P R O J E C T M E M O R A N D U M

RAND

The Effect of Urban Water Supply Reductions During the 1987-92 California Drought

Lloyd S. Dixon, Nancy Y. Moore, Ellen M. Pint

PM-407-CUWA/CDWR

April 1995

Prepared for California Urban Water Agencies and California Department of Water Resources

PREFACE

The project memorandum presents results from ongoing work at RAND on the impacts of the 1987-1992 drought on urban and agricultural users. It contains a conceptual discussion of the definition and measurement of drought impacts in urban areas and an analysis of data collected from 85 urban water agencies on drought management strategies and customer responses during the drought. The purpose of this work is to provide the conceptual framework and background information needed to value the drought's effect on residential, commercial, and industrial users.

This summer, we plan to publish an evaluation of the impact of water supply reductions during the drought on San Joaquin Valley agriculture. In the fall, we plan to issue a final report that combines the work presented here with estimates of residential losses during the drought in Alameda County using new statistical estimates of water demand relationships.

The analysis presented here was funded by California Urban Water Agencies (CUWA), an association of 11 large wholesale and retail water agencies, and California's Department of Water Resources.

CONTENTS

FIGURES

TABLES

SUMMARY

During the 1987-1992 drought, urban water agencies were frequently unable to meet the existing consumption patterns of their customers. They developed policies for resolving the imbalance between supply and demand that included a mix of quantity and type-of-use restrictions, public education and device distribution programs, price increases, and supply augmentation strategies. This report investigates the economic effects of these drought management policies on urban areas. Such an assessment can help inform legislators, water managers, and the general public about the cost of urban water shortages and help in formulating water policies that are efficient, equitable, and environmentally sound.

VALUING DROUGHT EFFECTS

We begin by evaluating one *measure* of the costs of water supply reductions: willingness-to-pay. In the context of the drought, willingness-to-pay is defined as the maximum individuals would have been willing to pay to avoid the drought management strategies. We discuss how various drought management policies generate willingness-to-pay among residential users. We then discuss the effects of water supply reductions on business firms and how these effects translate into willingness-to-pay first by individuals who receive firm profits and then by individuals who receive wages and salaries from the firm. We conclude that willingness-to-pay is a useful measure of the losses caused by the drought and we briefly discuss approaches to quantifying the willingness-to-pay.

MEASURING EFFECTS OF THE WATER SUPPLY REDUCTIONS

In the next section of the report we provide background information needed to quantify the willingness-to-pay to avoid the drought management policies adopted during the 1987-1992 drought. We investigate what type of consumers were affected and how severe the effects appear to have been. The basis for our discussion is a survey of 85 urban water agencies scattered throughout the state. The survey collected data on drought management strategies and consumer response

between 1986 and 1991. The data collection period began in 1986 because that was the last normal water before the drought began. Data for 1992 was not available when the survey was fielded, but the impacts of water supply reductions were likely greatest in 1991. Urban water cutbacks appear to have peaked in 1991 and then dropped somewhat in 1992.

Changes in Water Use

The bulk of the drought's effects occurred in 1991. Overall water use in our sample was fairly stable between 1986 and 1990 but dropped significantly in 1991. Population grew steadily during this period; thus, per capita water use fell 5 percent between 1986 and 1990 and another 14 percent in 1991.

Changes in water use varied across the state. Per capita water use fell significantly in the San Francisco Bay Area in 1988 and 1989 and then dropped another 12 percent in 1991. Per capita water use in Southern California changed little between 1986 and 1990 but dropped 16 percent in 1991.

Table S.1 reports the decline in water use between 1990 and 1991 by customer class. The changes suggest that all customer classes must be examined in assessing the effects of the drought. In terms of the aggregate affect of drought management policies, however, the impacts on residential and commercial classes are probably most important because between them they account for approximately 85 percent of the water use in our sample.

We are unable to formally disentangle the effect of the drought from other confounding factors such as the recession that hit California at the end of 1990 and changes in industrial wastewater discharge standards. It appears highly likely, however, that the changes in residential and public authority/institutional use were largely due to drought management policies. There is more uncertainty in how much of the commercial, industrial, and agricultural reductions were due to the drought, but it seems likely that the drought was a primary factor.

Table S.1

Percent Change in Water Deliveries Between 1990 and 1991 by Customer Class

Customer Class	Percent Change
Total Water Use	-12.4
Residential	-14.1
Single Dwelling Unit	-19.3
Multiple Dwelling Unit	-12.2
Commercial	-11.1
Industrial	-15.6
Public Authority/Institutional	-23.0
Agricultural[a]	-24.8

[a]Increased groundwater pumping may have partially offset this decline in agency deliveries.

Drought Management Strategies

The strategies adopted by urban water agencies to curtail use during the drought may provide additional evidence on the welfare losses caused by the observed changes in water use. We found that a sizable proportion of agencies adopted quantity and type-of-use restrictions, public education and device distribution programs, price-structure changes, and supply augmentation strategies.

Our investigation of drought management strategies suggests that

- Mandatory quantity restrictions coupled with price surcharges for excess use were common. The quantity restrictions were widely violated by residential users. But, commercial and industrial users were apparently shielded from adverse impacts to some extent.
- Type-of-use restrictions were common but not well-enforced.
- Public education and device distribution programs were widespread and focused on residential users. These programs presumably reduced the negative effects of drought management policies.
- Average water cost increased for all customer classes during the drought, which clearly had negative effects on consumers. The increases were comparable for residential, commercial, and industrial users, but lower for agricultural users.

- More than half the survey respondents received supplies from the 1991 Drought Water Bank. These purchases amounted to approximately 10 percent of 1991 usage and suggest that the Bank generated sizable urban benefits.

CONCLUSION

It appears that the negative effects of the drought were widespread in 1991. Our findings suggest that effects were focused in the residential sector which suffered nearly a 20 percent cutback in 1991 water use per capita relative to 1986. Given that residential use accounts for approximately two-thirds of overall urban water use, this suggests that studies to quantify aggregate drought effects should focus on the residential sector.

Water use also declined substantially in the commercial and industrial sectors (15 percent and 20 percent, respectively, between 1986 and 1991). This is particularly surprising given survey responses suggest that these sectors were shielded to some extent from drought management policies. Shielding commercial and industrial users from drought management policies implies wages, salaries, and profits were not substantially affected by the drought, even though there were likely certain subsectors of the economy, such as the landscaping industry, where the effects were significant.[1] The large reduction in water use also suggests that commercial and industrial users may have been able to absorb relatively large cutbacks without substantial cuts in wages, salaries, and profits.

Finally, the 1991 Drought Water Bank was an important source of water to many agencies. A majority of those receiving water had no alternate sources which suggests that drought effects would have been considerably worse without the Bank.

Our work on the economic effects of water supply reductions on urban areas continues. This fall we plan to release a final report that combines the work presented here with estimates of residential losses

[1]Note that depressed activity during the drought may possibly be compensated for by greater activity than normal after the drought.

during the drought in Alameda County, California using new statistical estimates of residential water demand relationships.

ACKNOWLEDGMENTS

The analysis presented here would not have been possible without the information provided by 85 urban water agencies spread throughout California. Agency staff donated considerable time to fill out a lengthy and detailed questionnaire on drought management practices and water use. The agencies responding to our survey are listed in Appendix B, and we thank them wholeheartedly for their efforts.

We would also like to thank the Project Advisory Committee for help in defining the project, designing the survey, and encouraging agencies to fill out the survey. The committee was headed by Lyle Hoag, executive director of California Urban Water Agencies (CUWA). Committee members were Art Bruington of Municipal Water District of Orange County, Leo Cournoyer of Santa Clara Valley Water District, Greg Ford of East Bay Municipal Utility District, Bob Harding and Tim Quinn of Metropolitan Water District, Ray Hoagland and Steve McCaulay of the California Department of Water Resources, Chris Morioka of San Francisco Water Department, Paul Piraino of Alameda County Water District, James Van Haun of Orange County Water District, and Richard West of Los Angeles Department of Water and Power.

Several people provided helpful comments on an initial draft of this project memorandum. We would like to thank Rosalie Bock, David Fullerton, Lyle Hoag, Ray Hoagland, and Wendy Illingsworth for their input.

Theo Downes-Le Guin, Melissa Bradley, Jo Levy, and Beverly Weidmer of RAND's Survey Research Group provided valuable assistance in designing and fielding the survey and coding the survey responses. We thank them for their conscientious work. John Adams also provided useful advice on survey sampling techniques. Finally, we would like to thank Pat Williams for her help in typing and correcting the document.

1. INTRODUCTION

Continuing growth and increasing instream water requirements are stressing the ability of California's current water supply infrastructure to meet current consumption patterns and increasing the likelihood of water shortages. If California's economy and environment are to remain healthy, an issue of central importance is the proper allocation of the state's limited water supplies.

The 1987-1992 California drought and increasing in-stream water requirements caused severe water supply shortages. An assessment of the economic impacts of the these water supply shortages on the state's environment, residents, and businesses can help inform legislators, water managers, and the general public about the cost of water shortages to various sectors. A better understanding of the impacts of these shortages will likely help in formulating water policies that are more efficient, equitable, and environmentally sound.

The focus of this report is the impact of water supply shortages on urban areas, and we take advantage of the shortages in urban areas during the drought to empirically examine these effects. In a 1993 study we outlined a number of approaches for valuing the effect of the drought on urban users (Moore, Pint, and Dixon, 1993). One of the conclusions of that analysis was that no matter what the approach, more information was needed on the drought management strategies actually adopted during the drought and customer responses to these strategies. Therefore, we concluded that the first step in quantifying urban drought effects--before we could even determine which approach or combination of approaches to valuing the effects made sense--should be a survey of urban water agencies to collect the necessary information.

This report presents and analyzes data from a survey of urban retail water agencies on drought management policies and consumer responses between 1986 and 1991. The data collection period begins in 1986 because that was the last normal water year before the drought began. Data for 1992 were not available when the survey was fielded, but the drought impacts were likely greatest in 1991. Urban water

cutbacks appear to have peaked in 1991 and then dropped somewhat in 1992 (see California Department of Water Resources, Vol. 1, 1993, p. 65).

The report is organized as follows. Section 2 outlines our conceptual framework for measuring drought effects and describes our data collection efforts. We examine changes in water use during the drought in Section 3 and characterize the drought management strategies in Section 4. In Section 4, we also investigate the effects of the 1991 Drought Water Bank on urban areas. We summarize our findings and recommend appropriate areas for further research to more accurately estimate the drought's effects on urban water customers in Section 5. The survey instrument is included as Appendix A. Listings of the water agencies that participated in the survey and that received 1991 Drought Water Bank water follow in Appendices B and C, respectively.

2. STUDY METHODS

In this section, we present a conceptual framework for evaluating the effects of the 1987-1992 drought and then describe the data collected to better understand these effects. We first outline the process through which water supply shortages were translated into drought effects on urban users, and then discuss how these effects might be valued. Finally, we describe the survey instrument and methods used to collect data from urban water agencies and the resulting response rates.

TRANSLATION OF WATER SUPPLY SHORTAGES INTO DROUGHT EFFECTS

During the 1987-1992 drought, urban water agencies were frequently unable to meet the demands of their customers at prevailing water prices. They were thus forced to develop policies for resolving the imbalance between supply and demand. These policies included a mix of price increases, quantity and type-of-use restrictions, conservation programs, and attempts to augment supplies. The mix of policies chosen determined which users were most affected by water supply shortages and the degree to which they were affected.

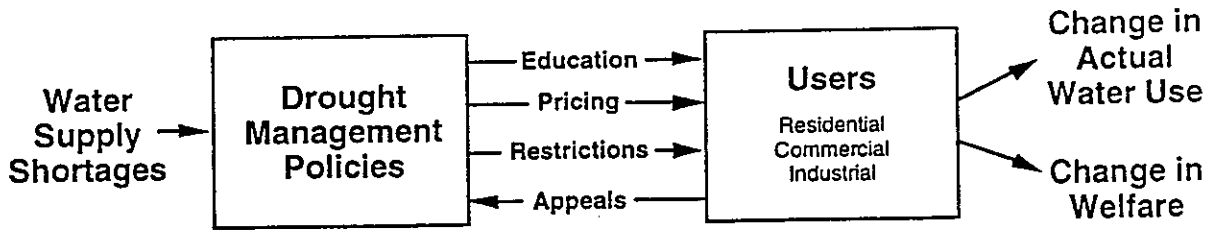

Figure 2.1--Translation of Water Supply Shortages into Reduction in Consumer Welfare

Figure 2.1 illustrates how water agency policy translates water supply shortages into changes in actual water use and consumer welfare.[1] The figure shows that the size of the water supply cutbacks, the drought management strategies adopted by water agencies, and customer response to these policies must all be considered when determining the effect of water supply shortages on welfare.

An appropriate measure of the drought's effects is to compare what actually happened during the drought with what would have happened had there been no drought. We can observe what actually happened, but we do not observe what would have happened had there been no drought, and assuming that all changes observed were due to the drought is almost certainly incorrect. For example, the California economy went into recession toward the end of 1990, and industrial firms were facing increasingly strict enforcement of waste water treatment standards.[2] To isolate the effect of the drought on urban users, we need to control for factors other than the drought that affected consumer welfare between 1987 and 1992.

VALUING DROUGHT EFFECTS

One measure of changes in welfare that is widely used in the economics literature is willingness-to-pay.[3] In the context of the drought, this measure of loss is defined as the maximum individuals would have been willing to pay to avoid the drought management strategies adopted by water agencies.[4] Because the value of money varies across individuals, the willingness-to-pay for two individuals may be identical, but their actual changes in welfare may be very

---

[1]Welfare is a term generally used synonymously with happiness or satisfaction in the economics literature. An individual's welfare is determined by the goods and services bought and the prices paid in the market as well as nonmarket or nonpriced goods such as clean air, clean water, and public parks (see Just, Hueth, and Schmitz, 1982, p. 3). We examine changes in consumer welfare due to drought management policies adopted by water agencies.

[2]Adopting new waste water treatment technologies usually makes disposal of waste water more expensive and thus may reduce industrial demand for intake water.

[3]See for example Just, Hueth, and Schmitz, 1982.

[4]In economics terminology, the maximum amount a consumer or firm would have been willing to pay is called the compensating variation.

different.[5] However, adding up willingness-to-pay across individuals gives a measure of how much society would be willing to invest to avoid similar drought management policies in the future.

Below, we first discuss how various drought management policies generate a willingness-to-pay among residential users. We then discuss the effects of drought on commercial and industrial firms and how these effects translate into willingness-to-pay first by individuals who receive firm profits and then by individuals who receive wages and salaries from the firm. Finally, we briefly discuss approaches to quantifying the willingness-to-pay.

The Effect of Drought Management Policies for Residential Use on Willingness-to-Pay

As mentioned above, water agencies adopt a wide variety of strategies to reduce residential water use during the drought. We now discuss how the most common translate into the willingness-to-pay to avoid the drought management programs adopted by urban water agencies.

Type-of-Use Restrictions. Many water agencies adopt type-of-use restrictions during periods of drought. Examples include prohibitions on washing off driveways and sidewalks, irrigating residential lots during the day, and allowing water from sprinklers to run off into gutters. Although some consumers are unaffected by these restrictions, those whose behavior is constrained are worse off under type-of-use restrictions. If they observe the restrictions they forgo the net benefits of some water uses. If they do not observe the restrictions, they risk being caught and paying penalties.[6] Consumers consequently would be willing to pay some amount to avoid these restrictions.

---

[5]One would expect that an additional dollar generates less utility for a very rich individual than for a poor one.

[6]During 1986-1992 drought, the penalty for violating a type-of-use restriction was usually a fine. These fines typically increased with each successive violation, culminating, at least in principle, in the installation of flow restrictors or the termination of water service. In deciding whether to observe a type-of-use restriction or not, a consumer must trade off the expected cost (probability of being caught multiplied by the fine) with the net benefit (benefit minus water cost) of engaging in the restricted activity.

The magnitude of the willingness-to-pay to avoid type-of-use restrictions is presumably a function of the type of restrictions, how often the user engaged in the restricted activity prior to the drought, the probability of being caught, and the penalty if caught.

Price Increases. Water agencies may attempt to reduce residential water consumption by increasing water price. The loss to the consumer consists of two parts. First, the consumer pays more than he or she would have for a given amount of water. Second, the higher price will presumably cause the consumer to consume less water, and the consumer forgoes the net benefit of water that is no longer consumed. To avoid these losses, consumers would be willing to pay the sum of the increased water costs on units consumed during the drought plus the forgone net benefit of the reduced water use.

Quantity Restrictions. Water agencies may restrict the amount of water that a household can buy in a given period. If this restriction is binding and observed by the household, there is clearly a loss to the household. The household loses the net benefits of the forgone water use and would be willing to pay a positive amount to avoid the restriction.

To enforce quantity restrictions, agencies often adopt surcharges on household water use above the target. These surcharges in effect create an increasing block-rate price schedule and make the quantity restriction resemble a type of price increase. These types of quantity restrictions thus generate willingness-to-pay as described previously for price changes. Some agencies also adopt increasingly severe fines for violating quantity restrictions culminating in the installation of flow restrictors or service cutoff. The cost of such penalties increases the consumer's willingness-to-pay to avoid the restrictions.

When deciding whether to observe quantity restrictions, consumers presumably weigh the forgone benefits of reduced consumption with the penalties and surcharges. Giving consumers the choice of violating quantity restrictions, even with substantial penalties or surcharges, will result in a willingness-to-pay to avoid the drought that is no higher and most likely lower than if consumers had no choice but to obey quantity restrictions. Consumers may be better off because they can

choose to consume additional water if its value in use is higher than the surcharge.

Conservation Programs. Water agencies often adopt a variety of water conservation programs during times of short supply. When analyzing willingness-to-pay it is useful to divide these programs into two categories: device distribution programs and education programs. Device distribution programs usually involve free distribution of low-flow shower heads, toilet dams, or toilet leak detectors and sometimes sizable rebates for installing ultra-low-flush (ULF) toilets.

In deciding whether to install the conservation devices or not, the consumer presumably weighs any expected reduction in satisfaction from water use (for example, decreased water flow from a low-flow showerhead) with the cost savings and behavioral changes that would be made if the devices were not installed (for example, shorter showers).[7] Consumers presumably also consider water costs and the probability of violating drought quantity restrictions with and without the conservation devices and weigh the benefits and costs over time--both for the expected duration of the drought and subsequent periods when drought management strategies are not in effect.[8] Device distribution programs are voluntary and presumably reduce the negative effects of the drought management programs as measured by willingness-to-pay.

Education programs can take many different forms. Common are public education programs such as bill inserts, television, radio and newspaper announcements, school programs, and public displays. Agencies may also provide individual water audits to identify water saving possibilities at little or no cost.

Public education programs may reduce consumers' willingness-to-pay to avoid drought management strategies. They may decrease willingness-to-pay by providing information that would otherwise be difficult for consumers to obtain and may enable consumers to better control their water use. For example, by learning the major water uses in their home,

---

[7]Expected reductions in satisfaction due to conservation devices may not actually materialize, however.

[8]Devices that are easily removed, for example low-flow showerheads, may also be replaced by the consumer when drought management policies are suspended.

consumers may be better able to identify low-value water uses that they can cut back with little negative effect. Public education programs may also reduce willingness-to-pay to avoid drought management programs by increasing consumer awareness of the environmental consequences of water diversions during drought. For example, an individual may be willing to pay very little to avoid drought management programs if the additional water would come from environmentally sensitive areas.[9]

Public education programs may also increase consumer willingness-to-pay to avoid drought management policies. For example, public education programs may link good citizenship with water conservation and thus increase the cost (not monetary, but in terms of satisfaction and happiness) to the individual of violating quantity or type-of-use restrictions.[10]

Willingness-to-Pay Induced by Drought Management Strategies for Business

Willingness-to-pay can also be used to measure the effect of the drought management policies on business firms, which affects the incomes of individuals who work for the firm, individuals who receive firm profits, and consumers who buy the firm's products. We first turn our attention to individuals who receive firm profits.

As discussed in subsequent sections, many of the drought management policies applied to residential consumers during the drought were also applied to businesses. These policies may affect firm profitability, although to widely varying degrees. For example, restrictions on washing down hard surfaces may have little effect on firm profitability, but water price increases may have a more significant effect. Profits may fall in the face of higher prices both because firms must pay a higher cost for a given amount of water, and also because higher water costs may cause the firms to reduce the amount of water consumed and production levels, eliminating the profit from units that are no longer produced.

---

[9]In economics terminology, the ecosystem health would be an argument in individual utility functions.

[10]Here, concern over how others perceive the individual enters the individual's utility function.

Drought management policies may also reduce the incomes of individuals who earn wages and salaries at firms if they cause firms to cut back on work hours or lay off workers. For workers whose hours are cut back, the willingness-to-pay is a function of the reduction in earnings. For workers who are laid off, the cost of finding a new job (including moving costs), the lost income during the period of unemployment, and any difference between the wages of the new and old jobs also contribute to the willingness-to-pay.

Firms may not only be directly affected by drought management strategies, but indirectly affected. Drought management strategies may reduce the demand for a firm's product and consequently its profits and wages and salaries. For example, restrictions on outdoor watering by residential customers may decrease the demand for landscape services and reduce profits, wages, and salaries in the landscaping industry.

Consumers may be adversely affected by increases in product prices due to the drought. Some firms may be able to pass on higher water costs to the consumer or a reduction in production may force product prices up. Consumers would be willing to pay to avoid these price increases.

Finally, it is important to note that some firms will be favorably affected by the drought and others may find some adverse impacts reversed once the drought has ended. For example, demand for certain goods, such as water conservation devices, will likely increase. And, after the drought is over, there may be unusually high demand for nursery products and landscaping services.

Quantifying Willingness-to-Pay

There are two basic approaches to quantify the willingness-to-pay to avoid the consequences of water supply shortages. First, individuals can be surveyed to directly elicit willingness-to-pay. Individuals can be asked how much they would have paid to avoid the negative effects of the 1986-1992 drought or of a hypothetical drought of similar characteristics.[11] Second, estimates of water demand relationships

[11]See for example Carson and Mitchell, 1987 or Barakat & Chamberlin, Inc., 1994.

(which capture the relationship between water price, household income, drought management strategies, and other variables and household water use) and labor supply relationships can be used as the basis for analytically determining willingness-to-pay (see Moore, Pint, and Dixon, 1993, pp. 27-32).

Both approaches have advantages and drawbacks. The advantage of the survey approach is that it directly focuses on the question of interest and can measure willingness-to-pay caused by all different types of impacts, whether reductions in hours worked caused by business slowdown or drought management policies targeted at the home. One disadvantage is that respondents do not have to actually make the payments they report and thus may over- or understate their willingness-to-pay to avoid the drought. A second disadvantage is that respondents may have little experience valuing these types of losses and may not give realistic answers, particularly if they have never experienced the loss.[12]

Determining willingness-to-pay by way of demand curve analysis can be done more quickly and more cheaply than using a survey approach if demand relationships that existed before the drought are used. However, these relationships may not accurately capture consumption responses to the various drought management programs implemented during the drought.[13] Thus, empirical work using data during the drought is likely to be necessary. Furthermore, there are a number of technical issues that need to be addressed before willingness-to-pay can be derived from demand relationships and the observed drought management strategies.[14]

---

[12]For example, many people bought flood insurance after the 1993 Mississippi flood who had not purchased insurance prior to the flood. See Kunreuther, 1978, for evidence that people tend to underestimate losses from floods, earthquakes, etc., *ex ante*.

[13]For example, water prices during the drought may be outside the range observed before the drought.

[14]For example, the error introduced by using uncompensated demand curves rather than compensated demand curves must be evaluated (see Just, Heuth, and Schmitz, 1982, Chapters 6 and 7).

Drought Effects Over Time

In concluding this discussion of a conceptual framework for evaluating drought effects, we briefly discuss valuing drought effects over time. Even though consumers can adjust consumption patterns very quickly, they likely can implement conservation techniques that minimize the losses from reduced consumption only gradually over time. Thus, it is reasonable to expect that the negative effects of drought management policies would be greatest at first and then decline somewhat over time as individuals adapt. This suggests that, ideally, measures of drought effects should look for responses over time that reduce consumer willingness-to-pay to avoid the consequences of water supply shortages.

DATA COLLECTION

The first step in quantifying the willingness-to-pay to avoid the drought is to develop information on the types of drought management strategies adopted by water agencies, where and when the effects appear most significant, and what types of customers seemed to be most affected. To do this, we collected data on water use and drought management policies between 1986 and 1991 from urban water agencies across the state and combined it with data on economic activity in California over the same period. The data collection period begins in 1986 because 1986 was the last normal water year before the 1987-1992 drought began. Data for 1992 was not yet available at the time the survey was conducted.[15]

Below, we describe our survey approach, sample selection, response rates, and the characteristics of the sample.

Survey Approach

We conducted a mail survey with telephone follow-up of a sample of urban water agencies in California.[16] The survey asked for detailed information on

---

[15]Even though we do not have data on the last year of the drought, it appears that we do have data on the years when the effects were most severe. Urban water cutbacks appear to have peaked in 1991 and then dropped somewhat in 1992 (see California Department of Water Resources, Vol. 1, 1993, p. 65).

[16]The survey instrument is attached as Appendix A.

- Water agency revenues
- Number of customer accounts by customer class (residential, commercial, industrial, etc.)
- Water supplies and deliveries by customer class
- Drought management programs
- Water rates
- Deliveries and use of water from the 1991 Drought Water Bank, which was run by the California Department of Water Resources.

Annual data were collected for all variables except water deliveries. Quarterly data were collected for water deliveries first because agencies report water use over water years that end in different months, and we wanted to obtain a consistent time-profile of water use across agencies. Second, water use is highly seasonal, and quarterly data allow us to identify different responses to the drought in summer and in winter.

To test the survey instrument, we sent the survey out to 10 agencies in the fall of 1992 and received 6 responses. The instrument was revised based on these responses, but only minor changes were necessary.

Sample Selection

The survey sample was drawn from a list provided by the California Department of Water Resources (DWR) of 684 water agencies that distribute drinking water to the public. This list includes all agencies that serve populations over 3,000 and provide over 3,000 acre-feet per year as well as some smaller agencies. Because we did not want to spend limited survey resources on agencies with relatively few customers, we decided to drop from the list agencies serving populations less than 10,000. DWR, however, did not have population data for all the agencies, so we added agency population provided by the Office of Drinking Water in California's Department of Health Services to the DWR

list.[17] We were able to determine that 338 of the 684 agencies had populations over 10,000. We were not able to determine population for 191 agencies, but these appeared to be predominately small agencies.

We used a proportionate sampling technique to draw a sample of 200, where the probability of being selected was proportional to the population served by the agency. Table 2.1 shows that 87 of the 207 agencies with population between 10,000 and 50,000 were selected (42 percent), 58 of the 75 agencies with population between 50,000 and 100,000 (77 percent), and 55 of the 56 agencies with populations greater than 100,000 (98 percent).

Table 2.1

Number of Agencies Surveyed and Response Rate

		Pretest		Survey		
	All Water Agencies[a]	Sampled	Respon-dents	Sampled	Respon-dents	Percent Responding
Total	338	10	6	200	79	40
Agency Population (thousands)						
10 to 50	207	5	3	87	22	25
50 to 100	75	5	3	58	27	47
> 100	56	0	0	55	30	54
Region						
Bay Area[b]	51	3	1	30	16	53
So. California[c]	182	7	5	117	44	38
Rest of State	105	0	0	53	19	36

[a]Agencies with service area populations greater than 10,000.

[b]Alameda, Contra Costa, San Mateo, San Francisco, Marin, Santa Clara, and Sonoma Counties.

[c]Los Angeles, Orange, Riverside, San Bernardino, San Diego, and Ventura Counties.

Survey Implementation and Response Rate

We mailed the survey in February, 1993. To encourage agencies to commit the considerable resources necessary to complete the survey, an initial contact letter describing the project was sent by the general

[17]The Office of Drinking Water in California's Department of Health Services lists 1,250 water agencies that distribute drinking water and have over 200 service connections.

managers of the CUWA member agencies. RAND staff then contacted the sampled agencies by telephone asking the initial contact person to designate a staff member to receive the survey and be responsible for returning it. RAND staff and, in some cases, CUWA representatives made follow-up telephone calls to non-respondents over a period of several months. Rather than fill out the entire survey themselves, most agencies enclosed materials that contained parts of the information requested. We then abstracted the information onto the survey forms.

When the survey period was closed in July 1993, 79 of the 200 sampled agencies had responded (40 percent). This relatively low response rate was due in part to the length of the survey and in part to the type of information requested. Many agencies did not keep records of some of the information requested and in many cases considerable effort was required to construct it. As will become apparent in the following sections, many agencies only partially completed the survey. Our experience illustrates the difficulty of assembling the data needed to evaluate the effects of the drought.

The response rate varied by agency location and population. As shown in Table 2.1, the response rate was higher in the Bay Area than other parts of the state and higher in agencies with larger service area populations. Large agencies in the sample were not disproportionately located in the Bay Area so both location and population appear to be important in explaining response rates.

Characteristics of Responding Agencies

Because the survey instrument used in the pretest was very similar to the final survey instrument, we added the six agencies responding to the pretest to the 79 agencies responding to the survey for the purposes of analysis. Table 2.2 reports the breakdown of the resulting 85 responding agencies by location and population. The responding agencies are distributed fairly evenly by population. This contrasts with the distribution of all urban water agencies with population greater than 10,000, which, as shown in Table 2.1, is heavily weighted toward agencies serving smaller populations. The difference is due to the over-sampling of larger agencies. Most of the responding agencies (58

percent) are in Southern California, but this corresponds fairly closely with the distribution of all urban water agencies with population greater than 10,000.

Even though the number of water agencies responding to the survey is not large relative to the total number of water agencies in the state, the responding agencies account for a sizable proportion of the total state population. Only 60 of the 85 responding agencies were able to estimate the population in their retail area, but the population in these 60 agencies was 36 percent of the total population (see table 2.3). A higher percent of the Bay Area population was covered by the responding agencies, and, as expected, the vast majority of the population in the responding agencies was in those agencies with the largest populations.

Table 2.2

Distribution of 85 Responding Agencies by Location and Size (Percent)

	Agency Population (1000s)			
Location	10 to 50	50 to 100	> 100	All Sizes
Bay Area	2	8	9	20
So California	22	15	20	58
Rest of State	5	12	6	22
All locations	29	35	35	100

Table 2.3

1991 Population for Respondents Reporting Population and All Water Agencies (N=65)

	Number Responding	Population (1000s) Respondents	Population (1000s) All Water Agencies[a]	Percent
Total	60	11,113	30,646	36
Region				
Bay Area	13	3,332	5,665	59
So. California	31	6,121	17,511	35
Rest of State	16	1,660	7,470	22
Agency population (thousands)				
< 10	0	0	NA	NA
10 to 50	15	517	NA	NA
50 to 100	22	1,651	NA	NA
> 100	23	8,945	NA	NA

NA = Not Available.

[a]California Statistical Abstract, 1992, Dept. of Finance, State of California, p. 13.

Table 2.4

1991 Water Use for Respondents Reporting Water Use for Urban Agencies and All Water Agencies (N=60)

	Number Responding	Water Use (1000s af)[a] All Water Agencies[b]	Water Use (1000s af)[a] Respondents	Percent
Total	65	7,800	1,995	26
Region				
Bay Area	14	1,300[c]	480	37
So. California	37	4,000[d]	1,266	32
Rest of State	14	2,500	249	10
Agency population (thousands)				
< 10	0	NA	0	NA
10 to 50	16	NA	92	NA
50 to 100	23	NA	255	NA
> 100	26	NA	1,648	NA

NA = Not Available.

[a]One acre-foot is approximately 326,000 gallons.

[b]California Department of Water Resources, 1993, p. 169.

[c]San Francisco Hydrologic Region.

[d]South Coast Hydrologic Region.

A sizable proportion of total urban water use is provided by the responding agencies. As shown in Table 2.4, the 65 agencies that were able to provide information on water use supplied 26 percent of urban water use in the state. The coverage ranged from 37 percent in the Bay Area to 10 percent in the rest of the state, and, again, the vast bulk of the water was supplied by agencies with the largest populations.

3. CHANGE IN WATER USE DURING THE DROUGHT

This section presents our findings on water use for the surveyed urban water agencies between 1986 and 1991. As discussed in Section 2, these changes are the result of the full range of factors affecting water use. In addition to the drought management strategies adopted by water agencies, these factors include changes in weather, the overall economy, population, and industrial wastewater discharge regulations. To the extent possible we make inferences in this section on the importance of the various factors in explaining changes in water use.

We first discuss aggregate water use and then present water use by customer class. The customer classes we examine are residential, commercial, industrial, public authority/institutional, and agricultural/horticultural. When possible, residential use is broken down into single-dwelling unit and multiple-dwelling unit use.

AGGREGATE WATER USE

As shown in Table 3.1, overall water use for the 53 agencies that were able to provide data on water use and population was fairly stable between 1986 and 1990 but then dropped significantly in 1991.[18] Population grew steadily during this period with the result that per capita water use fell 5 percent between 1986 and 1990 and another 14 percent in 1991 (see last column of Table 3.1).

There was some variation in changes in water use across the state. Per capita water use in Southern California changed little between 1986 and 1990 but then dropped 16 percent in 1991 (see Table 3.2). A similar pattern occurred in the rest of the state (areas outside Southern

[18]Throughout this report, we sum various measures of water use and conservation program activity across the agencies in the sample. Thus larger agencies have more influence on changes over time than the smaller agencies. In evaluating overall urban water use in California, this seems appropriate because larger agencies account for a greater proportion of water use than smaller agencies. We have not reweighted our sample to adjust for difference in sampling and response rate by agency population or region. Further work is necessary to determine if such reweighting would change our results significantly.

California and the Bay Area) although the declines between 1986 and 1990 were somewhat larger and the drop in 1991 was not as severe (see Table 3.4). Per capita water use dropped earlier in the Bay Area: as shown in Table 3.3, water use fell significantly in 1988 and 1989 and then dropped another 12 percent in 1991.

Table 3.1

Water Use in Responding Agencies
(N=53)

	Total Water Use (1000s of af)	Percent Change	Population (1000s)	Percent Change	Water Use per capita (af per capita)	Percent Change
1986	1806	---	9,659	---	0.187	---
1987	1855	2.7	9,852	2.0	0.188	0.7
1988	1828	-1.5	10,044	1.9	0.182	-3.2
1989	1840	0.7	10,206	1.6	0.180	-1.1
1990	1840	0	10,376	1.7	0.177	-1.7
1991	1611	-12.4	10,550	1.7	0.153	-13.6

Table 3.2

Water Use Per Capita in Southern California
(N=28)

	Total Water Use (1000s of af)	Percent Change	Population (1000s)	Percent Change	Water Use per capita (af per capita)	Percent Change
1986	1,049	---	5,328	---	0.197	---
1987	1,070	2.0	5,464	2.6	0.196	-0.6
1988	1,092	2.1	5,552	1.6	0.197	0.5
1989	1,136	4.0	5,671	2.1	0.200	1.5
1990	1,127	-0.8	5,768	1.7	0.195	-2.5
1991	966	-14.3	5,890	2.1	0.164	-15.9

Table 3.3

Water Use in the Bay Area
(N=12)

	Total Water Use (1000s of af)	Percent Change	Population (1000s)	Percent Change	Water Use per capita (af per capita)	Percent Change
1986	504	---	3,037	---	0.166	---
1987	528	4.8	3,061	0.8	0.173	3.9
1988	470	-10.0	3,079	0.6	0.153	-11.6
1989	436	-7.2	3,092	0.4	0.141	-7.8
1990	450	3.2	3,116	0.8	0.144	2.1
1991	398	-11.5	3,132	0.5	0.127	-11.8

Table 3.4

Water Use in the Rest of the State
(N=13)

	Total Water Use (1000s of af)	Percent Change	Population (1000s)	Percent Change	Water Use per capita (af per capita)	Percent Change
1986	253	---	1,294	---	0.195	---
1987	257	1.5	1,326	2.5	0.194	-0.9
1988	266	3.5	1,412	6.5	0.189	-2.6
1989	268	0.8	1,442	2.1	0.186	-1.6
1990	264	-1.5	1,493	3.5	0.177	-4.8
1991	247	-6.4	1,527	2.3	0.162	-8.5

Per capita water use in Southern California and the Rest of the State were similar at the beginning and end of this period--starting at approximately 0.20 acre-feet per capita in 1986 and dropping to approximately 0.16 acre-feet per capita in 1991. Per capita water use in the Bay Area was substantially lower, however. Its 1986 value was close to the 1991 level in the other parts of the state and fell to 0.13 acre-feet in 1991. These differences presumably reflect differences between the Bay Area and other parts of the state in weather and conservation efforts.

Even though these changes in aggregate per capita water use reflect the changes in the full panoply of factors affecting water use, in Section 4 we will see that these declines correspond in time to the drought management policies adopted by water agencies. The sudden decline in overall water use in 1991 thus suggests that the drought management programs did have an effect throughout the state in 1991. The pattern of water use in the Bay Area suggests that the drought affected the Bay Area starting in 1988.

WATER USE BY CUSTOMER CLASS

As shown in Table 3.5, residential use accounted for almost two-thirds of overall urban water use in 1986 with total use by single-dwelling units roughly twice as large as that by multiple-dwelling units. Commercial use accounted for 21 percent of use, and industrial and public authority/institutional use accounted for roughly 5 percent. Only 1 percent of water use went to urban agricultural/horticultural users in 1986.[19] This suggests that, when evaluating aggregate willingness-to-pay to avoid the drought across all classes of water use, residential use is of primary concern. Next in importance is the commercial sector. The industrial and public authority/institutional sectors may make some contribution, but probably not much, and changes in urban agricultural uses will likely have little effect on the aggregate willingness-to-pay.

Surprisingly, there was very little change in the breakdown of water use by customer class between 1986 and 1991. At first thought, this might suggest that the drought similarly affected the various customer classes. However, this comparison does not control for differing growth rates in the various sectors and other confounding factors that differentially affected customer classes, for example, changes in the economy and in industrial wastewater discharge standards. It also may be that the willingness-to-pay to avoid a given cutback varies a great deal across sectors. To develop a better understanding

---

[19]These proportions are similar to those reported by the Metropolitan Water District of Southern California in their 1990 report although the percent consumed by single-dwelling units in the responding agencies is somewhat greater (MWD, 1990, p. 27).

of how the drought effects varied by customer class, we now investigate changes in water use by each customer class.

Table 3.5

Breakdown of Water Use by Customer Class
(N=44, percent)

	1986	1991
Residential	64	64
Single-Dwelling Unit	41	40
Multiple-Dwelling Unit	23	24
Commercial	21	21
Industrial	5	5
Public Authority/Institutional	6	5
Agricultural/Horticultural	1	1
Other	3	3
Total	100	100

Residential Water Use

Residential water use in the responding agencies remained stable through 1990 but then fell 14 percent in 1991. When adjusted for population growth, residential use fell somewhat between 1986 and 1990 but dropped approximately 15 percent in 1991 (see Table 3.6). This closely mirrors the change in total use per capita, as ought to be expected because residential use accounts for almost two-thirds of overall use.

Table 3.6

Residential Water Use
(N=40)

	Total Water Use (1000s of af)	Percent Change	Population (1000s)	Percent Change	Water Use per Capita (af per capita)	Percent Change
1986	1,057	---	8,635	---	0.122	---
1987	1.089	3.0	8,795	1.8	0.123	1.2
1988	1,061	-2.6	8,937	1.6	0.119	-3.3
1989	1,063	0.2	9,033	1.1	0.118	-0.8
1990	1,053	-0.9	9,146	1.3	0.115	-2.5
1991	905	-14.1	9,267	1.3	0.098	-14.8

One factor other than the drought that may have contributed to the sharp decline in residential water use in 1991 is the economic recession that hit California at the end of 1990. Table 3.7 shows that per capita wages and salaries adjusted for inflation fell almost 5 percent in 1991, and because residential water use is affected by household income, this drop in real income could have caused a drop in water use. The drop in income, however, is not nearly enough to explain the drop in residential water use. The income elasticity for water demand is generally thought to be substantially less than one even in the long-run, which means that the decline in income would probably have reduced residential water use by less than 5 percent.[20] Other confounding factors need to be examined, such as changes in weather, which also affects water use, but it is likely that a substantial portion of the 14 percent drop in per capita residential consumption was due to the drought management programs adopted by water agencies. This suggests that the drought management programs for residential use generated a willingness-to-pay to avoid the consequences of such programs.

[20]For example, Griffin and Chang report long-run income elasticities for water use between 0.30 and 0.48 (Griffin and Chang, 1990) and Sewell and Roueche report a long-run income elasticity of 0.19 (Sewell and Roueche, 1974). Short-run elasticities are presumably even lower.

Table 3.7

Percent Change in California Wages and Salaries and Population

	Real Wages and Salaries	Population	Real Wages and Salaries per Capita
1986	---	---	---
1987	4.9	2.2	2.7
1988	3.7	2.5	1.1
1989	2.1	2.5	-0.4
1990	1.6	3.1	1.4
1991	-2.8	2.0	-4.7

Source: California Statistical Abstract, 1993, pp. 10,52,60. Wages adjusted using consumer price index.

The declines in use per account were larger for single-dwelling units than multiple-dwelling units (Tables 3.8-3.9).[21] The difference is substantial and suggests that drought management programs targeted single-dwelling units or that single-dwelling units were more responsive to the programs.[22] Greater cutbacks by single-dwelling units does not necessarily mean that the willingness-to-pay (adjusted for number of units) is greater for single-dwelling units than multiple-dwelling unit users. Cutbacks by single-dwelling unit users could have been restricted to low-value uses to a greater extent than those by multiple-dwelling unit users.[23]

---

[21]Population living in multiple- and single-dwelling units was not available, thus multiple- and single-dwelling use is normalized by the number of accounts. The percent change in the number of accounts, however, closely parallels percent change in population.

[22]Multiple-dwelling unit users may have been less responsive to drought management programs for several reasons. First, a landlord often pays the water bill for multiple-dwelling units and higher water costs may only appear as rent increases much later. Second, because there is only one water meter for many users, savings by one user are split among many users. Third, multiple-dwelling unit users may have fewer low-value uses to cut back than single-dwelling unit users.

[23]For example, outdoor use accounts for a larger share of total use for single-dwelling units than multiple-dwelling units, and it may be less painful to reduce outdoor use than indoor use.

Table 3.8

Water Use by Single-Dwelling Unit Accounts
(N=25)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	506	---	1,185	---	0.427	---
1987	518	2.4	1,199	1.2	0.432	1.1
1988	503	-2.9	1,187	-1.0	0.424	-1.9
1989	502	-0.2	1,198	0.9	0.420	-0.9
1990	487	-3.0	1,209	0.9	0.402	-4.3
1991	393	-19.3	1,216	0.6	0.324	-19.4

Table 3.9

Water Use for Multiple-Dwelling Unit Accounts
(N=22)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	276	---	148	---	1.86	---
1987	280	1.6	149	0.8	1.88	0.8
1988	280	0.0	151	1.3	1.85	-1.6
1989	286	2.1	153	1.3	1.87	1.1
1990	279	-2.4	155	1.3	1.80	-3.7
1991	245	-12.2	156	0.6	1.56	-13.3

Commercial Water Use

Commercial water use fell somewhat between 1986 and 1990 but then fell approximately 11 percent in 1991 (see Table 3.10).[24] The decline in commercial water use is likely due in part to agency drought management programs and in part to the recession that hit California at the end of 1990. Even though we found it likely that much of the change in residential water use can be attributed to the drought, there is much more uncertainty in how much of the fall in commercial use is drought-related. The recession may explain a large part of the nearly 3 percent

[24]For completeness, the number of commercial accounts and commercial use per account is also reported in Table 3.10.

fall in commercial wages and salaries in 1991 (see Table 3.11) as well as some of the decline in commercial water use.

Table 3.10

Commercial Water Use
(N=37)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	405	---	209	---	1.94	---
1987	414	2.1	215	2.8	1.92	-0.7
1988	401	-3.1	200	-7.0	2.01	4.7
1989	390	-2.7	203	1.5	1.92	-4.5
1990	389	-0.3	206	1.5	1.89	-1.6
1991	346	-11.1	208	1.0	1.67	-11.6

Even though we cannot isolate drought effects from other factors, based on the data presented here, we can infer that changes in water use caused by the drought are reflected less than proportionately in changes in wages and salaries. First, observe that commercial water use fell nearly 12 percent in 1991 while wages and salaries fell only 3 percent. These changes were caused by both the drought and other factors, but it is likely a similar relationship would remain if all factors other than the drought had remained unchanged. Taking this argument one step further, presumably a 100 percent water cutback for a commercial firm would result in closure of the firm and a 100 percent cutback in wages and salaries. Thus, the less than proportional relationship between water use and wages and salaries suggested during the drought (12 percent drop in water use versus a 3 percent drop in wages and salaries) would be offset with a greater than proportional relationship at higher cutbacks. This suggests water cutbacks over an initial range probably have little effect on commercial wages and salaries, but have increasingly severe effects as cutbacks escalate. It appears, however, that the drought management policies in 1991 caused cutbacks that fell into the initial range.

Table 3.11

Percent Change in Commercial and Industrial Wages and Salaries in California (adjusted for inflation)

	Commercial	Industrial
1986	---	---
1987	6.8	1.8
1988	4.6	2.5
1989	2.4	-0.7
1990	2.7	-2.2
1991	-2.6	-4.1

Source: California Statistical Abstract, 1993, pp. 52,60. Wages adjusted using consumer price index.

Another important aspect of drought effects is the effect on firm profits and thus on the individuals who receive profits, such as small business owners and shareholders. Data on profits by sector over this period is not readily available so we did not investigate the relationship between water cutbacks and changes in profit. However, it is likely that the relationship would be similar to that for wages and salaries but that significant changes in profits would occur before changes in wages and salaries.[25]

Industrial Water Use

Industrial water use fell approximately 5 percent between 1986 and 1990 but then fell nearly 15 percent in 1991 (see Table 3.12). This is as large as the fall in residential use and suggests that industrial users were affected by drought management policies. Some industrial users may have their own groundwater pumps, however, and partially offset reduced water agency deliveries by increased groundwater pumping. Changes in industrial groundwater use during the drought remain to be examined.

[25]If firms expect water supply shortages are short-term, they may want to conserve firm-specific human capital and maintain worker goodwill and thus be willing to forgo profits before reducing wages and salaries.

Table 3.12

Industrial Water Use
(N=28)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	93.3	---	16.9	---	5.51	---
1987	94.5	1.3	18.1	6.7	5.24	-5.0
1988	94.7	0.2	17.4	-3.9	5.43	3.6
1989	92.1	-2.7	17.6	1.1	5.73	5.5
1990	88.3	-4.1	17.6	0.0	5.03	-12.2
1991	74.5	-15.6	17.4	-1.1	4.27	-15.1

The same problem disentangling the drought effect from other effects holds for industrial use as held for commercial use. As shown in Table 3.11, industrial wages and salaries stagnated between 1986 and 1990 and then dropped 4 percent in 1991. The recession contributed to the decline in industrial water use as did the gradual adoption of industrial waste water treatment requirements during this period.[26] New treatment requirements make waste water discharge more expensive and presumably increase incentives to reduce fresh water use. The United States Environmental Protection Agency began issuing treatment technology requirements for the waste water produced by various industrial processes in 1982.[27] Requirements for different processes were released over time and California municipalities started to enforce these requirements in 1984 and 1985.[28] The aggressiveness with which these requirements were enforced varied across municipalities: it appears in some cases that there was little enforcement in some agencies until the late 1980s. The lag in enforcement and the release of new requirements over time suggests that these regulations put downward pressure on industrial water use between 1986 and 1991. In particular, this may account for part of the 5 percent decline in industrial water

[26]Increased awareness of liability for pollution under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund) may have also been a factor.

[27]The standards were released under the Clean Water Act.

[28]Based on telephone interview with B. Patel, Los Angeles Department of Public Works.

use between 1986 and 1990 that occurred even though industrial wages and salaries rose slightly.

The ratio between the percent change in industrial water use and industrial wages and salaries between 1990 and 1991 (3.8) is similar to that for commercial users (4.3). This again suggests that over an initial range industrial water cutbacks have little impact on wages and salaries, although any increased groundwater pumping remains to be factored in. Industrial profits may also have been affected by the drought, and most likely to a greater degree than wages and salaries.

Public Authority and Institutional Water Use

As shown in Table 3.13, public authority and institutional water use rose slightly between 1986 and 1990 but dropped approximately 16 percent in 1991. The number of public authority and institutional accounts grew rapidly through 1990 and the stability of water use between 1986 and 1990 may have been the result of early adoption of conservation practices.[29] Even though the water use dropped sharply in 1991, the number of accounts remained constant.

It seems less likely than for commercial and industrial users that factors other than the drought were major causes of the decline in public authority and in institutional water use. The decline in public authority and institutional water use thus suggests the drought management strategies of public water agencies had a substantial effect on public authority and institutional users. The willingness-to-pay generated by these cutbacks, however, is unknown. On the one hand, the cutbacks may have been in low-value uses such as water fountains. On the other hand, the sizable reduction suggests that high-value uses could possibly have been affected. Since public uses of water may

---

[29]The number of accounts may not be a good measure of the size of the public authority and institutional sectors. According to an expert on such issues, the number of accounts often changes even if the number of buildings, for example, physically connected remains stable. The number of commercial and industrial accounts apparently exhibits less such variability. Even when two commercial or industrial firms merge, the separate buildings of the two firms usually remain on separate water meters. (Written communication by Wendy Illingsworth to authors, October 6, 1994.)

involve benefits to the general public, willingness-to-pay to avoid cutbacks could be very difficult to measure.

Table 3.13

Public Authority/Institutional Water Deliveries
(N=33)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	84.3	---	14.3	---	5.89	---
1987	84.9	0.7	14.9	4.1	5.70	-3.3
1988	85.6	0.8	15.9	6.7	5.37	-5.8
1989	84.2	-1.6	16.3	2.5	5.17	-3.7
1990	87.5	3.9	16.6	1.8	5.27	1.9
1991	67.4	-23.0	16.6	0.0	4.05	-23.1

Agricultural and Horticultural Use

Agricultural and horticultural use in urban areas experienced the largest relative declines in water deliveries between 1986 and 1991 (see Table 3.14). Agricultural and horticultural deliveries were 25 percent lower in 1990 than 1986 and fell another 23 percent in 1991. This occurred even though the number of agricultural and horticultural accounts remained stable over the period. These declines may have been partially offset by increased groundwater pumping, but further work is needed to determine the extent to which this occurred.

Even if overall agricultural and horticultural water use did decline during the drought, factors other than drought management strategies may be to blame. Urbanization may have reduced the number of acres available to agriculture, even if the number of accounts remained stable. Adverse changes in agricultural crop prices and production costs may have also contributed to the decline.[30]

[30]Note also that only seven agencies provided data on agricultural/horticultural water use. This is in large part because relatively few agencies made large enough deliveries to this customer class to warrant reporting them separately. Given the small sample size, the significance of the changes reported in Table 3.14 should be interpreted with caution.

Table 3.14

Agricultural/Horticultural Water Deliveries
(N=7)

	Total Water Use (1000s of af)	Percent Change	Accounts (1000s)	Percent Change	Water Use per Account (af per acct.)	Percent Change
1986	9.1	---	1.2	---	7.5	---
1987	8.3	-8.9	1.3	10.3	6.2	-17.4
1988	8.3	0.0	1.3	0.0	6.3	1.6
1989	6.7	-19.3	1.3	0.0	5.0	-20.6
1990	7.3	9.0	1.1	-15.4	6.4	28.0
1991	5.5	-24.7	1.3	18.2	4.3	-32.8

The large decline in agricultural and horticultural water deliveries in urban areas suggests that water supply reductions during the drought may have significantly affected agriculture. Many farmers are on interruptible rates, which provide for a cessation of water deliveries in periods of short supply. Farmers may then have to turn to more expensive groundwater.[31] Losses to nurseries may be even larger than indicated by the water use. Nursery growers may have used water to grow plants but then not have been able to sell them during the drought because of reduced residential demand.

SUMMARY

It appears that the bulk of the drought's effects occurred in 1991, although there were likely some negative impacts starting in 1988 in the Bay Area. Table 3.15 summarizes the declines in water use by customer class between 1990 and 1991, and suggests that all customer classes must be examined in assessing the effects of the drought. In terms of the aggregate affect of drought management policies, the impacts on residential and commercial classes are probably most important because between them they account for approximately 85 percent of the water use

[31]Increased groundwater pumping may cause depth-to-water and thus pumping cost to increase over time. Water quality may also decline as depth-to-water increases. Both changes would negatively affect agriculture.

in our sample. However, policymakers may have special concerns about adverse affects on other sectors that warrant detailed examination.

We are unable to formally disentangle the effect of the drought from other confounding factors, but it appears highly likely that the changes in residential and public authority and institutional use were largely due to drought management policies. There is more uncertainty in how much of the commercial, industrial, and agricultural reductions were due to the drought, but it seems likely that the drought was a significant factor.

Table 3.15

Percent Change in Water Use Between 1990 and 1991 by Customer Class

Customer Class	Number of Agencies	Percent Change
Total Water Use	53	-12.4
Residential	40	-14.1
Single Dwelling Unit	25	-19.3
Multiple Dwelling Unit	22	-12.2
Commercial	37	-11.1
Industrial	28	-15.6
Public Authority/Institutional	33	-23.0
Agricultural	7	-24.8

Additional data collections and analyses might help to better isolate the drought from other factors. For example, data over a longer period of time on water use, wages and salaries, and the economy could be assembled, or more use could be made of variations in drought management strategies, wages and salaries, and economic conditions across the agencies responding to the survey.

Although we did not try to quantify the willingness-to-pay to avoid the drought, the results suggest that reductions by commercial and industrial users were translated much less than proportionately into changes in wages and salaries.[32] This raises the possibility that commercial and industrial cutbacks did not induce large willingness-to-

[32]Recall that between 1990 and 1991, commercial and industrial water use fell 12 percent and 15 percent respectively, while commercial and industrial wages and salaries fell 3 and 4 percent.

pay. Even though cutbacks in residential use were similar to those by commercial and industrial users, this does not necessarily suggest that residential effects were not large: residential cutbacks may have been far more painful than commercial and industrial cutbacks. More information on *how* the cutbacks were made by the various customer classes would help inform the determination of the magnitude of willingness-to-pay generated.

In the next section, we investigate the drought management strategies adopted by the responding water agencies. How these strategies varied by customer class will give us a better idea of what sectors were targeted by water agencies and which sectors would have been willing to pay a significant amount to avoid the drought management policies.

4. DROUGHT MANAGEMENT STRATEGIES

In this section we characterize the drought management strategies adopted by the responding agencies between 1986 and 1991. We start by describing agency water use reduction goals during the drought. We then examine agency restrictions on the quantity of water used, followed by restrictions on particular types of water use. We then turn to water conservation programs and changes in water pricing. Finally, we examine supply augmentation strategies, focusing on purchases from the 1991 Drought Water Bank run by the California Department of Water Resources.

WATER USE REDUCTION GOALS

A sizable majority of the water agencies responding to the survey set goals for reducing overall customer water use during the drought. Of the 85 respondents, 55 (65 percent) indicated that they set cutback goals at some point during the drought, and some of the others that did not answer this question may have developed goals as well. Few set goals at the beginning of the period. No agencies reported reduction goals in 1986 and 1987, but the number with reduction goals rose rapidly between 1988 and 1991 (see Table 4.1). Agencies in the Bay Area developed goals earlier than agencies in Southern California or other parts of the state (Rest of State). These patterns are consistent with the reductions in water use reported in Section 3 that suggested that drought impacts were concentrated in 1991 for Southern California and the Rest of the State but occurred earlier in the Bay Area.

The largest agencies in the sample began adopting cutback goals earlier than smaller agencies. This may have been because the largest agencies had more sophisticated planning departments, but it may also have been because a greater fraction of the largest agencies that responded to the survey were in the Bay Area (see Table 2.2). Further statistical work is needed to isolate the effect of agency size from other factors.[33]

---

[33]Another possibility is that smaller agencies we able to more easily increase groundwater pumping to offset reduced surface water

Table 4.1

Dates of Water Reduction Goals for Agencies that Specified Date of Goal (N=48)

	Survey Respondents	Number that Specified Goal	1986	1987	1988	1989	1990	1991
All	85	48	0	0	6	10	25	48
Region								
Bay Area	17	13	0	0	4	6	10	13
So. California	49	30	0	0	1	2	13	30
Rest of State	19	5	0	0	1	2	2	5
Population (thousands)								
10 to 50	25	13	0	0	1	2	6	13
50 to 100	30	16	0	0	1	3	9	16
> 100	30	19	0	0	4	5	10	19

On average, agencies who set water reduction goals in 1991 sought to reduce overall use 15 percent from 1989 levels (see Table 4.2). Agencies usually adjusted for growth in the number of accounts, so the desired cutback can be thought of as the desired cutback for each account, on average. The average reduction goal was lower in the Bay Area than either Southern California or the Rest of the State, but this may be because drought management strategies had already lowered 1989 use in many Bay Area agencies. Goals were somewhat lower in the largest agencies, but this may again be because a greater fraction of the largest agencies that responded are in the Bay Area, and, in any case, the difference is not large.

---

supplies than larger agencies. This conjecture, however, needs to be further examined.

Table 4.2

Water Reduction Goals in 1991
(Adjusted to 1989 Base Year)

	Number	Average Requested Cutback[a] (percent)	Minimum Requested Cutback[b] (percent)	Maximum Requested Cutback (percent)
All	42	15.1	-11.9	38.2
Region				
Bay Area	15	10.8	-0.2	21.9
So. Calif.	24	17.8	8.0	23.4
Rest of State	3	15.5	-11.9	38.2
Population				
10 to 50	12	16.7	8.0	21.0
50 to 100	13	16.1	-0.2	38.2
> 100	17	13.2	-11.9	23.0

[a]Simple average of responding agencies. In most cases agencies had in mind a cutback adjusted for growth in number of accounts.

[b]Some entries are negative because the requested cutbacks have been adjusted to a common base year (1989).

Table 4.3

1991 Water Reduction Goals by Customer Class in 1991
(N=10)

	Average Requested Cutback (percent)
Residential	19.9
Commercial	12.5
Industrial	10.8

Variation by Customer Class

Surprisingly, few agencies appear to have explicitly varied cutback goals by customer class. Cutback goals varied in only 12 of the 55 agencies reporting goals (22 percent). For the 10 agencies that both varied and reported cutback goals by customer class, cutback goals were substantially lower for commercial and industrial users than for residential users (see Table 4.3). Clearly some agencies were attempting to protect their commercial and industrial users from drought

management strategies, but our data suggests that only a minority did so explicitly. However, it may be the case that agencies that did not vary requested cutbacks by customer class used other policies to protect their commercial and industrial customers. For example, as will be discussed shortly, quantity restrictions may have been less stringent or easier to appeal for commercial and industrial users than residential users.

Table 4.4

Number and Proportion of Agencies Engaged in Various Drought Management Strategies

	Engaged in Activity (1)	Did Not Engage in Activity (2)	Did Not Answer Question (3)	Proportion answering who engaged in activity (1)/((1)+(2))	Lower bound on proportion engaged in activity (1)/Total Responding
Quantity Restrictions	40	16	29	71	47
Type-of-Use Restrictions	55	16	14	77	65
Conservation Programs					
Public education programs	73	3	9	96	86
Conservation kits	65	10	10	87	76
Water audits	25	44	16	36	29
Incentives for ULF toilets	23	50	12	32	27

QUANTITY RESTRICTIONS

A sizable proportion of the responding agencies adopted quantity restrictions at some point between 1986 and 1991. Of the 56 agencies answering the survey question on quantity restrictions, 40 (71 percent) reported that they issued quantity restrictions (see Table 4.4). The proportion may have been lower for agencies that did not answer the question, and the last column of Table 4.4 gives a lower bound on the proportion of agencies adopting quantity restrictions for all 85 responding agencies: it assumes that agencies that did not answer the

question did not implement quantity restrictions. This lower bound (47 percent) is undoubtedly an underestimate of the actual percent adopting quantity restrictions.

Most agencies expressed quantity allotments in terms of a percent reduction from a base year, although some expressed them as an absolute amount over some period of time (gallons per day per household, for example).

Table 4.5

Characteristics of Quantity Restrictions Between 1986 and 1991 (percent)

	Percent of Agencies with Quantity Restriction
Enforcement (N=33)	
Mandatory only	48
Vol. and man.	34
Voluntary only	18
Customer Class Targeted (N=40)	
Single-dwelling unit	90
Multiple-dwelling unit	83
Commercial	75
Industrial	67

Quantity restrictions were mandatory in most cases. The top half of Table 4.5 shows that 48 percent of the agencies with quantity restrictions adopted mandatory restrictions and that another 34 percent adopted a combination of voluntary and mandatory restrictions. In most cases the penalty for violating mandatory restrictions was a surcharge on all consumption above the allotment. The surcharge often rose with consumption over the baseline. The surcharge for use in an initial range over the allotment was frequently two or three times the normal unit cost of water, but it could go up to ten times the normal unit cost in some agencies for extremely high consumption. Penalties such as these result in an increasing block rate structure where the marginal cost of an additional unit of water depends on the amount consumed. In

these cases, quantity restrictions look much like changes in rate structures.

Rate surcharges were sometimes mixed with fines that did not necessarily depend on the amount of water consumed. These fines would increase with the number of violations, in many cases potentially culminating with installation of a flow restrictor or termination of water service. In some cases, fines alone were used and there was no surcharge on water use over the baseline.

Most agencies that adopted quantity restrictions set up a mechanism that could considerably soften the effect of quantity restrictions. Thirty-six of the 40 agencies (90 percent) reporting quantity restrictions set up an appeals process whereby customers could request that their quantity allotments be increased. For example, residential customers could make an appeal for medical reasons or if the number of family members had increased since the baseline period. Commercial and industrial customers could often make appeals if limiting use to their allotment would have meant a cutback in employment or output (Moore, Pint, and Dixon, p. 10).

Table 4.6

Exemptions from Quantity Restrictions Requested Between 1986 and 1991

	Number of Agencies	Exemptions Requested (1)	Accounts (2)	Percent of Accounts Requesting Exceptions
Residential	16	22,259	1,497,084	2
Single DU	10	13,994	1,062,123	1
Multiple DU	10	4,281	187,553	2
Commercial	16	8,748	141,702	6
Industrial	13	1,708	12,774	13
Public Authority	12	100	10,833	1
All Classes	19	43,466	1,067,323	4

Overall, only a small share of customers requested appeals. As shown in the last line of Table 4.6, 4 percent of customers requested exemptions, which were almost always granted (see last line of Table 4.7). As we will see shortly, a high percentage of customers were

assessed penalties for violating quantity restrictions, so the low percentage that requested exemptions is presumably not because the requested cutbacks were not binding. The low percentage presumably reflects fairly strict requirements to qualify for an exemption, although some customers may not have considered the time cost of applying for an exemption worth the expected decrease in the water bill.

Table 4.7

Exemptions from Quantity Restrictions Granted Between 1986 and 1991

	Number of Agencies	Exemptions Requested (1)	Exemptions Granted (3)	Percent of Requested Exemptions Granted
Residential	21	23,691	22,285	94
Single DU	17	17,604	16,471	94
Multiple DU	17	4,488	4,381	98
Commercial	21	8,773	8,006	93
Industrial	22	1,718	1,633	95
Public Authority	22	100	100	100
All Classes	21	199,105	184,101	93

It appears that violations of quantity restrictions were widespread and that a sizable share of customers were assessed penalties for violations. Of the 40 agencies that adopted restrictions, 34 (85 percent) assessed penalties for violations. As shown in Table 4.8, the number of penalties assessed was 55 percent of the number of accounts for the 13 agencies that were able to report both the number of penalties and the number of accounts. This suggests that roughly one-half of the customers in districts with mandatory quantity restrictions violated the quantity restrictions and were assessed penalties.[34] Violators also paid a sizable amount in penalties. The average penalty was approximately $40, generating over $24 million dollars just in the 13 agencies providing data (see Table 4.8).

[34]It is likely that there were some repeat violators (each billing period could produce a violation) so the percent of accounts penalized would have been lower than 55 percent.

Table 4.8

Number of Penalties and Surcharges Assessed for Quantity Restrictions in 1991 (N=13)

Number of Penalties	
Number assessed	614,343
Number of accounts	1,123,952
Number assessed/accounts	55
Surcharges Assessed	
Amount billed ($1000)	24,384
Number of penalties	603,874
Amount billed per penalty ($)	40.38

These high violation rates suggest real adverse impacts from quantity restrictions and imply that users would have been willing to pay a significant amount to avoid quantity restrictions. First, the sizable penalties were clearly a loss to consumers, although they were transferred to the water agencies and were not lost from a social perspective.[35] Second, the higher unit water costs created by the penalties would cause users to reduce the amount consumed and thus the net benefits generated. Finally, some users undoubtedly cut back use, and thus enjoyed fewer benefits of water use, in order to avoid penalties.[36]

Variation by Customer Class

There is evidence that water agencies attempted to shield their commercial and industrial users from severe economic damages during the drought. First, as shown in the bottom of Table 4.5, quantity restrictions were applied less frequently to commercial and industrial users than to residential users. Commercial and industrial users were issued quantity restrictions in 75 percent and 67 percent of agencies issuing quantity restrictions, respectively, compared with 90 and 83 percent for single-dwelling units and multiple-dwelling units. Second,

[35]They may have been partially used to subsidize conservation programs, a point which we return to below.

[36]The marginal value of water to users who did not incur penalties is presumably lower than that to users who did incur penalties, however.

the reduction goals were also lower for commercial and industrial accounts than residential accounts in some agencies (see Table 4.3), although as noted above, reduction goals did not vary by customer class for most agencies. Third, a higher percentage of commercial and industrial users requested and were granted exemptions from quantity restrictions than were residential users (see Tables 4.6 and 4.7). These three factors resulted in a lower proportion of agencies assessing penalties against commercial and industrial users than against residential users: in agencies that were able to report penalties for violations of quantity restrictions by customer class, 93 percent assessed penalties against residential users compared with 50 percent against commercial users and 36 percent against industrial users (see Table 4.9).

Table 4.9

Percent of Customer Classes Assessed Surcharges for Quantity Restrictions (N=14)

Residential	93
Commercial	50
Industrial	36
Public authority	36

Overall the findings suggest that quantity restrictions had widespread negative effects on residential users during the drought but that commercial and industrial users were spared to some extent. Two observations are worth making:

- The apparent protection of commercial and industrial users may explain why the changes in wages and salaries were much smaller than the change in water use. Commercial and industrial cutbacks that would have affected wages, salaries, and profits may have been largely avoided.
- The large drop in commercial and industrial use suggests that substantial reductions in commercial and industrial use were possible without major effects on wages and salaries. The effects on profits, however, still need to be explored.

TYPE-OF-USE RESTRICTIONS

A high proportion of the responding agencies adopted type-of-use restrictions at some time between 1986 and 1991. Examples included prohibitions on washing off driveways and sidewalks, irrigating during the day, and allowing water from sprinklers to run off into gutters. As shown in Table 4.4, between 65 and 77 percent of agencies adopted type-of-use restrictions. Most agencies adopted mandatory type-of-use restrictions. The top half of Table 4.10 shows that type-of-use restrictions were mandatory in 72 percent of the agencies reporting type-of-use restrictions and that an additional 12 percent adopted a combination of mandatory and voluntary restrictions. Only 16 percent adopted completely voluntary restrictions.

Table 4.10

Characteristics of Type-of-Use Restrictions Between 1986 and 1991 (percent, N=55)

	Percent of Agencies with Type-of-Use Restrictions
Enforcement	
Mandatory only	72
Vol. and man.	12
Voluntary only	16
Customer Class Targeted	
Single DU	96
Multiple DU	95
Commercial	95
Industrial	89

Even though a sizable proportion of agencies adopted mandatory type-of-use restrictions, only a few actually levied fines. In most cases the penalty for violating a mandatory type-of-use restriction was a fine that was not tied to water use. Penalties usually increased with each successive violation, culminating at least in principle in the installation of flow restrictors or termination of water service. Only 9 of the 46 agencies reporting mandatory type-of-use restrictions (20 percent) assessed penalties.

The fact that the few agencies that did levy penalties issued a sizable number of penalties ironically provides indirect evidence that type-of-use restrictions were not well enforced. Table 4.11 shows that the number of penalties assessed was 12 percent of the number of accounts in agencies levying penalties that were able to report this data. Twelve percent strikes one as substantial.[37] Because type-of-use restrictions and penalties were similar across agencies, it seems unlikely that there would have been a significant number of violations in only a small percentage of agencies, as found here. This seems to suggest, therefore, that type-of-use restrictions were not well enforced overall.

Table 4.11

Number of Penalties and Surcharges Assessed for Type-of-Use Restrictions in 1991

Number of Penalties (N=8)	
Number assessed	68,716
Number of accounts	582,604
Number assessed/accounts	12
Fines Assessed (N=5)	
Amount billed ($1000)	5,310
Number of penalties	68,674
Amount billed per penalty	77.00

Even though type-of-use restrictions were apparently not well enforced, consumers may still have been willing to pay a sizable amount to avoid them. Consumers may have obeyed the restrictions because of fears of penalties or social opprobrium even though the restrictions were not well enforced. Additional information on how frequently consumers altered consumption patterns because of type-of-use restrictions would help to determine how widespread welfare losses were from type-of-use restrictions during the drought.[38] The data from the

[37]Undoubtedly there were some repeat violators. How common these were, however, is not known.

[38]For example, one might estimate demand curves before and after the imposition of type-of-use restrictions and then calculate the change in consumer surplus.

water agency survey alone, however, do not provide strong evidence for substantial losses from type-of-use restrictions.

Variation by Customer Class

There is some evidence that agencies tried to protect commercial and industrial users from type-of-use restrictions. It is not as strong as the evidence for quantity restrictions, but given that type-of-use restrictions were not well-enforced overall, this is not surprising. The bottom half of Table 4.10 shows that type-of-use restrictions were applied equally to all customer classes. In contrast, it appears that penalties for violating type-of-use restrictions were issued more frequently against residential users than commercial and industrial users. All five agencies that were able to report type-of-use penalties by customer class assessed penalties against residential users, compared with only three against commercial users and two against industrial users. In summary, it appears that the already weak effect of type-of-use restrictions may have been further weakened for commercial and industrial users.

CONSERVATION PROGRAMS

As discussed in Section 2, voluntary conservation programs can reduce negative drought effects and can be categorized into two groups: education programs and device distribution programs. We first examine the education programs adopted during the drought.

Public Education Programs

Almost all agencies put in place some type of public education program between 1986 and 1991. Public education programs included bill inserts, television, radio, and newspaper announcements, school programs, and public displays. Seventy-three of the 76 agencies that answered the question on public education (96 percent) implemented some sort of public education program between 1986 and 1991 (see Table 4.4). At 86 percent, even the lower bound on the percent of agencies that implemented conservation programs remains high (see final column of Table 4.4). Individually-tailored education programs were far less common. Between 29 and 36 percent of the respondents conducted indoor

or outdoor water audits for customers to help them identify how they could cut back water use. These education programs may have provided valuable information on how to reduce water use with little loss in welfare and, as explained in Section 2, altered how much individuals were willing-to-pay to avoid drought management programs.

Device Distribution Programs

A high percentage of agencies established device distribution programs. As shown in Table 4.4, between 76 and 87 percent of the responding agencies distributed conservation kits. These kits typically contained low-flow shower heads, toilet dams, and toilet leak detectors and were distributed free of charge. Between 27 and 32 percent of the responding agencies offered financial incentives for ultra low-flush (ULF) toilets. ULF toilet programs typically provided a $100 rebate to the customer for every toilet installed that required no more than 1.6 gallons per flush.

Table 4.12

Expenditures on Conservation Programs (1986-1991)

	Number Engaged in Activity	Number of Agencies Reporting	Amount Spent ($1,000)	Number of Accounts (1,000s)	Dollars/ account
Public education	73	56	15,232	2,740	5.56
Conservation kits	65	47	10,782	2,420	4.45
Audits	25	7	2,696	1,605	1.67
ULF toilet rebates	23	19	22,924	974	23.54

Agencies spent considerable amounts on conservation programs. Table 4.12 shows the amount spent divided by the total number of accounts for agencies that could provide data on program expenditures. The most was spent per account on toilet rebates. Approximately $24 per account was spent on toilet rebates compared to $6 and $4 per account on public education and conservation kits, respectively. Relatively little was spent per account on water audits.[39] Even though a much smaller

[39]The results in Table 4.13 and 4.14 can be combined to determine the cost of conservation programs per unit. In case of ULF toilets, $23.54 was spent per account and .261 rebates were issued per account.

proportion of agencies had toilet rebate programs, the figure in Figure 4.12 suggests that, across all agencies, the most was spent on toilet rebates. The low amount spent per account and the relatively low proportion of agencies that offered audits suggests the least was spent on audits.[40]

Table 4.13

Conservation Program Activity per Account for Agencies Reporting Conservation Activity and Number of Accounts

	Number of Agencies	Number Performed or Issued	Number of Agencies	Number Performed or Issued per Account
Public Education	73	NA	NA	NA
Conservation Kits				
Residential	59	733,194	48	.223
Commercial	59	19,315	44	.046
Industrial	59	380	34	.002
Total	59	752,889	59	.315
Audits				
Residential	25	46,472	22	.026
Commercial	25	5,674	19	.036
Industrial	25	94	12	.004
Public Authority	25	126	16	.006
Total	25	52,366	24	.027
ULF Toilet Rebates				
Residential	10	192,172	7	.272
Commercial	10	9,296	7	.126
Industrial	10	10	6	.001
Public Authority	10	0	5	0
Total	10	201,478	10	.261

[a]Number of agencies upon which data is based.

The cost per rebate was approximately $90 ($23.54/.261). Conservation kits were approximately $14 per unit and water audits were approximately $62 per unit.

[40]As a rough approximation of the total amount spent by the responding agencies on each program, the amount spent for the reporting agencies (column 3 in Table 4.12) is scaled up to the number of agencies engaged in the activity (column 1).

Water agencies reached a considerable number of their customers with conservation programs during the drought. Table 4.13 shows that nearly 753,000 conservation kits were distributed in 59 of the 65 agencies that distributed conservation kits. This comes to nearly one-third of the total number of accounts. Similarly, ULF toilet rebates totaled 26 percent of the number of accounts in 10 of the 23 agencies that issued toilet rebates. These figures suggest that conservation programs may well have reduced the impact of the drought on water users.

The number of device distributions and audits per account also illustrate how much more could be done to mitigate the effects of quantity restrictions. Not only could the agencies with conservation programs reach a substantial number of additional customers,[41] but a substantial share of agencies have yet to adopt some programs. For example, only a minority of agencies had ULF toilet rebate programs. Whether agencies continue to push these programs and at what pace depends on the availability of resources. Whether it makes sense to continue to push these programs from a societal perspective, as opposed to the perspective of the device recipient, depends on the overall program benefits and costs.

Variation by Customer Class

It appears that conservation programs were targeted mainly at residential customers. Table 4.13 shows that the vast majority of conservation kits, water audits, and ULF toilet rebates went to residential users. Information on how agencies targeted public education programs was not readily available. Even when adjusted for the number of accounts in each customer class, residential users benefited disproportionately. For agencies that issued conservation kits, 0.22 kits were issued per residential account versus 0.05 per commercial account, and a negligible number per industrial account. The numbers are similarly skewed for ULF toilet rebates. The number of

[41]Individual customers may receive more than one conservation kit or ULF toilet rebate. Thus the percent of customers reached may be lower than the ratios in Table 4.14.

water audits per customer class is more uniform across customer classes, but the penetration rate was very low.

Agencies may have focused conservation kits, water audits, and ULF toilet rebates on residential users because they thought that their drought management programs had the greatest impact on residential users. Water agencies may also have assumed that commercial and industrial users had the resources and expertise to purchase conservation devices themselves.[42] For example, commercial and industrial users may have facilities managers who are explicitly tasked to reduce water costs. Additional data is necessary to determine whether commercial and industrial users installed conservation devices independently of agency programs.

PRICE CHANGES

Price increases may have been a major source of loss to consumers during the drought. Increasing prices will decrease the net benefit of consuming a given amount of water as well as reduce the amount consumed, further decreasing net benefits of water use. We find evidence that agencies increased water prices during the drought with consequent negative effect on consumers. Some of these changes would have happened had there been no drought, for example, due to increasingly strict drinking-water standards. Others may be directly attributed to the drought, for example, due to higher water purchase costs, the costs of device distribution and conservation programs, or the need to cover the same fixed costs with less water sold.

As discussed above, penalties for violations of quantity restrictions in effect created an increasing block rate pricing structure. Many agencies also changed their pricing practices independent of quantity penalties, usually to encourage conservation. Some went from flat to increasing block and some reduced the fixed component of bills and increased the variable costs. Survey respondents provided detailed information on how their rate structures changed, but

[42]Also the low-cost conservation devices commonly distributed to households, such as low-flow showerheads and toilet bags or dams, are frequently not relevant to business users. Business often have few or no showers and have flushometer toilets instead of tank toilets.

a full analysis of these data was beyond the scope of this project. Further analysis would provide valuable information on how consumers were affected by price changes.

We were able to analyze how average agency revenue per unit of water delivered changed over the period.[43] Changes in average revenue may either hide or exaggerate changes in price schedule due to the drought. Average revenue may not change if an agency moves to an increasing block rate structure but reduces fixed charges so that there is little change in average revenue. In contrast, increases in average revenue could simply reflect higher treatment costs thus exaggerating the impact of the drought on price.[44] In any case, it is instructive to look at how average revenue changed during the drought to gain some insight into how important price changes were and which sectors were most affected.

Table 4.14

Average Agency Revenue per af
(N=55)

	Total Water Use (millions of af)	Total Water Revenue (millions of dollars)	Average Revenue (dollars per af)	Annual Percent Change	
				Average Revenue	Real Average Revenue[a]
1986	2.09	795	381	---	---
1987	2.14	849	397	4.2	0
1988	2.11	906	430	8.3	3.7
1989	2.13	983	462	7.4	2.3
1990	2.12	1,069	505	9.3	4.0
1991	1.83	1,072	585	15.8	12.3

[a]Real average revenue calculated using consumer price index for California.

Average revenue rose 54 percent between 1986 and 1991 for the 55 agencies providing data (see Table 4.14). When adjusted for inflation,

[43]Average revenue per unit of water is calculated by dividing total agency revenue by water deliveries. Income from drought penalties and surcharges is included.

[44]An agency with a high fixed charge and low per unit price could also show an increase in average revenue if quantities fell but prices remained the same.

average revenue rose 2 and 4 percent in 1989 and 1990 and then rose approximately 12 percent in 1991. The large jump in 1991 suggests that the drought did cause large increases in price and that the observed price changes were not just the result in secular trends in, say, water treatment costs.

Table 4.15

Average Water Cost By Region, Agency Size, and Customer Class

		($/af)						Percent Change	
	N	1986	1987	1988	1989	1990	1991	1986-1990	1990-1991
All	55	381	397	430	462	505	585	33	16
Region									
Bay Area	11	409	405	471	476	514	683	26	33
So. California	30	385	408	436	484	529	576	37	9
Other	14	299	324	318	323	368	451	23	23
Agency Population (thousands)									
10--49	14	437	440	448	471	491	560	12	14
50--100	20	410	423	440	470	523	610	28	17
>100	21	374	391	427	460	504	582	35	15
Customer Class									
Residential	34	404	421	449	490	543	619	34	14
Commercial	31	378	395	453	496	533	618	41	16
Industrial	28	336	352	422	433	466	567	39	22
Agricultural	8	275	278	301	336	340	329	24	-3

Table 4.15 first reports how changes in average revenue per acre-foot varied by region and agency size. Average revenue grew fastest in Southern California between 1986 and 1990, but grew fastest in the Bay Area between 1990 and 1991. There was little difference in the change in average revenue between 1990 and 1991 by agency size, although average revenue grew faster in the larger agencies in the earlier years. Additional statistical analysis is necessary to determine whether the difference in cost growth can be attributed to agency size or location.

Variation by Customer Class

It appears that average revenue per acre-foot grew faster for commercial and industrial water sales than for residential sales both

between 1986 and 1990 and between 1990 and 1991.[45] These higher growth rates brought commercial and industrial average revenues closer to residential average revenue.

The difference in growth rates may be due to several factors. It may reflect rapid movement away from decreasing block rates for commercial and industrial users, something that largely had already happened for residential users. It may be that fixed charges account for a lower portion of industrial user bills so that comparable increases in the commodity charge for all customer classes result in a greater percentage increase in average cost for industrial customers.

It is unclear how much of the difference in growth rates was due to the drought. It may be that agencies would have attempted to narrow differences in average revenues across customer classes even if there had been no drought. In any case, the relatively rapid growth in commercial and industrial average revenue suggests, in contrast to previous findings in this section, that commercial and industrial users were not shielded from this aspect of drought management strategy.

Average revenues for agriculture grew far slower than those for other customer classes between 1986 and 1990 and actually fell between 1990 and 1991. What is more, the 1986 average cost for agriculture was substantially lower than for those in the other classes. These lower costs and growth rates may be because agricultural water is not treated to the same standards as water delivered to other customer classes or because agricultural service is often interruptible. Many urban water agencies do not have separate distribution systems for agricultural customers, however, so these findings may also suggest that agricultural users were treated favorably both before and during the drought.

Findings on changes in average revenue per acre-foot suggest that all sectors, with the exception of agriculture, were adversely affected by price changes caused by the drought.

---

[45]Since the number of agencies responding varies by customer class, care must be taken in interpreting differences in average revenue across customer classes. The same holds for growth rates in average revenue across customer classes over time, but the problem may be less significant.

SUPPLY AUGMENTATION STRATEGIES

More than half of the agencies responding to the survey received supplies from the 1991 Drought Water Bank run by the California Department of Water Resources. (A list of the urban agencies receiving water from the Bank and the amounts received is included as Appendix B.)[46] These supplies reduced drought impacts from what they would have been otherwise.

Water Bank purchases amounted to 5.3 percent of total 1991 water use in the 77 responding agencies that were able to provide data on water use (see Table 4.16). When attention is restricted only to those 43 responding agencies that purchased water-bank water, the percentage of water-bank water was correspondingly higher: nearly 10 percent of 1991 water use was purchased from the Bank. These percentages are sizable and suggest that the Bank generated sizable benefits in urban areas.

Table 4.16

1991 Water Bank Purchases

	Thousands of af		
	1991 Usage	Water Bank Purchases	Percent of Total
All respondents providing water use data (N=77)	2,760	147	5.3
All respondents providing water use data and receiving water-bank water (N=43)	1,546	147	9.5

[46]Many retail agencies were not aware that they had received water from the Drought Water Bank because bank water was purchased by wholesale agencies and commingled with other water supplies before it was passed on to the retail agencies. We contacted the purchasers of 1991 Drought Water Bank water and, in the case of the Metropolitan Water District of Southern California, another layer of wholesale agencies, to determine how bank supplies were allocated to retail water agencies (see Appendix B for details).

As shown in Table 4.17, 59 percent of the agencies receiving bank water had no alternate supplies. This suggests that in these agencies, water use would have dropped even more than it did in 1991 had there been no Bank. As reported in Section 2, per capita water use fell approximately 18 percent in the responding agencies between 1990 and 1991. This drop may have been 10 percentage points larger in agencies with no alternate water supplies. The remaining 41 percent of agencies had access to alternative water supplies. Presumably, these supplies were more expensive than the Bank, were of poorer quality, or were insurance against a sixth year of drought, and consumers in these districts were also better off as a result of the bank purchases.

Table 4.17

Availability of Alternative Supplies to Purchases of Water Bank Water
(N=22)

Alternate Supply Available	41
No Alternate Supply Available	59

Agencies receiving water-bank water were asked how their drought management strategies would have changed had there been no Bank. Their responses provide further evidence that the Bank benefited urban consumers. As shown in Table 4.18, almost all the agencies that received bank water and answered the question said they would have tightened quantity restrictions had there been no Bank. Sixty percent would have strengthened type-of-use restrictions and one-third would have increased prices. Agencies would also have tried to reduce water use by expanding conservation programs, with increased public education the most frequently mentioned.

Table 4.18

Drought Management Strategies that Would Have Been Modified in the Absence of Water Bank Water (15 Respondents)

Type of Policy	Percent Indicating
Quantity restrictions	87
Public education	67
Type-of-use restrictions	60
Device distribution	33
Price increases	33
Water audits	20
Conservation rebates	13

SUMMARY

Investigation of drought management strategies suggests that the drought had widespread negative effects in urban areas, with the principal effects in 1991. The main source of losses appears to have been due to quantity restrictions that were usually coupled with price surcharges for use over a target amount. Evidence suggests that commercial and industrial users were shielded from the drought effects to some extent, although they appear to have suffered price increases much like the residential sector.

Water agencies aggressively implemented device distribution, toilet rebate, and public education programs during the drought. These programs presumably reduced the drought's negative effects. Residential users were the main beneficiaries of these programs. This might be interpreted as evidence that residential users were hardest hit by the drought, leading agencies to focus attention on them.

Finally, the 1991 Drought Water Bank was an important source of water to many agencies. A majority of those receiving water had no alternate sources which suggests that drought effects would have been considerably worse without the Bank.

5. CONCLUSION

The 1986-1992 Drought caused most urban water agencies to adopt policies to reduce water consumption in their service areas. These policies determined how much customers reduced water use. The losses caused by these reductions are important because they should enter into decisions on how to allocate water among competing uses and whether or not to invest in new water projects.

The maximum amount that water users would have been willing to pay to avoid drought management policies appears to be a useful measure of the losses caused by the drought. The drought generates willingness-to-pay to avoid the need for drought policies both by affecting residential use as well as the wages, salaries, and profits generated by businesses.

This report did not attempt to quantify the willingness-to-pay; rather, it presents the results of a survey of urban water agencies to provide the background information needed for future studies that do attempt this quantification.[47] The data presented in this report suggests when and where the drought effects were most severe and how the effects were distributed across customer classes.

It proved very difficult to collect the information needed to characterize drought effects. A lengthy survey instrument was required and the response rate was low. Many agencies were only able to partially fill out the survey. Our experience illustrates how difficult, and expensive, it currently is to do detailed analyses of drought situations and probably explains why such analyses have not been done more frequently in the past. Urban water agencies may want to consider improving their data collection and reporting programs to gain valuable information for managing future water supply shortages.

Data provided by the 85 urban water agencies responding to the survey suggested that drought effects were felt primarily in 1991. Effects may well have persisted into 1992, but we were only able to

[47]A forthcoming report will include a pilot analysis of residential willingness-to-pay.

collect data through 1991. Evidence suggests, however, that drought effects in urban areas subsided somewhat in 1992.

It appears that the negative effects of the drought were widespread in 1991. A significant number of customers violated quantity restrictions and a paid a sizable amount in fines and rate surcharges. Our findings suggest that effects were focused in the residential sector which suffered nearly a 20 percent cutback in 1991 water use per capita relative to 1986. Given that residential use accounts for approximately two-thirds of overall water use, this suggests that studies to quantify aggregate drought effects should focus on the residential sector.

Water use also declined substantially in the commercial and industrial sectors (15 percent and 20 percent, respectively, between 1986 and 1991). This is particularly surprising because the survey responses suggest that these sectors were shielded to some extent from drought management policies. Shielding commercial and industrial users from drought management policies implies wages, salaries, and profits were not substantially affected by the drought, even though there were likely certain subsectors of the economy, such as the landscaping industry, where the effects were significant.[48] The large reduction in water use also suggests that commercial and industrial users may have been able to absorb relatively large cutbacks without substantial cuts in wages, salaries, and profits.

The changes in water use and measures of economic activity reported here are due not only to the drought but also to a number of other factors. The economic recession that hit California toward the end of 1990 most likely had an important effect on water use and economic activity. The drought was probably the overriding factor explaining reductions in residential water use, but the importance of the drought relative to other factors for commercial and industrial sectors is less clear.

---

[48]Note that depressed activity during the drought may possibly be compensated for by greater activity than normal after the drought.

NEXT STEPS

A more structured analysis to isolate drought effects in all sectors is necessary. One way to do this is to correlate differences in water cutbacks in a particular region with changes in economic activity. For example, variations in water supply conditions across the Bay Area, the Los Angeles area, and Sacramento might be used to isolate drought effects. Examining changes in commercial and industrial water use, wages and salaries, and profits during past recessions would also be helpful. The data collected for this study could be the starting point for such analyses.

The data collected here could also be used in studies that attempt to quantify the willingness-to-pay. If surveys were used to directly elicit the willingness-to-pay, the data collected here could be used to create realistic scenarios of likely drought consequences for the respondent to consider. Data on penalties paid and increased water costs could possibly be used to provide a lower bound on the willingness-to-pay.

Finally, the data collected here could also be used as the basis for a study of the effectiveness of drought management strategies. This may be of particular interest to urban water agencies as they plan for the next drought.

Appendix

A. SURVEY INSTRUMENT

A copy of the key portions of the survey instrument sent to urban water agencies follows in this appendix. In order to save space, we photoreduced the survey and omitted section title pages and pages containing only general directions. We also have not included pages that differ only in that they collect data for different years. We have noted where such pages are excluded. The actual survey instrument is available from the authors.

1) For the years 1986 - 1991 what were your total Water Agency Revenues in thousands of dollars from the following revenue sources? Include drought penalties or surcharges. If revenues from each customer type are not available, please provide as detailed a breakdown as possible and indicate how the customer types are aggregated. (If you can provide a breakdown only by meter size, please call RAND and we will provide an alternative survey format.)

Water Agency Revenues

CUSTOMER TYPE	01/01/86 - 12/31/86 (In thousands)	01/01/87 - 12/31/87 (In thousands)	01/01/88 - 12/31/88 (In thousands)	01/01/89 - 12/31/89 (In thousands)	01/01/90 - 12/31/90 (In thousands)	01/01/91 - 12/31/91 (In thousands)
Residential						
Single Dwelling Unit	$	$	$	$	$	$
Multiple Dwelling Unit	$	$	$	$	$	$
OR Total Residential	$	$	$	$	$	$
Commercial	$	$	$	$	$	$
Industrial	$	$	$	$	$	$
Public Authority/Institutional	$	$	$	$	$	$
Agriculture/Horticulture	$	$	$	$	$	$
Resale/Wholesale	$	$	$	$	$	$
Other (please specify)						
_____	$	$	$	$	$	$
_____	$	$	$	$	$	$
WATER SERVICES (e.g., ground water replenishment, fire protection, etc.)	$	$	$	$	$	$
All Other Sources of Revenue (e.g., tax, hydropower, etc.)	$	$	$	$	$	$
TOTAL OPERATING REVENUES (in thousands)	$	$	$	$	$	$

2) How many retail accounts did you have at the end of these calendar years for the following customer types? If numbers of accounts for each customer type are not available, indicate how the customer types are aggregated.

Number of Retail Accounts by Customer Class

CUSTOMER TYPE	December 31, 1986	December 31, 1987	December 31, 1988	December 31, 1989	December 31, 1990	December 31, 1991
Residential						
Single Dwelling Unit						
Multiple Dwelling Unit						
OR Total Residential						
Commercial						
Industrial						
Public Authority/Institutional						
Agriculture/Horticulture						
Resale/Wholesale						
Other (please specify)						
_____						
_____						
Total Retail Accounts						
Total Estimated Population in Retail Area						
Total Estimated Population in Wholesale Area, If Applicable						

If you answered this question, go to Question 4.

3) How many retail accounts did you have at the end of these calendar years for the following meter sizes?

Number of Retail Accounts by Meter Size

METER SIZE	December 31, 1986	December 31, 1987	December 31, 1988	December 31, 1989	December 31, 1990	December 31, 1991
3/4 inch and less						
1 inch						
1 1/2 inch						
2 inch						
3 inch						
4 inch						
6 inch						
8 inch						
10 inch						
12 inch						
> 12 inch						
Total Retail Accounts						
Total Estimated Population in Retail Area						
Total Estimated Population in Wholesale Area, If Applicable						

4) For each meter size, what was the <u>percentage of accounts</u> in each customer type in 1991?

	Percent of Meters in 1991					
	Residential		Commercial	Industrial	All Other	Total
Meter Size	Single family	Multiple family				
5/8 x 3/4 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
3/4 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
1 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
1-1/2 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
2 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
3 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
4 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
6 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
8 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
10 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %
12 in.	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % +	☐☐ % =	100 %

5) How much water did your agency obtain from each of your water sources in 1986 and 1991, and what were the source of supply or pumping cost per unit and treatment cost per unit (if applicable)? For agency owned sources, exclude depreciation and capital recovery costs.

Please specify units (e.g., CCF, HCF, AF, MG, Thou. Gal.): _____

Amount and Cost of Water

WATER SOURCES	January 1, 1986 - December 31, 1986			January 1, 1991 - December 31, 1991		
	Amount	Source of Supply / Pumping Cost Per Unit	Treatment Cost Per Unit (if Applicable)	Amount	Source of Supply / Pumping Cost Per Unit	Treatment Cost Per Unit (if Applicable)
Agency Owned Water						
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
Purchased Water						
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
Recycled Water						
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
Other (please specify)						
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
_____	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐	☐☐☐,☐☐☐	$☐☐.☐☐	$☐☐.☐☐
TOTAL WATER SUPPLY	☐,☐☐☐,☐☐☐			☐,☐☐☐,☐☐☐		

6) For the years 1986 - 1991 what were your quarterly water sales for the following customer classes? (If you can provide a breakdown only by meter size, please call RAND and we will provide you with an alternative survey format.)

How frequently are meters read?: _____

Please specify units (eg. CCF, HCF, AF, MG, Thou. Gal.): _____

Quarterly Water Sales From Meter Reads 1986

CUSTOMER TYPE	01/01/86 - 03/31/86	04/01/86 - 06/30/86	07/01/86 - 09/31/86	10/01/86 - 12/31/86
Residential				
Single Dwelling Unit				
Multiple Dwelling Unit				
OR Total Residential				
Commercial				
Industrial				
Public Authority/Institutional				
Agriculture/Horticulture				
Resale/Wholesale				
Other (please specify)				
_____				
_____				
Total Water Delivered				
Unaccounted for Water (Losses)				
Water Self-Supplied by Customers (e.g., pumped ground water)				

NOTE: This page was repeated for years 1987 to 1991.

7) Please indicate what public education programs were implemented and how much was spent on these programs per year (including both external and staff costs).

☐ No public education programs (GO TO NEXT PAGE)

Public Education Programs

Type of Program (please check)	1986	1987	1988	1989	1990	1991
Bill insert	☐	☐	☐	☐	☐	☐
TV	☐	☐	☐	☐	☐	☐
Radio	☐	☐	☐	☐	☐	☐
Newspaper	☐	☐	☐	☐	☐	☐
School Programs	☐	☐	☐	☐	☐	☐
Public displays	☐	☐	☐	☐	☐	☐
Other (please specify) _____	☐	☐	☐	☐	☐	☐
_____	☐	☐	☐	☐	☐	☐
Amount Spent	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐

8. Please indicate the number of water audits conducted, if applicable, and total spending in each year.

☐ No water audits (GO TO NEXT PAGE)

Number of Water Audits

Customer Class	1986	1987	1988	1989	1990	1991
Residential						
Both Indoor and Outdoor	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Indoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Outdoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Commercial						
Both Indoor and Outdoor	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Indoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Outdoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Industrial						
Both Indoor and Outdoor	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Indoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Outdoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Public Authority/Institutional						
Both Indoor and Outdoor	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Indoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Outdoor Only	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Large Turf Area	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐	☐,☐☐☐
Total Amount Spent	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐	$ ☐☐☐,☐☐☐

9) Please indicate the number of conservation kits or water saving devices distributed each year, the items included in these kits, and the total amount spent on the kits and their distribution in each year, not including ULF programs.

☐ No conservation kits or water saving devices distributed (GO TO NEXT PAGE)

Number of Conservation Kits

Type of Kits by Customer Class	1986	1987	1988	1989	1990	1991
Residential						
_____	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐
_____						
_____						
Commercial						
_____	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐
_____						
_____						
Industrial						
_____	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐
_____						
_____						
Other						
_____	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐	☐☐☐,☐☐☐
_____						
_____						
Did you have a follow-up program to determine whether customers installed the kits?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Did you offer installation services?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Total Amount Spent for Purchase, Distribution, and Installation of the Kits by Your Agency	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐

10a) If you had conservation incentive programs for water-saving devices, please indicate the dollar amount of the incentive, the number of rebates issued to each customer type, and the total amount spent on the program by year. If you need more space please xerox additional copies.

☐ No conservation incentive programs for water saving devices (GO TO PAGE 23)

Conservation Incentive Programs

	1986	1987	1988	1989	1990	1991
ULTRA LOW FLUSH TOILETS						
Amount of Rebate or Value of Incentive Per Toilet	$☐☐☐	$☐☐☐	$☐☐☐	$☐☐☐	$☐☐☐	$☐☐☐

Number of Rebates Issued
(count one per toilet)

Customer Class						
Residential						
Single Dwelling Unit	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
Multiple Dwelling Unit	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
OR Total Residential	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
Commercial	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
Industrial	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
Public Authority / Institutional	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
All Other	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐	☐☐,☐☐☐
Total Amount Spent on Toilet Rebate Programs per Year	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐	$☐☐☐,☐☐☐

Conservation Incentive Programs (continued)

10b. OTHER REBATE OR INCENTIVE ITEM (please describe): _____

Amount of Rebate or Value of Incentive	$	$	$	$	$	$

Number of Rebates Issued

Customer Class						
Residential						
Single Dwelling Unit						
Multiple Dwelling Unit						
OR Total Residential						
Commercial						
Industrial						
Public Authority / Institutional						
All Other						
Total Amount Spent on Other Rebate/Incentive Programs Per Year	$	$	$	$	$	$

11) If your agency implemented restrictions on type of use between 1986 - 1991, please indicate the type of restriction (e.g., no watering of hard surfaces), the type of customers affected, whether restrictions were voluntary or mandatory, the dates effective, and penalties for violations. Please start a new line for each change in restrictions.

☐ No restrictions on type of use (GO TO NEXT PAGE)

Restrictions On Type Of Use (Please Specify)	Type of Customers Effected: Residential Single DU	Residential Multiple DU	Comm.	Ind.	Other	Voluntary	Mandatory (Please use separate line if this varied by customer class.)	Dates Effective	Describe any Penalties or Enforcement Activities
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	

12) If your agency implemented restrictions on quantities used, please indicate the type of restriction (e.g., fixed amount per household per month, percentage cutback from specified base year), the type of customers affected, whether restrictions were voluntary or mandatory, the dates effective, and penalties for violations. Please start a new line for each change in restrictions.

☐ No restrictions on quantities used (GO TO NEXT PAGE)

Restrictions On Quantities Use (Please specify, including base year, if applicable)	Type of Customers Effected: Residential Single DU	Residential Multiple DU	Comm.	Ind.	Other	Voluntary	Mandatory (Please use separate line if this varied by customer class.)	Dates Effective	Describe any Penalties or Enforcement Activities
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	
	☐	☐	☐	☐	☐	☐	☐	to	

13a) If your agency had surcharges or penalty rates for exceeding base quantity allocations assessed as part of the customer's water bill, please indicate the number of customers penalized and total penalties billed by customer type.

☐ No surcharge or penalty rates for exceeding base quantity allocations (GO TO NEXT PAGE)

Number of Customers Assessed Surcharges

Customer Type	1986	1987	1988	1989	1990	1991
Residential						
Single Dwelling Unit						
Multiple Dwelling Unit						
OR Total Residential						
Commercial						
Industrial						
Public Authority/ Institutional						
All Other						

Surcharges Billed (in Thousands)

Customer Type	1986	1987	1988	1989	1990	1991
Residential						
Single Dwelling Unit	$	$	$	$	$	$
Multiple Dwelling Unit	$	$	$	$	$	$
OR Total Residential	$	$	$	$	$	$
Commercial	$	$	$	$	$	$
Industrial	$	$	$	$	$	$
Public Authority/Institutional	$	$	$	$	$	$
All Other	$	$	$	$	$	$
Total Surcharges Billed (in thousands)	$	$	$	$	$	$

13b) If your agency issued citations or otherwise enforced penalties for use restrictions (such as watering of hard surfaces), please indicate the number of customers penalized, total penalties billed by customer type, and the total yearly enforcement costs.

☐ No enforced penalties for use restrictions (GO TO NEXT PAGE)

Number of Customers Assessed Penalties

Customer Type	1986	1987	1988	1989	1990	1991
Residential						
Single Dwelling Unit						
Multiple Dwelling Unit						
OR Total Residential						
Commercial						
Industrial						
Public Authority/ Institutional						
All Other						

Penalties Billed (in Thousands)

Customer Type	1986	1987	1988	1989	1990	1991
Residential						
Single Dwelling Unit	$	$	$	$	$	$
Multiple Dwelling Unit	$	$	$	$	$	$
OR Total Residential	$	$	$	$	$	$
Commercial	$	$	$	$	$	$
Industrial	$	$	$	$	$	$
Public Authority/Institutional	$	$	$	$	$	$
All Other	$	$	$	$	$	$
Total Penalties Billed (In thousands)	$	$	$	$	$	$
Cost of Enforcement (In thousands)	$	$	$	$	$	$

14a) If your agency granted exemptions or appeals for water quantity or use restrictions between 1986 and 1991, please indicate the number of exemptions/appeals requested (R) and granted (G) for each customer type.

☐ No exemptions/appeals requested or granted (GO TO 14c)

Exemptions / Appeals Requested (R) and Granted (G)

	1986		1987		1988		1989		1990		1991	
CUSTOMER TYPE	R	G	R	G	R	G	R	G	R	G	R	G
Residential												
Single Dwelling Unit												
Multiple Dwelling Unit												
OR Total Residential												
Commercial												
Industrial												
Public Authority/Institutional												
Other (please specify) _____												
_____												

14b) What were the most common reasons for granting exemptions or appeals?

_____

_____

_____

_____

14c) What methods of appeal were available to customers?

_____

_____

_____

_____

15a) For the period 1986-1991, please indicate your requested percentage cutbacks in water use including the base year, effective dates, and every change in requested cutbacks thereafter.

Requested Water Use Cutbacks

	Dates In Effect ☐☐/☐☐/☐☐ to ☐☐/☐☐/☐☐	Dates In Effect ☐☐/☐☐/☐☐ to ☐☐/☐☐/☐☐	Dates In Effect ☐☐/☐☐/☐☐ to ☐☐/☐☐/☐☐	Dates In Effect ☐☐/☐☐/☐☐ to ☐☐/☐☐/☐☐	Dates In Effect ☐☐/☐☐/☐☐ to ☐☐/☐☐/☐☐
Base Year	19☐☐	19☐☐	19☐☐	19☐☐	19☐☐
Overall Reduction Goal	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %

15b) If the base year was adjusted for growth and/or climate, please indicate how this was calculated.

_____

_____

15c) If reduction goals varied by customer type, please indicate the goals for each of the following customer types:

☐ Reduction goals did not vary by customer type (GO TO NEXT PAGE)

CUSTOMER TYPE					
Residential					
Single Dwelling Unit	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Multiple Dwelling Unit	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
OR Total Residential	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Commercial	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Industrial	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Public Authority/Institutional	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Resale/Wholesale	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %
Other (please specify)					
_____	☐☐ %	☐☐ %	☐☐ %	☐☐ %	☐☐ %

16) Please list your monthly service charge for the following meter sizes on January 1, 1986 and for every change in rates thereafter. If monthly service charge varies by customer class, please provide rate schedules.

Monthly Service Charge

METER SIZE	1/01/86	Date of Change ☐☐/☐☐/☐☐	Date of Change ☐☐/☐☐/☐☐	Date of Change ☐☐/☐☐/☐☐	Date of Change ☐☐/☐☐/☐☐	Date of Change ☐☐/☐☐/☐☐
5/8 x 3/4 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
3/4 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
1 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
1-1/2 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
2 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
3 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
4 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
6 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
8 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
10 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐
12 in.	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐	$☐☐.☐☐

17) If your monthly service charge includes a quantity allowance, please list your monthly quantity allowance on January 1, 1986 and for every change in allowance thereafter. If monthly quantity allowance differs by customer class, please provide rate schedules.

Please specify units (e.g., CCF, HCF, AF, MG, Thou. Gal.): _____

☐ Not Applicable (GO TO NEXT PAGE)

Monthly Quantity Allowance

METER SIZE	01/01/86	Date of Change	Date of Change	Date of Change	Date of Change	Date of Change
5/8 x 3/4 in.						
3/4 in.						
1 in.						
1-1/2 in.						
2 in.						
3 in.						
4 in.						
6 in.						
8 in.						
10 in.						
12 in.						

18) Please indicate your water rates by customer type on January 1, 1986 and for every rate change thereafter. If the sizes of the blocks change or you have summer and winter rates, please begin a new section if necessary. Please xerox additional sheets if your rates changed more than once a year.

Please specify units (e.g., CCF, HCF, AF, MG, Thou. Gal.): _____

Water Rates By Customer Type

Customer Type (please specify)	As of 01/01/86	Date of Change	Date of Change	Date of Change	Date of Change	Date of Change
_____	Dollars Per Unit					
Block 1 (e.g., 0-500 cu. ft.) Specify: _____	$	$	$	$	$	$
Block 2 Specify: _____	$	$	$	$	$	$
Block 3 Specify: _____	$	$	$	$	$	$
Block 4 Specify: _____	$	$	$	$	$	$

Customer Type (please specify)	As of 01/01/86	Date of Change	Date of Change	Date of Change	Date of Change	Date of Change
_____	Dollars Per Unit					
Block 1 (e.g., 0-500 cu. ft.) Specify: _____	$	$	$	$	$	$
Block 2 Specify: _____	$	$	$	$	$	$
Block 3 Specify: _____	$	$	$	$	$	$
Block 4 Specify: _____	$	$	$	$	$	$

19a) Do you know of any urban drought impact studies about your service area?

☐ Don't Know (GO TO 19b)

Group	Study

19b) Please describe any serious concerns expressed by residential, commercial, or industrial users over water supply availability and/or quality during the drought.

☐ Don't Know (GO TO NEXT PAGE)

Group	Concern

20a) If the Drought Water Bank had not been created in 1991, we estimate that your surface water supplies would have been cut by:

☐,☐☐☐

What alternative sources of supply could have been used?

☐ No alternative supplies (GO TO 20b AND ENTER "0" FOR TOTAL ALTERNATIVE WATER SUPPLIES)

Source	Alternative Water Supplies (Acre-feet)	Cost / Acre-foot *
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐
	☐,☐☐☐	$☐,☐☐☐

20b) ☐,☐☐☐ - ☐☐☐,☐☐☐ = ☐☐☐,☐☐☐

Water Bank Water Provided — *Total Alternative Water Supplies* — *Additional Cutbacks Needed*

* Please use same definition of cost as in Question 4.

20c) How would the additional cutbacks have been distributed by customer type?

☐ Cutbacks would have been spread proportionally among users (GO TO 20d)

Customer type	Water Cutback (Acre Feet)
Residential	
Single Dwelling Unit	☐,☐☐☐
Multiple Dwelling Unit	☐,☐☐☐
OR Total Residential	☐,☐☐☐
Commercial	☐,☐☐☐
Industrial	☐,☐☐☐
Public Authority / Institutional	☐,☐☐☐
Agriculture / Horticulture	☐,☐☐☐
Resale/Wholesale	☐,☐☐☐
Other (please specify)	
	☐,☐☐☐
	☐,☐☐☐
TOTAL CUTBACKS	☐☐☐,☐☐☐

NOTE: AMOUNTS SHOULD BE EQUAL

20d) If you had not received [ ] from the Drought Water Bank water in 1991, how would your drought management stages/policies have changed (e.g. what additional phases of your drought management plan would have gone into effect)?

Stages/Policies	Changes	Please check customer type(s) the policy would have applied to: Residential	Commercial	Industrial	Other
Public Education		☐	☐	☐	☐
Water Audits		☐	☐	☐	☐
Device Distribution		☐	☐	☐	☐
Conservation Rebates		☐	☐	☐	☐
Use Restrictions		☐	☐	☐	☐
Quantity Restrictions		☐	☐	☐	☐
Price Increases		☐	☐	☐	☐
Other (please specify) _____ _____		☐ ☐	☐ ☐	☐ ☐	☐ ☐

B. SURVEY RESPONDENTS

The 85 urban retail water agencies that responded to the survey are listed below. They are grouped by location.

San Francisco Bay Area

Marin Municipal Water District
Great Oaks Water Company
San Jose Water Co.
City of Hayward
City of Daly City
City of Milpitas
North Coast County Water District
Contra Costa Water District
Alameda County Water District
East Bay Municipal Utility District
City of San Francisco
California Water Service
- Bear Gulch
- San Mateo
- Livermore
- San Carlos
- Los Altos
City of Santa Clara

Southern California

City of Westminster
El Toro Water District
Yorba Linda Water District
City of Garden Grove
Mesa Consolidated Water District
City of Huntington Beach
City of Buena Park
City of Long Beach
City of Manhattan Beach
Montebello Land and Water Co.
City of Corona
City of Redlands
City of Port Hueneme
City of Inglewood
Las Virgenes Municipal Water District
Quartz Hill Water District
City of Riverside
Jurupa Community Service District
Hesperia Water District
City of Glendale
Palmdale Water District
City of West Covina
Desert Water Agency
Hi-Desert Water District
City of Pico Rivera
City of Torrance
Park Water Company
City of Anaheim
City of Newport Beach
Ventura County WW #8
Padre Dam Municipal Water District
Santa Fe Irrigation District
Sweetwater Authority
City of Poway
Olivenhain Municipal Water District
San Dieguito Water District
Los Angeles Department of Water and Power
City of San Diego
California Water Service
-Westlake District
-East Los Angeles
-Palos Verdes
-Hermosa Redondo
California American
-Baldwin Hills
-Coronado
-Village
City of Burbank
Lincoln Av. Water Co.
Laguna Beach Water Co.
Vallecitos Water District

Rest of the State

City of Bakersfield
Tahoe City Public Utility District
Citrus Heights Irrigation District
Northridge Water District
City of Santa Barbara
Goleta Water District
City of Tulare
San Juan Suburban Water District
City of Merced
Elk Grove Water District
City of Manteca
City of Fresno
City of Santa Cruz
City of Fairfield
California Water Service
-Bakersfield
-Salinas
-Stockton
-Visalia District
California American-Monterey

C. DISTRIBUTION OF 1991 DROUGHT WATER BANK PURCHASES

Estimates of the water received from the 1991 Drought Water Bank by individual water agencies are listed below. The amounts obtained by the 12 direct purchasers (numbered 1 through 12 below) were obtained from the California Department of Water Resources (California Department of Water Resources, 1992, p. 6). Of these 12 agencies, five (City of San Francisco, Alameda County Flood Control & Water Conservation District, Santa Clara Valley Water District, Kern County Water Agency and the Metropolitan Water District of Southern California) passed on some share of Water Bank purchases through wholesale deliveries to other agencies. Usually, the resale of Water Bank supplies was not recorded separately from other wholesale deliveries, although there were a few exceptions where agencies or individual customers requested Water Bank supplies through the wholesale agencies. Therefore, we distributed Water Bank deliveries among the second tier of agencies in proportion to total wholesale water deliveries to those agencies in 1991 by the original purchaser of Water Bank water.

We obtained figures on 1991 wholesale water deliveries by contacting each of the five agencies, and in the case of Metropolitan Water District of Southern California (MWDSC), we contacted an additional layer of 12 wholesale water districts operating as middlemen between MWDSC and retail water agencies. In some cases, we were unable to obtain the complete names of the retail water agencies who received water bank supplies (these names are indicated by a question mark); in the case of the City of San Francisco, we obtained delivery figures for the set of agencies in the survey sample and estimated deliveries to the remainder of San Francisco's wholesale customers.

1991 Drought Water Bank – Buyers

Water Agency	Acre Feet
1. American Canyon County Water District	370
2. City of San Francisco (50,000 af total)	
Own retail customers	16,698
Alameda County Water District	2,150
Belmont County Water District[a]	794
City of Brisbane[a]	127
Guadeloupe Valley Municipal Improvement District[a]	23
City of Burlingame	903
California Water Service Company – Bear Gulch	2,063
California Water Service Company – San Carlos	801
California Water Service Company – San Mateo	2,492
California Water Service Company – South San Francisco[a]	1,556
Coastside County Water District[a]	451
East Palo Alto Water District[a]	408
City of Daly City	644
Estero Municipal Improvement District (Foster City)[a]	823
City of Hayward	3,463
Town of Hillsborough	614
Los Trancos County Water District (Portola Valley)[a]	26
City of Menlo Park[a]	410
City of Millbrae[a]	672
City of Milpitas	1,936
City of Mountain View	2,133
North Coast County Water District	658
City of Palo Alto	2,595
Purissima Hills Water District (Los Altos Hills)	307
City of Redwood City	2,084
City of San Bruno	413
City of Santa Clara[a]	2,488
Skyline County Water District (Woodside)[a]	47
Stanford University[a]	64
City of Sunnyvale	1,798
Westborough Water District (South San Francisco)[a]	359
3. Contra Costa Water District	6,717
4. Alameda County Water District	14,800
5. Alameda County Flood Control & Water Conservation District (500 af total)	
California Water Service Company–Livermore	137
City of Livermore	65
City of Pleasanton	234
Dublin–San Ramon Service District	64

[a]Estimated share of Drought Water Bank supplies based on relative number of service connections (covers 16% of total). Other figures were compiled by the San Francisco Water Department based on shares of water deliveries.

6. Santa Clara Valley Water District (19,500 af total)	
California Water Service Company—Los Altos	1,175
City of Cupertino	270
Great Oaks Water Company	1,060
City of Mountain View	284
City of San Jose	1,055
San Jose Water Company	12,063
City of Santa Clara	1,973
City of Sunnyvale	1,620
7. Oak Flat Water District	975
8. Westlands Water District	13,820
9. Dudley Ridge Water District	13,805
10. Kern County Water Agency (53,997 af total)	
Berrenda Mesa Water District	47,000
Lost Hills Water District	5,997
Belridge Water Service District	1,000
11. Crestline – Lake Arrowhead Water Agency	236
12. Metropolitan Water District of Southern California (215,000 af total)	
City of Anaheim	2,597
City of Beverly Hills	1,304
City of Burbank	1,957
City of Compton	417
City of Fullerton	758
City of Glendale	2,470
Las Virgenes Municipal Water District	1,937
City of Long Beach	3,802
City of Los Angeles	30,703
City of Pasadena	1,965
City of San Fernando	70
City of San Marino	78
City of Santa Ana	2,002
City of Santa Monica	552
City of Torrance	1,750
Calleguas Municipal Water District (2,014 af from MWDSC)	
Brandeis (?)	1
California American Water Company – Village	129
City of Camarillo	29
Camrosa Water District	800
Caypart (?)	2
Crestview Mutual Water Company	2
Lakeshore (?)	2
Metropolitan Water Company	30
City of Oxnard	135
Pleasant Valley Mutual Water Company	3

NOTE: (?) denotes that we were unable to obtain complete name of retail agency.

Calleguas MWD (continued)	
Russell Valley Municipal Water District	76
Southern California Water Company – Simi Valley	67
City of Thousand Oaks	86
Ventura County Waterworks District #1 (Moorpark)	482
Ventura County Waterworks District #8 (Simi Valley)	162
Ventura County Waterworks District #19 (Somis)	8
Central Basin Municipal Water District (13,322 af from MWDSC)	
City of Bell Gardens	122
City of Bellflower	392
California Water Service Company–East L.A.	1,416
City of Cerritos	207
City of Commerce	57
Rancho Los Amigos	45
La Habra Heights Water District	20
City of Lakewood	43
City of Lynwood	188
Maywood Mutual Water Company #1 (Huntington Park)	19
Maywood Mutual Water Company #2 (Maywood)	68
City of Montebello	126
Orchard Dale Water Company	84
City of Paramount	168
Park Water Company	812
San Gabriel Valley Water Company	63
City of Santa Fe Springs	545
City of Signal Hill	44
Southern California Water Company – Metropolitan	1,372
Suburban Water Systems	401
City of Vernon	159
Walnut Park Mutual Water Company	42
Orange County Water District (ground water replenishment)	174
Water Replenishment District	6,755
Chino Basin Municipal Water District (4,860 af from MWDSC)	
City of Chino	238
Chino Hills (?)	851
Cucamonga County Water District	1,798
First City (?)	5
Monte Vista Water District	267
City of Ontario	710
Southern California Edison	63
City of Upland	452
Watermasters (?)	476
Coastal Municipal Water District (5,808 af from MWDSC)	
Irvine Ranch Water District	30
Laguna Beach County Water District	612
City of Newport Beach	2,813
South Coast Water District	542
Tri-Cities Municipal Water District	1,811

Eastern Municipal Water District (5,749 af from MWDSC)	
Own retail customers	5,265
Direct request from real estate developer	78
Edgemont Gardens Mutual Water Company	53
March Air Force Base	154
City of Perris	199
Foothill Municipal Water District (942 af from MWDSC)	
La Cañada Irrigation District	225
Las Flores Water Company	49
Lincoln Avenue Water Company	138
Mesa Crest Water Company	59
Rubio Cañon Land & Water Association	57
Valley County Water District	169
Valley Water Company	245
Municipal Water District of Orange County (22,421 af from MWDSC)	
City of Brea	707
City of Buena Park	591
Capistrano Valley Water District	515
East Orange County Water District	700
El Toro Water District	962
City of Fountain Valley	286
City of Garden Grove	496
City of Huntington Beach	1,012
Irvine Ranch Water District	2,747
City of La Habra	151
City of La Palma	28
Los Alisos Water District	777
Mesa Consolidated Water District	782
Moulton Niguel Water District	2,839
City of Orange	916
Santa Ana Heights Water Company	180
Santa Margarita Water District	1,657
City of Seal Beach	23
Southern California Water Company – Orange County	771
Trabuco Canyon Water District	285
City of Westminster	208
Yorba Linda Water District	836
Orange County Water District (ground water replenishment)	4,952
San Diego County Water Authority (67,393 af from MWDSC)	
Bueno Colorado Municipal Water District	1,685
Carlsbad Municipal Water District	2,046
City of Del Mar	174
City of Escondido	2,220
Fallbrook Public Utility District	1,803
Helix Water District	4,115
City of National City	424
City of Oceanside	3,301
Olivenhain Municipal Water District	1,506
Otay Water District	2,558
Padre Dam Municipal Water District	2,205
Camp Pendleton Military Reservation	13
City of Poway	1,526

San Diego County Water Authority (continued)	
Rainbow Municipal Water District	3,526
Ramona Municipal Water District	1,771
Rincon Del Diablo Municipal Water District	928
City of San Diego	2,6061
San Dieguito Water District	733
Santa Fe Irrigation District	1,028
South Bay Irrigation District	2,387
Vallecitos Water District	1,504
Valley Center Municipal Water District	5,665
Yuima Municipal Water District	214
Three Valleys Municipal Water District (6,502 af from MWDSC)	
City of La Verne	1,625
City of Pomona	813
Rowland Water District	813
Southern California Water Company - Pomona	1,625
Walnut Valley Water District	1,626
Upper San Gabriel Valley Municipal Water District (7,976 AF from MWDSC)	
Own retail customers	800
City of Alhambra	236
Azusa Valley Water Company	16
Valley County Water District	124
City of West Covina	758
Ground water replenishment	6,042
West Basin Municipal Water District (17,169 af from MWDSC)	
California American Water Company-Baldwin Hills	70
California Water Service Company-Palos Verdes	2,905
Dominguez Water Corporation	2,549
City of El Segundo	1,950
Chevron Oil Refinery (by request)	1,550
City of Hawthorne	294
City of Inglewood	736
City of Manhattan Beach	478
City of Lomita	254
Los Angeles County Waterworks District #1	23
Los Angeles County Waterworks District #22	21
Los Angeles County Waterworks Districts #29-56	785
Southern California Water Company - Metropolitan Water Replenishment District	2,802 2,752
Western Municipal Water District (8,482 af from MWDSC)	
Own retail customers	3,985
Bedford Heights (?)	97
City of Corona	1,064
Eagle Valley Mutual Water Company	332
Elsinore Valley Municipal Water District	674
El Sobrante Water Company	829
March Air Force Base	142
Rancho California Water District	1,116
City of Riverside	243

Note: (?) denotes that we were unable to obtain complete name of retail agency.

REFERENCES

Barakat & Chamberlin, Inc., *The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers*, Oakland, California: August 1994.

California Department of Water Resources, *California Water Plan Update*, Volume 1, Draft Bulletin 160-93, Sacramento, Calif.: November, 1993.

California Department of Water Resources, *The 1991 Drought Water Bank*, Sacramento, Calif.: January, 1992.

Carson, R. T., and R. C. Mitchell, *Economic Value of Reliable Water Supplies For Residential Water Users in the State Water Project Service Area*, Palo Alto, Calif.: QED Research, Inc., June 9, 1987.

Griffin, Ronald, and Chan Chang, "Pretest Analysis of Water Demand in Thirty Communities," *Water Resources Research*, Vol. 26, No. 10, October, 1990, pp. 2251-2255.

Just, R. E., D. L. Hueth, and A. Schmitz, *Applied Welfare Economics and Public Policy*, Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1982.

Kunreuther, Howard, *Disaster Insurance Protection Public Policy Lessons*, John Wiley and Sons, New York, 1978.

Metropolitan Water District of Southern California, *The Regional Urban Water Management Plan for the Metropolitan Water District of Southern California*, Los Angeles, Calif.: November, 1990.

Moore, N. Y., E. M. Pint, and L. S. Dixon, *Assessment of the Economic Impacts of California's Drought on Urban Areas: A Research Agenda*, Santa Monica, Calif.: RAND, MR-251-CUWA/RC, 1993.

Northwest Economic Associates, *Economic Impacts of the 1991 California Drought on San Joaquin Valley and Related Industries*, Vancouver, Washington: March 16, 1992.

Sewell, W. R. Derrick, and Leonard Roueche, "Peak Load Pricing and Urban Water Management: A Case Study," *Natural Resources Journal*, Vol. 14, July 1974, pp. 383-400.