e., WTP) for reliability held by water utility customers.

The following sections briefly describe each approach, highlighting the differences between portfolio theory and WTP estimates (such as derived from this research), as applied to water supply reliability.

2.2.1 Portfolio Theory

Portfolio theory offers water supply managers a sound conceptual basis and statistical approach for revealing the added value that can be attributed to reliability enhancement projects. The portfolio approach is used to adjust the costs of alternative water supply options to account for differences in reliability relative to a given reliability target for the portfolio (e.g., to deliver a given targeted quantity of water with 95% confidence, year to year).

Originally developed for application in financial markets, portfolio theory provides some useful insights into how water supply planners might develop and manage the portfolios of water sources available to them. The central premise, long recognized and applied by financial managers, is to jointly maximize expected returns (water yields) and concurrently also reduce the overall variance (fluctuations in yields across years or seasons) in portfolio returns. This can be accomplished by minimizing the covariance in yield risks across the assets held in a portfolio (Markowitz, 1952).

In essence, portfolio theory is a statistics-based formalized embodiment of the old maxim about not placing all of one's eggs in one basket. The basic premise of portfolio theory applies to water resources planning. Each water supply option can be viewed as an asset that is subject to some sources and degree of risk (where risk refers to variability or uncertainty in water yield, cost, or both). There may well be a premium value that a risk-averse community would be willing to pay to better manage its water risks, by providing some insurance and/or by providing some variance-balancing water portfolio diversification. The portfolio approach, as applied to water supply planning, introduces the unique risk/benefit profiles of different water supplies into the analysis, thus allowing an assessment of increased (or at least equal-to-existing) supply reliability at the least cost, rather than merely the least-cost total supply irrespective of reliability and community values.

As with financial assets, sources and levels of risk vary across different types of water assets:

- For many traditional surface water sources, a key source of yield risk is the weather and its impact on local hydrologic conditions (e.g., droughts that leave stream flows or reservoirs too low to support desired levels of water extraction).
- Cost risks (or, more suitably, net revenue risks) may be associated with increased pumping and treatment costs, which may arise with declining aquifer levels, deteriorating raw water quality, added regulatory requirements, and other factors. Net revenue risks also can be linked to declines in revenue collections (as when drought restrictions curtail water use and sales, and revenues decline below total annualized costs because volume-based water pricing rates remain fixed—a problem that may be addressed where rate structures help maintain revenue neutrality).
- Other sources of risk for traditional surface and groundwater sources include contamination (e.g., pollutant spills), overextraction by other users (e.g., externalities arising where water is a common property resource), and new institutional constraints (e.g., minimum in-stream flow requirements to account for ecosystem needs or regulatory limits on groundwater extraction to prevent subsidence).

A more in-depth discussion of portfolio theory is provided in Kasower et al. (2007) and Wolff (2007). These papers also offer simple empirical illustrations of how much added value (in terms of reducing the cost of attaining a target level of reliability) may be derived from having a water supply with a yield variability that is uncorrelated (or negatively correlated) with the variability of other source water options in the community's water supply portfolio. This can be used to develop a "constant reliability-adjusted cost" per unit of water delivered, which can then be used to develop a reliability-adjusted cost-effectiveness comparison of water supply options.

2.2.2 Willingness-to-Pay Approach

Portfolio theory offers water supply managers a sound conceptual basis and a statistical approach for revealing the added value (cost savings) of reliability enhancement projects. However, the portfolio approach does not provide a direct empirical examination of how much "value" people place on added reliability (e.g., the WTP to have a higher level of reliability for the community supply, such as increasing the probability of meeting a target total portfolio yield from 95% to 99%).

Estimating WTP for changes in the reliability of water supply involves analytic techniques to elicit the values people place on reliability. Estimation procedures used to value changes in reliability for residential water users are generally based on one of two different primary research approaches:

- *Stated preference* methods determine estimates for reliability based on the analysis of household responses to hypothetical choices posed in surveys
- *Revealed preference* methods infer the value of reliability from data obtained from choices and decisions made in the marketplace (e.g., expenditures made to obtain higher levels of reliability or to avert potential shortages sometimes can be used to infer the value of reliability, but are generally more applicable when derived from customer choices rather than utility-level decisions, which may be driven by a suite of institutional factors)

Another estimation method is known as *benefits transfer* (BT). BT is considered a secondary valuation method because it relies on applying the empirical results derived from primary research, rather than deriving empirical results directly. BT is discussed in greater detail later (Chapter 5).

One other method of quantifying the value of reliability attempts to infer values from available cost and price data. Although "cost" does not necessarily equate to "value," the cost that a city incurs for increased storage to improve reliability can be used—with suitable caveats—as a rough proxy for the value of a reliable water supply. This is especially true when water demand is inelastic (i.e., for necessities), and least-cost supply alternatives are used as proxies for value. Additionally, avoided costs due to higher levels of reliability sometimes can be used to infer the value of reliability.

In recent years, economic and mathematical modeling techniques have also been developed to derive WTP estimates based on available data. These models have been used to estimate household WTP for changes in a combination of probabilistic water supply reliability and the retail price of water (see Lund, 1995; Jenkins and Lund, 2000; Alcubilla and Lund, 2006). Advantages of these models are their ability to examine a complete shortage probability distribution (not just specified events) and their ability to account for price effects (i.e., where higher water rates increase incentives for conservation and reduce the impact of shortages). Although this conceptual approach could provide useful insights into WTP to avoid a range of shortages, it has only been used to evaluate hypothetical scenarios and has not been applied based on real-world data.

2.3 Review of Existing Literature

The following sections overview stated preference, revealed preference, and cost-based studies related to how residential water users value the reliability of their water supply (i.e., WTP).[2] Given the nature of our research (using stated preference techniques to elicit WTP for improved reliability), we focus primarily on stated preference studies that examine the value of water supply reliability to residential customers.

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[2]The numbers reported here have been adjusted based on the Consumer Price Index (CPI) to reflect mid-2011 U.S.$ values.

2.3.1 Stated Preference Studies

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in reliability. The most widely used stated preference technique has been the contingent valuation method, where respondents are presented with information about water supply reliability and relationships between water supply reliability and usability of the resource. Respondents are then asked to state or indicate to the researcher how much a given change in water supply reliability would be worth to them.

More recently, choice experiments, an alternative stated preference approach, have begun to be used more extensively to estimate WTP. Choice experiments—long used in marketing studies—are a survey-based technique in which consumers are presented with two or more options for a good or service and are asked to state which options they prefer. By examining consumer preferences for the attributes and prices associated with the preferred option, WTP is inferred.

Values for reliability are typically defined in stated preference studies as WTP to avoid a particular shortfall event. Water-supply shortfall events are defined in different ways across studies. Factors used to describe a shortfall event include the percentage of water available compared to the amount fully demanded (the shortfall amount), the frequency with which this condition may occur (e.g., 1 in 10 years), and the probability of a single event. In other studies, respondents are questioned on their WTP to reduce the probability of an event, not avoid it. A few more recent studies have elicited WTP to avoid impacts associated with shortages (e.g., watering restrictions).

The following briefly summarizes stated preference studies that have attempted to value water supply reliability using both contingent valuation and choice experiment techniques (more detailed information on each study is provided in Appendix A).

2.3.1.1 Contingent Valuation Studies

In 1987, Carson and Mitchell conducted the first formal stated preference study related to water supply reliability. This study, conducted for the Metropolitan Water District of Southern California (MWD), used contingent valuation method techniques to determine the economic value that residents in southern and northern CA place on changes in water supply reliability. The authors used a discrete choice referendum survey format to estimate household WTP to avoid water shortages of a given magnitude and frequency. Specifically, respondents were asked whether they would vote yes or no on a referendum that would alleviate the threat of a specific water shortage scenario, given a specified (annual) cost to their household if the referendum were to pass. Median annual household WTP was determined for four reduction scenarios, based on a magnitude of reduction ranging from 10% to 35%.

In 1993, the California Urban Water Agencies (CUWA) hired Barakat and Chamberlin, Inc. to conduct a second stated preference study related to reliability.[3] The objective of this study

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[3]This study was republished by its authors in a peer-reviewed journal in 2001 (Koss and Khawaja, 2001).

was to measure WTP among water users in 10 CA water districts. More specifically, they sought to estimate how much residents are willing to pay to avoid water shortages of varying magnitude and frequency. Shortage magnitudes ranged from 10% to 50% and frequencies ranged from once every 3 years to once every 30 years. The authors used a referendum-style, double-bounded dichotomous choice survey to estimate household WTP.

In 1994, Howe and Smith used contingent valuation to measure customers' WTP for improved reliability (and WTA for *reduced* reliability) in three Colorado towns: Boulder, Aurora, and Longmont. For this study, respondents were asked to consider hypothetical changes in their city's level of reliability (increases and decreases in frequency of a specific shortage event) and to assert whether or not these changes would be acceptable if accompanied by appropriate (but unspecified) changes in their water bills. The type of water shortage investigated in the study was defined by the authors as a "standard annual shortage event" (SASE): a "drought of sufficient severity and duration that residential outdoor water use would be restricted to 3 hours every third day for the months of July, August, and September" (Howe and Smith, 1994).

Griffin and Mjelde (2000) used stated preference techniques to value water supply reliability among households in seven Texas cities. The primary objective of this study was to investigate the value of current water-supply shortfalls (existing shortages of known strength and duration). The authors also attempted to determine the value of future shortfalls (probabilistic shortages of differing strength, duration, and frequency). The survey used in the study included two contingent valuation questions: a closed-ended WTP question that described a current supply shortfall of X% of the community's water demand for a duration of Y summer days and an open-ended WTP or WTA question concerning a hypothetical increase or decrease in future water reliability.

2.3.1.2 Choice Experiment Studies

Two recent studies conducted in Australia (Hensher et al., 2006; Tapsuwan et al., 2007) used choice experiment survey formats to examine household preferences for water supply reliability in terms of WTP to avoid drought restrictions. In the surveys, consumers were presented with various options for goods or service levels (with different attributes) and asked to state which options they preferred. Because price is included as one of the attributes, WTP for a specific attribute is indirectly recovered from people's choices (Hanley et al., 2001 as cited in Tapsuwan et al., 2007).

Tapsuwan et al. (2007) used a choice experiment survey to estimate household WTP in Perth, Australia, for different source development options and for avoidance of outdoor water restrictions. To measure consumer preferences, the authors developed a choice experiment survey that included program options with different attributes such as measures of regular outdoor restrictions (e.g., number of days per week households are allowed to water their landscapes), probability and severity (duration) of a complete sprinkler ban, sources of alternative water supplies, and cost to the household (as an increase in annual household water bill). Overall, the study found it difficult to identify preferences to pay for reduced risk of water restrictions in either the short or long term. The authors conclude that respondents may have found the attributes presented in the choice set format too difficult to understand, particularly because it involved an assessment of the risk of an event that may have been difficult to grasp. Alternatively, the source development options included as attributes may have introduced a labeling bias in the questionnaire. If source development was seen as an overriding factor and respondents ignored associated levels of reliability presented in each choice set, some modifications to the survey instrument would be required in the future in order to assess the value of reliability.

Hensher et al. (2006) used a choice experiment to evaluate consumer preferences for avoiding drought restrictions in Canberra, Australia. For this study, the authors presented respondents with a series of six choice experiments covering restrictions on the use of water. Each experiment described two restriction scenarios, and respondents were asked which of the two options they preferred. Based on modeling of respondents' choices between the two options in each experiment, the authors found customers were not willing to pay to avoid most types of drought-induced restrictions. To estimate WTP, the variables included in the model were differentiated into two variables based on the findings previously discussed: "frequency of restrictions that matter," defined as those that apply every day, last all year, and are stage 3 or higher; and "frequency of restrictions that don't matter," which are all other restrictions. The "restrictions that don't matter" include those types of restrictions found to be nonsignificant in the economic model developed based on survey results.

2.3.1.3 Summary of Stated Preference Studies

Table 2.2 provides a summary of annual WTP for reliability improvements based on the studies previously reviewed. With the exception of households in Canberra, Australia (Hensher et al., 2006), it appears that most households are willing to pay in excess of $100 annually for reliability improvements.

Overall, although the stated preference studies previously discussed are valuable in terms of gaining insight into the value of reliability, none of them are perfect in their methodology. In addition, it is somewhat difficult to interpret how to apply the results of these studies to value reliability in the context of 2011. The survey methods used in most of these studies to develop the data, as well as the statistical approaches used to analyze these data, have improved over the years because most of these studies were implemented.

Although stated preference approaches have been applied to the valuation of nonmarket goods for many years, the method has limitations that need to be acknowledged and considered. For example, Griffen and Mjelde (2000) note that one difficulty with stated preference studies for water reliability is the notion of the "birthright" perspective. It is not uncommon for respondents to view water as an inalienable right. Consequently, although respondents value water reliability highly, the notion that water should be free can lead to a reduction in their stated WTP for reliability. However, if the limitations are acknowledged and efforts are made to perform the studies in an appropriate manner, stated preference studies can yield informative results.

Finally, in addition to the studies previously reviewed, a handful of stated preference studies have also been conducted in relation to WTP to avoid temporary disruption in supply (lasting a few hours to a couple of days) due to infrastructure failure and/or repair (see MacDonald et al., 2003; Damodaran et al., 2004; Hensher et al., 2005; Brozovi´c et al., 2007). These studies are more related to the reliability of infrastructure than to the overall reliability of supply and are therefore not emphasized here.

Table 2.2. Summary of Results from Stated Preference Studies

Source	Shortfall Amount	Frequency	Probability	Annual WTP/ Household (mid-2011 U.S.$)[a]
Carson and Mitchell (1987)	10% to 15%	1 in 5 years	20%	$165
Carson and Mitchell (1987)	10% to 15%	2 in 5 years	10%	$305
CUWA (1994)	20%	1 in 30 years	3.3%	$176
Carson and Mitchell (1987)	30% to 35%	1 in 5 years	20%	$228
Carson and Mitchell (1987)	30% to 35%	2 in 5 years	10%	$517
CUWA (1994)	50%	1 in 10 years	5%	$311
Griffin and Mjelde (2000)	na	na	na	$134
Griffin and Mjelde (2000)	na	na	na	$154
Howe and Smith (1994)[b]	0.16% to 9.2%[c]	na	na	$98[d]
Howe and Smith (1994)	0.23% to 12.2%[e]	na	na	$113[f]
Hensher et al. (2006)	na	na	na	$243[g]
Tapsuwan et al. (2007)	na	na	na	$57[h]

na = not applicable.

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US$ values.

[b]Howe and Smith (1994) also estimated WTA values for decreases in reliability. Annual WTA results per household for approximately a 0.7% to 11% decrease in reliability, depending on the city, ranged from $80 to $195. Annual WTA results for approximately a 1.7% to 40% decrease in reliability, depending on the city, ranged from $95 to $281.

[c]This percentage range does not represent the magnitude of the shortfall, as is the case in the other studies. This range represents increased probability over the base probabilities of the SASE. The actual percentage increase is dependent on the city. The associated dollar values are the annual WTP per respondent for an increase in current reliability. If "no" respondents for this increased probability range are included in the dataset (respondents' WTP = $0), the WTP range is from $19 to $33 per year per respondent.

[d]Value represents the average of the WTP range given in the study ($82 to $106 per year).

[e]See table note c. If "no" respondents for this increased probability range are included in the dataset, the WTP range is from $15 to $29 per year per respondent.

[f]Value represents the average of the WTP range given in the study ($75 to $140 per year).

[g]This is the average amount that householders are willing to pay to move from a situation with continuous restrictions at stage 3 or above all year every year to a situation with virtually no chance of restrictions.

[h]This is the annual amount householders are willing to pay for the option of moving from one day to three days of allowable sprinkler use.

2.3.2 Revealed Preference and Cost-Based Studies

A few studies have used the revealed preference and cost-based methods to determine values for water supply reliability. Fisher et al. (1995) explored how price can be used as a tool to reduce demand during a drought. Using a range of estimated price elasticities for residential customers (from selected studies), the authors calculated the loss of consumer surplus associated with a price-induced 25% reduction in consumption in the East Bay Municipal Utility District (CA) service area. With varying demand elasticities, welfare losses were estimated within a range from $63 to $283 per acre-foot (updated to 2011 U.S.$). This loss in consumer surplus is equated to WTP for improved reliability.

In 2002, the California Recycled Water Task Force was established to investigate specific recycled water issues. The economic group of the task force was charged with identifying economic impediments to enhance water recycling statewide. The resulting report uses a case study of the Groundwater Replenishment System (GWRS) in Orange County as an illustration for the importance of economic feasibility analysis. The GWRS was designed to recycle an estimated 70,000 acre-feet per year of effluent and inject it into the Orange County Aquifer. According to the Groundwater Replenishment System Financial Study (Public Resources Advisory Group, 2001), the value of droughtproofing (the value of reliability), based on drought penalties and rate increases for consumers ranged from $220 to $314 per acre-foot per year ($9.5 to $16.3 million per year for 40 years, with a total present value of $285 million with a 5.5% discount rate, updated to 2011 U.S.$) (Recycled Water Task Force, 2002).

In a similar investigation in 1997, the National Research Council (NRC) estimated that if Orange County were to lose its reliable groundwater supply to saltwater intrusion, the cost of securing water by retail producers would jump from the 1997 cost of $106 million to $210 million. The $104 million increase arises because the water once pumped from the aquifer would now have to be purchased from MWD at the uninterruptible rate (NRC, 1997). The sharp increase in price charged by MWD for uninterruptible water supplies highlights the fact that reliability has a key role in water pricing (Paul, 2004) (i.e., as actual or potential shortages worsen and demand outpaces supply, users are willing to pay more for water).

Varga (1991) investigated the role of local projects and programs in the city of San Diego in enhancing imported water supply and improving reliability. MWD provides water to San Diego from the Colorado River and northern California, based on availability. To encourage the use of existing local reservoir capacity and improve the reliability and yield of the imported water system, MWD and California introduced water rate credits for serviced cities. The first program instituted was the Interruptible Credit program. An interruptible credit applies to water that either could be reduced or could have its delivery interrupted by MWD or another external agency. In 1991, the interruptible credit rate was approximately $73 per acre-foot (2011 U.S.$). The second program is the Seasonal Storage Credit program. This program encourages water agencies to use available local storage to increase the capacity and yield of the imported water system. The 1991 seasonal storage rate was approximately $136 per acre-foot (2011 U.S.$). MWD is paying for direct increases in reliability, and therefore, the credit rates can be used as the value for an acre-foot increase in water supply reliability.

Thomas and Rodrigo (1996) measured the benefits of nontraditional water resource investments. The focus of the study was again on MWD and its member agencies. They investigated the benefits of developing additional resources in the region through several alternatives including increased imported supplies (base case), conjunctive storage of local groundwater basins, and recycled water and groundwater recovery projects (preferred case). To determine the value of the preferred case, the savings attributable to each of these resources were compared with the yield associated with the resource. Thomas and Rodrigo note that "dividing the total present value of benefits by the expected groundwater replenishment deliveries (e.g., the difference between the base case and the preferred case and the groundwater case for conjunctive use storage), yields a dollar/AF index" (Thomas and Rodrigo, 1996). In the case of conjunctive use storage, the modeling revealed that carryover or drought storage, which helps ensure greater reliability during dry periods, provides a benefit of approximately $433 per acre-foot (2011 U.S.$) to the region.

In 2003, Wade and Roach investigated the reduction in National Economic Development (NED) Benefits if water supplies to Metro Atlanta were capped at year 2000 water withdrawal levels and no new supply alternatives existed. This analysis estimated shortage costs including costs of shortage management (conservation and reclamation); agency revenues lost from reduced water sales; lost consumer surplus; and economic losses to the region. The water and wastewater NED Benefits were summed to determine total shortage losses through 2050 (present value at year 2000 using a federal discount rate of 6.625%). The present value NED Benefits loss associated with a cap on supplies was estimated to be more than $25.0 billion (2011 U.S.$). Total losses at 10-year intervals were converted to costs per acre-foot based on the total shortage amounts. Water and wastewater losses were found to range from $4090 per acre-foot (2011 U.S.$) for a 17% shortage to $28,650 per acre-foot (2011 U.S$) for a 47% shortage, over the 40-year period from 2010 to 2050.

An overview of the value of reliability inferred from results of revealed preference and cost-based approaches is provided in Table 2.3. When compared on a dollar per acre-foot basis, these estimates are considerably lower than those based on WTP from the stated preference studies previously highlighted. This reflects the fact that stated preference results are designed to reflect the real value (i.e., WTP) of water supply reliability to customers (e.g., households), whereas cost-differential-based results are simply reflective of agency pricing or expenditure decisions that are not likely to reflect value (WTP) considerations. In other words, stated preference studies—if suitably designed and implemented—provide a more relevant and better measure of household WTP for reliability than the available suite of revealed preference studies.

2.4 Conclusions

Although there is a reasonably large body of past empirical research on the value of enhanced water supply reliability to households, many of the underlying data are quite outdated (i.e., originating in the 1980s and 1990s). In addition, the framing of the valuation scenarios (often implying elimination of uncertainty and, in essence, guaranteeing no future shortages) and the valuation approach used in the older contingent valuation method studies make it difficult to interpret the results of prior studies within the practical context of water utility planning in 2011 and beyond (although a discussion of their possible interpretation is offered in Chapter 5).

Based on the limitations revealed by the literature review, there is considerable merit in developing current empirical estimates of WTP for water supply reliability to reflect current period economic and social realities. A more current investigation also enables us to deploy more advanced survey design (using choice experiments) and data analysis methods. The next chapters describe the development of the new empirical research and our findings.

Table 2.3. Water Supply Reliability Values Inferred from Revealed Preference or Cost and Price Differential Results

Source	Value (mid-2011 U.S.$ per acre-foot)[a]	Basis
Fisher et al. (1995)	\$63 to \$283	Welfare loss per acre-foot due to a price-induced reduction in water consumption of 25%
Recycled Water Task Force (2002)	\$220 to \$314	The value (acre-foot per year) of droughtproofing based on drought penalties and rate increases for the customer
NRC (1997)	\$406	The difference in cost of local groundwater supplies versus the MWD uninterruptible rate
Varga (1991)	\$73	The rate per acre-foot that MWD credits local water retailers to store imported water in local reservoir to increase reliability of imported supplies
Varga (1991)	\$136	The rate per acre-foot that MWD credits local water retailers to seasonally store imported water to increase capacity and yield of the imported water system
Thomas and Rodrigo (1996)	\$433	The benefit per acre-foot of conjunctive use storage to ensure greater reliability
Wade and Roach (2003)	\$4090 to \$28,650[b]	Total present value losses associated with a 17% and 47% (cumulative through 2050) reduction in supply in metropolitan Atlanta

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US\$ values.

[b]Present value over 40 years. In terms of annual values, this is equivalent to \$294 to \$2056 per acre-foot per year.

Chapter 3

Methods and Data

To meet our research objectives, the project team developed and implemented a series of choice experiment stated preference surveys of residential customers within five U.S. water utility service areas: Austin Water (TX), Long Beach Water Department (LBWD, southern CA), Orlando Utilities Commission (OUC, FL), San Francisco Public Utilities Commission (SFPUC, northern CA), and one other, anonymous North American utility. This chapter provides a detailed description of the survey methodology, implementation, and analysis, as follows:

- Overview of choice experiment form of stated preference
- Development of initial survey design
- Implementation of focus groups, including key insights and findings
- Development of final survey instrument and pretest
- Survey implementation and sampling methods
- Model and data analysis

3.1 Choice Experiment Form of Stated Preference

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in the availability or quality of a resource (e.g., water for household use). For this analysis, the project team used a stated choice, or choice experiment, version of the stated preference method to elicit utility customer WTP for improved water supply reliability.

Choice experiments are a survey-based technique in which a consumer is presented with two or more options for a good or service and asked to state which option he or she prefers. Each option typically is described by a series of attributes such as price, quality, and/or quantity. For example, in the survey deployed in this study, respondents were asked to choose between future water supply reliability scenarios with the following attributes: (1) number of avoided water use restrictions over the next 20 years (with two severity levels for the potential water use restrictions, as described in greater detail later) and (2) the cost to the household (stated in terms of the change in monthly and annual household water bills) associated with ensuring the given level of water supply reliability. By examining consumer preferences for the attributes and prices associated with their preferred option, WTP is inferred by the researcher using statistical analysis.

The following sections overview the different forms of stated preference evaluations, including contingent valuation and stated choice methods. This discussion helps to describe our rationale for the use of the stated choice method.

3.1.1 Alternative Stated Preference Approaches: Contingent Valuation

The earliest and most widely applied stated preference method is contingent valuation. A typical contingent valuation survey asks respondents about their values for one proposed action compared to the status quo. For example, a conventional contingent valuation exercise in the current context might have asked respondents about their values for reducing the imposition of water use restrictions from 2 years out of the next 10 to 1 year out of the next 10.

The contingent valuation approach was applied in most of the stated preference studies reviewed in Chapter 2. Indeed, contingent valuation was the approach deployed in all the cited studies from the late 1980s through 2000. Only the more recent, Australian-based efforts (Hensher et al., 2006; Tapsuwan et al., 2007) use the stated choice approach. The reliance on contingent valuation is one reason often cited that there is some skepticism about the validity of the empirical results from the earlier studies. For example, some reviewers have pointed out that the level of "mental math" required by respondents in the Carson and Mitchell (1987) survey—coupling severity of the impact (in terms of percentage reductions in water availability) with the probability associated with different potential frequencies of shortages—may explain why respondents did not appear to provide internally consistent responses in terms of their stated WTP.

Although contingent valuation has its limitations and critics, more than 6000 studies involving contingent valuation have been published in the United States and other countries since 1963, including many in the peer-reviewed literature. Contingent valuation—and other stated preference methods—are still evolving and hence continue to generate scientific discussion and research. Nevertheless, enough has been learned to gain wide acceptance of contingent valuation. It is commonly applied by a number of federal agencies. In fact, the Office of Management and Budget (OMB) and the U.S. Environmental Protection Agency (EPA) have published guidelines for its application in policy analyses. The National Oceanic and Atmospheric Administration (NOAA) and the U.S. Department of the Interior (DOI) have approved contingent valuation for natural resource damage assessments involving releases of oil and toxics into the environment.

In the consideration of contingent valuation for the current study, some limitations became apparent. Our goal was to evaluate a range of alternatives, representing a mix of changes in both the probability of future water shortage events (i.e., the number of years out of the next 20 in which restrictions would be required) and the severity of the associated water use restrictions put in place (i.e., whether a Stage 1 or a more severe Stage 2 set of restrictions would be imposed). Valuing more than one proposal in the same contingent valuation survey has significant potential pitfalls. Conducting separate contingent valuation studies, each focused on one of the alternatives, also has some undesirable features.

3.1.2 Alternative Stated Preference Approaches: Attribute-Based, Stated Choice

To address these issues, we looked to the other main branch of stated preference methods, the so-called attribute-based methods (ABMs), also referred to as stated choice questions. In ABM surveys, respondents are presented with two or more alternatives. Each alternative is described in terms of its features or "attributes." Dollar values are included by making one of the attributes the cost of each alternative to the respondent. Several alternatives can be introduced by varying the attributes. Respondents are asked either to choose their most preferred alternative or to rank the alternatives.

The general valuation method we applied to the study involves the use of stated choice questions (also known as "conjoint questions"). Holmes and Adamowicz (2003) and Kanninen (2007) provide overviews of stated choice methods and include citations to most of the literature on the topic. Stated choice questions in this context are used to present individuals with a tradeoff between differing levels of goods or services (e.g., frequencies and severities of potential future water use restrictions) and other attributes including cost. Choices are then used to infer economic values.

The research team considered the relative advantages of contingent valuation and stated choice approaches. A contingent valuation method has the virtues of directness and simplicity. In a typical contingent valuation study, respondents are asked about their values for a single program. Our goal, however, was to value various alternatives to the status quo, so we could discern whether (and how much) it might matter to differentiate the more severe water use restrictions (Stage 2) from the less severe versions (Stage 1). Valuing all options in a single survey using traditional contingent valuation methods would have been challenging. Numerous standalone contingent valuation questions would have been required, and splitting the sample and conducting separate contingent valuation surveys would have increased overall sampling costs or reduced the sample size per question to very small numbers. In contrast, ABMs are capable of valuing more than one program in the same survey, and we turned in that direction to incorporate these issues.

Stated choice questions for ABMs involve presenting survey respondents with two or more alternatives. Each alternative is described in terms of its characteristics or attributes. In a recreational fishing study, for example, fishing sites might be described in terms of their catch rates, distance from home, and other characteristics. Where monetary values are sought, the cost or price of the alternatives is also included as one of the characteristics. A group of alternatives defined in this way is known as a choice set. Alternatives are distinguished by having different characteristics or attribute levels. Traditionally, in stated choice studies, respondents are asked to reveal which of the alternatives from the choice set they most prefer.

The stated choice approach is well established in the literature on environmental economics (Kanninen, 2007). It evolved from conjoint analysis, a method used extensively in marketing and transportation research (Louviere et al., 2000). Conjoint studies have most often asked respondents to rank or rate alternatives (Holmes and Adamowicz, 2003). Choice questions used in environmental economics have typically been less demanding than the conjoint questions used in marketing and transportation. Rather than asking respondents to fully rank a number of alternatives or rate them depending on their relative preferredness, they require only that respondents choose the most preferred alternative (a partial ranking) from multiple alternative goods (i.e., a choice set). This procedure seeks to capitalize on the fact that choosing the most preferred alternative from some set of alternatives is a common experience in everyday life.

Morikawa et al. (1990) note that responses to choice questions often contain useful information on tradeoffs among characteristics. Johnson et al. (1995, p. 22) note, "The process of evaluating a series of pair wise comparisons of attribute profiles encourages respondents to explore their preferences for various attribute combinations." Furthermore, Adamowicz et al. (1998a) note that the repeated nature of choice questions makes it difficult to behave strategically. As mentioned previously, choice questions allow the construction of alternatives with characteristic levels that currently do not exist.

Examples of environmental economic applications are numerous. Magat et al. (1988) and Viscusi et al. (1991) estimate the value of reducing environmental health risks; Adamowicz et al. (1994, 1998b, 2004), Breffle et al. (2005), and Morey et al. (1999b) estimate recreational site choice models for moose hunting, fishing, and mountain biking, respectively; Breffle and Rowe (2002) estimate the value of broad ecosystem attributes (e.g., water quality, wetlands habitat); Adamowicz et al. (1998a) estimate the value of enhancing the population of a threatened species; Layton and Brown (1998) estimate the value of mitigating forest loss resulting from global climate change; and Morey et al. (1999a) estimate WTP for monument preservation in Washington, DC. In each of these studies, a price (e.g., a tax or a measure of travel costs) is included as one of the characteristics of each alternative, so that preferences for the other characteristics can be measured in terms of dollars. Other examples include Swait et al. (1998), who compare prevention versus compensation programs for oil spills, and Mathews et al. (1997) and Ruby et al. (1998), who ask anglers to choose between two saltwater fishing sites as a function of site characteristics.

Alternatively, a number of environmental studies have followed a more conventional conjoint approach by using ranking or rating questions. Ranking studies present respondents with three or more alternatives and ask them to rank them from most preferred to least preferred. Rating studies ask respondents to rate the degree to which they prefer one alternative over another, often on an integer scale such as 1 to 10. Adamowicz et al. (1998b) provide an overview of choice and ranking/rating experiments applied to environmental valuation. They argue that choice questions better predict actual choices than do rating questions because choice questions mimic the real choices individuals are continuously required to make, whereas individuals rank and rate much less often.

Ultimately, the stated choice approach was clearly the preferred approach for our investigation. It enabled comparisons across a range of possible alternatives, compared to the status quo. It enabled us to investigate not just the value of avoiding shortages, but also gave us an opportunity to investigate the degree to which the severity of water use restrictions might be an important determinant in household WTP for a more reliable water supply.

3.2 Initial Survey Design

Initial steps in the survey design effort entailed identifying what key questions and issues were to be addressed, given a target 15-min duration survey, which we anticipated would be deployed via the Internet. The overall survey design was intended from the outset to lead up to valuation questions for water supply reliability, wherein respondents would face choice sets in which they would select a preferred option from among two or three alternatives, one of which would always be the status quo (where no further water supplies were developed to increase water supply reliability). Because each option in the choice set would have a price associated with it (an impact on household water bills), this study design would enable us to interpret the results of the choice experiments to infer a WTP for a more reliable supply.

Two key issues arose in the initial survey design phase. First, there is the challenge of presenting sufficient background information to the respondent—before the stated choice questions are reached—in a credible and readily understandable fashion. This is necessary so that the respondent can make a reasonably informed choice when faced with the task of identifying and selecting their preferred options. As can be seen from the surveys ultimately implemented, we found through focus group and one-on-one pretests that it was effective to start by providing simplified factual information about typical water use levels and patterns of households in their communities, differentiated according to whether or not the respondents had their own yards (i.e., had outdoor irrigation demands). Then information was provided on water use restrictions and their pattern in the community over the past 20 years. This set the context for how water was typically used by residential customers, how frequently restrictions on those uses had been implemented in the past 20 years, and what types of restrictions applied (i.e., less or more restrictive). This historical discussion also revealed the implications of water use restrictions (e.g., how a Stage 2 restriction could lead to dead lawns and garden plantings). This enabled us to describe future scenarios in which water shortages—and hence future water use restrictions—would likely be more frequent and/or severe. This design effectively set up the choice experiment wherein the respondent could select adding no more water supply enhancements (status quo) and endure more frequent restrictions in the future, including some periods with severe "Stage 2 restrictions."

The second key challenge was determining how to convey to respondents that water supply enhancement options would have impacts not only on the potential frequency of water use restrictions but also on the severity of these restrictions. We also wanted to convey a range of options in which it was clear that not all future water use restrictions could be avoided (i.e., no option guaranteed complete elimination of the uncertainty about future restrictions) but only the expected number of such events and/or their severity could be reduced. This suite of issues was especially important because most of the past WTP studies on water supply reliability implied elimination of shortages, leading to potential upward bias in the WTP estimates derived. The research team struggled with various approaches to portraying this multidimensional water use restriction issue in a way that would be readily understood by respondents. The use of pie charts proved—via the focus groups—to be quite effective in this regard. Respondents could understand how each choice option might impact the number and severity of future water use restrictions, and the cost of each option to them was also clear.[4]

Finally, the researchers hoped that there would be sufficient time in the survey to enable questioning respondents about their preferences across various water supply enhancement options. Fortunately, we were able to design background information and survey exercises that enabled us to assess which supply enhancement options were preferred, where the range of options included variations focusing on conservation, water reuse, desal (where applicable), increased water importation, reservoir/storage expansion, and so forth.

3.3 Focus Groups

Following the initial survey design, 10 focus groups were conducted to help test and refine the survey and to help tailor it to the individual characteristics of the different service areas. As the survey was first being developed, four focus groups were held before the initial survey design was completed and field implemented. Each focus group included 10 individuals recruited by a local market research firm specializing in this activity; these entities also provided the focus group facilities where participants could be viewed and the proceedings

[4]A related challenge was that initial discussions suggested that people viewed water use restrictions as the "solution" to water shortages, rather than viewing restrictions as emblematic of the "problem." We carefully cast the discussion so that water use restrictions were seen as part of the problem and that investing funds to enhance the future water supply portfolio was the solution.

recorded. Each participant received a handout with draft materials from the survey and was led through the exercises. We then engaged the participants in discussions to ensure that they understood the materials, found them credible, and were able to answer the questions based on their knowledge and preferences. An example of the focus group handout materials is provided in Appendix B.

The focus groups helped refine the initial version of the survey, for Utility X, which was the first one implemented. The subsequent success in using the survey in the field indicated that the survey design and content were functioning as intended. We then conducted two focus groups in each subsequent study location (Austin, Long Beach, and San Francisco) to ensure that local issues were properly conveyed and understood, and to identify any refinements to the survey that might enhance its clarity for respondents. Focus groups were not held in Orlando, which was the final study location.[5]

Although the main intent of the focus groups was to ensure that the survey design and supporting materials functioned properly (i.e., the materials were understood and trusted by respondents and elicited useful responses to the choice sets and other questions), the focus group format also provided several additional insights of general interest to water utilities and other water sector professionals:

- Focus group members generally had little sense of how much residential water was applied to outdoor irrigation. When shown actual statistics for their service area, most focus group members were shocked or incredulous that more than half of residential water use in most areas was directed to summer yard irrigation.
- Focus group members frequently revealed a lack of knowledge of household water use patterns, even though they tended to express a high level of awareness of the need to conserve water and an interest in taking personal actions at home to do so. For example, in almost every focus group, attendees spoke of how they now opted to wash dishes by hand rather than using their dishwashers because they believed this saved water (in fact, hand washing dishes is far more water-intensive than properly using an automatic dishwasher). In general, there was a considerable disconnect between individuals' high level of awareness, concern, and motivation to help conserve water and the lack of specific information about the most meaningful ways to do so.
- In general, when asked if they believed their household water use was similar to, less than, or greater than the amounts shown for typical area households in the handout materials, the vast majority of focus group attendees tended to believe they used less water than typical households in their area.
- Given the apparent lack of understanding by most focus group attendees of how much water they use, and for what purposes, it is clear that more and better information on water use needs to be provided to residential customers.
- The participants expressed considerable interest in obtaining "real-time" information on their water use, reflecting frustration that they did not know how much water they were using until after the bill arrived for that billing period.

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[5]No focus groups were conducted in the Orlando service area, as this site was added late in the process, and the survey had proven to be well designed through its successful application at the other four locations.

- In the initial pair of focus groups, the consequences of water use restrictions were not readily apparent to respondents. This led to adding discussion on implications in subsequent versions, so that the consequences were more evident to respondents (e.g., having one's lawn and shrubs die under a year of severe water use restrictions, or after back-to-back years of lesser restrictions on outdoor irrigation).
- Initially, the status quo (i.e., do nothing new to enhance future supplies) was portrayed as resulting in a zero ($0) increase in household water bills. Focus group participants reacted with skepticism that water bills would not increase, even if no actions were taken to enhance regional supplies. We then changed the cost of the status quo option to $1 per month ($12 per year per household) to cover increasing costs for existing water utility activities. This was seen as credible by subsequent focus group participants.
- Initially, there were several misconceptions about what "recycled water" is, and several attendees thought the issue focused on what they did in their own homes and businesses (i.e., if they recycled water within their homes). An additional description was provided in later versions to explain that recycled water, or water reuse, options referred to programs implemented at the utility level for a variety of possible uses or options [including indirect potable reuse (IPR) and traditional dual piping/irrigation uses].
- Any discussion of trying to transfer water from agricultural to municipal use was met with very strong resistance, even when the discussion was cast in terms of helping farmers save water by increasing their water use efficiency and only transferring the water savings that the urban utility paid for. This was not surprising, given the past experience of researchers regarding this subject. Nonetheless, the strength of opinion on the need to ensure that farmers get to keep their water (regardless of how inefficiently some may use it) was noteworthy.

3.4 Final Survey Instrument and Pretest

As described earlier, the first part of the survey presented respondents with background information on typical household water use levels and patterns in their communities, differentiated according to whether or not respondents had their own yards (i.e., had outdoor irrigation demands). Information on personal characteristics that might influence a respondent's WTP to reduce water restrictions was also collected in the first part of the survey. For example, respondents were asked whether they paid their own water bills, how they felt about the importance of increasing water supplies in their community, and whether or not they had their own yards.

Next, respondents were presented with information on different levels of water use restrictions (typically enacted during drought periods) and the requirements associated with these restrictions (such as outdoor watering only being allowed two days per week). The water use restrictions described in the surveys vary to some degree with water utility service area, based on each utility's actual water shortage or drought management plans. Table 3.1 summarizes the restrictions included in four of the five surveys conducted, by city.

In addition to the requirements associated with different levels of water use restrictions, respondents were also provided with the following information:

- A description of the impacts of various restrictions after one year and after a period of several years (e.g., after one year, Level 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks)
- The number of years out of the last 20 that water use restrictions had been put in place by their utility
- The number of years that restrictions would be expected to be in place over the next 20 years if no action was taken to increase water supply (the status quo)

Table 3.1. Stage 1 and 2 Water Use Restrictions in Each City

	Austin	Long Beach	San Francisco	Orlando	Utility X
Stage 1 water use restrictions	Watering of lawns, gardens, and public areas with a hose-end sprinkler, a soaker hose, or drip irrigation is allowed only on designated outdoor water use days and must occur before 10:00 a.m. and after 7:00 p.m. Watering of lawns, gardens, and public areas with a permanently installed automatic irrigation system is allowed only on designated days and must occur between midnight and 10:00 a.m. Watering of lawns, gardens, and public areas with a hand-held hose or a hand-held bucket can occur at any time. Home vehicle washing using a hand-held bucket or hose with a shutoff nozzle is allowed only on designated days and must occur before 10:00 a.m. and after 7:00 p.m. Water is served in restaurants only upon request.	Landscape watering is only allowed two days per week (Monday and Thursday after 4:00 p.m. and before 9:00 a.m.), year-round. Filling residential swimming pools and spas with drinking water is not allowed.	All customers receive a monthly allotment of water based on past indoor and outdoor water use. Customers using more than the allotted amount pay "excess use" charges and may be subject to having devices installed on their water service line that will restrict the flow of water to their homes. Examples of additional water use restrictions include • The use of water to clean sidewalks, patios, and other hard surfaces may be prohibited • Water suitable for drinking may not be used for decorative fountains • The use of additional water may not be allowed for new landscaping unless low-water-use landscaping designs and irrigation systems are employed • Water-saving fixtures or devices may be required in all new construction	All water users must reduce their water use by 15% from the most recent year that water shortage restrictions were not in effect. Specific measures include • All water users are required to test and repair their irrigation system to address sources of water waste • Lawn and landscape irrigation is restricted to one day per week on designated days, between the hours of 6 p.m. and 9 a.m. • Cisterns, hand-watering, and low-volume irrigation systems may be used at any time • The use of water for fountains and other decorative displays is not allowed • The local water utility may implement additional measures as necessary	Apply when water supplies are projected to be 65% of normal for the summer. Lawns, gardens, and public parks cannot be watered more than twice a week and for no more than 15 min per zone. Enforcement is focused on severe and repeated violations.

Table 3.1—*Cont.*

	Austin	Long Beach	San Francisco	Orlando	Utility X
Stage 2 water use restrictions	Watering of lawns, gardens, and public areas is allowed only with a handheld hose or a handheld bucket, is limited to designated outdoor water use days, and must occur between 6:00 a.m. and 10:00 a.m. and between 7:00 p.m. and 10:00 p.m. No use of automatic irrigation systems. No vehicle washing. No operation of outdoor ornamental fountains or structures making similar use of water, other than the aeration necessary to preserve habitat for aquatic species. No filling of swimming pools, fountains, or ponds. No installation of new landscaping.	Most outdoor water use would not be allowed. Additional water use restrictions may be put in place by the LBWD as necessary.	Additional water use prohibitions and restrictions would be implemented, and customers would be subject to an increased level of rationing. Most outdoor watering would not be allowed.	All water users must reduce their water use by 20% from the most recent year that water shortage restrictions were not in effect. Specific measures include: Lawn and landscape irrigation is *prohibited*. Irrigation of child playgrounds and sports fields is allowed one day per week. Cisterns, hand watering, and low-volume irrigation systems may be used at any time to water nonturfgrass material. Washing or cleaning of vehicles is limited to one day per week and must be done using low-volume methods (including at car washes). Washing or cleaning of buildings and outdoor surfaces is generally not allowed. The local water utility may implement additional measures as necessary.	Apply when water supplies are projected to be 40% of normal for the summer. Require that lawns, gardens, and public parks cannot be watered at all, but trees can be watered by hand. Enforcement is strict for all violations.

Respondents were then presented with three sets of choice questions in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," or the status quo alternative. The experimental design for this study comprised 24 programs with varying levels of use restrictions. For each choice set, two of the programs were randomly selected. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice-set data observations for each respondent. Figure 3.1 provides an example survey choice set.

In addition to the stated choice questions, respondents were also asked about their preferences for different options that water suppliers in their region could undertake to improve future water supply reliability. Options presented in all surveys included

- Increasing available supplies of water by transferring more water from agricultural uses
- Increasing the price of water to residential, commercial, and industrial users so that they will use less
- Requiring low-water-use landscaping (e.g., Xeriscape) in new homes and redevelopment projects
- Expanding the use of recycled water for outdoor irrigation and industrial uses
- Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low-water-using appliances or landscaping)

In each survey, a water import option was also presented that involved importing surface water from outside the region or river basin.

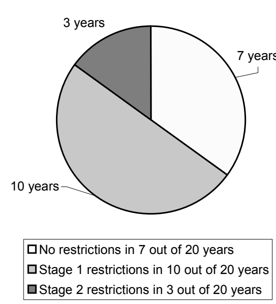
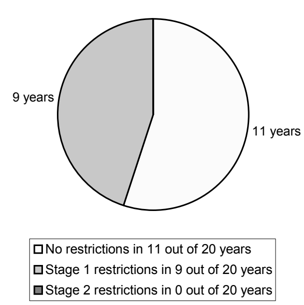
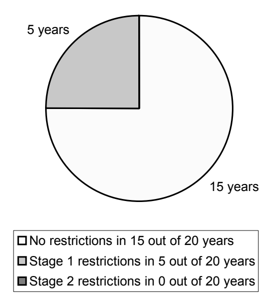
<table>
<tr><th></th><th>No additional actions</th><th>Plan B</th><th>Plan C</th></tr>
<tr><td>Available water supply such that water use restrictions in the next 20 years will be</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>Increase in your water cost</td><td>$1 per month, which would be $12 per year</td><td>$14 per month, which would be $170 per year</td><td>$25 per month, which would be $300 per year</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td>Which plan do you prefer?</td><td>☐</td><td>☐</td><td>☐</td></tr>
</table>

Figure 3.1. Example choice set.

Additional alternative options presented in different cities included

- Expanding water recycling to replenish groundwater reservoir supplies (Austin, Long Beach, Orlando, and San Francisco)
- Investing in regional desal facilities to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions (Long Beach, San Francisco, and Orlando)
- Increasing available water supplies by expanding or adding new storage reservoirs (Austin, Orlando, and San Francisco)
- Increasing the use of nonlocal groundwater sources (Austin and Long Beach)
- Increasing the use of local groundwater sources (Austin and Orlando)
- Increasing available supplies in dry years by acquiring more imported water in wet years and storing it underground for local use in dry years (Long Beach and Orlando)

For each option, a brief description, including advantages and disadvantages, was provided. Respondents were then asked to rank their five most preferred options, as well as their least preferred option. Following this section of the survey, individuals were presented with a series of questions asking them to indicate two relatively similar supply options (e.g., two recycled water options or two water conservation options). Examples of these questions from the Long Beach survey are included in Figure 3.2.

3.5 Survey Implementation and Sampling Methods

Knowledge Networks (KN, part of the Stratus Consulting project team) administered the online water supply reliability survey to 2115 individuals within the Austin, LBWD, Orlando, Utility X, and SFPUC service areas. A total of 298 people responded to the survey as part of the KnowledgeNetwork Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the participating water utilities, Stratus Consulting provided KN with a list of ZIP codes that were completely contained within the utility service areas. Survey weights were generated by KN to adjust for sample design, noncoverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific ZIP codes who participated in the study.

3.6 Economic Model and Willingness-to-Pay Analysis

Economists use a variety of models to analyze the type of data collected with the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model, which we employed for our analysis. This model is an extension of the multinomial logit model and is particularly appropriate for choice behavior models. As a simple description, conditional logit models estimate the probability that an individual will make a given choice based on different explanatory variables including attributes of the choice alternatives (e.g., cost of the water supply reliability program) and characteristics of the individuals making the choice (such as age and income). Figure 3.3 provides a description of the theory behind choice models, in general, and conditional logit models, specifically.

Does It Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Q17. Of the two underground water storage options below, which do you prefer?

Increasing underground storage of recycled water	1
Increasing underground storage of imported water in Wet years	2

Q17a. Of the two groundwater options below, which do you prefer?

Increasing use of local groundwater sources through replenishing the basin	1
Increasing use of non-local groundwater sources and pumping The water to Long Beach	2

Q18. Of the two water transfer and import options below, which do you prefer?

Increasing water imports from MWD	1
Increasing water transfers from agriculture	2

Q19. Of the two water conservation options below, which do you prefer

Requiring low-water landscaping in new homes	1
Promoting additional voluntary water conservation through Education and incentives	2

Q20. Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Expanding water recycling for outdoor irrigation and industrial uses	1
Expanding water recycling to replenish local Groundwater supplies	2

Figure 3.2. Questions regarding preferences for similar water supply options, as illustrated in the Long Beach version of the survey.

The analysis of multiattribute stated choice data typically involves statistical techniques based on random utility maximization (RUM) models (Haab and McConnell, 2002). The specific econometric techniques include discrete choice models such as logit and probit or more complex mixed logit or rank-ordered probit models. RUM models are used to estimate respondents' WTP to achieve particular levels of water supply reliability (or other applicable attributes). The tradeoff between monetary payments and reliability attributes provides the estimate of WTP for the changes. For example, responses to choice questions in the survey may indicate that people are willing to pay a specified increase in water bills if water shortages and water use restrictions in the future are reduced to a specified level.

Suppose that Y_i represents a discrete choice among J alternatives. Let U_{ij} represent the value or *utility* of the *j*th choice to the *i*th individual. We will treat the U_{ij} as independent random variables with a systematic component h_{ij} and a random component e_{ij} such that

$$U_{ij} = h_{ij} + e_{ij}. \tag{3.1}$$

We assume that individuals act in a rational way, maximizing their utility. Thus, subject I will choose alternative j if U_{ij} is the largest of choice set U_{i1}, U_{iJ}. Note that the choice has a random component, since it depends on random utilities. The *probability* that subject I will choose alternative j is

$$p_{ij} = \Pr\{Y_i = j\} = \Pr\{\max(U_{i1}, U_{iJ}) = U_{ij}\}. \tag{3.2}$$

It can be shown that if the error terms e_{ij} have standard Type I extreme value distributions with

density $f(e) = \exp\{-e - \exp(-e)\}$, (3.3)

then

$$p_{ij} = \exp\{h_{ij}\} / \exp\{h_{ik}\}, \tag{3.4}$$

which is the basic equation defining the multinomial logit model.

Luce (1959) derived Equation 3.5 starting from a simple requirement that the odds of choosing alternative j over alternative k should be independent of the choice set for all pairs *j, k.* For example, if A is preferred to B out of the choice set $\{A,B\}$, then introducing a third alternative X, which thus expands the choice set to $\{A, B, X\}$, must not make B preferable to A. In other words, preferences for A or B should not be changed by the inclusion of X; i.e., X is irrelevant to the choice between A and B.

Figure 3.3. General choice models.

Source: Rodriguez, 2009.

3.6.1 Conditional Logit Model

In analyzing stated choices, economists assume that the differences across respondents' choices are attributable to variation in both observed characteristics (e.g., respondents' demographic characteristics and/or responses to survey questions) and unobserved, random variation. Our model includes several variables to account for the variation in observed characteristics of a choice. For example, we include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the "no-action" scenario for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether or not the respondent believes increasing water supplies is of high or low importance, the amount of time living in the city where the survey was implemented, a dummy variable indicating yard ownership status, and a dummy variable indicating whether or not a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether or not the choice decision concerns an alternative to the status quo (e.g., whether the respondent chose Plan B or Plan C over the No Additional Actions alternative). This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the no-action scenario.

The following equation shows the general structure of the conditional logit model used in this analysis. On the left-hand side of the equation is the probability that an individual (with given characteristics) will choose an alternative to the status quo. On the right-hand side of the equation are the variables upon which this choice depends. In the model, the estimated value of the beta coefficients represents the extent to which each variable contributes to the choice:

$$\begin{aligned} P = \; & \beta_1(\text{Cost per year}) + \beta_2(\text{Reduction in Level 1 restrictions}) \\ & + \beta_3(\text{Reduction in Level 2 restrictions}) + \beta_4(\text{Chose alternative} \\ & \times \text{education}) + \beta_5(\text{Chose alternative} \times \text{age}) + \beta_6(\text{Chose alternative} \\ & \times \text{income}) + \beta_7(\text{Chose alternative} \times \text{increasing water supplies} \\ & \text{important}) + \beta_8(\text{Chose alternative} \times \text{time living in Long Beach}) \\ & + \beta_9(\text{Chose alternative} \times \text{own yard}) + \beta_{10}(\text{Chose alternative} \\ & \times \text{pay water bill}). \end{aligned} \tag{3.7}$$

The conditional logit model described here assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses were conducted to explore potential nonlinear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines). These more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many total years have use restrictions eliminated). The results of this evaluation revealed no statistically significant difference between the linear results reported earlier and the nonlinear variations we estimated.

3.6.2 Willingness to Pay to Reduce Water Use Restrictions

To estimate WTP to reduce water restrictions by one unit (i.e., one year), we divide the model coefficients for the number of fewer level 1 restrictions and the number of fewer level 2 restrictions each by the model coefficient for the cost variable. This provides the marginal WTP to reduce Level 1 and Level 2 water restrictions, respectively. WTP results and additional findings from the survey are provided in Chapter 4.

Chapter 4

Empirical Results

This chapter summarizes the empirical results of our analysis, including key findings related to

- Preferences for alternative water supply programs to improve water supply reliability compared to the status quo (i.e., doing nothing to increase future water supplies)
- WTP to avoid future water restrictions
- Preferences for different types of water supply sources

The following sections provide an overview and comparison of results in each city. Detailed results for each study location are provided in Appendices D–H.

4.1 Preferences for Alternative Water Supply Programs

As described in Chapter 3, the stated preference valuation portion of the survey included a series of three choice questions. For each question, respondents were asked to choose between the status quo (i.e., the utility not taking any additional actions to bolster the reliability of its current water supply portfolio) and two alternative options for increasing future water supply reliability. The two alternative options included in each choice question were randomly selected from a set of 24 options, which vary based on the annual cost to the customer, the number of years that future water use restrictions would be in place, and the severity of those use restrictions. The annual cost of the 24 alternative water supply options ranged from \$20 to \$300 per household, and the cost of the status quo option was \$12 per year above the current household annual water bill.

Under the status quo (no additional action) option, the scenario was presented as a projection that no water use restrictions would be needed in 7 of the next 20 years; Level 1 restrictions would be in place in 10 of the next 20 years; and Level 2 restrictions would be in place in 3 of the next 20 years. We applied a very similar status quo option scenario across all five of the surveyed service areas to develop a consistent basis for comparing results across regions (i.e., so that respondents essentially faced the same baseline and future choices, regardless of location). Under the alternative options, the number of Level 1 and/or Level 2 restriction years is reduced compared to the status quo. The Level 1 and Level 2 restrictions are very similar across regions, but the language in the surveys was tailored to better reflect each local utility's specific policies.

Table 4.1 displays the percentage of the time respondents in each city chose the status quo option over the other alternatives presented in their choice questions. The number of observations underlying these percentages is equal to three times the number of respondents, as each respondent was presented with three choice questions. As shown, respondents in Long Beach and Orlando chose the status quo option at a much higher rate than respondents in other cities. In Austin, San Francisco, and Utility X, respondents chose the status quo option about 50% of the time.

Table 4.1. Percentage of Time Status Quo Option Was Chosen as the Preferred Option, by City

City	Percentage of Time Status Quo Option Was Chosen (%)
Austin	45.4
Long Beach	61.7
Orlando	63.2
San Francisco	50.7
Utility X	48.3

To evaluate preferences across the 24 alternatives, we calculated the percentage of respondents who chose a given alternative when it was presented to them (i.e., of the respondents who were presented with Version X, Y% chose Version X over the status quo and the other version presented). Although this analysis does not address the variation of alternative versions presented to respondents, it does provide feedback about respondent responses to each alternative. Table 4.2 presents the alternative most frequently chosen in each city and the characteristics associated with that alternative, including annual cost to the customer (in addition to the regular water bill) and the number of years that Levels 1 and 2 restrictions would be in place (for reference, characteristics associated with the status quo alternative are also shown).

As shown in Table 4.2, the most frequently chosen alternative in Long Beach and San Francisco (Alternative 10) is more expensive than the most frequently chosen alternative in other cities. Alternative 10 would reduce the number of Level 2 restriction years by 3 (i.e., eliminate all expected Level 2 restrictions over the next 20 years) and the number of Level 1 restriction years by 2 relative to the status quo option. Although Alternative 10 is more expensive than the most frequently chosen alternatives in other cities, within the context of all 24 alternatives (with costs ranging from $20 to $300), Alternative 10 is relatively inexpensive, with 16 other options being more expensive.

Overall, cost seems to be a larger factor in the decision to select a given alternative than the decrease in the number of fewer restriction years that an alternative would provide. This is exemplified in Figures 4.1–4.5, which show the correlation between the cost of each alternative (not including the status quo) and the percentage of respondents who chose that alternative (when it was presented to them), as well as the correlation between the number of (weighted) fewer restriction years[6] under each alternative and the percentage of respondents who chose that alternative.

[6]The decrease in the number of Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

Table 4.2. Most Frequently Chosen Alternative to the Status Quo, by City

City	Most Frequently Chosen Alternative	Summers with No Restrictions	Summers with Level 1 Restrictions	Summers with Level 2 Restrictions	Added Cost per Year	Percentage Chosen, %
	Status Quo	7 (8)[a]	10 (8)[a]	3 (4)[a]	$12	
Austin	Alternative 24	10	9	1	$65	53.8
Long Beach	Alternative 10	12	8	0	$110	37.0
Orlando	Alternative 5	10	8	2	$60	37.2
San Francisco	Alternative 10	12	8	0	$110	39.6
Utility X	Alternative 2	12	6	2	$95	47.0

[a]Expected future is the same in all cities with the exception of Austin, which is shown in parentheses.

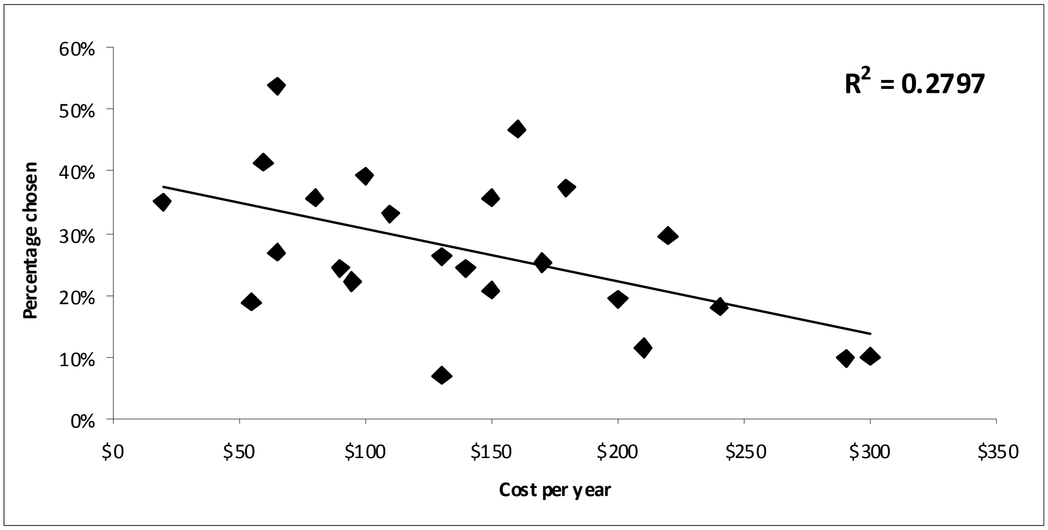
As shown in Figures 4.1–4.5, in all cities, there is a strong correlation between the cost of the alternative and the percentage of respondents who chose that alternative. This result indicates that cost is a much more important driver in the selection of alternatives across all cities, compared to reducing restriction levels.

4.2 Willingness to Pay to Avoid Water Use Restrictions

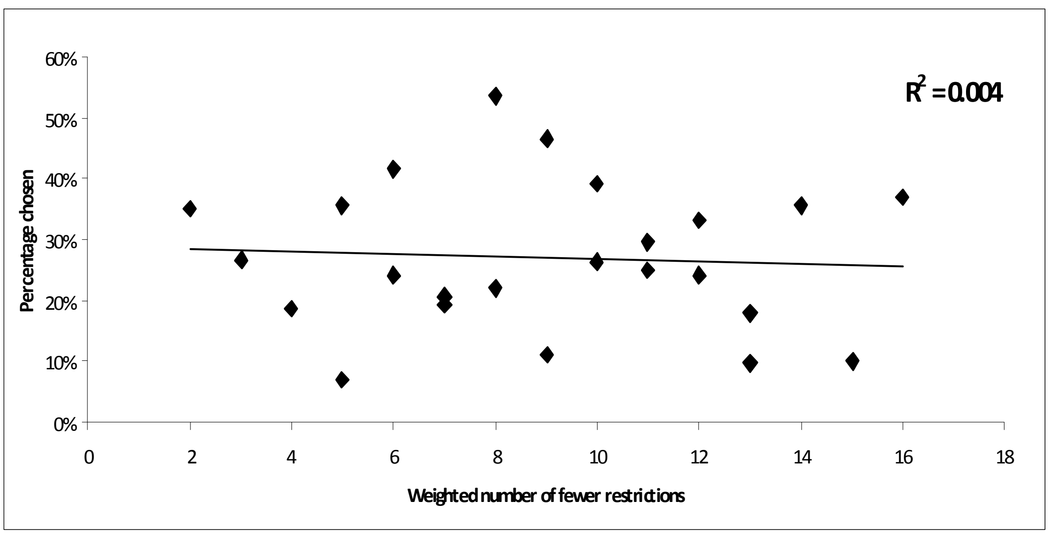
Based on the choices made by respondents, we are able to infer respondent WTP to avoid water use restrictions using a conditional logit model (see Chapter 3). This type of model is used to estimate the probabilistic effect of a choice attribute (e.g., cost of a water supply program) or personal characteristic (e.g., age, income, level of education) on the outcome of a given choice. The following sections discuss the choice attributes and individual characteristics that seem to influence WTP to avoid water use restrictions and provide mean annual WTP estimates for each study area.

4.2.1 Choice Attributes and Respondent Characteristics Influencing Choice Decisions

Because a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. First, we included the cost of the alternative associated with a given choice. We also defined two attributes as the decrease in the number of restriction years relative to the status quo for each restriction level. Finally, we used personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time lived in the service area, a dummy variable indicating yard ownership status, and a dummy variable indicating whether or not a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether or not the choice decision concerns an alternative to the status quo. This provides variability in the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

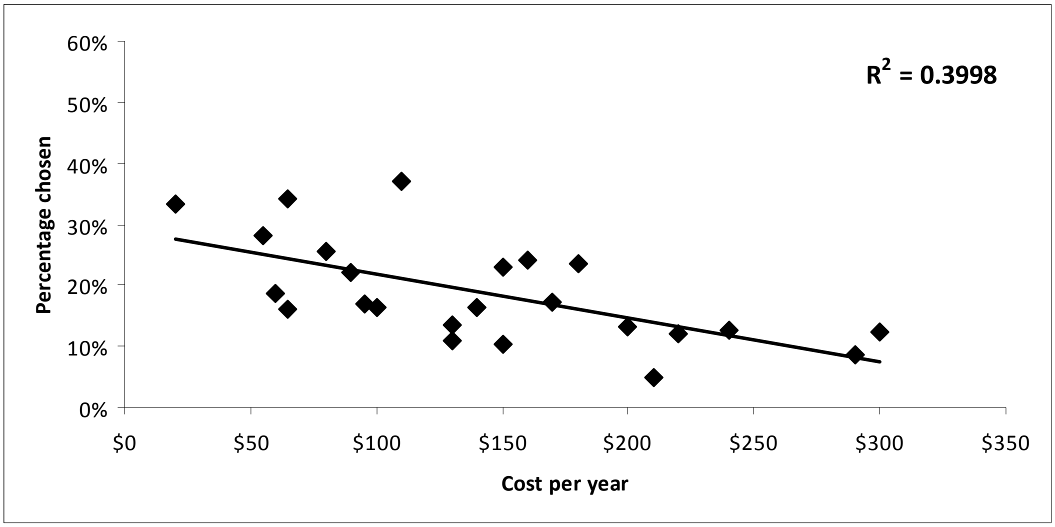


(a)

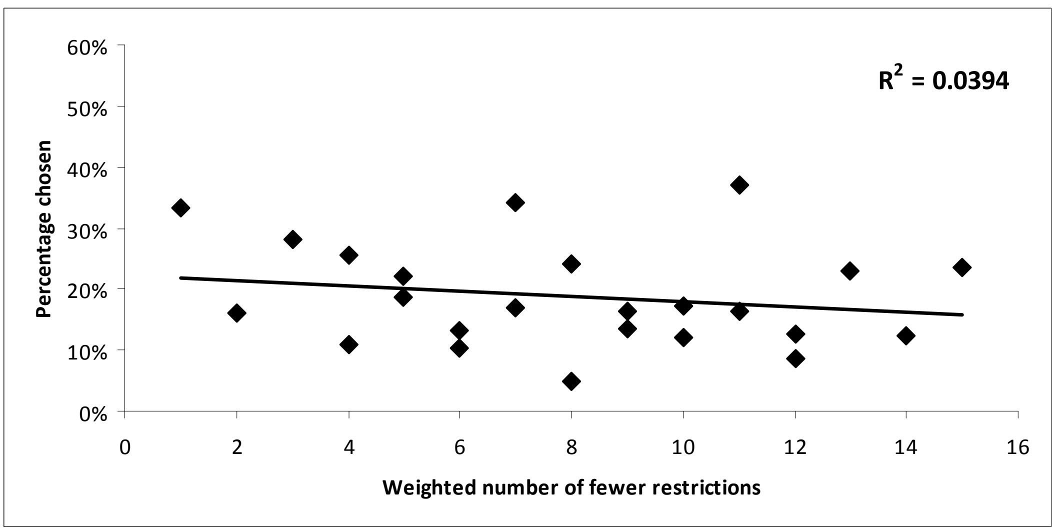


(b)

Figure 4.1. Austin: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.

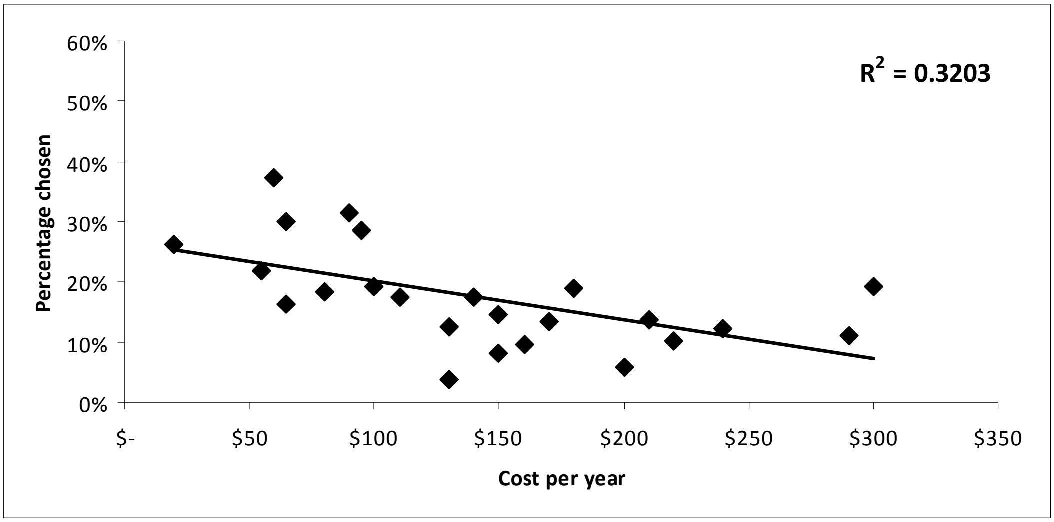


(a)

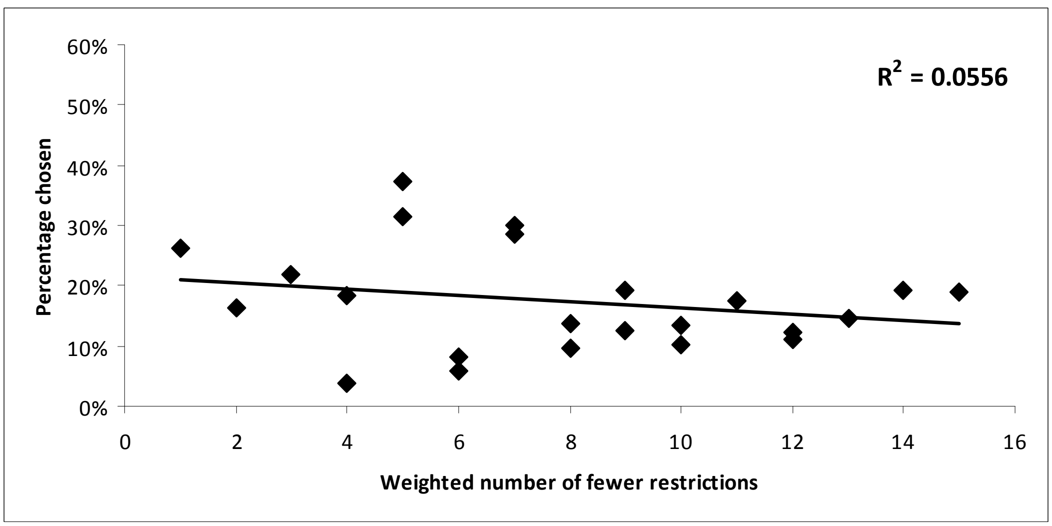


(b)

Figure 4.2. Long Beach: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.

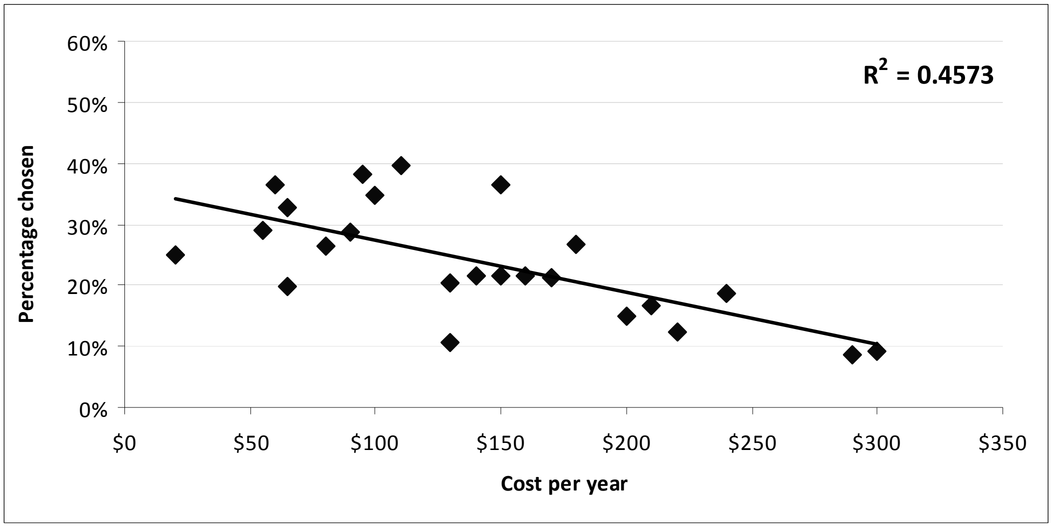


(a)

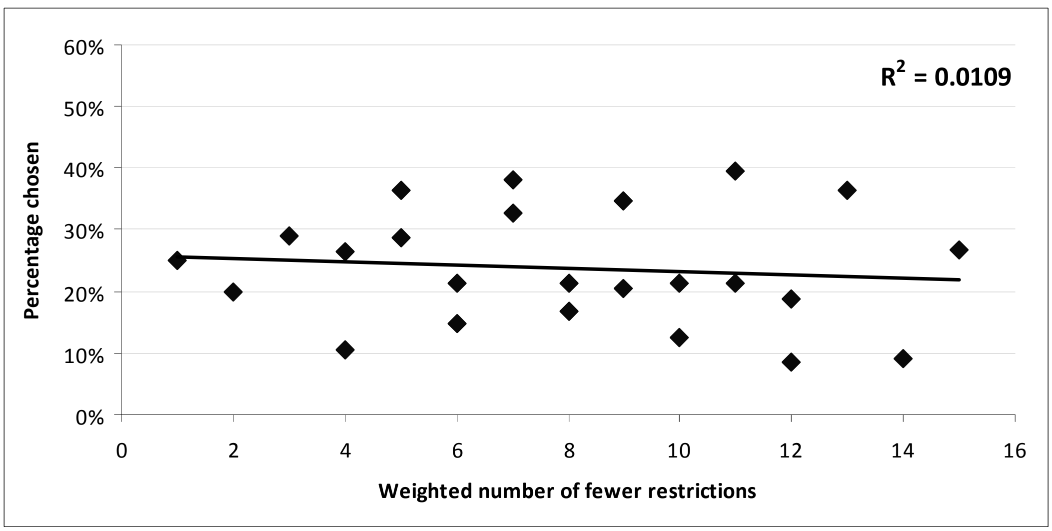


(b)

Figure 4.3. Orlando: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.

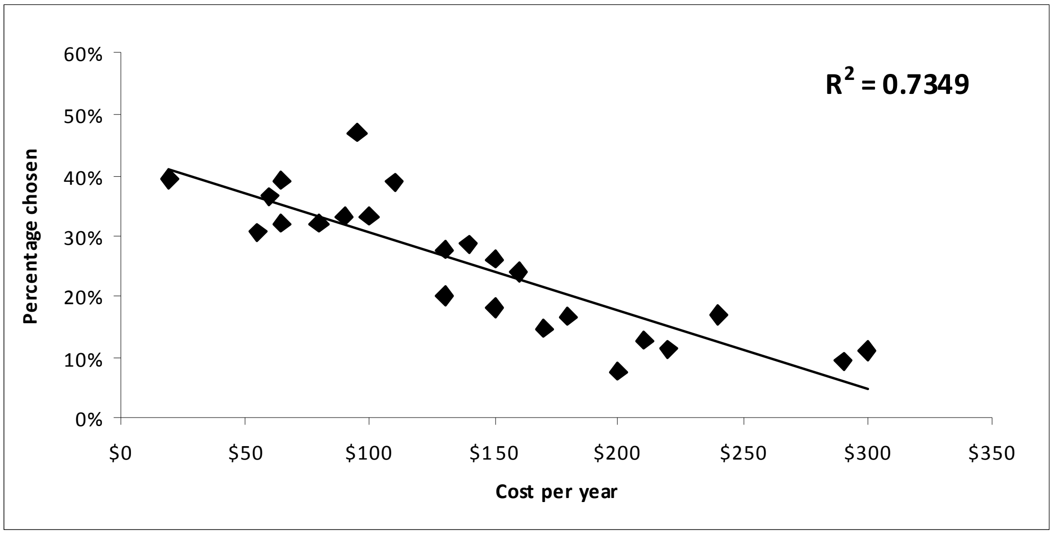


(a)

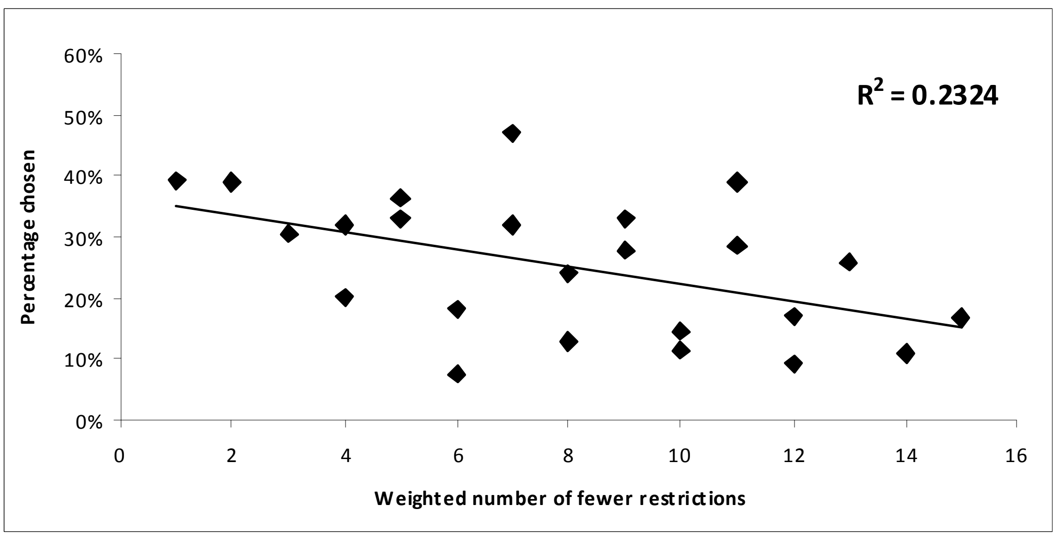


(b)

Figure 4.4. San Francisco: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.



(a)



(b)

Figure 4.5. Utility X: Alternative selection by (a) cost of alternative and (b) number of (weighted) fewer restriction years.

Table 4.3 shows respondent characteristics that were found to statistically influence a respondent's likelihood of choosing an alternative to the status quo in each city.[7] The relationship between a given characteristic and the choice of an alternative to the status quo is described by the positive and negative indicators in the table. For example, the positive indicator for education in Austin means that respondents with higher levels of education are more likely to choose an alternative to the status quo (and thus are willing to pay more to reduce water use restrictions) than their less-educated counterparts. Relationships are reported for those variables that are statistically significant from zero in the models estimated.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative to the no-action scenario decreases) in every city. In Austin, Long Beach, Orlando, and Utility X, the number of fewer restriction years relative to the no-action scenario for Level 1 restrictions does not significantly affect WTP. This means that most individuals are not willing to pay to reduce Level 1 restrictions.

Education is found to have a positive impact on the choice of an alternative in both Austin and San Francisco. Household income positively influences the choice of an alternative in Austin, Orlando, and Utility X, but does not significantly influence this choice in Long Beach or San Francisco. Individuals in Austin and Long Beach who believe increasing water supplies is an important issue in their region are also more likely to choose an alternative to the status quo, and thus are willing to pay more to reduce future water use restrictions.

In Long Beach and Utility X, age negatively affects an individual's likelihood of choosing an alternative, meaning that the older a respondent is, the less he or she is willing to choose an alternative or pay to avoid restrictions. Time spent living in the area also negatively affects the likelihood of choosing a given option in Austin, Orlando, and San Francisco, meaning that the longer a respondent has lived in the city, the less he or she is willing to pay for an alternative that would reduce restrictions. Finally, in Long Beach, respondents who pay their own water bill are less likely to choose an alternative to reduce restrictions compared to individuals for whom water costs are embedded in rental costs or homeowner association fees.

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[7]As part of this analysis, we also evaluated the potential for combining the individual datasets in order to develop one model. First, we implemented a Chow Test. The Chow Test is a method well known in econometrics that can be used to analyze the same variables obtained in two different datasets to determine if they are similar enough to be pooled together. The results of the Chow Test indicated that we would be able to pool the datasets for Austin, San Francisco, and Utility X, but not the datasets for Long Beach and Orlando. The results of the combined model were consistent with results from these individual cities. However, notably, the number of fewer Level 1 restriction years became significant due to the strong significance in San Francisco, and the near significance of Level 1 restrictions in Utility X (significant at the 11% level). This indicates that people are willing to pay to reduce Level 1 restrictions. Other variables that were significant and positive in the combined model include the number for fewer Level 2 restrictions, education, income, and the importance respondents place on increasing water supplies. Time spent living in the community was the only negative and significant variable.

Table 4.3. Respondent Characteristics Influencing the Likelihood of Choosing an Alternative to the Status Quo[a]

	Austin	Long Beach	Orlando	San Francisco	Utility X
Cost per year	-	-	-		-
Reduction in Level 1 restrictions				+	
Reduction in Level 2 restrictions	+	+	+	+	+
Education	+			+	
Age		-			-
Household income	+		+		+
Increasing water supplies is of high importance	+	+			
Time living in city	-		-		
Own a yard					
Pay water bill		-			

[a]Relationships are reported for those variables that are statistically significant at the 5% level.

In addition to the characteristics shown in Table 4.3, we also evaluated whether ethnicity plays a role in the choice of an alternative. In some cities, the small sample size for different ethnic groups makes it difficult to draw concrete conclusions. However, it is clear that relationships between ethnicity and the likelihood of choosing an alternative vary across cities. For example, in Long Beach, our model showed a statistically significant difference between Caucasian and African American respondents, and between Caucasian and Hispanic respondents. In both cases, Caucasian respondents were more likely to choose an alternative to the status quo. In Utility X, Hispanic respondents were less likely to choose an alternative than Caucasian and African American respondents in their community.

To account for small sample sizes, we compared Caucasian respondents to non-Caucasian respondents in each city, grouping all non-Caucasian respondents into one category. We found that in almost every city, Caucasian respondents were more likely to choose an alternative to the status quo compared to their non-Caucasian counterparts. This relationship was positive and statistically significant in all cities except for Austin. In Austin, Caucasian respondents were not found to be statistically different from respondents in their communities with different ethnic backgrounds.

Table 4.4. Residential Customer Annual Willingness to Pay

	Austin	Long Beach	Orlando	San Francisco	Utility X
WTP to reduce Level 1 restrictions by 1 year out of the next 20[a]				$12.25	
WTP to reduce Level 2 restrictions by 1 year out of the next 20	$33.94	$34.29	$20.20	$37.16	$20.55

[a]The WTP estimates for reducing Level 1 restrictions are not statistically significant from zero in Austin, Long Beach, Orlando, and Utility X (i.e., respondents are not willing to pay to reduce Level 1 restrictions) and are therefore not reported in this table.

4.2.2 Mean Annual Willingness-to-Pay Estimates

Using the parameter estimates from the conditional logit model, we calculated annual WTP measures for reducing Level 1 and Level 2 restrictions. Table 4.4 presents the estimated mean annual WTP for a one-summer reduction in each restriction. The WTP estimates for reducing Level 1 restrictions are not statistically significant from zero in Austin, Long Beach, Orlando, or Utility X (i.e., respondents are not willing to pay to reduce Level 1 restrictions) and are therefore not reported in Table 4.4. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 is positive and statistically significantly different from zero in all cities. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

As shown in Table 4.4, respondents in San Francisco are willing to pay the most to reduce drought restrictions. Respondents in Orlando and Utility X are not willing to pay as much as respondents in other cities. This is likely attributable to differences in the experiences and attitudes of residents in these locations.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the Long Beach survey, the next 20 years were portrayed as yielding an anticipated 7 years with no restrictions, 10 years with Level 1 restrictions, and 3 years with Level 2 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all the projected Level 1 and Level 2 use restrictions. The mean annual WTP results shown in Table 4.4 suggest that the total household WTP for this program would be [($0 × 10) + ($34.29 × 3)] = $102.87 per year. This conclusion assumes a constant WTP for reductions in restriction years.

4.3 Customer Preferences for Different Types of Water Supply Enhancement

The following sections present findings from the survey related to the types of water supply projects that customers think their utility should pursue to expand and enhance their existing supply portfolios.

4.3.1 Most Preferred Water Supply Enhancement Options

Respondents were asked to rank a series of different options that water suppliers in their region could undertake to improve future water supply reliability. In each city, 9 or 10 choices were presented on the survey. Options presented in all surveys included

- Increasing available supplies of water by transferring more water from agricultural uses
- Increasing the price of water to residential, commercial, and industrial users so they will use less
- Requiring low-water-use landscaping (e.g., Xeriscape) for new homes and redevelopment projects
- Expanding the use of recycled water for outdoor irrigation and industrial uses

- Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low-water-using appliances or landscaping)
- Adopting a water import option that involved importing surface water from outside the region or river basin

Additional alternative options presented in different cities included

- Expanding water recycling to replenish groundwater reservoir supplies (Austin, Long Beach, Orlando, San Francisco)
- Investing in regional desal facilities to convert ocean, bay, or brackish waters into part of the local drinking water supply (Long Beach, San Francisco, Orlando)
- Increasing available supplies of water by expanding or adding new storage reservoirs (Austin, Orlando, San Francisco)
- Increasing the use of nonlocal groundwater sources (Austin, Long Beach)
- Increasing the use of local groundwater sources (Austin, Orlando)
- Increasing available supplies in dry years by acquiring more imported water in wet years and storing it underground for local use in dry years (Long Beach, Orlando)

For each option, a brief description, including advantages and disadvantages, was provided. Respondents were then asked to rank their five most preferred options. Figure 4.6 shows the percentage of respondents who ranked a given option as one of their top three choices.

As shown in Figure 4.6, in Long Beach, Orlando, and San Francisco (results from the survey conducted within the Utility X service area are not reported here because of confidentiality agreements), the three most preferred water supply options included expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting additional voluntary conservation measures through education and incentives, and requiring low-water-use landscaping for new development and redevelopment projects. Compared to the other cities, a higher percentage of respondents in San Francisco selected these options as one of their top three choices. In Austin, although results were similar, respondents ranked using recycled water to replenish groundwater as one of their three most preferred options more frequently than requiring low-water-use landscaping.

Figures 4.7–4.10 show specific results for the top three water supply options in each city.

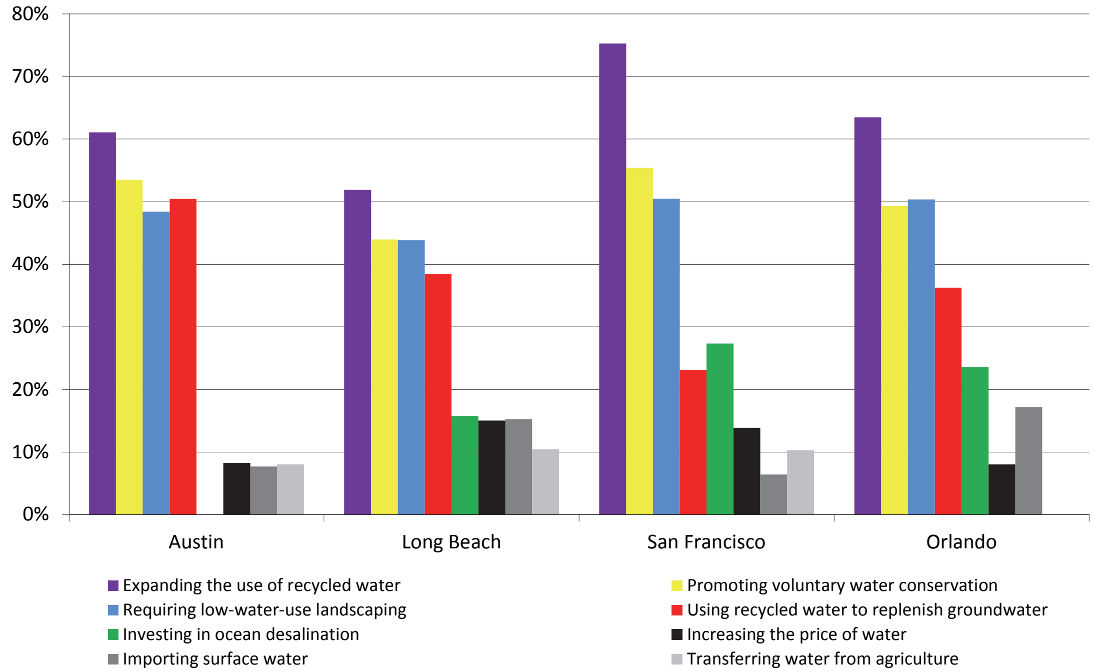

Figure 4.6. Percentage of respondents, by city, who selected a given option as one of their three most preferred options for water supply enhancement.

4.3.2 Least Preferred Water Supply Enhancement Options

As a follow-up to the ranking of various supply enhancement options, we asked respondents to choose their *least* preferred option of the remaining unranked choices. Figure 4.11 shows that in most cities surveyed, “increasing the price of water so that customers will use less” is the least-preferred option among respondents. In San Francisco, a slightly greater number of respondents chose “importing new surface water supplies outside the Bay Area” as their least preferred option. Importing surface water from outside the region or river basin was the second least preferred option in Austin and Long Beach. “Increasing available supplies of water by transferring more water from agricultural uses to urban areas” also seems to be a relatively unpopular option in most cities.

Interestingly, in San Francisco, about 13% of respondents chose investing in regional desal facilities as their least preferred option. However, close to 26% of respondents chose desal as one of their three most preferred options.

4.4 Summary

Overall, the survey results indicate that in most cities, customers are willing to accept some level of water use restrictions (e.g., limiting irrigation of lawns and landscape to two days per week). However, customers are willing to pay to avoid more severe restrictions (e.g., prohibition of the irrigation of lawns and landscape). Annual WTP values to avoid these more severe restrictions ranged from $20 (Orlando and Utility X) to about $37 (San Francisco).

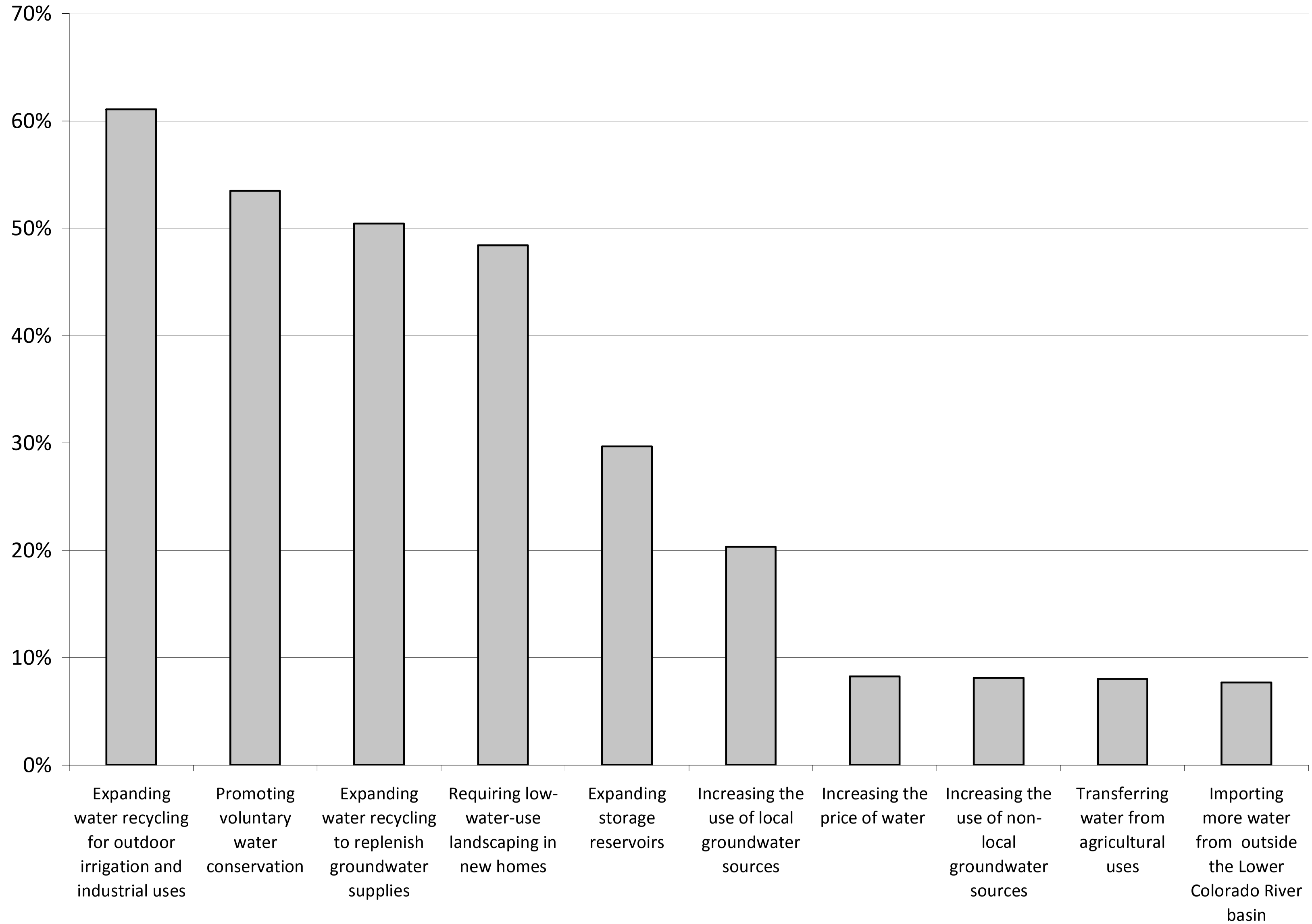

Figure 4.7. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Austin.

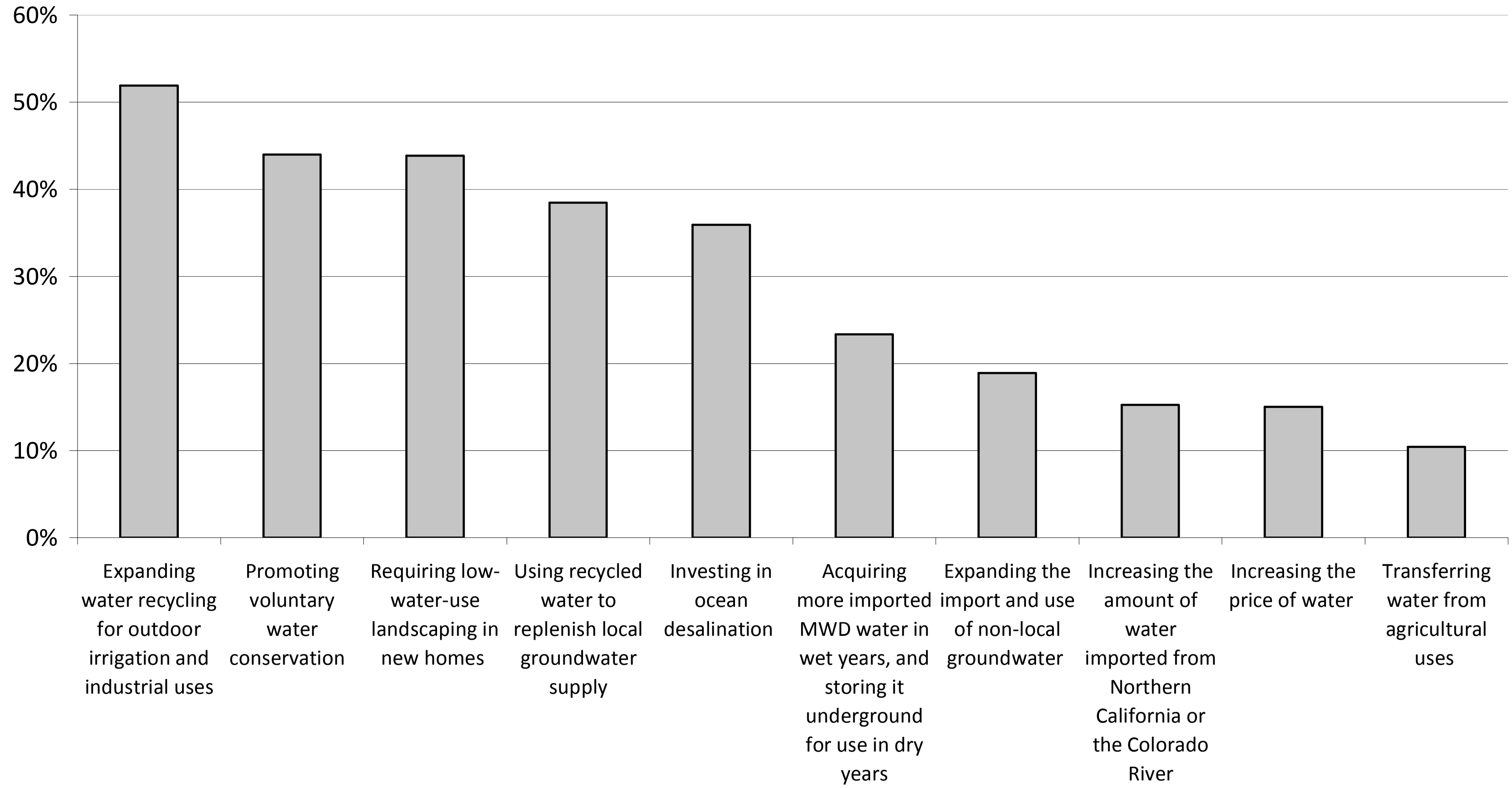

Figure 4.8. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Long Beach.

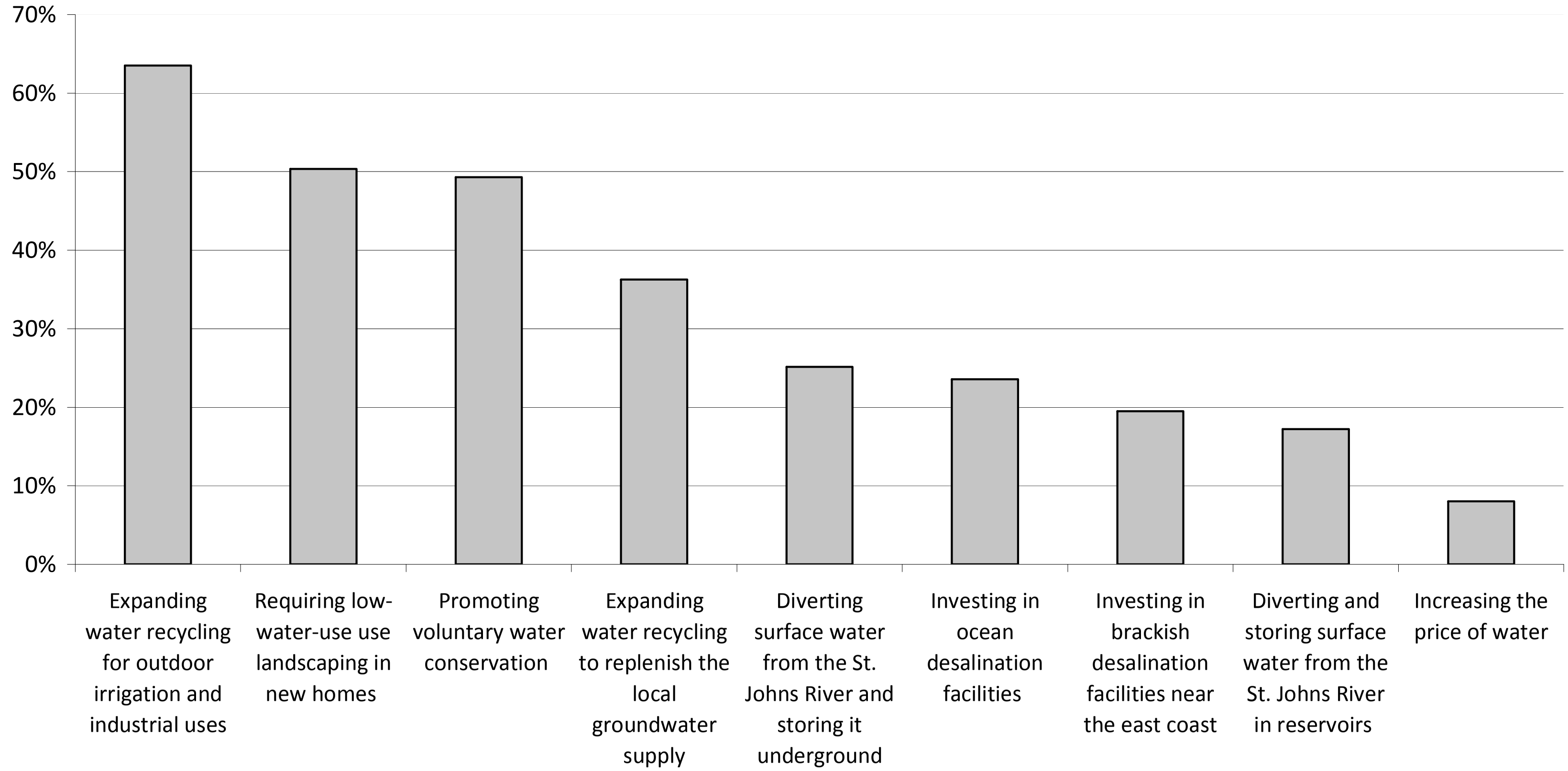

Figure 4.9. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: Orlando.

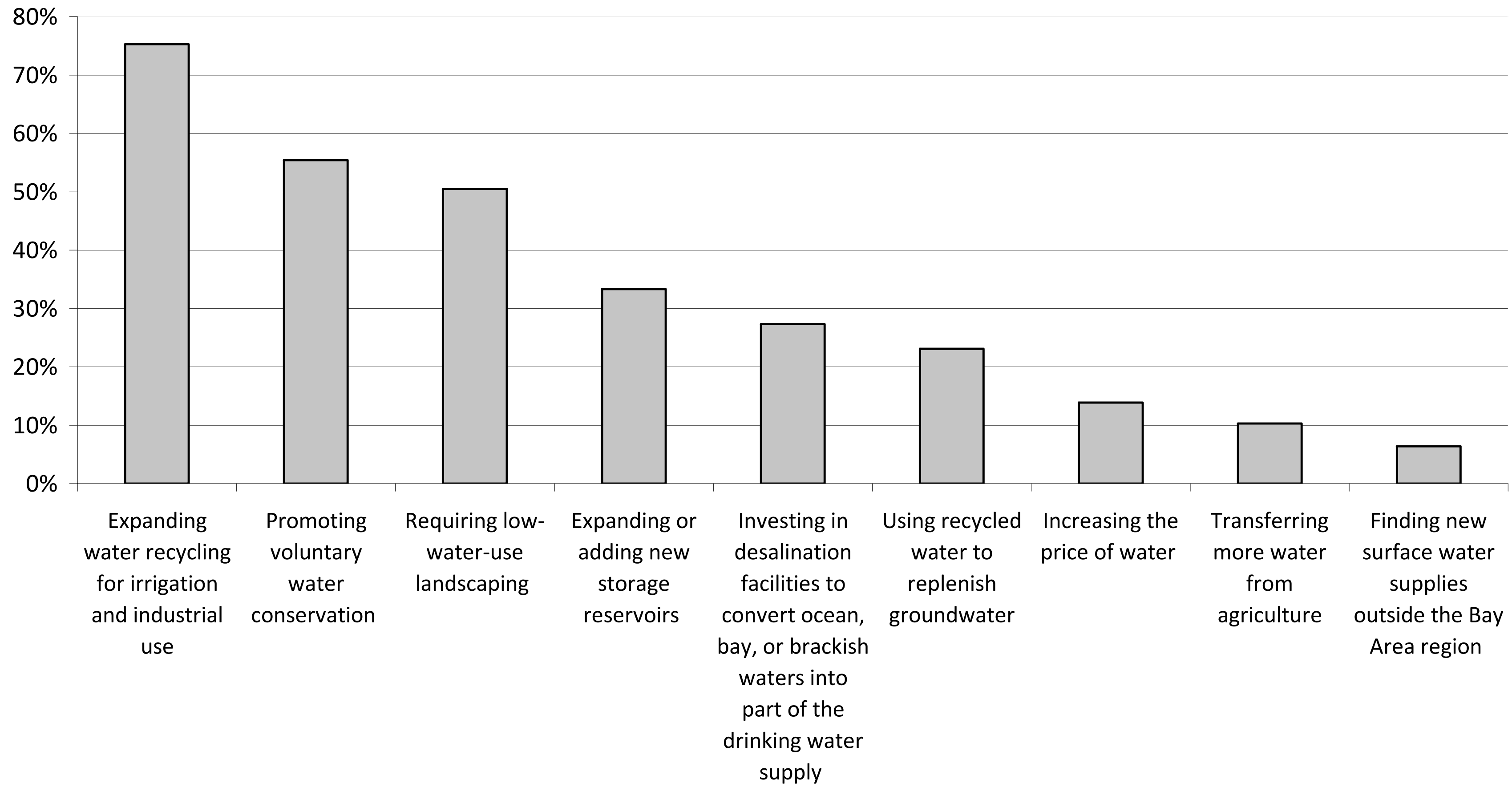

Figure 4.10. Percentage of respondents selecting a given option as one of their top three choices for water supply enhancement: San Francisco.

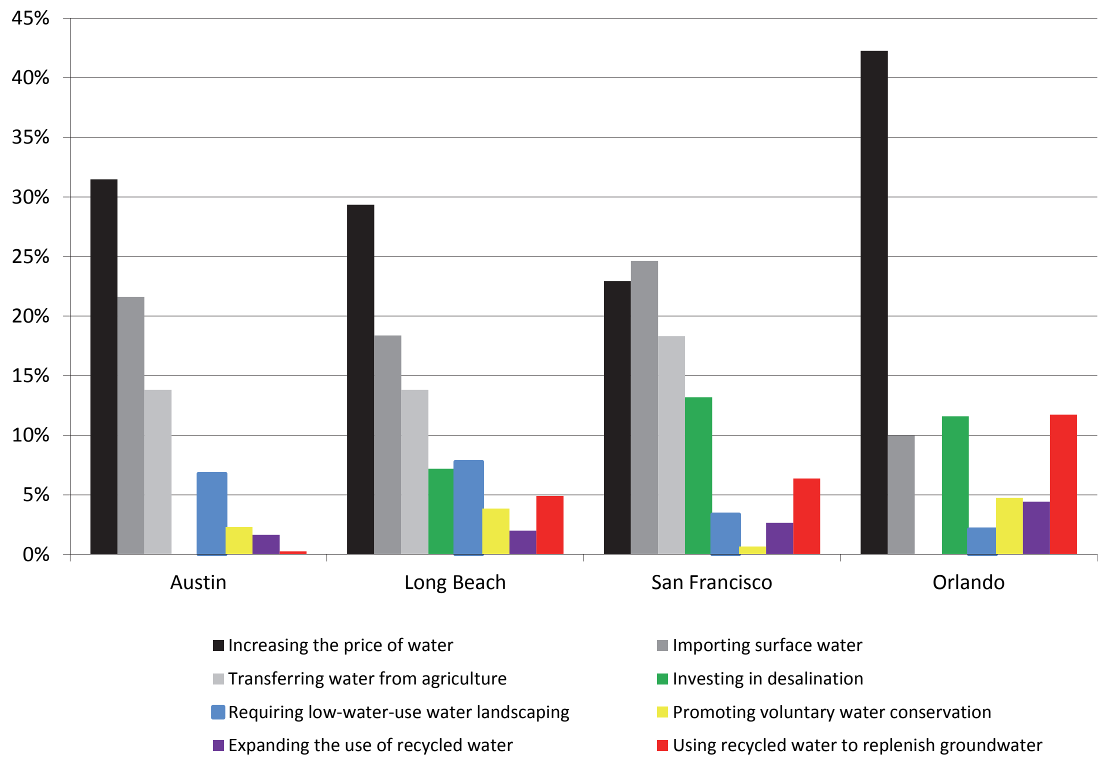

Figure 4.11. Percentage of respondents, by city, and their least preferred option rankings.

The most preferred water supply options in Long Beach, Orlando, and San Francisco included expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting additional voluntary conservation measures through education and incentives, and requiring low-water-use landscaping for new development. About 27%, 24%, and 15% of respondents in San Francisco, Orlando, and Long Beach, respectively, also chose investing in regional ocean desal facilities as one of their three most preferred options. Close to 17% of respondents in Orlando chose investing in brackish groundwater desal facilities as one of their three most preferred options. In Austin, nonpotable use of reclaimed water was also a top choice, and more respondents chose using recycled water to replenish groundwater supplies (i.e., IPR) than requiring low -water-use landscaping as one of their three most preferred options.

Chapter 5

Interpreting and Applying the Empirical Findings

This chapter summarizes the key empirical survey results and provides guidance on how these outcomes may be interpreted within the context of water utility planning. First, some general, qualitative observations are offered, based on the results derived from our survey efforts. Then, specific empirical findings are discussed with regard to how they might be interpreted and applied.

Also provided in this chapter is general guidance for utilities that may be interested in using or refining our survey instrument (or developing their own surveys) to assess customer attitudes and WTP for water supply reliability and water supply enhancement options.

5.1 General Observations and Interpretations

As described in Chapter 4, several empirical findings were consistently observed across the utility service areas in which customers were surveyed. Although these findings may not necessarily apply to customers in a specific utility, the consistency of findings across the five regions suggests that the preferences expressed may be consistently held in many other geographical areas. These general observations are discussed in the following paragraphs.

> *1. Residential customers consistently reveal a positive WTP to improve the reliability of their water supply in order to avoid relatively severe water use restrictions.*
>
> The estimated WTP to avoid Stage 2 water use restrictions was statistically significant (in terms of being statistically different from zero) in all five regions and ranged from \$20.20 per household per year (Orlando) to \$37.16 per household per year (San Francisco). These values reflect the WTP of households each year to avoid one year of Stage 2 restrictions at some point over the next 20 years. Complete results are provided in Chapter 4 (Table 4.4).
>
> Given that the scenarios evaluated in the survey reduced the projected number of Stage 2 restrictions by up to 3 years, the WTP to avoid all Stage 2 restrictions over the 20-year period ranged from \$60.60 to \$111.48 per household per year. These per household annual WTP values are consistent with the lower-end values derived by the earlier WTP studies described in Chapter 2 (e.g., typically near to or more than \$100 per household per year). However, the earlier studies typically implied a level of certainty for avoiding all restrictions. Consequently, we expect the WTP responses from those studies to be greater than the responses derived in our current empirical work, because our approach allows choices that do not eliminate all Stage 2 or Stage 1 restrictions (i.e., our approach has households purchasing less certainty regarding the elimination of restrictions than most of the older studies).

2. Residential customers tend to view low-level water use restrictions as an acceptable inconvenience and generally express a low WTP to avoid such water supply shortages.

The estimated WTP to avoid Stage 1 water use restrictions was typically quite low and was not statistically significant in four of the five regions (San Francisco being the one exception, where a statistically significant WTP of $12.25 per household per year to avoid a future year of Stage 1 restrictions was derived). This suggests that customers generally are willing to accept periodic imposition of low-level Stage 1-type restrictions, seeing them as a periodic inconvenience rather than an event necessitating significant financial investment in supply enhancement. This result is consistent with the findings from the Australian survey efforts that used choice experiments (Hensher et al., 2006; Tapsuwan et al., 2007).

This finding also supports policies under which utilities consider imposing Stage 1-type restrictions before water supplies reach critical levels, as a risk-avoiding, proactive effort to preclude the need for more restrictive Stage 2 policies later. That is, having more frequent and/or longer-duration imposition of Stage 1 restrictions may be warranted if this conservation of water helps reduce the likelihood that Stage 2 restrictions will be needed later.

3. Water reuse options, including IPR options, appear to have a high level of customer support.

In each service area, survey respondents were provided with an opportunity to review a list of 9 or 10 water supply enhancement options and to rank their top five preferences. We then determined which options were selected as the top choices. Because respondents may not have a significant degree of preference among their top three options (i.e., we do not know the strength of preference for a top choice relative to the second and third preferred options), we believe an examination of the options that tended to be selected in the top three preferred choices provides a reliable indication of general preference.

As shown in Chapter 4, in each of the five service areas, the option to expand water reuse for outdoor irrigation and industrial use was most frequently selected as one of the top three alternatives. Hence, the expanded use of recycled water for nonpotable uses (e.g., via purple pipe) was the most popular choice in each region.

The use of recycled water to replenish local groundwater (i.e., IPR) was also considered very favorably. As noted previously, it was the second most popular option in one region, and was ranked third, fourth (twice), and fifth—out of 10 options—in the other regions. This is a somewhat surprising show of public acceptance, given concerns often raised by some water sector professionals about potential or anticipated public opposition to IPR.

The other options that tended to rank relatively high as preferred water supply enhancements were those related to conservation, especially the option promoting voluntary efforts supported by rebates.

4. Raising water rates and importing more water from outside the service area were typically the least preferred options.

The survey also was used to elicit opinions on which options customers preferred the least (based on respondents being shown the options that they did not rank in their top five and being asked to select their "least preferred" of those four or five unranked alternatives). As shown in Chapter 4, the options that were consistently listed as least popular were raising the price of water to promote use of less water and importing more water from outside the region (or importing waters transferred from agricultural users).

The high degree of dislike for the option of using price as a rationing mechanism is noteworthy, especially when one considers that respondents also expressed a significant WTP to invest in water supply enhancements to reduce the frequency of water shortages and associated use restrictions. This adds strength to the WTP estimates because even though customers have a strongly expressed disapproval of rate increases to conserve water, they are nonetheless willing to pay to enhance supplies when this reduces the likelihood (frequency) of severe water use restrictions.

The general disapproval of water import options is also interesting and suggests a preference for solving local water issues with local resources (which in turn may enhance or explain the expressed support for water recycling options). Discussions within the focus groups about water importation options often generated statements reflecting concern over taking someone else's water and the desire or need to solve local water issues with local resources. Taking water from farmers was also widely rejected, and focus group discussions on this topic tended to reflect concern over actions that might impair farmers' ability to produce food crops (even though the option was framed as paying to improve agricultural water use efficiency, and only transferring the water saved).

5.2 Empirical Interpretation and Application

There are two basic approaches to using the empirical information developed from our survey research. One is to use the basic survey instrument, refine and test it so that it best reflects circumstances relevant to the local service area, and then implement the site-specific revised survey within the service area. This approach will typically provide the most reliable and utility-specific information. However, it will require an investment of time and resources to modify, pretest, and implement the survey and to analyze the data collected. Guidance on how to proceed with this process is provided later in this chapter.

The second approach to using the empirical information obtained in our research is through a method called "benefits transfer." In essence, this approach entails assuming that the empirical results presented here are indicative of the types of WTP values customers served by a utility have. This requires much less effort and little funding. However, the results may be less reliable, to the degree that customers and/or local water supply circumstances differ from those in the five utilities included in our investigation.

5.2.1 Applying Values Derived from This Study

The empirical WTP findings from this study are statistically significant and fairly consistent across service areas. Hence, they may be taken as a range to reflect household WTP for water supply reliability. More specifically, it seems reasonable to infer that, on the average, households have expressed a WTP to avoid one year of Stage 2-type severe water use restrictions that is on the order of \$20 to \$37 per household per year.[8]

Several important "standard practices" should be followed in applying these values in a BT context. First, you need to determine whether the study population (the 2000 + respondents to our survey) is similar to the service area population in your region. Are there reasons to believe that customers in your service area may be different in important ways from those who responded to our survey? For example, are they richer or poorer than the study population? Have they had similar exposure to and experiences with periodic imposition of water use restrictions? Do they have larger or smaller yards and outdoor irrigation needs or habits?

Second, one needs to consider if the water shortage and water use restriction scenarios applicable to your utility are similar to those characterized for the service areas surveyed. If there are similar stages defined for potential water use restrictions, similar histories of their deployment, and similar likelihood of future frequencies, then the scenarios evaluated in our work are probably similar enough to your utility's circumstances. If water shortages in your region are likely to be appreciably different in terms of likelihood and impact, then the results from our survey efforts are unlikely to be applicable to your utility's situation.

If there is reasonable confidence that BT is suitable, then apply the range of values to the number of households served by your system, adjusted for the number of Stage 2-type restrictions that you estimate are likely to be avoided over the relevant time horizon (e.g., three avoided Stage 2-like restrictions being imposed over the next 20 years). This provides a rough estimate of the potential dollar value of your residential customer sector, in terms of how much customers are willing to pay for supply-enhancing investments that will likely enable your utility to avoid those shortfalls. For example, if you are evaluating an option that you believe would preclude three years that otherwise would have resulted in Stage 2 restrictions and you serve 25,000 households, then the lower end of the range would be \$1.5 million per year (\$20 per household per year × 25,000 households × 3 years of severe restrictions avoided).

Another perspective can be attained by interpreting the household WTP estimates in terms of the value per unit of water provided (e.g., dollar per acre-foot). A rough approximation can be derived by calculating the per household amount of water use enabled by avoiding the restrictions (or, stated alternatively, the volume of water saved by imposing the restrictions) and comparing that with the household WTP estimate.

For example, in Utility X, the mean WTP estimate to avoid one year of Stage 2 restrictions is \$20.55 per household. The amount of additional water use reduction from moving from Stage 1 to Stage 2 restrictions is estimated by Utility X to be 15%. Per household water use

[8]We strongly recommend using the full range of values, rather than selecting a single dollar value for WTP.

for homes with yards is typically 340 gallons per day, or 38% of an acre-foot per year. A 15% reduction under Stage 2 restrictions thus amounts to 5.7% of an acre-foot of water use foregone per household (15% of 38%). A household WTP of $20.55 each year for 20 years has a present value of $250, when discounted at 6%. This $250 is the WTP to avoid losing use of 0.057 acre-feet in one future year. Therefore, the implied value to the household for that water use is $4386 per acre-foot (= $250/0.057 acre-foot).[9]

5.2.2 Revising and Applying the Survey Instrument to Your Service Area Customers

If you are interested in applying this survey to residential customers in your area, we recommend that you adhere to the accepted best practices for survey design and implementation that are described in the following paragraphs.

> *1. Review and revise the survey instrument* to best reflect your local circumstances. For example, apply water use data from your system, describe your water use restrictions as they have been applied or would apply in the future (though simplifying as needed to not overload or confuse respondents), show past and projected frequencies of water use restrictions as most applicable to your setting, and describe the water supply enhancement options that are most applicable to your region. For the choice experiments, use the 24 options we drew randomly if they all are suitable given your past history and projected future conditions. Otherwise, develop a suite of alternative future program options with costs and restriction frequencies that are internally consistent.
>
> *2. Conduct focus groups* to ensure that local customers understand the information provided to them. Focus groups should be recruited to reflect a representative sample, and facilitated by an experienced professional. Focus groups are essential to ensure that typical customers find the choices relevant and realistic, and can complete the tasks imposed on them in the survey (e.g., in the choice experiment portion, ensure that they understand what information the pie charts convey and can make informed choices between the status quo and the one or two alternatives presented to them). Focus groups also are invaluable to help find and apply the right words that resonate with laypeople rather than technical jargon that utility professionals use routinely.
>
> *3. Pretest the survey* by applying it to a small sample of the general public in a controlled setting. This step often adds value, especially when one-on-one debriefings are held with the pretesters, who can explain what they may have found confusing or other problems. Refine and repeat as necessary.
>
> *4. Implement the survey in the field* (i.e., collect data). Our survey was designed specifically for application over the Internet, using a representative sample of the general public from the Knowledge Networks Internet Panel. This approach provides many advantages, including the ability to have a more interactive survey. For

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[9]This is similar to the result derived in Raucher et al. (2006, Appendix D) in terms of evaluating the WTP results from the older stated preference studies as dollar per acre-foot values. There, the Griffin and Mjelde (2000) WTP results were shown to imply a value of roughly $4900 per acre-foot (updated to 2011 dollars).

example, a response can be used to steer the respondent to the next appropriate follow-up question, or respondents can be prompted to go back when they missed a question or failed to successfully complete the assigned task (e.g., rank options). The Internet-based approach also produces a very high response rate, eliminates coding errors, and enables extremely fast data collection turnaround. However, this approach can be costly (e.g., at least $25,000 for a target of 400 completed surveys), requires retaining a reputable Web-based survey firm, and may be limited by the size of panel sample available within a defined utility service area.

Alternative modes for survey implementation are mail and telephone. There are drawbacks to both approaches, such as low response rates, long implementation periods to successfully gather data from a sufficient sample size, data entry needs, associated labor expense, and the potential for introducing errors. Telephone surveys also provide less representative samples from the general public because fewer people retain landlines (and those who do tend to be elderly). Also, with caller identification and the prevalence of marketing calls, fewer people are willing to answer the telephone and complete a complex 20-minute survey. In addition, the survey will need some redesign to accommodate implementation by telephone or mail (e.g., to preselect the options provided in the choice experiments, with different respondents receiving a preselected suite from which to choose).

5. Analyze the data carefully and apply them prudently. The data require sophisticated statistical analysis, and specialized expertise may be needed for effective analysis. Also, be careful when interpreting the data (e.g., it may be tempting to overreach, using results that lack statistical significance). Strongly consider retaining a suitable expert as an independent reviewer to assess all aspects of the project effort, including the results and how they will be applied.

For all these steps, it may be prudent to retain outside, specialized expertise to guide you through the process, from recruiting and hosting focus groups, to developing the sampling strategy and implementing the survey, to analyzing the data.

5.3 Conclusions

The empirical findings derived from this study are generally robust and provide useful information. In particular, it is evident that households in the sampled areas of the United States have a significant WTP to enhance the local water supply portfolio to reduce the likelihood of severe water use restrictions in some future years (although there is much less inclination to pay for programs that reduce the frequency of less severe water use restrictions). There is thus an empirically demonstrated value for enhanced water supply reliability, and the guidance and illustrations provided here facilitate the practical use of these findings by water agencies.

There also are very interesting and robust results with respect to customer preferences for options they would opt to pursue to enhance the utility’s water supply portfolio. Water reuse consistently was among the top choices, even the IPR options, and conservation was also widely popular. In contrast, raising water rates to prompt less water use, water importation, and transfers from agriculture were generally viewed unfavorably.

Chapter 6

Suggested Future Research

Based on our research and the empirical results obtained, three follow-up research needs were identified to improve our understanding of reliability values. The following is a description of those needs.

1. Repeat and update the empirical effort in two to four years.

The results from the current study will be greatly enhanced and will retain their applicability if the survey effort is periodically updated and implemented, perhaps every two to four years. For example, our results are probably strongly influenced by the difficult economic climate most Americans were facing during the data collection period (last half of 2010 and first half of 2011). Once the economy improves, it will be instructive to determine if WTP for water supply enhancements increases when unemployment and fiscal worries are less prevalent among residential customers. In addition, it will be very instructive to observe how attitudes, preferences, and WTP may be impacted by different water scarcity conditions. How will respondents' WTP and supply preferences change if they have recently experienced more severe water shortages and use restrictions (or when they have just enjoyed relatively wet years)?

Finally, it will be useful to apply the updated versions of the survey to new regions and to repeat the effort in some regions that were previously investigated. Expanding the survey effort to new regions will enable us to see how WTP and attitudes vary across different parts of the nation and will facilitate the use of survey results by more utilities. Repeating the survey effort in a few already-surveyed service areas will enable us to discern trends over time within the same service area population (e.g., Have they changed their WTP? Have they modified their preferences regarding alternative water supply options? If so, why?).

2. Investigate the basis for and strength of supply option preferences more closely.

The survey provided very interesting, useful, and somewhat surprising results in terms of how strongly the respondents consider water recycling (including IPR) to be one of their most preferred reliability-enhancing options. This is very encouraging for the water reuse community, and additional work would enable us to more closely explore the basis and strength of the apparent high level of public support for reclamation. How much of the stated support expressed in our empirical results stems from having the other parts of the survey establish a suitable context (i.e., establishing the need to enhance water supply portfolios in order to reduce the likelihood and severity of future shortages), rather than discussing water reuse in more abstract terms (e.g., apart from the need to make a choice to solve a problem)? How will the provision of additional facts and issues potentially alter the level of support (e.g., pharmaceuticals and personal care products)?

The public preference for water reuse provides an important opportunity for the reuse community. More work should be done to strengthen our knowledge of the basis of those preferences and how they can be maintained and strengthened.

3. Investigate reliability values beyond the residential sector.

This research effort has focused exclusively on the value of water supply reliability to residential customers (i.e., households). It will be valuable to extend this line of empirical inquiry to other customers, notably those in the CII sectors.

References

Adamowicz, W.; Dupont, D.; Krupnick, A. The Value of Good Quality Drinking Water to Canadians and the Role of Risk Perceptions: A Preliminary Analysis. *Journal of Toxicology and Environmental Health* **2004**, *67*, 1825–1844.

Adamowicz, W.; Louviere, J.; Williams, M. Combining Revealed and Stated Preference Methods for Valuing Environmental Amenities. *Journal of Environmental Economics and Management* **1994,** *26*, 271–292.

Adamowicz, W.; Boxall, P.; Williams, M.; Louviere, J. Stated Preference Approaches for Measuring Passive Use Values: Choice Experiments and Contingent Valuation. *American Journal of Agricultural Economics* **1998a**, *80*, 64–75.

Adamowicz, W. L.; Boxall, P.; Louviere, J.; Swait, J.; Williams, M. Stated Preference Methods for Valuing Environmental Amenities. In *Valuing Environmental Preferences: Theory and Practice of the Contingent Valuation Method in the US, EC and Developing Countrie*s; Bateman, I., Willis, K., Eds.; Oxford University Press: London, UK, **1998b**, pp. 460–479.

Alcubilla, R. G.; Lund, J. R. Derived Willingness-to-Pay for Household Water Use with Price and Probabilistic Supply. *Journal of Water Resources Planning and Management* **2006**, *132*, 6.

Breffle, W. S.; Rowe, R. D. Comparing Choice Question Formats for Evaluating Natural Resource Tradeoffs. *Land Economics* **2002**, *78*, 2.

Breffle, W. S.; Morey, E. R.; Rowe, R. D.; Waldman, D. M. Combining Stated-Choice Questions with Observed Behavior to Value NRDA Compensable Damages: A Case Study of Recreational Fishing in Green Bay and the Lower Fox River. In *The Handbook of Contingent Valuation;* Bjornstad, D., Kahn, J., Alberini, A., Eds.; Edward Elgar: Northampton, MA, 2005.

Brozovi´c, N., Sunding, D. L.; Zilberman, D. Estimating Business and Residential Water Supply Interruption Losses from Catastrophic Events. *Water Resources Research* **2007**, 43, W08423.

Carson, R. T.; Mitchell, R. C. *Economic Value of Reliable Water Supplies for Residential Water Users in the State Water Project Service Area*; SWC Exhibit Number 54; The Metropolitan Water District of Southern California, Los Angeles, 1987.

CUWA. *The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers*, California Urban Water Agencies, Sacramento, CA. [Online] **1994.** http://www.cuwa.org/library/TheValueofWaterSupplyReliabilityAug94.pdf (accessed October 1, 2009).

Damodaran, N.; Pratt, J.; Cromwell, J.; Lazo, J.; David, E.; Raucher, R.; Herrick, C. *Customer Acceptance of Water Main Structural Reliability,* American Water Works Association Research Foundation, Denver, CO, 2005.

Damodaran, N.; Cromwell, J. E. III; Lazo, J. K.; David, E.; Pratt, J. L. External Costs and Customer Attitudes for Distribution System Renewal and Reliability, American Water Works Association 2004 Annual Conference and Exposition, June, 2004.

Fisher, A.; Fullerton, D.; Hatch, N.; Reinelt, P. Alternatives for Managing Drought: A Comparative Analysis. *Journal of Environmental Economic and Management* **1995**, *29*, 304–320.

Griffin, R. C.; Mjelde, J. W. Valuing Water Supply Reliability. *American Journal of Agricultural Economics* **2000**, *82*, 414–426.

Haab, T. C.; McConnell, K. E.; Eds. *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation*; Edward Elgar: Northampton, MA; 2002.

Hanemann, M. J.; Loomis, J.; Kanninen, B. Statistical Efficiency of Double-Bounded Dichotomous Choice Contingent Valuation. *American Journal of Agricultural Economics* **1991**, *73*, 4, 1255–1263.

Hanley, N.; Mourato, S.; Wright, R. Choice Modelling Approaches: A Superior Alternative for Environmental Valuation? *Journal of Economic Surveys* **2001**, *15*, 3, 435–462.

Hensher, D.; Shore, N.; Train, K. Households' Willingness to Pay for Water Service Attributes. *Environmental & Resource Economics* **2005**, *32*, 509–531.

Hensher, D.; Shore, N.; Train, K. Water Supply Security and Willingness to Pay to Avoid Drought Restrictions. *Economic Record* **2006**, *82*, 256, 55–66.

Holmes, T. P.; Adamowicz, W. L. A ttribute-Based Methods. In *A Primer on Nonmarket Valuation;* Champ, P. A.; Boyle, K. J.; Brown, T. C., Eds.; Kluwer Academic: Dordrecht, The Netherlands, 2003, pp. 171–220.

Howe, C. W.; Smith, M. G. The Value of Water Supply Reliability in Urban Water Systems. *Journal of Environmental Economics and Management* **1994**, *26*, 19–30.

Jenkins M. W.; Lund, J. R. Integrating Yield and Shortage Management Under Multiple Uncertainties. *Journal of Water Resources Planning and Management* **2000**, *126*, 5, 288–297.

Jenkins, M. W.; Lund, J. R.; Howitt, R. E. Using economic loss functions to value urban water scarcity in California. *Journal of the American Water Works Association* **2003**, *9* (2).

Johnson, F. R.; Desvousges, W. H.; Fries, E. E.; Wood, L. L. *Conjoint Analysis of Individual and Aggregate Environmental Preferences;* Triangle Economic Research Technical Working Paper No. T-9502; Triangle Economic Research: Cary, NC, 1995.

Kanninen, B., Ed. *Valuing Environmental Amenities Using State Choice Studies*. 1st ed. Springer: Dordrecht, The Netherlands, 2007.

Kasower, S.; Raucher, R.; Wolff, G.; Beuhler, M. *Portfolio Theory: Implications for Valuing New Sources in Water Supply Planning,* prepared with support from the Bureau of Reclamation, U.S. Department of Interior, Denver, CO, 2007.

Koss, P.; Khawaja, M. S. The Value of Water Supply Reliability in California: A Contingent Valuation Study. *Water Policy* **2001**, *3*, 165–174.

Layton, D.; Brown, G. *Heterogeneous Preferences Regarding Global Climate Change*. NOAA Applications of Stated Preference Methods, Presented at Resource Compensation Workshop, Washington, DC, 1998.

Louviere, J. J.; Hensher, D. A.; Swait, D. A. *Stated Choice Methods: Analysis and Application*. Cambridge University Press: Cambridge, UK, 2000.

Luce, R. D. *Individual Choice Behavior: A Theoretical Analysis*. Wiley: New York, NY, , 1959, ISBN 0-486-44136-9.

Lund, J. R. Derived Estimation of Willingness to Pay to Avoid Probabilistic Shortage. *Water Resources Research* **1995**, *31*, 1367–1372.

MacDonald, D. H, Barnes, M.; Bennett, J.; Morrison, M.; Young, M. D. *What Consumers Value Regarding Water Supply Disruptions: A Discrete Choice Analysis*? CSIRO: South Australia, 2003. http://www.cmis.csiro.au/Mary.Barnes/pdf/WTP_200305.pdf (accessed 10/1/2009).

Magat, W. A.; Viscusi, W. K.; Huber, J. Paired comparison and contingent valuation approaches to morbidity risk valuation. *Journal of Environmental Economics and Management* **1988**, *15*, 395–411.

Markowitz, H. M. Portfolio Selection. *Journal of Finance* **1952**, *7* (1), 77–91..

Mathews, K. E.; Desvousges, W. H.; Johnson, F. R.; Ruby, M C. *Using Economic Models to Inform Restoration Decisions: The Lavaca Bay, Texas Experience*. TER technical report presented at the Conference on Restoration of Lost Human Uses of the Environment, Washington, DC. May 7–8, 1997.

McFadden, 1973. *Conditional logit analysis of qualitative choice behavior.* National Science Foundation Grant GS-27226, University of California: Berkeley, CA http://elsa.berkeley.edu/pub/reprints/mcfadden/zarembka.pdf (accessed 7/19/2011).

McFadden, D. Conditional logit analysis of qualitative choice behavior. In *Frontiers in Econometrics;* Zarembka, P. (Ed.); Academic Press: New York, 1974.

McFadden, D. Contingent valuation and social choice. *American Journal of Agricultural Economics* **1994**, *76* (4), 689–708.

Morey, E. R., Buchanan, T.; Waldman, D. M. *Happy (hypothetical) Trails to You: The Impact of Trail Characteristics and Access Fees on a Mountain Biker's Trail Selection and Consumer's Surplus*. Working paper, University of Colorado, Boulder, 1999b.

Morey, E. R.; Rossmann,K. G.; Chestnut, L.; Ragland, S. Estimating E[WTP] for reducing acid deposition injuries to cultural resources: Using choice experiments in a group setting to estimate passive-use values. In *Valuing Cultural Heritage: Applying Environmental Valuation Techniques to Historic Buildings, Monuments and Artifacts,* Narvud, S. and Ready, R. C. (Eds.). Edward Elgar: Cheltenham, UK and Northampton, MA, 1999a, Chapter 10.

Morikawa, T.; Ben-Akiva, M.; McFadden., D. *Incorporating Psychometric Data in Econometric Travel Demand Models.* Prepared for the Banff Invitational Symposium on Consumer Decision Making and Choice Behavior, Banff, Canada, 1990.

NRC [National Research Council]. *Valuing Groundwater: Economic Concepts and Approaches.* National Academy Press: Washington, DC, 1997.

Paul, D. Agricultural Economics of the Pacific States: Water Supply Reliability and Pricing. *The Business Forum Journal,* 2004. http://www.bizforum.org/Journal/www_journalDP003.htm (accessed 12/18/09).

Public Resources Advisory Group. *Groundwater Replenishment System Financial Study;* financial study for Orange County Water District and Orange County Sanitation District; Orange County, CA, 2001.

Raucher, R.: Linsky, R.; Means, E.; Hurd, B.; Goldstein, J.; Huber-Lee, A.; Renwick, M.. *The Value of Water: Concepts, Estimates, and Applications for Water Managers*. Awwa Research Foundation, Denver, CO, 2005.

Raucher, R.; Darr, K.; Henderson, J.; Linsky, R.; Rice, J.; Sheikh, B.; Wagner, C. *An Economic Framework for Evaluating the Benefits and Costs of Water Reuse*. Final Project Report and User Guidance. Report No. 03-006-02. WateReuse Foundation, Alexandria, VA, 2006.

Recycled Water Task Force. Economics Work Group Draft White Paper. Department of Water Resources. November 18, 2002. http://www.owue.water.ca.gov/recycle/docs/WorkgroupWhitePapers.htm (accessed 3/16/2004).

Rodriguez, G. *Generalized Linear Models*; Office of Population Research, Princeton University, NJ, 2009. http://data.princeton.edu/wws509/notes/c6s3.html

Ruby, M. C.; Johnson, F. R.; Mathews, K. E. *Just Say No: Assessing Opt-Out Options in a Discrete-Choice Stated-Preference Survey of Anglers*. TER Technical Working Paper No. T-9801, Triangle Economic Research: Durham, NC, 1998.

Swait, J.; Adamowicz, W.; Louviere, J.. *Attribute-Based Stated Choice Methods for Resource Compensation: An Application to Oil Spill Damage Assessment*. Presented at the Natural Resources Trustee Workshop on Applications of Stated Preference Methods to Resource Compensation, Washington, DC. June 1–2, 1998.

Tapsuwan, S.; Brennan, D. C.; Ingram, G. D.; Burton, M. *Household Willingness to Pay to Avoid Drought Water Restrictions: A Case Study of Perth, Western Australia.* Accepted Conference Paper, 36th Australian Conference of Economists, Hobart, September 2007..

Thomas, B. and Rodrigo, D. Measuring the benefits of non-traditional water resource investments. In *Proceedings of Conserv 96: Responsible Water Stewardship.* January 4–8, 1996. Orlando, FL, pp. 195–199.

Varga, T. G. *The Role of Local Projects to Enhance the Imported Water Supply. Water Supply and Water Reuse: 1991 and Beyond*. American Water Works Association: Denver, CO, June 1991.

Viscusi, W. K.; Magat,W. A.; Huber, J. Pricing environmental health risks: Survey assessments of risk-risk and risk-dollar trade-offs for chronic bronchitis. *Journal of Environmental Economics and Management* **1991***, 21*, 32–51.

Wade, W. and Roach, B. *Economic Benefits of Municipal and Industrial Water Supply Reliability for Metropolitan Atlanta*. (draft). Energy and Water Economics, Columbia TN, 2003.

Wolff, G. Calculating constant-reliability water supply unit costs. In *Water Policy*. International Water Association: London, UK, 2007.

Appendix A

Reviewing the Literature and Establishing Context

This appendix summarizes literature related to valuing water supply reliability enhancement projects. First, we articulate the difference between WTP estimates (which focuses on the *value* of increasing or maintaining a target level of reliability) and the water supply "portfolio theory" (which provides a basis for adjusting the *cost* of maintaining a given reliability target).

Second, we provide a comprehensive review of the literature related to the value of water supply reliability. Given the nature of this research, we focus primarily on studies that have attempted to value WTP for improved reliability (or WTA a decrease in the level of reliability) using "stated preference techniques." For each study reviewed, we present key findings and provide an overview of study methodology. We also provide a brief assessment of utility-sponsored customer survey efforts (primarily from our participating utilities) that shed light on reliability-related attitudes and values for residential customers.

A primary objective of this review is to evaluate the methodology (including advantages and disadvantages associated with each approach) and results from the existing literature, which typically originate from 10 or more years ago when customer preferences, economic status, and drought experiences were different, and economic methods were less reliable. Findings from this evaluation served as a key input into the study (and survey) design for the current research.

A.1 Valuing Reliability of Water Supply

Utility managers and others recognize that maintaining or improving the reliability of their water supply yield is likely to be highly valued by their communities. However, the absence of suitable customer valuation data makes these reliability benefits difficult to quantify in a meaningful and credible manner. This impedes decision-making for long-term water supply investments because these investments are increasingly expensive. Thus, utility managers (and their governing Boards) typically desire credible information to assess whether the value (benefit) of water supply reliability investments are high enough for their customers to warrant the potential rate increases needed to pay for them.

There are two distinct tracks that can be used to investigate the value of reliability:

1. The "portfolio theory approach," as developed initially for managing financial assets, provides a framework for comparing water supply options using a reliability-based cost adjustment for attaining a given reliability target
2. The WTP approach (the focus of this research) uses economic valuation techniques to directly estimate the values (i.e., WTP) for reliability held by water utility customers

The following sections briefly describe each approach, highlighting the differences between WTP estimates (such as derived from this research) and portfolio theory, as applied to water supply reliability.

A.1.1 Portfolio Theory

Portfolio theory offers water supply managers with a sound conceptual basis and statistical approach for revealing the added value that can be attributed to reliability enhancement projects. The portfolio approach is used to adjust the costs of alternative water supply options to account for differences in reliability relative to a given reliability target for the portfolio (e.g., to deliver a given targeted quantity of water with 95% confidence, year to year).

Originally developed for application in financial markets, portfolio theory provides some useful insights into how water supply planners might develop and manage the portfolio of water sources available to them. The central premise, long recognized and applied by financial managers, is to jointly maximize expected returns (water yields) and concurrently also reducing the overall variance (fluctuations in yields across years or seasons) in portfolio returns. This can be accomplished by minimizing the covariance in yield risks across the assets held in a portfolio (Markowitz, 1952).

In essence, portfolio theory is a statistics-based formalized embodiment of the old maxim about not placing all of one's e.g.gs in one basket. The basic premise of portfolio theory applies to water resources planning. Each water supply option can be viewed as an asset that is subject to some sources and degree of risk (where risk refers to variability or uncertainty about the water yield, cost, or both). There may well be a premium value that a risk-averse community would be willing to pay to better manage its water risks, either by providing some insurance and/or by providing some variance-balancing water portfolio diversification. The portfolio approach, as applied to water supply planning, introduces the unique risk/benefit profiles of different water supplies to the analysis, thus allowing an assessment of increased (or at least equal-to-existing) supply reliability at the least cost, rather than merely the least-cost total supply irrespective of reliability and community values.

As with financial assets, sources and levels of risk vary across different types of water assets. In many traditional surface water sources, a key source of yield risk is the weather and its impact on local hydrologic conditions (e.g., droughts that leave stream flows or reservoirs too low to support desired levels of water extraction). Other sources of risk for traditional surface and groundwater sources include contamination (e.g., pollutant spills), over-extraction by other users (e.g., externalities arising where water is a common property resource), new institutional constraints (e.g., minimum instream flow requirements to account for ecosystem needs, or regulatory limits on groundwater extraction to prevent subsidence), and so forth. Cost risks (or, more suitably, "net revenue" risks) may be associated with increased pumping and treatment costs, as may arise with declining aquifer levels, deteriorating raw water quality, added regulatory requirements, and other factors. Net revenue risks also can be linked to declines in revenue collections (as when drought restrictions curtail water use and sales, and revenues decline below total annualized costs because volume-based water pricing rates remain fixed).

A more in-depth discussion of portfolio theory is provided in Kasower et al. (2007) and Wolff (2007). These papers also offer simple empirical illustrations of how much added value may be derived from having a water supply option with a yield variability that is uncorrelated (or negatively correlated) with the variability of other source water options in the community's water supply portfolio. This added value can also be used to develop a "constant reliability-adjusted cost" per unit of water delivered, which can then be used to develop a reliability-adjusted, cost-effectiveness comparison of water supply options.

A.1.2 WTP Approach

The portfolio theory offers water supply managers a sound conceptual basis and a statistical approach for revealing the added value (benefit) of reliability enhancement projects. However, the portfolio approach does not provide a direct empirical examination of how much "value" people place on added reliability (e.g., the WTP to have a higher level of reliability for the community supply, such as increasing the probability of meeting a target total portfolio yield from 95% to 99%).

Estimating the WTP for changes in the reliability of water supply involves analytic techniques to elicit the values people place on reliability. Estimation procedures used to value changes in reliability for residential water users are generally based on one of two different approaches: "stated preference" and "revealed preference." Stated preference methods determine estimates for reliability based on the analysis of household responses to hypothetical choices posed in surveys. Revealed preference methods infer the value of reliability from data obtained from choices and decisions made in the marketplace (e.g., expenditures made to obtain higher levels of reliability or to avert potential shortages sometimes can be used to infer the value of reliability).

Another method for quantifying the value of reliability attempts to infer values from available cost and price data. Although cost does not necessarily equate to value, the cost that a city incurs for increased storage to improve reliability can be used as a proxy for the value of a reliable water supply. Additionally, avoided costs due to higher levels of reliability sometimes can be used to infer the value of reliability.

In recent years, economic and mathematical modeling techniques have also been developed to derive WTP estimates based on available data. These models have been used to estimate household WTP for changes in a combination of probabilistic water supply reliability and the retail price of water (see Lund, 1995; Jenkins and Lund, 2000; Alcubilla and Lund, 2006). An advantage of these models is the capability to examine a complete shortage probability distribution (not just specified events) and the ability to account for price effects (i.e., where higher water rates increase incentives for conservation and reduce the impact of shortages). Although this approach provides useful insights into WTP to avoid a range of shortages, it has only been used to evaluate hypothetical scenarios and has not been applied based on real-world data.

A.2 Review of Existing Literature

The following sections overview stated preference, revealed preference, and cost-based studies related to how residential water users value the reliability of their water supply (i.e., WTP).[1] Given the nature of our research (using stated preference techniques to elicit WTP for improved reliability), we focus primarily on stated preference studies that examine the value of water supply reliability to residential customers.

1. The numbers reported later have all been adjusted based on the CPI to reflect mid-2009 US$ values.

A.2.1 Stated Preference Studies

Stated preference methods rely on survey questions that ask individuals to make a choice, describe a behavior, or state directly what they would be willing to pay for specified changes in reliability. The most widely used stated preference technique has been the contingent valuation method, where respondents are presented with information about water quality and relationships between water quality and usability of the resource. Respondents are then asked to state or indicate to the researcher how much a given change in water supply reliability would be worth to them.

More recently, choice experiments are a stated preference approach that has begun to be used more extensively to estimate WTP. Choice experiments are a survey-based technique in which consumers are presented with two or more options for a good or service and are asked to state which option he or she prefers. By examining consumer preferences for the attributes and prices associated with their preferred option, WTP is inferred.

As detailed in the following sections, values for reliability are typically defined by stated preference studies as WTP to avoid a particular shortfall event. Water supply shortfall events are usually defined in different ways across studies. Factors used to describe a shortfall event include the percent of water available compared to the amount fully demanded (the shortfall amount), the frequency with which this condition may occur (e.g., 1 in 10 years), and the probability of a single event. In other studies, respondents are questioned on their WTP to reduce the probability of an event, not avoid it. A few more recent studies have elicited WTP to avoid impacts associated with shortages (e.g., watering restrictions).

In 1987, Carson and Mitchell conducted the first formal stated preference study related to water supply reliability. This study, conducted for the MWD, used contingent valuation method techniques to evaluate how residents in southern and northern CA value reliability. The authors used a discrete choice referendum survey format to estimate household WTP to avoid water shortages of a given magnitude and frequency. Specifically, respondents were asked whether they would vote yes or no on a referendum that would alleviate the threat of a specific water shortage scenario, given a specified (annual) cost to their household if the referendum were to pass. Median annual household WTP was determined for four reduction scenarios, based on a magnitude of reduction ranging from 10% to 35%.

The authors used their estimates for individual household WTP to determine aggregate annual WTP by households within the State Water Project (SWP) service area. Based on 1983 census data, there were approximately 5.5 million households within the SWP district at the time of the survey.

Table A.1 presents the results of the 1987 Carson and Mitchell study. WTP estimates have been adjusted to reflect mid-2009 dollar values.

Carson and Mitchell made significant attempts to ensure that the results of the study represent lower bound estimates for WTP. First, the study defines the value of water reliability in terms of WTP rather than WTA. Studies have shown that WTA is typically 2 to 6 times larger than WTP for public goods for which there are no substitutes (Carson and Mitchell, 1987). Second, the study's WTP estimates are based on median values rather than on mean values. The authors note that mean WTP is usually used in economic valuation and mean WTP values are typically 1.5 to 4 times larger than median WTP (Carson and Mitchell, 1987).

Table A.1. Annual Median Household WTP to Avoid Water Shortages under Four Scenarios (mid-2009 US$) (baseline = household's current consumption of water)

Scenario	Description of Scenario	Household Annual Median WTP	Annual Aggregate Value of Supply Reliability (millions)
A	A 30–35% reductions from the baseline once every five years	$218.04	$1204
B[a]	A 10–15% reduction from baseline once every five years	$158.25	$880
C	A 30–35% reduction from baseline in two out of five years	$493.51	$2673
D	A 10–15% reduction from baseline in two out of every five years	$290.72	$1606

Source: Based on data from Carson and Mitchell (1987).

[a]The results for Scenario B were given using a 95% confidence interval ($765 million to $994 million). The mid-point of the confidence interval is reported in the table.

Third, those respondents that refused to participate in the survey or responded "don't know," are treated as households who are truly not willing to pay the specified amount. Therefore, they are treated as respondents willing to pay $0 and are not discarded from the sample (Carson and Mitchell, 1987).

Though the authors attempt to be sound in their methodology, there are some inherent problems with the study. First, as noted previously, the study uses a referendum format, which has been shown to produce inconsistent (unreliable) estimates and to overstate WTP (McFadden 1994; Jenkins et al., 2003). Second, the "single-bounded" discrete choice format used in the study involves asking the respondent only one referendum style question: whether or not he or she would be willing to pay a specified dollar amount to avoid a water shortage of a given magnitude and frequency. However, Hanemann et al. (1991) show that a variation of this approach, the "double-bounded" discrete choice format (described later), is asymptotically more efficient than the conventional single-bounded method (Koss and Khawaja, 2001).

Finally, the survey allows for the prevention of a water shortage rather than a reduction in likelihood or severity. However, the elimination of shortfalls is not a realistic scenario, indicating that the study's WTP values should be interpreted as upper bound estimates (Griffin and Mjelde, 2000). [It should be noted, however, that Griffin and Mjelde used an improved survey design that did not allow for the complete avoidance of shortages, and still obtained inconsistent WTP values (see following text).]

In 1993, CUWA hired Barakat and Chamberlin, Inc. to conduct a second stated preference study related to reliability.[2] The objective of this study was to measure WTP among water users in 10 CA water districts to avoid shortages of varying magnitude and frequency.

2. This study was republished by its authors in a peer-reviewed journal in 2001: Koss and Khawaja (2001).

The authors used a referendum style, double-bounded dichotomous choice survey to estimate household WTP. With the double-bounded dichotomous choice model, respondents are engaged in two rounds of questioning. If the respondent answers yes to the initial question—”Are you willing to pay $X (a specified bid amount) for the referendum just described?”—then the follow-up question asks the respondent if they would be willing to pay a higher specified amount. Alternatively, if the response to the initial question is no, then the follow-up question uses a lower value. As a result, the researcher can place each respondent in one of four categories: “yes/yes,” “yes/no,” “no/yes,” or “no/no,” all of which correspond to smaller, more informative intervals around each respondent (Koss and Khawaja, 2001). As noted earlier, studies have shown that a double-bounded dichotomous choice format is asymptotically more efficient than the single-bounded approach used by Carson and Mitchell (1987).

As shown in Table A.2, the magnitude of the water shortage scenarios used in the survey ranged from 10% to 50%, with frequencies ranging from once every 3 years to once every 30 years. Bid amounts ranged from $1 to $50 (1994 US$), in increases to the respondent’s monthly water bill.

The study found that mean WTP varied across the counties included in the study, ranging from a low of $16.91/month ($203/year) to avoid a 20% shortage once every 30 years to a high of $24.63/month ($296/year) to avoid a 50% shortage once every 20 years. These results are relatively similar to those from the Carson and Mitchell (1987) study.

These WTP results were not used to calculate the annual aggregate value of providing water reliability, nor is there any indication of the total number of users served by CUWA members. However, the study does indicate that additional customer payments would total more than $1 billion per year (CUWA, 1994; 1994 US$) when aggregating across all consumers in the state. Additional key findings include:

- WTP increases with increasing magnitude and frequency of shortages
- Respondents were willing to pay to even avoid minor shortage scenarios
- Users may make a greater distinction between “shortage” and “no shortage” than between magnitude and frequency
- Shortage magnitude is a more important determinant of WTP than shortage frequency
- Individuals who indicated a desire for their community to grow have a higher WTP than those who wish that their communities stay the same size or get smaller
- Those respondents who considered water to be a long-term problem in the area have a higher WTP than those who did not

The survey was designed and executed well, and the study is cited several times in water reliability literature. However, similar to Carson and Mitchell (1987), a shortfall in the design of the survey was their use of WTP to “avoid” a shortage, rather than to reduce the likelihood or severity. Barakat and Chamberlin’s findings should therefore be interpreted as upper bounds on household WTP (Griffin and Mjelde, 2000). Furthermore, again like Carson and Mitchell (1987), the survey asks questions in a referendum format, which has been shown to produce unreliable and overestimated values (McFadden, 1994; Jenkins et al., 2003).

Table A.2. Mean Monthly WTP to Avoid Water Shortages of Varying Magnitude and Frequency (mid-2009 US$) [from detailed model, Barakat and Chamberlin (CUWA, 1994)]

Shortage (% reduction from full service)	Frequency (occurrences/years)				
	1/30	1/20	1/10	1/5	1/3
10			$16.93	$17.44	$17.64
20	$16.91	$17.95	$19.01		
30	$18.99	$20.08	$21.21		
40	$21.19	$22.33	$23.48		
50	$23.46	$24.63			

Results of the study also show a high “threshold effect” and declining marginal WTP related to the extent and duration of shortage (Wade and Roach, 2003). For example, the authors report a monthly WTP to avoid a 10% shortage once in 10 years of about $17, whereas the WTP to avoid a 40% shortage is only about $23. This threshold effect can be explained by a common finding in contingent value studies known as embedding. Embedding describes the situation when “the value placed on a resource is virtually independent of the scale of the resource” (McFadden, 1994). Wade and Roach (2003) report that the declining marginal loss curve led this study to be rejected in CA policy applications because of people’s observed rising penalty costs to use water in droughts.

In an attempt to improve upon the methodology used in previous studies, Griffin and Mjelde (2000) used stated preference techniques to value water supply reliability among households in seven TX cities. The primary objective of this study was to investigate the value of *current* water supply shortfalls (i.e., existing shortages of known strength and duration). The authors also attempted to determine the value of *future* shortfalls (i.e., probabilistic shortages of differing strength duration and frequency).

The survey used in the study included two contingent valuation questions:

1. A closed-ended WTP question that described a current supply shortfall of X% of the community’s water demand for a duration of Y summer days. The respondents were asked if they would be willing to pay a one-time fee of $Z to be exempt from the outdoor water restrictions.
2. An opened-ended WTP or WTA question concerning a hypothetical increase or decrease in future water reliability. For this question, an initial situation was posed to the respondents in which approximately once every U years a shortfall of V% would occur for a duration of W days. Depending on the survey, the question then posed a potential improvement in one of the parameters, and the others stayed constant. This question design was intended to be an improvement on the “avoided shortage” problem in the Carson and Mitchell (1987) and the CUWA (1994) studies.

For WTP to avoid a current water supply shortfall, respondent WTP decreased as the fee (to avoid water use restrictions) increased. Further, respondents were found to be more likely to pay to avoid restrictions as the duration and/or strength of the restrictions increases. Income was also found to positively influence WTP. In addition, respondents who live at the survey residence (as opposed to landlords who do not) are more likely to be willing to pay for reliability improvements.

For the future shortfall scenario, individual income levels were also found to positively influence WTP. Respondents in cities with a higher average rainfall were found to be willing to pay less than respondents in drier cities. In contrast to the value of a current shortfall, individual characteristics appear to help explain WTP bid levels. For example, as the number of people living at a residence increases, the respondent is willing to pay more for reliability enhancement. In addition, respondents who have experienced water shortfalls in the last five years are, on average, willing to pay less for the reliability increase than those who have not experienced a shortfall.

As shown in Table A.3, the average respondent was willing to pay $37.40 to avoid a three-week current shortfall of 20%. A one-week increase/decrease in shortfall duration increases/decreases this value by $3.00. Every 10% increase or decrease in shortfall strength increases or decreases this value by $2.65. In addition, as duration increases, respondents are likely to pay more to avoid restrictions (i.e., the value of reliability increases with duration of the shortage).

For the future shortfall scenario, WTP and WTA measures were obtained as means from the survey responses as well as calculated from the economic model developed as part of the study. As noted previously, the WTP to modify future shortfalls was determined based on an increase in the respondent's monthly water bill (reported as follows in annual values in 2009 US$):

- Mean WTP and WTA per respondent are $128/year and $191/year, respectively
- The mean model-predicted WTP and WTA per respondent are $147/year and $199/year, respectively

Table A.3. Respondents' WTP to Avoid Water Restrictions from a Single Current Shortfall Event (mid-2009 US$[a])

	Shortfall Duration		
Shortfall Strength	**14 Days**	**21 Days**	**28 Days**
10%	$31.74	$34.76	$37.77
20%	$34.40	$37.40	$40.42
30%	$37.05	$40.06	$43.08

Source: Griffin and Mjelde (2000).

[a]Dollars adjusted from 2000 value to mid-June 2009 US$ based on CPI.

As noted previously, the authors used an open-ended question format to evaluate future shortfall scenarios to improve upon the methodology used in previous studies. However, the future shortfall values appear to be inconsistent with the reported current shortfall values. When the current shortfall values are used to calculate the future shortfall values, the calculated values are much lower than the WTP and WTA from the survey results. The authors believe that the future shortfall valuation is the source of the discrepancy because the current shortfall scenario was easily understood by respondents and is a common line of questioning for contingent valuation surveys. On the other hand, respondents did not appear to understand the future shortfall query. The authors concluded that using frequency to convey probability might have confused the respondents. Therefore, although the study may have been an improvement in design from previous studies, the results are inconsistent and somewhat overstated for small changes in future probability shortages (Jenkins et al., 2003).

In 1994, Howe and Smith used contingent valuation to measure customers' WTP for improved reliability (and WTA reduced reliability) in three Colorado towns: Boulder, Aurora, and Longmont. For this study, respondents were asked to consider hypothetical changes in their city's level of reliability (increases and decreases in frequency of a specific shortage event), and to assert whether or not these changes would be acceptable if accompanied by appropriate (but unspecified) changes in their water bills. The questions were set up in a "yes" or "no" format. For "yes" responses, quantitative WTP and WTA values were elicited from the respondents for two increased reliability scenarios (WTP) and two decreased reliability scenarios (WTA).

The type of water shortage investigated in the study was defined by the authors as a "standard annual shortage event": a "drought of sufficient severity and duration that residential outdoor water use would be restricted to three hours every third day for the months of July, August, and September" (Howe and Smith, 1994). The base probabilities of the SASE occurring for each city were 1/300 for Boulder, 1/10 for Aurora, and 1/7 for Longmont.

The authors compared the study's WTP and WTA estimates to the costs or savings associated with investments in increased supply or reductions in reliability (e.g., savings associated with selling water rights). This comparison was used to determine whether an increase or reduction in reliability would be justified. Key findings from the study include:

- In general, as expected, larger WTA amounts are required for greater decreases in reliability and larger WTP amounts are offered for greater increases in reliability.
- Household WTA compensation for a decrease in reliability under the first WTA scenario (0.7% to 11%, depending on the city) ranged from \$80/year in Boulder to a high of \$195/year in Longmont. WTA compensation for a decrease in reliability under the second scenario (1.7% to 40%, depending on the city) ranged from \$95/year in Boulder to \$281/year in Longmont. In Boulder, under both scenarios, this would be enough to justify a reduction in the reliability of supply.
- In Aurora and Longmont, the two towns with lower levels of reliability, consumers were not willing to pay enough to cover the cost of investment necessary to improve reliability. In Boulder, a town with very reliable water supplies, consumers were willing to pay even less for improved reliability, and no increase in reliability was justified.
- For the WTP scenarios, two sets of averages were developed. The first average is based only on "yes" answers to the accompanying WTP. For the second average,

"no" responses were counted as a WTP of $0 and incorporated into the overall average.

- WTP for the first scenario (increase in reliability in a range of approximately 0.16% to 9.2%, depending on the city) ranged from $82/year in Boulder to $106/year in Longmont. The WTP, including "no" respondents, ranged from $19/year in Boulder to $33/year in Aurora.
- The WTP for the second scenario (increase in reliability in a range of approximately 0.23% to 12.2%, depending on the city) ranged from $75/year in Boulder to $140/year in Longmont. The WTP, including "no" respondents, ranged from $18/year in Boulder to $34/year in Aurora.

When compared to the results of the other contingent valuation surveys, the results of this study are lower. This is likely due to differences in survey design and methodology. As noted previously, Carson and Mitchell (1987) and CUWA (1994) both asked respondents their WTP for complete avoidance of a shortfall with a given percentage. Griffin and Mjelde (2000) questioned respondents on their WTP to reduce the probability of a potential shortfall. All three of these studies determined what people were willing to pay to maintain their current well-being. However, Howe and Smith (1994) determined respondents' WTP for a percentage increase in reliability. The lower values of their study may be attributable to the fact that respondents were already content with their current level of reliability. People may be more willing to pay for maintaining a level of service they currently have than for a potential improvement in that service.

Although Howe and Smith's study is also widely cited in the water supply reliability literature, it should be noted that the study's emphasis on a single type of shortage, the SASE, limits the transferability of the results (Griffin and Mjelde, 2000). More severe or moderate events are not considered in the authors' calculations of the WTP and WTA.

Two recent studies conducted in Australia (Hensher et al., 2006; Tapsuwan et al., 2007) used choice experiment survey formats to examine household preferences for water supply reliability in terms of WTP to avoid drought restrictions. Choice experiments are a survey-based technique used to model consumer preferences for goods or services defined by certain attributes. In the survey, consumers are presented with two or more options for goods or service levels (with different levels of attributes) and asked to state which option he or she prefers. By including price as one of the attributes, WTP for a specific attribute can be indirectly recovered from people's choices (Hanley et al., 2001, as cited in Tapsuwan et al., 2007).

Tapsuwan et al. (2007) used a choice experiment survey to estimate household WTP in Perth, Australia, for different source development options and for avoiding outdoor water restrictions. The authors chose to use choice experiments because it allowed for "flexible alternatives and generated considerable cost savings through the ability to value a number of options simultaneously" (Tapsuwan et al., 2007). To measure consumer preferences, the authors developed a choice experiment survey that included the following attributes:

- Measures of regular outdoor restrictions
- Probability and severity (duration) of a complete sprinkler ban
- Sources of alternative water supplies
- Cost to the household (as an increase in annual household water bill)

Each questionnaire presented three options, including a status quo option (doing nothing about future supplies), which remained the same across all choice sets. Under this option, households would be restricted to watering one day per week (a level five sprinkler restriction) for the entire 10-year period being considered. They would also face a one-in-three year chance of a total sprinkler ban. Household water bills would remain the same.

The authors found that households consider water bill level, the supply source, and the ability to water three days a week as important factors affecting household WTP for a particular option. One of the most interesting findings of the study was the lack of significance of any variable relating to the probability or severity of a complete sprinkler ban. The authors believe that this may be because respondents felt that the development of new sources would override these outcomes. Households do show a preference for increasing sprinkler days from one day a week (under the status quo option) to three days a week, which indicates that respondents value access to sprinkler use, and therefore must have some concern over complete sprinkler bans (Tapsuwan et al., 2007).

For the option of moving from one day to three days of sprinkler use, the authors found consumers are willing to pay 22% extra on their annual water bill (around $54[3] based on average bills of respondents of $246). This was the only statistically significant variable in the economic model developed based on the choice experiment surveys.

Another interesting finding of the study is the equivalence of the status quo option (sprinkler use one day per week) and the option allowing sprinkler use five days per week. As the five-day use includes the possibility of using sprinklers on three days, one might expect that the option to move to five days would be valued as much as the option to move to three days. A possible interpretation of this finding is that respondents place a value on responsible water use (i.e., respondents might be attaching a social unacceptance to the use of sprinklers five days per week) (Tapsuwan et al., 2007).

Overall, the study found it was difficult to identify preferences to pay for the reduced risk of water restrictions in either the short or long term. The authors conclude that respondents may have found the attributes presented in the choice set format too difficult to understand, particularly because it involved an assessment of the risk of an event that may have been difficult to grasp. Alternatively, the source development options included as attributes may have introduced a labeling bias into the questionnaire. If source development was seen as an overriding factor and respondents ignored associated levels of reliability presented in each choice set, some modifications to the survey instrument would be required in the future in order to assess the value of reliability.

Hensher et al. (2006) used choice experiments to evaluate consumer preferences for avoiding drought restrictions in Canberra, Australia. For this study, the authors presented respondents with a series of six choice experiments covering restrictions on the use of water. Each experiment described two restriction scenarios and respondents were asked which of the two options they preferred. The range of attributes and levels that comprised each of the options in the choice experiments were:

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3. Adjusted to 2008 US$ from original study value of $57 AU$, using Australian to U.S. exchange rate of $0.90938.

- Frequency and duration of the restriction
- Days the water restrictions apply (every day, on alternate days, and no restrictions)
- Level of water restriction, based on Canberra's current drought policy (levels ranged from "no restriction" to "Stage 5 restriction," where all outdoor water use is banned)
- Price, expressed as "total water and sewerage bill for the year"
- Appearance of urban landscape including public lawns, parks, and spaces (levels of this attribute included "some brown lawns and no lush green lawns" and "lush green lawns")

The respondent's choice between the two options in each experiment was modeled with a standard binary logit model (McFadden, 1974). The authors found evidence that customers are unwilling to pay (i.e., a WTP that is not statistically different from zero) to avoid most types of drought-induced restrictions. More specifically:

- Respondents appear unwilling to pay to avoid any low-level restrictions (Stage 1 or 2 level restrictions, as defined in the survey)
- Respondents also appear unwilling to pay to avoid higher levels of restrictions (Stage 3 or higher) that are not in place every day and all year
- Given the option of watering on alternative days, customers appear willing to adjust their watering schedules compared to paying higher water bills
- Customers appear willing to tolerate high-level restrictions for limited periods each year (up to all summer), compared to paying higher water bills
- Customers display an unwillingness to pay to avoid brown lawns in public areas

To estimate WTP, the variables included in the model were differentiated into two variables based on the findings noted previously: "frequency of restrictions that matter," defined as those that apply every day, last all year, and are Stage 3 or higher; and "frequency of restrictions that don't matter," which are all other restrictions. The "restrictions that don't matter" include those types of restrictions found to be insignificant in the (binary logit) model developed based on survey results.

Model results indicate that respondents are willing to pay 31.26% of their water bill, or $232[4] on average, for a one unit reduction in the frequency of restrictions "that matter." Note that because restrictions that matter last all year, a frequency of 1 (once a year) means that restrictions apply continuously, all year, every year. Similarly, a frequency of 0 means that there is virtually no chance that restrictions will be imposed. Thus, $232 is the amount that householders are willing to pay annually, on average, to move from a situation with continuous restrictions at Stage 3 or above every day, all year, every year, to a situation with virtually no chance of restrictions.

The authors used the model results to calculate the amount customers are willing to pay to reduce the frequency of restrictions that matter under various scenarios. For example, WTP to reduce these restrictions from, say, once every 10 years to once every 20 years was calculated as $11.60 per household, annually, on average (one-twentieth of $232—because the situation

4. Adjusted to 2008 US$ from the original study value of $239 AU$ using the Australian to U.S. exchange rate of $0.90938. This assumes original study reported results in 2006 US$. Actual study/survey was conducted in 2003 so this is a conservative estimate.

reflects a reduction in frequency of restrictions by one-twentieth). Similarly, the amount householders would be willing to pay to reduce the frequency of restrictions that matter from once every 20 years to once every 30 years is estimated to be $3.87 on average (one-sixtieth of $232) per year.

Several points are important to consider when interpreting the results of this analysis. First, the choice experiment used in the survey included only three options for the length of restriction: one month, all summer, and all year. Interpolation of the results to other lengths is a matter of interpretation beyond the actual data obtained in the study. Second, in the experiments, the length of the restrictions is stated to the respondent, such that the respondent knows how long the restrictions would last when evaluating them. In practice, water restrictions have been, and probably will be in the future, imposed without a specified ending date. That is, the length of the restriction is not known beforehand, but only after the restrictions have been lifted. It is possible that customers react differently to restrictions whose length is not known beforehand than to restrictions of a known length.

A.2.2 Summary of Stated Preference Study Results

Table A.4 summarizes annual WTP for reliability improvements based on the studies highlighted previously. With the exception of households in Canberra, Australia (Hensher et al., 2006), it appears that most households are willing to pay in excess of $100 annually for reliability improvements.

Overall, whereas the stated preference studies discussed earlier are valuable in terms of gaining insight into the value of reliability, none are perfect in their methodology. In addition, it is somewhat difficult to interpret how to apply the results of these studies to value reliability in the context of 2009. The survey methods used in most of these studies to develop the data, as well as the statistical approaches used to analyze these data, have improved in the years since the studies were implemented.

Although stated preference approaches have been applied to the valuation of nonmarket goods for many years, the method has limitations that need to be acknowledged and considered. For example, Griffin and Mjelde (2000) note that one difficulty with stated preference studies for water reliability is the notion of the “birthright” perspective. It is not uncommon for respondents to view water as an inalienable right. Consequently, whereas they highly value water reliability, the notion that water should be free can lead to a reduction in the respondents’ stated WTP for reliability. If the limitations are acknowledged and efforts are made to perform the studies in an appropriate manner, stated preference studies can yield informative results.

Finally, in addition to the studies highlighted earlier, a handful of stated preference studies have also been conducted in relation to WTP to avoid temporary disruption in supply (lasting a few hours to a few days) due to infrastructure failure and/or repair (see MacDonald et al., 2003; Damodaran et al., 2004; Hensher et al., 2005; Brozovi´c et al., 2007). These studies are more related to the reliability of infrastructure rather than the overall reliability of supply and are therefore not highlighted here.

Table A.4. Summary Table of Results from Stated Preference Studies (2009 US$)

Source	Shortfall Amount	Frequency	Probability	Annual WTP/ Household
Carson and Mitchell (1987)	10% to 15 %	1 in 5 years	20%	$158
Carson and Mitchell (1987)	10% to 15 %	2 in 5 years	10%	$291
CUWA (1994)	20%	1 in 30 years	3.3%	$168
Carson and Mitchell (1987)	30% to 35%	1 in 5 years	20%	$218
Carson and Mitchell (1987)	30% to 35%	2 in 5 years	10%	$494
CUWA (1994)	50%	1 in 10 years	5%	$297
Griffin and Mjelde (2000)	na	Na	na	$128
Griffin and Mjelde (2000)	na	Na	na	$147
Howe and Smith (1994)[a]	0.16% to 9.2%[b]	Na	na	$94[c]
Howe and Smith (1994)	0.23% to 12.2%[d]	Na	na	$108[e]
Hensher et al. (2006)	na	Na	na	$232[f]
Tapsuwan et al. (2007)	na	Na	na	$54[g]

na = not applicable.

[a]Howe and Smith (1994) also estimated WTA values for decreases in reliability. Annual WTA results per household for approximately a 0.7% to 11% decrease in reliability, depending on the city, ranged from $80 to $195. Annual WTA results for approximately a 1.7% to 40% decrease in reliability, depending on the city, ranged from $95 to $281.

[b]This percentage range does not represent the magnitude of the shortfall, as is the case in the other studies. This range represents increased probability over the base probabilities of the SASE. The actual percentage increase is dependent on the city. The associated dollar values are the annual WTP per respondent for an increase over their current reliability. If "no" respondents for this increased probability range are included into the dataset (respondents' WTP = $0), the WTP range is from $19/year to $33/year per respondent.

[c]Value represents the average of the WTP range given in the study ($82 to $106 per year per respondent).

[d]See table note c. If "no" respondents for this increased probability range are included into the dataset, the WTP range is from $15/year to $29/year per respondent.

[e]Value represents the average of the WTP range given in the study ($75 to $140 per year per respondent).

[f]This is the average amount that householders are willing to pay to move from a situation with continuous restrictions at Stage 3 or above all year every year, to a situation with virtually no chance of restrictions.

[g]This is the annual amount householders are willing to pay for the option of moving from one day to three days of sprinkler use.

A.2.3 Revealed Preference and Cost-Based Studies

A few studies have used the revealed preference and cost-based methods to determine values for water supply reliability. Fisher et al. (1995) explored how price can be used as a tool to reduce demand during a drought. Using a range of estimated price elasticities for residential customers (from selected studies), the authors calculated the loss of consumer surplus associated with a price-induced 25% reduction in consumption in the East Bay Municipal Utility District (CA) service area. With varying demand elasticities, welfare losses were estimated within a range of $60 to $270 per acre-foot. This loss in consumer surplus is equated to WTP for improved reliability.

In 2002, the California Recycled Water Task Force was established to investigate specific recycled water issues. The economic group of the task force was charged with identifying economic impediments to enhancing water recycling statewide. The resulting report uses a case study of GWRS in Orange County as an illustration for the importance of economic feasibility analysis. The GWRS was designed to recycle an estimated 70,000 acre-feet per year of effluent and inject it into the Orange County Aquifer. According to the Groundwater Replenishment System Financial Study (Public Resources Advisory Group, 2001), the value of drought proofing (the value of reliability), based on drought penalties and rate increases for consumers, ranged from \$210 to \$300 acre-feet per year (\$9.1–\$15.6 million a year for 40 years with a total present value of \$272 million at a 5.5% discount rate) (Recycled Water Task Force, 2002).

In a similar investigation in 1997, NRC estimated that if Orange County were to lose its reliable groundwater supply to saltwater intrusion, the cost of securing water by retail producers would jump from the 1997 cost of \$106 million to \$210 million. The \$104 million increase arises because the water once pumped from the aquifer would now have to be purchased from MWD at the non-interruptible rate (NRC, 1997). The sharp increase in cost charged by MWD for non-interruptible water supplies highlights the fact that reliability has a key role in water pricing (Paul, 2004) (i.e., as actual or potential shortages worsen and demand outpaces supply, users are willing to pay more for water).

As mentioned earlier, although the cost of a water project does not necessarily equal the value of the project or program, cost sometimes can be used as a lower bound proxy estimate of the value attached to increased reliability. Varga (1991) investigated the role of local projects and programs in the City of San Diego to enhance imported water supply and improve reliability. The MWD provides water to San Diego from the Colorado River and northern CA, based on availability. To encourage the use of existing local reservoir capacities and improve the reliability and yield of the imported water system, MWD and CA introduced water rate credits for serviced cities. The first program instituted was the Interruptible Credit Program. An interruptible credit applies to water that either could be reduced or have its delivery interrupted by the MWD or another external agency. In 1991, the interruptible credit rate was approximately \$70 per acre-foot. The second program is the Seasonal Storage Credit Program. This program encourages water agencies to use available local storage to increase the capacity and yield of the imported water system. The 1991 seasonal storage rate was approximately \$130 per acre-foot. MWD is paying for direct increases in reliability and, therefore, the credit rates can be used as the value for an acre-foot increase in water supply reliability.

Thomas and Rodrigo (1996) measured the benefits of nontraditional water resource investments. The focus of the study was again on MWD and its member agencies. They investigated the benefits of developing additional resources in the region through several alternatives, including increased imported supplies (base case), conjunctive storage of local groundwater basins, and recycled water and groundwater recovery projects (preferred case). To determine the value of the preferred case, the savings attributable to each of these resources were compared to the yield associated with the resource. Thomas and Rodrigo (1996) note that “dividing the total present value of benefits by the expected groundwater replenishment deliveries (e.g., the difference between the base case and the preferred case and the groundwater case for conjunctive use storage), yields a dollar/AF index.” In the case of conjunctive use storage, the modeling revealed that carryover or drought storage, which helps ensure greater reliability during dry periods, provides a benefit of approximately \$414 per acre-foot to the region.

In 2003, Wade and Roach investigated the reduction in NED Benefits if water supplies to metro Atlanta were capped at 2000 water withdrawal levels and no new supply alternatives existed. This analysis estimated shortage costs including costs of shortage management (conservation and reclamation); agency revenues lost from reduced water sales; lost consumer surplus; and economic losses to the region. The water and wastewater NED Benefits were summed to determine total shortage losses through 2050 (present value at year 2000 using a federal discount rate of 6.625%). The present value NED Benefits loss associated with a cap on supplies was estimated to be more than $23.9 billion. Total losses at 10-year intervals were converted to costs per acre-foot based on the total shortage amounts. Water and wastewater losses were found to range from $3908 per acre-foot for a 17% shortage to $27,380 per acre-foot for a 47% shortage, over the 40-year period from 2010 to 2050.

An overview of the value of reliability inferred from results of revealed preference and cost-based approaches is provided in Table A.5. When compared on a dollar per acre-foot basis, these results are considerably lower than those based on WTP from the stated preference studies highlighted previously. This reflects the fact that stated preference results are designed to reflect the real *value* (i.e., WTP) of water supply reliability, whereas *cost*-differential based results are simply reflective of agency pricing decisions that are not likely to reflect value (WTP) considerations.

Table A.5. Water Supply Reliability Values Inferred from Revealed Preference or Cost and Price Differential Results (mid-2011 US$)[a]

Source	Value ($ per acre-foot)	Basis
Fisher et al. (1995)	$63 to $283	Welfare loss per acre-foot due to a price-induced reduction in water consumption of 25%
Recycled Water Task Force (2002)	$220 to $314	The value (acre-foot per year) of drought proofing based on drought penalties and rate increases for customer
NRC (1997)	$406	The difference in cost of local groundwater supplies versus the MWD noninterruptible rate
Varga (1991)	$73	The rate per acre-foot that MWD credits local water retailers to store imported water in local reservoir to increase reliability of imported supplies
Varga (1991)	$136	The rate per acre-foot that MWD credits local water retailers to seasonally store imported water to increase capacity and yield of imported water system
Thomas and Rodrigo (1996)	$433	The benefit per acre-foot of conjunctive use storage to ensure greater reliability
Wade and Roach (2003)	$4090 to $28,650[b]	Total present value losses associated with a 17% and 47% (cumulative through 2050) reduction in supply in metropolitan Atlanta

[a]The numbers reported here have been adjusted based on the CPI to reflect mid-2011 US$ values.

[b]Present value over 40 years. In terms of annual values, this is equivalent to $294 to $2,056 per acre-foot per year.

Appendix B

Long Beach Focus Group Materials

B.1 Focus Group Recruitment Script, Long Beach Example

CITY OF LONG BEACH FOCUS GROUPS

RECRUITMENT SCREENER: City of Long Beach, CA

Notes on recruitment, per agreement:

Wednesday, August 25, 2010, 5:30 p.m. and 8:00 p.m.

- *Each night recruit:*
  - ***Education Distribution****: Participants should be roughly distributed across education categories based on U.S. Census distribution for the area.*
  - ***Age Distribution****: Participants should be roughly distributed across age categories based on U.S. Census distribution for the area.*
  - *Participants should NOT have participated in a focus group during the last 9 months.*

Recruit per attached schedule. ***Track the number of attempts, no contacts, refusals, and acceptances.***

INTRO. Hello, may I speak with **[Contact name]**? My name is **[caller's name]** and I am calling from **[name of firm]**. I'm calling to offer you $125 and invite you to participate in a two-hour research study we're doing of people's opinions on issues facing City of Long Beach area residents. I'm not selling anything, and would only like to ask you a few quick questions. *(If asked: 3-4 minutes).*

B. Are you 20 years old or older?

1. No, Less than 20 years of age ----------------> Continue to Q2
2. Yes, 20 or more years of age ---------> Continue to Q3

Q1. Can I speak to someone in your household who is 20 years old or older?

1. No -----------------------------> *Thank and TERMINATE*
2. Yes ----------------------------> Ask to have that person put on the phone

(GO BACK TO **INTRO**)

We'll be holding a 2-hour group discussion on [fill in date]. To thank you for giving us your time, and we will give you $125 at the end of the discussion.

<< Did respondent self-terminate at this point?

1. *No (continue)*

2. *Yes (end of data) >>>*

Before I tell you more about the discussion, I'd like to ask you a few questions about yourself and your household. Answering these questions will take just a couple of minutes – all your answers will be kept confidential.

BACKGROUND, IF NEEDED IN RESPONSE TO QUESTIONS:

>> This is for research and is not sales or marketing related in any way.

>>We want to talk with people from a wide variety of backgrounds and experiences.

C. In what type of residence do you currently live? *[Would like 60% to be from 1 or 2 and 40% from 3, 4, 5, and 6]*

3. Single family home **[Skip to Q6]**
4. Mobile home with a private lot **[Skip to Q6]**
5. Mobile home with no private lot
6. Townhouse or condominium
7. Duplex, triplex, or fourplex
8. Larger apartment building (5 or more units)

Q2. Is there a lawn or garden area shared by other residents?

1. Yes **[Ask Q5 and skip Q6]**
2. No **[Skip to Q7]**

Q3. About how large is the lawn or garden area shared by other residents?

1. Small (less than 5,000 square feet)
2. Large (5,000 square feet or larger)

Q4. About how large is your lot size?

1. Small (less than 1,000 square feet)
2. Large (1,000 square feet or more)

Q5. In what year were you born? (RECORD YEAR)

____

Q6. What is the highest level of education you have completed? (DO NOT READ LIST)

1. 8 years or less of school
2. 9 to 12 years of school (high school)
3. Some college or technical school
4. Completed technical school or an associates degree program
5. Completed four year college degree
6. Some or completed graduate school work
7. REFUSED

Q7. How comfortable do you feel reading in English?

1. Completely comfortable
2. Very comfortable
3. Moderately comfortable
4. Slightly comfortable [*Do not terminate until interview complete then do not select]*
5. Not comfortable at all [*Do not terminate until interview complete then do not select]*

Q8. RECORD RESPONDENT'S GENDER <*Need a mix*>

1. Male
2. Female

Q9. Do you, or does any member of your household, work for a market research firm

1. Yes ----> *Do not terminate until interview complete*
2. No

Q10. Have you participated in any group discussion for research during the last 9 months?

1. No -------> Continue.
2. Yes -------> *Thank and TERMINATE*. "Thank you for your time, these interviews are open only to individuals who have not recently participated in a focus group or interviews at a survey center."

Q11. As I mentioned earlier, our group discussion will be about people's opinions on issues facing City of Long Beach area residents. This will last about 2 hours, and we will pay you $125 for your time.

The study will take place at [FILL IN NAME OF RESEARCH FACILITY]. The facility is located at [ADDRESS]. We are scheduling two groups; the first begins at 5:30 p.m., the second at 8 p.m. Which time would work best for you?

9. RESPONDENT REFUSED --> Thank and terminate.

Thank you. We will mail you a letter to remind you of the date, time, and location of the interview, and give you directions on how to get to the <*site*>.We will also give you a reminder call the day before the study. If you need glasses for reading, be sure to bring them with you. Also, we are not able to provide childcare during this time, so please make other arrangements if needed.

Since we are recruiting only a small number of people for these interviews, your participation is very important to us. If for some reason you cannot make this time, please call us at (XXX) XXX-XXXX and let us know so that we might find a replacement.

Name:	____________________
Address:	____________________
	____________________
	____________________
Phone Number:	(XXX) XXX-XXXX

Thank you for agreeing to share your opinions!

If you have questions before the focus group meets, please call **[ENTER APPROPRIATE NAME FOR CONTACT PERSON]** at **[ENTER APPROPRIATE CONTACT PHONE NUMBER]**.

B.2 Focus Group Moderator Script, Long Beach Example

Focus Group Script
Long Beach Water Department
August 25, 2010

Materials

- Each participant will need a sharp pencil, and the moderator should have additional pencils if participants need them.
- Each participant should have a pad of paper in front of them.
- There should be a board/easel in the room.

• Part 1. INTRODUCTION – 10 minutes

Hello, my name is ____, and on my left is _____. We will be leading the discussion this evening.

Thank you very much for coming out tonight.

There are stapled bundles of paper in front of you. We will turn to those shortly, but first, let's do some preliminary stuff. I will tell you when to open the packet.

How many people here have participated in a focus group before? ***[Show of hands]***

Focus groups are a way to better understand <u>people's ideas and opinions</u>. They are used, for example, to find out how people feel about a political candidate or a new product or some issue in the news. They are also useful in learning about people's attitudes and preferences on public policy issues.

Our goal tonight is to explore the ideas and opinions you have on some issues related to <u>water</u> in Long Beach. We are conducting these focus groups on behalf of a water research foundation. In today's session, we are talking to people who live in the Long Beach area.

Before we begin, I would like to go over some ground rules that will help keep us on track and make the discussion flow smoothly.

- ***Ground Rules***
- One person talks at a time.
- I want to hear from everyone tonight. If I haven't heard from you in a while, I might ask you to say what you are thinking.

- I am interested in <u>your</u> views and opinions. Please feel comfortable letting me know what you think, <u>even if it is different</u> from what others have said.
- Part of my job is to keep us on track. Questions may come up during the session, some I'll be able to answer, some I'll have to answer at the end, and some I may not know the answer to.
- These notes are for me to make sure I cover all the topics I'm supposed to and help make sure we stay on track.
- To help us keep your responses anonymous, please write only your first name on any materials I provide you throughout this discussion.
- We may not cover all of the information.
- Discuss refreshments.
- Restrooms (*tell people where the restrooms are*).
- Don't forget to get paid on your way out.
- Remember to turn off cell phones.
- Any questions before we get started?

Part II. HOW YOU USE WATER – 15 minutes

As I said, the topic will be water. We are going to start out by talking about how much water people use and for what purpose.

HANDOUT 1

Let's look at the papers in front of you. Put your name on the first page, then turn the page to what's called "Handout 1." Read the material there and answer questions as you come to them. When you come to a note to do so, just stop and we will discuss before moving on to the next handout. **[Wait until most people have finished]**

I see that most of you have finished. Let's go ahead and review some of your answers. What was your reaction to the information provided on the second page of this handout? **[Go around the table]**

How do you think your water use compares to these averages? **[Go around the table]**

Let's talk now about how you use water outdoors. How many of you use water to water your lawns or gardens? **[Show of hands]** How many of you use it to wash your cars? **[Show of hands]** How about for cleaning your walkway or driveway? **[Show of hands]** What about for washing your pets? **[Show of hands]** Do any of you use water outdoors for other reasons?

Now what about water that is used to maintain green spaces. What types of activities do you do outdoors that involve public green spaces that require watering? **[Call on 2 or 3 people to provide their answers]**

Does anyone happen to know how much water they use each year? **[Show of hands]**

HANDOUT 2

Now turn the page and answer the questions on Handout 2.

Starting with the first question, how many of you pay your own water bill? **[Show of hands]**

If you don't pay a water bill, do you know who pays one for you? **[Ask for volunteers]**

Does everyone pay a bi-monthly bill? **[If not, ask how often]**

Do most of you pay one bill for water and sewer or are these services billed separately?

Can you tell me about how much you pay for water and sewer combined for your average water bill? **[Ask people who answered yes to question 1b]**

HANDOUT 3

One issue I want to talk about in more detail is years when water is in short supply in the City of Long Beach. In other words, whether there is enough water from year to year or in most years to meet everyone's needs.

Please turn the page to Handout 3 and answer the questions on it.

Is water in short supply in some years in this area? **[Ask for volunteers] [PROBE: What seasons of the year do water shortages generally occur?]**

What do you remember about water shortages? **[Ask for volunteers] [PROBE: does anyone remember anything else?]**

What sorts of steps did your water provider take to deal with water shortages? **[PROBE: voluntary? Mandatory?]**

How much did the water shortages inconvenience you personally? **[Go around the table] [PROBE: if severe, how were you affected?]**

Did your household take any additional voluntary actions to reduce your indoor water use during past water shortages? **[Show of hands]** If yes, what actions did you take? **[Probe: Do you think that others reacted in similar ways if not what do you think they did?]**

Did your household take any voluntary actions to reduce your <u>outdoor</u> water use during past water shortages? **[Show of hands]** If yes, what actions did you take? **[Probe: Do you think that others reacted in similar ways if not what do you think they did?]**

[If necessary] Did your local water provider require your household to cut back on the use of water? **[show of hands] [PROBE: what did they do?] [Probe if necessary: what time of year, how long did it last, was the type or use limited or was it all use, do you remember why these restrictions were put in place by your local water agency]**

[PROBE: Do you do anything different in years when water is short?]

HANDOUT 4

Please turn to the next page with Handout 4 at the top and answer the questions on it.

Do you think water supply shortages in the future will occur more often, about the same as now, or less often? Why do you feel that way? **[Go around the table]**

[If not addressed, probe about growth and climate change]

Do you know of steps that have already been taken to deal with future water shortages? **[Ask for volunteers]**

HANDOUT 5

I'd like to get a better understanding of how you feel about different ways water agencies can ensure there is enough water to go around in the future.

Please turn to the next page of your handout, the one that says “Handout 5” at the top

To minimize future water shortages, Long Beach water providers are considering several alternatives to increase water supplies.

On Handout 5 is a list of potential options for addressing with future water needs. Please choose your 4 most preferred options. Put a “1” for your most preferred option, a “2” for your second most preferred option, and so on.

If you would like to rank more options, please feel free to do so. **[Wait for folks to finish]**

Let’s start with ________. What did you put down for your three most preferred options to reduce future water shortages and why do you prefer them? **[Go around the table]**

(EASEL WORK/ Prep easel with the 12 items?)

Ask people if they have other ideas?

[If these ideas not mentioned probe: What about…?

- ***Increase rates to prevent waste/reduce water use***
- ***Protection of water sources that are currently clean***
- ***Expanded water recycling (PROBE: reuse versus recycling)]***

In thinking about these alternative sources that we just discussed, what concerns do you have?

- ***What about fairness to downstream water users? Fairness to other parts of the state?***
- ***What about environmental concerns (e.g., fisheries and instream flows)?***
- ***What about limiting costs and rate increases?***
- ***What about enabling growth (or restricting growth)?***
- ***Other?***

Prompt on:

Local vs. non-local groundwater sources – any reaction to taking in water from elsewhere (from someone else)?

Reuse / recycling of water for different types of uses – any strong reaction to possible reuse for replenishment of drinking water supplies?

Desalination: any strong reaction to feasibility, cost, or other aspects of ocean desal?

- **Requiring new homes to have low water use irrigation**

- **Transfer from agricultural uses**
Importing more Bay-Delta Water via Metropolitan Water District

HANDOUT 6

Now I would like you to turn to the next page in your handout, the one that says “Handout 6” at the top. This handout provides you with some background information and asks you to consider several options your water supplier could do to reduce future water shortages.

Walk people through the directions. Is it clear what we are asking you to do?

Please read the material and choose which option you prefer. When you are done, please put your pencils down. **[Wait for folks to finish]**

Probes:

Description of the project attributes and levels

Were they clear?

Did the different levels of each come through?

Did they seem like good options?

Comparison of future water shortages

Were the pie charts clear?

Did it seem reasonable to you that the future could look like this?

Growth?

<u>**Choice Tables**</u>

Was it clear what you were supposed to do?

Was there enough information for you to make an informed choice?

If not, what additional information would be helpful?

Was there too much information?

What could be cut out?

What are the pie charts showing?

Is this helpful or confusing?

What did people choose?

Why – what was it about that option that made it your most preferred/

How certain are you about your choice?

[PROBE: was the information presented in the table helpful in making your decision? Were the pie charts helpful?]

Which one of the alternative programs did you prefer and why? **[Go around the table]**

[If time available:

a. How much would you like to see more real-time data on your water use? If this information was available, do you think that would affect your water use patterns?

b. Use of water budgets – would you opt to pay more above your budget?]

Well, that's all the time we have this evening. Thank you very much for coming out tonight. I really appreciate all of your thoughts and opinions. Please leave all of your materials in front of you so that I can collect them. Don't forget to get paid on your way out.

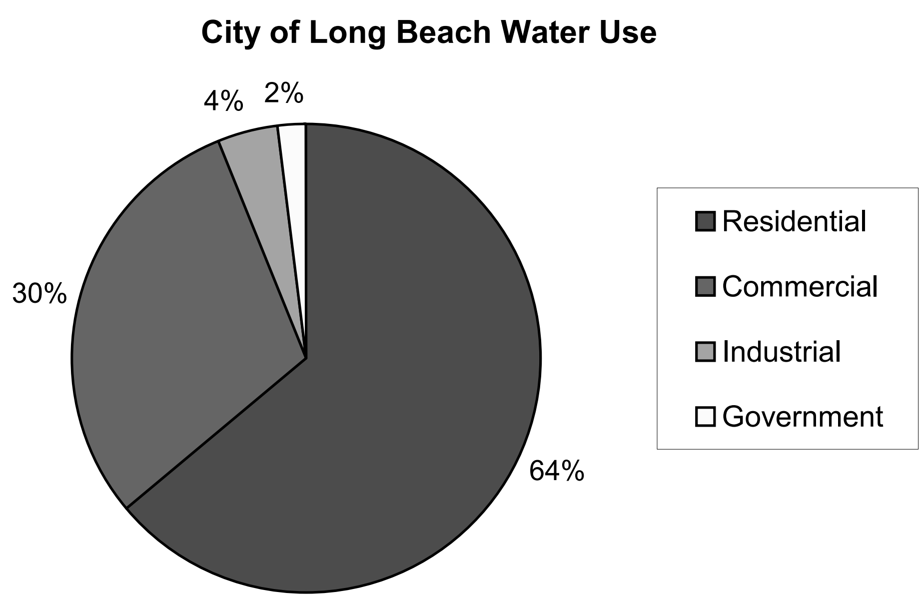
B.3 Focus Group Participant Handout, Long Beach Example

Your First Name: ______________________

Please do not turn to the next page until asked to do so by the moderator

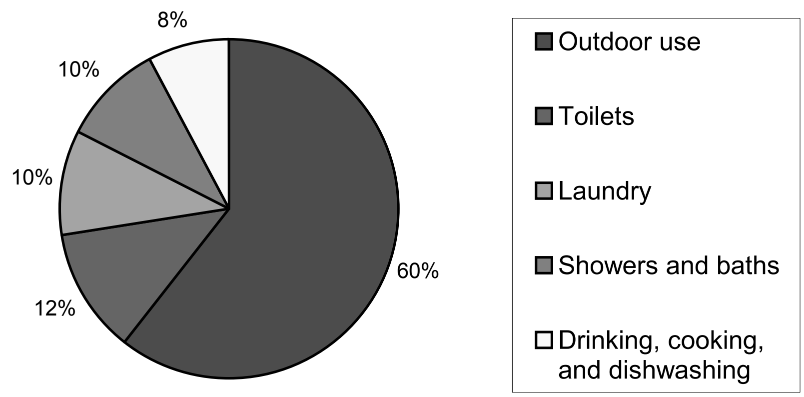
HANDOUT 1

Currently, Long Beach Water Department's (LBWD's) residential, commercial, and industrial customers use approximately 20 billion gallons of water each year, which is enough to fill over 60,000 football fields with one foot of water. The pie chart below shows how much water is used for residential, commercial, industrial, and government purposes. Nearly two-thirds (64%) of the water produced by LBWD is used by residential customers.

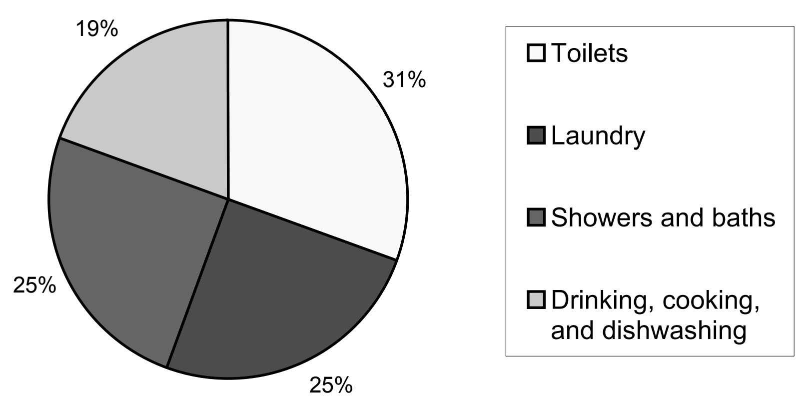


The typical single family household in Long Beach uses an average of about 210 gallons of water per day. In the summertime, Long Beach residents use much more water than in the winter (average summer use is about 390 gallons per day). Typically 80% of household *summer* water use is outside, primarily for watering lawns and gardens. The pie charts below shows how much water is used throughout the year by residents living in an average household with a yard, and by residents living in an average household without a yard, for various purposes.

Average Water Usage by Households with a Yard (260 gallons per day)



Average Water Usage by Households without a Yard (180 gallons per day)



1. Did any of the information in the pie chart about the average residential customer's water use surprise you?

Yes	☐
No	☐

   a. If so, what surprised you?

2. How do you think your household's water use compares to the averages presented in the pie chart? Do you use more, less, or about the same in each category? Why?

3. What types of <u>outdoor</u> activities do you do <u>at your home</u> that involve using water? **(Please check <u>all</u> that apply)**

Watering your lawn or garden	☐
Washing your car	☐
Swimming in your own pool	☐
Washing your pets	☐
Decorative fountains	☐
Cleaning your walkway or driveway	☐
Other (please specify)	☐

4. What types of outdoor activities do you do <u>away from your home</u> that involve neighborhood parks and other public green spaces that require watering? **(Please check <u>all</u> that apply)**

Walking, running, or picnicking in a public park	☐
Driving along green spaces	☐
Playing on sports fields	☐
Other (please specify_________________)	☐

5. Are you connected to a public water supply system?

Yes	☐
No	☐

a. If no, do you know where you get your water?

Private wells	☐
Other (please specify _________________)	☐
I don't know where my water comes from	☐

Please do not turn to the next page until asked to do so by the moderator.

HANDOUT 2

1. Do you pay your own water bill? **(Check <u>one</u> box)**

   Yes ☐
   No ☐

   a. If you answered no, do you know who pays your water bill (e.g., homeowners association, landlord)?

   b. If you answered yes, is your water and sewer bill combined or are they separate bills? Is your electricity cost also included in the same bill?

   c. If you do pay your water bill, how often are you billed (e.g., monthly, every two months)?

   d. If you know how much you pay for your water bill, about how much is your average monthly water bill? If you use more water in the summer than the winter, please make your best estimate for the average monthly amount.

   e. Have you noticed any increase in your water bill over the past few years?

Please do not turn to the next page until asked to do so by the moderator.

HANDOUT 3

1. Is the amount of water available to households in your area in short supply in some years?

Yes	☐
No	☐

a. If yes, how did the last water shortage affect your household?

2. Did your local water provider ever require mandatory cutbacks on your household's water use (e.g., restricting the days you can water your lawn)?

Yes	☐
No	☐

a. If yes, what did they require you to do?

b. If yes, how much did the actions taken by your water agency inconvenience you personally?

Not at all	☐
Slightly inconvenienced	☐
Moderately inconvenienced	☐
Very inconvenienced	☐
Extremely inconvenienced	☐

3. Did your local water provider ever encourage <u>voluntary</u> cutbacks on your household's water use?

Yes	☐
No	☐

a. If yes, what did they encourage you to do?

4. Did your household take any additional <u>voluntary</u> actions beyond those required or encouraged by your water provider to reduce your water use during the last water shortage?

Yes	☐
No	☐

a. If yes, what did you do?

5. How did the water shortage affect your <u>indoor</u> water use? Please explain.

6. How did the water shortage affect your <u>outdoor</u> water use? Please explain.

7. Do you feel that the water shortage affected your indoor or outdoor water use more? Please explain.

Please do not turn to the next page until asked to do so by the moderator.

HANDOUT 4

1. Do you think water supply shortages in the future will occur more often, about the same as now, or less often?

More often	☐
About the same as now	☐
Less often	☐
I don't expect water shortages in the future	☐

   a. Why do you feel water supply shortages will occur more often, less often, or about the same as now?

2. Do you know of steps that have already been taken by your local water provider to deal with future water shortages? If so, please write them in the space below.

Please do not turn to the next page until asked to do so by the moderator.

HANDOUT 5

To minimize future water shortages, Long Beach's water provider, LBWD, is considering several alternatives to increase water supplies for the future. Below is a list of several options for addressing future water shortages. Please choose your 4 most preferred options. Put a "1" for your most preferred option, a "2" for your second most preferred option, and so on. If you would like to rank more options, please feel free to do so.

Rank	Options for dealing with future water shortages
________	Increasing the amount of water that is imported from Northern California (from the Bay-Delta) and purchased from the Metropolitan Water District (MWD)
________	Increasing available supplies of water by transferring more water from agricultural uses in the state to Long Beach or MWD
________	Investing in desalination facilities, to convert ocean waters into part of the local potable supply
________	Increasing the price of water to residential, commercial, and industrial users so they will use less
________	Requiring low water landscaping (e.g., xeriscape) in new homes and redevelopment projects
________	Increasing available supplies of water by expanding the use of local groundwater (i.e., water found underground and accessed by wells)
________	Expanding water reuse for outdoor irrigation and industrial uses
________	Using highly treated recycled water to replenish the local groundwater supply
________	Increasing available supplies in dry years by acquiring more imported MWD water is wet years, and storing it underground for use in dry years
________	Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water landscaping and water efficient appliances)

Please do not turn to the next page until asked to do so by the moderator.

HANDOUT 6

Water shortages are defined by the amount of water available in a given year. When there is not enough water to meet current needs, there is a shortage and people have to reduce the amount of water they use.

In many parts of California, and elsewhere throughout the western U.S., water shortages and water use restrictions are common. These shortages may be caused by several factors including drought, reduced levels of snow in mountains that feed our MWD water supplies and groundwater, regulations or Court rulings that limit the amount of non-local water that can be imported to the City, or earthquakes or other events that may disrupt the flow of imported water into the local region.

Typically if there is only a small shortfall in the amount of available water, the reductions can be met through voluntary cutbacks or minimal restrictions. When there are more severe water shortages, water providers are likely to require greater reductions in the amount of water you can use.

To reduce the likelihood of a severe water shortage, the Long Beach Board of Water Commissioners adopted a number of water use prohibitions that have been incorporated into city code. These “permanent” water use prohibitions are in place year-round. They include restrictions on outdoor landscape watering. For example, landscape irrigation is limited to 15 minutes per area on Monday, Thursday, and Saturday after 4:00 p.m. and before 9:00 a.m., and water is not allowed to run off irrigated landscape areas onto sidewalks and streets.

The permanent water use prohibitions have helped to substantially reduce water demand in Long Beach. However, severe water shortages may still occur. In the event of a drought or other water shortage event, the LBWD’s Board of Water Commissioners has the authority to issue a declaration of Imminent Supply Shortage, which establishes mandatory water conservation measures and prohibited uses of water, based on three stages of water shortage. Mandatory water use restrictions under each stage are as follows:

- **Stage 1 Water Supply Shortage**. In addition to the permanent water use restrictions described above, Stage 1 water use restrictions include:
  - Landscape watering only on Mondays and Thursdays after 4:00 p.m. and before 9:00 a.m., between the months of October and April
  - Filling residential swimming pools and spas with potable water is not allowed

Stage 1 restrictions (or their equivalent) have been necessary in 5 of the past 20 years.

- **Stage 2 Water Supply Shortage**. In addition to the permanent water use restrictions, Stage 2 water use restrictions include:

  - Stage 1 water restrictions

  - Landscape watering only on Monday or Thursday after 4:00 p.m. and before 9:00 a.m., year-round

  Stage 2 restrictions (or similar rules) have been required in Long Beach in 3 of the past 20 years.

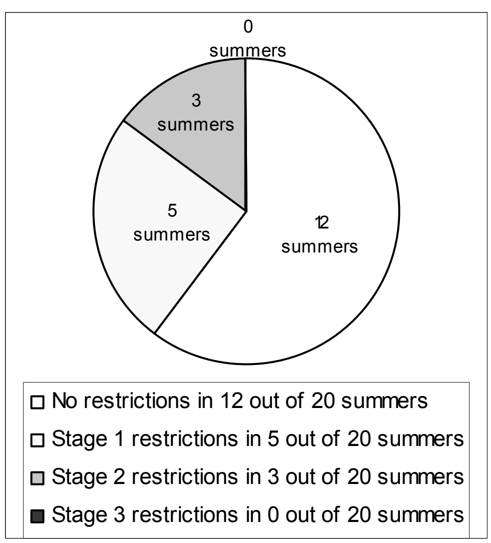
- **Stage 3 Water Supply Shortage.** In addition to the permanent water use restrictions, under Stage 3 water use restrictions:

  - Most outdoor water use would not be allowed

  - Additional water use restrictions may be put in place by the Board as necessary

  There have been no “Stage 3” restrictions put in place in the last 20 years in Long Beach.

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.



There are a number of actions that water providers can take to address future residential water use shortages. These include:

Increasing groundwater use

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice in the mountains and is the source of water for aquifers, springs, and wells. With careful planning and state approval, the use of groundwater from local or non-local sources may be increased to expand available drinking water supplies.

Importing or transferring additional water to the region

Additional water supplies could be created by importing more water from outside of Long Beach (such as purchasing Bay-Delta water from MWD), or by improving agricultural water use practices and transferring the saved water from agricultural uses to residential uses.

Increasing water storage

Water storage could be expanded by purchasing additional imported Bay-Delta water from MWD in years when Northern California Bay-Delta waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used in dry years.

Increasing the amount of water conservation

Increased water conservation actions could include rebates for water saving appliances or for converting to low water use landscaping. Alternatively, mandatory low water landscaping could be required of new homes and redevelopment projects.

Increasing the recycling of water

After water is highly treated, it can be reused for watering of public landscape areas, parks, and golf courses. Also, after it is highly treated, recycled water can be used to replenish existing local groundwater supplies and later reused for drinking water.

Adding desalinated water

Saltwater, such as found in the Pacific Ocean, can be transformed into high-quality fresh water through the use of a variety of advanced water treatment processes. Desalination facilities can be built to provide fresh water to supplement the City's other supplies.

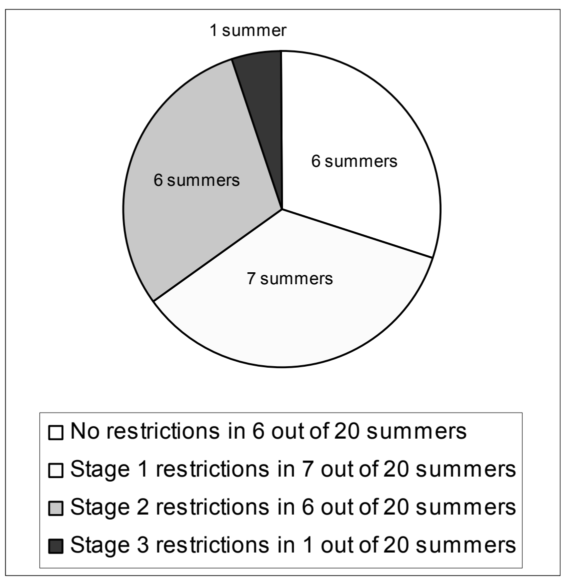
The questions on the next page ask you to choose among alternative programs that could be implemented to address future water shortages in Long Beach. These programs would be in addition to other projects that are already planned or in progress.

Each of the potential additional programs has different combinations of actions and would cost your household different amounts of money.

The different programs involve different combinations of actions that would reduce the frequency and severity of future water shortages by enhancing local and/or imported water supplies. Some programs do more than others, but those programs typically also cost more.

Even without any additional water programs put in place, it is expected that your annual water bill will increase due to ongoing improvements and general cost increases faced by your water provider.

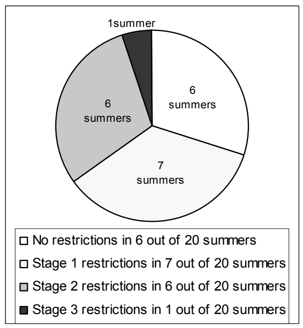
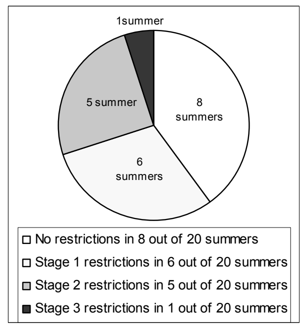
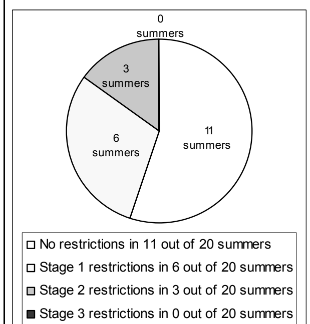
Given expected future growth, with only the currently planned water supplies, the number and severity of water shortages will increase. The pie chart below shows the expected change in water use restrictions over the next 20 years if no additional actions are taken to address future water needs.

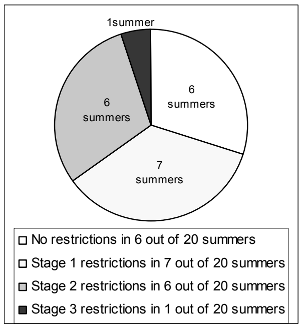
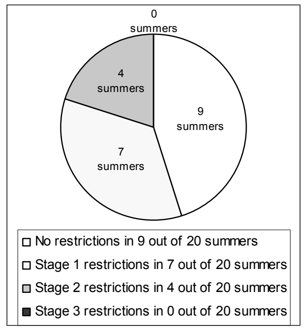
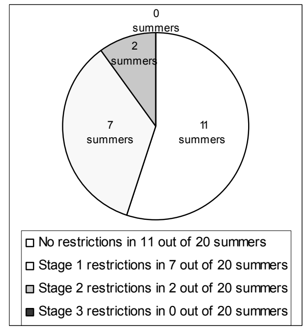


Expected future with no new actions

The tables on the next two pages present options for addressing future water needs. At the bottom of each table, you are asked to choose which of the programs you prefer. Make a preferred choice on each page.

Remember, if you choose to spend additional money for an additional water program, that money won't be available for you to buy other things. If you do not want to spend additional money to reduce future water use restrictions, you should check the No Additional Actions box as your preferred option.

	No Additional Actions	**Plan A**	**Plan B**
Addition to your <u>annual</u> water cost each year for the next 20 years.	$1 per month, which would be $12 per year	$10 per month, which would be $120 per year	$25 per month, which would be $300 per year
Available water supply such that water use restrictions in the next 20 years will be:			
Which option do you prefer? *Check <u>one</u> box.*	☐	☐	☐

	No Additional Actions	Plan C	Plan D
Addition to your <u>annual</u> water cost each year for the next 20 years.	$1 per month, which would be $12 per year	$18 per month, which would be $216 per year	$30 per month, which would be $360 per year
Available water supply such that water use restrictions in the next 20 years will be:			
Which option do you prefer? *Check <u>one</u> box.*	☐	☐	☐

Appendix C

Value of Water Supply Reliability Survey Instrument

C.1 Austin Version

Screen shots from the Survey Instrument are provided below.

Your Views on Issues in Texas

We are faced with many issues in Texas, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

Issues in Texas	Not Important At All	Slightly Important	Moderately Important	Very Important	Extremely Important
Improving education in public schools	○	○	○	○	○
Improving local libraries	○	○	○	○	○
Increasing water supplies	○	○	○	○	○
Reducing crime	○	○	○	○	○
Helping farmers increase their incomes	○	○	○	○	○
Reducing taxes	○	○	○	○	○

Next

Screen 1

This survey focuses on issues related to water in the Austin metropolitan area.

Decisions are being made now that will affect the amount of water we have available in the future. Austin area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

Screen 3

How long have you lived in the Austin metro area?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 4

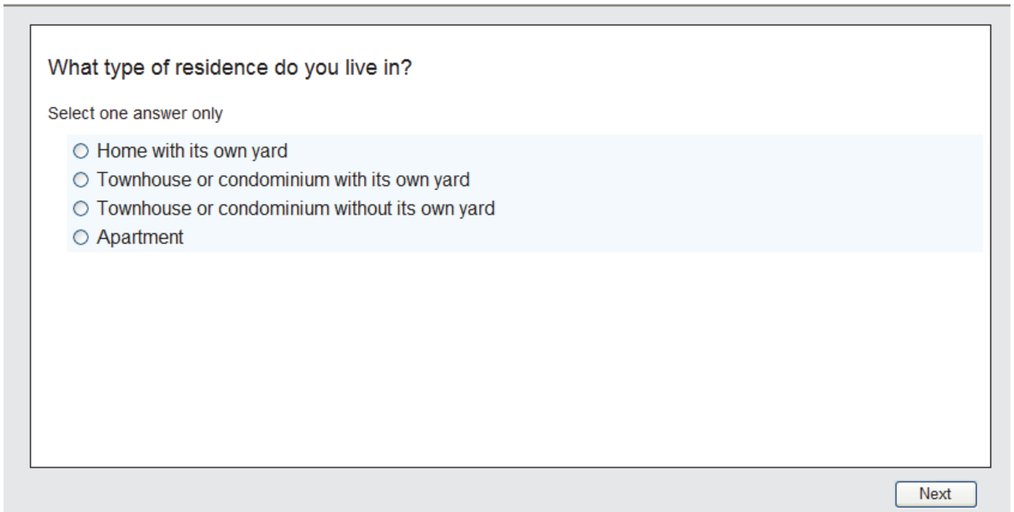
How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

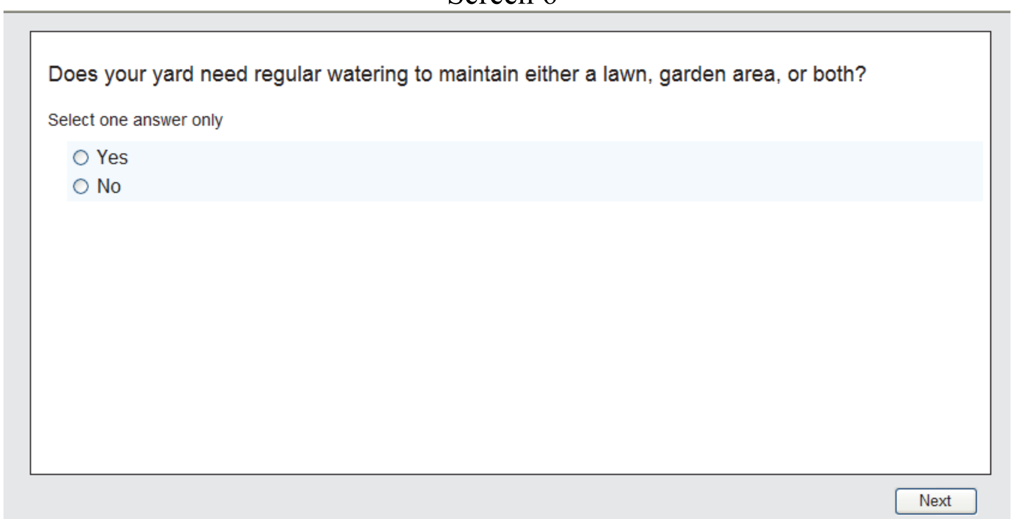
Area	Not good at all	Slightly good	Moderately good	Very good	Extremely good
Making sure you have enough water	○	○	○	○	○
Providing safe and healthy drinking water	○	○	○	○	○
Providing good tasting drinking water	○	○	○	○	○
Promoting water conservation	○	○	○	○	○

Next

Screen 5



Screen 6[5]



1. [5]. Screen 6 reflects the choice made in Screen 5.

Screen 7

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- ○ Yes
- ○ No

Next

Screen 8

Who pays your water bill?

Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify: ________
- ○ I don't know how my water bill is paid

Next

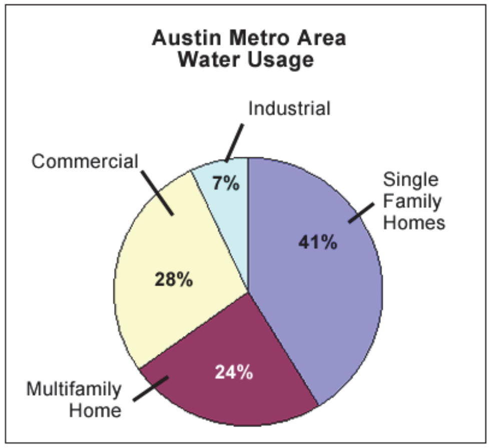
Screen 9

The next few screens will provide information about the sources and amount of water used in the Austin metro area.

Next

Screen 10

Water suppliers in the Austin metro area provide just over 56 billion gallons of water each year for a variety of different users. The pie chart below shows how much water is used for single- and multifamily homes and commercial and industrial purposes. About 2/3rds (65%)of this water goes to residential customers.



Next

Screen 11

The actual amount of water any one household uses depends on:

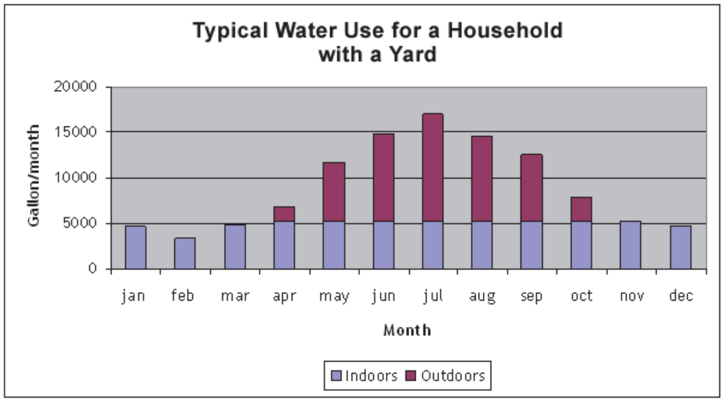
- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

The typical household with its own yard in the Austin metro area, on average, uses 290 gallons of water per day or about 105,000 gallons per year. Most of this water is used during the summer months for watering lawns and gardens.

Next

Screen 12

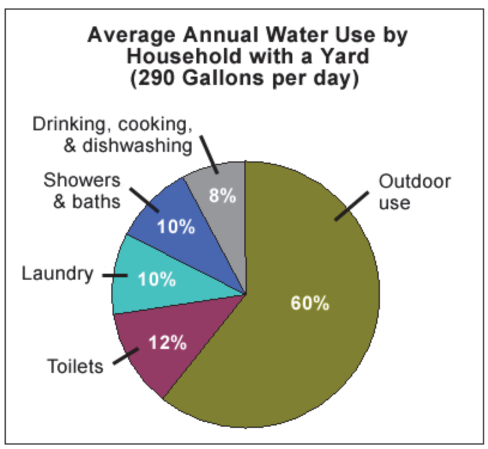
The chart below shows monthly water usage for the average household with its own yard. Typically, water use increases during the summer.



Next

Screen 13

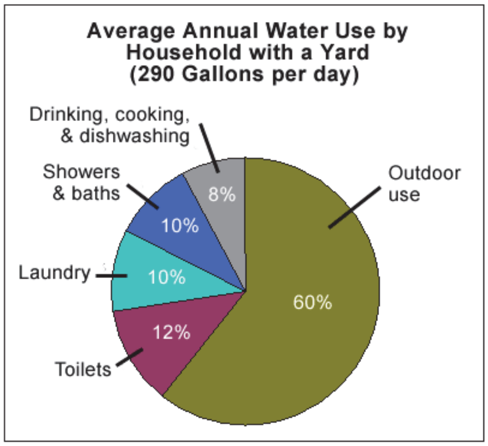
The pie chart below shows how an average household with its own yard uses water throughout the year.



Next

Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for outdoor use?



Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND

The goal of water suppliers is to match available water supplies with demand by taking into account river flow, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect growing water demands in the Austin metro area over the next 20 years. Growing demands, coupled with uncertainty over future rainfall and river levels, means that water demands will periodically exceed the available water supply in several of the next 20 years.

To achieve the goal of ensuring an adequate supply of clean water, water suppliers in the Austin metro area are considering options to make sure that enough water is available in the future. For this reason, water suppliers are interested in your views of whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 16

Methods to Address Current Water Shortages

In this region, in addition to voluntary water conservation measures, there are some water use rules that are always in place. These permanent restrictions include:

- No outdoor watering between 10 a.m. and 7 p.m.
- Water should not run off pavement surfaces
- No watering on rainy or very windy days
- Leaks should be fixed quickly

Next

When there is not enough water to meet demand, mandatory water use restrictions become necessary, and they can have significant effects on residents, businesses, and public parks. When needed, water use restrictions are typically put in place during summer and fall months.

Water suppliers in the Austin metro area currently have three levels of mandatory water use restrictions to address water shortages. The level selected depends on the severity of water shortages. These restrictions typically apply from May 1 through September 30 , but some water use restrictions also apply at other times when water supplies are insufficient to meet needs.

Stage 1 restrictions apply every year from May through September, and include the following limits for residential customers:

- Watering of lawns, gardens, and public parks is limited to no more than twice a week on designated days.
- Watering by sprinkler or irrigation is allowed only on designated days, before 10:00 a.m. and after 7:00 p.m.
- Watering with a hand-held hose or hand-held bucket is allowed at any time.

Stage 2 restrictions include the following limits for residential and other customers:

- Watering of lawns, gardens, and public areas with a hose-end sprinkler, a soaker hose, or drip irrigation is allowed only on designated outdoor water use days, and must occur before 10:00 a.m. and after 7:00 p.m.
- Watering of lawns, gardens, and public areas with a permanently installed automatic irrigation system is allowed only on designated outdoor water use days, and must occur between midnight and 10:00 a.m.
- Watering of lawns, gardens, and public areas with a hand-held hose or a hand-held bucket can occur at any time.

Screen 17

- Home vehicle washing using a hand-held bucket or hose with a shutoff nozzle is allowed only on designated outdoor water use days, and must occur before 10:00 a.m. and after 7:00 p.m.
- Water is served in restaurants only upon request.

Stage 3 restrictions include the following limits for residential and other customers:

- Watering of lawns, gardens, and public areas is allowed only with a hand-held hose or a hand-held bucket, is limited to designated outdoor water use days, and is limited to 6:00 a.m. to 10:00 a.m. and 7:00 p.m. to 10:00 p.m.
- No use of automatic irrigation systems.
- No vehicle washing at all.
- No operation of outdoor ornamental fountains or structures making similar use of water, other than the aeration necessary to preserve habitat for aquatic species.
- No filling of swimming pools, fountains, or ponds.
- No installation of new landscaping.

Next

Screen 18

Stage 2 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one summer.
- If water shortages require Stage 2 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).

Stage 3 restrictions can lead to dead lawns and landscaping for households and public parks after only one year.

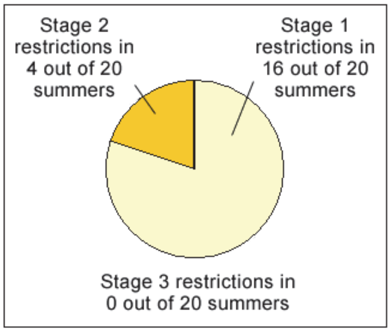
Next

Screen 19

Stage 1 restrictions occur every year between May 1 and September 30. Stage 2 and Stage 3 water use restrictions are put in place if water shortages become more severe or prolonged.

Stage 2 restrictions have been needed during four summers over the last 20 years.

Stage 3 restrictions have not been needed in the last 20 years. The pie chart below illustrates how often Stage 2 restrictions have been needed in the last 20 years.



Next

Screen 20

Water Suppliers Need to Identify a Water Supply Strategy

Developing new water supplies can help reduce the frequency and severity of future water shortages. Water suppliers are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

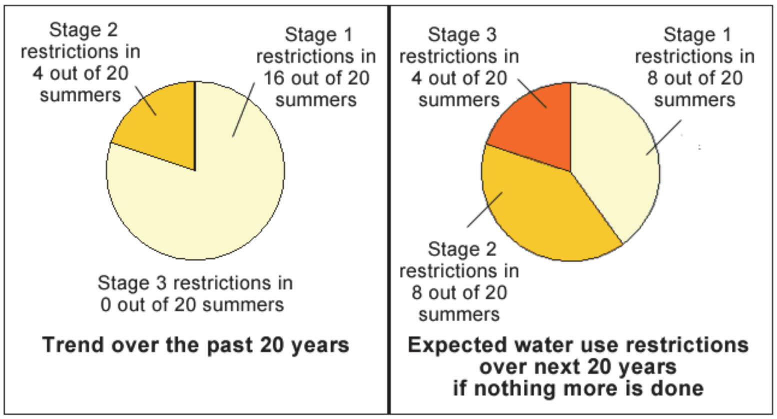
While additional water supplies are not mandatory, without new supplies, water use restrictions will become more severe and frequent in the future.

Next

Screen 21

The two pie charts below compare the frequency of water use restrictions in the past with expected restrictions that will be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that in the past, Stage 2 restrictions have been needed four out of the past 20 years. This is the same chart you saw on a previous screen.
- The pie chart on the right shows that Stage 2 restrictions are likely to be more frequent in the future than in the past, and Stage 3 restrictions will be needed for the first time if no new water supplies are developed.



Next

Screen 22

Your Opinion on How Much Should be Done to Increase Future Water Supplies

The more water supplies that are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The tables also show the increased costs to you.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, Stage 1 water use restrictions will be in place 8 of the next 20 summers, Stage 2 restrictions will be in place 8 of the next 20 summers, and Stage 3 restrictions in 4 of the next 20 summers.

Over the past 20 years, Stage 1 restrictions have occurred in 16 summers, Stage 2 restrictions have occurred in 4 summers, and there have been no Stage 3 restrictions.

If you would like to be reminded of the permanent water use restrictions, and Stage 1, Stage 2, and Stage 3 restrictions, please click the button on the right. Click here

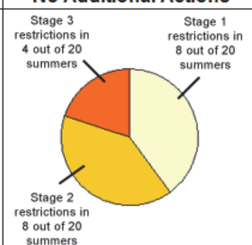
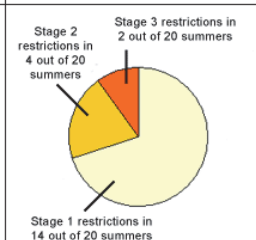
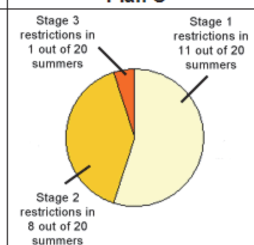
Water Supply Plans B and C both increase water supplies and have different levels of future restrictions.

The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Please review the table and check the box under the plan you most prefer.

Screen 23

	No Additional Actions	Plan B	Plan C
Available water supply such that water use restrictions in the next 20 years will be:			
Increase in your water cost	$1 per month, which would be $12 per year	$11 per month, which would be $130 per year	$13 per month, which would be $160 per year
Which plan do you prefer?	○	○	○

Next

Screen 24[6]

Please provide a brief comment to help us understand why you chose $11 per month, which would be $130 per year as your most preferred plan.

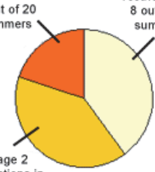
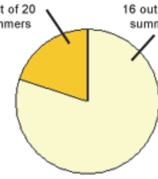
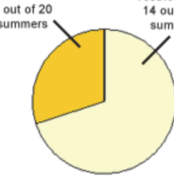
Type in the answer

Next

Screen 25

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans at different costs to you.

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan D	Plan E
Available water supply such that water use restrictions in the next 20 years will be:	Stage 3 restrictions in 4 out of 20 summers; Stage 1 restrictions in 8 out of 20 summers; Stage 2 restrictions in 8 out of 20 summers 	Stage 2 restrictions in 4 out of 20 summers; Stage 1 restrictions in 16 out of 20 summers; Stage 3 restrictions in 0 out of 20 summers 	Stage 2 restrictions in 6 out of 20 summers; Stage 1 restrictions in 14 out of 20 summers; Stage 3 restrictions in 0 out of 20 summers 
Increase in your water cost	$1 per month, which would be $12 per year	$15 per month, which would be $180 per year	$13 per month, which would be $150 per year
Which plan do you prefer?	○	○	○

Next

2. [6] Screen 24 reflects the choice made in Screen 23.

Screen 26[7]

Please provide a brief comment to help us understand why you chose $15 per month, which would be $180 per year as your most preferred plan.

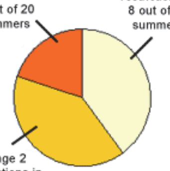
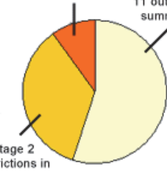
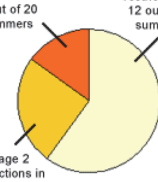
Type in the answer

Next

Screen 27

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans at different costs to you.

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan F	Plan G
Available water supply such that water use restrictions in the next 20 years will be:	Stage 3 restrictions in 4 out of 20 summers Stage 1 restrictions in 8 out of 20 summers  Stage 2 restrictions in 8 out of 20 summers	Stage 3 restrictions in 2 out of 20 summers Stage 1 restrictions in 11 out of 20 summers  Stage 2 restrictions in 7 out of 20 summers	Stage 3 restrictions in 3 out of 20 summers Stage 1 restrictions in 12 out of 20 summers  Stage 2 restrictions in 5 out of 20 summers
Increase in your water cost	$1 per month, which would be $12 per year	$13 per month, which would be $150 per year	$8 per month, which would be $90 per year
Which plan do you prefer?	○	○	○

Next

3. [7]. Screen 26 reflects the choice made in Screen 25.

Screen 28[8]

Please provide a brief comment to help us understand why you chose $13 per month, which would be $150 per year as your most preferred plan.

Type in the answer

Next

Screen 29

Your Opinion on How We Should Increase Future Water Supplies

Austin area water suppliers are evaluating different options to increase the amount of water available in the future to reduce water use shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing water storage facilities
- Importing additional water into the region
- Increasing groundwater use
- Increasing the amount of water conservation
- Transferring water from agricultural uses
- Increasing the use of recycled water

The next few screens provide more details on each of these options.

Next

4. [8]. Screen 28 reflects the choice made in Screen 27.

Screen 30

Increasing water storage facilities

Increased water storage facilities could be created by:

- Developing underground reservoirs (groundwater storage) to store additional water in wet years for use in dry periods.
- Increasing the capacity of reservoirs on the Lower Colorado River.

Additional storage would allow water suppliers to store more water in years when water is plentiful for use in dry years.

While increasing the size of existing surface reservoirs could create additional recreation opportunities on these reservoirs, it might also cause the loss of some property along the reservoirs' current shoreline and the need to replace some recreational access points. It also might have some negative effects on ecosystems, including:

- Loss of river and wildlife habitat
- Decreased flows in some rivers at some times of the year, which could impact some fish and other types of wildlife that rely on adequate stream flows

Next

Screen 31

Transferring water from agricultural uses

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. The saved water could be transferred to the Austin area for residential and business use. Water could be saved by having Austin metro area water suppliers:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.

Next

Screen 32

Increasing groundwater use

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. Groundwater from both local and non-local sources can be used for drinking water supplies.

Use of non-local groundwater supplies would require the installation of additional pipelines and pumps to transfer water to the Austin area, and have increased energy costs associated with moving the water to the Austin metro area.

Use of local groundwater supplies would reduce the amount of water available in local springs and natural pools.

Next

Screen 33

Increasing the use of recycled water

Most of the water used in the Austin metro area is treated and discharged to the Lower Colorado River , and flows out of the region. Some of the treated water can be used again in the Austin metro area. After it is treated, recycled water can be used:

- For watering public landscape areas, parks, and golf courses.
- To replenish groundwater reservoirs. This water can later be treated again and used for drinking water.
- For some industrial processes, such as cooling in power plants.

There are currently opportunities to increase the amount of recycled water in the Austin metro area

Next

Screen 34

Increasing the amount of water conservation

Increased water conservation actions could include:

- Rebates for water saving appliances
- Rebates for converting to low-water use landscaping (e.g., xeriscape)
- Mandatory low-water landscaping for new homes.

A lot of individual water conservation measures have already been taken by residents and businesses in the Austin metro area. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use by giving up lawns at homes, athletic fields, and public parks.

Next

Screen 35

Importing additional water into the region

Additional water supplies could be created by importing water from outside the Lower Colorado River basin.

Importing water from outside the Lower Colorado River basin may have some negative consequences. Removing water from other rivers and lakes could:

- Impact ecosystems and recreational opportunities
- Limit the amount of water available to people living near the rivers from which the water is exported to Austin
- Increase energy costs associated with moving the water to the Austin metro area

Next

Your Opinion on How We Should Meet Future Water Needs

In the table below, you are presented with different options that water suppliers could undertake to improve the future water supply reliability.

Please rank your top 5 options for increasing our future water supply according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

Increasing the use of non-local groundwater sources	
Increasing the price of water to residential, commercial, and industrial users so they will use less	
Requiring low water landscaping in new homes (e.g., xeriscape)	
Increasing available supplies of water by expanding storage reservoirs or building new reservoirs	
Increasing the use of local groundwater sources	
Expanding water recycling for outdoor irrigation and industrial uses	
Promoting voluntary water conservation through education and incentives (e.g., rebates)	
Expanding water recycling to replenish groundwater reservoir supplies	
Increasing available supplies of water by importing more water from outside the Lower Colorado River basin	

Screen 36

Increasing available supplies of water by transferring more water from agricultural uses	

Next

Screen 37

Of these five options, which do you like the least?

Select one answer only

- ○ Increasing available supplies of water by importing more water from outside the Lower Colorado River basin
- ○ Increasing available supplies of water by transferring more water from agricultural uses
- ○ Increasing the use of non-local groundwater sources
- ○ Increasing the price of water to residential, commercial, and industrial users so they will use less
- ○ Increasing available supplies of water by expanding storage reservoirs or building new reservoirs

Next

Screen 38

Does it Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate what option you prefer.

Next

Screen 39

Does it Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate what option you prefer.

Next

Screen 40

Of the two water storage options below, which do you prefer?

Select one answer only

- ○ Increasing underground water storage
- ○ Increasing surface reservoir storage

Next

Screen 41

Of the two groundwater water options below, which do you prefer?

Select one answer only

- ○ Increasing use of local groundwater sources
- ○ Increasing use of non-local groundwater sources

Next

Screen 42

Of the two water transfer and import options below, which do you prefer?

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from outside the Lower Colorado River basin

Next

Screen 43

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes
- ○ Promoting voluntary water conservation through education and incentives

Next

Screen 44

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Select one answer only

- ○ Expanding water recycling to replenish groundwater reservoir supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 45

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 46

Thank you for completing this survey. We have successfully received your responses.

C.2 Long Beach

Value of Water Supply Reliability Survey Instrument: Long Beach Version

Screen shots from the Survey Instrument are provided below.

Screen 1

Your Views on Issues in Southern California

We are faced with many issues in Southern California, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

Issues in Southern California	Not Important At All	Slightly Important	Moderately Important	Very Important	Extremely Important
Improving local libraries	○	○	○	○	○
Improving education in public schools	○	○	○	○	○
Reducing taxes	○	○	○	○	○
Increasing water supplies	○	○	○	○	○
Helping farmers increase their incomes	○	○	○	○	○
Reducing crime	○	○	○	○	○

Screen 2

This survey focuses on issues related to water in the Long Beach area.

Decisions are being made now that will affect the amount of water we have available in the future. Southern California area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 3

How long have you lived in Long Beach?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 4

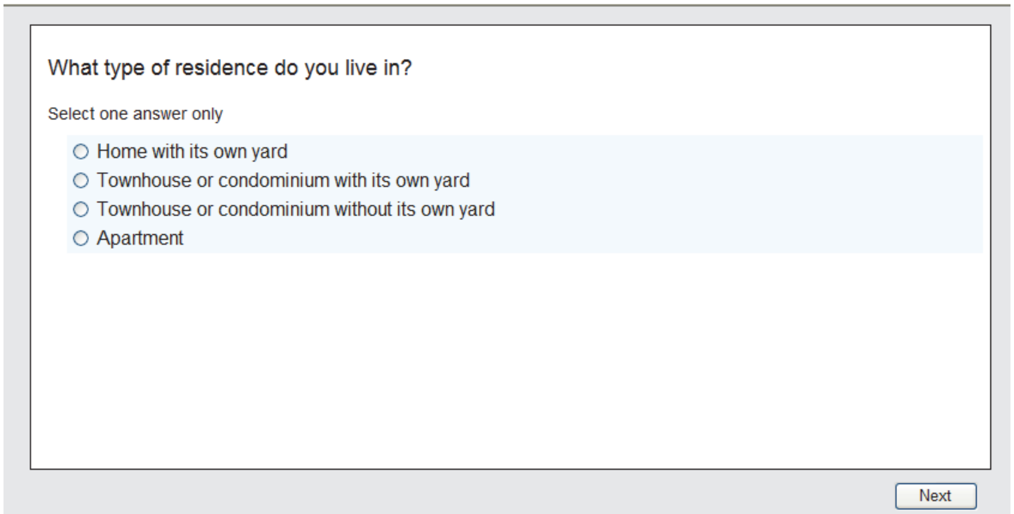
How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

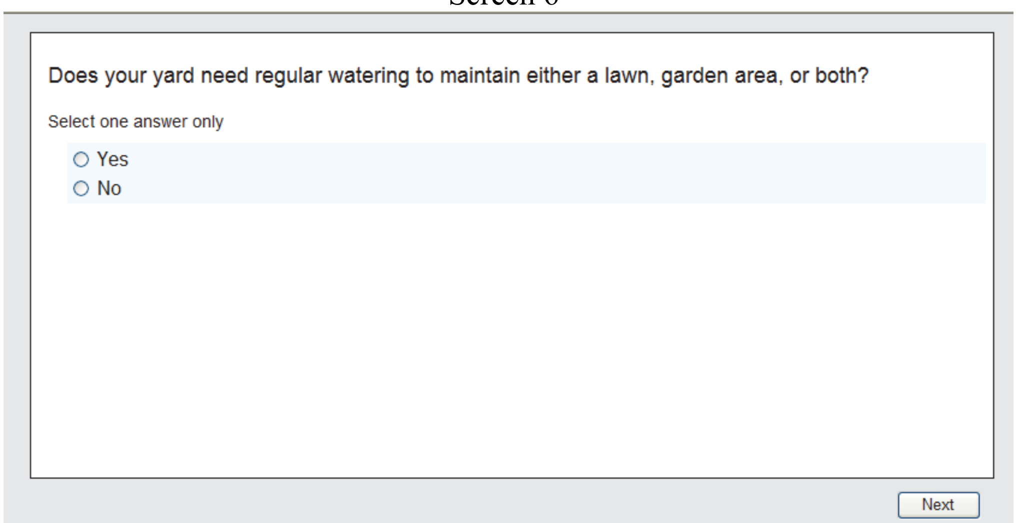
Area	Not good at all	Slightly good	Moderately good	Very good	Extremely good
Making sure you have enough water	○	○	○	○	○
Providing safe and healthy drinking water	○	○	○	○	○
Providing good tasting drinking water	○	○	○	○	○
Promoting water conservation	○	○	○	○	○

Next

Screen 5



Screen 6[9]



5. [9]. Screen 6 reflects the choice made in Screen 5.

Screen 7

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- ○ Yes
- ○ No

Next

Screen 8

Who pays your water bill?

Select one answer only

- ○ My household pays its own water bill
- ○ My landlord pays the water bill
- ○ My water bill is part of my HOA fees
- ○ Other specify:
- ○ I don't know how my water bill is paid

Next

Screen 9

The next few screens will provide information about the sources and amount of water used in Long Beach.

Next

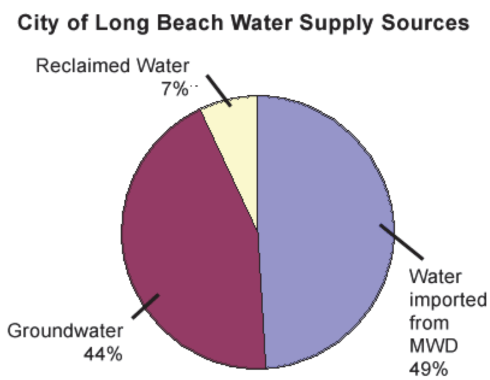
Current Water Use

The Long Beach Water Department (LBWD) serves close to half a million people. LBWD has three major sources of water supply:

- ***Treated imported water purchased from the Metropolitan Water District (MWD).*** MWD is the nation's largest water supplier, and its mission is to provide water to 26 cities and water districts throughout Southern California. MWD imports this water from the Colorado River, and from the Northern California Bay Delta Region. Examples of communities that receive imported water from MWD include Los Angeles, Riverside, San Diego, and Long Beach. Roughly half of Long Beach's water is imported and acquired from MWD.
- **What is imported water?**
- ***High-quality local groundwater, extracted and treated by LBWD.*** Groundwater is water that has found its way underground, where it is naturally filtered and stored in the spaces found in the underground environment. The groundwater used by LBWD originates in the San Gabriel Mountains, and travels down the San Gabriel River drainage area, slowly making its way underground along its path to the City. LBWD extracts the groundwater from wells that are greater than 1,000 feet deep. This groundwater supplies about 44% of Long Beach's water needs.
- **What is groundwater?**
- ***Recycled water.*** Recycled water is highly treated wastewater, which is provided to Long Beach by the Los Angeles County Sanitation District. LBWD then distributes this recycled water through a special piping network to locations where it can be safely used for outdoor irrigation and industrial purposes.
- **What is recycled water?**

Screen 10

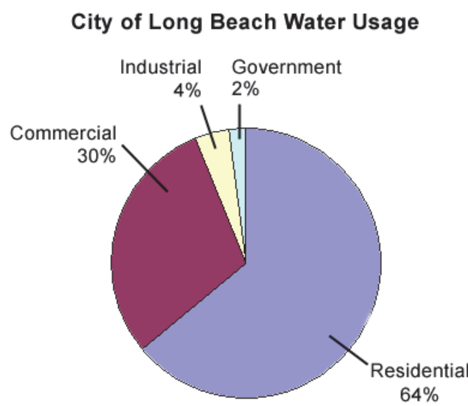
The pie chart below shows the percentage of LBWD water that comes from these various sources.



Next

Screen 11

LBWD provides close to 21 billion gallons of water each year for a variety of different users. The pie chart below shows how much water is used for residential, government, commercial, and industrial purposes. About two-thirds (64%) of water provided by LBWD goes to residential customers.



Next

Screen 12

The actual amount of water any one household uses depends on:

- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

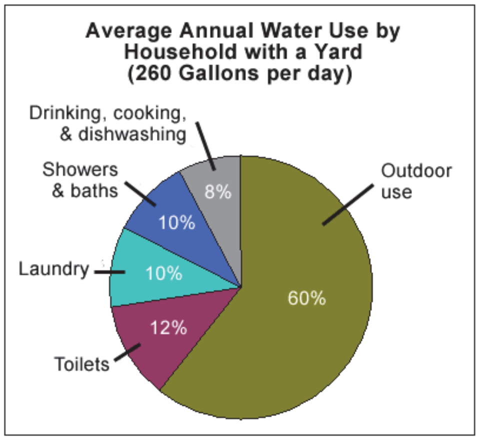
In the Long Beach area, the typical household with its own yard uses 260 gallons of water per day, on average, or about 95,000 gallons per year. Most of this water is used during the summer months for watering lawns and gardens, washing cars, and other outdoor activities.

Households that do not have yards use about 180 gallons of water per day, on average, or about 66,000 gallons per year.

Next

Screen 13

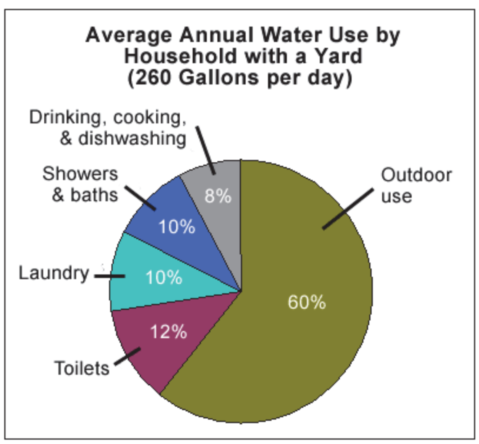
The pie chart below shows how an average household with its own yard uses water throughout the year.



Next

Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for <u>outdoor</u> use?



Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND

The goal of water suppliers is to match available water supplies with demand by taking into account river flow, groundwater levels, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect water demands to increase in the Long Beach area over the next 20 years. Growing demands, coupled with uncertainty over future rainfall, river levels, and groundwater availability, means that water demands will periodically exceed available water supply in several of the next 20 years. These factors will affect water supplies in all Southern California communities.

The reliability of imported surface water will also be an issue for communities in Southern California (including Long Beach), which largely rely on water imported by MWD:

- In recent years, the amount of water California has imported from the Colorado River has been scaled back by more than 50%. This is due to long-term drought in the Colorado River basin and the fact that California is no longer allowed to use more than its allocated share of Colorado River water.
- Water imported from Northern California has also been limited due to a number of factors, including reduced snow melt, less river water flowing into the Bay Delta, and increased demands from competing water users. In recent years, there also have been court orders that have significantly limited extraction of water from the Bay Delta in order to protect endangered fish.

Screen 15

The availability of imported water is expected to continue to decrease over the next 20 years.

Next

Screen 16

To achieve the goal of ensuring an adequate supply of clean water, LBWD and other regional water suppliers are considering options to make sure that enough water is available in the future. For this reason, LBWD and other water planners in the region are interested in your views on whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 17

Methods to Address Current Water Shortages

In Long Beach, in addition to voluntary water conservation measures, there are some water use rules that are always in place. These permanent water use restrictions include limitations on outdoor landscape watering. For example, under the permanent water use restrictions:

- Landscape irrigation is limited to 15 minutes per area on Monday, Thursday, and Saturday, after 4:00 p.m. and before 9:00 a.m.
- Water is not allowed to run off irrigated landscape areas onto sidewalks and streets.
- Operating a fountain or similar structure that does not recirculate the water is not allowed.
- All water leaks are required to be fixed in a timely manner.

Next

Screen 18

When there is not enough water to meet demand, additional mandatory water use restrictions become necessary, and they can have significant effects on residents, local businesses, and public parks.

To address water shortages, LBWD currently has two stages of mandatory water use restrictions that can be applied in addition to the permanent water use restrictions that are always in place. The stage selected depends on the severity of water shortages:

Stage 1 Restrictions. In addition to the permanent water use restrictions described above, under Stage 1 water use restrictions:

- Landscape watering is only allowed two days per week (Mondays and Thursdays after 4:00 p.m. and before 9:00 a.m.), year-round.
- Filling residential swimming pools and spas with drinking water is not allowed.

Stage 2 Restrictions. In addition to the permanent water use restrictions described above, under Stage 2 water use restrictions:

- Most outdoor water use would not be allowed
- Additional water use restrictions may be put in place by the Long Beach Water Board as necessary

Next

Screen 19

Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one year.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).
- Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 1 restrictions.

Stage 2 restrictions can lead to dead lawns and landscaping for households and public parks after only one year. Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 2 restrictions.

Next

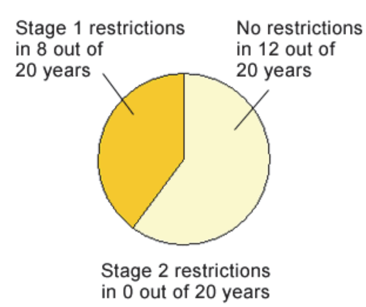
LBWD Stage 1 and Stage 2 water use restrictions are in addition to the permanent water use restrictions that are in place year-round. Stage 1 and Stage 2 water use restrictions are put in place if water shortages become severe or prolonged. Restrictions typically remain in place over a period of several months (e.g., over the summer), and can be lifted by LBWD as the severity of a water shortage is reduced.

In Long Beach, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- Stage 1 restrictions have been needed in 8 of the past 20 years.
- Stage 2 restrictions have not been needed in the last 20 years.

Screen 20

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.



Next

Screen 21

Water Suppliers Need to Identify a Water Supply Strategy

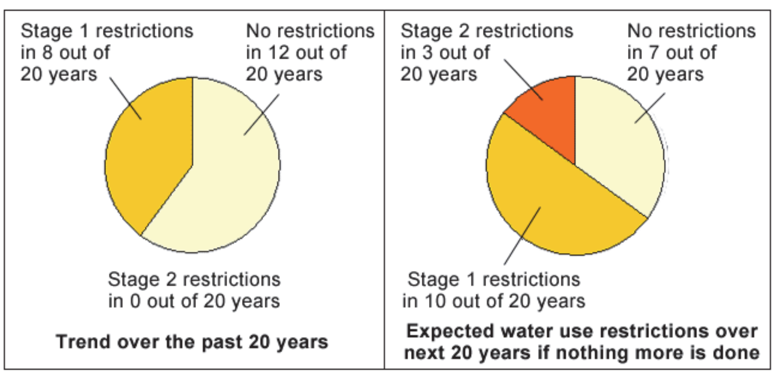
Developing new water supplies can help reduce the frequency and severity of future water shortages. Long Beach and other regional water suppliers are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

While additional water supplies are not mandatory, without new supplies, water use restrictions are expected to become more severe and frequent in the future.

Next

The two pie charts below compare the frequency of water use restrictions in the past with expected restrictions that will be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that Stage 1 restrictions have been needed 8 out of the past 20 years. Stage 2 restrictions have not yet been required. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future will be like if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions will be needed in 3 years out of 20 if no actions are taken to develop new water supplies.



Screen 22

Next

Screen 23

Your Opinion on How Much Should be Done to Increase Future Water Supplies

The more water supplies that are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water use restrictions that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

The exact timing and length of future restrictions is unknown, but it is likely that restrictions would be in place for multiple years in a row (e.g., two seasons of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 8 years, and there have been no Stage 2 restrictions.

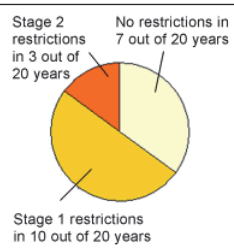
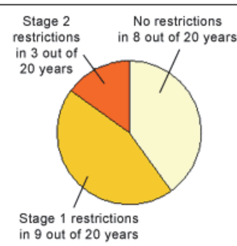
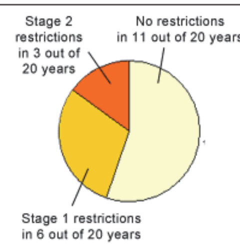
If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Please review the table and check the box under the plan you most prefer.

Screen 24

	No Additional Actions	Plan B	Plan C
Available water supply such that water use restrictions in the next 20 years will be:			
Increase in your water cost	$1 per month, which would be $12 per year	$2 per month, which would be $20 per year	$11 per month, which would be $130 per year
Which plan do you prefer?	○	○	○

Next

Screen 25[10]

Please provide a brief comment to help us understand why you chose $2 per month, which would be $20 per year, as your most preferred plan.

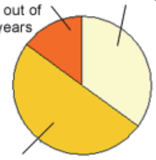
Type in the answer

Next

Screen 26

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

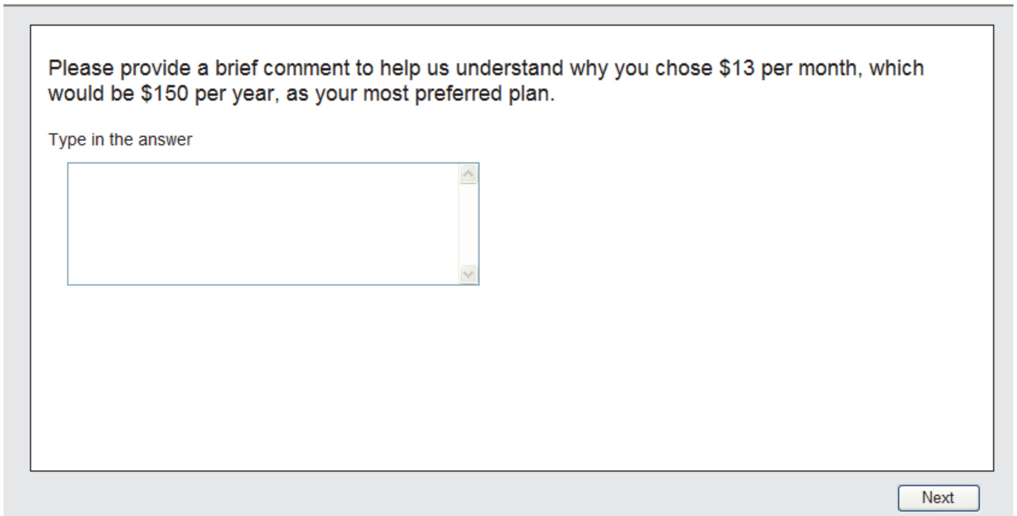
Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan D	Plan E
Available water supply such that water use restrictions in the next 20 years will be:	Stage 2 restrictions in 3 out of 20 years; No restrictions in 7 out of 20 years; Stage 1 restrictions in 10 out of 20 years 	Stage 2 restrictions in 2 out of 20 years; No restrictions in 11 out of 20 years; Stage 1 restrictions in 7 out of 20 years 	Stage 2 restrictions in 3 out of 20 years; No restrictions in 10 out of 20 years; Stage 1 restrictions in 7 out of 20 years 
Increase in your water cost	$1 per month, which would be $12 per year	$13 per month, which would be $150 per year	$5 per month, which would be $55 per year
Which plan do you prefer?	○	○	○

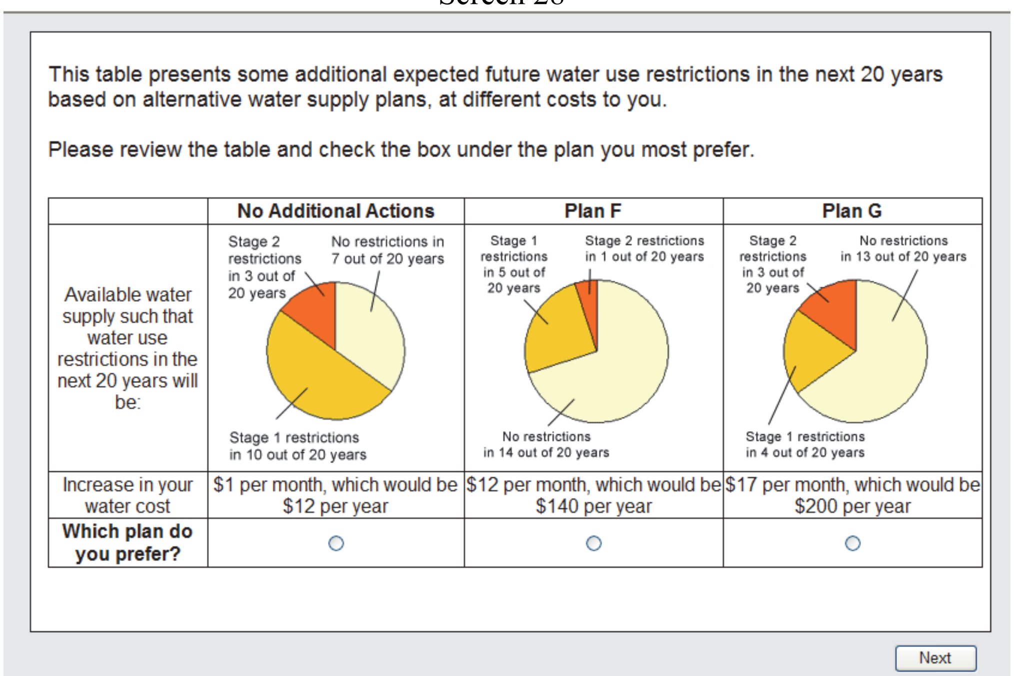
Next

6. [10]. Screen 25 reflects the choice made in Screen 24.

Screen 27[11]



Screen 28



7. [11]. Screen 27 reflects the choice made in Screen 26.

Screen 29[12]

Please provide a brief comment to help us understand why you chose $12 per month, which would be $140 per year, as your most preferred plan.

Type in the answer

Next

Screen 30

Your Opinion on How We Should Increase Future Water Supplies

LBWD is evaluating different options to increase the amount of water available in the future to reduce water use shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing groundwater use **What is groundwater?**
- Importing additional water to the region **What is imported water?**
- Increasing water storage
- Transferring water from agricultural uses
- Increasing the amount of water conservation
- Increasing the use of recycled water **What is recycled water?**
- Adding desalinated water

The next few screens provide more details on each of these options.

Next

8. [12]. Screen 29 reflects the choice made in Screen 28.

Screen 31

Transferring water from agricultural uses

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. This saved water could be transferred to the Long Beach area for residential and business uses. Water could be saved by having LBWD:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation.
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.
- Purchase agricultural land and take it out of agricultural production.

Next

Screen 32

Increasing underground water storage

Water storage could be expanded by purchasing additional imported Bay-Delta water from MWD in years when Northern California Bay-Delta waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used locally in dry years.

Long Beach could also increase the amount of recycled water it currently acquires from Los Angeles County's Long Beach Reclamation Plant, and store it underground in the local groundwater basin. This would help replenish groundwater levels and could later be extracted, re-purified, and used for tap water and other uses.

Next

Screen 33

Increasing the amount of water conservation

A lot of individual water conservation measures have already been taken by residents and businesses in Long Beach. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use by giving up lawns at homes, athletic fields, and public parks. Increased water conservation actions could include:

- Rebates for water saving appliances
- Rebates for converting to low-water use landscaping (e.g., xeriscape)
- Mandatory low-water landscaping for new homes.

Next

Screen 34

Increasing groundwater use

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. High-quality groundwater from both local and non-local sources can be used for drinking water supplies.

Use of additional local groundwater supplies is limited by Court-imposed pumping restrictions, which are designed to ensure the water is not over-pumped and depleted. Additional local groundwater use would only be possible if additional water is used to replenish the local groundwater system. Groundwater replenishment could include pumping reclaimed water into the groundwater. In wet years, imported water could also be used to replenish the local groundwater basin.

Use of non-local groundwater supplies would require acquiring rights to that non-local water, and installing additional pipelines and pumps to transfer the water to Long Beach. This approach would also have increased energy costs associated with moving the water to the Long Beach area.

Next

Screen 35

Increasing the use of recycled water

About 6% of the LBWD's current water supply is made up of highly purified recycled water from Los Angeles County's Long Beach Reclamation Plant. LBWD would like to increase the amount of reclaimed water it receives from this facility, and distribute it for suitable uses throughout the city. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, and golf courses. It might also be available for watering some household yards.
- For some industrial processes, such as cooling in power plants.
- To replenish the local groundwater basin. This stored water could later be extracted, re-purified, and used for tap water.

The use of recycled water is not impacted by external factors such as drought or climate change. Recycled water is therefore considered a very reliable source of water supply.

Next

Screen 36

Importing additional water into the region

Additional water supplies could be created by importing more water from outside of Long Beach (e.g., purchasing more Bay-Delta water from MWD). Importing additional water from outside Long Beach may have some negative consequences. Removing water from distant rivers and lakes could:

- Harm ecosystems and limit recreational opportunities in Northern California
- Limit the amount of water available to people living near the rivers from which the water is exported to MWD
- Increase energy costs associated with transferring the water to Long Beach

In addition, imported water could become less available in the future, due to court rulings, regulations, droughts, or earthquakes that might disrupt the long import supply canals and pipelines

Next

Screen 37

Adding desalinated water

LBWD is currently developing the Long Beach Seawater Desalination Project, which will convert ocean water to drinking water. It will use well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States. Desalination provides a local source of supply that is reliable and not impacted by weather or climate.

Desalination requires a large amount of energy and can be relatively expensive. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also decreased costs.

The environmental impacts of desalination can be a concern. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. To avoid this problem, LBWD has designed and tested a path-breaking beach sand water intake system that will not harm fish (because it eliminates the need for an ocean intake pipe).

The disposal of the salt and other compounds that are extracted from the seawater can be a concern. However, the potential Long Beach desal facility will be designed such that the salts removed from the seawater are safely mixed back into the ocean.

LBWD is planning to develop the desalination project in an aesthetically pleasing manner that will not impact local beach areas. The desal treatment plant is planned to be located inland, away from the City's beaches.

Next

Your Opinion on How We Should Meet Future Water Needs

In the table below, you are presented with different options that water suppliers could undertake to improve the future water supply reliability.

Please rank your top 5 options for increasing our future water supply according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

Screen 38

Requiring low water landscaping (e.g., xeriscape) in new homes and redevelopment projects	
Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the City)	
Expanding the use of reclaimed water for outdoor irrigation and industrial uses	
Using highly purified reclaimed water to replenish the local groundwater supply, allowing greater use of local groundwater	
Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years	
Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water landscaping and water efficient appliances)	
Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD)	
Increasing available supplies of water by transferring more water from agricultural uses in the State to Long Beach or MWD	
Investing in desalination facilities to convert ocean waters into part of the local potable supply	
Increasing the price of water to residential, commercial, and industrial users so that they will use less	

Next

Screen 39[13]

Of these five options, which do you like the least?

Select one answer only

- ○ Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD)
- ○ Increasing available supplies of water by transferring more water from agricultural uses in the State to Long Beach or MWD
- ○ Increasing the price of water to residential, commercial, and industrial users so that they will use less
- ○ Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the City)
- ○ Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years

Next

Screen 40

Does it Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

9. [13]. Screen 39 reflects the choices made in Screen 38.

Screen 41

Of the two underground water storage options below, which do you prefer?

Select one answer only

- ○ Increasing underground storage of imported water in wet years
- ○ Increasing underground storage of recycled water

Next

Screen 42

Of the two groundwater water options below, which do you prefer?

Select one answer only

- ○ Increasing use of local groundwater sources through replenishing the basin
- ○ Increasing use of non-local groundwater sources and pumping the water to Long Beach

Next

Screen 43

Of the two water transfer and import options below, which do you prefer?

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from MWD

Next

Screen 44

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes
- ○ Promoting additional voluntary water conservation through education and incentives

Next

Screen 45

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish local groundwater supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 46

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

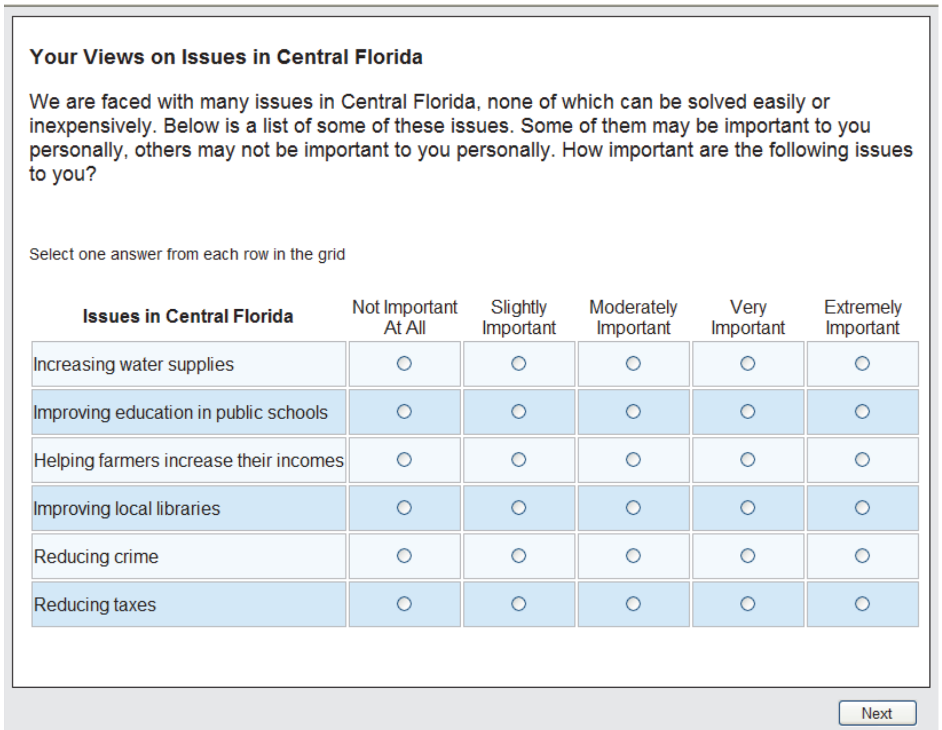
Screen 47

Thank you for completing this survey. We have successfully received your responses.

C.3 Orlando

Value of Water Supply Reliability Survey Instrument: Orlando Version

Screen shots from the Survey Instrument are provided below.



Your Views on Issues in Central Florida

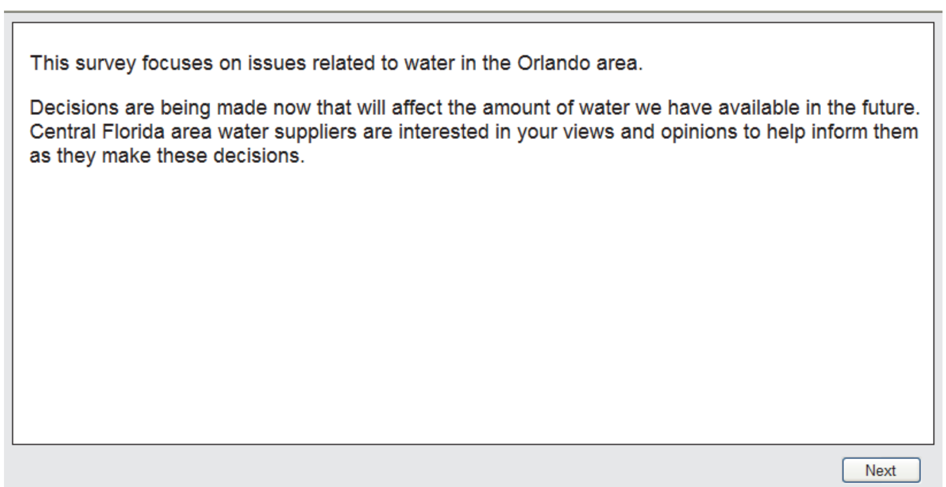
We are faced with many issues in Central Florida, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

Issues in Central Florida	Not Important At All	Slightly Important	Moderately Important	Very Important	Extremely Important
Increasing water supplies	○	○	○	○	○
Improving education in public schools	○	○	○	○	○
Helping farmers increase their incomes	○	○	○	○	○
Improving local libraries	○	○	○	○	○
Reducing crime	○	○	○	○	○
Reducing taxes	○	○	○	○	○

Next

Screen 1



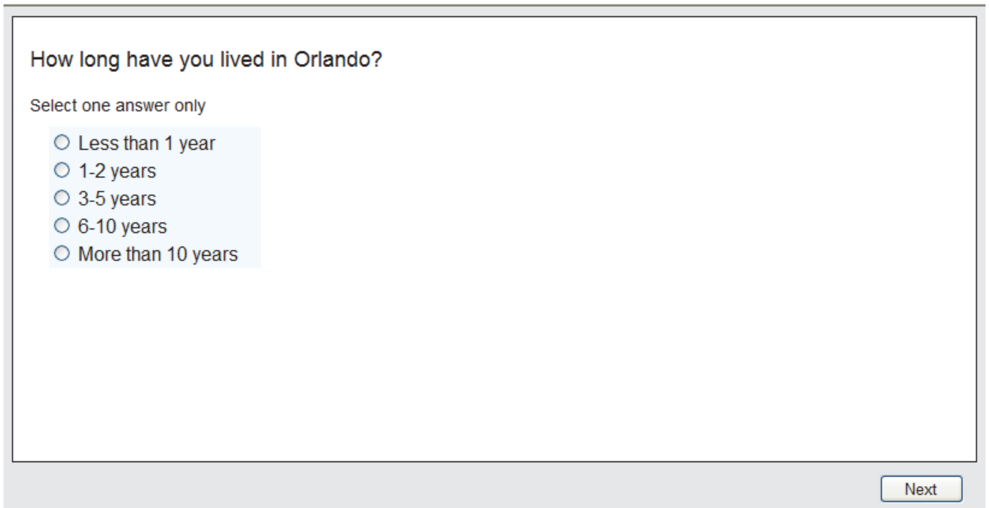
This survey focuses on issues related to water in the Orlando area.

Decisions are being made now that will affect the amount of water we have available in the future. Central Florida area water suppliers are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

Screen 3



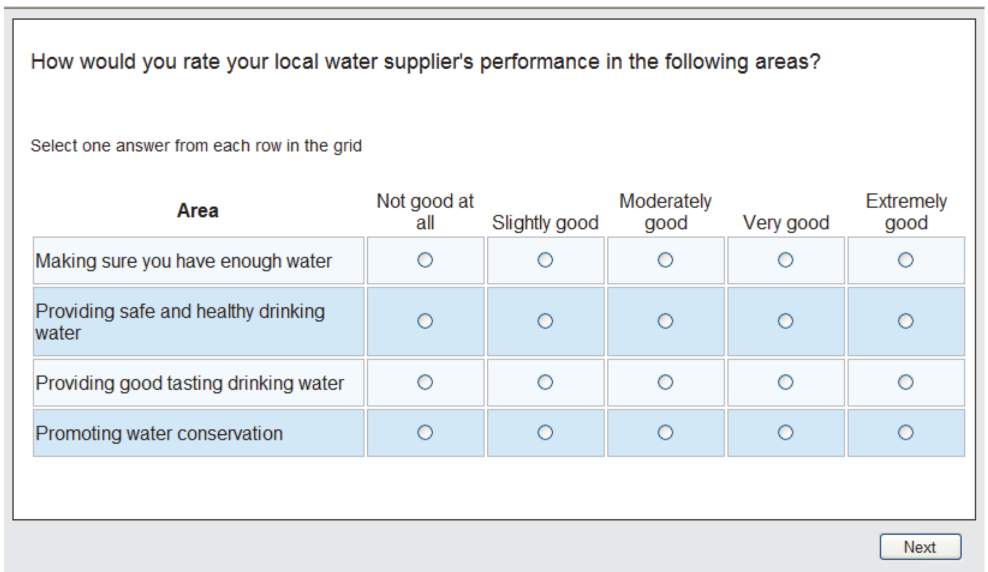
How long have you lived in Orlando?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 4



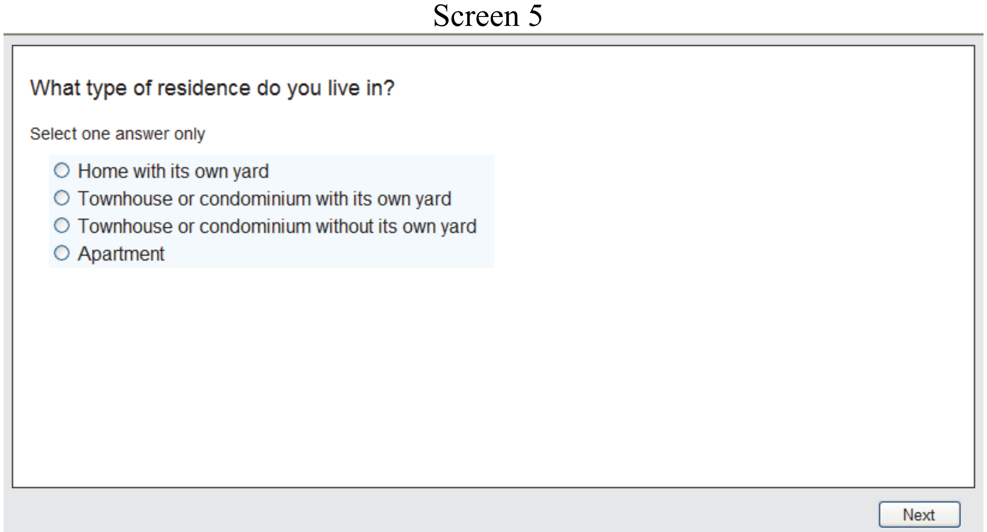
How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

Area	Not good at all	Slightly good	Moderately good	Very good	Extremely good
Making sure you have enough water	○	○	○	○	○
Providing safe and healthy drinking water	○	○	○	○	○
Providing good tasting drinking water	○	○	○	○	○
Promoting water conservation	○	○	○	○	○

Next

Screen 5



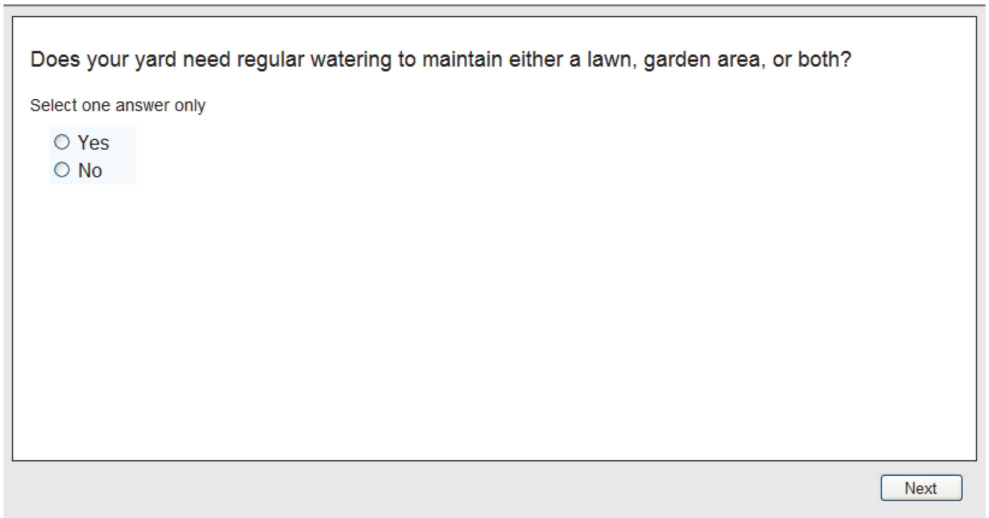
What type of residence do you live in?

Select one answer only

- ○ Home with its own yard
- ○ Townhouse or condominium with its own yard
- ○ Townhouse or condominium without its own yard
- ○ Apartment

Next

Screen 6[14]

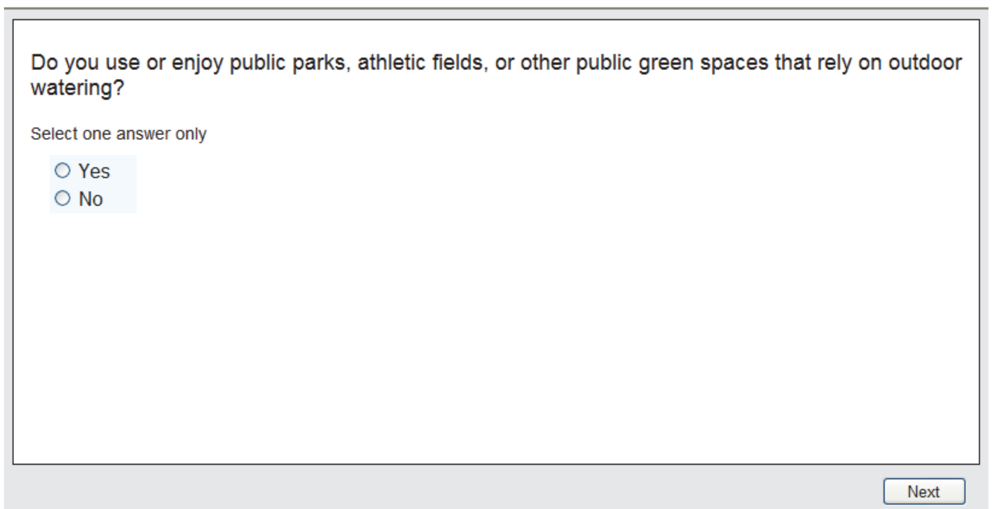


Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- Yes
- No

Next



Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

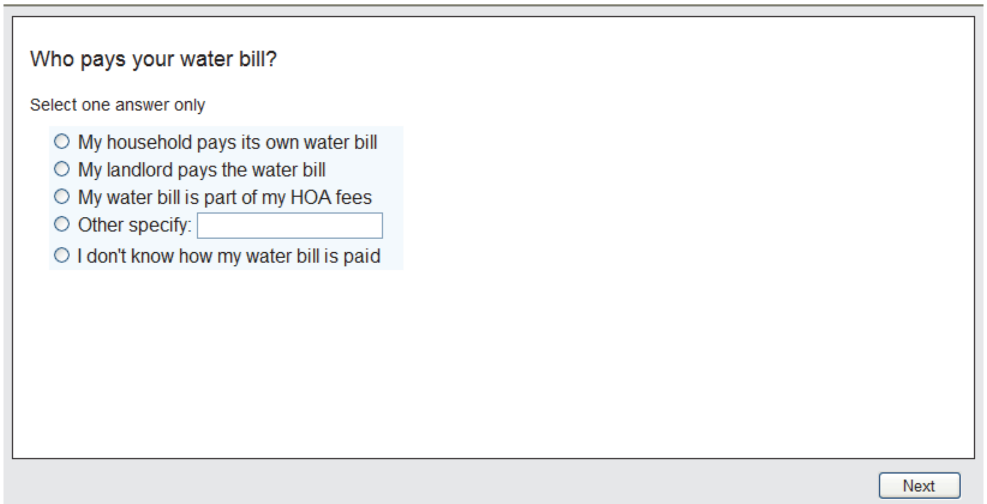
Select one answer only

- Yes
- No

Next

Screen 7

10. [14]. Screen 6 reflects the choice made in Screen 5.



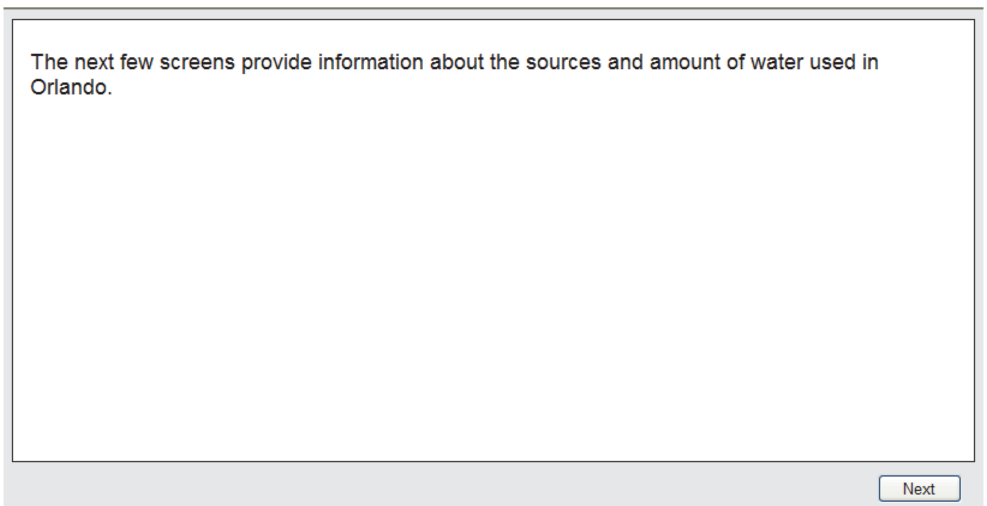
Who pays your water bill?

Select one answer only

- My household pays its own water bill
- My landlord pays the water bill
- My water bill is part of my HOA fees
- Other specify:
- I don't know how my water bill is paid

Next

Screen 8

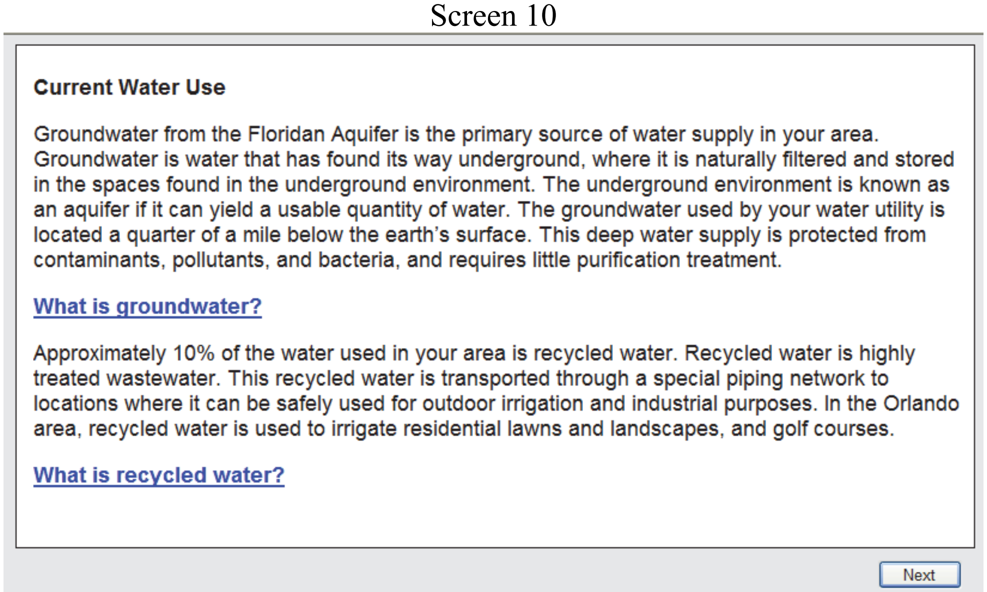


The next few screens provide information about the sources and amount of water used in Orlando.

Next

Screen 9

Screen 10



Current Water Use

Groundwater from the Floridan Aquifer is the primary source of water supply in your area. Groundwater is water that has found its way underground, where it is naturally filtered and stored in the spaces found in the underground environment. The underground environment is known as an aquifer if it can yield a usable quantity of water. The groundwater used by your water utility is located a quarter of a mile below the earth's surface. This deep water supply is protected from contaminants, pollutants, and bacteria, and requires little purification treatment.

What is groundwater?

Approximately 10% of the water used in your area is recycled water. Recycled water is highly treated wastewater. This recycled water is transported through a special piping network to locations where it can be safely used for outdoor irrigation and industrial purposes. In the Orlando area, recycled water is used to irrigate residential lawns and landscapes, and golf courses.

What is recycled water?

Next

Screen 11

Your water utility provides 25 billion gallons of water each year for a variety of different users. About half of the water (50%) supplied by your local water utility goes to residential customers. The other half is used for commercial, industrial, and public use (e.g., governmental) purposes.

Next

Screen 12

The actual amount of water any one household uses depends on:

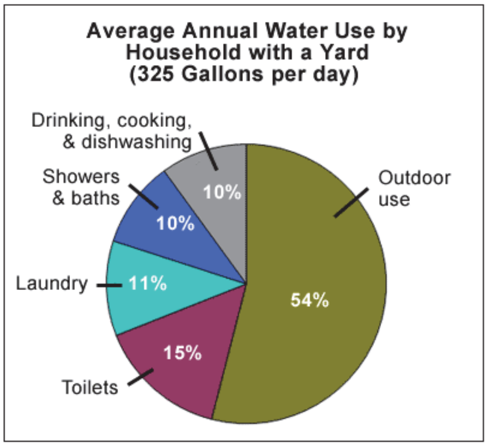
- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

In the Orlando area, the typical household with its own yard uses about 325 gallons of water per day, on average, or about 119,000 gallons per year. About 54 percent of this water is used for watering lawns and gardens. Households that do not have yards use about 150 gallons of water per day, on average, or about 55,000 gallons per year.

Next

Screen 13

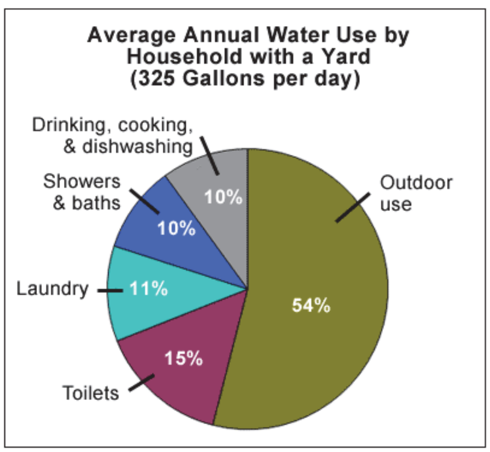
The pie chart below shows how an average household with its own yard uses water throughout the year.



Next

Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for outdoor use?



Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

CURRENT SUPPLIES WILL NOT MEET FUTURE DEMAND

The goal of water suppliers is to provide the highest quality water at a reasonable cost and in sufficient quantity to meet customer needs. To meet this goal, water suppliers in your area match available water supplies with demand by taking into account groundwater levels, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Even after accounting for savings associated with the existing and planned water conservation activities, we expect that water demands in the Orlando area will increase over the next 20 years. Growing demands, coupled with uncertainty over future rainfall and groundwater availability, means that water demands are expected to periodically exceed available water supply in several of the next 20 years. These factors will affect water supplies in many Florida communities.

In addition, using too much groundwater in the future for drinking water supplies may result in environmental impacts, such as drying out wetlands, reducing spring flows, lowering lake and ground water levels and degrading groundwater quality. Florida's regulatory program works to ensure these types of impacts do not occur.

Next

Screen 16

To achieve the goal of ensuring an adequate supply of clean water, water suppliers in the Orlando region are considering options to make sure that enough water is available in the future. For this reason, water suppliers in the region are interested in your views on whether some options for avoiding future water shortages should be taken.

Water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 17

Methods to Address Current Water Shortages

In Orlando, in addition to voluntary water conservation measures, there are some water conservation requirements that are always in place. These water conservation requirements limit the days and times when households may water their lawns. For example:

- Irrigation is prohibited between 10 a.m. and 4 p.m.
- From March through November, irrigation is limited to two days per week on scheduled days.
- From November through March, irrigation is limited to one day per week on scheduled days.
- Irrigation is limited to ¾ inch of water per irrigation day and to no more than one hour per irrigated area per irrigation day.
- Persons irrigating with an automatic lawn irrigation system installed after May 1991 are required to install, maintain and operate a rain sensor device.
- The use of recycled water and irrigation using a low-volume system (e.g., micro-spray, micro-jet, drip or bubbler irrigation) is allowed anytime.
- Irrigation of *new* landscape is allowed at any time of day on any day for the initial 30 days and every other day for the next 30 days.

Next

When there is not enough water to meet demand, mandatory water use restrictions may become necessary, and they can have significant effects on residents, local businesses, and public parks. Depending on the severity of the water supply shortage, Stage 1 or Stage 2 water use restrictions may be implemented.

Stage 1 Restrictions In addition to the permanent water use restrictions described on the previous screen, under Stage 1 water use restrictions:

- All water users are required to test and repair their irrigation system to address broken pipes and other leaks, damaged or tilted sprinkler heads, and other sources of water waste.
- Lawn and landscape irrigation at residences, common areas, golf courses, and parks is restricted to one day per week on designated days, between the hours of 6 pm and 9 am all year long.
- Irrigation of child playgrounds and play areas for sports is allowed any day from the hours of 6 p.m. to 9 a.m.
- Cisterns, hand-watering using a hose with a trigger nozzle, and low-volume irrigation systems – such as drip, bubble and micro-jet systems that apply water directly to plant root zones – may be used at any time, although voluntary reductions are encouraged.
- Irrigation with recycled water is exempt from all water use restrictions.
- The use of water for fountains and other decorative displays is prohibited.
- All water users including residences, golf courses, industrial and commercial businesses, and farmers must reduce their water use by 15 percent from the most recent previous year that water shortage restrictions were not in effect.
- Additional water use restrictions may be put by in place by your local water utility as necessary.

Screen 18

Stage 2 Restrictions Stage 2 restrictions are in addition to all Stage 1 restrictions. Under Stage 2 restrictions:

- Lawn and landscape irrigation at residences, common areas, golf courses, schools, and parks is prohibited.
- Irrigation of child playgrounds and play areas for sports is allowed one day per week from the hours of 6 pm to 9 a.m.
- Cisterns, hand-watering using a hose with a trigger nozzle, and low-volume irrigation systems may be used at any time to water non-turfgrass landscape, although voluntary reductions are encouraged.
- Irrigation with recycled water is exempt from all water use restrictions.
- Washing or cleaning of non-emergency vehicles is limited to one day per week and must be done using low volume methods. This includes vehicle washing or cleaning at car washes.
- Washing or cleaning of buildings, structures and other outdoor surfaces is prohibited unless necessary to either maintain a warranty, allow for a construction practice, clean up after a public event, or remove mold, mildew and other potentially hazardous material that cannot be removed by mechanical means.
- All water users must reduce their water use by 20 percent from the most recent previous year that water shortage restrictions were not in effect.
- Additional water use restrictions may be put by in place by your local water utility as necessary.

Next

Under Stage 1 restrictions, businesses, households and water utilities will likely incur costs as they make irrigation system repairs and implement additional water conservation activities. Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households, golf courses, and public areas.

- Lawns and landscaping can recover if these restrictions are needed for only one summer.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low water use landscaping (e.g., Florida Friendly landscaping).

Under Stage 1 restrictions, lawns and landscaping irrigated with recycled water or using low-volume irrigation systems would not be impacted because they are not subject to the water restrictions.

Stage 2 restrictions may lead to dead lawns and landscaping for households, golf courses, and public parks after only one year. Irrigation of all turf grass at would be prohibited, with the exception of irrigation of child playgrounds and play areas for sports, which is allowed one day per week.

Dead lawns and landscaping would require replacement. To lessen the extent of dead lawns and landscaping, irrigators may choose to replace dead lawns with low-water use landscaping (e.g., Florida Friendly landscaping), convert their sprinkler systems to low-volume irrigation systems, or install cisterns.

Under Stage 2 restrictions, lawn and landscape irrigated with recycled water would not be impacted because they are not subject to the water restrictions. Irrigators using low-volume irrigation systems would still be able to water their plant beds, shrubs and other non-turfgrass material.

Screen 19

Next

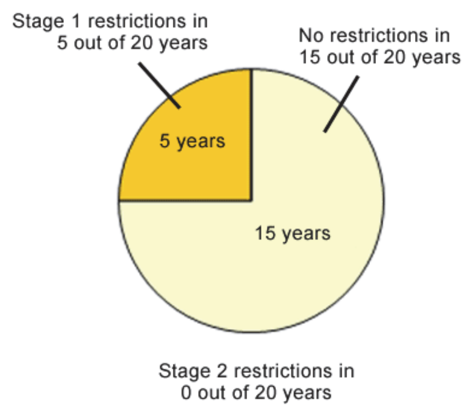
Stage 1 and Stage 2 water use restrictions are put in place by the St. Johns River Water Management District if water shortages become severe or prolonged. Restrictions can remain in place over a period of several months to several years, and can be lifted by the District as the severity of a water shortage is reduced.

In Orlando, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- Stage 1 restrictions have been needed in 5 of the past 20 years.
- Stage 2 restrictions have not been needed in the past 20 years.

The pie chart below shows how often the different water use restrictions have been in place in this region over the last 20 years.

Screen 20



Next

Screen 21

Water Suppliers Need to Identify a Water Supply Strategy

Developing new water supplies can help reduce the frequency and severity of future water shortages. Water suppliers in central Florida are developing a Long-Term Reliable Water Supply Strategy to evaluate how much, if any, additional water supplies should be developed to meet future needs.

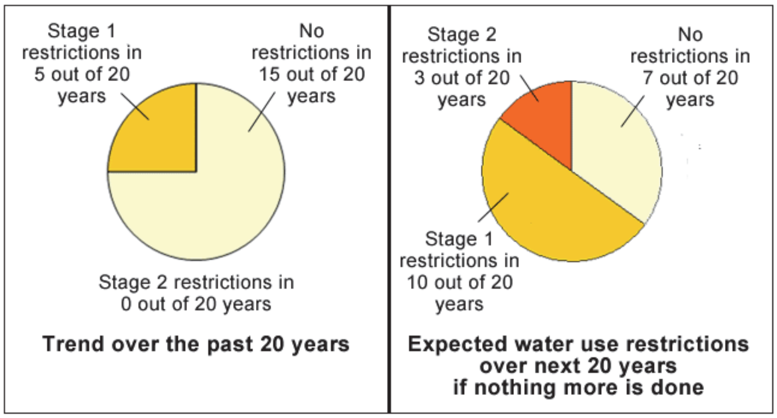
While additional water supplies are not mandatory, without new supplies, water use restrictions are expected to become more severe and frequent in the future.

Next

Screen 22

The two pie charts below compare the frequency of water use restrictions in the past with restrictions that are expected to be needed in the future if no new water supplies are developed.

- The pie chart on the left shows that Stage 1 restrictions have been needed 5 out of the past 20 years. No restrictions have been needed in 15 of the last 20 years. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future will be like if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions will be needed in 3 years out of 20 if no actions are taken to develop new water supplies.



Next

Screen 23

Your Opinion on How Much Should be Done to Increase Future Water Supplies

New water supplies are expected to be more expensive, gallon for gallon, than the existing water supply from the Floridan aquifer. As more expensive water supplies are developed to meet future needs, the more you will have to pay for water in the future. These costs would be passed on to you through your monthly water bill, increased HOA fees, or rent.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with expected levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water conservation requirements that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

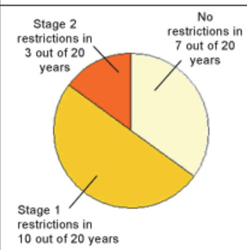
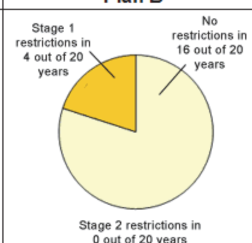
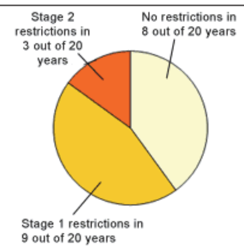
The exact timing and length of future restrictions is unknown, but it is likely that restrictions would be in place for multiple years in a row (e.g., two years of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 5 years, and Stage 2 restrictions have not been implemented.

If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things. Please review the table and check the box under the plan you most prefer.

Screen 24

<table>
<tr><th></th><th>No Additional Actions</th><th>Plan B</th><th>Plan C</th></tr>
<tr><td>Available water supply such that water use restrictions in the next 20 years will be:</td><td>
</td><td>
</td><td>
</td></tr>
<tr><td>Increase in your water cost</td><td>$1 per month, which would be $12 per year</td><td>$15 per month, which would be $180 per year</td><td>$2 per month, which would be $20 per year</td></tr>
<tr><td>Which plan do you prefer?</td><td>○</td><td>○</td><td>○</td></tr>
</table>

Next

Screen 25[15]

Please provide a brief comment to help us understand why you chose $15 per month, which would be $180 per year, as your most preferred plan.

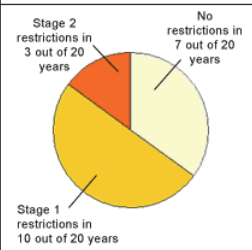
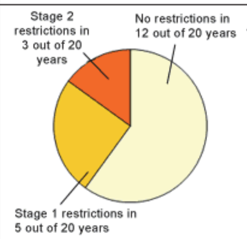
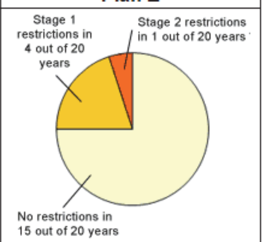
Type in the answer

Next

Screen 26

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan D	Plan E
Available water supply such that water use restrictions in the next 20 years will be:			
Increase in your water cost	$1 per month, which would be $12 per year	$8 per month, which would be $90 per year	$24 per month, which would be $290 per year
Which plan do you prefer?	○	○	○

Next

11. [15]. Screen 25 reflects the choice made in Screen 24.

Screen 27[16]

Please provide a brief comment to help us understand why you chose $8 per month, which would be $90 per year, as your most preferred plan.

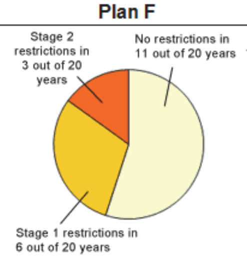
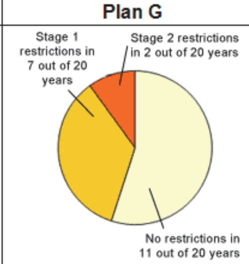
Type in the answer

Next

Screen 28

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan F	Plan G
Available water supply such that water use restrictions in the next 20 years will be:			
Increase in your water cost	$1 per month, which would be $12 per year	$11 per month, which would be $130 per year	$13 per month, which would be $150 per year
Which plan do you prefer?	○	○	○

Next

12. [16]. Screen 27 reflects the choice made in Screen 26.

Screen 29[17]

Please provide a brief comment to help us understand why you chose $11 per month, which would be $130 per year, as your most preferred plan.

Type in the answer

Next

Screen 30

Your water utility and other utilities in the region are evaluating different options to increase the amount of water available in the future to reduce water shortages.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options that are being considered include:

- Increasing use of fresh groundwater **What is groundwater?**
- Using surface water supplies, by diverting water from the St. Johns River to storage reservoirs
- Storing recycled water underground when plentiful and withdrawing the water when needed
- Storing river water imported from the St. Johns River underground when it is plentiful and withdrawing the water when needed
- Increasing the amount of water conservation
- Increasing the use of recycled water **What is recycled water?**
- Adding desalinated seawater from the Atlantic Ocean
- Adding desalinated brackish groundwater from wells near the east coast

The next few screens provide more details on each of these options.

Next

13. [17]. Screen 29 reflects the choice made in Screen 28.

Screen 31

Diverting water from the St. Johns River to storage reservoirs

Additional water supplies could be created by diverting and storing surface water from the St. Johns River. However, importing this water may have some negative consequences. Removing water from the river could:

- Harm ecosystems and limit recreational opportunities in the water body from which the water is diverted
- Increase energy costs associated with transferring the water to Orlando
- Increase water treatment costs relative to current groundwater sources

To help offset these potential consequences, the diversion of water from the St. Johns River would be managed so that they do not take too much water from the river in times of low flow. In other words, water diversions would maintain minimum flows and levels - known as MFLs - that have been established by the St. Johns River Water Management District. The purpose of the MFLs is to protect the water resources and ecology of the area. To ensure compliance with MFLs, specific projects can be designed to withdraw water during times of moderate to high flow so that no water is withdrawn during periods of low flow.

Next

Screen 32

Increasing fresh groundwater use

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice and is the source of water for aquifers, springs, and wells. High-quality groundwater from both local and non-local sources can be used for drinking water supplies. The term "fresh" means that the ground water is not salty.

Use of additional local fresh groundwater supplies is limited by the St. Johns River Water Management District, which manages this water supply to ensure the water is not over-pumped and depleted. Additional local groundwater use would only be possible if additional water is used to replenish the local groundwater system. Groundwater replenishment could include pumping reclaimed water into the groundwater. In wet years, imported water could also be used to replenish the local groundwater basin.

Use of non-local groundwater supplies would require acquiring rights to that non-local water, and installing additional pipelines and pumps to transfer the water to the Orlando region. This approach would also have increased energy costs associated with transporting the water.

Next

Screen 33

Adding desalinated seawater

Seawater desalination, which converts ocean water to drinking water, is an option that could augment the tap water supply in the Orlando area. Desalination uses well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States, such as in the Tampa Bay area. Desalination provides a source of supply that is reliable and not impacted by droughts.

Desalination requires a large amount of energy and can be very expensive compared to current fresh ground water supplies. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also reduced costs and energy requirements.

The desalinated water would need to be piped a long distance inland from Florida's east coast to the Orlando area, which would require additional energy. These high energy requirements result in a high carbon footprint relative to other water supply sources.

The environmental impacts of desalination can be a concern. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. Methods exist to minimize this impact and would be used.

The disposal of the salt and other compounds that are extracted from the seawater can also be a concern. However, the desal facility would be designed such that the salts removed from the seawater are safely mixed back into the ocean.

Finally, the desalination project would be developed in an aesthetically pleasing manner that will not impact local beach areas. The desal treatment plant would be located away from local beaches.

Next

Increasing the use of recycled water

About 10% of the water used in the Orlando area is highly purified recycled water. This recycled, or reclaimed, water is used to irrigate the lawns and landscaping of some single-family homes and golf courses in the Orlando area. Additional quantities of recycled water can be used to replace freshwater consumption. This water would be reclaimed from purified wastewater generated by water utility customers, and distributed throughout the city for suitable uses. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, golf courses, and household yards.
- For some industrial processes, such as cooling in power plants.
- To replenish the local groundwater basin. This stored water could later be extracted, re-purified, and used for tap water.

Although recycled water offers significant potential as an alternative water supply source, there is typically too much of it available during periods of high rainfall and not enough of it available to meet demands during low rainfall periods.

Recycled water is produced constantly throughout the year, with no dramatic seasonal highs or lows. But irrigation, which currently is the most common use for reclaimed water in the Orlando area, fluctuates seasonally, with demand being higher from March to July. Thus, it is desirable to store unused recycled water during times of excess supply for use during times of peak demand.

- Recycled water could be stored underground in the local aquifer. The water could later be pumped and used as part of the Orlando area's water supply.
- If not used to replenish the local aquifer, recycled water would need to be stored in very large lakes located in the Orlando area. No recreation would be allowed on these lakes.

Screen 34

In addition, reclamation facilities are not necessarily located near the areas where the recycled water would be used, so the recycled water would have to be transported. Transmission lines and facilities can be expensive to construct, and disruptive (particularly in older or built-out areas).

Next

Screen 35

Adding desalinated brackish groundwater

Brackish (salty) ground water pumped from deep wells near the east coast of Florida can be purified to drinking water standards. This brackish water contains less salt than seawater so the treatment cost, including the energy required, is less than desalinating seawater. The cost to treat brackish water is greater than the cost to treat the existing fresh groundwater supply.

The desalinated water would need to be piped a long distance inland from Florida's east coast to the Orlando area and would require additional energy to transport. These high energy requirements result in a high carbon footprint relative to other water supply sources.

The disposal of the salt and other compounds that are extracted from the brackish water can be a concern. Possible disposal methods, such as deep wells and the ocean, are being evaluated to minimize negative impacts to water and ocean resources. The desalination project would not be located near beach areas.

Next

Screen 36

Storing river water or recycled water underground when plentiful and withdrawing the water when needed

Water storage could be expanded by importing water from the St. Johns River or other water bodies in years when waters are more plentiful, and storing it underground in the local groundwater basin, where it could be extracted and used locally in dry years.

Orlando could also increase the amount of recycled water it currently produces, and store it underground in the local groundwater basin. This would help replenish groundwater levels and could later be extracted, re-purified, and used for tap water and other uses. The water would be treated to meet ground water quality standards prior to injection.

Next

Screen 37

Increasing the amount of water conservation

A lot of individual water conservation measures have already been taken by residents and businesses in Orlando. However, there are still opportunities for additional conservation, especially for reducing outdoor water use by converting lawns at homes, athletic fields, and public parks to Florida-friendly landscaping, which requires less water than traditional turf grass. Increased water conservation actions could include:

- Rebates for indoor water-saving appliances
- Rebates for converting to low-water use landscaping (e.g., Florida-friendly landscaping)
- Mandatory low-water use landscaping for new homes
- Rebates for replacing sprinkler systems with low volume irrigation systems such as micro-spray, micro-jet, drip or bubbler irrigation systems
- Rebates for installing soil moisture sensors in irrigated lawns and landscaping.

Next

Your Opinion on How We Should Meet Future Water Needs

In the table below, you are presented with different options that water suppliers could undertake to improve the reliability of Orlando's future water supply.

Please rank your top 5 options for increasing future water supply in your local area according to your personal views. If you want to rank more, please feel free to do so.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

Expanding the use of recycled water for outdoor irrigation and industrial uses	
Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater	
Increasing available supplies by diverting surface water from the St. Johns River and storing it underground, allowing greater use of local groundwater	
Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water use landscaping and water efficient appliances)	
Increasing available supplies by diverting and storing surface water from the St. Johns River in reservoirs, and using these surface waters as part of the potable water supply	
Investing in desalination facilities to convert ocean waters into part of the local potable water supply	
Investing in desalination facilities to convert brackish groundwater near the east coast into part of the Orlando region's local potable water supply	
Increasing the price of water to residential, commercial, and industrial users so that they will use less	
Requiring low water use landscaping (e.g., Florida Friendly landscaping) in new homes and redevelopment projects	

Screen 38

Next

Screen 39

Of these four options, which do you like the least?

Select one answer only

- ○ Investing in desalination facilities to convert ocean waters into part of the local potable water supply
- ○ Increasing the price of water to residential, commercial, and industrial users so that they will use less
- ○ Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater
- ○ Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low water use landscaping and water efficient appliances)

Next

Screen 40

Does it Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide the same amount of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

Screen 41

Of the two underground water storage options below, which do you prefer?

Select one answer only

- ○ Increasing underground storage of local or imported surface water in wet years
- ○ Increasing underground storage of recycled water every year

Next

Screen 42

Of the two groundwater options below, which do you prefer?

Select one answer only

- ○ Increasing use of local groundwater sources by storing recycled or river water underground
- ○ Increasing use of non-local groundwater sources and pumping the water to Orlando

Next

Screen 43

Of the two water import options below, which do you prefer?

Select one answer only

- ○ Importing and treating brackish groundwater from Florida's east coast
- ○ Importing water from the St. John's River and storing it in surface water reservoirs

Next

Screen 44

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water use landscaping in new homes
- ○ Promoting additional voluntary water conservation through education and incentives

Next

Screen 45

Of the two water recycling options below, which do you prefer? Note that because new piping and storage is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish local groundwater supplies
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

How would you rate your perception of the quality of water supplied to you from these water sources and for these uses?

Select one answer from each row in the grid

Water Source	Quality not good at all	Quality slightly good	Quality moderately good	Quality very good	Quality extremely good
Increasing fresh groundwater use (drinking water)	○	○	○	○	○
Diverting water from the St. Johns River to storage reservoirs (drinking water)	○	○	○	○	○
Storing river water underground when plentiful and withdrawing the water when needed (drinking water)	○	○	○	○	○
Adding desalinated seawater from the Atlantic Ocean (drinking water)	○	○	○	○	○
Adding desalinated brackish groundwater from wells near the east coast (drinking water)	○	○	○	○	○
Storing recycled water underground when plentiful and withdrawing the water when needed (drinking water)	○	○	○	○	○
Increasing the use of recycled water (irrigation and non-potable industrial uses)	○	○	○	○	○
	Quality not good at all	Quality slightly good	Quality moderately good	Quality very good	Quality extremely good

Screen 46

Next

Screen 47

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 48

Thank you for completing this survey. We have successfully received your responses.

C.4 San Francisco

Value of Water Supply Reliability Survey Instrument: San Francisco Version

Screen shots from the Survey Instrument are provided below.

Your Views on Issues in Northern California

We are faced with many issues in Northern California, none of which can be solved easily or inexpensively. Below is a list of some of these issues. Some of them may be important to you personally, others may not be important to you personally. How important are the following issues to you?

Select one answer from each row in the grid

Issues in Northern California	Not Important At All	Slightly Important	Moderately Important	Very Important	Extremely Important
Reducing taxes	○	○	○	○	○
Improving local libraries	○	○	○	○	○
Increasing water supplies	○	○	○	○	○
Reducing crime	○	○	○	○	○
Helping farmers increase their incomes	○	○	○	○	○
Improving education in public schools	○	○	○	○	○

Next

Screen 1

This survey focuses on issues related to water in San Francisco and the greater Bay Area, and throughout the State of California.

Decisions are being made now that will affect the amount of water we will have available in the future. Water suppliers in the San Francisco region and across the state are interested in your views and opinions to help inform them as they make these decisions.

Next

Screen 2

How long have you lived in San Francisco?

Select one answer only

- ○ Less than 1 year
- ○ 1-2 years
- ○ 3-5 years
- ○ 6-10 years
- ○ More than 10 years

Next

Screen 3

How would you rate your local water supplier's performance in the following areas?

Select one answer from each row in the grid

Area	Not good at all	Slightly good	Moderately good	Very good	Extremely good
Making sure you have enough water	○	○	○	○	○
Providing safe and healthy drinking water	○	○	○	○	○
Providing good tasting drinking water	○	○	○	○	○
Promoting water conservation	○	○	○	○	○

Next

Screen 4

Screen 5

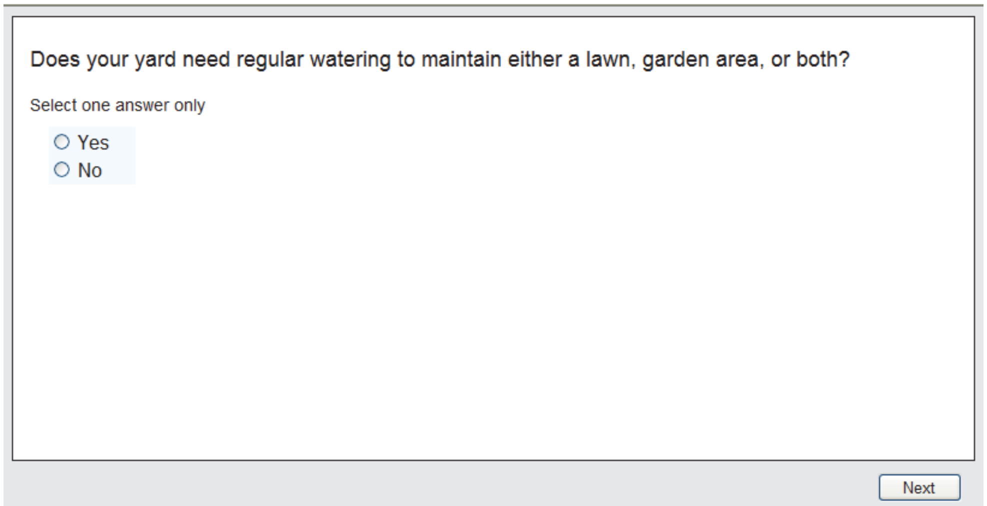
What type of residence do you live in?

Select one answer only

- ○ Home with its own yard
- ○ Townhouse or condominium with its own yard
- ○ Townhouse or condominium without its own yard
- ○ Apartment

Next

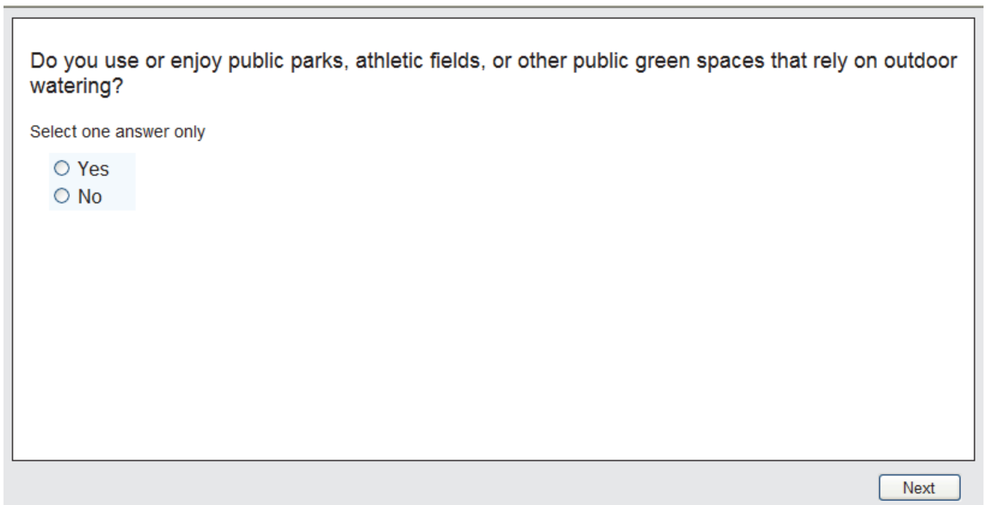
Screen 6[18]


Does your yard need regular watering to maintain either a lawn, garden area, or both?

Select one answer only

- Yes
- No

Next

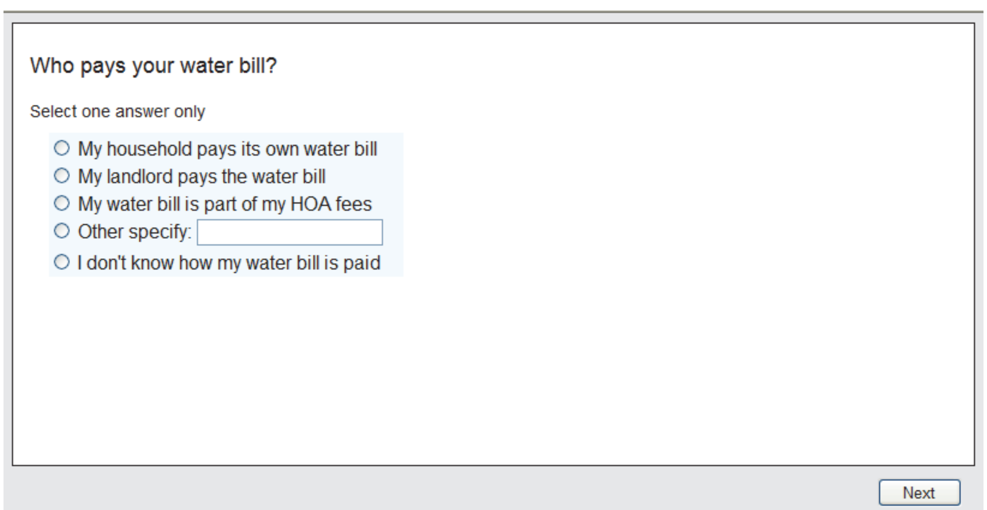

Do you use or enjoy public parks, athletic fields, or other public green spaces that rely on outdoor watering?

Select one answer only

- Yes
- No

Next

Screen 7


Who pays your water bill?

Select one answer only

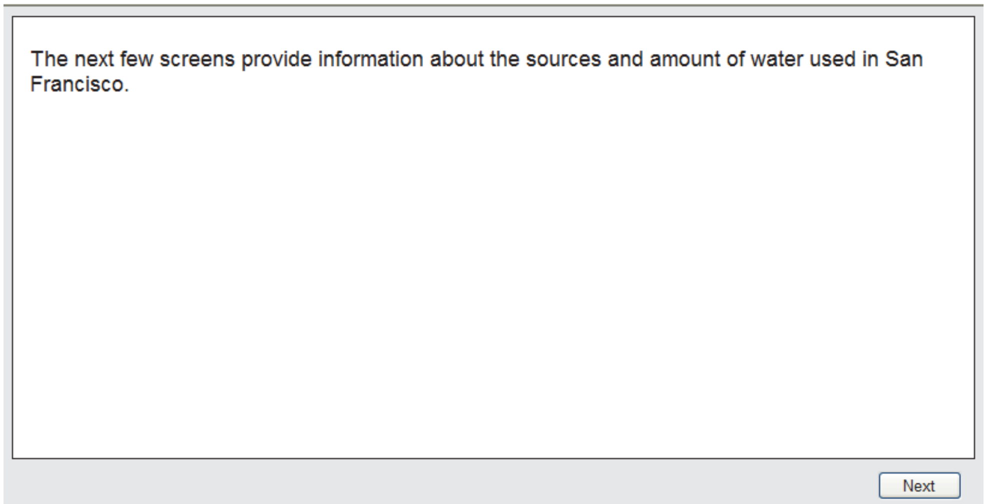
- My household pays its own water bill
- My landlord pays the water bill
- My water bill is part of my HOA fees
- Other specify:
- I don't know how my water bill is paid

Next

Screen 8

14. [18]. Screen 6 reflects the choice made in Screen 5.

Screen 9


The next few screens provide information about the sources and amount of water used in San Francisco.
Next

Current Water Use

The San Francisco Public Utilities Commission (SFPUC) provides water to about 800,000 people within the City of San Francisco. SFPUC also sells water to 27 municipalities and water districts within the counties of San Mateo, Santa Clara, Alameda, and Tuolumne. Some of these communities and water districts are entirely reliant on SFPUC for their water supply. In total, the SFPUC service area includes about 2.4 million residents in the greater Bay Area.

SFPUC supplies about 265 million gallons of water per day (mgd) to residents and businesses within the Bay Area through the SFPUC Regional Water System (RWS). The SFPUC RWS provides 96% of SFPUC's total water supply (and 100% of its drinking water supply) and relies primarily on two sources of water supply, including:

- Diversions from the Tuolumne River through the Hetch Hetchy Water and Power Project (HHWP)
- Rainfall collected and stored in local Bay Area reservoirs

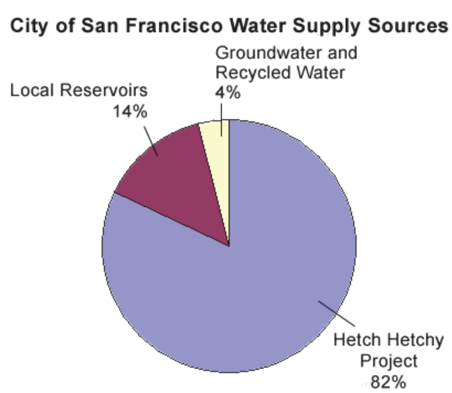
Water delivered to the Hetch Hetchy Reservoir through the HHWP Project represents the majority of the water supply available to San Francisco. On average, the HHWP Project provides 85% of the water delivered through the SFPUC RWS each year, while local rainwater collected and runoff stored in local reservoirs typically accounts for about 15% of total RWS supplies. During drought periods (i.e., during which very little runoff is stored in local reservoirs), water from the HHWP Project can account for more than 93% of total RWS water supply.

In addition to the SFPUC RWS, a small portion of San Francisco's total water demand (less than 5% of the total) is met through local groundwater supplies (which are used solely for outdoor watering). A very small portion is met through recycled water (which is used solely for equipment cleaning purposes).

What is groundwater?

What is recycled water?

The pie chart below shows the percentage of water supplied by SFPUC that comes from the different sources described above. Together, local reservoirs and the Hetch Hetchy project account for the water supplies delivered through RWS (which provides 96% of SFPUC's total water supply).



Next

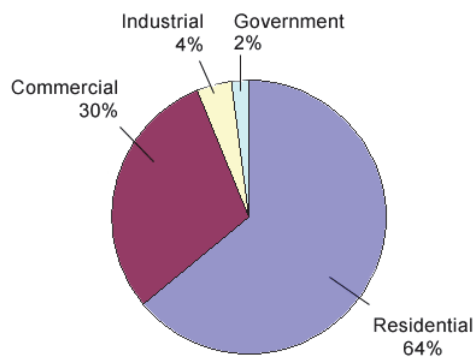
Screen 10

Screen 11

In San Francisco, average water use per person has been declining since the 1960s and 1970s. Several factors have contributed to this reduction, including changes in the mix of local water-using industrial and commercial businesses, and more efficient water use (i.e., water conservation) by San Francisco residents.

Currently, SFPUC provides close to 30 billion gallons of water each year to its customers within the City of San Francisco for a variety of different uses. The pie chart below shows how much water is used for residential, government, and commercial and industrial purposes. About two-thirds (62%) of water provided by SFPUC goes to residential customers.

City of San Francisco Water Usage



Next

Screen 12

The actual amount of water any one household uses depends on:

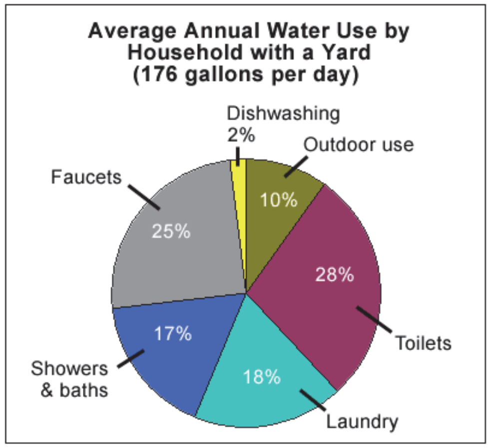
- The number of people who live in the house;
- What type of home it is, such as houses with their own yards, townhomes, condominiums, or apartments; and
- The amount and type of outdoor landscaping.

Due to the moderate climate and the high density housing in San Francisco, residential water use occurs mostly indoors. A typical San Francisco household with its own yard uses 176 gallons of water per day, on average (about 65,000 gallons per year). Households that do not have yards use about 158 gallons of water per day, on average (about 58,000 gallons per year).

Next

Screen 13

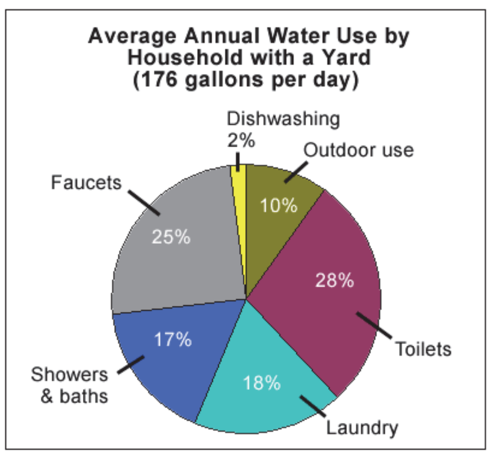
The pie chart below shows how an average household with its own yard uses water throughout the year.



Next

Screen 14

In thinking about how your household uses water compared to the averages presented in the pie chart, does your household use more, less, or about the same amount of water for <u>outdoor</u> use?



Select one answer only

- ○ More
- ○ Less
- ○ About the same

Next

Screen 15

CURRENT SUPPLIES MAY NOT MEET FUTURE DEMAND

The goal of SFPUC is to match available water supplies with demand by taking into account snow pack, river flow, reservoir storage, climate, customer demand, and population estimates. This helps to ensure that there will be an adequate supply of clean water in the future.

Across the greater Bay Area, and most of California, periodic water shortages are anticipated over the coming decades. Even after accounting for savings associated with existing and planned water conservation activities, we expect water demands to increase across the Bay Area, and the State as a whole, over the next 20 years. There is also uncertainty over future rainfall, river levels, snow pack, and the amount of imported water that may be available to water users across the region and state in some future years. Combined, this means that water demands may periodically exceed available water supply over the next 20 years.

SFPUC and other water suppliers throughout the region and state are considering various options to ensure that enough clean water is available in the coming decades. For this reason, we are interested in your views on different options for avoiding future water shortages, and whether some of these options should be taken.

Regional water suppliers do not want to implement new options unless people are willing to pay for them. One way to find out about this is to give people like you information about possible new options, so that you can make up your own mind about them.

Some people think the options they are asked about are not needed; others think they are. We want to get the opinions of all kinds of people.

Next

Screen 16

Methods to Address Current Water Shortages

In San Francisco, there are some water use rules that are always in place. For example, flooding or runoff of excess irrigation water from lawns into the street or gutters is prohibited, and there is a requirement that all homes and buildings install low-water use toilets, showerheads, and sinks when they replace old fixtures.

In addition, in advance of an anticipated minor water supply shortage, SFPUC will implement a number of measures to encourage water conservation by its customers. For example, SFPUC will alert water customers to the current status of water supply conditions, and remind them of existing water use prohibitions. SFPUC also will remind customers of currently available incentives and programs that will help them reduce their water use (such as rebates for installing water efficient fixtures and appliances). If a modest shortage is expected, SFPUC may also initiate new rebate programs ahead of their planned implementation dates, in order to promote the associated water savings in the near-term. In most cities, the goal of these types of actions is to reduce overall water use in the city by up to 10%.

Next

When there is not enough water to meet demand, additional mandatory water use restrictions become necessary, and they can have significant effects on residents, local businesses, and public parks.

To address water shortages, SFPUC currently has two stages of mandatory water use restrictions that can be applied in addition to any existing water use restrictions or voluntary conservation measures. The stage selected depends on the severity of water shortages.

Stage 1 Restrictions. The objective of Stage 1 restrictions is to achieve a system-wide reduction in water use of 11 to 20%. In addition to the permanent water use restrictions and voluntary measures described on the previous screen, under Stage 1 water use restrictions:

- All customers receive a monthly allotment of water based on past indoor and outdoor water use.
- Customers using more than their allotted amount pay “excess use” charges, and may be subject to having devices installed on their water service line that will restrict the flow of water they can receive (or may have their water service shut off).
- Additional water use restrictions may be applied and enforced. For example:
    - The use of water to clean sidewalks, patios, or other hard surfaces is prohibited.
    - Water suitable for drinking cannot be used to clean, fill or maintain levels in decorative fountains.
    - Use of additional water is not allowed for new landscaping or expansion of existing facilities unless low water use landscaping designs and irrigation systems are employed.

Screen 17

- Water service connections for new construction may be granted only if water saving fixtures or devices are incorporated into the plumbing system.

Stage 2 Restrictions The objective of Stage 2 restrictions is to achieve a reduction in water use of more than 20%. Stage 2 water use restrictions would be placed on top of the existing permanent water use restrictions and Stage 1 restrictions described above. Under Stage 2 water use restrictions, additional water use prohibitions and restrictions would be implemented, and customers would be subject to an increased level of rationing. Most outdoor watering would not be allowed.

Next

Screen 18

Stage 1 restrictions can lead to brown lawns and temporary damage to landscaping for households and public parks.

- Lawns and landscaping can recover if these restrictions are needed for only one year.
- If water shortages require Stage 1 restrictions multiple years in a row, this can lead to dead lawns and landscaping for households and public parks.
- Dead lawns and landscaping would require replacement or conversion to low-water use landscaping (e.g., xeriscape).
- Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 1 restrictions.

Stage 2 restrictions can lead to dead lawns and landscaping for households and public parks after only one year. Lawns and public parks irrigated with recycled water would not be impacted because they are not subject to Stage 2 restrictions.

Next

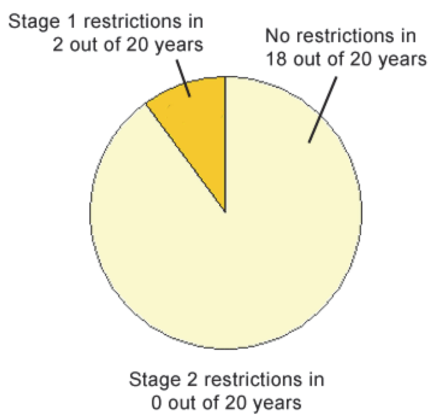
SFPUC Stage 1 and Stage 2 water use restrictions are in addition to any voluntary water use restrictions implemented in advance of an anticipated shortage. Stage 1 and Stage 2 water use restrictions are put in place if water shortages become severe or prolonged. Restrictions typically remain in place over a period of several months, and can be lifted by SFPUC as the severity of a water shortage is reduced. In multi-year drought periods, Stage 1 or Stage 2 restrictions may be required for 2 or 3 years in a row.

In San Francisco, water use restrictions have tended to occur with the following frequencies over the past 20 years:

- No restrictions (excluding voluntary water conservation programs) have been in place in 18 of the past 20 years
- Stage 1 restrictions have been needed in 2 of the past 20 years
- Stage 2 restrictions have not been needed in the last 20 years.

The pie chart below shows how often the different water use restrictions have been in place in San Francisco over the last 20 years.

Screen 19



Some other communities in the Bay Area have had more frequent and severe water shortages over the past two decades than San Francisco itself. This is because they rely in whole or in part on other sources of water supply.

Next

Screen 20

Water Suppliers Need to Identify a Water Supply Strategy

Developing new water supplies can help reduce the frequency and severity of future water shortages. SFPUC and other regional water suppliers are developing long-term water supply reliability strategies to evaluate how much, if any, additional water supplies should be developed to meet future needs.

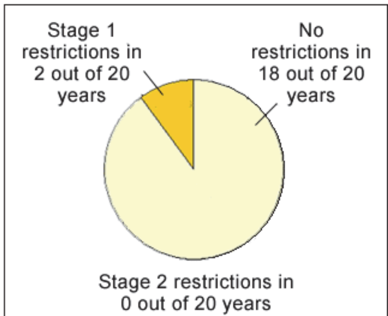
While additional water supplies are not mandatory, without new supplies, water use restrictions in parts of the greater Bay Area, and across the State, may become more severe and frequent in the future.

Next

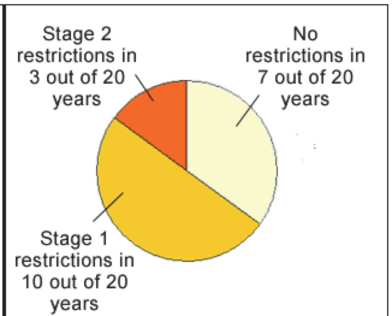
The two pie charts below compare the frequency of water use restrictions in the past with restrictions that may occur in the future if no new water supplies are developed.

- The pie chart on the left shows that, in the City of San Francisco, Stage 1 restrictions have been needed in 2 out of the past 20 years. Stage 2 restrictions have not yet been required. This is the same chart you saw on a previous screen.
- The pie chart on the right is a projection of what the future could be like for the greater Bay Area region, and other parts of the state, if no new water supplies are developed. It shows that Stage 1 restrictions are likely to be more frequent in the future than in the past, and that Stage 2 restrictions are likely to be needed in 3 years out of 20 if no actions are taken to develop new water supplies.

Screen 21



Trend over the past 20 years, for City of San Francisco



Predicted Bay Area Region water use restrictions over next 20 years if nothing more is done

Next

Screen 22

Your Opinion on How Much Should be Done to Increase Future Water Supplies

The more water supplies that are developed to meet future needs, the more you and other state residents will have to pay for water in the future. These costs would be passed on to you through your monthly water bill.

Water suppliers do not want to develop new water supplies unless people like you are willing to pay for them. For this reason, they are trying to balance the amount of water supplies in the future against the costs you would face.

On the next three screens, you will have an opportunity to provide your views on reducing the severity of future water use restrictions based on six alternative water supply plans. In later sections, you can provide your opinions on different options for how additional future water supplies, if any, should be developed.

Next

In the table below, you are presented with predicted levels of future water use restrictions given different future water supply plans. The table also shows the increased costs to you under each plan.

The first row uses pie charts to show the frequency of different stages of water use restrictions in the next 20 years given different levels of available water supply.

Under the No Additional Actions column, aside from the permanent water use restrictions that are always in place, no additional restrictions will be needed in 7 of the next 20 years. Stage 1 water use restrictions will be in place 10 of the next 20 years, and Stage 2 restrictions will be in place in 3 of the next 20 years.

The exact timing and length of future restrictions is unknown, but it is likely that restrictions could be in place for multiple years in a row (e.g., two seasons of Stage 1 restrictions may be followed by a year of Stage 2 restrictions). This is because drought periods often last 2 or 3 years in a row, and may be followed by one or more years in a row that are wetter. Over the past 20 years, Stage 1 restrictions have occurred in 2 years, and there have been no Stage 2 restrictions.

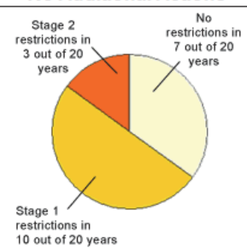
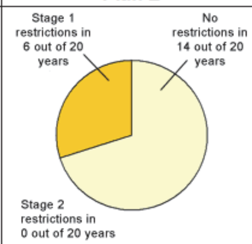
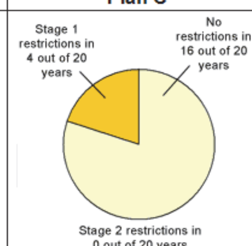
If you would like to be reminded of the permanent water use restrictions, and Stage 1 and Stage 2 restrictions, please click the button on the right. More Info

Water Supply Plans B and C both increase water supplies and have different levels of restrictions over the next 20 years. The second row of the table shows the increase in your water cost under each plan. Under the No Additional Actions column, your monthly water costs will increase by $1, which means that you will pay an additional $12 per year.

If you choose to spend money for a plan that increases water supplies, that money will not be available for you to buy other things.

Screen 23

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan B	Plan C
Available water supply such that water use restrictions in the next 20 years could be:			
Increase in your water cost	$1 per month, which would be $12 per year	$13 per month, which would be $150 per year	$15 per month, which would be $180 per year
Which plan do you prefer?	○	○	○

Next

Screen 24[19]

Please provide a brief comment to help us understand why you chose $13 per month, which would be $150 per year, as your most preferred plan.

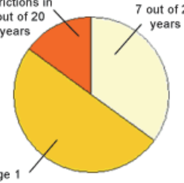
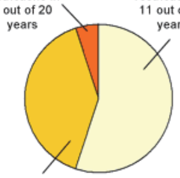
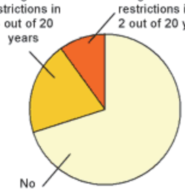
Type in the answer

Next

Screen 25

This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

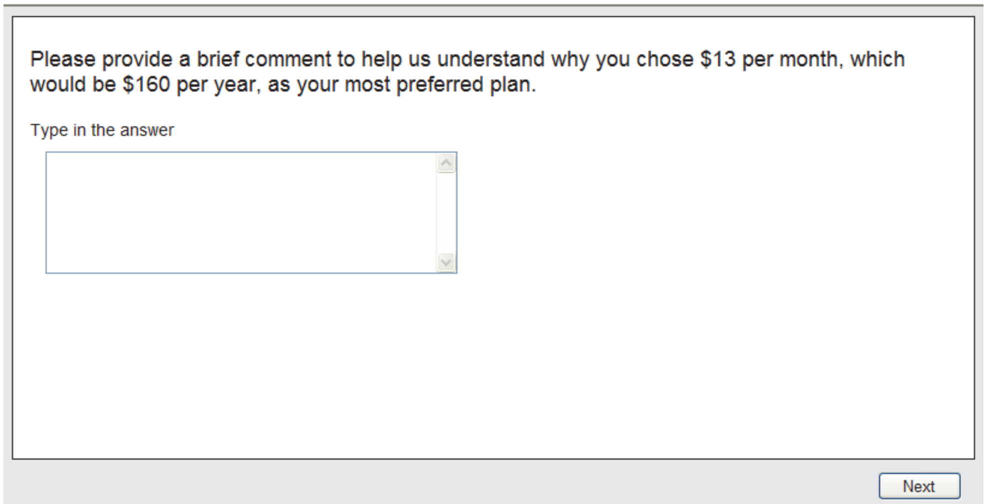
Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan D	Plan E
Available water supply such that water use restrictions in the next 20 years could be:			
Increase in your water cost	$1 per month, which would be $12 per year	$13 per month, which would be $160 per year	$11 per month, which would be $130 per year
Which plan do you prefer?	○	○	○

Next

15. [19]. Screen 24 reflects the choice made in Screen 23.

Screen 26[20]

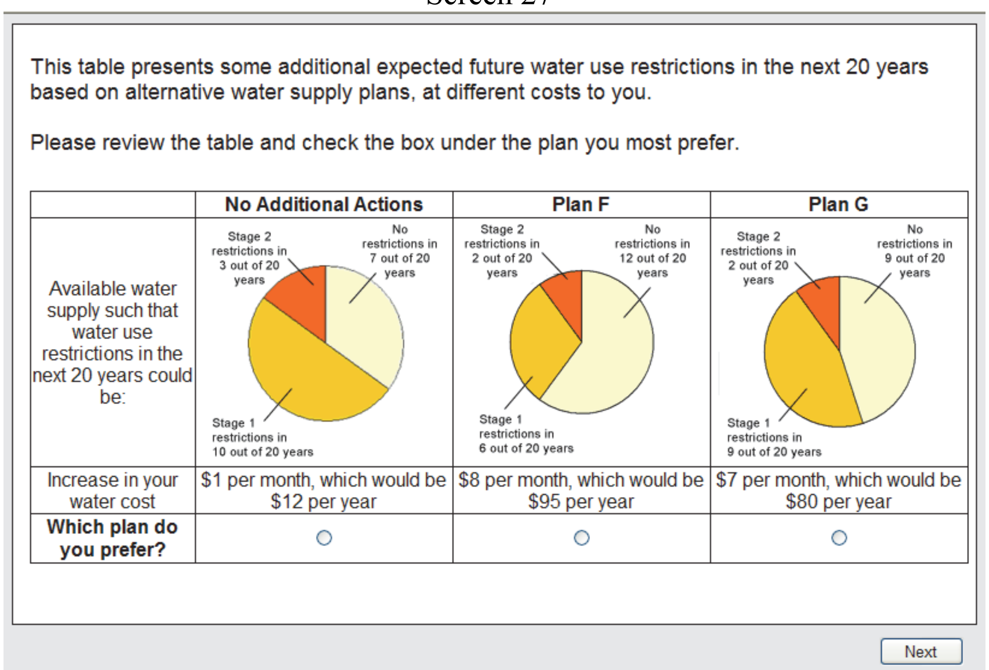


Please provide a brief comment to help us understand why you chose $13 per month, which would be $160 per year, as your most preferred plan.

Type in the answer

Next

Screen 27



This table presents some additional expected future water use restrictions in the next 20 years based on alternative water supply plans, at different costs to you.

Please review the table and check the box under the plan you most prefer.

	No Additional Actions	Plan F	Plan G
Available water supply such that water use restrictions in the next 20 years could be:	Stage 2 restrictions in 3 out of 20 years; No restrictions in 7 out of 20 years; Stage 1 restrictions in 10 out of 20 years	Stage 2 restrictions in 2 out of 20 years; No restrictions in 12 out of 20 years; Stage 1 restrictions in 6 out of 20 years	Stage 2 restrictions in 2 out of 20 years; No restrictions in 9 out of 20 years; Stage 1 restrictions in 9 out of 20 years
Increase in your water cost	$1 per month, which would be $12 per year	$8 per month, which would be $95 per year	$7 per month, which would be $80 per year
Which plan do you prefer?	○	○	○

Next

16. [20]. Screen 26 reflects the choice made in Screen 25.

Screen 28[21]

Please provide a brief comment to help us understand why you chose $8 per month, which would be $95 per year, as your most preferred plan.

Type in the answer

Next

Your Opinion on How We Should Increase Future Water Supplies

There are a number of different options that can be considered to increase the amount of water available in the future to reduce water use shortages and increase the reliability of supplies. We want your opinions about which possible future water supply options you like, and which ones you do not like.

While no actions are perfect, there are opportunities to improve the reliability of future water supplies and reduce the frequency and severity of future water use restrictions.

The options we want you to consider include:

- Increasing water storage capacity (such as by expanding reservoirs)
- Increasing groundwater use
- Importing additional water to the region
- Transferring water from agricultural uses
- Increasing the amount of water conservation
- Increasing the use of recycled water
- Adding desalinated water

Screen 29

The next few screens provide more details on each of these options.

Next

17. [21]. Screen 28 reflects the choice made in Screen 27.

Screen 30

Adding desalinated water

Some California water suppliers are exploring the possibility of developing regional desalination facilities to convert ocean water to drinking water.

Desalination facilities use well established, tested, and effective water treatment technologies (e.g., reverse osmosis membranes). Desalination has been used extensively in other parts of the world and is beginning to be implemented more extensively in the United States. Desalination provides a local source of supply that is reliable and not impacted by weather or climate.

Desalination requires a large amount of energy and can be relatively expensive. However, the cost of desalination relative to the development of other new water supply sources is becoming more favorable. Developments in technology have also decreased costs.

The environmental impacts of desalination can be a concern, if proper precautions are not taken. When ocean water is drawn into the desalination plant, fish and other species can get trapped against the intake screens. To avoid this problem, California water suppliers are focusing on the use of new technologies that minimize these potential environmental effects. For example, new path-breaking beach sand water intake systems that will not harm fish have been developed and tested in California (because they eliminate the need for an ocean intake pipe).

The disposal of the salt and other compounds that are extracted from the seawater can be a concern. However, potential regional desalination facilities will be designed such that the salts removed from the seawater are safely mixed back into the ocean.

In California, water agencies would also develop desalination projects in an aesthetically pleasing manner that will not impact local beach areas. Desalination treatment plants can be located inland, away from local beaches.

Next

Screen 31

Increasing water storage capacity

Water storage could be expanded by increasing the capacity of reservoirs throughout the State. Additional storage would allow water suppliers to store more water in years when water is plentiful.

Increasing the size of existing reservoirs or building new reservoirs could potentially create additional recreation opportunities. However, it might also reduce recreational opportunities on some rivers. It may also have some negative effects on ecosystems, including:

- Loss of river and wildlife habitat
- Decreased flows in some rivers at some times of the year, which could impact some fish and other types of wildlife that rely on adequate stream flows

Next

Screen 32

Increasing the amount of water conservation

A lot of individual water conservation measures have already been taken by residents and businesses in San Francisco, the greater Bay Area, and other parts of the state. However, there are still opportunities for additional conservation measures, especially for reducing outdoor water use. Increased water conservation actions could include:

- Rebates for water-saving appliances
- Rebates for converting to low-water use landscaping (e.g., Xeriscape)
- Mandatory low-water landscaping for new homes

In some cases, the amount of water saved from individual water conservation measures is small when compared to typical water supply development alternatives. Conservation programs also can be relatively expensive, given the amount of water they actually save.

Next

Screen 33

Transferring water from agricultural uses

Improvements in how agriculture uses water could be made, which would reduce the amount of water that is needed by farmers. This saved water could be transferred to urban areas in the state (including the Bay Area) for residential and business uses. Water could be saved by having water supply utilities:

- Pay for the use of improved agricultural irrigation systems that can reduce the amount of water lost to evaporation.
- Pay the extra cost for farmers to use new plant breeds that can provide the same harvest with less water.

Next

Screen 34

Increasing groundwater use

Groundwater is water that collects or flows beneath the Earth's surface, filling the porous spaces in soil, sediment, and rocks. Groundwater originates from rain and from melting snow and ice that soaks into the ground, and is the source of water for aquifers, springs, and wells. High-quality groundwater can be used for drinking water supplies.

In most of California, expanding local groundwater use would only be possible if additional water is used to replenish the local groundwater system. The amount of additional groundwater that could be used in most areas of the State is therefore very limited. Without additional water being supplied to the groundwater system, groundwater supplies would ultimately be depleted.

Groundwater supplies in the Bay Area could be replenished faster if the amount of green area in the region is increased or if special materials are used for sidewalks, roads and other pavement areas. Green areas and special pavement materials allow water to infiltrate into the ground and provide other social and environmental benefits. However, the use of green space or special pavement material can be expensive.

Next

Screen 35

Importing additional water into the region

Additional water supplies for the greater Bay Area could be acquired by importing water from river basins outside of the San Francisco region. Importing additional water from other river basins may have some negative consequences. Removing water from distant rivers and lakes could:

- Harm ecosystems and limit recreational opportunities in the basins from which the water is taken
- Limit the amount of water available to people living near the rivers from which the water is exported
- Increase energy costs associated with transferring the water to the Bay Area

In addition, imported water could become less available in the future, due to court rulings, regulations, droughts, or earthquakes that might disrupt long import water supply canals and pipelines.

Next

Increasing the use of recycled water

In much of the Bay Area and California, a small percentage of current water supply is made up of highly purified recycled water. Many water suppliers would like to increase the amount of recycled water they produce, and make the recycled water available for suitable uses. After it is purified to meet applicable standards, recycled water can be used:

- For watering public landscape areas, parks, and golf courses. It might also be available for watering some household yards.
- For some industrial processes, such as cooling in power plants.
- For other limited non-drinking water uses such as toilet flushing.
- To replenish groundwater basins in some parts of the state. This stored water is later extracted, re-purified, and used for various purposes, including tap water in some parts of the state.

The use of recycled water is not impacted by external factors such as drought or climate change. Recycled water is therefore considered a very reliable source of water supply.

However, because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses can be expensive due to high up-front construction costs and high energy use associated with additional pumping and distribution of the recycled water.

Screen 36

Next

Your Opinion on How We Should Meet Future Water Needs

In the table below, you are presented with different options that could be undertaken to improve future water supply reliability in the greater Bay Area and elsewhere in the State.

Put a "1" for the option you would first like to see done to reduce future water shortages, a "2" next to your second most preferred option, and so on until you have ranked at least 5 options.

Type in the answer into each cell in the grid

Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored from wet years	
Expanding the use of recycled water for outdoor irrigation and industrial uses	
Using highly purified recycled water to replenish groundwater supplies in parts of the state, thereby enabling greater use of local well water in those areas	
Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping)	
Finding new surface water supplies outside the Bay Area region (i.e., importing water from other parts of the State)	
Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area	
Investing in regional desalination facilities, to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions	
Increasing the price of water to residential, commercial, and industrial users so they will use less	
Requiring low water landscaping (e.g., Xeriscape) in new homes and redevelopment projects	

Screen 37

Next

Screen 38

Of these four options, which do you like the least?

Select one answer only

- Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area
- Increasing the price of water to residential, commercial, and industrial users so they will use less
- Expanding the use of recycled water for outdoor irrigation and industrial uses
- Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping)

Next

Screen 39

Does it Matter How We Reduce Future Water Shortages?

There are different ways that water suppliers can provide adequate amounts of water supply in the future. The next few questions ask you to choose among options that could be implemented to reduce the frequency of water shortages in the future. For each of the following questions, please indicate which option you prefer.

Next

Screen 40

Of the two water storage options below, which do you prefer?

Select one answer only

- ○ Increasing water storage capacity by expanding or building new reservoirs in the Bay Area
- ○ Increasing water storage capacity by expanding existing reservoirs or building new reservoirs in other areas of the state (and importing the water to the Bay Area)

Next

Screen 41

Of the two water transfer and import options below, which do you prefer?

Select one answer only

- ○ Increasing water transfers from agriculture
- ○ Increasing water imports from outside of the Bay Area region

Next

Screen 42

Of the two water conservation options below, which do you prefer?

Select one answer only

- ○ Requiring low-water landscaping in new homes and existing homes that remodel more than 1,000 square feet
- ○ Promoting additional voluntary water conservation beyond what is already required through education and incentives

Next

Screen 43

Of the two water recycling options below, which do you prefer? Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish groundwater supplies.

Select one answer only

- ○ Expanding water recycling to replenish groundwater supplies in parts of the state
- ○ Expanding water recycling for outdoor irrigation and industrial uses

Next

Screen 44

Many of the options discussed above apply to the broader Bay Area or to the Northern California region. In thinking about water supply planning for the City of San Francisco, we want to know if you think SFPUC should consider the approaches described below. Some of these options may be under consideration by SFPUC, and some may not. Please indicate whether you agree or disagree with each of the following statements:

Select one answer from each row in the grid

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
SFPUC should actively expand the amount of water conservation in the City	○	○	○	○	○
SFPUC should consider expanding the amount of recycled water used in the City	○	○	○	○	○
SFPUC should seriously consider desalination to provide more water to the City	○	○	○	○	○
SFPUC should raise rates for households and businesses that use more than their fair share of water	○	○	○	○	○

Next

Screen 45

Thinking about this topic, do you have any comments you would like to share?

Any comments welcome!

Next

Screen 46

Thank you for completing this survey. We have successfully received your responses.

Appendix D

Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Austin Water Service Area

D.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 406 panelists within the Austin Water service area from August 11, 2010 to August 18, 2010. KN administered the survey to 101 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of Austin, Stratus Consulting provided KN with a list of zip codes that were completely contained within the Austin Water service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 406 observations from Austin, Texas. Weights were generated by KN to adjust for sample design, non-coverage, and non-response biases. These weights were used in the analysis in order to generalize results to residents of specific Austin zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, and payment of water bill. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

D.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that indicates a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following cross tabs demonstrate how various respondent characteristics affected the outcome of this choice variable.

D.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

Table 1. Education (n = 405[a])

Choice	Less than high school (%)	High school (%)	Some college (%)	Bachelor (%)
Status quo	100.0	100	68.9	45.8
Alternative	0.0	0	31.1	54.2

a. 405 out of the 406 respondents completed the choice questions; thus only 405 observations support Table 1.

D.2.2 Age

Table 2 suggests that older individuals (45+) are slightly more likely to choose alternatives to the status quo than their younger counterparts.

Table 2. Age (n = 405)

Choice	18–29 (%)	30–44 (%)	45–59 (%)	60+ (%)
Status quo	62.5	65.0	56.1	57.9
Alternative	37.5	35.0	44.0	42.1

D.3.3 Gender

Table 3 demonstrates that there is no difference in the likelihood of choosing alternatives to the status quo across gender.

Table 3. Gender (*n* = 405)

Choice	Male (%)	Female (%)
Status quo	60.8	60.5
Alternative	39.2	39.5

D.2.4 Income

Table 4 shows an increased likelihood of choosing alternatives to the status quo in all three choice questions for individuals with household incomes of greater than $75,000. At lower income levels, this relationship is not as clear.

Table 4. Income (*n* = 391)

Choice	< $20,000 (%)	$20,000–$29,999 (%)	$30,000–$49,999 (%)	$50,000-$74,999 (%)	$75,000–$99,999 (%)	> $100,000 (%)
Status quo	67.8	76.8	60.4	74.3	44.1	46.5
Alternative	32.2	23.2	39.6	25.8	55.9	53.5

D.2.5 Ownership status of living quarters

Table 5 reveals a clear difference between respondents who own or rent their living quarters with payment compared to those who occupy their living quarters without payment of cash rent. Respondents who do not pay for their living quarters are more likely to choose alternatives to the status quo.

Table 5. Ownership status of living quarters (*n* = 405)

Choice	Owned or being bought by you or someone in your household (%)	Rented for cash (%)	Occupied without payment of cash rent (%)
Status quo	59.8	63.5	49.3
Alternative	40.2	36.6	50.7

D.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are not working due to a disability or who are not working but looking for work have the greatest likelihood of choosing alternatives to the status quo. Those not working due to a temporary layoff universally chose the status quo.

Table 6. Work status (*n* = 405)

Choice	Working – as a paid employee (%)	Working – self-employed (%)	Not working – on temporary layoff from job (%)	Not working – looking for work (%)	Not working – retired (%)	Not working – disabled (%)	Not working – other (%)
Status quo	57.8	60.6	100.0	52.0	59.3	31.2	83.2
Alternative	42.2	39.4	0	48.0	40.6	68.8	16.8

D.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in Texas. Table 7 shows respondents who answered "very" or "extremely important" to Question 2 had a greater likelihood of choosing alternatives to the status quo in all three choice questions than those who consider the issue less important.

Table 7. Opinion on increasing water supplies (*n* = 405)

Choice	Increasing water supplies of low importance (%)	Increasing water supplies of high importance (%)
Status quo	66.1	56.9
Alternative	33.9	43.1

D.2.8 Ownership status of yard

Table 8 shows that respondents who own a yard have a much higher likelihood of choosing alternatives to the status quo across choice questions.

Table 8. Ownership status of yard (*n* = 405)

Choice	Do not own yard (%)	Own yard (%)
Status quo	77.8	56.2
Alternative	22.3	43.8

D.2.9 Payment of water bill

Table 9 shows a higher proportion of respondents who pay their own water bill choosing alternatives to the status quo in all three choice questions compared to those who do not pay their own bill.

Table 9. Payment of water bill (*n* = 405)

Choice	Does not pay own bill (%)	Pays own bill (%)
Status quo	74.5	58.8
Alternative	25.5	39.4

D.2.10 Time living in Austin

Table 10 demonstrates no clear relationship between the amount of time an individual has been living in Austin and the likelihood of choosing an alternative to the status quo. However, individuals living in Austin for 6 or more years are less likely to choose an alternative relative to individuals living in the city for 3 to 5 years.

Table 10. Time living in Austin (*n* = 405)

Choice	Less than 1 year (%)	1–2 years (%)	3–5 years (%)	6–10 years (%)	More than 10 years (%)
Status quo	100	85.2	43.4	59.6	61.7
Alternative	0	14.8	56.6	40.5	38.3

It is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in Austin and the likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small. Only about 6.2% of respondents have been living in Austin for fewer than 10 years. As shown in Table 10, the majority of this small sample did not choose an alternative. The majority of respondents sampled (70.5%) have been living in Austin for more than 10 years. These respondents chose an alternative to the status quo at a much higher rate.

D.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 46.7% chose Version 1 over the status quo and the other version presented. There are 1,218 observations underlying Table 11, as each of the

406 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents,

Table 11. Distribution of choices by version alternative (*n* = 1,218)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
Refused						0.8
Status quo	8	8	4	12	1	45.4
1	11	8	1	160	13	46.7
2	12	6	2	95	8	22.1
3	13	5	2	210	18	11.2
4	15	5	0	300	25	10.0
5	10	8	2	60	5	41.6
6	11	6	3	130	11	7.0
7	13	7	0	240	20	17.9
8	15	4	1	290	24	9.7
9	12	5	3	90	8	24.2
10	12	8	0	110	9	33.2
11	9	8	3	65	5	26.7
12	14	6	0	150	13	35.6
13	13	6	1	220	18	29.6
14	11	7	2	150	13	20.7
15	8	9	3	20	2	35.2
16	10	7	3	55	5	18.8
17	14	4	2	130	11	26.4%
18	14	5	1	140	12	24.3
19	13	4	3	200	17	19.3
20	12	7	1	100	8	39.3
21	11	9	0	170	14	25.1
22	16	4	0	180	15	37.2
23	9	9	2	80	7	35.6
24	10	9	1	65	5	53.8

Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. About half of the responses were refusals or choices for the status quo (46.2%). The remaining responses were allocated across alternatives to the status quo, with more responses allocated to alternatives with lower costs.

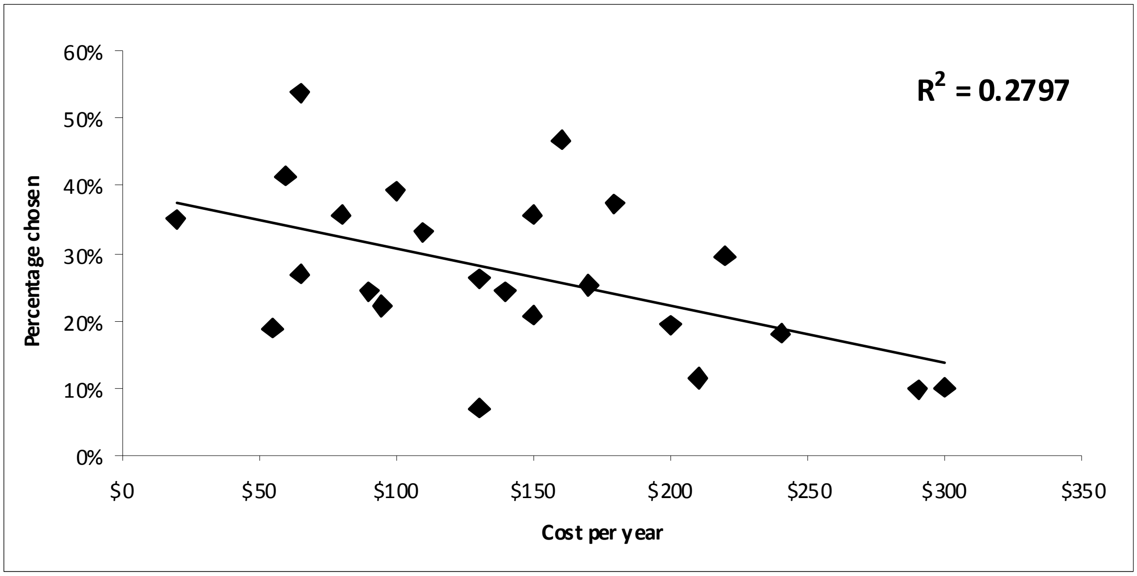


Figure 1. Distribution of choices by program cost.

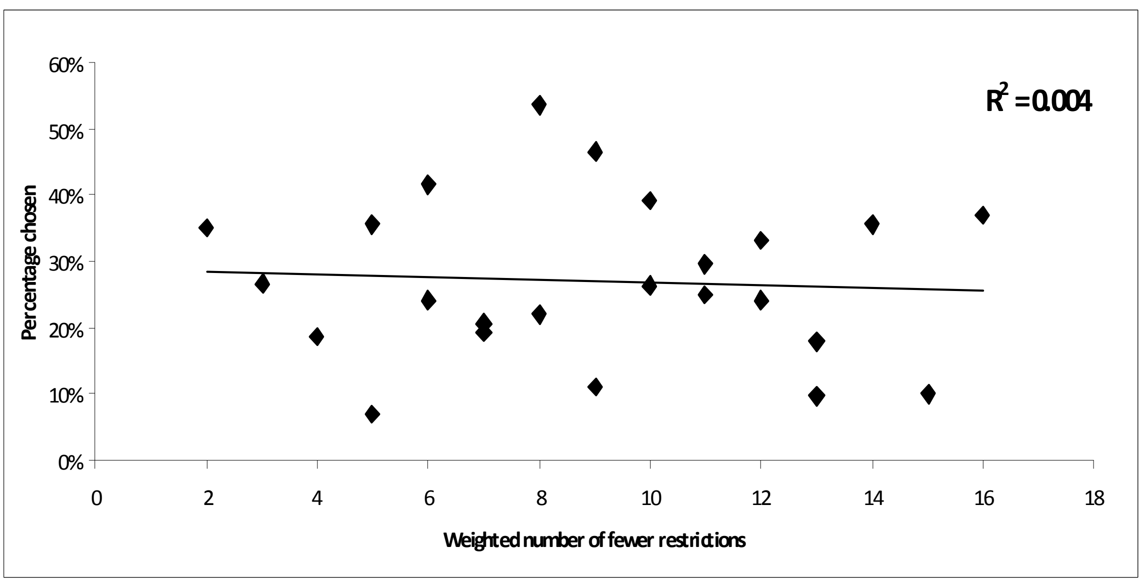


Figure 2. Distribution of choices by number of (weighted) fewer restriction years.

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[22] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.28. This is compared to a correlation of 0.004 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

D.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 10 choices presented on the survey, including:

1. Increasing available supplies of water by importing more water from outside the Lower Colorado River basin
2. Increasing available supplies of water by transferring more water from agricultural uses
3. Increasing the use of non-local groundwater sources
4. Increasing the price of water to residential, commercial, and industrial users so that they will use less
5. Requiring low-water-use landscaping in new homes (e.g., Xeriscape)
6. Increasing available supplies of water by expanding storage reservoirs
7. Increasing the use of local groundwater sources
8. Expanding water recycling for outdoor irrigation and industrial uses
9. Promoting voluntary water conservation through education and incentives (e.g., rebates)
10. Expanding water recycling to replenish groundwater reservoir supplies.

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected each option as one of their top three most-preferred choices for dealing with future water shortages.

Four responses stand out as the preferred choices: expanding water recycling for outdoor irrigation and industrial uses; promoting voluntary water conservation through education and incentives; using recycled water to replenish groundwater supplies; and requiring low-water-use landscaping for new homes. Expanding reservoirs was also a relatively popular option.

[22]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that about one-third of respondents chose increasing the price of water to residential, commercial, and industrial users as their least preferred option. Almost one-quarter of respondents chose increasing supplies of water by importing water from outside the Lower Colorado River basin as the option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of the two water storage options they preferred and which of the two water reuse options they preferred. Responses are summarized in Tables 12–16.

D.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in Austin, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

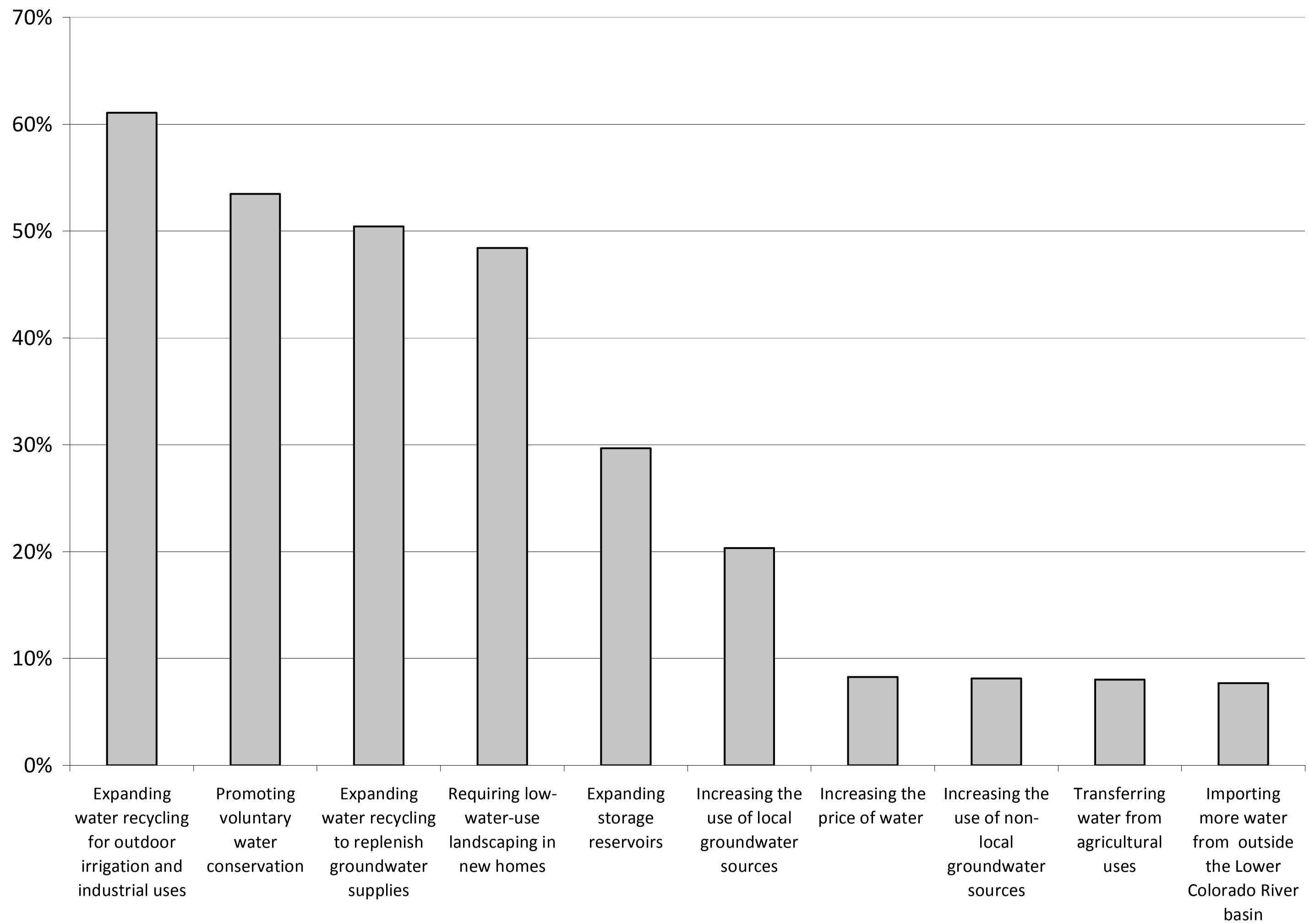


Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages.

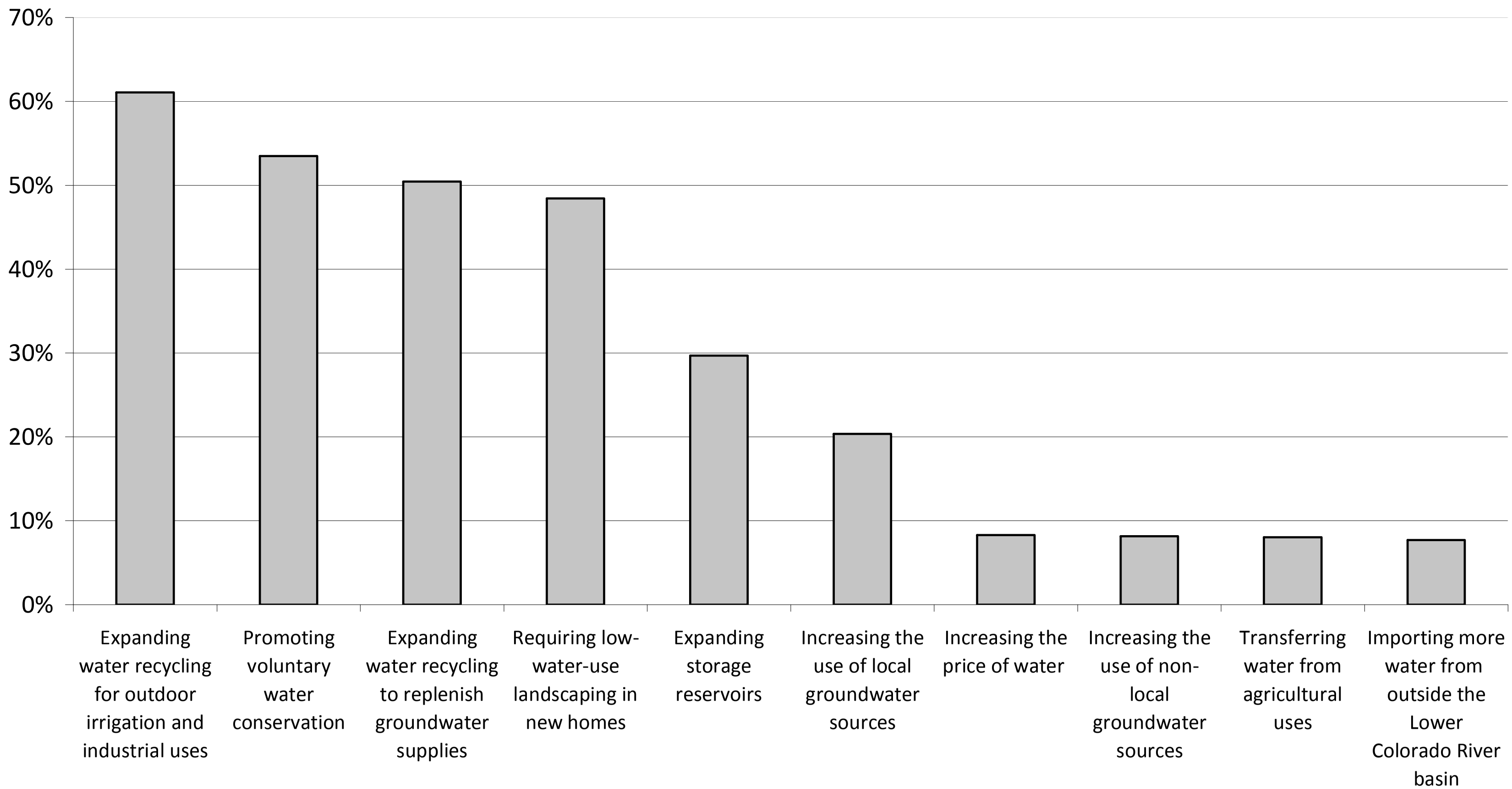


Figure 4. Percentage of respondents who selected a given option as their least preferred option for dealing with future water shortages

Table 12. Q17: Of the two water storage options below, which do you prefer?

Refused	2.2%
Increasing surface reservoir storage	33.6%
Increasing underground water storage	64.3%

Table 13. Q17a: Of the two water storage options below, which do you prefer?

Refused	0.2%
Increasing use of local groundwater sources	77.7%
Increasing use of non-local groundwater sources	22.2%

Table 14. Q18: Of the two water transfer and import options below, which do you prefer?

Refused	0.2%
Increasing water imports from outside the Lower Colorado River basin	48.5%
Increasing water transfers from agriculture	51.2%

Table 15. Q19: Of the two water conservation options below, which do you prefer?

Refused	0.0%
Requiring low-water-use landscaping in new homes	48.7%
Promoting voluntary water conservation through education and incentives	51.3%

Table 16. Q20: Of the two water recycling options below, which do you prefer?[a]

Refused	0.0%
Expanding water recycling for outdoor irrigation and industrial uses	37.2%
Expanding water recycling to replenish reservoir supplies	62.9%

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Table 17 displays the results from the conditional logit model. The model uses 3,513 observations, an expansion of the 406 observations by nine choices (three choice questions and three choices per question), less 141 observations due to questions that were left unanswered by respondents.

Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,513; log likelihood = -1,159.557)

Choice	Coefficient	Robust standard error	*z*	*P* > |*z*|	[95% confidence	interval]
Cost per year	-0.009	0.002	-4.60	0.000	-0.012	-0.005
Reduction in Level 2 restrictions[a]	0.00061	0.059	0.01	0.992	-0.114	0.116
Reduction in Level 3 restrictions	0.297	0.092	3.21	0.001	0.115	0.478
Chose alternative education	0.275	0.131	2.10	0.036	0.018	0.532
Chose alternative × age	-0.078	0.108	-0.72	0.471	-0.291	0.135
Chose alternative × income	0.255	0.078	3.26	0.001	0.101	0.409
Chose alternative × increasing water supplies important	0.792	0.207	3.83	0.000	0.387	1.197
Chose alternative × time living in Austin	-0.496	0.112	-4.43	0.000	-0.716	-0.277
Chose alternative × own yard	0.333	0.335	0.99	0.320	-0.323	0.990
Chose alternative × pay water bill	-0.425	0.399	-1.06	0.288	-1.208	0.358

a. WTP to reduce Level 1 restrictions was not evaluated because it is assumed that Level 1 restrictions will remain permanently in place in the future.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). Time spent living in Austin is also found to have a negative impact on the likelihood of choosing a given option, while income and higher education have a positive impact. Finally, respondents who feel that increasing water supplies is an important issue in their community are more likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

D.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 2 and Level 3 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 2 restrictions is not statistically significant from zero. This means that respondents are not willing to pay to reduce Level 2 restrictions. The mean WTP for reducing Level 3 restrictions by 1 summer out of the next 20 is statistically significant from zero. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 3 restrictions.

Table 18. WTP estimates (n = 3,513)

Choice	Coefficient	Robust standard error	z	$P > \|z\|$	[95% confidence interval]	
WTP to reduce Level 2 restrictions by 1 summer out of the next 20	0.07	6.70	0.01	0.99	-13.07	13.21
WTP to reduce Level 3 restrictions by 1 summer out of the next 20	33.94	7.15	4.74	0.00	19.92	47.96
WTP to avoid all restrictions	135.76	28.62	4.74	0.00	79.67	191.85

a. WTP to avoid all restrictions assumes that WTP to reduce Level 1 restrictions by 1 summer out of the next 20 is $0.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 2 and Level 3 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($0 × 8) + ($33.94 × 4) = $135.76 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 2 and Level 3 use restrictions = $123.63. This estimate is not statistically different from the estimate using the linear model ($135.76). More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the non-linear models and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

Appendix E

Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Long Beach Water Department Service Area

E.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 426 panelists within the Long Beach Water Department (LBWD) service area from October 25, 2010 through November 8, 2010. KN administered the survey to 23 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of Long Beach, Stratus Consulting provided KN with a list of zip codes that were completely contained within the LBWD service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called “No Additional Actions,” which we refer to in this report as the “status quo.” The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 426 observations from Long Beach, California. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in Long Beach. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

E.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

E.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

Table 1. Education (*n* = 424[a])

Choice	Less than high school (%)	High school (%)	Some college (%)	Bachelors (%)
Status quo	88.6	75.4	74.0	69.9
Alternative	11.4	24.6	26.0	30.1

a. 424 out of the 426 respondents completed the choice questions; thus only 424 observations support Table 1.

E.2.2 Age

Table 2 suggests that individuals over the age of 30 are less likely to choose alternatives to the status quo compared to their younger counterparts.

Table 2. Age (*n* = 424)

Choice	18–29 (%)	30–44 (%)	45–59 (%)	60 + (%)
Status quo	67.2	77.2	75.0	78.2
Alternative	32.9	22.8	25.0	21.8

E.2.3 Gender

Table 3 demonstrates that males are slightly more likely to choose an alternative to the status quo than females.

Table 3. Gender (*n* = 424)

Choice	Male (%)	Female (%)
Status quo	72.3	75.8
Alternative	27.7	24.2

E.2.4 Income

Table 4 shows an increased likelihood of choosing alternatives to the status quo in all three choice questions for individuals with household incomes of between \$20,000 to \$29,999; \$50,000 to \$74,999; and over \$100,000. Overall, there seems to be no clear trend in the way that income affects an individual's decision to choose an alternative to the status quo. However, households that make less than \$20,000 per year are much less likely to choose an alternative compared to households in higher income categories.

Table 4. Income (*n* = 424)

Choice	< \$20,000 (%)	\$20,000–\$29,999 (%)	\$30,000–\$49,999 (%)	\$50,000-\$74,999 (%)	\$75,000–\$99,999 (%)	> \$100,000 (%)
Status quo	89.0%	69.7%	77.7%	66.6%	74.6%	72.1%
Alternative	11.0%	30.3%	22.3%	33.4%	25.4%	27.9%

E.2.5 Ownership status of living quarters

Table 5 reveals that respondents who rent their living quarters with payment are more likely to choose an alternative to the status quo compared to those who own their living quarters. Respondents who do not pay for their living quarters are less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

Table 5. Ownership status of living quarters (*n* = 424)

Choice	Owned or being bought by you or someone in your household (%)	Rented for cash (%)	Occupied without payment of cash rent (%)
Status quo	75.6	71.2	79.6
Alternative	24.4	28.8	20.4

E.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are not working due to a disability or who are not working but looking for work are less likely to choose an alternative to the status quo. Respondents that are self-employed, not working due to a temporary layoff from their job, or not working due to other reasons, are the most likely to choose an alternative to the status quo.

Table 6. Work status (*n* = 424)

Choice	Working – as a paid employee (%)	Working – self-employed (%)	Not working – on temporary layoff from job (%)	Not working – looking for work (%)	Not working – retired (%)	Not working – disabled (%)	Not working – other (%)
Status quo	74.3	69.2	68.8	79.0	73.6	84.5	65.2
Alternative	25.7	30.8	31.2	21.0	26.4	15.5	34.8

E.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in Southern California. As shown in Table 7, respondents who answered "very" or "extremely" important to Question 2 have a greater likelihood of choosing alternatives to the status quo in all three choice questions.

Table 7. Opinion on increasing water supplies (*n* = 424)

Choice	Increasing water supplies low importance (%)	Increasing water supplies high importance (%)
Status quo	76.6	73.0
Alternative	23.5	27.0

E.2.8 Ownership status of yard

Table 8 shows that respondents who do not own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

Table 8. Ownership status of yard (*n* = 424)

Choice	Do not own yard (%)	Own yard (%)
Status quo	69.1	77.1
Alternative	30.9	22.9

E.2.9 Payment of water bill

Table 9 shows that a lower proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

Table 9. Payment of water bill (*n* = 424)

Choice	Does not pay own bill (%)	Pays own bill (%)
Status quo	70.2	76.3
Alternative	29.8	23.7

E.2.10 Time living in Long Beach

Table 10 shows that individuals that have been living in Long Beach for three or more years are much more likely to choose an alternative compared to individuals that have lived in the city for less time.

It is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in Long Beach and their likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small. Only about 2.8% of respondents have been living in Long Beach for less than 1 year, and about 6.5% have been living in Long Beach for 1 to 2 years. The majority of respondents sampled (70.1%) have been living in Long Beach for more than 10 years. These respondents chose an alternative to the status quo at a much higher rate.

Table 10. Time living in Long Beach (*n* = 424)

Choice	Less than 1 year (%)	1–2 years (%)	3–5 years (%)	6–10 years (%)	More than 10 years (%)
Status quo	91.9	91.9	72.0	62.4	74.0
Alternative	8.1	8.1	28.0	37.6	26.0

E.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 24% chose Version 1 over the status quo and the other version presented. There are 1,278 observations underlying Table 11 as each of the 426 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (62.5%). The remaining responses were allocated across alternatives to the status quo.

Table 11. Distribution of choices by version alternative (*n* = 1,278)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
Refused						0.8
Status quo	7	10	3	12	1	61.7
1	11	8	1	160	13	24.2
2	12	6	2	95	8	16.9
3	13	5	2	210	18	4.8
4	15	5	0	300	25	12.4
5	10	8	2	60	5	18.8
6	11	6	3	130	11	10.9
7	13	7	0	240	20	12.7
8	15	4	1	290	24	8.7
9	12	5	3	90	8	22.0
10	12	8	0	110	9	37.0
11	9	8	3	65	5	16.0
12	14	6	0	150	13	23.0
13	13	6	1	220	18	12.1
14	11	7	2	150	13	10.2
15	8	9	3	20	2	33.2
16	10	7	3	55	5	28.1
17	14	4	2	130	11	13.5
18	14	5	1	140	12	16.3
19	13	4	3	200	17	13.3

Table 11. Distribution of choices by version alternative (*n* = 1,278) (cont.)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
20	12	7	1	100	8	16.5
21	11	9	0	170	14	17.2
22	16	4	0	180	15	23.4
23	9	9	2	80	7	25.5
24	10	9	1	65	5	34.3

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[23] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.3998. This is compared to a correlation of 0.0394 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

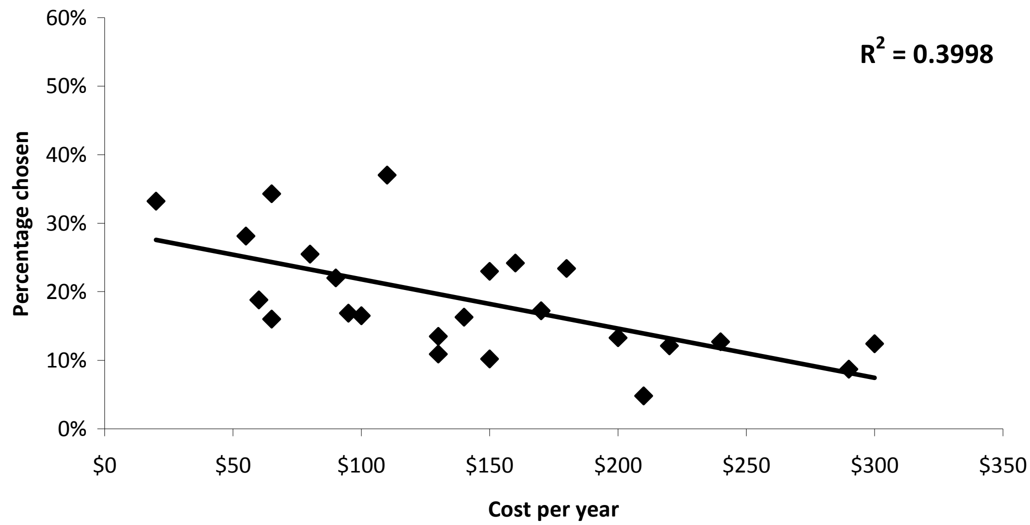


Figure 1. Distribution of choices by program cost.

18. [23]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

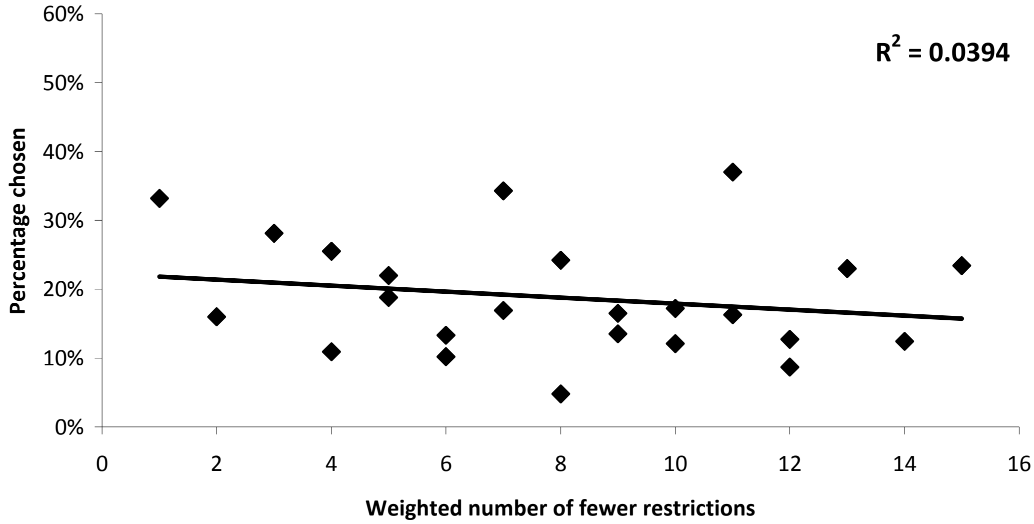


Figure 2. Distribution of choices by number of (weighted) fewer restriction years.

E.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 10 choices presented on the survey, including:

11. Increasing the amount of water that is imported from Northern California (from the Bay-Delta) or the Colorado River, and purchased from the Metropolitan Water District (MWD)
12. Increasing available supplies of water by transferring more water from agricultural uses in the state to Long Beach or MWD
13. Investing in desal facilities to convert ocean waters into part of the local potable supply
14. Increasing the price of water to residential, commercial, and industrial users so that they will use less
15. Requiring low-water-use landscaping in new homes and redevelopment projects (e.g., Xeriscape)
16. Increasing available supplies of water by expanding the import and use of non-local groundwater (i.e., water found underground and accessed by wells at locations some distance from Long Beach, and then pumped to the city)
17. Expanding the use of reclaimed water for outdoor irrigation and industrial uses
18. Using highly purified reclaimed water to replenish the local groundwater supply, allowing greater use of local groundwater

19. Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low-water-use landscaping and water efficient appliances)
20. Increasing available supplies in dry years by acquiring more imported MWD water in wet years, and storing it underground for local use in dry years.

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected a given option as one of their top three preferred choices. Five responses stand out as the preferred choices: expanding the use of reclaimed water for outdoor irrigation and industrial purposes; promoting more voluntary conservation through incentives and education; requiring low-water-use landscaping in new homes and redevelopment projects; using highly purified recycled water to replenish the groundwater supply; and investing in ocean desal facilities.

Question 16A asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that close to 30% of respondents chose increasing the price of water to residential, commercial, and industrial users so they will use less as their least preferred option. About 18% of respondents chose increasing supplies of water by importing water from northern California or the Colorado River as the water supply option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of the two underground water storage options they preferred, and which of two water reuse options they preferred. Responses are summarized in Tables 12–16.

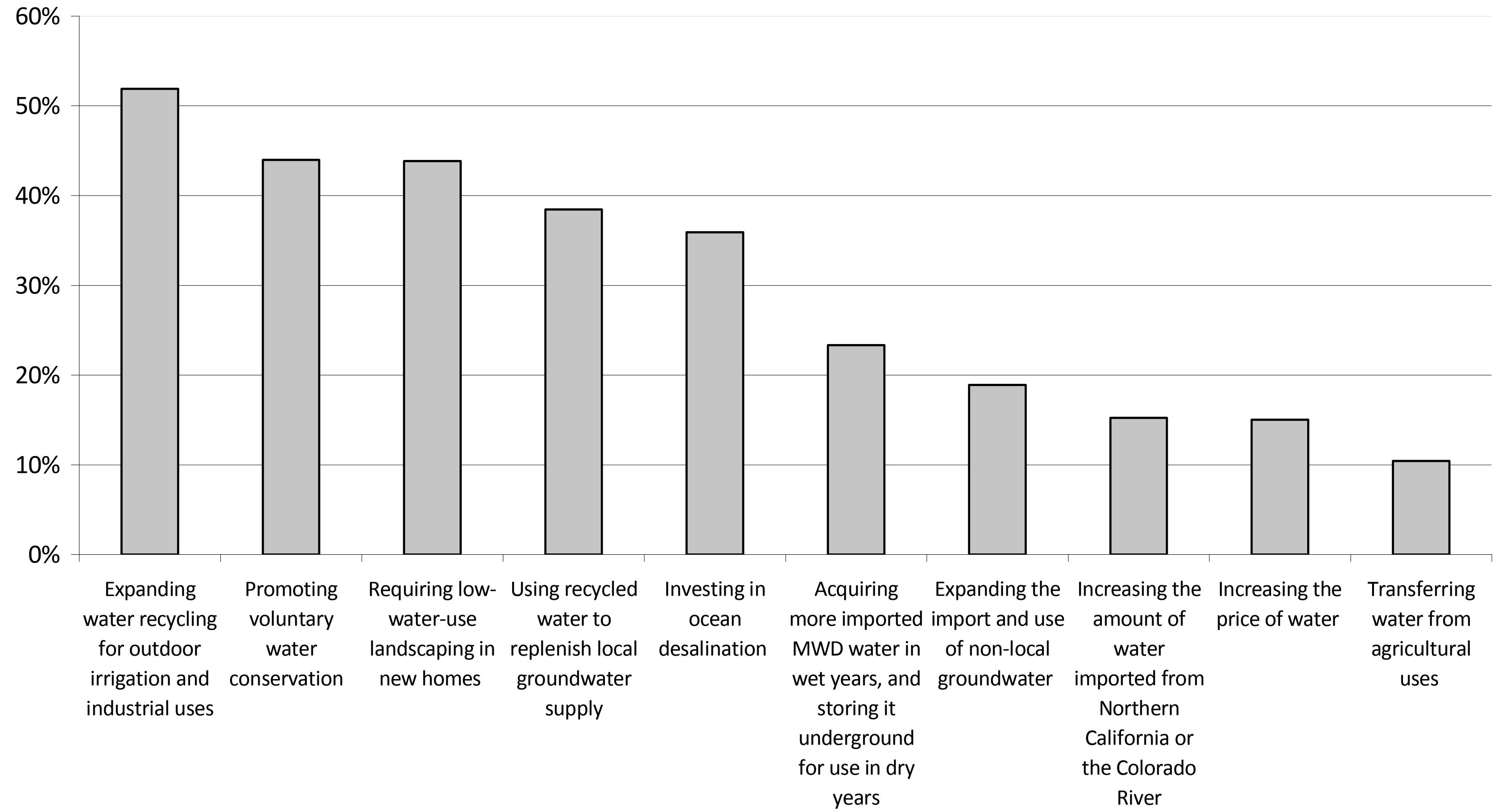


Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages.

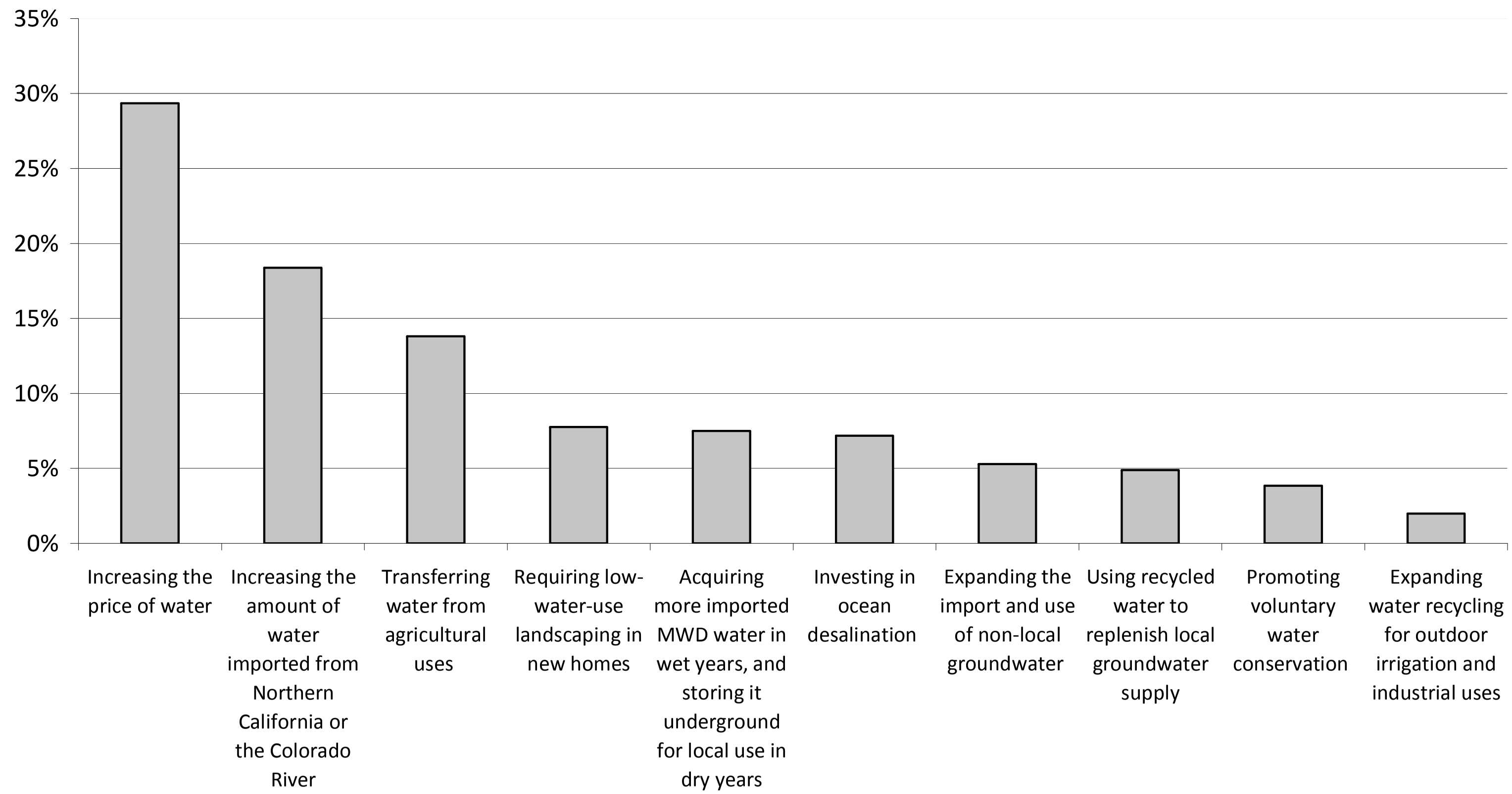


Figure 4. Percentage of respondents who selected a given option as their least preferred option for dealing with future water shortages.

Table 12. Q17: Of the two underground water storage options below, which do you prefer?

Refused	1.2%
Increasing underground storage of recycled water	56.6%
Increasing underground storage of imported water in wet years	42.3%

Table 13. Q17a: Of the two groundwater options below, which do you prefer?

Refused	0.2%
Increasing use of local groundwater sources through replenishing the basin	78.6%
Increasing use of non-local groundwater sources and pumping the water to	21.2%

Table 14. Q18: Of the two water transfer and import options below, which do you prefer?

Refused	0.04%
Increasing water imports from MWD	58.1%
Increasing water transfers from agriculture	41.9%

Table 15. Q19: Of the two water conservation options below, which do you prefer?

Refused	0.04%
Requiring low-water-use landscaping in new homes	51.6%
Promoting voluntary water conservation through education and incentives	48.4%

Table 16. Q20: Of the two water recycling options below, which do you prefer?[a]

Refused	0.6%
Expanding water recycling for outdoor irrigation and industrial uses	36.6%
Expanding water recycling to replenish local groundwater supplies	62.8%

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

E.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in Long Beach, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 17 displays the results from the conditional logit model. The model uses 3,633 observations, an expansion of the 426 observations by nine choices (three choice questions and three choices per question), less 201 observations due to questions that were left unanswered by respondents.

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). Age of the respondent is also found to have a negative impact on the likelihood of choosing a given option. Finally, respondents who feel that increasing water supplies is an important issue in their community are more likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential nonlinear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,633; log likelihood = -1,060.835)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence	interval]
Cost per year	-0.007	0.002	-4.07	0.000	-0.011	-0.004
Reduction in Level 1 restrictions[a]	-0.018	0.054	-0.33	0.740	-0.124	0.088
Reduction in Level 2 restrictions	0.255	0.090	2.85	0.004	0.079	0.431
Chose alternative x education	0.021	0.092	0.23	0.821	-0.160	0.201
Chose alternative × age	-0.313	0.098	-3.20	0.001	-0.504	-0.121
Chose alternative × income	0.041	0.063	0.65	0.517	-0.082	0.164
Chose alternative × increasing water supplies important	0.549	0.188	2.92	0.003	0.181	0.917
Chose alternative × time living in Long Beach	-0.013	0.066	-0.19	0.847	-0.142	0.117
Chose alternative × own yard	0.018	0.234	0.08	0.938	-0.440	0.477
Chose alternative × pay water bill	-0.590	0.233	-2.53	0.012	-1.05	-0.132

a. WTP to reduce Level 1 restrictions was not evaluated because it is assumed that Level 1 restrictions will remain permanently in place in the future.

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the nonlinear variations we estimated.

E.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 1 restrictions is not statistically significant from zero. This means that respondents are not willing to pay to reduce Level 1 restrictions. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 years is positive and statistically significant from zero. These results imply a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

Table 18. WTP estimates (n = 3,633)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence interval]	
WTP to reduce Level 1 restrictions by one summer out of the next 20	-2.41	7.66	-0.31	0.75	-17.41	12.60
WTP to reduce Level 2 restrictions by one summer out of the next 20	34.29	8.73	3.93	0.00	17.19	51.39
WTP to avoid all restrictions	102.86	26.18	3.93	0.00	51.56	154.17

a. WTP to avoid all restrictions assumes that WTP to reduce Level 1 restrictions by 1 summer out of the next 20 is $0.

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be ($0 × 10) + ($34.29 × 3) = $102.86 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = $104.18 (WTP to avoid Level 1 restrictions is not statistically significant from 0). This estimate is not statistically different from the estimate using the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

Appendix F

Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Orlando Area

F.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 448 panelists within the Orlando Utilities Commission (OUC) service area from June 1, 2011 through June 20, 2011. KN administered the survey to 32 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the OUC, Stratus Consulting provided KN with a list of zip codes that were completely contained within the OUC service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 448 observations from Orlando, FL. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in Orlando. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

F.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

F.2.1 Education

Table 1 shows that individuals with a bachelor's degree are more likely to choose an alternative to the status quo.

Table 1. Education

Choice	Less than high school (*n* = 4; %)	High school (*n* = 34; %)	Some college (*n* = 154; %)	Bachelors (*n* = 256; %)
Status quo	100	80.2	81.9	70.7
Alternative	0	19.8	18.1	29.3

F.2.2 Age

Table 2 suggests that individuals over the age of 60 are much more likely to choose alternatives to the status quo in all three choice questions, compared to their younger counterparts. Individuals between the ages of 18 and 29 are the least likely to choose an alternative.

Table 2. Age

Choice	18–29 (*n* = 79; %)	30–44 (*n* = 137; %)	45–59 (*n* = 144; %)	60 + (*n* = 88; %)
Status quo	85.3	77.4	80.7	69.3
Alternative	14.7	22.6	19.3	30.7

F.2.3 Gender

Table 3 demonstrates that males are slightly more likely to choose alternatives to the status quo than females.

Table 3. Gender

Choice	Male (*n* = 173; %)	Female (*n* = 275; %)
Status quo	77.5	79.1
Alternative	22.5	20.9

F.2.4 Income

The decision to choose an alternative to the status quo seems to be influenced by income. Table 4 shows that individuals with household incomes of more than $50,000 are much more likely to choose alternatives to the status quo in all three choice questions compared to most of their counterparts. Individuals with household incomes of greater than $100,000 are most likely to choose alternatives.

Table 4. Income (*n* = 405)

Choice	< $20,000 (*n* = 20; %)	$20,000–$29,999 (*n* = 39; %)	$30,000–$49,999 (*n* = 97; %)	$50,000–$74,999 (*n* = 99; %)	$75,000–$99,999 (*n* = 64; %)	> $100,000 (*n* = 105; %)
Status quo	1. 77.7	79.5	86.5	73.7	74.5	69.6
Alternative	22.3	20.5	13.5	26.3	25.5	30.5

F.2.5 Ownership status of living quarters

Table 5 reveals that respondents who own their living quarters are more likely to choose an alternative to the status quo compared to those rent their living quarters with payment. Respondents who do not pay for their living quarters are much less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

Table 5. Ownership status of living quarters (*n* = 424)

Choice	Owned or being bought by you or someone in your household (*n* = 309; %)	Rented for cash (*n* = 123; %)	Occupied without payment of cash rent (*n* = 16; %)
Status quo	75.0	81.0	97.4
Alternative	25.1	19.0	2.6

F.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are working as a paid employee or not working due to a temporary layoff from their job are less likely to choose an alternative to the status quo. Respondents who are not working due to a disability are much more likely to choose an alternative compared to all other respondents.

Table 6. Work status

Choice	Working – as a paid employee (*n* = 287; %)	Working – self-employed (*n* = 38; %)	Not working – on temporary layoff from job (*n* = 5; %)	Not working – looking for work (*n* = 31; %)	Not working – retired (*n* = 57; %)	Not working – disabled (*n* = 9; %)	Not working – other (*n* = 21; %)
Status quo	81.4	73.4	87.3	77.9	70.2	34.6	77.8
Alternative	18.6	26.6	12.7	22.1	29.8	65.4	22.2

F.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important "increasing water supplies" is as an issue in the Orlando area. Respondents who answered "very" or "extremely" important were categorized as placing a high importance on increasing water supplies in their community. As shown in Table 7, these respondents are more likely to choose alternatives to the status quo in all three choice questions.

Table 7. Opinion on increasing water supplies

Choice	Increasing water supplies low importance (*n* = 202; %)	Increasing water supplies high importance (*n* = 246; %)
Status quo	80.8	76.6
Alternative	19.2	23.4

F.2.8 Ownership status of yard

Table 8 shows that respondents who own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

Table 8. Ownership status of yard

Choice	Do not own yard (*n* = 125; %)	Own yard (*n* = 323; %)
Status quo	82.5	76.5
Alternative	17.5	23.5

F.2.9 Payment of water bill

Table 9 shows that a higher proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

Table 9. Payment of water bill

Choice	Does not pay own bill (n = 57; %)	Pays own bill (n = 389; %)
Status quo	80.3	77.9
Alternative	19.7	22.1

F.2.10 Time living in Orlando

Table 10 shows no clear relationship between the amount of time an individual has been living in Orlando and their likelihood of choosing an alternative to the status quo. Individuals who have been living in Orlando for less than one year are less likely to choose alternatives to the status quo in all three choice questions. Individuals that have lived in Orlando for 3 to 5 years are the most likely to choose an alternative to the status quo.

Table 10. Time living in Orlando

Choice	Less than 1 year (n = 11; %)	1–2 years (n = 24; %	3–5 years (n = 54; %)	6–10 years (n = 76; %)	More than 10 years (n = 283; %)
Status quo	85.2	77.0	70.0	82.6	79.1
Alternative	14.8	23.0	30.0	17.4	20.9

F.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled "Percentage chosen" displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 9.66% chose Version 1 over the status quo and the other version presented. There are 1,344 observations underlying Table 11 as each of the 448 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (64.4%).

Table 11. Distribution of choices by version alternative (*n* = 1,344)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
Refused						1.24
Status quo	7	10	3	12	1	63.2
1	11	8	1	160	13	9.66
2	12	6	2	95	8	28.53
3	13	5	2	210	18	13.65
4	15	5	0	300	25	19.16
5	10	8	2	60	5	37.15
6	11	6	3	130	11	3.81
7	13	7	0	240	20	12.25
8	15	4	1	290	24	11.04
9	12	5	3	90	8	31.48
10	12	8	0	110	9	17.54
11	9	8	3	65	5	16.27
12	14	6	0	150	13	14.53
13	13	6	1	220	18	10.10
14	11	7	2	150	13	8.16
15	8	9	3	20	2	26.32
16	10	7	3	55	5	21.83
17	14	4	2	130	11	12.39
18	14	5	1	140	12	17.52
19	13	4	3	200	17	5.76
20	12	7	1	100	8	19.22

Table 11. Distribution of choices by version alternative (*n* = 1,344) (cont.)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
21	11	9	0	170	14	13.47
22	16	4	0	180	15	18.87
23	9	9	2	80	7	18.44
24	10	9	1	65	5	30.08

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[24] (Figure 2). Based on these figures, program cost seems to play a larger role in

19. [24] The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.28. This is compared to a correlation of 0.004 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

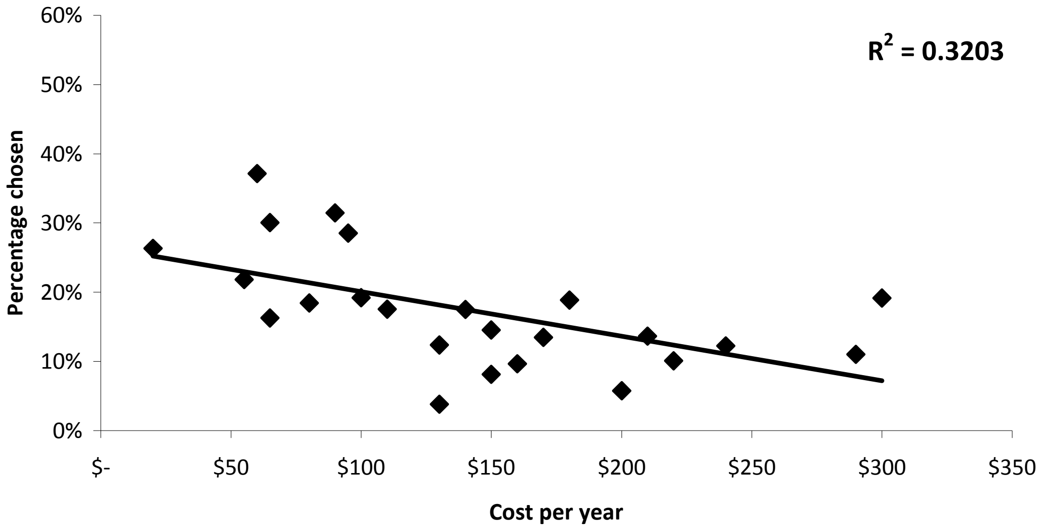


Figure 1. Distribution of choices by program cost.

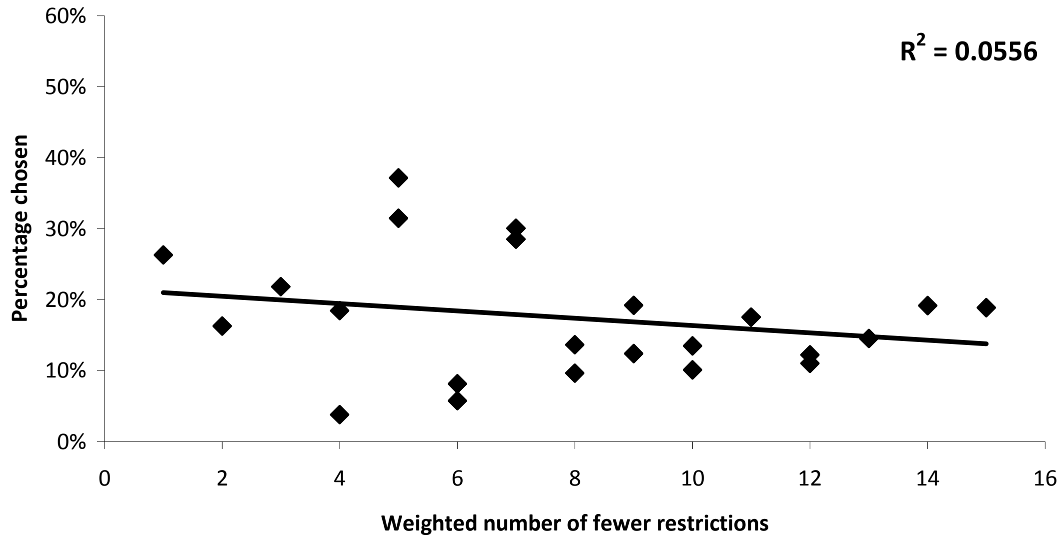


Figure 2. Distribution of choices by number of (weighted) fewer restriction years.

F.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve the future water supply reliability. There were 10 choices presented in the survey, including:

21. Increasing available supplies by diverting and storing surface water from the St. Johns River in reservoirs, and using these surface waters as part of the potable water supply
22. Investing in desal facilities to convert ocean waters into part of the local potable water supply
23. Investing in desal facilities to convert brackish groundwater near the east coast of Florida into part of the Orlando region's local potable water supply
24. Increasing the price of water to residential, commercial, and industrial users so that they will use less
25. Requiring low-water-use landscaping (e.g., Florida Friendly landscaping) in new homes and redevelopment projects
26. Expanding the use of recycled water for outdoor irrigation and industrial uses
27. Increasing the use of local groundwater sources
28. Using highly purified recycled water to replenish the local groundwater supply, allowing greater use of local groundwater
29. Increasing available supplies by diverting surface water from the St. Johns River and storing it underground, allowing greater use of local groundwater
30. Promoting more voluntary water conservation through additional education and incentives (e.g., rebates to convert to low-water-use landscaping and water efficient appliances).

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected the given options as one of their top three most-preferred choices.

Three responses stand out as the preferred choices: expanding the use of recycled water for outdoor irrigation and industrial uses; requiring low-water-use landscaping in new homes and redevelopment projects; and promoting more voluntary water conservation through additional education and incentives. Using highly purified recycled water to replenish the local groundwater supply was also a relatively popular option.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals that more than 40% of respondents chose increasing the price of water to residential, commercial, and industrial users as their least preferred option.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of two underground water storage options they preferred, which of two groundwater options they preferred, which of two water import options they preferred, which of two water conservation options they preferred, and which of two water recycling options they preferred. Responses are summarized in Tables 12–16.

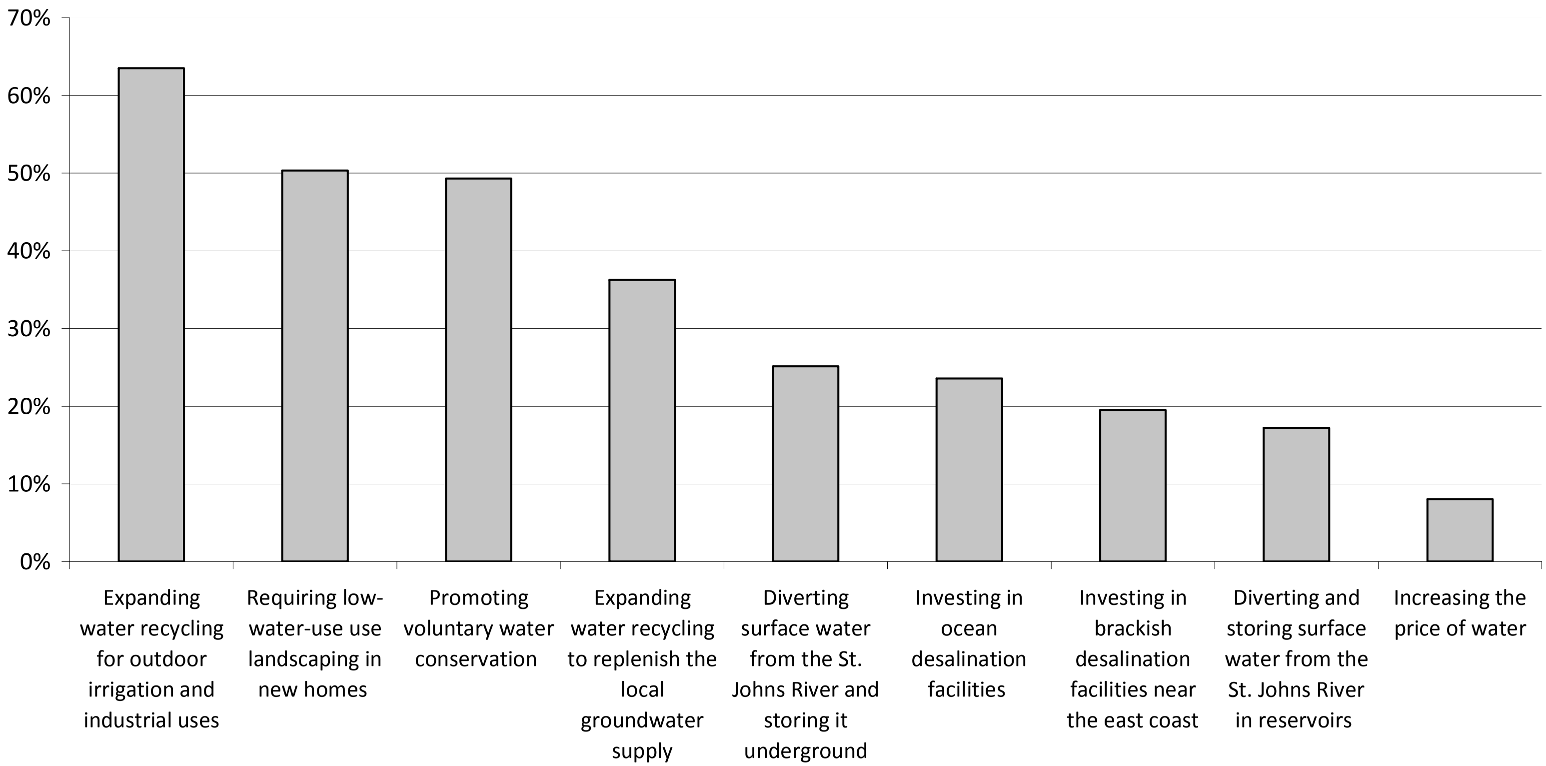


Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages.

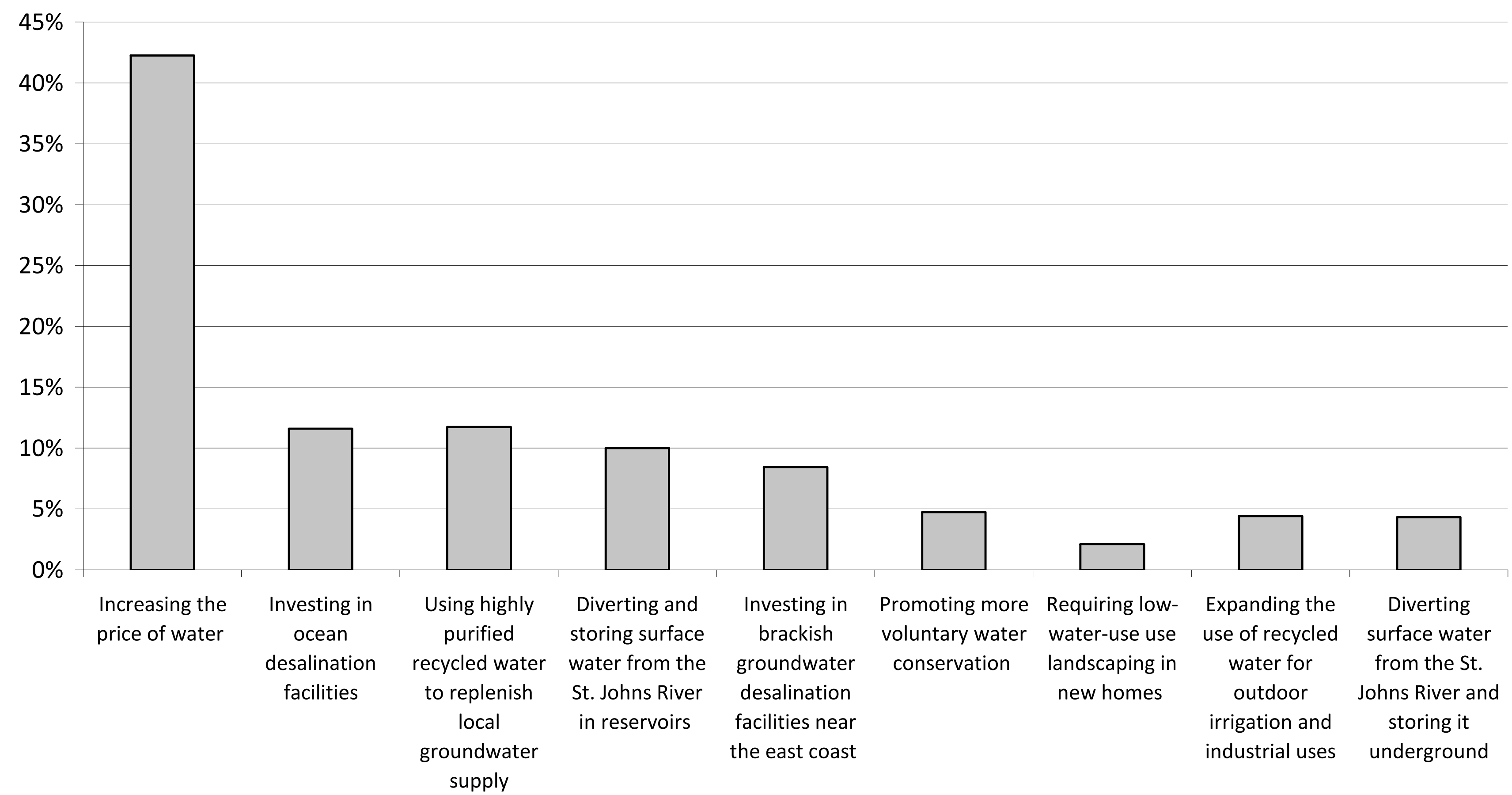


Figure 4. Percentage of respondent who selected a given option as their *least* preferred option for dealing with future water shortages.

Table 12. Q17: Of the two underground water storage options below, which do you prefer?

Refused	0.6%
Increasing underground storage of recycled water every year	60.3%
Increasing underground storage of local or imported surface water in wet years	39.1%

Table 13. Q18: Of the two groundwater options below, which do you prefer?

Refused	0.4%
Increasing the use of local groundwater sources by storing recycled or river water underground	80.2%
Increasing use of non-local groundwater sources and pumping the water to Orlando	19.5%

Table 14. Q19: Of the two water import options below, which do you prefer?

Refused	0.4%
Importing water from the St. John's River and storing it in surface water reservoirs	53.6%
Importing and treating brackish groundwater from Florida's east coast	46.0%

2.

Table 15. Q20: Of the two water conservation options below, which do you prefer?

Refused	0.4%
Requiring low-water-use landscaping in new homes	55.2%
Promoting additional voluntary water conservation through education and incentives	44.0%

3.

Table 16. Q21: Of the two water recycling options below, which do you prefer?[a]

Refused	0.4%
Expanding water recycling for outdoor irrigation and industrial uses	55.5%
Expanding water recycling to replenish local groundwater supplies	44.2%

a. Note that respondents were informed that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Finally, to explore how OUC customers feel about specific options, respondents were asked about their perceptions regarding the quality of water supplied to them from various water sources for different uses**.** As shown in Table 17, customers rated the quality of water supplied from most sources as “Moderately good.” Respondents seem to be a little more skeptical of desal of seawater or brackish water. About 32.3% of respondents rated the quality of desalinated seawater for drinking water as “slightly good” or “not good at all.” Approximately 37.1% of respondents rated the quality of desalinated brackish groundwater as “slightly good” or “not good at all.” Respondents seem to be the most comfortable with the quality of fresh groundwater use, with 15.8% rating the quality of this source as “extremely good.”

Table 17. OUC customer preferences for various local options and uses

Water source	Water use	Not good at all (%)	Slightly good (%)	Moderately good (%)	Very good (%)	Extremely good (%)	Refused (%)
Increasing fresh groundwater use	Drinking water	6.0	12.0	34.7	31.5	15.8	
Diverting water from the St. Johns River to storage reservoirs	Drinking water	3.7	18.7	49.8	24.1	3.7	
Storing river water underground when plentiful and withdrawing the water when needed	Drinking water	4.8	14.1	42.7	31.3	7.1	
Adding desalinated seawater from the Atlantic Ocean	Drinking water	10.3	22.0	39.4	22.4	5.7	0.3
Adding desalinated brackish groundwater from wells near the east coast	Drinking water	14.2	22.9	38.8	21.0	2.8	0.4
Storing recycled water underground when plentiful and withdrawing the water when needed	Drinking water	11.6	17.3	37.6	26.3	6.9	0.4
Increasing the use of recycled water	Irrigation and industrial uses	7.9	14.8	39.7	27.5	10.1	

F.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent’s choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time a respondent has lived in Orlando, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 18 displays the results from the conditional logit model. The model uses 3,813 observations, an expansion of the 448 observations by nine choices (three choice questions and three choices per question), less 219 observations due to questions that were left unanswered by respondents.

Table 18. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,813; log likelihood = -1,086.27)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence	interval]
Cost per year	-0.009	0.002	-3.440	0.001	-0.013	-0.004
Reduction in level 1 restrictions	0.078	0.060	1.290	0.198	-0.041	0.196
Reduction in level 2 restrictions	0.173	0.085	2.040	0.042	0.006	0.340
Chose alternative × education	-0.083	0.114	-0.730	0.465	-0.306	0.140
Chose alternative × age	0.054	0.103	0.530	0.597	-0.147	0.256
Chose alternative × income	0.205	0.081	2.540	0.011	0.046	0.363
Chose alternative × increasing water supplies important	0.236	0.204	1.150	0.248	-0.165	0.636
Chose alternative × time living in Orlando	-0.285	0.086	-3.330	0.001	-0.453	-0.117
Chose alternative × own yard	0.200	0.286	0.700	0.485	-0.361	0.761
Chose alternative × pay water bill	-0.471	0.328	-1.440	0.150	-1.113	0.171

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). The amount of time an individual has lived in Orlando is also found to have a negative impact on the likelihood of choosing a given option. Household income seems to have a positive impact on the likelihood of choosing an alternative option (i.e., as household income increases, the likelihood of choosing an alternative increases). The number of fewer Level 2 restriction years relative to the status quo also has a positive impact on the likelihood of choosing an alternative (i.e., people are willing to pay more to avoid a greater number of Level 2 restrictions). The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines). The more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

F.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 19 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimate for reducing Level 1 restrictions is not statistically significant than zero. This result implies that OUC customers are not willing to pay to reduce Level 1 restrictions. The mean WTP for reducing Level 2 restrictions by 1 summer out of the next 20 years is positive and statistically significant from zero. This implies a positive WTP by respondents for increasing water reliability to avoid Level 2 restrictions.

Table 19. WTP estimates (*n* = 3,813)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence interval]	
WTP to reduce Level 1 restrictions by 1 summer out of the next 20	9.05	5.63	4. 1.61	0.11	-2.00	20.09
WTP to reduce Level 2 restrictions by 1 summer out of the next 20	20.20	7.87	2.57	0.01	4.77	35.63
WTP to avoid all restrictions	151.09	63.39	2.38	0.02	26.85	275.34

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be (\$9.05 × 10) + (\$20.20 × 3) = \$151.09 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with nonlinear specifications. In general, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

Appendix G

Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the San Francisco Area

G.1 Introduction

Knowledge Networks (KN) administered the water supply reliability survey to 417 panelists within the San Francisco Public Utilities Commission (SFPUC) service area from April 8, 2011 through April 23, 2011. KN administered the survey to 80 people on the KnowledgeNetwork™ Internet Panel; the remaining sample was supplemented using another Internet panel (e-Rewards). To ensure that all respondents received their water from the City of San Francisco, Stratus Consulting provided KN with a list of zip codes that were completely contained within the SFPUC service area.

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the "status quo." The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections rely on 417 observations from San Francisco, California. Weights were generated by KN to adjust for sample design, non-coverage, and nonresponse biases. These weights were used in the analysis in order to generalize results to residents of specific zip codes who participated in the study.

The following sections present the results of this analysis. Section 2 presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, payment of water bill, and length of time living in San Francisco. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

G.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that would indicate a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following tables demonstrate how various respondent characteristics affected the outcome of this choice variable.

G.2.1 Education

Table 1 demonstrates no clear relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions. The table shows that individuals with a high school diploma are much more likely to choose an alternative to the status quo. However, a very small number of respondents fall into this category; thus, it is difficult to draw specific conclusions about this group.

Table 1. Education

Choice	Less than high school (*n* = 2; %)	High school (*n* = 6; %)	Some college (*n* = 77; %)	Bachelors (*n* = 332; %)
Status quo	69.0	26.9	78.1	59.7
Alternative	31.0	73.1	21.9	40.3

G.2.2 Age

Table 2 suggests that individuals under the age of 30 are much more likely to choose alternatives to the status quo in all three choice questions, compared to their older counterparts.

Table 2. Age

Choice	18–29 (*n* = 35; %)	30–44 (*n* = 139; %)	45–59 (*n* = 127; %)	60 + (*n* = 116; %)
Status quo	39.3	66.4	67.8	67.5
Alternative	60.7	33.6	32.2	32.5

G.2.3 Gender

Table 3 demonstrates that males are more likely to choose alternatives to the status quo than females.

Table 3. Gender

Choice	Male (*n* = 203; %)	Female (*n* = 214; %)
Status quo	61.7	68.0
Alternative	38.3	32.0

G.2.4 Income

Table 4 shows that individuals with household incomes of between $50,000 and $74,999 are slightly more likely to choose alternatives to the status quo in all three choice questions compared to most of their counterparts. Individuals with household incomes between $20,000 and $29,000 are much less likely to choose alternatives (however, only 14 respondents fall into this category). Overall, the decision to choose an alternative to the status quo does not seem to be heavily influenced by income.

Table 4. Income

Choice	< $20,000 (*n* = 24; %)	$20,000–$29,999 (*n* = 14; %)	$30,000–$49,999 (*n* = 35; %)	$50,000–$74,999 (*n* = 81; %)	$75,000–$99,999 (*n* = 83; %)	> $100,000 (*n* = 180; %)
Status quo	5. 63.0	81.9	63.5	58.2	64.9	65.4
Alternative	37.0	18.1	36.5	41.8	35.2	34.7

G.2.5 Ownership status of living quarters

Table 5 reveals that respondents who rent their living quarters with payment are more likely to choose an alternative to the status quo compared to those who own their living quarters. Respondents who do not pay for their living quarters are less likely to choose alternatives to the status quo compared to both cash payment renters and owners.

Table 5. Ownership status of living quarters

Choice	Owned or being bought by you or someone in your household (*n* = 227; %)	Rented for cash (*n* = 176; %)	Occupied without payment of cash rent (*n* = 14; %)
Status quo	67.3	60.3	81.0
Alternative	32.7	39.7	19.0

G.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who are self-employed, not working due to a temporary layoff from their job, or not working due to other reasons, are less likely to choose an alternative to the status quo. Respondents who are not working due to a disability are much more likely to choose an alternative compared to all other respondents.

Table 6. Work status

Choice	Working – as a paid employee (n = 247; %)	Working – self-employed (n = 48; %)	Not working – on temporary layoff from job (n = 4; %)	Not working – looking for work (n = 25; %)	Not working – retired (n = 67; %)	Not working – disabled (n = 9; %)	Not working – other (n = 17; %)
Status quo	63.6	73.4	100	60.6	62.3	33.9	81.9
Alternative	36.4	26.6	0	39.4	37.7	66.1	18.1

G.2.7 Opinion on increasing water supplies

Question 2 of the survey asked respondents how important “increasing water supplies” is as an issue in the San Francisco area. As shown in Table 7, respondents who answered “very” or “extremely” important to Question 2 are surprisingly less likely to choose alternatives to the status quo in all three choice questions.

Table 7. Opinion on increasing water supplies

Choice	Increasing water supplies low importance (n = 74; %)	Increasing water supplies high importance (n = 180; %)
Status quo	63.8	66.1
Alternative	36.2	33.9

G.2.8 Ownership status of yard

Table 8 shows that respondents who do not own a yard have a higher likelihood of choosing alternatives to the status quo across all three choice questions.

Table 8. Ownership status of yard

Choice	Do not own yard (n = 198; %)	Own yard (n = 219; %)
Status quo	59.5	69.7
Alternative	40.5	35.3

G.2.9 Payment of water bill

Table 9 shows that a lower proportion of respondents who pay their own water bill chose alternatives to the status quo, compared to those who do not pay their own bill.

Table 9. Payment of water bill

Choice	Does not pay own bill (n = 214; %)	Pays own bill (n = 200; %)
Status quo	60.4	69.5
Alternative	39.6	30.5

G.2.10 Time living in San Francisco

Table 10 shows that individuals who have been living in San Francisco for less than one year are less likely to choose alternatives to the status quo in all three choice questions. However, it is difficult to draw conclusions about the relationship between the amount of time a respondent has been living in San Francisco and the likelihood of choosing an alternative to the status quo because the sub-populations for some categories are very small (i.e., only 2 respondents have been living in San Francisco for less than 1 year, and 4 have been living in San Francisco for 1 to 2 years). The majority of respondents sampled (333 or 80%) have been living in San Francisco for more than 10 years.

Table 10. Time living in San Francisco

Choice	Less than 1 year (n = 2; %)	1–2 years (n = 4; %)	3–5 years (n = 29; %)	6–10 years (n = 49; %)	More than 10 years (n = 333; %)
Status quo	75.6	48.8	43.8	50.6	68.9
Alternative	24.4	51.2	28.0	49.4	31.1

G.3 Distribution of Choices by Version Alternative

Table 11 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 11, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 21.4% chose Version 1 over the status quo and the other version presented. There are 1,251 observations underlying Table 11 as each of the 417 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. More than half of the responses were refusals or choices for the status quo (53.1%). The remaining responses were allocated across alternatives to the status quo.

Table 11. Distribution of choices by version alternative (n = 1,251)

Version	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Summers with Level 3 restrictions	Cost per year	Cost per month	Percentage chosen
Refused						2.4
Status quo	7	10	3	12	1	50.7
1	11	8	1	160	13	21.4
2	12	6	2	95	8	38.1
3	13	5	2	210	18	16.7
4	15	5	0	300	25	9.1
5	10	8	2	60	5	36.5
6	11	6	3	130	11	10.5
7	13	7	0	240	20	18.7
8	15	4	1	290	24	8.6
9	12	5	3	90	8	28.8
10	12	8	0	110	9	39.6
11	9	8	3	65	5	19.8
12	14	6	0	150	13	36.5
13	13	6	1	220	18	12.4
14	11	7	2	150	13	21.4
15	8	9	3	20	2	25.0
16	10	7	3	55	5	29.0
17	14	4	2	130	11	20.5
18	14	5	1	140	12	21.4
19	13	4	3	200	17	14.9
20	12	7	1	100	8	34.7
21	11	9	0	170	14	21.3
22	16	4	0	180	15	26.8
23	9	9	2	80	7	26.4
24	10	9	1	65	5	32.8

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[25] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.4573. This is compared to a correlation of 0.0109 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

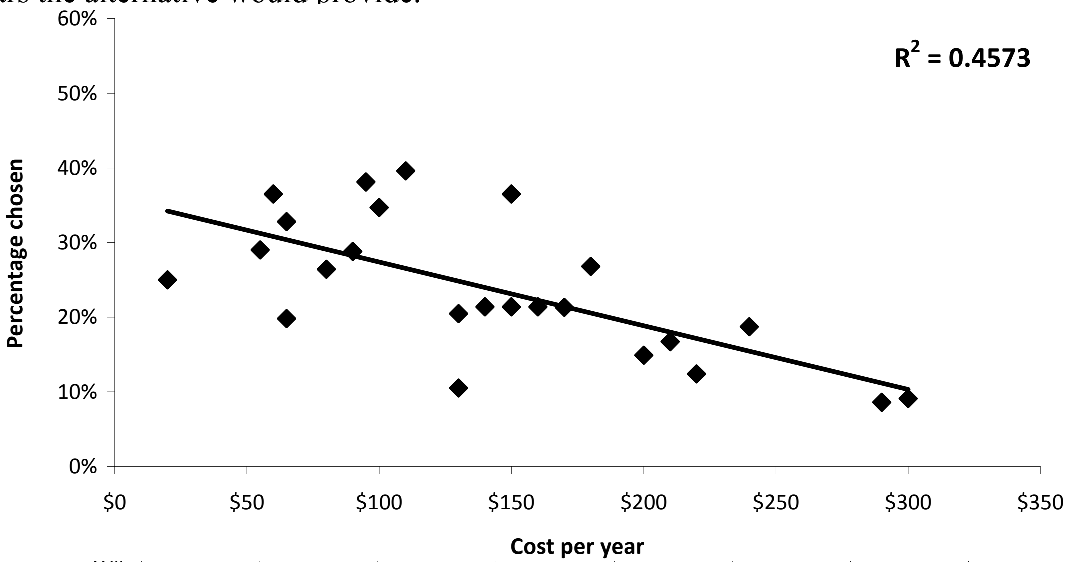


Figure 1. Distribution of choices by program cost.

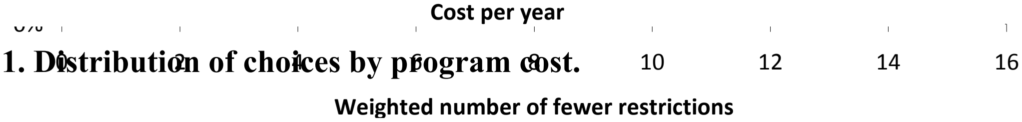


Figure 2. Distribution of choices by number of (weighted) fewer restriction years.

G.2.4 Supply Option Preferences

Question 16 asked respondents to rank different options that water suppliers could undertake to improve future water supply reliability. There were 9 choices presented on the survey, including:

31. Finding new surface water supplies outside the Bay Area region (i.e., importing water from other parts of the state)
32. Increasing available supplies of water by transferring more water from agricultural uses in the state to urban areas such as the Bay Area

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20. [25]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

33. Investing in regional desalination facilities, to convert ocean, bay, or brackish waters into part of the local drinking water supply in some regions.
34. Increasing the price of water to residential, commercial, and industrial users so they will use less
35. Requiring low-water-use landscaping (e.g., Xeriscape) in new homes and redevelopment projects
36. Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored from wet years
37. Expanding the use of recycled water for outdoor irrigation and industrial uses
38. Using highly purified recycled water to replenish groundwater supplies in parts of the state, thereby enabling greater use of local well water in those areas
39. Promoting voluntary water conservation through education and incentives (e.g., rebates for homes that switch to low water using appliances or landscaping).

Respondents were asked to rank their top five most-preferred options. Figure 3 shows the percentage of respondents who selected a given option as one of their top three most-preferred choices. Three responses stand out as the preferred choices: expanding the use of recycled water for outdoor irrigation and industrial purposes, promoting more voluntary conservation through incentives and education; and requiring low-water-use landscaping in new and remodeled homes (e.g., Xeriscapes). Increasing available supplies of water by expanding or adding new storage reservoirs so more water can be stored in wet years was also a relatively popular option.

Question 16A of the survey asked respondents to choose their least preferred option of the remaining unranked choices. Figure 4 reveals close to 25% of respondents chose "finding new surface water supplies from outside the Bay Area region" as their least preferred option. About 23% of respondents chose "increasing the price of water to residential, commercial, and industrial users so that they will use less" as the option they prefer the least.

In addition to the supply option preferences reflected above, we also asked specific questions about preferences for different versions of similar program options. For example, we asked respondents to indicate which of two water storage options they preferred, and which of two water reuse options they preferred. Responses are summarized in Tables 12–15.

Finally, to further explore how SFPUC customers feel about specific options, respondents were asked whether they agreed with a series of statements related to potential water management strategies. As shown in Table 16, support for the expanded use of recycled water within the city seems to be fairly high (with 84.4% of respondents agreeing or strongly agreeing that SFPUC should consider expanding the amount of recycled water used in the city). The majority of respondents (74.3%) also agree or strongly agree that SFPUC should actively expand the amount of water conservation in the city. Both of these observations are consistent with findings from

Question 16 of the survey (see Figures 3–4). A number of respondents (57.9%) feel that SFPUC should raise rates for households or businesses that use more than their fair share of water. Fewer respondents (45.5%) agree or strongly agree that SFPUC should consider desal as an alternative source of water supply.

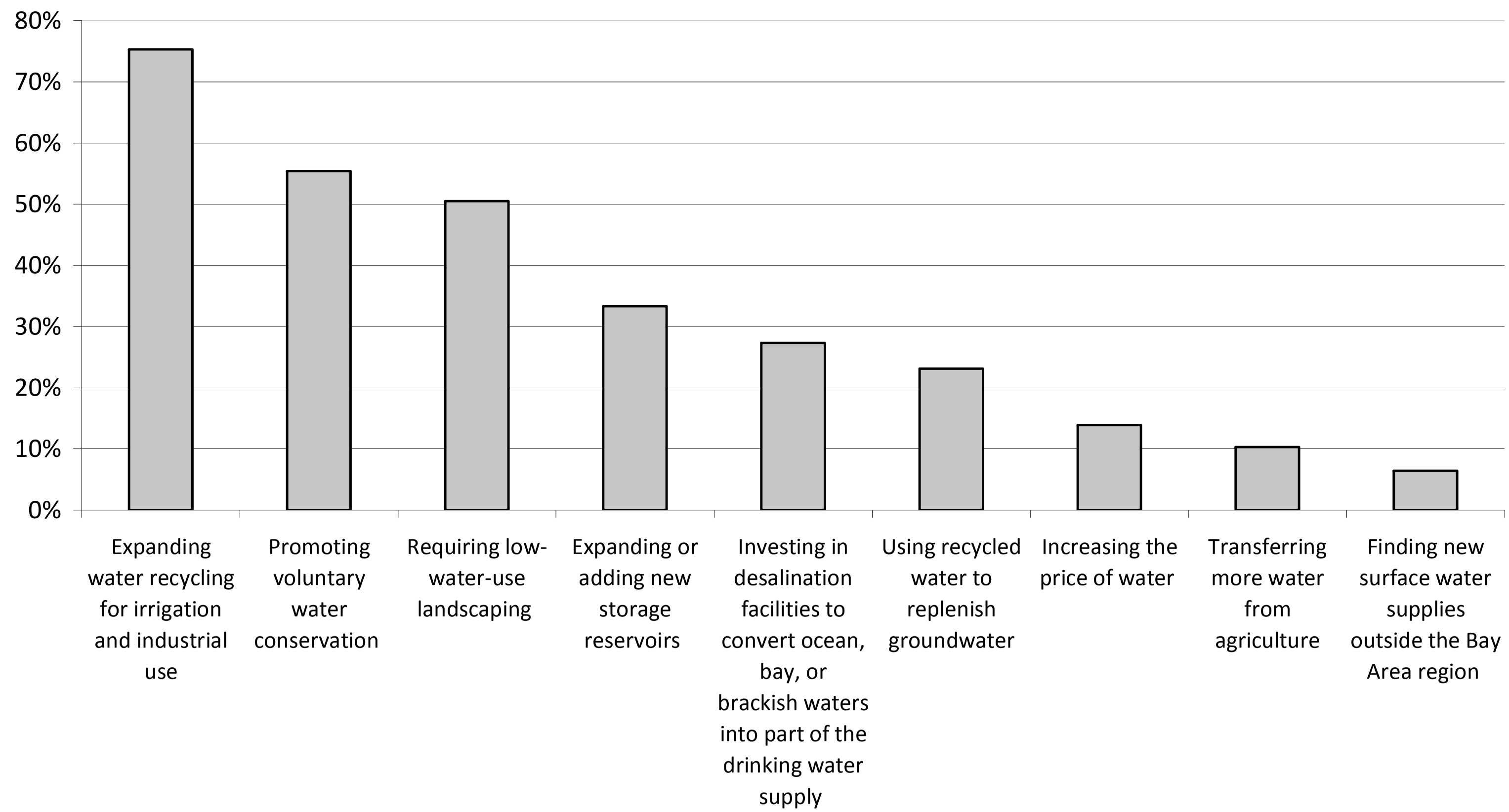

Figure 3. Percentage of respondents who selected a given option as one of their top three choices for dealing with future water shortages.

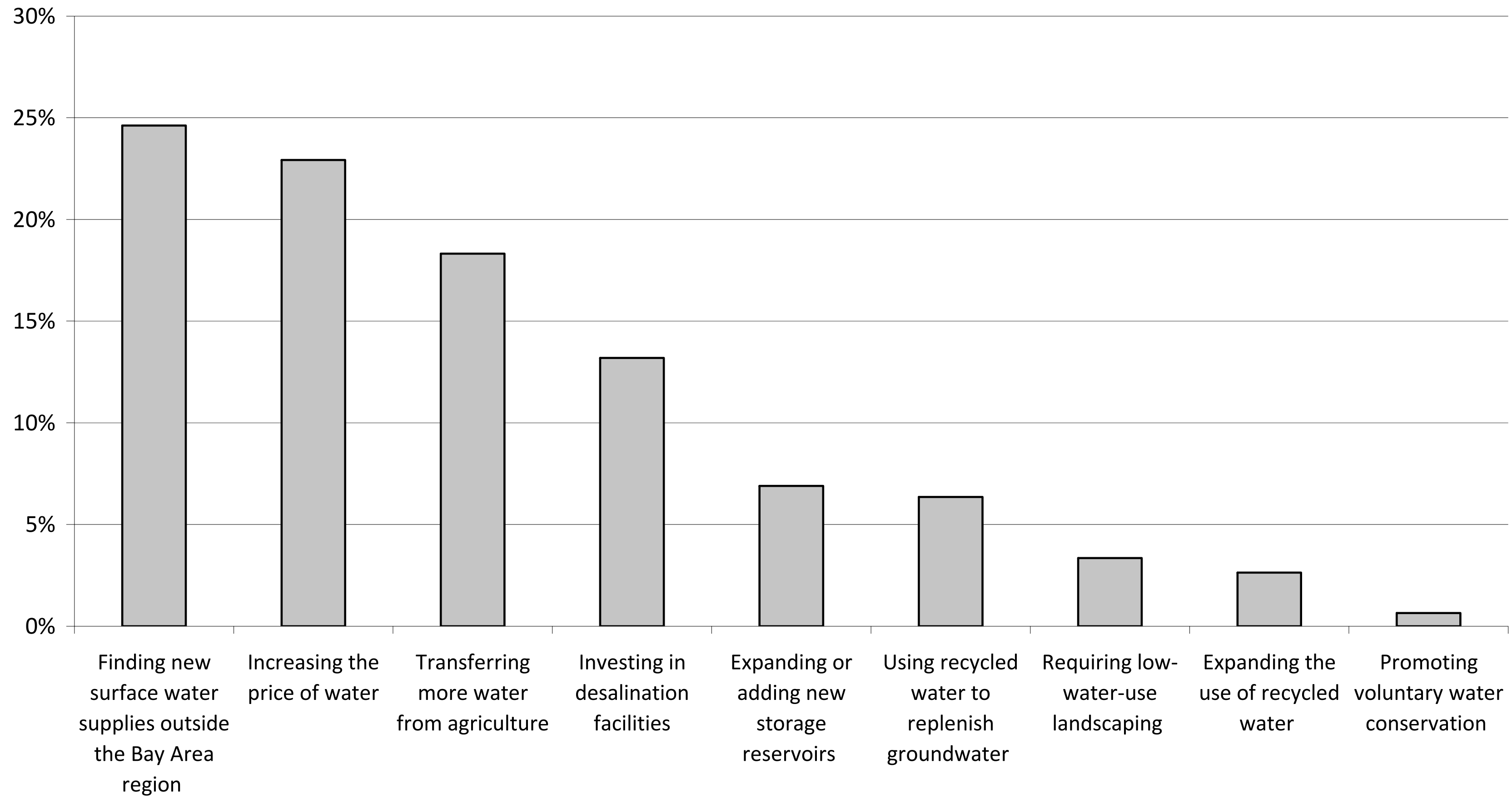

Figure 4. Percentage of respondent who selected a given option as their *least* preferred option for dealing with future water shortages.

Table 12. Q17: Of the two water storage options below, which do you prefer?

Refused	1.2%
Increasing water storage capacity by expanding or building new reservoirs in the Bay Area	71.8%
Increasing water storage capacity by expanding existing reservoirs or building new reservoirs in other areas of the state (and importing the water to the Bay Area)	27.0%

Table 13. Q18: Of the two water transfer and import options below, which do you prefer?

Refused	1.2%
Increasing water imports from outside of the Bay Area region	54.0%
Increasing water transfers from agriculture	44.8%

Table 14. Q19: Of the two water conservation options below, which do you prefer?

Refused	0.9%
Requiring low-water-use landscaping in new homes and existing homes that remodel more than 1,000 square feet	61.8%
Promoting voluntary water conservation through education and incentives	37.3%

Table 15. Q20: Of the two water recycling options below, which do you prefer?[a]

Refused	0.9%
Expanding water recycling for outdoor irrigation and industrial uses	57.0%
Expanding water recycling to replenish local groundwater supplies in parts of the state	42.0%

a. Note that because new piping is necessary for outdoor irrigation and industrial uses, expanding water recycling for outdoor irrigation and industrial uses costs three times as much as expanding water recycling to replenish reservoir supplies.

Table 16. Agreement with proposed water management strategies

	Refused (%)	Strongly disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly agree (%)
SFPUC should actively expand the amount of water conservation in the City	0.9	1.6	2.5	20.7	43.7	30.6
SFPUC should consider expanding the amount of recycled water used in the City	0.9	1.2	0.9	12.6	44.5	39.9
SFPUC should seriously consider desalination to provide more water to the City	1.0	4.2	11.6	37.7	28.1	17.4
SFPUC should raise rates for households and businesses that use more than their fair share of water	0.9	7.3	7.0	26.8	32.1	25.8

G.2.5 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in San Francisco, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 17 displays the results from the conditional logit model. The model uses 3,561 observations, an expansion of the 417 observations by nine choices (three choice questions and three choices per question), less 192 observations due to questions that were left unanswered by respondents.

Table 17. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,753; log likelihood = -1,141.382)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence	interval]
Cost per year	-0.011	0.001	-7.59	0.000	-0.013	-0.008
Reduction in level 1 restrictions	0.129	0.042	3.10	0.002	0.047	0.211
Reduction in level 2 restrictions	0.391	0.067	5.86	0.000	0.260	0.522
Chose alternative × education	0.320	0.114	2.81	0.005	0.096	0.543
Chose alternative × age	0.0340	0.079	0.43	0.668	-0.121	0.189
Chose alternative × income	-0.020	0.052	-0.38	0.703	-0.121	0.081
Chose alternative × increasing water supplies important	0.066	0.143	0.46	0.642	-0.214	0.347
Chose alternative × time living in San Francisco	-0.303	0.099	-3.07	0.002	-0.497	-0.110
Chose alternative × own yard	-0.341	0.181	-1.89	0.059	-0.695	0.013
Chose alternative × pay water bill	-0.118	0.177	-0.67	0.505	-0.465	0.229

As expected, cost has a negative impact on the likelihood of choosing a given option (i.e., as cost increases, the likelihood of choosing an alternative decreases). The amount of time an individual has lived in San Francisco is also found to have a negative impact on the likelihood of choosing a given option. The level of education an individual seems to have a positive impact on the likelihood of choosing an alternative option (i.e., as level of education increases, the likelihood of choosing an alternative increases). Finally, respondents that have their own yard are less likely to choose an alternative option. The other variables are not statistically significant from zero in the model estimated.

Note that the empirical conclusion above assumes a constant (i.e., linear) WTP for reductions in restriction years. Additional statistical analyses have been conducted to explore potential non-linear effects of changes in restriction years on WTP (i.e., to explore whether the anticipated reduction in marginal WTP is observed as the number of avoided restrictions declines).

Our more complex empirical analyses were aimed to better examine how the WTP estimates may be influenced by the total number of years of restrictions avoided (rather than assuming each year is valued equally, regardless of how many years in total have use restrictions eliminated). The results of our empirical evaluation (shown below) revealed no statistically significant difference between the linear results reported above and the non-linear variations we estimated.

G.2.6 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 18 presents the estimated mean WTP for a one-summer reduction in each restriction separately. As shown, the WTP estimates for reducing Level 1 and 2 restrictions are statistically significant than zero. These results imply a positive WTP by respondents for increasing water reliability to avoid both levels of restrictions.

Table 18. WTP estimates (*n* = 3,753)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence interval]	
WTP to reduce Level 1 restrictions by 1 summer out of the next 20	12.25	3.28	3.74	0.00	5.83	18.67
WTP to reduce Level 2 restrictions by 1 summer out of the next 20	37.16	4.63	8.03	0.00	28.09	46.22
WTP to avoid all restrictions	233.98	34.53	6.78	0.00	166.29	301.65

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be (\$12.25 × 10) + (\$37.16 × 3) = \$233.98 per year. This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption, we estimated several models with nonlinear specifications. Using the best-fit nonlinear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = \$202.16. This estimate is not statistically different from the estimate using the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in summers with restrictions relative to the non-linear models, and overestimates WTP for larger changes in summers with restrictions. However, in the range of reductions presented in the survey scenarios, the linear model provides a reliable average approximation of WTP for these scenarios.

Appendix H

Data Analysis of a Willingness to Pay Stated Choice Survey of Water Supply Reliability in the Utility X Service Area

H.1 Introduction

Knowledge Networks (KN) administered the Utility X Survey to 418 panelists in the City X metro area in the first half of June, 2010. KN administered the survey to 418 people, drawn from the KnowledgeNetwork™ Internet Panel, as supplemented using another Internet panel accessed by KN. All panelists who completed the survey live in the area served by Utility X. To ensure this, we provided KN with a list of zip codes that were completely contained within the Utility X service area (including water served by wholesale utility customers to their residential accounts).

Respondents were presented with three sets of choice questions near the end of the survey in order to evaluate their preferences for a range of possible programs to reduce (to varying degrees) different levels of water use restrictions over the next 20 years. Each choice set allowed respondents to choose the program called "No Additional Actions," which we refer to in this report as the status quo. The experimental design for this study comprised 24 different programs with varying levels of use restrictions. For each choice set, KN randomly selected two of these programs. Once a program was selected in any of the choice questions for a given participant, it was not selected again in future choice questions (i.e., no replacement of programs). This allowed us to get three choice set data observations for each respondent.

The results presented in the following sections relied on 418 observations from City X. Weights were generated by KN to adjust for sample design, non-coverage, and non-response biases. These weights were used in the analysis in order to generalize results to residents of specific City X zip codes who participated in the study.

Section 2 first presents how select respondent characteristics affected the likelihood of a respondent choosing an alternative to the status quo. This includes a summary of education, age, gender, income, ownership status of living quarters, work status, opinion on increasing water supplies, ownership status of yard, and payment of water bill. Section 3 presents the distribution of choices by version alternative. Sections 4, 5, and 6 provide more detailed empirical analysis of the data, including willingness to pay (WTP) estimates and respondent preferences for specific water supply options.

H.2 Characteristics Predicting Choice Behavior

This section presents how select respondent characteristics affected the likelihood of choosing an alternative to the status quo. Since each respondent was asked three choice questions, there are multiple ways to define a binary choice variable that indicates a respondent's choice for the status quo or an alternative. The most stringent definition – the one used for this analysis – requires a respondent to have chosen an alternative to the status quo in all three choice questions for this choice variable to take on a value of 1, and 0 otherwise. The following cross tabs demonstrate how various respondent characteristics affected the outcome of this choice variable.

H.2.1 Education

Table 1 demonstrates a positive relationship between education level and the likelihood of choosing alternatives to the status quo in all three choice questions.

Table 1. Education (*n* = 415)

Choice	Less than high school (%)	High school (%)	Some college (%)	Bachelors (%)
Status quo	100.0	70.8	66.2	57.7
Alternative	0.0	29.2	33.8	42.3

H.2.2 Age

Table 2 suggests there is no clear relationship between age and the likelihood of choosing alternatives to the status quo across choice questions.

Table 2. Age (*n* = 415)

Choice	18–29 (%)	30–44 (%)	45–59 (%)	60 + (%)
Status quo	64.9	57.4	63.6	74.1
Alternative	35.1	42.6	36.4	26.0

H.2.3 Gender

Table 3 demonstrates only a slight difference in sample proportions across gender for those choosing alternatives to the status quo, with males being more likely to choose an alternative.

Table 3. Gender (*n* = 415)

Choice	Male (%)	Female (%)
Status quo	62.5	66.8
Alternative	37.5	33.2

H.2.4 Income

Table 4 shows an increasing likelihood of choosing alternatives to the status quo in all three choice questions as income category increases.

Table 4. Income (*n* = 410)

Choice	< $20,000 (%)	$20,000–$29,999 (%)	$30,000–$49,999 (%)	$50,000–$74,999 (%)	$75,000–$99,999 (%)	> $100,000 (%)
Status quo	6. 69.5	70.0	70.7	60.0	67.7	49.6
Alternative	30.5	30.1	29.3	40.1	32.3	50.4

H.2.5 Ownership status of living quarters

Table 5 reveals a clear difference between respondents who own or rent their living quarters with payment compared to those who occupy their living quarters without payment of cash rent. Respondents who do not pay for their living quarters have a far greater likelihood of choosing alternatives to the status quo.

Table 5. Ownership status of living quarters (*n* = 415)

Choice	Owned or being bought by you or someone in your household (%)	Rented for cash (%)	Occupied without payment of cash rent (%)
Status quo	66.2	66.2	14.8
Alternative	33.8	33.8	85.2

H.2.6 Work status

Work status appears to affect a respondent's likelihood of choosing alternatives to the status quo in all three choice questions, as shown in Table 6. Respondents who work as paid employees have the greatest likelihood of choosing alternatives to the status quo, while those not working due to a temporary layoff have the lowest likelihood and chose the status quo almost universally.

Table 6. Work status (*n* = 415)

Choice	Working – as a paid employee (%)	Working – self-employed (%)	Not working – on temporary layoff from job (%)	Not working – looking for work (%)	Not working – retired (%)	Not working – disabled (%)	Not working – other (%)
Status quo	52.2	67.8	95.7	76.2	74.8	80.6	63.0
Alternative	47.8	32.2	4.3	23.8	25.2	19.4	37.0

H.2.7 Opinion on increasing water supplies

Question 2 asked respondents how important “increasing water supplies” is as an issue in the state. Table 7 shows respondents who answered “very” or “extremely important” to Question 2 had a greater likelihood of choosing alternatives to the status quo in all three choice questions than those who consider the issue less important.

Table 7. Opinion on increasing water supplies (*n* = 415)

Choice	Increasing water supplies low importance (%)	Increasing water supplies high importance (%)
Status quo	70.1	61.2
Alternative	29.9	38.8

H.2.8 Ownership status of yard

Table 8 suggests there is no clear relationship between yard ownership and the likelihood of choosing alternatives to the status quo across choice questions.

Table 8. Ownership status of yard (*n* = 415)

Choice	Do not own yard	Own yard
Status quo	64.5	65.2
Alternative	35.5	34.9

H.2.9 Payment of water bill

Table 9 shows a higher sample proportion of respondents who pay their own water bill choosing alternatives to the status quo in all three choice questions compared to those who do not pay their own bill.

Table 9. Payment of water bill (*n* = 415)

Choice	Does not pay own bill (%)	Pays own bill (%)
Status quo	69.2	62.1
Alternative	30.8	38.0

H.3 Distribution of Choices by Version Alternative

Table 10 and Figures 1 and 2 summarize the distribution of choices across the status quo, alternatives, and refusals. In Table 1, the column titled “Percentage chosen” displays the percentage of respondents who chose each version out of the respondents who were presented that version. For example, of the respondents who were presented Version 1, 24% chose Version 1 over the status quo and the other version presented. There are 1,254 observations underlying Table 10, as each of the 418 respondents were asked three choice questions. Although this analysis does not address the variation of alternative versions presented to respondents, Table 11 and Figures 1 and 2 provide feedback about respondent responses to each alternative version. About half of the responses were refusals or choices for the status quo (50.3%). The remaining responses were allocated across alternatives to the status quo, with more responses allocated to alternatives with lower costs.

Figures 1 and 2 show the distribution of choices by the cost of each alternative (Figure 1) as well as the distribution of choices by the number of fewer restriction years[26] (Figure 2). Based on these figures, program cost seems to play a larger role in the decision to choose an alternative than the number of fewer restriction years that the alternative offers. The figures illustrate that the correlation between program cost and the percentage of time an alternative was chosen (when it was presented to respondents) was 0.73. This is compared to a correlation of 0.23 between the percentage of time an alternative was chosen and the number of fewer restriction years the alternative would provide.

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21. [26]. The number of fewer Level 2 restriction years was assigned a weight of 3 to represent the significance respondents placed on reducing Level 2 restrictions compared to Level 1 restrictions, which are much less severe.

Table 10. Distribution of choices by version alternative (*n* = 1,254)

Version	Summers with no restrictions	Summers with Level 1 restrictions	Summers with Level 2 restrictions	Cost per year	Cost per month	Percentage chosen
Refused						2.0
Status quo	7	10	3	12	1	48.3
1	11	8	1	160	13	24.0
2	12	6	2	95	8	47.0
3	13	5	2	210	18	12.8
4	15	5	0	300	25	11.0
5	10	8	2	60	5	36.4
6	11	6	3	130	11	20.2
7	13	7	0	240	20	17.1
8	15	4	1	290	24	9.3
9	12	5	3	90	8	33.0
10	12	8	0	110	9	38.9
11	9	8	3	65	5	39.0
12	14	6	0	150	13	25.9
13	13	6	1	220	18	11.4
14	11	7	2	150	13	18.2
15	8	9	3	20	2	39.3
16	10	7	3	55	5	30.6
17	14	4	2	130	11	27.7
18	14	5	1	140	12	28.6
19	13	4	3	200	17	7.7
20	12	7	1	100	8	33.1
21	11	9	0	170	14	14.7
22	16	4	0	180	15	16.7
23	9	9	2	80	7	31.9
24	10	9	1	65	5	32.0

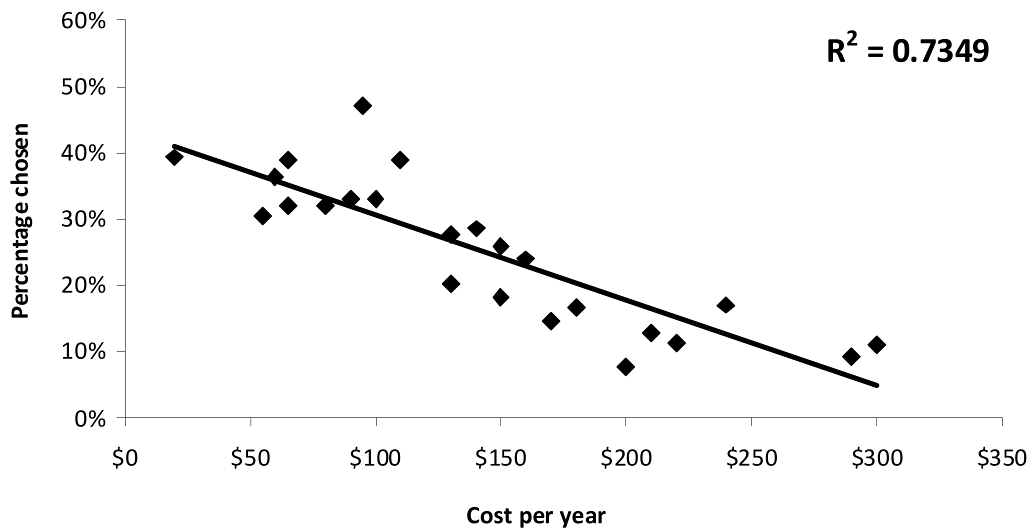

Figure 1. Distribution of choices by program cost.

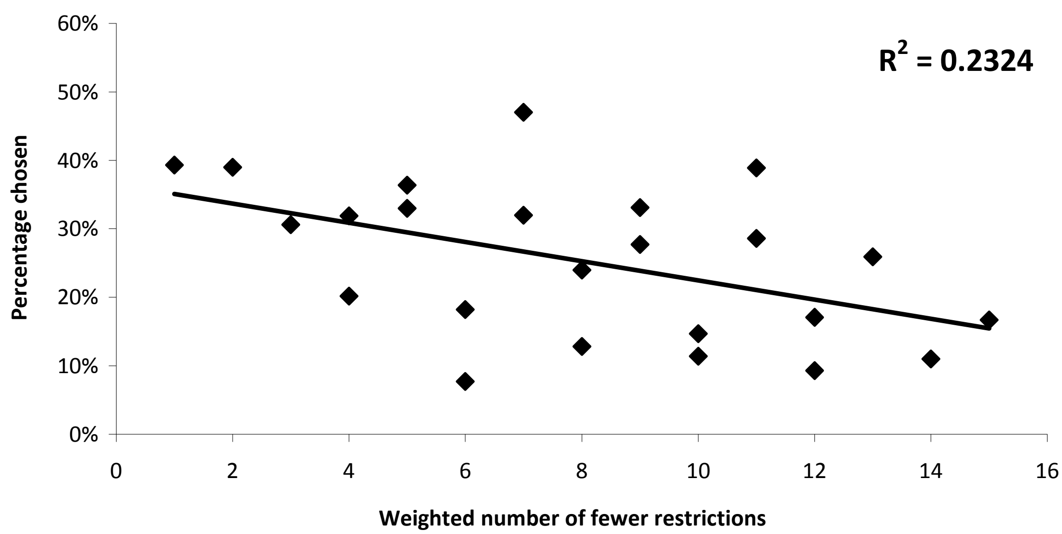

Figure 2. Distribution of choices by number of fewer restriction years.

H.4 Conditional Logit Model for Estimating WTP

Economists use a variety of models to analyze the type of data collected in the choice questions used in this survey. A well-accepted and straightforward model often applied is the conditional logit model. This model is used to estimate the probabilistic effect of a choice attribute or personal characteristic on the outcome of a given choice.

Since a respondent's choice is contingent on observed and random respondent characteristics, our model includes several variables to account for the variation in observed characteristics of a choice. We include the cost of the alternative associated with a given choice. We also define two attributes as the number of fewer restriction years relative to the status quo for each restriction level. Finally, we include personal characteristics, including education, age, income, a dummy variable indicating whether the respondent believes increasing water supplies is of high or low importance, the amount of time living in City X, a dummy variable indicating yard ownership status, and a dummy variable indicating whether a respondent pays his or her own water bill. The personal characteristics are interacted with a dummy variable indicating whether the choice decision concerns an alternative to the status quo. This provides variability to the data and allows the model to estimate the impact of personal characteristics on choosing an alternative to the status quo.

Table 11 displays the results from the conditional logit model. The model uses 3,678 observations, an expansion of the 418 observations by nine choices (three choice questions and three choices per question), less 84 choices that were left unanswered by respondents.

Table 11. Conditional logit model for selecting an option as an alternative to the status quo (*n* = 3,678; log likelihood = -1,189.99)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence interval]	
Cost per year	-0.010	0.002	-6.71	0.00	-0.014	-0.007
Reduction in Level 1 restrictions	0.072	0.045	1.61	0.11	-0.016	0.160
Reduction in Level 2 restrictions	0.216	0.073	2.95	0.00	0.072	0.359
Chose alternative education	0.118	0.085	1.40	0.16	-0.048	0.285
Chose alternative × age	-0.174	0.089	-1.95	0.05	-0.349	0.001
Chose alternative × income	0.109	0.056	1.99	0.05	-0.002	0.216
Chose alternative × increasing water supplies important	0.231	0.157	1.47	0.14	-0.077	0.540
Chose alternative × time living in City X	-0.077	0.068	-1.13	0.26	-0.210	0.056
Chose alternative × own yard	-0.184	0.232	-0.79	0.43	-0.639	0.271
Chose alternative × pay water bill	0.139	0.224	0.62	0.54	-0.300	0.577

As expected, cost has a negative impact on the likelihood of choosing a given option, while reducing Level 2 restrictions and higher education have a positive impact. Age is also found to have a negative impact on the likelihood of choosing a given option. The other variables are not statistically significant from zero in the model estimated. Additional models will be run that explore other functional forms (e.g., non-linear models) that allow for greater flexibility in the parameter estimates (e.g., random parameters logit).

H.5 WTP Measures

Using the parameter estimates from the conditional logit model in Section 5, we calculated WTP measures for reducing Level 1 and Level 2 restrictions. Table 12 presents the estimated mean WTP for a one-summer reduction in each restriction separately. Both WTP estimates are statistically significant from zero. The mean WTP for reducing Level 1 restrictions by 1 year out of the next 20 is $6.89, while the corresponding WTP measure for reducing Level 2 restrictions by 1 year out of the next 20 is $20.55. These results imply a positive WTP by respondents for increasing water reliability and thereby reducing summer restrictions with a higher WTP to avoid the more severe restriction level.

Table 12. WTP estimates (*n* = 3,678)

Choice	Coefficient	Robust standard error	z	P > |z|	[95% confidence interval]	
WTP to reduce Level 1 restrictions by one summer out of the next 20	$6.89	$3.71	1.85	0.06	-$0.40	$14.16
WTP to reduce Level 2 restrictions by one summer out of the next 20	$20.55	$5.40	3.81	0.00	$9.97	$31.13
WTP to avoid all restrictions	$130.49	$41.09	3.18	0.01	$49.96	$211.02

To interpret these results in the context of understanding the mean household WTP for specific water supply enhancement programs, one needs to add the mean values based on the number and type of restrictions the program is expected to eliminate. For example, in the survey, the next 20 years were portrayed as yielding an anticipated eight summers with Level 1 restrictions, eight summers with Level 2 restrictions, and four summers with Level 3 restrictions. Suppose an ambitious supply enhancement program was expected to eliminate imposition of all of the projected Level 1 and Level 2 use restrictions. The mean annual WTP results above suggest that the total household WTP for this program would be (6.89 × 10) + ($20.55 × 3) = $130.49 per year (does not add due to rounding). This conclusion assumes a constant WTP for reductions in restriction years.

To gauge the strength of this assumption of constant (i.e., linear) WTP across the number of water use restrictions avoided, we estimated several models with non-linear specifications. Using the best-fit non-linear model, the mean WTP for a program that eliminates the imposition of all projected Level 1 and Level 2 use restrictions = $109.51. This estimate is not statistically different from the estimate shown in the previous paragraph as derived from the linear model. More generally, we find that the linear model underestimates WTP for smaller changes in the number of summers with restrictions relative to the nonlinear models, and overestimates WTP for larger changes in the number of future summers with restrictions. However, in the range of reductions presented in the survey scenarios – 1 to 6 summer reductions for level 1 restrictions, and 0 to 3 summer reductions for level 2 restrictions – the linear model provides a reliable average approximation of WTP for these scenarios.

Advancing the Science of Water Reuse and Desalination




1199 North Fairfax Street, Suite 410
Alexandria, VA 22314 USA
(703) 548-0880
Fax (703) 548-5085
E-mail: Foundation@WateReuse.org
www.WateReuse.org/Foundation

Calculating Constant-Reliability Water Supply Unit Costs

Gary Wolff, P.E., Ph.D.[1]

Abstract

Water planners facing a choice between water "supply" options (including conservation) customarily use the average unit cost of each option as a decision criterion. This approach is misleading and potentially costly when comparing options with very different reliability characteristics. For example, surface water, desalinated seawater or recycled wastewater, and some outdoor demand management programs have very different yield patterns. This paper presents a method for calculating constant-reliability unit costs that adapts some concepts and mathematics from financial portfolio theory. Comparing on a constant-reliability basis can significantly change the relative attractiveness of options. In particular, surface water, usually a low cost option, is more expensive after its variability has been accounted for. Further, options that are uncorrelated or inversely correlated with existing supply sources – such as outdoor water conservation -- will be more attractive than they initially appear. This insight, which implies options should be evaluated and chosen as packages rather than individually, opens up a new dimension of yield and financial analysis for water planners.

Keywords

Reliability, value of reliability, portfolio theory, water supply planning, drought planning, integrated resource planning, water conservation, uncertainty, adjusted unit costs.

[1] Principal Economist and Engineer, The Pacific Institute, 654 13th Street, Oakland CA 94612, Telephone: 510 251 1600, Mobile: 510 823 3935, Facsimile: 251 2203, gary_wolff@pacinst.org

Introduction

Water planners commonly estimate an average unit cost for each water supply option (including conservation measures) by dividing average annual total yield of the option by annual average total cost (the sum of average annual fixed plus variable costs).[2] Lower unit cost options are preferred on a financial basis, although other decision criteria are also used (e.g., see Bureau of Reclamation 1983 or DWR 2005). A time sequence of new facilities is often planned based on anticipated growth of demand, with new facilities brought on line in time to prevent a supply shortfall under appropriate hydrologic (e.g., dry-year rainfall) or other (e.g., average reservoir yield) assumptions. Facilities with lower estimated average unit costs are typically built first.

This procedure is understandable and often appropriate when water supply options do not vary enormously in availability. Two source watersheds with very different rainfall patterns might have similar variation in annual water availability if there are appropriately sized reservoirs in each watershed. Similarly, the variation in availability between a surface water reservoir and a groundwater aquifer might not be that different if the reservoir is large relative to annual demand.

However, annual availability may also vary significantly between options. Consider a run-of-the-river system on an intermittent stream as compared with a deep groundwater aquifer. Furthermore, when demand grows more rapidly than supply, there is an implicit

[2] Since variable costs tend to rise over time, planners often compare "levelized average costs" over the planning horizon (e.g., 30-50 years).

decline in the adequacy or reliability of a variable water source because the frequency with which demand exceeds supply increases. In addition, new sources of supply, such as surface and groundwater from previously unutilized watersheds or aquifers, desalinated seawater, recycled wastewater, and demand management programs often have very different patterns of availability than traditional surface water supplies.

Retirement fund and water managers face a similar challenge. Each must deliver a minimum quantify of something (money or water) every year while the source of that something (e.g., securities markets or nature) varies randomly. Fortunately, random variation can be at least partially characterized with statistics. Of course past investment success is not a prediction of future performance; just as past hydrologic patterns (at least since modern records became available) are not necessarily predictive of future patterns in a world whose climate is changing. Nonetheless, retirement managers who use the statistical tools of portfolio theory are much more successful than those who ignore such considerations.[3] This paper shows water planners how to improve their performance by applying a mathematical adaptation from financial portfolio theory.

What Is Water-Supply Reliability and How Do We Measure It?

Water-supply reliability is an important characteristic of all municipal systems. For example, California's water utilities invest substantial amounts of money to reduce the risk of supply interruptions due to earthquakes. They understand that the cost to their customers of supply disruptions is often far greater than the cost of improved system

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[3] Markowitz (1952) provided the first mathematically rigorous analysis of the value of diversification in investment portfolios. There have since been thousands of peer-reviewed articles on this subject.

reliability. Similarly, dams and reservoirs are widely used to reduce the risk of supply interruption due to dry weather. Other threats to water supply reliability include climate change, changes in runoff patterns as more impermeable surfaces are created by land development, changes in water quality or environmental regulations, variation in important cost factors (e.g., interest rates, labor, or energy), legal issues related to water rights or contracts for water deliveries, and cultural and political factors.

There is no widely accepted method for measuring water-supply reliability. The simplest method is to measure the risk of projected supply falling below projected demand, on average. For example, a system with a reliability level of 95% implies that supply will meet or exceed demand 19 years out of 20. This approach has the advantage of being simple. However, like most simple approaches, it has drawbacks. The most notable one is that it does not measure the severity of the water shortfalls. One can imagine a system with reliability of 90% that is more desirable than another system with reliability of 95% because the shortfalls in water supply in the first system are very small while the less frequent shortfalls in the second system are very large.

Nonetheless, for the discussion below we use this definition because it allows a clear discussion of an important issue. The reliability percentages presented in the numeric illustration are intended as a summary statistic for all of the uncertain issues mentioned above, although in practice many of these factors are very difficult to quantify accurately.

How Do We Measure or Account for the Value of Reliability?

Economists typically address this question by assessing customer willingness to pay for a slightly reduced chance of water shortages. For example, suppose the chance of a water shortage that would require rationing is 1 in 20 in any given year, but an investment in a new reservoir can reduce that chance to 1 in 21. If additional water isn't needed (except in severe drought), then customer willingness to pay for the reservoir is a measure of the value customers place on increased reliability. Numerous economic studies have found high willingness to pay to avoid drought-related or other restrictions on water use; ranging from \$32 to \$421 dollars per household per year (Griffin and Mjelde 2000, Carson and Mitchell 1987, Howe, et.al. 1994, Barakat and Chamberlin 1994), in year 2003 dollars. When the estimated quantity of water use foregone due to a drought restriction is multiplied by the probability (frequency) of the drought scenario investigated, these annual household WTP estimates imply a reliability value to residential customers as high as about \$4,000 per acre-foot (Raucher et al., 2005).

This approach, unfortunately, doesn't help answer our question. Customers don't need to know <u>how</u> reliability will increase in order to value it. Customers aren't saying anything about the relative value of different options for increasing reliability. They're just saying that more reliability – regardless of how it is achieved – has a value. Consequently, we developed a method for adjusting estimated average unit costs of water supply options, including conservation and end-use efficiency, to obtain "constant-reliability unit costs" that fairly compare supply options with different uncertainty characteristics. Our approach is quite different than that presented in papers that quantify the value of reliability (e.g., Howe, et.al. 1994). We do not quantify the value of reliability, but instead estimate the costs of options when they are sized to provide equal reliability.

Our method involves a two-step process. In the first step, water managers define the level of reliability benefit they want to maintain or achieve. For example, they might want to ensure that enough water is available to meet demand in 19 out of 20 years, on average. We call this a reliability level (R) of 95%. In the second step, they create an “apples to apples” comparison of options by adjusting average unit costs ($/unit of water) to get constant-reliability unit costs. The following example illustrates the method. The relevant math is presented in Appendix A.

Constant-Reliability Unit Costs Illustrated

Suppose a community is served by a run-of-the-river water supply. Figure 1 shows the maximum supply available from the river for human extractive purposes[4] each year as having a normal distribution. Although flow data usually follows distributions other than normal,[5] the normal distribution is useful for an illustration. The method presented in this paper can be applied to any statistical distribution.[6]

Insert Figure 1 here

[4] That is, in-stream flows required by law have been subtracted from gross flow before drawing this graph.
[5] The Pearson Type III distribution, for example, is often used for extreme events like floods and droughts.
[6] A reviewer of this paper remarked that a water system he once worked with had a hydrologic probability of annual shortage of only 1 in 3,000. However, it once experienced an ice clog in the main water treatment supply pipeline, and when operators went to activate a bypass valve to bring water from a backup source, the valve broke. At the worst point in time, only hours of treated water remained. Ideally, the probability of supply failure from events like this will be included in the statistical distributions representing supply from each option. But some uncertainty cannot be quantified.

In the normal distribution, the average supply is the most common amount. Low and high supplies are increasingly rare as they get further from the average. The relative "flatness" of the bell is described by the coefficient of variance (V): the standard deviation (SD) divided by the mean (A). The larger the coefficient of variance, the flatter the bell; and the more variable is the annual supply available for human extractive purposes in percentage terms.

The average (S_A) and critical (S_C) year supplies are represented by tick marks on Figure 1. We define critical year supply as the supply that is just large enough to satisfy critical year demand (D_C). Critical year demand is usually higher than average year demand because outdoor water use will increase when rainfall is below average or temperature is above average. Because maximum water available for supply will decrease when weather is drier, critical demand will always equal maximum water available for supply at some quantity. That quantity is the critical supply = critical demand shown in the Figure.

The figure shows critical supply at "Z (R)" standard deviations below average supply. This number is related to the reliability of existing supply, and will vary from system to system. A property of the normal distribution is that in about 5% of the years, flow will be less than the lower tick mark when it is located 1.65 standard deviations below the mean. That is, if Z(R) has value of 1.65, the figure shows a system reliability of 95% (shortage about 1 year in 20).

If the system had another reliability level, say 84%, the critical supply would be 1.00 standard deviation below average supply. The appropriate multiplier (e.g., 1.65, 1.00, etc.) for a chosen reliability level is found from a table (or formula) that is present in most statistics textook:[7] the area under one tail of the standard normal distribution (expressed as a number between 0 and 1) as a function of the standard normal variable. The relevant area under one tail is equal to one minus the reliability level (e.g., 1.00 - 0.95 = 0.05). The multiplier is equal to the value of the standard normal variable that is paired with this area (e.g., a tail area of 0.05 implies 1.65; a tail area of 0.16 implies 1.00).

Assume for our example that average annual maximum supply is 100,000 kilolitres (kL) and the standard deviation of annual maximum supply is 10,000 kL. This implies that the coefficient of variance of the supply is 10% (10,000/100,000). Under these assumptions, the lower tick mark in Figure 1 has value 84,000 kL per year. Suppose critical demand (and therefore the critical supply level) is projected[8] to grow to 90,000 kL over the next decade. As critical demand grows, reliability will decrease. The likelihood of a water shortage will increase from 1 in 20 (95% reliability) to 1 in 6 (84% reliability) as the part of the bell curve left of critical supply grows from 5% to 16%. One of the standard jobs of water managers is to prevent reliability from deteriorating too much. But how they augment supply or manage demand growth in response to their projection of demand growth affects reliability in ways that are often not fully understood or evaluated.

[7] For example, Table A-3 in Khazanie (1990).
[8] A water demand projection is based on many factors, including projected growth in population and employment in the service area, changes in water distribution or use technologies, etc.

Suppose they want to maintain reliability at 95%. This is the first step in the planning process – chose a design reliability level based on the willingness of customers to pay for reliability. Second, the planner will consider various options for new supply and conservation measures sufficient to satisfy customer needs. The amount of physical water or conservation required to do this in a critical year is the difference between projected critical demand (PD_C) and existing critical demand (D_C). This has been labeled S_N in Figure 1, and in our example is 6,000 kL. If a supply option were to provide exactly this amount in every year, the planner should procure S_N of new supply. Water from advanced treatment processes (e.g., desalinated seawater or recycled wastewater) has this characteristic if treatment facilities are designed with enough redundancy to prevent downtime other than for regularly scheduled maintenance.[9]

But if the yield from a water supply or conservation option is variable from year to year, the planner must procure enough of it to have S_N available 19 out of 20 years or reliability will fall. For example, when the chosen option is a surface water source, the amount available in an average year must be greater than S_N in order to ensure S_N is available in the critical, drier-than-average year.

The amount of water supply greater than S_N that has to be purchased depends on two factors. First, higher standard deviations of annual yield from the new surface water source imply that more water needs to be procured to ensure adequate water in a critical

[9] Some indoor water conservation measures may also have this characteristic of supplying exactly D_N every year if they are designed carefully. While the issue of "savings decay" in water conservation has been hotly debated, the author believes savings decay can be eliminated or made quite small by carefully specifying water-use efficiency devices.

year. Second, lower correlations of annual yield between the new source and the existing source imply that less of the new source will be required, on average, to ensure S_N is available when water from the existing source is at or below the lower tick mark in Figure 1. That is, if the new source is wet when the existing source is dry, one can procure less than S_N on average and still get S_N when the existing source is at its critical, drier-than-average level.

What this means is that comparing unit costs for options based on the average amount of water each option will deliver leaves out an important piece of the economic picture. Suppose for illustration purposes that advanced treatment of a low-quality water,[10] a new surface water supply, and outdoor conservation, all have an average unit cost of US$1.00 per kL. Ignoring reliability impacts, there is no financial difference between these sources. But a constant-reliability comparison of unit costs (Figure 2), as described below and mathematically in Appendix A, will show substantial financial differences.

Insert Figure 2 here

For the purpose of this illustration, we've assumed that advanced treatment is neither variable from year to year nor correlated with the existing water source. Consequently, a facility designed to deliver 6,000 kL per year[11] will satisfy the growth in demand in all years: average, critical, or otherwise. The average cost per unit is the same as the cost per unit in the critical and all other years.

[10] This could be seawater desalination, brackish water desalination, wastewater reclamation, or other processes. The average unit cost provided is generic and does not represent any particular technology.
[11] After allowing for normal interruptions in operation such as downtime for maintenance.

However, we've assumed that the new surface water supply is perfectly correlated with the existing surface water supply (has a similar pattern of wet and dry years), but is more variable. Then ensuring the 6,000 kL of new supply that will be needed in a critical year requires that the new source be sized to deliver more than 6,000 kL of water each average year, just as the old source was capable of providing 100,000 kL on average but only 84,000 kL with the desired level of reliability. If the new surface water source has a coefficient of variance of 20%, the water planner will need to procure 8,955 kL in an average year to ensure 6,000 in the 95% reliability design year (8,955 – 1.65 x 0.2 x 8,955 = 6,000). This in turn implies that each unit of water during drought will cost US$1.49 per kL on a constant-reliability benefit basis (US$1.00/ (1 – 1.65 x 0.2)). On a reliability-adjusted basis, this option is 49% more costly than it first appeared.[12]

If an outdoor water conservation measure were to save more water during dry weather, [13] its constant-reliability unit cost would be less than the assumed US$1.00 per kL. If it were perfectly counter-correlated with the current surface water source, and had a coefficient of variation of 10%, its constant-reliability unit cost would be $0.86 per acre-foot ($1.00/(1+1.65 x 0.1)). Since the current water source has been assumed to have a coefficient of variance of 10%, this 14% adjustment in unit cost is purely the result of the

[12] Stated differently, the utility could pay 49% more *per average unit* of water from the advanced treatment facility (US$1.49/US$1.00=149%) compared to each *average* unit in the new surface water alternative -- and provide the same economic benefit at the same cost to customers. Note that the premium is not in total, but per unit. The smaller advanced treatment facility is just as good as the larger surface water facility at reliably providing 6,000 kL in the critical year, so a *per unit* premium is justified.

[13] For example, laser leveling, drip or micro-spray irrigation, evapo-transpiration (ET) controllers, adjustments in sprinkler heads to improve distribution uniformity, all reduce the percent of applied water that percolates or evaporates. Since applied water goes up during dry weather, these measures will save more water during drought than during average or wet weather. Auto-rain shut-off devices, in contrast, save more water when it rains than when it is dry.

counter-correlation. Conventional sensitivity analysis of the financial impact of the variability in yield from the option would miss this adjustment entirely.

Stated in terms of yield, ensuring 6,000 kL of water in the critical year would require outdoor conservation measures sized to deliver only 5,150 kL in an average year. The counter-correlation implies that during a drought where maximum supply from the current surface water source is 1.65 standard deviations below its mean, outdoor conservation would save 1.65 standard deviations above its mean, which equals 6,000 kL when the mean is 5,150 kL and the standard deviation is 515 kL (10% of the mean).

Conclusion

Accounting for variance and correlation between water supply sources – as is done for securities when managing a portfolio of financial assets – is clearly important. Water supply planners who do not consider these factors might think options are similar in cost when they are in fact quite different once reliability benefits of the options are equalized. Worse yet, an apparently inexpensive source might turn out to be very expensive on a constant-reliability basis, or an apparently expensive source might turn out to have the lowest unit cost once reliability is considered.

The method presented in this paper is a powerful starting point for quantitative evaluation of the cost implications of uncertainty in water supply and demand management options. For the first time in the published water literature, it quantitatively evaluates these impacts on a portfolio rather than individual option basis. An option that is attractive when combined with an existing water supply in one setting might be unattractive if combined with a different existing water supply in a different setting. The correlation between the yields of options is a new dimension of overall yield and financial analysis for water planners. For water supply portfolios with numerous sources, as is the case in some regional systems, quantifying the impacts of these correlations may lead to surprising outcomes and changes in water supply plans.

Application of the method may be hindered, however, by data limitations or patterns that are difficult to describe via normal or other statistical distributions. As many a financial planner has found, the mathematics of portfolio theory do not guarantee superior investment results. One must struggle with the data and other decision criteria every time an investment decision is made. Nonetheless, better or additional tools have value.

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Appendix A: Constant-Reliability Unit Cost Adjustment

Finding constant-reliability unit costs involves a two-step process. First, a constant-reliability-benefit standard must be specified. When supply is modeled as normally distributed, the standard normal variable (Z) will be a function of the reliability design standard (R) the planner chooses (e.g., 95%). Mathematically, this means that the annual average of the supply portfolio (P) minus the standard normal variable times the standard deviation of the supply portfolio must be equal to projected future critical demand:

(1) $A(P) - Z(R)SD(P) = PD_C$

The average supply of a portfolio is the sum of the average supplies of its components. If the portfolio has only two components[14] – existing supply (E) and a new supply or demand management program (N), the average supply of the portfolio is:

(2) $A(P) = A(E) + A(N)$

$$Where \quad A(x) = \frac{1}{n}\sum_{i=1}^{n} Q_{xi}$$

$x = A \; or \; N$

$n = the\;number\;of\;\;years\;of\;\;annual\;yield\;data\;for\;each\;option$

$Q_{xi} = the\;annual\;yield\;in\;year\;i\;\;from\;option\;x$

[14] The mathematics for three or more components is a straightforward extension of the equations shown here. However, there will not be a unique answer when three or more components are involved. Instead, one would find numerous pairs of components two and three that would combine with existing supply to satisfy projected demand and the reliability design standard. Choosing between these pairs would require a straightforward but journal-space-consuming third planning step – cost minimization – to select from among the many possible portfolios that satisfy demand with suitable reliability.

The standard deviation of a portfolio depends on the standard deviation and average of each component, the correlation between the components, and the percentage of water from each component. The standard deviation of a portfolio is the square root of the variance of the portfolio. The appropriate formula (modified by the author from Tucker et. al. 1994) when two components are involved is:

$$\text{(3)} \quad V(P) = \sqrt{W(E)^2 V(E)^2 + W(N)^2 V(N)^2 + 2W(E)W(N)Rho(E,N)V(E)V(N)}$$

$$\begin{aligned}
&\textit{Where} \quad W(E) + W(N) = 1 \\
&\qquad W(x) \equiv \frac{A(x)}{A(P)} \\
&\qquad V(x) \equiv \frac{SD(x)}{A(x)} \\
&\qquad Rho(E,N)\,\textit{is the correlation coefficient between E and N}
\end{aligned}$$

Formulas for the standard deviation (SD) and correlation coefficient (Rho) are provided in any statistics textbook. One can calculate these summary statistics for each water supply option using any spreadsheet program. Combining (1), (2) and (3) yields:

$$\text{(4)} \quad \sqrt{\left(\frac{A(E)}{A(P)}\right)^2 V(E)^2 + \left(\frac{A(N)}{A(P)}\right)^2 V(N)^2 + 2\left(\frac{A(E)}{A(P)}\right)\left(\frac{A(N)}{A(P)}\right) Rho(E,N)V(E)V(N)} = \frac{A(P) - PD_C}{Z(R)A(P)}$$

$$\textit{Where} \quad A(P) = A(E) + A(N), \textit{as above}$$

If one specifies a reliability standard (R) and projected critical year demand (PD_C), and knows the average existing supply (A(E)), the coefficients of variance of the existing and new sources of supply (V(E) and V(N)), and the correlation coefficient between supplies (Rho(E,N), equation (4) will contain only one unknown (A(N)). This is the average new supply required to ensure that the chosen reliability standard (e.g., 95%) will be achieved. A(N) can be found by assuming a value for A(N), seeing how close or far apart the left and right hand sides of the equation are, and iteratively adjusting the assumed value until the value of A(N) that solves the equation is found.

For example, in this paper, we have specified R=95% (which implies Z(R) = 1.65) and PD_C=90,000 kL, and assumed A(E)=100,000 kL, V(E)=0.10, and D_C=84,000 kL. Then the A(N) that solves (4) under various assumptions about the supply options is:

Table A-1: Sample Calculations

Option	**V(N)**	**Rho(E,N)**	**A(N)**
New Surface Water	0.2	1.0	8,955 kL
Advanced Technology	0.0	0.0	6,000 kL
Outdoor Water Conservation	0.1	-1.0	5,150 kL

Finally, the constant reliability unit price for each option is found by multiplying the average unit cost for each option by the ratio of A(N)/ S_N. When A(N) equals growth in critical demand (S_N)[15], as with desalination and similar options, the average unit cost for that water supply option is also the constant-reliability unit cost. When A(N) is greater than or less than S_N , as with the surface water and outdoor conservation examples, the constant-reliability unit cost for each option is higher or lower than the average unit cost for that option, respectively.

[15] Recall that S_N = equals PD_C-D_C. In our example, 6,000 kL = 90,000 kL – 84,000 kL.

References

Barakat and Chamberlin, 1994. The value of water supply reliability: results of a contingent valuation survey of residential customers. Prepared for California Urban Water Agencies (CUWA). CUWA: Sacramento. Accessed February 6, 2006 at: <http://www.cuwa.org/library/TheValueofWaterSupplyReliabilityAug94.pdf

Bureau of Reclamation. 1983. Economic and environmental principles and guidelines for water and related land resources implementation studies. United States Bureau of Reclamation: Denver

Carson, R.T., and R.C. Mitchell. 1987. Economic value of reliable water supplies for residential water users in the State Water Project services area. SWC Exhibit Number 54. Prepared for The Metropolitan Water District of Southern California

Conrad, J.M. 1980. "Quasi Option Value and the Expected Value of Information. Quarterly Journal of Economics. June. 813-820

DWR. 2005. Guidebook to assist water suppliers in the preparation of a 2005 urban water management plan. California Department of Water Resources (DWR): Sacramento

Griffin, R.C., and J.W. Mjelde. 2000. Valuing water supply reliability. American Journal of Agricultural Economics 82:414-426

Howe, Charles W., M.G. Smith, L.Bennett, C.M. Brendecke, J. E. Flack, R.M. Hamm, R. Mann, L. Rozeklis, K. Wunderlich. 1994. The value of water supply reliability in urban water systems. Journal of Environmental Economics and Management 26:19-30

Markowitz, H.M. 1952. Portfolio Selection. Journal of Finance 7:77-91

Raucher, R., D. Chapman, J. Henderson, M. Hagenstad, J. Rice, J. Goldstein, A. Huber-Lee, B. Hurd, R. Linsky, E. Means, and M. Renwick. 2005. The value of water: concepts, empirical evidence, and their application to water management decisions. American Water Works Association: Denver

Tucker, Alan L., K.G. Becker, M.J. Isambabi, J.P.Ogden. 1994.Contemporary Portfolio Theory and Risk Management. West Publishing Company: St. Paul

Figure 1: Yield Uncertainty For a Run-of-the-River Water Supply

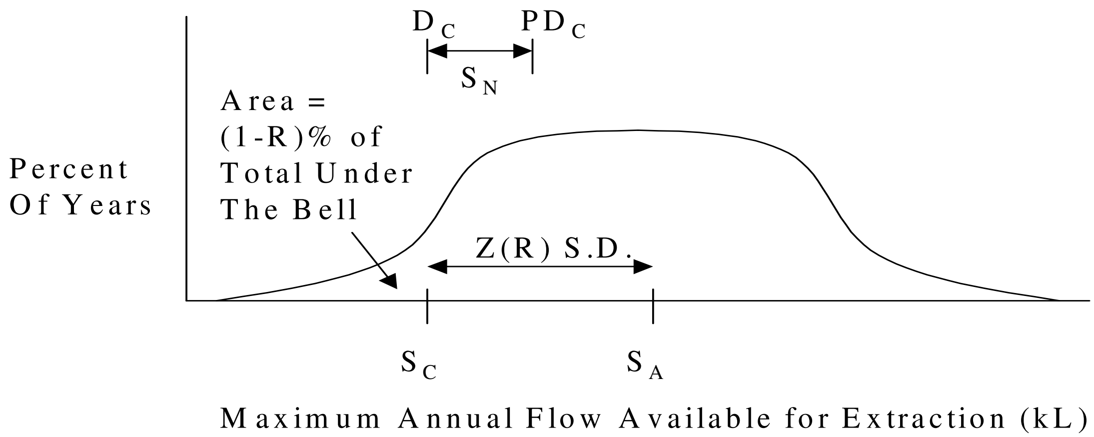

Figure 2: Illustration of Average and Constant-Reliability Unit Costs