UNIVERSITY OF CALIFORNIA, SANTA CRUZ

THE RESPONSE OF LARGE IRRIGATION ACCOUNTS IN SANTA CRUZ COUNTY TO A CHANGE IN BILLING CYCLE: IMPLICATIONS FOR CONSERVATION

A Senior Thesis submitted in partial satisfaction

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ENVIRONMENTAL STUDIES

by

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ABSTRACT: This study tests whether large irrigators in Santa Cruz County have a conservation response to the extra information provided by monthly water bills. The data contains water consumption of 129 irrigation accounts, including residential, municipal, and commercial entities, from the years 2006 through 2011. These accounts switched billing cycles from bi-monthly to monthly in August of 2010. Using three regression models, consumption data from these accounts is analyzed to determine whether customers conserved more water after the billing change than in preceding years when these same accounts were receiving bi-monthly bills. The first pooled all accounts together; no significant results were found indicating a conservation response to the billing change. The regression run for only residential accounts showed a significant conservation response to the billing change, while the commercial regression suggested a significant increase in consumption. To further study the behavior of these accounts, ten residential and commercial account holders were interviewed. The survey study found that all residential accounts closely monitor water usage. Alternatively, a majority of the commercial accounts do not look at their bill; instead, it is paid by corporate headquarters. These results illuminate the need for policies that require more efficiently managed water use among businesses.

KEYWORDS: Santa Cruz County, irrigation accounts, billing cycle, conservation

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Introduction

Water conservation is becoming increasingly important to many utilities worldwide. Not only are water departments encouraging demand curtailment among individual households, they are also urging customers that use large amounts of water, such as businesses and homeowners association, to conserve. Utilities often use price structure and other demand side management tools to send a conservation signal. These methods imposed are supported by extensive research regarding the effect of pricing on water demand. Ward (2012) discusses the management of residential water demand. Through survey data and other statistical methods, he concludes that volumetric water pricing is the most effective tool for managing residential consumption. Klaiber et al. (2010) estimate price elasticity of water demand using quasi-experimental methods. They employ a basic regression model, taking estimates of water demand from an existing model called the Discrete and Continuous Choice Model, developed in 1979 by J. Hausman. Their study found that demand response to the price of water was very high, but the effect was also seasonal: residential demand was more elastic to price in the summer than in the winter. Similar to Klaiber et al, Espey et al (1997) used a regression model to estimate demand, but they did not receive their estimates from an existing model. Instead, they used data from the region of study to create estimates for each variable in the model. Their study concludes that price structure and rates have the largest effect on residential water demand when compared to other variables, such as temperature and household size.

All of the aforementioned studies focus on rate structure and price as a means to manage consumption. Very few studies have been published that discuss the effect of billing cycles on water conservation. Billing cycles can be defined as the time period between billing. Most water utilities either use monthly (once a month), or bi-monthly (once every two months) billing. Monthly billing allows customers to more frequently look at their consumption patterns, while a bi-monthly billing cycle does not. The following study will examine the effects on consumption from billing cycles.

A research memorandum by the Tualatin Valley Water district (TVWD) in Northern Oregon compares bi-monthly and monthly billing in regards to cost-of-service equity. It compares the cost of water for households that had the same consumption over the same period of time, but were on different billing cycles. They found that the bills for these customers differed, despite the fact that these customers used the same amount of water at the same price The study concludes that the length of billing cycles does have an effect on the equity of a customer's water bill; shorter billing cycles (monthly) provides a more equal cost of service (P. Matthews, personal communication, April 20, 2012) To move their water utility from bi-monthly to monthly billing, TVWD issued another memorandum comparing the two billing cycles. In order to gain a better understanding of the benefits of monthly billing, this study surveyed customers and agency officials in monthly billed areas. The paper found that monthly billing brings an "awareness of usage" for the customer. Since the customer has less time in between each bill, they can potentially change their habits based on timely information. Similarly, when a utility implements conservation rates, the survey showed that a monthly billing schedule provides a better user response to these rates (P. Matthews and S. Bicke, personal communication, April 20, 2012). The first memoranda mentioned above compares bi-monthly and monthly billing in regards to cost of service equity, this study will compare consumption between billing cycles. The second memorandum is more applicable to this study because it discusses the effect of billing cycles on conservation. Although the study includes conservation, it approaches the question with a survey on individual households, rather than large scale accounts, and it does not conduct any statistical analyses. Statistical analyses that compares whether conservation is greater under a monthly or bi-monthly billing cycle did not emerge in a literature review.

The TVWD memoranda compare the two billing cycles for individual household use. Alternatively, this study looks at large scale water users, including businesses and homeowner associations. This study will take up the question of whether the additional information provided by more frequent billing cycles leads customers to increase their conservation behavior.

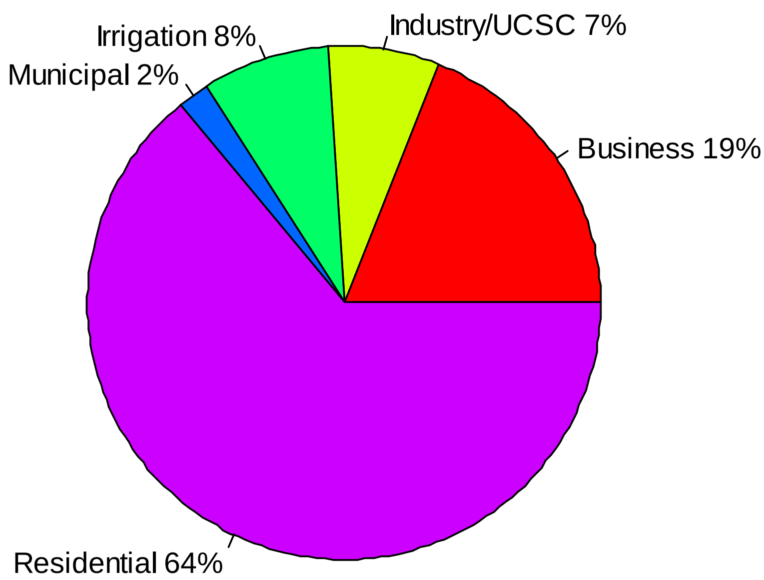
This study looks at 129 irrigation accounts located in Santa Cruz, California. Irrigation accounts do not refer to agriculture. For urban water utilities, irrigation accounts refer to any large irrigated landscape that is not a residential unit, including business lawns, homeowners associations landscaping and maintenance, and city parks. These 129 accounts were switched from bi-monthly to monthly billing in August of 2010. The reason for this switch, according to a press release from the Santa Cruz Water Department, was for larger irrigators to have a better sense of their water use and to lower their utility costs (T. Goddard, personal communication, April 2, 2012). The data for the accounts consist of three types of irrigators: business, residential, and city or county managed areas, otherwise referred to as interdepartmental. This project looks at yearly consumption of all these accounts, starting from January of 2006 through January of 2011. Data from these irrigation accounts is analyzed to identify whether more water was conserved after the billing cycle was changed to monthly in 2010, compared to preceding years, when these same customers were receiving bi-monthly bills. To examine whether the results of the analyses is consistent with the behavior of these irrigation accounts, a small survey study is included in this paper.

If results show that these customers conserved more water when they were receiving monthly bills as compared to bi-monthly bills, it will lend credence to the claim that providing additional information on cost of water service will lead to additional water conservation behavior.

Context and Data

The irrigation accounts are located outside the city boundaries in unincorporated areas served by the City Water Department. Water usage in the Santa Cruz Water Department service territory is split up into several categories: irrigation, municipal, residential, industry, and business. The following pie chart shows the percentages of water use for each category.

Figure 1: Percentages of Water Usage by Category



Eight percent of city water supply goes to irrigation. The data set used here consists of accounts outside the city. Water use for the accounts which I have data for is considerably less than 8% of the city's total for irrigation, totaling 4.8%, and divided among municipal, residential and business irrigators. The table below represents the trisection of this 4.8% into the three respective categories (T. Goddard, personal communication, May 1st, 2012)

Table 1: Categories and Percentages of Irrigation Account Use Outside of City Boundaries

Category	Percentage Use (Total=4.8%)
Municipal	2.0%
Residential	1.3%
Business	1.5%

Data Collection

In the form of an excel file, data was obtained from the Santa Cruz Water department. The original data was raw and unorganized, and included about 180 accounts of irrigation areas that are outside the city of Santa Cruz, but still in the billing district of the water department. For roughly 50 accounts, a large portion of the data was missing due to faulty meters. These accounts were dropped from the dataset, resulting in 129 accounts.

The original data included the following information for each account: account number, service address, service city and zip code, type of account, consumption in CCF, and consumption in gallons.

Concerning “type of account”, according to the Urban Water Management Plant (2010), irrigation accounts are split into three categories, and the data was organized accordingly: (1) Residential, which consists of parks or recreation areas located in neighborhoods or homeowner’s associations, (2) Business, which refers to parks or lawns on business property, and (3) Municipal, which are parks or recreation areas are owned and managed by the city. The data includes only two municipal accounts. Of the 127 remaining accounts, 72 are in business category and 55 of them are in the residential category. The accounts in the data represent a variety of different sized areas. Some are traffic medians with very small square footage, while others are large parks and recreation areas. Water consumption for each account is strongly correlated to lot size.

The original data includes consumption from January of 2006 to January of 2012. From 2006-2010 consumption for each account is given on a bi-monthly basis, but after the change in policy in 2010, the data has monthly readings. The consumption values in the data are given in both CCF (1 CCF= 748 Gallons), and gallons. In terms of time scale, since we are looking at consumption over 6 years, from 2006-2012, and running analyses on the overall yearly trends before and after the change in billing, it does not make a difference whether monthly data or yearly data is used. In general, yearly data is less onerous to work with, so each account's monthly consumption has been summed obtain yearly numbers.

The timing of change in the billing cycle raised statistical issues. The change in billing cycle from bi-monthly to monthly billing occurred in August of 2010. Before I even decided what type of econometric method I was going to use for this project, I knew that if I were to run the analyses using the calendar year, just like the data was given to me (January-December), my results would be incorrect. For example, for eight months in 2010, the irrigation accounts were receiving bills once every two months, but in August, they began receiving monthly reports; it would be very difficult to delineate in the statistical model that the treatment effect occurred after 8 months of a given year. On the advice of Cameron Speir, a fishery economist at the National Ocean and Atmospheric Administration, we changed the scale of a year, in other words, created my own year where the first month is August (the month that the treatment effect occurred) and the last month is July (C. Speir, personal communication, April 29th, 2012). The dataset was reorganized so that its years matched the treatment effect.

Since the data begins in at January of 2006, but the selected year starts in August of 2006, the first 7 months of data in 2006 were removed. Second, after the billing cycle transition in August 2010, there is a full year of data, and then we are left with only six more months of data, from August of 2011 to January of 2012. These extra six months cannot be used in the annual data. The final dataset contains five years of data, from 2006 to 2010. The following table below shows the range of each year in my model.

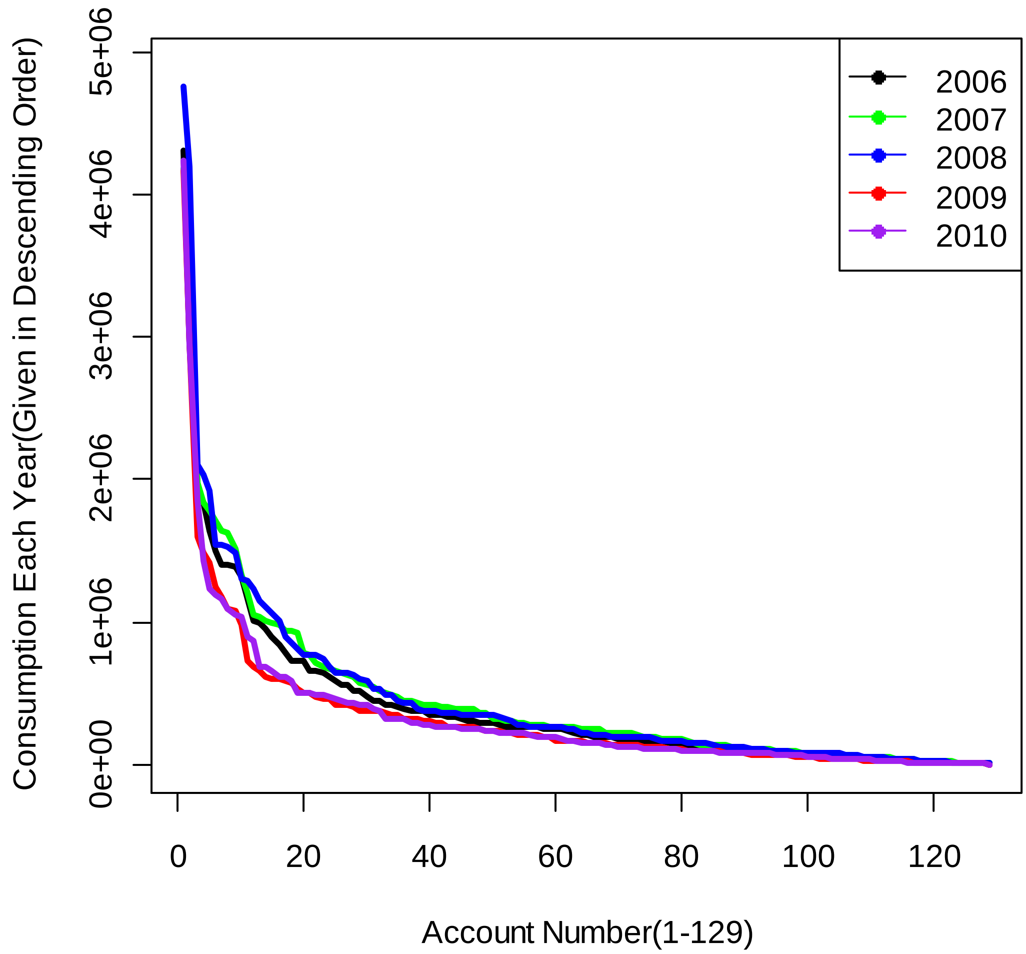
Table 2: Ranges of Years in the Model

Year	Range
2006	August 2006 – July 2007
2007	August 2007 – July 2008
2008	August 2008 – July 2009
2009	August 2009 – July 2010
2010	August 2010 – July 2011

Data Trends

The modified data contains interesting properties. Figure 2 below shows yearly consumption trends from the data, organized in descending order.

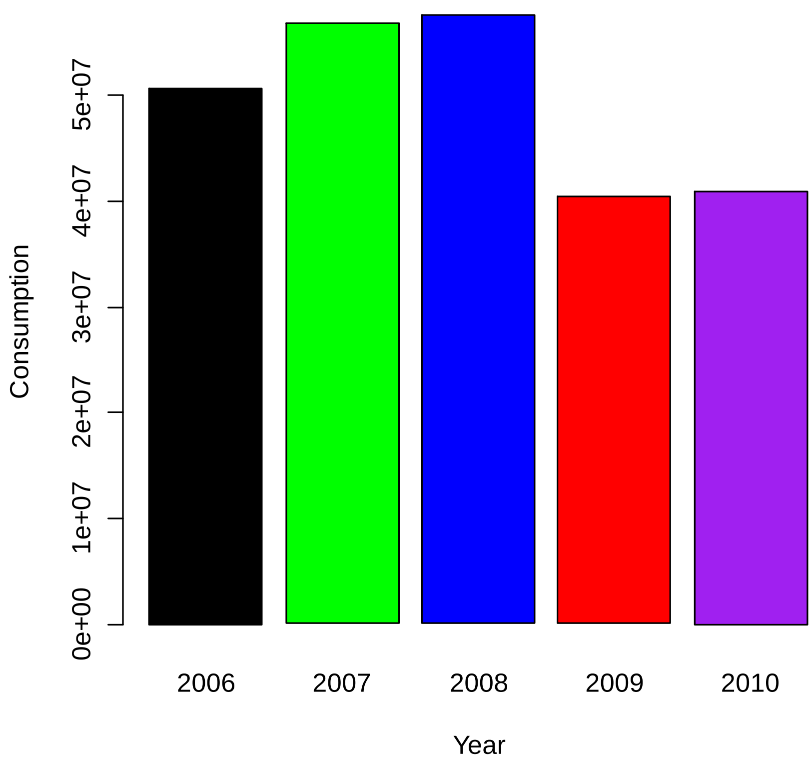
Figure 2:Yearly Consumption Trends



Each point corresponds to an account number (given from 1 to 129) and a level of consumption in that year. To clarify the trend, the yearly consumption values for each year were put into descending order.

The graph shows that consumption significantly drops off in 2009 and 2010 (the red and purple lines, respectively). To further delineate this decline, consumption was summed up on a yearly basis; Figure 3 below shows a bar plot of total yearly consumption.

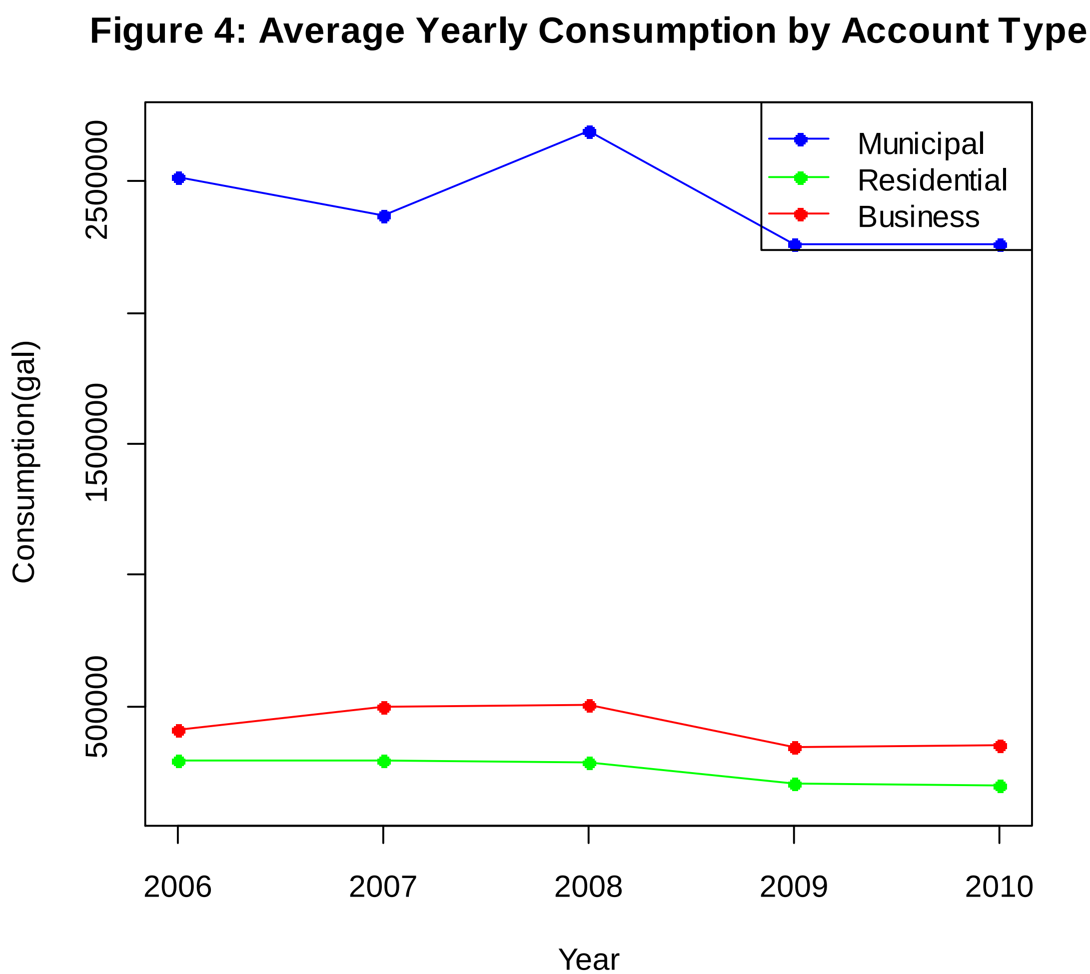
Figure 3:Total Yearly Consumption



For figures 2 and 3, the colors representing each year are the same. Similar to figure 2, figure 3 shows that consumption was significantly less in 2009 and 2010 than in preceding years. It is not exactly clear what caused this decrease in consumption in 2009. One speculation for this decline is the economic downturn. Although the economic crisis officially occurred in 2008, unemployment in Santa Cruz County increased 3% between the model years of 2008 and 2009, from 9.00% to 12.00% (Bureau of Labor Statistics, 2012). Since this experiment looks at whether consumption was significantly less in 2010, but trends show that consumption dropped off in 2009, it will be more difficult to isolate the effect of the billing change.

Distinguishing Data by Type

A key factor of analyzing this dataset is the distinction between the three types of accounts. The three categories are municipal, residential, and commercial. In the dataset, two accounts are municipal, 55 are residential, and 72 are commercial. Although there are only two municipal accounts in the dataset, the two accounts combined use about 10% of the total water use over the 5 recorded years. The 55 residential accounts use about 30%, and the 72 business accounts use about 60% of total water use over the 5 recorded years. Figure 4 below shows the yearly consumption averages for each account type. The statistical analyses will contain distinguishing factors to differentiate between account types.



This plot better demonstrates the consumption patterns of each account type, and the large difference in usage of municipal accounts from the other two. The residential and business account averages do not exceed 500,000 gallons in any year, but the municipal average is above 2 million gallons every year. Due to the large scale of figure 4, the plot shows the small amount of water consumption that business and residential accounts used compared to municipal. Commercial and residential accounts still use a very large amount of water when compared to smaller units. A typical single family resident in Santa Cruz County uses about 226 gallons of water per day, which is about 82,000 gallons of water per year. This is about 150,000 gallons less water than any yearly average of the residential accounts in the plot shown above, and about 350,000 gallons less than any commercial account yearly average, indicating the importance of conservation within these large accounts (Goddard, 2011).

The Analyses

This study attempted three different types of statistical analyses, one of which produced results that were analyzable. All analyses are a modified form of a regression model. The first is called the Chow Test. It estimates two models using basic regression. One is a model for consumption before the treatment effect (change in billing cycle), and the other is a model for consumption after the treatment effect. The regression model contained explanatory variables, such as rainfall amount, temperature, and water rate. Using the estimates obtained from the regression, the two models are compared. If the two models differ, depending on the significance of the estimates, one can say that the billing change had a significant effect on consumption. After trial and error with this method, it became clear that the dataset at hand constrained the range of statistical methods for this project. Since there are four years of data before the treatment and only one year after the treatment effect, the model estimates for the Chow Test would not be accurate.

The second method involves forecasting with a basic regression model. Using the data from 2006-2009, a regression model was created, excluding 2010, when the billing cycle change occurred. Then, the consumption in 2010 was forecasted by inserting data from the unexplained variables, such as rate and rainfall, into the regression equation predicted for 2006 to 2009. From this step, we obtained a set of predicted values of consumption for each account in 2010. Then, we compared the observed values in 2010 from our data, with the predicted values. If the predicted data falls in the observed confidence limit, then one can conclude that the billing cycle had no effect on consumption. If the predicted data falls outside the observed confidence limit, then one can say that the billing cycle did have an effect on consumption. The issue with this method was one of computer power and efficiency; it was both difficult and inefficient for the computer to forecast consumption for 129 separate accounts.

The final analysis is a regression model. It includes several unexplained variables. To obtain manageable coefficients in this model, consumption in gallons was converted to consumption in hundreds of cubic feet (1 CCF=748 gallons). Thus, every consumption value was divided by 748.

This study is testing the claim of whether the change in billing cycle led to less water consumption among irrigation accounts. To test this claim, the regression model includes a dummy variable for the year 2010. The dummy variable assigns the number 1 to every observation from the year 2010 and assigns a 0 to every observation that is not 2010. The coefficient on the dummy variable for the year 2010 represents the average number of gallons more, or less, that the accounts consumed in 2010 compared to the other years. For example, if the coefficient was equal to 2 on the 2010 dummy variable, then one can conclude that the average consumption was 2 gallons higher in 2010 than the average consumption for all other years combined. The sign and significance of the 2010 dummy coefficient will determine whether the utilities conserved more after the billing change. The reason why a dummy variable on 2010 is the determining value of this analysis is because it is assumed all other confounding factors in the regression, such as rain and water price, are controlled for. Thus, it is reasonable to assume that any change in consumption could be attributed to the billing change. This leads to the hypothesis for this paper. The null hypothesis says that the billing cycle had no effect on consumption. If this were the case, then the coefficient on the 2010 dummy should equal to 0. The alternative says that the billing cycle did have an effect on consumption, thus, the coefficient on the dummy should be different from 0. The hypothesis is given mathematically in equation 1 below.

$$\begin{aligned} H_0 &: \beta_j = 0 \\ H_A &: \beta_j \neq 0 \end{aligned} \qquad \textbf{(1)}$$

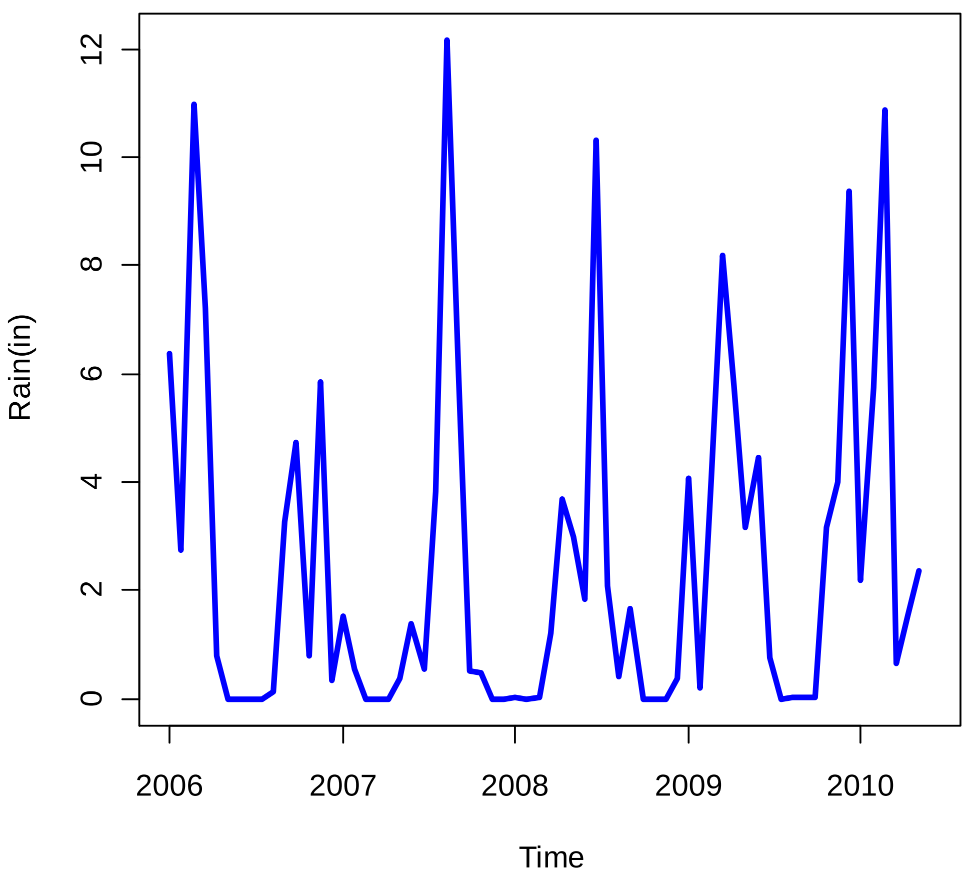
The regression includes explanatory variables that attempt to capture variation within the model. In this experiment, the confounding factors that affect consumption directly are the amount of rainfall, the economy, and the price of water.

Since the years in the model are not standard calendar years, but range from August to July, each explanatory variable was adjusted accordingly. For yearly rainfall, monthly rainfall data obtained from California Data Exchange Center was summed up from August to July for every year. The first table shows the yearly rainfall values inputted into the regression model, and the next figure (figure 5) shows a plot of the rainfall pattern from August 2006 to July 2010.

Table 3: Yearly Rainfall Values

Year	Rainfall
2006	17.20 in.
2007	25.41
2008	24.21
2009	31.06
2010	39.94

Figure 5:Rainfall Over Time



As shown by the graph and table, the year 2010(after the billing change) shows more rainfall than in 2009 by roughly 8 inches. This result delineates the importance of including rainfall in the regression; if rainfall was not controlled for in the regression, and the model shows that accounts curbed their consumption in 2010, it would not be clear whether the accounts used less water due to the billing change, or whether they used less water because it rained more often.

The water rate information for this study was obtained from Toby Goddard who is the conservation manager at the Santa Cruz Water Department. Residential units are billed using a block rate, in other words, they are billed more for x amount of units above a baseline. Irrigation accounts are not billed in the same way; instead, the price per cubic foot of water stays constant despite the amount of water used (T. Goddard, personal communication, April 22, 2012). This greatly simplifies the analysis; if these accounts were billed on a block rate system, then in order to represent the effect of price accurately in the model, the regression would have to include a variable that signifies each accounts average price paid for water for each year. This would have been very time consuming to calculate for 129 accounts.

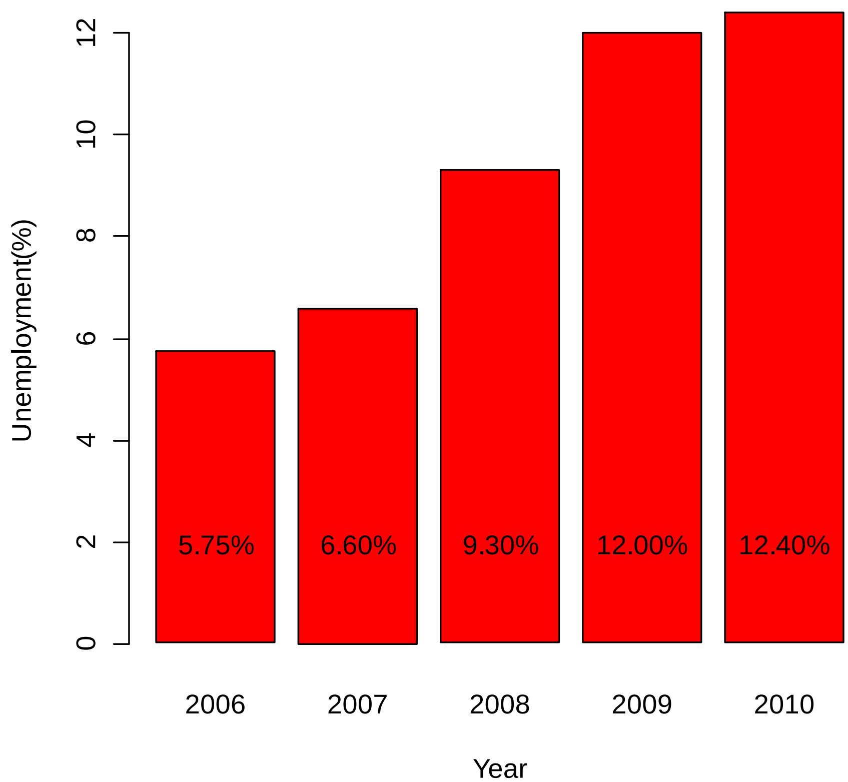
Since the model years are different from the calendar years, water rates for two consecutive years were averaged to obtain one value. For example, to obtain the rate for the year 2007, the rate for the year 2006 and the rate for the year 2007 were averaged. The following table (Table 4) shows the water rate for each selected year in my model (T. Goddard, personal communication, March 28, 2012)

Table 4: Yearly Water Rates

Year	Rate per CCF
2006	$ 4.17
2007	4.64
2008	4.86
2009	4.86
2010	4.98

The last continuous variable this model measures is the economy. To do so, this study uses the unemployment rate in Santa Cruz County. The unemployment rate was obtained from the Bureau of Labor Statistics. Similar to the water price, to calculate the unemployment rate for the selected years in the model, two consecutive years were averaged. The following bar plot (Figure 6) shows the unemployment rate from 2006 to 2010 in Santa Cruz County

Figure 6: Unemployment Rate from 2006-2010



The unemployment rate has increased dramatically between 2007 and 2010, which could explain a decrease in water consumption. If unemployment was not controlled for, a decrease in consumption could be attributed to the billing change, when truly it is because of an economic downturn.

The next variables introduced are the dummy variables that distinguish between the different account types.

The data contains three types of accounts. Two are municipal (or city managed), 55 are Residential, and 72 are Commercial. To control for the different types of accounts, three dummy variables were inputted into my regression model. Two of the dummy variables represent each of the city managed accounts. The reason for separating the municipal accounts is because their water use is very different; one account is DeLaveaga Park, which uses a very large amount of water, while the other is the Live Oak Public library, which uses only a moderate amount. The third dummy variable represents the residential accounts. The coefficient on each of those three dummy variables represents how much more or less water is used in comparison to the type of account that was not assigned a dummy coefficient, in this case, the commercial accounts. These coefficients will provide better insight for comparing water consumption between account types.

To summarize, the final regression model includes the following variables: rainfall, water price, unemployment rate, Interdepartmental dummy variable 1, Interdepartmental dummy variable 2, Residential dummy variable, and the 2010 dummy variable. Mathematically,

$$Consumption = \beta_0 + \beta_1 Rain + \beta_2 Rate + \beta_3 Unemployment + \beta_4 IDdummy1 + \beta_5 IDdummy2 + \beta_6 ResDummy + B_7 2010Dummy \quad \textbf{(2)}$$

In the above equation, interdepartmental is abbreviated to ‘ID’ and Residential is abbreviated to ‘Res’.

In order to separately quantify the residential and commercial accounts, two more regressions were run; one using the consumption from only the residential accounts, and the other using the consumption from only the commercial accounts. The regression equations look different than the one presented above, because the dummy variables representing type were removed. The residential and commercial regression equations look as follows:

$$ResConsumption = B_0 + \beta_1 Rain + \beta_2 Rate + \beta_3 Unemployment + B_4 2010Dummy \quad \textbf{(3)}$$

$$ComConsumption = B_0 + \beta_1 Rain + \beta_2 Rate + \beta_3 Unemployment + B_4 2010Dummy \quad \textbf{(4)}$$

In the previous equations, residential and commercial are abbreviated to ‘Res’ and ‘Com’ respectively.

The Results

The first regression (see equation 2) where all accounts were considered did not provide significant results to indicate that the billing change had an effect on consumption. The following table (Table 5) shows the coefficients and corresponding p- values for each unexplained variable in the model.

Table 5: Pooled Regression Results (1)

Variable	**Coefficient**	**P -Value**
Intercept	-715.95	0.3196
Rainfall	-11.93	0.0308**
Rates	408.94	0.0435**
Unemployment	-35.73	0.1005
Interdepartmental Dummy 1	5227.83	0.0907*
Interdepartmental Dummy 2	119.63	0.6694
Residential Dummy	-223.00	0.00887653***
2010 Dummy	76.93	0.5744

*indicates significance at 10%
**indicates significance at 5%
***indicates significance at 1%

The results show both variables that are statistically significant, and ones that are not. The rainfall coefficient is both practically significant and statistically significant, the coefficient is -11.93, which means that accounts on average used 11 less CCF(1 CCF=748 gallons) of water when rained increase by 1 inch. Rain serves as a natural irrigator, so it is realistic to assume that accounts would use less during rainy seasons. The unemployment coefficient almost made the cut off for 10% significance, but despite the p-value, the actual coefficient is sensible; the accounts used roughly 35 less CCF when the unemployment rate increased. As the economy was depressed, it is reasonable to assume that large irrigators cut down on expenses, which includes irrigation. The coefficient on rate, although significant at 5%, is an odd result; it says the accounts increased usage by 408 CCF, or 30,000 gallons as the rate increased by one dollar. Studies suggest that rates and consumption bear a negative relationship, but perhaps this idea only prevails when studying households, not large irrigators.

The dummy variables representing type all are sensible, although only the interdepartmental dummy 1 and residential dummy bear significance, one at 10%, and the other at 1%. All of these dummies look at how much more, or less, water is used compared to commercial accounts. The coefficients on all of these are practical; the first interdepartmental value is so large because it represents a county park. The second interdepartmental value is a lawn outside of a library; the model shows that it uses more than a commercial account, but less than a park. Finally, the third variable shows that residential accounts on average use 223 CCF less than commercial accounts, which is another reasonable result.

The most important variable in this regression is the dummy coefficient for the year 2010. Given by the value of this coefficient, the test would determine whether the billing change had a significant effect on the water consumption of these accounts. The null states that the billing change had no effect on consumption, in other words, the coefficient should not be different from 0, while the alternative states that the billing change did have an effect, which means the coefficient should be something different from 0. The interpretation of the 2010 dummy coefficient (see table 5) is as follows; the accounts, on average, used 76 more CCF in 2010 than in preceding years. The value of the coefficient is not significant, and the p-value is greater than the significance level, which leads to failing to reject the null hypothesis (see equation 1). In other words, there is not sufficient evidence to show that the variable had an effect on consumption, indicating that the billing change did not have an impact for these accounts.

Two more regressions were run, given by equations 3 and 4 respectively. These models were created to look at how the two account types making up most of the data (residential and commercial) behaved with the same explanatory variables. Tables 6A and 6B show the coefficients and p-values from these regression results.

TABLE 6A: Residential Regression Results (2)

Variable	Coefficient	P-Value
Intercept	93.746	0.69027
Rain	-12.4258	0.04431**
Rates	112.7038	0.06140*
Unemployment	-13.6349	0.16476
2010 Dummy	-35.8921	0.027497**

TABLE 6B: Commercial Regression Results (3)

Variable	Coefficient	P-Value
Intercept	-1321.7771	0.1975
Rain	-5.5031	0.0414534**
Rates	568.1946	0.07632177*
Unemployment	-49.5240	0.1742
2010 Dummy	76.2649	0.03475**

*indicates significance at 10%
**indicates significance at 5%
***indicates significance at 1%

A main trend following the three tables of results is that the coefficient on the variable 'rates' is large and significant in all three regressions, which is an interesting result, as one would assume that rates and consumption work inversely. The effect of rain on consumption is negative and significant in all three regressions, indicating a natural response of using less water during rainy season.

There are interesting results when juxtaposing the commercial and residential regressions (Table 6). First, the residential accounts respond to an increase in rainfall more negatively than the commercial accounts. More specifically, the residential accounts decrease consumption by roughly 5000 gallons more than the commercial accounts do when rainfall increases.

An important result from these two regressions (Table 6) is the difference between the 2010 dummies which are both significant at the 5% level. The coefficient for 2010 on the commercial regression is 76.296, while the coefficient for the residential regression is -35.8921. This result delineates the comparison in response between these account types; the residential accounts responded to the billing change by curbing their consumption by roughly 36 CCF. Conversely, the commercial accounts also responded to the billing change, but they did not conserve. Instead, they increased consumption by about 76 CCF. It is possible that the result of the pooled regression (see table 5) was biased because of the large amount of business accounts in the dataset. Perhaps if there were not as many commercial accounts in the data, the regression which considered all account types would show a negative response to the billing change. The difference between the commercial and residential regressions in terms of their response to both rainfall and billing change brings up an important issue of conservation. To delve more into this issue, and to determine whether the results from the regressions are consistent with the management behavior of these accounts, a small survey study was conducted.

Survey Study (See Appendix for Further Description)

This survey contacted 20 accounts, 10 residential accounts and 10 commercial accounts. All accounts were asked the following questions:

(1) Is your water bill looked at every month?

(2) Is there someone in charge of determining whether use was too high in a given month?

(3) Is there someone in charge of modifying the sprinkler system in response to a bill, or during a rainy season?

Of the 10 residential accounts, 6 of them described that the contractor for their complex or land closely monitors the water bill and ensures efficient use. These 6 accounts also explained that the contractor sets a price budget for water so they will not exceed a level of use. The remaining 4 residential accounts explained that their accountants look at the water bill, and notify the contractor if there is a price or amount of water use that is extraordinarily large. According to all these accounts mentioned above, the managers ensure that the sprinklers are turned down during rainy times. Of the 10 commercial accounts contacted, 8 of them were not local businesses, but larger corporations. These 8 accounts had no connectivity to their water bill. Instead, their water bill is sent to the corporate offices where it is paid. The corporations for these accounts do set a budget for water, but the individual branches are not fined for exceeding it. 4 of these 8 account managers did not possess a clear plan to turn down sprinklers during a rain, and it was not clear whether the other 4 accounts had a method for decreasing water use during rainy times, as none of the managers I spoke to were aware of one. The remaining 2 accounts interviewed were local businesses, which monitored their water use more similar to the residential entities and decreased consumption in times of rain. These survey results bear consistency with the regression results presented in table 6, which show that the residential accounts respond to rain and a billing change more so than do the commercial accounts.

Conclusions and Implications

Although the accounts analyzed all together did not have a conservation response to the billing change as the hypothesis suggested, the compared result between the residential and commercial accounts is notable. First of all, given by the regression results, the residential accounts responded more negatively to an increase in rainfall than did the commercial accounts, showing consistency with the survey study. Conversely, for the commercial accounts, 8 of the 10 accounts either did not have a plan to decrease use during rain, or the managers were not aware if they did. In light of the billing change, perhaps the residential accounts responded to the extra monthly billing information simply because there is a clear chain of connectivity between the contractor and the individual managing the water. Alternatively, some of managers of the commercial accounts do not even look at the water bill.

This result clears way for an important conservation intervention. As figure 4 shows, these commercial accounts use on average between 450,000 to 500,000 gallons of water per year, which can supply seven single family households in Santa Cruz County with water for a year (Goddard, 2012). This large sum of irrigation water going to businesses should be overseen closely by owners, but given by the results from this analysis; it is not managed as efficiently as it could be.

These results illuminate the important role of integrating information in management. Both the business and residential accounts began receiving more frequent bills, but their response was very different. Due to the low connectivity of commercial account managers with the water use, the extra information was not making any impact on consumption. Alternatively, the residential accounts possess management tools that allowed them to respond to the change in billing cycle, as the survey study and analysis also suggested. Water agencies could work with commercial accounts and help them in better connecting their management and management decisions with their water consumption. Also, to encourage these account holders to pay better attention to water use, agencies can provide incentives for conservation. It is possible for a more frequent billing cycle to become a strong conservation tool for large irrigators, but there must be a clear chain of management of the resource for a positive result. The extra information provided by monthly water bills is useless without proper oversight and incentives.

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APPENDIX I: Description of Survey Methods

The chosen residential and commercial account holders interviewed were picked at random. First, I split up the commercial accounts and residential accounts. Then, I generated a series of 10 random numbers twice. For each number generated and for each dataset, I chose the account that corresponded to the number in the data frame. For example, if the number was 5, I would choose the account that is the 5^{th} row down. The original data included addresses, so once I picked the accounts to interview, I looked up the address to figure out what type of entity it was. Some accounts did not respond, so I generated more random numbers to fill in the gaps. For all the accounts, I either spoke to an operations manager, a general manager, or an accountant. I am not disclosing the names of the businesses or residential units interviewed.