A COMPARISON OF AUSTIN AND SAN ANTONIO RESIDENTIAL WATER USE DURING TWO YEARS OF DROUGHT-INDUCED CONSERVATION POLICIES

THESIS

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CHAPTER 1

THE PROBLEM AND ITS SETTING

Statement of the Problem

This study will determine and analyze differences between San Antonio, Texas and Austin, Texas residential water use during the drought conditions of 1995 and 1996. Water is a precious resource that is often abused or taken for granted. This study will give insight into how two cities in Texas use this resource.

Importance

Domestic water use, which includes households, businesses, restaurants, public offices, sanitation, landscaping and fire protection, accounts for 26.1% of the water used in Texas, second only to irrigation at 45.9% (Texas Center for Policy Studies 1990). The Texas Water Development Board (TWDB) predicts that the population of Texas will double by 2040, and water needs will increase by 72% (TWDB 1990). The 1990 Water Plan points out that water is a finite resource. Despite new reservoirs and yield enhancement, the supply of water cannot increase indefinitely. Therefore, more efficient use, reuse and conservation must be a part of Texas' future (TWDB 1990). The 1992 Water for Texas plan states that: "The State of Texas should aggressively pursue water conservation and related efforts to stretch availability and use of existing surface water supplies..." (TWDB 1992, 20).

Setting and Situation

San Antonio and Austin are 75 miles apart, along Interstate 35 in Central Texas. The two cities make up the two ends of what is referred to as the Austin-San Antonio Corridor.

San Antonio draws its water from the Edwards Aquifer. It is the only city of its size in the United States completely dependent on groundwater for its municipal water supply. There are many areas around San Antonio that also depend on the aquifer. In addition to other municipalities and farming communities in the surrounding area, there are also five endangered species that are dependent on the aquifer for survival. In Comal Springs, in New Braunfels, there is the Texas Blind Salamander, *Typhlomolge rathbuni* and the Fountain Darter, *Etheostoma fonticola*. In San Marcos Springs, in San Marcos, there is the San Marcos Gambusia, *Gambusia georgei,* the San Marcos Salamander, *Eurycea nana,* and Texas Wild Rice, *Zizania texana* (Eckhardt 1995A). In 1956, during a serious state-wide drought, Comal Springs stopped flowing. Since the occurrence of this drought in the 1950s, there has been pressure on San Antonio to reduce its demand on the aquifer. Almost forty years later, in 1995 and 1996, another drought occurred. Fingers again pointed at San Antonio to reduce its withdrawals from the aquifer. In May 1991, the Sierra Club filed suit against the United States Fish and Wildlife Service, and the Secretary of the Interior to protect endangered species in San Marcos Springs and Comal Springs. The Sierra Club continued to push the issue against opposition from San

Antonio and state officials. US District Court Judge Lucius D. Bunton III set many deadlines for reductions in water use. He ordered the development of a drought management plan in order to limit pumping from the aquifer. In early August 1996, the plan was ready to be implemented. On August 23, 1996, Hurricane Dolly hit the Gulf of Mexico bringing rain to the recharge area. One result of the drought relief was that the plan was not implemented. However, the court case gained much public attention.

The city of Austin draws its water from Lake Travis, a lake in a chain of six reservoirs created along the Colorado River and referred to as the Highland Lakes. Mansfield Dam, the dam that creates Lake Travis was completed in 1941. The reservoir was designed to hold 380 billion gallons of water for water supply and it also has room for 260 billion gallons of flood control storage (LCRA 1996). Unlike the situation with the Edwards Aquifer, there are no endangered species in the lake. However, the Lower Colorado River Authority (LCRA) manages the Highland Lakes and must ensure adequate water supplies for instream uses and rice irrigation downstream from Austin. In addition, there are many residents and businesses along the lake that felt the effects of the drought. Docks and piers no longer reached the water in the lake, because the lake levels had dropped so much from lack of rain.

During the 1995-1996 drought, both San Antonio and Austin implemented conservation programs that encouraged restrictions on residential water use. The plans that were developed and implemented by each city differed on several aspects. In the context of the TWDB's concern for water conservation, it is important to determine the manner in which two cities in the same region responded to drought. This research will analyze the differences between the conservation programs of these two cities and differences between the cities' residential water use during this period of drought. The research will attempt to answer the following questions: Were there significant differences in residential water use between San Antonio and Austin during the summer drought of 1995 and 1996? Were there any significant differences in water use between the neighborhoods of similar income levels in each city? Were there significant differences between residential water use in 1995 as compared to residential water use in 1996 in both cities?

Hypotheses

In this study, the following hypotheses will be examined:

- Per meter residential water use will be similar in both cities in 1995 and 1996 despite different conservation strategies implemented in each city.
- Residential water use among different income levels will be similar despite different conservation strategies implemented in each city.
- 1995 per meter water use will be similar to 1996 per meter water use in both cities despite a year of incipient drought and conservation strategies encouraged by the cities in 1995.

As the population in Texas grows, the state must learn to use water wisely. This study is important to Texas because it will shed light on two municipalities' residential water use and how it is affected by income, number of people per household, price, conservation programs, and perception of drought, and climatic conditions.

CHAPTER 2

REVIEW OF THE LITERATURE

Six basic factors affect levels of residential water use. These are income, number of people per household, climatic conditions, price of water, conservation techniques, and drought perception. Suggested methods for assessing each of these factors will be examined in some detail.

Income

Income or economic level of household is the most widely-accepted factor as a determinant of residential water use (Grima 1972). Larson and Hudson (1951) studied 13 Illinois communities and found that the highest use occurred in communities that were located in more prosperous areas of the state. Headly (1963) studied the relationship between water demand and income in the San Francisco-Oakland Area. He considered precipitation, air temperature, and price to be constant in the region, and used linear and log-linear equations to determine that as income increases by 1%, water use increases by 1.5%. Similarly, since home value is strongly related to income, many studies have found home value to be a good predictor of water use (Dunn and Larson 1963; Agthe, Billings & Dworkin 1988; Thompson and Stoutemyer 1991).

Dunn and Larson (1963) suggested that higher income households used more water because they were more likely to have water-intensive appliances such as washing machines and dishwashers. More recent research shows that these appliances have become commonplace and can no longer explain the difference (Clouser and Miller 1980). Clouser and Miller (1980) suggest that landscaping is the reason for the difference. Landscaping can represent an expensive home improvement investment which often outweighs water costs and risk of fines during conservation times. In more affluent neighborhoods, social pressure and subdivision guidelines encourage green, manicured lawns.

Number of Residents per Household

Several studies have also found a significant relationship between the number of residents per household and water use (Dunn and Larson 1963; Grima 1972; Clouser and Miller 1980; Morgan 1973; Thompson and Stoutemyer 1991). The relationship is not as strong as home value. However, this is an important factor because a positive linear relationship is assumed in many forecasting procedures (Grima 1972). Yet, Howe and Linaweaver (1967) did not find a significant relationship between water use and household size for metered users in their study of 39 areas in the United States. The 39 study areas included: ten areas of metered and public sewer systems in the Oakland, the Los Angeles, and San Diego metropolitan areas; eleven areas, both metered and public, in the Des Moines, Fort Worth, Little Rock, Washington, D.C., Baltimore, and

Philadelphia metropolitan areas; five areas metered with septic tanks in Des Moines, Baltimore, and suburban areas of Philadelphia; eight areas with flat-rate public water and sewers in Sacramento, Great Falls, and Denver; and five areas of apartments, where buildings, but not individual apartments, were metered in San Diego, Denver, and Washington, D. C. metropolitan areas (Howe and Linaweaver 1967).

Price

Probably the most comprehensive study on the price of water was done by Howe and Linaweaver (1967). In studying regions across the United States, they found domestic demands to be relatively inelastic with respect to price. Elasticity of demand is the percentage change in quantity demanded, divided by the percentage change in price (Ruffin and Gregory 1986). In other words, if the water demand is described as elastic, it means that as the price of water changes, the amount of water used also changes. If water demand is described as inelastic, it means that water use does not change with respect to price. Contrary to the findings of Howe and Linaweaver (1967), Bruvold and Smith (1988) found that demand for residential water is price elastic. Their study shows that the relationship between price and consumption was statistically significant. The higher the price of water, the less people used. Turnovsky (1969) also found that domestic demand is significantly related to price. He points out that, although significant, the influence of price is not very strong in magnitude as measured by elasticity. "Thus although price or variance changes will certainly affect demand, a substantial change will be required in either of these variables to bring about some desired change in consumption" (Turnovsky 1969, 359). He further states that rationing may be necessary to reduce domestic water use.

It is very difficult to test the effect of price on demand, because many areas have a declining block rate pricing structure for water (Griffin, Martin, and Wade 1981; Grima 1972). Under a declining block rate structure, the average price of a unit of water will fall as a customer's consumption increases. Both San Antonio and Austin employ increasing block rate structures. In other words, after customers use a specified amount of water each month, the price of the water unit increases. There have been several studies on the effects of increasing block rate structures and their effect on water use (Loudon 1986; Agthe, Billings, and Dworkin 1988). Agthe, Billings, and Dworkin (1988) found that residents of Tucson, Arizona who were informed of the increasing rate structure used more water. However, this does not imply that increasing water rates are not effective in encouraging water conservation. A previous study in Tucson by Agthe and Billings (1980) found that all groups of water users, regardless of income levels, reduce water use in response to increasing prices. They concluded that the higher volume users in Tucson have an economic incentive to become informed because they are subject to the higher price blocks with corresponding higher bills.

Response to Conservation Programs

A factor very closely related to price, is response to conservation programs. There is usually the risk of fines for those who do not abide by the limits. Several studies have been conducted on the effects of conservation plans on residents' actual water use (Geller, Erickson, and Buttram 1983; Bruvold and Smith 1988; Agras, Jacob, and Lebedeck 1980; Shaw and Maidment 1987 and 1988; Lee and Warren 1981; Foster, Karpiscak, and Brittain 1988; Jones 1992). Four types of residential conservation programs are outlined in the literature: 1) public education; 2) pricing to encourage less use; 3) restrictions on use; 4) building and plumbing code requirements.

Public education is certainly the least controversial of the four (Martin, et al. 1984). Geller, Erickson, and Buttram (1983) compared the effects of education, behavior, and engineering strategies on water conservation. The group that received educational material alone showed no change in water use. Educating people about the amount of water they use has also been shown to be ineffective. Hamilton (1985) found no significant differences in water use between people who could accurately estimate their water use and those who could not during a water conservation campaign. In fact, water use was higher among those who could accurately estimate their water use. In their thirteen-year study of nine San Francisco Bay Area water districts, Bruvold and Smith (1988) found that residents who were aware of a increasing block rate structure use more water than residents who were not familiar with the block rate structure. This supports conclusions by Agthe and Billings (1987) mentioned earlier, that the higher volume users have an economic incentive to become informed because they are subject to the higher price blocks. Bruvold and Smith (1988) suggest an increasing block rate structure, coupled with an information program to inform residents of their consumption, would have an effective impact on reducing water use. San Antonio employs this method by displaying a bar graph of the resident's annual water use on each month's water bill. The bills also inform the residents how much water they use compared with their neighbors.

Agras, Jacob, and Lebedeck (1980) studied the effect of fines in the 1976-1977 drought in the San Francisco Bay Area. They found that on a community level, significant savings of water occurred regardless of whether or not fines were imposed. However, at an individual level, fines appeared to have an effect on consumers who had received at least one fine.

Restrictions on water use are the most common conservation method employed. Often, they begin with voluntary conservation with recommended restrictions and move to mandatory restrictions as a drought worsens (Shaw and Maidment 1987 and 1988). Lee and Warren (1981) found that mandatory programs which set quantitative per capita restrictions are the most effective conservation method. Shaw and Maidment (1988) confirmed this in their study of the 1984 drought in Corpus Christi, Texas. Corpus Christi's conservation plan was implemented in four stages. The first stage, voluntary reduction, had little or no effect on water use. Stage two, mandatory limits on water use, reduced water use by 33%. However, the more severe restrictions of stages three and four had little effect, because residents had already reduced their water use to winter levels.

Conservation strategies written into building code requirements and plumbing codes have been shown to be effective at reducing long-term residential water use (Foster, Karpiscak, and Brittain 1988; Jones 1992). These would include low flow toilets and low flow shower heads.

The most commonly used method to analyze conservation programs is the Box-Jenkins time series analysis (Box and Jenkins 1976). Bruvold and Smith (1988), Shaw and Maidment (1988) and Lee and Warren (1981) used this technique in their analyses. Maidment, et al. (1985) also used this technique to develop a water forecasting model they call WATFORE. The City of Austin used WATFORE in the summer drought of 1984 and 1985 to predict water use a few days ahead on the basis of current water use and forecasts of daily maximum air temperature and rainfall. Water utility officials used the WATFORE system to provide early warnings to citizens of changes in the conservation strategies. This gave residents the chance to modify their water use in advance so that they may avoid stricter conservation requirements. In addition to water use forecasting, Shaw and Maidment (1987) used this model to estimate the amount of water conserved under the various strategies implemented in 1984 and 1985 in Austin. They concluded that the model was a useful tool for quantifying the overall effectiveness of conservation policies. However, they caution that the model fails to reveal any change in the real impacts over time. For example, water use may change throughout a mandatory conservation period as users become more comfortable with the regulations (Shaw and Maidment 1987). In a separate study, WATFORE accounted for 48-99 percent of the variability in the daily water use data in nine cities in three regions of the United States (Maidment, et al. 1985). It accounted for 99% in Dallas, Texas and 48% in Allentown, Pennsylvania (Maidment, et al. 1985).

Perception and Reaction to Drought

The reaction to drought can be explained with the diagram shown as Figure 1.

Figure 1. The reaction to drought.

Drought => Awareness => Concern => Panic => Rain => Apathy

(Matthai 1988, 190).

This is the case of too little, too late. Often, drought conditions exist long before the effects are seen in the water supply. People are not prepared to make the necessary changes in their daily habits (Matthai 1988). Instead of being prepared for a drought by conserving water on a daily basis, by xeriscaping lawns or installing low flow toilets, people react to drought. Unfortunately, the reaction is only temporary. After the drought breaks, the public is reassured that everything will return to normal. Apathy often results from skepticism and disbelief by the public (Matthai 1988) especially when the drought passes without serious, long term harm.

Thompson and Stoutemyer (1991) explain the public's reaction to drought as what Garrett Hardin (1968) called a commons dilemma. In other words, drought involves a conflict between short-term self-interest (green lawns and long showers) and long-term community interests. In a study of energy conservation attitudes by Nietzel and Winett (1977) survey respondents recognized the dwindling supply of resources and viewed the solution to the problem as requiring the development of new resources. This is a common view in drought perception.

The public's perception of drought is greatly influenced by the credibility of the local government as a source of water shortage information (Lee and Warren 1981). Credibility is enhanced when communities are near other places where the effects of drought have been more severe. For example, if wells have gone dry in nearby communities, conservation practices have been more effective (Lee and Warren 1981). However, Turnovsky (1969) has also shown that a consumer who has experienced uncertainty (of water supply) in the past, will react less positively to increases in conservation methods. In other words, a person exposed to drought once, learns he or she can survive it and responds less actively than a person confronting it for the first time.

Agras, Jacob, and Lebedeck (1980) indicate that a response to a stimulus (in this case conservation encouragement) that causes people to change their behavior happens when there is the perception of a crisis. They suggest that future research should focus on what conditions constitute a crisis and what conditions do not. As seen in the literature, a stimulus can be credibility or proximity to drought conditions (Lee and Warren 1981), or past experiences (Turnovsky 1969), or media coverage, lack of rain, dry reservoirs, and desiccated vegetation (Agras, Jacob, and Lebedeck 1980). Both San Antonio and Austin experienced desiccated vegetation and lack of rain. Austin could see the reservoir level (Lake Travis) dropping. San Antonio could not see aquifer levels dropping, but the well levels were broadcast daily by the news media.

Climatic Conditions

Many studies have considered the relationship between climatic conditions and water use. One of the most extensive was conducted by Linaweaver, Geyer, and Wolf (1967). The study included data from subdivisions representing all important climatic regions in the United States. They discovered that sprinkling demand (outside, seasonal use) was generally lower in the East than in the West, but about the same on maximum (driest) sprinkling days. Maidment, et al. (1985) studied water use in Austin from 1961 to 1981 and discovered that base use comprised 40% and seasonal use 60% of peak daily water use rate. Graeser (1958) found that daily demands for water in Dallas, Texas were significantly related to the daily maximum air temperature. In several linear regression models of daily municipal water use in Fort Collins, Colorado, Anderson, Miller, and Washburn (1980) discovered that about half of the drop in water use during a conservation period resulted from an unusually high rainfall during that period. This study will consider rainfall and temperature in San Antonio and Austin to explain variances in water use.

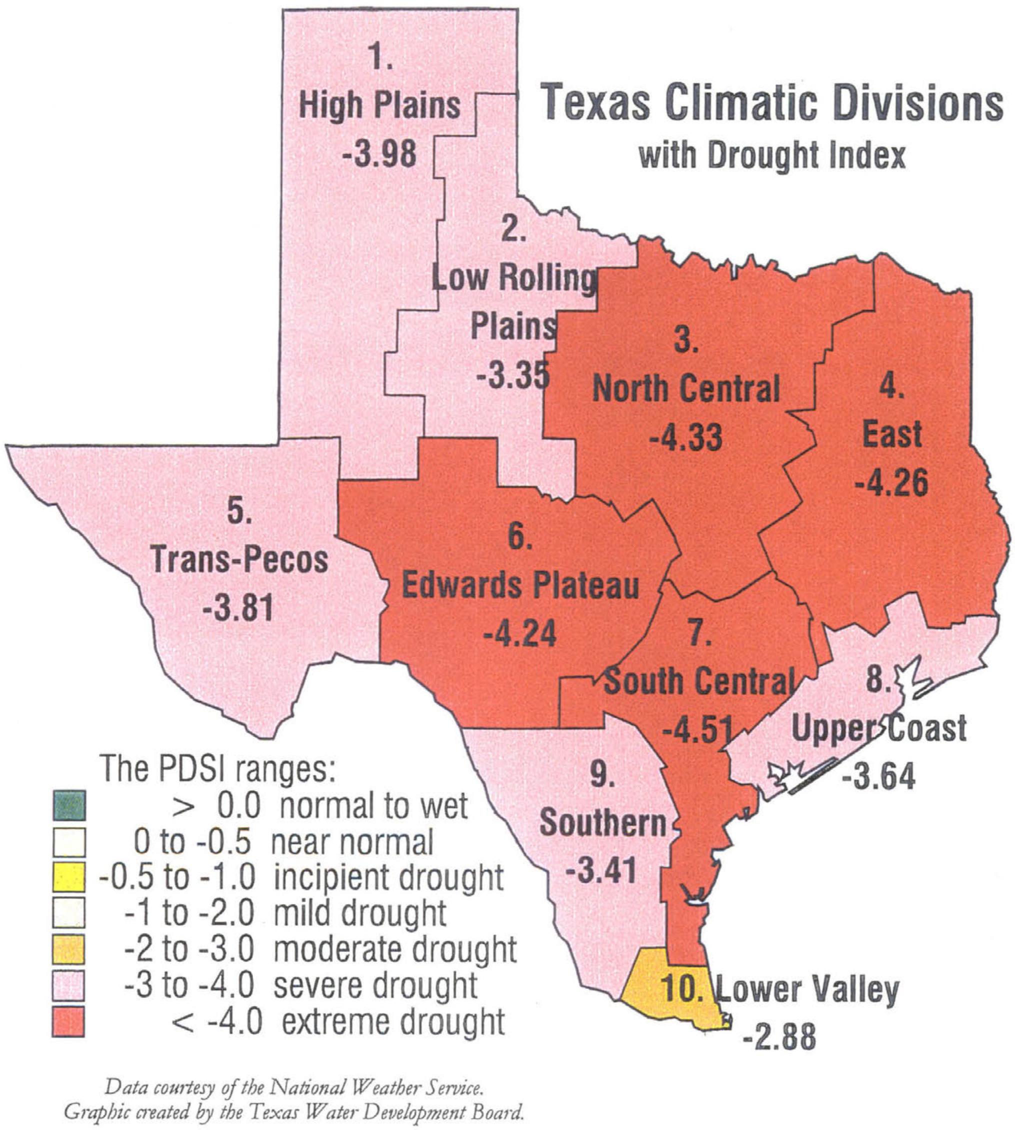
CHAPTER 3:

STUDY AREA CHARACTERISTICS

Defining Drought

Water conservation receives high levels of public attention and concern during times of drought, such as in 1995-1996, when Texas experienced drought conditions. To help understand the magnitude of a drought, it is important to provide some definitions and background. The Palmer Drought Severity Index (PDSI) is an established method of categorizing drought. The PDSI takes into account precipitation, evaporation, and soil moisture (TWDB, 1996). The index generally ranges from -6 to +6, with negative values indicating dry spells and positive values indicating wet spells. The Palmer index uses six groups to classify drought. Values 0 to -0.5 represent normal conditions, values -0.5 to -1.0 represent incipient drought, values -1.0 to -2.0 represent mild drought, values -2.0 to -3.0 represent moderate drought, values -3.0 to -4.0 represent severe drought, and values greater than -4.0 represent extreme drought (National Climatic Data Center 1998). Texas is divided into ten climatic regions by the National Climatic Data Center. San Antonio and Austin lie in the South Central region (see Figure 2). In 1996, the South Central region was classified as a -4.51 by the Palmer Drought Severity Index, indicating a severe drought (TWDB 1996).

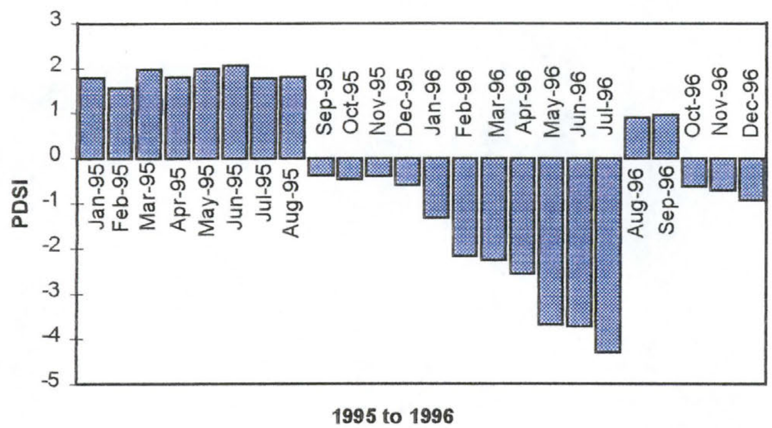
Figure 2. The Palmer Drought Severity Index for 1996.



(TWDB 1996)

Figure 3 shows the progression of the drought. The chart begins with January 1995 and ends with December 1996.

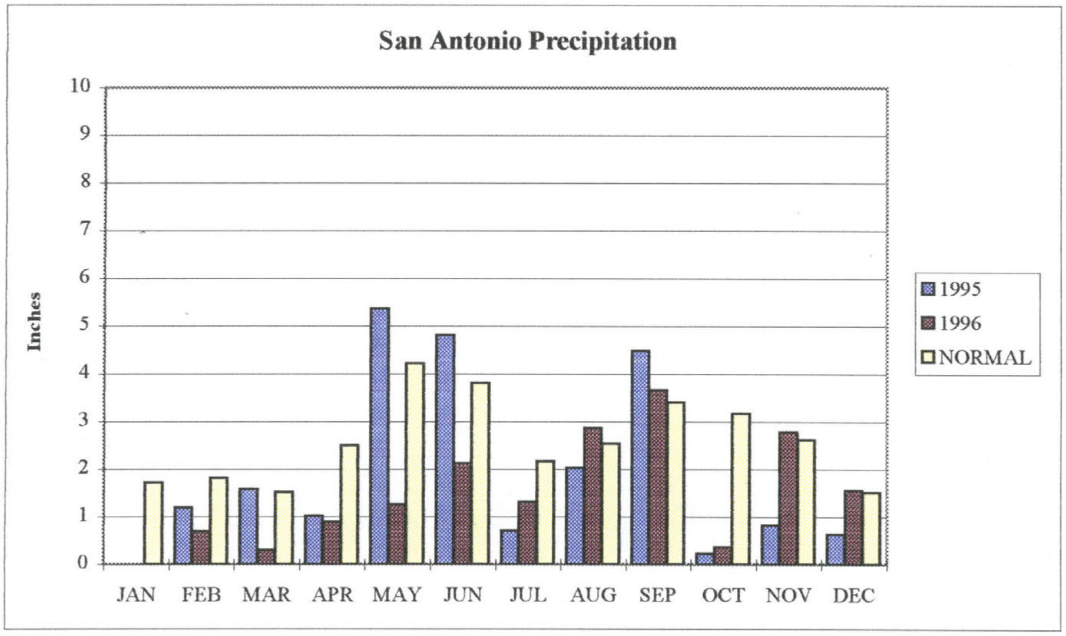
Figure 3. Palmer Drought Severity Index for the South Central Texas Division, 1995 and 1996.

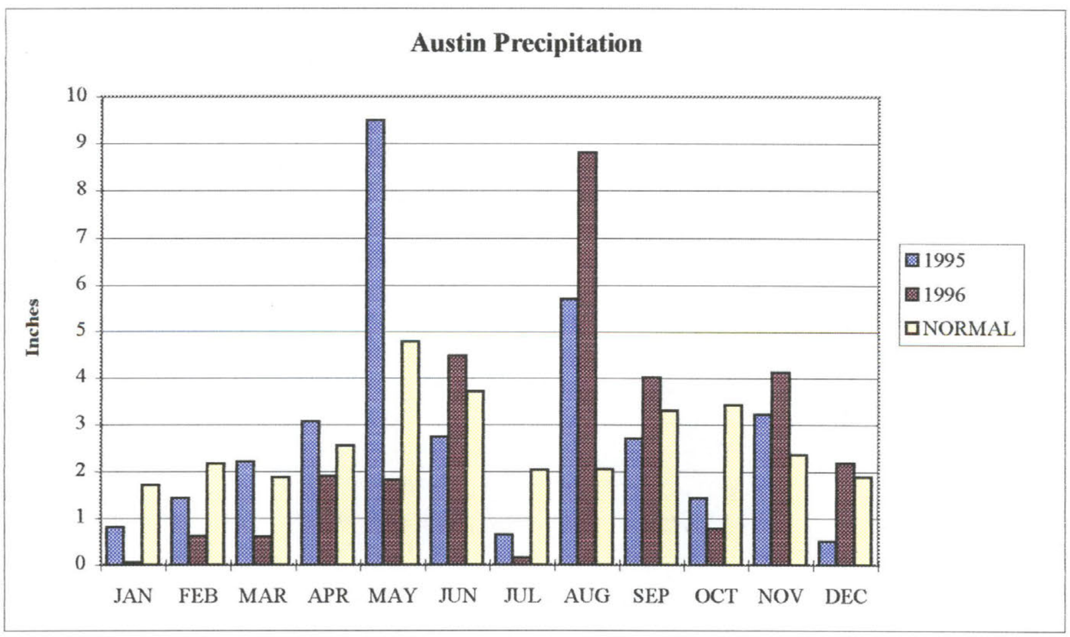


(Data from National Climatic Data Center 1998).

The Palmer Drought Index is limited in this case because it classifies an entire region. An alternative way to view the drought is by examining rainfall compared to the normal rainfall for each city. Normal rainfall is defined here as the 30 year average from 1961 to 1990. San Antonio's normal annual rainfall is 30.98 inches. In 1995 San Antonio received 7.84 inches less than its normal annual rainfall. In 1996 it received 13.1 inches less. Figure 4 displays the normal, 1995 and 1996 precipitation. (The data used in this study are from the National Climatic Data Center).

Figure 4. San Antonio and Austin Precipitation.





(Data from National Climatic Data Center)

Austin's normal annual rainfall is 31.88 inches. In 1995 Austin received very close to its average with 33.98 inches of rain, with an unusually high amount of rain in May (9.49 inches) and August (5.71 inches). Most of the other months in 1995 were below normal rainfall (see Figure 4). In 1996, Austin received 29.56 inches which is 2.32 inches less than the normal. Again, there was an unusually high rainfall in August. The source of this rain was due to Hurricane Dolly which struck in the Gulf of Mexico on August 23rd and brought rain to the Central Texas area (see Figure 4). (The data used in this study are from the National Climatic Data Center).

Another way to view the drought of 1995 and 1996 is to consider the available water supply. The City of Austin gets its water from Lake Travis. In August 1996, at the height of the drought, the lake level dropped to 652.77 feet, which is the tenth lowest level on record. The lowest level occurred during the drought of the 1950s in August 1951 at 615.29 feet, compared to the average level of Lake Travis at 665.87 feet (LCRA 1998). It was easy to see the effects of the drought on Lake Travis. Homes and marinas with decks that are supposed to reach out into the lake were several feet from the edge of the water. Boat ramps did not reach the water and large sandbars emerged as lake levels dropped.

It was not as easy to see the effects of the drought in the San Antonio water supply. San Antonio Water System gets its water from the Edwards Aquifer. The aquifer level in San Antonio is measured by an index well called J-17. The J-17 well is located near Fort Sam Houston in San Antonio, and has been used as the index well since 1963 (Eckhardt 1995B). During the drought, the J-17 well dropped to a low of 627.5 feet MSL on June 23, 1996. The lowest level on record occurred on August 17, 1956 at 612.5 feet MSL. The long term average is 664 feet MSL (Edwards Aquifer Authority 1997). These well levels guide San Antonio's water conservation plan.

Characteristics of San Antonio and Austin

The water regulating body in San Antonio is San Antonio Water System (SAWS). The water regulating body in Austin is the City of Austin Water and Waste Water Department. Both San Antonio and Austin encourage water conservation in households despite drought conditions. Both cities provide literature on water-saving appliances, xeriscaping, and general water saving tips. Austin has an extensive xeriscaping program which includes a rebate program for efficient irrigation systems. Under the program, Austin residents may request an irrigation audit and then are eligible for rebates on equipment used to improve their irrigation systems. SAWS also has a xeriscape rebate program that focuses on native plants and landscape improvements. In addition, both cities employ increasing block rate structures to encourage conservation. Each city's pricing structure is described below.

SAWS Water Rates

SAWS basic charge for a 5/8 inch meter inside the city limits is $5.13 per month. There is also a standard rate and a seasonal rate for water use. The seasonal rate is in effect from July 1st to October 31st and is slightly higher. The rates are shown in Table 1.

Table 1. San Antonio Water Rates.

Step in Gallons	Standard Rate per 100 gallons	Seasonal Rate per 100 gallons
First 7,481	$0.0661	$0.0661
Next 5,236	0.0950	0.1032
Next 4,488	0.1178	0.1270
Over 17,205	0.2473	0.3193

(Data from San Antonio Water System 1997).

City of Austin Water Rates

The City of Austin's basic charge for a standard 5/8 inch meter inside the city limits is $4.40 per month and employs only one rate throughout the year. The rates are shown in Table 2.

Table 2. Austin Water Rates.

Step in Gallons	Rate per 1000 gallons
First 2900	$1.25
Next 4000	$2.00
Next 8000	$2.75
Over 14901	$4.00

(Data from the City of Austin, 1997)

Thus, for example, if a household were to use 18,000 gallons of water in San Antonio, during a non-seasonal month, it would cost $22.30. If the same amount of water were used during a seasonal month in San Antonio, it would cost $23.72. In Austin, if a household were to use 18,000 gallons of water it would cost $50.43.

SAWS Conservation Program

SAWS's water conservation program is based on the water level in the J-17 well. The details about the conservation program were provided by Peggy McCray (1997). When the water level reaches 655 feet MSL, Stage 1 is implemented. Stage 1 is the Aquifer Awareness Stage. Under this stage: 1) wasting water is prohibited; 2) reduction is recommended for agriculture, golf courses, commercial nurseries, park areas, etc; 3) continues Ordinance 72834 which prohibits watering from 10:00 AM to 8:00 PM; 4) and the Water Advisory Council is organized. Stage 1 was declared on July 28, 1995.

Stage 2, Aquifer Watch, is declared when the J-17 well reaches 640 feet MSL. Stage 2 continues Stage 1 measures, and 1) landscape watering is limited to designated days and methods (2 days/week); 2) non-commercial vehicle washing and other equipment is restricted; 3) restaurants are prohibited from serving water unless it is requested; 4) fountains must be turned off unless they use recycled water; 5) and pools may only be drained on a permeable surface. This stage also allows for additional measures as required by City Council. Stage 2 was implemented on April 19, 1996.

Stage 3, the Aquifer Alert stage is declared when the J-17 well reaches 620 feet MSL. Stage 3 continues measures from Stages 1 and 2; plus additional measures which include: 1) vehicle washing for health and safety only, and use of water by commercial wash facilities is prohibited; 2) time restrictions on landscape watering are reduced to only one day a week; 3) and the installation of new landscape is prohibited. Stage 3 was implemented on May 17, 1996 and terminated March 20, 1997. In addition, on June 13, 1996, the City of San Antonio approved a resolution that reduced watering to one day a week based on residential address. Those residents with addresses ending in even numbers could only water on Saturday, and those with addresses ending in an odd number could only water on Sunday (Powers 1997).

The SAWS plan also includes a Stage 4, the Aquifer Risk stage. This is declared when the water quality of the aquifer is at risk. There is no specific well depth named. Stage 4 was not declared in 1995 or 1996.

In addition to the above water use restrictions above, the City of San Antonio has adopted an ordinance that raises the price of water during times of drought. San Antonio Ordinance 80330, adopted on June 16, 1994 developed the 4-block increasing rate structure discussed previously. It also provides for an excess use surcharge to be implemented during a critical period as specified by City Council. A Phase 1 Critical Period Surcharge doubles the fourth block rate charge to residential customers whose consumption exceeds 17, 205 gallons per month. Phase 1 Critical Period was declared July 14, 1996 and rescinded September 17, 1996. Phase 2 Critical Period Surcharge charges the fourth block rate on all consumption over each customer's winter average plus 2, 244 gallons. A Phase 2 Critical Period was not declared in 1995 or 1996.

In addition, SAWS introduced a new format for their water bills in June 1994, that was designed to encourage water conservation. The bills are an educational tool that provides water use and water supply information to residents. The water bills include information about water levels in the Edwards Aquifer and notes on aquifer awareness. The bills also include information that water users can easily understand, such as water use graphs with comparisons of household water use to neighborhood averages and region-wide average water use. They also include more personalized message that compares water use during the current billing period with the same billing period for the previous year, as well as providing seasonal averages. San Antonio also had the added pressure of a pending Federal Court case.

City of Austin's Conservation Strategy

Unlike San Antonio, Austin's conservation strategies are not guided by available water supply. Instead, the City of Austin depends on the capacity of its three water plants (Petersen 1998). In the winter months, about 80 to 90 million gallons of water per day are pumped through the three plants. During ordinary summer months, the amount doubles. The maximum pumping capacity of the plants is 215 million gallons per day in order to maintain superior water quality. If the pumpage exceeds 200 million gallons per day, the city will institute mandatory conservation policies. The specific trigger points are: three days of 205 million gallons per day pumped through the plants; or one day of 210 million gallons per day pumped through the plants. If either of these scenarios occurs, the City of Austin will enforce mandatory conservation strategies (Petersen 1998).

During the summers of 1995 and 1996, no mandatory restrictions were imposed (Petersen 1998). The city does have a summer voluntary reduction conservation plan. Based on addresses, residents have a particular day to water outside. The system allows each residence to water only once every five days. A symbol in the water bill is used to help residents identify which day to water. During the summer of 1996, watering days were highly publicized on television by the local news stations, in the Austin American Statesman and by billboards posted by the city. The billboards read: "Do You Know Your Symbol?"

CHAPTER 4

STUDY PROCEDURE

Data Acquisition

The San Antonio water use data were obtained from the SAWS (San Antonio Water System) Information Services department. The water use information was recorded in 100s of cubic feet, and then converted to 100s of gallons by the author. The information is organized by census tract and further divided into residential, commercial, apartment, industrial and wholesale usage. For each of these categories, the number of meters, consumption, and revenue are listed. This study is concerned only with the residential category. The consumption was divided by the number of meters in each census tract to produce the per meter usage for this study. There are 226 census tracts in Bexar County. This study includes 156 of them. Some tracts were eliminated because they lacked an adequate representation of single family homes. If a census tract contained less than five meters for single family residents per census tract, it was eliminated from this study. Other census tracts were eliminated from the study because of data errors or missing data.

The data for Austin were obtained from the City of Austin Water and Wastewater department. There is an individual record for each meter in Austin in 1995 and 1996. Each record contains a usage code, monthly and annual water use in 100s of gallons, the census tract and an X-Y coordinate. In order to calculate the per meter usage, the residential water use was calculated for each census tract and then divided by the number of residential meters in that census tract. There are 144 census tracts in Travis County. This study covers 135 census tracts.

Hypotheses Tests

Ho1: No difference in per meter residential water use occurred between Austin and San Antonio in 1995 and 1996.

$$\mu_A - \mu_{SA} = 0$$

The first step was to calculate per meter water usage. The water use and the number of meters in each census tract, for each month were provided by both cities. Per meter monthly water use was calculated for each tract by dividing the water use by the number of meters or households using water that month. Then, the average per meter water use of all the census tracts was calculated for each month.

Since this is a relatively small sample (sample size less than 30), the Student's t-test was selected to test for significance. A two-tailed test was employed because it is not known which city uses more water. Significance will be accepted based on a 90% confidence level.

$\alpha = .10$ or less

Ho2: No difference in per meter water use occurred among different income levels in each city in 1995 and 1996.

$$\mu_{A1} - \mu_{SA1} = 0 \qquad \mu_{A4} - \mu_{SA4} = 0$$

$$\mu_{A2} - \mu_{SA2} = 0 \qquad \mu_{At} - \mu_{SAt} = 0$$

$$\mu_{A3} - \mu_{SA3} = 0$$

The data from both cities are organized by census tract, allowing a comparison of how different income levels respond to conservation methods, and whether the results differ between San Antonio and Austin. Average income of each city were obtained form the 1990 census. The data were divided into five income groups: Bottom 20%, 2nd 20%, 3rd 20%, 4th 20% and Top 20%. Then, the average per meter water use was calculated for each month in each income group. San Antonio census tracts that fall into the Bottom 20% will be compared with Austin census tracts that fall into the Bottom 20%. The two-tailed t-test was used to test significance at the 90% confidence level.

$$\alpha = .10 \text{ or less}$$

Ho3: No difference in per meter water use occurred between 1995 and 1996 in Austin and San Antonio.

$$\mu_{A95} - \mu_{A96} = 0 \qquad \mu_{SA95} - \mu_{SA96} = 0$$

This last test was included to see if residents changed their water use from 1995 to 1996. As stated previously, 1995,was a year of awareness and 1996 was a year of more serious drought. This test used the average monthly per meter water use for each year. Austin

1995 per meter water use was compared to Austin 1996 per meter water use. Likewise, San Antonio 1995 per meter water use was compared to San Antonio 1996 per meter water use. The two-tailed t-test was used to test for significant differences at a 90% confidence level.

$\alpha = .10$ or less

CHAPTER 5

STUDY RESULTS

The test of the hypotheses revealed significant differences in water use between San Antonio and Austin. However, there were no significant differences found between 1995 and 1996 in each city. The results of the three hypothesis tests are outlined below.

t-Test 1:

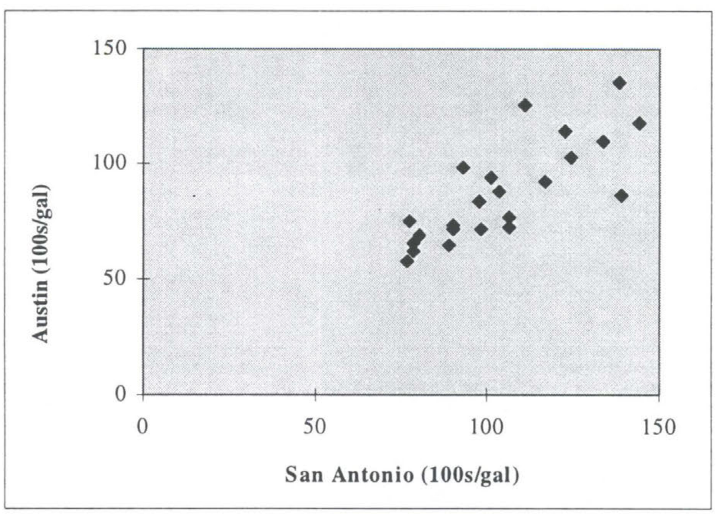
The difference between Austin and San Antonio residential water use in 1995 and 1996.

The variables AUSTIN and SA were compared to determine if there was a significant difference between Austin and San Antonio per meter water use. Test 1 compared data in Austin from January 1995 to December 1996 to data in San Antonio from January 1995 to November 1996. (The San Antonio data for December 1996 were unavailable). The degrees of freedom are 22. The t-test showed there was a significant difference between Austin and San Antonio per meter residential water use (see Table 3). Of the 23 months compared, San Antonio was the higher per meter water user between the two cities 21 times. Austin residents used more water per meter in July 1995 and December 1995, but only by a small amount. Austin used 14. 8 100s/gal per meter more than San Antonio in July 1995 and 5.3 100s/gal per meter more in December 1995. Overall, from January 1995 to November 1996, San Antonio's average use per meter was 104.22 100s/gal. Austin's average per meter was 87.25 100s/gal. (see Appendix 1). Figure 5 depicts the results in a scatter plot. There is a distinct difference between water use during the winter months and the summer months. The summer months are much more scattered signifying more differences in use between the two cities during the summer months.

Table 3. The difference between San Antonio and Austin water use for 1995-1996.

t-Value	2-Tailed Significance
-5.86	.001

Figure 5. Mean monthly water use per single family resident, San Antonio vs. Austin 1995-1996.



t-Test 2:

The difference between different income levels in San Antonio and Austin.

As mentioned before, the data were divided into five categories based on income. LOW represents the bottom 20% of the income bracket, 2ND represents the 20-40 percentile, 3RD represents the 40-60 percentile, 4TH represents the 60-80 percentile and TOP represents the top 20% of the income bracket.

This test was performed for all months in 1995 and for just the summer months in 1995, and for all months in 1996 and for just the summer months in 1996. (Summer is defined as May through September). A_LOW was compared to SA_LOW, A_2ND TO SA_2ND, etc. LOW and 3RD are the only two variables that showed a significant difference in per meter water use both for the entire year and for the summer months (see Table 4). San Antonio per meter water use was greater than Austin per meter water use for the LOW and 3RD groups. (See Appendix 2). Figure 6 depicts the results in scatter plots. Again, there is a visible difference between winter use and summer use. The summer values are more dispersed signifying more differences between the two cities. Figure 6 also shows two months in 1995 where Austin used more water per meter than San Antonio. These are especially noticeable in the 4TH group and the TOP group. In July 1995, the A_TOP per meter water use was 238.26 100s/gal. The SA_TOP group only used 154.11 100s/gal per meter in July 1995. A_4TH used 149.61 100s/gal per meter in July 1995 while SA_4TH used only 113.92 100s/gal. See Appendix 2 for additional data values.

Table 4. The difference between San Antonio and Austin residential water use in five income groups for 1995.

	1995 Whole Year		Summer 1995	
	t-Value	**Significance**	**t-Value**	**Significance**
LOW	-2.97	.013	-3.39	.028
2ND	-1.11	.292	-1.36	.247
3RD	-5.10	.001	-3.20	.033
4TH	-1.20	.257	-.70	.523
TOP	-1.04	.320	-.27	.798

In 1996, the variables representing the bottom three income levels (LOW, 2ND and 3RD) each showed a significant difference for both the whole year and for the summer months. 2ND did not show a significant difference for the whole year in 1995 or for Summer 1995, but was significant in both tests for 1996. The reason for this new result is that the A_2ND group used consistently less water in 1995 as compared with 1996, while the SA_2ND group used a similar amount in 1995 as in 1996. See Appendices 2 and 3. The variables representing the top two income brackets (4TH and TOP) again showed no significant difference for the whole year or for the summer months (see Table 5). Figure 7 shows the results in scatter plots. The points show that San Antonio is the predominant higher per meter water user. The charts for 4TH and TOP show months where per meter water use was higher in Austin than in San Antonio.

Figure 6. San Antonio water use vs. Austin water use for five income groups in 1995.

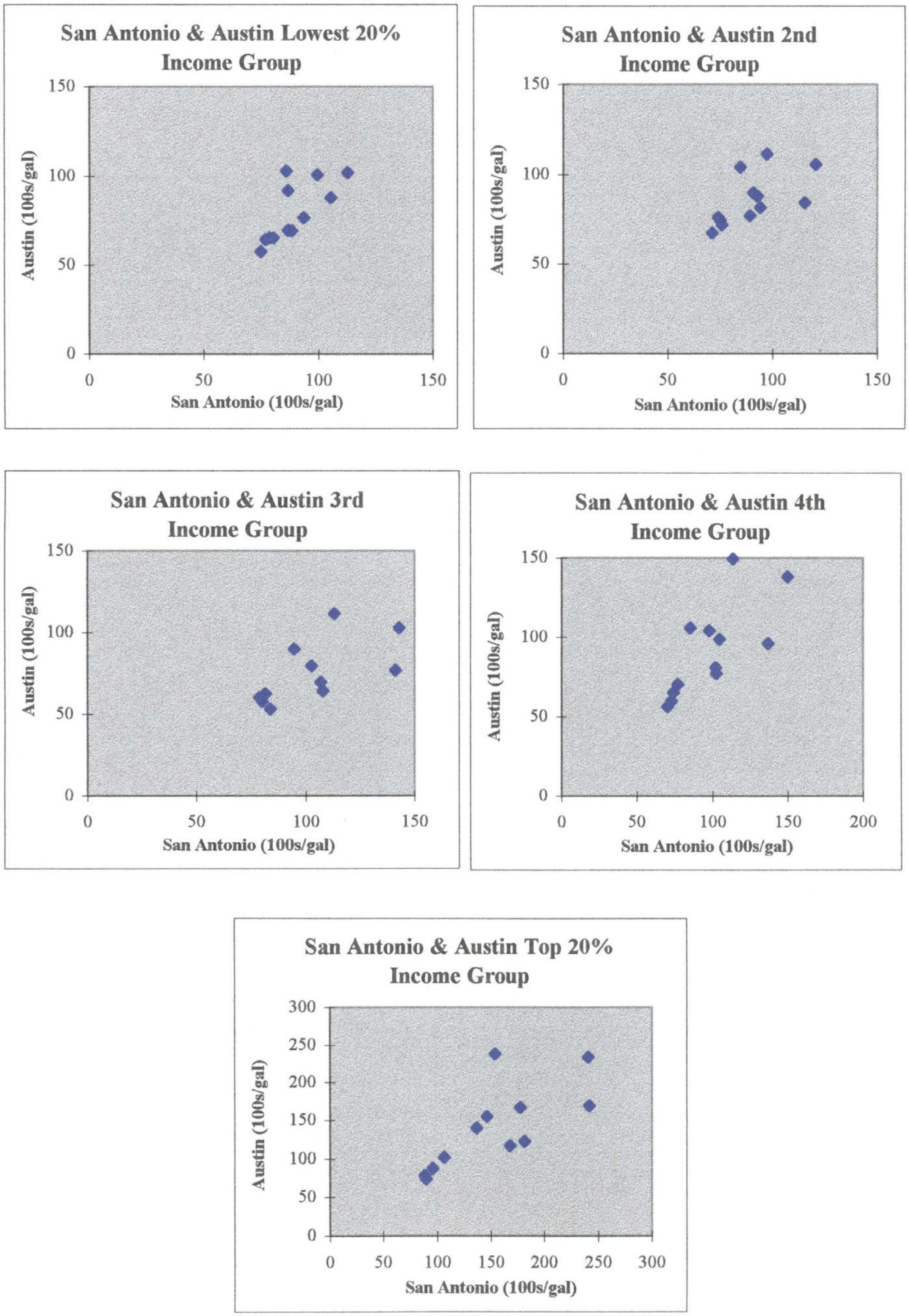
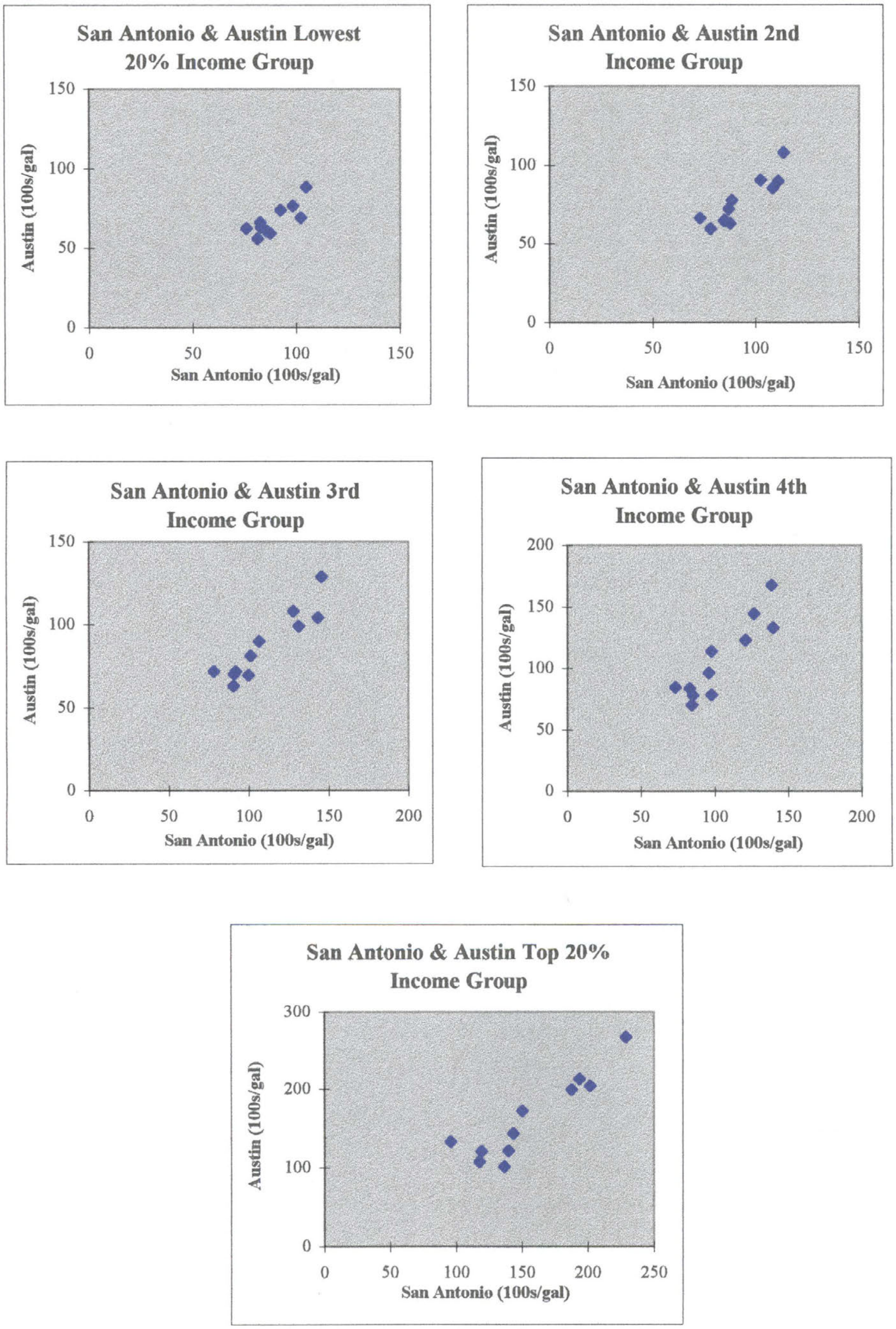


Figure 7. San Antonio water use vs. Austin water use for five income groups in 1996.



Two examples that really stand out are in July. In July, A_TOP used 267.65 100s/gal of water per meter and SA_TOP used 229.11 100s/gal of water per meter. A_4TH used 167.59 100s/gal of water per meter in July and SA_4TH used 138.76 100s/gal of water per meter.

Table 5. No difference between San Antonio and Austin water use occurred in five income groups for 1996.

	1996 Whole Year		Summer 1996	
	t-Value	**Significance**	**t-Value**	**Significance**
LOW	-12.60	.001	-7.89	.001
2ND	-8.22	.001	-4.72	.009
3RD	-8.30	.001	-6.68	.003
4TH	.60	.564	.51	.636
TOP	.86	.410	1.11	.328

t-Test 3:

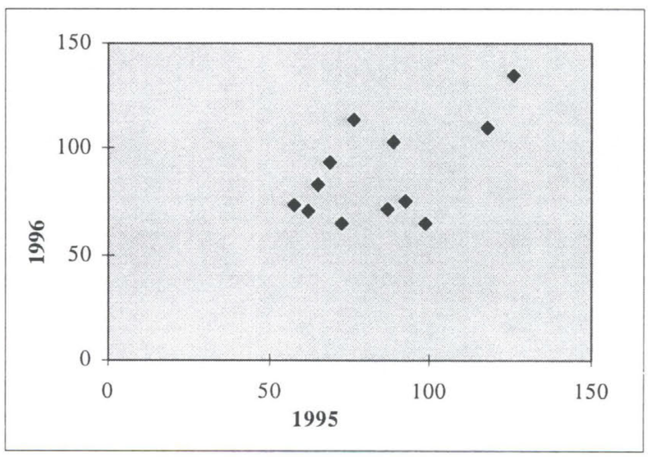
There is no difference in residential water use between 1995 and 1996 in San Antonio and Austin.

For this test, the variable AUS95 was compared to AUS96. There was no significant difference between the two years. The significance level is .516. The results were similar for the summer months (see Table 6). Figure 8 depicts this graphically with a scatter plot. There are a few outliers. For example, Austin used 37.56 100s/gal more in May 1996 compared to May 1995.

Table 6. Austin water use in 1995 vs. Austin water use in 1996.

	t-Value	Significance
Whole Year	-.67	.516
Summer Months	-.82	.458

Figure 8. Austin 1995 water use vs. Austin 1996 water use.

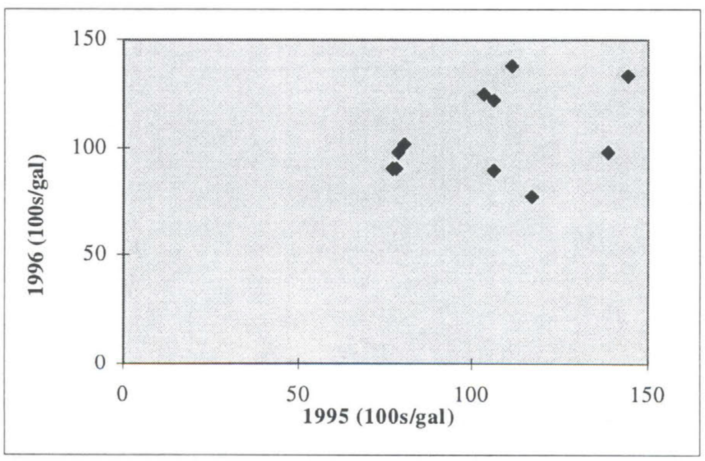


The same test was done for San Antonio. There was also no significant difference in water use between 1995 and 1996 in San Antonio. SA1995 and SA1996 have a significance level of .797. A second t-test also showed no significant difference between the summer months of 1995 and 1996 in San Antonio. The results of SA1995 and SA1996 have a significance level of .264 (see Table 7). Figure 9 is a scatter plot of the results. Although the two years are not significantly different, San Antonio used more water in 1996. Exceptions to this occurred in September, October and November. See Appendix 5.

Table 7. San Antonio water use in 1995 vs. San Antonio water use in 1996.

	t-Value	Significance
Whole Year	-.26	.797
Summer Months	1.30	.264

Figure 9. San Antonio water use 1995 vs. San Antonio use 1996.



CHAPTER 6:

ANALYSIS OF THE RESULTS

Previous studies have suggested that there are five factors that could cause a difference in water use between residents of San Antonio and Austin. The factors are: precipitation, price, conservation strategies implemented in each city, level of drought awareness in each city, and the number of people per household.

Precipitation

Test 1 revealed a significant difference between San Antonio and Austin per meter water use. A possible reason for this is the amount of rainfall. San Antonio received less rainfall than Austin in 1995 and 1996. San Antonio's normal annual rainfall is 30.98 inches. In 1995, San Antonio received only 74.69% of its normal rainfall. Austin's normal annual 33.78 inches and the city received 106.59% of normal rainfall in 1995. Austin received unusual amounts of rain in May (198.54% of normal) and in August (278.54% of normal). Thus, San Antonio received 10.84 inches less than Austin in 1995 and 7.84 inches less than its normal rainfall.

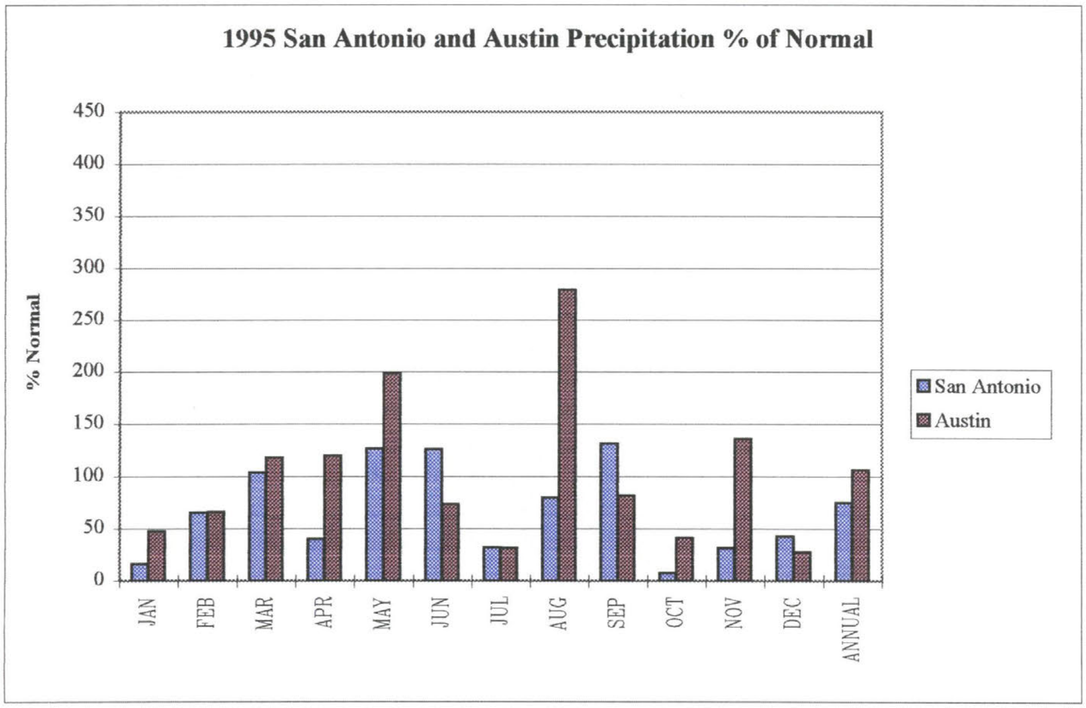
There were two months in 1995 where Austin used more water per meter than San Antonio. In July 1995, Austin used 14.8 100s/gal per meter more water than San

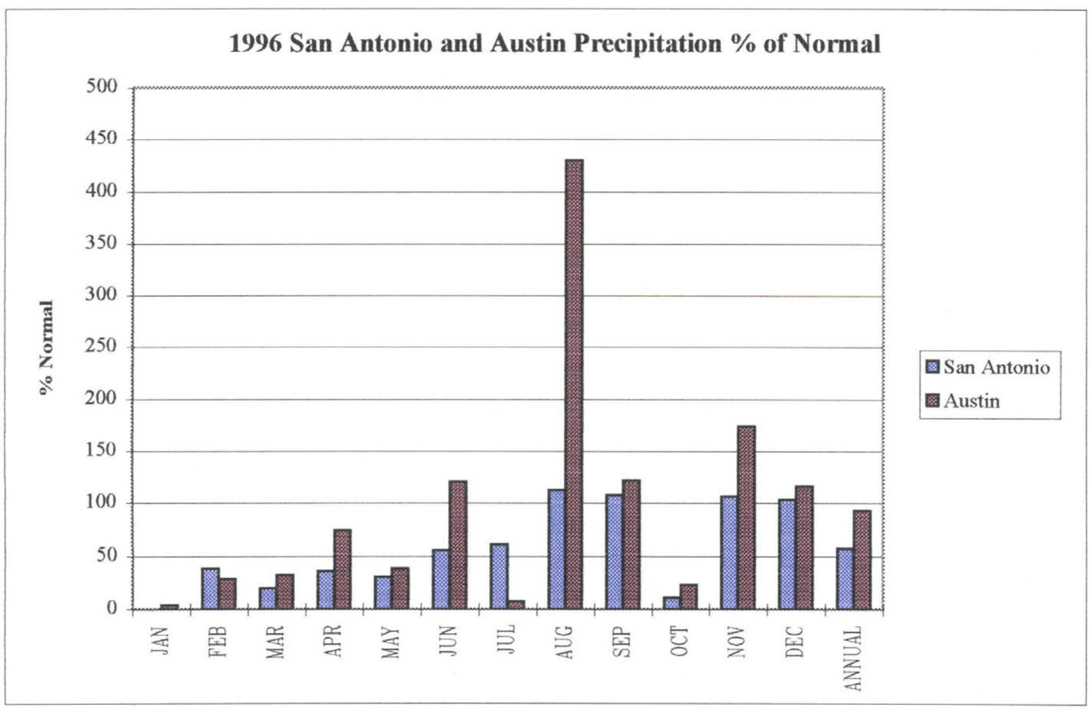
Antonio. The rainfall only varied by .06 inches between the two cities in July. However, in June, San Antonio received 4.81 inches of rain, which is one inch greater than the normal rainfall for June in San Antonio. Austin received only 2.74 inches in June, which is approximately one inch less that the normal rainfall for June in Austin. Therefore, in July, there was less water demand for landscape in San Antonio than there was in Austin. In December, Austin used 5.3 100s/gal per meter more water than San Antonio. In December, when landscaping demand is minimal, rainfall should not have had much effect on water use. However, San Antonio received .64 inch and Austin received .51 inch (see Figure 10).

Residential water use can be divided into base use and seasonal use. Base use is defined by the water use during the winter months, when there is little or no outside watering. Seasonal use is the summer months when there is more outside watering for landscape, swimming pools, etc. A study done by Maidment, Miaou, and Crawford (1985) in Austin found that occurrence of rainfall causes a temporary reduction in seasonal use that diminishes over time and eventually becomes negligible. In Austin, they found that if it rains more than .05 inch in a day, that day's seasonal water use drops by 49% compared to the previous day, and residents continue to use less water for approximately two weeks. If it rains less than .05 inch in a day, the immediate drop is 27% of the previous day's use. In this case, residents continue to use less water for about one week.

It is expected that rainfall would have less impact in the winter months. Given this assumption, rainfall should not be a factor explaining why San Antonio used more

Figure 10. San Antonio and Austin % Normal Precipitation for 1995 and 1996.





(Data from National Climatic Data Center) water than Austin in the winter months of 1995 and 1996. However, there is a significant difference between the two cities' per meter water use during the winter months. San Antonio used more water than Austin except in December 1995, when Austin received less rain than San Antonio. Therefore, it can be concluded that precipitation is a possible factor affecting water use differences between San Antonio and Austin.

Price of Water

Another factor that could be contributing to the difference in water use is the price of water. As mentioned before, San Antonio's water cost is about one-half that of the price of water in Austin. To further understand the issue of price, it is helpful to look at the difference between the various income groups in San Antonio and Austin. In all four tests performed with the income variables, there was no significant difference between San Antonio and Austin in the two highest income groups (4TH and TOP). On the other hand, the lowest income group LOW, and the middle income group, 3RD, always showed a significant difference between the two cities. 2ND did not show a significant difference in 1995 or Summer 1995, but was significant in both tests for 1996.

Given these findings, it makes sense that the lower income households in Austin are deterred by a price of water that is twice as high as it would be in San Antonio. Also, the results show that the higher income residents are virtually unaffected by price. The two cities use similar amounts of water in income levels represented by 4TH and TOP because these people are using the maximum, or necessary amount, without regard to price.

Conservation Strategies

Another factor that could be causing the difference between Austin and San Antonio water use is the conservation plans implemented in each city. In 1995 and 1996, San Antonio had much stricter conservation plans than Austin. Austin never implemented any mandatory policies. San Antonio, on the other hand, reached Stage III of its mandatory conservation plan.

Furthermore, Test 3 was designed to see if there is a difference in per meter water use between 1995 and 1996 in each city. For both San Antonio and Austin, no difference was found between the two years. In other words, San Antonio residents used approximately the same amount of water in 1996 with mandatory restrictions in effect as they did in 1995 when there were less restrictions. Likewise, Austin used the same amount of water in 1995 as in 1996. These results are important, because, despite less rain in 1996 in both cities, residents did not use significantly more water between the two years. This is an indication that the conservation strategies in the cities did do some good. However, they do not explain the difference between San Antonio and Austin per meter water use.

Level of Drought Awareness

Awareness of water use and drought is another possible factor affecting water use differences. It is difficult to judge awareness, but it seems that San Antonio residents would be more aware of drought and water use than residents of Austin. San Antonio was facing a drought management plan to be implemented by a Federal court judge in order to protect endangered species dependent on the aquifer. San Antonio residential water bills are designed to heighten awareness. They include graphs of water use and information about aquifer levels. This is in sharp contrast to Austin bills which are on the back of the electric bill in about three square inches of space. The drought received media attention in both cities. However, San Antonio went so far as to publish the names of high water users in the daily newspaper. Therefore, it is unlikely that a level of awareness was causing the differences between Austin and San Antonio water use.

Number of People per Household

One other factor that could be affecting water use differences between the cities is the number of people per household in each city. This would help explain the greater amounts of water used by San Antonio during the winter months. San Antonio has an average of 3.1 people per household (U.S. Census Bureau 1990). Austin has an average of 2.7 people per household (U.S. Census Bureau 1990). These numbers include multifamily dwellings such as apartment buildings, which were not included in this study. However, the number of people per household, as calculated from 1990 U.S. Census Bureau data, was multiplied by the number of meters used in this study in order to calculate an approximate per capita water use for each city. In 1995, San Antonio used 35.08 100s/gal of water per person and in 1996 they used 33.18 100s/gal of water per person. Austin used 31.26 100s/gal of water per person in 1995 and 32.72 100s/gal of water in 1996. This calculation does not support the idea that number of people per household is causing the difference in water use between San Antonio and Austin.

Final Analysis

Of the five factors listed as possible factors affecting differences in water use, price is the most likely explanation in this study. The only users consistently similar to each other (no significant differences) are the two highest income levels. These are also the two groups that would least likely be affected by price.

Precipitation is also a likely factor for explaining the differences between the two cities. San Antonio received less rain than Austin over the two years and used more water per meter than Austin. In the two months that Austin used more water per meter than San Antonio, Austin received less rain. However, there were months that San Antonio received more rain than Austin and still used more water per meter than Austin. In addition, it is assumed that rainfall would have little effect on winter or base use. Yet, there was a significant difference between the two cities during the winter months, with San Antonio as the higher per meter water user. Therefore, precipitation is believed to have some effect on the difference in water use between the two cities, but it is not as convincing as price.

Conservation strategies and awareness can be eliminated as possible factors. The city with the more stringent conservation strategies, San Antonio, was also the higher water user. Number of people per household is difficult to judge given the scope of this study. However, the averages per household are similar between the two cities and the per capita calculation shows that San Antonio uses more water per capita than Austin.

CHAPTER 7:

CONCLUSION

This study has achieved its goal of determining whether or not differences exist in water use between San Antonio and Austin. There are several differences between the two cities. It would be interesting to repeat this study using a multiple regression method to better identify factors affecting water use differences between San Antonio and Austin. A public opinion survey might also add further insight to the analysis.

As the populations of Austin and San Antonio grow, it is critical for both these cities to strive to conserve water. SAWS has the beginnings of a good conservation strategy. It seems however that the price of water in San Antonio should increase for conservation strategies to be truly effective. Currently, water in San Antonio is inexpensive because it comes from the Edwards Aquifer and does not have to go through an extensive treatment process. Water has been a controversial issue in San Antonio for a long time. There have been, and probably always will be, arguments over use of water in the Edwards Aquifer. It has been an ongoing struggle involving landowners, the City of San Antonio, and endangered species. Strategies that involve raising water rates will definitely be met with controversy. San Antonio voters turned down construction of the

Applewhite Reservoir project in 1991 and again in 1994, a project that would have helped secure their city's water supply. Currently, San Antonio is considering purchasing surface water rights from the Guadalupe River to supplement its water supply and reduce its reliance on the aquifer. Water prices will almost certainly increase when the city uses that water.

An argument against increasing the price of water is that water is a basic need, and price increases would unfairly impact low income households (Jones 1992). Both San Antonio and Austin could boost the effectiveness of their water conservation efforts by increasing the price of water in the top tiers of their block rate structure. This would help encourage water conservation among the top water users in the high income neighborhoods.

Water is a basic need; yet, there is not an infinite supply. This is especially evident in times of drought. Although drought is a natural occurrence, as the population of Central Texas increases, the impacts of a drought also increase. Municipalities must do their part by encouraging conservation and efficient use of this precious resource.

APPENDIX 1.

San Antonio and Austin Average Per Meter Water Use

	San Antonio 100s/gal	Austin 100s/gal
Jan-95	78.35	61.85
Feb-95	76.85	57.63
Mar-95	78.57	65.18
Apr-95	80.46	68.79
May-95	106.35	76.42
Jun-95	103.51	88.44
Jul-95	110.98	125.70
Aug-95	144.04	117.78
Sep-95	138.77	86.62
Oct-95	116.96	92.35
Nov-95	106.35	72.72
Dec-95	93.09	98.48
Jan-96	90.38	71.17
Feb-96	90.08	73.25
Mar-96	97.83	83.50
Apr-96	101.12	93.99
May-96	122.48	113.98
Jun-96	124.70	102.79
Jul-96	138.15	134.87
Aug-96	133.50	109.81
Sep-96	98.26	71.40
Oct-96	77.17	75.19
Nov-96	89.21	64.87
Dec-96	unavailable	64.71
Average	104.22	86.31

(Data from San Antonio Water System and City of Austin)

APPENDIX 2.

San Antonio and Austin Per Meter Water Use By Income Group for 1995

San Antonio (SA)	SA_LOW 100s/gal	SA_2ND 100s/gal	SA_3RD 100s/gal	SA_4TH 100s/gal	SA_TOP 100s/gal
January	80.36	76.15	80.33	72.85	88.83
February	75.10	71.48	83.90	70.24	90.03
March	78.87	75.30	78.88	74.29	96.20
April	77.12	74.21	81.63	77.36	106.64
May	88.47	94.41	107.01	102.51	167.99
June	93.72	93.03	102.72	104.75	146.38
July	99.63	97.40	113.18	113.92	154.11
August	112.95	120.66	142.97	149.96	240.95
September	105.49	115.58	141.39	137.28	242.01
October	86.83	90.91	151.02	97.93	177.60
November	86.92	89.46	108.15	102.76	181.88
December	86.04	84.78	94.78	85.58	136.70
Average	89.29	90.28	107.16	99.12	152.44
Summer Average	100.05	104.22	121.45	121.68	190.29
Average Income	$9,856	$18,478	$28,939	$39,889	$61,747

Austin (A)	A_LOW 100s/gal	A_2ND 100s/gal	A_3RD 100s/gal	A_4TH 100s/gal	A_TOP 100s/gal
January	65.37	72.06	57.93	60.09	78.30
February	57.81	67.55	53.25	56.54	74.15
March	65.31	74.42	60.43	65.46	87.25
April	64.46	76.27	62.67	70.58	101.67
May	69.37	81.76	69.83	81.10	117.34
June	76.67	88.09	79.80	98.89	155.24
July	100.84	111.35	111.74	149.61	238.26
August	102.02	105.65	102.86	138.40	233.97
September	87.89	84.53	76.98	96.23	169.46
October	92.03	89.81	80.12	104.42	167.26
November	69.71	77.22	64.38	77.33	122.57
December	102.99	104.08	89.93	106.21	140.23
Average	79.54	86.07	75.83	92.07	140.48
Summer Average	87.36	94.28	88.24	112.85	182.85
Average Income	$8,839	$18,957	$29,865	$41,489	$63,919

(Data from San Antonio Water System and City of Austin)

APPENDIX 3.

San Antonio and Austin Per Meter Water Use By Income Group for 1996

San Antonio (SA)	SA_LOW 100s/gal	SA_2ND 100s/gal	SA_3RD 100s/gal	SA_4TH 100s/gal	SA_TOP 100s/gal
January	87.67	85.32	91.01	85.19	117.56
February	85.95	84.67	92.09	83.19	119.54
March	83.07	86.94	101.30	96.21	143.55
April	82.83	88.67	106.79	97.86	150.55
May	92.57	102.37	127.84	126.82	194.00
June	102.13	108.53	131.29	121.28	188.10
July	104.69	113.55	145.69	138.76	229.11
August	98.45	110.92	143.47	139.93	201.91
September	85.53	87.85	99.98	98.16	139.80
October	75.96	73.00	78.18	73.59	95.94
November	81.32	78.26	90.81	84.51	136.87
Average	89.11	92.74	109.86	104.14	156.09
Summer Average	96.67	104.64	129.65	124.99	190.58
Average Income	$9,856	$18,478	$28,939	$39,889	$61,747

Austin (A)	A_LOW 100s/gal	A_2ND 100s/gal	A_3RD 100s/gal	A_4TH 100s/gal	A_TOP 100s/gal
January	59.37	65.23	70.43	78.03	107.23
February	60.81	64.78	71.82	84.03	120.17
March	63.21	72.27	81.38	96.42	143.25
April	66.28	77.61	90.18	114.05	171.89
May	73.96	90.58	108.07	144.38	213.15
June	69.18	85.61	99.15	123.02	199.58
July	88.40	108.08	128.89	167.59	267.65
August	76.76	90.14	104.17	133.40	204.32
September	61.01	63.78	69.64	78.53	120.93
October	62.47	66.37	71.78	84.54	132.69
November	56.10	59.55	63.03	70.37	100.88
Average	67.05	76.73	87.14	106.76	161.98
Summer Average	73.86	87.64	101.98	129.38	201.13
Average Income	$8,839	$18,957	$29,865	$41,489	$63,919

(Data from San Antonio Water System and City of Austin)

APPENDIX 4.

Austin Average Per Meter Water Use and Rainfall for 1995 and 1996

	A1995 100s/gal	A1996 100s/gal		A_RAIN 95 inches	A_RAIN 96 inches
January	61.85	71.17		0.81	0.06
February	57.63	73.25		1.44	0.62
March	65.18	83.50		2.21	0.60
April	68.79	93.99		3.08	1.90
May	76.42	113.98		9.49	1.82
June	88.44	102.79		2.74	4.48
July	125.70	134.87		0.64	0.15
August	117.78	109.81		5.71	8.81
September	86.62	71.40		2.70	4.02
October	92.35	75.19		1.43	0.78
November	72.72	64.87		3.22	4.13
December	98.48	64.71		0.51	2.19
Average	84.33	88.29	**Total**	33.98	29.56

(Data from City of Austin and National Climatic Data Center)

APPENDIX 5.

San Antonio Average Per Meter Water Use and Rainfall for 1995 and 1996

	SA1995 100s/gal	SA1996 100s/gal		SA_RAIN 95 inches	SA_RAIN 96 inches
January	78.35	90.38		0.28	0.00
February	76.85	90.08		1.19	0.69
March	78.57	97.83		1.58	0.30
April	80.46	101.12		1.01	0.89
May	106.35	122.48		5.36	1.26
June	103.51	124.70		4.81	2.12
July	110.98	138.15		0.70	1.31
August	144.04	133.50		2.03	2.86
September	138.77	98.26		4.49	3.66
October	116.96	77.17		0.23	0.36
November	106.35	89.21		0.82	2.79
December	93.09	unavailable		0.64	1.56
Average	102.86	105.72	**Total**	23.14	17.80

(Data from San Antonio Water System and National Climatic Data Center)

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