Appendix C: Statistical Analysis of Water Savings

The Residential Runoff Reduction Study

Appendix C - Statistical Analysis of Water Savings

Prepared for
Municipal Water District of Orange County and
The Irvine Ranch Water District

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Summary

Findings

$ **Single Family Residences:** Households receiving an evapotranspiration (ET) controller and education were found to save approximately 41.2 gallons per day on average (33.2 gpd – 49.2 gpd is the 95 percent confidence level). Households receiving the education treatment alone were found to save approximately 25.6 gallons per day on average (20.1 gpd – 31.1 gpd is the 95 percent confidence level). This sample compared 93 ET controller/education participants and 192 education-only participants to 1236 nonparticipating single family customers.

A secondary finding in this sample related to seasonal shape in this average savings effect. For the one year of post-intervention consumption data within our sample, the water savings was not constant. The ET controller/education intervention, in particular, saved more water in the autumn and less in the spring growing season.

$ **Landscape-Only Accounts:** Among a smaller sample of 21 landscape-only accounts, significant water savings (16 percent) were obtained from the use of ET controllers. A sample of 76 matched sites (similar in landscaped area and type of use) also showed the effects of City water efficiency improvements. Since both of these samples contain a large number of medians and streetscapes, it is possible that each gallon saved from irrigation-only sites contributes more to runoff reduction than a gallon saved at a single family site. Since the runoff reduction was not measured by customer account, this study will not be able to confirm or deny this hypothesis.

Introduction

The purpose of this work is a statistical analysis of water savings among customers who installed evapotranspiration (ET) controllers and customers given irrigation education in the Irvine Ranch Water District. This report documents a careful statistical analysis of historical water consumption data to derive estimates of the net water savings from these interventions.

Approach

Historical water consumption records (July 1997 to August 2002) for a sample of participants and for a sample of nonparticipating customers were examined statistically. The hypothesis was that installation of new irrigation technology or better management of existing equipment would reduce the observed water consumption of customers participating in this program. This study empirically estimates the water savings that resulted from both types of interventions—(1) customers receiving both ET controllers and follow-up education and (2) customers receiving an education-only intervention.

Since installation of ET controllers required the voluntary agreement of the customer to participate, this sample of customers can be termed "self-selected." Customers were randomly chosen to receive the education-only treatment. While this analysis does quantitatively estimate the reduction of participant's water consumption, one may not directly extrapolate this finding to nonparticipants. This is because self-selected participant can differ from customers that decided not to participate.

The explanatory variables in these models include

- Deterministic functions of calendar time, including
    - The seasonal shape of demand
- Weather conditions
    - measures of air temperature
    - measures of precipitation, contemporaneous and lagged
- Customer-specific mean water consumption
- "Intervention" measures of the date of participation and the type of intervention

Data and Methods

Consumption records were compiled from the IRWD customer billing system for customers in the study areas. Billing histories were obtained from meter reads between July 1997 and August 2002. It is important to note that a meter read on August 1 will largely represent water consumption in July. Since the ET controllers were installed in May and June of 2001, the derived sample will only contain slightly more than one year of data for each participant. Table 1 presents descriptive statistics on the sample.

Table 1: Single Family Residential Sample Descriptive Statistics

	Site 1001		Site 1004	Site 1005	
	ET Controller Participant	Non-Participant	Control	Education Participant	Non-Participant
Number of Usable Accounts	97	213	264	196	346
Pre-period: July 1997-May 2001					
Mean Use (gpd)	375	371	405	390	418
No. of observations	4,504	9,860	12,452	9,251	16,364
Post-period: June 2001-August2002					
Mean Use (gpd)	366	379	427	395	421
No. of observations	1,358	2,982	3,694	2,744	4,856

The landscape-only customers (21 accounts) were handled separately. Two control groups were developed for these irrigation accounts: A matched control group was selected by IRWD staff by visual inspection, finding 3-5 similar control sites for each participating site. Similarity was judged by irrigated area and type of use (Home Owner Association, Median, Park, or Streetscape). Since the City of Irvine was improving irrigation efficiency on the City-owned sites during the post-intervention period, this matched control group also had potential water savings. A second control group was developed where the selection was done solely located by geographic area. In this way, the statistical models can separately estimate the water savings effects for each group.

Table 2: Landscape Accounts
Descriptive Statistics

	Participant	Matched Control	Unmatched Control
Number of Usable Accounts	21	76	895
Acres per Account	0.93	0.92	0.96
Type of Account (if known)			
HOA	3	13	
Median	3	11	
Park	1	6	
Streetscape	14	47	
Pre-period: July 1997-June 2001			
Mean Use (gpd)	2,948	2,768	3,042
Mean Use per Acre (inches/day)	0.11702	0.11823	0.12893
No. of observations	967	3,503	39,352
Post-period: July 2001-August2002			
Mean Use (gpd)	2,845	2,990	3,271
Mean Use per Acre (inches/day)	0.10813	0.12012	0.13013
No. of observations	293	1,052	12,121

The first major issue with using meter-read consumption data is the level and magnitude of noise in the data. The second major issue is that records of metered water consumption can also embed non-ignorable meter mis-measurement. To keep either type of data inconsistencies from corrupting statistical estimates of model parameters, this modeling effort employed a sophisticated range of outlier-detection methods and models. These are described in the next section.

Daily weather measurements—daily precipitation, maximum air temperature, and evapotranspiration—were collected from the CIMIS weather station located in Irvine. The daily weather histories were collected as far back as were available (January 1, 1948) to provide the best possible estimates for "normal" weather through the year. Thus we have at least 54 observations upon which to judge what "normal" rainfall and temperature for January 1^{rst} of any given year.

Robust regression techniques were used to detect which observations are potentially data quality errors. This methodology determines the relative level of inconsistency of each observation with a given model form. A measure is constructed to depict the level of inconsistency between zero and one; this measure is then used as a weight in subsequent regressions. Less consistent observations are down-weighted. Other model-based outlier diagnostics were also employed to screen the data for any egregious data quality issues.

Specification

A Model of Water Demand

The model for customer water demand seeks to separate several important driving forces. In the short run, changes in weather can make demand increase or decrease in a given year. These models are estimated at a household level and, as such, should be interpreted as a condensation of many types of relationships—meteorological, physical, behavioral, managerial, legal, and chronological. Nonetheless, these models depict key short-run and long-run relationships and should serve as a solid point of departure for improved quantification of these linkages.

Systematic Effects

This section specifies a water demand function that has several unique features. First, it models seasonal and climatic effects as continuous (as opposed to discrete monthly, semi-annual, or annual) function of time. Thus, the seasonal component in the water demand model can be specified on a continuous basis, then aggregated to a level comparable to measured water use (e.g. monthly). Second, the climatic component is specified in different form as a similar continuous function of time. The weather measures are thereby made independent of the seasonal component. Third, the model permits interactions of the seasonal component and the climatic component. Thus, the season-specific response of water demand can be specific to the season of the year.

The general form of the model is:

Equation 1

$$Use = m_i + S_t + W_t + E_{i,t}$$

where ***Use*** is the quantity of water demand within time *t*, the parameter $\boldsymbol{\mu_i}$ represents mean water consumption per meter *i*, $\boldsymbol{S_t}$ is a seasonal component, $\boldsymbol{W_t}$ is the weather component, $\boldsymbol{E_{i,t}}$ is the effect the landscape interventions for meter *i* at time period *t*. Each of these components is described below.

Seasonal Component : A monthly seasonal component can be formed using monthly dummy variables to represent a seasonal step function. Equivalently, one may form a combination of sine and cosine terms in a Fourier series to define the seasonal component as a continuous function of time.[1] The following harmonics are defined for a given day *T*, ignoring the slight complication of leap years:

Equation 2

$$S_t \equiv \sum_{1}^{6}\left[b_{i,j} \cdot \sin\left(\frac{2p \cdot jT}{365}\right) + b_{i,j} \cdot \cos\left(\frac{2p \cdot jT}{365}\right)\right] = Z \cdot b_S$$

[1] The use of a harmonic representation for a seasonal component in a regression context dates back to *Hannan* [1960]. *Jorgenson* [1964] extended these results to include least squares estimation of both trend and seasonal components.

where T = (1,...365) and j represents the frequency of each harmonic.[2] Because the lower frequencies tend to explain most of the seasonal fluctuation, the higher frequencies can often be omitted with little predictive loss.

To compute the seasonal component one simply sums the multiplication of the seasonal coefficient with its respective value. This number will explain how demand changes due to seasonal fluctuation.

Weather Component: The model incorporates two types of weather measures into the weather component–maximum daily air temperature and rainfall.[3] The measures of temperature and rainfall are then logarithmically transformed to yield:

Equation 3

$$R_t \equiv \ln\left[1+\sum_{t=T}^{T_d} Rain_t\right], A_t \equiv \ln\left[\sum_{t=T}^{T_d} \frac{AirTemp_t}{d}\right]$$

where d is the number of days in the time period. For monthly aggregations, d takes on the values 31, 30, or 28, ignoring leap years; for daily models, d takes on the value of one. Because weather exhibits strong seasonal patterns, climatic measures are strongly correlated with the seasonal measures. In addition, the occurrence of rainfall can reduce expected air temperatures. To obtain valid estimates of a constant seasonal effect, the seasonal component is removed from the weather measures by construction.

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[2] If measures of water demand are available on a daily basis, the harmonics defined by Equation 2 can be directly applied. When measures of water demand are only observed on a monthly basis, two steps must be taken to ensure comparability. First, water demand should be divided by the number of days in the month to give a measure of average daily use. Otherwise, the estimated seasonal component will be distorted by the differing number of days in a month. The comparable measures of the seasonal component are given by averaging each harmonic measure for the number of days in a given time period.

[3] Specifically it uses the maximum daily air temperature and the total daily precipitation at the Irvine weather station. This station was selected due to its proximity to the study area.

Specifically, the weather measures are constructed as a departure from their "normal" or expected value at a given time of the year. The expected value for rainfall during the year, for example, is derived from regression against the seasonal harmonics. The expected value of the weather measures ($\hat{\boldsymbol{A}}=\boldsymbol{Z}\bullet$) is subtracted from the original weather measures:

Equation 4

$$W_t \equiv (R_t - \widehat{R}_t) \cdot b_R + (A_t - \widehat{A}_t) \cdot b_A$$

The weather measures in this deviation-from-mean form are thereby separated from the constant seasonal effect. Thus, the seasonal component of the model captures all constant seasonal effects, as it should, even if these constant effects are due to normal weather conditions. The remaining weather measures capture the effect of weather departing from its normal pattern.

The model can also specify a richer texture in the temporal effect of weather than the usual fixed contemporaneous effect. Seasonally-varying weather effects can be created by interacting the weather measures with the harmonic terms. In addition, the measures can be constructed to detect lagged effects of weather, such as the effect of rainfall one month ago on this month's water demand.

Effect of Landscape Interventions: Information was compiled on the timing and location of each ET controller installation and education-only customer participation. The account numbers from these data were matched to meter consumption histories going back to 1997. All raw meter reads were converted to average daily consumption by dividing by the number of days in the read cycle. Using these data, relatively simple "intervention analysis" models[4] were statistically estimated where, in this case, the intervention is ET controller installation and/or participation in the landscape education program. The form of the intervention is:

Equation 5

$$E_{i,t} \equiv I_{ET} \cdot b_{ET} + I_{Ed} \cdot b_{Ed}$$

The indicator variable I_{ET} takes on the value one to indicate the presence of a working ET controller and is zero otherwise. The indicator variable I_{Ed} takes on the value one if a household agreed to participate in the education program and is zero otherwise.

The parameter $\hat{b}_{ET}$ represents the mean effect of installing an ET controller and is expected to be negative (installing an ET controller reduces water consumption.) The parameter $\hat{b}_{Ed}$ has a similar interpretation for the education-only participants.

This formulation also permits formal testing of the hypothesis that landscape interventions can affect the seasonal shape of water consumption within the year. Since numerous studies have identified a tendency of customers to irrigate more than ET requirements in the fall and somewhat less in the spring, it will be informative to examine the effect of ET controllers designed to irrigate in accord with ET requirements. The formal test is enacted by interacting the participation indicators with the sine and cosine harmonics.

[4]See Box and Tiao, "Intervention Analysis with Applications to Economic and Environmental Problems" *Journal of the American Statistical Association*, Vol 70,No. 349, March 1975, pp. 70-70.

Stochastic Effects

To complete the model, we must account for the fact that not every data point will lie on the plane defined by **Equation 1**. This fundamental characteristic of all systematic models can impose large inferential costs if ignored. Misspecification of this “error component” can lead to inefficient estimation of the coefficients defining the systematic forces, incorrect estimates of coefficient standard errors, and an invalid basis for inference about forecast uncertainty. The specification of the error component involves defining what departures from pure randomness are allowed. What is the functional form of model error? Just as the model of systematic forces can be thought of as an estimate of a function for the “mean” or expected value, so too can a model be developed to explain departures from the mean—i.e., a “variance function” If the vertical distance from any observation to the plane defined by **Equation 1** is the quantity **e**, then the error component is added to **Equation 1**:

Equation 6

$$Use = \mathbf{f}\left(\mathbf{S}_t, \mathbf{C}_t, \mathbf{T}_t\right) + e$$

The error structure is assumed to be of the form:

Equation 7

$$\begin{aligned} & e_{it} = m_i + x_{it} \\ & where \\ & m_i \sim N(0, s_m^2) \\ & x_{it} \sim N(0, s_x^2) \end{aligned}$$

The *X* and *?* are assumed to be independent of each other and of *µ*. The individual component *µ* represents the effects of unmeasured household characteristics on household water use. An example of such an unmeasured characteristic might be the water use behavior of household members. This effect is assumed to persist over the estimation period. The second component *?* represents random error. Because *µ* and *?* are independent, the error variance can be decomposed into two components:

Equation 8

$$s_e^2 = T \cdot s_m^2 + s_x^2$$

This model specification is accordingly called an error components or variance components model. The model was estimated using maximum likelihood methods.

Estimation Results

Estimated Landscape Customer Water Demand Model

Table 3 presents the estimation results for the model of landscape (irrigation-only) customer water demand in the R3 study sites. This sample represents water consumption among 992 accounts between June 1997 and August 2002. This sample contains 21 ET controller accounts, 76 matched control accounts, and 895 unmatched control accounts.

The constant term (1) describes the intercept for this equation. The independent variables 2 to 9—made up of the sines and cosines of the Fourier series described in Equation 2—are used to depict the seasonal shape of water demand. The estimated weather effect is specified in "departure-from-normal" form. Variable 10 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated similarly (Variable 11). One month lagged rainfall deviation is also included in the model (Variables 12). The next variable accounts for the amount of irrigated acreage on the site. (Note that while measured acreage is available for all irrigation-only accounts, this is not true for single family accounts.)

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers (15) suggests that the mean change in water consumption is 472 gallons per day, approximately 16 percent of the pre-intervention water use. The matched control group (17) did experience water savings, approximately 241 gallons per day or 8.7 percent of their pre-intervention water use. The variables testing for differences in pre-intervention use cannot distinguish any differences between the different types of accounts.

Table 3: Landscape Customer Water Demand Model Dependent Variable: Average Daily Metered Water Consumption (in gallons per day)		
Independent Variable	**Coefficient**	**Std. Error**
1. Constant (Mean intercept)	2619.0670	234.8112
2. First Sine harmonic, 12 month (annual) frequency	-811.6864	26.3271
3. First Cosine harmonic, 12 month (annual) frequency	-1984.6310	25.9776
4. Second Sine harmonic, 6 month (semi-annual) frequency	104.1141	26.5769
5. Second Cosine harmonic, 6 month (semi-annual) frequency	-18.5088	26.9614
6. Third Sine harmonic, 4 month frequency	-124.1069	28.1396
7. Third Cosine harmonic, 4 month frequency	107.1129	28.4812
8. Fourth Sine harmonic, 3 month (quarterly) frequency	39.5420	30.5372
9. Fourth Cosine harmonic, 3 month (quarterly) frequency	-62.1012	30.7453
10. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	6306.4130	562.5547
11. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-747.0860	51.9108
12. Monthly lag from rain deviation	-209.8997	46.2994
13. Irrigated Acreage (in acres)	490.5891	139.6673
14. ET controller sites, test for difference in pre-intervention use	-46.2624	1278.0470
15. Average Effect of ET controller (21 accounts)	-472.1763	279.4630
16. Matched accounts, test for difference in pre-intervention use	-166.3042	691.8883
17. Average Effect of city efficiency improvements (76 accounts)	-240.9208	148.0551
Number of observations		57017
Number of customer accounts		983
Standard Error of Individual Constant Terms		5749.64
Standard Error of White Noise Error		4179.81
Time period of Consumption	June 1997- July 2002	

Estimated Single Family Residential Water Demand Model

Table 4 presents the estimation results for the model of single family water demand in the R3 study sites. This sample represents water consumption among 1,525 single family households between June 1997 and July 2002. This sample contains 97 ET controller/education participants (in Site 1001) and 192 education-only participants (in Site 1005).

The constant term (1) describes the mean intercept for this equation. (A separate intercept is estimated for each of the 1,525 households but these are not displayed in Table 4 for reasons of brevity.) The independent variables 2 to 8—made up of the sines and cosines of the Fourier series described in Equation 2—are used to depict the seasonal shape of water demand. The predicted seasonal effect (that is, $Z \cdot \widehat{b}_S$) is the shape of demand in a normal weather year. This seasonal shape is important in that it represents the point of departure for the estimated weather effects (expressed as departure from normal). We will also test to see if the landscape interventions have any effect on this seasonal shape.

The estimated weather effect is specified in "departure-from-normal" form. Variable 11 is the departure of monthly temperature from the average temperature for that month in the season. (Average seasonal temperature is derived from a regression of daily temperature on the seasonal harmonics.) Rainfall is treated in an analogous fashion (Variable 14). One month lagged rainfall deviation is also included in the model (Variables 15). The reader should also note that the contemporaneous weather effect is interacted with the harmonics to capture any seasonal shape to both the rainfall (Variables 12 and 13) and the temperature (Variables 9 and 10) elasticities. Thus, departures of temperature from normal produce the largest percentage effect in the spring growing season. Similarly, an inch of rainfall produces a larger effect upon demand in the summer than in the winter.

The effect of the landscape conservation program interventions is captured in the following rows. The parameter on the indicator for ET controllers/education (16) suggests that the mean change in water consumption is 41.2 gallons per day while the education only participants (19) saved approximately 25.6 gallons per day. The model cannot say whether education-only participants saved this water through improved irrigation management or by also reducing indoor water consumption. Since the sample includes only one year of post-intervention date, the model cannot say how persistent either effect will be in future years.

Table 4: Single Family Residential Water Demand Model Dependent Variable: Average Daily Metered Water Consumption (in gallons per day)		
Independent Variable	**Coefficient**	**Std. Error**
1. Constant (Mean intercept)	405.6593	3.1660
2. First Sine harmonic, 12 month (annual) frequency	-45.4215	0.9636
3. First Cosine harmonic, 12 month (annual) frequency	-89.1494	0.9629
4. Second Sine harmonic, 6 month (semi-annual) frequency	3.6549	0.6798
5. Second Cosine harmonic, 6 month (semi-annual) frequency	1.0709	0.6733
6. Third Cosine harmonic, 4 month frequency	1.7312	0.7151
7. Fourth Sine harmonic, 3 month (quarterly) frequency	4.4016	0.7403
8. Fourth Cosine harmonic, 3 month (quarterly) frequency	3.3491	0.7865
9. Interaction of contemporaneous temperature with annual sine harmonic	48.7897	17.1559
10. Interaction of contemporaneous temperature with annual cosine harmonic	-72.4672	22.3626
11. Deviation from logarithm of 31 or 61 day moving average of maximum daily air temperature	284.7163	13.542
12. Interaction of contemporaneous rain with annual sine harmonic	10.1102	1.8546
13. Interaction of contemporaneous rain with annual cosine harmonic	5.9969	2.6904
14. Deviation from logarithm of 31 or 61 day moving sum of rainfall	-34.0117	1.8931
15. Monthly lag from rain deviation	-13.3173	1.0549
16. Average Effect of ET controller/Education (97 participants)	-41.2266	4.0772
17. Interaction of ET intervention with annual sine harmonic	38.9989	5.3327
18. Interaction of ET intervention with annual cosine harmonic	-6.3723	4.8980
19. Average Effect of Education-only intervention (192 participants)	-25.5878	2.8081
20. Interaction of Ed.-only intervention with annual sine harmonic	6.0357	3.5870
21. Interaction of Ed.-only intervention with annual cosine harmonic	-3.0703	3.3826
Number of observations	94,655	
Number of customer accounts	1,525	
Standard Error of Individual Constant Terms		120.85
Standard Error of White Noise Error		129.81
Time period of Consumption	June 1997- July 2002	

How ET Controllers Affect Peak Demand

The question of how these programs affected the seasonal shape of water demand can be interpreted from the remaining interactive effects—the indicators interacted with the first sine and cosine harmonics. For example, the seasonal shape of demand can be derived before and after ET controller/education participation:

$$\text{Pre\_Intervention}: S_t = Z \cdot \hat{b}_S \approx -45.4 \cdot \sin_1 - 89.1 \cdot \cos_1 + 3.6 \cdot \sin_2 + 1.1 \cdot \cos_2 + \ldots + 3.4 \cos_4$$

$$\text{Post\_ETIntervention}: S_t^{'} \approx Z \cdot \hat{b}_S + 39 \cdot I_{ET} \cdot \sin_1 - 6.4 \cdot I_{ET} \cdot \cos_1$$

When the pre/post seasonal patterns are combined with their pre/post mean water consumption, the following before and after picture can be seen throughout the year.

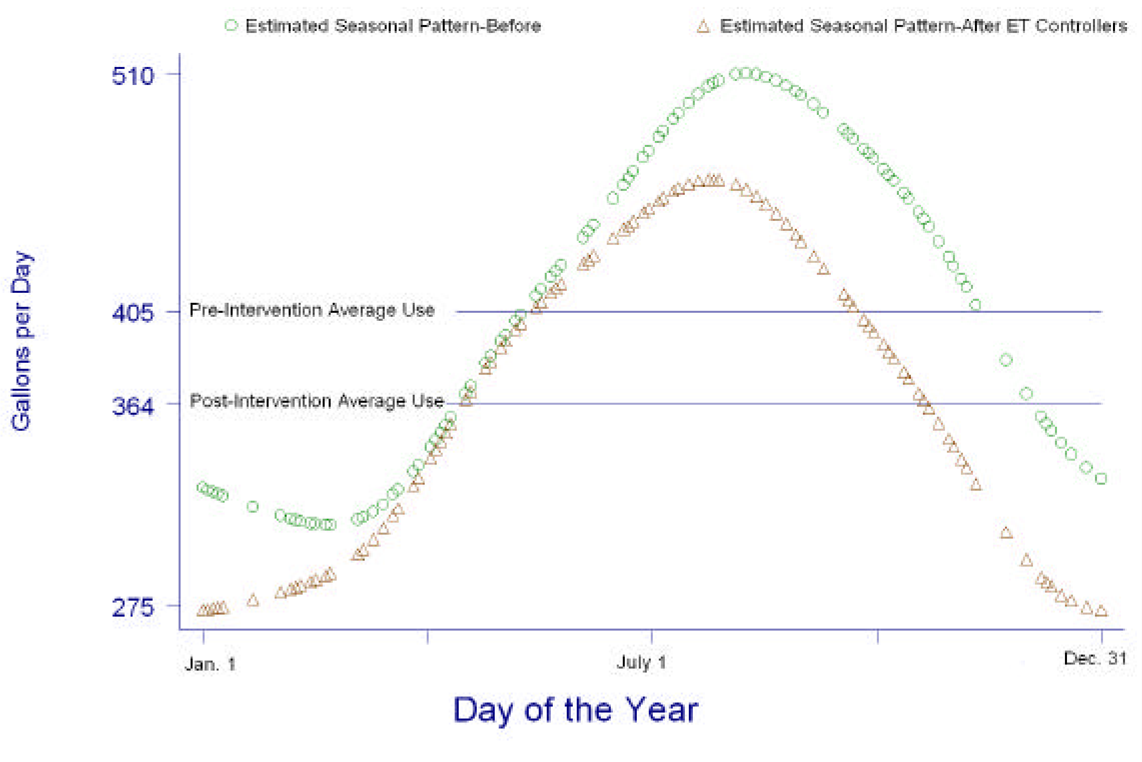

Figure 1-Effect of ET intervention on Water Demand

In Figure 1, several observations should be made. First, the difference between the two horizontal lines corresponds to the estimated mean reduction of approximately 41 gallons per day. Second, the assumption of a constant 41 gallon per day effect does not hold true throughout the year. The reduction is barely noticeable in the spring growing season and is much larger in the fall.

The reduction in peak demand—though dependent upon how the seasonal peak is defined[5]—is greater than the average reduction. The estimated peak day demand, occurring on August 8, is reduced by approximately 51 gallons. This “load-shaping” effect of the ET controller intervention can translate into an additional benefit to water agencies. The benefits from peak reduction derive from the avoided costs of those water system costs driven by peak load and not average load—the costs for new treatment, conveyance, and distribution all contain cost components driven by peak capacity requirements.

Figure 2 plots the corresponding estimates for the Education-only intervention. The reduction in average demand is less—approximately 25 gallons per day. The effect upon the estimated seasonal shape of demand is much more muted. In fact, the change to the estimated seasonal shape of demand induced by the education-only intervention is not significantly different from zero at classical levels of significance.

[5] This is the issues of “coincident” versus “noncoincident” peak demand: the extent to which the peak load of a customer coincides with the system peak. Water systems by their nature have a strong and predictable tendency to peak seasonally—for Southern California, this occurs in the summer. Given the predictability of system peaks, and the attendant costs, the empirical case for the contribution of ET controller load shaping to the reduction of systems cost is relatively straightforward. The additional value of peak reduction--over and beyond reductions in average consumption--require careful specification of the additional incremental costs necessitated by peak flow requirements.

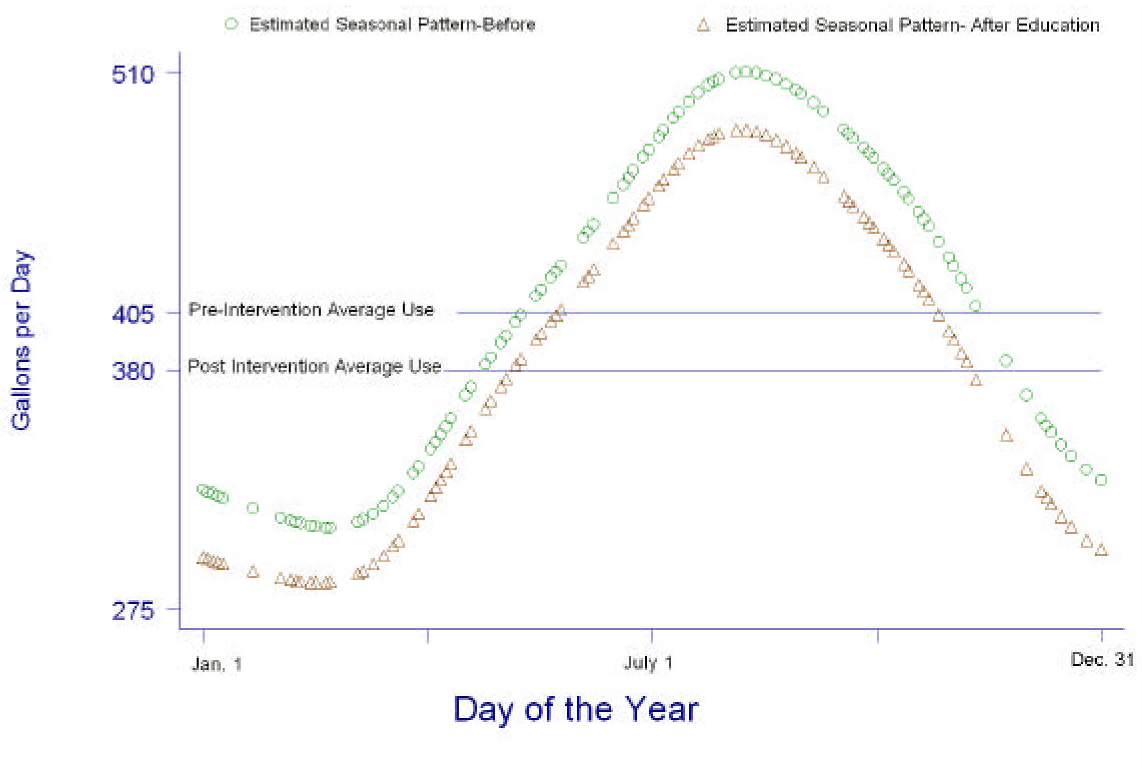

Figure 2-Estimated Effect of Education-only on Water Demand

Caveats and Additional Work

This modeling effort focused on developing the best depiction of net changes in water consumption due to the landscape interventions of ET controllers and/or education. Much of the modeling effort was expended on data cleaning, diagnosis, and validation. We believe that the most serious data issues were identified and appropriately handled. To the extent that future data quality can be improved, future work could provide several statistical refinements in model specification:

- The empirical effort has quantified the change in mean water consumption and the shift in seasonal consumption. The models have not been extended to document how water savings vary across households—how are savings decreased/increased among lower/higher water use households?
- Since the sample only contains about one year of post installation data, the statistical models can say little about the persistence of water savings. Additional follow-up quantification of water savings in subsequent years is required.
- The modeling effort to date has *not* attempted to estimate the effect of self-selection. Thus, we make no attempt to extend the inference from the existing sample of participants to (1) the rest of the service area or (2) to other service areas.
- The error component of the estimated models could be improved by specifying a function form to explain the variance. This should only be attempted after all major data issues have been resolved.

Conclusion

This report documents the shape of water savings achieved by the landscape interventions of ET controllers and/or education. Households participating in these programs saved significant amounts of water. The education-only program showed less water savings than the ET controller/education program, but were still significant. The ET controller/education program changed both the level and shape of water demand.