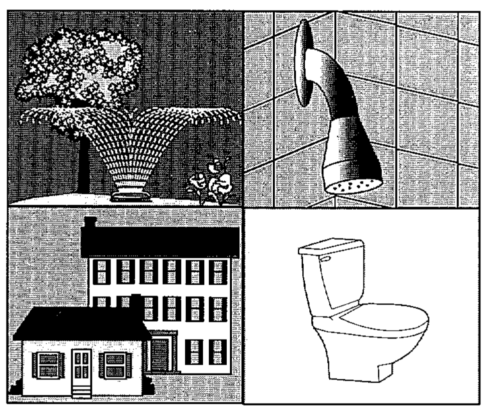
Summary

The Value of Water Supply Reliability:

Results of a Contingent Valuation Survey of Residential Customers



California Urban Water Agencies

Prepared by:
Barakat & Chamberlin, Inc.

August 1994

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THE VALUE OF WATER SUPPLY RELIABILITY:
Results of a Contingent Valuation Survey of Residential Customers

CALIFORNIA URBAN WATER AGENCIES

Participating Agencies:

Alameda County Water District
Contra Costa Water District
Los Angeles Department of Water and Power
Metropolitan Water District of Southern California
Municipal Water District of Orange County
Orange County Water District
San Diego County Water Authority
San Diego Water Utilities Department
San Francisco Public Utilities Commission
Santa Clara Valley Water District

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ACKNOWLEDGEMENTS

The authors would like to thank California Urban Water Agencies for sponsoring this study. The study greatly benefitted from the expertise of Dr. Michael Hanemann of the University of California, Berkeley, who served as special consultant to the project. We also are grateful for the assistance and the sustained interest of the Project Advisory Committee. Committee members included:

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FOREWORD

California Urban Water Agencies (CUWA) is an organization of the largest urban water providers in California. Its member agencies serve water to metropolitan areas comprising about two-thirds of the state's 32 million population. CUWA was formed to work on water supply issues of common concern to its members. Paramount among these concerns is the reliability of our urban water supplies. Statewide surveys show that California citizens rank water shortages close to crime, taxes, and traffic in listing their concerns about current problems in our society.

CUWA has an ongoing program to improve understanding of all aspects of urban water supply reliability. One important component of planning for supply reliability is being able to estimate the economic impact of water shortages so that an appropriate balance between costs and benefits of water management improvements can be found. CUWA and its member agencies sponsored earlier work on the cost of water shortages in California's manufacturing industries and the urban horticulture industry. However, the largest shortage cost component in some communities is in the residential sector, and this factor has proven difficult to quantify. CUWA and its consultant, Barakat & Chamberlin, Inc., determined that contingent valuation (CV) is the best available method for studying residential water shortage losses, and so undertook this survey—the most comprehensive and informative survey of its type conducted in the urban water supply industry.

This report detailed results of the CV surveys which shows that, on average, California residents are willing to pay $12 to $17 more per month per household on their water bills to avoid the kinds of water shortages which they or their regional neighbors have incurred in recent memory. The statewide magnitude of such additional consumer payments would be well over $1 billion per year. This customer value can be considered in planning for various demand- and supply-related options to meet reliability goals. While environmental and social impacts were not assessed in the CV survey, this report points out that they must be considered in water resource planning. CUWA is planning an additional phase of its Water Supply Reliability Program which will help water managers integrate all aspects of reliability planning.

California Urban Water Agencies

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Summary

INTRODUCTION

California Urban Water Agencies (CUWA) is conducting ongoing research on issues of water supply reliability. The goal of the CUWA reliability project is to provide the framework and tools with which each water agency can better incorporate reliability issues into its overall resource planning. One of the key pieces of information needed to do this is the *value* that customers place on reliability.

To address this question, CUWA engaged the consulting firm of Barakat & Chamberlin, Inc., to design, conduct, and analyze the results of a *contingent valuation* survey to estimate the value to residential customers of water supply reliability. The survey was conducted within the service areas of ten CUWA member agencies. This summary discusses combined results for the ten participating agencies. The individual results for each agency are included as appendices to the full report.

As will be discussed below, estimates and patterns of willingness to pay (WTP) for increased water supply reliability are remarkably consistent across participating agencies. This consistency supports the integrity of the results and general findings of the study. However, contingent valuation is not an exact science, and dollar figures should be used with caution.

THE CUWA CONTINGENT VALUATION SURVEY

The primary purpose of the CUWA contingent valuation (CV) survey is to estimate the value residential customers place on water supply reliability, specifically how much they are willing to pay to avoid water shortages of varying magnitude and frequency.

The CUWA CV survey asked participants whether they would vote "yes" or "no" in a hypothetical referendum. Participants were told that if a majority votes "yes," water bills would be increased by a designated amount, and there would be no future water shortages; if a majority votes "no," respondents were told that water bills would remain the same as they otherwise would have been, but water shortages of a specified magnitude and frequency would occur. Of course, individual customers differ in their willingness to pay to avoid different shortages.

The survey purposely did not tell customers where additional supply would come from, but rather indicated that it could come from any of a number of different sources. The intent was to avoid responses that were unduly influenced by preferences for or against particular resource types.

The CV questions are preceded by a series of questions that address a number of experiential and attitudinal issues, which help to place the CV questions in context and are also used in the analysis. The actual CV questions include a carefully worded description of the hypothetical "scenario" that will form the basis of a "yes" or "no" vote. The CV questions are followed by several "debriefing" questions that provide information on the reasons why respondents voted as they did. The survey concludes with a series of demographic questions.

Respondents are distributed randomly across a range of shortage scenarios. Shortage magnitudes range from 10% to 50%. Frequencies range from once every 3 years to once every 30 years. Bid amounts range from $1 to $50 increments to monthly water bills.[1]

Magnitudes and frequencies were combined to accomplish three objectives:

- To cover a wide range of shortage severity;
- To present shortage scenarios that would be perceived by respondents as realistic possibilities; and
- To avoid shortage scenarios that are too mild to elicit reliable WTP responses.

There are some critical concerns that are intentionally not addressed by the survey. The amount that some customers are willing to pay to avoid shortages will likely depend on one or more "external" impacts associated with the resource(s) added. These might include environmental or various social impacts. The CUWA Project

[1]Initial bid amounts ranged from $5 to $20. However, the follow-up portion of the double-bounded question accommodated values as low as $1 or as high as $50, if necessary.

Advisory Committee (PAC) and the consultants determined that, in the context of an agency's resource planning process, these issues would be best treated as costs associated with particular resource additions. Pretests and focus groups conducted during the survey design process indicated that, through proper wording of the survey questions, respondents could, in fact, give answers that were not influenced by such matters.

Because of the complexity of a survey of this type, it was decided to use a combination mail/telephone survey. A package of information was mailed to potential respondents. The mail package contained material that explained the purpose of the survey and helped customers understand the impacts of various shortage magnitudes. Interviewers called several days after the mail material was received.

The survey was conducted from August 1993 through February 1994. The total number of completions across all participating agencies was 3,769.

ANALYTICAL APPROACH

As described earlier, the contingent valuation (CV) survey uses the referendum approach. The referendum approach "bounds" the maximum willingness to pay (WTP) by asking the respondent whether he or she would be willing to pay a specified amount. A "yes" response indicates that the respondent would be willing to pay that amount or more, i.e, it gives a lower bound to the maximum WTP; a "no" response gives an upper bound. The mean WTP to avoid particular shortage scenario can be estimated statistically from responses of different residential customers to different shortage descriptions.

An extension of this approach, and one which is more statistically reliable, is the "double-bounded" technique. The CUWA contingent valuation survey asked respondents whether they would pay an additional monthly amount (or bid) to avoid a particular percentage shortage occurring with a specified frequency. A second choice question, whose bid depended on the answer to the first question, was then asked. If the response to the first question was "yes," then the second bid was an amount greater than the first bid, and if it was "no," the second bid was an amount smaller.

The superior statistical efficiency of the "double-bounded" approach makes intuitive sense given that the "double-bounded" approach yields more information than the "single-bounded" approach about each respondent's preferences. The solution to the double-bounded model used maximum likelihood techniques, applying a program that was written in GAUSS, a statistical software package widely used by economists and statisticians.

Specification of the Statistical Model

As described above, many questions pertaining to sociodemographic, attitudinal, and perceptual variables were included in the survey. Responses to many of these questions were included as explanatory variables in the statistical model. By doing this, we can see how these factors affect WTP. Figure S-1 describes the key explanatory variables included in the model.

Two statistical models were estimated. The so-called "detailed" model included all of the key explanatory variables discussed above. A "simplified" model included only those variables that can be obtained from census or agency billing records. These include:

- Age
- Household income
- Education level
- Dwelling type
- Household size

To the extent that this simplified model is statistically valid, it will enable agencies to reestimate willingness to pay in the future without resurveying residential customers.

The approach results in the following expression for the mean WTP for each shortage frequency (FREQ) and magnitude (REDUCE) combination:

$$WTP(REDUCE,FREQ) = \frac{\log(1+\exp(\alpha+\beta_1(REDUCE)+\beta_2(FREQ)+\sum \gamma_n X_{mean_n}+\sum \delta_t Z_{prop_t}))}{-\beta_3}$$

Figure S-1
KEY EXPLANATORY VARIABLES

- **Number of years living in area**
- **Household size†**
- **Age†**
- **Income†**
- **Education†**
- **Housing type†**
- **Concern for other public issues**
- **Perception of drought severity**
- **Perception of water shortages as a long-term problem**
- **Awareness of agency mandates to cut back on water use**
- **Home ownership/rental status and water bill responsibility**
- **Amount and type (private or shared) of external landscaping**
- **Population growth preferences**
- **Average residential water rate for respondent's water agency**
- **Northern California or Southern California agency**

†Included in simplified model.

where:

X_{mean} = the mean of those explanatory variables that are not binary (i.e., either zero or one)

Z_{prop} = the proportion of customers for which each of the binary explanatory variables takes on a value of one.

This expression enables us to derive *customer loss functions* that express average customer willingness to pay as a function of shortage magnitude and frequency. Such functions can be a key tool for agency resource planners.

ANALYTICAL RESULTS

Willingness to pay (WTP) can be interpreted as the losses that residential customers incur as a result of particular shortage scenarios. The amount that a customer is willing to pay to avoid an event is a measure of the losses that customer would incur if that event were to occur. Therefore, we refer to these willingness to pay results as a "loss function."

Tables S-1A and S-1B present the mean WTP for the detailed model and the simplified model for each magnitude and frequency of shortage. WTP figures represent increments to monthly water bills.

WTP for the detailed model varies from a low of approximately $11.60/month to avoid either a 10% shortage every 10 years or a 20% shortage once every 30 years, to a high of about $16.90/month to avoid a 50% shortage every 20 years. The results of the simplified model are almost identical to the results of the detailed model. While results for individual agencies do exhibit some differences, the range of WTP estimates is remarkably consistent across all participating agencies.

Table S-1A
MEAN MONTHLY WILLINGNESS TO PAY, DETAILED MODEL
(Additional $/Month)

Shortage (Percent Reduction From Full Service)	Frequency (Occurrences/Years)				
	1/30	1/20	1/10	1/5	1/3
10%			$11.63	$11.98	$12.12
20%	$11.62	$12.33	$13.06		
30%	$13.05	$13.80	$14.57		
40%	$14.56	$15.34	$16.13		
50%	$16.12	$16.92			
Blank cells in the table reflect scenarios that were not part of the survey.					

Table S-1B
MEAN MONTHLY WILLINGNESS TO PAY, SIMPLIFIED MODEL
(Additional $/Month)

Shortage (Percent Reduction From Full Service)	Frequency (Occurrences/Years)				
	1/30	1/20	1/10	1/5	1/3
10%			$11.67	$12.00	$12.14
20%	$11.71	$12.39	$13.08		
30%	$13.13	$13.84	$14.56		
40%	$14.61	$15.35	$16.10		
50%	$16.15	$16.92			
Blank cells in the table reflect scenarios that were not part of the survey.					

The "loss function" is shown graphically in Figure S-2. In examining the tabular and graphical results, two major conclusions can be drawn:

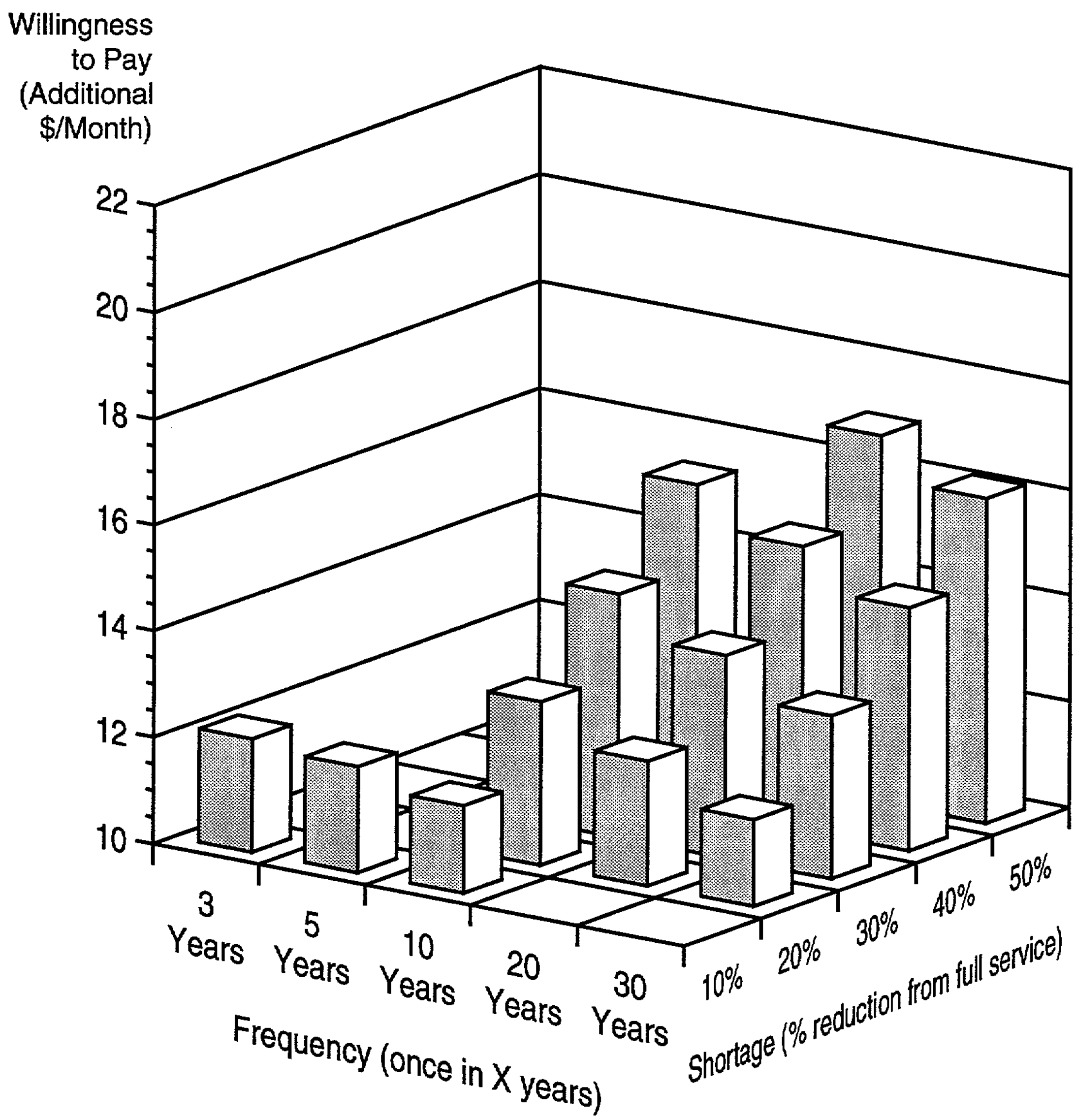
- As expected, respondents are willing to pay more to avoid larger shortages and for shortages that occur with higher frequency. However, the impact of frequency variations is considerably smaller than the impact of shortage magnitude on consumers' responses.

  Put another way, it appears that residential customers believe that infrequent large shortages impose higher losses than more frequent small shortages. This result is also consistent across all of the individual agencies. This type of conclusion may be important to agencies as they plan supply-side or demand-side resource additions and make system operations decisions.

- To avoid even apparently minor shortage scenarios (e.g., 10% once every 10 years), respondents are willing to pay substantial amounts. This type of "threshold" response is not uncommon in surveys of this type and may indicate that respondents regard even a mild shortage scenario as an inconvenience that they want to avoid. They may make a greater distinction between "shortage" and "no shortage" than between different magnitude or frequencies of shortages. Again, this pattern of responses holds for all participating agencies.

Figure S-2

Mean Monthly Willingness to Pay to Avoid Particular Shortage Frequencies and Magnitudes



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Impact of Key Explanatory Variables on Willingness to Pay

As described previously, the statistical model includes many variables that could potentially explain the variation in willingness to pay. For example, the variable "RATE" was included to determine if the average residential rate charged by the respondent's water agency affected WTP. The impact of this variable was not statistically distinguishable from zero. The following discussion selects three explanatory variables that are statistically significant and illustrates their impact on WTP.

Figures S-3 to S-5 show the variation of WTP at various shortage magnitudes when all other variables, other than the one in question, are held constant.

Landscape Area

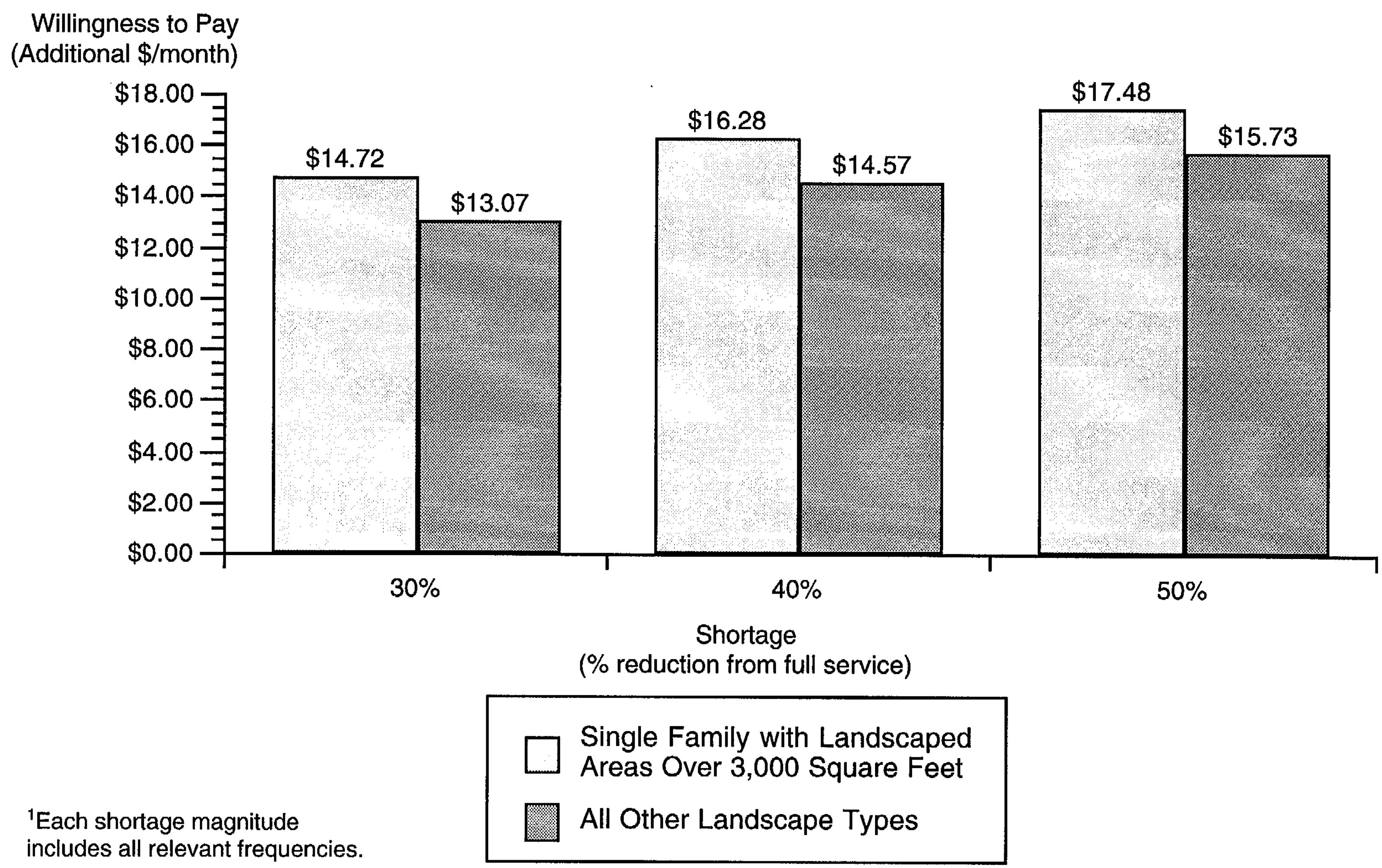
Not unexpectedly, the quantity and type of outdoor landscaping has a statistically significant influence on respondents' willingness to pay to avoid future shortages. Figure S-3 illustrates this by using the variables in the model that capture variations in landscaped area. The results show that respondents who have private lots with landscapes larger than 3,000 square feet have higher WTP than families with other types of landscaping.

Growth Preferences

Another interesting relationship is demonstrated in Figure S-4, which shows the relationship between participant feelings about community growth and their willingness to pay to avoid water shortages. Individuals who indicate a desire for their communities to grow in size have a higher WTP than do people who want their communities to stay the same size or to get smaller. Many in the latter group may perceive a relationship between water resource development and growth and are therefore more likely to prefer enduring more severe and/or frequent water shortages rather than adding to the resource base.

Figure S–3

Effect of Landscape Characteristics on Willingness to Pay[1]



[1]Each shortage magnitude includes all relevant frequencies.

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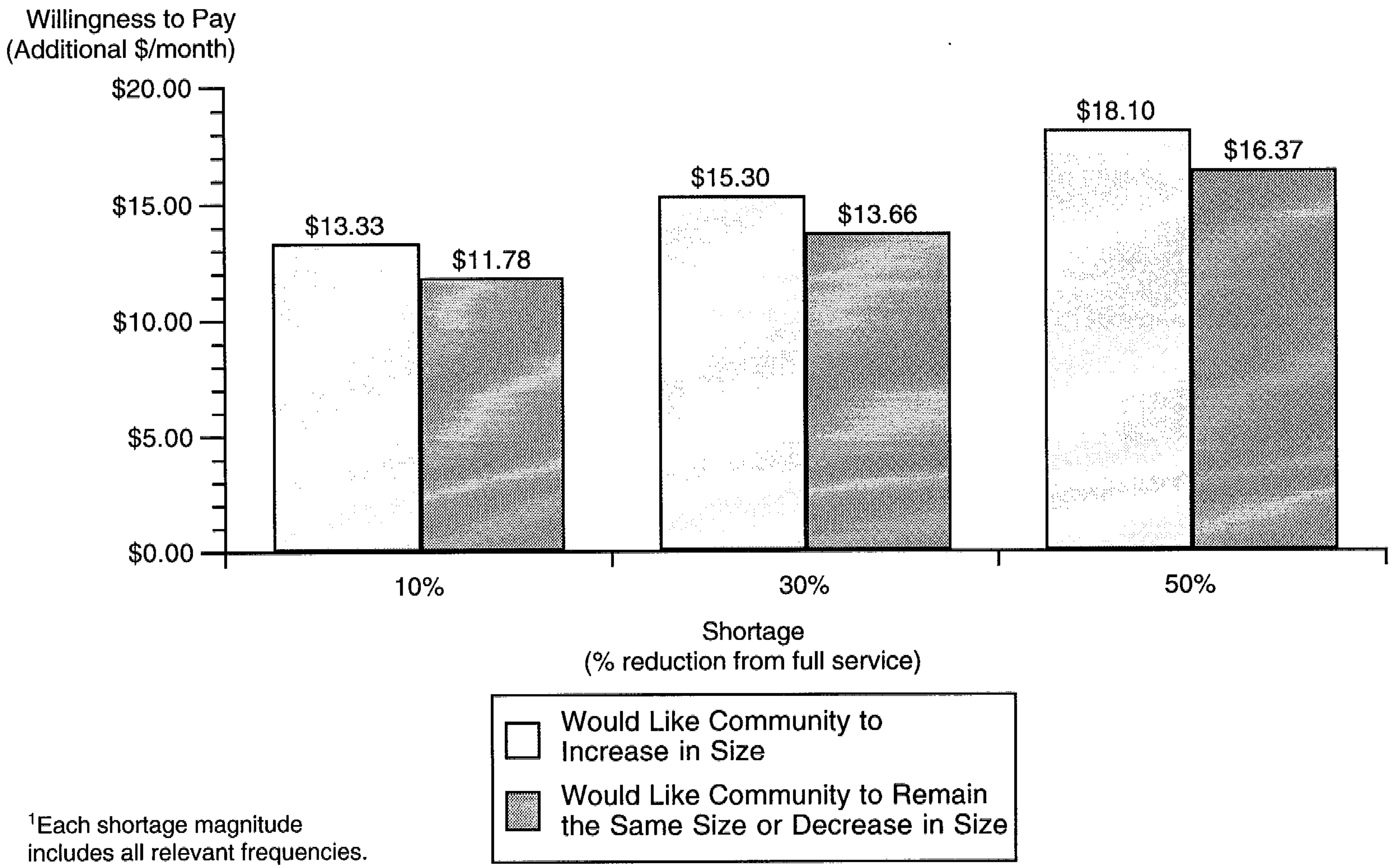
Figure S–4

Effect of Population Growth Preferences on Willingness to Pay[1]



[1]Each shortage magnitude includes all relevant frequencies.

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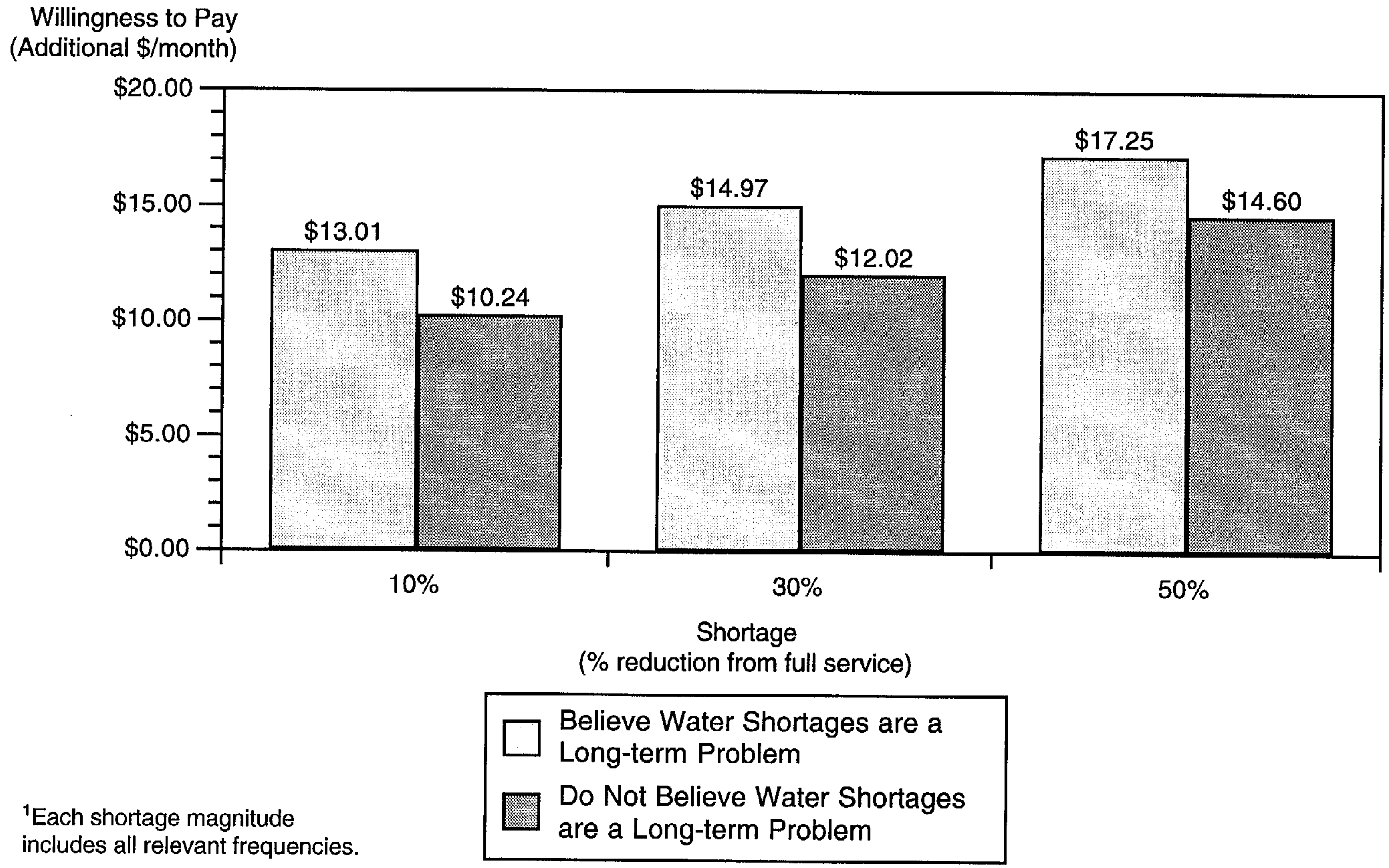
Figure S–5

Effect of Perception of Water Shortages as a Long-term Problem on Willingness to Pay



[1]Each shortage magnitude includes all relevant frequencies.

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Perception of Water Shortages as a Long-Term Problem

Survey respondents were asked to what extent they considered water shortages to be a long-term problem in their area. Those who considered the water shortages to be a long-term problem have higher WTP than those who do not. WTP for these two groups is illustrated in Figure S-5.

Regional Comparisons

An analysis was done to determine whether Northern California respondents had different WTP than Southern California respondents. To isolate the variation that is due to regional differences, a variable NORTH was included in the model.
The variable was set equal to 1 if the respondent was in the service area of:

- Alameda County Water District
- Contra Costa Water District
- San Francisco Public Utilities Commission
- Santa Clara Valley Water District

The variable was set to 0 if the respondent was in the service area of:

- Los Angeles Department of Water and Power
- Metropolitan Water District of Southern California
- Municipal Water District of Orange County
- Orange County Water District
- San Diego County Water Authority
- City of San Diego

Although all Southern California mean values are slightly lower than the corresponding Northern California mean values, the variable "North" was not statistically different from zero.

Separate models were then run for the Northern California and Southern California agencies to determine whether, apart from a difference that could be attributed to living in Northern or Southern California, there were demographic and attitudinal differences that were captured in other model variables and that resulted in different estimates of WTP for the two populations. The results, illustrated in Table S-2, indicate no significant differences in WTP.

Table S-2
MEAN MONTHLY WILLINGNESS TO PAY, BY REGION
(Additional $/Month)

Shortage (% Reduction from Full Service)	Frequency (One Occurrence in X Years)	Northern California	Southern California
10%	10	$12.32	$11.13
10%	5	$12.70	$11.50
10%	3	$12.85	$11.64
20%	30	$12.10	$11.19
20%	20	$12.85	$11.93
20%	10	$13.63	$12.68
30%	30	$13.40	$12.75
30%	20	$14.19	$13.52
30%	10	$14.99	$14.32
40%	30	$14.75	$14.38
40%	20	$15.57	$15.20
40%	10	$16.40	$16.02
50%	30	$16.15	$16.09
50%	20	$16.99	$16.93

The confidence interval for the Southern California model is +/- $0.51; the confidence interval for the Northern California model is +/-$0.63. Except at the 10% shortage magnitude, the differences all fall within the overlapping confidence intervals. Given that the confidence interval is underestimated at that level because there are fewer observations, it is likely that the actual confidence intervals overlap at the 10% shortage as well and that there is therefore no statistically significant difference in WTP between Northern and Southern California respondents.

Water Shortages as a Public Concern

In the survey, respondents were asked to rate the importance of various public problems, including water shortages, as "not at all important," "somewhat important," or "very important." There were three reasons for asking this question:

- To analyze the extent to which concern with any given set of issues (e.g., financial issues) affected willingness to pay.

- To test the perceived importance of water shortages relative to other public issues.

- To see how respondents categorized water shortages. With what other issues are water shortages associated?

Overall, the mean response for each issue is illustrated in Table S-3.

Water shortages fall in the middle of the list of concerns.[2]

The factor analysis showed that respondents grouped issues as illustrated in Table S-4. Water shortages fall into the category that includes issues that can best be described as having public service components. The factors are ranked within each category according to the strength of their rating in the factor analysis.

Each of the four factors was included in the model as a binary variable to test its explanatory impact on WTP.[3] Each of these variables was assigned the value of 1 if the mean value of all of a respondent's ratings for the issues included in that factor exceeded the value assigned to the water shortage issue, and zero otherwise. For the combined CUWA results, the social concerns, quality of life, and financial factors are statistically significant in explaining WTP. Respondents who placed any of those concerns above their concern for water shortages had lower WTP.

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[2]It is possible that had this survey been conducted a year earlier, when the state was still in the grip of a serious drought, water shortages would have been viewed as much more of a concern.

[3]The "public services/environmental" factor included in the model excluded the water shortages variable.

Table S-3
ISSUE RANKING AND MEAN RESPONSE

Issue	Mean Rating	Standard Error
Economy	2.66	.0095
Drug abuse	2.38	.0126
Education	2.35	.0136
Housing costs	2.32	.0122
Taxes	2.31	.0123
Traffic	2.29	.0122
Crime	2.26	.0122
Drinking water quality	2.18	.0138
Water shortages	**2.17**	**.0129**
Air pollution	2.08	.0124
Homelessness	1.98	.0130
Overcrowding	1.92	.0129
Trash disposal	1.88	.0138
Racial issues	1.73	.0126

Table S-4
FACTOR ANALYSIS OF PUBLIC ISSUES

Public Services Concerns	Social Concerns	Quality of Life Concerns	Financial Concerns
Trash disposal	Crime	Overcrowding	Taxes
Education	Racial issues	Traffic	Economy
Water shortages	Drug abuse	Air pollution	
Homelessness			
Drinking water quality			

SUMMARY OF KEY CONCLUSIONS

The important conclusions that can be drawn from the analysis are as follows:

- Monthly willingness to pay higher residential water bills to avoid shortages ranged from $11.60 to $16.90. Individual agency results, while exhibiting some variation, are generally consistent with this range.

- As expected, respondents' willingness to pay increases with increasing magnitude and frequency of shortages.

- To avoid even apparently minor shortage scenarios (e.g. 10% once every 10 years), respondents are willing to pay substantial amounts. This type of "threshold" may indicate that respondents regard even a mild shortage scenario as an inconvenience that they want to avoid. They may make a greater distinction between "shortage" and "no shortage" than between different sizes or frequencies of shortages.

- Shortage frequency is not as important a determinant of willingness to pay as shortage magnitude. Residential customers appear to be more willing to tolerate frequent small shortages than infrequent large ones.

- There are no significant differences in willingness to pay between Northern California and Southern California respondents.

- The simplified model has virtually the same predictive power as the detailed model. Participating agencies who wish to replicate this type of analysis in the future can therefore use the simplified model rather than resurveying their customers to gather data on the remaining variables required for the detailed model.