EVALUATING THE EFFECTIVENESS OF THE SAN ANTONIO WATER SYSTEM RESIDENTIAL "KICK THE CAN" RETROFIT PROGRAM

THESIS

Presented to the Graduate Council of
Southwest Texas State University
in Partial Fulfillment of
the Requirements

For the Degree

Master of Applied Geography

By

Humberto Ramos, B.A. and B.S.

San Marcos, Texas
December 2002

Para mi familia.

ACKNOWLEDGEMENTS

I would like to thank all the educators throughout my educational career that gave unselfishly of their time and instruction and unknowingly inspired me down this road of academics.

My sincere gratitude goes toward the members of my committee, Dr. Richard Earl, Dr. Susan Macey and Dr. Richard Dixon for their patience, support and more importantly guiding me with their expertise.

I would like to thank my parents, Emilia R. Ramos and Frank L. Ramos, for instilling the value of an education, the importance and need to obtain one and for all their personal sacrifices so that I could pursue one. I would also like to thank my siblings, for if it were not for our academic competitive nature, while growing up, this could not be possible.

To my children Francisco and Maria Elena, thank you for your understanding during those times when I was not there to tell a bedtime story, see you fall asleep or kiss you good night, because daddy was at "college."

Finally, to my wife, Helen K. Alvarez-Ramos, thank you for your love, devotion, and support while I was away, all those many nights.

This manuscript was submitted on December 18, 2002.

TABLE OF CONTENTS

TABLE OF CONTENTS

Chapter

LIST OF TABLES

Table Page

LIST OF ILLUSTRATIONS

CHAPTER 1

THE PROBLEM AND ITS SETTING

Problem Statement

This study evaluated the effectiveness of the San Antonio Water System (SAWS) residential "Kick the Can" program based on the difference of water consumption before and after the replacement of conventional toilets with ultra low-flow toilets (ulft's). It further examined if participation in this program significantly reduces household water use when water use by participants is compared to non-participants.

The Setting

Water is a finite resource that requires careful and proactive management; the era of plentiful and inexpensive water is rapidly ending. Water conservation, sound water management strategies, and efficient and adequate investment in a range of solutions are all essential to the development of additional water supplies required to meet municipalities' growing population and economic needs (Texas Water Development Board 2002). Those who planned properly will have enough water to sustain themselves into the future while those that failed to plan will be faced with higher priced water and higher cost for development of infrastructure to bring water to their area. Therefore, the need to have enough water for sustainability has become a priority for many municipalities, city planners and water agencies.

Water has been referred to as "a life and death matter" in California, "a life blood" in Georgia and "liquid gold" in Texas (Yardley 2001; Pavley 2002; *Atlanta Journal –Constitution* 2002). Such terms in themselves stress the importance of water and the relationship with sustainability. Many neighboring cities, states and countries are experiencing " water wars" in an effort to obtain this resource. For example, water wars erupted in West Texas when speculators bought water rights from willing ranchers to establish " water ranches", to supply cities in the Texas Panhandle. South Carolina and Tennessee are to "put up a fight" if Atlanta tries to tap the Savannah or Tennessee river systems as additional water supply (Yardley 2001; *Atlanta Journal –Constitution* 2002). The City of El Paso was forced to negotiate with New Mexico and Mexico to insure that they have an ample supply of water for their future (Earl and Czerniak 1996). Water has become so valuable that a complicated scramble to obtain enough water for future growth has erupted in many regions.

Unfortunately the city of San Antonio, similar to large cities such as New York and Los Angles, is not immune to the need for more water. San Antonio, a city with over a million inhabitants is located in south Texas on the edge of the Gulf Coastal Plains. San Antonio is the largest municipality within the United States dependent on a single water resource, the Edwards Aquifer. With this distinction of being the "largest user" comes criticism from other users of the aquifer such as the cities of San Marcos and New Braunfels and agricultural communities west of San Antonio.

Within the next 50 years, it is expected that the population of Texas will double from 21 million residents in 2000 to about 40 million residents in 2050. Water demand is also expected to increase for Texas municipalities by 67%, from 4.23 million acre-feet per year (AFY) in 2000 to 7.06 million AFY in 2050 (Texas Water Development Board 2002). This trend is expected to be similar for San Antonio. The population is expected to increase from 1,137,000 in 2000 to 2,390,000 residents in 2050. Water demand is also expected to increase from 189,000 AFY in 2000 to 354,000 AFY in 2050 (Table 1).

Table 1 SAWS 50 Year Supply Goals
(San Antonio Water System 1998)

	2000	2010	2020	2030	2040	2050
Population	1,137,000	1,360,000	1,622,000	1,886,000	2,125,000	2,395,000
Demand Per Capita (gpcd)	148	140	135	132	132	132
Demand (Acre-Feet)	189,000	213,000	245,000	279,000	314,000	354,000

With population and water demand projections far exceeding current withdrawal from the Edwards Aquifer, the realization that the aquifer will not be able to solely sustain the city for the next 50 years is evident. On November 5, 1998 SAWS implemented a 50 year water resources plan, Securing our Water Future Together, to address the need of diversifying water resources in order to meet the future water demand.

San Antonio's location, in South Texas, directly impacts the availability of water. The climate of San Antonio is predominately continental during the winter months and marine during the summer months. Monthly mean temperatures in San Antonio range from 50.7° F in January to a high of 84.5°F in July. While summer is hot, with daily maximum temperatures above 90°F over 80 percent of the time, extremely high temperatures are rare, the highest on record is 107°F. Mean annual precipitation is approximately 30 inches with great year to year variability (Earl and Kimmel 1995; San Antonio Water System 2000).

Aquifer water levels, recharge, and springflow are closely related to precipitation and decrease during periods of low precipitation (Jennings et al.1992; Jensen 1996; Edwards Aquifer Authority 2000). Recharge to the San Antonio section of the Edwards Aquifer, varied from a low of 44,000 acre feet in 1956 to more than 2,000,000 acre feet in 1987 (Edwards Aquifer Research and Data Center 2002). Due to its climatic variability and the correlation with precipitation to recharge, during the period of 1999 – 2002, San Antonio experienced drought conditions and imposed mandatory water restrictions every other year (Table 2).

The San Antonio Water System, SAWS, is the largest of 69 water purveyors within the city limits of San Antonio (Figure 1). SAWS serves the majority of the citizens in San Antonio. Its customer base ranges from 285,887 households in 1999 to 297,632 households in 2001(Table 2). The customer base consists of 90% residential and 10% general class customers (commercial and wholesale users).

Table 2 SAWS Customer Distribution and Annual Pumpage 1999 - 2001
(San Antonio Water System Water Statistics 1999 - 2001)

Year	Annual Pumpage (AF)	System Customers End of December	Residential Customer Distribution (Water)	Residential Customer Percent of Total Demand (Water)	Estimate of System Population Served	Pumpage in Gallons Per Capita Per Day	Mandatory Water Restrictions Enacted
1999	183,111	285,887			1,074,935	152	No
2000	180,564	292,424	91.67%	51.25%	1,099,514	146	Yes
2001	180,564	297,632	91.68%	51.25%	1,115,210	143	No

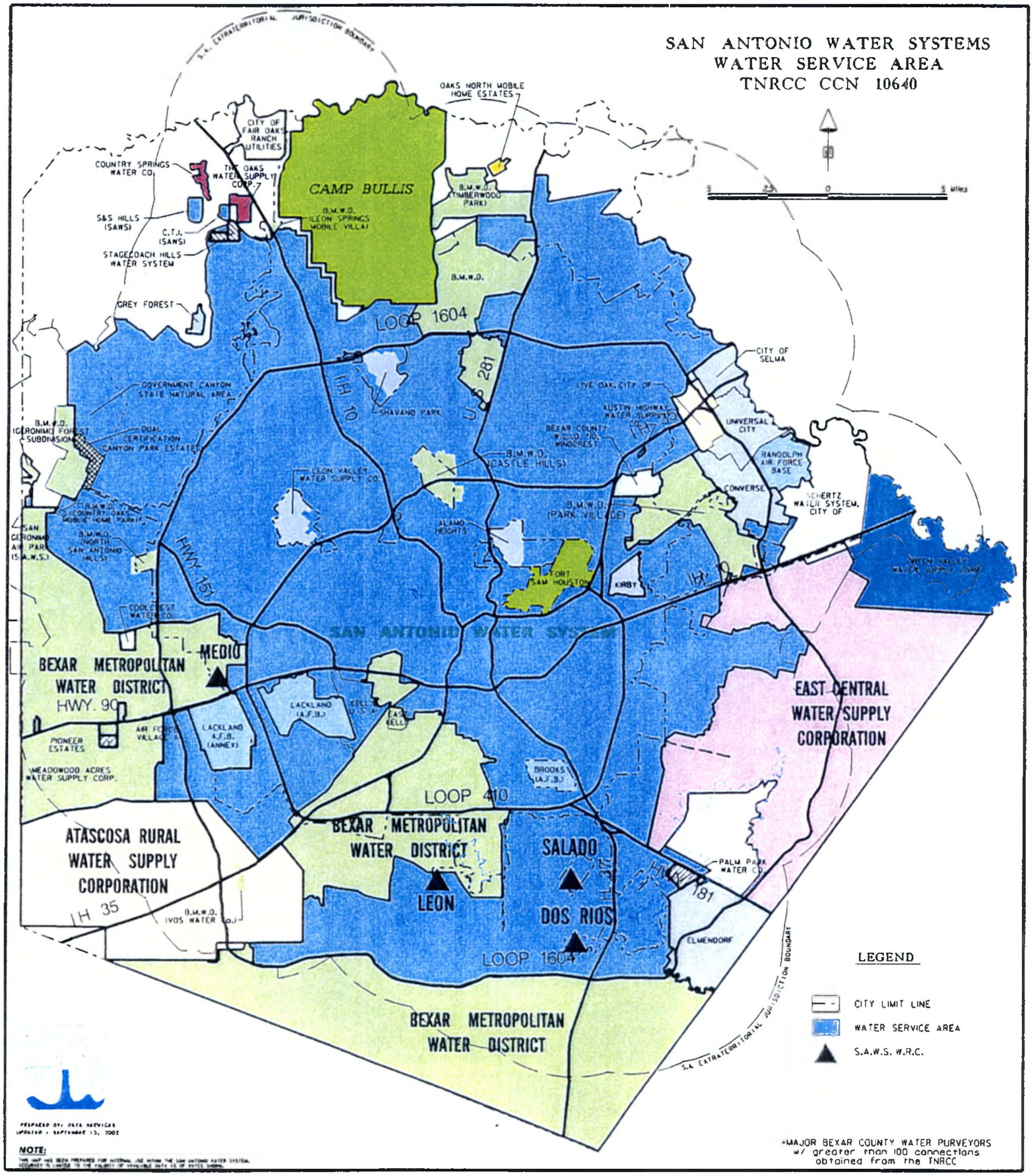

Figure 1. SAWS Water Service Area
(San Antonio Water System Data Services Department 2002).

Since 1988, SAWS has emphasized methods to decrease water demand over the years. In 1988 SAWS adopted a Drought Management Plan that outlined mandatory water restrictions when drought conditions exist. In 1993, SAWS adopted a Conservation and Reuse Plan that outlined conservation goals and initiatives. In 1994, a residential conservation rate structure was implemented to fund residential conservation programs. Conservation incentive type programs began in late 1994. In 1998 SAWS implemented a 50 year water resources plan, Securing our Water Future Together (San Antonio Water System 1998). For these many initiatives, SAWS has been regarded as a leader in promoting conservation in the region.

During below-normal rainfall, increased summer temperatures and drought conditions, SAWS enacts mandatory restrictions, which are outlined in the Drought Management Plan. These restrictions are enacted when the indicator well (J-17) measures the Edward's Aquifer water level below 650 ft mean sea level, (msl). Restrictions are typically geared toward reducing landscape watering, which is seen as the largest seasonal consumer of water. Restrictions stay in place until the water level at J-17 is above the designated "Stage Level" for 30 consecutive days. As the level continues to drop, different stages and restrictions are put in place. Stage I restrictions occur when the water level is below 650' msl, Stage II occurs when water level is below 640' msl, and Stage III level is 630 msl (San Antonio Water System 2002).

Stage I restrictions include the designation of landscape watering days and times based on the last digit of the home address. Watering can occur between the hours of 12 a.m. to 10 a.m. and 8 p.m. to 12 a.m. Stage II restrictions reduced the available watering times for Stage I from 3 a.m. to 8 a.m. and 8 p.m. to 10 p.m. (San Antonio Water System 2002).

In 1999 and 2001 no mandatory restrictions were in place (Table 2). Although in 2000 Stage I restrictions were enacted from May 4 to July 27 and again from October 13 to November 13. Stage II restrictions were enacted from July 28 to October 13 (San Antonio Water System 2000). Mandatory restrictions again occurred in June 26, 2002 and were rescinded on July 27, 2002 after the record floods of June 29 – July 10 (San Antonio Water System 2002).

As water restrictions address limiting outside water use, SAWS has in place incentive type conservation programs to encourage reduction of indoor water use. Similar to other municipalities such as San Diego and Austin, SAWS has implemented a toilet rebate program which promotes the voluntary installation of ulft's for single family residential customers by providing a financial incentive to retrofit (Steirer 1994; Poch 1996). The SAWS program, known as "Kick the Can" (KTC), allows customers to receive a credit for replacing a maximum of two conventional toilets with ultra-low flow toilets (ulft's). The incentive is a one-time $75 credit applied to a customer's water bill for each toilet replaced. Since the program began in 1994 the rebate program has encouraged customers to install 54,513 ulft's (Table 3).

Table 3. SAWS Annual Kick the Can Toilet Retrofits
(San Antonio Water System Conservation Monthly Report on Calls and Rebates 2002)
(*Estimation for period)
(**Information to October 23, 2002)

Year	Toilet's Replaced
94-97*	22000
98	8082
99	8096
00	7220
01	4673
02**	4442
Total	**54513**

Other programs that SAWS utilized for retrofitting toilets are the Plumbers to People program, the Toilet Distribution Pilot program, and the Toilet Distribution Program.

Since 1994, SAWS has assisted roughly 3,500 customers through its Plumbers to People program. The intent of the Plumbers to People program is to provide plumbing assistance to low-income residential customers who have water leaks inside or outside and cannot afford to hire a plumber for repair(s). Participants must: own their homes, be a SAWS water customer, meet Federal Assistance Guidelines and apply through the City of San Antonio Community Action Division (CAD). There is no cost for participation. Although the intent of the Plumbers to People program is to repair water leaks, many toilets were and continue to be retrofitted through this program.

In February 1999, SAWS implemented a toilet distribution pilot program with the hopes of converting 1522 toilets within the inner city at no cost to participants. The purpose of the pilot program was to distribute and install low flow toilets in the densely populated inner city where low income levels prevented participation in the KTC program. All toilet installations were done by a professional plumber on contract with SAWS. Criteria for participation in this program were as follows (Ramos 1999):

1.) Must have an active SAWS residential customer with a water and\or sewer account.
2.) Reside in a residence housing three or more people.
3.) Meet Federal Assistance Guidelines.
4.) Reside in a specific geographic area as determined by SAWS.
5.) Have not participated in the SAWS "Kick the Can" Toilet Rebate Program nor have had a new toilet installed through the Plumbers to People Program.
6.) Apply through CAD.

This program was phased out in June 1999 after only 727 low flow toilets were installed (Ramos 1999).

In 2001, SAWS initiated the Residential Toilet Distribution program which currently has distributed 1491 low flow toilets at no cost to participants. This program is available to any residential customer who did not participate in the Kick the Can, the Pilot program or had a toilet retrofitted through the Plumbers to People programs. There is no cost for participation and participants are responsible for any installation of toilets. This program is still offered as one of SAWS' ongoing conservation programs.

Importance of the Study

San Antonio's need to reduce water consumption due to expected reduction in permitted withdrawal of Edwards water and projected population increases within the next 50 years is vital for providing water to future residents and for future development.

As SAWS aggressively moves toward reducing per capita use from 148 gallons per capita per day (gpcd) in 2000 to a goal of 132 gpcd by 2050, incentive type conservation programs such as toilet retrofits are viewed as an effective means for reducing per capita use (Table 1). Per capita water use is the average amount of water used by each person, which is based on the calculation of total water divided by population (Texas Water Development Board 2002). To avoid any unpredicted shortages, studies to determine the effectiveness of conservation programs using water consumption should be conducted. This study is the first to evaluate the effectiveness of the KTC Program.

CHAPTER 2

REVIEW OF LITERATURE

Water Use

The patterns of water use are a concern to utilities for providing adequate water to consumers, hydraulic design of waterworks and water facilities, and planning for growth and development (Bowen et al. 1993). Its use varies from domestic and residential, industrial, agricultural, energy development, recreation, navigation and hydroelectric power. Water is measured in terms of withdrawal and consumption. Withdrawal refers to water that is extracted from surface or groundwater sources. Consumption is that part of withdrawal that is ultimately used and removed from the immediate water environment whether through evaporation, transpiration, or by incorporation into crops or food products (Dzurik 1990).

National patterns of water use indicate that the largest demand for water withdrawals (fresh and saline) is for thermoelectric generation (47 percent), followed by irrigation (34 percent), public supply (9 percent), industrial (6 percent), mining (1 percent), livestock (1 percent), domestic (1 percent), and commercial uses (1 percent) (Solley et al. 1993; U.S. Environmental Protection Agency 1995). In terms of actual consumptive use the largest consumer is agriculture (81 percent), followed by domestic

(6 percent), industrial mining (5 percent), thermoelectric (4 percent), livestock (3 percent) and commercial (1 percent) (U.S. Environmental Protection Agency 1995).

Per Capita Use

Per capita water use is the average amount of water used by each person, which is based on calculation of total water used divided by population (Texas Water Development Board 2002). In the United States, 1990 per capita daily use averaged 183 gpcd (U.S. Environmental Protection Agency 1995). The average per capita use can vary greatly between communities for any number of reasons, including:

- Climate differences (rainfall event accompanied a decrease in temperature and a decrease in water production (Bowen et al. 1993).
- The mix of domestic, commercial, and industrial uses
- Household size
- Public uses
- Differences in household income
- Age and condition of distribution system (U.S. Environmental Protection Agency EPA 1995)

Nationally, residential water uses comprise the majority of municipal water demand, reaching up to 90% of total demand in some cities during peak summer watering months (Jones et al. 1984). Efforts to reduce municipal water use must address water consumption habits of residential customers during seasonal activities (Jones 1992).

Per capita use in 2000 varied in major Texas cities from a low of 120 gpcd in Killeen to a high of 275 gpcd in Richardson. Examples of high per capita water use include Dallas-Fort Worth metropolitan (260 and 230 gpcd, respectively), College Station (259 gpcd), and Midland (233 gpcd). Low per capita water use cities include Pasadena (122 gpcd), El Paso (144 gpcd), Baytown (146 gpcd), San Antonio (173 gpcd), and Houston (180 gpcd) (Texas Water Development Board 2002).

SAWS customer per capita use has been decreasing since 1988 from a high of 188 gpcd to 143 gpcd in 2001 (Table 2). SAWS efforts such as adopting a Drought Management Plan and a Conservation and Reuse Plan and establishing a conservation rate to encourage conservation have contributed to the per capita decline from 1988 to now. As stated earlier SAWS per capita goal is to reach 132 gpcd by 2050 (Table 1). Fifty-one percent of total annual SAWS water demand is attributed to residential use (Table 2).

Profile of High Residential Water User

High water users tend to be of a high economic status, have high-income levels, higher education attainment levels and live in homes with higher home value (Larson and Hudson 1951; Thompson and Stoutmeyer 1991; Jones 1992). High users live in the more affluent areas, those areas of new growth, and are commonly referred to as urban sprawlers. They occupy large lots with large turf areas. In a San Antonio study, it was found that 10% of residential customers account for 25% of total residential water use and exhibited lot sizes ranging from 1/4 acre to over 1/2 acre. The remaining 75% of total residential water use can be characterized by lots sizes no greater than 1/4 acre (Whitcomb 2000).

Water Used Inside the Home

Water used inside the home typically ranges from 60 to 80 gpcd. Water used outside the home varies considerably with climate and type of landscaping and can range from 30 gpcd to well over 100 gpcd. Typical inside water used with old style plumbing averages 77 gpcd while water efficient fixtures can be expected to use 60 gpcd. (Maddaus 1987; U.S. Environmental Protection Agency 1995). The largest percentage of indoor water use occurs in the bathroom with 41 percent used for toilet flushing (Foster, Karpiscak and Brittain 1990; Steirer, Parham and Lukes 1994; U.S. Environmental Protection Agency 1995).

The Effect of Ultra Low Flow Toilets On Water Use

The Energy Policy Act of 1992, created uniform conservation standards for toilets, urinals, showerheads, and faucets manufactured after January 1994. The Energy Policy Act had three basic components: the establishment of maximum water use standards for plumbing fixtures, product marking and labeling requirements, and recommendations for state and local incentive programs to accelerate voluntary fixture replacement. The importance of this act is that it required the manufacture and sale of residential toilets that use no more than 1.6 gallons per flush in an effort to conserve water (Vickers 1993). Prior to the 1992 act, cities such as Glendale, Arizona and Goleta, California passed ordinances, and states such as Massachusetts and Texas passed laws requiring the use of ulft's and the creation of efficiency standards for plumbing fixtures (Vickers 1993; Texas Water Development Board 2002).

There is great potential for reduction of water consumption, when installing ultra low flush toilets that use 1.6 gallons per flush instead of conventional toilets that use 3.5 to 5 gallons or more. As stated earlier toilets account for nearly 40 percent of all indoor water use (Foster, Karpiscak and Brittain 1990; Steirer, Parham and Lukes 1994, U.S. Environmental Protection Agency 1995; DeOreo and Mayer 1996). Roughly 4.8 billion gallons (15,000 AF) of water is flushed down toilets each day in the United States. The average American uses about 9,000 gallons of water to flush 230 gallons of waste down the toilet per year (Anderson and Siegrist 1989; Jensen 1991). Thus replacing a conventional toilet with a 1.6 gal./flush unit would reduce a typically household's per-capita water use by an estimated 8 gpcd – 22 gpcd, which translates into a total annual savings of 21-59.4 gpcd per households (7,900 – 21,700 gal/year, a savings of 57-78 percent (Vickers 1993).

A study by Gregg and Curry (1995) determined water savings for replacing conventional toilets with ulft's using the following equation:

SAVINGS = [(delta T)(R)(F)] / B

> Where parameter delta T, is a measure of the change in toilet size. This parameter is constant at 3.0 gallons per flush (gpf) which is estimated from measuring the difference between the new toilet volume and old toilet volume during final inspection. The next parameters are R which represents the average number of residents per household based, F estimated at four (4) flushes per person per day. Parameters B is the average number of bathrooms per household collected at the time the resident acquired the toilet. In the formula, we conservatively assume that all of the bathrooms are equally used. Based on this assumption, the:

$$\frac{(3.0\ \text{gpf})(2.65\ \text{residents})(4\text{fgd})}{2\ \text{bathrooms}} = 15.9\ \text{gpcd}$$

Gregg and Curry calculated the total savings for each toilet replacement to be:

> 15.9 toilet + 6.2 leaks = 22.1 gpcd., (where 6.2 gpcd is a constant derived from the savings by replacing an old toilet that leaked).

Gregg and Curry's finding is consistent with findings from Maddus (1987), Anderson and Siergrist (1989), and U.S. Environmental Protection Agency (1995).

The performance of ulft's has been well documented (Anderson and Siergrist 1989, Steirer, Parham and Lukes 1994, Peak International 1996, Poch 1996, Planning and Management Consultants, Ltd 1999). These studies have consistently shown that the improved and innovative features of ulft's allow them to perform as well as or better than conventional toilets with high customer satisfaction ratings.

Effects of Conservation

Water conservation measures initiated by municipalities have evolved from short-term efforts to minimize the effects of a drought or other temporary water shortage to long-term policies. The reasoning for the evolution is the impact conservation has on water demand. Without conservation, excessive water use can contribute to nonpoint source pollution in various forms, including:

- Altered instream flows due to surface withdrawals
- Saltwater intrusion due to excessive withdrawals in aquifers
- Polluted runoff resulting from the excess of water applied for irrigation and landscape maintenance that carries with it sediments, nutrients, salts and other pollutants
- Overusing water in the household can lead to the failure of onsite sewage disposal systems (OSDS), as well as increased addition of pollutants associated with household water uses to surface and ground waters
- Building of dams to meet urban water demand contributes to the loss of biological habitats resulting from inundation of wetlands, riparian areas, and farmland in upstream areas of the impounded waterway, or erosion of these resources in downstream areas. As dams trap sediment and other pollutants, changes in water quality especially in tailwaters and downstream areas occur. They include:
    - Reduced sediment delivery

- Decreased dissolved oxygen
- Altered temperature regimes
- Increased levels of some pollutants, such as hydrogen sulfide, nutrients and manganese
- Reduction of volume of wastewater produced (Maddaus 1987).
- Decreased pollution outputs and decreased chemical use at water treatment plants (Vickers 1993).

A major benefit from conservation would be the reduction in wastewater flows to water treatment plants (Anderson and Siegrist 1989). Thus city planners and water agencies view conservation as a cost-effective complement or alternative to developing new supplies and waste water treatment facilities that can be environmentally, economically, and politically feasible.

CHAPTER 3

RESEARCH METHOD

The research method used water consumption data obtained from monthly water meter readings during the period of Average Winter Consumption (AWC) for a one-year period prior to and one-year post toilet retrofit. AWC consist of months designated as "winter" in which all water use during this time period is for indoor use (Maddaus 1994; Mayer and DeOreo 1995). Based on the assumption that indoor water use is fairly constant throughout the year, the remainder of the difference between the annual consumption and the winter consumption can be classified as outdoor use.

The period of comparison for this study are the winter months of December, January, February, and March for the periods of 1999-2000 and 2001-2002. Total water consumption of the participants of KTC were then compared to that of a control group for the period of 2001-2002. The control group was determined to be similar to the participant group in terms of housing characteristics.

All statistical analyses were conducted using the computer program SPSS 10 for windows.

RESEARCH QUESTIONS

Q1: Which independent variables (IVs) (number of toilets replaced, number of people per household, total property value, outside grounds area, inside living area, median household income, number of whole baths, number of stories, number of rooms and age of house are predictors of average winter consumption for the participants of the Kick the Can Program, in 2001?

Q2: Is there a significant difference in gallons per capita per day for participants, who entered the Kick the Can Program in January 2001, during winter consumption for 1999-2000 and 2001-2002?

Q3: Is there a significant difference in gallons per capita per day, when participants are compared to a control group during 2001-2002?

CHAPTER 4

STUDY PROCEDURE

Data Acquisition of Study Group

Study Group

On any given month for any given year approximately 300 to 500 applications for the SAWS KTC program are processed. For this study only those customers (310), who submitted completed applications for the month of January in 2001 were considered. Information regarding the name, address, number of toilets replaced at a given address and account number for KTC participants was obtained from the SAWS KTC database. Information regarding the number of household members was obtained from viewing filed original applications of participants. The SAWS customer database, which includes all current customer activities such as account and history information contains a specific field that is used to identify participants of the KTC program. Participants for the program who replaced toilet(s) and received a credit are coded with either a "T", for one toilet or a "Z", for replacement of two toilets. This designation will be used to verify that the KTC database of participants is consistent with the SAWS customer database.

Household Water Consumption

Each SAWS residential customer has a single domestic water meter, which measures all water used in the household. Water meters are read in thousands of cubic feet (ccf's) by meter readers and converted to gallons on SAWS customer database for printing of customer water bills. Water use information is displayed in units of gallons and ccf's in the SAWS Customer database. For this study units of gallons were used.

The account number is a series of 13 digits assigned to each customer. The first two digits of the account number are referred to as the billing cycle for which the SAWS service area is geographically divided into 20 cycles (Figure 2).

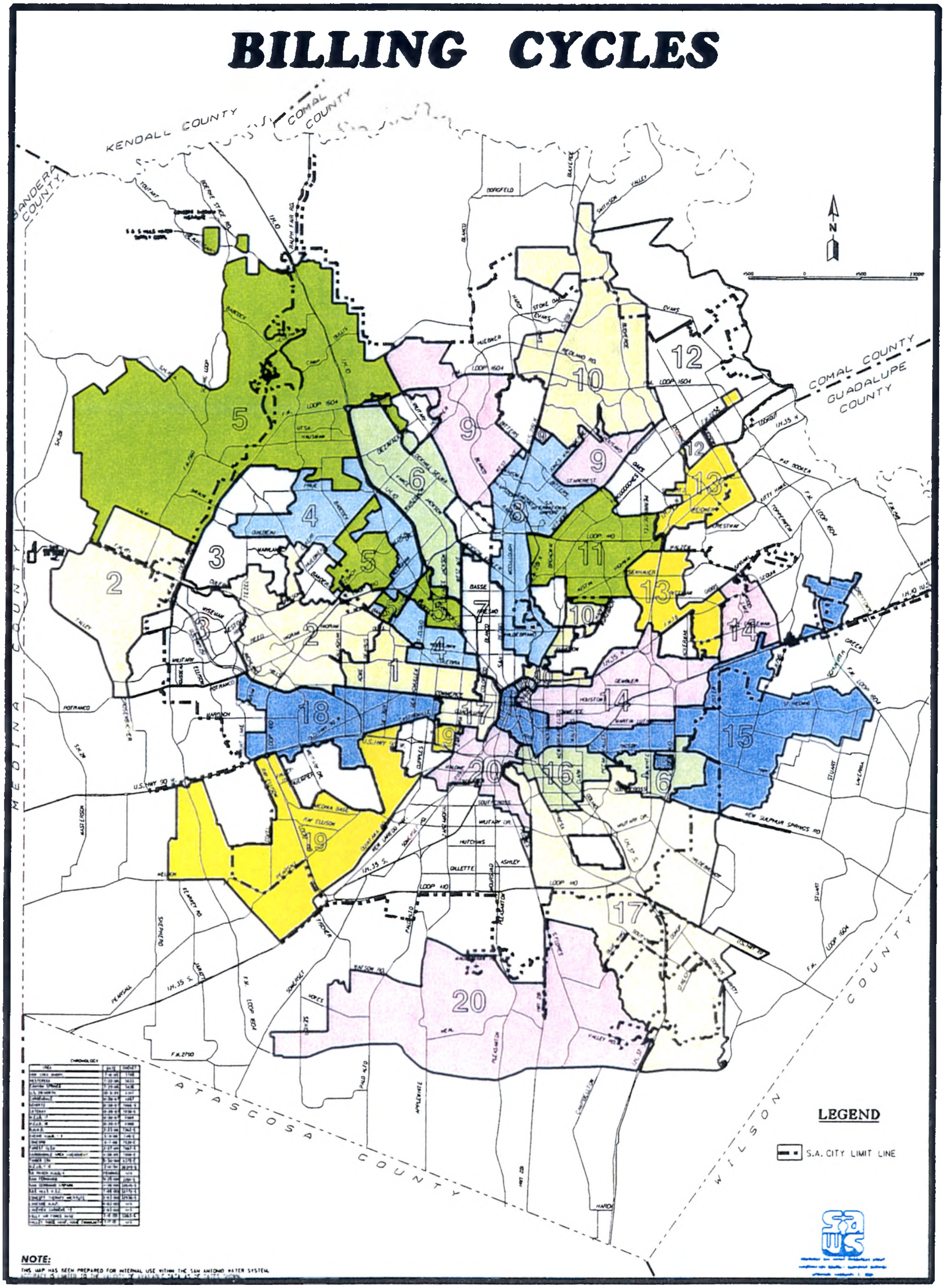

Figure 2. SAWS Billing Cycles
(San Antonio Water System Data Services Department 2002).

The next four digits are referred to as the route number, which further defines the geographic region in which the customer resides. Table 4 illustrates the billing cycle and corresponding route numbers within each cycle.

Table 4. Cycle and Route Number
(San Antonio Water System Meter Reading and Billing Schedule 2001)

Cycle	Route
21	0002-9999
1	0030-0430
2	0435-0678
3	0679-0729
4	0730-0968
5	0970-1585
6	1600-1900
7	1950-3460
8	3470-3720
9	3730-3810
10	3811-4000
11	4010-4600
12	4680-4890
13	4900-5694
14	5700-6640
15	6645-7032
16	7033-7410
17	7430-7860
18	7870-8254
19	8296-8390
20	8440-9320

The next 6 digits are referred to as the tap number, which is the number assigned to the water service at a specific address. This number is forever linked to the specific address of the structure regardless of the name of the billed customer. There is no correlation between tap number and number of customers within the SAWS service area. The last digit is referred to as the customer number, which indicates the number of that customer at the given address. Unlike cycle, route or customer numbers, the tap number never changes. For example account number 1-0371-132901-6 follows: located in the geographic region known as billing cycle 1; the route number is within the boundaries of cycle 1; the tap number is for service at 150 Alicia St; and this is the sixth customer at this residence.

For this study, tap numbers were used to obtain water consumption information for the participants and the control group in the SAWS customer database. Water consumption data for both participants and control group was obtained for the months of December, January, February, and March at different time periods. The first period, 1999–2000, is the period one year prior to the installation of ulft's. The second period, 2000-2001, is the period of installation of ulft's or participation in the KTC program. The final period 2001-2002, is the period one year after the installation of ulft's.

Although the SAWS customer database has SAWS information regarding customer history such as water consumption, it only contains the preceding 12 months of history for the current time period it is being viewed. Water consumption data regarding non-current periods such as December 1999 – December 2000 are stored in archived microfiche format known as SAWS daily billing registry. Water consumption data is stored as units of ccf's and is organized by account number. Therefore water consumption for the period of January 2001-March 2002 was obtained using tap numbers and the SAWS customer database, while water consumption for the period of December 1999 –December 2000 was obtained using archived microfiche based on account number. Water consumption data expressed in ccf's units were converted to gallons.

Housing Profile

After obtaining water consumption data, these cases were then cross- referenced with an online address search using the Bexar County Appraisal District website to extract the housing and property profile for the period of 2001. The housing profile included total property value (value of the structure and land), calculated acreage (property in acres excluding living area), living area (portion of the house that is actually lived in excluding garage space), number of whole and half baths, number of stories, number of rooms, and year structure was built. Next an on-line address search using the U.S. Census Bureau website was performed to extract census tract identification and median household income from the 2000 Census.

Study Group Database

Information obtained was placed in a database that contained the following fields:

Name of customer
Address of customer
Zip code of customer
SAWS Account #
Number of toilets replaced through KTC
Number of household members
Total property value
Census tract
Median household income
Outside grounds area
Living area of structure
Number of stories of structure
Number of whole baths in structure
Number of half baths in structure
Number of rooms in structure
Year structure built
December water consumption
January water consumption
February water consumption
March water consumption
Total winter consumption

Merging of Fields/ Creating New fields

Half baths and whole baths fields were merged. The reasoning is that it can be assumed that each half bath would contain one toilet. After merging cases, the half bath field was removed. After merging 41 cases, the half bath column was removed.

New fields were created for age of house, average winter consumption, gallons per capita per day, and gallons per household per day. Age of house was calculated from the difference of the study year, 2001, and the year the structure was built. Average winter consumption was calculated using water consumption data during the months of December, January, February, and March for the periods of 1999-2000, 2000-2001, and 2001-2002. Gallons per capita per day (gpcd) was calculated by multiplying the number of household members by the number of days of winter consumption (121 days) and then dividing the product into the total winter consumption. Gallons per household per day (gphd) was calculated by dividing the number of days of winter consumption (121 days) into the total winter consumption.

Resulting fields used for this study were: number of toilets replaced, number of household members, total property value, outside grounds area, living area, median household income, number of stories, number of whole baths, number of rooms, age of house, gpcd, gphd, and average winter consumption.

Study Group Data Screening

Water consumption data was screened to insure appropriate data in fields are complete and the analysis can be done. Those cases that had incomplete data were eliminated. Criteria for eliminating cases were: lack of water consumption information for the study periods; differences of names on account numbers with regard to KTC participants and the SAWS customer database, and water consumption values of 99999 and 00000. A water consumption value of 99999 constituted no activity or disconnection of services at that particular address for the month that it was reported. Water consumption values of 00000 constituted no water use for the month. In addition, cases in which houses were built after 1992 were eliminated. Fields and data that were eliminated were as follows: Forty cases were eliminated due to lack of customer information linked to an account number. Seventeen cases were eliminated due to the names of participants of the KTC database were different from the SAWS customer database for the different study periods. Water consumption values of 99999 resulted in removing eighteen cases, while water consumption values 00000 resulted in removing nine cases. Five cases were removed due to houses built after 1992. One case was removed due to the structure being a mobile home. The researcher felt that mobile home water consumption patterns would not be similar to a single-family residence and should not be included in the study group. The resulting database consisted of 220 cases of KTC participants in January 2001 from which complete information was obtained . The resulting study cases were cross- referenced with the SAWS customer base to insure that the remaining cases had either a "T" or "Z" code affixed to their account history, illustrating participation in the KTC program.

Data Acquisition of the Control Group

Control Group List

A request was made to the SAWS Information System to extract an initial control group listing from the SAWS customer database for all customers that had not participated in the KTC program. Selection was based on meeting the following criteria: All selected must have been an active residential customer account, must have no "T" or "Z" codes affixed to the customer records, have been a SAWS customers since at least 2000, selection must be random and coincide with a percentage of each case residing in the billing cycle of the study group. These criteria resulted in the following number of control samples for each billing cycle:

Cycle 1 – 72 cases
Cycle 2 – 75 cases
Cycle 3 – 66 cases
Cycle 4 – 75 cases
Cycle 5 –48 cases
Cycle 6 – 57 cases
Cycle 7 – 66 cases
Cycle8 – 39 cases
Cycle9 – 45 cases
Cycle 10 – 90 cases
Cycle 11- 27 cases
Cycle 12 – 57 cases
Cycle 13 – 48 cases
Cycle 14 – 234 cases
Cycle 15 – 174 cases
Cycle 16 – 93 cases
Cycle 17 – 48 cases
Cycle 18 – 75 cases
Cycle 19 – 66 cases
Cycle 20 – 45 cases

A large data set was requested to insure the following: selection of non-participants be random, billing cycle representation was similar to that of the study group and that after screening there would be enough control cases to match with a study case. A control list of 1501 customers which met the above the criteria was obtained.

Control Group Housing Profile

Information regarding median household income was obtained from the U. S. Census website and housing profile information (property value, calculated acreage, living area, number of whole and half baths, number of stories, number of rooms and year structure was built) was obtained from the Bexar County Appraisal District website. Water consumption for the period of 2001-2002 was obtained using the SAWS customer database.

All information was placed into a database that contained the following fields:

Name of customer
Address of customer
Zip code of customer
SAWS Account #
Total property value
Census tract
Median household income
Calculated acreage of property
Living area of structure
Number of stories of structure
Number of whole baths in structure
Number of half baths in structure
Number of rooms in structure
Year structure built
December water consumption
January water consumption
February water consumption
March water consumption
Total water consumption

Control Group Merging of Fields / Creating New fields

Similar to the study group, half baths and whole baths fields were merged and new fields were created for age of house, average winter consumption, gallons per capita per day (gpcd) and gallons per household per day (gphd). The same methods were used for calculating age of house, average winter consumption, gpcd and gphd.

Control Group Data Screening

After compiling information to complete the fields for the preliminary control group, cases of the control group were then screened and eliminated. Elimination was based on the same criteria as the control group: structure was built after 1992, meter reading was 999999 or 000000, or original customer no longer resides at the residence based on difference of names. One hundred and seventy-three cases were eliminated leaving 1328 cases in the preliminary control group.

Control Group Final Screening

In order to keep the number of control cases similar to the study group (220), cases from the study group were then matched to cases from the preliminary control group in order to obtain a final control group that resembled the study group. Matching consisted of pairing a study case with control case based on the following housing profile: both study and control case are similar in age of house, have the same number of bathrooms, are similar in property value and have similar outside ground area. Next, all control cases were then cross-referenced with the program databases of Plumbers to People, Residential Pilot Toilet Distribution and Residential Toilet Distribution programs to insure that none of the control cases had participated in these other SAWS programs or received a low flow toilet. No control cases were found in the other program databases.

CHAPTER 5

STUDY RESULTS

Research Questions I

Q1: Which independent variables (IVs) (number of toilets replaced, number of people per household, total property value, calculated outside grounds area, living area, median household income, number of whole baths, number of stories, number of rooms and age of house are predictors of average winter consumption (DV) for the participants of the Kick the Can Program, in January 2001?

Research Question I Results

Stepwise multiple linear regression was conducted to determine which independent variables: Number of toilets replaced (toilets); number of people in household (number_o); total property value (total_p); calculated outside grounds area (grounds); inside living area (living_a); median household income (median_i); number of whole baths (v17); number of stories (v16); number of rooms (v18); and age of house (age_of_h) were predictors of average winter consumption, (winter_c), for the participants of the Kick the Can program in January 2001.

Multiple linear regression is an extension of simple linear regression which takes into account more than one independent variable. In this study, the dependent variable "y" is average winter consumption.

The goal of the analysis is to find a linear equation of the form

$$y = a_1x_1 + a_2x_2 \;\ldots\ldots a_nx_n + b$$

where y is the dependent variable,

a_1 a_n are the regression coefficients of each variable,

and b is a constant.

Developing this equation can be accomplished by using a method of least squares. The method determines the coefficients a_1 through a_n and b such that the sum of the squared deviations between observed y's and fitted or calculated y's is minimized. Once the coefficients are determined, an equation can be written which predicts y based on the set of independent or explanatory variable (Norusis 1985).

Data screening led to the elimination of one case. Evaluation of linearity led to the natural log transformation of toilets, number_o, total_p, grounds, living_a, median_i, v16, v17, v18, age_of_h and winter_c. Regression results indicated an overall model of two predicators (number_o and total_p) that significantly predict average winter consumption, $R^2 = .313$, $R^2_{adj} = .307$, $F(2,216)=49.271$, $p<.001$. This model accounted for 31.3% of variance in average winter consumption. A summary of the regression model is presented in Table 5. In addition, bivariate and partial correlation coefficients between each predictor and the dependent variable are presented in Table 6 (Coefficients for Final Model) followed by the prediction equation for average winter consumption.

Table 5 Model Summary

Step	R	R^2	R^2_{adj}	$chg\ R^2$	F_{chg}	p	df_1	df_2
1. Number of people in household	0.531	0.263	0.259	0.263	77.336	<.001	1	217
2. Total property	0.56	0.313	0.307	0.051	15.897	<.001	1	216

Table 6 Coefficients for Final Model

	B	*Beta*	*t*	*Bivariate r*	*Partial r*	*Part*
Number of people in household	0.612	0.518	9.182	0.513	0.53	0.518
Total property	0.244	0.225	3.987	0 213	0.262	0.225
Constant	2.317		7.97			

Prediction Equation:

$$\textit{Average winter consumption} = .612_{\, lognumber\_O} + .244_{\, logtotal\_p} + 2.317$$

$$Z_{\, winter\ \ consumption} = .518_{\, lognumber\_O} + .225_{\, logtotal\_p}$$

Discussion of Results for Question I

Using multiple linear regression analysis, 31.3% of average winter consumption could be explained by two variables. These two variables are the number of people in the household and the total property value. None of the other variables (number of toilets replaced; calculated outside grounds area; inside living area; median household income; number of whole baths; number of stories; number of rooms; and age of house) had a significant relationship to winter water consumption.

Research Question II

Q2: Is there a significant difference in gallons per capita per day during the months of average winter consumption (December, January, February and March) for participants who participated in the Kick the Can Program (January 2001) for one year before the toilet retrofitting (1999-2000) and one year after toilet (2001-2002)?

Research Question II Results

To address Research Question 2, a paired samples *t* test was calculated to compare the for mean gpcd pre-installation period(GPCD99K) to the mean gpcd for post installation period (GPCD01K). Table 7 Paired Samples Statistics, illustrates the results of the paired samples t test descriptive statistics.

Table 7 Paired Samples Statistics

	Mean	N	St. Deviation	Std. Error Mean
Pair 1 GPCD99K	127.95	220	129.74	8.75
GPCD01K	84.65	220	59.65	4.02

The mean gpcd for the period of pre installation (GPCD99K) was 127.95 (*sd*= 129.74) and the mean on the post installation (GPCD01K) was 84.65 (*sd*=59.65).

Interpretation of a t test is based on the significance level of the results. That is if the significance level is greater than .05, then the difference would not be significant. If the significance level is less than .05, then the differences would be significant (Cronk 1999).

Table 8. Samples Test

	Paired Differences							
				95% Confidence Interval of the Difference				
	Mean	Std. Deviation	St. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1 GPCD 99K GPCD01K	43.30	113.05	7.62	28.28	58.33	5.681	219	0.00

Table 8 shows a significant decrease from pre-installation to post-installation was found ($t(219)= 5.681, p<.001$).

Discussion of Results for Research Question II

Those participants who participated in the KTC program achieved a savings of 43.30 gallons per capita per day (gpcd) during the average winter consumption period of 121 days. Unfortunately, these savings cannot be attributed solely to the replacement of toilets but instead are the result of savings accrued in the entire household and not by replacement of individual toilets. Therefore, any water savings achieved would be attributed to the net household water use during this period. Based upon this finding, households which participated yielded a water savings of 43.30 gpcd.

In order to determine savings achieved by the replacement of toilet(s), I used the principle that toilets account for nearly 40 percent of all indoor water use (Foster, Karpiscak and Brittain 1990; Steirer, Parham and Perlman 1994; U.S. Environmental Protection Agency 1995; DeOreo and Mayer1996). Incorporating this principle (toilets use 40 percent of all indoor water use), I determined that water savings achieved from participation in the KTC program resulted in savings of 17.3 gallons per capita per day after replacement of conventional toilets. This value of 17.3 gpcd is consistent with Gregg's and Curry's (1995) findings of 15.9 gpcd savings and Poch's (1996) finding of 17.7 gpcd savings. If these participants were to continue this savings trend (17.3 gpcd) for the entire the year, an annual water savings of 4,200 gallons per year would be achieved by each household for a combined program savings of 933,000 gallons (2.86 acre feet) for the combined study group.

Research Question III

Q3: Is there a significant difference, gallons per household per day (gphd), when participants of the Kick the Can Program (January 2001) are compared to a control group during the months of average winter consumption (December, January, February and March) for 2001-2002?

Research Question III Results

An independent samples t test was calculated comparing the mean gphd (gallons per household per day) of participants of the KTC program (GPDH 1) to the mean gphd of a control group (GPDH 0). Table 9 (Independent Group Statistics) and Table 10 (Independent Samples Test), illustrates the results of the independent test.

Table 9. Independent Group Statistics

Study		N	Mean	St Deviation	Std. Error Mean
GPDH	1	220	223.27	147.13	9.92
	0	220	268.05	380 67	25.66

The mean of the participants was (*m* = 223.27, *sd* = 147.13) was not significantly different from the mean of the control group (*m* = 268.05, sd = 380.67). A mean difference of 45 gallons was observed between the participants and non-participants.

Table 10 Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% of Confidence Interval of the Mean Lower	Upper
GPDH Equal variances assumed	2.06	0.152	-1.628	438	0.104	44.78	27.51	98.86	9.30
Equal variances not assumed			-1.628		0.105	44 78	27 51	98.64	9.38

Recall that the significance of a t-test is determined by the significance level of the result either being greater or lesser than .05. In this study the significance level was .104 as seen in Table 9. Therefore, the difference between the two groups was not statistically significant ($t(218) = 1.628, p > .05$). However, these findings at least suggest a lower water use of 45 gallons per day (*m* = 223.27, *sd* = 147.13) by KTC participants as opposed to a mean of the control group (*m* = 268.05, sd = 380.67).

Discussion of Results for Research Question III

These results indicate that although participants in the KTC program saved approximately 45 gphd when compared to control group, based upon the t-test these results are not statistically significant. Although property values and grounds area were slightly higher in KTC group, with difference in $1,121 and 668 sq. ft., respectively, both groups were similar in profiles Table 11.

Table 11 Comparison of KTC vs Control Group

	Average Per Household				
	Property Value	Grounds Area (sq.ft)	Living Area (sq ft)	Age of House (yrs)	No of Toilets
KTC Group	$76,066	9,382	1547	37	1 9
Control Group	$74,437	8,874	1525	37	1.9

There may be several contributing factors as to why there is no significant difference in water savings between the KTC group and the Control group, which were not taken into account for this study. One possible factor is free ridership, the retrofitting of a toilet without knowingly participating in a conservation program. Some participants of the control group may have replaced their high flow toilets without participating in the KTC program. Another possible factor relates to the number of household members. This number was not known for the control group. As illustrated in this study, there is a direct correlation with number of people per household and total property value predicting average winter consumption. Therefore not knowing the number of people per household for the control group may have had an effect on the result; that is there may be fewer people per household in the control group. Further research should be conducted to incorporate free ridership and number of people per household for the control group to resolve this uncertainty.

CHAPTER 6

POLICY RECOMMENDATIONS AND CONCLUSIONS

Policy Recommendations

This study determined that the SAWS KTC program is effective in reducing indoor residential water consumption. Therefore SAWS should be more aggressive with promoting and actively recruiting participants for its current KTC program as well as recruiting for its free toilet retrofit programs.

Free toilet programs such as the Residential Toilet Distribution program, can address the issue of lack of participation from low-income customers in conservation programs that require up-front financial cost, such as the KTC. Poch (1999) found that free toilets for low-income customers reduced water consumption by 45.1 gallons per toilet per day due to the greater number of people per household and older plumbing fixtures. Therefore SAWS should actively recruit low-income customers for its conservation programs in the hopes of achieving more water savings per household.

Conclusion

Conservation can contribute to SAWS meeting its long-term water needs and demands. Conservation in the form of education, awareness, or providing for incentive type programs can change behavioral habits and water use impacts of users and thus achieve a reduction on water demand.

Although conservation has been deemed to be critical to achieving a reduction in water use, the determination of the effectiveness of conservation programs is equally critical. A conservation program is only as good as its conservation potential or ability to reduce total water use. As SAWS becomes a conservation leader in the region, a self-evaluation of its programs to determine the effectiveness of true water savings should be conducted to prevent any future shortfalls or any unforeseen shortages due to ineffective conservation programs. Conservation thus should be thought of as another "source" of water and be treated with the same level of attention as any other source of water supply.

WORKS CITED

Anderson, D. L., and R. L. Siegrist. 1989. Performance of ultra-low-volume flush toilets in Phoenix. *Journal of American Water Works Association* 25 (March): 51-54.

Atlanta Journal – Constitution. [Atlanta]. 2002 Water conservation moves beyond the optional stage, 20 May 20, sec. A, p. 9.

Bowen, Paul T. et al. 1993. *Residential water use patterns*. Denver CO. AWWA Research Foundation and American Water Works Association.

Cronk, Brian C. 1999. How to use SPSS, a step-by-step guide to analysis and interpretation. Los Angeles: Pyrczak Publishing.

DeOreo, William B. and Peter W. Mayer. 1996. Evaluating conservation retrofit savings with precise end-use data. *Proceedings of the American Water Works Association 1996 Annual Conference 23-27 June 1996.*

Dzurik, Andrew. 1990. *Water resource planning*. Savage: Rowman & Littlefield Publishers, Inc.

Earl, Richard A. and Troy Kimmel. 1995. The weather and climate of south-central Texas. In *Pathways in Geography* no. 12:31- 40.

Earl, Richard A., and Robert Czerniak. 1996. Sunbelt water war: The El Paso-New Mexico water conflict. *Social Science Journal* 33: 359-379.

Edwards Aquifer Authority. 2000. *Hydrogeologic data report for 1999*. San Antonio: Edwards Aquifer Authority.

Edwards Aquifer Research and Data Center. n.d. Edwards Aquifer Information; available from http://www.eardc.swt.edu/chart2.html/; Internet accessed 14 August 2002.

Fleming, William and Alice Grisham. 1989. Long-term options for municipal water conservation. *Journal of American Water Works Association* 25 (March): 34-42.

Foster, Kennith E., Martin M. Karpiscak and Richard G. Brittain. 1990. Residential water conservation: Casa Del Agua. *Water Resources Bulletin* 26 (December): 939-948.

Gregg, Tony P. E. and James Curry. 1995. Confirming Benefit Cost-Models by Using Effective Information Management and Analysis. *Proceedings of the American Water Works Association 1995 Annual Conference, Anaheim 18-22 June 1995.*

Jensen, Ric. 1996. Why droughts plague Texas. *Texas Water Resources*, 22 (Summer): available from http: //tamu.edu/twripubs/WtrResrc/v22nhtml; Internet accessed 29 January 2001.

Jennings, Marshall , E. Peter W. Bush and Greg N. Nalley. 1992. Generalized hydrologic characteristics of the Edwards Aquifer. *Proceedings of American Water Resources Association Texas section, fall meeting.*

Jones, Alice L. 1992. The determinants of household water use and conservation in San Antonio, Texas. M.A.G. thesis. Southwest Texas State University.

Jones, C. Vaughan, John J. Boland, James E. Crews, C. Frederick Dekay and John R. Morris. 1984. *Municipal water demand: statistical and management issues.* Boulder: Westview Press.

Larson, Bernt and H. E. Hudson, Jr. 1951. Residential water use and family income. *Journal of American Water Works Association* 43 (August): 603-611.

Maddaus, William O. 1987. *Water conservation.* Denver: AWWA Research Foundation and American Water Works Association.

Maddus, William O. 1994. Planning Cost-effective conservation programs for public and private utilities. *Proceedings of the American Water Works Association 1994 Annual, New York 19-23 June 1994.*

Mayer, Peter W. and William DeOreo. 1995. *Process approach for measuring residential water use and assessing conservation effectiveness: Proceedings of the American Water Works Association 1995 Annual Conference, Anaheim 18-22 June 1995.*

Michelsen, J., Thomas McGuckin and Donna Stumpf. 1999. Nonprice water conservation programs as a demand management tool. *Journal of the American Water Resources Association* 35 (June): 593-602.

Norusis, M. 1985. *Advanced statistics guide: SPSS.* New York: McGraw- Hill Book Co.

Pavely, Fran. 2002. Flushing away a resource. *The Los Angeles Times*, 8 April, B, p. 10.

Planning and Management Consultants, Ltd. 1999. *Estimating water savings and cost-effectiveness of water conservation projects in the cities of Lacey, Olympia, and Tumwater.* Carbondale: PMCL.

Peak International. 1996. *Ultra low flush toilet program customer satisfaction surveys for Metropolitan Water District of Southern California.* Newport Beach: Peak International.

Poch, Ximena. 1996. Austin's Free Toilet Program: Cheaper than rebates! *Proceedings of Conserv 96, Orlando 4-8 January 1996.*

Ramos, Humberto. 1999. Program draft for SAWS toilet distribution program. San Antonio: San Antonio Water System.

San Antonio Water System. 1998. *San Antonio Water System water resource plan: Securing our Water Future Together.* San Antonio: San Antonio Water System.

San Antonio Water System. 2000. *San Antonio Water System 2000 water stats book.* San Antonio: San Antonio Water System.

San Antonio Water System. 2002. *San Antonio Water System conservation monthly report on calls and rebates.* San Antonio: San Antonio Water System.

San Antonio Water System. 2002. *San Antonio Water System service area map.* San Antonio: San Antonio Water System.

San Antonio Water System. 2002. *San Antonio Water System billing cycles map.* San Antonio: San Antonio Water System.

San Antonio Water System. n.d. Aquifer management plan; available from http://www.saws.org/conservation/aquifermgmt/. Internet accessed 14 August 2002.

Steirer, Marsi A., Dianne Parham and Leisa Lukes. 1994. San Diego's toilet rebate program experience an evolutionary approach. *Proceedings of the American Water Works Association 1994 Annual Conference, New York 19-23 June 1994.*

Solley, W. B., R. R. Pierce and H. A. Perlman. 1988. *Estimated use of water in the United States in 1990.* Washington, D.C.: U.S. Geological Survey Circular 1004.

Texas Water Development Board. 2002. *Water for Texas –2002.* Austin: Texas Water Development Board.

Thompson, Suzanne C. and Kirsten Stoutemyer. 1991. Water use as a commons dilemma: the effects of education that focuses on long-term consequences and individual action. *Environment and Behavior* 23 (May): 314-333.

U.S. Environmental Protection Agency. 1995. *Cleaner water through conservation.* Washington, D.C.: Environmental Protection Agency.

Whitcomb, John. 2000. *Evaluation of residential water budget rate structure.* Boulder: Stratus Consulting Inc.

Vickers, Amy. 1993. The energy policy act: assessing its impact on utilities. *Journal of American Water Works Association* 29 (August): 56-62.

Yardley, Jim. 2001. For Texas now, water and not oil is liquid gold, *The New York Times*, 16 April, A, p. 14.

VITA

Humberto Ramos was born ın San Antonio, Texas, January 27, 1969, the son of Emılia R. Ramos and Frank L. Ramos. After completıng his work at Louis W. Fox Academic and Technical High School, San Antonio, Texas, in 1987 he entered Southwest Texas State University in San Marcos, Texas. He received the degrees of Bachelor of Arts and Bachelor of Science from Southwest Texas State University in San Marcos, Texas. In September 1993, he entered the Graduate School of Southwest Texas State University, San Marcos, Texas.

Permanent Address: 522 Craigmont

San Antonio, Texas 78213

This thesıs was typed by Humberto Ramos.