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STUDY TO DETERMINE POTABLE QUALITY WATER OFFSET FROM REUSE

FINAL REPORT
SEPTEMBER 30, 2008

The St. Johns River Water Management District

STUDY TO DETERMINE POTABLE QUALITY WATER OFFSET FROM REUSE

Final Report

September 30, 2008

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September 30, 2008

Dr. Donald Brandes
Senior Project Manager
Department of Resource Management
St. Johns River Water Management District
4049 Reid Street
Palatka, Florida 32177

Re: FY 2008 Study to Determine Potable Quality Water Offset from Reuse – Final Report

Dear Dr. Brandes:

Burton & Associates is pleased to present this Report for the above referenced FY 2008 Study to Determine Potable Quality Water Offset from Reuse that we conducted for the District. This report presents the analyses conducted and the results of the Study.

We would like to acknowledge the assistance of Volusia County, Orange County and the City of Ocoee in providing utility billing data that served as the basis for the analyses conducted and the conclusions that are presented herein.

If you have any questions, or require any additional information, please do not hesitate to call me at (904) 247-0787.

Very truly yours,

Michael E. Burton
President

MEB/TI/cs
Enclosure

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I. Introduction

This section presents a discussion of the background of this study and the the objectives, scope, and methodology used in the conduct of the study.

A. <u>Background</u>

The St. Johns River Water Management District (District) regards reclaimed water as an alternative water supply source that should be used to make more water available for reasonable-beneficial use, provided the use of reclaimed water is technically, environmentally, and economically feasible. Reclaimed water is water that has received at least secondary treatment and basic disinfection and is reused after flowing out of a domestic wastewater treatment facility (62-610(45), Florida Administrative Code (F.A.C.)). Reuse is the deliberate application of reclaimed water, in compliance with Florida Department of Environmental Protection (FDEP) and water management district (WMD) rules, for beneficial purposes (62-610(50), F.A.C.). The District seeks to achieve water resource benefits with reclaimed water by using it in place of higher quality water for uses that do not require higher quality and to augment water supply sources, typically by groundwater recharge. Uses for reclaimed water include irrigation of landscapes, golf courses, parks, cemeteries, and agriculture; aesthetic features; groundwater recharge; industrial uses; environmental enhancement; fire protection; or other beneficial purposes.

The District has a variety of District-wide programs that require, promote, and facilitate reuse in order to achieve water resource benefits. The District's practice has been to encourage or require reuse to the extent feasible in accordance with state of Florida objectives concerning water conservation and reuse (373.250(1), Florida Statutes [F.S.]); 403.064(1), F.S.; and 62-40, F.A.C.). The District has designated its entire jurisdiction as a water resource caution area for the purpose of requiring reuse feasibility studies by the FDEP during the wastewater treatment facilities permitting process (62-610.820, F.A.C.).

The District's consumptive use permit conditions routinely require use of reclaimed water in place of groundwater when technically, environmentally, and economically feasible. Some water users have had their groundwater allocations reduced significantly when their permits were renewed because groundwater was replaced by reclaimed water. Replacement of permitted groundwater allotments with reclaimed water has raised the issues of how much potable quality water offset occurs when reclaimed water is used and what level of offset is reasonable to achieve. "Potable quality water offset" is defined in (62-610(21), F.A.C.) as:

> *"the amount of potable quality water (Class F-I, G-I, or G-II groundwater or water meeting drinking water standards) saved through the use of reclaimed water expressed as a percentage of the total reclaimed water used. The potable quality water offset is calculated by dividing the amount of potable water saved by the amount of reclaimed water used and multiplying the quotient by 100."*

B. Objectives

The goal of this study was to determine the estimated amount of potable quality water offset that occurs when reclaimed water is used in place of potable quality water for irrigation. Knowledge of estimated potable quality water offset ratios then can be used to determine quantities of potable water use that would be replaced by given quantities of reclaimed water use. This information will be valuable for water supply planning and water use regulation to make better decisions concerning the management of water supplies to better meet future needs. Potable quality water offset from reuse is a dependent variable that is influenced by rate structure, weather and possibly other conditions.

Two major objectives must be accomplished to quantify the variable relationships: 1) quantification of water use before and after the introduction of reuse; and 2) identification and quantification of factors that affect reclaimed water use and potable quality water offset.

C. Scope of Work

This study examined, described, and quantified the relationship between the amount of reclaimed water used and the amount of potable water that otherwise would be used if reclaimed water were not available in order to estimate potable quality water offset and consequent total quantities of potable water savings. This study included data collection and analysis, numerical modeling, and production of a written report. The principal task was the development of a model or set of equations to forecast the potable quality water offset that would occur as a result of reclaimed water use under various circumstances. Contract deliverables were designed so as to be readily usable to assist real-world decision-making concerning water supply planning and regulation and the selection, funding, and implementation of reuse projects. This study does not address the percentage of treated wastewater that is feasible to reuse.

D. Methodology

This section presents a description of the analyses that were conducted during the course of the study.

1. Utility Billing Data

In order to develop the econometric models for this study, it was necessary to obtain reliable data regarding water use before and after introduction of reuse as a substitute for irrigation with potable quality water. Therefore, we reviewed an inventory of utilities surveyed in another study performed by a District consultant and identified nine (9) local utilities, presented in the following table, that appeared to have significant enough use of reclaimed water to potentially serve as sources of water usage data for this study.

Cities Contacted
• City of Ocoee
• Orange County Utilities
• Volusia County
• City of Altamonte Springs
• City of Cocoa
• Green Cove Springs
• Indian River County
• City of Lake Mary
• City of Sanford

We contacted the above referenced local utilities about their willingness and ability to participate in the study and sent follow-up specifications regarding the utility billing data that would need to be provided to support the study analyses. Of the local utilities contacted, three were able to attempt to provide the requested utility billing data[1], Volusia County, Orange County and the City of Ocoee. Of these participants, the City of Ocoee presented a case in which utility billing data was available at the account level by monthly bill from 2002 through 2008 in

[1] The timing of the request for utility billing data prohibited most of the other utilities from being able to participate as they were in the middle of their budget process and were dealing with the effects of the recently passed property tax reform initiatives and could not devote the time to participate in this study. Most indicated that they would have liked to participate and if future data requests could be made at a time that did not coincide with their budget process they would be happy to assist.

neighborhoods where reclaimed water was introduced in the middle of the period (in June of 2005). This history of use prior to and after the introduction of reuse matched up exactly with the objectives of this study; therefore, the analysis presented herein is based upon the City of Ocoee data.

2. *Econometric Modeling*

In order to evaluate the affects of the substitution of reuse in place of potable quality water for irrigation, it was necessary to evaluate the historical utility billing data provided by the City of Ocoee to determine the variables that may have changed over time that would affect water use other than the substitution of reuse for potable quality water for irrigation. To the extent that utility accounts could be identified that contained clearly identifiable variables, they were eliminated from the sample used in the econometric models.

For instance, if a parcel changed ownership during the period 2002 through 2008, it was excluded from the analysis because the characteristics of the new owner[2] could contribute to changes in water use. Also, for the same reason, parcels where the owner and the account holder are different were eliminated, because such cases would represent renters which may change during the study period. Also, all accounts that had zero usage in any month during the study period were eliminated because such accounts could represent seasonal occupants who were not resident year-round and whose usage would not be representative relative to the objectives of the study.

In order to perform the above referenced analysis of the utility billing data, it was also necessary to obtain parcel data from the Orange County Property Appraiser's database to evaluate parcel ownership. We conducted this account/parcel analysis and the result was that of the approximately 800 accounts in the data received from the City of Ocoee, sixty (60) accounts qualified for inclusion in the database used in the econometric modeling performed.

In addition to the variables that may affect water use (explanatory variables) that were eliminated by exclusion of some accounts from the database, other explanatory variables were identified and included in the econometric modeling as follows:

- Rainfall (current and previous month),

[2] Characteristics such as attitudes about water use, income, household size, etc.

- Temperature (number of days in month above average),
- Humidity, and
- Price (rate structure and cost)

Other explanatory variables could affect water use, but were not able to be included in the econometric modeling without conducting a survey of accounts, which was beyond the scope of this study. These explanatory variables include account attributes such as income, household size, conservation awareness, etc. However, it is important to note that even though the econometric modeling does not directly include these types of explanatory variables, the inclusion of only accounts owned and occupied by the same family during the study period serves to eliminate to a great degree the affects of these variables in each account's usage history.

For instance, if the occupant of an account realizes normal increases in income during the study period, water use for that account will not be affected materially by income because the cost of water (and reuse after introduction) in the study area increased by an annual inflationary level adjustment of 3% per year. Likewise, if the household size did not change during the study period, water use for that account will not be affected materially by household size. Clearly some of the accounts may have experienced greater than normal changes in income (new job, layoff, etc.) and some may have experienced changes in household size (children leaving, children born, etc.), but it is assumed that such changes will not materially affect the analysis[3].

After determining the sixty (60) accounts to be included in the database, we developed econometric models of water usage before and after the introduction of reclaimed water as a substitute for potable quality water for irrigation. Based upon the results of this econometric modeling, we developed conclusions regarding the expected change in potable quality water use after the introduction of reuse. We then met with District staff to review the results of the analysis, presented our preliminary conclusions and discussed the applicability of applying the results of this study to predicting reductions in potable quality water usage after introduction of reuse in other utilities in the District that may have different characteristics from the accounts in the City of Ocoee that were included in our analysis.

[3] Further analysis could be conducted on this database of accounts by conducting a survey of the account database relative to these variables and including these variables in the econometric modeling; however, that approach was outside of the scope of this study.

Based upon the analysis conducted and the discussions with District staff, we then prepared this report of the results of the Study.

II. Summary of Results and Conclusions

This section presents a summary of the results of the analysis conducted during the study and conclusions that can be made regarding expected reduction in potable quality water usage after the substitution of reuse for irrigation and how these results can be used in the water supply planning process. A detailed description of the econometric modeling conducted, and which served as the basis for the results and conclusions presented in this section, is presented in Section III – Econometric Modeling.

A. Results

Based upon the econometric modeling that was performed during the study and which is described in Section III – Econometric Modeling, we were able to determine the change in potable water use in the subject accounts after the introduction of reclaimed water. As was stated in the previous section, a number of other explanatory variables can affect water use; however, by selecting only accounts that had continuous use and financial responsibility for the account over the study period we were able to eliminate a number of those variables. Also, in the development of the econometric models we identified a number of variables such as rainfall, temperature, humidity, price, etc. that we accounted for in the econometric modeling[4].

In order to present the results of the study, it is helpful to re-state the objectives of the study and to respond to each objective. The objectives of the study as described in the District's Statement of Work and in Section I.B – Objectives of this report are as follows:

> "*The goal of this study was to determine the actual amount of potable quality water offset that occurs when reclaimed water is used in place of potable quality water. Knowledge of actual potable quality water offset ratios then can be used to determine quantities of potable water use that would be replaced by given quantities of reclaimed water use. This information will be valuable for water supply planning and water use regulation to make better decisions concerning the management of water supplies to better meet future needs. Potable quality water*

[4] It should be noted that other variables may affect water usage such as household size, change in household size during the study period, income, etc. Inclusion of such variables would require surveying of the sample, which was not within the scope of this study. However, we believe that the results of this study account for a substantial portion of the variables that affect water usage and that inclusion of these additional variables may add an additional level of granularity to the results, but that the general results and conclusions presented herein are meaningful and useful, with the understanding of the potential variations that inclusion of variables identified herein may cause when applied to other areas.

> *offset from reuse is a dependent variable that is influenced by rate structure, weather and possibly other conditions.*
>
> *Two major objectives must be accomplished to quantify the variable relationships: 1) quantification of water use before and after the introduction of reuse; and 2) identification and quantification of factors that affect reclaimed water use and potable quality water offset.*"

Simply stated, the objectives were to answer the following two questions:

1. What is the estimated amount of potable quality water offset that occurs when reclaimed water is used in place of potable quality water and what level of demand for reclaimed water can be estimated based upon existing potable water irrigation patterns and the cost of reclaimed water?

2. What factors affect reclaimed water use and potable quality water offset?

A third question is implicit in the objectives and that question is:

3. How can the results of this study be used to determine quantities of potable water use that would be replaced by given quantities of reclaimed water use in the water supply planning and water use regulation process to make better decisions concerning the management of water supplies to better meet future needs?

We address these questions separately in the following sub-sections.

1. <u>Potable Quality Water Offset from Reuse</u>

In order for the results to be properly understood, it is first important to understand the configuration of service and pricing in the study area before the introduction of reuse and after the introduction of reuse. Prior to the introduction of reuse, all accounts had irrigation meters which were separate from the potable water meter serving the household (household potable water meter). The irrigation meters were subject to the same rates as the household potable water meter except that no sewer charge was assessed against the water usage through the potable water irrigation meter.

After the introduction of reuse, the system was reconfigured so that the meters that served as potable water irrigation meters, were converted to reuse. The rates for water delivered through the reuse meters equated to 75% of the household potable water meter rates for the duration of the study period.

The structure of the rates changed during the period prior to the introduction of reuse and the rates after introduction of reuse were subject to 3% annual adjustments. At the beginning of the study period FY 2002, the water rates were uniform rates with a usage charge of $0.57 per 1,000 gallons. In FY 2003 the water usage rates were converted to inclining block rates. This rate structure applied to both water delivered through the household potable water meter and the separate irrigation water meter.

After FY 2003, all water and wastewater rates were increased across-the-board by 3% per year. When reclaimed water was introduced in June 2005, the reclaimed water rates were inclining block rates which were set at 75% of the potable water rates for the duration of the study period.

A table of the City of Ocoee rates throughout the study period is presented below.

Historical Ocoee Rates

	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006	FY 2007	FY 2008
Water Rates[1]							
Base Facility Charge	$ 7.64	7.64	7.87	8.11	8.35	8.60	8.86
Volumetric Charges							
0 - 6,000	$ 0.57	0.84	0.87	0.90	0.93	0.96	0.99
6,001 - 12,000	$ 0.57	1.05	1.08	1.11	1.14	1.17	1.21
12,001 - 18,000	$ 0.57	1.31	1.35	1.39	1.43	1.47	1.51
18,001 - 24,000	$ 0.57	3.28	3.38	3.48	3.58	3.69	3.80
24,001 - 30,000	$ 0.57	4.92	5.07	5.22	5.38	5.54	5.71
30,001 - More	$ 0.57	5.98	6.16	6.34	6.53	6.73	6.93
Reuse Rates[2]							
Base Facility Charge	N/A	N/A	N/A	6.08	6.26	6.45	6.65
Volumetric Charges							
0 - 6,000	N/A	N/A	N/A	0.68	0.70	0.72	0.74
6,001 - 12,000	N/A	N/A	N/A	0.83	0.86	0.88	0.91
12,001 - 18,000	N/A	N/A	N/A	1.04	1.07	1.10	1.13
18,001 - 24,000	N/A	N/A	N/A	2.61	2.69	2.77	2.85
24,001 - 30,000	N/A	N/A	N/A	3.92	4.04	4.16	4.28
30,001 - More	N/A	N/A	N/A	4.76	4.90	5.05	5.20
Sewer Rates							
Base Facility Charge	$ 13.81	13.81	14.22	14.65	15.09	15.54	16.01
Volumetric Charges							
0 - 12,000	$ 1.56	1.98	2.04	2.10	2.16	2.22	2.29
12,001 - More	$ 0.00	0.00	0.00	0.00	0.00	0.00	0.00

1. In FY 2003, the Utility switched to an inclining block rate structure. In the period FY 2004-2008, the City increased all water and sewer rates by 3% each year. Prior to introduction of reuse in June 2005, irrigation with potable water through an irrigation meter was subject to the same water rates as water provided through a household meter, except there was no sewer charge applied to water usage through an irrigation meter.
2. Reuse was introduced into this community in June of FY 2005.

The results of the econometric modeling analysis shows that the average water use through the potable water irrigation meter, adjusted for the variables identified in Section I.2 – Econometric Modeling, prior to the introduction of reuse was approximately 10,510 gallons per month per account, while the average water use through the household potable water meter was approximately 6,000 gallons per month, for a total average water use per account of 16,510 gallons per month, all of which was potable quality water.

After introduction of reuse, the econometric modeling analysis shows that the average water use through the reuse meter, adjusted for the variables identified in Section I.2 – Econometric Modeling, was approximately 9,050 gallons per month per account[5], while the average water use through the household potable water meter was approximately 6,600 gallons per month, for a total average water use per account of 15,650 gallons per month, only 6,600 gallons per month of which was potable quality water. This represents an average reduction in potable water use per account of 9,910 gallons per month. These results are summarized in the following table.

Water Use Before and After Reuse

	Monthly Water Use Before Reuse	Monthly Water Use After Reuse
Potable Water		
Household (indoor) Meter	6,000	6,600
Irrigation Meter	10,510	NA
Reuse Meter	NA	9,050
Total Usage	**16,510**	**15,650**
Total Potable Water	16,510	6,600
Reduction in Potable Water	NA	**9,910**
Reduction in Gallons of Potable Water Use for Every Gallon of Reuse Used		**1.10**
Gallons of Reuse Required to Achieve a One Gallon Reduction in Potable Water		**0.90**

It is interesting to note that the average monthly amount of irrigation water decreased slightly after the introduction of reuse and the average monthly amount of potable water through the

[5] Normalized for rainfall , humidity and temperature pre-reuse and post-reuse.

household potable water meter increased slightly after the introduction of reuse. This seems counter-intuitive at first glance. However, factors that may have caused the slight reduction in irrigation use after the introduction of reuse include 1) conservation awareness and resultant change in behavior over the study period, 2) experience relative to the amount of irrigation actually required to meet each account's objectives, 3) hesitancy to use reuse for irrigation in areas judged to be too sensitive for reuse, such as lawn and/or shrubs close to houses, driveways or pathways, and 4) the fact that the price for reclaimed water was not dramatically less that potable irrigation water. Factors that may have caused the slight increase in potable water use through the household potable water meter after the introduction of reuse include 1) changes in household size and/or make-up during the period, 2) changes in income over the period, 3) use of potable water via hose-bibs through the household potable water meter for irrigation in areas judged to be too sensitive for reuse, such as lawn and/or shrubs close to houses, driveways or pathways, and 3) management to a total water resource household cost/budget.

Whatever the reasons for the change in potable water and irrigation use after the introduction of reuse, the evidence is that for the City of Ocoee accounts studied, there was a reduction in potable water use of 1,100 gallons for every 1,000 gallons of reuse used. It can also be stated that to achieve a reduction of 1,000 gallons of potable quality water use, 900 gallons of reclaimed water were used.

2. *Significant and Measurable Factors Affecting Reclaimed Water Use and Potable Quality Water Offset*

When attempting to relate the results of a study such as this to other utilities and particularly to broad policies regarding the expected reduction in potable quality water use that will be caused by the introduction of reuse in other areas of the District, it is important to understand the significant and measurable factors that can affect the net reduction in potable quality water use. There were several attributes of the study sample that our econometric modeling determined may be significant in application of these results to other utilities. These attributes are discussed in the following sub-sections.

a. Price and Cost

The first significant attribute or factor is price, or more precisely cost. The reuse rates in this study were 75% of the water rates from the time reuse was introduced throughout the study period and embodied an inclining block rate structure. Using the price elasticity determined in the econometric modeling and described in Section III – Econometric Modeling, we constructed the following Reuse Substitution Table which compares the estimated demand for reuse compared to 1,000 gallons of potable water used for irrigation at varying costs of reuse as a percentage of the cost of potable water that would otherwise be used for irrigation. In application of the findings of this study to other utilities it will be important to account for the difference in price and cost of reuse compared to potable quality water used for irrigation prior to the introduction of reuse, or as an alternative irrigation source to reuse.

Based upon the results of the econometric modeling conducted during this study, we have developed the following substitution table which represents the demand for reuse as a substitute for 1,000 gallons of potable water that takes into account the relationship between the cost of reuse and the cost of potable quality water that would otherwise be used for irrigation.

Reuse Substitution Table

		Substitution Ratio		
		Potable Demand in Gallons	**Reuse Demand in Gallons**	**Potable Water Offset**
Reuse Cost as a percentage of Potable Water Cost	**100%**	1,000	752	1.3
	75%	1,000	900	1.1
	50%	1,000	1,049	1.0
	25%	1,000	1,415	0.7

It should be noted that the above substitution table applies to the accounts in this study. Application of this substitution table to other utilities should be made cautiously because other variables besides price/cost could also affect the substitution rate. Notwithstanding this caution, we believe that the general conclusion that the lower the price of reuse compared to the alternative cost of potable quality water, the more reuse will be used as a substitute for each gallon of reduction of potable quality water and the above Reuse Substitution Table could serve as a general approximation of that relationship.

b. Presence of a Potable Quality Water Irrigation Meter Prior to the Introduction of Reuse

In the sample accounts evaluated in this study, all had separate potable quality irrigation meters prior to the introduction of reuse. This could be a factor in the results of the analysis because many of these accounts would have installed in-ground irrigation systems and the cycle frequencies and durations may not have been changed after introduction of reuse. Also, in this sample the pre-reuse amount of potable quality water used for irrigation was calculable, however, in service areas where there are no, or few, separate potable quality irrigation meters prior to introduction of reuse, the amount of irrigation that is being accomplished through the potable quality household meter is difficult to precisely determine.

However, in areas with similar characteristics to the sample in this study, one could impute potable quality water usage for irrigation through the household meter. This study showed that the average account used 6,000 gallons per month of potable quality water through the household meter. In applying the results of this study to other utilities with no or few potable quality irrigation meters, the average monthly household potable water usage from this study could be subtracted from the average monthly water usage through the household potable water meter in the subject utility to derive the imputed average monthly irrigation usage subject to reduction by the introduction of reuse. It should be noted that the water usage through the household meter in this study could include some outdoor usage via hose-bibs; therefore, more study would be required to determine a more precise estimate of average indoor use[6].

c. Adequate Supplies of Reuse

In the sample service area, adequate supplies of reuse were available to meet the irrigation demands of the service area after the introduction of reuse. If adequate reuse supplies are not available after its introduction, the reduction in potable quality water may not be as great if utility customers supplement their irrigation needs (that can not be met with reuse due to inadequate supply) with potable quality water through their household potable water meter.

d. Other Factors Affecting Reuse

There are a number of other factors that may affect the reduction in potable quality water after the introduction of reuse. Variations relative to these the following factors were either substantially eliminated from our analysis by selection of the sample accounts to include only those accounts that during the study period had the same owner/party with financial

[6] Such usage via hose-bibs could be for car washing and irrigation of areas where in-ground irrigation systems do not reach.

responsibility for the account and also had no months with zero usage through the irrigation meter.

- Changes in household usage patterns as an account changes ownership/financial responsibility,
- Seasonal occupancy,

As stated in Section I.D.2 – Econometric Modeling, other factors that may affect the amount of reduction in potable quality water after the introduction of reclaimed water in the study area that were accounted for in the econometric modeling conducted during this study include:

- Rainfall (current and previous month),
- Temperature (number of days in month above average),
- Humidity, and
- Price (rate structure and cost).

In addition, other factors that may affect the amount of reduction in potable quality water after the introduction of reclaimed water that were not accounted for in this analysis include:

- Lot size[7],
- Type of landscaping,
- Watering restrictions,
- Income,
- Environmental/conservation awareness, and
- Other factors.

In applying the results of this study to other utilities, it is important to consider how such service areas differ from the accounts included in this study with regard to the aforementioned attributes and to make appropriate adjustments to the determination of the amount of reduction in potable quality water that can be expected by introduction of reuse, as well as the amount of reuse that will be necessary to achieve the potable quality water reduction and the amount of reuse that can will be expected to be used in the service area.

[7] Lot sizes for the sample accounts used in this study were similar and the lot size for each account remained constant over the study period; therefore, lot size was not modeled as a variable in the analysis.

3. Estimating Potable Quality Water Offset from Reuse in Water Supply Planning

One of the most important contributions that this study can make is to provide insights to District staff to be used in determining quantities of potable water use that would be replaced by given quantities of reclaimed water use in the water supply planning and water use regulation process to make better decisions concerning the management of water supplies to better meet future needs. We believe that, although this study was limited in terms of the diversity of sample utility accounts due to time and budgetary constraints, the results can be useful in the water supply planning process if applied with caution relative to the assumptions as to the precision of the results.

Our conclusions as to how the results of this study can contribute to the water supply planning process are presented in the following sub-section.

B. Conclusions Regarding the Water Supply Planning Process

We believe that the following conclusions can be used in the water supply planning process in making determinations of the reduction in potable quality water that may result from the introduction of reuse for a service area with comparable charge rates to the City of Ocoee and similar cultural attitutudes to the sampled neighborhood. These conclusions assume that the service areas for which such determinations will be made would irrigate (in the alternative to reuse) with potable quality water through an irrigation meter that is separate from the household meter[8].

1. All other variables being equal, if the cost of reuse is approximately 50% of the cost of potable water that would otherwise be used for irrigation, the substitution of reuse for irrigation with potable quality water will be on an approximately one for one basis; that is, the off-set of 1,000 gallons of potable water will result in reclaimed water use of 1,049 gallons.

2. If the cost of reclaimed water is 75% of the cost of potable water that would otherwise be used for irrigation, the amount of reuse necessary to offset that potable water demand is

[8] Due to time, budget and data constraints, this study only evaluated substitution of reuse in a controlled sample of accounts that previously irrigated with potable water through a separate irrigation meter. Although general application of the results of this study can be made to service areas where irrigation is achieved through the household meter, such applications should be made with caution and the knowledge that behavior patterns of water users experiencing such a substitution may be different than those of water users who previously irrigated through a separate irrigation meter.

less, with the potable offset ratio being approximately 1.1; that is, the off-set of 1,000 gallons of potable water will result in reclaimed water use of 900 gallons.

3. If the cost of reclaimed water is 100% of the cost of potable water that would otherwise be used for irrigation, the amount of reuse necessary to offset that potable water demand is less, with the potable offset ratio being approximately 1.3; that is, the off-set of 1,000 gallons of potable water will result in reclaimed water use of 752 gallons.

4. If the cost of reclaimed water is lower than 50% of the cost of potable water that would otherwise be used for irrigation, the amount of reuse necessary to offset that potable water demand is greater, with the potable offset ratio being approximately 0.7; that is, the off-set of 1,000 gallons of potable water will result in reclaimed water use of 1,415 gallons.

5. Availability of amounts of reuse in excess of irrigation demand based upon the above assumptions, will not result in additional reductions in potable quality water usage.

6. Assuming that the cost of reuse is equal to or less than the cost of potable quality water that would otherwise be used for irrigation, the cost of reuse can be a significant factor in evaluation of the potable quality offset affect, as much in determining the quantities of reuse that will be used as a substitute for potable quality water as in determining the amount of reduction in potable water usage that can be expected from introduction of reuse.

We conclude that the answer to the following question regarding reuse substitution for potable quality water will serve to inform the water supply planning process for not only management of the potable quality water resource, but also the reclaimed water resource:

> "How much reuse is *required* to achieve maximum reduction in potable quality water usage, and how much reuse *will be used* after introduction of reuse?

The answer to the first part of the question is included in the first four conclusions and in the Reuse Substitution Table in Section II.A.2.a –Price and Cost. The answer to the second part of the question will be a function of reuse pricing (and its cost relative to the cost of potable quality water that would otherwise be used for irrigation), weather and the other variables identified in this study. Generally, all other variables being equal, the lower the cost of reuse compared to the cost of potable quality water that would be used for irrigation in the alternative, the more reclaimed water will be used[9], even though less reclaimed water may be necessary to achieve reduction of the potable quality water that would otherwise be used for irrigation.

[9] Refer to the Reuse Substitution table in Section II.A.2.a – Price and Cost.

The summary conclusion that can be drawn here is that, as with potable quality water, the price/cost of reuse can be used 1) as a significant factor in managing the amount of reuse that is used, and 2) consequentially as a tool in the management of reuse supply relative to potential demand.

7. This study can serve as an initial guide in estimating the reduction in potable quality water after the introduction of reuse. However, additional studies of the sample accounts included in this study and of other service areas with different characteristics would provide a basis for drawing conclusions across a broader base as to the affects of more of the explanatory variables that can affect irrigation usage as discussed in Section II.A.2 - Significant and Measurable Factors Affecting Reclaimed Water Use and Potable Quality Water Offset.

III. Econometric Modeling

This section presents the econometric modeling that was performed during the study and which served as the basis for the results and conclusions presented in Section II – Summary of Results and Conclusions.

A. <u>Analysis Objectives</u>

The primary objective of the analysis is to provide estimates of the off-set to potable quality water use resulting from the provision of reclaimed water for irrigation. Conversely, the estimate of this potable quality water off-set represents the estimated demand on a reclaimed water system based upon existing potable quality water irrigation and potable quality water and reclaimed water prices.

Understanding the functional relationship between demand and the many factors that influence consumer choices is critical to achieving the objectives of the Analysis. These relationships can be statistically estimated from price and quantity data using econometrics.

Econometrics is the quantitative measurement and analysis of actual business and economic phenomena or the application of statistical methods to the study of economic data. Literally, econometrics means “economic measurement”. The common uses of econometrics include:

1. The description of actual economic relationships,
2. The testing of hypotheses about economic theory, and
3. The forecasting of future economic activity.

Regardless of the objective of economic research, the use of econometric models attempts to quantify economic reality and bring together the elements of economic theory and observed business activity. There are many approaches to obtaining estimates for an econometric model; the type of econometric tool used depends in part on the objectives of the research. While one model could accomplish each of the common uses, it is quite likely that a model developed solely for describing an economic theory is different than a model developed for forecasting the same economic theory.

B. Research Process

There are five major steps in this type of economic research:

1. Review economic literature related to the research subject,
2. Specify the relationships to be studied, tested or predicted,
3. Hypothesize the expected signs of independent variable coefficients,
4. Collect the necessary data to quantify those relationships, and
5. Quantify models with estimates obtained from the observed data.

The processes involved in the first two steps are generally similar for many types of quantitative analysis across a variety of fields of study. The quantification of models (Step 5), however, can differ widely between and within research disciplines. Given a set of data, there are many different alternative approaches to quantifying the same presumed relationships that may provide different results. Individual researchers should weigh the benefits and tradeoffs of each approach given the particular set of data and research question to be answered. While statistics is the science that governs if a certain technique results in a "good", "bad", or "acceptable" model, choosing a certain technique versus another is the "art" of econometrics.

C. Econometrics and Regression Analysis

Researchers conducting econometric studies commonly use *regression analysis* as the primary means of quantifying theoretical economic relationships. Regression analysis is a statistical technique that estimates or "explains" changes in one variable (the dependent variable) as a function of the changes in one or a set of other variables (the independent variables). A common and less complex econometric technique to define, test, and predict an economic relationship is single-equation linear regression analysis using Ordinary Least Squares (OLS). OLS is popular and arguably the most widely used technique as a result of two important benefits:

1. OLS is the simplest of the estimation techniques,
2. The estimated regression line runs through the means of Y (dependent variable) and the set of Xs (independent variable),
3. The sum of the residuals (estimation errors) is exactly zero,

4. The OLS estimation technique results in the minimum sum of squared errors, and
5. OLS is "the best" estimator available under a set of realistic assumptions.

Most other estimation techniques are extensions of OLS or involve complicated non-linear equations or simultaneous estimation models. Provided a single-equation linear regression model does not result in a violation of The Classical Assumptions[10], OLS is the best estimation technique available. Even if minor violations occur given a particular set of data and a single-equation linear regression model, a researcher might choose OLS based on the benefits and tradeoffs involved with more complicated, non-linear, or multi-equation techniques.

Using OLS, regression analysis takes a theoretical equation such as:

$$Y = f(X_1, X_2) \tag{1.1}$$

and uses a set of data containing the dependent variable (Y) and independent variables (X_1, X_2) to estimate the equation:

$$\hat{Y} = ß_0 + ß_1X_1 + ß_2X_2 \tag{1.2}$$

where the constant, ß0, and coefficients, ß1 and ß2, minimizes the sum of the squared differences between the actual Ys and the estimated Ys ($\hat{Y}$s in Equation 1.2).

D. Evaluating Model Results

Evaluating the results of econometric models estimated using OLS should address three general questions:

1. How well do the estimated coefficients conform to expectations?
2. How well does the model as a whole fit the data?
3. Does the data meet The Classical Assumptions?

[10] The Classical Assumptions is a set of fairly basic assumptions required to be true in order for OLS to be considered the best estimation technique. If all assumptions are met in a single-equation linear regression model using OLS, the estimated relationships are considered to be the *b*est *l*inear *u*nbiased *e*stimators (BLUE) available. If one or more of these assumptions are not true, other estimation techniques *may* be better than OLS.

Poor regression results for any of the above questions might result from missing or inaccurate data, incorrectly formulated relationships, or poorly chosen estimating techniques. The process of evaluation is an attempt to identify the possibility of these issues and determine if any corrections or adjustments should be made in order to generate better estimates.

The values of estimated coefficients should at minimum conform to expected sign (+, -) which is often an expression of economic theory. The magnitude of individual coefficients might be a subjective issue that could be confirmed by the regression model and should not be initially dismissed if they are larger or smaller than expected. A result counter to expectations might result from the general errors described earlier, but might also indicate an observed relationship that is counter to theory. Regression results, however, cannot prove causality even if they are determined to be statistically significant.

A regression model should be capable of estimating observations of the dependent variable with some degree of accuracy. The two measures of how well the model as estimated fits the observed values of Y include:

1. The coefficient of determination (R^2), and
2. F-ratio.

In each case, these measures reflect ratios of how well the model does or does not explain the total sum of squares. The total sum of squares is the quantity of squared variations of Y around its mean and is written as:

$$TSS = \Sigma(Y_i - Y_{mean})^2 \qquad (1.3)$$

The coefficient of determination or R^2 is the ratio of the sum of square explained by the independent variables (ESS) to the total sum of squares thus lies between the interval 0 and 1 (see Equation 1.4).

$$R^2 = ESS \div TSS \qquad (1.4)$$

A value of R^2 close to one (1) represents a “good” overall fit; a value close to zero (0) illustrates a “poor” fit. Measures of this type are often referred to a “goodness of fit” measure.

While the coefficient of determination is a measure of the overall degree of fit, the F-ratio is a statistical test of the overall degree of fit of the equation which allows the researcher to accept or reject the overall equation. The F-ratio is adjusted for the number of independent variables (K) and the number of observations in the sample (n) and is defined as:

$$F = (ESS \div K) \div [RSS \div (n - K - 1)] \quad (1.5)$$

The overall fit of the equation is considered statistically acceptable if the computed value of F is greater than a defined critical value.

Evaluating regression models relative to The Classical Assumptions is beyond the intent of this discussion of regression analysis. However, it is incumbent on the individual researcher to evaluate individual regression models for violations of The Classical Assumptions beyond the basic evaluations introduced within this section.

E. Data Types

Data sets are broadly classified according to the number of dimensions being measured. These classifications include 1) time series, 2) cross sectional, and 3) pooled time series-cross section. 'Time series' data is a set of observations on a single metric over multiple time periods. For example, total system water use by month from 2002 to 2008 is a time series. In this example, both value and ordering have meaning and the time series measures only the temporal dimension; observations illustrate changes in water use over time.

A 'cross section' is a data set containing observations on multiple metrics at a single point in time. For example, water use by customer in any month of a particular year is a cross sectional data set. In this example, value has meaning but order does not and the cross section measures only the spatial dimension; observations illustrate the differences in water use between accounts.

'Pooled' data is a combination of time series and cross sectional observations on multiple metrics over multiple time periods. For example, combining data sets of water use by account for multiple time periods in order represents a pooled time series-cross sectional data set. In this example, both value and order have meaning and the pooled data set measures both temporal and spatial dimension; observations illustrate both the differences in water use between accounts and changes over time.

To meet the objectives of this analysis, utility data was pooled in order to estimate household potable water and irrigation water usage based on changes in factors over time and among individual accounts (both temporal and spatial dimensions).

An additional process of data reduction was employed in order to develop the utility data in the form of panel data. Panel data is a specific type of pooled data based on constant consumer units. Pooled data by itself does not control for lapses in consumption over time, changes in the number of consumer units, and changes in the composition of consumer units. A set of observations from the same consumer units over time is referred to as a panel and controls for changes in consumer units.

In each of our utility data sets, prior to pooling consumer units over time, accounts were eliminated based on the following criteria:

1. Accounts with usage gaps,
2. Accounts with the most recent sales transaction past the initial time period of billing data,
3. Accounts with different owners listed on sales deeds compared with existing financial responsibility on the utility bill.

This process of data reduction provides a high quality sample of water use over time that is potentially not influenced by changes in socioeconomic factors. Absence of control of these socioeconomic factors would require these variables to be specified within the regression models.

F. Regression Model Data

This section describes the data used in the econometric modeling and how each type of data was used.

1. Water Use

A total of three utilities within the SJRWMD provided monthly billing records for residential customers covering at least more than one time period between 2002 and 2008. These records for each year generally included the following variables:

- Date bill was issued
- Customer number
- Physical Address
- Subdivision number
- Equipment number
- Metered use (kgal)
- Meter size
- Service (water, sewer, irrigation)

Accounts within these utility data sets were identified at subdivision levels between users with and without access to reclaimed irrigation. The preferable situation was determined to be a subdivision with separate household potable water and irrigation meters that rolled out reclaimed water during the observed history of water use. As a result of these constraints, and the characteristics of each of the utilities that provided data, our analysis utilized subdivision account data from the City of Ocoee data only because it was the only utility that met the above described criteria.

2. Price

It is universally acknowledged that an increase in the price of an *economic* good or service reduces the demand for that good or service (holding all other things constant)[11]. Almost the entire edifice of economics is built on the laws of supply and demand and these relationships are fundamental to the development of economic markets. Markets for public goods and the

[11] The Law of Demand

relationship between price and demand is arguably more complicated, but it is generally accepted that similar market clearing occurs albeit less efficiently.

The impact of the price of water on use is not as universally accepted and is often debated. Until recently, most efforts to reduce the demand for water were focused on non-price initiatives (i.e. marketing campaigns, use restrictions, etc.) because of a general lack of confidence in the ability of price to affect demand. Does the price of water impact how consumers use water?

Intuitively, water as a commodity should be inelastic relative to price (a small change in the quantity demanded resulting from a change in price) because of basic nutrition, hydration, and hygienic requirements with little ability for substitution. But even in cases with high levels of discretionary use (well above basic health needs), the marginal price of water is often unknown and is *very rarely* priced at rates that reflect consumer value. As a result, lower water use from changes in price over time could be difficult to detect and may even be offset by changes in weather and socio-economic factors, fueling the debate of the responsiveness of households to the price of water.

The debate that customers would not respond to higher prices is flawed for two reasons. Foremost, price inelasticity is not synonymous with zero price responsiveness. Although changes are potentially small, water use does decline when real prices increase (holding all other things constant). Second, a market demand curve for most functional forms (other than a horizontal demand curve) is inelastic in some price ranges and elastic in other price ranges. Thus, there are likely higher price ranges at which the demand for water becomes more elastic, even for uses involving health and hygiene. Multiple price increases over time could create more price elasticity even if current demand is observed to be highly inelastic.

3. <u>Weather</u>

The impact of weather on water use is primarily driven by irrigation demands. Net irrigation requirements, measured as precipitation less evapotranspiration is the most accurate measure of weather related changes in water use, specifically irrigation.

Evapotranspiration is the sum of evaporation and plant transpiration. Potential evapotranspiration is the amount of water that could be evaporated or transpired at a given temperature and humidity, if there was plenty of water available. Actual evapotranspiration can not be any greater than precipitation, and will usually be less because some water will run off in rivers and flow to the oceans. If potential evapotranspiration is greater then actual precipitation (reflecting positive net irrigation requirements) soils are extremely dry without irrigation.

Historical weather data was obtained for the utility study area from NOAA for the last 56 years. This set of weather related measurements included the following:

- Average Day Wind Speed
- Cooling Degree Days
- Departure from Normal Temperature
- Average Day Dew-point Temperature
- Heat Degree Days
- Minimum Relative Humidity
- Average Temperature
- Maximum Relative Humidity
- Total Precipitation
- Normal Precipitation
- Departure from Normal Precipitation
- Cumulative Departure from Precipitation (6 months)
- Maximum Temperature
- Minimum Temperature
- Average Day Wet Bulb Temperature
- Days Above Average Daily Precipitation (56 year norm)
- Cumulative Days Above Average Precipitation

The use of the weather data within our regression models does not attempt to calculate evapotranspiration at the account or subdivision level but instead uses the factors of precipitation, temperature, and humidity to roughly estimate the impacts of net irrigation requirements on water use.

4. <u>Regression Models</u>

A total of four regression models were specified for the purposes of estimating potable water use through the household meter and irrigation use through a separate irrigation meter. These models were developed from pooled utility data.

First, models for irrigation consumption were estimated for pre- and post-reuse time periods. Based on the panel data developed from the billing data at the subdivision level, the dependent variables were defined as follows:

- Irrigation Consumption; Pre-reclaimed use (Model A)
- Irrigation Consumption; Post-reclaimed use (Model B)

Each irrigation consumption model was specified in a single-log form with total monthly irrigation consumption as a function of the following:

- Price; inclining block in the pre-reclaimed period and average rate change in the post-reclaimed period (INCL_BLK and PRICE_ST)
- Departure from normal precipitation; current and lagged one month (DEP_NORM PRECIP and DEP_NORM_PRECIP(-1))
- Number of rain days in the month above the 50 year average monthly precipitation (DAYS_ABOVE_AVG)
- Maximum temperature (MAX_TEMP)
- Minimum relative humidity (MIN_REL_HUM)
- Monthly potable water use (POTABLE_USE)

The time series panel data irrigation consumption model specifications for estimation are as follows (Model A and Model B):

```
LOG(IRR_USE) = C(1) + C(2)*INCL_BLK + C(3)*DEP_NORM_PRECIP +
               C(4)*DEP_NORM_PRECIP(-1) + C(5)*DAYS_ABOVE_AVG +
               C(6)*MAX_TEMP + C(7)*MIN_REL_HUM + C(8)*POTABLE_USE

LOG(IRR_USE) = C(1) + C(2)*PRICE_ST + C(3)*DEP_NORM_PRECIP +
               C(4)*DEP_NORM_PRECIP(-1) + C(5)*DAYS_ABOVE_AVG +
               C(6)*MAX_TEMP + C(7)*MIN_REL_HUM + C(8)*POTABLE_USE
```

In order to estimate the cause of the observed increase in potable water use, total potable consumption (pre-reclaimed period includes irrigation use) was estimated with total monthly potable water use as a function of the following:

- Price; real average rate change (REAL_PRICE_LT)
- Prior irrigation use patterns for the period with potable irrigation (IRR_USE*POT_IRR)
- Implementation of reclaimed irrigation (RECL)

The pooled irrigation consumption model specification for estimation is as follows (Model C):

TOT_POTABLE_USE = C(1) + C(2)*REAL_PRICE_LT + C(3)*(IRR_USE*POT_IRR) +
C(4)*RECL

Finally, the panel data of irrigation consumption was estimated over both the pre- and post-reclaimed period (Model D). This model was specified in a double-log form with monthly irrigation use as a function of the following:

- Price; real average rate change (REAL_PRICE_LT)
- Prior period irrigation use (PRIOR_IRRIGATION_USE)
- Market value of dwelling (VALUE)
- Departure from normal precipitation; current and lagged one month (DEP_NORM PRECIP)

The pooled irrigation consumption model specification for estimation is as follows (Model D):

LOG(IRR_USE) = C(1) + C(2)*PRICE + C(3)*LOG(PRIOR_IRR_USE) + C(4)*VALUE + C(5)*
DEP_NORM_PRECIP

Each model was estimated using ordinary least squares (OLS) estimation (see Appendix A).

G. Summary of Results

Overall, the models provide reasonably good overall fit and were observed to be statistically significant with no major violations of the assumptions of OLS. The functional form of each model was not adjusted and variables were not excluded based on low relative *t* scores.

Price and weather were consistently observed within the models to be estimated with the correct sign and with statistically significant *t* scores. Price elasticity estimates consistently ranged between -0.2 and -0.6 measured from each regression model (see Table 1).

Table 1 – Irrigation Consumption and Responsiveness to Price and Weather

	Irrigation Consumption	
	Pre-	Post-
Period	2002:1-2005:5	2005:5-2008:8
Average consumption (gal)	9,490	9,950
Price elasticity	0.16 - 0.58	0.19 - 0.54
Change in irrigation from 1% change in…		
Potable use (gal)	0.46%	-0.04%
Precipitation (in)	-0.28%	-0.29%
Rain days above average	-0.10%	-0.16%
Tempurature (^{o})	1.95%	3.39%
Humidity (%)	-0.55%	-0.13%

In addition to the responsiveness of irrigation demand to price and weather, the relative level of potable water usage was estimated to have a significant, positive impact on irrigation consumption in the pre-reclaimed period. This suggests that a high relative indoor water consumer (potable water through the household meter) would also be a high outdoor water user, holding all else constant. This might be more a condition of attitude since price is accounted for within the model.

Based on absolute change between the pre- and post-reclaimed period, weather impacts in the post-period have the biggest impact on overage irrigation consumption. Specifically, drier than normal weather (also reflected by higher average temperature and lower relative humidity) in the post-reclaimed period is estimated to have impacted average irrigation consumption per account by nearly 1,300 gallons per month. This increase in demand was off-set by slightly more than 800 gallons per month per account decrease as a result of price increases between the two periods, specifically the implementation of inclining block rates (see Table 2).

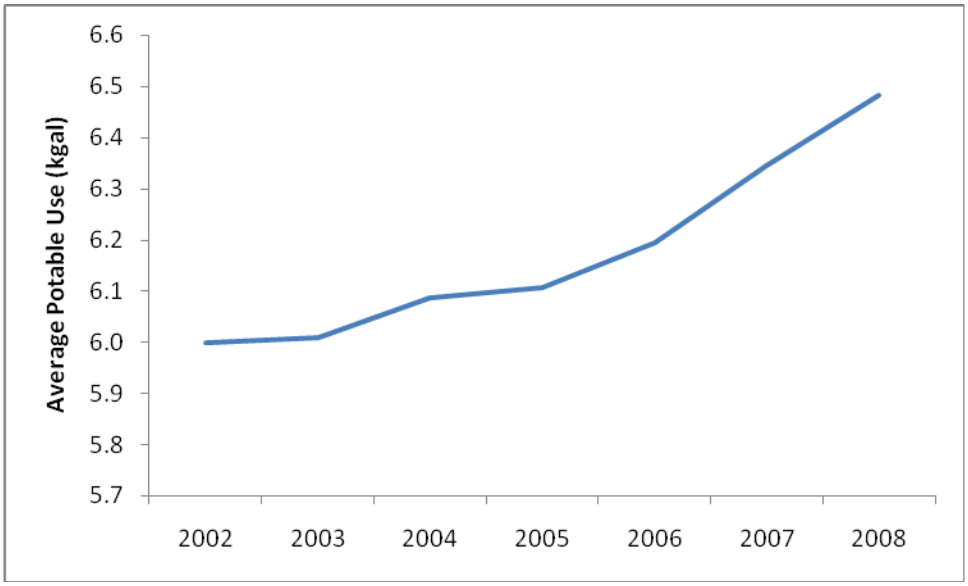
Table 2 – Irrigation Consumption Cause of Change

Pre-reclaimed irrigation consumption (avg gal)	9,490
Cause of change:	
Price	(811)
Potable use	(16)
Precipitation	612
Rain days above average	38
Temperature	516
Humidity	80
Unquantified variance	42
Subtotal	460
Post-reclaimed irrigation consumption (avg gal)	9,950

Potable water off-set from Reclaimed (without price impacts)	
Pre-reclaimed irrigation consumption (avg gal)	10,510
Period-over-period adjustments for weather & other	(1,460)
Adjusted post-reclaimed use	9,050

Adjusting both periods for changes in price and holding weather constant, average irrigation consumption changed from 10,510 per month per account in the pre-reclaimed period to 9,050 per month per account in the post reclaimed period. At face value, this would imply a potable off-set of only 86% for each gallon of reclaimed irrigation consumption. However, the regression model for potable water use through the household meter using the panel data suggested a roughly 10% increase in potable water use through the household meter after the implementation of reclaimed irrigation (from average monthly use of 6,000 gallons per month per account to 6,600 gallons per month per account), holding price and prior irrigation patterns constant (Model C). This trend of increased potable water use through the household meter is observed in average potable water use that illustrates a significant rate of change in the post-reclaimed period after 2004 despite the switch from a uniform to an inclining block rate structure (see Figure 1).

Figure 1 – Average Potable Consumption



This phenomena possibly suggests barriers to acceptance of reclaimed water for irrigation purposes, a shift of outdoor water use through an irrigation meter to a potable water household meter, consumers managing overall water budgets and changing indoor water use habits, or water conservation efforts not captured within the model.

Irrespective of the actual cause of this change in behavior, it would appear more prudent to estimate an off-set of potable water use less than a ratio of 1:1 to account for these potential net impacts. Adding the observed and estimated net increase in potable consumption to the change in pre- and post-reclaimed irrigation results in an estimated off-set ratio of approximately 90%. In other words, holding all else constant, our models imply that a 1,000 gallon increase in reclaimed irrigation use would off-set potable water demand by 900 gallons.

An additional factor affecting potable water off-set is the cost of the reclaimed water. Within this panel, the reclaimed water rates were set at 75% of potable water. Based upon the price elasticity findings of the econometric modeling, Table 3 provides an estimate of the reclaimed water demand relative to 1,000 gallons of potable irrigation water demand at varying costs points of reclaimed water compared to the cost of potable water that would be alternatively used for irrigation. The range of price elasticity from 100% relative cost to 25% relative cost was estimated based on the limited ability to significantly change indoor water use habits even with significant reductions in overall water charges.

Table 3 – Potable water off-set per 1,000 gallons or reuse

1,000 gal Potable Demand Equates to Reclaimed Demand at Varying Cost Points….

Reclaimed Cost Relative to Potable Cost	Reclaimed Water Demand
100%	752
75%	900
50%	1,049
25%	1,415

The Appendix to this report presents outputs of the econometric models described in this section.

APPENDIX - Model Outputs

The following pages of this Appendix present the outputs of the models described in Section III – Econometric Modeling.

Model A – Irrigation Consumption; Pre-reclaimed water use

Dependent Variable: LOG(IRR_USE)

Method: Least Squares

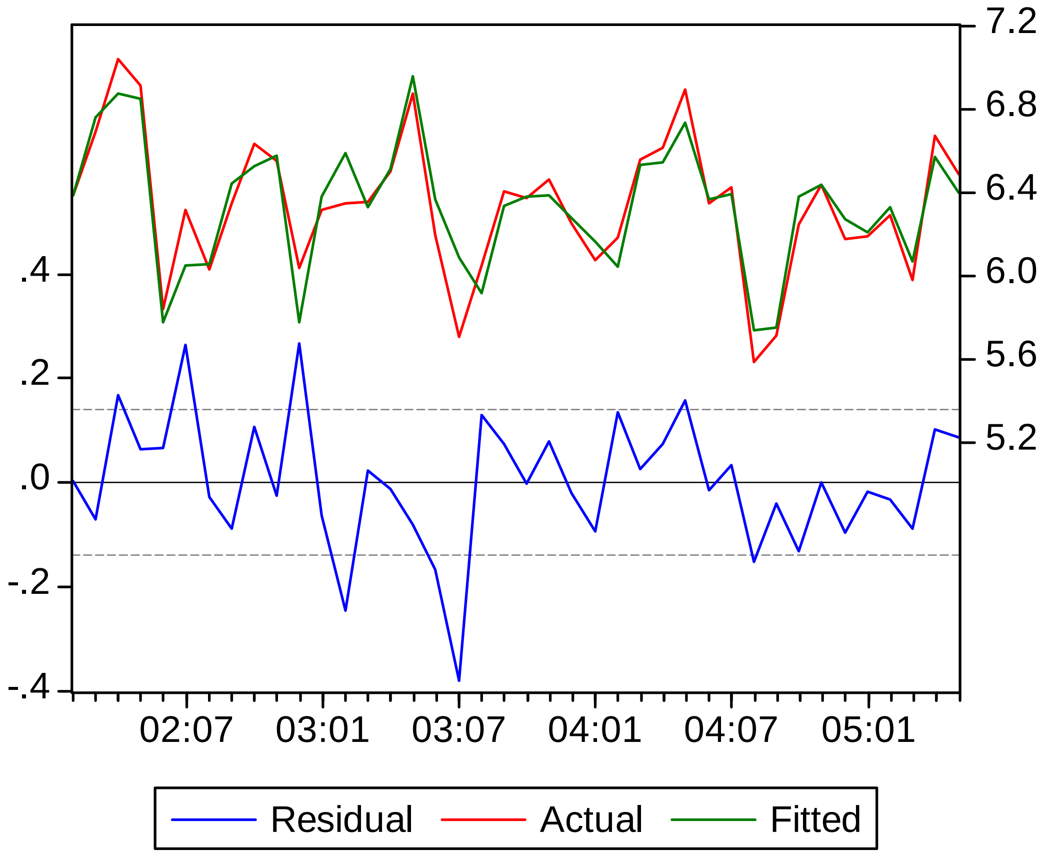
Sample(adjusted): 2002:02 2005:05

Included observations: 40 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.1728	0.4029	12.8388	0.0000
INCL_BLK	-0.2088	0.0473	-4.4128	0.0001
DEP_NORM_PRECIP	-0.0005	0.0001	-5.0941	0.0000
DEP_NORM_PRECIP(-1)	-0.0001	0.0001	-1.4457	0.1580
DAYS_ABOVE_AVG	-0.0204	0.0104	-1.9660	0.0580
MAX_TEMP	0.0217	0.0036	6.0723	0.0000
MIN_REL_HUM	-0.0112	0.0052	-2.1708	0.0375
POTABLE_USE	0.0012	0.0008	1.6312	0.1127

R-squared	0.8537	Mean dependent var	6.3360
Adjusted R-squared	0.8217	S.D. dependent var	0.3279
S.E. of regression	0.1385	Akaike info criterion	-0.9393
Sum squared resid	0.6137	Schwarz criterion	-0.6015
Log likelihood	26.7851	F-statistic	26.6705
Durbin-Watson stat	1.8542	Prob(F-statistic)	0.0000

Model A – Irrigation Consumption; Actual and Fitted



Model B – Irrigation Consumption; Post-reclaimed water use

Dependent Variable: LOG(IRR_USE)

Method: Least Squares

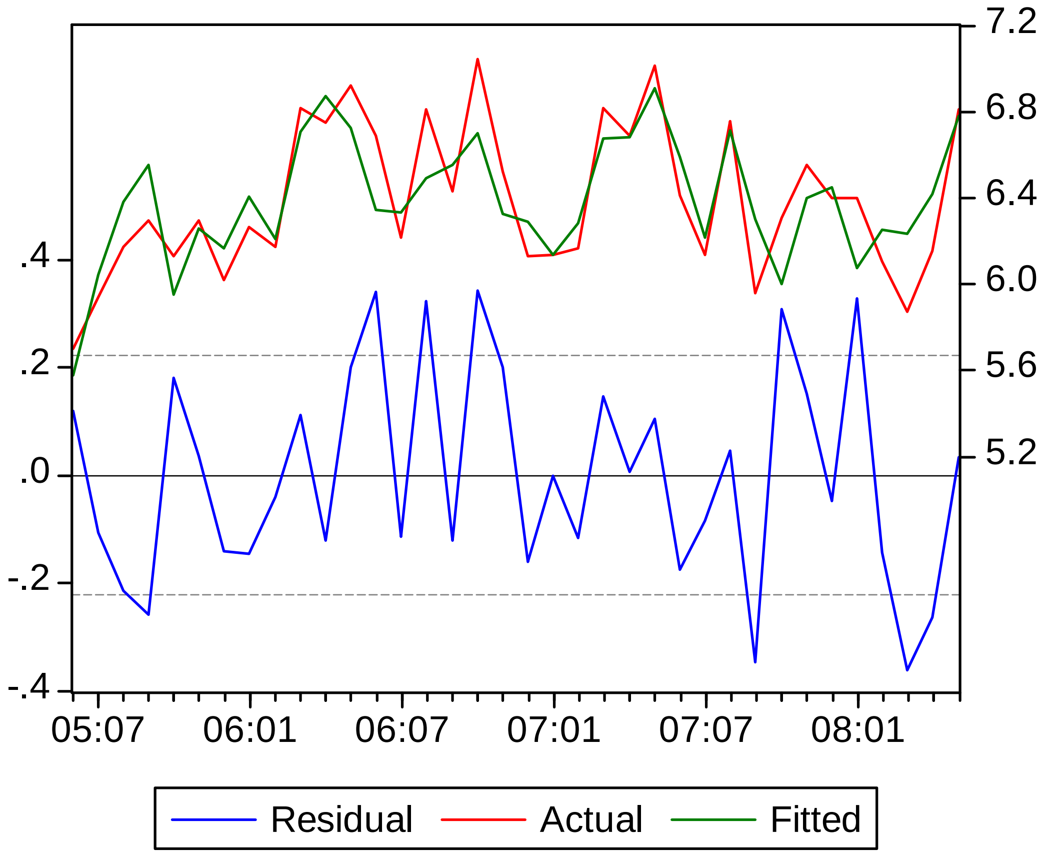
Sample: 2005:06 2008:05

Included observations: 36

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.5260	1.3516	3.3485	0.0023
PRICE_ST	-0.4703	0.9723	-0.4837	0.6324
DEP_NORM_PRECIP	-0.0005	0.0002	-2.4499	0.0208
DEP_NORM_PRECIP(-1)	-0.0003	0.0002	-1.9194	0.0652
DAYS_ABOVE_AVG	-0.0325	0.0201	-1.6152	0.1175
MAX_TEMP	0.0350	0.0076	4.6267	0.0001
MIN_REL_HUM	-0.0040	0.0076	-0.5253	0.6035
POTABLE_USE	0.0003	0.0010	0.3057	0.7621

R-squared	0.6746	Mean dependent var	6.3884
Adjusted R-squared	0.5932	S.D. dependent var	0.3465
S.E. of regression	0.2210	Akaike info criterion	0.0116
Sum squared resid	1.3672	Schwarz criterion	0.3635
Log likelihood	7.7918	F-statistic	8.2918
Durbin-Watson stat	2.1042	Prob(F-statistic)	0.0000

Model B – Irrigation Consumption; Actual and Fitted



Model C – Total Potable Consumption; Pre- and Post-reclaimed water use

Dependent Variable: TOTAL_POTABLE_USE

Method: Least Squares

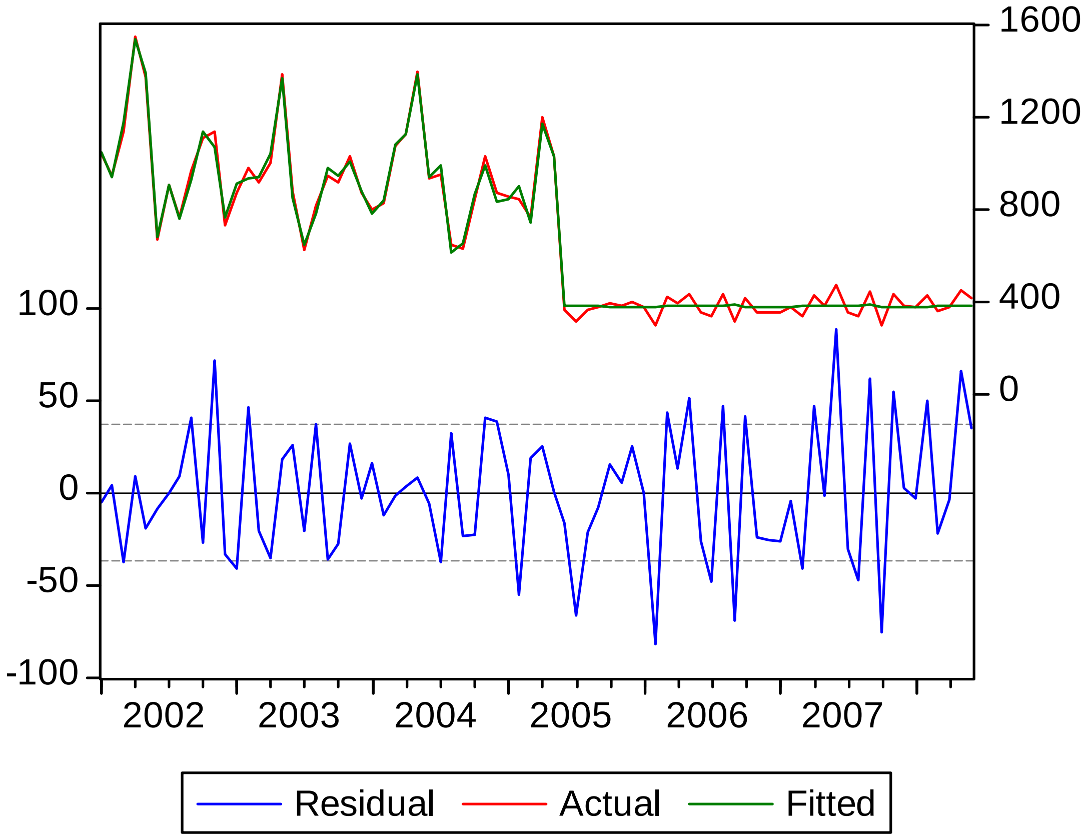
Sample(adjusted): 2002:01 2008:06

Included observations: 78 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	797.1103	412.1439	1.9341	0.0569
REAL_PRICE_LT	-499.6301	430.5997	-1.1603	0.2497
IRR_USE*POT_IRR	1.0816	0.0313	34.6081	0.0000
RECL	59.1483	19.3145	2.9886	0.0038

R-squared	0.9880	Mean dependent var	683.5513
Adjusted R-squared	0.9876	S.D. dependent var	329.8717
S.E. of regression	36.7946	Akaike info criterion	10.0985
Sum squared resid	100184.2	Schwarz criterion	10.21936
Log likelihood	-389.8414	F-statistic	2038.3000
Durbin-Watson stat	2.6255	Prob(F-statistic)	0.0000

Model C – Potable Consumption; Actual and Fitted



Model D – Irrigation Consumption; Pooled pre- and post-reclaimed

Dependent Variable: LOG(IRR_USE)

Method: Least Squares

Sample(adjusted): 62 420

Included observations: 358

Excluded observations: 1 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.3419	0.2370	5.6615	0.0000
PRICE	-0.2511	0.2877	-0.8726	0.3834
LOG(PRIOR_IRR_USE)	0.6203	0.0381	16.2989	0.0000
VALUE	0.0000	0.0000	1.9325	0.0541
DEP_NORM_PRECIP	-0.0011	0.0003	-3.4075	0.0007

R-squared	0.4667	Mean dependent var	2.2875
Adjusted R-squared	0.460627	S.D. dependent var	0.509663
S.E. of regression	0.3743	Akaike info criterion	0.8864
Sum squared resid	49.4572	Schwarz criterion	0.9406
Log likelihood	-153.6630	F-statistic	77.2200
Durbin-Watson stat	1.6016	Prob(F-statistic)	0.0000

Model D – Potable Consumption; Actual and Fitted