



Water Use in Turlock, CA:

Evaluating the Water Rate System, the Effectiveness of Water Conservation Materials, and Estimating Residential Water Demand

*by the
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at
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EXECUTIVE SUMMARY

The city of Turlock currently has a population of approximately 67,000 and is located within one of the fastest growing regions of California. As a result of population growth and residential development, considerable pressure is being placed upon the city's water resources. In addition to these growth factors, the city reports that the average citizen uses approximately 250 gallons of water per day as compared to the national average of only 150 gallons per day. As the demand for water continues to increase, the city will face significant expenses as it needs to install new water wells, convert to surface water supplies, expand water treatment facilities, implement drastic conservation efforts, switch to a metered billing system, or some combination of these activities. In order to reduce or avoid some of these future water expenses, the city must have a better understanding of how water is currently being used and how to motivate the residents of Turlock to decrease their water usage. This study examines several issues relating to water use within the city as outlined in the following three sections: (1) Evaluation of the Current Water Rate Structure, (2) The Effectiveness of Water Conservation Materials, and (3) Estimating the Residential Demand for Water.

The first section of the report evaluates whether or not the current system (based on number of rooms and lot size) used to calculate the monthly water fee for a home reflects the actual water usage of the home. The results of this analysis indicate the following:

- The current system for determining monthly water rates does not result in charges that reflect actual water usage. (No significant correlation between the amount of water used by each home and the monthly fee being charged).
- The number of rooms in each home does not significantly correlate with water usage.
- Although lot size is significantly correlated with water usage, it only accounts for approximately 11.3% of the total variation in monthly water use.
- Only 30% of the households that were surveyed supported switching to a water billing system that uses meters.

The second section of the study evaluates the effectiveness of two different sets of water conservation materials. This was accomplished by randomly assigning homes that have had monitor water meters installed on them into one of three treatment groups. One group did not

receive any water conservation materials, another received a flyer indicating several ways to reduce water use, and a third group received the conservation flyer as well as a “Water Conservation Kit” that was purchased from the Water Education Foundation of California. Statistical techniques were used to determine whether or not these water conservation materials significantly affected household water use. The results of this analysis indicated the following:

- Neither the water conservation flyer nor the water conservation kit resulted in a significant reduction in household water use. (This result does not indicate whether or not other materials or existing efforts are effective)

The third section of the study evaluates the factors that influence residential water demand. This is accomplished by statistically analyzing a data set containing household characteristics and monthly water use. The data for this analysis were collected from a variety of sources including: The City of Turlock’s Municipal Services Department, Stanislaus County Assessor’s office, and a household survey. The analysis tested to determine the relationship between 15 different household factors and the average monthly water use per household. The results of the analysis are as follows:

- The number of bathrooms, lot size, square footage of grass, number of occupants, and number of kids are positively correlated to average monthly water use.
- The two most significant factors affecting monthly water usage are the number of occupants and the square footage of grass for each home. These two factors provided the best model for predicting average monthly water use.
- Each additional occupant is estimated to increase average monthly water use by 3,867 gallons.
- Each additional square foot of grass was estimated to increase average monthly water use by 2.853 gallons.
- The number of bedrooms, head of household’s years of education, home size, income level, having a pool, number of rooms, number of sewer fixtures, having an automatic sprinkler system, water conservation attitude, and year of home construction were not significantly correlated with average monthly water use.

One of the main limitations of this study (affecting all three sections) was the relatively small sample size that was available. Due to the high cost of installing and reading monitor water

meters, the Municipal Services Department of Turlock was only able to provide monthly water use data for approximately 100 homes throughout the city. For the section evaluating the water rate structure, a total of 93 complete observations were available for the analysis. When examining the effectiveness of the two different sets of water conservation materials, complete data were available to create three different groups that contained a total of 31 homes each. To evaluate the factors that affect household water demand, a survey was needed to collect additional information about each home. After two different mailings, 37 out of 93 (40%) of the households responded and were available for this analysis. Although the number of observations used for this study is relatively small, it is adequate to provide useful information regarding the water rate structure, the effectiveness of the two different water conservation materials, and the demand for water within the city. However, it is anticipated that a larger sample size could potentially improve the overall results. It is recommended that the general results of the study be used freely for guiding policy making decisions while the precise magnitude of the results should be applied cautiously.

SECTION 1: EVALUATION OF THE CURRENT WATER RATE STRUCTURE

1.1 Introduction

The majority of all homes within the city of Turlock are billed at a flat monthly rate for their water service regardless of how much water each residence actually uses. Although the rates are not dependent upon water use, they do vary from household to household. Current water charges are based upon the square footage of the lot and the number of rooms in each home. The details of how these charges are determined can be found in section 6-5-601 of the Turlock Municipal Code and have been summarized below.

Table 1.1: Water Charge Based Upon the Number of Rooms.

Number of Rooms	Charge Per Living Unit	Effective Dates				
		July 1, 2004	July 1, 2005	July 1, 2006	July 1, 2007	July 1, 2008
0-5 Rooms	\$7.05	\$9.35	\$11.35	\$13.30	\$14.80	\$15.55
6-8 Rooms	\$7.90	\$10.50	\$12.70	\$14.90	\$16.55	\$17.40
More than 8	\$8.70	\$11.55	\$14.00	\$16.45	\$18.25	\$19.15

Table 1.2: Water Charge Based Upon the Square Footage of Lot

Square Footage	Rate	Effective Dates				
		July 1, 2004	July 1, 2005	July 1, 2006	July 1, 2007	July 1, 2008
0 to 5,500 Square Feet	\$5.55	\$7.35	\$8.95	\$10.50	\$11.65	\$12.25
Each additional 2,000 square feet or fraction thereof	\$0.85	\$1.15	\$1.35	\$1.60	\$1.80	\$1.85

Using the tables above, the current monthly water fee for a home that has seven rooms and a 6,300 square foot lot can be calculated as \$23.00 per month (as of December 2005). This is calculated by adding the room charge (\$12.70) to the charge for the first 5,500 square feet of lot (\$8.95) and adding the charge for the additional fraction of the next 2,000 square feet of lot (\$1.35) for a total of \$23.00 (\$12.70+\$8.95+\$1.35).

This type of flat rate billing system, would appear to have been designed in an attempt to approximate the monthly water usage of each home. That is, a home with more rooms and a larger lot would use more water than a smaller home and therefore receive a larger bill each

month. However, this method of approximating household water usage may not actually reflect the water use patterns of the homes within the city.

1.2 Methods and Analysis

Over the last few years, water meters have been installed on approximately 100 homes across the city in order to monitor monthly water usage. Using data collected from these monitor water meters, statistical analysis can be used to evaluate how well the current billing system actually reflects the amount of water that is being used by the metered households each month. This was accomplished by calculating a Pearson's Product Moment Correlation (Pearson's Correlation) to determine the extent to which the two variables (monthly water bill and average monthly water usage) are related. The value for a Pearson's Correlation (r) can fall between 0.00 (no correlation) and 1.00 (perfect correlation). Although the interpretation of the correlation coefficient can vary given specific circumstances, a common rule of thumb is that a correlation of less than .30 indicates little if any relationship between the variables (Hinkle, et al., 1988).

Using the monthly data from the homes with monitor water meters, the average monthly water use of 93 different homes throughout the city during the 2004/2005 fiscal year were identified (Appendix 1). These data were combined with each home's monthly water bill (Appendix 1) in order to calculate the Pearson's Correlation coefficient. The results of this analysis are presented in Table 1.3. All statistical analysis was conducted using the analytical software package SPSS version 13.0 (SPSS Inc, 2004).

Table 1.3: Correlation between monthly water bill and average monthly water use (July 1, 2004 – June 30, 2005).

Pearson Correlation (r)	0.123
Significance (2-tailed)	0.242
Number of Observations (N)	93

Table 1.3 indicates that the correlation coefficient between these variables is only 0.123, which indicates that there is **not a statistically significant correlation** between the size of the homes monthly water bill and the average amount of water used each month by that home. As such, the current billing system does not appear to reflect monthly water usage very well.

A more precise interpretation of the correlation coefficient can be done by squaring the value of r (R^2 , referred to as the "coefficient of determination"), which indicates the percentage of the variation in one variable (water use) that is associated with the other variable (water bill). Thus, a correlation coefficient (r) of .123 would yield a coefficient of determination (R^2) of only .015. In this situation, only 1.5% of the variation in the monthly water use is associated with the variation in the water bill.

The lack of correlation between monthly water bill and the average monthly water usage can also be seen graphically in Figure 1.1.

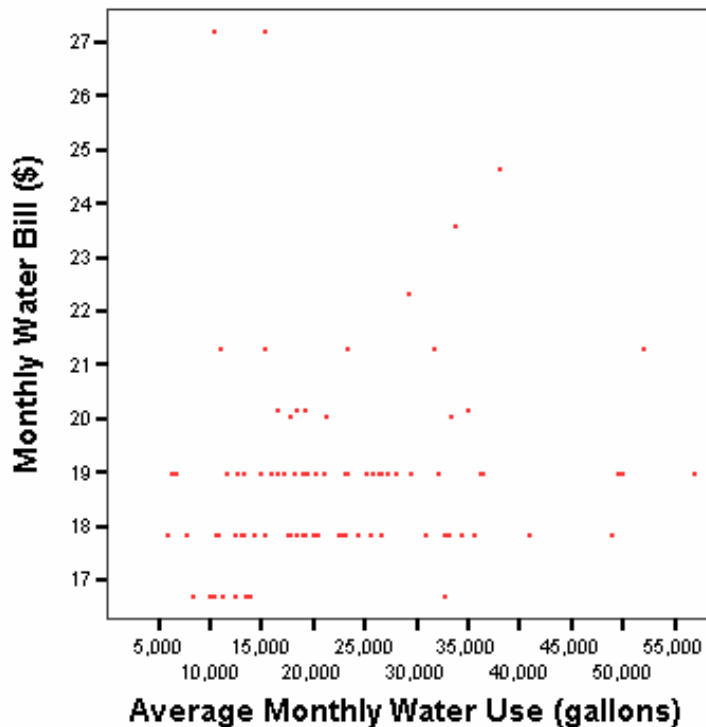


Figure 1.1: Relationship between Monthly Water Bill and Average Monthly Water Use (July 1, 2004 – June 30, 2005).

This figure shows how some of the homes paying relatively low water bills (\$17.85-\$19.00 per month) are some of the highest average monthly water users (>45,000 gallons/month). In addition, the two highest paying customers (\$27.20 per month) are among the lowest water users.

Although the current billing system fails to significantly correlate with actual water usage, further tests were conducted to examine how well the factors used to determine the water

bill relate to water usage. To determine if either the number of rooms and/or the lot size of a home are significantly correlated to monthly water usage, a Pearson's Correlation coefficient is estimated for each of these variables by themselves. The correlation between the number of rooms in a home and the average monthly water usage is presented in Table 1.4.

Table 1.4: Correlation between average monthly water use and the number of rooms in each home (July 1, 2004 – June 30, 2005).

Pearson Correlation (r)	0.044
Significance (2-tailed)	0.680
Number of Observations (N)	91

Table 1.4 indicates that there is **not a statistically significant correlation** between the number of rooms in a household and the amount of water that is used by each household each month. This indicates that the number of rooms in a home would not be expected to significantly affect the quantity of water used by that home.

The correlation between the lot size of each home (in square feet) and the average monthly water usage are presented in Table 1.5.

Table 1.5: Correlation between average monthly water use and the lot size of each home (July 1, 2004 – June 30, 2005).

Pearson Correlation (r)	0.336
Significance (2-tailed)	0.001
Number of Observations (N)	93

Table 1.5 indicates that there **is a significant correlation** between the lot size of each home and the amount of water that is used each month. This could relate to the considerable amount of water that is used to support outdoor watering (lawn irrigation, washing automobiles, etc.). Although outdoor residential water use can vary significantly, a study by the American Water Works Association Research Foundation (AWWARF) estimated that it accounts for approximately 58% of total household water use (Mayer et. al. 1999). Since outdoor water use plays such a big role in determining total household water use, it was expected that lot size would significant affect water usage. The results of the statistical analysis support this and indicate that homes with larger lot sizes do use significantly more water than those on a smaller lot. Although the relationship is significant, lot size only appears to account for a small

percentage of the variation in water use. Squaring the Pearson's Correlation of .336 to calculate the coefficient of determination (R^2) indicates that only 11.3% of the variation in the monthly water use is associated with the variation in the lot size. Therefore, other factors are significantly contributing to total household water use.

1.3 Conclusions

The city of Turlock currently has a water billing system that uses a flat monthly rate regardless of how much water each household uses. The flat monthly rate for each household is determined by the number of rooms and lot size of each home. Although the goal of this billing system may be to approximate each home's monthly water use, this analysis indicates that it is failing to do so. Data collected from the 93 homes with monitor water meters indicate that there is no significant correlation between the amount of water that is used by each home and the amount they are charged. Therefore, houses that are paying more for water do not appear to be universally using more water each month.

Further investigation into the two factors currently used to determine the flat monthly rates indicate that the number of rooms in each home does not significantly affect water usage, but that the lot size of each home does significantly affect water usage. Although lot size was found to significantly affect water usage, it only accounted for approximately 11.3% of the variation in monthly water use which indicates that there are other factors playing a large role in determining household water usage. Although other factors could be identified to estimate household water usage, the only way to charge customers based upon their actual water use would be to use a water metering system. However, a survey conducted as part of this study indicated that only 30% of the 37 households that responded were in favor of a water meter based billing system.

SECTION 2: ESTIMATING THE EFFECTIVENESS OF WATER CONSERVATION MATERIALS

2.1 Introduction

The city of Turlock currently uses a water billing system that uses a flat monthly fee for providing water service. This type of non-volumetric water pricing system provides no financial incentive for water conservation. Although water meters are often effective in reducing water usage, opponents argue that it is not fair to manage water use by pricing it in a way that may make it too expensive for some households to afford. Opponents also cite how the substantial cost associated with the installation and maintenance of water meters may preclude it from being a cost-effective alternative. Regardless of how a community feels about water metering, once the decision has been made to forgo water meters the alternative approaches for promoting water conservation must be considered. This section evaluates the effectiveness of distributing two different sets of water conservation materials to households within the City of Turlock.

2.2 Methods and Analysis

The effectiveness of water conservation materials is evaluated by comparing the quantity of water used by households that have received different water conservation materials. This was accomplished by randomly assigning 93 homes that have had monitor water meters installed into one of three different equally sized treatment groups (control, low intensity conservation, and high intensity conservation). The control group did not receive any additional water conservation materials above those that had existed before the study was initiated. The households within the low intensity water conservation group received a flyer in the mail that indicated the importance of water conservation and provided a list of techniques that they could use to reduce their water usage (See Appendix 2). The households within the high intensity water conservation group received the water conservation flyer associated with the low intensity group as well as a “Water Conservation Kit” that was hand delivered to each household. The kit was purchased from the Water Education Foundation (www.water-ed.org) and included: toilet leak detector tablets, toilet tank displacement bag, water conserving landscape design materials, water fact brochure, shower flow restrictor, and a faucet flow restrictor. The water conservation

materials were distributed during the last week of May, 2005 just prior to the summer months. During the summer months average household water usage is higher as the need for outdoor watering increases. Studies have indicated that a household’s outdoor water use is likely to be more responsive to water conservation efforts as compared to their indoor water uses. As such, any response to the water conservation materials might be amplified during the summer months. The effectiveness of the water conservation programs was estimated using statistical analysis to compare the water use levels across the three different groups of households. This is done by performing a one way ANalysis Of VAriance (ANOVA) between the three groups.

The one-way ANOVA allows one to compare several groups of observations to determine if the means of each group are equal or if one or more of the groups is statistically different. The ANOVA puts all the data into one number (F-statistic) and gives a level of significance (p-value) regarding the null hypothesis (all means are equal). If the F-statistic is appropriately large to result in a significantly small p-value (generally less than .05) the null hypothesis that all of the groups have equal mean can be rejected. For this study, the monthly water use data for each group of homes (31 homes in each of the three groups) is compared to determine whether or not the distribution of water conservation materials had a significant effect upon their water use (Data available in Appendix 3). An ANOVA was performed for each month following the distribution of the water conservation materials (June-September 2005). The results from this analysis are presented in Table 2.1 below. All statistical analysis was conducted using the analytical software package SPSS version 13.0 (SPSS Inc, 2004).

Table 2.1: Results from the Analysis of Variance Between the Control, Low Intensity Conservation, and High Intensity Conservation Groups. (June-September 2005)

		Sum of Squares	df	Mean Square	F	Sig. (p)
June	Between Groups	381121438.710	2	190560719.355	.752	.474
	Within Groups	22802750277.420	90	253363891.971		
	Total	23183871716.130	92			
July	Between Groups	565605898.925	2	282802949.462	.466	.629
	Within Groups	54590327483.871	90	606559194.265		
	Total	55155933382.796	92			
August	Between Groups	195438374.194	2	97719187.097	.291	.748
	Within Groups	30215821290.323	90	335731347.670		
	Total	30411259664.517	92			
September	Between Groups	442593941.328	2	221296970.664	1.278	.284
	Within Groups	15414840602.151	89	173200456.204		
	Total	15857434543.479	91			

The results summarized in Table 2.1 show that there **is not a statistically significant difference in the means** of the three different groups of households (control, low intensity conservation, and high intensity conservation). This indicates that the treatments applied to the low intensity conservation and high intensity conservation groups **did not** significantly reduce the water use of those groups during these months. Further analysis of the data revealed that the standard deviation of the water use variable is very large, indicating that the data display a lot of variability and has a large variance. A high variance in the data makes it more difficult for statistical techniques like the ANOVA procedure to identify minor differences in variables as statistically significant. Increasing sample size may reduce this potential problem.

A survey was sent to the households with monitor meters in September of 2005 to gain additional information about these homes. One of the questions that the households were asked in this survey is as follows: “Have you installed any water saving devices within the last 6 months? (YES/NO) If yes, please describe...”. This question was used to get an idea of whether or not the households that had received the water conservation kit had installed any of the devices that were distributed to them as part of the kit (toilet tank displacement bag, shower flow restrictor, faucet flow restrictor). Nine (29%) of the 31 homes that received the conservation kit responded to the survey. Only one of the nine respondents indicated that they had installed any water savings devices and further stated that they had installed low flow shower heads (not one of the devices distributed). These results appear to indicate that none of the households which responded to the survey actually used the toilet displacement bags, shower flow restrictor, or faucet flow restrictor that was provided.

2.3 Conclusions

Since there is currently no financial incentive for households to conserve water, other techniques for promoting water conservation are needed in the city of Turlock. This analysis tested the effectiveness of two specific water conservation programs and found that neither program resulted in a statistically significant decrease in water consumption. These voluntary programs were limited to the distribution of a simple flyer indicating “Ten Ways to Save Water” and a more comprehensive water conservation kit. Although these specific attempts to reduce water usage were not found to be effective, this study did not attempt to evaluate the

effectiveness of the water conservation efforts that were in effect prior to this project or other potential methods for promoting water conservation. That is, the existing water conservation programs and other potential water conservation methods may effectively reduce water usage. In addition, the author believes that the degree of variability in the data may require a larger sample size to further improve the statistical analysis that was undertaken.

Future research regarding water conservation within the city of Turlock might benefit from a study that evaluates the impact that water meters might have on the city. Several studies have estimated the effectiveness of water metering as a method for reducing household water usage. W. O. Maddaus (1984) is often cited as identifying a 20 percent reduction in water use associated with meters. L. A. Maddaus (2001) reported a 13 percent reduction in water use after the city of Davis, California switched from flat monthly fees to a water meter system. L. A. Maddaus (2001) conducted an extensive review of literature that indicated that the installation of water meters typically reduced water use by around 10 to 30 percent and in some cases as much as 50 percent. Although the installation of water meters is fairly simple and it has been shown to reduce water use, identifying the appropriate price that should be charged once the meters are installed is much more difficult. It would be impossible to estimate the effect that water meters may have on water usage unless the potential pricing system was accounted for.

SECTION 3: ESTIMATING THE RESIDENTIAL DEMAND FOR WATER

3.1 Introduction

The city of Turlock is located within one of the fastest growing regions of California. As a result of population growth and residential development, considerable pressure is being placed upon the city's water resources. As the demand for water continues to increase, the city faces significant expenses as it installs additional water wells, converts to surface water supplies, expands water treatment facilities, implements drastic conservation efforts, or some combination of these activities. In order to prepare for these situations, the city must have a better understanding of how the residents of Turlock are currently using their water. This is accomplished by using statistical analysis to identify the factors that significantly influence residential water demand. This section of the study will provide valuable information and analysis regarding the current use of water within the city of Turlock. The results will help the city be better equipped to examine how future development will affect their water supply, potentially improve water conservation efforts, and provide valuable information that may be useful in determining the need for water meters.

3.2 Methods and Analysis

Identifying the factors that significantly influence residential water demand is accomplished by analyzing a data set containing household characteristics and monthly water use. The data for this analysis have been collected from a variety of sources. The city of Turlock has been collecting monthly water use data from approximately 100 homes that have had monitor water meters installed. Information concerning some of the property characteristics (square footage, bedrooms, bathrooms, etc.) was made available by the city of Turlock's Municipal Services Department or was collected from the Stanislaus County Assessor's office. In addition to the conventional property characteristics, it was necessary to conduct a household survey to collect data regarding the characteristics of the occupants of these households. During the last week of September (2005) a total of 93 surveys were sent out to the homes that have had

monitor water meters installed. A copy of the survey is available in Appendix 4. In an attempt to increase the response rate of the survey, households were informed that their names would be entered into a drawing for a gift certificate to a local restaurant if they responded. Twenty seven (27) responses were received after the initial mailing and in mid November a second mailing was conducted that resulted in an additional 10 responses for a total of 37. An overall response rate of 40% for a voluntary survey that contained personal information was considered successful. In addition to average monthly water use, a summary of the data that were collected from the city of Turlock, the Stanislaus County Assessor’s office, and the household survey are summarized in Table 3.1 below. Descriptive statistics and all analysis were conducted using the analytical software package SPSS version 13.0 (SPSS Inc, 2004).

Table 3.1: Descriptive Statistics of the Data Compiled to Estimate Household Water Demand

Variable (units)	N	Minimum	Maximum	Mean	Std. Deviation
Average Monthly Water Use (Gallons) ¹	37	6,048	56,996	21,376	11,160
Bathrooms (Number) ²	37	1	3	2.11	0.39
Bedrooms (Number) ²	37	2	5	3.30	0.74
Education (Years) ³	37	9	18	13.76	1.96
Grass (Square Feet) ³	37	242	5,860	3,331	1,342
Home Size (Square Feet) ²	37	1,000	3,750	1,657	637
Income (Dollars) ³	35	\$15,000	\$300,000	\$72,286	\$53,459
Kids (Number) ³	37	0	5	1.22	1.40
Lot Size (Square Feet) ¹	37	4,478	14,783	7,041	2,211
Occupants (Number) ³	37	1	7	3.27	1.77
Pool (1=Yes, 0=No) ³	37	0	1	0.27	0.45
Rooms (Number) ¹	35	4	10	6.20	1.57
Sewer Fixtures (Number) ¹	33	22	69	29.21	8.92
Sprinkler System (1=Yes, 0=No) ³	34	0	1	0.62	0.49
Water Conservation Attitude (1=Important, 0=Not Important) ³	37	0	1	0.76	0.44
Year of Home Construction (Year) ²	37	1940	2003	1988	13.62

¹ Data provided by the city of Turlock.

² Data gathered from Stanislaus county assessor's office.

³ Data gathered from household survey.

Although many of the descriptive statistics presented in Table 3.1 are self explanatory, some variables may need further explanation. The variable identified as “Grass” reflects the square foot estimate of the homes total lot size that is in grass. Total lot size was also included, but there is rationale to adjust this variable to account for the fact that many homes have large portions of their lots covered in concrete, dirt, rock, or other areas that may not contribute to their water usage. The square footage of grass was estimated by evaluating the size of each home and

using the household survey to solicit each homeowner for an estimate of how much of their front and back yards were covered in grass. For example, if a home has 1,400 square feet of living space on a lot size of 6,000 square feet and the home owner indicated that 60% of the front yard and 30% of the back yard was landscaped in grass, the total square footage of grass was estimated to be 1,890 square feet. This was calculated by subtracting the house size (including a 400 square foot garage) from the lot size ($6,000 - 1,400 - 400 = 4,200$), then dividing this value by two ($4,200 / 2 = 2,100$) to estimate the size of their front and back yards (this assumes the front and back yards are the same size), then multiplying the estimated size of each yard by the estimated percentage of the yard in grass and summing them together ($2,100 * .60 + 2,100 * .30 = 1,890$). Although there are several limitations to this estimate of total grass area, this adjustment to lot size may provide valuable information regarding water use. There are also many binary values (1/0) collected for this analysis (Pool, Sprinkler System, Water Conservation Attitude). The average response for these values indicates that 27% of the respondents had a pool, 62% of the respondents had automatic sprinkler systems, and 76% indicated that water conservation was important.

As a preliminary step in analyzing the data, a correlation coefficient for each of the variables identified in Table 3.1 and average monthly water use was calculated. This procedure indicated whether or not each of the variables was significantly correlated to average monthly water use given the sample. The results of this procedure are summarized in Table 3.2, the details of the analysis are available in Appendix 5.

Table 3.2: Variables Identified as Being Significantly Correlated to Average Monthly Water Usage.

Not Significantly Correlated	Significantly Correlated
Bedrooms	Bathrooms (+)
Education	Lot Size (+)
Home Size	Grass (+)
Income	Occupants (+)
Pool	Kids (+)
Rooms	
Sewer Fixtures	
Sprinkler System	
Water Conservation Attitude	
Year of Home Construction	

*Symbol in parentheses indicates whether the variables are positively or negatively correlated.

Table 3.2 indicates that the number of bathrooms, lot size, area in grass, number of occupants, and number of kids are significantly correlated to average monthly water use given the data that has been collected. For all of these variables, the positive sign of the correlation should be intuitive. That is, **more** bathrooms, lot size, grass, occupants, and kids are significantly correlated with **higher** average monthly water use. It may be surprising that some of the other variables evaluated were found to not be significantly correlated with average monthly water use. For example, having more bedrooms, larger homes size, more rooms, and more sewer fixtures all relate to having a larger home, but were not significantly correlated with higher water use. This is because a larger home does not necessarily mean that it uses more water, indoor water use is likely to be more dependent upon how many people are using the home rather than size.

There may be expectations that the homes with swimming pools would have used significantly more water, but this also was not found to be the case. Since swimming pools do not need to be drained and refilled annually in this region due to the climate, having a pool may only require replacing the amount of water lost during usage and evaporation. In addition, the space required for a pool would often be used for grass or landscaping and would have required water even if the pool was not there.

Year of home construction may have been expected to have had a negative correlation with water usage, since newer homes may have more efficient water fixtures. However, many homes have been retrofitted with these water saving fixtures and the water uses that they affect only reflect a portion of the of the total household water use.

The variable “Water Conservation Attitude” captures the household’s response to the survey question as to whether or not they thought water conservation was important. It would be expected that homes that indicated water conservation as important may use less water than those that reported it as unimportant, however the data did not show a significant correlation between the response to this question and average monthly water use. The calculation used to determine if the variables were significantly correlated to average water use is a univariate statistical technique that only looks at the relationship between two different variables. However, total household demand would actually be determined as a function of several explanatory variables that **simultaneously** affect the household’s water usage decisions. As such, a method that simultaneously evaluates how several variables affects water usage is needed.

Multiple regression analysis was used to simultaneously estimate how each of the variables influences household water use. Extensive literature on estimating residential water demand using multiple regression analysis has been conducted (Agthe et al. 1986, Billings & Day 1989, Foster & Beattie 1979, Griffin & Chang 1990, Metzner 1989, Morgan 1973, Palencia 1988, Dandy et al. 1997). This multivariate statistical technique is used to examine the relationship between one dependent variable (Y) and several other independent or explanatory variables (Xi) that have been selected (a priori) as potentially impacting the dependent variable. The regression parameters or coefficients (bi) that are calculated in the regression equation are estimated using the method of least squares. The method of least squares minimizes the sum of squared residuals between the regression plane and the observed values of the dependent variable (creates a model that “best fits” the data). The analysis indicates whether or not the relationship between the dependent and each of the independent variables is significant and estimates the linear relationship between these variables. Once the regression equation is estimated for the dependent variable, the model can be used to predict/forecast values of the dependent variable. The multiple regression model can be represented mathematically as follows:

$$Y = b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + \dots + b_k X_k$$

For this project, the relationship between the dependent variable (average monthly water use) and the five (5) independent/explanatory variables identified in Table 3.2 is evaluated. Although five different explanatory variables were found to be individually correlated with average annual water usage, it is expected that fewer variables will be estimated as significant when analyzed simultaneously. This can be explained by the fact that some of the variables that are significantly correlated to average monthly water use are also significantly correlated with each other. Since “lot size” and “grass” are directly related to each other and they are capturing similar effects, only one of these two variables should be included in the final model. A similar situation exists for the number “occupants” and the number of “kids” in each home. To determine which variables fit best, a stepwise multiple regression technique was used to model average monthly water use. In the first step or stage, only the independent variable that is most significantly correlated with the dependent variable is included in the equation. In the second step or stage, another independent variable with the highest partial correlation with the

dependent, controlling for the first independent, is entered. This process is repeated until the addition of a remaining independent variable does not increase the R^2 (Measure of goodness of fit) of the model by a significant amount (or until all variables are entered). Alternatively, the process can also work backward, where it includes all of the independent variables in the first step of the model and then systematically removes the least significant variable one step at a time. Both forward and backward stepwise regressions were performed for this analysis and both approaches resulted in the same final model. After two forward steps (three backward steps) a model was estimated in which all of the remaining variables were simultaneously estimated to be significant with at least a 5% confidence level (for complete sequence of output see Appendix 6). Table 3.3 indicates which variables were excluded from the analysis in this step and which variables remained in the final model of average monthly household water use.

Table 3.3: Independent Variables that were Excluded and Included in the Final Multivariate Regression Model for Average Monthly Water Use.

Variables Excluded (not found significant)	Variables Included (found significant)
Bathrooms	Grass
Lot Size	Occupants
Kids	

During the stepwise regression technique the variables “bathrooms”, “lot size”, and “kids” were excluded from the model because they were estimated to not significantly affect average monthly water use when examined simultaneously with the other variables. This indicates that the variable “grass” fit the average monthly water use data better than “lot size” and that this was also the case for the variable “occupants” when evaluated simultaneously with the number of “kids”. It is not surprising that the number of bathrooms in each home dropped out of the model at this point since having more bathrooms does not necessarily result in using more water. It appears that the number of occupants in the home drives total indoor water usage not the number of bathrooms. The detailed output regarding the final multivariate regression model is as follows:

Table 3.4: SPSS Multiple Regression Output for Average Monthly Water Use Estimated as a Function of the Number of Household Occupants and Square Footage of Grass.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.722 ^a	.521	.490	8240.979

a. Predictors: (Constant), Grass, Occupants

ANOVA^b

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2E+009	2	1144395550	16.851	.000 ^a
	Residual	2E+009	31	67913729.17		
	Total	4E+009	33			

a. Predictors: (Constant), Grass, Occupants

b. Dependent Variable: AvgWater

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	353.918	4386.739		.081	.936
	Occupants	3867.009	819.682	.598	4.718	.000
	Grass.	2.853	1.181	.306	2.415	.022

a. Dependent Variable: AvgWater

There are many ways of interpreting the output above, some of the most relevant pieces of information have been highlighted. The R^2 and F-statistic report how well this model has captured the overall relationship between the dependent variable (Average Monthly Water Use) and the two independent variables (Occupants and Grass). Since the F-statistic is 16.851 and significant (at the .000 level), it indicates that there is a significant relationship between the independent variables and the dependent variables that have been modeled. The R^2 of .521 indicates that this model is successfully capturing 52.1% of the total variation that exists in the average monthly water use data. The “Unstandardized Coefficients” indicate the estimated effect that each of the independent variables has upon the independent variable and the corresponding t-statistics indicate that both of these variables have a significant impact upon

average monthly water use. According to the significance levels, the total number of occupants is the most significant factor affecting average monthly water usage. The coefficient for “occupants” indicates that each additional occupant is expected to increase the average monthly water use by 3,867 gallons. The coefficient for “grass” indicates that each additional square foot of grass is expected to increase the average monthly water use by 2.853 gallons. These coefficients can be used to write the following equation that identifies average monthly water use as a function of the number of occupants and the square footage of grass.

$$\textit{Average Monthly Water Use} = 353.92 + 3,867 * \textit{Occupants} + 2.85 * \textit{Grass}$$

This equation can be used to estimate the average monthly water use for any level of occupants and square footage of grass. For example, given the average number of occupants (3.27) and the average square footage of grass (3,331), the model estimates the average monthly water use to be 22,492 gallons per month.

3.3 Conclusions

After thorough analysis of the available data relating to household water demand within the city of Turlock, it appears that the most significant factors affecting monthly water usage are the number of occupants and the square footage of grass for each home. Although many variables were evaluated, these two factors ultimately provided the best model for predicting the average monthly water use of a home. It was estimated that each additional occupant would be expected to increase average monthly water use by 3,867 gallons while each additional square foot of grass is expected to increase average monthly water use by 2.853 gallons. Although the equation estimated to predict average monthly water use can be used for any combination of occupants and square footage, the associated r-squared indicates that the model explains 52% of the variation in water use and that 48% of the variation in water use is explained by other factors that have not been identified by this model. The results also indicate that several household characteristics that may have been expected to have affected water usage were not found to be significant factors.

A limitation of this study is the relatively small sample size that was used. Due to the high cost of installing and reading monitor water meters, there was only data available regarding

monthly water use for 93 homes throughout the city. Although all 93 homes were surveyed in order to collect additional household information, only 37 responses were received. Although the number of observations used for this study is adequate to provide general information regarding the demand for water within the city, it is anticipated that a larger sample size would improve the overall results. As such, it is recommended that the precise magnitude of the results of this study be applied cautiously to policy making situations.

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Appendix 1

Data for Evaluating Current Water Rate Structure

Fiscal Year 2004/2005 Water Use (Gallons)

Home #	Rooms	Lot Size (Sq ft)	Water Rate (04/05)	2004						2005						Average
				Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
1	8	6000	\$19.00	44,850	22,300	24,640	5,640	24,140	15,560	7,690	2,210	11,010	14,820	33,940	27,240	19,503
2	6	6223	\$19.00	10,000	4,480	5,230	2,510	3,340	7,840	7,280	3,680	6,100	1,740	8,320	21,170	6,808
3	6	6223	\$19.00	20,860	24,290	29,740	9,130	45,570	20,160	12,350	14,990	21,910	30,690	24,910	24,740	23,278
4	6	6220	\$19.00	60,060	40,380	55,650	6,860	39,680	7,920	7,060	8,500	11,890	12,240	32,860	27,350	25,871
5	5	6848	\$17.85	36,790	14,600	24,200	3,010	17,930	8,400	5,010	2,160	3,510	9,700	9,530	24,910	13,313
6	5	6000	\$17.85	36,150	14,630	23,830	2,190	19,100	3,490	2,800	2,820	6,020	4,910	1,140	13,980	10,922
7	5	6000	\$17.85	25,340	12,030	15,960	6,510	16,540	14,710	13,320	6,300	9,950	9,410	21,480	21,880	14,453
8	6	6000	\$19.00	49,730	27,670	36,470	12,930	31,000	28,990	14,730	9,010	21,030	25,170	29,100	31,890	26,477
9	5	6000	\$17.85	32,010	18,710	32,770	11,790	24,700	28,430	15,940	10,480	14,370	15,940	29,900	35,660	22,558
10	6	6000	\$19.00	45,310	24,040	28,620	6,940	26,630	15,530	12,800	5,890	10,150	8,900	12,890	31,060	19,063
11	5	6000	\$17.85	35,610	19,670	34,050	9,920	16,370	10,420	9,230	530	11,730	26,020	25,540	32,640	19,311
12	5	6007	\$17.85	42,000	23,610	37,490	11,540	29,690	17,880	13,720	7,540	12,070	23,910	37,350	35,710	24,376
13	6	6000	\$19.00	20,280	34,310	23,150	5,730	15,730	14,240	11,220	5,880	12,260	12,670	18,420	19,170	16,088
14	5	6000	\$17.85	42,470	20,230	24,660	16,010	15,710	18,360	7,300	2,900	6,560	19,540	31,920	36,060	20,143
15	5	7194	\$17.85	67,550	49,710	59,580	17,380	36,630	38,140	20,920	14,070	24,010	18,250	32,620	49,170	35,669
16	5	6017	\$17.85	36,360	21,220	29,690	11,430	16,150	14,940	900	3,580	33,640	34,470	34,610	38,270	22,938
17	5	6017	\$17.85	17,290	14,260	16,040	3,560	14,790	8,220	5,440	2,240	6,030	6,180	18,120	16,090	10,688
18	5	6017	\$17.85	52,410	23,970	30,220	2,440	52,990	2,400	2,570	1,110	9,770	9,420	15,070	19,900	18,523
19	6	6502	\$19.00	39,250	23,790	32,460	9,910	16,200	6,500	270	1,100	9,090	25,230	31,770	33,810	19,115
20	5	6508	\$17.85	57,590	30,990	31,400	9,450	24,380	16,630	11,790	6,590	9,780	17,860	29,950	31,120	23,128
21	5	6700	\$17.85	67,530	27,460	22,030	42,020	29,850	31,770	20,820	10,800	21,540	19,650	36,020	68,430	33,160
22	6	6200	\$19.00	61,670	35,920	29,600	10,090	29,070	24,700	11,970	5,350	16,720	20,370	33,470	30,840	25,814
23	5	6718	\$17.85	40,340	15,700	24,620	8,440	14,150	12,280	9,990	4,350	7,010	24,020	39,330	28,750	19,082
24	5	7740	\$19.00	35,860	36,910	26,310	3,820	4,550	11,370	1,060	14,380	10,640	20,610	71,720	41,830	23,255
25	4	7740	\$19.00	23,440	83,760	30,690	10,290	25,520	13,110	7,880	4,240	17,650	20,480	93,000	6,920	28,082
26	5	7740	\$19.00	100,780	44,860	45,100	22,440	57,280	54,580	49,840	31,280	51,280	38,850	58,070	47,400	50,147
27	5	7740	\$19.00	102,260	67,130	53,030	22,850	1,150	52,520	48,810	24,070	54,510	51,200	62,960	56,180	49,723
28	4	7740	\$19.00	53,320	42,680	32,310	15,570	31,400	26,180	22,280	9,810	18,440	19,520	39,660	27,420	28,216
29	5	7740	\$19.00	-	-	-	-	-	28,340	20,920	16,140	21,580	24,440	68,880	75,960	36,609
30	5	7740	\$19.00	58,700	38,380	27,230	11,260	16,220	25,700	20,390	8,170	16,460	30,510	37,670	37,750	27,370
31	4	7740	\$19.00	21,960	14,560	13,190	9,530	11,450	30,490	25,450	13,150	13,330	11,290	23,380	18,710	17,208
32	5	11817	\$21.30	30,750	14,650	22,010	14,380	13,790	27,960	25,600	12,430	16,290	33,510	39,290	29,990	23,388
33	6	10978	\$21.30	27,410	17,000	10,870	1,990	11,640	8,390	5,920	3,510	6,180	4,410	19,470	16,850	11,137
34	5	7740	\$19.00	8,180	8,670	5,430	2,900	13,080	7,880	7,070	3,980	6,090	5,530	4,280	3,370	6,372
35	5	7740	\$19.00	24,970	18,130	18,300	4,720	15,440	15,210	13,310	5,610	14,410	24,530	23,390	21,180	16,600
36	4	7740	\$19.00	36,010	22,480	22,610	8,070	20,400	17,290	13,150	6,730	16,110	22,540	29,220	30,290	20,408
37	4	7740	\$19.00	62,960	50,160	29,220	7,250	18,190	10,000	10,740	4,230	11,670	21,420	40,570	36,820	25,269
38	5	7740	\$19.00	73,530	32,710	28,580	4,570	26,500	9,470	8,810	2,400	28,590	55,690	42,120	40,800	29,481
39	4	7740	\$19.00	75,710	56,140	49,510	8,790	52,880	6,380	4,090	2,150	13,000	37,100	65,340	64,290	36,282
40	5	7740	\$19.00	47,400	48,150	56,910	42,620	9,160	52,950	129,400	97,410	91,340	23,380	44,780	40,450	56,996
41	5	6575	\$17.85	90,240	70,590	65,110	21,230	30,040	23,050	14,950	5,750	8,510	7,810	26,210	35,070	33,213
42	4	6198	\$17.85	62,470	41,860	34,410	10,370	34,920	29,220	21,580	12,120	26,400	34,830	55,510	50,450	34,512
43	5	6000	\$17.85	24,190	20,360	16,980	10,410	18,720	27,130	23,300	9,580	72,150	169,180	36,660	62,690	40,946
44	5	8680	\$19.00	44,400	62,460	52,850	15,700	48,160	9,850	6,140	3,720	16,160	32,160	46,290	49,400	32,274
45	5	6400	\$17.85	76,110	55,120	44,060	3,070	42,830	12,810	3,120	1,430	14,260	20,140	48,590	50,750	31,024
46	Duplex	6325	\$27.20	22,730	19,120	13,740	4,860	15,650	11,630	9,390	4,890	7,470	14,030	19,630	41,460	15,383
47	6	10500	\$21.30	109,950	89,430	69,690	12,240	-	50,780	26,620	2,290	6,260	69,390	63,620	72,000	52,025
48	5	9800	\$20.15	51,160	17,800	14,100	5,520	20,070	8,980	7,750	4,210	7,170	9,990	29,000	24,990	16,728

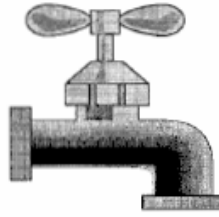
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Fiscal Year 2004/2005 Water Use (Gallons)

Home #	Rooms	Lot Size (Sq ft)	Water Rate (04/05)	2004						2005						Average
				Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	
49	6	10333	\$21.30	13,020	6,600	28,280	970	38,510	940	3,450	2,020	2,250	2,260	30,260	57,590	15,513
50	6	6048	\$19.00	45,340	34,850	30,880	3,580	25,240	12,720	8,920	4,950	7,810	34,670	33,820	37,480	23,355
51	5	5105	\$16.70	17,950	12,230	9,670	6,580	12,700	10,770	6,100	4,290	6,360	9,160	11,310	14,890	10,168
52	5	5859	\$17.85	50,650	10,430	18,360	7,030	9,670	17,680	13,880	3,390	4,420	9,460	14,240	24,690	15,325
53	5	6048	\$17.85	16,720	10,030	5,910	1,470	7,170	3,780	3,350	1,670	2,650	2,660	6,440	10,730	6,048
54	7	8200	\$20.15	20,900	27,580	14,730	7,420	40,010	17,610	14,800	8,330	12,770	12,900	19,550	24,980	18,465
55	10	10275	\$22.35	90,140	40,010	18,980	4,550	22,330	9,900	9,960	5,790	16,610	33,950	47,190	52,830	29,353
56	9	14560	\$24.65	75,820	57,530	43,230	13,400	-	26,640	20,290	16,660	23,450	34,710	50,010	57,890	38,148
57	7	10010	\$21.30	68,860	41,540	27,930	10,340	29,460	19,530	15,580	9,110	27,910	17,900	49,290	63,940	31,783
58	8	14783	\$23.60	67,460	51,790	47,390	14,520	29,010	27,400	8,740	4,630	8,950	29,960	47,500	68,790	33,845
59	7	6200	\$19.00	16,310	9,050	8,560	1,630	64,040	3,970	5,640	1,020	2,100	6,700	9,400	11,390	11,651
60	9	6200	\$20.05	40,210	25,460	28,330	10,280	7,630	11,840	6,010	3,300	13,250	18,790	24,830	24,720	17,888
61	7	6200	\$19.00	29,080	22,480	14,040	7,460	7,220	12,810	4,820	3,110	8,330	7,830	17,610	19,230	12,835
62	6	7024	\$19.00	42,100	21,420	28,340	5,750	21,050	9,500	6,830	5,430	19,230	18,720	18,010	23,890	18,356
63	5	6571	\$17.85	37,510	22,430	17,820	12,180	13,870	27,560	5,670	3,270	11,580	16,720	19,930	24,760	17,775
64	5	5601	\$17.85	64,660	40,920	68,480	39,380	20,090	10,340	9,410	4,330	8,970	10,390	20,120	22,920	26,668
65	5	5559	\$17.85	34,590	30,770	22,170	9,120	10,590	16,870	15,560	9,560	13,330	18,320	30,470	35,750	20,592
66	7	5744	\$19.00	37,300	25,310	22,880	11,750	21,610	34,610	31,040	16,710	23,940	20,180	39,150	35,610	26,674
67	6	6377	\$19.00	37,210	24,140	18,720	7,320	22,270	11,940	16,120	6,610	12,800	18,470	27,120	28,990	19,309
68	5	6639	\$17.85	39,200	27,210	27,570	2,300	15,770	12,740	5,540	2,920	11,440	12,350	26,280	27,630	17,579
69	7	5225	\$17.85	34,280	21,210	26,130	3,180	11,080	2,000	3,410	2,490	6,640	5,580	15,940	18,800	12,562
70	5	5227	\$16.70	17,040	13,220	12,940	4,940	9,480	10,910	8,860	6,760	8,680	9,580	13,460	20,190	11,338
71	5	6743	\$17.85	43,380	34,580	32,900	15,750	26,170	34,670	12,430	8,550	28,550	20,550	18,020	33,730	25,773
72	7	6054	\$19.00	28,680	16,900	12,470	3,450	31,520	11,720	28,520	7,720	16,220	16,670	16,060	16,520	17,204
73	6	5227	\$17.85	34,110	21,520	19,010	9,100	18,280	22,820	10,170	9,110	9,760	19,410	19,990	21,050	17,861
74	5	5391	\$16.70	48,880	43,370	39,840	13,470	27,350	59,920	20,040	7,580	12,420	37,080	43,010	40,630	32,799
75	5	5321	\$16.70	28,810	20,950	21,670	8,460	21,670	3,270	3,340	1,680	2,150	15,860	16,180	24,060	14,008
76	5	5225	\$16.70	22,600	19,660	17,590	4,700	27,870	10,440	5,140	2,380	6,040	11,110	12,010	12,290	12,653
77	5	4688	\$16.70	21,450	27,160	32,980	1,770	8,250	4,590	3,580	2,070	3,000	2,820	8,160	11,280	10,593
78	6	4999	\$17.85	16,450	12,510	13,430	3,610	11,430	5,000	5,980	1,450	1,580	4,210	5,580	11,780	7,751
79	5	5000	\$16.70	18,700	17,830	16,950	10,180	18,120	6,710	11,600	5,270	8,050	12,300	18,310	19,080	13,592
80	6	5000	\$17.85	14,070	21,870	17,440	10,190	11,620	14,030	34,300	10,560	770	620	6,160	9,790	12,618
81	5	5000	\$16.70	19,660	14,490	8,770	3,130	10,080	7,350	4,000	2,140	6,800	6,450	8,550	10,120	8,462
82	6	8060	\$20.15	43,340	33,820	25,770	10,980	25,220	21,150	14,970	3,370	1,780	1,590	21,390	28,000	19,282
83	Duplex	6388	\$27.20	20,770	11,320	11,120	4,960	11,740	10,450	10,390	6,180	8,780	6,530	12,050	12,370	10,555
84	8	6297	\$19.00	22,490	17,280	14,800	7,660	18,300	8,720	5,730	5,790	14,510	16,620	11,870	16,420	13,349
85	8	8271	\$20.15	54,090	43,270	42,920	21,510	41,730	44,230	28,710	17,040	25,960	21,890	42,700	37,100	35,096
86	6	5963	\$19.00	28,410	23,830	15,770	5,220	-	19,450	8,570	4,150	11,210	11,850	17,100	19,420	14,998
87	7	9220	\$20.15	36,040	25,810	16,880	4,830	10,020	12,620	7,420	3,730	15,160	15,440	24,520	26,980	16,621
88	10	7433	\$20.05	45,080	27,690	18,120	11,970	17,090	25,590	12,230	8,050	12,860	22,650	22,560	32,300	21,349
89	9	6590	\$20.05	49,270	41,880	32,540	4,090	37,320	25,470	14,720	11,680	54,540	57,290	37,630	35,720	33,513
90	8	6355	\$19.00	36,480	26,410	22,620	10,340	29,600	29,980	9,610	4,150	8,800	26,640	24,400	25,710	21,228
91	8	4478	\$17.85	75,490	59,670	54,570	37,000	-	103,530	36,010	20,720	32,310	36,350	41,300	43,310	49,115
92	5	6200	\$17.85	24,980	22,480	11,800	4,010	14,840	9,980	5,480	2,210	3,680	17,690	18,500	21,880	13,128
93	5	7492	\$17.85	83,190	51,630	32,380	10,070	41,660	20,980	13,500	7,010	12,420	26,500	47,420	46,420	32,765
Average	5.75	6967	\$18.95	42,158	29,665	27,478	9,799	22,705	18,962	13,671	7,685	15,193	21,000	29,494	31,683	22,458

Appendix 2

Flyer Indicating Ten Ways to Save Water



Water is an essential part of life and a precious natural resource. Wasting water negatively affects the environment and costs our society. The average citizen of Turlock uses approximately 250 gallons of water per day as compared to the national average of only 150 gallons per day. Reducing our water usage would decrease the costs of supplying water and would lessen the need for future water rate increases. Please consider the following tips for how you can reduce your water usage!

***Ten Ways to Save Water:**

- Water your lawn only when it needs it. Step on your grass. If it springs back, when you lift your foot, it doesn't need water. So set your sprinklers for more days in between watering. **Saves 750-1,500 gallons** per month. Better yet, especially in times of drought, water with a hose.
- Fix leaky faucets and plumbing joints. **Saves 20 gallons** per day for every leak stopped.
- Don't run the hose while washing your car. Use a bucket of water and a quick hose rinse at the end. **Saves 150 gallons** each time. For a two-car family that's **up to 1,200 gallons** a month.
- Install water-saving shower heads or flow restrictors. **Saves 500 to 800 gallons** per month.
- Run only full loads in the washing machine and dishwasher. **Saves 300 to 800 gallons** per month.
- Shorten your showers. Even a one or two minute reduction can **save up to 700 gallons** per month.
- Use a broom instead of a hose to clean driveways and sidewalks. **Saves 150 gallons** or more each time. At once a week, that's **more than 600 gallons** a month.
- Don't use your toilet to flush trash. **Saves 400 to 600 gallons** per month.
- Capture tap water. While you wait for hot water to come down the pipes, catch the flow in a watering can to use later on house plants or your garden. **Saves 200 to 300 gallons** per month.
- Don't water the sidewalks, driveway or gutter. Adjust your sprinklers so that water lands on your lawn or garden where it belongs—and only there. **Saves 500 gallons** per month.

*Source: www.monolake.org/socalwater/wctips.htm

Turlock's Mandatory Watering Schedule

Addresses Ending in an Even Number (0, 2, 4, 6, 8) Can Water on:

Tuesday
Thursday
Saturday

Addresses Ending in an Odd Number (1, 3, 5, 7, 9) Can Water on:

Wednesday
Friday
Sunday

- No Watering is Allowed on Mondays.
- No Watering is Allowed Any Day Between 12:00 Noon and 6:00 PM.

* Call 668-5590 for more information about Turlock's water conservation



CALIFORNIA STATE UNIVERSITY, STANISLAUS

801 West Monte Vista Avenue • Turlock, CA 95382

Mr. Water User
1234 Sprinkler Way
Turlock CA, 95382

Appendix 3

Data for Evaluating Water Conservation Materials

		2005 (gallons)			
Home #	Group	Jun	Jul	Aug	Sep
1	2	27,240	30,820	15,800	10,050
2	3	21,170	10,110	7,750	4,590
3	1	24,740	57,750	46,010	28,480
4	2	27,350	29,000	29,030	27,600
5	2	24,910	24,920	9,080	10,220
6	3	13,980	8,730	19,990	12,850
7	2	21,880	12,090	11,820	11,230
8	1	31,890	32,580	36,810	25,520
9	1	35,660	22,690	20,670	14,480
10	2	31,060	31,260	43,590	36,090
11	1	32,640	40,410	25,770	23,850
12	1	35,710	34,970	44,140	32,640
13	2	19,170	19,610	21,220	12,610
14	2	36,060	23,500	24,050	22,280
15	1	49,170	96,470	70,520	37,890
16	1	38,270	43,470	47,900	38,830
17	3	16,090	17,400	12,570	9,900
18	3	19,900	28,750	25,890	11,450
19	3	33,810	35,460	39,620	1,630
20	2	31,120	33,490	34,330	22,340
21	3	68,430	56,170	44,850	40,510
22	2	30,840	36,660	28,040	23,050
23	1	28,750	26,200	31,940	28,200
24	2	41,830	67,800	60,000	32,400
25	2	6,920	51,900	50,560	28,290
26	1	47,400	34,780	34,730	34,780
27	2	56,180	71,900	57,780	47,290
28	3	27,420	37,260	28,320	18,880
29	2	75,960	79,810	35,300	17,470
30	2	37,750	40,750	27,700	20,330
31	1	18,710	20,210	21,900	34,040
32	1	29,990	78,900	20,570	-
33	1	16,850	18,930	17,740	13,720
34	3	3,370	3,720	5,130	5,140
35	1	21,180	18,050	22,140	13,490
36	3	30,290	30,800	25,970	17,680
37	3	36,820	39,550	20,920	16,210
38	2	40,800	32,950	41,850	32,530
39	1	64,290	84,720	60,640	40,120
40	3	40,450	38,260	46,330	41,890
41	1	35,070	40,810	47,320	11,430
42	1	50,450	49,010	45,650	25,810
43	3	62,690	187,170	75,250	15,960
44	2	49,400	48,080	68,920	30,450
45	1	50,750	68,350	72,690	35,980
46	1	41,460	39,970	19,900	12,110
47	3	72,000	80,570	74,110	45,820
48	3	24,990	36,180	65,410	20,290
49	3	57,590	42,390	64,150	55,370
50	3	37,480	37,410	43,680	31,840

Continued Next Column....

		2005 (gallons)			
Home #	Group	Jun	Jul	Aug	Sep
51	2	14,890	13,200	8,560	3,610
52	3	24,690	31,880	21,670	11,420
53	2	10,730	8,940	7,480	5,320
54	2	24,980	21,270	25,540	22,570
55	1	52,830	51,720	56,360	28,870
56	2	57,890	60,040	84,110	57,150
57	3	63,940	45,520	32,950	18,590
58	1	68,790	57,550	58,230	54,660
59	3	11,390	11,150	11,370	7,160
60	3	24,720	29,960	32,390	27,650
61	2	19,230	14,360	23,310	13,020
62	2	23,890	29,230	28,730	17,740
63	1	24,760	25,750	27,170	19,470
64	3	22,920	17,360	28,650	12,320
65	2	35,750	33,230	25,330	18,620
66	1	35,610	33,930	42,020	34,040
67	2	28,990	27,690	25,620	16,210
68	3	27,630	29,130	29,660	21,280
69	1	18,800	23,920	17,710	14,090
70	1	20,190	20,340	16,340	14,100
71	3	33,730	49,500	29,830	22,010
72	2	16,520	21,360	17,960	15,430
73	3	21,050	26,160	26,770	19,310
74	1	40,630	46,550	45,410	40,550
75	3	24,060	24,750	28,450	25,120
76	2	12,290	20,620	25,300	10,990
77	3	11,280	18,400	22,330	26,780
78	3	11,780	18,790	20,260	14,420
79	2	19,080	17,020	30,000	10,680
80	3	9,790	15,970	46,690	20,480
81	3	10,120	13,080	14,470	12,330
82	2	28,000	30,580	22,640	14,490
83	1	12,370	14,490	15,060	10,830
84	1	16,420	16,370	19,160	19,000
85	2	37,100	37,730	44,630	14,800
86	1	19,420	21,780	19,250	16,270
87	1	26,980	28,960	25,910	17,370
88	1	32,300	31,420	30,850	29,160
89	3	35,720	39,180	39,200	32,510
90	2	25,710	26,160	24,700	18,850
91	2	43,310	63,650	80,870	75,250
92	3	21,880	24,770	14,140	6,370
93	1	46,420	52,140	46,160	18,920
Average		35,559	42,655	36,921	24,196

Group 1: Control Group
Group 2: Low Intensity
Group 3: High Intensity

Appendix 4

Household Water Use Survey



Residential Water Survey



**1234 Sprinkler Way
Turlock, CA 95382**

Bedrooms: 3, Bathrooms: 2, Square Feet: 1,600

- 1.) Does the address and information above correctly describe your current home?.....YES/NO
(If not, please make corrections above.)
- 2.) Is your home a single story house?YES/NO
- 3.) How long have you been living in your current home?
 - less than 3 months.
 - between 3 months and 6 months.
 - between 6 months and 1 year.
 - between 1 year and 2 years.
 - more than 2 years.
- 4.) Including yourself, how many people live in your household?....._____
- 5.) How many children under the age of 18 live in your household?....._____
- 6.) Do you have a swimming pool?.....YES/NO
- 7.) What percentage of your front yard would you estimate is grass? (0% - 100%)....._____%
- 8.) Does your front yard have an automatic sprinkler system?.....YES/NO
- 9.) What percentage of your back yard would you estimate is grass? (0% - 100%)....._____%
- 10.) Does your back yard have an automatic sprinkler system?.....YES/NO
- 11.) Are you aware of Turlock’s mandatory watering schedule that limits outdoor watering to only 3 days a week and prohibits watering between Noon and 6:00 PM ?YES/NO
If Yes, do you typically comply with the cities watering schedule?YES/NO
(Admitting your failure to comply will be kept confidential)
- 12.) How important do you believe water conservation to be?
 - Very Unimportant
 - Unimportant
 - Neutral (no opinion)
 - Important
 - Very Important
- 13.) Have you installed any water saving devices within the last 6 months?.....YES/NO
If yes, please describe:_____
- 14.) Would you like more information about how you could reduce your water usage?.....YES/NO

*Please complete the reverse side of this survey.



15.) How much water do you think your household uses as compared to others within the city of Turlock?

- I think my home uses More water than the average home in Turlock.
- I think my home uses Less water than the average home in Turlock.

16.) The current billing system charges a flat fee for water regardless of how much you use. An alternative would be to have a water meter installed at each house and charge customers for how much water they use each month. Please select the box that best represents how you feel about this issue.

- I prefer the current system where everybody pays a flat fee.
- I would prefer water meters and have everybody pay according to how much water they use.
- Do not care either way.

17.) Please check the most appropriate response describing the employment condition for the **head of your household** during the last twelve months.

- Employed Full Time (40 hours or more a week)
- Employed Part Time (less than 40 hrs/wk)
- Homemaker
- Retired
- Unemployed
- Other (Please Specify): _____

18.) Please check the box that reflects your **household's total income** before taxes last year. (This question is vital to the economic analysis of our study. We encourage you to answer this question and remind you that all of your answers are completely CONFIDENTIAL. If you choose not to answer this question, please return the survey anyway.)

- | | | |
|--|--|--|
| <input type="checkbox"/> Under \$10,000 | <input type="checkbox"/> \$50,000 – \$59,999 | <input type="checkbox"/> \$100,000 – \$149,999 |
| <input type="checkbox"/> \$10,000 – \$19,999 | <input type="checkbox"/> \$60,000 – \$69,999 | <input type="checkbox"/> \$150,000 – \$199,999 |
| <input type="checkbox"/> \$20,000 – \$29,999 | <input type="checkbox"/> \$70,000 – \$79,999 | <input type="checkbox"/> \$200,000 – \$300,000 |
| <input type="checkbox"/> \$30,000 – \$39,999 | <input type="checkbox"/> \$80,000 – \$89,999 | <input type="checkbox"/> Over \$300,000 |
| <input type="checkbox"/> \$40,000 – \$49,999 | <input type="checkbox"/> \$90,000 – \$99,999 | |

19.) Please check the highest year of formal education that the **head of your household** has completed.

- Grade 1 Through 8
- Some High School
- Finished High School or Completed GED
- Some College
- Obtained an Associates Degree from Community College
- Obtained a College Degree
- Some Graduate Work
- Obtained Graduate Degree

20.) Which of the following categories do you think best describes your household?

- | | |
|---|---|
| <input type="checkbox"/> African American/Black | <input type="checkbox"/> Native American Indian/Alaska Native |
| <input type="checkbox"/> Asian | <input type="checkbox"/> Native Hawaiian/ Pacific Islander |
| <input type="checkbox"/> Assyrian | <input type="checkbox"/> White |
| <input type="checkbox"/> Hispanic | <input type="checkbox"/> Other (Please Identify): _____ |
| <input type="checkbox"/> Indian | |

Thank you for taking the time to complete this survey. **Please mail the completed questionnaire back to us in the enclosed postage-paid return envelope and you will be entered into the drawing for the free gift certificate.** Please use the space below if you would like to provide any additional information. Thanks again!

COMMENTS:

Appendix 5

Correlations with Average Monthly Water Use

Pearson's Correlation Between each Variable and Average Monthly Water Use.

Year of Home Construction	Pearson Correlation	0.06
	Sig. (2-tailed)	0.73
	N	34
Bedrooms	Pearson Correlation	0.21
	Sig. (2-tailed)	0.24
	N	34
Home Size	Pearson Correlation	0.21
	Sig. (2-tailed)	0.24
	N	34
Rooms	Pearson Correlation	0.16
	Sig. (2-tailed)	0.37
	N	32
Sewer Fixtures	Pearson Correlation	0.22
	Sig. (2-tailed)	0.24
	N	30
Pool	Pearson Correlation	0.06
	Sig. (2-tailed)	0.73
	N	34
Water Conservation Attitude	Pearson Correlation	-0.06
	Sig. (2-tailed)	0.73
	N	34
Income	Pearson Correlation	0.21
	Sig. (2-tailed)	0.24
	N	32
Education	Pearson Correlation	0.08
	Sig. (2-tailed)	0.65
	N	34
Sprinkler System	Pearson Correlation	0.04
	Sig. (2-tailed)	0.82
	N	34

Baths	Pearson Correlation	0.45
	Sig. (2-tailed)	0.01
	N	34
LotSize	Pearson Correlation	0.43
	Sig. (2-tailed)	0.01
	N	34
Grass	Pearson Correlation	0.42
	Sig. (2-tailed)	0.01
	N	34
Occupants	Pearson Correlation	0.66
	Sig. (2-tailed)	0.00
	N	34
Kids	Pearson Correlation	0.61
	Sig. (2-tailed)	0.00
	N	34

Appendix 6

Stepwise (Forward) Multivariate Regression Output

Stepwise (Forward) Multivariate Regression Output from SPSS

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.656 ^a	.431	.413	8841.513
2	.722 ^b	.521	.490	8240.979

a. Predictors: (Constant), Occupants

b. Predictors: (Constant), Occupants, GrassAdj

ANOVA^c

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	2E+009	1	1892601394	24.211	.000 ^a
	Residual	3E+009	32	78172353.44		
	Total	4E+009	33			
2	Regression	2E+009	2	1144395550	16.851	.000 ^b
	Residual	2E+009	31	67913729.17		
	Total	4E+009	33			

a. Predictors: (Constant), Occupants

b. Predictors: (Constant), Occupants, GrassAdj

c. Dependent Variable: AvgWater

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	8260.580	3132.948		2.637	.013
	Occupants	4246.749	863.085	.656	4.920	.000
2	(Constant)	353.918	4386.739		.081	.936
	Occupants	3867.009	819.682	.598	4.718	.000
	GrassAdj	2.853	1.181	.306	2.415	.022

a. Dependent Variable: AvgWater

Excluded Variables^c

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	GrassAdj	.306 ^a	2.415	.022	.398	.963
	Kids	-.010 ^a	-.027	.978	-.005	.136
	Baths	.086 ^a	.515	.610	.092	.648
	LotSize	.223 ^a	1.599	.120	.276	.873
2	Kids	-.100 ^b	-.292	.773	-.053	.134
	Baths	.122 ^b	.780	.442	.141	.642
	LotSize	.072 ^b	.449	.657	.082	.623

a. Predictors in the Model: (Constant), Occupants

b. Predictors in the Model: (Constant), Occupants, GrassAdj

c. Dependent Variable: AvgWater