The Consequences of Water Consumption Restrictions During the Corpus Christi Drought of 1996

Volume 1: Overview

by

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Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project, in the course of which two or more faculty members from different disciplines direct the research of 10 to 30 graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency. This “client orientation” brings the students face to face with administrators, legislators, and other officials active in the policy process and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of political realities.

*The Consequences of Water Consumption Restrictions During the Corpus Christi Drought of 1996* is the product of a year-long analysis of the city of Corpus Christi’s drought management program, which was implemented in 1996 in response to a three-year drought that had dramatically altered in-stream flows and reservoir levels. The report presents a method for estimating the water savings and economic costs resulting from implementation of the drought management program. The approach combines an analysis of water savings and an economic impact assessment with focus group sessions, written surveys, and interviews with Corpus Christi water utility customers.

The curriculum of the LBJ School is intended not only to develop effective public servants but also to produce research that will enlighten and inform those already engaged in the policy process. The project that resulted in this report has helped to accomplish the first task; it is our hope that the report itself will contribute to the second.

Finally, it should be noted that neither the LBJ School nor The University of Texas at Austin necessarily endorses the views or findings of this report.
Acknowledgments

The Lyndon B. Johnson School of Public Affairs wishes to thank the many individuals who assisted in various ways with a number of aspects of this project. The Texas Water Development Board and the city of Corpus Christi provided the funding to support this project. The project team wishes to thank James Dodson, Susan Cable, Ed Garana, and Hubert Hall of the city of Corpus Christi for their varied and helpful assistance. Susan Cable worked closely with the project team to implement focus group sessions and identify those issues which were most important to the city’s design and implementation of its water management program. Ed Garana and Hubert Hall discussed the water supply system and provided the water supply records needed for forecasting and water savings analysis. The project team also wishes to thank Joe Rios and Omar Mendoza of Corpus Christi’s Municipal Information Systems Department for their cooperation and assistance in developing the municipal utility database. Kay Hoover of the city of Corpus Christi assisted by contacting potential focus group participants. John Sutton and Bill Hoffman of the Texas Water Development Board provided useful guidance and assistance at several points during this project. Chandler Stolp of the LBJ School advised on development of the forecasting models.

Several individuals assisted with the economic impact assessment. Don Hoyt of the State of Texas Office of the Comptroller of Public Accounts discussed applications of input-output analysis to economic impact assessment. Sandra Martinez of the State of Texas Office of the Comptroller of Public Accounts assisted with collection of background information to characterize the Corpus Christi Metropolitan Statistical Area. Herb Grubb of HDR Engineering, Inc., and Mickey Wright of the State of Texas Office of the Comptroller of Public Accounts provided useful feedback on the application of input-output analysis. The Corpus Christi Board of Trade Technical Committee discussed economic impacts of water rationing in the ship channel industries.

The many individuals that participated in focus group and discussions of water savings analysis and economic impact assessment also deserve recognition. Several individuals assisted in this project through participation in a group discussion held in Austin that considered the approach and methods used in this study. Participants included John Sutton and Bill Hoffman of the Texas Water Development Board, Bruce Moulton of the Texas Natural Resource Conservation Commission, Mark Hughes of the Texas Workforce Commission, and Susan Cable of the city of Corpus Christi. The project team also wishes to thank the water utility customers that volunteered as focus group participants in the city of Corpus Christi for their active participation in this project. Their names are not listed to preserve the confidentiality of their responses.

The authors are solely responsible for any errors, interpretations, or omissions.
Executive Summary

Chapter 1. Introduction

The city of Corpus Christi began implementation of its drought management program on April 9, 1996, in response to a three-year drought that reduced reservoir inflows to a rate less than the "worst case scenario" of water supply planners. As of December 1996, the combined storage in the reservoirs was about 30 percent of capacity, twelve percentage points less than in December 1995, and capable of providing approximately 18 months of water supply with drought management efforts in place. The Lyndon B. Johnson School of Public Affairs of The University of Texas at Austin began an evaluation of Corpus Christi's drought management program in June 1996, with funding from the Texas Water Development Board and the city of Corpus Christi. The objective of this evaluation is to provide information on water savings in real time to provide feedback to water managers who must make decisions based on expectations of water savings, changes in utility revenues, and the effectiveness of alternative drought management strategies. Policymakers were also weighing the cost of drought management strategies against expected benefits to the region. An assessment of the economic impact of drought management could assist policymakers in comparing the cost of drought management with the cost of alternative supplies and any opportunity costs associated with long-term risks of water shortage.

This report presents a method for estimating the water savings and economic costs resulting from implementation of the drought management program during the drought of 1996. Chapter 2 provides a brief overview of the drought management program and water use in Corpus Christi. Chapter 3 provides an introduction to water savings analysis and a brief literature review. This analysis of water savings is based on the results of two water demand forecasting models. Chapter 4 presents a rainfall-temperature time-series regression model that could be used to accomplish the analysis. This rainfall-temperature time-series regression model is applied to analyze water demand at an aggregate level and in individual water user sectors. Price elasticities are calculated for residential, commercial, and industrial water users. Chapter 5 introduces a second time-series regression model that uses a moving average index to model seasonality in water demand. Results and performance of this model applied to treated and total water use are compared with those of the rainfall-temperature model. Chapter 6 uses customer-level records from the municipal utility database to identify changes in the distribution of water among single-family residential customers. The analysis tests whether water restrictions had a greater impact among high-volume residential water users than among low-volume residential water users.

Chapter 7 describes a method for estimating household income and employment effects of drought management in Corpus Christi's petrochemical manufacturing industries. The method could be extended to other production sectors. This is an application of a regional input-output
model to quantify income and employment effects of water management decisions at the local level. First, the input-output model is described. Second, how to estimate direct, indirect, and induced income and employment effects given estimates of the output effect is discussed. Economic impacts such as these indicate how drought management decisions affect residents in the Choke Canyon/Lake Corpus Christi service area. This report argues that water rationing and water supply decisions should not be made by equating income and employment effects with economic costs alone, because those costs ignore service costs and incentives that govern supply and demand for water. A decision-making model for water rationing and water supply could be based on maximization of the total net value of water in the service area. Chapter 7 discusses problems with the use of income and employment effects to evaluate the costs of water rationing. The direct economic cost of water rationing is proposed as an alternative measure for cost assessment.

This project combined an analysis of water savings and an economic impact assessment with focus group sessions, written surveys, and interviews with Corpus Christi water utility customers. Results from the focus groups, surveys, and interviews provided water utility managers with feedback on customer practices, the potential effects of proposed policies, and attitudes toward specific water supply alternatives. Focus group activities included 18 sessions involving 9 residential customers and 63 representatives of 43 commercial and industrial utility customers. Most focus group participants completed written surveys. A total of 67 surveys were completed. Six industrial water utility customers from the petrochemical manufacturing industries also contributed to this project by agreeing to one-on-one interviews. Chapter 8 describes selection of participants and focus group methods. Also discussed is the input of commercial and industrial water customers, as well as the input of residential customers. Finally, this chapter combines responses from commercial and industrial customers to summarize information on attitudes toward water supply and drought management.

Summary of Project Results

Water Savings Analysis

Water demand forecasting is a well-established means of estimating water savings associated with drought management. Though such methods can work well, model selection is an important step toward developing credible results. A variety of models were considered for this project. Criteria for model selection required that the method (1) provide a reasonably precise estimate of potential water use without drought management given economic activity and weather patterns during the drought management period, (2) allow identification of water savings by water user sector, and (3) enable water managers to obtain feedback on drought management program effects in real time at minimum cost.

A time-series regression model that uses significant lagged error terms to correct for autocorrelation provided the most straightforward real-time solution to the forecasting problem. The method is logically interpretable and could be implemented by water utility personnel using
spreadsheet software and monthly billing records. The speed with which rainfall-temperature
models can produce feedback on water savings is limited by the time required to read all utility
meters, approximately one month, and an additional one month lag in the availability of monthly
billing records. Initial results are available about 60 to 90 days after implementation of a drought
management program.

Information on water use was obtained from the city of Corpus Christi’s monthly billing reports,
which are produced by the city’s accounting division and subsequently corrected and revised by
water utility managers when necessary. These data are provided with monthly mean maximum
daily temperature and aggregate rainfall in Appendix A (see Volume 2). Accounting reports
include sufficient detail to allow aggregation of water use by residential, commercial, and
industrial sectors. Identification of water savings by water user sector allows utility managers to
better direct their drought management program if some water user sectors are not achieving
water savings.

The forecasting and evaluation methods outlined in this report could be implemented by water
utility managers using spreadsheet software. Instructions for applying the model are provided in
Chapter 4. However, more sophisticated software would be required to reestimate the forecasting
model or recalculate operational criteria used to evaluate water savings. Operational criteria for
water savings, defined as a one-sided lower 95 percent confidence bound of predicted water use,
may be identified for each month of the forecast and can only be calculated after rainfall and
temperature in the forecast month are known. Although the model remains valid while Corpus
Christi remains under its drought management plan, the quality of forecasts will deteriorate as the
length of the drought management period continues. Chapter 4 discusses the deterioration of
forecasts.

Results of Water Savings Analysis

Results of the water savings analysis show that actual water use is less than the water use forecast
during the period May through November 1996. The analysis is designed to test the effects of
mandatory water rationing as implemented through drought condition 2 beginning May 6, 1996.
Results of the analysis of water demand for residential and commercial customers inside the city
limits are illustrative of project results. Municipal per capita water demand is defined as
residential and commercial water use inside the city limits expressed in gallons per capita per day
(gpcpd). Population figures were estimated by the city of Corpus Christi Planning Department.
Water savings by residential and commercial customers inside the city limits during the
mandatory drought management period, May 6 through November 1996, are estimated to be 4.48
percent in May, 16.14 percent in June, 6.74 percent in July, 18.58 percent in August, 28.44
percent in September, 32.29 percent in October, and 16.04 percent in November. Not all
differences between forecast and actual water sales meet statistical criteria for distinguishing
between drought management effects and random errors of the forecast. Differences in estimates
of water savings across months could be attributed to errors in the forecast, the differential effects
of regulations on water uses, or both.
Figure 1.1 graphs municipal per capita water demand forecast and actual water use. Water savings is calculated as the difference between forecast and actual water use. The y-axis is gallons per capita per day and the x-axis indicates the numerical sequence of months, taking January 1986, as 25 and May 1996, as 197. The model estimation period begins in January 1986, and continues through April 1996. Ex-post forecasts for months within the estimation period are connected by a solid line. Model forecasts are represented by "x" and the 95 percent confidence bound of predicted values is shown by the faded dashed line.

The model produces similar results when applied to five other aggregations of water demand. These aggregations include total water sales (the sum of treated and raw water sales including sales to wholesale customers), treated water sales (including treated water sales to wholesale customers), and water sales to retail customers in three water user sectors: residential, commercial, and industrial. Results show that water savings have appeared gradually during this drought management period. For example, estimates of treated water savings are 3.48 percent in May, 15.34 percent in June, 8.63 percent in July, 10.3 percent in August, 24.6 percent in September, 18.79 percent in October, and 14.25 percent in November. Not all differences between forecast and actual water sales meet statistical criteria for distinguishing between drought management effects and random errors of the forecast. Details of the water savings analysis are provided in Chapter 4.

Table 1.1 describes some key results of this water savings analysis in general terms. Other results of the forecasting exercise include trends in water demand within the city's retail service area and estimates of the price elasticity of demand in water user sectors. This study found statistically significant increasing trends in per account water use in commercial and industrial sectors. The increases are 87 gallons per month per commercial account and 16,522 gallons per month per industrial account. There is no statistically significant trend in per account residential water demand within the city's retail service area. The water forecasting equation controls for changes in the number of water utility customers. However, because the forecasting equation does not include variables to control for changes in productivity over the estimation period, changes in per account water demand do not necessarily reflect increases or decreases in water efficiency. Trends such as these may not be used to evaluate long-term water conservation programs.

Price elasticity is the percent change in water demand that results from a 1 percent change in water price. Elasticities can serve as a tool for comparing the effectiveness of water rationing with hypothetical water utility price increases. Water price is included as a variable in the forecast of residential, commercial, and industrial demand. Parameter estimates for the price variable are used to calculate long-run point price elasticities for each sector. Only commercial water customers showed statistically significant responses to price changes. The price elasticity in that water user sector is -0.519. The interpretation is that commercial utility customers will reduce water use 0.52 percent in response to a 1 percent increase in the price of water. The interpretation of insignificant price elasticities is that residential and industrial water customers have not adjusted water use over the estimation period in response to price changes. Chapter 4 discusses why price elasticities may
not be significant in the forecasting equation. Appendix B lists nominal prices for residential and non-residential water customers from 1978 to 1996 (see Volume 2).

A set of evaluative criteria is presented for comparing rainfall-temperature model results with results of other water demand forecasting equations. Results of a moving average index time-series regression model applied to total water use and treated water use are compared with results of the rainfall-temperature model. Comparisons based on evaluative criteria show that the moving average index performs slightly better as a forecasting tool, but this results in no change in conclusions about the effectiveness of the drought management program during the period May through August 1996. Overall, the rainfall-temperature model is considered a better alternative to the moving average index model because it describes underlying processes rather than model the data and therefore better preserves the ability to interpret other variables that might be incorporated into the analysis.

Potential Improvements in Water Demand Forecasting

One of the efforts of this project has been to develop the customer-level municipal utility database for use in water demand forecasting. Some analysis of that database is included in this report (Chapters 2 and 6) as is a method for converting the city's accounting files to a format suitable for analysis by conventional statistical software (Appendixes E and F). A manual for converting the database to dBASE format is provided in Appendix E. A collection of FORTRAN programs used in this conversion process is provided in Appendix F (all Appendixes in Volume 2).

Monthly billing records are adequate for evaluating water savings. However, some improvements could prove useful in identifying water savings and interpreting model results. Benefits of using the customer-level utility records include replication of the water demand time series over 21 utility billing cycles and better specification of rainfall-temperature variables. Water utility customers are billed monthly on a rotational basis known as cycles. One cycle of customer meters is read and billed during each business day of each month. Using customer-level records allows aggregation of water customers by cycle as well as by water user sector.

Some advantages of using the customer-level database could include an increase in the number of observations during the forecasting period and a decrease in the lag time required before a water savings assessment is complete. The project team estimates that an installed system could reduce the lag time needed to obtain results from two or three months to one to four weeks. Another potential benefit of using customer-level data may be a decrease in the confidence interval width associated with predicted values. This could be the result of increasing the number of observations, the number of variables, or better definition of independent variables such as rainfall and temperature. One complication associated with increasing the number of observations is the need to account for additional variation in levels of water use between cycles.

Those cycles read and billed during the beginning of the month reflect water use primarily in the preceding month. Those cycles read and billed at the end of the month reflect water use primarily
in the billing month. As this pattern occurs regularly and each cycle is read and billed on approximately the same day each month, specification of rainfall and temperature values for aggregate water billed misstates rainfall and temperature for those cycles billed early in the month. Even though forecasts may be accurate, there may be an erroneous coefficient for the rainfall and temperature variables. Use of the municipal utility database resolves this problem by assigning rainfall and temperature for the water use period to each customer account.

Customer-level data can be aggregated by zip code as well as by cycle. This aggregation enables the analyst to use other data available by zip code to explain patterns in water demand. For example, personal income or other population and housing characteristics could be used in conjunction with the utility database. This is less true for commercial and industrial customers than for residential customers if single-family residential customers are treated as an homogenous group. In contrast, the characteristics and activities of commercial and industrial customers vary widely. It seems more information is needed about these customers in the utility database, including information on site-level activity and standardized industrial classification codes.

Utility of Database Screens

Another potential use of the customer utility database is the ability to create database screens. The utility database is designed to access information for specific accounts, but analysis of groups of accounts or aggregation of accounts by location, water user sector, water use, or other criteria requires a time-consuming programming effort. The converted database enables water managers to create up-to-date database screens in a short period of time. To demonstrate how database screens can be used, the project team created dBASE files listing commercial and industrial utility customers using 100,000 gallons of water or more each month. Alternatively, customers could be identified by other account characteristics such as meter information, billing history, or location. To preserve the confidentiality of water utility billing records, these results are not provided in this report.

Evaluating the Economic Impact and Costs of Water Rationing

This report presents a method for estimating income and employment effects of water rationing. Water rationing is defined as a system that restricts the timing, period, or volume of water use. This includes such things as limitations on the volume of water use, watering restrictions that specify the day or time of outdoor water use, or the length of the watering period. All are classified as water rationing because each system attempts to limit the volume of water used by each customer in a specific group. In contrast, water conservation is a long-term process that seeks to increase water efficiency by changing people’s habits and promoting substitutes for water such as more efficient equipment or processes. The purpose of assessing the costs of water rationing is that water managers could weigh these costs against the benefits of proposed levels of water rationing or against the costs of alternative courses of action.
The input-output method used to assess economic impacts requires an independent projection of the change in output levels in commercial and industrial sectors. To demonstrate how the 1986 Nueces Mission-Aransas Estuary Input-Output Model can be used, estimates of income and employment effects of a 5 percent change in output are presented for the petrochemical manufacturing industry. Model coefficients indicate that, dollar for dollar, these two sectors have the largest potential impact of all input-output sectors on income and employment in Corpus Christi. Moreover, chemical and petroleum manufacturing accounted for 91 percent of the manufacturing output in Corpus Christi in 1992 (Bureau of the Census 1996).

A 5 percent decrease in production is used as a hypothetical output effect associated with proposed water rationing in the petrochemical manufacturing sector. This estimate, based on information obtained from industry representatives, is not indicative of what output change would be under any specific water rationing plan. Representatives would not release any estimates of what output effects might be. A 5 percent change in the output of each chemical and petroleum manufacturer results in a total direct, indirect, and induced decrease in employment of 1.54 percent. Similarly, a five percent change in the output of petroleum and chemical manufacturers results in a total direct, indirect, and induced decrease in wage and salary income of 2.07 percent in the Corpus Christi Metropolitan Statistical Area. The term direct effect refers to the change among those employed in the industry, while the terms indirect and induced effects refer to changes in other industries.

Income and employment costs are useful measures of economic impact. However, income and employment effects of output change reflect only a portion of the total cost of water rationing. A decision criterion for water rationing and water supply investment should compare the total direct cost of water rationing with total direct benefits in the service area. Total direct benefit is measured by consumer surplus, which is related to the present value of water and its supply cost. The total value of a unit of water is equal to the value of that water used in production to commercial and industrial customers plus the utility of that water to residential customers, minus its acquisition and delivery costs. The cost of water rationing is the net change in economic value of water.

Price manipulation is an alternative means of controlling the volume of water use. This differs from water rationing because each water customer responds to price changes by adjusting water use according to an individual set of incentives and priorities. The effect is to minimize economic losses associated with a given quantity of water savings. Although noneconomic policy goals may suggest that minimizing economic losses is not the most desirable objective and institutional limitations may effectively prevent price manipulation in practice, the economic benefits of such a strategy are worth considering.
Focus Group, Survey, and Case Study Results

Input of Commercial/Industrial Customers

Between July and September 1996, representatives of 43 Corpus Christi commercial and industrial organizations discussed impacts of the water shortage and water consumption restrictions with project team members. Table 1.2 lists observations about patterns of water use drawn from focus group discussions, survey results, and case study interviews with commercial and industrial water customers. Observations listed in Table 1.2 are discussed in Chapter 8.

Condition 2 watering restrictions and the city request for voluntary water savings prompted changes in patterns of commercial/industrial water use. Participants report an increased awareness of how water is used, implementation of employee education programs, reduction of non-production related water use, increased equipment repair and maintenance costs, and alteration of production processes without capital investment. They also report capital investment in water saving equipment in anticipation of condition 3 water rationing.

Participating organizations express a preference for working to save water in a number of activities rather than focusing on a single activity. For example, after reducing non-production water use for safety and sanitation, they prefer to reduce water use across a variety of processes before eliminating water use in selected processes. In theory, organizations will reduce water use so that the last gallon of water used in production, cooling, sanitation, and other processes has equal value. Water uses should be restricted or eliminated in order of increasing marginal value. The city's request for voluntary water savings during conditions 1 and 2 was structured to allow water customers to independently identify and initiate the most cost-effective set of water saving measures possible. The ability to implement cost-effective water saving measures appears to assist implementation of drought conditions 1 and 2.

Implementation of condition 3 water rationing as proposed may create an incentive for customers to adopt water savings measures that are not presently cost-effective. Most study participants report they intend to comply with water rationing rather than pay surcharges and risk negative publicity or removal from the water supply system. However, customers that risk significant decreases in production may choose to pay surcharges in the short term. Aside from proposed restrictions affecting outdoor water use in industries like landscaping and building washing, condition 3 water rationing is also structured to enable water customers to adopt the most cost-effective water saving measures first. As long as total water use remains within a monthly water ration, customers will choose those water saving measures that best serve their interest. Firm-level case studies in Chapter 8 describe selected water saving decisions of industrial water customers.

Understanding the economic impacts of water rationing can help explain why patterns of water use change. Table 1.3 lists economic impacts identified through analysis of focus group discussions, survey results, and case study interviews. Chapter 8 describes economic impacts in
commercial and industrial water user sectors, reflected in changes in revenue and cost, which affect employment, production, and expansion.

Smaller commercial enterprises did not report significant fixed or variable cost increases due to conditions 1 and 2, but larger industries did. Surveys and focus groups did not yield sufficient information that could be aggregated to estimate total costs. Customer-level case studies provide detailed examples of the variety and magnitude of capital water savings expenditures in local industries.

Most target sectors report that revenue and employment could be good indicators with which to measure the short-term impact of drought management. The city lacks a standard method for reporting revenue and employment information, so anecdotal information gathered through focus group and survey research cannot be corroborated. With the exception of landscape and building washing businesses, few participants report any effect on revenue and employment during conditions 1 and 2. Landscape and building washing businesses were restricted from using water freely in operations, and they were also affected by drought-induced reductions in demand for their services. Landscapers may have lost stock due to the watering restrictions, for example, but they have also been affected by residents’ reduced demand for landscaping materials and services since implementation of condition 2 watering restrictions. Calculation of the revenue and employment effects of conditions 1 and 2 would be further complicated by the fact that the landscape industry can expect to regain some lost revenue replacing dead lawns, trees, and plants after the water shortage. Hotels, other manufacturers, and industrial customers report no revenue and employment effects in conditions 1 and 2.

Anticipation of economic impacts from proposed condition 3 water rationing is complicated because condition 3 program parameters are unclear. Few commercial/industrial customers were able to estimate the revenue and employment effects of condition 3 water rationing. Chemical and petroleum manufacturers estimated the potential revenue and employment effects of condition 3 at hypothetical levels of rationing (5, 10, 15, and 25 percent). These customers anticipate substantial decreases in employment and revenue at 15 and 25 percent reductions in water use. No firm conclusions about potential revenue and employment effects of proposed condition 3 water rationing could be drawn from focus groups, surveys, and interviews.

The cost of long-term water shortage is reflected in the investment and production decisions of existing and future utility customers. For example, landscaping and power washing businesses that depend on discretionary water use by Corpus Christi residents postponed long-term expansion plans in response to the water shortage. Most other participating water customers report concern about the opportunity costs of long-term water shortage, but few report any effect of the current water shortage on long-term production decisions. The Greater Corpus Christi Business Alliance conducts business recruitment and retention surveys, through which many large industrial water customers have indicated that inadequate long-term water supply is a significant disadvantage to the local business environment.
Input of Residential Customers

Between July and September 1996, nine residential utility customers in Corpus Christi provided focus group input on household-level impacts of the water shortage and water restrictions. Twenty-six residential water customers, including eight focus group participants, completed surveys. Table 1.4 lists observations about patterns of household water use drawn from focus group discussions and survey responses. Observations in Table 4 are discussed in Chapter 8. Overall, households report little difficulty complying with condition 2 outdoor watering restrictions and anticipate little difficulty complying with condition 3 water rationing. Residential participants express concern about long-term foundation damage if water rationing interferes with their ability to water foundations. Foundation watering can prevent cracks and costly repairs.

Residential water customers report maintaining or reimplementing many water saving practices adopted during the 1984-1985 water shortage, and a possible willingness to maintain current voluntary water saving measures beyond the water shortage. Like commercial and industrial customers, residential customers adopt water saving measures that are most cost-effective. Costs could be reflected in equipment costs or in the relative convenience of one water saving measure over another. Nonmonetary measures may better reflect incentives because dollar costs of household-level water savings seem small and many households have already invested in the necessary equipment.

Residential customers generally report implementing those water saving measures they consider to be most effective. In contrast to cost-effectiveness, described above, effectiveness refers to the largest potential volume of water savings. Residents should have access to information about how much water is used in common household activities and how much is saved through alternatives so that they can more accurately assess the effectiveness of each. For example, residents could be more water efficient if they were informed about optimal watering of different types of foundations and landscapes. However, liability issues may prevent the city from acting as the source of information about foundation watering.

Uninformed residential customers often express resistance to city drought management policies and the possibility of sharing the costs of additional long-term water supplies. Enhanced education about industrial, commercial, and residential water savings and city water planning could defuse resistance caused by a lack of accurate information.

Table 1.5 lists observations about marginal household water use drawn from focus group discussions and survey results. Observations listed in Table 1.5 are discussed in Chapter 8. Because outdoor water uses appear marginal relative to indoor water uses among residential focus group participants, condition 2 water restrictions on outdoor water use probably did not conflict with the water use decisions of most households. Given time to adjust to a program like condition 3 water rationing, which regulates the total volume of water each household uses, it is likely that residential water customers would reduce outdoor watering in the absence of specific regulations.
Residential customers, like commercial and industrial customers, report a preference for incremental reductions in water use. They prefer to limit water use for a variety of outdoor and indoor activities before eliminating specific water uses. This complicates the design of conditions 1 and 2 restrictions on water use, which regulate specific uses, but supports the idea that pricing or rationing may work more efficiently than regulation governing how water is used. This report also presents information that suggests pricing is more economically efficient than water rationing.

Assessment of Attitudes Toward Drought Management and City Water Policies

Focus group participants and survey respondents answered questions designed to assess their knowledge and perceptions of the water shortage, attitudes toward mandatory and voluntary water savings, confidence in city management of the water shortage, and long-term water supply preferences. Table 1.6 lists observations about these issues drawn from residential focus group results. These observations are discussed in Chapter 8.

During drought conditions 1 and 2, publicity about the long-term implications of falling reservoir levels and associated water quality problems focused residential customer attention on the water shortage and long-term water supply issues. Residential customers demonstrate reasonable perceptions regarding the causes and severity of the water shortage, but do not express a great deal of confidence in the city's ability to manage the water shortage. Public discussion of enforcement, commercial and industrial water saving efforts, and long-term supply negotiations and costs might increase residential confidence in city policies. Again, the lack of accurate information appears to have created some resistance to reducing water use. Residential customer attitudes appear to be strongly affected by perceptions of fairness. For example, residents do not object to saving water and contributing to long-term water supply costs, but they seek assurances that other customers are contributing in equal proportion. Further study would be necessary to determine aggregate residential attitudes toward long-term supply options. Residential customers did not express clear support for one long-term option over others.

The increased risk that water shortage may limit production and increase costs in the short term has helped commercial and industrial customers focus their attention on the water shortage. Perhaps because many commercial and industrial customers factor water availability and price into long-term capital investment decisions, most commercial/industrial participants are well informed about the causes and severity of the water shortage. Table 1.7 lists observations drawn from commercial/industrial focus groups. These observations are discussed in Chapter 8.

Commercial/industrial attitudes toward mandatory and voluntary water saving measures are shaped by how those measures affect customer-level capital and operating costs, production, and revenue. Study participants do report a willingness to participate in the citywide effort to reduce water use. To assist them in these efforts, customers report a need for consistent implementation and enforcement of city policies. Commercial and industrial customers make water use decisions and plans based on drought contingency ordinances, statements of city officials, letters, press releases, and other communications. Participants report that knowing condition 3 water rationing
requirements with certainty well in advance of implementation could enhance their ability to plan a response to the water shortage and evaluate alternatives.

Commercial and industrial customers express greater confidence than residents in the city’s ability to manage the water shortage. Like residential customers, they report that regular communication between the city and water utility customers could enhance their ability to plan and comply with drought restrictions. If water rationing is to become a strategy for coping with long-term water shortage, the city should establish its water restrictions before there is a need to implement water rationing. In addition, incentives that give credit to water customers who reduce water use over the long term are also needed. For example, monthly water rations based on an average of previous monthly water use tend to penalize water customers who have already achieved permanent water efficiency gains.

With regard to selection of long-term water supply options, reliability and price are the primary concerns of commercial and industrial customers. Although industrial customers express a strong preference for the Lake Texana pipeline in focus group discussions, most commercial and industrial participants suggest that the city should continue to investigate a variety of long-term water supply options. Many customers were unaware of the water supply studies already completed by the city.

**Recommendations**

This section presents several recommendations based on project results. In general, recommendations are limited to those for which project results provide substantial support.

**Reassess or strengthen the combination of restrictions on water use in conditions 1 and 2.** Analysis of water rationing effects shows that restrictions on water use in Corpus Christi have not achieved the goals established for each drought condition in the city’s drought management plan. That plan establishes a goal of 10 percent reduction in total water use during condition 1, an additional 5 percent reduction in water use in condition 2, and another 10 percent in condition 3. The combined effect of conditions 1 and 2, can be seen in the period May through October. Estimated water savings exceed the savings goal in only two of those three months, September and October. The combined effects of conditions 1, 2, and 3 in November should be 25 percent, but the city achieved less than 11 percent water savings in that month.

Results of this water savings analysis show that aggregate water savings between May and November 1996 are below established goals for the drought management program. The approach used to estimate water savings is to compare water demand forecasts with actual water consumption. The ability of the method to detect water savings is demonstrated during the 1984-1985 drought management period.

A reassessment of program goals or strengthening of water restrictions is warranted. Lowering projections of how much water savings can be achieved through the drought management
program as implemented makes expectations more realistic and better enables the city to plan its response to the water shortage. However, it may be more important that the city achieve its 15 percent goal during conditions 1 and 2 as described in the present plan. In that case, the city might consider strengthening the combination of restrictions or the enforcement of restrictions established in its drought management plan.

Information drawn from focus group input supports this recommendation. The perception among residents who report complying with outdoor water restrictions during condition 2 is that restrictions on outdoor water use may not have reduced their outdoor water consumption. Outdoor watering restrictions limited lawn watering to specific days of the week and hours of the day. More stringent limits on the frequency and timing of outdoor water use could improve condition 2 restrictions as a tool for reducing water consumption. Residential customers report little cost or inconvenience in achieving compliance with existing condition 2 restrictions. This suggests that restrictions could be tightened without imposing an undue burden on residential customers.

Formally adopt a method for evaluating water savings due to water rationing. A number of good statistical methods for evaluating water savings can be used. Unless a specific method for evaluating effects of water rationing, interpreting results, and using these results to identify program needs are established in advance, the city may not have confidence in conclusions drawn from analyses. For example, this analysis shows differences in water demand forecasts and actual water use. Some of these differences are not statistically significant, but this may reflect the sensitivity of this model to small water savings. Statistical criteria present an operational minimum for qualification of water savings. Unless a water savings is larger than the operational minimum, it cannot be distinguished from random error of the forecast. Although such criteria are conventional bounds in statistical theory, they may be arbitrary from a policy standpoint from which small water savings may be as important as large water savings. Water savings may be small, may fluctuate from month to month, or appear gradually after program implementation. The existence of this operational minimum is a limitation of any method based on statistical inference.

This report presents several criteria that could be used in model selection and evaluation. For example, the relative sensitivity of the model to water savings has already been discussed. The scope of parameters for which the analysis controls is also important. For example, this report uses a rainfall-temperature model, which compares actual water use to potential water use given variations in population, rainfall, temperature, and long-term trends. The implication is that water savings should be measured only after allowing for differences in water use related to these variables. In contrast, the model provides for no differences in water use related to changes in the productivity of water users. The implication is that water users may increase water use in response to temperature without jeopardizing compliance with program goals, but may not do so in response to increased production demands. Another way of stating this is that water savings are conditional on changes in temperature but not on changes in production. A production variable was excluded from this model for statistical reasons; it could not be justified as an independent
explanatory variable. For any long-term model it would be argued that an output on production variable should be included.

The purpose of a real-time assessment of water rationing effects is to provide feedback to decision makers and water utility managers on how well the drought management plan has met established goals. Developing consensus on how the results of the analysis will be used provides insights into how to conduct analysis and communicate information. For example, this analysis uses a method that preserves the ability to identify how the program affects water user sectors. There may be a trade-off between preserving sectoral analysis versus some other characteristic, as the need for this information may preclude the use of some other method. Evaluation of this trade-off requires determination of what set of information is needed and how it will be used.

Another advantage of adopting a method in advance of program implementation is that data needed to carry out the analysis can be collected and in place before implementation of the drought management plan. However, the cost of conducting the studies and developing the consensus must be weighed against the potential benefits of the analysis. For example, a community like Corpus Christi, which faces a real risk of water shortage, could justify this cost, but a community that faces no risk of water shortage might not be able to justify this cost.

**Improve communications, public information, and public relations with respect to both drought management and long-term water supply activities, alternatives, and comparative costs.** Water utility customers report a need to improve public information programs regarding water saving methods, city drought management policies, and long-term water supply options. Communication from the city could increase the effectiveness of voluntary efforts to reduce water use in conditions 1 and 2. For example, residential customers report implementing many of the water saving measures they think will achieve the greatest volume of water savings. If the city made available information on the relative water savings of different measures, customers could make better informed decisions about water use and perhaps achieve greater water savings.

Focus group participants reported an apparent lack of other information as well. Many customers were unfamiliar with the city's four-stage drought contingency plan. Residential participants seemed unaware that commercial and industrial customers had been asked to reduce water consumption during conditions 1 and 2. Focus group participants reported little knowledge of city participation in the Trans-Texas Water Study. Focus group participants made statements that suggested the city had done nothing since 1984 to prepare for water shortage. The absence of a public information program may help to create resistance to the city’s drought management efforts. For example, a lack of understanding on the part of customers about the alternatives, costs, and benefits of long-term water supply options could inhibit the city’s ability to pursue the most practical and cost-effective options. Consider desalination, for which a number of residential and commercial/industrial participants expressed initial support over all other options. In focus group sessions, participants knowledgeable about the costs and by-products of desalination often convinced others that it was not the most cost-effective option. The city should consider
improving access to information so it may play a lead role in the dialogue on long-term supply options.

Integration of rebate programs to offset the cost of water saving plumbing fixtures and retrofit kit distribution programs could enhance a citywide information program. These programs should be accompanied by information about equipment installation, use, and maintenance. For example, some school districts and other organizations capable of achieving substantial water savings with low-flow faucets and other fixtures reported problems with these devices. Problems related to installation, use, or maintenance can increase water use or make sustained use of equipment unlikely. If the city’s retrofit promotion program also provided information on maintenance and use, that program might better achieve its goals.

Water utility customers also suggest that improvements in public information and communications could reduce the level of resistance to drought management policies. Public support for condition 3 water rationing among focus groups, survey, and interview participants seemed contingent on perceptions of equity. Convincing the public that the burden of water rationing is distributed equitably could be accomplished by the periodic release of appropriate information. For example, the California Department of Water Resources (CDWR 1991) suggests that pertinent information regarding water use and water supply should be published and disseminated at least weekly to maintain customer commitment to the water saving program. One factor that makes public information programs difficult to implement in Corpus Christi is a lack of funding (Cable 1996).

Examples of recent steps to improve public access to water shortage information include the city’s “Weekly Water Update,” which began in August 1996 and is broadcast on the local public access cable channel, and publication of answers to frequently asked questions, or Water FAQs, which began in October 1996. Other low-cost alternatives could include periodic utility bill inserts discussing water supply issues or the creation of a World Wide Web page. A web page could provide information on the water shortage, recognize customers who have implemented substantial or creative water saving measures, and carry up-to-date progress reports on how well the city is meeting water-saving goals. Regardless of the variety of instruments established to facilitate drought management communications, focus group participants expressed a need for city representatives to speak with one voice if public information programs are to be effective.

Adopt seasonal water prices and or drought conditional water prices. Prices create incentives for customers to allocate water to highly valued use. Seasonal and drought conditional water prices could help reduce water consumption by internalizing the social cost of water use in each customer’s decision to apply water to specific uses. This shift in water price can eliminate the least-valued water uses and reduce aggregate water consumption when some customers’ willingness to pay for water is less than the price. Because each customer allocates water to its most highly valued use, the economic losses associated with reduced water consumption are minimized. Seasonal water prices are surcharges for water used during the outdoor watering season. The fraction of water used for seasonal uses can be estimated by comparing water use
during the seasonal period with water use during the winter period, which is defined as a customer's base level of water use. Drought conditional water prices are surcharges for water used specifically during drought periods. Although utility rate increases can be difficult to accomplish politically, price increases can accomplish goals similar to water rationing without imposing the same community-wide economic costs as specific regulations governing how customers use water or how much water each customer may use.

Unlike utility water rates that are designed to cover the cost of water supply, seasonal and drought conditional water prices are a kind of tax that reflect the social cost of water use. Seasonal water uses presently account for approximately 15 percent of annual water consumption and seasonal water rates work only to reduce seasonal water uses. The potential water savings associated with implementation of seasonal rate structures may be limited. In contrast, drought conditional water prices could achieve short-term water savings that exceed those of seasonal water rates. A drought conditional water price should reflect the risk of water supply depletion and could become effective as part of drought conditions 1 or 2. The limitations of a rate cap in Corpus Christi that restricts utility costs and water price increases to no more than 6 percent per year may not preclude use of seasonal water prices or drought conditional water prices.

The argument for use of market incentives to encourage water savings is based on the logic that conditional water prices can achieve water savings at a lower cost than regulation. However, noneconomic policy goals may suggest some adjustments to a flat conditional water price. For example, conditional water prices can be seen as a regressive tax on water consumption. When measured as a percentage of household income, the greatest impact may fall on lower income residential water users that may not use much water in the first place, and a conditional water price may have little effect on wealthier water customers who are responsible for a large percentage of residential water use. If it is not the objective to place a disproportionate amount of the burden for reducing water consumption on lower income residents, this effect could be moderated by providing assistance in paying conditional water prices to certain classes of customer. The city already maintains a similar assistance program called Heat Help. Alternatively, drought conditional water prices could be applied to water increments above a specified minimum.

How do conditional water prices compare with current proposed surcharges for water use above proposed allocations of water under drought condition 3 water rationing? Unlike proposed surcharges, there is no penalty for water use above a specified level. This preserves the economic benefits associated with using prices to create incentives that reduce water consumption. Another difference between proposed surcharges and drought conditional water prices is that the latter reflect the risk of water supply depletion. Conditional water prices may be relatively low initially but could increase as a water shortage continued or as the risk of water supply depletion increased. There is presently no apparent link between the social costs of water consumption in Corpus Christi and surcharges proposed for exceeding condition 3 water allocations. A third difference is that drought conditional water prices are in place before a water shortage occurs.
Adopt training programs for commercial water users to teach water conservation methods and strategies. This report describes several obstacles to water savings based on discussions with residential, commercial, and industrial customers. One obstacle expressed by commercial customers, especially smaller commercial customers, was a need for training programs that provide information on how to achieve water savings. Efforts at training could pay off by increasing the effectiveness of short-term water rationing and longer-term water conservation. Activity-based training programs rather than industry-based programs are recommended to reach the greatest possible number of participants. An effective training program could lower both the level and rate of growth in water demands in the future.
Table 1.1
Some Key Results of This Water Savings Analysis

- Water savings are apparent in aggregate total and treated uses between May and November 1996.
- Water savings are apparent in commercial and residential water user sectors between May and November 1996.
- All water user sectors respond to rainfall and temperature variables.
- Statistically significant price elasticities are apparent only in the commercial water user sector. When aggregated by sector, industrial and residential water customers show little response to price changes occurring between 1986 and 1996.
- Small but statistically significant increasing trends appear in aggregate per capita total water use. No significant increasing or decreasing trends appear in per capita treated water uses.
- Significant increasing trends appear in commercial and industrial water user sectors, but these estimates do not control for differences in productivity across years.
- Although per account residential water demand has decreased in absolute terms over the past 15 years, there are no apparent increasing or decreasing trends in the residential water user sector given model determinants of water demand.
Production Related Water Saving Measures
- Businesses reported implementing measures to conserve water in production in advance of condition 3 water rationing.
- Businesses began saving water by repairing, maintaining, and altering current production processes to affect the greatest possible water savings before investing in new capital equipment or additional labor hours.
- Some organizations implemented voluntary water saving measures to avoid perception of water waste.

Non-Production Related Water Saving Measures
- Participants reported implementing non-production related efforts beyond those required by the city in drought conditions 1 and 2.
- Relatively few participating businesses implemented voluntary indoor water saving measures that do not relate to production.
- A majority of commercial/industrial participants formally encouraged their employees to conserve water.

Total Water Use
- Participants reported using less water in July 1996 than in July 1995.

Marginal Water Use
- Significant water use reductions may require an emphasis on reducing water use in production.
- Many commercial/industrial participants waited to learn the requirements of condition 3 water rationing to decide which processes to alter.
- Outdoor water use may be more marginal than indoor water use for non-production related processes.
- Organizations make water savings decisions based in large part on the relative cost-effectiveness of potential projects.
- Firms in which water is a minor expense generally plan to revert to previous water consumption behavior when drought restrictions and voluntary savings requests expire.
- Firms in which water is a major expense might keep in place investments made during the current water shortage that prove to be cost-effective.
Table 1.2 (cont.)
Commercial/Industrial Input: Observations about Patterns of Water Use

**Obstacles to Water Savings**
- Uncertainty about condition 3 water rationing and the baseline from which the city will calculate rations is a significant obstacle to increased voluntary water savings.
- Lack of information about methods of reducing water use is an obstacle to increased water savings among smaller commercial enterprises.
- Some commercial/industrial customers face the additional obstacle of reliance on their own customers’ water savings to reduce water use.
- Facility and equipment constraints are obstacles to increasing voluntary water savings.
- Health, safety, and liability issues are obstacles to increasing voluntary water savings in some commercial/industrial sectors.
- Public resistance can prevent organizations from implementing voluntary water saving measures.
- Water quality problems resulting from the water shortage are an obstacle to increased voluntary water savings among larger industries.

**Possible Substitution Effects**
- Commercial/industrial participants are able to substitute other inputs for city water in some production processes.
- Where substitution of other inputs for city water is cost-effective, most of the city’s largest industrial water customers have already invested in the necessary technology.
Table 1.3
Commercial/Industrial Input: Observations about Economic Impact

**Indicators of Economic Impact**
- Focus group and survey results indicate that revenue and employment would be appropriate indicators of the economic impact of the water shortage and city restrictions on most commercial/industrial sectors.

**Perceived Short-Term Economic Impact**
- Revenue and employment have been hurt in industries affected most directly by drought condition 2 mandatory water restrictions.
- Many participants experienced small increases in fixed costs to comply with condition 2 outdoor watering restrictions and with the city request for voluntary water savings.
- Many participants experienced small increases in variable costs to comply with condition 2 outdoor watering restrictions and with the city request for voluntary water savings.
- Many participants were unable to estimate the revenue and employment impacts of condition 3 water allocation.
- Anticipated impacts of condition 3 water rationing on revenue and employment are unclear.
- The revenue and employment effects of condition 3 water rationing depend on the reduction required by the city and the baseline from which the reduction is calculated.

**Possible Long-Term Economic Impact**
- A majority of commercial/industrial participants believed that the long-term risk of drought in Corpus Christi is high enough to justify the cost of water saving investments.
- The current water shortage affected few participants' long-term expansion plans.
- Industrial participants expected water shortage long-term risks to affect their ability to compete for resources from parent firms.
- Commercial/industrial participants expressed concern that the long-term risk of water shortage will harm the local economy.
Table 1.4
Residential Customer Input: Observations about Patterns of Water Use

Mandatory Water Savings
- Residential customers report compliance with drought condition 2 outdoor watering restrictions.
- Residents report that compliance with condition 2 watering restrictions is not costly.
- Households report that they will be able to comply with the short-term requirements of condition 3 allocation.
- Anticipated long-term foundation and landscaping costs may reduce residents’ willingness to restrict outdoor watering under condition 3.
- The current surcharge plan for drought condition 3 may not discourage households’ use of water beyond their allocation.

Voluntary Water Savings
- Residents report implementing voluntary outdoor water saving measures beyond those required by drought condition 2.
- Residents report implementing voluntary indoor water saving measures in conditions 1 and 2.
- Households report maintaining or reimplementing many water saving practices implemented in response to the 1984-1985 water shortage.
- Households report implementing many of the water saving measures they consider to be most effective.

Total Water Use
- Residents report that water saving efforts are reducing their total household water use.
- Residents report that compliance with mandatory water restrictions does not necessarily reduce outdoor water use.

Obstacles to Water Savings
- Cost, convenience, and lack of information are the three most commonly reported obstacles to household water savings.
Table 1.5
Residential Customer Input: Observations about Marginal Water Use

• Outdoor water use is marginal relative to indoor water use among residential focus group participants.
• Residents report greater willingness to reduce water use for a variety of purposes than to cease water use for selected purposes in the short term.
Table 1.6
Residential Customer Input: Attitudes toward Drought Management and City Water Policies

Knowledge and Perceptions of the Water Shortage
• Focus group participants consistently rank the water shortage among the most important city concerns.
• Residents demonstrate reasonable perceptions of the causes and severity of the water shortage.

Attitudes toward Drought Management and Water Savings
• Residents express positive attitudes toward mandatory and voluntary household water saving measures in conditions 1 and 2.
• Most residents perceive current plans for household water rationing under condition 3 to be adequately restrictive, but not timely.
• Most residents perceive condition 3 household water rationing to be fair, provided it is adequately enforced.
• Residential perceptions about the fairness of condition 3 rationing are influenced by perceptions of the extent to which business and industry have pursued water savings.
• Residents see a role for voluntary household water savings, but not mandatory restrictions on water use, in long-term drought management programs.

Attitudes toward City Management of the Water Shortage
• Many residents are unfamiliar with the city’s four-stage drought contingency plan.
• Residents are divided over the city’s ability to plan a solution to the current water shortage.
• Residents would like the city to provide information about how to save water and about city water policy on an ongoing basis.

Long-Term Water Supply Preferences
• Residents report the need for more information to identify preferred long-term water supply alternatives.
• Residents prefer a strictly proportional distribution of costs for long-term water supply solutions among water customers.
• Residents appear less willing to share the costs of long-term water supply solutions when responding to a specific cost scenario.
Table 1.7
Commercial/industrial Input: Attitudes Toward Drought Management and City Water Policies

Knowledge and Perceptions of the Water Shortage
- Most commercial/industrial customers are well informed about the causes and severity of the water shortage.

Attitudes toward Mandatory and Voluntary Water Savings
- Commercial/industrial attitudes toward mandatory and voluntary water savings are shaped by firm-level economic effects of water saving measures.
- Most commercial/industrial participants report that condition 3 and 4 drought management measures should be implemented as planned or in a manner less restrictive than planned.
- Commercial/industrial customers see a role for voluntary water savings, but not mandatory restrictions, in long-term city water management plans.

Attitudes toward City Management of the Water Shortage
- Most commercial/industrial customers are familiar with the city’s drought contingency plan.
- Commercial/industrial participants express confidence in the city’s ability to plan a solution to the current water shortage.
- Commercial/industrial participants identify consistent policy and enforcement as important elements of the city’s drought management program.
- Participants report a need to improve the two-way flow of information between the city and commercial/industrial interests.
- Participants suggest that city drought management policies should incorporate incentives to save water in advance of mandatory restrictions.

Long-Term Water Supply Preferences
- Commercial/industrial participants report that preferences regarding long-term water supply options are based chiefly on the cost of water produced.
- Most commercial/industrial participants would prefer the cost of long-term water supply options be distributed in proportion to total water use.
Figure 1.1
Forecast of Municipal Per Capita Per Day Water Demand
(gallons per capita per day)
Chapter 2. Overview of Drought Management and Water Supply

Drought Management Program Summary

The city’s drought management plan consists of four conditions which may be put into effect when reservoirs reach specified trigger levels. Condition 1 imposes a once-a-week limit on lawn watering and requests voluntary reductions in water use among customers with the goal of achieving a 10 percent water savings. The city Council began implementation of condition 1 measures on April 9, 1996. Condition 2 further restricts seasonal water uses such as building washing, car washing and other outdoor water uses with the goal of achieving an additional 5 percent water savings. Seasonal water use accounts for about 15 percent of annual water demands in Corpus Christi. Condition 3 requires residential customers to ration water. Water rations range from a minimum of 6,000 gallons per month to a maximum of 12,000 gallons per month, depending upon the number of household residents. Rations are enforced by surcharges to customers who exceed them. Residential customers who exceed the water ration by more than 4,000 gallons per month will be removed from the system and charged $50 and $500 for reinstatement after the first and second offenses, respectively. Customers that exceed their water rations more than twice during the drought management period will be permanently removed from the system until after the drought management period. Condition 3 also requires mandatory use reductions among commercial and industrial customers. The city began implementation of condition 3 drought restrictions on November 1, 1996, and was poised to begin water rationing when combined storage of the reservoirs reached 20 percent of capacity. The goal of condition 3 water restrictions is to reduce water use an additional 10 percent. Condition 4 further restricts water use by prohibiting new connections to the city’s water supply system, revising industrial and commercial allocations, and establishing revised rate schedules for maximum monthly residential use.

When fully implemented, the drought management program is expected to reduce water consumption 35 percent. A 1988 study showed significant water savings associated with implementation of that program in 1984 (Shaw and Maidment 1988). However, there remains considerable uncertainty on the part of water managers about the effectiveness of this program in 1996. This project clarifies both the effectiveness and the cost of program implementation. This project also includes a significant public participation component that addresses economic effects of restrictions on water uses and behavioral changes in patterns of water use. Residents and business managers provided input through survey responses and a series of focus group sessions. Analysis of participant input provides a means to evaluate the effect of water use restrictions on investment decisions, operations, and residential water uses. Such information appears potentially more useful to policymakers than estimates of income and employment effects. City staff report that information about public attitudes gained from participants not ordinarily involved in local water issues has been a valuable product of this effort.
Water Supply

The city of Corpus Christi and surrounding communities in 12 counties depend on river flows in the Nueces, Frio, and Atascosa Rivers which drain into two reservoirs, Choke Canyon Reservoir and Lake Corpus Christi, before draining into the Gulf of Mexico. The city completed its dams at Lake Corpus Christi in 1958 and at Choke Canyon Reservoir in 1978. According to the 1990 census, the total population of the 12-county area is 530,878, with 65.9 percent of that population in the Corpus Christi Metropolitan Statistical Area (MSA). The MSA is defined as Nueces and San Patricio Counties. Three years of drought in the river basins resulted in a combined inflow to the reservoirs that was less than the rate of withdrawal. At the time this study began, steadily declining reservoir levels were at approximately 30 percent of capacity.

Water Use in the Corpus Christi Service Area

The city of Corpus Christi database includes information on water sales to both retail and wholesale customers. Of total water sales, 69.8 percent are treated water sales and 30.3 percent are untreated water sales (see Figure 2.1). Industrial raw water uses account for 10 percent of total water use. Wholesale customers that resell water for commercial, industrial, and residential uses outside the city’s end-user area account for 26.3 percent of total water sales. Direct sales of treated water by Corpus Christi Water Division to commercial, industrial, and residential endusers account for 63.8 percent of total water sales. Figure 2.2 shows that 44.8 percent of this use is industrial, 25.4 percent is residential, and 17.6 percent is commercial (including apartments).

Average monthly per capita water use in the Corpus Christi area is listed by year in Table 2.1 for total water use and treated water use. Total water use is the sum of treated water sales to retail and wholesale customers plus the sum of raw water sales to wholesale and industrial customers. Treated water use is the sum of all treated water sales to retail and wholesale customers. Analysis of per capita water use controls for changes in water demand related to changes in population and identifies technological or behavioral trends in water use. Because population estimates do not correspond directly to the population served, the implicit assumption is that population growth in the MSA is equal to the population growth in the Choke Canyon/Lake Corpus Christi service area. This allows a comparison of water demand across years.

Population estimates do not correspond directly to the area served. The reason is that approximately 7.8 percent of the population served by the Choke Canyon/Lake Corpus Christi system is located outside the MSA. Similarly, HDR Engineering, Inc., estimates that only about 92 percent of the MSA population is served by the Choke Canyon/Lake Corpus Christi water supply system (HDR Engineering 1995). While this method serves the purpose of the analysis presented in this report, caution is advised in direct interpretation of (1) per capita water demands or (2) comparison of Corpus Christi per capita water demands versus per capita water demands in other cities.
Table 2.1 lists average water use per account for residential, commercial, and industrial customers in the Corpus Christi retail service area. Like per capita water use, per account water use controls for changes in water demand related to an increasing number of service connections. For example, an increasing level of commercial water use per account might suggest long-term changes in water efficiency or increased productivity of commercial and industrial customers. Short-term changes in the level of per account water use could be related to temperature and rainfall effects, or other factors.

**Growth of Water-User Sectors**

The residential water user sector is the strongest growing water user sector in Corpus Christi. The number of residential customer accounts increased by 16.66 percent between 1982 and 1996. The number of commercial and industrial customers fluctuated over the same 10-year period, but there was a net increase in the number of accounts between 1982 and 1996. The number of commercial accounts increased 5.6 percent and the number of industrial accounts increased 15.47 percent. Table 2.2 lists the number of customer accounts in each water user sector serviced by the city's retail water utility. Also listed in Table 2.2 is the number of residents in the Corpus Christi MSA. As described above, these population estimates include some residents in Nueces and San Patricio counties not serviced by the Choke Canyon/Lake Corpus Christi water supply system.

**Focus on Residential Water Sales**

Residential water sales, retail water sales to single-family residences and duplexes, account for approximately 25 percent of annual water demand. The residential water-user sector is the fastest growing water user sector in Corpus Christi. Figure 2.3 compares the distribution of residential accounts over a range of water volumes representing the mean monthly volume of water billed during a four-month period including May, June, July, and August in four separate years, 1993 through 1996. For graphical purposes, the figure makes no distinction between lines representing years 1993-1995. A special symbol has been added to the line representing the distribution in 1996 to show how it compares to those years prior to the drought management period. The figure shows little difference in this distribution between years and that a significant portion of residential water sales can be attributed to a small percentage of residential accounts. Figure 2.3 also shows the percentage of customers billed for a given quantity of water. For example, the average monthly water bill during the four-month period was 6,000 gallons or less for 30 percent of households.

The purpose of Figure 2.3 is to compare the distribution of residential water accounts in years preceding 1996 with the distribution of accounts during the drought management period, May-August 1996. A water savings could be reflected in a unique distribution. For example, this graph could show that drought restrictions or water rationing has a larger impact on high-volume water users than on low-volume water users. Although some change in the level of distributions can be attributed to rainfall and temperature effects, this analysis does not control for rainfall or temperature. Visual inspection of distributions across years suggests that program efforts
produced little effect on the pattern of water sales between high- and low-volume water users in that period. No comparable analysis was completed for the period after August 1996. Figure 2.3 also suggests that a small percentage of residential water accounts are responsible for a large percentage of the residential water sales. Evidence of this fact is more pronounced in Figure 2.4 in which the x-axis represents a cumulative percentage of residential water accounts and the y-axis is the 1993-1995 average percent of residential water sales during the four-month period May through August. Figure 2.4 shows that the 25 percent of residential water accounts in the upper quartile was responsible for approximately 50 percent of all residential water sales between May and August. The 10 percent of residential water accounts in the upper decile account for 30 percent of residential water sales during that same period.

**Water Prices**

In theory, water price is a determinant of water demand. One goal of this report is to assess the potential effectiveness of price change as an incentive for encouraging customers to reduce water use. The city of Corpus Christi maintains separate rate structures for commercial and industrial customers and residential water customers. Commercial and industrial customers pay a decreasing block rate both inside and outside the city limits. Residential water customers pay an increasing block rate inside the city limits and a flat rate outside the city limits. Since 1990, nominal rate increases have averaged about 6 percent per year, which is the maximum rate allowed by the city's utility rate limit. In general, nominal commercial and residential water prices change at the same rate. For example, in 1995, the price of each rate block increased 6 percent. Appendix B lists nominal water prices by the year and month in which they became effective (see Volume II).

Nominal water prices were converted to real prices by dividing by a price index based on monthly series of producer and consumer price indexes obtained from the Bureau of Labor Statistics. Real marginal price in the residential water sector is defined as the price of the eighth thousand gallon delivered during the billing month divided by the consumer price index of the billing month (1982-1984 = 1.00). The consumer price index is for all urban consumers and all items (series identification number "cuur00000sa0"; Bureau of Labor Statistics 1996). Real commercial/industrial price is the marginal price of the next thousand gallons after the first 100,000 gallons during the billing month divided by an adjusted monthly producer price index. The producer price index is a national average price for all commodity categories relative to that price in another month. The average is weighted by the value of shipments (series identification number "wpu00000000"; Bureau of Labor Statistics 1996). The raw producer price index has a base year of 1982 = 1.00. It was converted to 1982-1984 = 1.00 for consistency with the consumer price index.

Figure 2.5 compares an index of real marginal price of water over time in the commercial/industrial and residential sectors. The index of marginal water price is the real price divided by the average real price during the period 1982-1984, which is the base year of the index. The purpose of Figure 6 is to show the cost of water today relative to the cost of water in the past.
and in comparison to prices of other consumer products and producer inputs. Real water prices have fluctuated over the past 14 years but are higher today relative to other consumer products and producer inputs. For example, the net increase in real price of water between 1982 and 1996 is about 22 percent in the residential sector and 41 percent in the commercial and industrial sectors.

The city applies price increases equally in both commercial and industrial water sectors. For example, when residential prices increase 6 percent, commercial and industrial prices also increase 6 percent. Differences in the change in real marginal price between water user sectors shown in Figure 2.5 are related to differences in the consumer and producer price indexes used to standardize prices across years. The producer price index used to standardize commercial/industrial water prices has risen at a slower rate than the consumer price index, making water price increases in the commercial/industrial sector higher relative to other inputs.
Table 2.1  
Mean Monthly Per Capita and Per Account Water Use (1982-1995)  
(Corpus Christi Metropolitan Statistical Area)

<table>
<thead>
<tr>
<th>Year</th>
<th>Per capita water use per month</th>
<th>Per account water use per month</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(thousand gallons)</td>
<td>(thousand gallons)</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>Residential</td>
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<tr>
<td></td>
<td>Treated</td>
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</tr>
<tr>
<td>1982</td>
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<td>5.25</td>
</tr>
<tr>
<td>1983</td>
<td>7.52</td>
<td>5.35</td>
</tr>
<tr>
<td>1984</td>
<td>7.16</td>
<td>5.01</td>
</tr>
<tr>
<td>1985</td>
<td>6.53</td>
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</tr>
<tr>
<td>Year</td>
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<tr>
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<td>1996</td>
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</table>

Sources:
1. Bureau of Economic Analysis 1996
2. City of Corpus Christi Planning Department.

Notes:
3. Estimated by the authors
4. Adjusted to 257.45 for the period April-December 1990
Figure 2.1
Total Water Sales by the City of Corpus Christi, Fiscal Year 1995

Figure 2.2
Treated Water Sales by the City of Corpus Christi, Fiscal Year 1995
Figure 2.3
Cumulative Distribution of Average Monthly Residential Water Billed During the Period May-August by Year, 1993-1996

Figure 2.4
Chapter 3. Water Demand Forecasting and Water Savings Analysis

When the purpose of the forecasting exercise is to evaluate water savings from drought management, the overall approach is to develop water demand forecasts over the drought management period as if no drought management program were in place. The difference between forecast values and actual water use is interpreted as water savings. Several methodological approaches to water demand forecasting exist. The utility of any one method may vary depending upon the scale of the time series. For example, the time series may be hourly, daily, weekly, or monthly. The purpose of the analysis is fundamental to selection of time series scale. Daily and hourly models may be most appropriate for utilities that frequently need to adjust production levels in response to highly variable demands. While monthly models are less useful for making short-term production decisions, they have proven to be entirely adequate for understanding the factors that affect water use, predicting demands in the months ahead, and detecting and measuring water savings.

Shvartser, Shamir, and Feldman (1993) used pattern recognition in conjunction with autoregressive integrated moving average (ARIMA) models to forecast hourly water demands up to several days ahead using the past 15 days of hourly water use data. Anderson, Miller, and Washburn (1980) used regression to forecast daily water use and estimate water savings in Fort Collins, Colorado. Maidment and Miaou (1986) developed models of daily water use for cities in Texas, Pennsylvania, and Florida using time-series decomposition and Box-Jenkins transfer function noise models. These authors provide an overview of water demand forecasting methods used in the literature through 1984. Shaw and Maidment (1987) applied these methods using an intervention component in their transfer function noise model to estimate water savings during 1984-1985 in Austin and Corpus Christi, Texas. The Austin model is reviewed in Maidment, Miaou, and Crawford (1985). The Corpus Christi drought management study is reviewed in Shaw and Maidment (1988).

Hansen and Narayanan (1981) used time-series regression to estimate monthly water demands and interpret price elasticities in Salt Lake city, Utah. These authors explained over 90 percent of the variation in monthly water demands using regression procedures. Maidment and Parzen (1984) developed a time-series decomposition and climatic regression procedure for monthly water use in five Texas Cities and for Deerfield Beach Florida. That model explained 86 percent of the variance of the monthly series in Canyon, Texas. These authors suggest that multiple regression is suitable for annual and monthly data in slowly changing cities. Time-series works best in rapidly growing cities, and for daily and weekly water use data. The relatively high computational requirement of time-series analysis must be balanced with any expected increase in the forecasting ability of the model. Franklin and Maidment (1986) compared the use and performance of weekly and monthly time-series forecasts with forecasts based on a time-series decomposition and regression approach. Models of weekly water use performed only slightly better than their monthly counterparts.
Berk, LaCivita, Sredl, and Cooley (1981) used Box-Jenkins ARIMA models to estimate the effects of drought management programs on monthly water consumption in several California cities during the drought of 1976-1977. The study estimated water savings in different water user sectors including agricultural, commercial, industrial, and residential sectors. These authors list two reasons that the Box-Jenkins method might be preferred to regression corrected for autocorrelation (correlated residuals): (1) logical selection of autoregressive terms and (2) flexibility to use lagged dependent variables with autoregressive error terms to model delayed responses. The latter is necessary because the effect of drought management programs may not be immediate.

Some authors study the effect of alternative forms of climatic specification on regression results. Morgan and Smolen (1976) studied a set of variables including (1) simple temperature and precipitation variables; (2) potential evapotranspiration minus precipitation; and (3) monthly seasonal dummy variables. Evaluation of model results included the effect of regressors on price and family income variables as well as assessment of each model’s forecasting power. The authors concluded that simple temperature and rainfall variables outperformed alternatives. Weber (1989) used regression of monthly water demand on a seasonal index and rainfall, temperature, and price variables to estimate price elasticities of water demand. His model incorporates a moving average index to model transitions in water use between winter and summer months.

The selected method should provide a reasonably precise estimate of what water use would be given economic activity and weather patterns during the drought management period. The utility of results to water managers was an important concern in selection of methods. The perception among utility managers has been that information on total water savings is more valuable when accompanied by identification of those water sectors in which savings are realized. Provided in real time, such information could identify water user sectors where more effort or alternative program designs are needed. Information about water uses by water user sector were readily available on a monthly basis from billing records. Thus, the project team settled on the analysis of monthly water use to forecast water demand.
Chapter 4. A Rainfall-Temperature Model of Water Use

Rainfall-Temperature Model Development

One difficulty with using ordinary least squares regression to forecast water sales is that the presence of serial correlation, a correlation between residuals of the regression model, violates one of the underlying assumptions of the method. Regression results may not be interpretable because of inefficient parameter estimates and inflated estimates of the R-squared statistic. Two rainfall temperature models have been developed to forecast water use in Corpus Christi. The first is a rainfall-temperature regression model that corrects for autocorrelation with an autoregressive error term. The second is a moving average index model that does not exhibit autocorrelation. In general, the latter performs slightly better as a forecasting tool, but the rainfall-temperature model is preferred for making inferences from parameter estimates.

The model uses monthly rainfall and temperature as independent variables to estimate per capita and per account water sales. Separate analyses have been developed using six aggregations of water sales. These are total, treated, municipal, residential, commercial, and industrial water sales. This chapter of the report uses an analysis of total water sales, treated water sales, and municipal water sales to inform the reader of the forecasting approach and interpretation of results. Per capita total water sales is calculated as the sum of all treated and raw water sales divided by the combined population of Nueces and San Patricio Counties. Per capita treated water sales are the sum of all wholesale and retail treated water sales by the city of Corpus Christi divided by the combined population of Nueces and San Patricio Counties. Both are expressed in thousand gallons per capita and include sales to wholesale customers serving the surrounding areas such as Alice, Beeville, Mathis, Port Aransas, and San Patricio Municipal Water District. Municipal water sales are defined as treated water sales to residential and commercial customers inside the city limits divided by the population inside the city limits and again divided by the number days in the month. Unlike the other aggregations, municipal water demand is expressed in gallons per capita per day (gpcpd).

The minimum data requirements needed to forecast demand using these methods include the year and month of water sales, volume of water sales, number of active accounts billed, population, the mean maximum daily temperature, and aggregate rainfall over the billing month. Specification of the dependent variable on a per capita basis eliminates changes in the total water use related to an increasing or decreasing number of residents, although it does not control for changes in water demand related to an inflow of tourists. Total water use and treated water use were analyzed using population to standardize across time because much water is sold to wholesale customers outside the city’s water utility retail service area. Because population estimates do not exclude all persons outside the service area, standardizing the dependent variable by number of accounts is potentially more accurate. However, no data were available on the number of accounts beyond the city’s immediate retail service area.
The explanation of equation 4.1 is that as temperature increases, per capita (or per account) water use increases as people begin summer activities such as lawn watering and car washing. Indoor water use may also increase as people take more showers and wash more clothing. There is also evidence that industrial demand for cooling water also increases as outdoor temperatures rise. The model also includes precipitation which reduces outdoor water demand. These variables describe short-run determinants of water use. If the series extends over more than a few years, the addition of a trend variable can capture long-run determinants of demand such as technological change. The equation states that per capita water use is a function of temperature, rainfall, and long-term determinants of water demand other than population:

\[
\hat{W}_t = \beta_0 + \beta_1 T_t + \beta_2 T_t^2 + \beta_3 R_t + \beta_4 T_t + v_t
\]

\[
v_t = \epsilon_t - \phi_1 u_{t-1} - \phi_2 u_{t-3} - \phi_3 u_{t-10} - \phi_4 u_{t-12}
\]

\[
\epsilon_t \sim N(0, \sigma^2)
\]

where:

\(W\) = per capita water sales (thousand gallons)

\(T\) = mean maximum daily temperature (fahrenheit)

\(R\) = aggregate rainfall (inches)

\(v\) = an error term

\(u_t = W_t - (\alpha_0 + \alpha_1 T_t + \alpha_2 T_t^2 + \alpha_3 R_t + \alpha_4 T_t)\) = residuals of the structural equation

\(\alpha\) = parameters estimated by a preliminary regression

\(\beta\) = parameters estimated by regression

\(\phi\) = autoregressive parameters for error terms

\(t\) = an index of months \(i = \{1, 2, 3, \ldots, n\}\) (January, 1982 = 25)

\(i\) = the lag of significantly correlated residual errors

The error term corrects for autocorrelation. Autocorrelation is a positive or negative correlation between the difference in predicted and actual values of a regression and that difference at one or more lags in the past. Autocorrelation results in inefficient parameter estimates. Interpretation is
more difficult than in the structural model and provides little in terms of understanding water use processes. However, the presence of the error term can improve the forecasting ability of a model and allow for separate interpretation of structural parameters. Model coefficients for per capita total and treated water sales are provided in Table 4.1.

This model forecasts monthly per capita treated water sales when estimated over the period January 1986 to April 1996. The 1996 drought management period May to August is excluded from the period over which parameters are estimated. The structural parameters of this model—temperature, rainfall, and trend—account for 70.36 percent of the variation in treated water use. The autoregressive error term accounts for an additional 16.39 percent of that variation. Overall, the model accounts for 86.75 percent of the variation in treated water use. Although the model of per capita total water use works well also, the R-squared statistic for structural parameters is relatively low.

The squared temperature term of the rainfall equation accommodates seasonality in water use. A nonlinear relationship is needed because water sales increase more rapidly in relation to temperature increases at higher temperatures and during late spring and summer months. Inclusion of a squared temperature term describes an increasing rate of water use relative to a $1^\circ$ change in temperature. Although a negative coefficient for the temperature term implies decreasing water use with increasing temperature, this is balanced by a positive coefficient for the squared temperature term. The method outperformed seasonal dummy variables and logarithmic transformations that might also be used to describe these temperature effects.

Figure 4.1 plots the relationship between water use and temperature. There is an increasing rate of water use for each $1^\circ$ change in temperature. These estimates represent water use over a range of temperatures while holding rainfall at 2.601 inches per month and other structural parameters constant. Interpretation of the precipitation variable is straightforward. One inch of rainfall reduces per capita treated water use on average 42 gallons per month. The parameter estimate for the trend variable is positive but small and statistically insignificant. This indicates no long-term change in per capita treated water use that might be attributed to changes in water use patterns or changes in technology.

Results for per capita total water use are slightly different. Although the temperature terms are almost identical to those estimated for treated water use, the parameter estimate for rainfall shows a larger effect. The trend variable which measures long-term change in water use is also positive and statistically significant, which suggests per capita water use is increasing at a rate of nine gallons per capita per month. Because analysis of per capita treated water use shows no statistically significant trend, this increase in total water use could be attributed to raw water users or increased demand for water outside the metropolitan statistical area.

40
Evaluation of the Rainfall-Temperature Model

This model can be evaluated on several bases. Among these are its ability to (1) explain those processes causing high or low water uses; (2) its ability to forecast accurately over the estimation period, or one or more months ahead; and (3) the precision of water demand estimates. The interpretation of model parameters to explain possible causes of high or low water use has already been discussed. Structural parameters account for 48 percent of the variation in total water use and 70 percent of variation in treated water use. One variable potentially missing from this model is related to economic causes of water use. Commercial and industrial customers account for 49.8 percent of treated and untreated water sales. It is likely that long-term economic growth or short-term changes in productivity and demand could be identified as causal factors of water demand. Income and employment variables tested during development of this forecasting model have been excluded because they produced inconsistent results. Price variables were difficult to specify for total, treated, and municipal water sales, but are evaluated in models of sectoral water demand.

The accuracy of forecasts over the estimation period can be evaluated by the average absolute relative error (AARE). This measures how closely the predicted values match the actual values of the time series over a period of one or more months ahead. AARE is the absolute value of the residual divided by the actual value of water use (Franklin and Maidment 1986). Equation 2 describes how the mean AARE is calculated over n time intervals:

\[ AARE = \frac{1}{n} \sum_{i=1}^{n} \frac{|\epsilon_i|}{W_i} \]  

where:

AARE = average absolute relative error

W = actual water use

\( \epsilon \) = the error of the forecast

\( t \) = an index of time interval \( t = \{1, 2, 3, \ldots, n\} \)

Table 4.2 lists the average AARE for models of per capita total and treated water sales during each year over the estimation period. For example, in 1986 the mean AARE of the treated water sales model is 7.3 percent. The overall mean AARE of that model during the estimation period, January 1986, through April 1996, is 4.3 percent and the range in monthly AARE is 0.06 percent
to 17 percent. Unusually high errors occur in the first year due to adjustment of the error term, \( v \), in equation 4.1. After 1986, the monthly AARE exceeds 10 percent during only three months and has a maximum monthly error of 13 percent in one month.

A third measure of how well the forecasting model will detect water savings is precision of model estimates, measured by the relative width of the mean confidence interval around water demand forecasts. The confidence interval reflects the bounds in which the true mean estimate of the forecast would fall 95 out of 100 times, given the independent variables of the regression equation and the variability in the data. It is desirable to have a forecasting model with narrow confidence bands that is sensitive to small differences in water use. Confidence intervals expand at an increasing rate as one moves from the center of the estimation period to the beginning or end, and at a much faster rate when forecasting beyond the period over which the coefficients are estimated. Confidence intervals are bigger at the beginning of the series because there are no past error terms to use in making the early forecasts (SAS Institute 1993, p. 243).

Water demand forecasts are estimates of water sales in the absence of the drought management program because the model is estimated over a period of time during which no drought management plan was in place. Because there is an error associated with estimates, differences between forecast and actual water sales during the drought management program must exceed some criterion that is an operational definition of water savings before these differences can be distinguished from random error of the forecast. Confidence limits are one such criterion. Figure 4.2 plots the absolute difference between the lower two-sided 95 percent confidence bound and the treated water sales forecast from equation 4.1 as a percent of the forecasted value. Peaks in this operational criteria occur in winter months, when per capita water use is relatively low (Figure 4.2, A). For example, in July 1996, when \( t = 199 \), the minimum treated water savings that exceeds the criteria is 13.26 percent (Figure 4.2, B). If the difference in the water demand forecast and actual water use in that month exceeds the criterion, the estimate of water savings is the difference in forecast and actual values. If the difference is less than this criterion, the conclusion is that any apparent water savings are not large enough to distinguish between water savings and random error of the water demand model. This differs from the statement that no water savings is observed. Use of a two-sided 95 percent confidence bound is conventional, but in some cases there are legitimate reasons for adopting alternative confidence bounds.

Alternate Rainfall-Temperature Model Specification

Reliance on rainfall and temperature alone imply that equation 4.1 models “seasonal” water use while ignoring changes in water use related to productivity, income, or price. Better forecasts and more information about the economic impact of mandatory reductions in water use could be obtained by incorporating these variables into the analysis. Price variables are excluded from the analysis of treated and total water use. The reason for this is that given multiple water user sectors with different block rate structures, the marginal price of water is hard to define. Water prices and price elasticities are addressed later in the analysis of residential, commercial, and industrial water demand sectors.
Income, sales, and employment data were available for the Corpus Christi MSA. Total annual income and income by standardized industrial classification (SIC) code were obtained from the 1994 Regional Economic Information System (Bureau of Economic Analysis 1996). Monthly total employment and employment by SIC code were obtained from the Bureau of Labor Statistics on-line database (Bureau of Labor Statistics 1996). Monthly gross sales and sales tax revenue were available from the Texas Comptroller of Public Accounts. However, anomalies in reporting and tracking of sales data may make these data unsuitable for analysis.

Incorporation of income and employment variables into the analysis produced inconclusive results. Both are theoretically strong determinants of water use (Berk et al. 1981; Weber 1993; Carver and Boland 1980). The results of these preliminary analyses may reflect the quality and applicability of these input "economic" data for the intended use. For example, annual income data can, at best, be averaged over a 12-month period to estimate monthly income. Without monthly or spatial variation, the relationship to monthly water sales can be hard to identify. Although monthly employment data provide the strongest results of all economic variables tested, these data estimate only the total number of jobs held on the 12th day of each month.

Some alternative specification of rainfall and temperature variables may be in order. Aggregate billing records represent the volume of water for which customers were billed during a particular month. These data are produced by the utility operations division by aggregating for each sector the volume of water billed. Although the city reads all water meters each month, reported water use cannot be accurately assigned to monthly rainfall and temperature values because only 60 to 70 percent of water use occurs in the reporting month. Some customers' water use could be attributed to climatic factors during the previous month. This implies a misspecification related to the assignment of rainfall and temperature values, and these parameter estimates may not be interpretable despite accuracy of monthly forecasts. This will not affect the ability of the method to estimate water savings. However, there may be some question about when the savings occurred. For example, savings observed in August billing records may have occurred in July, and savings occurring in August may not be detected until September.

**Water Savings Analysis: Demonstration over the 1984-1985 Drought Period**

The rainfall-temperature model works well as a means of detecting and measuring water savings. To demonstrate how the method works, water savings during the 1984-1985 drought period can be estimated by forecasting backward ("backcasting") over the most recent period during which the city implemented its mandatory drought management program, which included water rationing to residential customers. Model parameters are estimated between January 1986 and April 1996 and water use is estimated for prior months using rainfall and temperature data. The solid line in Figure 4.3 shows the first year of the ex-post forecast over the estimation period. The symbol "x" represents predicted values outside the estimation period. Faint dashed lines above and below the predicted values are the two-sided 95 percent confidence limits. The estimate of water savings during the mandatory drought management period is the difference between forecast water use and actual water use. The effectiveness of that program can be seen in Figure 4.3.
4.3. It shows water savings beginning with implementation of condition 3 water rationing in July 1984 and continuing over several months. Water rationing ended in November of that year.

In this example, the estimated savings is approximately 18.5 million gallons per day. This is less than the 27.2 million gallons per day reported in a study by Shaw and Maidment (1987), but this difference can be attributed to "backcasting." In this example, backcasting is expected to underestimate potential water use during the 1984-1985 drought management period. Because the forecasting equation is estimated after that water shortage, when less water-intensive processes and practices had been adopted and new equipment installed, it does not portray the predrought management water use processes against which water savings should be measured. This discussion has demonstrated that backcasting with this model detects water savings in 1984 despite these problems, and, therefore, forecasting with this model should be able to detect the presence of water savings in 1996.

**Water Savings Analysis: Measuring Aggregate Water Savings in 1996**

A forecast of treated water use on a per capita basis can be developed for the future using rainfall and temperature data from the Corpus Christi International Airport. Forecasts are developed by substituting rainfall, temperature, and time into equation 4.1 with the coefficients listed in Table 4.3. For example, the forecast of per capita treated water sales for May 1996 ($Y_{197}$) is:

$$\hat{Y}_{197} = 16.649 \times 0.363(87.6) + 0.0027(87.6)^2 \times 0.042(1.14) + 0.003(197) + V_{197} = 6.09$$

[Eq.4.3]

$$V_{197} = 0.372u_{196} + 0.211u_{194} \times 0.132u_{187} + 0.409u_{185}$$

The mean maximum temperature during May was 87.6°F Fahrenheit and there were 1.14 inches of rain at the Corpus Christi International Airport. The trend variable for May is defined by the numerical sequence of months in the data series when January 1982 is taken to be 25. While the assignment of indices is somewhat arbitrary because the series could begin at any point in time, changes in the initial assignment of indexes must be completed before estimation of model parameters. The second equation is the autoregressive error term. A series of coefficients is multiplied by the difference in predicted and actual values at significantly correlated lags.

When a forecast of water use is created for more than one time period over the drought management period or after the drought management period has begun, the residuals of lagged forecasts will not be available. The reason is that there is no measurement of water use in the absence of the drought management program. This problem is resolved by substituting the value of the error term at each lag for which the lagged residual is missing. For example, a forecast for August 1996 is missing the first and third lagged residual.
\[ \hat{y}_{200} = 16.649 \cdot 0.363(94.21) + 0.0027(94.21) + 0.042(6.26) + 0.003(200) + \nu_{200} = 6.59 \]

\[ \nu_{200} = 0.372 \nu_{199} + 0.211 \nu_{197} + 0.132 \nu_{197} + 0.409 \nu_{188} \]  

The effect of the error term on the forecast decreases as the number of successive months in the forecast increases.

Figure 9 shows a forecast of water use from July 1993 through November 1996. The x-axis denotes the numerical sequence of months such that 175 represents June 1994, 185 represents April 1995, and 197 represents May 1996. The bands around the forecast line reflect the two-sided 95 percent confidence interval. The lower bound of the two-sided 95 percent confidence interval could serve as an operational definition of water savings. The difference between the forecast and the bound ranges from approximately 885 to 949 gallons per capita between May and November, 1996. That is approximately 14 percent of forecast water sales. With this confidence bound as a criterion for distinguishing between random error and water savings, only differences between forecast and actual water use larger than that difference could be interpreted as an effect of efforts undertaken during drought conditions 2 and 3. Figure 4.4 shows that this condition is met in June, September, and October. However, Figure 4.4 also shows a strong pattern overall that suggests effects of the program each month. Other criteria exist for interpreting water savings. These criteria are discussed later in the text.

Application of Rainfall-Temperature Model to Water User Sectors

The rainfall-temperature model may also be applied to residential, commercial, and industrial water user sectors. Specification of the model and interpretation of results are similar to analyses of treated and total water use. Two differences distinguish these estimates from those generated using equation 4.1. Equation 4.3 includes a marginal price term and is specified on a per account basis rather than a per capita basis. It is applied to three water user sectors. Residential water use consists of all retail water sales to meters at single-family homes and duplexes. Commercial water use includes retail sales of treated water to meters servicing nonindustrial and nonresidential establishments including hospitals, schools, and churches, but not governmental accounts. Industrial water use is retail sales of treated and raw water to industrial customers.

Real marginal prices are specified for water user sectors but were excluded from equation 4.1. The logic for this is that prices vary across users and locations. For example, in the city retail service area there are four different rate structures, including two commercial/industrial rate structures and two residential rate structures. Inside the city limits, residential rate structures are an increasing block rate, while commercial/industrial rates are a decreasing block rate. Outside the city limits, residential prices are a flat rate and commercial/industrial prices are a decreasing block rate, although these prices are higher than inside the city limits. Marginal prices in equation 4.3 are defined for residential customers as the real price of an additional 1,000 gallons when the average customer has already consumed 7,000 gallons in one billing month. Marginal prices for commercial/industrial customers are defined as the real price of an additional 1,000 gallons when the average customer has already consumed 100,000 gallons during the billing month.
The explanation and interpretation of this model are the same as described for equation 4.1 with the exception of the price term. The price term measures customer responses to changes in the real marginal water price. The equation for this sector-specific water demand forecast is

$$\hat{W}_t = \beta_0 + \beta_1 T_t + \beta_2 T_t^2 + \beta_3 R + \beta_4 P + v_t$$

$$v_t = \epsilon_t + \sum_{i=1}^{q} \phi_i u_{t-i}$$

$$\epsilon_t \sim N(0, \sigma^2)$$

where:

- $W$ = per account water use (thousand gallons)
- $T$ = mean maximum daily temperature (fahrenheit)
- $R$ = aggregate rainfall (inches)
- $P$ = real marginal price of water (dollars)
- $u$ = residuals of the structural equation
- $v$ = an error term
- $\beta$ = parameters estimated by regression
- $\phi$ = autoregressive parameters for error terms
- $t$ = an index of months $t = \{1, 2, 3, \ldots, n\}$ (January 1982 = 25)
- $i$ = the lag of significantly correlated residual errors

Model coefficients and t-statistics are presented in Table 4.3. AARE values are listed in Table 4.4. Rainfall and temperature coefficients are similar in sign and significance to those in equation 4.1. The value of coefficients is larger because they reflect change on a per account basis rather than a per capita basis. For example, equation 4.1 showed that 1 inch of rainfall over the period of the month reduces treated water use 42 gallons per capita. Equation 4.3 shows that 1 inch of rainfall reduces treated water use in the residential sector 151 gallons per residential account, and in the commercial sector 468 gallons per commercial account. The rainfall coefficient in the column labeled Industrial Water Use is -35.102. This suggests that rainfall has a negative effect on
industrial water demand; however, the t-statistic is less than the critical value of 1.96. That suggests the slope coefficient is indistinguishable from zero. The interpretation is that rainfall has no measurable effect on industrial water use.

**Trends in Water Demand in Water user Sectors**

There are statistically significant increasing trends in per account water use in commercial and industrial sectors (Table 4.3). The increases are 87 gallons and 16,522 gallons per account per month in the commercial and industrial sectors respectively. A slight decreasing trend in per account water use, 9 gallons per month, appears in the residential water sectors. However, this trend in the residential sector is statistically insignificant.

These trends may be compared to those obtained from equation 4.1 applied to total, treated, and municipal water use. Those trends describe changes in per capita water use, not per account water use. Those results showed a 9-gallon per capita per month increase in per capita total water use, but no significant increase in treated water use. One logical conclusion is that water use by commercial and industrial customers has increased and there has been no change in the amount of water used by residential customers. However, several caveats accompany the interpretation of these trend estimates.

Trend must be distinguished from random drift. The longer the time series under analysis, the less likely that random drifts in the data will appear as trends. Analysis of subsets of a time series is likely to result in as many different estimates of the trend coefficient. In addition, estimates of the trend coefficient are sensitive to beginning and ending values of the dependent variable and to outliers (McCleary and Hay 1980). As with random drift, these effects diminish as the length of the series increases.

Positive trends in per account water consumption do not necessarily reflect decreases in the efficiency of water use. For example, increases in per account water use may be offset by increases in the level of production. Controlling for the number of commercial and industrial accounts serviced each month helps clarify the estimate of trend, but better estimates of trend could be obtained by including a variable that better reflects production in the forecasting equation. Trend over the long-term might also be interpreted as a performance measure reflecting the success of a long-term water conservation program. However, conservation programs should be evaluated on the difference between actual water use and potential water use, which reflects what water use would have been without conservation. Trends say nothing about potential water use in the absence of water conservation.

**Significant Temperature Effects in Each Water User Sector**

Temperature emerges as a statistically significant determinant of aggregate water use in all three water user sectors. On average, residential water demand increases approximately 2 percent for every 1° increase in temperature between 60° and 96° Fahrenheit, and commercial water demand
increases approximately 0.9 percent. On average, aggregate industrial demand increases about 0.51 percent for every 1° increase in temperature between 60° and 96° Fahrenheit. Figure 4.5 plots the response of industrial water demand to temperature. This supports the hypothesis that industrial water demand increases in response to increased cooling needs.

**Calculation and Interpretation of Price Elasticities**

Price elasticities measure the percent change in demand that results from a 1 percent change in price. Price elasticities close to zero indicate inelastic demand. The more negative the price elasticity, the more a price increase will reduce water demand. Water prices can be included in the forecasting model to estimate price elasticities. Elasticities can be used to evaluate customer response to historic changes in water prices. Results could also be used to evaluate price as a water conservation or drought management tool. For example, Weber (1993) recommends using price elasticities to estimate the impact of a new block rate structure or summer-winter rates on water demand. Ordinarily, price elasticity is estimated while controlling for income as a causal factor of water demand because theory suggests water demand increases with income. For example, Agthe and Billings (1980) found income elasticities of water demand to be positive and greater than one. However, the use of variables representing income led to consistently poor results and were therefore dropped from the forecasting model. This problem may be related to the use of annual income data. Berk et al. (1981) also calculate price elasticities without specifying income in their demand equation. Price elasticity is best calculated using cross sectional data because patterns in the data are repeated over a variety of customer types. The aggregate monthly data from which these elasticities are calculated are not cross sectional.

Specification of marginal price variables is often problematic when increasing or decreasing block rate structures are used to calculate user fees because each customer has a marginal price unique to his or her own water increment. One approach has been to divide total water utility revenue by total water used and calculate an average price (Morgan and Smolen 1976). Billings and Agthe (1980) show that this leads to incorrect results because average price can decrease while marginal prices increase. These authors also show that use of marginal price to analyze price elasticity in block rate structures, as in a study by Howe and Linaweaver (1967), also leads to erroneous conclusions unless intramarginal prices have changed at a constant rate. Intramarginal prices are those prices for all water increments less than the marginal increment and greater than zero. Billings and Agthe recommend dissaggregating the elasticity to calculate one price elasticity coefficient which measures only income and substitution effects and one elasticity coefficient which measures the income effect of changes in intramarginal rates. Berk et al. (1981) use the marginal price for the average consumer at each point in time to identify the marginal price in a decreasing block rate structure. That price is also defined as "the average consumption that identified the marginal block in the rate schedule" (p. 91). Prices used later in this analysis of Corpus Christi water demand follow this model; however, the authors of this report thought it made more sense to observe the effect of price increases while holding identification of the average rate block constant.
Interpretation of price elasticities is sometimes unclear as it is uncertain how much of the
elasticity is manifest in the short run and how much is delayed or manifest in the long-run
response. In the long run, price elasticities tend to be more negative because customers have more
opportunity to develop and install technological alternatives to water. Carver and Boland (1980)
specify a water demand model to estimate both short- and long-run price elasticities. Time-series
rather than cross sectional data are needed to estimate these elasticities. The authors note that if
the change in marginal and intramarginal prices has been stable, a single elasticity approximates
the long-run elasticity. Intramarginal rate increases in Corpus Christi have been relatively constant
since 1986. In addition, since these data span a 10-year period, these elasticity estimates may be
interpreted as long-run elasticities.

From equation 4.3, the price elasticity is calculated as the slope coefficient of the price term times
the price divided by the predicted water use:

$$\epsilon = \hat{\beta} \cdot \frac{P}{\hat{W}}$$

where $\epsilon$ is the point price elasticity of water demand.

Price elasticities are tabulated in Table 4.5 for each Corpus Christi water user sector. However,
only the commercial sector shows a statistically significant price elasticity. Results show that
commercial water demand decreases 0.51 percent in response to a 1 percent increase in the price
of the marginal rate block. Water demand is inelastic in the residential and industrial water user
sectors. All estimates of price elasticity are based on prices and forecasts for August 1996.

The limits of the elasticity range in Table 4.5 are calculated by substituting the 95 percent
confidence limit of the estimate for $\hat{\beta}$, in equation 4.4. These represent upper and lower elasticity
estimates. The better the estimate of price elasticity, the narrower this range. When the range of
elasticities overlaps zero, elasticities are considered insignificant, or not statistically different than
zero. Residential and industrial elasticities are not significantly different than zero, suggesting that
price plays little role as a determinant of water demand in these demand sectors.

There are several reasons that price may not appear to be a significant determinant of water
demand, as is the case in these residential and industrial water user sectors. The price of water
may be so low that demand may truly be inelastic at prices and quantities modeled. For example,
this could be the case if the cost of altering production technologies to use less water in response
to water price increases is more expensive than paying the new water rates. Howe and Linaweaver
(1967) and Berk et al. (1981, p. 98) note that water prices are a function of water consumption
because price is established by dividing the production costs by the volume of water sales.
Marginal prices therefore do not reflect the marginal value of water to consumers. Another reason
for insignificant elasticity estimates is a potentially delayed customer response to price changes.
That is a statistical problem that might be resolved with lagged price variables, although some
independent means of establishing that lag is needed to incorporate delayed response into the
model. Other reasons, such as specification of the price variable, for example, have already been discussed.

It should be noted that water prices used in calculating these elasticity estimates reflect only the cost of water supply. Wastewater disposal costs might also be included in estimates of marginal water price. For example, residential water customers pay a minimum $9.404 for wastewater disposal plus an additional $1.899 for every thousand gallons of water over the first 2,000 gallons. If wastewater charges increase at the same rate as water prices, the effect could be to increase elasticity estimates.

**Water Savings Analysis: Measuring Water Savings by Water User Sector**

Differences between forecast and actual water use can be attributed to random error of the forecast or to water savings resulting from implementation of drought conditions 2 and 3. The confidence with which random error is distinguished from water savings increases with the difference between actual and forecast values. Confidence limits are often two-sided. However, when there are strong reasons to suspect that differences are unidirectional, a confidence bound can be one-sided. A one-sided confidence bound tests whether the actual water use is less than the forecast. The logic for using a one-sided confidence bound is that, if there are water savings, actual water demand will not be greater than the forecast. Table 4.6 lists one-sided confidence bounds for forecasts during the drought management period. When actual values of water use are less than the value listed as the one-sided confidence bound, differences could be interpreted as water savings. For example, Table 4.6 lists actual and forecast values for treated water sales in thousand gallons per capita. Per capita water use is calculated by dividing all wholesale and retail treated water sales in a given month by the population of the Corpus Christi MSA.

Actual treated water sales are not less than the one-sided 95 percent confidence bound until September 1996, when actual treated water sales were 4.57 thousand gallons per capita. In September, therefore, the percent difference, -24.6 percent of forecast water sales, is an estimate of water savings. No conclusions about whether small water savings occurred during the period May-August are possible. A lower level of confidence could also be used to distinguish random error from water savings. For example, a 90 percent confidence bound could be used to evaluate whether water savings occurred during the drought management period, June through September 1996. If actual water sales are less than the lower confidence bound, percent differences can be interpreted as water savings. Similar logic could be used in adopting a one-sided 80 percent confidence bound as a criterion for detecting water savings. However, these tests of water savings are slightly weaker than the 95 percent confidence bound and their use increases the risk of interpreting random variation as water savings.

What guidance exists for determining which confidence bound is appropriate for detecting water savings? One measure is to compare the performance of the forecast before the drought management period (January 1986-April 1996) with its performance during the drought management period (May-November 1996). Table 4.7 lists the number of months and the
percentage of months in which actual water use exceeds proposed confidence bounds over the entire series. For example, over the entire water use period January 1986 through November 1996, actual treated water sales fall below the one-sided 95 percent confidence bound 5 out of 124 times. That represents 3.82 percent of observations in that period. Before the drought management period, 2 observations fall below the one-sided 95 percent confidence bound. That number represents 1.61 percent of these observations. During the seven-month drought management period, 3 observations fall below the confidence bound. That represents 42.86 percent of observations. The pattern shows a stronger tendency for water sales to be less than the confidence bound during the drought management period. That suggests a systematic change in the level of water use that may be related to the drought management program. The rest of Table 4.7 can be read in a similar manner for each water user sector and each confidence bound. Figures 4.6 through 4.11 display graphically the one-sided confidence bounds, water demand forecasts, and actual water use during the drought management period. Graphics are presented for all aggregations of water sales used in this study including per capita total, treated, and municipal water sales and per account residential, commercial, and industrial water user sectors.

How Far into the Future Can Forecasts Be Created?

The purpose of this water demand forecast is to estimate potential water use during the drought management program so that actual water use may be compared with forecasts and water savings may be estimated. The forecasting method makes use of an autoregressive term, lagged errors of the structural model. Therefore, the quality of forecasts will deteriorate as the number of time intervals from the end of the estimation period increases. The reason is that during forecast months there is no information on potential water use in the absence of drought management. Therefore, the lagged residuals cannot be calculated and the accuracy of the forecasts is not known.

This section evaluates the ability of the model to forecast water use beyond the estimation period. Implementation of the forecasting model was simulated by estimating the model over four time periods and evaluating the forecasts against actual water use during nondrought management months. Results are evaluated in terms of the average absolute relative error. Table 4.8 describes the four runs. Trial 1 was completed by estimating the model over the entire available period and calculating a mean AARE for the estimation period. Trial 1 provided a baseline absolute relative error of forecasts against which to compare the performance of 12-, 24-, and 36-month forecasts. Trial 2 was completed by estimating the model over the period January 1986 through April 1995 and forecasting over the remaining 12 months for which actual water use in the absence of drought management is known. An AARE was then calculated for the estimation period and for the forecast period. Trials 3 and 4 were completed in a same way as trial 2, but with each successive trial the last 12 months of the preceding estimation period were transferred to the forecast period.

Table 4.9 lists the AARE of each forecast and estimation period. With the exception of trial 1, all means and standard deviations are for forecasts after the estimation period only. For trial 1, the
mean and standard deviation are for the AARE of *ex-post* forecasts during the estimation period. Water managers in Corpus Christi may use these results to gauge the accuracy of their forecasts as they implement the forecasting model. Results of these trials are also presented in Figures 4.12 and 4.13. Figure 4.12 plots the 12-month moving average of the absolute relative error for each trial. The vertical distance between moving average lines is a measure of how the AARE changes with definition of the estimation period and how much forecasts deteriorate in the future. Trial 3 exhibits the highest AARE during the estimation period. This can be attributed to the relatively short period over which parameter estimates are calculated, 88 months. The lowest moving average AARE line occurs during the estimation period of trial 1. Those parameter estimates are based on 124 months of data. That could be considered a minimum error for the model. At 12 months into the forecast period there is little deterioration of the forecast. This is measured by the vertical distance between lines for trial 1, marked “0,” and for trial 2, marked “12.” Numbers reflect the number of months between the end of the estimation period and the last forecast. However, trial 3 shows that at 24 months into the forecast there is an increase in the 12-month moving average error. At 24 months, the 12-month moving average AARE for the last 12 months of the forecast increases to about 10 percent.

Figure 4.13 displays the mean absolute relative error (ARE) for each month into the forecast period. Mean ARE differs from AARE in that it is calculated across trials for some given number of months beyond the estimation period. Points in Figure 4.13 represent the mean absolute relative error for each successive month into the forecast period. For example, the fifth month into the forecast there are three water demand forecasts and three estimates of the absolute relative error. The mean absolute relative error for the fifth month is approximately 5 percent, not much more than the AARE over the estimation period, 4.3 percent. At 21 months into the forecast there are two estimates of water demand. The mean absolute relative error of these two forecasts is approximately 7 percent. After 24 months, there is only one estimate of water demand and the absolute relative error of the forecast because only trial 4 is used to estimate water demand that far into the future. The greater spread of mean absolute relative error beyond 24 months reflects this small sample. The line in Figure 4.13 represents the best linear fit of these points and can be used to estimate the mean absolute relative error of forecasts during the drought management period.
Table 4.1
Parameter Estimates for Total, Treated, and Municipal Water Sales
(Equation 4.1)

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Variable</th>
<th>Total Water Sales</th>
<th>Treated Water Sales</th>
<th>Municipal Water Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>15.994</td>
<td>16.649</td>
<td>338.566</td>
</tr>
<tr>
<td>$\beta_0$</td>
<td>Intercept</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>T</td>
<td>-0.335 (2.871)</td>
<td>-0.363 (-5.778)</td>
<td>-7.329 (-3.869)</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>$T^2$</td>
<td>0.0027 (3.599)</td>
<td>0.0027 (6.798)</td>
<td>0.057 (4.784)</td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>R</td>
<td>-0.067 (-3.407)</td>
<td>-0.042</td>
<td>-1.588 (-4.991)</td>
</tr>
<tr>
<td>$\beta_4$</td>
<td>t</td>
<td>0.009 (2.790)</td>
<td>0.003</td>
<td>-0.018 (-0.310)</td>
</tr>
</tbody>
</table>

Autoregressive Error Terms

<table>
<thead>
<tr>
<th>Model $R^2$</th>
<th>Structural Parameters $R^2$</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8145</td>
<td>0.4819</td>
<td>124</td>
</tr>
<tr>
<td>0.8675</td>
<td>0.7036</td>
<td>124</td>
</tr>
<tr>
<td>0.8532</td>
<td>0.6608</td>
<td>124</td>
</tr>
</tbody>
</table>

Notes: (1) Coefficients in thousand gallons per capita per month; (2) Coefficients in gallons per capita per day; (*) Indicates significance of parameter estimates at the 95 percent confidence level.
Table 4.2
AARE Values for the Rainfall-Temperature Forecast of Water Use

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Total Water</td>
<td>0.089</td>
<td>0.037</td>
<td>0.053</td>
<td>0.069</td>
<td>0.044</td>
<td>0.033</td>
<td>0.059</td>
<td>0.050</td>
<td>0.049</td>
<td>0.059</td>
<td>0.023</td>
</tr>
<tr>
<td>Treated Water</td>
<td>0.073</td>
<td>0.025</td>
<td>0.034</td>
<td>0.055</td>
<td>0.032</td>
<td>0.027</td>
<td>0.045</td>
<td>0.045</td>
<td>0.035</td>
<td>0.062</td>
<td>0.031</td>
</tr>
<tr>
<td>Municipal Water</td>
<td>0.069</td>
<td>0.035</td>
<td>0.055</td>
<td>0.073</td>
<td>0.044</td>
<td>0.063</td>
<td>0.071</td>
<td>0.036</td>
<td>0.038</td>
<td>0.099</td>
<td>0.052</td>
</tr>
</tbody>
</table>

Note: * 1996 mean AARE based on estimates from January through April 1996.
## Table 4.3
Parameter Estimates for Rainfall-Temperature Model in Water-User Sectors

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>Variable</th>
<th>Total Water Sales</th>
<th>Treated Water Sales</th>
<th>Municipal Water Sales</th>
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<td>$R$</td>
<td>-0.151</td>
<td>-0.467</td>
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<td>$t$</td>
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Autoregressive Error Terms

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<th>$v_{t-i}$</th>
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<td>$v_{t-2}$</td>
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<td>$v_{t-3}$</td>
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<td>$v_{t-4}$</td>
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Model R$^2$ 0.8342 0.7896 0.6875
Structural Parameters R$^2$ 0.5481 0.6344 0.4691
Number of observations 124 124 124

Note: (*) Indicates significance of parameter estimates at the 95 percent confidence level.
Table 4.4
AARE Values for the Rainfall-Temperature Forecast of Water Use

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<td>Residential</td>
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<td>0.046</td>
<td>0.072</td>
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<td>0.052</td>
<td>0.087</td>
<td>0.087</td>
<td>0.056</td>
<td>0.057</td>
<td>0.092</td>
<td>0.067</td>
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<tr>
<td>Commercial</td>
<td>0.048</td>
<td>0.033</td>
<td>0.050</td>
<td>0.060</td>
<td>0.026</td>
<td>0.033</td>
<td>0.060</td>
<td>0.033</td>
<td>0.027</td>
<td>0.111</td>
<td>0.044</td>
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<td>0.035</td>
<td>0.040</td>
<td>0.063</td>
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<td>0.053</td>
<td>0.061</td>
<td>0.038</td>
<td>0.041</td>
<td>0.075</td>
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Note: (*) 1996 mean AARE based on estimates from January through April 1996.

Table 4.5
Point Price Elasticities for Water-User Sectors, August 1996

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<th>Water-User Sector</th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
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</thead>
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<td>Price Elasticity Estimate</td>
<td>-0.014</td>
<td>-0.519*</td>
<td>-0.119</td>
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<tr>
<td>95% Confidence Interval</td>
<td>±0.565</td>
<td>±0.289</td>
<td>±0.476</td>
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<tr>
<td>Real Marginal Price ($/1,000 gal)</td>
<td>1.108</td>
<td>1.255</td>
<td>1.255</td>
</tr>
<tr>
<td>Demand Forecast (1,000 gal/account)</td>
<td>9.554</td>
<td>70.082</td>
<td>13,493.700</td>
</tr>
</tbody>
</table>

Note: * statistically significant elasticity estimates

* Range based on 95 percent confidence interval of \( \beta \),
Table 4.6
1996 Forecasts, Actual Water Use, Percent Difference, and One-Sided Confidence Intervals

**Total Water Sales** (all treated and raw water sales, 1000 gal per capita)

<table>
<thead>
<tr>
<th>Month</th>
<th>Actual Water Use</th>
<th>Forecast Water Use</th>
<th>Percent Difference</th>
<th>95 percent</th>
<th>90 percent</th>
<th>80 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>8.64</td>
<td>8.86</td>
<td>-2.48</td>
<td>7.84</td>
<td>8.07</td>
<td>8.34</td>
</tr>
<tr>
<td>June</td>
<td>8.37</td>
<td>9.58</td>
<td>-12.62</td>
<td>8.53</td>
<td>8.77</td>
<td>9.05</td>
</tr>
<tr>
<td>August</td>
<td>8.63</td>
<td>9.40</td>
<td>-8.20</td>
<td>8.32</td>
<td>8.56</td>
<td>8.85</td>
</tr>
<tr>
<td>September</td>
<td>6.57</td>
<td>8.86</td>
<td>-25.81</td>
<td>7.82</td>
<td>8.05</td>
<td>8.33</td>
</tr>
<tr>
<td>October</td>
<td>7.04</td>
<td>8.51</td>
<td>-17.29</td>
<td>7.48</td>
<td>7.71</td>
<td>7.98</td>
</tr>
<tr>
<td>November</td>
<td>6.83</td>
<td>7.67</td>
<td>-10.89</td>
<td>6.63</td>
<td>6.86</td>
<td>7.14</td>
</tr>
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</table>

**Treated Water Sales** (wholesale and retail sales, 1000 gal per capita)

<table>
<thead>
<tr>
<th>Month</th>
<th>Actual Water Use</th>
<th>Forecast Water Use</th>
<th>Percent Difference</th>
<th>95 percent</th>
<th>90 percent</th>
<th>80 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
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<td>6.10</td>
<td>-3.48</td>
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</tr>
<tr>
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<td>6.77</td>
<td>-15.34</td>
<td>6.01</td>
<td>6.18</td>
<td>6.39</td>
</tr>
<tr>
<td>July</td>
<td>6.42</td>
<td>7.03</td>
<td>-8.63</td>
<td>6.24</td>
<td>6.42</td>
<td>6.63</td>
</tr>
<tr>
<td>August</td>
<td>5.91</td>
<td>6.59</td>
<td>-10.30</td>
<td>5.80</td>
<td>5.97</td>
<td>6.19</td>
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<td>September</td>
<td>4.57</td>
<td>6.07</td>
<td>-24.61</td>
<td>5.29</td>
<td>5.46</td>
<td>5.67</td>
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<tr>
<td>October</td>
<td>4.66</td>
<td>5.74</td>
<td>-18.79</td>
<td>4.96</td>
<td>5.13</td>
<td>5.34</td>
</tr>
<tr>
<td>November</td>
<td>4.38</td>
<td>5.11</td>
<td>-14.25</td>
<td>4.33</td>
<td>4.50</td>
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</table>

**Municipal Per Capita Water Demand Inside City Limits** (gallons per capita per day)

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<thead>
<tr>
<th>Month</th>
<th>Actual Water Use</th>
<th>Forecast Water Use</th>
<th>Percent Difference</th>
<th>95 percent</th>
<th>90 percent</th>
<th>80 percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>128.15</td>
<td>134.17</td>
<td>-4.48</td>
<td>110.89</td>
<td>114.93</td>
<td>119.786</td>
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<td>June</td>
<td>126.85</td>
<td>151.26</td>
<td>-16.14</td>
<td>134.30</td>
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<td>144.024</td>
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<td>138.85</td>
<td>148.88</td>
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<td>134.16</td>
<td>138.57</td>
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<td>114.94</td>
<td>141.18</td>
<td>-18.58</td>
<td>118.10</td>
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(Continued)
Table 4.7 (cont.)

**Total Water Sales** (All treated and raw water Sales, 1000 gallons per capita)

<table>
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<th>Month</th>
<th>Actual Water Use</th>
<th>Forecast Water Use</th>
<th>Percent Difference</th>
<th>95 percent</th>
<th>One-sided CI</th>
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<td></td>
<td></td>
<td></td>
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<tr>
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<td>-6.33</td>
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**Total Water Sales** (All treated and raw water Sales, 1000 gallons per capita)

<table>
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<th>Month</th>
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<th>Forecast Water Use</th>
<th>Percent Difference</th>
<th>95 percent</th>
<th>One-sided CI</th>
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<td></td>
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<td>90 percent</td>
<td>80 percent</td>
</tr>
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Table 4.8
Number and Percent of Times Actual Water Use is Less than the Lower One-Sided Confidence Interval

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<th>Number</th>
<th>Percent</th>
<th>Number</th>
<th>Percent</th>
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<td>90% CI</td>
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<td>80% CI</td>
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<tr>
<td>1/86 – 9/96</td>
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<td>3.82</td>
<td>13</td>
<td>9.92</td>
<td>29</td>
<td>22.14</td>
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<td>18.55</td>
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<td>85.71</td>
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<tr>
<td>Treated Water Sales</td>
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<td>3.82</td>
<td>8</td>
<td>6.11</td>
<td>17</td>
<td>12.98</td>
</tr>
<tr>
<td>1/86 – 9/96</td>
<td>124</td>
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<td>1.61</td>
<td>3</td>
<td>2.42</td>
<td>11</td>
<td>8.87</td>
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<tr>
<td>Pre-drought management</td>
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<td>3</td>
<td>42.86</td>
<td>5</td>
<td>71.43</td>
<td>6</td>
<td>85.71</td>
</tr>
<tr>
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<td>6.87</td>
<td>12</td>
<td>9.16</td>
<td>23</td>
<td>17.56</td>
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<td>7</td>
<td>5.65</td>
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<td>71.43</td>
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<td>1/86 – 9/96</td>
<td>124</td>
<td>3</td>
<td>2.42</td>
<td>8</td>
<td>6.45</td>
<td>17</td>
<td>13.71</td>
</tr>
<tr>
<td>Pre-drought management</td>
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<td>3</td>
<td>42.86</td>
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<td>2.42</td>
<td>5</td>
<td>4.03</td>
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<tr>
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<td>7</td>
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<td>71.43</td>
<td>5</td>
<td>71.43</td>
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<td>6.11</td>
<td>12</td>
<td>9.16</td>
<td>26</td>
<td>19.85</td>
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<tr>
<td>1/86 – 9/96</td>
<td>124</td>
<td>5</td>
<td>4.03</td>
<td>9</td>
<td>7.26</td>
<td>21</td>
<td>16.94</td>
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<td>Pre-Drought management</td>
<td>7</td>
<td>3</td>
<td>42.86</td>
<td>3</td>
<td>42.86</td>
<td>5</td>
<td>71.43</td>
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<tr>
<td>Drought management</td>
<td>69</td>
<td>5</td>
<td>71.43</td>
<td>5</td>
<td>71.43</td>
<td>5</td>
<td>71.43</td>
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</table>

59
Table 4.9
Description of Trial Per Capita Treated Water Demand Forecasts

<table>
<thead>
<tr>
<th>Trial</th>
<th>Estimation period</th>
<th>Months in estimation period</th>
<th>Forecast period</th>
<th>Months in forecast period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/86 to 4/96</td>
<td>124</td>
<td>None</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1/86 to 4/95</td>
<td>112</td>
<td>5/95 to 4/96</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>1/86 to 4/94</td>
<td>100</td>
<td>5/94 to 4/96</td>
<td>24</td>
</tr>
<tr>
<td>4</td>
<td>1/86 to 4/94</td>
<td>88</td>
<td>5/93 to 4/96</td>
<td>36</td>
</tr>
</tbody>
</table>
Table 4.10  
Mean and Standard Deviation of AARE Observed in Per Capita Treated Water Demand Trial Forecasts

<table>
<thead>
<tr>
<th>Trial</th>
<th>Number of Observations</th>
<th>Mean AARE</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>124</td>
<td>0.04305</td>
<td>0.03211</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>0.06523</td>
<td>0.04101</td>
</tr>
<tr>
<td>3</td>
<td>24</td>
<td>0.08395</td>
<td>0.05624</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>0.09366</td>
<td>0.05782</td>
</tr>
</tbody>
</table>

Note: * Mean and standard deviation for *ex post* forecasts during the estimation period.
Figure 4.1
Model Estimates of Per Capita Treated Water Sales Over Different Temperatures

Figure 4.2
An Operational Criteria for Water Savings as a Percent of the Per Capita Treated Water Sales Forecast
Figure 4.3
Backcasting Treated Water Use over the 1984-1985 Drought Period
Percent of the Per Capita Treated Water Sales Forecast

Figure 4.4
Per Capita Treated Water Use Forecast, July 1993 - November 1996
Figure 4.5
Response of Industrial Water Demand to Temperature

Figure 4.6
Per Capita Total Water Use Forecast with Confidence Bounds
Figure 4.7
Per Capita Treated Water Use Forecast with Confidence Bounds

Figure 4.8
Per Capita Municipal Water Sales Inside City Limits with Confidence Bounds
Figure 4.9
Per Account Residential Water Sales Forecast with Confidence Bounds

Figure 4.10
Per Account Commercial Water Use Forecast with Confidence Bounds
Figure 4.11
Per Account Industrial Water Use Forecast with Confidence Bounds

Figure 4.12
12-Month Moving Average Absolute Relative Error of Trial Treated Water Demand Forecasts
Figure 4.13
Mean Absolute Relative Error of Trial Treated Water Demand Forecasts
Chapter 5. A Moving Average Index Model of Water Demand

Moving Average Index Model Development

The moving average index model is described by Weber (1989) in a water demand forecasting study for East Bay Municipal Utility District, Oakland, California, and further described by Weber (1993). It is the purpose of this section to present the moving average index model as an alternative to the rainfall-temperature model. These results are compared with results of the rainfall-temperature model described in Equation 4.1. The moving average index estimates seasonal variations in water use. According to Weber, the logic for selecting this approach is that seasonality alone can account for much of the variation in monthly water use and the monthly index can model the transitions from seasonal to nonseasonal water use better than climatic variables. The purpose of the moving average is to capture long-term trends and exclude these effects from the index. The moving average index is calculated as the mean ratio of water use in a particular month to a 13-month moving average:

\[
\theta_i = \frac{1}{k} \sum_{i=1}^{k} \frac{W_{ij}}{\omega_{ij}} \quad \text{for all } i \quad \text{[Eq. 5.1]}
\]

\[
\omega_{ij} = \frac{1}{13} \sum_{t=1}^{13} W_{it} \quad \text{for all } i, j
\]

where:

\( \theta_i \) = monthly index of water use

\( W \) = monthly per capita water use

\( i \) = an index of the month of the year \( i = \{1, 2, 3, \ldots, 12\} \)

\( j \) = an index of year \( j = \{1, 2, 3, \ldots, k\} \)

\( t \) = an index of the numerical sequence of months \( t = \{1, 2, 3, \ldots, n\} \)

Figure 5.1 graphs the moving average index of treated water use. The faint line is per capita treated water consumption. The dark line tracking actual water use is the 13-month moving average.
average of that series. The moving average index ranges from 0.8 to 1.2. Table 5.1 lists the index for each month of the year calculated based on data from January 1986 to April 1996. For example, the moving average index for treated water use in August is 1.208, and the standard deviation of that mean is 0.0587. The minimum ratio was 1.131 and the maximum ratio was 1.328. The mean moving average index less one can be interpreted as the percent difference in per capita water use in one month relative to an annual average of a detrended water demand time series. For example, treated water use in August is, on average, 20.8 percent higher than the annual average monthly water demand. The last line of Table 5.1 lists the mean ratio of treated water use to the moving average water use for the entire series and the standard deviation of that mean. Minimum and maximum are the minimum ratio of any month in the series, and n is the number of observation in the series. Table 5.2 lists information on the moving average index for total water use.

Although a monthly index accounts for the seasonality in water use, climatic variables are still needed to explain departures from the seasonal index. The forecasting model uses departures from a 30-year average rainfall and temperature to account for differences in climate across the same months in different years. Average rainfall and temperature are calculated using monthly data collected between 1960 and 1990. As in Equation 4.1, autocorrelation is removed using an error term. The model states that water demand follows a defined seasonal pattern, and that departures from this pattern are a function of departures from normal climatic patterns and long-term trends:

\[ \hat{W}_t = \hat{\beta}_0 + \hat{\beta}_1 r_t + \hat{\beta}_2 DT_t + \hat{\beta}_3 DR_t + \hat{\beta}_4 D_t + v_t \]

\[ v_t = \varepsilon_t + \sum_{i=1}^{4} \phi_i u_{t-i} \quad [Eq.5.2] \]

\[ \varepsilon_t \sim N(0, \sigma^2) \]

where:

- \( W \) = per capita water use (thousand gallons)
- \( \theta \) = moving average index
- \( DT \) = departure from normal mean maximum temperature (Fahrenheit)
- \( DR \) = departure from normal aggregate rainfall (inches)
- \( v \) = an error term
- \( u \) = residuals of structural regression estimates
- \( \beta \) = parameters estimated by regression
\( \phi \) = autoregressive parameters for error terms

t = an index of time, the numerical sequence of months \( t = \{1, 2, 3, \ldots, n\} \)

i = the lag of significantly correlated residuals

Results of this model applied to per capita total and treated water use are provided in Table 5.3. The signs of rainfall and temperature coefficients are in the expected direction. For example, treated water use decreases 55 gallons per capita for every inch of rain above the 30-year average. Total water use decreases 73 gallons per capita for every inch above the 30-year average. AARE values, listed in Table 5.4, show that the model fits these data fairly well. The average absolute relative error for Equation 4.6 applied to treated water use between January 1986 and April 1996 is 0.040, or 4 percent. AARE for total water use over the same period is 4.7 percent.

**Comparison of Moving Average Temperature Model with Rainfall-Temperature Model**

The moving average index model can be compared with the rainfall-temperature model using the evaluative criteria described above. When estimated over the same data series, the moving average index model results show similar rainfall and trend coefficients as the rainfall-temperature model (Equation 4.1). Because of differences in the definitions of variables between Equation 4.1 and Equation 4.6, the temperature coefficients cannot be compared directly. The R-squared statistic measures the fraction of total variation explained by each model. The structural and error components of the moving average index model explain more variation in the data series. In addition, AARE values are lower for the moving average index model, suggesting forecasts of water use are more accurate than those using the rainfall-temperature model. AARE for the moving average index model applied to treated water use between January 1986 and April 1996 is 0.3 percentage points lower over the estimation period than AARE for the rainfall-temperature model.

The two remaining evaluative criteria are logical interpretability and confidence interval width. In the rainfall-temperature model, temperature coefficients were not directly interpretable. Both rainfall and temperature coefficients of the moving average index model are directly interpretable. However, the coefficient of the moving average index is difficult to interpret. From an interpretability standpoint, the risks associated with using the moving average index model are related to interpretation of potential covariates. This index may not account for variation due to nonclimatic determinants of water demand that may also be seasonal. For example, if coefficients of price or income are later estimated in this model, it is not certain that some of this variation has not been assigned to the moving average index, which models the data rather than the process. Examining the data for multicollinearity before estimating coefficients could help prevent misinterpretation.
If the sole purpose of estimating water demand is to generate forecasts of water use, a moving average index model may provide a better solution. Estimates produced by the moving average index model are more efficient than those of the rainfall-temperature model, and this is reflected in the narrower confidence intervals around predicted values. The moving average index model produces two-sided 95 percent confidence intervals for predicted values during the drought management period that are 5 to 10 percent smaller than the rainfall-temperature model. Over the first four months of the forecast (May-August 1996), the differences in the water savings needed to exceed the lower confidence bound is between 45 and 150 gallons per capita. For example, in July 1996, treated water savings must reach 51 gallons per capita more than the moving average index model to exceed its lower confidence bound.

The homoscedasticity assumption of the regression model requires constant error variance. That means the variance of the residual should not be more or less at the beginning of the series than at the end of the series. If the variance of residuals changes, confidence intervals may be inflated. Results of Portmanteau’s Q Test and Engle’s Lagrange Multiplier Test indicate that the moving average index model is heteroscedastic (SAS Institute 1993). Heteroscedasticity will not bias parameter estimates, but will inflate the confidence interval widths of parameter estimates and water demand forecasts. Correcting this problem by modeling the error variance should reduce confidence interval width in the moving average index model and improve the efficiency with which the model detects water savings. Portmanteau’s Q Test and the Lagrange Multiplier Test showed no heteroscedasticity in the rainfall-temperature model.

Overall, the moving average index model seems to provide a slightly better forecast of per capita water use than the rainfall-temperature model. It explains a larger percentage of the variation and it has lower AARE. The main reason for selecting the rainfall-temperature model over the moving average index is the logical interpretability of the latter. The rainfall-temperature model was selected over the moving average index model because it preserved the ability to interpret the coefficients of new variables that might later be incorporated into the analysis. Selection of one model over the other has no effect on the outcome of this evaluation of water savings during the period May-August 1996.
Table 5.1
Monthly Moving Average Index for Treated Water Use

<table>
<thead>
<tr>
<th>Month</th>
<th>Index</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.84081</td>
<td>0.04696</td>
<td>0.75046</td>
<td>0.92027</td>
<td>12</td>
</tr>
<tr>
<td>February</td>
<td>0.83816</td>
<td>0.04565</td>
<td>0.74860</td>
<td>0.91485</td>
<td>12</td>
</tr>
<tr>
<td>March</td>
<td>0.93435</td>
<td>0.04964</td>
<td>0.83986</td>
<td>1.02049</td>
<td>12</td>
</tr>
<tr>
<td>April</td>
<td>0.95491</td>
<td>0.04794</td>
<td>0.86570</td>
<td>1.03894</td>
<td>12</td>
</tr>
<tr>
<td>May</td>
<td>1.02225</td>
<td>0.05270</td>
<td>0.93564</td>
<td>1.11408</td>
<td>11</td>
</tr>
<tr>
<td>June</td>
<td>1.10606</td>
<td>0.05551</td>
<td>1.02379</td>
<td>1.21086</td>
<td>11</td>
</tr>
<tr>
<td>July</td>
<td>1.17922</td>
<td>0.05520</td>
<td>1.10219</td>
<td>1.28748</td>
<td>11</td>
</tr>
<tr>
<td>August</td>
<td>1.20814</td>
<td>0.05871</td>
<td>1.13116</td>
<td>1.32809</td>
<td>11</td>
</tr>
<tr>
<td>September</td>
<td>1.04540</td>
<td>0.05082</td>
<td>0.97819</td>
<td>1.14020</td>
<td>11</td>
</tr>
<tr>
<td>October</td>
<td>0.97729</td>
<td>0.04742</td>
<td>0.89962</td>
<td>1.05873</td>
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</tr>
<tr>
<td>November</td>
<td>0.91981</td>
<td>0.04574</td>
<td>0.83729</td>
<td>0.99606</td>
<td>11</td>
</tr>
<tr>
<td>December</td>
<td>0.91497</td>
<td>0.04514</td>
<td>0.82764</td>
<td>0.98243</td>
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</tr>
<tr>
<td>Series</td>
<td>0.99143</td>
<td>0.12568</td>
<td>0.74860</td>
<td>1.32809</td>
<td>136</td>
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</table>

Table 5.2
Monthly Moving Average Index for Total Water Use

<table>
<thead>
<tr>
<th>Month</th>
<th>Index</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
<th>n</th>
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</thead>
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<tr>
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<td>0.05901</td>
<td>0.75898</td>
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<td>0.82786</td>
<td>0.05575</td>
<td>0.73863</td>
<td>0.92484</td>
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<tr>
<td>March</td>
<td>0.94113</td>
<td>0.06065</td>
<td>0.84796</td>
<td>1.05370</td>
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<tr>
<td>April</td>
<td>0.97161</td>
<td>0.05984</td>
<td>0.88577</td>
<td>1.09053</td>
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<td>May</td>
<td>1.02998</td>
<td>0.06643</td>
<td>0.94355</td>
<td>1.15319</td>
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<tr>
<td>June</td>
<td>1.09057</td>
<td>0.07371</td>
<td>1.00390</td>
<td>1.23471</td>
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<tr>
<td>July</td>
<td>1.16326</td>
<td>0.07592</td>
<td>1.08606</td>
<td>1.31588</td>
<td>11</td>
</tr>
<tr>
<td>August</td>
<td>1.21962</td>
<td>0.08249</td>
<td>1.14229</td>
<td>1.40040</td>
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</tr>
<tr>
<td>September</td>
<td>1.05346</td>
<td>0.07123</td>
<td>0.98361</td>
<td>1.21266</td>
<td>11</td>
</tr>
<tr>
<td>October</td>
<td>1.00369</td>
<td>0.06575</td>
<td>0.91983</td>
<td>1.14904</td>
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</tr>
<tr>
<td>November</td>
<td>0.93357</td>
<td>0.06172</td>
<td>0.84455</td>
<td>1.06853</td>
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<tr>
<td>December</td>
<td>0.90452</td>
<td>0.05545</td>
<td>0.81942</td>
<td>1.02340</td>
<td>11</td>
</tr>
<tr>
<td>Series</td>
<td>0.99565</td>
<td>0.13060</td>
<td>0.73863</td>
<td>1.40040</td>
<td>136</td>
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<td>Coefficient</td>
<td>Variable</td>
<td>Total Water Sales</td>
<td>Municipal Water Sales</td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------</td>
<td>----------</td>
<td>-------------------</td>
<td>----------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_0$</td>
<td>Intercept</td>
<td>-1.997</td>
<td>0.937</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>$\theta$</td>
<td>8.549</td>
<td>6.115</td>
<td></td>
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</tr>
<tr>
<td>$\beta_2$</td>
<td>DT</td>
<td>0.041</td>
<td>0.013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\beta_3$</td>
<td>DR</td>
<td>-0.073</td>
<td>-0.055</td>
<td></td>
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</tr>
<tr>
<td>$\beta_4$</td>
<td>$t$</td>
<td>0.009</td>
<td>0.003</td>
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</table>

### Structural Parameters

#### Error Terms

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<tr>
<th>$\phi_i$</th>
<th>$v_{t-1}$</th>
<th>$-0.483$</th>
<th>$-0.508$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$v_{t-2}$</td>
<td>-0.076</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$v_{t-3}$</td>
<td>-</td>
<td>-0.166</td>
</tr>
<tr>
<td></td>
<td>$v_{t-4}$</td>
<td>-</td>
<td>-0.183</td>
</tr>
</tbody>
</table>

Model $R^2$ 0.8504 0.8903
Structural Parameters $R^2$ 0.6246 0.7397
Durban Watson Statistic 1.9755 1.9642

Note: * Significance of parameter estimates at the 95 percent confidence level.
Table 5.4
AARE Values for the Moving Average Index Model of Water Use

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Water</td>
<td>0.082</td>
<td>0.046</td>
<td>0.072</td>
<td>0.083</td>
<td>0.052</td>
<td>0.087</td>
<td>0.087</td>
<td>0.056</td>
<td>0.057</td>
<td>0.092</td>
<td>0.067</td>
<td></td>
</tr>
<tr>
<td>Treated Water</td>
<td>0.048</td>
<td>0.033</td>
<td>0.050</td>
<td>0.060</td>
<td>0.026</td>
<td>0.033</td>
<td>0.060</td>
<td>0.033</td>
<td>0.027</td>
<td>0.111</td>
<td>0.044</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>0.058</td>
<td>0.048</td>
<td>0.035</td>
<td>0.040</td>
<td>0.063</td>
<td>0.048</td>
<td>0.053</td>
<td>0.061</td>
<td>0.038</td>
<td>0.041</td>
<td>0.075</td>
<td></td>
</tr>
</tbody>
</table>

Note: * 1996 mean AARE based on estimates from January through April 1996.
Figure 5.1
Moving Average Index of Per Capita Treated Water Use, January 1986 - August 1996
Chapter 6. Evaluation of the Distribution of Water among Residential Customer Accounts

The drought management program may have had little effect on the total volume of water demand until August 1996. However, that program may have had other effects on the pattern of water use. How strongly did restrictions on water use affect the distribution of water among users in the residential water user sector? In the absence of restrictions on water use, the distribution of water among residential customers is a function of household size, lot size, soil and vegetation types, wealth, willingness to pay, and other variables. Some water restrictions may eliminate some of these variables as factors affecting the distribution of water. If so, a unique distribution of water is expected under programs that place restrictions on either how water is used or the volume of water sales to each customer account.

In the extreme case of condition 3 water rationing, the distribution of water among residential customer accounts is a function primarily of household size. Condition 3 water rationing limits monthly water sales to each residential customer account to 6,000 gallons per resident with an additional 1,000 gallons for each one or two residents thereafter. No residential account may purchase more than 12,000 gallons of water each month without paying surcharges and facing possible removal from the water supply system.

The condition 3 water rationing goal is to limit water use to a maximum quantity and distribute it among residential accounts on the basis of household size. The distributional goal of water rationing can be estimated as the distribution of persons per housing unit reported in the 1990 U.S. Census (Table 6.1). For example, the number of housing units with exactly two persons represented 28.36 percent of all Corpus Christi housing units. Under condition 3 water rationing, this group could be expected to consume a maximum of 115,860 thousand gallons during one month. This represents 25.89 percent of potential water use in the residential sector under condition 3 water rationing. Potential water use, 453,898 thousand gallons, is the amount of water used in one month if each customer uses the maximum volume of water allowed. Although the U.S. Census includes apartments as housing units and the Corpus Christi Water Utility excludes apartments from its residential customer count, this population and housing distribution provides a rough approximation of the distribution of residents by residential customer account and the approximate distributional goal of Corpus Christi's condition 3 water rationing program.

Were there no allowance in the rationing plan for household size, each residential account would account for an equal amount of residential water use. This hypothetical distribution of water is shown by line 1 in Figure 6.1. Line 2 represents the distributional goal under proposed condition 3 water rationing. Figure 6.1 also shows how the water rationing goal (line 2) compares with the empirical distribution of residential water sales during the four-month period May through August, 1993-1995 (line 3). Line 3 represents a typical distribution of water among residential customers without water rationing. The goal represents a more even distribution of water among
residential accounts. For example, the 25 percent of residential accounts that use the most water were responsible for 50 percent of water use during 1993-1995. Under condition 3 water rationing, the 25 percent of residential accounts using the most water are responsible for only about 30 percent of all residential water use. Those users in the top 25 percent are qualified by the number of people per household rather than wealth, lot size, or other factors.

The distribution of housing units by persons per household approximates the distribution of water under the proposed condition 3 water rationing program. The distribution of water is approximated by an exponential equation which states that the fraction of water used by each group is a function of the number of people per household and the number and size of other households:

\[ Y_j = aX^b = aZ^b \]  

where:

- \( Y \) = fraction of water use by housing unit in persons per housing unit increment \( j \)
- \( X \) = fraction of housing units by people per housing unit
- \( Z \) = fraction of residential water use by volume of sales under condition 3 water rationing
- \( b \) = a slope coefficient estimated by regression
- \( j \) = an index of household size increment (\( j = 1, 2, 3, \ldots, k \))

Household size increment is defined by water rationing program parameters. For example, the increment \( j = 1 \) includes housing units with one or two people per household and the increment \( j = 2 \) includes housing units with three or four people per household. The functional form of equation 7 was selected fo
condition 3 water rationing (Figure 6.2, line 2). The closer slope parameters are to each other, the more similar the distributions.

**Did Water Restrictions in 1996 Affect the Distribution of Water among Residential Customer Groups?**

Because drought restrictions regulate how water is used, regulations can have a disproportionate effect on customers that use water in specific ways. For example, the use of water by customers that use a large portion of their water for lawn watering could be constrained by these water restrictions. Customers who use little or no water outdoors would not be affected. The share of total water use by customers who usually use little water will increase, because customers who have used water for lawn watering would decrease their use due to city restrictions. This alters the distribution of water by reducing the slope of the transformed empirical distribution. A large difference between the pre-drought management slope and the slope during drought management could be interpreted as an effect of the drought management program. Conversely, little difference between the slope parameters could lead an analyst to conclude the water restrictions had little effect on the relative distribution of water among residential customers.

This analysis shows no statistically significant change in the distribution of water among residential customers resulting from water restrictions during the period May-August, 1996. The estimate of $b$ during the drought management period is 1.74. The estimate of $b$ during the period May-August, 1993-5 is 1.76. The 95 percent confidence interval of the pre-drought management slope is $1.730 \leq b \leq 1.792$. The drought management estimate of $b$ between May and August, 1996, is 1.747. This estimate lies between the upper and lower bounds of the confidence interval suggesting little distributional effect associated with water restrictions.

**Is the Distribution of Water Consistent with the Distributional Goals of Water Rationing?**

A similar analysis could be completed to evaluate performance of a water rationing program with explicit distributional goals. Suppose a condition 3 water rationing program were implemented during the drought management period and one goal of that program were to achieve a predetermined distribution of water. In the case of Corpus Christi, that goal is to distribute water strictly by the distribution of people per household. The slope coefficient for the goal represented by line 2 and an empirical slope coefficient could be compared to test whether the drought management program reached its goal. The 95 percent confidence interval around the slope of line 2 is $1.142 \leq b \leq 1.207$. 

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Table 6.1
Distribution of People Per Housing Unit and Potential Distribution of Water During Proposed Condition 3 Water Rationing

<table>
<thead>
<tr>
<th>Persons Per Housing Unit</th>
<th>Percent of Housing Units</th>
<th>Approximate Water Use Under Condition 3 Water Rationing (1,000 gal/month)</th>
<th>Water Use as a Percentage of Water Use Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.52</td>
<td>92,015</td>
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</tr>
<tr>
<td>2</td>
<td>28.36</td>
<td>115,860</td>
<td>25.53</td>
</tr>
<tr>
<td>3</td>
<td>18.01</td>
<td>85,847</td>
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<td>4</td>
<td>16.26</td>
<td>77,503</td>
<td>17.08</td>
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<td>5</td>
<td>8.66</td>
<td>47,180</td>
<td>10.39</td>
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<tr>
<td>6</td>
<td>3.66</td>
<td>19,961</td>
<td>4.40</td>
</tr>
<tr>
<td>7 or more</td>
<td>2.53</td>
<td>15,530</td>
<td>3.42</td>
</tr>
<tr>
<td>Total</td>
<td>100.00</td>
<td>453,898'</td>
<td>100.00</td>
</tr>
</tbody>
</table>

Note: * Assumes 68,100 residential customer accounts. ('') May not add to 100 percent up due to rounding.

Table 6.2
Coefficients Estimated for Equation 4.4

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>-0.048</td>
<td>-0.026</td>
</tr>
<tr>
<td>Slope</td>
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<td>1.175</td>
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<td></td>
<td></td>
<td>(111.34)'</td>
<td>(120.59)'</td>
<td>(59.81)'</td>
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<tr>
<td>R²</td>
<td></td>
<td>0.992</td>
<td>0.994</td>
<td>0.998</td>
</tr>
</tbody>
</table>

Note:

T-statistics in parenthesis

* Significance at the 95 percent confidence level.
Figure 6.1
The Distribution of Water Use by Percent of Number of Accounts

Figure 6.2
Logarithmic Transformation of Equation 4.1
Chapter 7. Economic Impact Assessment: What Are the Costs of Drought Management?

There are costs associated with the implementation of mandatory reductions in water use, the persistent risk of water shortage, and the selection of drought management strategies. This chapter describes types of costs and information needed to evaluate water supply investments and drought management alternatives. An example of how to estimate income and employment effects of water rationing using an input-output model is provided for the petrochemical manufacturing industry. This chapter concludes with a discussion of how local policymakers and state officials might apply concepts of economic value to evaluate costs of water rationing.

Imposing mandatory limits on the volume of water used or the types of water uses allowed implies some form of water rationing. Water rationing is defined as a limit on the timing, rate, or volume of water used by each customer in some customer groups or as restrictions on water uses. Volume limits may or may not be explicit. For example, a program that restricts the volume of water delivered to households each month is obviously a form of water rationing. A program that restricts the times of day that outdoor watering is allowed may also be classified as a water rationing program. Reducing the length of the watering period could restrict the maximum volume of water delivered in a water supply system, although the volume of water use allowed is not stated.

Economic impacts of drought management programs such as employment and income effects arise from constraints on the volume of water used in commercial and industrial enterprise. These effects occur when water rationing limits production capacity. Output effects are defined as a change in the volume of production related to water rationing. These output effects associated with mandatory reductions in water inflows could reduce the demand for labor, cause a net decrease in local income levels, and reduce profits among commercial and industrial interests. Output effects are extremely difficult to measure due to limitations in the availability of suitable data at local and regional levels.

Water rationing can increase production costs without creating output effects. For example, some commercial and industrial interests may find that the production strategy that maximizes profits under water rationing is to maintain output levels, make no changes in the production process, and pay the prescribed surcharges or fines for violating water rations. This “use it and pay for it” strategy would not be viable for the firm if the city were to enact a regulation that a customer would be removed from the water supply system if he/she violates water rations during more than two billing cycles.

Commercial and industrial interests may be able to increase water efficiency by altering the production process without creating output effects. A firm could reduce water consumption for uses other than production, such as lawn watering or washing. The purchase of new capital may
become rational in the face of water rationing. If the firm is a price taker, these production costs are borne by the producer. If prices change to reflect local production costs, the cost is borne by consumers. In other cases, a combination of production cost and output effects may result and the cost is borne by both consumers and producers.

The need to implement drought management is an acute symptom of persistent water shortage, and the social expectation of water shortage has real costs. This cost may exist when water users perceive a risk of water rationing and may increase as the risk of water rationing increases. For example, there may be a reluctance among potential commercial and industrial interests to make long-term investments and there may be a migration of existing plants and commercial activity to water-rich sites.

There are other costs associated with drought management that cannot be measured directly. Drought management programs that impose limits on water use are by nature command-and-control approaches to regulation. Program outcomes are potentially less efficient than market-based incentives. The cost of a drought management program may also depend upon the mix of program elements, and the analysis of program costs is relevant to design of drought management programs.

**An Input-Output Model Approach to Economic Impact Assessment**

The economic impact of water shortage and drought management is a question for regional economic analysis. The purpose of this chapter is to describe how costs of drought management can be estimated when the effect of water rationing is to reduce output. The input-output method measures costs in terms of household income and employment effects. The regional model used in this study is a 1986 input-output model developed for a six-county area including Aransas, Bee, Jim Wells, Nueces, Refugio, and San Patricio Counties. Although this area does not correspond directly with the study area, the population and economic activity centers are located in Nueces and San Patricio Counties where most of the Choke Canyon/Lake Corpus Christi water supply is used.

Input-output models describe sales and revenues between commercial and industrial sectors, governments, and households. Input-output models are perhaps best used to describe industrial linkages. More complex applications are sometimes burdened by several model assumptions. For example, these models assume a linear and homogenous production function in each input-output sector. That implies no economies or diseconomies of scale and no substitution of inputs or technological innovation. Other assumptions include no joint production, no limits to production capacity, and perfect elasticity of supply (there is no change in prices as demand increases). Despite this range of assumptions, input-output models have been in use since 1936, and the applications of input-output models have increased rapidly since the 1960s, especially at the national level. The development of regional input-output models is a less well-developed field, in part because of the difficulty in acquiring the necessary data.
The transactions matrix consists of rows of producing sectors and columns of output sectors. Table elements describe the purchases of one sector from another. This matrix is converted to a direct requirements table that describes the ratio of purchases from one sector to another to total purchases. These table elements represent the amount of input required to produce one unit of output, and the vector of coefficients can be thought of as a linear production function for that producing sector. The direct requirements matrix is then inverted to express gross output as a function of final demand. This is the Leontief inverse matrix, and the table elements of this matrix are known as interdependence coefficients. These represent the direct and indirect input requirements needed by the producing sector to produce one unit of output.

One application of the input-output model as a forecasting tool is to use income and employment multipliers generated from the model to estimate the total effect of a change in the output of one sector. No modifications to the interindustry transactions matrix are needed if changes represent expansion or rundown of industrial sectors and there is no attempt to model the entry or exit of firms (Richardson 1972).

Type II income or employment multipliers are the ratio of total impact (direct, indirect, and induced effects) to direct impact resulting from changes in the level of output within an industrial sector. Direct impacts are those income and employment changes occurring within the input-output sector in which the output change occurs. Indirect effects are income and employment changes in sectors supplying and purchasing from the sector in which output change occurs. Induced effects represent "flow-on" income and employment changes in remaining sectors. Total income effects are estimated as the product of the Type II income multiplier and the household row coefficient from the direct requirements table times the change in output value. An employment impact is calculated as the product of an employment-production coefficient and the interdependency coefficient from the Leontief matrix times the value of an output change (Hewings and Jensen 1986; Richardson 1972). Output change must be adjusted for inflation when the employment-production coefficient is based on data from some prior year. The main requirement in addition to multipliers is a forecast of output change. Changes in the output of industrial sectors can be estimated using informed judgment gained through interaction with focus group participants.

Estimates of economic impact described below are based on multipliers generated from the 1986 Nueces Mission-Aransas estuary input-output model. This model was developed at Texas A&M University by updating the 1979 Texas input-output model using nonsurvey methods and regionalizing by wage-based regional control totals and the location quotient method. Table 6.3 lists Type II income and employment multipliers as they are presented in the report on the model (Fesenmaier et al. 1987). SIC major groups are assigned by logical interpretation of input-output sector titles. Table 6.4 describes how estimates are developed for the economic impact of water rationing in the petroleum refining and chemical industries defined as SIC major groups 28 and 29. These sectors were selected because chemical and petroleum manufactures were responsible for 91 percent of the total value of manufacturing output in Corpus Christi in 1992 (Bureau of the
Census 1996). Table 6.4 also disaggregates income and employment effects to describe both direct effects and indirect and induced effects.

Given assumptions about the rate of decrease in output associated with limiting water supplies to some percentage of past use, the economic impact of output change resulting from water rationing can be calculated. At this time, the output effect of water rationing is not known, but it seems clear that the rate of output change will be less than the rate of change in water use. For example, 9 out of 16 Board of Trade members reported no decrease in throughput resulting from a 10 percent decrease in water use over the short term. Only modest decreases in output at 15 percent decrease in water use are expected. Estimates of the output effect were said to be much higher in relative terms at 20 and 25 percent of water use (Smith 1996). This reflects a nonlinear relationship between changes in water consumption and output. Board of Trade members did not disclose estimates of throughput change (Smith 1996). Since estimates of the output effect have not been disclosed, this study uses a hypothetical 5 percent change in output as a response to water rationing to demonstrate the method. That level seems reasonable given the information provided, and may over- or underestimate the actual output change.

Illustrative Example of the Household Income and Employment Costs of Output Effects

Input-output models are static because time is not a factor in the analysis. However, the transactions table from which multipliers are calculated are constructed using annual data on sales and purchases between sectors. The implication is that income and employment losses occur over the period of a year. Therefore, full realization of the income and employment forecast would require a 5 percent change in the annual output level. For this reason, model results are perhaps most easily interpreted as percent change in total employment and household income. Total personal income in 1992 dollars in the MSA was $5,943.352 million. Wage and salary income was $3,331.579 million (1992 dollars) and total wage and salary employment in 1992 was 148,847 jobs (Bureau of Economic Analysis 1996). The total value of manufacturing output measured by the value of shipments in 1992 dollars was $8,625 million and the total manufacturing value added was $1.818 million (Bureau of the Census 1996).

Note that the employment multiplier used to estimate employment effects in the petrochemical sector in Table 26 differs from the employment multiplier derived from the 1986 Nueces Mission-Aransas Estuary Input-Output Model listed in Table 25. The 7.69 value in Table 26 originates from the 1986 Texas Input-Output Model developed by the Texas Comptroller of Public Accounts. Grubb (1996) recommends substituting 7.69 for 12.013 because he believes the latter is too high and may therefore overstate employment effects. The reasoning is that most crude oil is shipped into Corpus Christi rather than generated in a local production base. There is no logical explanation as to why employment effects of decreased output should be more in Corpus Christi than the value forecast for the state as a whole.
Table 6.4 shows estimates of the impact of a 5 percent change in chemical and petroleum production. The value of total shipments from chemical and petroleum manufactures was $7.88 billion (Bureau of the Census 1996). The total output of 19 chemical manufactures employing 3,000 workers in the Corpus Christi MSA was $1,716 million in 1992. A 5 percent decrease in the output of this industrial sector would produce a total economic impact (direct, indirect, and induced) that reduces household income $15.39 million. That represents 0.25 percent of total personal income in 1992, or 0.46 percent of total 1992 wage and salary income in the MSA. The total effect can also be expressed in employment terms. Approximately 223 jobs in the MSA would be lost as a result of the output change (74 direct jobs and 148 jobs in other input-output sectors). That was 0.14 percent of total wage and salary employment in 1992.

In 1992 the output of 12 petroleum manufactures employing 2,800 workers totaled $6.1735 billion (Bureau of the Census 1996). A 5 percent decrease in the output of this industrial sector would produce a total economic impact (direct, indirect, and induced) that reduces household income $48.351 million. The total employment effect is estimated to be 2,066 jobs (269 direct jobs and 1,797 jobs in other input-output sectors). Using the alternative multiplier, 12.013, the employment effect is estimated to be 3,227 jobs (268 direct jobs and 2,959 jobs in other input-output sectors).

When the modeled change consists of output effects in more than one input-output sector, the sum of effects in each sector can misstate the total impact. This problem is avoided by estimating an aggregate multiplier that is an average of sectoral income and employment multipliers weighted by the ratio of the output change to the total output change in the combined sector. The change in employment resulting from lost production represents approximately 1.54 percent of employment in Corpus Christi. The change in income represents approximately 2.07 percent of wage and salary income.

The cost of output effects is best estimated when the output effect is known. If output effects are not known but there is a need to estimate costs, output effects may be estimated using informed judgement. In such cases it may be best to estimate a maximum and a minimum cost. Because the input-output model assumes a linear production function, the cost remains constant across output changes. In the above example, the cost of output effects is estimated for the petrochemical manufacturing sector. Using 1992 wage and salary income in the MSA as a base, wage and salary income decreases 2.07 percent for a 5 percent change in petrochemical manufacturing output. The first five percent change in petrochemical manufacturing output represents a $68.9 million decrease in wage and salary income. A 10 percent change in petrochemical manufacturing output causes a $137.92 million decrease in wage and salary income.

**Evaluating the Cost of Water Rationing**

The income and employment measures described above clarify the negative direct, indirect, and induced effects of proposed courses of action. However, income and employment effects of output change are only a portion of the cost of water rationing and ignore the potential benefits of loss-
mitigating activities. Examples of other costs include capital expenses, increased production costs, drought damage to residential and commercial landscapes, reduced tourism, and damage to building foundations. Loss-mitigating activities could include opportunistic income-generating employment in nonwater-intensive industries. For example, resources left idle by water rationing might be employed in the best production alternative. The net economic loss is the difference in the value of the products. What is needed is a better measure of the economic value of water and the net costs of water rationing. The purpose of this chapter is to present consumer surplus as a better means of evaluating economic costs than income and employment effects.

Accounting stance is also an important concept in evaluating the costs of water rationing. Accounting stance describes the perspective of the decision maker and what he/she considers to be a net cost or a net benefit. For example, water rationing may reduce the demand for traditional landscape vegetation, but this cost could be balanced by an increase in demand for xeriscape vegetation. A landscape nursery selling both traditional and xeriscape vegetation may experience no net losses. A landscape nursery with no interest in xeriscape vegetation may experience a net loss. A different landscape nursery offering only xeriscape vegetation may gain from the shift in demand with no losses. Individually, this transfer of benefits from one party to another is considered a gain or a loss.

If a policymaker thinks in terms of the aggregate welfare of residents, there is no net economic cost associated with the transfer of sales from one landscape nursery to another and no basis for preferring one course of action to another. As Whittlesey (1990) states, "The argument becomes one of distribution or political constituency but not economic value." Similarly, a policymaker in Corpus Christi may see only economic costs while a policymaker at the state or national level may see those losses being offset by economic gains in other places. As a practical matter, it is accepted that local policymakers should make decisions that maximize net benefits within their areas of responsibility.

The preceding discussion reveals two flaws associated with using income and employment measures of economic impact to evaluate water rationing. One flaw with using income and employment costs associated with projected output effects is that these describe only the negative economic consequences of water rationing. There is no statement of trade-off or measure of net economic loss. Another flaw with using income and employment costs is that these reflect the accounting stance of the individual measuring economic costs and benefits. Maximization of net economic benefits is a potential Pareto optimal decision criterion that ignores the distribution of costs among residents. Pareto optimal decisions are economically efficient because they result in trades that maximize the productive output of water. NonPareto optimal decisions require value judgements on the part of a policymaker. For example, water price increases may be more economically efficient than water rationing, but price increases may distribute the burden of water shortage disproportionately on low-income residents or some other group, a consequence that may not be consistent with other public policy goals.
Consumer Surplus is the Economic Value of Water

The aggregate economic value of water is defined as the value that water utility customers derive from access to water less the cost of supplying that water to users. This concept, also called consumer surplus, is the difference between maximum willingness to pay for water used and the cost of water supply. Saliba and Bush (1986) and Gibbons (1987) provide discussions on ways to assess economic values of water. The relative costs of two courses of action can be evaluated by estimating the net change in the level of consumer surplus. Choosing the alternative that results in the highest net economic value should minimize income and employment effects (Whittlesey 1990). Unlike input-output analysis, demand analysis incorporates information about opportunity costs and production alternatives.

Total direct benefit is measured by consumer surplus, which is a function of the present value of water and its supply cost. The total value of a unit of water is equal to the value of that water used in production to commercial and industrial customers plus the utility of that water to residential customers. Consumer surplus is equal to the total value of water minus its acquisition and delivery costs:

\[ CS = \int_0^{q^*} f(q) - p^* q^* \]  
\[ Eq.7.1 \]

where:

\[ CS \] = consumer surplus
\[ f(q) \] = a demand function for water
\[ q^* \] = equilibrium quantity of water demanded
\[ p^* \] = average cost of water supply

Water rationing and water supply decisions should maximize consumer surplus while recovering the costs of water supply. As the price of water increases, consumer surplus decreases. As the level of demand increases or decreases, there is a change in consumer surplus.

Figure 6.3 describes consumer surplus in graphical terms. The area below the demand curve and above the price line represents consumer surplus (CS). This is the net benefit of water supply in the service area. The variable \( q^* \) is the equilibrium quantity of water demanded at a price, \( p^* \). Line AC is the average cost function of the water utility (assume that price is determined on a cost-of-service basis). This discussion will ignore complications related to estimating consumer surplus under the city’s current pricing strategy. The assumption is that all water customers pay a single
price, and that this price is determined by average cost. In practice, there are different water price schedules for different water user sectors. One way to address this problem would be to carry out separate analyses of consumer surplus and then aggregate benefits and costs in a final analysis.

**Using Consumer Surplus to Evaluate the Cost of Water Rationing**

The relevant cost of water rationing is the change in consumer surplus less any transfer of consumer surplus to the water utility. Designing or manipulating a water rationing program based on information about income and employment effects does not work toward minimizing the economic burden of water rationing and water shortage. Economic cost is measured by the change in consumer surplus; to measure it, the analyst must obtain information about the direct fixed and variable costs associated with increasing water efficiency and the direct opportunity costs of lost production. Costs may be borne by residential or commercial water customers. While noneconomic policy goals can be equally valid, from an economic perspective these are competing environmental, social, political, or financial goals that have economic costs.

To demonstrate how water rationing can reduce consumer surplus, consider the following discussion. Assume there is an equilibrium in the supply and demand for water. Water utility customers purchase \( q' \) units of water at average cost, \( p' \). If a water rationing program requires each customer to reduce water use to a percentage of past water use, \( q'/q \), water demand shifts to the left, \( q'/q \) percent. The slope of the demand curve also increases because each user allocates water to its most highly valued uses. A change in water consumption necessitates a change in price so that water sales cover the cost of service. This price change will probably not be immediate, but any utility deficits associated with difference between revenues during the rationing period and actual costs will be recovered over the long run. Because prices increase, some of the lost consumer surplus is captured by the water utility. Transfers such as these are excluded from the calculation of cost. The change in consumer surplus is the difference between the old consumer surplus and the new consumer surplus plus any surplus transferred to the water utility:

\[
C_{WR} = \left( \int_0^q f(q) - p\cdot q' \right) - \left( \int_0^q g(q) - p'q' \right) + q'(p' - p^*) \quad \text{(Eq. 7.2)}
\]

where:

- \( C_{WR} \) = immediate cost of water rationing
- \( g(q) \) = a demand function for water under water rationing
- \( p' \) = average cost of water supply under water rationing
- \( q' \) = quantity of water demanded under water rationing
Figure 6.4 shows how this change in consumer surplus can be evaluated graphically. Demand for water under water rationing, $D'$, lies to the left of the original demand curve. Assuming increasing returns to scale in the water supply system, the average cost of service increases to $p'$. A portion of the loss measured by the area $q'(p' - p^*)$ represents a transfer from consumer surplus to utility expenditures. Given a potential Pareto optimal criterion, this change in consumer surplus is not counted as net loss.

**Price Manipulation is More Economically Efficient than Water Rationing**

Theory suggests that price manipulation is a more economically efficient tool for reducing water consumption than is water rationing. Raising prices allows each consumer to use water according to its contribution to production or the user's willingness to pay. Because each user allocates water to the most highly valued uses, the productive output of water is maximized. If the water utility raises water price from $p'$ to $p''$, then demand decreases from $q^*$ to $q'$. The economic cost of the price change is the shaded area.

Figure 6.5 demonstrates how price effects water consumption differently than water rationing. Because water rationing affects each user by reducing water use a certain percentage, water rationing results in a shift in the demand curve. In contrast, price manipulation ensures that the productive output of water is maximized by allocating water to those residential, commercial, and industrial users with the highest willingness to pay. The shaded area in Figure 6.5 is a deadweight loss, a loss of consumer surplus due to water rationing in Corpus Christi. Comparison with Figure 6.45 shows that this loss is potentially much less than lost consumer surplus associated with water rationing for a given quantity of water.

As discussed above, the best solution is not necessarily the most economically efficient solution. Noneconomic policy goals may suggest an economically inefficient allocation of water is a desirable outcome. However, explicit goals of water rationing should be evaluated with a knowledge of the potential costs, and those costs are best measured by changes in consumer surplus rather than changes in income and employment. An appropriate goal of water rationing may be to maximize the change in consumer surplus subject to social, environmental, political, and financial conditions. Such conditions could include income and employment effects and the affordability of water to low-income residents.
<table>
<thead>
<tr>
<th>Sector</th>
<th>Name of Sector</th>
<th>SIC Major Group</th>
<th>Type II Income Multiplier</th>
<th>Type II Employment Multiplier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Irrigated agriculture</td>
<td>01</td>
<td>1.745</td>
<td>1.311</td>
</tr>
<tr>
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<td>Dryland agriculture</td>
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<td>2.003</td>
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<td>3</td>
<td>Livestock and products</td>
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<td>12.013</td>
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<td>Fabricated metal products</td>
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<td>1.389</td>
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<td>20</td>
<td>Nonelectrical machinery</td>
<td>35</td>
<td>1.399</td>
<td>1.498</td>
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<tr>
<td>21</td>
<td>Electrical machinery</td>
<td>36</td>
<td>1.318</td>
<td>1.517</td>
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<tr>
<td>22</td>
<td>Transportation equipment</td>
<td>37</td>
<td>1.394</td>
<td>1.133</td>
</tr>
<tr>
<td>23</td>
<td>Instruments</td>
<td>38</td>
<td>1.485</td>
<td>1.473</td>
</tr>
<tr>
<td>24</td>
<td>Misc. manufacturing</td>
<td>39</td>
<td>1.421</td>
<td>1.393</td>
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<tr>
<td>25</td>
<td>Transportation</td>
<td>40,47</td>
<td>1.418</td>
<td>1.819</td>
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<tr>
<td>26</td>
<td>Communications</td>
<td>48</td>
<td>1.344</td>
<td>1.339</td>
</tr>
<tr>
<td>27</td>
<td>Utilities</td>
<td>49</td>
<td>2.179</td>
<td>3.299</td>
</tr>
<tr>
<td>28</td>
<td>Wholesale trade</td>
<td>50,51</td>
<td>1.408</td>
<td>1.493</td>
</tr>
<tr>
<td>29</td>
<td>Eating and drinking places</td>
<td>58</td>
<td>1.569</td>
<td>1.325</td>
</tr>
<tr>
<td>30</td>
<td>Other retail trade</td>
<td>52,57,59</td>
<td>1.397</td>
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<tr>
<td>31</td>
<td>Financial, insurance, real estate</td>
<td>60,67</td>
<td>1.269</td>
<td>1.596</td>
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<tr>
<td>32</td>
<td>Health service</td>
<td>80</td>
<td>1.373</td>
<td>1.223</td>
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<td>33</td>
<td>Education service</td>
<td>82</td>
<td>1.294</td>
<td>1.186</td>
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<tr>
<td>34</td>
<td>Other service</td>
<td>70,79,81,83,87</td>
<td>1.340</td>
<td>1.154</td>
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Source: 1986 Nueces Mission-Aransas Input-Output Model (Fesenmaier et al 1987)
Table 7.2
Impact of Petroleum and Chemical Output Losses, Corpus Christi MSA

<table>
<thead>
<tr>
<th>Area data for chemical and petroleum sectors</th>
<th>Chemicals</th>
<th>Input-Output Sector Petroleum</th>
<th>Combined Sector</th>
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<tbody>
<tr>
<td>Value of output ($ million – 1992)¹</td>
<td>1,716.3</td>
<td>6,173.5</td>
<td>7,889.8</td>
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<tr>
<td>Inflation-adjusted output ($ million – 1986)</td>
<td>1,493.7</td>
<td>5,372.9</td>
<td>6,866.6</td>
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<tr>
<td>Number of firms</td>
<td>19</td>
<td>12</td>
<td>31</td>
</tr>
<tr>
<td>Number of employees</td>
<td>3,000</td>
<td>2,800</td>
<td>5,800</td>
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<table>
<thead>
<tr>
<th>Input-output multipliers and model coefficients¹</th>
<th></th>
<th></th>
<th></th>
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</thead>
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<tr>
<td>Type II income multiplier</td>
<td>2.506</td>
<td>4.297</td>
<td>3.907</td>
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<tr>
<td>Household direct requirements coefficient</td>
<td>0.0715586</td>
<td>0.0372036</td>
<td>0.044677</td>
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<tr>
<td>Type II employment multiplier</td>
<td>2.98</td>
<td>7.69</td>
<td>6.665</td>
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</table>

<table>
<thead>
<tr>
<th>Estimated impact of five percent change in output</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Estimated change in output ($ million – 1992)</td>
<td>85.815</td>
<td>308.675</td>
<td>394.49</td>
</tr>
<tr>
<td>Total change in household income ($ million – 1992)</td>
<td>15.393</td>
<td>49.352</td>
<td>68.876</td>
</tr>
<tr>
<td>Total change in employment (number of jobs)</td>
<td>222.56</td>
<td>2,065.89</td>
<td>2,288.45</td>
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</table>

<table>
<thead>
<tr>
<th>Total income change as a percent of income</th>
<th></th>
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<tbody>
<tr>
<td>As a percent of total personal income</td>
<td>0.258</td>
<td>0.830</td>
<td>1.159</td>
</tr>
<tr>
<td>As a percent of household wage and salary income</td>
<td>0.462</td>
<td>1.481</td>
<td>2.067</td>
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<table>
<thead>
<tr>
<th>Total employment change as a percent of employment</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>As a percent of wage and salary employment</td>
<td>0.149</td>
<td>1.388</td>
<td>1.537</td>
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<table>
<thead>
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<th>Indirect income and employment effects</th>
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<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Indirect and induced income effect ($ million – 1992)</td>
<td>9.252</td>
<td>37.868</td>
<td>51.252</td>
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<tr>
<td>Indirect and induced employment effect (number of jobs)</td>
<td>148</td>
<td>1,797</td>
<td>1,945</td>
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<table>
<thead>
<tr>
<th>Direct income and employment effects</th>
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<th></th>
<th></th>
</tr>
</thead>
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<tr>
<td>Direct income effect ($ million – 1992)</td>
<td>6.141</td>
<td>11,483</td>
<td>17.7625</td>
</tr>
<tr>
<td>Direct employment effect (number of jobs)</td>
<td>74</td>
<td>269</td>
<td>343</td>
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</table>

Figure 7.1
Consumer Surplus as a Measure of the Benefits of Water Supply

Figure 7.2
Measuring the Change in Consumer Surplus Resulting from Water Rationing
Figure 7.3
Economic Cost of Price Manipulation

[Diagram showing the economic cost of price manipulation with axes labeled Price and Quantity, and a deadweight loss indicating the inefficiency caused by price manipulation.]
Chapter 8. Economic and Behavioral Responses to Water Shortage and Drought Management

Methodological Approach to Surveys, Focus Groups, and Interviews

A series of meetings with residential water customers and representatives of six target commercial and industrial sectors addressed qualitative issues of drought impact to supplement the quantitative portions of the study. Focus group participants described changes in patterns of water use, anticipated the consequences of drought management alternatives, and provided public input on city water management and water supply policies. Table 8.1 briefly describes the composition of each focus group.

As Table 8.1 illustrates, residential and commercial/industrial groups met twice, and state and local government groups met once. During the first meeting of each group, completed between July 17 and August 8, 1996, participants answered a survey consisting of 40 questions related to water consumption, drought management preferences, and opinions about current and potential city policies. Results of the commercial/industrial and residential surveys are provided in Appendixes C and D, respectively. Following the survey, focus group moderators asked a series of discussion questions. The second meetings of each group were completed between August 14 and September 5 and were used to clarify issues addressed in the first meetings.

Focus group moderators used a series of questions as an interview guide. Questions addressed four main issues, which are listed in Table 8.2. Questions related to each of the four main issues were ordered by relative importance to the research agenda and, as often as possible, from the general to the specific. University and city staff moderated focus group sessions. The first meeting with each focus group was recorded and transcribed. Focus group results were processed and combined with results of survey data. In addition, university staff supplemented this information with interviews of petrochemical and ship channel industry representatives.

Recruitment of Participants

The city recruited residential focus group participants by requesting nominations from 24 neighborhood associations throughout Corpus Christi. Neighborhood associations were asked to nominate three members. Nine residential customers representing six different neighborhood associations participated in the focus group sessions. Seventeen residential customers who did not participate in focus groups completed surveys distributed through neighborhood associations and an apartment management company. A total of 26 residential customers completed surveys. Because participants were self-selected, the group was not a random cross section of water utility customers.
Commercial and industrial focus groups represented six target commercial/industrial sectors. Focus group participants were selected by managers from within selected organizations. The city asked top managers in selected organizations to nominate participants. Nominees were then contacted by mail and phone to recruit a suitable number of participants. Commercial/industrial focus groups comprised 63 participants representing 43 different organizations. Forty-one commercial/industrial organizations completed the survey. The project team did not offer any incentives for focus group participation. As with residential customers, participants did not represent a random cross section of water utility customers.

Surveys

The project team designed two surveys, one for residential participants and one for commercial and industrial participants, to collect detailed information about water use, drought management, and attitudes toward the drought and city policies. Information gathered through surveys supplemented information on behavior and attitudes gathered through focus group sessions. Completed surveys provide a basis for aggregation, comparison, and contrast of behaviors and attitudes among participants. Survey responses are tabulated in Appendixes C and D (see Volume 2).

Analysis

The following sections analyze results of the focus group and survey research. Sections 8.2 and 8.3 describe some economic effects of the water shortage. The information contained in these sections was generated through six commercial/industrial focus groups and interviews with large water utility customers. Section 8.4 addresses the behavioral effects of the water shortage using information generated by the two residential focus groups. Section 8.5 combines the contributions of both the commercial/industrial and the residential focus groups with regard to attitudes about the water shortage, city drought management policies, and similar issues.

Focus Group and Survey Results: Commercial and Industrial Water Utility Customers

The project team conducted focus group sessions and interviews with commercial and industrial water customers in Corpus Christi to describe economic effects of the water shortage and city water restrictions. This information is presented in three parts: patterns of water use, economic indicators of the effects of drought management, and case studies.

Patterns of Water Use

The term patterns of water use in this study refers to an observed set of features characterizing the ways in which residential and commercial/industrial customers use water. The project team used surveys, focus group discussions, and case study interviews to identify changes in patterns of production related and non-production-related water use that might be attributed to the water
shortage or city water restrictions. Production related water uses are those that are integral to a production process, such as cooling or cleaning. Non-production-related water uses refer to activities such as janitorial water or outdoor watering by commercial and industrial customers. Research on patterns of water use also helped to identify marginal uses of water, obstacles to drought management, and potential substitutes for city water among commercial and industrial participants.

**Production-Related Water Use**

The city may eventually implement mandatory restrictions on commercial/industrial water use in production or operations. However, as of December 1996, the city’s only action had been to request voluntary reductions in water use of 10 to 15 percent by members of the Board of Trade, Corpus Christi’s 16 largest industrial water customers. In addition, mandatory outdoor watering restrictions have affected production related water use in the landscape/nursery and government/schools sectors. Table 8.3 describes production related drought management measures implemented since the city declared drought condition 1 in April 1996.

Businesses have begun repairing, maintaining, and altering current production processes to affect the greatest possible water savings before investing in new capital equipment or additional labor hours. According to focus group discussions, cost-effectiveness is the most common reason that organizations delay investing in water saving capital equipment. However, uncertainty about the length of the water shortage, city plans for water allocation, and their own ability to complete capital projects within the drought management period are all factors in this decision.

Some organizations are implementing voluntary water saving measures to avoid perception of water waste. Commercial enterprises in which water use is highly visible to the public, including hotels, landscaping businesses, and building washing businesses, wish to avoid the appearance of wasting water. This concern has caused them to implement some water saving measures either at customer request or to avoid negative publicity. For example, commercial building washers have reported recapturing water to use on customers’ landscapes and transported groundwater in tank trucks for some clients who wish to avoid the appearance of wasting city water. In this case, the adoption of both water saving measures were prompted by customer requests. One power washing business even stopped all washing of private homes, an activity that generated about 40 percent of its revenue. In response to the same incentive, participating hotels have repaired malfunctioning sprinklers and other outdoor equipment in order to avoid visible noncompliance with mandatory city restrictions. Focus group participants mentioned several times the fear of bad publicity in local news broadcasts. The incentive to avoid the appearance of wasting water seems less relevant for businesses that use water in a less visible manner.

**Non-Production Related Water Use**

Table 8.4 summarizes participants’ responses to a survey question that assessed measures taken to decrease non-production related water use in response to the water shortage and city restrictions.
Participants report implementing efforts not related to production to achieve water savings beyond those required by the city in drought conditions 1 and 2. Participating commercial/industrial organizations report compliance with mandatory watering restrictions. In addition, they report implementing voluntary water saving measures not related to production. Measures listed in Table 8.4 might be considered marginal relative to those described in Table 8.3, because these measures do not affect production. Businesses report that water saving measures not related to production are less costly than production related measures. However, businesses do not report implementing more efforts not related to production than measures related to production. Businesses have implemented production- and non-production-related water saving measures in approximately equal proportion.

Relatively few participating businesses have implemented voluntary indoor water saving measures that do not relate to production. Three of the four most common non-production related measures reduce outdoor water use. A relatively small number of participants report retrofitting indoor plumbing fixtures. This may be due to either perceived or real costs related to such a project. Lack of information about retrofit options may be another cause. Many focus group participants had not considered the possibility of retrofitting and were unaware that some kits may be available from the city water department.

A majority of commercial/industrial participants formally encourage their employees to save water. Sixty-three percent of participating organizations are educating employees about how to reduce water use. In some cases, participants' education efforts reach beyond their own employees. One city department, for example, is educating local restaurants about safe ways to reduce water consumption during the shortage. In the landscape and hotel industries, participants’ ability to reduce their total water use depends upon their ability to influence their customers’ water consumption. Informing customers about potential water saving measures is therefore an important part of these organizations’ overall drought response.

**Total Water Use**

Commercial and industrial participants also answered a number of questions designed to gauge their perceptions of how total water use might have changed due to the water shortage and water restrictions. Participants were asked to assess the impact of their own drought management efforts on their total water use. Table 8.5 summarizes participants' assessments of their water use in July 1996 relative to their water use in July 1995. No water restrictions were in place in July 1995. By July 1996, the city had been in condition 2 of the drought contingency plan for approximately two months.

Participants report using less water in July 1996 than in July 1995. Sixty-one percent of commercial and industrial participants estimated that they used less water in July 1996 than in July 1995. Focus group discussions generally reinforced this perception, except in the landscape/nursery industry. For example, landscape industry representatives discussed the possibility that their customers might be watering more since the city implemented restrictions.
This does not imply that customers are not observing city water restrictions. Rather, it implies that complying with restrictions does not necessarily lead to a reduction in overall water use. In contrast, when landscape maintenance comprises a large portion of production related water use, water restrictions have greatly reduced overall water use. One school district reported using 25.5 percent less water in June 1996, than in June 1995, and approximately 50 percent less in July 1996, than July 1995. The district attributes this to its compliance with mandatory outdoor watering restrictions on its many athletic fields.

More pronounced changes in water use can be expected if the city limits water sales to commercial and industrial enterprises as prescribed in condition 3 of the drought contingency plan. Focus groups, surveys, and individual case studies all included a number of questions that asked participants to describe the water savings measures that they would implement at the onset of condition 3 and to estimate the costs of those measures. Participants’ answers to these questions contribute to the following discussion of marginal uses of water in commercial and industrial enterprise.

**Marginal Water Use**

Conclusions about the marginal uses of water in Corpus Christi commercial and industrial enterprises can be drawn from the information on changes in production- and non-production related water use in Tables 8.2 and 8.1. It would be reasonable to assume that organizations’ current curtailments in water use, made in response to a request for voluntary water savings and the possibility of limitations on water sales, have been made in areas of relatively marginal water use. In order to identify more precisely marginal commercial and industrial water uses, participants were asked what changes they might make if the city allocates water in later stages of the shortage and what changes they would consider keeping in place after the shortage.

Table 8.6 lists responses to a survey question that presented participants with a hypothetical water allocation scenario similar to that in the city’s drought contingency plan. The project team did not ask a question directly related to the city allocation plan because the city had not yet determined the extent of commercial and industrial water consumption restrictions in drought conditions 3 and 4. Only 28 of 41 survey respondents answered this question. Responses are grouped into common categories and aggregated across commercial/industrial sectors.

Significant water use reductions may require production related water saving efforts. Forty-one percent of respondents reported they would reduce production related water use as the first step toward compliance with water restrictions. If non-production-related water uses are more marginal than water uses in production, these results seem contrary to the expected response. Production-related water savings should be implemented only after less costly water savings are achieved. This response can be explained by a number of factors. Most firms have already reduced water consumption in marginal processes, especially non-production-related processes, in response to mandatory outdoor watering restrictions and a request for voluntary water savings. More than half of the respondents who would reduce production related water use are firms in the
petrochemical and ship channel industries. Of the 10 petrochemical firms that answered the question, 5 would increase water recycling in production and 5 would reduce production if they were required to reduce water use by 25 percent.

Both survey and focus group results indicate that reducing production is the least preferred drought response among commercial and industrial customers. This implies that reducing water use in specific production processes is a necessary step to achieving proposed water savings. Most petrochemical and ship channel participants report they have already scaled back non-production-related water uses. Some examples of the "next most marginal" uses of water in these firms can be found in the case studies in section 8.3. Water utility customers who agreed to provide anonymous information through interviews for the case studies were asked to identify the specific water savings measures they were implementing in response to the water shortage and in anticipation of city restrictions.

Many commercial/industrial participants are waiting to learn the requirements of condition 3 water rationing before determining which processes to alter. Marginal uses of water in production may be more apparent when the city implements condition 3 water rationing. Although most organizations report projects under way in anticipation of restrictions, both the required change in water use and the benchmark against which these changes will be measured could influence firm-level responses to water restrictions.

Outdoor water use may be more marginal than indoor water use for non-production-related processes. The relative cost of outdoor and indoor non-production related water saving measures is apparent in the response to this survey question. Only one respondent reported plans to reduce indoor water use upon implementation of drought restrictions. Obstacles to water savings described in the following section might also influence firm-level decisions about indoor and outdoor water use.

Organizations make decisions about how to reduce water use in part on basis of the relative cost-effectiveness of potential projects. The relative cost-effectiveness of water saving measures points to the relative marginality of the water uses that the projects seek to alter. Firms in all target sectors have implemented water saving efforts for their associated cost savings or efficiency. For example, two of the three local electric utility plants use seawater for power generation. Petrochemical and other large firms recycle water through cooling towers. In industries in which water is a major expense, cost-effective water savings are already in place.

Firms in which water is a minor expense generally plan to revert to previous water consumption behavior when drought management requirements and voluntary water savings requests expire. When water is not a major production input, reducing water use may not produce significant firm-level cost savings. Firms that do not save money as a result of their efforts during the drought will most likely revert to previous patterns of water use after the water shortage. Some firms noted an exception to this general rule. If their customers specifically request continuance of water saving efforts, there would be an incentive keep these in place indefinitely. For example, power washers
who began using groundwater at customer request during the water shortage do not plan to continue to use groundwater after the shortage unless their customers request it.

Firms in which water is a major expense might keep in place cost-effective investments made during the current water shortage. Measures that require no capital investment and positive or insignificant change in variable costs are likely to be permanent if production, safety, and, in some cases, convenience do not suffer. In order to avoid reducing production, firms may attempt measures that require capital investment but do not generate sufficient savings in variable costs in the short term. Most firms that have implemented water saving measures with these qualities will lease the necessary equipment in the short term and plan to revert to past practices when restrictions are lifted. Reductions in water use that require capital investment that is not cost-effective, even in the short term, are likely to drive facilities and parent firms to consider reducing production in the short term. In the long-term, if firms cannot conserve enough water by implementing cost-effective projects, they and their parent corporations are likely to reconsider the long-term economic feasibility of potential expansions or continued operations in Corpus Christi.

Obstacles to Water Savings

In order to identify some of the obstacles to water savings in Corpus Christi commercial and industrial organizations, focus group moderators asked whether participating businesses had implemented as many water saving measures as they would like, and if not, what was preventing them from doing so. Table 8.7 lists the most common answers to this question. Cost is the primary barrier to increased water savings among Corpus Christi commercial and industrial enterprises, but the other obstacles listed in Table 8.7 were frequently mentioned across sectors.

Uncertainty about condition 3 water rationing and the baseline from which the city will calculate rations is a significant obstacle to increased voluntary water savings. According to the drought contingency plan, in July 1996, the water allocation to commercial and industrial customers was to be a percentage of water use in the same month of the prior year. Such a limitation would not reward voluntary water saving efforts undertaken prior to the enactment of restrictions. This disincentive to reduce water use in advance of drought restrictions is paired with a classic “free rider” problem. If one firm voluntarily reduces water use through long-term water conservation, it might be penalized by receiving a smaller monthly water allocation under drought restrictions than another firm in the same industry. Firms report no perceived benefits to water conservation if they have no assurance that other firms are behaving similarly or that they will receive credit for voluntary water savings when the city implements water restrictions. These views were expressed by representatives of the larger industries as well as those from smaller commercial enterprises.

Lack of information about how to achieve additional water savings is an obstacle to increased water savings among smaller commercial enterprises. Organizations like hotels and landscaping businesses, which might conserve significantly by plumbing modification, gray water reuse, and other indoor measures, often lack the necessary information. This did not seem to be a significant
obstacle to increased water savings among larger industries. Many focus group participants suggested that availability of information on methods of reducing water use would enhance their own employee education and awareness efforts.

Some commercial/industrial customers face the additional obstacle of reliance on their own customers’ water use to reduce water consumption. Landscapers, for example, could reduce overall water use if more of their residential and commercial customers agreed to water-wise plant selection, irrigation systems, and landscape designs. Most customers, however, are concerned less with improving the drought tolerance of landscapes than with compliance with a city ordinance that regulates landscaping around new buildings. That ordinance establishes a point system for water-wise materials and designs and requires a minimum number of “points” at each construction site. This ordinance does include incentives for selecting drought-tolerant landscape materials, but costs often deter customers from selecting them. Similarly, the behavior of guests can restrict a hotel’s ability to achieve water savings.

Facility and equipment constraints are obstacles to increased voluntary water savings. Low water pressure and aging properties can prevent businesses from installing water saving plumbing devices or reducing the level of water in existing toilets, for example. In addition, school districts and other focus group participants that might achieve significant water savings by retrofitting faucets have experienced numerous difficulties with water saving valves. One school district is replacing these valves with traditional faucets due to excessive water waste. City departments and other organizations concerned with groundskeeping fear that reducing outdoor watering any further than current levels will irreversibly damage watering equipment, an expensive capital investment. Keeping systems minimally operational can avert this problem. Organizations facing this obstacle are therefore unlikely to further reduce water consumption voluntarily.

Health, safety, and liability issues are obstacles to increased voluntary water savings in some commercial/industrial sectors. These issues have limited the extent to which some organizations have voluntarily reduced landscape watering, dust control, facility washing, and other non-production related water consumption. In some cases, further reduction in these areas conflicts with local, state, or federal environmental or safety regulations. For example, one military facility is required to wash helicopters at a minimum frequency for corrosion control. Another is required to flush fire hydrants at a minimum frequency. Some focus group participants who have considered using effluent as a substitute for city water are prevented from doing so by liability issues and city rules. In some cases, regulatory issues generate a firm-level trade-off of one environmental side effect for another. For example, one local refinery installed a wet gas scrubber to control sulfur dioxide emissions. This technology has increased water consumption in the company’s cooling process relative to other firms and complicates water recycling; this could be interpreted as an obstacle to voluntary water savings. One local manufacturer may consider increasing its percentage of solvent-based products relative to water-based products if water restrictions threaten to reduce production.
Public resistance can prevent organizations from implementing voluntary water savings measures. For example, city departments and school districts face public outcry over the deteriorating condition of parks and athletic fields. This may prevent these customers from altering water use patterns. Likewise, petrochemical industries that would consider recycling city wastewater effluent streams for use in production face public resistance to the depletion of wetlands and birding areas currently fed by those streams.

Water quality problems resulting from the water shortage are an obstacle to increased voluntary water savings among larger industries. As the level of the city's reservoirs has declined, water quality has declined, requiring both additional chemical and mechanical treatment and, in some cases, increased use of water in production among larger industries. Low quality of initial water inputs also poses an obstacle to maximizing water recycling.

Potential Substitution Effects

Commercial/industrial participants are able to substitute other inputs for city water in some production processes. Substitutes for water discussed by focus groups include city effluent, internally recycled water, groundwater, and seawater. A few other sector-specific substitutes for city water were mentioned in focus group discussions. For example, one landscaping business is promoting turf painting as a substitute for sod, one manufacturer would consider substituting distilled water or solvent for city water in some production processes, and one hotel has devoted extra labor hours to stairwell-sweeping instead of washing with water.

Where substitution of other inputs for city water is cost-effective, most of the city's largest industrial water customers have already invested in the necessary technology. For example, one Board of Trade member designed two of its Corpus Christi facilities to use seawater for cooling. Another invested $500,000 in two groundwater wells in response to the 1984-1985 water shortage. The cost-effectiveness of substitution of other inputs for city water might increase if city water restrictions remain in place for any length of time or if city water rates for commercial and industrial customers rise significantly.

The obstacles to substituting other inputs for city water are almost identical to the obstacles to voluntary water savings listed earlier. Cost and technology are the biggest obstacles to substitution among larger industries. Health and safety risks are obstacles to substitution of effluent for city water in most sectors. Lack of information about city effluent availability and gray water reuse is an obstacle for smaller commercial enterprises. Conflicts with local, state, or federal environmental regulations are obstacles to using effluent in some processes and also make recycling water more complicated. Effluent streams and recycled water cannot be used if use of such wastes would conflict with regulatory standards.
Economic Indicators

Economic impact estimates presented in Chapter 7 address the impact of the current water shortage on the Corpus Christi economy. The second major function of the study’s commercial and industrial focus groups was to identify sector-level indicators of economic impact and to assess firm-level perceptions of how those indicators may be affected by the water shortage and city restrictions. Firms’ perceptions of economic impact are not necessarily accurate, nor can they be aggregated to calculate total economic impact. They are, however, a barometer of how firms may act in response to water restrictions and how the water shortage may influence their long-term plans for production in Corpus Christi.

Indicators of Economic Impact

Indicators of economic impact vary by sector. The project team met with a group of local and regional government representatives to identify potential measures of the water shortage’s aggregate economic impact. The local government working group suggested a number of indicators, listed in Table 8.8, that might measure the long-term impacts of the water shortage and city restrictions on aggregate economic conditions in Corpus Christi.

Focus group and survey results indicate that revenue and employment would be appropriate indicators of the economic impact of the water shortage and city restrictions on most commercial/industrial sectors. Table 8.8 summarizes the sector-specific indicators of economic impact identified by study participants as potential appropriate measures of how strongly the water consumption restrictions affect their industries.

Perceived Short-Term Economic Impact

The focus groups and survey results discussed below describe economic effects of drought restrictions. This project was not designed to measure empirically the short-term impacts of the water shortage and restrictions on the indicators listed in Tables 8.8 and 8.9. Survey and focus group results regarding changes in revenue, employment, and other indicators allow generalizations regarding how firms make water use decisions in response to economic incentives. These observations cannot be used to calculate average or overall economic impact.

Revenue and employment have been hurt in industries affected most directly by the mandatory water restrictions of drought condition 2. Focus group participants from the landscaping industry indicated that monthly sales were down about 50 percent in July. One firm has cut its employee work weeks to four days rather than 5, a 20 percent drop in employment measured in hours worked. Firms that work on a contract basis have seen less impact on revenue and employment in the short term. While some landscaping firms might recover some losses with increased revenue from landscape replacement activity in the spring, other types of commercial customers may not recover loses. For example, power washing businesses with monthly contracts may see revenue...
return to previous levels after the water shortage, but they will not recover any revenue for work lost.

Many participants have experienced small increases in fixed costs to comply with condition 2 outdoor watering restrictions and with the city request for voluntary water savings. Focus groups and surveys asked participants to estimate the short-term fixed and variable costs of the water shortage in drought condition 1 and part of drought condition 2, from April through August 1996. Table 8.10 illustrates the effects of conditions 1 and 2 on fixed costs. According to survey results, the water shortage has raised fixed costs in 49 percent of participating commercial/industrial organizations. Examples of fixed costs incurred by participating organizations include opening of groundwater wells by wholesale customers; purchase of new irrigation equipment by smaller commercial enterprises; capital expenditures for water saving equipment by larger industries; and commissioning of an engineering study on effluent reuse by a military installation.

More detailed examples of fixed costs associated with the water shortage can be found in the case studies in section 8.3.

Many participants have experienced small increases in variable costs to comply with condition 2 outdoor watering restrictions and with the city request for voluntary water savings. Sixty percent of participating organizations report increased variable costs. Some firms located in Corpus Christi during the 1984-1985 water shortage invested in water saving equipment that they are reusing in 1996. This may partially explain the lower percentage of firms incurring fixed costs relative to variable costs. In addition, some variable cost increases can be associated with low water quality. Low water quality caused by low reservoir levels can raise operating expenditures. Table 8.11 illustrates the effects of conditions 1 and 2 on variable costs.

Survey and focus group results also describe some anticipated economic impacts of proposed allocations of water to business and industry. Interpretation of these observations is complicated by frequent changes in the city’s proposed allocation and surcharge plans. For example, participants were asked to estimate the anticipated revenue and employment effects of condition 3 restrictions according to city ordinances in July. At that point, condition 3 was expected to yield a 25 percent reduction in commercial and industrial water use compared to the same month in the prior year. Current policies may involve both a different percentage reduction and a different baseline for calculating the reduction. Estimates of the economic impact of water restrictions are descriptive, but they cannot be used to calculate the aggregate impact of drought condition 3 on revenue and employment.

Many participants are unable to estimate the revenue and employment impact of condition 3 water allocation. Table 8.12 describes responses to commercial/industrial survey questions 28 and 29, which identify expected changes in sales revenue and employment if the city allocates water according to the July 1996 requirements of drought condition 3. The percent of participants responding to these questions is perhaps equally as useful as the average anticipated change in revenue and employment that they report. Only 53 percent of all participants were able to estimate
an economic impact of condition 3 water allocation in terms of revenue. Only 27 percent were
able to estimate an impact of allocation in terms of employment.

Anticipated impacts of condition 3 water rationing on revenue and employment are unclear. Study
participants from the landscape/nursery sector expect allocation to depress revenue and
employment to a greater extent than participants from any other sector. For example, more firms
were able to estimate changes in revenue than changes in employment. This may suggest revenue
effects will be stronger than employment effects. Alternatively, employment effects may simply
be more difficult to estimate. These observations are consistent with focus group discussions.
Many refineries and other industrial facilities do not have the flexibility to reduce employment in
the short term even if they reduce production, because a full staff is required to keep all units
operating even below capacity.

The revenue and employment effects of condition 3 water rationing will depend on the reduction
required by the city and the baseline from which the reduction is calculated. How sensitive are
production cost, revenue, and employment to water consumption restrictions? It is believed these
effects will become increasingly large as the level of water rationing increases. For example, one
industrial participant maintained that the cost of compliance with a 25 percent reduction
requirement among Board of Trade members would increase a hundredfold over the cost of
compliance with a 15 percent reduction requirement. That participant did not specify whether he
was referring to opportunity costs of lost production, production costs, or some other cost
measure. Table 8.13 lists Board of Trade estimates of the economic impact associated with
reducing water use 15 percent and 25 percent.

The Board of Trade technical committee also estimated job losses resulting from reduced
production levels under condition 3 water rationing. If Board of Trade members reduce water use
15 percent, they anticipate a direct employment loss of 80 jobs in the petrochemical
manufacturing industry. Board of Trade members project this may result in a combined direct,
indirect, and induced employment loss of 400 jobs in all area industries combined. More stringent
levels of water rationing will increase employment losses. If condition 3 requires a reduction of 25
percent, Board of Trade members project a direct employment loss of 415 jobs. Board of Trade
members further project that combined direct, indirect, and induced employment losses resulting
from changes in petrochemical manufacturing output levels could be as many as 2,200 jobs.

Possible Long-Term Economic Impact

Commercial and industrial water customers are concerned about long-term economic impacts
related to the risk of water shortage in Corpus Christi. From June through August 1996, the
Greater Corpus Christi Business Alliance conducted business recruitment and retention surveys
with 16 large commercial and industrial corporations. Half of those surveyed listed water supply
among the top three needed improvements to the local business environment. More than one third
listed water supply as the most needed improvement. In the Business Alliance survey, four of the
area's largest water customers indicated that they anticipate long-term production and employment impacts if the water issue is not resolved.

A majority of commercial/industrial participants feel that the long-term risk of drought in Corpus Christi is high enough to justify the cost of investments to reduce water use. As Table 8.15 illustrates, 68 percent of participants felt that the long-term risk of drought justified investments to reduce water use. Only 20 percent disagreed with the statement. Focus group results and firm-level case studies also indicate that long-term investments to reduce water use are a priority for commercial/industrial participants.

The current water shortage has affected few participants' long-term expansion plans. Table 8.15 summarizes responses to a survey question that was designed to determine the extent to which the current water shortage had affected participants’ expansion plans, an indicator of long-term economic impact. Only one fourth of survey respondents indicated that the current water shortage had affected company expansion decisions through July 1996. One explanation for this is that expansion and capital investment decisions usually have a long horizon. The effects of drought contingency measures that have been in place for only a few months are not likely to be significant for many firms. Decisions regarding current capital projects and investments at military installations, for example, are often made five years or more in advance. In addition, many firms will wait to know the details of city water restriction measures before they make changes to expansion and investment plans already under way. One school district is postponing use of a multimillion-dollar bond issue for athletic facility improvements until it knows how later stages of the drought contingency plan will affect potential investments. Industries that depend on discretionary water use by Corpus Christi residents, like the landscaping and power washing industries, have put all long-term expansion plans on hold in response to the water shortage.

Industrial participants express concern that the long-term risk of water shortage will impact the local economy negatively. Table 8.16 lists responses to several survey questions that...
assessed participants' opinions about the impact of the long-term risk of water shortage on the Corpus Christi economy as a whole. Perceptions about how sensitive economic conditions are to the water shortage may affect organizations' long-term decisions about production and expansion in Corpus Christi.

**Interview Results: Six Industrial Water Utility Customers**

To supplement the economic impact information obtained through focus group and survey research, university staff conducted interviews with six members of the Corpus Christi Board of Trade, which represents the city's 16 major industries. Board of Trade members' combined water consumption is approximately 14.6 billion gallons per year, roughly 40 percent of all city water sales. Case studies A through F describe the impact of the water shortage and city restrictions on some of Corpus Christi's largest water customers at an individual level. The interviewer asked each the same series of nine questions, which covered the topics listed in Table 8.17.

None of the firms interviewed planned to wait for mandatory water restrictions to begin reducing water use. All had undertaken significant projects in response to the city's request for voluntary reduction in drought conditions 1 and 2. In addition, it should be noted that concern over the long-term water supply in Corpus Christi has driven the city's largest industries to conserve water on an ongoing basis. For example, the refinery industry in Corpus Christi is relatively water efficient. Corpus Christi refineries use an average of 30 to 35 gallons of water per barrel of crude oil throughput. Houston area refineries use an average of 90 gallons. All firms interviewed had made significant efforts to educate employees about ways to reduce water use and to improve leak inspection and the overall condition of water systems. Most had implemented non-production related measures to save water, including reduced landscape watering, dust control, and facility washing.

Interview questions provided a more comprehensive look at the production related water use behavior of individual firms. All firms interviewed have experienced an increase in costs associated with the decrease in city water quality, which requires the firms to invest more in chemical and mechanical treatment with no resultant savings in water costs. These costs are not included in the estimates reported for each firm.

**Case Study A**

Company A is a refinery that used an average of 150 million gallons of water per month from August 1995 through August 1996. Table 8.18 lists the efforts to reduce water use undertaken by company A in response to the current drought. Table 8.18 lists water saving measures implemented since the 1984-1985 water shortage.
Economic Approach to Reducing Water Use

Decisions about how to reduce water use are based on comparisons of cost per thousand gallons of water produced to cost per thousand gallons of city water. Measures implemented through August 1996 are those that produce recyclable water at a cost lower than that of city water.

Preparation for Potential Water Allocation

If current water saving efforts do not enable company A to meet future city water restrictions, it will consider implementing other capital projects to save water, even though those projects will produce water at a price much higher than that of city water. Company A intends to do everything short of decreasing production to meet city restrictions and avoid incurring surcharges. Management is not comparing the costs of surcharges to the costs of compliance with potential city restrictions.

Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi

The costs to company A of the long-term risk of water shortage function like a local tax. Costs cannot be passed on through its product, as pricing in the refinery industry is driven almost wholly by the Houston market. Management is not concerned with the water shortage’s long-term impact on company A’s ability to compete with other firms in the Corpus Christi refinery industry. If the water shortage continues indefinitely and city restrictions or water costs impede its ability to produce at capacity, company A might anticipate an effect on its ability to compete for resources and capital investment from its parent corporation.

Case Study B

Company B is a refinery that used an average of 210 million gallons of water per month from August 1995 through August 1996. Table 8.20 lists water saving measures implemented by company B in response to the current water shortage. Table 8.21 lists water saving measures implemented since 1994-1995.

Economic Approach to Reducing Water Use

Company B has been recognized for its efforts. The company has a three-stage drought contingency plan which anticipates restrictions associated with the city’s four-stage plan and implements them proactively. Decisions about how to achieve water savings are based on comparisons of cost of recyclable water produced to cost of city water, but management will consider any project with long-term economic return. Less practical projects will be considered especially as an alternative to decreasing production.
Preparation for Potential Water Allocation

Water saving measures associated with the third stage of company B's drought contingency plan are expected to bring water use to the level anticipated to be required by city restrictions. If implemented projects do not conserve as much water as expected, company B may have to consider paying surcharges in the short term. Management would prefer to comply with city restrictions rather than make an economic decision to pay surcharges.

Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi

The ability of company B to compete with other firms in the refining industry in Corpus Christi has not yet been affected by the water shortage. The company places heavy emphasis on reducing water use in its Corpus Christi operations, but it does not anticipate that long-term costs associated with water savings will negatively affect its ability to compete.
Case Study C

Company C is a refinery that used an average of 180 million gallons of water per month from August 1995 through August 1996. Table 8.22 lists water saving measures implemented by company C in response to the current water shortage. Table 8.23 lists water saving measures implemented since the 1984-1985 water shortage.

Economic Approach to Reducing Water Use

company C is implementing the most economically practical water-saving projects to meet anticipated city restrictions. Management does not plan to reduce production or employment due to the water shortage. However, water-saving projects do not result in increased earnings, resulting in a zero return on capital investment.

Preparation for Potential Water Allocation

Company C has established a target for water savings. Its goal is to reduce monthly water use by 15 percent of 1995 water use. It anticipates that this reduction will meet the short-term requirements of city water restrictions. If the water shortage continues and further reduction is necessary, the company might have to consider paying surcharges.

Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi

One of the newer refineries in Corpus Christi, company C had to meet stricter environmental regulations than others in the industry when constructing its facility. For example, the company installed a wet gas scrubber for sulfur dioxide control. Some of the requirements of these regulations have increased water consumption and/or complicated water recycling for company C relative to other local firms. As a result, company C will incur higher costs than other firms to meet city restrictions. In the long-term, this will affect the company's ability to compete. In addition, the water shortage presents a risk factor to the corporation's Corpus Christi facility relative to other facilities in the same firm. Although this has not yet affected company C's ability to attract capital investment from the parent corporation, it might in the long-term.

Case Study D

Company D is a petrochemical manufacturer that used an average of 160 million gallons of water per month from August 1995 through August 1996. Table 8.24 lists water saving measures implemented by company D in response to the current water shortage. Table 8.25 lists water saving measures implemented since the 1984-1985 water shortage.

Economic Approach to Reducing Water Use

company D is implementing the most economically practical water saving projects possible to meet anticipated city restrictions. Two of the measures implemented, the recycling of treated wastewater to cooling towers and the installation of an RO unit for
the demineralizer, may be economically practical to maintain after the water shortage eases.

**Preparation for Potential Water Allocation**

The company anticipates that projects under way will reduce water consumption enough to meet city restrictions. One additional capital project, a more permanent RO unit for the demineralizer, could be in place by early 1997 if necessary. Management is also researching the economic feasibility of additional options including recycling of municipal treatment plant effluent, refrigeration units for cooling, fan cooling, groundwater wells, and importation of fresh water by ship. Company C will avoid reducing production if at all possible, but would consider transporting materials to another facility in order to process two of its products elsewhere and still comply with city restrictions and avoid surcharges.

**Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi**

The ability of company D to compete with other local firms has not yet been affected by the long-term risk of water shortage. The company's ability to attract capital investment from the parent corporation is market driven and has not been affected by the long-term risk of water shortage. The parent corporation has recently invested in an expansion of one of its Corpus Christi facilities and is very concerned about the impact of water restrictions on its ability to begin using this expansion.

**Case Study E**

Company E is a refinery that used an average of 105 million gallons of water per month from August 1995 through August 1996. Table 8.26 lists water saving measures implemented by company E in response to the current water shortage. Table 8.27 lists water saving measures implemented since the 1984-1985 water shortage.

**Economic Approach to Water Reducing Water Use**

Company E reports implementing all economically feasible water saving measures.

**Preparation for Potential Water Allocation**

The efforts presently under way at company E may not reduce water use to the level required by potential city restrictions. The next most feasible water-saving measure at company E would involve a $2 million capital investment. The company would have to consider paying surcharges in the short and/or long-term if current saving measures do not bring the facility into compliance with city restrictions.

**Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi**

Company E's ability to compete with other local firms has not yet been affected by the long-term risk of water shortage in Corpus Christi. If the current water shortage continues
and the firm is unable to meet city restrictions, its ability to compete may be affected. If company E had to implement additional capital water-saving projects, the parent corporation would compare the feasibility of maintaining production in Corpus Christi to the cost of moving production to another facility.

**Case Study F**

Company F is a Board of Trade member that used an average of 93 million gallons of water per month from August 1995 through August 1996. Table 8.28 lists water saving measures implemented by company F in response to the current water shortage. Table 8.29 lists water-saving measures implemented since the 1984-1985 water shortage.

**Economic Approach to Reducing Water Use**

Company F has implemented water-saving projects that produce water cost savings high enough to cover project capital, chemical, and operational costs. As a result, the company will maintain these measures beyond the current water shortage unless a degradation of equipment is noted.

**Preparation for Potential Water Allocation**

Projects to reduce water use currently under way may not reduce water use at company F to the level required by potential city restrictions. If the city does allocate water, the company may further increase the cooling tower cycles on one of its units for additional water savings. It would then consider leasing an RO unit for the short term in order to comply with restrictions. Company F would also consider the economic feasibility of obtaining its product from other company locations or from its competition if company F is unable to produce the product in Corpus Christi. The company might consider paying surcharges rather than reducing production if it could not meet city restrictions and still supply its customers' requirements. Company F's monthly usage varies widely from year to year. The 1995 water usage was not typical of usage trends from previous years. Company F will be affected severely if the city allocates water based on 1995 usage rather than historical usage from 1993 to 1995.

**Potential Impacts of Long-Term Risk of Water Shortage in Corpus Christi**

If the long-term risk of water shortage slows growth in local industries, this will directly affect company F's growth potential. In addition, competition in company F's industry has increased potential for long-term risk of company F's ability to compete due to water shortage. Water is a major production cost on several of company F's units. Higher water costs resulting from the acquisition of additional long-term water supplies would have a heavy impact. Of company F's facilities in Corpus Christi, several units use city water for cooling and would face a significant increase in operating costs. One facility, in particular, would be vulnerable to closure if a competitor constructed a less water intensive plant in the Corpus Christi market.
Focus Group and Survey Results: Residential Water Utility Customers

Focus group sessions and surveys of residential water customers in Corpus Christi described behavioral effects of the water shortage and city water restrictions. Nine residential customers participated in focus group meetings, and 26 responded to surveys. Residential participants described the impacts of current mandatory restrictions, reported current voluntary water saving measures, and identified those they might implement to comply with condition 3 water rationing. Information about behavioral responses is described in terms of patterns of water use and marginal water uses.

Mandatory Reductions in Water Use

Residential lawn watering was restricted during July and August to one day per week, based on customer street address, between the hours of 6:00 p.m. and 10:00 a.m., with authorized watering equipment. Condition 2 also prohibits run-off from lawns to streets and gutters and prohibits the washing of automobiles, trucks, boats, and any other type of mobile equipment without a bucket. The term mandatory water savings in this section refers to residential compliance with these aspects of condition 2 of the drought contingency plan. In mid-September the city implemented additional condition 2 restrictions, the effects of which are not included in the following description.

Residential customers report compliance with drought condition 2 outdoor watering restrictions. Residential focus group participants report that they are complying with condition 2 restrictions. Fifty-four percent of survey respondents feel that their efforts at the household level have made a meaningful contribution to the citywide effort to reduce water use. Residents believe that their water saving measures contribute to high compliance rates. In addition, 73 percent of survey respondents agree or strongly agree that their neighbors are complying with mandatory condition 2 restrictions.

Residents report that compliance with condition 2 watering restrictions is not costly. Survey responses to two questions that assessed the costs of compliance with condition 2 restrictions indicate that the fixed and variable costs of compliance are insignificant for most participating households. Only 11 of 26 survey respondents were able to describe or estimate a fixed cost of their efforts to reduce water use in conditions 1 and 2. By the end of July, only three households surveyed had spent more than $60 to reduce water use. Expenses reported were for soaker hoses and indoor retrofitting. Only the former can be considered a cost of complying with mandatory restrictions.

The effects of mandatory water restrictions on patterns of household water use may increase if the city enters drought condition 3 and rations water to residential customers. The drought contingency plan limits monthly residential water use based upon household size. Table 8.30 describes condition 3 residential water allocation. In contrast to the mandatory restrictions of condition 2, drought condition 3 will not require residential customers to implement specific water saving measures.

Households report that they will be able to comply with the short-term requirements of condition 3 allocation. Although most participating households agree that they will be
able to manage with the water allowance prescribed for condition 3 (Table 8.31), household size and knowledge about water use may influence compliance with water rationing. Some participants anticipated that larger households would have a harder time complying with water rationing than smaller households.

Anticipated long-term foundation and landscaping costs may reduce residents’ willingness to restrict outdoor watering under condition 3. As Table 8.32 indicates, residential customers are divided about whether household costs will increase if the city limits residential water use under condition 3. Focus group results indicate that residents’ main cost concerns are the long-term costs of structural foundation repair and landscape replacement, rather than the short-term costs of compliance with condition 3 water allocation. In condition 3, households will pay a surcharge for water use that exceeds their water allowance. Table 8.33 describes the city’s cumulative residential surcharge plan for condition 3.

When focus group moderators explained condition 3 residential allocation and surcharge plans, one participant pointed out that residents could not have 1,000 gallons of effluent delivered for outdoor watering for a price as low as the penalty the city would charge for the first 1,000 gallons of water in excess of a customer’s allocation. All seven participants at one residential meeting agreed that if no further penalty threatened, they would pay a surcharge for using more than their water ration rather than reduce their water use, especially to continue foundation watering.

Survey results were less conclusive, as Table 8.34 illustrates. When asked whether the city’s residential surcharge policy provided an incentive to reduce water consumption, residential participants were divided as to the effectiveness of those restrictions.

Voluntary Water Savings

Any water saving measures implemented by residents during July and August beyond those required by drought condition 2 can be considered voluntary. Table 8.34 lists the voluntary efforts undertaken by residential survey respondents in response to the water shortage. All but one survey respondent reported implementing voluntary water saving efforts.

Residents report implementing voluntary outdoor water saving measures beyond those required by drought condition 2. Sixty-five percent of respondents have reduced outdoor watering to a level lower than that required by the mandatory restrictions of condition 2. This indicates that compliance with condition 2 restrictions is not an excessive burden on Corpus Christi households.

Residents report implementing voluntary indoor water saving measures in conditions 1 and 2. Survey respondents have also implemented measures to reduce indoor water use. Residential focus group participants report increased awareness of water use. For example, most participants wait to accumulate full loads before running washing machines and dishwashers. Many also report turning off bathroom faucets while brushing teeth and shaving. Residents have installed water saving plumbing devices and started
household water reuse programs at a relatively low rate. Retrofitting and water reuse are the only two indoor measures listed in Table 8.35 that can be costly. This may explain the lower rate at which households have implemented these measures relative to other voluntary indoor water saving measures.

Households report maintaining or reimplementing many water-saving practices implemented in response to the 1984-1985 water shortage. Many households retrofitted bathroom and kitchen fixtures with water saving devices in response to the 1984-1985 water shortage. In addition, focus group participants report maintaining water saving behavior since 1984-1985, like running appliances with full loads and reusing dishwater for plant watering. No focus group participants report voluntarily maintaining outdoor watering restrictions since the water shortage of 1984-1985. Instead, they have reimplemented outdoor water saving measures in response to mandatory restrictions, often using equipment purchased during the last water shortage. Focus group participants do report having increased their use of drought-tolerant landscaping materials since the last water shortage.

Households report implementing many of the water saving measures they consider to be most effective. One residential survey question asked respondents to identify the three household water saving measures they considered to be most effective. Sixty-six percent of respondents have implemented at least two of the three measures that they consider to be most effective. This does not imply that households are implementing the most effective water saving measures. It does, however, imply that they are making a conscious effort to save as much water as possible. All focus group participants expressed a desire to know which measures were most effective. Amount of water saved appears to be an important factor affecting household decisions about what water saving measures to adopt, even though most households lack the information necessary to compare water savings between measures.

Total Water Use

Survey and focus group questions gauged residents’ perceptions of the impact of their water saving efforts on their water consumption.

Residential water customers report that water saving efforts have reduced their household water use. Table 8.36 lists responses to a survey question that asked residential water customers whether their household water use had been reduced through water saving efforts.

Residents report that compliance with mandatory water restrictions does not necessarily reduce outdoor water use. Although residents report using less water as a result of their water saving efforts, many report increased outdoor water use in response to condition 2 watering restrictions. For example, customers that might have watered once every 10 days watered once every week when the city restricted household watering to assigned days. Changes in watering frequency might be due to lack of rain or a reaction to the assignment of days to water. Two focus group participants maintained, and others agreed, that they felt compelled to water on their assigned day, regardless of need.
Another example illustrates a similar point. A wholesale water customer participating in the study routinely notifies its own customers, towns, and rural areas about system maintenance 24 hours in advance. Each of these customers is required to maintain a 24-hour above-ground storage supply. When notification is given to residents and businesses that water service may be suspended for maintenance, a town's 24-hour water supply often disappears in 12 hours.

Focus group participants admit they may use more water than necessary in anticipation of restricted water use. In condition 3, water will be rationed and residents will make decisions about watering landscaping in relation to trade-offs with alternative uses. This may be a more effective way to reduce outdoor water use. Focus group participants indicate that when faced with a trade-off between indoor and outdoor, they will be more willing to decrease outdoor watering than indoor water use.

**Obstacles to Water Savings**

Cost, convenience, and lack of information are the three most commonly reported obstacles to reducing household water use. Anticipation of the long-term costs of reducing water use, including foundation repair and landscape replacement, appears to be an important obstacle to increased voluntary efforts. Focus group participants agreed that they would continue to water foundations, even under the threat of surcharge for using more than their allocation, unless the city implemented a mandatory restriction on watering foundations with city water. Residents agreed that effluent could be a substitute for city water on foundations, although many had not yet determined the costs of purchasing and applying effluent.

Convenience is an additional obstacle to increased household water saving efforts. Responses to survey question 27, listed in Table 8.37, indicate that inconvenience appears to be more of an issue than cost at the residential level. For example, when residents are restricted to watering on an assigned weekday, they are forced to choose between watering and other activities. The outdoor watering restrictions are considered inconvenient by many focus group participants because of this interference with normal use of time during nonworking hours.

Incomplete information is an obstacle to voluntary reduction of household water use in two different respects. First, households' level of knowledge about their own water use is low. Households will not be able to increase voluntary reduction of water use or to comply with water rationing unless they become more familiar with their own water use. While approximately one half of survey respondents were able to estimate their monthly water bill, only 42 percent reported any ability to estimate monthly household water use. While most respondents know the location of their water meter, only one half are able to read their meter. Residents' ability to monitor their own water use will influence the extent to which condition 3 restrictions reduce household water use in Corpus Christi.

In addition, residential customers lack information about methods of saving water. For example, participants at the first residential focus group meeting agreed unanimously that if they were asked to implement one more water-saving measure, they would like to reuse

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household gray water to water foundations. Only two participants knew what water they would reuse and how they would accomplish it. Most lacked the requisite knowledge about equipment purchase and plumbing modification to begin a reuse program.

**Marginal Uses of Water**

Focus group and survey questions assessed marginal uses of water in Corpus Christi households by asking residents to identify preferred methods of reducing water use. During the second residential focus group meeting, moderators asked participants to establish a hierarchy of preferences. Moderators described the city allocation and surcharge plan for condition 3 and asked residents to identify the measures they would implement to comply with water rationing. Given a list of eight categories of household water use, participants settled unanimously on the order in which they would implement water saving measures in these categories. Table 8.38 illustrates the results of this exercise in the order in which participants would begin to implement water saving measures if required to abide by city water rationing.

Outdoor water use is marginal relative to indoor water use among residential focus group participants. With the exception of foundation watering, which all residential participants are reluctant to cease because of the risk of long-term structural home damage, residents would prefer to limit all outdoor water consumption before limiting indoor water consumption.

Residents report greater willingness to reduce water use for a variety of purposes than to cease water use for selected purposes in the short term. The hierarchy of water-saving preferences in Table 8.34 does not imply that residents would first cease all car-washing, then cease all lawn watering, and so on in response to water rationing. Instead, residents would limit use in the first category, car washing, to the extent that it was convenient and cost-effective for them to do so before implementing water saving measures in lawn watering. Similarly, they would limit lawn-watering to household limits of cost, convenience, and other factors before limiting outdoor plant watering.

Water saving measures listed in Table 8.39 demonstrate marginality of household water uses in greater detail. Survey question 40 asked residents to identify measures they would implement in response to water rationing other than those already implemented. Responses therefore incorporate participants’ current compliance with mandatory outdoor watering restrictions and their implementation of outdoor water saving measures beyond what is required by condition 2. This is reflected in the presence of a number of indoor water saving measures near the top of the list.

When residential customers were asked to choose between specific water saving measures, their preferences described a different hierarchy of water-saving preferences than those described in Table 8.38. Many factors might contribute to this difference. First, only 9 of 26 survey respondents participated in focus groups. When the surveys answered by focus group participants are analyzed separately, water saving preferences expressed in Question 40 resemble more closely the list in Table 8.38. In addition, question 40 asked respondents to identify the water saving measures that they would prefer to
implement beyond what they are already doing. In the focus group water-saving preferences exercise, participants did not distinguish between measures that they have implemented and measures that they have not.

The results listed in Table 8.39 do, however, have an important feature in common with those listed in Table 8.38. Again, residents report a preference to reduce water use across a variety of household activities rather than ceasing water use in selected activities. In addition to the mandatory and voluntary measures to reduce water use they have already implemented, for example, households' first five preferred water-saving alternatives represent one outdoor measure, one indoor measure each in kitchens, bathrooms, and laundry rooms, and one indoor/outdoor measure. Residents' preference for incrementalism in water restrictions poses a challenge to the design of specific water restrictions like those of drought condition 2. City plans for condition 3 rationing, in contrast, are structured to take advantage of marginal uses of water in Corpus Christi households. Condition 3 restrictions will allow residents to make incremental water use decisions as long as the sum total of their water saving measures brings their water use to a point at or below their household allocation.

Focus Group and Survey Results: Attitudes toward the Water Shortage and Water Supply Policies

Focus group and survey research assessed residential and commercial/industrial customer attitudes toward water savings and city water policies. This section presents separate analysis of residential and commercial/industrial responses and addresses knowledge and perceptions of the water shortage, attitudes toward mandatory and voluntary water savings, opinions about how the city has handled the water shortage, and long-term water supply preferences.

Residential Customers

As discussed earlier, one obstacle to increased voluntary household water savings is lack of knowledge about water use and how to measure it. For example, many residential customers do not know how much water they use each month, and few can accurately estimate the price of water. This conclusion is based on one survey question that asked participants to estimate residential water rates. Eight respondents completed the question, and few chose the option closest to the actual price of any water increment. Residents' perceptions about their own water use may be influenced by incomplete understanding of how to monitor it. In addition, residents' perceptions about city water shortage issues may be based on incomplete information.

Knowledge and Perceptions of the Water Shortage

Focus group participants consistently rank the water shortage among the most important city concerns. Many focus group participants maintained that a solution to the water shortage should be the city's highest priority. Table 8.40 lists responses to survey question 24, which assessed customers' interest in the water shortage and related issues.
Residential customers report paying close attention to news of the current water shortage. Water quality problems associated with the drop in reservoir levels have focused increased residential concern on the water issue.

Residents demonstrate reasonable perceptions of the causes and severity of the water shortage. When asked to identify what they perceive to be the primary cause of the water shortage, a majority of residents chose “high evaporation combined with lack of rainfall to the city’s reservoirs” (Table 8.41). Freshwater inflow requirements to bays and estuaries generate political interest and strong opinions in Corpus Christi. This may explain why many residents also identified freshwater releases as a primary cause of the shortage.

Survey questions also assessed residents’ perceptions of the severity of the water shortage. Survey question 37 asked respondents to estimate when the city would begin condition 3 water rationing. Eighty-one percent estimated that water rationing would begin one to three months from the date of the survey. In July 1996, the city anticipated entering condition 3 around November 1, 1996, approximately four months from when surveys were completed. Residents are aware of the severity of the water shortage.

Residents accurately estimated the ability of the present level of water supplies to sustain water demand. Survey question 38 asked residents to estimate the period of time that water supplies remaining in the reservoirs would sustain residents and businesses under current rates of water use and reservoir recharge. One half of respondents recorded an estimate. All but two of these estimates ranged between six and 18 months, not far from the city’s July 1996 estimate of 12 to 15 months.

Survey question 36 asked residents how long it had been since reservoirs were at 50 percent of total capacity. Seventy-seven percent of residential participants estimated that city reservoirs were at one half of total capacity sometime between July 1994 and July 1995. Total reservoir capacity reached 50 percent in August 1995. Residents underestimated the speed of past reservoir decline.

**Attitudes Toward Mandatory and Voluntary Water Savings**

Residents express positive attitudes toward mandatory and voluntary household water saving measures in conditions 1 and 2. Residents reported willingly implementing household water saving measures in conditions 1 and 2 as part of the citywide drought management effort. Both residential focus groups discussed potential negative impacts of Corpus Christi water quality and quantity problems on the economy and feared the water shortage might drive some industries and residents out of the city altogether. These concerns appeared to reinforce their willingness to implement water saving efforts under conditions 1 and 2. Residents expressed frustration with neighbors who might not be complying with condition 2 outdoor watering restrictions.

Most residents perceive current plans for household water rationing under condition 3 to be adequately restrictive, but not timely. Focus group moderators described city plans for residential water allocation under drought condition 3 and solicited participants’ opinions.
Most residents reported that condition 3 water rationing appeared to be adequately restrictive and that most households would be able to comply if they ceased landscape watering and practiced basic indoor water conservation. Some expressed concern that larger households would have more difficulty complying with established limits than smaller households. As Table 8.42 demonstrates, 56 percent of survey respondents felt household water rationing under condition 3 should be implemented either as planned or in a more restrictive manner than planned.

Residential participants' chief objection to condition 3 allocation was that it might not be timely. Focus group participants felt that, at the time of the survey, condition 3 trigger levels (11 percent of combined reservoir capacity) and start dates were not pro-active enough. Table 69 lists responses to survey Question 35, which gauged residential participants' attitudes toward the original policy. Sixty-five percent of respondents felt the city should implement household allocation sooner than provided for by the drought contingency plan.

Most residents perceive condition 3 household water rationing to be fair, provided it is adequately enforced. As Table 8.44 indicates, 50 percent of residential participants feel that condition 3 household water allocation will result in a fair distribution of water among city residents. Only 35 percent disagreed with the statement. Focus group participants report condition 3 household water allocation might be unfair if the city does not enforce prescribed penalties, including surcharges and removal from the system.

Residential perceptions about the fairness of condition 3 rationing are influenced by perceptions of business and industry efforts to reduce water use. Residents perceive that Corpus Christi business and industry should be required to conserve in at least equal measure to households. Residential participants report willingness to contribute proportionally to citywide saving efforts. In addition, some residents who incorrectly believed the city would not ration water to business and industry under condition 3, perceived that households were being asked to shoulder too much of the burden of saving water. As illustrated in Table 8.45, 84 percent of residential participants would object to residential water rationing under condition 3 without comparable limits on commercial/industrial water use.

Residents see a larger role for voluntary reductions in water use as opposed to mandatory restrictions on water use in long-term city water conservation plans. Residential participants feel that households should practice conservative water use beyond the water shortage. Residents stop short, however, of identifying mandatory drought management practices that should be kept in place on a permanent basis. Focus group participants agreed that the severity of the current water shortage has focused attention on the semi-arid climate in Corpus Christi and that they would continue to use drought-tolerant landscaping where feasible beyond the water shortage. They also agreed that households should continue to avoid indoor and outdoor water waste. Otherwise, most residential participants look forward to returning to "normal" water use when the water shortage passes.
City Management of the Water Shortage

Many residents are unfamiliar with the city’s four-stage drought contingency plan. Survey results listed in Table 8.46 indicate that while 58 percent of residential participants are familiar with the drought contingency plan, 42 percent are not. Moderators reviewed basic components of the plan’s four drought conditions at all residential focus group meetings. Focus group results may therefore reflect a better understanding of the plan than do survey results, which captured participants’ impressions prior to the first focus group sessions.

Residents are divided over the city’s ability to plan a solution to the current water shortage. Table 8.47 lists responses to survey question 22, which gauged residents’ confidence in the city’s ability to plan a solution to the current water shortage. The results of this question are complicated by the fact that many residential participants are not well informed about the drought contingency plan and long-term city water conservation planning.

In focus group discussions, residents expressed less confidence in the city’s ability to achieve long-term than short-term water savings. Most residential participants report that they initially assumed that the water shortage would end before mandatory restrictions or shortly thereafter, as occurred in the 1984-1985 shortage. As the water shortage intensified, residents expressed resentment that the city had not acquired a large enough long-term water supply to avert the current crisis. Residents seem generally unaware of city participation in the Trans-Texas Water Study and other long-term planning efforts.

Residents would like the city to provide information on long-term water conservation and water policy on an ongoing basis. Focus group discussions indicate that if household water conservation is to be part of a long-term strategy, the city should promote the benefits to residential customers on an ongoing basis. Participants expressed interest in receiving information about monitoring and reducing household water use, as well as information on reservoir levels, long-term water supply options and other city policies, relative water use of residential and commercial/industrial customers, and conservation efforts of major industries. They also suggested that information would be more accessible and useful if it were available through utility bill inserts and the public school system than if it were available only through local media.

Long-Term Water Supply Preferences

Residents report the need for more information to identify preferred long-term water supply alternatives. Table 8.48 lists survey respondents’ long-term water supply preferences. Desalination of seawater is the most common preference expressed by residential participants. However, results are complicated by the fact that residents are not well informed about long-term supply options. Focus group participants expressed a desire for information about feasibility, cost, and timelines of long-term water supply options. For example, in most focus group discussions, participants knowledgeable about the costs and by-products of desalination convinced others that it was not the best option. This is not reflected in survey results.
Residents prefer a strictly proportional distribution of costs for long-term water supply solutions among water customers. Focus group discussions indicate that residents are willing to bear a share of costs for long-term water supply solutions. Although residential customers do not want higher water costs to drive business and industry out of Corpus Christi, they expect commercial/industrial customers to pay for long-term solutions in proportion to their total city water use. Participants were not given a set of cost allocation scenarios from which to choose and did not discuss proportionality based on use of water produced by potential projects, willingness to pay, or any other factor.

Residents appear less willing to share the costs of long-term water supply solutions when responding to a specific cost scenario. In order to better assess residents’ willingness to share the costs of long-term water supply solutions, survey question 42 asked respondents to react to a series of hypothetical water rate increases to support the construction of one long-term supply alternative, the Lake Texana pipeline. As Table 8.49 demonstrates, residents may be substantially less willing to pay for a long-term water supply than focus group discussions indicate. The five options represent 0 percent, 25 percent, 50 percent, 100 percent, and 150 percent increases in residential water rates. Seventy-seven percent of respondents would support construction of the pipeline with no increase in water rates. Less than one half of respondents would support a 25 percent water rate increase. Only 12 percent of residential survey respondents would support a 50 percent water rate increase to contribute to the costs of the pipeline.

It is unclear whether attitudes measured in question 42 are transferable to other long-term water supply options, or whether they are specific to the pipeline. For example, some respondents would not support the pipeline even if it could be constructed with no increase in water rates.

Commercial/Industrial Customers

Knowledge and Perceptions of the Water Shortage

Commercial/industrial participants demonstrated greater knowledge about the causes and severity of the water shortage than did residential participants. One possible reason is that some of these participants have incorporated the needs of water conservation and information about the reliability of water supplies into the corporate decision process.

Most commercial/industrial customers are well informed about the causes and severity of the water shortage. Table 8.50 lists responses to survey question 21, which asked respondents to identify what they perceived to be the primary cause of the water shortage. Most participants chose “high evaporation combined with lack of rainfall to the city’s reservoirs.” As among residential participants, respondents perceived freshwater releases to bays and estuaries to be another primary cause of the drought.

Commercial/industrial customers accurately estimated the ability of the present level of water supplies to sustain water demand. One survey question asked respondents to estimate the period of time that current reservoir supply would last at current rates of use.
and recharge. Seventy-one percent of participants answered the question. The average answer was 17 months, compared to the city estimate at the time of 12 to 15 months. Only seven respondents recorded answers that did not fall between 12 and 24 months.

Participants also accurately estimated the speed of past reservoir decline. When asked to estimate the period of time since reservoir levels were at 50 percent of total capacity, 93 percent of survey respondents answered the question. Of those, 84 percent recorded an estimate within six months of the approximate answer of one year.

**Attitudes toward Mandatory and Voluntary Water Conservation**

Commercial/industrial attitudes toward mandatory and voluntary water conservation are shaped by firm-level economic effects of conservation measures. Most focus group participants expressed support for citywide conservation and understood the need for commercial/industrial water conservation. However, individual attitudes about specific mandatory and voluntary restrictions to achieve short-term water savings can be attributed to the relative costs and benefits to commercial/industrial customers. Most commercial/industrial participants did not object to mandatory condition 2 water restrictions because these apply to non-production related water uses. Similarly, major industries did not raise objections to city requests for voluntary 10 to 15 percent water use reduction because these organizations were able to make individually cost-effective conservation decisions in response to the request.

Attitudes about water rationing under condition 3 are mixed. Organizations that foresee cost-effective compliance with water rationing report fewer objections. Some commercial and industrial sectors that anticipate a disproportionate condition 3 impact compared to other sectors have communicated their concerns through city committees.

Most commercial/industrial participants report that condition 3 and 4 mandatory water saving measures should be implemented as planned or in a manner less restrictive than planned. The city has changed its plans for water rationing in conditions 3 and 4 since the surveys were designed and completed, so rationing scenarios presented in some survey questions differ from current city plans. For example, the rationing scenario in survey question 27, described in Table 8.51, is somewhat different from current city plans. Nevertheless, it is useful to analyze answers to question 27 because these demonstrate a trend that appeared in focus group discussions. Commercial/industrial participants generally prefer that the city follow through with ordinances, public statements, and other prior communications. Many commercial and industrial organizations have already made decisions about production, employment, and capital investment based on early plans for conditions 3 and 4. Although most would not object to enactment of measures less restrictive than anticipated, commercial/industrial participants express a strong preference for consistency in city policy and communication.

Commercial/industrial customers see a role for voluntary conservation but not mandatory restrictions on how water is used in long-term city water conservation plans. While commercial/industrial participants generally support ongoing voluntary water conservation, they would not support maintenance of mandatory restrictions beyond the
end of this water shortage. Some representatives of larger industries suggested that prices rather than ordinances provide a better incentive to save water. If conservation is to become a permanent part of city water policy, water prices could be a more effective tool than other forms of regulation. Commercial/industrial participants suggested that voluntary conservation can be encouraged in other ways, as well. For example, representatives of the landscaping industry suggested that the city start a certification program for water-wise landscaping. Other participants suggested that the city distribute retrofit kits along with recycling bins for new homeowners.

**Attitudes toward City Management of the Water Shortage**

Most commercial/industrial customers are familiar with the city’s drought contingency plan. Table 8.52 lists responses to a survey question that gauged commercial/industrial familiarity with the drought contingency plan. Most focus group participants were knowledgeable about the four drought conditions and reported preparing in advance for anticipated mandatory water restrictions.

Commercial/industrial participants express confidence in the city’s ability to plan a solution to the current water shortage. As Table 8.53 illustrates, 64 percent of commercial/industrial participants agree or strongly agree that the city is capable of planning a solution to the current water shortage.

Commercial/industrial participants identify consistent policy and enforcement as important elements of the city’s drought management program. Focus group discussions indicate that commercial/industrial participants expect consistency in two aspects of city drought responses: policy and enforcement. Policies, especially mandatory water restrictions, should be consistent with city ordinances, findings of committees established to provide public input, and expectations expressed to commercial/industrial organizations by city staff. For example, many commercial/industrial participants, especially larger industries, have reported problems in implementing their plans to save water that seem to result from the fluctuation of city policies. Early clarification of condition 3 water rationing levels and the baseline from which individual rations will be calculated could have been beneficial in this regard.

In addition, many commercial/industrial participants perceive that any failure to enforce condition 2 lawn-watering restrictions might send a mixed message to commercial/industrial organizations anticipating restrictions in condition 3.

Participants report a need to improve the two-way flow of information between the city and commercial/industrial interests. Commercial/industrial participants are generally satisfied with the role of city committees as channels for the flow of information about the water shortage and city policies. Some participants maintain that their satisfaction with city management of the water shortage will be directly related to the city’s incorporation of committee findings and suggestions into drought management policy, especially condition 3 restrictions. They will be satisfied with city management of condition 3, for example, if Council implements Water Conservation Advisory Committee suggestions about commercial/industrial water rationing. Regarding the flow
of information from the city to commercial/industrial interests, participants expressed a desire for the city to speak with one voice, especially about mandatory restrictions.

Participants suggest that city water conservation policies should incorporate incentives to save water in advance of mandatory restrictions. Commercial/industrial participants report that condition 3 restrictions should reward organizations that have successfully implemented measures to reduce water use. For example, recent water savings from voluntary water saving efforts could count toward customer-level compliance with condition 3 water rationing. Firms could receive credit for reducing water use as much as months or years in advance of mandatory water restrictions. Commercial/industrial participants that report reducing water consumption on an ongoing basis express concern that drought management policy is not structured to reward this effort. Implementation of an allocation plan that does not reward this kind of proactive water conservation could provide a disincentive for water conservation in the future.

**Long-Term Water Supply Preferences**

Commercial/industrial participants report that preferences regarding long-term water supply options are based chiefly on the cost of water produced. Table 8.54 lists responses to survey question 22, which gauged the long-term water supply preferences of commercial/industrial participants. Many respondents marked more than one choice, and focus group discussions reinforced participants’ reluctance to support one long-term option over all others. Most participants maintained that, given enough information on the costs of each option, they would choose the option that produced additional water supplies at the lowest cost per thousand gallons. Larger industries report a strong preference for the cost-effectiveness of the Lake Texana pipeline in focus group discussions. Most participants perceive that the city will need to investigate a number of the options listed in Table 8.54 in order to provide for current and future commercial/industrial water needs.

Most commercial/industrial participants would prefer that the cost of long-term water supply options be distributed in proportion to total water use. Focus group discussions indicate that commercial/industrial organizations prefer the costs of long-term water supplies to be distributed proportionally among all water users. Some participants suggested that new connections should be charged at higher rates than existing connections, perhaps in the form of higher connection fees. Commercial/industrial focus group participants did not choose from a given set of cost allocation scenarios and did not discuss proportionality based on use of water produced by potential projects, willingness to pay, or any other factor.
Table 8.1
Focus Group Composition and Meeting Dates

<table>
<thead>
<tr>
<th>Focus Group</th>
<th>Meeting Dates</th>
<th>Number of Participants</th>
<th>Number of Organizations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential customers</td>
<td>July 17, August 14</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Residential customers</td>
<td>July 18, August 14</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Landscape/nursery</td>
<td>July 24, August 21</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Tourism/hotel</td>
<td>July 25, August 22</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Government/schools</td>
<td>July 31, August 28</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Manufacturing/other commercial</td>
<td>August 1, August 29</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Petrochemical/ship channel</td>
<td>August 7, September 4</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Military</td>
<td>August 8, September 5</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Local government</td>
<td>July 25</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>State government</td>
<td>August 12</td>
<td>7</td>
<td>5</td>
</tr>
</tbody>
</table>

Note: For residential groups, “organizations” are neighborhood associations.

Table 8.2
Main Issues Addressed by Residential and Commercial/industrial Focus Groups

Residential Focus Groups
- Effects of voluntary and involuntary drought responses on patterns of household water use
- Marginal uses of water and preferred drought management alternatives
- Perceptions of the drought and necessity of drought management
- Attitudes toward city drought management policies and policy options

Commercial/Industrial Focus Groups
- Effects of voluntary and involuntary drought responses on patterns of production and non-production water use
- Economic indicators of the impact of the water shortage and restrictions on businesses and industries
- Substitution and production effects of the water shortage
- Attitudes toward city drought management policies and policy options
Table 8.3  
Commercial/Industrial Survey Responses: Question 1

Question: Below is a list of production related water conservation efforts. Please identify those efforts that your organization has implemented SINCE April 1996 or in response to warnings of water shortage by placing check marks in the appropriate spaces. (The city of Corpus Christi declared drought condition 1 on April 9.)

<table>
<thead>
<tr>
<th>Drought Management Measure</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased systematic leak inspection</td>
<td>54</td>
</tr>
<tr>
<td>Altered process without capital investment</td>
<td>49</td>
</tr>
<tr>
<td>Started or expanded water re-capture and reuse</td>
<td>44</td>
</tr>
<tr>
<td>Established stricter time limits on water in production process</td>
<td>44</td>
</tr>
<tr>
<td>Established stricter volume limits on water in production process</td>
<td>39</td>
</tr>
<tr>
<td>Purchased/installed new water saving equipment</td>
<td>24</td>
</tr>
<tr>
<td>Increased use of labor</td>
<td>20</td>
</tr>
<tr>
<td>Decreased production</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>17</td>
</tr>
<tr>
<td>Started or increased use of lower quality water</td>
<td>12</td>
</tr>
<tr>
<td>None of the above</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.4  
Commercial/Industrial Survey Responses: Question 2

Question: Please identify those non-production related water conservation efforts listed below that your organization has adopted to save water SINCE April 9, 1996 or in response to warnings of water shortage. Please check all that apply.

<table>
<thead>
<tr>
<th>Drought Management Measure</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceased or reduced washing of buildings, sidewalks, and other structures</td>
<td>68</td>
</tr>
<tr>
<td>Ceased or reduced landscape watering to a level lower than city restrictions require</td>
<td>66</td>
</tr>
<tr>
<td>Formally encouraged employees to conserve water at all times</td>
<td>63</td>
</tr>
<tr>
<td>Reduced or ceased washing of company vehicles</td>
<td>51</td>
</tr>
<tr>
<td>Replaced existing faucets with water saving faucets in rest rooms/kitchens</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets</td>
<td>12</td>
</tr>
<tr>
<td>Reduced janitorial water use</td>
<td>5</td>
</tr>
<tr>
<td>Replaced existing toilets with water saving toilets</td>
<td>5</td>
</tr>
<tr>
<td>None of the above</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 8.5
Commercial/Industrial Survey Responses: Question 12

Question: How does your organization’s water use this July compare to its water use last July?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>We are using less water this July than last July</td>
<td>61</td>
</tr>
<tr>
<td>We are using about the same amount of water this July as last July</td>
<td>20</td>
</tr>
<tr>
<td>We are using more water this July than last July</td>
<td>10</td>
</tr>
<tr>
<td>Don’t know</td>
<td>7</td>
</tr>
<tr>
<td>Business was not located in Corpus Christi last July</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 8.6
Commercial/Industrial Survey Responses: Question 31

Question: Suppose your business is located in the city of San Diego, California. The city of San Diego declares a drought emergency and requires all organizations to cut their water use by at least 25% to avoid paying a substantial fine. Assume that your organization cannot afford to pay the fine. What is the first measure you would recommend that your organization take to comply with the city’s demand?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce production related water use</td>
<td>41</td>
</tr>
<tr>
<td>Reduce outdoor nonproduction related water use</td>
<td>17</td>
</tr>
<tr>
<td>Develop new water source</td>
<td>5</td>
</tr>
<tr>
<td>Reduce indoor non-production related water use</td>
<td>2</td>
</tr>
<tr>
<td>Increase water conservation education efforts</td>
<td>2</td>
</tr>
<tr>
<td>Did not respond</td>
<td>32</td>
</tr>
</tbody>
</table>

Note: Percentages may not add to 100 percent due to rounding.
Table 8.7
Most Common Obstacles to Commercial/Industrial Water Savings

Question: If you are not taking as many steps to save water as you would like in your business, what is preventing you from doing so?

- High cost of additional water saving measures
- Uncertainty about city water restriction percentage, baseline for reduction
- Lack of information about conservation methods
- Inability to influence customers' water use
- Health and/or safety risk
- Conflicts with federal, state, and local regulatory requirements
- Public objection/resistance
- Low water quality

Table 8.8
Focus Group and Survey Results, Sector-Specific Economic Impact Indicators

Focus Group Question: If you were going to try to put a dollar figure on the impact of the current water shortage and restrictions on your business, where would you look first? What indicators might first register the economic impact of this shortage on your business?

Survey Question #13: What would you consider to be the three best measures of the economic impact of restricted water use on your business?

<table>
<thead>
<tr>
<th>Commercial/industrial sector</th>
<th>Suggested Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape/Nursery</td>
<td>Total Revenue</td>
</tr>
<tr>
<td></td>
<td>Number of Employees (FTE)</td>
</tr>
<tr>
<td>Hotel/Tourism</td>
<td>Hotel Occupancy</td>
</tr>
<tr>
<td></td>
<td>Average Room Rates ($)</td>
</tr>
<tr>
<td>Government/Schools</td>
<td>Total Revenue</td>
</tr>
<tr>
<td>Manufacturing/Other Commercial Users</td>
<td>Total Revenue</td>
</tr>
<tr>
<td></td>
<td>Number of Employees (FTE)</td>
</tr>
<tr>
<td></td>
<td>Long-term Maintenance Costs</td>
</tr>
<tr>
<td></td>
<td>Capital Expenditures</td>
</tr>
<tr>
<td>Petrochemical/Ship Channel</td>
<td>Total Production</td>
</tr>
<tr>
<td></td>
<td>Total Revenue</td>
</tr>
<tr>
<td>Military</td>
<td>Capital Expenditures</td>
</tr>
<tr>
<td></td>
<td>Number of Employees (FTE)</td>
</tr>
</tbody>
</table>

Note: Measures of economic impact in the government/schools sector are difficult to identify. Some participating government/school organizations expect to see an impact on total revenue, but this should not be interpreted as a common measure of the water shortage's economic impact in this sector.
Table 8.9
Possible Local and Regional Economic Indicators

- Industrial tax revenue
- Sales tax revenue
- Platting acreage or fees
- Zoning acreage or fees
- New connections to utilities
- New home starts
- Assessed valuation

Table 8.10
Commercial/Industrial Survey Responses: Question 25

Question: Please describe and estimate the fixed cost of any one-time purchases or repairs your organization has made to comply with the current request for voluntary reduction in water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Described and estimated fixed costs</td>
<td>22</td>
</tr>
<tr>
<td>Described but was unable to estimate fixed costs</td>
<td>5</td>
</tr>
<tr>
<td>Believes there are fixed costs but was unable to describe or estimate them</td>
<td>22</td>
</tr>
<tr>
<td>Believes there are no fixed costs</td>
<td>39</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Did not respond</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 8.11
Commercial/Industrial Survey Responses: Question 26

Question: Please describe and estimate any regular (daily, weekly, monthly) costs, or variable costs, to your organization that can be directly attributed to the current request for voluntary reduction in water use. Do not include any fines for violation of city ordinances related to water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Described and estimated variable costs</td>
<td>20</td>
</tr>
<tr>
<td>Described but was unable to estimate variable costs</td>
<td>20</td>
</tr>
<tr>
<td>Believes there are variable costs but was unable to describe or estimate them</td>
<td>20</td>
</tr>
<tr>
<td>Believes there are no variable costs</td>
<td>29</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: Percentages may not add to 100 percent due to rounding.
Table 8.12
Commercial/Industrial Survey Responses: Questions 28-29

Question 28: Assume that the city allocates water to your business as described in the drought contingency plan. Please describe any effects you may anticipate in terms of a change in sales revenue.

Question 29: Assume that the city allocates water to your business as described in the drought contingency plan. Please describe any effects you may anticipate in terms of a change in employment.

<table>
<thead>
<tr>
<th>Commercial/Industrial Sector</th>
<th>Percent of Participants Responding</th>
<th>Average Anticipated Change in Sales Revenue</th>
<th>Percent of Participants Responding</th>
<th>Average Anticipated Change in Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape/Nursery</td>
<td>56</td>
<td>-66</td>
<td>56</td>
<td>-57</td>
</tr>
<tr>
<td>Hotel/Tourism</td>
<td>100</td>
<td>-18</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Government/Schools</td>
<td>0</td>
<td>n/a</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Other</td>
<td>60</td>
<td>-20</td>
<td>33</td>
<td>-25</td>
</tr>
<tr>
<td>Commercial/Manufacturing</td>
<td>45</td>
<td>-22</td>
<td>27</td>
<td>-13</td>
</tr>
<tr>
<td>Petrochemical/Ship Channel</td>
<td>100</td>
<td>-15</td>
<td>50</td>
<td>-25</td>
</tr>
</tbody>
</table>

Table 8.13
Anticipated Economic Impact of Water Rationing, Board of Trade Members

<table>
<thead>
<tr>
<th>Economic Indicator</th>
<th>Effect of 15% Reduction ($ million)</th>
<th>Effect of 24% Reduction ($ million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating costs</td>
<td>1.85</td>
<td>8.46</td>
</tr>
<tr>
<td>Capital project costs</td>
<td>2.09</td>
<td>11.20</td>
</tr>
<tr>
<td>Throughput reduction costs (lost profit)</td>
<td>6.50</td>
<td>142.40</td>
</tr>
</tbody>
</table>

Note: Operating costs are yearly costs at 15 and 25 percent reductions in water use.

Source: Board of Trade Technical Committee, Presentation to Water Conservation Advisory Committee, Corpus Christi, Texas, August 21, 1996.
Table 8.14  
Commercial/Industrial Survey Responses: Question 18

Question: Please indicate whether you agree or disagree with the following statement: Over the long-term, the risk of drought is not high enough to justify the cost of investments in equipment and/or practices to reduce water use in our organization.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>17</td>
</tr>
<tr>
<td>Disagree</td>
<td>51</td>
</tr>
<tr>
<td>Agree</td>
<td>20</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>5</td>
</tr>
<tr>
<td>Did not respond</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 8.15  
Commercial/Industrial Survey Responses: Question 16

Question: Has the risk of water shortage been a factor in your company’s decisions to expand operations in areas supplied with water from Corpus Christi’s reservoirs?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>24</td>
</tr>
<tr>
<td>No</td>
<td>59</td>
</tr>
<tr>
<td>Don’t know</td>
<td>12</td>
</tr>
<tr>
<td>Did not respond</td>
<td>7</td>
</tr>
</tbody>
</table>

133
Table 8.16
Commercial/Industrial Survey Responses: Questions 33-37

Question: Please indicate whether you agree or disagree with the following statements.

33. The availability of water influences the decisions of new businesses to locate in Corpus Christi.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>39</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>46</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

34. The reliability of the Corpus Christi water supply could prevent the expansion of existing city businesses.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>41</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>44</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

35. Employment in Corpus Christi will be affected by the drought restrictions.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
</tr>
<tr>
<td>Agree</td>
<td>41</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>37</td>
</tr>
<tr>
<td>Don’t know</td>
<td>5</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

36. The water shortage could contribute to a decrease in tourism this season.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>34</td>
</tr>
<tr>
<td>Agree</td>
<td>32</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>17</td>
</tr>
<tr>
<td>Don’t know</td>
<td>2</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>
37. The value of land and homes in Corpus Christi could erode if more reliable water supplies cannot be acquired.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>2</td>
</tr>
<tr>
<td>Disagree</td>
<td>5</td>
</tr>
<tr>
<td>Agree</td>
<td>51</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>27</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

Table 8.17
Topics Addressed in Board of Trade Interviews

- Voluntary water saving measures implemented in response to current water shortage
- Total fixed and monthly costs of organization’s response to current water shortage
- Water conservation investments made since last water shortage (1984-1985)
- Conservation measures planned in anticipation of drought condition 3 water restrictions
- Anticipated costs of compliance with potential water restrictions
- Role of potential noncompliance surcharges in economic water conservation decisions
- Effects of long-term risk of water shortage on ability to compete with other firms and other facilities within same firm

Table 8.18
Company A: Water Saving Measures Started or Implemented April-August 1996

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented discretionary reduction</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Recycled RO reject to cooling towers</td>
<td>$50,000</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Recycled cooling tower blowdown to firewater</td>
<td>$65,000</td>
<td>0</td>
<td>150</td>
</tr>
<tr>
<td>Other</td>
<td>$35,000</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Total</td>
<td>$150,000</td>
<td>0</td>
<td>450</td>
</tr>
</tbody>
</table>
# Table 8.19
## Company A: Water Saving Measures Implemented Since 1984-1985

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed RO for boiler feedwater treatment</td>
<td>$4,000,000</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$4,000,000</strong></td>
<td><strong>n/a</strong></td>
</tr>
</tbody>
</table>

# Table 8.20
## Company B: Water Saving Measures Started or Implemented April-August 1996

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycled up desalter water</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Increased water recycling</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Completed detailed water balance</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Revamped condensate return</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>n/a</strong></td>
<td><strong>n/a</strong></td>
<td><strong>n/a</strong></td>
</tr>
</tbody>
</table>

# Table 8.21
## Company B: Water Saving Measures Implemented Since 1994-1995

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased cycles in cooling towers</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Replaced water cooling with air cooling where possible</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Added new RO and softener for boiler feedwater</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Upgraded wastewater treatment plant</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>n/a</strong></td>
<td><strong>n/a</strong></td>
</tr>
</tbody>
</table>
### Table 8.22
**Company C: Water Saving Measures Started or Implemented April-August 1996**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled cooling tower blowdown to firewater</td>
<td>$100,000</td>
<td>n/a</td>
<td>50</td>
</tr>
<tr>
<td>Leased EDR unit for cooling tower blowdown</td>
<td>$60,000</td>
<td>$27,000</td>
<td>150</td>
</tr>
<tr>
<td>Recycled scrubber water</td>
<td>$50,000</td>
<td>n/a</td>
<td>100</td>
</tr>
<tr>
<td>Installed RO unit for demineralizer return</td>
<td>$3,000,000</td>
<td>$75,000</td>
<td>325</td>
</tr>
<tr>
<td>Re-routed wash water within refinery</td>
<td>$75,000</td>
<td>n/a</td>
<td>75</td>
</tr>
<tr>
<td>Other</td>
<td>$50,000</td>
<td>n/a</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td>$3,335,000</td>
<td>$102,000</td>
<td>750</td>
</tr>
</tbody>
</table>

### Table 8.23
**Company C: Water Saving Measures Implemented Since 1984-1985**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled stripped sour water</td>
<td>n/a</td>
<td>450</td>
</tr>
<tr>
<td>Maximized condensate recovery</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Recycled blowdown to cooling tower makeup</td>
<td>n/a</td>
<td>100</td>
</tr>
<tr>
<td>Re-used oily condensate as desalter wash water</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Optimized demineralizer trains</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Installed air coolers where economically practical</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Installed new scrubber</td>
<td>n/a</td>
<td>32</td>
</tr>
<tr>
<td>Total</td>
<td>n/a</td>
<td>582</td>
</tr>
</tbody>
</table>

### Table 8.24
**Company D: Water Saving Measures Started or Implemented April-August 1996**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recycled treated wastewater to cooling towers</td>
<td>0</td>
<td>0</td>
<td>300</td>
</tr>
<tr>
<td>Installed RO unit for demineralizer</td>
<td>$800,000</td>
<td>$30,000</td>
<td>200</td>
</tr>
<tr>
<td>Installed RO unit for cooling tower blowdown</td>
<td>$300,000</td>
<td>$70,000</td>
<td>325</td>
</tr>
<tr>
<td>Accelerated schedule for plant turnaround</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Total</td>
<td>$1,100,000</td>
<td>$100,000</td>
<td>825</td>
</tr>
</tbody>
</table>
### Table 8.25
Company D: Water Saving Measures Implemented Since 1984-1985

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced caustic soda usage for acid gas scrubbing</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Reduced water use in decoking process</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Implemented condensate recovery projects</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Table 8.26
Company E: Water Saving Measures Started or Implemented April-August 1996

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycled up five cooling towers</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Recycled effluent to firewater</td>
<td>$252,600</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Re-used tank testing waters</td>
<td>0</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Check water, steam, condensate leaks weekly</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>$252,600</td>
<td>$102,000</td>
<td>n/a</td>
</tr>
</tbody>
</table>

### Table 8.27
Company E: Water Saving Measures Implemented Since 1984-1985

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implemented condensate recovery projects</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>
Table 8.28
Company F: Water Saving Measures Started or Implemented April-August 1996

<table>
<thead>
<tr>
<th>Measure</th>
<th>Fixed Cost</th>
<th>Monthly Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased cycles on cooling towers</td>
<td>0</td>
<td>$400</td>
<td>71</td>
</tr>
<tr>
<td>Recycled cooling tower blowdown</td>
<td>0</td>
<td>0</td>
<td>n/a</td>
</tr>
<tr>
<td>Installed new controls on demineralizer</td>
<td>$70,000</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Began lubricating pumps with seawater</td>
<td>$8,500</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$78,500</strong></td>
<td><strong>$400</strong></td>
<td><strong>192</strong></td>
</tr>
</tbody>
</table>

Table 8.29
Company F: Water Saving Measures Implemented Since 1984-1985

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cost</th>
<th>Estimated Water Savings (gpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed equipment to recycle cooling tower blowdown</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Added control valves to cooling tower blowdown</td>
<td>$20,000</td>
<td>n/a</td>
</tr>
<tr>
<td>Added two RO units on boiler makeup</td>
<td>$200,000</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$220,000</strong></td>
<td>5</td>
</tr>
</tbody>
</table>

Table 8.30
Residential Water Allocation Plan, Drought Condition 3

<table>
<thead>
<tr>
<th>Number of Residents in Household</th>
<th>Maximum Monthly Water Allowance (gallons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>6,000</td>
</tr>
<tr>
<td>3-4</td>
<td>7,000</td>
</tr>
<tr>
<td>5-6</td>
<td>8,000</td>
</tr>
<tr>
<td>7-8</td>
<td>9,000</td>
</tr>
<tr>
<td>9-10</td>
<td>10,000</td>
</tr>
<tr>
<td>11 or more</td>
<td>12,000</td>
</tr>
</tbody>
</table>
### Table 8.31
Residential Survey Responses: Question 31

Question: Please indicate whether you agree or disagree with the following statement: My household can easily manage with the water allowance prescribed for drought condition 3 under the drought management plan.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>31</td>
</tr>
<tr>
<td>Agree</td>
<td>50</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>4</td>
</tr>
<tr>
<td>Don’t know</td>
<td>12</td>
</tr>
<tr>
<td>Did not respond</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.

### Table 8.32
Residential Survey Responses: Question 32

Question: Please indicate whether you agree or disagree with the following statement: I anticipate that monthly expenses in my household will increase if the city decides to limit household water use as planned under drought condition 3.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>8</td>
</tr>
<tr>
<td>Disagree</td>
<td>35</td>
</tr>
<tr>
<td>Agree</td>
<td>42</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>4</td>
</tr>
<tr>
<td>Don’t know</td>
<td>12</td>
</tr>
<tr>
<td>Did not respond</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
Table 8.33
Residential Surcharge Plan, Drought Condition 3

<table>
<thead>
<tr>
<th>Gallons over monthly water allocation</th>
<th>Surcharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 1,000</td>
<td>$3.00</td>
</tr>
<tr>
<td>Second 1,000</td>
<td>$5.00</td>
</tr>
<tr>
<td>Third 1,000</td>
<td>$10.00</td>
</tr>
<tr>
<td>Each additional 1,000</td>
<td>$25.00</td>
</tr>
</tbody>
</table>

Table 8.34
Residential Survey Responses: Question 39

Question: Please indicate whether you agree or disagree with the following statement: The surcharge described above provides little or no incentive for most people to reduce water consumption by changing patterns of water use or replacing existing equipment with water saving equipment.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>42</td>
</tr>
<tr>
<td>Agree</td>
<td>31</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>15</td>
</tr>
<tr>
<td>Don't know</td>
<td>8</td>
</tr>
<tr>
<td>Did not respond</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
Table 8.35  
Residential Survey Responses: Question 1

Question: Please identify those water conservation efforts listed below that your household has adopted to save water SINCE April 9, 1996 or in response to warnings of water shortage. (The city of Corpus Christi declared drought condition 1 on April 9 and instituted mandatory water conservation efforts on May 6, 1996.) Please check all that apply.

<table>
<thead>
<tr>
<th>Drought Management Measure</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceased or reduced lawn watering to a level lower than city restrictions require</td>
<td>65</td>
</tr>
<tr>
<td>Repaired leaky faucets</td>
<td>62</td>
</tr>
<tr>
<td>Reduced/ceased use of dishwasher</td>
<td>62</td>
</tr>
<tr>
<td>Avoid flushing toilet as much as possible</td>
<td>54</td>
</tr>
<tr>
<td>Reduced use of washing machine</td>
<td>50</td>
</tr>
<tr>
<td>Reduced/ceased use of garbage disposal</td>
<td>50</td>
</tr>
<tr>
<td>Replaced existing shower head with water saving shower head</td>
<td>42</td>
</tr>
<tr>
<td>Adopted strict limits on showering time</td>
<td>38</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets</td>
<td>31</td>
</tr>
<tr>
<td>Began a household water reuse program</td>
<td>31</td>
</tr>
<tr>
<td>Replaced existing faucets with water saving faucets in kitchen/bathroom sinks</td>
<td>19</td>
</tr>
<tr>
<td>Ceased indoor and outdoor plant watering (other than lawns)</td>
<td>15</td>
</tr>
<tr>
<td>Other</td>
<td>15</td>
</tr>
<tr>
<td>Replaced existing toilet with water saving toilet</td>
<td>8</td>
</tr>
<tr>
<td>None of the above</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 8.36  
Residential Survey Responses: Question 16

Question: How does your water use this July compare to your water use last July?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>We are using less water this July than last July</td>
<td>62</td>
</tr>
<tr>
<td>We are using about the same amount of water this July as last July</td>
<td>15</td>
</tr>
<tr>
<td>We are using more water this July than last July</td>
<td>8</td>
</tr>
<tr>
<td>Don't know</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
**Table 8.37**  
Residential Survey Responses: Question 27

Question: Which is closest to your view? Current restrictions on water use under drought condition 2:

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are both an inconvenience and a cost</td>
<td>19</td>
</tr>
<tr>
<td>Are more of an inconvenience than a cost</td>
<td>35</td>
</tr>
<tr>
<td>Are more of a cost than an inconvenience</td>
<td>4</td>
</tr>
<tr>
<td>Are neither an inconvenience nor a cost</td>
<td>35</td>
</tr>
<tr>
<td>Did not respond</td>
<td>8</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.

**Table 8.38**  
Hierarchy of Residential Water Saving Preferences

1. Car washing
2. Lawn watering
3. Outdoor plant watering
4. Tree watering
5. Laundry water use
6. Bathroom water use
7. Kitchen water use
8. Foundation watering
Table 8.39
Residential Survey Responses: Question 40

Question: Pretend for a moment that you live in San Diego, California, and that the city of San Diego has rationed water use in each household and adopted a mandatory $1,000 fine for the first violation and for each violation thereafter. In column B, indicate which four of the practices listed below you would implement first to live within your water ration. Mark exactly four. None of the items below are required by the drought management plan. Do not mark in column B any of the measures that your household has already implemented.

<table>
<thead>
<tr>
<th>Drought Management Measure</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cease lawn watering</td>
<td>46</td>
</tr>
<tr>
<td>Reduce/cease use of dishwasher</td>
<td>38</td>
</tr>
<tr>
<td>Adopt strict limits on showering time</td>
<td>35</td>
</tr>
<tr>
<td>Begin a household water reuse program</td>
<td>35</td>
</tr>
<tr>
<td>Reduce use of washing machine</td>
<td>27</td>
</tr>
<tr>
<td>Repair leaky faucets</td>
<td>27</td>
</tr>
<tr>
<td>Reduce/cease use of garbage disposal</td>
<td>23</td>
</tr>
<tr>
<td>Replace existing toilet with water saving toilet</td>
<td>19</td>
</tr>
<tr>
<td>Avoid flushing toilet as much as possible</td>
<td>19</td>
</tr>
<tr>
<td>Cease indoor and outdoor plant watering (other than lawns)</td>
<td>19</td>
</tr>
<tr>
<td>Reduce the level of water in existing toilets</td>
<td>15</td>
</tr>
<tr>
<td>Replace existing faucets with water saving faucets in kitchen/bathroom sinks</td>
<td>12</td>
</tr>
<tr>
<td>Replace existing shower head with water saving shower head</td>
<td>8</td>
</tr>
<tr>
<td>None of the above</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>15</td>
</tr>
<tr>
<td>Marked less than four options</td>
<td>8</td>
</tr>
</tbody>
</table>

Table 8.40
Residential Survey Responses: Question 24

Question: Please indicate whether you agree or disagree with the following statement: I read all the information I can find about current events surrounding the city’s water management program and the current water shortage.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>27</td>
</tr>
<tr>
<td>Agree</td>
<td>62</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>12</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
Table 8.41  
Residential Survey Responses: Question 25  

Question: The present water shortage is PRIMARILY a result of (please choose one):  

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>High evaporation combined with lack of rainfall to the city's reservoirs</td>
<td>57</td>
</tr>
<tr>
<td>Overuse of city water by residential customers</td>
<td>3</td>
</tr>
<tr>
<td>Overuse of city water by industrial customers</td>
<td>6</td>
</tr>
<tr>
<td>Inadequate management of the city's reservoirs</td>
<td>9</td>
</tr>
<tr>
<td>Freshwater inflow requirements to bays and estuaries</td>
<td>17</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Percentages may not add to 100 percent due to rounding. Percent of responses is listed rather than percent of respondents because six respondents marked more than one answer.

Table 8.42  
Residential Survey Responses: Question 30  

Question: Water rationing will begin when the city of Corpus Christi moves from drought condition 2 to drought condition 3. The plan allows each household to use a limited amount of water each month. In the first stages of drought condition 3, households will pay a surcharge for water use that exceeds their water allowance. What is closest to your view of how the city should act? (A table of monthly household limits was provided in the survey.)  

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>The city should not implement a water rationing program under drought condition 3</td>
<td>11</td>
</tr>
<tr>
<td>The city should implement a water rationing program less restrictive than the current plan under drought condition 3</td>
<td>30</td>
</tr>
<tr>
<td>The city should implement the water rationing program as planned under drought condition 3</td>
<td>52</td>
</tr>
<tr>
<td>The city should implement a water rationing program more restrictive than the current plan under drought condition 3</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding. One respondent included in "did not respond" marked more than one choice.
Table 8.43
Residential Survey Responses: Question 35

Question: The current drought management plan requires the city to limit household water use as described in Question 30 when the combined volume of the reservoirs is 11 percent of total capacity. Please indicate which of the following policies most closely represents your view of how the city should act.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limit household use as soon as possible</td>
<td>38</td>
</tr>
<tr>
<td>Limit household water use when reservoirs are 20 percent of total capacity</td>
<td>27</td>
</tr>
<tr>
<td>Limit household water use when reservoirs are 11 percent of total capacity</td>
<td>31</td>
</tr>
<tr>
<td>Wait even longer to limit household water use</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.44
Residential Survey Responses: Question 33

Question: Please indicate whether you agree or disagree with the following statement: The system that will be used to ration water among residential customers in drought condition 3 (described in Question 30) results in a fair distribution of water among city residents.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>35</td>
</tr>
<tr>
<td>Agree</td>
<td>46</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>4</td>
</tr>
<tr>
<td>Don’t know</td>
<td>15</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 8.45
Residential Survey Responses: Question 34

Question: Please indicate whether you agree or disagree with the following statement: The city should limit water use among residential customers first before limiting water use among businesses and commercial interests.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>42</td>
</tr>
<tr>
<td>Disagree</td>
<td>42</td>
</tr>
<tr>
<td>Agree</td>
<td>12</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>4</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.46
Residential Survey Responses: Question 20

Question: Are you familiar with drought conditions 1-4 of the city’s drought management plan?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>58</td>
</tr>
<tr>
<td>No</td>
<td>42</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 8.47  
Residential Survey Responses: Question 22  

Question: Please indicate whether you agree or disagree with the following statement: The city is capable of planning a solution to the current water shortage.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>4</td>
</tr>
<tr>
<td>Disagree</td>
<td>38</td>
</tr>
<tr>
<td>Agree</td>
<td>38</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>19</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
Table 8.48
Residential Survey Responses: Question 26

Question: Which alternative do you consider to be the BEST method of producing increased water supplies to the city of Corpus Christi? (Please choose one.)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased water conservation by city residents</td>
<td>0</td>
</tr>
<tr>
<td>Increased water conservation by industry and businesses</td>
<td>0</td>
</tr>
<tr>
<td>Construction of pipeline to city from Lake Texana</td>
<td>19</td>
</tr>
<tr>
<td>Desalination of seawater</td>
<td>38</td>
</tr>
<tr>
<td>Exploration of local groundwater options</td>
<td>0</td>
</tr>
<tr>
<td>Modified operation of city reservoirs</td>
<td>0</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
</tr>
<tr>
<td>Don't know</td>
<td>8</td>
</tr>
<tr>
<td>Marked a combination of choices</td>
<td>23</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.49
Residential Survey Responses: Question 42

Question: Studies show that the present water shortage could have been avoided if the proposed pipeline from Lake Texana had been completed. It is likely that the proposed pipeline could be approved and built in 18 months. Based on what you know now, please answer each of the following questions.

Would you support construction of the pipeline with no increase in water rates?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>77</td>
</tr>
<tr>
<td>No</td>
<td>8</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

Would you support a price increase of 44 cents per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>46</td>
</tr>
<tr>
<td>No</td>
<td>23</td>
</tr>
<tr>
<td>Don't know</td>
<td>15</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>

Would you support a price increase of 87 cents per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>12</td>
</tr>
<tr>
<td>No</td>
<td>46</td>
</tr>
<tr>
<td>Don't know</td>
<td>27</td>
</tr>
<tr>
<td>Did not respond</td>
<td>15</td>
</tr>
</tbody>
</table>
Would you support a price increase of $1.74 per 1,000 gallons to pay for the pipeline?

**Answer**  
*Yes*  
*No*  
*Don’t know*  
*Did not respond*

**Percent of Respondents**  
*4*  
*65*  
*15*  
*15*

Would you support a price increase of $2.61 per 1,000 gallons to pay for the pipeline?

**Answer**  
*Yes*  
*No*  
*Don’t know*  
*Did not respond*

**Percent of Respondents**  
*4*  
*77*  
*4*  
*15*

---

**Table 8.50**  
**Commercial/Industrial Survey Responses: Question 21**

Question: The present water shortage is **PRIMARILY** a result of (please choose one):

**Answer**  
*High evaporation combined with lack of rainfall to the city’s reservoirs*  
*Overuse of city water by residential customers*  
*Overuse of city water by industrial customers*  
*Inadequate management of the city’s reservoirs*  
*Freshwater inflow requirements to bays and estuaries*  
*Other*  
*Don’t know*  
*Did not respond*

**Percent of Respondents**  
*54*  
*2*  
*3*  
*10*  
*24*  
*5*  
*0*  
*2*

Note: Percent of responses is listed rather than percent of respondents because 11 respondents marked more than one answer.
Table 8.51
Commercial/Industrial Survey Responses: Question 27

Question: If the city reaches drought condition 4, each commercial and industrial customer’s water use may be limited to a maximum monthly allowance. Each customer’s monthly water allocation could be 75 percent of average monthly water use over the previous 12 months. If the city allocates water, businesses will pay a surcharge for water use that exceeds that allowance. What is closest to your view?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>The city should not implement a water rationing program</td>
<td>2</td>
</tr>
<tr>
<td>The city should delay implementation of a water rationing program or implement a program less restrictive than the current plan</td>
<td>32</td>
</tr>
<tr>
<td>The city should implement the water rationing program as planned</td>
<td>49</td>
</tr>
<tr>
<td>The city should implement a water rationing program as soon as possible or implement a water rationing program more restrictive than the current plan</td>
<td>17</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.52
Commercial/Industrial Survey Responses: Question 10

Question: Are you familiar with drought conditions 1-4 of the city’s drought management plan?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>83</td>
</tr>
<tr>
<td>No</td>
<td>17</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>
### Table 8.53
**Commercial/Industrial Survey Responses: Question 20**

Question: Please indicate whether you agree or disagree with the following statement: The city is capable of planning a solution to the current water shortage.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>12</td>
</tr>
<tr>
<td>Disagree</td>
<td>15</td>
</tr>
<tr>
<td>Agree</td>
<td>54</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>10</td>
</tr>
<tr>
<td>Don’t know</td>
<td>7</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2</td>
</tr>
</tbody>
</table>

### Table 8.54
**Commercial/Industrial Survey Responses: Question 22**

<table>
<thead>
<tr>
<th>Answer</th>
<th>Percent of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased water conservation by city residents</td>
<td>0</td>
</tr>
<tr>
<td>Increased water conservation by industry and businesses</td>
<td>2</td>
</tr>
<tr>
<td>Construction of pipeline to city from Lake Texana</td>
<td>37</td>
</tr>
<tr>
<td>Desalination of seawater</td>
<td>24</td>
</tr>
<tr>
<td>Exploration of local groundwater options</td>
<td>7</td>
</tr>
<tr>
<td>Modified operation of city reservoirs</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>7</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
</tr>
<tr>
<td>Marked a combination of choices</td>
<td>20</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Percentages may not add up to 100 percent due to rounding.
Chapter 9. Topics for Further Study

The conclusions and recommendations presented in this report could be enhanced through further study. For example, the water demand forecasting method presented here could be adapted to better address issues related to policy alternatives. Incorporation of population, housing, and economic variables into the forecasting equation could improve the utility and interpretive power of the analysis. For example, the analysis could incorporate local area economic data such as taxable sales or gross revenue from the Texas State Comptroller of Public Accounts or employment data from the Texas Workforce Commission. Population and housing variables from the U.S. Census might also serve as new explanatory variables.

At a minimum, this water savings analysis should be continued for the duration this water shortage. This analysis evaluates water savings between May and November 1996 only. Aggregate billing data with which to extend the analysis are not yet available. Water savings may show up only gradually as water restrictions go in force and customers adopt new habits or implement new processes. Modifications to the drought management program or analysis of water savings later in the program may show additional water savings. A reformulation of the water demand forecast and the water savings analysis to reflect policy goals other than drought management may also show nonvolumetric drought management effects.

Verification of output effects associated with water rationing could improve the reliability and usefulness of economic impact estimates. This report estimates the income and employment effects of reduced production in Corpus Christi's petrochemical manufacturing industry. It remains to be seen, however, whether condition 3 water rationing will result in reduced production in the petrochemical industry, as forecast, or whether other industries in Corpus Christi experience output effects as a direct result of some form of water rationing. To document the output effects of water rationing, the city could establish a method to collect and aggregate information on firm-level or industry-level production. Verification of output effects could allow more reliable application of an input-output model with which to estimate employment or income effects.

Further study could also assist in assessing the economic cost of water restrictions over the long term. For example, if the city implements condition 3 water rationing, customers may become increasingly aware of the risks of water shortage in Corpus Christi. This may influence expansion decisions and other capital investments. The city could attempt to monitor the effects of condition 3 water rationing on commercial and industrial expansion. Data from Corpus Christi's planning department could assist in this effort. For example, information on the number and kinds of zoning decisions, and the number of applications to rezone for higher intensity use may be useful in this regard. To track changes in industrial expansion plans, the city could work in cooperation with the Greater
Corpus Christi Business Alliance to analyze business recruitment and retention survey results or to expand the scope of that program. The business recruitment and retention survey assesses some effects of water scarcity on some business investment decisions. Estimates of economic cost will be incomplete if these ignore the opportunity cost of foregone commercial and industrial investment. Coupled with reliable estimates of output effects, long-run cost information could provide the city with a better picture of how to efficiently manage drought risks, drought responses, and water supply decisions.

Water savings appeared slowly in 1996. Some study of differences between drought management program implementation during condition 2 in 1996 and during condition 2 in 1984 is warranted. Corpus Christi’s drought management program appears to have produced much different results in 1984 than in 1996. What causes lie behind these differences? Further study could identify differences in water restrictions and enforcement or differences in industrial, commercial, or residential water use behavior. For example, Shaw and Maidment (1988) report that condition 2 restrictions in 1984 allowed outdoor watering only once every 10 days. Under condition 2 in 1996, water customers were allowed to water outdoors once every week. Did this contribute to lower measurable water savings in 1996 than in 1984? One focus group participant suggested that water utility customers would not cooperate in 1996 as in 1984 because the city had responded to its success in the earlier period by raising water utility rates too high.

Differences in water savings between 1996 and 1984 might also be attributed to differences in the response of water customers to condition 2 restrictions and requests for voluntary water savings in 1996. For example, if many industrial efforts to reduce water use implemented in 1984-1985 have remained in place, industrial customers may have less slack to achieve water savings in 1996. The fact that many industrial customers report it is more cost-effective to lease capital equipment to achieve mandatory reductions in water use in response to condition 3 water rationing in 1996 may support this concept. Also of interest are the possible effects of increased environmental regulation that may require higher commercial and industrial water use. Examples include landscape ordinances and federal, state, and local air pollution regulations. New industrial facilities that install wet scrubbers for emissions control, for example, may require increased water use and experience more complications in water reuse.

Further study could also assess the persistence of water savings beyond the water rationing period. Some water savings associated with drought management may persist once rationing is no longer required. The city could consider measuring the persistence and volume of water savings, whether the persistence or volume of water savings differs among water user sectors, and the kinds of water saving measures customers report using beyond the drought management period. The city could use this information to formulate its response to water shortage in the future.
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Smith, Mark, 1996, personal communication, Director, Technical Issues Committee, Board of Trade, Corpus Christi, Texas.


The Consequences of Water Consumption Restrictions During the Corpus Christi Drought of 1996

Volume 2: Appendixes

by

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Sheila M. Cavanagh
Bisheng Gu
David J. Eaton

The University of Texas at Austin
2000
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Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project, in the course of which two or more faculty members from different disciplines direct the research of 10 to 30 graduate students of diverse backgrounds on a policy issue of concern to a government or nonprofit agency. This "client orientation" brings the students face to face with administrators, legislators, and other officials active in the policy process and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of political realities.

The Consequences of Water Consumption Restrictions During the Corpus Christi Drought of 1996 is the product of a year-long analysis of the city of Corpus Christi's drought management program, which was implemented in 1996 in response to a three-year drought that had dramatically altered in-stream flows and reservoir levels. The report presents a method for estimating the water savings and economic costs resulting from implementation of the drought management program. The approach combines an analysis of water savings and an economic impact assessment with focus group sessions, written surveys, and interviews with Corpus Christi water utility customers.

The curriculum of the LBJ School is intended not only to develop effective public servants but also to produce research that will enlighten and inform those already engaged in the policy process. The project that resulted in this report has helped to accomplish the first task; it is our hope that the report itself will contribute to the second. Finally, it should be noted that neither the LBJ School nor The University of Texas at Austin necessarily endorses the views or findings of this report.
Acknowledgments

The Lyndon B. Johnson School of Public Affairs wishes to thank the many individuals who assisted in various ways with a number of aspects of this project. The Texas Water Development Board and the city of Corpus Christi provided the funding to support this project. The project team wishes to thank James Dodson, Susan Cable, Ed Garana, and Hubert Hall of the city of Corpus Christi for their varied and helpful assistance. Susan Cable worked closely with the project team to implement focus group sessions and identify those issues which were most important to the city's design and implementation of its water management program. Ed Garana and Hubert Hall discussed the water supply system and provided the water supply records needed for forecasting and water savings analysis. The project team also wishes to thank Joe Rios and Omar Mendoza of Corpus Christi's Municipal Information Systems Department for their cooperation and assistance in developing the municipal utility database. Kay Hoover of the city of Corpus Christi assisted by contacting potential focus group participants. John Sutton and Bill Hoffman of the Texas Water Development Board provided useful guidance and assistance at several points during this project. Chandler Stolp of the LBJ School advised on development of the forecasting models.

Several individuals assisted with the economic impact assessment. Don Hoyt of the State of Texas Office of the Comptroller of Public Accounts discussed applications of input-output analysis to economic impact assessment. Sandra Martinez of the State of Texas Office of the Comptroller of Public Accounts assisted with collection of background information to characterize the Corpus Christi Metropolitan Statistical Area. Herb Grubb of HDR Engineering, Inc., and Mickey Wright of the State of Texas Office of the Comptroller of Public Accounts provided useful feedback on the application of input-output analysis. The Corpus Christi Board of Trade Technical Committee discussed economic impacts of water rationing in the ship channel industries.

The many individuals that participated in focus group and discussions of water savings analysis and economic impact assessment also deserve recognition. Several individuals assisted in this project through participation in a group discussion held in Austin that considered the approach and methods used in this study. Participants included John Sutton and Bill Hoffman of the Texas Water Development Board, Bruce Moulton of the Texas Natural Resource Conservation Commission, Mark Hughes of the Texas Workforce Commission, and Susan Cable of the city of Corpus Christi. The project team also wishes to thank the water utility customers that volunteered as focus group participants in the city of Corpus Christi for their active participation in this project. Their names are not listed to preserve the confidentiality of their responses.

The authors are solely responsible for any errors, interpretations, or omissions.
Appendix A. Rainfall, Temperature, and Aggregate Monthly Water Demand Time Series, 1982-1996

Forecasting data including rainfall, temperature, and aggregate monthly water demand are listed in Table A.1. These data originate from monthly billing reports produced by the accounting division and corrected or updated by the Corpus Christi Water Division. Water demand is listed at an aggregate level in terms of total water use and treated water use as well as at the levels of residential, commercial, and industrial water-user sectors. Total water demand is defined as all treated and raw water sales by Corpus Christi’s water division during the billing month to which those sales are assigned. For example, meters read at the beginning of one month may reflect some water use in the preceding month, but this water is charged to the month in which the meter was read. Treated water demand is defined as all treated water sales to both retail and wholesale water customers such as the Alice, Beeville, and San Patricio Municipal Water District. Residential water demand is all retail treated water sales to residential water customers. Commercial water demand is all retail treated water sales to commercial water customers. Industrial water demand is all retail treated and raw water sales to industrial water customers.

Population of the Corpus Christi Metropolitan Statistical Area and the number of retail water customers are listed alongside water demand. Population is used to control for the effects of increasing population on water demand. For example, total water demand in January 1982 was 2.154 million gallons and the population of Corpus Christi Metropolitan Statistical Area was 343,800 people. Per capita total water demand is total water demand divided by the population, or 6.267 thousand gallons per capita. This figure can be compared with water demand during months when population levels differ. For example, per capita water demand in January 1996 was 7.178 thousand gallons per capita. No population data are available for the retail service area. Therefore, the number of accounts is used to standardize water demand across years rather than population. For example, residential water demand in January 1996 was 404,032 thousand gallons and there were 58,043 accounts active during the billing month. Per account water use in the residential sector was 6.96 thousand gallons per capita.

Listed on the far right of Table A.1 is aggregate rainfall (inches) and mean maximum temperature (Fahrenheit). These data are from the Office of the State Climatologist at Texas A&M University.
Table A.1. Rainfall, Temperature, and Aggregate Monthly Water Demand Time Series, 1982-1996

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Table A.1. Rainfall, Temperature, and Aggregate Monthly Water Demand Time Series

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Appendix B. Residential and Commercial Water Prices, 1978-1996

Table B.1 lists the marginal cost of water to retail customers of the Corpus Christi municipal water utility that are classified as residential water users inside the city limits. Month and year refer to the first month and year that the prices in each row became effective. For example, the most recent change in water prices occurred on August 1, 1995. Each customer is charged a fixed rate each month for account maintenance. Included in this charge is the first 2,000 gallons of water delivered to each account. Therefore, the marginal price of the first two thousand gallons to a residential water customer is $0.00, and the table indicates there is no charge for the first two thousand gallons each month. If a customer uses between 2,000 and 3,000 gallons of water, the charge is $1.74 for the third thousand gallons. The total water bill is the fixed monthly rate plus $1.74. If a customer uses between 5,000 and 6,000 gallons of water during a billing period, the marginal cost of the last thousand gallon increment, the increment from 5,000 to 6,000 gallons, is $1.74. The total water cost is the fixed rate plus three times $1.74. If a customer uses 11,000 gallons, the marginal water cost is $1.87. The total water cost is the fixed cost plus four times $1.74 plus five times $1.87. Water costs are rounded to 1,000 gallons each month. The city of Corpus Christi maintains an increasing block rate for residential water customers. Table B.2 lists the marginal cost of water to residential customers outside the city limits. That rate schedule is a flat rate.

Residential water customers are residents in single-family residences or duplexes. Water sales to Corpus Christi apartment complexes and other multifamily residences are considered nonresidential water sales for billing purposes. Nonresidential rates and rate structures differ from residential rates and rate structures. For example, nonresidential customers tend to pay higher fixed rates depending upon meter size; their rate structure is a decreasing block rate. All nonresidential water customers and multifamily residences other than duplexes pay nonresidential water rates. Table B.3 lists the commercial water rates inside the city limits. Table B.4 lists the nonresidential water rates outside the city limits.
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<th>2,000</th>
<th>3,000</th>
<th>15,000</th>
<th>20,000</th>
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<td>0.000</td>
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<td>0.750</td>
<td>0.560</td>
<td>0.470</td>
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</tr>
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</table>

### Table B.4. Nonresidential Water Rates Outside the City Limits
(Nominal dollars per 1,000 gallons)

<table>
<thead>
<tr>
<th>Month</th>
<th>Year</th>
<th>2,000</th>
<th>3,000</th>
<th>15,000</th>
<th>20,000</th>
<th>100,000</th>
<th>1,000,000</th>
<th>10,000,000</th>
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<tbody>
<tr>
<td>8</td>
<td>95</td>
<td>0.000</td>
<td>3.484</td>
<td>3.484</td>
<td>3.155</td>
<td>3.155</td>
<td>2.511</td>
<td>1.489</td>
<td>1.021</td>
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<td>8</td>
<td>94</td>
<td>0.000</td>
<td>3.287</td>
<td>3.287</td>
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<td>2.977</td>
<td>2.369</td>
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<td>94</td>
<td>0.000</td>
<td>3.101</td>
<td>3.101</td>
<td>2.809</td>
<td>2.809</td>
<td>2.235</td>
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</tr>
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<td>9</td>
<td>92</td>
<td>0.000</td>
<td>2.926</td>
<td>2.926</td>
<td>2.650</td>
<td>2.650</td>
<td>2.109</td>
<td>1.251</td>
<td>0.859</td>
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<tr>
<td>3</td>
<td>91</td>
<td>0.000</td>
<td>2.760</td>
<td>2.760</td>
<td>2.500</td>
<td>2.500</td>
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<td>2.810</td>
<td>2.550</td>
<td>2.550</td>
<td>2.030</td>
<td>1.210</td>
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<td>8</td>
<td>88</td>
<td>0.000</td>
<td>2.730</td>
<td>2.730</td>
<td>2.480</td>
<td>2.480</td>
<td>1.970</td>
<td>1.170</td>
<td>0.800</td>
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<td>2.600</td>
<td>2.360</td>
<td>2.360</td>
<td>1.880</td>
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<td>8</td>
<td>83</td>
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<td>2.250</td>
<td>2.250</td>
<td>1.730</td>
<td>1.410</td>
<td>0.840</td>
<td>0.560</td>
</tr>
<tr>
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<td>0.000</td>
<td>1.750</td>
<td>1.750</td>
<td>1.300</td>
<td>1.100</td>
<td>0.640</td>
<td>0.410</td>
</tr>
<tr>
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<td>0.000</td>
<td>0.000</td>
<td>1.500</td>
<td>1.500</td>
<td>1.120</td>
<td>0.940</td>
<td>0.550</td>
<td>0.350</td>
</tr>
</tbody>
</table>
Appendix C. Commercial/Industrial Survey Results

Appendix C reports results of commercial/industrial surveys. Surveys were completed at the start of the first meeting of each commercial/industrial focus group, before discussion began. Forty-one organizations from the study's six target commercial/industrial sectors completed surveys. The first column in Table C.1 describes participating organizations. Table C.1 lists responses to eight descriptive questions.

In survey questions 3 through 9 and question 11, respondents described their organizations' primary product, estimated average monthly sales, number of employees, average monthly water bill, and average monthly water use. In addition, they identified their high and low seasons, if any. Respondents also reported whether their organizations were considered inside city limits (ICL) or outside city limits (OCL) for the purposes of utility billing.

Tables C.2 through C.33 each list responses to individual survey questions in the order they were asked. Each table reports results first by sector and then in aggregate, on the far right side. For example, reading the first row in Table C.2, two hotels, six government/school participants, six manufacturers, five petrochemical firms, and one military installation have altered production processes without capital investment in an effort to conserve water during the current shortage. A total of 20 respondents from all sectors combined have implemented this conservation measure, representing 14 percent of all conservation measures implemented by commercial/industrial survey respondents.

Tables C.2 through C.33 can each be read in a similar manner. Results of survey question 15 and part of question 31 were too few and too varied to summarize in this appendix.
Table C.1. Results of Commercial/Industrial Survey Questions 3-9, 11
Descriptive Information

<table>
<thead>
<tr>
<th>Survey No.</th>
<th>Type of Organization or Primary Product</th>
<th>Estimated Average Monthly Sales</th>
<th>Seasonal Change in Water Use?</th>
<th>Estimated No. of Employees</th>
<th>Respondent Potential Impact on Water Use</th>
<th>Estimated Average Monthly Water Use</th>
<th>Estimated Average Monthly Water Bill</th>
<th>ICL/OCL</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Nursery/sod</td>
<td>$25,000</td>
<td>Yes</td>
<td>NR</td>
<td>High</td>
<td>DK</td>
<td>$150.000</td>
<td>ICL</td>
</tr>
<tr>
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<td>Landscape design</td>
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<td>5</td>
<td>Medium</td>
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<td>$0.000</td>
<td>ICL</td>
</tr>
<tr>
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<td>Landscape equipment</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Landscape pest control</td>
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<td>Yes</td>
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<td>Medium</td>
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<td>DK</td>
<td>ICL</td>
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<tr>
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<td>Landscape retail</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>6</td>
<td>Irrigation</td>
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<td>High</td>
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<tr>
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<td>Interior landscaping</td>
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<td>DK</td>
<td>ICL</td>
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<tr>
<td>9</td>
<td>Fertilizer/pest control</td>
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<td>4</td>
<td>Medium</td>
<td>100,000</td>
<td>$150.000</td>
<td>ICL</td>
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<tr>
<td>10</td>
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<td>Low</td>
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<td>DK</td>
<td>ICL</td>
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<tr>
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<td>NR</td>
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<td>DK</td>
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<tr>
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<td>ICL</td>
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<td>ICL</td>
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<td>$20,000</td>
<td>OCL</td>
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<td>DK</td>
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<td>NR</td>
<td>ICL</td>
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<td>Medium</td>
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<td>ICL</td>
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<td>150</td>
<td>None</td>
<td>118,000</td>
<td>DK</td>
<td>ICL</td>
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<td>Medium</td>
<td>DK</td>
<td>DK</td>
<td>ICL</td>
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<tr>
<td>20</td>
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<td>Medium</td>
<td>DK</td>
<td>DK</td>
<td>ICL</td>
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<td>9,000,000</td>
<td>DK</td>
<td>ICL</td>
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(Continued)
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<th>Commercial/Industrial Survey Questions 3-9, 11</th>
<th>Descriptive Information</th>
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<td>DK No DK High DK DK DK</td>
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<td>Pharmaceutical</td>
<td>DK No 1,200 Medium 142,500,000 $40,000 OCL</td>
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<td>Concrete mfr.</td>
<td>$300,000 No 45 Low 300,000 DK OCL</td>
</tr>
<tr>
<td>25</td>
<td>Pigment mfr.</td>
<td>$1,400,000 Yes 50 High 1,300,000 $1,500 ICL</td>
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<td>26</td>
<td>Chemical</td>
<td>DK No 250 Medium 100,000,000 $110,000 OCL</td>
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<tr>
<td>27</td>
<td>Paint mfr.</td>
<td>$400,000 Yes 27 High 20,000 DK ICL</td>
</tr>
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<td>Military contractor</td>
<td>DK No 41 Medium DK DK ICL</td>
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<td>Petrochemical</td>
<td>$1,000,000.0 No 5,000 Medium 150,000,000 $125,000 OCL</td>
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<td>Refining</td>
<td>DK Yes 375 Medium 3,640,000 $102,000 OCL</td>
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<td>31</td>
<td>Electric utility</td>
<td>$35,000,000 Yes 140 High 90,000,000 $80,000 Both</td>
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<td>32</td>
<td>Refining</td>
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<td>Hazardous recycling</td>
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<td>Petrochemical</td>
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<td>38</td>
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<td>DK No 300 Medium 180,000,000 $185,000 OCL</td>
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<td>Refining</td>
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<td>40</td>
<td>Military installation</td>
<td>DK No 3,000 High DK $20,000 ICL</td>
</tr>
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<td>41</td>
<td>Military installation</td>
<td>NR No 3,000 High 35,000,000 $30,000 ICL</td>
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</table>

DK = Don't know  
NR = No response
Table C.2. Results of Commercial/Industrial Survey Question 1
Production-Related Water Conservation Efforts

**Question:** Below is a list of production-related water conservation efforts. Please identify those efforts that your organization has implemented since April 1996 or in response to warnings of water shortage by placing check marks in the appropriate spaces. (The city of Corpus Christi declared drought condition 1 on April 9.)

<table>
<thead>
<tr>
<th>Conservation Measure</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altered process without capital investment.</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>1</td>
<td>20</td>
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<tr>
<td>Increased use of labor to reduce water consumption.</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Purchased and installed new water-saving equipment (please describe).</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Started water re-capture and re-use program.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Expanded water re-capture and re-use program.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Began using lower-quality water (groundwater, seawater) to replace/supplement treated water.</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Increased use of lower-quality water to replace/supplement treated water.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Established stricter volume limits on water use at specific stages of production.</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Established stricter time limits on water use at specific stages of production.</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>18</td>
</tr>
<tr>
<td>Increased systematic inspection for water leaks in production process.</td>
<td>2</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>7</td>
<td>2</td>
<td>22</td>
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<tr>
<td>Decreased production.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>None of the above.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond to question.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
<td><strong>9</strong></td>
<td><strong>30</strong></td>
<td><strong>28</strong></td>
<td><strong>49</strong></td>
<td><strong>7</strong></td>
<td><strong>138</strong></td>
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</tbody>
</table>

**Total number of organizations surveyed**

<table>
<thead>
<tr>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
Table C.3. Results of Commercial/Industrial Survey Question 2
Non-Production-Related Conservation Efforts

**Question**: Please identify those non-production related water conservation efforts listed below that your organization has adopted to save water SINCE April 9, 1996 or in response to warnings of water shortage. Please check all that apply.

<table>
<thead>
<tr>
<th>Conservation Measure</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Number of Responses</th>
<th>All Sectors Number</th>
<th>All Sectors Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced washing of buildings, sidewalks, and other structures (please estimate percent reduction).</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Ceased washing of buildings, sidewalks, and other structures.</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Reduced janitorial water use (please estimate percent reduction).</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Replaced existing faucets with water-saving (low-flow) faucets in restroom and kitchen sinks.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Replaced existing toilets with new water-saving toilets.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Formally encouraged employees to conserve water at all times.</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>Reduced landscape watering to a level lower than present city restrictions require.</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Ceased landscape watering.</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>None of the above.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond to question.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>20</strong></td>
<td><strong>13</strong></td>
<td><strong>23</strong></td>
<td><strong>29</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

**Total number of organizations surveyed** | **9** | **4** | **9** | **6** | **11** | **2** | **41** | **41** |
Table C.4. Results of Commercial/Industrial Survey Question 10
Familiarity with Drought Contingency Plan

**Question:** Are you familiar with conditions 1-4 of the city's drought management plan?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>6</td>
<td>10</td>
<td>2</td>
<td>34</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

Table C.5. Results of Commercial/Industrial Survey Question 12
Perceived Impact of Water Conservation on Total Water Consumption

**Question:** How does your organization's water use this July compare to its water use last July?

<table>
<thead>
<tr>
<th>Conservation Measure</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>We are using less water this July than last July.</td>
<td>5</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>We are using about the same amount of water this July as last July.</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>We are using more water this July than last July.</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Don't know</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
Table C.6. Results of Commercial/Industrial Survey Question 13  
Indicators of Economic Impact

**Question:** What would you consider to be the three (3) best measures of the economic impact of restricted water use on your business? Please list the best measure first.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem/ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Indicator 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total sales/revenue</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Employment</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Operating expenses</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Production</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Capital expenses</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>No response</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

| **Indicator 2** | | | | | | | |
| Total sales/revenue | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 7 |
| Employment | 3 | 0 | 1 | 1 | 1 | 0 | 6 | 15 |
| Operating expenses | 0 | 0 | 0 | 2 | 3 | 0 | 5 | 12 |
| Capital expenses | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 7 |
| Other | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 5 |
| No response | 6 | 3 | 7 | 1 | 3 | 2 | 22 | 54 |
| **Total** | 9 | 4 | 9 | 6 | 11 | 2 | 41 | 100% |

| **Indicator 3** | | | | | | | |
| Total sales/revenue | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| Employment | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 5 |
| Operating expenses | 0 | 0 | 0 | 0 | 4 | 0 | 4 | 10 |
| Production | 0 | 0 | 0 | 1 | 2 | 0 | 3 | 7 |
| Capital expenses | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 |
| Other | 2 | 0 | 0 | 1 | 0 | 0 | 3 | 7 |
| No response | 7 | 4 | 9 | 2 | 3 | 2 | 27 | 66 |
| **Total** | 9 | 4 | 9 | 6 | 11 | 2 | 41 | 100% |
Table C.7. Results of Commercial/Industrial Survey Question 14
Appropriateness of Economic Impact Measure

**Question:** Are these common measures of economic condition in your industry?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>9</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>No</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>No response</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

Table C.8. Results of Commercial/Industrial Survey Question 16
Impact of Risk of Water Shortage on Commercial/Industrial Expansion Plans

**Question:** Has the risk of water shortage been a factor in your company’s decisions to expand operations in areas supplied with water from Corpus Christi’s reservoirs?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>4</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
Table C.9. Results of Commercial/Industrial Survey Question 17
Perception of Efficacy of Water Conservation

Question: My organization’s water use accounts for such a small amount of the total water demand in Corpus Christi that our individual efforts to date HAVE NOT made meaningful contribution to reducing overall water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Disagree</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>8</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

Table C.10. Results of Commercial/Industrial Survey Question 18
Long-Term Cost/Benefit of Investments in Water Conservation

Question: Over the long term, the risk of drought is not high enough to justify the cost of investments in equipment and/or practices to reduce water use in our organization.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Disagree</td>
<td>4</td>
<td>0</td>
<td>4</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
### Table C.11. Results of Commercial/Industrial Survey Question 19
Perceptions of Cooperation with Request for Voluntary Conservation

**Question:** Other businesses in our industry in Corpus Christi are implementing water conservation measures.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Agree</td>
<td>7</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

### Table C.12. Results of Commercial/Industrial Survey Question 20
Confidence in City Ability to Manage the Water Shortage

**Question:** The city is capable of planning a solution to the current water shortage.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Agree</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Don’t know</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
Table C.13. Results of Commercial/Industrial Survey Question 21
Perceptions of Primary Cause of the Water Shortage

Question: The present water shortage is PRIMARILY a result of (please choose one):

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landscape/</td>
<td>Hotel/</td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>Tourism</td>
</tr>
<tr>
<td>High evaporation combined with lack of rainfall to city reservoirs</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>Overuse of city water by residential consumers</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overuse of city water by industrial and commercial consumers</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Inadequate management of the city's reservoirs</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Freshwater inflow requirements to bays and estuaries</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Other (please describe)</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>16</td>
<td>4</td>
</tr>
</tbody>
</table>

Table C.14. Results of Commercial/Industrial Survey Question 22
Perceptions of Cost-Effective Long-Term Water Supply Alternatives

Question: Which alternative do you consider to be the BEST method of producing increased water supplies to Corpus Christi?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landscape/</td>
<td>Hotel/</td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>Tourism</td>
</tr>
<tr>
<td>Increased water conservation by city residents</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Increased water conservation by industry and businesses</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Construction of pipeline to city from Lake Texana</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Desalination of seawater</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Exploration of local groundwater options</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Modified operation of city reservoirs</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other (please describe)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td>6</td>
</tr>
</tbody>
</table>
Table C.15. Results of Commercial/Industrial Survey Question 23  
Perceptions of Drought Severity  
Question: What is your best estimate of how long it has been since the city reservoirs were at 50 percent (one-half) of total capacity?

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6 months</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>7-12 months</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>13-18 months</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>19-24 months</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Over 24 months</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

Table C.16. Results of Commercial/Industrial Survey Question 24  
Question: Please estimate the period of time you think that water supplies remaining in the reservoirs will sustain residents and businesses dependent upon these supplies under current rates of water use and current rates of reservoir recharge (provide your closest estimate in weeks, months, or years).

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-6 months</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7-12 months</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>13-18 months</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>19-24 months</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>More than 24</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
Table C.17. Results of Commercial/Industrial Survey Question 25

Question: Please describe and estimate the fixed cost of any one-time purchases or repairs your organization has made to comply with the CURRENT request for voluntary reduction in water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The estimated cost is $_____. Please describe these costs in the space provided below.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>9 (22%)</td>
</tr>
<tr>
<td>There are fixed costs but I am unable to estimate them. Please describe these costs below.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2 (5%)</td>
</tr>
<tr>
<td>I believe there are fixed costs to my organization but I can neither describe nor estimate them.</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>9 (22%)</td>
</tr>
<tr>
<td>There are no fixed costs to my organization.</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>16 (39%)</td>
</tr>
<tr>
<td>Other (please explain briefly in the space below).</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (2%)</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4 (10%)</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41 (100%)</td>
</tr>
</tbody>
</table>

Note: Fixed cost descriptions and estimates were too varied to report.
Table C.18. Results of Commercial/Industrial Survey Question 26

**Question:** Please describe and estimate any regular (daily, weekly, monthly) costs (variable costs) to your organization that can be directly attributed to the CURRENT request for voluntary reduction in water use. Do not include any fines for violation of city ordinances related to water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>The estimated cost is $_____. Please describe these costs in the space provided below.</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>5</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>There are variable costs but I am unable to estimate them. Please describe these costs below.</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>I believe there are variable costs to my organization but I can neither describe nor estimate them.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>There are no variable costs to my organization.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>Other (please explain briefly in the space below).</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response.</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

Note: Variable cost descriptions and estimates were too varied to report.
Table C.19. Results of Commercial/Industrial Survey Question 27
Perceptions of Risk of Running Out of Water

**Question**: Under the current plan, the city will enter drought condition 4 when the combined total capacity of the reservoirs reaches 7 percent. If the city reaches drought condition 4, each commercial and industrial customer's water use may be limited to a maximum monthly allowance. Each customer's monthly water allocation could be 75 percent of average monthly water use over the previous 12 months. If the city allocates water, businesses will pay a surcharge for water use that exceeds that allowance. What is closest to your view?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landscape/ Nursery</td>
<td>Hotel/ Tourism</td>
</tr>
<tr>
<td>The city should not implement a water rationing program.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>The city should delay implementation of a water rationing program or implement a water rationing program less restrictive than the current plan.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>The city should implement the water rationing program as planned.</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>The city should implement a water rationing program as soon as possible or implement a water rationing program more restrictive than the current plan.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
**Table C.20. Results of Commercial/Industrial Question 28**

**Anticipated Effects of Condition 3 Water Rationing on Sales Revenue**

**Question:** Assume that the city allocates water to your businesses as described in question 27. Please describe any effects you may anticipate in terms of a change in sales revenue. If you anticipate an increase or decrease in sales revenue, please estimate the percent change.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anticipated increase in sales revenue.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No change anticipated.</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Anticipated 5-15% decrease in sales revenue.</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Anticipated 16-25% decrease in sales revenue.</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Anticipated 26-35% decrease in sales revenue.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Anticipated 36-50% decrease in sales revenue.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Anticipated greater than 50% decrease in sales revenue.</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Anticipated but could not estimate decrease in sales revenue.</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

Percent: 100%
Table C.21. Results of Commercial/Industrial Survey Question 29
Anticipated Effects of Condition 3 Water Rationing on Employment

**Question:** Please describe any effects you may anticipate in terms of a change in employment if the city allocates water as described in question 27. If you anticipate an increase or decrease in employment, please estimate the percent change.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Sectors</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landscape/</td>
<td>Hotel/</td>
<td>Government/</td>
<td>Other Comm./</td>
<td>Petrochem./</td>
<td>Military</td>
<td>Number</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>Tourism</td>
<td>Schools</td>
<td>Manufacturing</td>
<td>Ship Channel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anticipated increase in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No change anticipated.</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>16</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Anticipated 5-15% decrease in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Anticipated 16-25% decrease in employment.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Anticipated 26-35% decrease in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Anticipated 36-50% decrease in employment.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Anticipated greater than 50% decrease in employment.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Anticipated but could not estimate decrease in employment.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>10</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table C.22. Results of Commercial/Industrial Survey Question 30

**Question:** Under present conditions, what is your closest estimate of when the city of Corpus Christi will enter drought condition 4?

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Number of Responses</th>
<th>All Sectors</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Landscape/</td>
<td>Hotel/</td>
<td>Government/</td>
<td>Other Comm./</td>
<td>Petrochem./</td>
<td>Military</td>
<td>Number</td>
<td>Percent</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nursery</td>
<td>Tourism</td>
<td>Schools</td>
<td>Manufacturing</td>
<td>Ship Channel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-6 months</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>23</td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>7-12 months</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>12</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>13-18 months</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>19-24 months</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>More than 24 months</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
<td><strong>100%</strong></td>
<td></td>
</tr>
</tbody>
</table>
Question: Suppose your business is located in the city of San Diego, California. The city of San Diego declares a drought emergency and requires all organizations to cut their water use by at least 25 percent to avoid paying a substantial fine. Assume that your organization cannot afford to pay the fine. What is the first measure you would recommend that your organization take to comply with the city's demand?

Table C.23. Results of Commercial/Industrial Survey Question 31

<table>
<thead>
<tr>
<th>Answer Number</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem/Ship Channel</th>
<th>Military</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>reduce stock</td>
<td>replace</td>
<td>sell less water</td>
<td>recycle</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td></td>
<td>watering</td>
<td>toilets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>NR</td>
<td>NR</td>
<td>sell less water</td>
<td>cease non-production</td>
<td>recycle</td>
<td>recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>water use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NR</td>
<td>educate</td>
<td>stop outdoor</td>
<td>drill well</td>
<td>transfer</td>
<td>recycle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>guests</td>
<td>watering</td>
<td></td>
<td></td>
<td>wastewater</td>
</tr>
<tr>
<td>4</td>
<td>reduce stock</td>
<td>educate</td>
<td>stop use of water</td>
<td>reduce production 35%</td>
<td>install RO unit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>watering</td>
<td>guests</td>
<td>for pool</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NR</td>
<td>NR</td>
<td>stop outdoor</td>
<td>NR</td>
<td>cut production</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>watering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>NR</td>
<td>NR</td>
<td>stop outdoor</td>
<td>NR</td>
<td>recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>watering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>reduce stock</td>
<td>NR</td>
<td>stop outdoor</td>
<td>recycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>watering</td>
<td></td>
<td>watering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>reduce stock</td>
<td>NR</td>
<td>stop outdoor</td>
<td>reduce</td>
<td>recycle</td>
<td></td>
</tr>
<tr>
<td></td>
<td>watering</td>
<td></td>
<td>watering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>NR</td>
<td>reducwater</td>
<td>reduce water in</td>
<td>recycle</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>in</td>
<td>toilets</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>shut low priority units</td>
</tr>
</tbody>
</table>
**About how much water would that measure save?**

<table>
<thead>
<tr>
<th>Answer Number</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem/ Ship Channel</th>
<th>Military</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>20</td>
<td>25</td>
<td>25</td>
<td>NR</td>
<td>25</td>
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<tr>
<td>2</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>35</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>3</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>NR</td>
<td>10</td>
<td>75</td>
<td>25</td>
<td>8</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>25</td>
</tr>
<tr>
<td>6</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>35</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>8</td>
<td>25</td>
<td>NR</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>25</td>
<td>NR</td>
<td>25</td>
</tr>
<tr>
<td>10</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>10</td>
</tr>
</tbody>
</table>

Note: Question 31 asked three more brief questions, but responses to these questions were too few and too varied to report.

**Table C.24. Results of Commercial/Industrial Survey Question 32**

**Question:** Please indicate whether you agree or disagree with the following statement.

*The city should limit water use among residential customers before limiting water use among businesses and commercial interests.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landscape/ Nursery</td>
<td>Hotel/ Tourism</td>
<td>Government/ Schools</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
</tr>
</tbody>
</table>
### Table C.25. Results of Commercial/Industrial Survey Question 33

**Question:** Please indicate whether you agree or disagree with the following statement.

*The availability of water influences the decisions of new businesses to locate in Corpus Christi.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

### Table C.26. Results of Commercial/Industrial Survey Question 34

**Question:** Please indicate whether you agree or disagree with the following statement.

*The reliability of the Corpus Christi water supply could prevent the expansion of existing city businesses.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
Table C.27. Results of Commercial/Industrial Survey Question 35

Question: Please indicate whether you agree or disagree with the following statement.

Employment in Corpus Christi will be affected by the drought restrictions.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm/Manufacturing</th>
<th>Petrochem/Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>17</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>

Table C.28. Results of Commercial/Industrial Survey Question 36

Question: Please indicate whether you agree or disagree with the following statement.

The water shortage could contribute to a decrease in tourism this season.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm/Manufacturing</th>
<th>Petrochem/Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>13</td>
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<tr>
<td>Agree strongly</td>
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<td>3</td>
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<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>9</strong></td>
<td><strong>4</strong></td>
<td><strong>9</strong></td>
<td><strong>6</strong></td>
<td><strong>11</strong></td>
<td><strong>2</strong></td>
<td><strong>41</strong></td>
</tr>
</tbody>
</table>
Table C.29. Results of Commercial/Industrial Survey Question 37

Question: Please indicate whether you agree or disagree with the following statement.
The value of land and homes in Corpus Christi could erode if more reliable water supplies cannot be acquired.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Agree</td>
<td>6</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>11</td>
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<tr>
<td>Don’t know</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

Table C.30. Results of Commercial/Industrial Survey Question 38

Question: Was your business located in Corpus Christi during the water shortage of 1984-1985?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/ Nursery</th>
<th>Hotel/ Tourism</th>
<th>Government/ Schools</th>
<th>Other Comm./ Manufacturing</th>
<th>Petrochem./ Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>5</td>
<td>2</td>
<td>6</td>
<td>4</td>
<td>7</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>
**Table C.31. Results of Commercial/Industrial Survey Question 39**

**Question:** Please estimate the impact of the water shortage of 1984-1985 on employment in your organization.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem/Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated increase in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No impact on employment.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Estimated 5-15% decrease in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Estimated 16-25% decrease in employment.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Estimated 26-35% decrease in employment.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Estimated 36-50% decrease in employment.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Estimated greater than 50% decrease in employment.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>No response</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All Sectors</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>46</td>
</tr>
</tbody>
</table>

**Table C.32. Results of Commercial/Industrial Question 40**

**Question:** Please estimate the impact of the water shortage of 1984-1985 on revenue in your organization.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem/Ship Channel</th>
<th>Military</th>
<th>All Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated increase in revenue.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No impact on revenue.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Estimated 5-15% decrease in revenue.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Estimated 16-25% decrease in revenue.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Estimated 26-35% decrease in revenue.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Estimated 36-50% decrease in revenue.</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Estimated greater than 50% decrease in revenue.</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Reported decrease without estimating amount.</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>No response</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>4</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>2</td>
<td>41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All Sectors</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>100</td>
</tr>
</tbody>
</table>
Table C.33. Results of Commercial/Industrial Survey Question 41

**Question:** If the water shortage of 1984-1985 affected aspects of your business other than employment and revenue, please describe these effects below.

<table>
<thead>
<tr>
<th>Answer Number</th>
<th>Landscape/Nursery</th>
<th>Hotel/Tourism</th>
<th>Government/Schools</th>
<th>Other Comm./Manufacturing</th>
<th>Petrochem./Ship Channel</th>
<th>Military</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Stock loss,</td>
<td>No response</td>
<td>No response</td>
<td>Expansion delay, job</td>
<td>No response</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>expansion delay</td>
<td></td>
<td></td>
<td>security loss</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>Equipment damage</td>
<td>No response</td>
<td>No response</td>
</tr>
<tr>
<td>3</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>Customer loss</td>
<td>Considered moving</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>production elsewhere</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>No response</td>
<td>No response</td>
<td>Safety hazard</td>
<td>No response</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>Fined for dust emission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td>No response</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix D: Residential Survey Results

Appendix D reports results of residential customer surveys. Surveys were completed by all eight residential focus group participants at the start of the first meeting of each group, before discussion began. In addition, 18 residential customers completed surveys distributed through apartment complexes and neighborhood associations.

Tables D.1 through D.5 list responses to 14 descriptive questions. In survey questions 4 through 6, respondents identified their annual household income, the number of persons in their residence, and their type of residence. Questions 7, 7a, and 7b asked apartment dwellers whether water costs were included in monthly rent, whether their apartment had an individual water meter, and whether their apartment management had started a water conservation program. Questions 8 through 15 asked whether respondents were responsible for paying their household water bills, whether they were the member of their household with the most knowledge about water use, and whether they had the greatest impact on water use. Respondents were also asked to list their gender, age, educational background, typical monthly water bill, and typical monthly water use.

Tables D.6 through D.41 list responses to individual survey questions in the order they were asked. Each table first reports results of focus group participants, then of mailed survey respondents, and then in aggregate on the far right side. For example, the first row in Table D.6 shows that focus group participants and 10 mailed survey respondents indicated in response to question 1 that they had reduced use of household washing machines due to the water shortage. A total of 13 respondents reported implementing this household conservation measure, representing 9 percent of the total number of measures implemented by participating households. Tables D.7 through D.41 can be read in a similar manner.

Survey questions are reported above tabular results. Results of survey question 28 were not sufficient to report in this appendix.
Table D.1. Results of Residential Survey Questions 4-6

Descriptive Information

<table>
<thead>
<tr>
<th>Respondent Number</th>
<th>Annual Household Income</th>
<th>Number in Residence</th>
<th>Residence Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$25-35,000</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>2</td>
<td>&gt;$75,000</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>3</td>
<td>&gt;$75,000</td>
<td>3</td>
<td>Single family home</td>
</tr>
<tr>
<td>4</td>
<td>$45-55,000</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>5</td>
<td>$35-45,000</td>
<td>7</td>
<td>Single family home</td>
</tr>
<tr>
<td>6</td>
<td>$65-75,000</td>
<td>3</td>
<td>Single family home</td>
</tr>
<tr>
<td>7</td>
<td>$45-55,000</td>
<td>3</td>
<td>Single family home</td>
</tr>
<tr>
<td>8</td>
<td>$55-65,000</td>
<td>3</td>
<td>Single family home</td>
</tr>
<tr>
<td>9</td>
<td>NR</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>10</td>
<td>$55-65,000</td>
<td>3</td>
<td>Single family home</td>
</tr>
<tr>
<td>11</td>
<td>$65-75,000</td>
<td>4</td>
<td>Single family home</td>
</tr>
<tr>
<td>12</td>
<td>$15-25,000</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>13</td>
<td>$45-55,000</td>
<td>4</td>
<td>Single family home</td>
</tr>
<tr>
<td>14</td>
<td>NR</td>
<td>2</td>
<td>Single family home</td>
</tr>
<tr>
<td>15</td>
<td>$65-75,000</td>
<td>4</td>
<td>Single family home</td>
</tr>
<tr>
<td>16</td>
<td>$15-25,000</td>
<td>2</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>17</td>
<td>$35-45,000</td>
<td>5</td>
<td>Single family home</td>
</tr>
<tr>
<td>18</td>
<td>$35-45,000</td>
<td>2</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>19</td>
<td>$15-25,000</td>
<td>1</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>20</td>
<td>NR</td>
<td>1</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>21</td>
<td>$35-45,000</td>
<td>2</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>22</td>
<td>$35-45,000</td>
<td>4</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>23</td>
<td>$25-35,000</td>
<td>3</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>24</td>
<td>$25-35,000</td>
<td>1</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>25</td>
<td>NR</td>
<td>NR</td>
<td>Apt/Condominium</td>
</tr>
<tr>
<td>26</td>
<td>$15-25,000</td>
<td>1</td>
<td>Apt/Condominium</td>
</tr>
</tbody>
</table>
Table D.2. Results of Residential Survey Question 7  
**Question:** Do you live in an apartment or other building where water costs are included in monthly rent?  

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26</td>
</tr>
</tbody>
</table>

Table D.3. Results of Residential Survey Question 7a  
**Question:** Does your apartment/condominium have an individual water meter?  

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>No response</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26</td>
</tr>
</tbody>
</table>

Table D.4. Results of Residential Customer Survey Question 7b  
**Question:** Has the management at your apartment/condominium complex started a water conservation program?  

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>8</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26</td>
</tr>
</tbody>
</table>
### Table D.5. Results of Residential Survey Questions 8-15
#### Descriptive Information

<table>
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<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>NR</td>
<td>NR</td>
<td>Male</td>
<td>&gt;65</td>
<td>high school</td>
<td>$30-35</td>
<td>$7,000</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>40-49</td>
<td>grad school</td>
<td>$45</td>
<td>$8,000</td>
</tr>
<tr>
<td>3</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>grad school</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>4</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Female</td>
<td>50-65</td>
<td>grad school</td>
<td>$43</td>
<td>$10,000</td>
</tr>
<tr>
<td>5</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>college grad</td>
<td>$45</td>
<td>NR</td>
</tr>
<tr>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>grad school</td>
<td>$7</td>
<td>$3,000</td>
</tr>
<tr>
<td>7</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Female</td>
<td>40-49</td>
<td>college</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>college</td>
<td>$45</td>
<td>$11,000</td>
</tr>
<tr>
<td>9</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Male</td>
<td>&gt;65</td>
<td>grad school</td>
<td>$40</td>
<td>$19,000</td>
</tr>
<tr>
<td>10</td>
<td>NR</td>
<td>Yes</td>
<td>No</td>
<td>Female</td>
<td>21-29</td>
<td>college</td>
<td>$48</td>
<td>NR</td>
</tr>
<tr>
<td>11</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>&gt;65</td>
<td>grad school</td>
<td>$18</td>
<td>$6,000</td>
</tr>
<tr>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>&gt;65</td>
<td>college</td>
<td>$31</td>
<td>$3,000</td>
</tr>
<tr>
<td>13</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>30-39</td>
<td>college</td>
<td>$45</td>
<td>$10,000</td>
</tr>
<tr>
<td>14</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Female</td>
<td>40-49</td>
<td>college</td>
<td>$40</td>
<td>$5,000</td>
</tr>
<tr>
<td>15</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>40-49</td>
<td>college grad</td>
<td>$35</td>
<td>$7,000</td>
</tr>
<tr>
<td>16</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>&gt;65</td>
<td>college</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>17</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>voc/tech</td>
<td>$45</td>
<td>DK</td>
</tr>
<tr>
<td>18</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>&lt;21</td>
<td>college</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>19</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>&gt;65</td>
<td>grad school</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>20</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>50-65</td>
<td>college grad</td>
<td>NR</td>
<td>DK</td>
</tr>
<tr>
<td>21</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Female</td>
<td>40-49</td>
<td>college</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>22</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>Female</td>
<td>30-39</td>
<td>college</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>23</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>30-39</td>
<td>voc/tech</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>24</td>
<td>NR</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>21-29</td>
<td>grad school</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>25</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Female</td>
<td>40-49</td>
<td>college</td>
<td>DK</td>
<td>DK</td>
</tr>
<tr>
<td>26</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Male</td>
<td>&gt;65</td>
<td>grad school</td>
<td>DK</td>
<td>DK</td>
</tr>
</tbody>
</table>
Table D.6. Results of Residential Survey Question 1

**Question:** Please identify those water conservation efforts listed below that your household has adopted to save water SINCE April 9, 1996 or in response to warnings of water shortage. (The city of Corpus Christi declared drought condition 1 on April 9 and instituted mandatory water conservation efforts on May 6, 1996.) Please check all that apply.

<table>
<thead>
<tr>
<th>Voluntary Conservation Measure</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Reduced use of washing machine (please estimate percent of decrease).</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>Reduced use of garbage disposal (please estimate percent of decrease).</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>Ceased use of garbage disposal.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Reduced use of dishwasher (please estimate percent of decrease).</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Ceased use of dishwasher in favor of hand washing.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Adopted strict limits on showering time (indicate time limit if any).</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Replaced existing shower head with water-saving (low-flow) shower head.</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Replaced existing faucets with water-saving (low-flow) faucets in kitchen and bathroom sinks.</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Repaired leaky faucets.</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets.</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Replaced existing toilet with new water-saving toilet.</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Avoid flushing as much as possible.</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Began a household water re-use program.</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Ceased indoor and outdoor plant watering (other than lawns).</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Reduced lawn-watering to a level lower than present city lawn-watering restrictions require.</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Ceased lawn-watering.</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>None of the above.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Total 39 106 145 100%
Table D.7. Results of Residential Survey Question 2

Question: Which three (3) of the water conservation practices listed in question 1 do you think are most effective? Please look again at the list of choices in question 1 and place an asterisk (*) next to the three practices that you think save the most water. You do not have to limit your answers to those you checked in response to question 1.

<table>
<thead>
<tr>
<th>Voluntary Conservation Measure</th>
<th>Number of Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
</tr>
<tr>
<td></td>
<td>Participants</td>
</tr>
<tr>
<td></td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td></td>
<td>All Respondents</td>
</tr>
<tr>
<td></td>
<td>Number</td>
</tr>
<tr>
<td>Reduced use of washing machine (please estimate percent of decrease).</td>
<td>5</td>
</tr>
<tr>
<td>Reduced use of garbage disposal (please estimate percent of decrease).</td>
<td>0</td>
</tr>
<tr>
<td>Ceased use of garbage disposal.</td>
<td>0</td>
</tr>
<tr>
<td>Reduced use of dishwasher (please estimate percent of decrease).</td>
<td>2</td>
</tr>
<tr>
<td>Ceased use of dishwasher in favor of hand washing.</td>
<td>1</td>
</tr>
<tr>
<td>Adopted strict limits on showering time (indicate time limit if any).</td>
<td>2</td>
</tr>
<tr>
<td>Replaced existing shower head with water-saving (low-flow) shower head.</td>
<td>1</td>
</tr>
<tr>
<td>Replaced existing faucets with water-saving (low-flow) faucets in kitchen and bathroom sinks.</td>
<td>3</td>
</tr>
<tr>
<td>Repaired leaky faucets.</td>
<td>2</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets.</td>
<td>1</td>
</tr>
<tr>
<td>Replaced existing toilet with new water-saving toilet.</td>
<td>2</td>
</tr>
<tr>
<td>Avoid flushing as much as possible.</td>
<td>1</td>
</tr>
<tr>
<td>Began a household water re-use program.</td>
<td>0</td>
</tr>
<tr>
<td>Ceased indoor and outdoor plant watering (other than lawns).</td>
<td>0</td>
</tr>
<tr>
<td>Reduced lawn-watering to a level lower than present city lawn-watering restrictions require.</td>
<td>1</td>
</tr>
<tr>
<td>Ceased lawn-watering.</td>
<td>1</td>
</tr>
<tr>
<td>None of the above.</td>
<td>0</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>0</td>
</tr>
<tr>
<td>No response.</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>23</strong></td>
</tr>
</tbody>
</table>

Note: One mailed survey respondent marked only two choices.
Table D.8. Results of Residential Survey Question 3

Question: Water prices for a household in the city of Corpus Christi increase as the amount of water used by the household increases. Please circle the price that you believe is closest to the actual price of each water increment.

<table>
<thead>
<tr>
<th>Responses, by Water Increment</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 2,000 gallons</td>
<td>Focus Group</td>
<td>Mailed</td>
</tr>
<tr>
<td>Chose estimate closest to actual price.</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Underestimated actual price by $1.00 or less.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Underestimated actual price by $1.01 to $3.00.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Underestimated actual price by more than $3.00.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Overestimated actual price by $1.00 or less.</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Overestimated actual price by $1.01 to $3.00.</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Overestimated actual price by more than $3.00.</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond.</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Next 4,000 gallons
| Chose estimate closest to actual price. | 2                   | 1               | 3      | 12      |
| Underestimated actual price by $1.00 or less. | 1                   | 1               | 2      | 8       |
| Underestimated actual price by $1.01 to $3.00. | 0                   | 1               | 1      | 4       |
| Underestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Overestimated actual price by $1.00 or less. | 2                   | 1               | 3      | 12      |
| Overestimated actual price by $1.01 to $3.00. | 0                   | 3               | 3      | 12      |
| Overestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Did not respond. | 3                   | 11              | 14     | 54      |
| Total | 8                   | 18              | 26     | 100%    |

Next 9,000 gallons
| Chose estimate closest to actual price. | 0                   | 1               | 1      | 4       |
| Underestimated actual price by $1.00 or less. | 1                   | 1               | 2      | 8       |
| Underestimated actual price by $1.01 to $3.00. | 0                   | 0               | 0      | 0       |
| Underestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Overestimated actual price by $1.00 or less. | 1                   | 1               | 2      | 8       |
| Overestimated actual price by $1.01 to $3.00. | 2                   | 4               | 6      | 23      |
| Overestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Did not respond. | 4                   | 11              | 15     | 58      |
| Total | 8                   | 18              | 26     | 100%    |

Next 15,000 gallons
| Chose estimate closest to actual price. | 0                   | 1               | 1      | 4       |
| Underestimated actual price by $1.00 or less. | 1                   | 0               | 1      | 4       |
| Underestimated actual price by $1.01 to $3.00. | 0                   | 0               | 0      | 0       |
| Underestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Overestimated actual price by $1.00 or less. | 1                   | 1               | 2      | 8       |
| Overestimated actual price by $1.01 to $3.00. | 2                   | 3               | 5      | 19      |
| Overestimated actual price by more than $3.00. | 0                   | 1               | 1      | 4       |
| Did not respond. | 4                   | 12              | 16     | 62      |
| Total | 8                   | 18              | 26     | 100%    |

Next 20,000 gallons
| Chose estimate closest to actual price. | 0                   | 1               | 1      | 4       |
| Underestimated actual price by $1.00 or less. | 1                   | 0               | 1      | 4       |
| Underestimated actual price by $1.01 to $3.00. | 0                   | 0               | 0      | 0       |
| Underestimated actual price by more than $3.00. | 0                   | 0               | 0      | 0       |
| Overestimated actual price by $1.00 or less. | 1                   | 1               | 2      | 8       |
| Overestimated actual price by $1.01 to $3.00. | 1                   | 3               | 4      | 15      |
| Overestimated actual price by more than $3.00. | 1                   | 1               | 2      | 8       |
| Did not respond. | 4                   | 12              | 16     | 62      |
| Total | 8                   | 18              | 26     | 100%    |
Table D.9. Results of Residential Survey Question 16

**Question:** How does your water use this July compare to your water use last July?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>I am using less water this July than last July.</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>I am using about the same amount of water this July as last July.</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>I am using more water this July than last July.</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Don't know.</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table D.10. Results of Residential Survey Question 17

**Question:** Do you know where your water meter is located?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Yes</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>No</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table D.11. Results of Residential Survey Question 18

**Question:** Do you know how to read your water meter?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Yes</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table D.12. Results of Residential Survey Question 19

**Question:** Were you a resident of Corpus Christi or of a community served by the Corpus Christi Water Department during 1984-1985?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Yes</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>
Table D.13. Results of Residential Customer Survey Question 20

**Question:** Are you familiar with drought conditions 1-4 of the city's drought management plan?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Yes</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

Table D.18. Results of Residential Survey Question 25

**Question:** The present water shortage is PRIMARILY a result of (please choose one):

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>High evaporation combined with lack of rainfall to the city's reservoirs.</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Overuse of city water by residential customers.</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Overuse of city water by industrial customers.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Inadequate management of the city's reservoirs.</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Freshwater inflow requirements to bays and estuaries.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Don't know.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>27</td>
</tr>
</tbody>
</table>

Table D.19. Results of Residential Survey Question 26

**Question:** Which alternative do you consider to be the BEST method of producing increased water supplies to the city of Corpus Christi? (Please choose one.)

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Increased water conservation by city residents.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Increased water conservation by industry and business.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Construction of pipeline to city from Lake Texana.</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Desalination of seawater.</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Exploration of local groundwater options.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Modified operation of city reservoirs.</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Don't know.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>29</td>
</tr>
</tbody>
</table>
Table D.20. Results of Residential Survey Question 27

**Question:** Which is closest to your view? Current restrictions on water use under drought condition 2:

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Are both an inconvenience and a cost.</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Are more of an inconvenience than a cost.</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Are more of a cost than an inconvenience.</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Are neither an inconvenience nor a cost.</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

Table D.21. Results of Residential Survey Question 29

**Question:** Please describe and estimate any regular (daily, weekly, monthly) costs to your household that can be directly attributed to the CURRENT regulations on water use. Do not include any fines for violation of city ordinances related to water use.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>The estimated cost is $___. Please describe these costs in the space provided below.</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>There are costs but I am unable to estimate them. Please describe these costs below.</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I believe there are costs to my household but I can neither describe nor estimate these costs.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>There are no daily/weekly/monthly costs to my household.</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Other (please explain briefly in the space below).</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>
Table D.22. Results of Residential Survey Question 30

**Question**: Water rationing will begin when the city of Corpus Christi moves from drought condition 2 to drought condition 3. The plan allows each household to use a limited amount of water each month. (Table of monthly household allocations was included in survey.) In the first stages of drought condition 3, households will pay a surcharge for water use that exceeds their water allowance. What is closest to your view of how the city should act?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>The city should not implement a water rationing program under drought condition 3.</td>
<td>0</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>The city should implement a water rationing program less restrictive than the current plan under drought condition 3.</td>
<td>2</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>The city should implement a water rationing program as planned under drought condition 3.</td>
<td>6</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>The city should implement a water rationing program more restrictive than the current plan under drought condition 3.</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>19</strong></td>
<td><strong>27</strong></td>
</tr>
</tbody>
</table>

Table D.23. Results of Residential Survey Question 31

**Question**: Please indicate whether you agree or disagree with the following statement. *My household can easily manage with the water allowance prescribed for drought condition 3 under the drought management plan.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
</tr>
</tbody>
</table>
### Table D.24. Results of Residential Survey Question 32

**Question:** Please indicate whether you agree or disagree with the following statement.  
*I anticipate that monthly expenses in my household will increase if the city decides to limit household water use as planned under drought condition 3.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>2</td>
<td>2, 8</td>
</tr>
<tr>
<td>Disagree</td>
<td>3</td>
<td>6</td>
<td>9, 35</td>
</tr>
<tr>
<td>Agree</td>
<td>4</td>
<td>7</td>
<td>11, 42</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>1</td>
<td>0</td>
<td>1, 4</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>3</td>
<td>3, 12</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>0</td>
<td>0, 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26, 100%</td>
</tr>
</tbody>
</table>

### Table D.25. Results of Residential Survey Question 33

**Question:** Please indicate whether you agree or disagree with the following statement.  
*The system that will be used to ration water among residential customers in drought condition 3 (described in question 30) results in a fair distribution of water among city residents.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0, 0</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
<td>7</td>
<td>9, 35</td>
</tr>
<tr>
<td>Agree</td>
<td>5</td>
<td>7</td>
<td>12, 46</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>1</td>
<td>1, 4</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>3</td>
<td>4, 15</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>0</td>
<td>0, 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26, 100%</td>
</tr>
</tbody>
</table>

### Table D.26. Results of Residential Survey Question 34

**Question:** Please indicate whether you agree or disagree with the following statement.  
*The city should limit water use among residential customers first before limiting water use among businesses and commercial interests.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>4</td>
<td>7</td>
<td>11, 42</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
<td>9</td>
<td>11, 42</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
<td>1</td>
<td>3, 12</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>0</td>
<td>1</td>
<td>1, 4</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
<td>0, 0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0</td>
<td>0</td>
<td>0, 0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>8</td>
<td>18</td>
<td>26, 100%</td>
</tr>
</tbody>
</table>
**Table D.27. Results of Residential Survey Question 35**

*Question:* The current drought management plan requires the city to limit household water use as described in question 30 when the combined volume of the reservoirs is 11 percent of total capacity. Please indicate which of the following policies most closely represents your view of how the city should act.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Limit household water use as soon as possible.</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Limit household water use when reservoirs are 20 percent of total capacity.</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Limit household water use when reservoirs are 11 percent of total capacity.</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Wait even longer to limit household water use.</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

**Table D.28. Results of Residential Survey Question 36**

*Question:* What is your best estimate of how long it has been since the city reservoirs were at 50 percent (one-half) of total capacity?

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>1-6 months</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>7-12 months</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>13-18 months</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>19-24 months</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>More than 24 months</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

**Table D.29. Results of Residential Survey Question 37**

*Question:* Under present conditions, what is your closest estimate of when the city of Corpus Christi will enter drought condition 3 and begin limiting water use as described in question 30?

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>1-6 months</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>7-12 months</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>13-18 months</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19-24 months</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>More than 24 months</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>
Table D.30. Results of Residential Survey Question 38

**Question:** Please estimate the period of time you think that water supplies remaining in the reservoirs will sustain residents and businesses under current rates of water use and reservoir recharge (provide your closest estimate in weeks, months, or years).

<table>
<thead>
<tr>
<th>Estimates (months)</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>1-6 months</td>
<td>2 2</td>
<td>4 15</td>
</tr>
<tr>
<td>7-12 months</td>
<td>0 5</td>
<td>5 19</td>
</tr>
<tr>
<td>13-18 months</td>
<td>1 1</td>
<td>2 8</td>
</tr>
<tr>
<td>19-24 months</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>More than 24 months</td>
<td>1 1</td>
<td>2 8</td>
</tr>
<tr>
<td>Don't know</td>
<td>4 7</td>
<td>11 42</td>
</tr>
<tr>
<td>No response</td>
<td>0 2</td>
<td>2 8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8 18</strong></td>
<td><strong>26 100%</strong></td>
</tr>
</tbody>
</table>

Table D.31. Results of Residential Survey Question 39

**Question:** Please indicate whether you agree or disagree with the following statement. (Table of residential surcharges included in survey.)

*The surcharge described above provides little or no incentive for most people to reduce water consumption by changing patterns of water use or replacing existing equipment with water-saving equipment.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>0 0</td>
<td>0 0%</td>
</tr>
<tr>
<td>Disagree</td>
<td>4 7</td>
<td>11 42%</td>
</tr>
<tr>
<td>Agree</td>
<td>3 5</td>
<td>8 31%</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>1 3</td>
<td>4 15%</td>
</tr>
<tr>
<td>Don't know</td>
<td>0 2</td>
<td>2 8%</td>
</tr>
<tr>
<td>Did not respond</td>
<td>0 1</td>
<td>1 4%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8 18</strong></td>
<td><strong>26 100%</strong></td>
</tr>
</tbody>
</table>
Table D.32. Results of Residential Survey Question 40  

**Question**: In column A below, please mark those water conservation efforts that your household has adopted to save water during the city’s water shortage. Then, pretend for a moment that you live in San Diego, California, and that the city of San Diego has rationed water use in each household and adopted a mandatory $1,000 fine for the first violation and for each violation thereafter. In column B indicate which four (4) of the practices listed below you would implement first to live within your water ration. Mark exactly four. None of the items below are required under the drought management plan. Do no mark in column B any of the choices that you marked in column A.

<table>
<thead>
<tr>
<th>Voluntary Conservation Measure</th>
<th>Number of Responses</th>
<th>All Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed</td>
</tr>
<tr>
<td></td>
<td>Participants</td>
<td>Surveys</td>
</tr>
<tr>
<td>Reduced use of washing machine (please estimate percent of decrease).</td>
<td>1 6</td>
<td>7 8</td>
</tr>
<tr>
<td>Reduced use of garbage disposal (please estimate percent of decrease).</td>
<td>0 3</td>
<td>3 3</td>
</tr>
<tr>
<td>Ceased use of garbage disposal.</td>
<td>1 2</td>
<td>3 3</td>
</tr>
<tr>
<td>Reduced use of dishwasher (please estimate percent of decrease).</td>
<td>0 3</td>
<td>3 3</td>
</tr>
<tr>
<td>Ceased use of dishwasher in favor of hand washing.</td>
<td>0 8</td>
<td>8 9</td>
</tr>
<tr>
<td>Adopted strict limits on showering time (indicate time limit if any).</td>
<td>5 4</td>
<td>9 10</td>
</tr>
<tr>
<td>Replaced existing shower head with water-saving (low-flow) shower head.</td>
<td>1 1</td>
<td>2 2</td>
</tr>
<tr>
<td>Replaced faucets with water-saving (low-flow) faucets in kitchen/bathroom sinks.</td>
<td>3 4</td>
<td>7 8</td>
</tr>
<tr>
<td>Repaired leaky faucets.</td>
<td>1 2</td>
<td>3 3</td>
</tr>
<tr>
<td>Reduced the level of water in existing toilets.</td>
<td>1 3</td>
<td>4 4</td>
</tr>
<tr>
<td>Replaced existing toilet with new water-saving toilet.</td>
<td>1 4</td>
<td>5 6</td>
</tr>
<tr>
<td>Avoid flushing as much as possible.</td>
<td>2 3</td>
<td>5 6</td>
</tr>
<tr>
<td>Began a household water re-use program.</td>
<td>4 5</td>
<td>9 10</td>
</tr>
<tr>
<td>Ceased indoor and outdoor plant watering (other than lawns).</td>
<td>2 3</td>
<td>5 6</td>
</tr>
<tr>
<td>Ceased lawn-watering.</td>
<td>2 10</td>
<td>12 13</td>
</tr>
<tr>
<td>None of the above.</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>Other (please describe).</td>
<td>0 0</td>
<td>0 0</td>
</tr>
<tr>
<td>No response.</td>
<td>2 2</td>
<td>4 4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>26 63</td>
<td>89 100%</td>
</tr>
</tbody>
</table>
Table D.33. Results of Residential Survey Question 41

**Question:** Suppose that as the drought continues, there is no end in sight. The city Manager has asked you to select five water-use restrictions to begin immediately. Please select the next five (5) restrictions on water use by placing a check in the space provided.

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>New customer connections to the city’s water supply are prohibited.</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Use of water to serve at restaurants unless requested by customer is prohibited.</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Use of water to expand commercial nurseries is prohibited.</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>Use of water for scenic and recreational ponds and lakes is prohibited.</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>Use of water for private residential swimming pools, hot tubs, and wading pools is prohibited.</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Use of water for pools in hotels, health clubs, and country clubs is prohibited.</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Use of water in public swimming pools is prohibited.</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Use of water to begin growing crops on new agricultural land is prohibited.</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Use of water to begin new planting and landscaping is prohibited.</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>No response.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>42</td>
<td>89</td>
</tr>
</tbody>
</table>

Table D.34. Results of Residential Survey Question 42

**Question:** Studies show that the present water shortage could have been avoided if the proposed pipeline from Lake Texana had been completed. It is likely that the proposed pipeline could be approved and built in 18 months. Based on what you know now, please answer each of the following questions.

A. Would you support construction of the pipeline with no increase in water rates?

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Yes</td>
<td>6</td>
<td>14</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>
B. Would you support a price increase of 44 cents per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>3</td>
<td>9</td>
<td>12</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>23</td>
<td>8</td>
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<tr>
<td>Don't know</td>
<td>1</td>
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<td>4</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
<td>26</td>
<td>100%</td>
<td>26</td>
</tr>
</tbody>
</table>

C. Would you support a price increase of 87 cents per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td>9</td>
<td>12</td>
<td>46</td>
<td>8</td>
</tr>
<tr>
<td>Don't know</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
<td>26</td>
<td>100%</td>
<td>26</td>
</tr>
</tbody>
</table>

D. Would you support a price increase of $1.74 per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>5</td>
<td>12</td>
<td>17</td>
<td>65</td>
<td>8</td>
</tr>
<tr>
<td>Don't know</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
<td>26</td>
<td>100%</td>
<td>26</td>
</tr>
</tbody>
</table>

E. Would you support a price increase of $2.61 per 1,000 gallons to pay for the pipeline?

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don't know</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>No</td>
<td>6</td>
<td>14</td>
<td>20</td>
<td>77</td>
<td>8</td>
</tr>
<tr>
<td>Don't know</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>15</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
<td>26</td>
<td>100%</td>
<td>26</td>
</tr>
</tbody>
</table>
Table D.35. Results of Residential Survey Question 43

Question: Some people have suggested that the city of Corpus Christi could achieve the goals of water conservation by raising the price of water rather than limiting the amount of water people use. Please indicate whether you would prefer limits on your water use or the price increases listed below.

A. If water prices were two (2) times current rates, would you prefer:

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Higher rates</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Limits on water use</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>No response</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>

B. If water prices were three (3) times current rates, would you prefer:

<table>
<thead>
<tr>
<th></th>
<th>Higher rates</th>
<th>Limits on water use</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>18</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>69</td>
<td>19</td>
<td>100%</td>
</tr>
</tbody>
</table>

C. If water prices were four (4) times current rates, would you prefer:

<table>
<thead>
<tr>
<th></th>
<th>Higher rates</th>
<th>Limits on water use</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>19</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>73</td>
<td>19</td>
<td>100%</td>
</tr>
</tbody>
</table>

D. If water prices were five (5) times current rates, would you prefer:

<table>
<thead>
<tr>
<th></th>
<th>Higher rates</th>
<th>Limits on water use</th>
<th>No response</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>7</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>12</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>19</td>
<td>5</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>73</td>
<td>19</td>
<td>100%</td>
</tr>
</tbody>
</table>
Table D.36. Results of Residential Survey Question 44

**Question:** How would you rank the cost of your water bill relative to other costs in your household? Please indicate whether the monthly household costs listed below are higher or lower than your monthly water cost by circling your choices in the table below.

<table>
<thead>
<tr>
<th>Other Household Cost</th>
<th>Number of Responses</th>
<th>All Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
</tr>
<tr>
<td>Monthly grocery bills</td>
<td></td>
<td></td>
</tr>
<tr>
<td>are higher than monthly water bill.</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>are lower than monthly water bill.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>no response</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Monthly electric utility bill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>is higher than monthly water bill.</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>is lower than monthly water bill.</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>no response</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Monthly cost of gasoline for one car</td>
<td></td>
<td></td>
</tr>
<tr>
<td>is higher than monthly water bill.</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>is lower than monthly water bill.</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>no response</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Monthly cable television bill</td>
<td></td>
<td></td>
</tr>
<tr>
<td>is higher than monthly water bill.</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>is lower than monthly water bill.</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>no response</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Monthly laundry or dry-cleaning costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>are higher than monthly water bill.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>are lower than monthly water bill.</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>no response</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
<tr>
<td>Monthly cost of garbage pickup</td>
<td></td>
<td></td>
</tr>
<tr>
<td>is higher than monthly water bill.</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>is lower than monthly water bill.</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>no response</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>18</td>
</tr>
</tbody>
</table>
Table D.37. Results of Residential Survey Question 45  
**Question:** Please indicate whether you agree or disagree with the following statement. *The availability of water influences the decisions of new businesses to locate in Corpus Christi.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
<td>13</td>
<td>15</td>
<td>58</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table D.38. Results of Residential Survey Question 46  
**Question:** Please indicate whether you agree or disagree with the following statement. *The reliability of the Corpus Christi water supply could prevent the expansion of existing city businesses.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Focus Group</td>
<td>Mailed Surveys</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>12</td>
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<tr>
<td>Agree</td>
<td>2</td>
<td>11</td>
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<td>Agree strongly</td>
<td>3</td>
<td>4</td>
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<td>27</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Table D.39. Results of Residential Survey Question 47  
**Question:** Please indicate whether you agree or disagree with the following statement. *Employment in Corpus Christi will be affected by the drought restrictions.*

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>All Respondents</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
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<td>Focus Group</td>
<td>Mailed Surveys</td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Disagree strongly</td>
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<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Agree</td>
<td>3</td>
<td>12</td>
<td>15</td>
<td>58</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>19</td>
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<tr>
<td>Don’t know</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>
### Table D.40. Results of Residential Survey Question 48

**Question:** Please indicate whether you agree or disagree with the following statement. 
_The water shortage could contribute to a decrease in tourism this season._

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>27</td>
<td>2</td>
<td>42</td>
</tr>
<tr>
<td>Agree</td>
<td>1</td>
<td>10</td>
<td>11</td>
<td>42</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>15</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Did not respond</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>15</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
<td><strong>100%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table D.41. Results of Residential Survey Question 49

**Question:** Please indicate whether you agree or disagree with the following statement. 
_The value of land and homes in Corpus Christi could erode if more reliable water supplies cannot be acquired._

<table>
<thead>
<tr>
<th>Answer</th>
<th>Number of Responses</th>
<th>Focus Group Participants</th>
<th>Mailed Surveys</th>
<th>All Respondents</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disagree strongly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Disagree</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Agree</td>
<td>2</td>
<td>12</td>
<td>14</td>
<td>54</td>
<td>2</td>
<td>54</td>
</tr>
<tr>
<td>Agree strongly</td>
<td>3</td>
<td>4</td>
<td>7</td>
<td>27</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>Don’t know</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Did not respond</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>12</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8</strong></td>
<td><strong>18</strong></td>
<td><strong>26</strong></td>
<td><strong>100%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Anonymous Participant Questionnaire
Residential Water Users

The following survey is designed to help the city of Corpus Christi obtain information about customers' preferences and interests. The time allotted for this survey is 30 minutes. We would rather you make a reasonable estimate than skip a question, but if you don't feel comfortable answering a question, please skip it. If you do not finish all of the questions, please draw a line across the page below your last response.

1. Please identify those water conservation efforts listed below that your household has adopted to save water SINCE April 9, 1996 or in response to warnings of water shortage. (The city of Corpus Christi declared drought condition 1 on April 9 and instituted mandatory water conservation efforts on May 6, 1996.) Please check all that apply.

___ Reduced use of washing machine (please estimate percent of decrease ________%).
___ Reduced use of garbage disposal (please estimate percent of decrease ________%).
___ Ceased use of garbage disposal.
___ Reduced use of dishwasher (please estimate percent of decrease ________%).
___ Ceased use of dishwasher in favor of hand washing.
___ Adopted strict limits on showering time (indicate time limit in minutes if any ________).
___ Replaced existing shower head with water-saving (low-flow) shower head. List make and/or model if known: ________________________________________________
___ Replaced existing faucets with water-saving (low-flow) faucets in kitchen and bathroom sinks.
___ Repaired leaky faucets.
___ Reduced the level of water in existing toilets.
___ Replace existing toilet with new water-saving toilet.
___ Avoid flushing toilet as much as possible.
___ Began a household water reuse program.
___ Ceased indoor and outdoor plant watering (other than lawns).
___ Reduced lawn watering to a level lower than present city lawn-watering restrictions require.
___ Ceased lawn watering.
___ None of the above.

Please describe any other water conservation practices you have adopted in your household (use back of page for more space):

2. Which three of the water conservation practices listed in question 1 do you think are most effective? Please look again at the list of choices in question 1 and place an asterisk (*) next to the three practices that you think save the most water. You do not have to limit your answers to those you checked in response to question 1.
3. Water prices for a household in the city of Corpus Christi increase as the amount of water used by the household increases. Please circle the price that you believe is closest to the actual price of each water increment. Do not include any fixed monthly charges. Please mark one price for each water increment.

<table>
<thead>
<tr>
<th>Water Increment</th>
<th>Price per 1,000 gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>first 2,000 gallons</td>
<td>$0.00 $0.50 $1.00 $1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50</td>
</tr>
<tr>
<td>next 4,000 gallons</td>
<td>$0.50 $1.00 $1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00</td>
</tr>
<tr>
<td>next 9,000 gallons</td>
<td>$1.00 $1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00 $5.50</td>
</tr>
<tr>
<td>next 15,000 gallons</td>
<td>$1.50 $2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00 $5.50 $6.00</td>
</tr>
<tr>
<td>next 20,000 gallons</td>
<td>$2.00 $2.50 $3.00 $3.50 $4.00 $4.50 $5.00 $5.50 $6.00 $6.50</td>
</tr>
</tbody>
</table>

We appreciate your patience. Now, we ask that you answer the following questions about your household to help us in our study.

4. Which of the following categories most closely describes your annual household income.

- less than $15,000 per year
- $15,001 - $25,000 per year
- $25,001 - $35,000 per year
- $35,001 - $45,000 per year
- $45,001 - $55,000 per year
- $55,001 - $65,000 per year
- $65,001 - $75,000 per year
- over $75,000 per year

5. How many people live in your household? ______________________

6. Which best describes the place where you live:

- Single-family home
- Apartment/condominium
- Duplex
- Other (describe)

If you answered “single-family home” to this question, please skip to question 8.

7. Do you live in an apartment or other building where water costs are included in monthly rent?

- Yes
- No
- Don’t know

If you answered no to question 7, please skip questions 7a and 7b. If you answered “yes” to question 7, please answer the following questions:

7a. Does your apartment/condominium have an individual water meter?

- Yes
- No
- Don’t know

7b. Has the management at your apartment/condominium complex started a water conservation program?

- Yes
- No
- Don’t know

8. If your household receives a water bill each month, are you the person responsible for paying it?
9. Are you the person most knowledgeable about how water is used in your household? ____Yes ____No

10. Are you the person in your household with the greatest impact on water use strategies? ____Yes ____No

11. Gender: ____ Male ____ Female


13. Please check the category that best describes the level of your education:
   ____ Eighth grade or less  ____ Vocational/technical or trade school
   ____ Some high school  ____ Some college
   ____ High school completed  ____ College graduate  ____ Graduate work

14. Please provide your best estimate of the typical monthly water bill in your household:
   $__________  ____ Don't know

15. Please provide your best estimate of the typical volume of water used in your household each month:
   ____________ gallons  ____ Don't know

16. How does your water use this July compare to your water use last July?
   ____ I am using less water this July than last July.
   ____ I am using about the same amount of water this July as last July.
   ____ I am using more water this July than last July.

17. Do you know where your water meter is located? ____Yes ____ No

18. Do you know how to read your water meter? ____ Yes ____ No

Thank you . . . Just a few more general questions.

19. Were you a resident of Corpus Christi or of a community served by the Corpus Christi Water Department during 1984-1985? ____ Yes ____ No
20. Are you familiar with drought conditions 1-4 of the city’s drought management plan? ___Yes ___No

Please indicate whether you agree or disagree with the following statements:

21. My household water use accounts for such a small amount of the total water demand in Corpus Christi that my individual efforts to date HAVE NOT made a meaningful contribution to reducing overall water use.

<table>
<thead>
<tr>
<th>Disagree strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree strongly</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

22. The city is capable of planning a solution to the current water shortage.

<table>
<thead>
<tr>
<th>Disagree strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree strongly</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

23. People in my neighborhood abide by the city’s regulations for outdoor water use.

<table>
<thead>
<tr>
<th>Disagree strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree strongly</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

24. I read all the information I can find about current events surrounding the city’s water management program and the current water shortage.

<table>
<thead>
<tr>
<th>Disagree strongly</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree strongly</th>
<th>Don’t know</th>
</tr>
</thead>
</table>

25. The present water shortage is PRIMARILY a result of (please choose one):

- high evaporation combined with lack of rainfall to the city’s reservoirs.
- overuse of city water by residential consumers.
- overuse of city water by industrial consumers.
- inadequate management of the city’s reservoirs.
- freshwater inflow requirements to bays and estuaries.
- other (please describe: ________________________________).
- don’t know

26. Which alternative do you consider to be the BEST method of producing increased water supplies to the city of Corpus Christi (please choose one)?
increased water conservation by city residents
increased water conservation by industry and businesses
construction of pipeline to city from Lake Texana
desalination of seawater
exploration of local groundwater options
modified operation of city reservoirs
other (please describe: ________________________________)
don’t know

27. Which is closest to your view? Current restrictions on water use under drought condition 2:

___ are both an inconvenience and a cost.
___ are more of an inconvenience than a cost.
___ are more of a cost than an inconvenience.
___ are neither an inconvenience nor a cost.

28. Please describe and estimate the cost of any one-time purchases or repairs you have made to comply with the
CURRENT regulations on outdoor water use.
29. Please describe and estimate any regular (daily, weekly, monthly) costs to your household that can be directly attributed to the CURRENT regulations on water use. Do not include any fines for violation of city ordinances related to water use.

  ___ The estimated cost is $_______ (please circle: daily/weekly/monthly). Please describe these costs in the space provided below.

  ___ There are costs but I am unable to estimate them. Please describe these costs below.

  ___ I believe there are costs to my household but I can neither describe nor estimate these costs.

  ___ There are no daily/weekly/monthly costs to my household.

  ___ other (please explain briefly in the space below:)

  .

  .

  .

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30. Water rationing will begin when the city of Corpus Christi moves from drought condition 2 to drought condition 3. The plan allows each household to use a limited amount of water each month. The monthly limits will be:

<table>
<thead>
<tr>
<th>Number of residents in household</th>
<th>Maximum monthly water allowance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 people</td>
<td>6,000 gallons</td>
</tr>
<tr>
<td>3-4 people</td>
<td>7,000 gallons</td>
</tr>
<tr>
<td>5-6 people</td>
<td>8,000 gallons</td>
</tr>
<tr>
<td>7-8 people</td>
<td>9,000 gallons</td>
</tr>
<tr>
<td>9-10 people</td>
<td>10,000 gallons</td>
</tr>
<tr>
<td>11 or more</td>
<td>12,000 gallons</td>
</tr>
</tbody>
</table>

In the first stages of drought condition 3, households will pay a surcharge for water use that exceeds their water allowance. What is closest to your view of how the city should act?

___ The city should not implement a water rationing program under drought condition 3.

___ The city should implement a water rationing program less restrictive than the current plan under Drought Condition 3.

___ The city should implement the water rationing program as planned under drought condition 3.

___ The city should implement a water rationing program more restrictive than the current plan under Drought Condition 3.

Please indicate whether you agree or disagree with the following statements about the rationing plan described in question 30:

31. My household can easily manage with the water allowance prescribed for drought condition 3 under the drought management plan:

<table>
<thead>
<tr>
<th>Disagree strongy</th>
<th>Disagree</th>
<th>Agree strongly</th>
<th>Agree</th>
<th>Don't know</th>
</tr>
</thead>
</table>

32. I anticipate that monthly expenses in my household will increase if the city decides to limit household water use as planned under drought condition 3.

<table>
<thead>
<tr>
<th>Disagree strongly</th>
<th>Disagree</th>
<th>Agree strongly</th>
<th>Agree</th>
<th>Don't know</th>
</tr>
</thead>
</table>
33. The system that will be used to ration water among residential customers in drought condition 3 (described in question 30) results in a fair distribution of water among city residents.

Disagree Disagree Agree Agree Don't
strongly strongly strongly know

34. The city should limit water use among residential customers first before limiting water use among businesses and commercial interests.

Disagree Disagree Agree Agree Don't
strongly strongly strongly know

35. The current drought management plan requires the city to limit household water use as described in question 30 when the combined volume of the reservoirs is 11 percent of total capacity. Please indicate which of the following policies most closely represents your view of how the city should act.

___ Limit household water use as soon as possible.
___ Limit household water use when reservoirs are 20 percent of total capacity.
___ Limit household water use when reservoirs are 11 percent of total capacity.
___ Wait even longer to limit household water use.

36. What is your best estimate of how long it has been since the city reservoirs were at 50 percent (one half) of total capacity?

___ 1 month ___ 3 months ___ 9 months ___ 18 months
___ 2 months ___ 6 months ___ 1 year ___ 2 years

37. Under present conditions, what is your closest estimate of when the city of Corpus Christi will enter drought condition 3 and begin limiting water use as described in question 30?

___ 1 month ___ 3 months ___ 9 months ___ 18 months
___ 2 months ___ 6 months ___ 1 year ___ 2 years

38. Please estimate the period of time you think that water supplies remaining in the reservoirs will sustain residents and businesses under current rates of water use and current rates of reservoir recharge (provide your closest estimate in weeks, months, or years).

____ weeks ________ months ________ years ________ Don’t know

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39. In the next stage of the drought management plan, each household that uses more than its maximum monthly water allowance will pay a surcharge for water, in addition to regular water rates. The surcharge for water is as follows:

<table>
<thead>
<tr>
<th>Number of gallons over allocation</th>
<th>Surcharge per 1,000 gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>First 1,000 gallons over allocation</td>
<td>$3.00</td>
</tr>
<tr>
<td>Next 1,000 gallons over allocation</td>
<td>$5.00</td>
</tr>
<tr>
<td>Next 1,000 gallons over allocation</td>
<td>$10.00</td>
</tr>
<tr>
<td>Each additional 1,000 gallons over allocation</td>
<td>$25.00</td>
</tr>
</tbody>
</table>

Please indicate whether you agree or disagree with the following statement:

The surcharge described above provides little or no incentive for most people to reduce water consumption by changing patterns of water use or replacing existing equipment with water-saving equipment.

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

40. In column A below, please mark those water conservation efforts that your household has adopted to save water during the city’s water shortage.

Then, pretend for a moment that you live in San Diego, California, and that the city of San Diego has rationed water use in each household and adopted a mandatory $1,000 fine for the first violation and for each violation thereafter. In column B, indicate which four (4) of the practices listed below you would implement first to live within your water ration. **Mark exactly four.** None of the items below are required under the drought management plan. **Do not mark in column B any of the choices that you marked in column A.**

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce use of washing machines (please estimate percent of decrease ________ %).</td>
<td></td>
</tr>
<tr>
<td>Reduce use of garbage disposal (please estimate percent of decrease ________ %).</td>
<td></td>
</tr>
<tr>
<td>Cease use of garbage disposal.</td>
<td></td>
</tr>
<tr>
<td>Reduce use of dishwasher (please estimate decreased use as a percentage ________ %).</td>
<td></td>
</tr>
<tr>
<td>Cease use of dishwasher in favor of hand washing.</td>
<td></td>
</tr>
<tr>
<td>Limit showering time (please indicate time limit ________ minutes).</td>
<td></td>
</tr>
<tr>
<td>Replace existing shower head with water-saving shower head.</td>
<td></td>
</tr>
<tr>
<td>Replace existing faucets with water-saving (low-flow) faucets in kitchen and bathroom sinks.</td>
<td></td>
</tr>
<tr>
<td>Repair leaky faucets.</td>
<td></td>
</tr>
<tr>
<td>Reduce water level in the existing toilet.</td>
<td></td>
</tr>
<tr>
<td>Replace existing toilet with water-saving toilet.</td>
<td></td>
</tr>
<tr>
<td>Avoid flushing toilet as much as possible.</td>
<td></td>
</tr>
<tr>
<td>Begin a household water reuse program.</td>
<td></td>
</tr>
<tr>
<td>Cease watering of indoor and outdoor plants (other than lawns).</td>
<td></td>
</tr>
<tr>
<td>Cease lawn watering.</td>
<td></td>
</tr>
<tr>
<td>None of the above.</td>
<td></td>
</tr>
</tbody>
</table>
If there are any water conservation practices NOT listed above that you would adopt in your household BEFORE undertaking the water conservation strategies listed above, please describe them below.

41. Suppose that as the drought continues, there is no end in sight. The city Manager has asked you to select five water-use restrictions to begin immediately. Please select the next five (5) restrictions on water use by placing a check in the space provided.

___New customer connections to the city's water supply are prohibited.
___Use of water to serve at restaurants unless requested by the customer is prohibited.
___Use of water to expand commercial nurseries is prohibited.
___Use of water for scenic and recreational ponds and lakes is prohibited.
___Use of water for private residential swimming pools, hot tubs, and wading pools is prohibited.
___Use of water for pools in hotels, health clubs, and country clubs is prohibited.
___Use of water in public swimming pools is prohibited.
___Use of water to begin growing crops on new agricultural land is prohibited.
___Use of water to begin new planting and landscaping is prohibited.

42. Studies show that the present water shortage could have been avoided if the proposed pipeline from Lake Texana had been completed. It is likely that the proposed pipeline could be approved and built in 18 months. Based on what you know now, please answer each of the following questions.

Would you support construction of the pipeline with no increase in water rates?

___Yes ___No ___Don't know

Would you support a price increase of 44 cents per 1,000 gallons to pay for the pipeline?

___Yes ___No ___Don't know

Would you support a price increase of 87 cents per 1,000 gallons to pay for the pipeline?

___Yes ___No ___Don't know

Would you support a price increase of $1.74 per 1,000 gallons to pay for the pipeline?

___Yes ___No ___Don't know

Would you support a price increase of $2.61 per 1,000 gallons to pay for the pipeline?

___Yes ___No ___Don't know
43. Some people have suggested that the city of Corpus Christi could achieve the goals of water conservation by raising the price of water rather than limiting the amount of water people use. Please indicate whether you would prefer limits on your water use or the price increases listed below:

If water prices were two (2) times current rates, would you prefer: □ higher rates □ limits on water use

If water prices were three (3) times current rates, would you prefer: □ higher rates □ limits on water use

If water prices were four (4) times current rates, would you prefer: □ higher rates □ limits on water use

If water prices were five (5) times current rates, would you prefer: □ higher rates □ limits on water use

44. How would you rank the cost of your water bill relative to other costs in your household? Please indicate whether the monthly household costs listed below are higher or lower than your monthly water cost by circling your choices in the table below.

<table>
<thead>
<tr>
<th>Monthly water bill is:</th>
<th>monthly grocery bills</th>
</tr>
</thead>
<tbody>
<tr>
<td>higher than</td>
<td>lower than</td>
</tr>
<tr>
<td>higher than</td>
<td>lower than</td>
</tr>
<tr>
<td>higher than</td>
<td>lower than</td>
</tr>
<tr>
<td>higher than</td>
<td>lower than</td>
</tr>
<tr>
<td>higher than</td>
<td>lower than</td>
</tr>
</tbody>
</table>

If the city enters drought condition 4, it may begin to allocate water to business and industry and to charge a penalty to businesses that use more than their monthly allocation. If this happens, will the water shortage begin to affect the Corpus Christi economy? Please indicate whether you agree or disagree with the following statements.

45. The availability of water influences the decisions of new businesses to locate in Corpus Christi.

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

46. The reliability of the Corpus Christi water supply could prevent the expansion of existing city businesses.

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

47. Employment in Corpus Christi will be affected by the drought restrictions.

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

48. The water shortage could contribute to a decrease in tourism this season.
49. The value of land and homes in Corpus Christi could erode if more reliable water supplies cannot be acquired.

<table>
<thead>
<tr>
<th>Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Agree</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>strongly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Thank you very much for your cooperation. In a few minutes we will collect the surveys and begin the focus group session.
Appendix E. A Manual for Converting the Municipal Utility Database to Analyzable Form

This appendix describes the process and programs the project team used to convert the municipal utility database to a format suitable for analysis with conventional database and statistical software. The city of Corpus Christi maintains its municipal utility database on an IBM mainframe machine in a system called VSAM constructed in COBOL. The system was designed in 1977 as an accounting system suitable for tracking and viewing information by customer account. All system programming is accomplished using the COBOL language. Because the municipal information system maintains a high workload and a significant programming effort is required to access and convert the database, the system is not accessible to water utility managers who want to carry out analyses of water demand or the water supply system at the level of customer account. One objective of this project has been to develop database screens and to incorporate these data into a water conservation analysis that would permit a level of data disaggregation not available from other sources.

The Municipal Information System (MIS) Department of the city of Corpus Christi provided the project team with copies of the backup municipal utility database files for fiscal years 1992 through 1996 and for the first month of fiscal year 1997. The fiscal year runs from August 1 through July 31. Backup files consist of three databases including the master file, the history file, and the support file. Only information contained in the master and history files were relevant to the goals of this project. Master files describe the details of accounts current in any one fiscal year. For example, the files contain information on customer name, service address, billing address, and payment history. Each master file record is indexed by a single account number and codes describing rate structures and utility services. History files are a record of each customers' water use, gas use, billing date, and meter read date during each month of the fiscal year. In addition, each history file contains a record of water use, gas use, billing date, and meter read date during the immediate past fiscal year for residential customer accounts and the immediate past two years for nonresidential customer accounts. History records for each fiscal year were referenced from the master file by account number for the fiscal year of the master file. Support files contain information for accounts with multiple meters associated with a single service address.

The MIS department created copies of master and history files, converted these copies from COBOL to EBCDIC format, and stored these data on 6,250 reel tapes and 210-megabyte 3,480 cartridge tapes. Most data files obtained from the city of Corpus Christi required multiple tapes. University of Texas at Austin (UTA) hardware requirements made routine use of 6,250 reel tapes impractical and the project team adopted 3,480 cartridge tapes as the standard early in the project. Data were transferred from the 3,480 cartridge tapes to UTA's VAX machine and converted to ASCII format. Table E.1 describes each data tape received from the city, names the download file, identifies UTA's conversion program, and describes information about the output file and its location. For example, the city of Corpus Christi provided the project team with the fiscal year 1993 utility master file on Tape ID Number 1009 and specified the record length as 1,065 characters and the block size as 31,950. The download file contained on the tape was MAS93, which was 131 megabytes. The project team used a FORTRAN program,
MAS1065.FOR, to convert selected information in the database to a format suitable for dBASE IV and SAS. The FORTRAN program appends a unique "out" extension to the output file. Therefore, MAS93 was converted to MAS93.0UT, which is 37 megabytes.

The conversion process consists of transferring the original download files to a mainframe or personal computer and running the appropriate FORTRAN conversion programs to create subset ASCII files. Conversion programs are titled MAS80.FOR, MAS1065.FOR, and HIS250.FOR. All subset files for each fiscal year are combined into a single dBASE file for each fiscal year based upon a control file titled CTRLFILE, which is produced automatically by the FORTRAN conversion program. The format and structure of this intermediate dBASE file is provided in Table E.2 along with brief information about the source field in the original history and master files. The original field name in the municipal utility database is underlined beneath its corresponding field name. The abbreviations MF and AR that prefix field names stand for master and history files, respectively, and indicate the origin of the data field. A data dictionary describing the complete contents of master and history files and field subcodes is available from the Municipal Information Systems Department. Data may be aggregated or further processed while in dBASE format, as in the addition of aggregate rainfall and monthly mean maximum temperature (FILMAS.PRG) based on each customer's meter read date, or the calculation of marginal water prices (PTPRICE.PRG). Analysis of the database is accomplished using a single aggregate database created by combining subset databases from each fiscal year. Output datasets can be created using only the variables necessary for specific analyses. Separate dBASE files for each fiscal year are maintained because these files are smaller and can therefore be used to minimize the processing time and space requirements of some tasks.

The contents and structure of the multiyear dBASE file, HMSA3456.DBF, are provided in Table E.3. This project accessed only that information that appeared useful to accomplish project goals. Thirteen fields from the original master file and 24 fields from the original history files were combined to form the output databases. Database records are indexed by key fields including account number, rate code, and water code. The account number is a nine-digit number in which the first two digits represent the billing cycle and the last digit is a location-specific customer identification code. Account numbers are permanently assigned to individual meters and the last digit of the account number increments by one when a new customer takes over the account. Each customer account is classified by a six-digit rate code used to identify the rate structure which the account falls into for billing purposes for services being used. The first digit describes whether the account falls inside or outside the city limits. Subsequent digits indicate the types of available services purchased, including water, utility gas, sewer, and garbage pickup. The water code is used to identify water utility customer type; for example, whether this account is a residential, commercial, industrial, or city account. This project made routine use of the account number, rate code, and water codes to cross-reference records and aggregate information in the master and history files.

The final database, HMSA3456.DBF, includes 41 fields, including 3 fields that are either calculated or merged from other databases. Aggregate monthly rainfall (inches) and mean maximum monthly temperature (Farenheit) represent rainfall and temperature for each account during the water use period. These variables are calculated by aggregating daily rainfall and
averaging daily temperature data over the water use period. Rainfall and temperature data were obtained from the Office of the Texas State Climatologist at Texas A&M University. The third calculated variable is PRICE. PRICE represents the marginal price paid by this customer for the last thousand-gallon increment.

Data Processing Procedure
The data conversion system developed for the Corpus Christi municipal utility database is an unintegrated system. A description of procedural steps is provided in Table E.5. While this maximizes the amount of flexibility a user has to adapt the project as needed, that user needs to know how the conversion process works to successfully complete the procedure. Knowledge of FORTRAN programming and dBASE IV are minimum requirements.

The objective of the procedure is to create an output dataset consisting of a set of variables that are appropriate for the selected analysis. A procedural flowchart (Figure E.1) describes the process. Steps in the figure are numbered, and these steps and numbers correspond to the numbers in Table E.5. The location of files created at each step during the conversion process is listed according to location on data tapes. UT/A staff provided data tapes used in the analysis to city of Corpus Christi staff upon completion of this report.
Table E.1. Table Listing File Types

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<th>Record Length</th>
<th>Block Size</th>
<th>Conversion Program</th>
<th>Original Download File</th>
<th>ASCII Subset</th>
<th>dBASE IV File</th>
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### Table E.2. Format and Structure of the Intermediate dBASE IV file HISMAS9x.DBF

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<th>Content (Municipal Utility Reference Field Underlined)</th>
<th>Type</th>
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<td>ACCT_NUM</td>
<td>Account number</td>
<td>Character 9</td>
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</tr>
<tr>
<td></td>
<td>MF-Account - customer account number for service address</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NAME</td>
<td>Customer name</td>
<td>Character 25</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MF-Name - Name of customer at the service address standardized to last name, first name, middle initial, suffix</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STR_CODE</td>
<td>Street code</td>
<td>Character 4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MF-Service Address - Physical address of the water meter location</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S_A_BLOCK</td>
<td>Service address block</td>
<td>Character 5</td>
<td></td>
</tr>
<tr>
<td>S_A_SUFF</td>
<td>Service address suffix</td>
<td>Character 3</td>
<td></td>
</tr>
<tr>
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<td>Service address direction</td>
<td>Character 2</td>
<td></td>
</tr>
<tr>
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<td>Service address street</td>
<td>Character 20</td>
<td></td>
</tr>
<tr>
<td>S_A_SSUF</td>
<td>Service street suffix</td>
<td>Character 2</td>
<td></td>
</tr>
<tr>
<td>S_A_ATYP</td>
<td>Service address apartment type</td>
<td>Character 2</td>
<td></td>
</tr>
<tr>
<td>S_A_ANO</td>
<td>Service address apartment number</td>
<td>Character 4</td>
<td></td>
</tr>
<tr>
<td>M_A_BLOCK</td>
<td>Mailing address block</td>
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<td></td>
</tr>
<tr>
<td>M_A_SUFF</td>
<td>Mailing address suffix</td>
<td>Character 3</td>
<td></td>
</tr>
<tr>
<td>M_A_DIRE</td>
<td>Mailing address direction</td>
<td>Character 2</td>
<td></td>
</tr>
<tr>
<td>M_A_STRE</td>
<td>Mailing address street</td>
<td>Character 20</td>
<td></td>
</tr>
<tr>
<td>M_A_SSUF</td>
<td>Mailing street suffix</td>
<td>Character 2</td>
<td></td>
</tr>
<tr>
<td>M_A_ATYP</td>
<td>Mailing address apartment type</td>
<td>Character 2</td>
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</tr>
<tr>
<td>M_A_ANO</td>
<td>Mailing address apartment number</td>
<td>Character 4</td>
<td></td>
</tr>
<tr>
<td>M_A_CITY</td>
<td>Mailing address city name</td>
<td>Character 15</td>
<td></td>
</tr>
<tr>
<td>M_A_ZCOD</td>
<td>Mailing address zipcode</td>
<td>Character 11</td>
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</tr>
<tr>
<td>BILLDATE</td>
<td>The date which the city of Corpus Christi bills the customer</td>
<td>Character 6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>AR-PROCESS-DATE - DDMYYY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>READDATE</td>
<td>Meter read date. Date the water meter was read (DDMMYY)</td>
<td>Character 6</td>
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Table E.2. Format and Structure of the Intermediate dBASE IV file HISMAS9x.DBF

substring from **AR_KEY** - MMDDYY

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<th>Description</th>
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<tr>
<td>RATES</td>
<td>Indicates inside of outside city limits and utility services used. MF-Rates identifies the rate structure for billing purposes</td>
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</tr>
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<td>ACCT_STA</td>
<td>Account status. MF-Acct-Status indicates current status of the account.</td>
<td>Character</td>
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<tr>
<td>WCI_DATE</td>
<td>Water meter cut in date. MF-Water-Cut-In-Date - Date water service starts on this account/meter</td>
<td>Character</td>
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</tr>
<tr>
<td>WCO_DATE</td>
<td>Water meter cut off date. MF-Water-Cut-Off-Date - Date water service discontinued for non-payment, seasonal, etc...</td>
<td>Character</td>
<td>6</td>
</tr>
<tr>
<td>INS_DATE</td>
<td>Water meter install date. MF-Water-Mr-Instal-Date - Date meter was installed</td>
<td>Character</td>
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</tr>
<tr>
<td>EST_FLAG</td>
<td>The label for estimated bill. flag for records with AR-TRANS-CODE subcoded 'EE'</td>
<td>Character</td>
<td>1</td>
</tr>
<tr>
<td>S_A_ZCOD</td>
<td>Service address zip code. MF-Serv-Addr-Zipcode</td>
<td>Character</td>
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</tr>
<tr>
<td>PRECIP</td>
<td>Aggregated precipitation (inches) during month of meter reading</td>
<td>Numeric</td>
<td>6</td>
</tr>
<tr>
<td>MAXTEMP</td>
<td>Averaged daily maximum temperature (degrees Fahrenheit)</td>
<td>Numeric</td>
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</tr>
<tr>
<td>PRICE</td>
<td>The marginal water price (calculated)</td>
<td>Numeric</td>
<td>6</td>
</tr>
<tr>
<td>TRAN_COD</td>
<td>Transaction code. AR-TRANS-CODE - Code that identifies the type of history file record</td>
<td>Character</td>
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<tr>
<td>W_U_DAY</td>
<td>The number of days water was used since last reading or estimate AR-WATER-USE-DAYS</td>
<td>Character</td>
<td>3</td>
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<tr>
<td>W_READ</td>
<td>Water meter reading. AR-WATER-READING</td>
<td>Character</td>
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<tr>
<td>W_CONS</td>
<td>Water consumption (thousand gallons). AR-WATER-CONS</td>
<td>Character</td>
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<tr>
<td>W_AMT</td>
<td>Dollar amount billed for water. AR-WATER-AMT</td>
<td>Character</td>
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<tr>
<td>G_U_DAY</td>
<td>Gas use days. AR-GAS-USE-DAYS</td>
<td>Character</td>
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<tr>
<td>G_READ</td>
<td>Gas meter reading number. AR-GAS-READING</td>
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<td>Gas consumption. AR-GAS-CONSUMPTION</td>
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<td>Dollar amount billed for gas consumption. AR-GAS-AMT</td>
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### Table E.3. Format and Structure of the dBASE IV file HMSA3456.DBF

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<tr>
<td>NAME</td>
<td>Customer name</td>
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<tr>
<td>BILLDATE</td>
<td>The date which the city of Corpus Christi bills the customer</td>
<td>Character</td>
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</tr>
<tr>
<td>READDATE</td>
<td>The date which the water meters were read</td>
<td>Character</td>
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</tr>
<tr>
<td>RATES</td>
<td>Water code to identify the sectors and the area to the city</td>
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<td>ACCT_STA</td>
<td>Account status</td>
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<td>WCL_DATE</td>
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</tr>
<tr>
<td>WCO_DATE</td>
<td>Water meter cut off date</td>
<td>Character</td>
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<td>INS_DATE</td>
<td>Water meter install date</td>
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<td>S_A_ZCOD</td>
<td>Service address zip code</td>
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<td>Aggregated precipitation</td>
<td>Character</td>
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<tr>
<td>MAXTEMP</td>
<td>Averaged daily maximum temperature</td>
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<td>The marginal water price</td>
<td>Character</td>
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<td>Water use days</td>
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</tbody>
</table>

### Table E.4. Aggregated dBASE Files Created and Archived for this Project

<table>
<thead>
<tr>
<th>Fiscal Year</th>
<th>Data File</th>
<th>Data Size (megabytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>not processed</td>
<td>-</td>
</tr>
<tr>
<td>1993</td>
<td>hismas93.dbf</td>
<td>245</td>
</tr>
<tr>
<td>1994</td>
<td>hismas94.dbf</td>
<td>178</td>
</tr>
<tr>
<td>1995</td>
<td>hismas95.dbf</td>
<td>251</td>
</tr>
<tr>
<td>1996</td>
<td>hismas96.dbf</td>
<td>223</td>
</tr>
<tr>
<td>1993-96</td>
<td>hmsa3456.dbf</td>
<td>499</td>
</tr>
</tbody>
</table>

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Table E.5. Description of Flowchart Steps for Conversion Procedure

Step 1. Request copies of original backup data
Backup files containing the municipal utility data can be obtained in EBCDIC format from the Municipal Information System Department, city of Corpus Christi. The department can create copies of backup files on either 10-inch reels or 3480 cartridge tapes. Two backup files in EBCDIC format are required for each fiscal year of the study period—the master file and the history file.

Steps 2 and 3. Transfer data from tapes
Backup files should be transferred to an IBM-compatible computer. Both master and history files require multiple tapes for each fiscal year of data. A separate file containing only a portion of the complete database is created when each tape is downloaded. These are referred to as the “subset data.” At least 450 megabytes of free storage are required to complete conversion of utility data for one fiscal year. Because the city’s backup files are saved in EBCDIC format, they need to be converted to ASCII format before continuing the procedure.

Step 4. Run conversion programs to create ASCII files
Raw data contain all variables in the utility database. Substantial amounts of time and storage space can be saved by discarding in the process any data that will not be analyzed. FORTRAN programs for this conversion are coded to write the subset data with only the necessary variables. Since both 6250 reel tapes and 3480 cartridge tapes were used for this project and these storage systems differ, two routines were needed: MAS80.FOR and HIS80.FOR. These routines download data from reel tapes. The routines MAS1650.FOR and HIS250.FOR manage data downloaded from 3480 cartridge tapes. Users can alter the selection of variables by making changes in the FORTRAN program. A complete list of codes and subcodes is available from the municipal information system. Table E.5 presents a partial list of variables used for the water conservation analysis.

Step 5. Create subset data in dBASE format
Outputs of the FORTRAN conversion program include a subset data file and a control file. These indicate the selection of variables (the subset datafile) and the data structure for dBASE files (control file). One blank dBASE file named HIS.DBF has been provided with the collection of datasets archived on tape for this project (HIS.DBF). If the selection of variables changes, a user should create a new dBASE file with the appropriate structure to receive the subset data.

Step 6. Copy datafile structure to new dBASE file
Copy the subset datafile structure output from that provided in the archive (HIS.DBF) to a new file to which all subset data will be appended. For example, this file could be called HIS93.DBF if it were to include the utility data for fiscal year 1993. This same procedure is completed in a separate step 6b for the master files.

Step 7. Append subset data (HIS101.OUT) to HIS93.DBF
The dBASE command Append should be used to store the subset data HIS101.OUT or other subset data in the storage database for the appropriate fiscal year. HIS93.DBF is a temporary storage file that contains all subset history files. This file is later merged with data from the master files. This same procedure should be completed in step 7b for the master files.

Step 8. Create output dataset in dBASE format
This is the dBASE file contained the subset history data. A separate dBASE file containing the master file is obtained by completing steps 6b and 7b.

Step 9. Run the dBASE program FILMAS.PRG
After history and master files have been converted to a dBASE file, the next step is to combine them by using account number (ACCT_NUM). The dBASE program "FILMAS.PRG" serves this purpose. The program will prompt the user for input and output file names during the run. For example, if fiscal year 1993 history and
master files are being merged, then the user would indicate the input file names are HIS93.DBF and MAS93.DBF. The output file name would be HISMAS93.DBF.

**Step 10. Obtain climatological data**
   Daily precipitation and mean maximum temperature were obtained in digital format from the Office of State Climatologist at Texas A&M University.

**Step 11. Create rainfall temperature input dataset**
   Daily rainfall and temperature data must be available in digital format corresponding to the entire period of the history and master files. These data, beginning January 1, 1992 and running through August 31, 1996, are provided in a file entitled RAINTEMP.DBF.

**Step 12. Run the dBASE program PTPRICE.PRG**
   The dBASE program "PTPRICE.PRG" combines the weather data and calculates each user's marginal water price with utility data to form a comprehensive database.

**Step 13. Program output is the combined dBASE file**
   This file contains utility data, weather data, and water price data. For the fiscal year 1993 data the output dataset would be named HISMAS93.DBF. The procedure beginning with steps 1 through 13 should be completed for each relevant fiscal year of the municipal utility database before going on to step 14.

**Step 14. Run the dBASE program copyfile.prg**
   The purpose of this program is to combine the data for each fiscal year into one single file and eliminate unnecessary variables. The large size of output data files may make them difficult to use with some systems, so the set of variables is reduced according to the purpose of the analysis. COPYFILE.PRG creates the output dataset with only those fields necessary for the intended analysis. In this case, the output file is "HMSA3456.DBF".

**Step 15. The final output aggregated data**
   This is an output file including selected variables covering four fiscal years of the municipal utility database including 1993, 1994, 1995, and 1996.
Appendix F. A Collection of FORTRAN Programs for Converting the Municipal Database Files

Sections 1 through 4 of this appendix are printouts of the FORTRAN programs used to convert the database files as described in Appendix E.

- Section 1 is MAS1065.FOR, which reads data converted to ASCII files from backup master files on 3480 cartridge tapes.
- Section 2 is MAS80.FOR, which reads data converted to ASCII from backup master files on 6250 reel tapes.
- Section 3 is HIS250.FOR, which reads data converted to ASCII files from backup history files on 3480 cartridge tapes.
- Section 4 is HIS80.FOR, which reads data converted to ASCII files from backup history files on 6250 reel tapes.
1. **MAS1065.FOR**

```
* LOW = the number of elements of RECORD(1065) that has been written so far
* RECORD(1065) = an array holding each record
* REMAIN = the number of elements of LINE(80) for next RECORD(1065)
* CHK = chk if the length of 1065 has been reached
* BCH = chk if fixline has been called so that LINE(161) and LINE(162) can be chked
* TLINE = total number of lines read
* ERRCHK = the number of times FIXSUB is called
* ERNLIN = the number of lines that are thrown away due to record error
* NSLT = the number of fields selected
* OUTNSLT = the number of fields selected for outpatient
* NRCRD = the number of records read in the block
* CTRL(12) = ctrl the field selection
* OUTCTRL(*) = field selection control for outpatient
* CNT(12) = chk the number of non-zero entries
* ERRCNT(3) = count err records for 3 file types
* SLCT(12) = collect all the fields that are selected
* fname(12) = fieldnames
* kept(12) = kept/drop: all=all, drop=drop
* errfile = file which contains the error record content checked out by program
* state = the column number of TX

************************************************************************************
* $DEBUG  
  integer begin_time, end_time, dif_time
  real tlline
  character*20 status
  character*12 infile, recfile
  character*12 masfile, errfile, err2file
  character*1 line, line1, line2, record
  dimension record(1065)
  dimension line(80), line1(80), line2(80)
  integer low, remain, length, chk, errchk, errline, nrcrd, trcrd,
      length, outslct, errcnt, k, fcnt
  integer ctrl, outctrl, bfpt, efpt, slct, endlabel,
      outslct, exchange, backward, linenum, wrtchk
  real outcnt
  character*12 outfile
  character*11 kept(97)
  character*16 fname(97)
  dimension ctrl(97), bfpt(97), efpt(97), slct(97), cnt(97),
       outctrl(97), outcnt(97)
  common /ctrlctr/ ctrlO

************************************************************************************
* ctrl(i)=0 -> field(i) is not selected, 1 -> field(i) is selected
* CtrlO=0, print GFILE only
* CtrlO=3, print both

******************************************************************************
* data ctrl/10.
  DATA CTRL/0,0,0,0,0,0,0,0,0,0,0,
    1  0,0,0,0,0,0,0,0,0,0,0,
    2  0,0,0,0,0,0,0,0,0,0,0,
    3  0,0,0,0,0,0,0,0,0,0,0,
    4  0,0,0,0,0,0,0,0,0,0,0,
    5  0,0,0,0,0,0,0,0,0,0,0,
    6  0,0,0,0,0,0,0,0,0,0,0,
    7  0,0,0,0,0,0,0,0,0,0,0,
    8  0,0,0,0,0,0,0,0,0,0,0,
    9  0,0,0,0,0,0,0,0,0,0,0,
  DATA OUTCTRL/1,0,1,0,1,0,1,0,1,0,1,
      1  1,0,1,0,1,0,1,0,1,0,1,
      2  1,0,1,0,1,0,1,0,1,0,1,
      3  1,0,1,0,1,0,1,0,1,0,1,
      4  1,0,1,0,1,0,1,0,1,0,1,
      5  1,0,1,0,1,0,1,0,1,0,1,
      6  1,0,1,0,1,0,1,0,1,0,1,
      7  1,0,1,0,1,0,1,0,1,0,1,
      8  1,0,1,0,1,0,1,0,1,0,1,
      9  1,0,1,0,1,0,1,0,1,0,1,
  DATA exchange/580,583,593,621,624,634,643,673,681,689,
  DATA backward/6,1,8,6,1,8,10,6,6,

******************************************************************************
* data BFPT/1, 3, 4, 13, 14, 39, 50, 54, 55, 60,
  1  61, 64, 65, 67, 68, 88, 89, 91, 92, 94,

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```
* write('*,*) ' labelin= ?'
* read('*,*) end label
begin_time = seconds()
open(unit=5, file=infile, status='old')

* initialize the SCLT
NSLT=0
INSLT=0
OUTSLT=0
DSLT=0

* GENERAL
Do 30 i=1,97
cnt(i)=0.
outcnt(i)=0.
if (cntl(i) .eq. 1) then
   NSLT=NSLT+1
   slct(NSLT)=i
endif
30 continue
i=1,ns1t
length=efpt(slct(i)) - bfpt(slct(i))
write(6,'(5hfield,i2,4i4)'
      slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length
low=low+length+1
40 continue

* quick initialization
trcrd=0
* do i=1,3
* read(5,'(80A11, err=100) (line(j), j=1,80)
* enddo
* data cutting loop (1) Read in 80 characters in a line
* (2) write them into a record (400 characters long) !!This is an OLD
say
* (2) write them into a record (1065 characters long)
* -------------------------------
50 read(5,'(1065A11, err=100) (record(i), i=1,1065)

   * remark
   * write(status, '(20AL)', (record(i), i=1,20)
* chk to see if MOD(nrcrrecord/23)=0 * chk to see if MOD(nrcrrecord/30)=0
nrcrd=nrcrd+1
* write(12,') ' status=',status
* write('**', ' nrcrd=nrcrd
* write('**', ' status=',status
* the following section chks to see if this record is correct
150 if(record(546) .ne. '9' .or. record(553) .ne. '9')
   1 .or. record(161) .eq. ' ' .or. record(162) .eq. ' '
   1 .or. record(160) .ne. ' ' .or. record(163) .ne. ' ') then
      if(record(546) .ne. '9' .or. record(553) .ne. '9')
         1 .or. record(161) .eq. ' ' .or. record(162) .eq. ' '
         1 .or. record(160) .ne. ' ' .or. record(163) .ne. ' ')
      endif
      if(record(161) .ne. 'T' .or. record(162) .ne. 'X') .or.
      1 record(160) .ne. ' ' .or. record(163) .ne. ' ') then
if (record(161) .ne. 'C' .or. record(162) .ne. 'A' .or. 
record(160) .ne. ' ' .or. record(163) .ne. ' ') then 
endf 
endif 
endif 
endif 
endif 
endif 
endif 
endif 
endif 
endif 
endif 
endif

start with next record's processing

if (lnrcrd .gt. 943001) then 
endif 
write(9,'(1065A1)')(record(i),i=1,1065) 
errchk=errchk+1 
bchk=1! bchk=1 to indicate fixsub is called 
call fixsub(line,tlline,record,length,low) 
goto 50 
endif 
endif 

************************************************** FOR GENERAL FILE ***************
write {?,' 1lx.6hfieldl,2x,3hRBF,lx,3hREF,lx,3hCBF,lx,3hCEF, 
+1x,3hFWD.2x,6hvalid%,3x,9hkeep/drop,6x,5hFNAMEI') 
low=1 
do 200 i=1,nslt 
if (trcrd .ne. 0.) then 
cnt(i)=cnt(i)/float(trcrd)*100. 
endif 
length=efpt(slct(i))-bfpt(slct(i)) 
write(7,'(5hfield:12.5j4.3x,$6.2,3x,A11,3x,A16)') 
+ slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length, 
+ length+1,cnt(i),kept(slct(i)),fnamel(slct(i)) 
low=low+length+1 
continue 
************************************************** FOR outpatient file ***************
write(7,'(1lx.6hfield#:2x,3hRBF,1x,3hREF,1x,3hCBF,1x,3hCEF, 
+1x,3hFWD.2x,6hvalid%,3x,9hkeep/drop,6x,5hFNAMEI') 
low=1 
do 220 i=1,outnslt 
if (trcrd .ne. 0.) then 
outcnt(i)=outcnt(i)/float(trcrd)*100. 
endif 
length=efpt(outsct(i))-bfpt(outsct(i)) 
write(7,'(5hfield:12.5j4.3x,$6.2,3x,A11,3x,A16)') 
+ outsct(i),bfpt(outsct(i)),efpt(outsct(i)),low,low+length, 
+ length+1,outcnt(i),kept(outsct(i)),fnamel(outsct(i)) 
low=low+length+1 
continue 
end_time=seconds() 
dif_time = end_time - begin_time 
write(*,'(1x,6hstart:.,i10.2x,6hlapse:,i5,1hs)') 
+ begin_time,end_time,dif_time 
close(5) 
close(9) 
close(10) 
close(11) 
close(12) 
stop 
end

* This section was completed at 01:12:27AM:11-Jun-1994

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real FUNCTION seconds()
INTEGER*2 hour, minute, second, hundredth
CALL GETTIM( hour, minute, second, hundredth )
seconds = (DBLE( hour ) * 3600.0) + (DBLE( minute ) * 60.0) +
+ DBLE( second ) + (DBLE( hundredth ) / 100.0)
END

* subroutine wrtsub takes record(382), slct, bfpt, efpt, nslt from CUTCLAIM main
* program, and writes the selected fields (characters) to outstr(382) before
* it writes outstr to events files based on the values in the events identifying field.
* SLCT(i) returns the series # of the selected field(i) 1<=SLCT(i)<=72
* bfpt(k) returns the BEGINNING point of field(k)
* EFPT(k) returns the ENDING point of field(k) 1<=EFPT(k),BFPT(k)<=382

subroutine wrtsub(slct, outslct, bfpt, efpt, record,
1 nslt, outnslt, exchange, backward)
integer nslt, outnslt, kout, trcrd, errcnt
integer bfpt, efpt, slct, outslct, chk, exchange, backward
real outcnt, cnt
character*1 record(1), outstr(1065)
* character*2 cntycode
* character*12 plantype
dimension bfpt(l), efpt(l), slct(l), outslct(l),
1 cnt(l), outcnt(l), exchange(9), backward(9)
common /ctrlctrl/ ctrl0
* write(cntycode, '(3A1) ') (record(i),i=25,27)
* write(plantype, '(12A1) ') (record(i),i=90,101)
* write them out to general file
*
do i=1,9
  if (record(exchange(i)) .eq. ([', .or.
1    record(exchange(i)) .eq. ']') then
    record(exchange(i))='0'
  else if (record(exchange(i)) .eq. 'A') then
    record(exchange(i))='1'
  else if (record(exchange(i)) .eq. 'B') then
    record(exchange(i))='2'
  else if (record(exchange(i)) .eq. 'C') then
    record(exchange(i))='3'
  else if (record(exchange(i)) .eq. 'D') then
    record(exchange(i))='4'
  else if (record(exchange(i)) .eq. 'E') then
    record(exchange(i))='5'
  else if (record(exchange(i)) .eq. 'F') then
    record(exchange(i))='6'
  else if (record(exchange(i)) .eq. 'G') then
    record(exchange(i))='7'
  else if (record(exchange(i)) .eq. 'H') then
    record(exchange(i))='8'
  else if (record(exchange(i)) .eq. 'I') then
    record(exchange(i))='9'
  else if (record(exchange(i)) .eq. 'J') then
    record(exchange(i))='1'
  else if (record(exchange(i)) .eq. 'K') then
    record(exchange(i))='2'
  else if (record(exchange(i)) .eq. 'L') then
    record(exchange(i))='3'
  else if (record(exchange(i)) .eq. 'M') then
    record(exchange(i))='4'
  else if (record(exchange(i)) .eq. 'N') then
    record(exchange(i))='5'
  else if (record(exchange(i)) .eq. 'O') then
    record(exchange(i))='6'
  else if (record(exchange(i)) .eq. 'P') then
    record(exchange(i))='7'
  else if (record(exchange(i)) .eq. 'Q') then
    record(exchange(i))='8'
  else if (record(exchange(i)) .eq. 'R') then
    record(exchange(i))='9'
  else if (record(exchange(i)) .eq. 'S') then
    record(exchange(i))='1'
  else if (record(exchange(i)) .eq. 'T') then
    record(exchange(i))='2'
  else if (record(exchange(i)) .eq. 'U') then
    record(exchange(i))='3'
  else if (record(exchange(i)) .eq. 'V') then
    record(exchange(i))='4'
  else if (record(exchange(i)) .eq. 'W') then
    record(exchange(i))='5'
  else if (record(exchange(i)) .eq. 'X') then
    record(exchange(i))='6'
  else if (record(exchange(i)) .eq. 'Y') then
    record(exchange(i))='7'
  else if (record(exchange(i)) .eq. 'Z') then
    record(exchange(i))='8'
end do
* write them out to events file
record(exchange(i))='4'
record(exchange(i)-backward(i))='-' else
if (record(exchange(i)) .eq. 'N') then
record(exchange(i))='5'
record(exchange(i)-backward(i))='-' else
if (record(exchange(i)) .eq. 'O') then
record(exchange(i))='6'
record(exchange(i)-backward(i))='-' else
if (record(exchange(i)) .eq. 'P') then
record(exchange(i))='7'
record(exchange(i)-backward(i))='-' else
if (record(exchange(i)) .eq. 'Q') then
record(exchange(i))='8'
record(exchange(i)-backward(i))='-' else
if (record(exchange(i)) .eq. 'R') then
record(exchange(i))='9'
record(exchange(i)-backward(i))='-' else
endif endif endif endif endif endif endif enddo IF (ctrlO .eq. 0 .or. ctrlO .eq. 3.) then  ! WIFI
kout=0 do 20 i=1,nslt
chk=0 do 15 k=bfpt(slct(i)),efpt(slct(i))
+ if (chk .eq. 0) then ! WIFI-1
+ if (record(k) .ne. ' ', .and. record(k) .ne. '0') then ! WIFI-2
+ cnt(i)=cnt(i)+1.0
+ chk=1
+ endif ! WIFI-2
endif ! WIFI-1
kout=kout+1 outstr(kout)=record(k) 15 continue 20 continue c write(6,'(80A1)') (outstr(i),i=1,kout) write(6,'(1065A1)') (outstr(i),i=1,kout) ENDIF  ! WIFI
* IF (ctrlO .eq. 1 .or. ctrlO .eq. 3.) THEN  ! WIFI2
***************OUTPATIENT FILE**************
* if (ctrlO .eq. 3) goto 100 ! added so that outpat is not written
kout=0 do 50 i=1,outslt
chk=0 do 45 k=bfpt(outslt(i)),efpt(outslt(i))
+ if (chk .eq. 0) then ! WIFI-1
+ if (record(k) .ne. ' ', .and. record(k) .ne. '0') then
+ outcnt(i)=outcnt(i)+1.0
+ chk=1
+ endif ! WIFI-2
+ endif ! WIFI-3
kout=kout+1 outstr(kout)=record(k) 45 continue 50 continue
* if (record(34) .eq. ' ' .or. record(34) .eq. '3' .or.
* 1 record(34) .eq. '5' .or. record(34) .eq. '6' .or.
2. KASSO.FOR

******************************************************************************
* LOW = the number of elements of RECORD(1065) that has been written so far
* RECORD(1065) = an array holding each record
* REMAIN = the number of elements of LINE(80) for next RECORD(1065)
* CHK = chk if the length of 1065 has been reached
* BCHK = chk if fixline has been called so that LINE(161) and LINE(162) can be chked
* TLLINE = total number of lines read
* ERRCHK = the number of times FIXSUB is called
* ERRLINE = the number of lines that are thrown away due to record error
* NSLT = the number of fields selected
* OUTNSLT = the number of fields selected for outpatient
* NRECORD = the number of records read in the block
* CTRL(12) = ctrl the field selection
* OUTCTRL(*) = field selection control for outpatient
* CNT(12) = chk the number of non-zero entries
* ERRCNT(3) = count err records for 3 file types
* OUTCNT(12) = chk the number of non-zero fields for outpatient
* BFPT(12) = returns a field's beginning point
* EFPT(12) = returns a field's ending point
* SLCT(12) = collect all the fields that are selected
* fname(12)= fieldnames
* kept(12)=kept/drop: all=all, drop=drop
* errfile= file which contains the error record content checked out by program
* state=the column number of TX
* $DEBUG
* integer begin_time, end_time, dif_time
* real tlline
* character*20 status
* character*12 infilename, recfilename, errfilename, err2filename
* character*1 line, line1, line2, record
* dimension record(1065)
* dimension line(80), line1(80), line2(80)
* integer low, remain, length, chk, errchk, errline, nrcrd, trcrd,
* 1 bchk, nslt, remain, length, chk, errchk, errline, nrcrd, trcrd,
* 2 integer ctrl(i)=0 -> field(i) is not selected, 1 -> field(i) is selected
* Ctrl0=0, print GFILE only, Ctrl0=1, print Inpatient, etc, files only
* Ctrl0=3, print both
* integer begin_time, end_time, dif_time
* DATA ctrl0/3.1
* DATA ctrl0/0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0
* DATA OUTCTRL/1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0,1.0
* DATA exchange/500,583,593,621,624,634,673,681,689/
DATA backward/6.1.8.6.1.8.10.6.6/  

* initialize fname(i) and kept(i)  

* give output filenames and open output files  
  outfile='gfile'  
  DATA masfile='mas.out'  
  err1file='err1file'  
  err2file='err2file'  
  recfile='recfile'  

* open output files  
  open(unit=6.file=outfile,status='unknown')  
  open(unit=7.file='ctrlfile'.status='unknown')  
  open(unit=9.file=masfile'.status='unknown')  
  open(unit=10.file=errlfile'.status='unknown')  
  open(unit=11.file=err2file'.status='unknown')  
  open(unit=12.file=recfile'.status='unknown')  

* get the infile names  
  write('(*')' infile='  
  read(*)' (A12)') infile  
  write(*)' labelln=1'  
  read(*'(A11)') endlabel  
  begin_time = secnds()  
  open(unit=5.file=infile'.status='old')  

* fill the SLC  

NSLT=0  
INSLT=0  
OUTSLT=0  
DSLT=0  

Do 30 i=1,63  
  cnt(i)=0.  

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outcnt(i)=0.
if (ctrl(i) .eq. 1) then
NSLT=NSLT+1
slct(NSLT)=i
endif

**********************************************************
OUTPATIENT
**********************************************************
if (outctrl(i) .eq. 1) then
outNSLT=outNSLT+1
outsct(outNSLT)=i
endif

continue
low=1
do 40 i=1,nslt
length=efpt(slct(i))-bfpt(slct(i))
write(6,' (5hfield,i2,4i4) ')
+ slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length
low=low+length+1
40
continue

initialize low, length, remain, etc.

errchk=0
bchk=0
low=0
length=1065
remain=0
linenum=0
tlline=0
nrcrd=0
wrtchk=0

quick initialization

dotr=0
do i=1,3
read(5,'(SOA1)',err=100) (line(j),j=1,80)
enddo

* data cutting loop (1) Read in 80 characters in a line
(2) write them into a record (1065 characters long)

* remind=0
tlline=tlline+1.
linenum=linenum+1
1
if(line(1) .eq. 'T' .and. line(2) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 6) then
  tlline=3
endif
if(line(26) .eq. 'T' .and. line(27) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 19) then
  tlline=16
endif
if(line(51) .eq. 'T' .and. line(52) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 32) then
  tlline=29
endif
if(line(76) .eq. 'T' .and. line(77) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 45) then
  tlline=42
endif
if(line(21) .eq. 'T' .and. line(22) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 59) then
  tlline=56
endif
if(line(46) .eq. 'T' .and. line(47) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 72) then
  tlline=69
endif
if(line(71) .eq. 'T' .and. line(72) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 85) then
  tlline=82
endif
if(line(16) .eq. 'T' .and. line(17) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 99) then
  tlline=96
endif
if(line(41) .eq. 'T' .and. line(42) .eq. 'X' .and. 
  tlline.gt. 1 .and. tlline.lt. 112) then
  tlline=109
endif if (line(66) .eq. 'T' .and. line(67) .eq. 'X' .and.
  tlline .gt. 119 .and. tlline .lt. 125) then
tlline=122
endif if (line(11) .eq. 'T' .and. line(12) .eq. 'X' .and.
  tlline .gt. 136 .and. tlline .lt. 139) then
tlline=136
endif if (line(36) .eq. 'T' .and. line(37) .eq. 'X' .and.
  tlline .gt. 149 .and. tlline .lt. 152) then
tlline=149
endif if (line(61) .eq. 'T' .and. line(62) .eq. 'X' .and.
  tlline .gt. 162 .and. tlline .lt. 165) then
tlline=162
endif if (line(6) .eq. 'T' .and. line(7) .eq. 'X' .and.
  tlline .gt. 176 .and. tlline .lt. 179) then
tlline=176
endif if (line(31) .eq. 'T' .and. line(32) .eq. 'X' .and.
  tlline .gt. 189 .and. tlline .lt. 192) then
tlline=189
endif if (line(56) .eq. 'T' .and. line(57) .eq. 'X' .and.
  tlline .gt. 202 .and. tlline .lt. 205) then
tlline=202
endif if (line(1) .eq. 'T' .and. line(2) .eq. 'X' .and.
  tlline .gt. 216 .and. tlline .lt. 219) then
tlline=216
endif if (line(26) .eq. 'T' .and. line(27) .eq. 'X' .and.
  tlline .gt. 229 .and. tlline .lt. 232) then
tlline=229
endif if (line(51) .eq. 'T' .and. line(52) .eq. 'X' .and.
  tlline .gt. 242 .and. tlline .lt. 245) then
tlline=242
endif if (line(76) .eq. 'T' .and. line(77) .eq. 'X' .and.
  tlline .gt. 255 .and. tlline .lt. 258) then
tlline=255
endif if (line(21) .eq. 'T' .and. line(22) .eq. 'X' .and.
  tlline .gt. 269 .and. tlline .lt. 272) then
tlline=269
endif if (line(46) .eq. 'T' .and. line(47) .eq. 'X' .and.
  tlline .gt. 282 .and. tlline .lt. 285) then
tlline=282
endif if (line(71) .eq. 'T' .and. line(72) .eq. 'X' .and.
  tlline .gt. 295 .and. tlline .lt. 298) then
tlline=295
endif if (line(16) .eq. 'T' .and. line(17) .eq. 'X' .and.
  tlline .gt. 309 .and. tlline .lt. 312) then
tlline=309
endif if (line(41) .eq. 'T' .and. line(42) .eq. 'X' .and.
  tlline .gt. 322 .and. tlline .lt. 325) then
tlline=322
endif if (line(66) .eq. 'T' .and. line(67) .eq. 'X' .and.
  tlline .gt. 335 .and. tlline .lt. 338) then
tlline=335
endif if (line(11) .eq. 'T' .and. line(12) .eq. 'X' .and.
  tlline .gt. 349 .and. tlline .lt. 352) then
tlline=349
endif if (line(36) .eq. 'T' .and. line(37) .eq. 'X' .and.
  tlline .gt. 362 .and. tlline .lt. 365) then
tlline=362
endif if (line(61) .eq. 'T' .and. line(62) .eq. 'X' .and.
  tlline .gt. 375 .and. tlline .lt. 378) then
tlline=375
endif
if (line(6) .eq. 'T' .and. line(7) .eq. 'X' .and. line(8) .eq. '9')
tlline = 389
endif
if (tlline .eq. 213) then
rerrind = 1
else
if (tlline .eq. 400) then
rerrind = 1
tlline = 0
endif
endif
chk = length - 80
if (chk .gt. 0) then
length = length - 80
do i = 1, 80
record(i + low) = line(i)
enddo
low = low + 80
goto 50
else
chk to see if MOD(nrcrecord/23) = 0
chk to see if MOD(nrcrecord/30) = 0
nrcrd = nrcrd + 1
write(12, *) 'statu5~·.status
nrcrd = ', nrcrd
endif
linenum = 0
!!! write(10, '(1065A1)') (record(i), i = 1, 1065)
errchk = errchk + 1
bchk = 1
bchk = 1 to indicate fixsub is called
call fixsub(line, tlline, record, length,
low)
goto 50
endif
endif
endif
endf

*****************************************************************************
start with next record's processing
*****************************************************************************
if (nrcrd .gt. 94300) then
wrtchk = wrtchk + 1
write(9, ', (1065A1)') (record(i), i = 1, 1065)
*****************************************************************************
using subroutine wrtsub to write records to event files
*****************************************************************************
call wrtsub(slct, outslct, bfpt, efpt, record, nslt,
outnslt, exchange, backward)
endif
linenum = 0
*****************************************************************************
start with next record's processing
*****************************************************************************
low=0
if(remind .eq. 1) then
  remain=0
endif
if(remain .ne. 0) then
do l=1,remain
  record(low+i)=line(SO-remain+i)
enddo
low=low+remain
endif
length=1065-remain
goto 50

continue
write(7,*'trcrd=', trcrd, 'errchk', errchk
  
write(7,*'trcrd=', trcrd, 'errchk', errchk

write(7,'(lx,6hfield#, 2x, 3hRBF, 1x, 3hREF, 1x, 3hCBF, 1x, 3hCEF,' + 1x, 3hFWD, 2x, 6hvalid%, 3x, 9hkeep/drop, 6x, 5hFNAME)')
low=1
do 200 i=l,nslt
  if (trcrd .ne. 0.) then
    cnt(i)=cnt(i)/float(trcrd)*100.
  endif
length=efpt(slct(i))-bfpt(slct(i))
write(7, '(5hfield,i2,5i4,3x,f6.2,3x, A11,3x,A16)') slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length,
  + length+1,cnt(i),kept(slct(i)),fname(slct(i))
low=low+length+1
  
  
200 continue

continue
write(7, 'trcrd=', trcrd, 'errchk=', errchk, 'wrtchk', wrtchk

k=1
write(7, I 'OutFile=', ' # of rcrd', fcnt

END

real FUNCTION secnds()
INTEGER hour, minute, second, hundredth
CALL GETTIM(hour, minute, second, hundredth)
secnds = (DBLE(hour) * 3600.0) + (DBLE(minute) * 60.0) +
  + DBLE(second) + (DBLE(hundredth) + 100.0)
END

Subroutine 'Fixsub' is going to check if the record is a bad record
which means that 'record(161) .ne. 'T' .or. record(162) .ne. 'X' has
been found and then the record is put into a file which is specially
prepared for bad records. The program will continue to search the right
position of T and X untill it finds them that means a new good record has
been found

This section was completed at 01:12:27AM;11-Jun-1994
subroutine fixsub(lines, tllines, records, lengths, 
1 lows)
  real tllines
  integer lows, lengths, state
  integer onlythre, remain
  character*1 line1(80), records(1065)
  character*1 linei(80), line2(80), line3(80)

* initialize low, length, remain

lows=0
lengths=1065
onlythre=0
do i=1,80
  line3(i)=lines(i)
  line2(i)=lines(i)
  line1(i)=lines(i)
enddo
read(5,'(80A1)', err=20) (lines(i),i=1,80)
tllines=tllines+1
  if (lines(1) .eq. 'T' .and. lines(2) .eq. 'X' .and. 
1 tllines .gt. 1 .and. tllines .lt. 6) then 
  tllines=3
endif
  if (lines(26) .eq. 'T' .and. lines(27) .eq. 'X' .and. 
1 tllines .gt. 13 .and. tllines .lt. 19) then 
  tllines=16
endif
  if (lines(51) .eq. 'T' .and. lines(52) .eq. 'X' .and. 
1 tllines .gt. 26 .and. tllines .lt. 32) then 
  tllines=29
endif
  if (lines(76) .eq. 'T' .and. lines(77) .eq. 'X' .and. 
1 tllines .gt. 39 .and. tllines .lt. 45) then 
  tllines=42
endif
  if (lines(21) .eq. 'T' .and. lines(22) .eq. 'X' .and. 
1 tllines .gt. 53 .and. tllines .lt. 59) then 
  tllines=56
endif
  if (lines(46) .eq. 'T' .and. lines(47) .eq. 'X' .and. 
1 tllines .gt. 66 .and. tllines .lt. 72) then 
  tllines=69
endif
  if (lines(71) .eq. 'T' .and. lines(72) .eq. 'X' .and. 
1 tllines .gt. 79 .and. tllines .lt. 85) then 
  tllines=82
endif
  if (lines(16) .eq. 'T' .and. lines(17) .eq. 'X' .and. 
1 tllines .gt. 93 .and. tllines .lt. 99) then 
  tllines=96
endif
  if (lines(41) .eq. 'T' .and. lines(42) .eq. 'X' .and. 
1 tllines .gt. 106 .and. tllines .lt. 112) then 
  tllines=109
endif
  if (lines(66) .eq. 'T' .and. lines(67) .eq. 'X' .and. 
1 tllines .gt. 119 .and. tllines .lt. 125) then 
  tllines=122
endif
  if (lines(11) .eq. 'T' .and. lines(12) .eq. 'X' .and. 
1 tllines .gt. 133 .and. tllines .lt. 139) then 
  tllines=136
endif
  if (lines(36) .eq. 'T' .and. lines(37) .eq. 'X' .and. 
1 tllines .gt. 146 .and. tllines .lt. 152) then 
  tllines=149
endif
  if (lines(61) .eq. 'T' .and. lines(62) .eq. 'X' .and. 
1 tllines .gt. 159 .and. tllines .lt. 165) then 
  tllines=162
endif
  if (lines(6) .eq. 'T' .and. lines(7) .eq. 'X' .and. 
1 tllines .gt. 173 .and. tllines .lt. 179) then 
  tllines=176
endif
  if (lines(31) .eq. 'T' .and. lines(32) .eq. 'X' .and. 
1 tllines .gt. 186 .and. tllines .lt. 192) then
tllines=189
endif
  if(lines(56) .eq. 'T' .and. lines(57) .eq. 'X' .and. 1 tllines .gt. 199 .and. tllines .lt. 205) then 
    tllines=202
  endif
endif
  if(lines(1) .eq. 'T' .and. lines(2) .eq. 'X' .and. 1 tllines .gt. 213 .and. tllines .lt. 219) then 
    tllines=216
  endif
endif
  if(lines(26) .eq. 'T' .and. lines(27) .eq. 'X' .and. 1 tllines .gt. 226 .and. tllines .lt. 232) then 
    tllines=229
  endif
endif
  if(lines(51) .eq. 'T' .and. lines(52) .eq. 'X' .and. 1 tllines .gt. 239 .and. tllines .lt. 245) then 
    tllines=242
  endif
endif
  if(lines(76) .eq. 'T' .and. lines(77) .eq. 'X' .and. 1 tllines .gt. 252 .and. tllines .lt. 258) then 
    tllines=255
  endif
endif
  if(lines(21) .eq. 'T' .and. lines(22) .eq. 'X' .and. 1 tllines .gt. 266 .and. tllines .lt. 272) then 
    tllines=269
  endif
endif
  if(lines(46) .eq. 'T' .and. lines(47) .eq. 'X' .and. 1 tllines .gt. 279 .and. tllines .lt. 285) then 
    tllines=282
  endif
endif
  if(lines(71) .eq. 'T' .and. lines(72) .eq. 'X' .and. 1 tllines .gt. 292 .and. tllines .lt. 298) then 
    tllines=295
  endif
endif
  if(lines(16) .eq. 'T' .and. lines(17) .eq. 'X' .and. 1 tllines .gt. 306 .and. tllines .lt. 312) then 
    tllines=309
  endif
endif
  if(lines(41) .eq. 'T' .and. lines(42) .eq. 'X' .and. 1 tllines .gt. 319 .and. tllines .lt. 325) then 
    tllines=322
  endif
endif
  if(lines(66) .eq. 'T' .and. lines(67) .eq. 'X' .and. 1 tllines .gt. 332 .and. tllines .lt. 338) then 
    tllines=335
  endif
endif
  if(lines(11) .eq. 'T' .and. lines(12) .eq. 'X' .and. 1 tllines .gt. 346 .and. tllines .lt. 352) then 
    tllines=349
  endif
endif
  if(lines(36) .eq. 'T' .and. lines(37) .eq. 'X' .and. 1 tllines .gt. 359 .and. tllines .lt. 365) then 
    tllines=362
  endif
endif
  if(lines(61) .eq. 'T' .and. lines(62) .eq. 'X' .and. 1 tllines .gt. 372 .and. tllines .lt. 378) then 
    tllines=375
  endif
endif
  if(lines(6) .eq. 'T' .and. lines(7) .eq. 'X' .and. 1 tllines .gt. 386 .and. tllines .lt. 392) then 
    tllines=389
  endif
endif
if(tllines .ge. 400) then
  tllines=0
endif
doi=1,80
  line3(i)=line2(i)
  line2(i)=line1(i)
  line1(i)=lines(i)
enddo

*************************************************************************
' search for the pattern
*************************************************************************
do i=2,80
  if(lines(i-1) .eq. 'T' .and. lines(i) .eq. 'X') then
    lows=0
    state=1-1
    remain=80-state-1
    lengths=1065-remain
    do j=1,remain
      records(j)+lows=lines(80-remain+j)
  endif
**---***._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-_._._._-
record(exchange(i))='9'
else
if (record(exchange(i)) .eq. 'J') then
  record(exchange(i))='1'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'K') then
  record(exchange(i))='2'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'L') then
  record(exchange(i))='3'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'M') then
  record(exchange(i))='4'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'N') then
  record(exchange(i))='5'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'O') then
  record(exchange(i))='6'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'P') then
  record(exchange(i))='7'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'Q') then
  record(exchange(i))='8'
  record(exchange(i)-backward(i))='-'
else
if (record(exchange(i)) .eq. 'R') then
  record(exchange(i))='9'
  record(exchange(i)-backward(i))='-'
else
endif
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endi
do 50 i=1,outnslt
    chk=0
    do 45 k=bfpt(outslct(i)),efpt(outslct(i))
       if (chk .eq. 0) then
          if (record{k) .ne. ' ' .and. record{k) .ne. '0') then
              outcnt{i}=outcnt{i}+1.0
              chk=1
          endif
       endif
    kout=kout+1
    outstr{kout}=record{k)
    continue
45 continue
100 continue
end

3. HIS250.FOR

******************************************************************************
* LOW = the number of elements of RECORD(1065) that has been written so far
* RECORD(1065) = an array holding each record
* REMAIN = the number of elements of LINE(80) for next RECORD(1065)
* CHK = chk if the length of 1065 has been reached
* BCHK = chk if fixline has been called so that LINE(161) and LINE(162) can be chked
* TLINE = total number of lines read
* ERRLINE = the number of lines that are thrown away due to record error
* NSLT = the number of fields selected
* OUTNSLT = the number of fields selected for outpatient
* NRCRD = the number of records read in the block
* CTRL(12) = ctrl the field selection
* outctrl(*) = field selection control for outpatient
* CNT(12) = chk the number of non-zero entries
* FCNT(4,3) = rcd count for 4 cntgroup 3 file types
* ERRCNT(3) = count err records for 3 file types
* OUTCNT(12) = chk the number of non-zero entries for outpatient
* BFPT(12) = returns a field's ending point
* EFPT(12) = returns a field's beginning point
* SLCT(12) = collect all the fields that are selected
* fname(12) = fieldnames
* kept(12) = kept/drop: all=all, drop=drop
* ERRFILE = file which contains the error record content checked out by program
* STATE=the column number of TX
******************************************************************************
$DEBUG
integer begin_time, end_time, dif_time
real tlline
character*20 status
character*12 infile,recfile
character*12 hisfile,errfile,err2file
character*1 line, linel, line2, record, recordl, record2
dimension record(250),recordl(250),record2(250)
dimension line(80),line1(80),line2(80)
integer low,remain,length,chk,errchk,erline,nrcrd,trcrd,
     1 bchk,nslt,outnslt,ercnt,k,fcnt
integer ctrl, outctrl, bftp, efpt, slct, endlabel,
1 outslct, exchange, backward
real outcnt
character*12 outfile
character*11 kept(78)
character*16 fname(78)
dimension ctrl(78),bfpt(78),efpt(78),slct(78),cnt(78),
   1 outslct(78),exchange(9),backward(9),
   2 outctrl(78),outcnt(78)
common /ctrlctrl/ ctrl0
******************************************************************************
* ctrl{i)=0 -> field{i) is not selected, 1 -> field{i) is selected
* Ctrl0=0, print GFILE only
* Ctrl0=3, print both
******************************************************************************
data ctrl0/3./
DATA CTRL/0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0
1 0,0,0,0,0,0,0,0,0,0,0,0
DATA OUTCTRL/1,0,1,1,0,1,0,1,0,0,0,
1 1,0,1,0,1,0,1,0,0,0,0,
2 0,0,0,0,0,0,0,0,0,0,0,
3 0,0,0,0,0,0,0,0,0,0,0,
4 0,0,0,0,0,0,0,0,0,0,0,
5 0,0,0,0,0,0,0,0,0,0,0,
6 0,0,0,0,0,0,0,0,0,0,0,
7 0,0,0,0,0,0,0,0,0,0,0,
DATA exchange/17,39,47,55,65,69,77,85,95/0,0,0,0,0,0,0,0,0,0,
DATA backward/5,2,6,6,8,2,6,6,2/0,0,0,0,0,0,0,0,0,0,
DATA BFPT/1,2,3,12,18,21,22,28,29,33,40,41,48,49,56,57,66,67,70,71,78,79,86,87,96,97,100,101,108,109,110,111,112,113,116,117,124,125,132,133,140,141,142,143,148,149,156,157,162,163,170,171,178,179,182,183,190,191,198,199,202,203,210,211,222,223,224,225,234,235,246,247,248,249,250/0,0,0,0,0,0,0,0,0,0,
DATA EFPT/1,2,11,17,20,21,27,28,32,33,35,36,39,40,47,48,55,56,65,66,69,70,77,78,85,86,95,96,99,100,107,108,109,110,111,112,115,116,123,124,131,132,133,140,141,142,147,148,155,156,161,162,169,170,177,178,181,182,189,190,197,198,201,202,209,210,221,222,223,224,233,234,245,246,247,248,249,250/0,0,0,0,0,0,0,0,0,0,
* initialize fname(i) and kept(i)

* give output filenames and open output files

** initialize filenames and kept(i)

outHile='gfile'
DATA hisfile/'his.cut'/
errlfile='errlfile'
er2file='err2file'
recfile='recfile'

* open output files

open(unit=6,file=outHile,status='unknown')
open(unit=7,file='ctrlfile',status='unknown')
open(unit=9,file=hisfile,status='unknown')
open(unit=10,file=errlfile,status='unknown')
open(unit=11,file=err2file,status='unknown')
open(unit=12,file=recfile,status='unknown')

* get the infile names
write(*,*), infile=?'
read('(','AU') infile
write(*,*) , labelln=?
read(',(I1)',I
endlabel
begin_time = seconds()
open(unit=5, file=infile, status='old')

******************************************************************************
* initialize the SLCT
******************************************************************************
NSLT=0
INSLT=0
OUTSLT=0
DSLT=0

****************************************GENERAL
Do 30 i=1,78
  cnt(i)=0.
  outcnt(i)=0.
  if (ctrl(i) .eq. 1) then
    NSLT=NSLT+1
    slct(NSLT)=i
  endif
30  continue
low=1
do 40 i=1,NSLT
  length=efpt(slct(i))-bfpt(slct(i))
  write(6,'(5hfield,i2,4i4)') + slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length
  low=low+length+1
40  continue

******************************************************************************
* quick initialization
******************************************************************************
tcrd=0
* do i=1,endlabel
  read(5,'(80A1)',err=100) (line(j),j=1,80)
  enddo

******************************************************************************
* data cutting loop (1) Read in 80 characters in a line
* (1) Read in 80 characters in a line
  (This is an OLD say
* (2) write them into a record (400 characters long) !!
* (2) write them into a record (400 characters long)
50  read(5,'(250A1)',err=100) (record(i),i=1,250)

******************************************************************************
nrcrd=nrcrd+1
write(*,*) 'status=',status
write(*,'(150)') (record(i),i=1,250)

******************************************************************************
nrcrd=rcrecord+1
write(*,'(150)') (record(i),i=1,250)

******************************************************************************
if (record(34) .eq. 'Z' .and. record(35) .eq. 'Z' .or.
150 if (record(245) .eq. ') then
  write(10,'(250A1)') (record(i),i=1,250)
  errchk=errchk+1
  goto 50
endif

******************************************************************************
* start with next record's processing
******************************************************************************
if(tcrd .gt. 120000) then

96
** subroutine wrtsub to write records to event files **

```fortran
write(9,'(250A1)') (record(i,i=1,250)

* using subroutine wrtsub to write records to event files *

180 call wrtsub(slct, oustrl, bfpt, efpt, record, nslt.
  1 outnslt, exchange, backward)
* endif
* endif

* start with next record's processing *

100 continue

100 continue

start with next record's processing

low=0
length=250
goto 50

* FOR GENERAL FILE **

write(7,*) 'trcrd=', trcrd, 'errchk', errchk
write(6,*) 'trcrd=', trcrd, 'errln=', errline, 'errchk=', errchk
write(7,*) 'trcrd=', trcrd, 'errln=', errline, 'errchk=', errchk

write(7,*(1x,6$hfield#, 2x, 3$hRF, 1x, 3$hREF, 1x, 3$hCF, 1x, 3$hCEF, 1x, 3$hCEF, 1x, 3$hCEF,
  1x, 3$hFWD, 2x, 6$valid#, 3x, 9$keep/drop, 6x, 5$hFNAME))'

low=1
do 200 i=1, nslt
  if (trcrd .ne. 0.) then
cnt(i)=cnt(i)/float(trcrd)*100.
  endif
length=efpt(slct(i))-bfpt(slct(i))
write(7,*(5$hfield,12,5$l,4,3x,f6.2,2x,A1,13x,A16))'
  + slct(i),bfpt(slct(i)),efpt(slct(i)),low,low+length,
  + length+1,cnt(i),kept(slct(i)),fname(slct(i))
low=low+length+1
200 continue

* FOR outpatient file ****

write(7,*) 'OutTotal=', trcrd
k=1
write(7,*) 'OutFile=', ' # of rcd=', ' of rcd', 'cnt',
write(7,*(1x,6$hfield#, 2x, 3$hRF, 1x, 3$hREF, 1x, 3$hCF, 1x, 3$hCEF,
  1x, 3$hFWD, 2x, 6$valid#, 3x, 9$keep/drop, 6x, 5$hFNAME))'

low=1
do 220 i=1, outnslt
  if (trcrd .ne. 0.) then
outcnt(i)=outcnt(i)/float(trcrd)*100.
  endif
length=efpt(outslct(i))-bfpt(outslct(i))
write(7,*(5$hfield,12,5$l,4,3x,f6.2,2x,A1,13x,A16))'
  + outslct(i),bfpt(outslct(i)),efpt(outslct(i)),low,low+length,
  + length+1,outcnt(i),kept(outslct(i)),fname(outslct(i))
low=low+length+1
220 continue

end_time=secnds()
dif_time = end_time - begin_time
write(*,'(1x, 6$hstart::i10,2x, 4$hend::i10,2x, 6$hlap:::i5,1hs)'
  + begin_time, end_time, dif_time
close(5)
close(9)
close(10)
close(11)
close(12)
stop

real FUNCTION  secnds()
INTEGER*2 hour, minute, second, hundredth
CALL GETTIM( hour, minute, second, hundredth )
secnds = (DBLE( hour ) * 3600.0) + (DBLE( minute ) * 60.0) +
  + DBLE( second ) + (DBLE( hundredth ) / 100.0))
END

* subroutine wrtsub takes record(382), slct, bfpt, efpt, nslt from CUTCLAIM main
* program, and writes the selected fields (characters) to oustr(382) before
* it writes oustr to events files based on the values in the events identifying field.

* SLCT(i) returns the series # of the selected field(i) 1<=SLCT(i)<=72
* bfpt(k) returns the BEGINNING point of field(k)

real FUNCTION  secnds()
* EFPT(k) returns the ENDING point of field(k) 1<=BFPT(k),EFPT(k)<=382

```
subroutine wrtsub(slct,outslct,bfpt,efpt,record,
  1 nslt,outnslt,exchange,backward)
  integer nslt,outnslt,chk,exchange,backward
  character*1 record(i),outstr(250)
  character*3 cntycode
  character*12 plantype
  integer bfpt,efpt,slct,outslct,chk,exchange,backward
  real outcnt1,cnt
  dimension bfpt(1),efpt(1),slct(1),outslct(1),
  1 cnt(1),outcnt(1),exchange(9),backward(9)
  common /ctcltrl/ ctrlO

  write(cntycode, '(3AI)',
  1 '(record(il,i=2S,27)
  write (plantype,
  1' (12AI)') (record(i,i=90,101)

  write them out to general file

  do i=1,9
    if (record(exchange(i)) .eq. 'A') then
      record(exchange(i))='1'
    else
      if (record(exchange(i)) .eq. 'B') then
        record(exchange(i))='2'
      else
        if (record(exchange(i)) .eq. 'C') then
          record(exchange(i))='3'
        else
          if (record(exchange(i)) .eq. 'D') then
            record(exchange(i))='4'
          else
            if (record(exchange(i)) .eq. 'E') then
              record(exchange(i))='5'
            else
              if (record(exchange(i)) .eq. 'F') then
                record(exchange(i))='6'
              else
                if (record(exchange(i)) .eq. 'G') then
                  record(exchange(i))='7'
                else
                  if (record(exchange(i)) .eq. 'H') then
                    record(exchange(i))='8'
                  else
                    if (record(exchange(i)) .eq. 'I') then
                      record(exchange(i))='9'
                    else
                      if (record(exchange(i)) .eq. 'J') then
                        record(exchange(i))='1'
                      else
                        if (record(exchange(i)) .eq. 'K') then
                          record(exchange(i))='2'
                        else
                          if (record(exchange(i)) .eq. 'L') then
                            record(exchange(i))='3'
                          else
                            if (record(exchange(i)) .eq. 'M') then
                              record(exchange(i))='4'
                            else
                              if (record(exchange(i)) .eq. 'N') then
                                record(exchange(i))='5'
                              else
                                if (record(exchange(i)) .eq. 'O') then
                                  record(exchange(i))='6'
                                else
                                  if (record(exchange(i)) .eq. 'P') then
                                    record(exchange(i))='7'
                                  else
                                    if (record(exchange(i)) .eq. 'Q') then
                                      record(exchange(i))='8'
                                    else
                                      write (record(i), i=25,27)
                                      write (record(i), i=90,101)
```

98
record(exchange(i)-backward(i))=-'
else if (record(exchange(i)) .eq. 'R') then
    record(exchange(i))='9'
    record(exchange(i)-backward(i))=-'
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* BCHK = chk if fixline has been called so that LINE(161) and LINE(162) can be chked
* TLLINE = total number of lines read
* ERRCHK = the number of times FIXSUB is called
* ERRLINE = the number of lines that are thrown away due to record error
* NSLT = the number of fields selected
* INNSLT = the number of fields selected for inpatient
* OUTNSLT = the number of fields selected for outpatient
* DNSLT = the number of fields selected for drug vendor
* ERRCNT = the number of times FIXSUB is called
* NRCRD = the number of records read in the block
* TRCRD(i) = total number of records read, i = General file, 2 = inpatient, 3 = outpatient, 4 = drug
* CTRL(12) = ctrl the field selection
* INCTRL(i) = field selection control for inpatient
* OUTCTRL(i) = field selection control for outpatient
* DCNT(i) = the number of non-zero entries for inpatient
* CNTR(i) = the number of non-zero entries for outpatient
* DCNT(i) = the number of non-zero entries for drug vendor
* BFPT(i) = returns a field's beginning point
* EFPT(i) = returns a field's ending point
* SLCT(i) = collect all the fields that are selected
* NAME(i) = field names
* KEPT(i) = kept/drop: 1 = inpatient, 2 = outpatient, 3 = drug, all = all 3, drop = drop
* ERRFILE = file which contains the error record content checked out by program
* RCKIND = the number used to indicate the subroutine has been called
* STATE = the column number of TX

DEBUG
integer begin_time, end_time, dif_time
real tlline
character*20 status
character*12 infile, recfile
character*12 hisfile, errfile, err2file
character*12 line, line1, line2, record1, record2
dimension record(250), record1(250), record2(250)
dimension line(80), line1(80), line2(80)
integer low, remain, length, chk, errchk, errline, nrcrd, trcrd,
1 bchk, nslt, outnslt, errcnt(K), fcnt
integer ctrlout, outctrl, bfpt, efpt, slct, endlbl,
1 outsclt, exchange, backward
real outcnt
character*12 outfile
character*12 kept(78)
dimension ctrl(78), bfpt(78), efpt(78), slct(78), cnt(78),
1 outslct(78), exchange(9), backward(9),
2 outctrl(78), outcnt(78)
common /ctrlcltrl/ ctrlO

******************************************************************************

* ctrl(i)=0 -> field(i) is not selected, 1 -> field(i) is selected
* Ctrl0=0, print GFILE only, Ctrl0=1, print Inpatient, etc, files only
* Ctrl0=3, print both

******************************************************************************

data ctrl0/3. /
data CTRL/0,0,0,0,0,0,0.
data OUTCTRL/0,0,1,1,0,0,0.
data exchange/17,39,47,55,65,69,77,85,95.
data backward/5,2,6,6,8,2,6,6,8.
******************************************************************************
DATA EFPT/1, 2, 11, 17, 20, 21, 27, 28, 32, 33,
1 25, 36, 39, 40, 47, 48, 55, 56, 55, 66,
2 69, 70, 77, 78, 85, 86, 95, 96, 99:100,
3 107,108,109,110,111,112,115,116,123,124,
4 131,132,139,140,141,142,147,148,155,156,
5 161,162,169,170,177,178,181,182,189,190,
6 197,198,201,202,209,210,221,222,223,224,
7 233,234,245,246,247,248,249,250/
* initialize filename(i) and kept(i)
DATA KEPT/
' (drop),' (drop),' (all), (all)', (drop), (drop), (all), (all), (drop), (drop),
1 (all), (drop), (all), (drop), (all), (drop), (all), (drop), (all), (drop),
2 (drop), (all), (drop), (all), (drop), (all), (drop), (all), (drop), (all), (drop),
3 (drop), (all), (drop), (all), (drop), (all), (drop), (all), (drop), (all), (drop),
4 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
5 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
6 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
7 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
8 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
9 (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop), (drop),
9 (drop) /
* DATA frame/
'Date', 'Acct-Num', 'Pro-Date', 'Seq', , 'Date', ,
1 'Pro-Time', 'Tran-Cod', 'W-U-Day', , W-Read ,
2 'W-Amt', 'G-U-Day', 'G-Read',,
3 'G-Amt', 'S-U-Day', S-Amt', ,
4 'W-S-Code', 'G-S-Code', 'Sw-U-Day', Sw-Read',,
5 'Sw-Amt', 'Sw-Am', 'Sw-Amt', ,
6 'W-U-Day', 'Gb-Amt', 'Tc-Tot', 'Bund-Nr', ,
7 'Depo-Nr', 'M-T-Amt', 'Tra-Code', 'Tra-No', ,
8 'Arrears', 'Tape-Flg', 'G-T-EFlg', ,'/
* give output filenames and open output files
outfile='gfile'
DATA hisfile/'his.out'/
err1file='err1file'
err2file='err2file'
recfile='recfile'
* open output files
open(unit=6, file=outfile, status='unknown')
open(unit=7, file='ctrlfile', status='unknown')
open(unit=9, file=hisfile, status='unknown')
open(unit=10, file=err1file, status='unknown')
open(unit=11, file=err2file, status='unknown')
open(unit=12, file=recfile, status='unknown')
* get the infile names
write(*, *) infile= '
read(*, ' (A12) ') infile
write(*, *) ' labelln= '
read(*, ' (11) ') endlabel
begin_time = seconds()
open(unit=5, file=infile, status='old')
* initialize the SLCT
NSLT=0
INSLT=0
OUTSLT=0
DSLT=0
**'GENERAL**
Do 30 i=1,78
  ctn(i)=0.
  if (ctrl(i) .eq. 1) then
    NSLT=NSLT+1
    slct(NSLT)=i
  endif
30 continue
101
endif

*** OUTPATIENT

if (outctrl(i) .eq. 1) then
    outNSLT=outNSLT+1
    outslct(outNSLT)=i
endif

continue
low=1
do 40 i=1,nslt
    length=efpt(slct(i)) - bfpt(slct(i))
    write(6, '(5hfield,12.4f)')
        slct(i),bfpt(slct(i)),efpt(slct(i)),low,length
    low=low+length+1
40 continue

initialize low, length, remain, etc.

errchk=0
bchk=0
low=0
length=250
remain=0
tlline=0
nrcrd=0

quick initialization

trcrd=0
do i=1,endlabel
    read(5, '(80A1)', err=100) (line(j), j=1,80)
enddo

* data cutting loop (1) Read in 80 characters in a line
* (2) write them into a record (400 characters long) !!!This is an OLD say
* (2) write them into a record (1065 characters long)
50 read(5, '(80A1)', err=100) (line(i), i=1,80)

tlline=tlline+1.

1 if (tlline .gt. 19 .and. tlline .lt. 40 .and.
2      line(12) .eq. '9' .and. line(26) .eq. '9') then
3     tlline=25
4   else
5     if (tlline .gt. 39 .and. tlline .lt. 65 .and.
6         line(12) .eq. '9' .and. line(26) .eq. '9') then
7        tlline=50
8      else
9      if (tlline .gt. 64 .and. tlline .lt. 90 .and.
10         line(12) .eq. '9' .and. line(26) .eq. '9') then
11        tlline=75
12       else
13       if (tlline .gt. 89 .and. tlline .lt. 115 .and.
14          line(12) .eq. '9' .and. line(26) .eq. '9') then
15          tlline=100
16        else
17        if (tlline .gt. 114 .and. tlline .lt. 140 .and.
18           line(12) .eq. '9' .and. line(26) .eq. '9') then
19            tlline=125
20          else
21          if (tlline .gt. 139 .and. tlline .lt. 165 .and.
22             line(12) .eq. '9' .and. line(26) .eq. '9') then
23              tlline=150
24            else
25            if (tlline .gt. 164 .and. tlline .lt. 190 .and.
26               line(12) .eq. '9' .and. line(26) .eq. '9') then
27                  tlline=175
28                else
29                if (tlline .gt. 189 .and. tlline .lt. 215 .and.
30                   line(12) .eq. '9' .and. line(26) .eq. '9') then
31                     tlline=200
32                else
33                if (tlline .gt. 214 .and. tlline .lt. 240 .and.
34                   line(12) .eq. '9' .and. line(26) .eq. '9') then
35                     tlline=225
36                else
37                if (tlline .gt. 239 .and. tlline .lt. 265 .and.
38                   line(12) .eq. '9' .and. line(26) .eq. '9') then
39                     tlline=250
40                else
41                if (tlline .gt. 264 .and. tlline .lt. 290 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=275
else
if(tlline .gt. 289 .and. tlline .lt. 315 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=300
else
if(tlline .gt. 314 .and. tlline .lt. 340 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=325
else
if(tlline .gt. 339 .and. tlline .lt. 365 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=350
else
if(tlline .gt. 364 .and. tlline .lt. 390 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=375
else
if(tlline .gt. 389 .and. tlline .lt. 410 .and.
1  line(12) .eq. '9' .and. line(26) .eq. '9') then
tlline=400
else
if(tlline .eq. '9' .and. line(32) .eq. '9') then
tlline=407
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end
if(tlline .eq. 325) then
  remind=1
else
  if(tlline .eq. 350) then
    remind=1
  else
    if(tlline .eq. 375) then
      remind=1
    else
      if(tlline .eq. 400) then
        remind=1
      else
        if(tlline .eq. 410) then
          remind=1
        else
          remind=0
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ende
tlline=404
endif
if (status .eq. 200925504941129100')
tlline=376
endif
if (status .eq. 730309206930203900')
tlline=404
endif
chk to see if MOD(nrcrecord/23)=0
*chk to see if MOD(nrcrecord/30)=0
nrcrd=nrcrd+1
write(12,*) 'status=',status
write(',·) 'trcrd=',trcrd
write(',·) 'nrcrd=',nrcrd
write(-,·) 'status=',status
if (tlline-(INT(tlline/410)*410) .eq. 0)
remain=O
trcrd=trcrd+131
write(12,*)
'trcrd=',trcrd
write(12,*) 'tlline=',tlline
write(·,')
'trcrd='·trcrd
write(12,*) 'status=',status
write(',·) 'status=',status
tlline=O
endif
the following section chks to see if this record is correct
150 if(record(12) .ne. '9' .or. record(26) .ne. '9'
1 .or. record(232) .eq. .or. record(2) .ne. 1 .or. record(3) .eq. 'I'
1 .or. record(245) .eq. ') then
go to 180
else
1 .or. record(245) .eq. 'F' .or. record(245) .eq. 'B') then
go to 180
endif
write(10,') (250A1)') (record(i),i=1,250)
errchk=errchk+1
bchk=l
bchk=1 to indicate fixsub is called
call fixsub(line, record, length,
1 low,tlline,status)
go to 50
endif
start with next record's processing
'180 if(record(12) .ne. '9' .or. record(26) .ne. '9'
1 .or. record(232) .eq. .or. record(2) .ne.
1 .or. record(3) .eq. ') then
if(record(12) .eq. '9' .and. record(26) .eq. '9'
1 .and. record(221) .eq. 'I'.and. record(2) .eq.
1 .and. record(3) .eq. '') then
go to 185
else
1 .or. record(245) .eq. ') then
go to 180
endif
write(9,') (250A1)') (record(i),i=1,250)
185 call wrtsub(slct,outslct,bfpt,efpt,record,nslt,
1 outnslt,exchange,backward)
go to 50
endif
start with next record's processing
3150 if(record(12) .ne. '9' .or. record(26) .ne. '9'
1 .or. record(232) .eq. .or. record(2) .ne.
1 .or. record(3) .eq. ') then
if(record(12) .eq. '9' .and. record(26) .eq. '9'
1 .and. record(221) .eq. 'I'.and. record(2) .eq.
1 .and. record(3) .eq. '') then
go to 185
else
1 .or. record(245) .eq. ') then
go to 150
endif
if(trcrd .gt. 1200001) then
write9,') (250A1)') (record(i),i=1,250)
endif
using subroutine wrtsub to write records to event files
180 call wrtsub(slct,outsclt,bfpt,efpt,record,nslt,
1 outsclt,exchange,backward)
go to 50
endif
start with next record's processing
75 low=O
if(remind .eq. 1) then
remain=0

endif
if(remain ne. 0) then
  do i=1,remain
    record(low+i)=line(SO-remain+i)
  enddo
  low=low+remain
endif
length=250-remain
goto 50

******************************************************-
100 continue
write(7,*) 'trcrd=', trcrd, 'errchk', errchk
write(7,*) 'errln=', errline, 'errchk=', errchk
write(6,*) 'trcrd=',trcrd, 'errln=', errline, 'errchk=',errchk
write(*,*) 'trcrd=',trcrd, 'errln=', errline, 'errchk=',errchk
***··*******************FOR GENERAL FILE--------_·-
write I?, 'llx,6hfield',2x,3hRBF,lx,3hREF,lx,3hCBF,lx,3hCEF,
+ lx, 3hFWD,2x, 6hvalid%,3x,9hkeep/drop, 6x,5hFNAME) ')
  low=l
  do 200 i=1,nslt
    if (trcrd ne. 0.) then
      cntli)=cntli)/floatltrcrd)"lOO.
    endif
    length=efptlslctli))-bfptlslctli))
    write(7, 't5hfield,i2,5i4,3x,f6.2,3x,All,3x,A16) 'I
      + slctli),bfptlslctli)),efptlslctli)),low,low+length,
      + length+1,cntli),keptlslctli)I
      low=low+length+l
  200 continue
-****····*****······*******************FOR outpatient file
-------------------------------
write I?,")
'OutTotal=',trcrd
k=l
write(?,·)
'OutFile=',
oerce:
write I?, 'llx,6hfield4,2x,3hRBF,lx,3hREF,lx,3hCBF,lx,3hCEF,
+ lx, 3hFWD,2x, 6hvalid%,3x,9hkeep I
write(*,*) 'OutTotal=',trcrd, 'OutFile=','OutF
-****····*****······*******************FOR outpatient file
-------------------------------
write I?,")
'OutTotal=',trcrd
k=l
write(?,·)
'OutFile=',

* This section was completed at 01:12:27AM;11-Jun-1994

real FUNCTION secnds()
INTEGER*2 hour, minute, second, hundredth
CALL GETTIM( hour, minute, second, hundredth )
  secnds = ((DBLE( hour ) * 3600.0) + (DBLE( minute ) * 60.0) +
+ DBLE( second ) + (DBLE( hundredth ) / 100.0))
END

Subroutine 'Fixsub' is going to check if the record is a bad record
which means that 'record(161) .ne. 'T' .or. record(162) .ne. 'X' has
been found and then the record is put into a file which is specially
prepared for bad records. The program will continue to search the right
position of T and X until it finds them that means a new good record has
been found

subroutine fixsub(lines,records,lengths,
  1 lowns,tllines,status)
real ttlines
integer lows, lengths, brace, j, nrcards
integer remains, chkline
character*20 status
character*1 lines(80), records(250)
character*1 line(80), line2(80), line3(80), line4(80)

**initialize low, length, remain**

```fortran
lows=0
lengths=250
chkline=0
```
do i=1,80
  line4(i)=lines(i)
  line3(i)=lines(i)
  line2(i)=lines(i)
  line1(i)=lines(i)
endo
5
read(5, '(80A1)', err=20) (lines(i), i=1,80)

**search the pattern**

```
ttlines=ttlines+1.
if(ttlines .gt. 410) then
  ttlines=0
else
  if(ttlines .eq. 25) then
    remains=1
  else
    if(ttlines .eq. 50) then
      remains=1
    else
      if(ttlines .eq. 75) then
        remains=1
      else
        if(ttlines .eq. 100) then
          remains=1
        else
          if(ttlines .eq. 125) then
            remains=1
          else
            if(ttlines .eq. 150) then
              remains=1
            else
              if(ttlines .eq. 175) then
                remains=1
              else
                if(ttlines .eq. 200) then
                  remains=1
                else
                  if(ttlines .eq. 225) then
                    remains=1
                  else
                    if(ttlines .eq. 250) then
                      remains=1
                    else
                      if(ttlines .eq. 275) then
                        remains=1
                      else
                        if(ttlines .eq. 300) then
                          remains=1
                        else
                          if(ttlines .eq. 325) then
                            remains=1
                          else
                            if(ttlines .eq. 350) then
                              remains=1
                            else
                              if(ttlines .eq. 375) then
                                remains=1
                              else
                                if(ttlines .eq. 400) then
                                  remains=1
                                else
                                  if(ttlines .eq. 410) then
                                    remains=1
                                  else
                                    ttlines=0
                                  else
                                    remains=0
                                  endif
                              endif
                          endif
                    endif
                endif
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endif

110  l0ws=0

remainder=80-straint+12
lengths=250-remainder
do j=1, remainder
  records[(j+10ws)] = line2(80-remainder+j)
endo

d0 w=0+remainder
lengths=lengths-80
do j=1, 80
  records[(j+10ws)] = line1(j)
endo

d0 w=0+80

goto 20
endo

120

d0 i=70, 80

if (line3(i) .eq. '9' .and. line2(i-66) .eq. '9') then
  brn=1
  if (brace .eq. 72) then
    l0ws=0
    remain1=20
    lengths=250-remainder
    do j=1, remain1
      records[(j+10ws)] = line3(80-remain1+j)
endo
    l0ws=low+remain1
    lengths=lengths-80
    do j=1, 80
      records[(j+10ws)] = line2(j)
endo
    "0ws=0+80
    lengths=lengths-80
    do j=1, 80
      "0ws=0+80
      goto 20
endo

endif

endif
endo

d0 i=70, 80

if (line3(i) .eq. '9' .and. line2(i-66) .eq. '9') then
  brn=1
  if (brace .eq. 72) then
    l0ws=0
    remain1=20
    lengths=250-remainder
    do j=1, remain1
      records[(j+10ws)] = line3(80-remainder+j)
endo
    l0ws=low+remain1
    lengths=lengths-80
    do j=1, 80
      records[(j+10ws)] = line2(j)
endo
    "0ws=0+80
    lengths=lengths-80
    do j=1, 80
      "0ws=0+80
      goto 20
endo

endif

endo

l0ws=0
lengths=250

goto 5

d0 w=0

goto 5

continue

return
end

******************************************************************************

********·***************·GENERAL

do i=1, 9

  if (record(exchange(i)) .eq. '9' .or. 
    record(exchange(i)) .eq. ')') then
    continue
  endif

******************************************************************************

* subroutine wrtsub takes record[382], slct, bfp, efpt, nslt from CUTCLAIM main
  * program, and writes out the selected fields (characters) to outstr[382] before
  * it writes outstr to events files based on the values in the events identifying field.
  * SLCT(i) returns the series # of the selected field(i) 1<=SLCT(i)<=72
  * bfp[k] returns the BEGGINNING point of field[k]
  * EFPT[k] returns the ENDING point of field[k] 1<=EFPT(k),EFPT(k)<382

******************************************************************************

* subroutine wrtsub(slct, outslct, bfp, efpt, record,
  1 nslt, outrnslt, exchange, backward)
  integer nslt, outnslt, kout, trcrd, errcnt
  integer bfp, efpt, slct, outslt, chk, exchange, backward
  real outrcnt, cnt
  character*1 record(1), outstr(250)
  * character*3 cntycode
  * character*12 plantype
  dimension bfp(1), efpt(1), slct(1), outslct(1),
  1 cnt(1), outrcnt(1), exchange(9), backward(9)
  common /ctrlctrll /ctrl10
  * write(cntycode,'(3A1)') (record(i), i=25,27)
  * write(plantype,'(12A1)') (record(i), i=90,101)

******************************************************************************

* write them out to general file

******************************************************************************

*GENERAL FILE

********·***************·GENERAL

do i=1, 9

  if (record(exchange(i)) .eq. '9' .or. 
    record(exchange(i)) .eq. ')') then
    continue
  endif

******************************************************************************

109
record(exchange(i))='Q'
else
if (record(exchange(i)) .eq. 'A') then
  record(exchange(i))='1'
else
if (record(exchange(i)) .eq. 'B') then
  record(exchange(i))='2'
else
if (record(exchange(i)) .eq. 'C') then
  record(exchange(i))='3'
else
if (record(exchange(i)) .eq. 'D') then
  record(exchange(i))='4'
else
if (record(exchange(i)) .eq. 'E') then
  record(exchange(i))='5'
else
if (record(exchange(i)) .eq. 'F') then
  record(exchange(i))='6'
else
if (record(exchange(i)) .eq. 'G') then
  record(exchange(i))='7'
else
if (record(exchange(i)) .eq. 'H') then
  record(exchange(i))='S'
else
if (record(exchange(i)) .eq. 'I') then
  record(exchange(i))='1'
else
if (record(exchange(i)) .eq. 'J') then
  record(exchange(i))='l'
record(exchange(i)-backward(i))='-' 
else
if (record(exchange(i)) .eq. 'K') then
  record(exchange(i))='2'
else
if (record(exchange(i)) .eq. 'L') then
  record(exchange(i))='3'
else
if (record(exchange(i)) .eq. 'M') then
  record(exchange(i))='4'
else
if (record(exchange(i)) .eq. 'N') then
  record(exchange(i))='5'
else
if (record(exchange(i)) .eq. 'O') then
  record(exchange(i))='6'
else
if (record(exchange(i)) .eq. 'P') then
  record(exchange(i))='7'
else
if (record(exchange(i)) .eq. 'Q') then
  record(exchange(i))='8'
else
if (record(exchange(i)) .eq. 'R') then
  record(exchange(i))='9'
elseret
ENDIF
ENDIF
ENDIF
ENDDO
IF (ctrlO.eq.O .or. ctrlO.eq.3) then ! WIF1
kout=0
DO 20 i=1,nsit
chk=0
DO 15 k=bftp(slc(i)),efpt(slc(i))
  IF (chk .eq. 0) then ! WIF1-1
    IF (record(k) .ne. '' .and. record(k) .ne. '0') then ! WIF1-2
      cnt(i)=cnt(i)+1.0
      chk=1
    ENDIF
  ENDIF
  KOUT=KOUT+1
  OUTSTR(KOUT)=RECORD(k)
15 CONTINUE
20 CONTINUE
WRITE(6,'(BOAII'I') OUTSTR(i),i=1,kout)
WRITE(6,'(250AI') OUTSTR(i),i=1,kout)
ENDIF ! WIF1

********************************************************************OUTPATIENT FILE*****************************
* IF (ctrlO.eq.1 .or. ctrlO.eq.3) THEN ! WIF2
* if (ctrlO.eq.3) goto 100 ! added so that outpat is not written

KOUT=0
DO 50 i=1,OUTNLT
  CHK=0
  DO 45 K=BFTP(OUTSLCT(i)),EFPT(OUTSLCT(i))
    IF (CHK .EQ. 0) THEN
      IF (RECORD(K) .NE. '' .AND. RECORD(K) .NE. '0') THEN
        OUTCNT(I)=OUTCNT(I)+1.0
        CHK=1
      ENDIF
    ENDIF
    KOUT=KOUT+1
    OUTSTR(KOUT)=RECORD(K)
45 CONTINUE
50 CONTINUE
IF (RECORD(34) .EQ. '' .OR. RECORD(34) .EQ. '3' .OR. RECORD(34) .EQ. '5' .OR. RECORD(34) .EQ. '6' .OR. RECORD(34) .EQ. 'C' .OR. RECORD(34) .EQ. 'E' .OR. RECORD(34) .EQ. 'R') THEN
  WRITE(9,'(250AI') OUTSTR(i),i=1,kout)
ENDIF ! WIF2
END
100 CONTINUE
RETURN
Appendix G. A Process for Estimating Water Demand

Aggregations of water demand used in this study are described in Table G.1. Real-time forecasts of water demand are created using spreadsheet software and readily available data series. The data required to forecast water demand are described in Table G.2.

An Example of How to Forecast Treated Water Demand
Forecasts are developed by substituting rainfall, temperature, and time into equation G.1 with the coefficients listed in Table 4.1 of the main report. The forecast of per capita treated water sales for May 1996 (Y_{197}) is created by substituting the variables for that month into the equation and applying the model coefficients (Tables 4.1 and 4.3):

\[ Y_{197} = 16.649 \cdot 0.363(87.6) + 0.0027(87.6) \cdot 0.042(1.14) + 0.003(197) + v_{197} = 6.09 \]
\[ v_{197} = 0.372 u_{196} + 0.211 u_{194} \cdot 0.132 u_{187} + 0.409 u_{185} \]

The mean maximum temperature during May was 87.6°F Fahrenheit and there were 1.14 inches of rain at the Corpus Christi International Airport. The trend variable for May is defined as 197 because May is 197th in the sequence of months in the data series. While the assignment of indexes is somewhat arbitrary because the series could begin at any point in time, changes in the initial assignment of indices must be completed before estimation of model parameters. The second equation is the autoregressive error term. A series of coefficients is multiplied by the difference in predicted and actual values at significantly correlated lags.

For a forecast of water use for more than one time period over the drought management period or after the drought management period has begun, the residuals of lagged forecasts will not be available because there is no measurement of water use in the absence of the drought management program. This problem is resolved by substituting the value of the error term at each lag for which the lagged residual is missing (equation G.2). For example, a forecast for August 1996 is missing the first and third lagged residual.

\[ Y_{200} = 16.649 \cdot 0.363(94.21) + 0.0027(94.21) \cdot 0.042(6.26) + 0.003(200) + v_{197} = 6.59 \]
\[ v_{200} = 0.372 u_{196} + 0.211 u_{194} \cdot 0.132 u_{187} + 0.409 u_{185} \]

The effect of the error term on the forecast decreases as the number of successive months in the forecast increases.

Creating Forecasts for Water-User Sectors
The only difference between creating forecasts for water demand sectors and creating forecasts for total water use is the inclusion of a price term. The coefficients for water-user sectors are listed in Table 4.3 of the main report. Residential water prices are divided by the consumer price index before being multiplied by model coefficients. Commercial and industrial water prices are divided by an adjusted producer price index (1982 minus 4 = 1.00). The adjusted producer price index is calculated by dividing the raw producer price index (1982 = 1.00) by 1.01667. Marginal water prices for the residential water-user sector are defined as the price of an additional
thousand gallons after the customer has purchased 7,000 gallons and for the commercial/industrial water-user sector as the price of an additional thousand gallons after the customer has purchased 100,000 gallons of water.

**How to Interpret Results**

The result of the forecasting equation expresses water demand on a per capita or a per account basis. Estimates of total and treated water demand are expressed on a per capita basis. The next step is to convert the per capita or per account estimates to a total volume of water and multiply total and treated water demand estimates by the population of Corpus Christi MSA and municipal water demand. This can be done by multiplying the per capita use by the city's estimate of population inside the city limits or the per account use by the number of accounts.

For example, the estimate of treated water demand for August 1996 is 6.59 thousand gallons per capita. The population of the Corpus Christi Metropolitan Statistical Area in that year was estimated to be 382,710 from a Regional Economic Information System data series of the Bureau of Economic Analysis, U.S. Department of Commerce (Table 2.2 of the main report). The demand for treated water during August is therefore 382.71 thousand people times 6.59 thousand gallons of water per person, or 2,522 million gallons. Estimates of water demand in the three water-user sectors are expressed in per account terms. The number of accounts was obtained from utility billing reports produced by the City of Corpus Christi.
<table>
<thead>
<tr>
<th>Data Series</th>
<th>Data Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total water demand</td>
<td>All treated and raw water sales by the City of Corpus Christi to retail and wholesale customers including industrial customers and wholesale customers purchasing raw water supplies for treatment and sale to the surrounding communities in Mathis, Port Aransas, Beeville, San Patricio, and other places. Total water sales are divided by the population of the Corpus Christi Metropolitan Statistical Area, which is defined as the entire counties of Nueces and San Patricio. The measure is expressed in thousand gallons per capita per month.</td>
</tr>
<tr>
<td>Treated water demand</td>
<td>All treated water sales to retail and wholesale customers including residential, commercial, and industrial customers. Treated water sales are divided by the population of the Corpus Christi Metropolitan Statistical Area, which is defined as the entire counties of Nueces and San Patricio. The measure is expressed in thousand gallons per capita per month.</td>
</tr>
<tr>
<td>Municipal water demand</td>
<td>Residential and commercial water sales inside the city limits divided by an estimate of the population inside the city limits and again divided by the number of days each month. Population estimates are generated by the City of Corpus Christi planning department. The measure is expressed in gallons per capita per day.</td>
</tr>
<tr>
<td>Residential water demand</td>
<td>Retail treated water sales by the Corpus Christi Water Division to end-user residential customers inside and outside the city limits. Retail water sales include sales to single-family accounts and duplexes but exclude water sales to apartments and condominiums. Residential water sales are divided by the number of residential retail accounts reported in the monthly utility billing report. The measure is expressed in thousand gallons per account per month.</td>
</tr>
<tr>
<td>Commercial water demand</td>
<td>Retail treated water sales by the Corpus Christi Water Division to end-user commercial customers inside and outside the city limits. Commercial water sales include apartments and condominiums, and are distinguished from industrial water customers by the diameter of the water meter connection. Commercial water sales are divided by the number of commercial retail accounts reported in the monthly utility billing report. The measure is expressed in thousand gallons per account per month.</td>
</tr>
<tr>
<td>Industrial water demand</td>
<td>Retail and wholesale treated and raw water sales by the Corpus Christi Water Division to end-user industrial customers inside and outside the city limits. Industrial water sales are distinguished from commercial water sales by the size of the meter connection. Industrial water sales are divided by the number of industrial retail accounts reported in the monthly utility billing report. The measure is expressed in thousand gallons per account per month.</td>
</tr>
</tbody>
</table>
Table G.2. Description of Data Required to Forecast Water Demand

<table>
<thead>
<tr>
<th>Data Series</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean maximum temperature</td>
<td>The average of daily high temperature is available from the National Weather Service's meteorological station at Corpus Christi International Airport. The mean maximum temperature is expressed in degrees Fahrenheit. Data can be obtained for a week/month on the first day of the subsequent month.</td>
</tr>
<tr>
<td>Aggregate rainfall</td>
<td>Aggregate rainfall is the sum of rainfall during the month to be forecast. These data are available from the National Weather Service's meteorological station at Corpus Christi International Airport. Aggregate rainfall is expressed in inches of rain per month. Data can be obtained for a week/month on the first day of the subsequent month.</td>
</tr>
<tr>
<td>Marginal water price</td>
<td>The marginal price of water in the residential sector is the price of the eighth thousand gallon of water to residential customers and the 101st thousand gallon of water to commercial and industrial customers. The marginal water price is expressed in dollars per thousand gallons.</td>
</tr>
<tr>
<td>Consumer price index</td>
<td>The monthly consumer price index is used to convert nominal prices to real prices for the residential demand analysis. The index is calculated by dividing average prices in one month by average prices during the period 1982-1984 so that the average price index for the period 1982-1984 = 1.00. The index reflects the relative cost of common purchases to all urban consumers throughout the nation in one month relative to that average at some other point in time. This data series is available from the Bureau of Labor Statistics (BLS) online information center on the World Wide Web (<a href="http://www.bls.gov">http://www.bls.gov</a>) and has the series identification number &quot;cuur0000sa0.&quot; From the BLS home page choose &quot;Data&quot; (from below the buttons), then choose &quot;Series Report,&quot; enter the series identification number, request the appropriate years, and request the desired format.</td>
</tr>
<tr>
<td>Producer price index</td>
<td>The monthly producer price index is used to convert nominal prices to real prices in commercial and industrial demand analyses. The raw index is based on an average monthly producer price index for 1982. The raw index reflects the weighted average price of all commodities purchased by producers throughout the nation relative to the weighted average price in 1982. The average is weighted by the value of shipments. For consistency with the consumer price index, the 1982 index is converted to an average base year of 1982-1994 by dividing by 1.01667. This data series is available from the Bureau of Labor Statistics (BLS) online information center on the World Wide Web (<a href="http://www.bls.gov">http://www.bls.gov</a>) and has the series identification number &quot;wpu00000000.&quot; From the BLS home page choose &quot;Data&quot; (from below the buttons), then choose &quot;Series Report,&quot; enter the series identification number, request the appropriate years, and request the desired format.</td>
</tr>
<tr>
<td>Sequence of forecast month</td>
<td>The sequence of the forecast month is the numerical sequence of the month in question; the base month, January 1982, is defined as 25. For example, May 1996 is defined as 197 because it is the 172nd month after January 1982. This sequence variable is used to describe trends in water use.</td>
</tr>
</tbody>
</table>

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