WATER CONSERVATION EVALUATIONS WITHIN THE CONTEXT OF REGIONAL WATER SUPPLY PLANNING IN FLORIDA

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INTRODUCTION

EZ Guide 2.0 (EZG) has been developed as a water conservation analysis tool for Florida public water utilities (PWUs). It generates an optimal mix of water conservation BMPs that meets target goals such as a specified maximum gallons per capita per day or an economic criterion of maximizing total benefits minus total costs as seen from the perspective of the utility. A water budget is a vital tool in water planning. EZG includes a water budget for a recent year that is calibrated against measured water use data for that same period. The initially assumed water use estimates are adjusted to match the measured values. The purpose of this paper is to describe how EZG can be used to help utilities and water management districts develop regional water supply plans that are based on parcel-level data that provide the basis for a bottom-up assessment that integrates nicely into the existing approaches.

EVOLUTION OF REGIONAL WATER SUPPLY PLANNING IN FLORIDA

State legislative actions in 1997 launched regional water supply planning initiatives in Florida. Carriker (2006) presents an overview of Florida's growth management programs. Water management districts (WMDs) were charged to conduct water supply assessments and identify areas of concern in terms of undesirable impacts of water development activities. Regional water supply plans (RWSPs) need to be developed for identified areas of concern. These water supply plans identify how water supply needs can be met for the next 20 years. Local governments that are within RWSP areas need to develop 10-year water supply facilities work plans that include alternative water supplies, water reuse and conservation programs. These work plans are incorporated into the local government's comprehensive plans. The initial RWSPs were developed in 1998 and have been updated about every five years. The WMDs have divided their service areas into planning regions and RWSPs have been developed for these regions as needed. Jackson (2006) presents the general sequence of recurring events in the adaptive management process for regional water supply planning in South Florida Water Management District.

A. Regional water supply plan is updated

B. Within six months, local governments are notified of projects recommended in plans

C. Within twelve months of District notification, local governments tell the District what projects they will implement

D. Within 18 months after RWSPs are approved, local governments submit 10-year Water Supply Facilities Work Plan to Florida Department of Community Affairs.

E. Local governments report annually to the District by November 15 on progress in implementing projects

The Florida Department of Community Affairs (FDCA) is the State's land planning and community development agency. The department ensures that new growth and established communities comply with the State's growth management laws. The Division of Community Planning within FDCA evaluates whether communities have adequate roads, schools, water, parks and sewer facilities for their residents. Water Supply Planning is one program within the Division of Community Planning.
(**http://www.dca.state.fl.us/fdcp/dcp/WaterSupplyPlanning/index.cfm**)

FDCA requires each local government to adopt an evaluation and appraisal (EAR) report every seven years that assesses progress in implementing the local comprehensive plan. The content of these plans is as follows:

A. Not subject to a regional water supply plan
    a. Develop a 5 year schedule of capital improvements
    b. Update the Conservation Element of the land use plan
    c. Update the Intergovernmental Coordination Element
B. Subject to a regional water supply plan
    a. Do the above three items
    b. Indicate status of implementation of the Infrastructure Element
    c. Indicate extent of identifying alternative water supply projects and conservation and reuse programs
    d. Update the comprehensive plan as needed

The Office of Water Policy in DEP is responsible for regional water supply planning (http://www.dep.state.fl.us/WATER/waterpolicy/rwsp.htm). The Office of Water Policy provides guidance to the water management districts as they develop their regional water supply plans. DEP produces an annual progress report on the Regional Water Supply Planning program (FDEP 2010). This report provides a good overview of the current status of this planning process. According to the 2010 FDEP report, regional water supply planning is required in most parts of Florida. Florida's water management districts are responsible for water supply planning, flood control, stormwater management, and compliance of the water element of the comprehensive plans of local governments. WMDs regulate the amount of raw water that can be withdrawn from a water source through the consumptive use permit process. FDEP regulates the operating capacity of each water treatment facility that processes the raw water.

The next sections of this paper describe some of the ways that EZG can enhance our current capabilities in evaluating selected important aspects of regional water supply planning.

EZ GUIDE EVALUATIONS OF SELECTED FACTORS IN REGIONAL WATER SUPPLY PLANNING

The purpose of this section is to illustrate how results from EZ Guide can provide useful input to regional water supply planning evaluations. The included items are a sample of the useful results.

Population Estimates to Calculate Gallons per Capita per Day

The Florida DEP and the water management districts have established uniform statewide methods of measuring gallons per capita per day (gpcd) for public water supplies (Anonymous 2008). Two different measures are used:

- Uniform gross per capita
- Uniform residential per capita

Estimates of gpcd are used for water use planning and forecasting, water use permitting, water conservation, WMD use reports and program evaluation, public communication, and research and analysis (Anonymous 2008). Population can be estimated based on the number of dwelling units and the number of people per dwelling unit. EZG provides disaggregated data from FDOR on number of dwelling units for single family (SFR) and multi-family (MFR) residential categories. SFR units are relatively easy to estimate since each occupied SFR parcel contains a single dwelling unit. MFR is more complicated to analyze since there are multiple units per parcel.

According to the 2007 DCA guidelines, local governments must base their population projections on the mid-range population projections developed by the University of Florida Bureau of Economic and Business Research (BEBR) unless an alternative method has been approved. The projections are made for 20 years with 5 year reporting increments. BEBR population projections are made for counties and cities, not public utilities. Water use data is available for utilities, not cities. Thus, it is necessary to apportion BEBR projections down to the utility level. Friedman et al. (2010) have developed methods using FDOR and U.S. Census data to obtain accurate estimates of the number of MFR dwelling units and the associated persons per dwelling units. This refinement allows partitioning the most important residential water use into SFR and MFR dwelling units and the associated persons per house. These estimates can be done for the entire state of Florida or any desired level of aggregation ranging from parcels on up to the entire State. Results for the entire State are shown in Table 1. The number of parcels is tabulated for each of the FDOR residential land use categories. Single family residences comprise the majority of the residential parcels. There is one residential unit per residential parcel. Multi-family parcels are more complex since it is necessary to determine the dwelling units per parcel. However, this data is provided in the same FDOR parcel-level files. Thus, an accurate estimate of dwelling units is obtained. The availability of correct utility boundaries is critical to accurate assessments (Cornejo et al. 2010).

Table 1. Illustration of bottom-up approach to estimate the population of the state of Florida.

DORUC	FDOR stratum	FDOR description	Total parcels	Dwelling units/ parcel	Dwelling units	Persons/ dwelling unit	2009 Population
1	Single family res.	Single Family Residential	4,860,912	1.00	4,860,912	2.5	12,152,280
2	Single family res.	Mobile Homes	445,582	1.00	445,582	2.5	1,113,955
3	Multi-family res.	Multi-family – 10 units or more	14,064	53.04	746,022	2	1,492,044
4	Single family res.	Condominiums	1,568,927	1.00	1,568,927	2	3,137,854
5	Single family res.	Cooperatives	40,759	1.00	40,759	2	81,518
6	Multi-family res.	Retirement Homes	576	40.45	23,297	2	46,594
7	Multi-family res.	Miscellaneous residential	26,972	1.00	26,972	2	53,944
8	Multi-family res.	Multi-family – less than 10 units	161,698	1.88	304,058	2	608,116
28	Commercial	Mobile home parks	15,481	4.66	72,105	2	144,210
		Total	7,134,971	1.13	8,088,634		18,830,515

Information on the persons per dwelling unit was developed from several sources (Friedman 2009). These persons per dwelling unit can be adjusted to calibrate the population estimate to match with the U.S. Census estimate. The selected persons per dwelling unit is 2.5 for single family residential and 2.0 for multi-family residential. The U.S. Census estimates that the 2009 population of Florida was 18.8 million people. The key information generated by the EZG analysis is the number of parcels and the number of dwelling units. This bottom up approach to estimating population is being used by Southwest Florida WMD (GIS Associates 2008). The Conserve Florida Water Clearinghouse (CFWC) can provide the parcel and dwelling unit data for individual utilities if an accurate GIS estimate of the service area is provided. This information uses census block population level estimates of persons per dwelling unit that are disaggregated to separate single from multi-family units (Friedman et al. 2010)

Inventory of Reuse and Private Irrigation Wells

Florida is the national leader in reuse with a reported reuse of 36.8 gallons per capita per day (gpcd). California is a distant second with an average of 2.4 gpcd of reuse (Florida DEP 2010). Private irrigation wells are popular in Florida. Based on a survey of 3,521 home in Florida, Whitcomb (2005) found that 28% of them use private wells, 4% use surface water sources, and 3% use reclaimed water for irrigation. These percentages vary widely from city to city, e.g., the range for 16 cities was 0 to 74% using private wells. Unfortunately, it is often difficult to obtain accurate data on the number of customers who are not using utility water for irrigation. Thus, alternative methods may be needed. The most accurate and direct way to estimate the portion of utility accounts that use alternative sources of irrigation water is to have this information recorded in the billing database but this information may be unavailable. The most direct way to evaluate irrigation water use patterns for customers on the public water supply system is by evaluating customers with a separate irrigation meter.

Palenchar et al. (2009) describe how billing data can be evaluated to classify single family residential customers into irrigators and non-irrigators served by Gainesville Regional Utilities (GRU). One year of monthly data on single family residential (SFR) water use was obtained from GRU for the period from October 2007 to September 2008 for 1,402 dual metered and

29,504 single metered residential customers. The monthly water use patterns for GRU customers with dual and single meters are shown in Figure 1 for this year. The monthly results show the dramatic differences between indoor and outdoor water use patterns across the year for dual and single metered customers. Mean indoor water use varies little from month to month and averages about 177 gallons per account per day (gpad) for both dual and single meters. Peak indoor water use patterns are very similar for dual and single meter groups with an average of 200 gpad. However, major differences exist between average and peak water use patterns for dual and single meter customers.

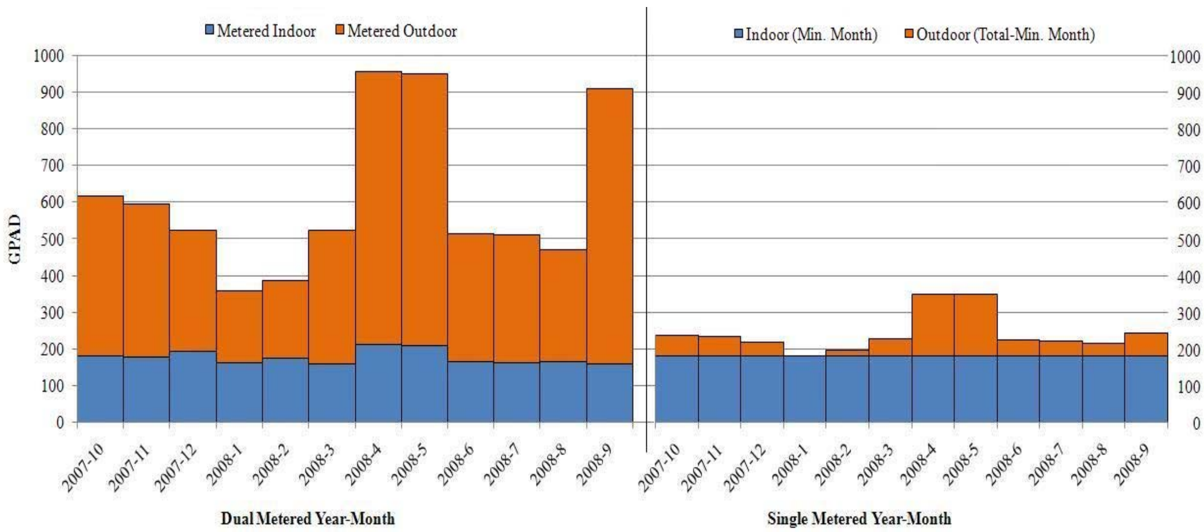

Figure 1. Average indoor and outdoor water use for 1,402 dual metered (left figure) and 29,504 single metered (right figure) residential accounts in Gainesville, Florida.

A direct way to estimate the offline customers has been developed using billing data for a year or two to infer from the time series signatures of the water use patterns how many customers appear to be using water only for indoor purposes. Single family residential users can be grouped into categories that are of interest using a k-means clustering algorithm. This analysis was performed using XLSTAT© Version 2009.4.03 (Addinsoft 2009). Each data point is the mean and standard deviation of monthly water use for the customer. The mean gives a direct measure of the size of the water use whereas the standard deviation measures the variability in water use for each customer. Thus, offline irrigation users would be expected to have a monthly water use pattern similar to the indoor water use shown in Figure 1 with relatively low mean and variability. The mean indoor water use is directly proportional to the persons per house. The users were divided into the following three clusters: 1) larger users with higher variation, 2) medium users with medium variation, and 3) smaller users with lower variation. We hypothesize that cluster 3 members correspond to customers who are using other sources of irrigation water or that they have no or minimal demand for irrigation water.

The results of the clustering for all of the 1,402 dual meter and 29,504 single meter customers are shown in Figure 2 and Table 2. Nearly 71% of the SFR customers have little or no irrigation. Thus, it would be counterproductive to target this group for irrigation retrofits. On the other hand, the top 5% to 10% of the users are the prime candidates for switching to alternative water sources. In this case, significant savings could be achieved albeit for only a small portion of the users.

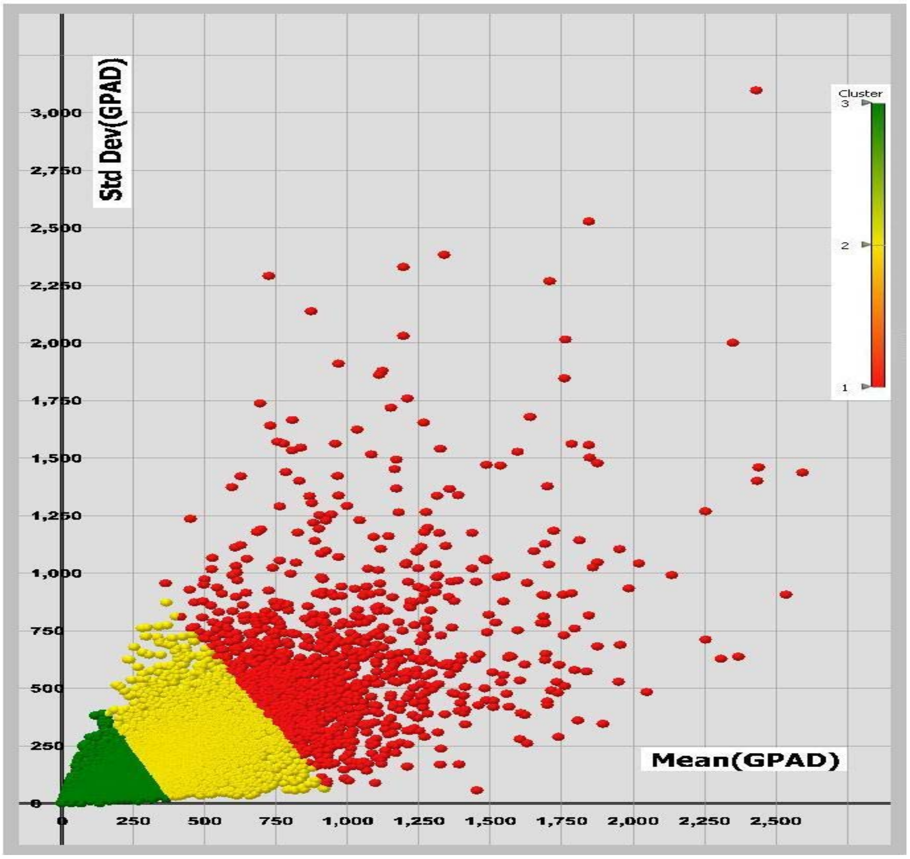

Figure 2. Results of clustering the 30,906 GRU SFR customers into three categories: 1 (upper irrigation), 2 (mid-range irrigation), and 3 (minimal irrigation/offline) (Palenchar et al. 2009).

Table 2. Statistics of the membership in each cluster (Palenchar et al. 2009).

Irrigation Group	Mean GPAD	Standard Deviation GPAD	% of SFR Customers	% of SFR Water Use
Minimal/Offline	156	65	70.6%	42.5%
Mid-range	434	233	25.3%	42.4%
Upper	949	598	4.1%	15.1%
Total			100.0%	100.0%
Average	259			

The ability to identify the proportion of users who are not using the public supply for irrigation is a major factor in being able to understand the nature of the water use profile for a given utility. It also provides key insights into the target market for outdoor irrigation BMPs. EZG provides default estimates of the proportion of users who are not using the public supply for irrigation based on the GRU case study. These estimates can be changed to reflect local conditions using the procedures shown if data is available.

Commercial, Industrial, and Institutional Water Use

Morales et al. (2011) describe methods to evaluate commercial, industrial, and institutional (CII) water use as a function of heated area and an associated water use coefficient for utilities in Florida. Accurate heated area estimates are available for every parcel in Florida. The water use coefficients are based on parcel level CII estimates from two utilities in Florida. This information is pre-populated for users of EZ Guide. Morales and Heaney (2010) focus on commercial water use, the largest of the CII sector, and provide more detailed water use coefficients that allow users to estimate base and seasonal use in addition to average use. Users can also estimate commercial water use during the peak month of May. May is typically the peak month across all users primarily due to higher irrigation demands associated with lower precipitation. Water use coefficients and heated areas also vary over time. Data are presented for three periods: pre-1983, 1983-1994, and 1995 to present. These three periods correspond to the implementation of indoor water conservation regulations in Florida that were enacted in 1983 and 1994. A sample result from an EZ Guide water budget for a South Florida utility is shown in Figure 3. In this case, the total per capita water use is partitioned into seven components that more accurately reflect the relative importance of each water use sector. Water use coefficients for each sector are expressed in terms of monthly gallons of water used per square foot of heated area a shown in Figure 3. These monthly water use rates are fairly similar. The main driver of total water use is the heated area that varies widely from sector to sector. These heated areas are estimated accurately in EZ Guide.

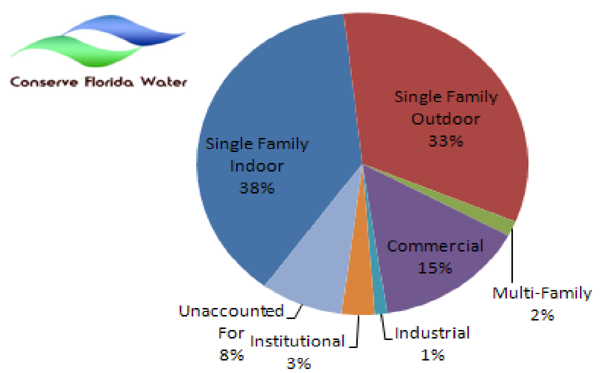

Figure 3.2.1 Calibrated Water Budget by Sector

Table 3.2.1 Percentage and gpcd Summary by Sector

Sector	% of Total Water Use	Breakdown of Gross gpcd	Breakdown of Gal/Htd. Sq. Ft./Month
Single Family	71.3%	95	5.01
Single Family Indoor	38.2%	51	2.68
Single Family Outdoor	33.1%	44	2.32
Multi-Family	1.6%	2	0.96
Commercial	14.7%	20	4.72
Industrial	1.2%	2	0.78
Institutional	3.2%	4	3.38
Unaccounted For	8.0%	11	0.37
TOTAL	100.0%	134	4.65

Figure 3. EZ Guide 2 water budget for a water utility in South Florida (Morales and Heaney 2010).

The next stage in the CII analysis was to estimate the end uses in order to generate an end use inventory. The results of the first phase of this analysis that estimates basic domestic uses are presented in Morales et al. (2010). Information from the Florida building and plumbing codes was used to estimate plumbing requirements as a function of heated area and the expected number of occupants. This information was combined with literature sources to estimate the frequency of uses. CII water use varies seasonally due not only to irrigation but also to seasonal business cycles that are affected strongly by tourism patterns. Irrigation should be less important for the CII sector since much of this higher valued land is developed for building and associated parking. Data are available on which commercial parcels have automatic sprinklers. This information was used to cluster commercial parcels into irrigated and non-irrigated. Significant differences in water use exist in water use for these two categories. These results allow commercial water use to be partitioned into base use, seasonal use, and irrigation use.

Nature of Changes in Water Use Patterns

A new feature of EZG is the inclusion of a calibrated water budget for a recent year (Cornejo et al. 2010). This calibration exercise provides valuable insights into how water was used during a test year. The Profile section of EZG displays a tabular and graphical summary of water use from 1999 to present. Water utilities in Florida have been conducting water demand management programs including water reuse and water loss control at least since 1990. One question that arises is to explain the nature of observed changes in water use during the past two decades. Florida DEP provides monthly average and peak daily water use data from January 1999 to the present. The Clearinghouse provides direct access to this data for interested users. The illustrative analysis presented in this section uses the 1999 to present data.

Water use trends for Gainesville Regional Utilities (GRU) from January 1999 to present are shown in Figure 4. Average and peak water use have been fairly stable with a significant decrease in daily peak water use and a general decline in average water use since mid 2007.

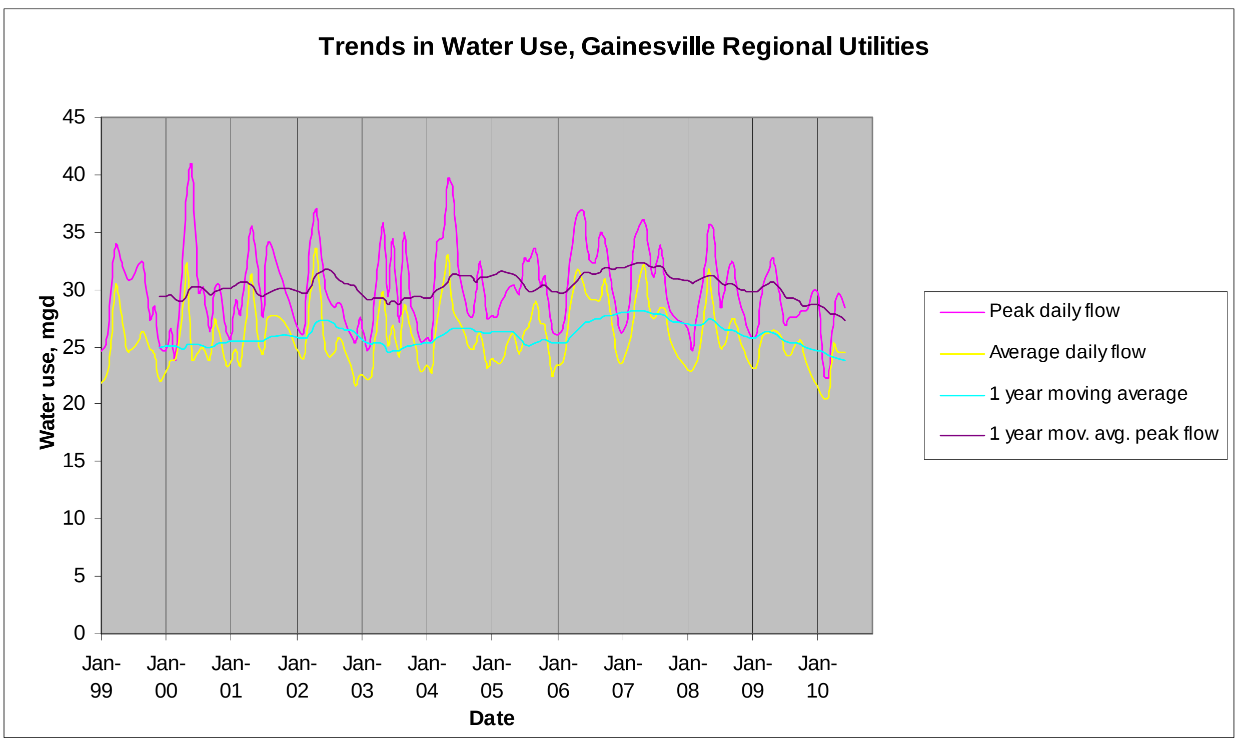

Figure 4 . Monthly trends in water use for Gainesville Regional Utilities for 1999 to early 2010.

A variety of reasons can be offered as to why water use patterns are changing. These causative factors can be divided into two major categories: exogenous-outside of the control of the utility, and endogenous-within the control of the utility. Some examples of these factors are shown below:

- Illustrative exogenous factors
  - Climate, e.g., precipitation patterns
  - Changing land use, e.g., number and mix of residential and non-residential land use
  - Economy, e.g., recent recession
- Illustrative endogenous factors
  - Local plumbing regulations, e.g., required use of high efficiency toilets
  - Lawn watering restrictions e.g., restrictions on days per week
  - Incentives/disincentives to switch to reuse or private wells for irrigation

Exogenous-Impact of Climate

Annual precipitation in Gainesville, Florida for the last 110 years is shown in Figure 5. These long-term precipitation data are available from the Florida Climate Center at Florida State University (http://coaps.fsu.edu/climate_center/data/precip_gainesville.shtml). The long-term average annual precipitation for Gainesville is 51.51 inches. The average annual precipitation for 1999 to 2009 is 44.84 inches, the lowest of the past ten 11-year periods. The second driest 11 year period was 1977 to 1987 with an average annual precipitation of 48.54 inches. The 1999-2009 period also included three of the top ten driest years since 1900: 1999 (38.34 inches), 2000 (34.35 inches), and 2006 (35.43 inches). Finally, hurricane-related rainfall in August and September of 2004 of 30.77 inches was the wettest consecutive two month period since 1900. Other factors equal, one would expect per capita water use to increase during the past 11 years due to record low precipitation.

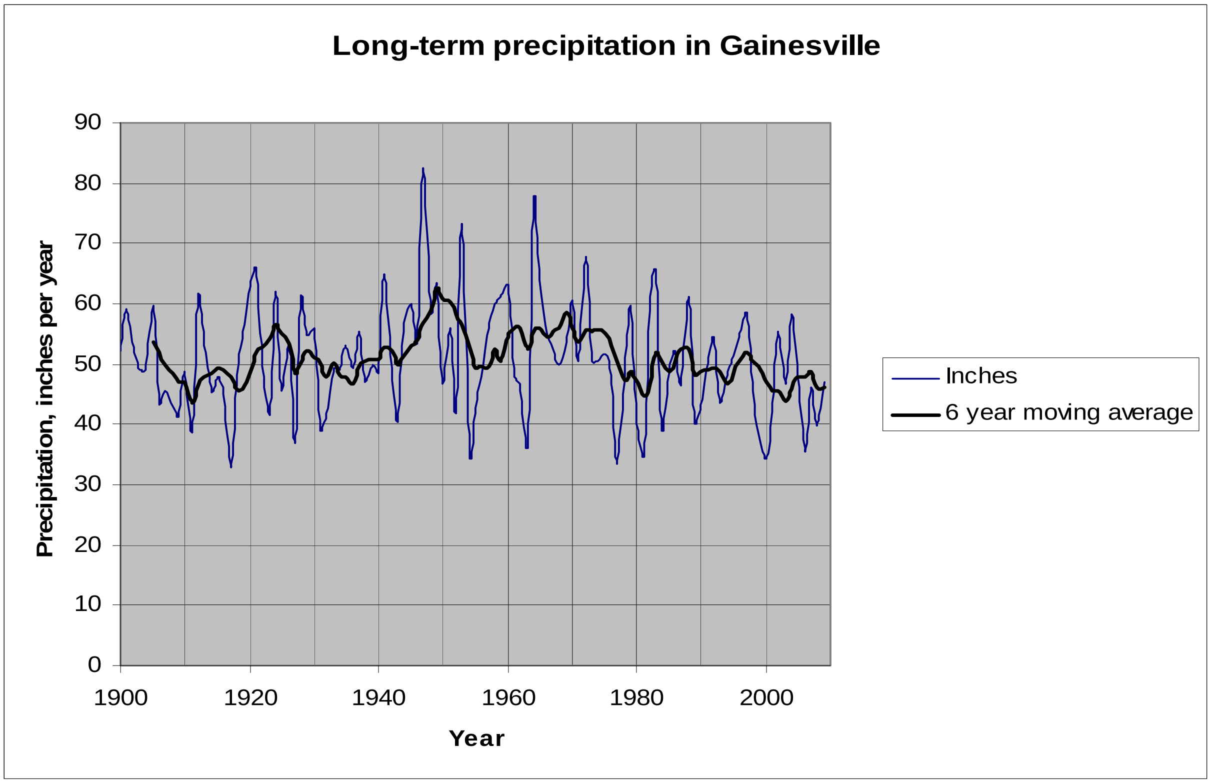

Figure 5. Annual precipitation in Gainesville Florida from 1900 to 2009 based on data from the Florida Climate Center (2010).

Exogenous-Number of Accounts

Estimates of the number of accounts from the FDOR database indicate a growth of over 22% from 1999 to 2007 while total water use has been declining.

Exogenous-Economy

Demand for commodities including water depends on the price of water, the income of the individual, and the availability of substitutes. The responsiveness of customers to changes in water rates has been studied extensively (Green 2003, Griffin 2006). However, less is known regarding the effects of changing income on water use. Green (2003) argues that income elasticity can be more important than price elasticity in affecting water use. The recent economic downturn may be affecting water demand. The unemployment rate for Gainesville that is shown in Figure 6 can be used as a measure of the income effect. Unemployment for Gainesville remained fairly constant at about 3% from 2000 to 2006. However, it has risen rapidly since 2006 to its current level of 9%. This increase in unemployment occurred during the same time as water use began to decline. EZG does not currently incorporate these economic effects on water usage.

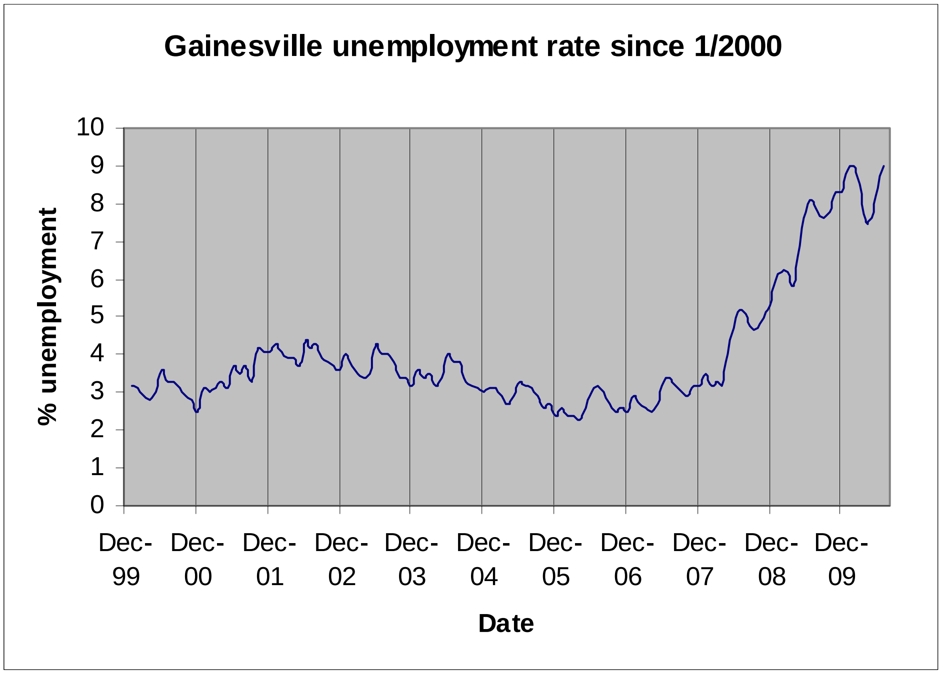

Figure 6. Trends in unemployment in Gainesville, Florida based on data from the Bureau of Labor Statistics
http://data.bls.gov/PDQ/servlet/SurveyOutputServlet?series_id=LAUMT12235403&data_tool=Xgtable

Endogenous-Plumbing Code Changes

Two significant changes occurred in plumbing standards in 1983 and 1994 which affected residential water use (SFWMD 2004). In 1983, Chapter 553, F.S., was modified, lowering the maximum allowable flow rates for water fixtures in new construction to a maximum use of 3.5 gallons per flush for toilets and a flow rate of 3.0 gallons per minute (gpm) for showerheads. Prior to this state legislation, the typical volume of water for toilet flushing was 5.0 gallons and showerhead flow was 5.0 gpm. In 1994, new plumbing standards for water use were implemented under the Federal Energy Policy Act of 1992, setting national plumbing code standards of 1.6 gallon per flush for toilets, 2.5 gpm for showerheads and 2.0 gpm for faucets.

EZG provides time series data on the number of accounts based on the effective year built provided by FDOR. An example is shown in Figure 7 for single family homes in Gainesville Regional Utilities (GRU). For GRU, the oldest home without significant modification dates back to 1920. EZG tabulates the number of accounts in three periods: pre-1983, 1983 to 1994, and 1995 to present. If service life is ignored, then the blend of SFR accounts in these three categories stays the same except for adding the new accounts for the most recent year. EZG accounts for service life by assuming a fixed service life of n years. After n years, the fixture is replaced with the standard fixture that is available unless the utility offers an incentive to purchase a more water efficient fixture. For example, a 5.0 gallon per flush (gpf) toilet that was installed in 1950 with a 40 year service life would be replaced in 1990 with a 3.5 gpf toilet. This toilet would be replaced in 2030 with a 1.6 gpf model. Because annual data are used, this method results in a smooth transition from older to newer fixtures. The result of this analysis is an estimate of the changes in per capita water use due to plumbing fixtures. Overall, indoor water use for new homes is expected to decline from about 70 gpcd prior to 1994 to 40 gpcd with state of the art fixtures, a major improvement.

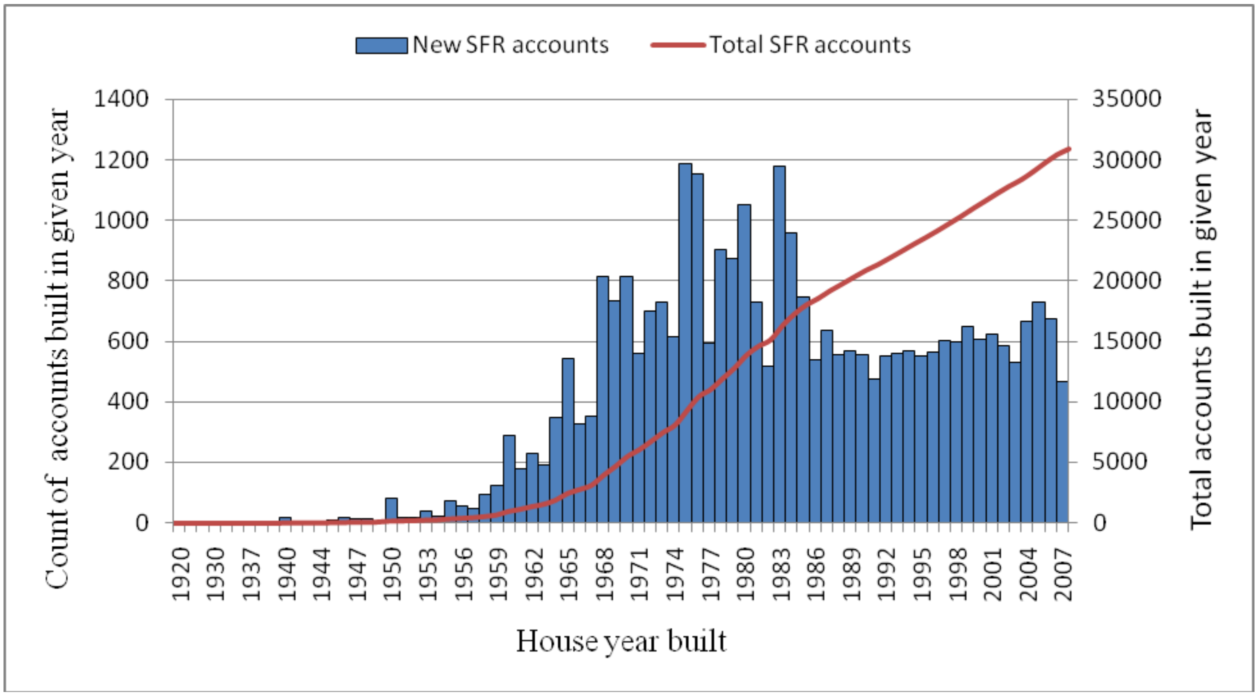

Figure 7. Number of new single family residences served by Gainesville Regional Utilities from 1920 to 2007.

Endogenous-Lawn Watering Restrictions

The response to lawn watering restrictions depends on a variety of factors including the extent of the restrictions and the associated level of enforcement. An excellent opportunity exists now to evaluate the impact of large-scale implementation of year round watering restrictions in the state of Florida, e.g., once a week watering during the winter months and twice a week watering during the summer months.

Endogenous-switching customers to reuse or private wells

From a water budget perspective for the public utility, switching customers to reuse or private wells to provide their outdoor water needs will result in a significant reduction in water use if they previously had an automatic sprinkling system as described earlier. Other factors need to be considered in evaluating whether this is a good idea overall.

Methods of Analysis

Explaining the nature of urban water use that is driven by a variety of exogenous and endogenous factors is a challenging task. Two related approaches are being taken to address this problem:

- Time series and regression analysis to remove the non-water conservation factors and then do a final cause-effect analysis of the residual time series along the lines described in Mays and Tung (1991)
- Process simulation and optimization model that provides a daily time step simulation of water demand over multiple years using a water budget approach that incorporates rainfall-runoff relationships from associated stormwater models, e.g., (Lee and Heaney 2005)

An important feature of the ongoing analysis using both of these approaches is that systems can be analyzed at any desired level of aggregation of customers. For example, it may not be possible to see the effect of a retrofit of 1,000 toilets in a utility that has 50,000 toilets but it may be possible to see the impact by focusing on the billing data for the 1,000 toilets that have been retrofitted. EZG will incorporate these approaches in the future.

SUMMARY AND CONCLUSIONS

Water conservation analyses are done for a variety of applications including consumptive use permitting, regional and statewide water supply planning and conservation effectiveness tracking, EZ Guide 2 uses a bottom up approach based on data at the individual parcel level for every parcel in the state of Florida. This approach provides a unique capability to do in-depth water conservation analyses that provide a data driven approach to doing rigorous evaluation of water conservation and how it can be an integral component of an urban water supply management program. Illustrative applications to water supply planning are described to demonstrate these capabilities.

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