Conservation and Drought Water Rates:

State-of-the-art practices and their application

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Project developed for UF Water Institute and Conserve Florida Water Clearinghouse

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I. Introduction

As Florida continues to balance the need for growth with protection of its natural resources, scientists and policy makers look more closely at the problem of balancing water use and water resources available. Two approaches can be used by water managers to achieve this balance. The first is supply increase through the use of traditional or alternative water sources. However, alternative water sources are often associated with high cost (such as desalination of ocean water), low reliability (such as seasonal variations in surface water storage), water quality concerns (reclaimed water), or environmental degradation (e.g., due to withdrawals of water from surface water sources).

The second approach is water demand management, which focuses on increasing water use efficiency and water conservation in the short and the long term (Baumann and Boland 1997). Currently, water conservation is seen as "…the most important action we can take to sustain our water supplies, meet future needs, and reduce demands on Florida's fragile water-dependent ecosystems" (FDEP 2008). Demand management strategies include educational programs, financial incentives for voluntary water use reduction (e.g., for installing water-efficient home appliances and fixtures), mandatory restrictions in water use imposed by water agencies, leak detection, and price incentives through conservation water pricing. This paper focuses on conservation pricing, which is included in recommendations made for a drought resistant Florida by Conserve Florida work groups (FDEP 2007), and suggested by the Florida Section of American Water Works Association as a strategy to achieve the Florida 2030 vision of elimination of the "…wasteful, uneconomical, impractical or unreasonable use of water resources" (Section 373.227, F.S., cited by FSAWWA 2008).

II. Study Objectives

The overall purpose of this synthesis paper is to identify and summarize state of the art conservation and drought pricing practices, and explore the challenges and opportunities associated with conservation pricing. The paper is designed to be a contribution to the Conserve Florida Collaborative Research Agenda. The paper is also meant to serve as a reference for utilities and regulatory professionals. There two specific objectives are:

1) to review state of the art practices for conservation and drought rate design;
2) to identify research gaps and needs for future research.

III. Methods

The primary method used in this study is literature review. About 90 academic publications, government reports, industry articles, and relevant privately or publicly funded studies conducted in the various US states and in other countries have been reviewed for this study. In addition, this study incorporates information obtained through informal contact with utility and regulatory agency representatives.

IV. Results

A. Types of Water Rates

Water rates are the mechanism through which utilities generate revenue to cover economic costs and finance expansion. In this document and in the literature analyzed, "water rate" usually refers to the rate per unit of water (e.g., thousand gallons or cubic meter) charged by utilities. "Rate structure" usually denotes the change in the water rates as water use increases. "Fee" usually refers to a payment that is independent from the amount of water used, such as a connection fee. However, many literature sources use the words "fee", "charge", "tariff", "price" and "rate" interchangeably.

The most basic type of water charge is a fixed fee (sometime referred to as "fixed rate"). With fixed fees, users pay a set amount regardless of water usage. This is usually a monthly fee, although it can be weekly, biweekly, bimonthly, or quarterly. The advantage of fixed fees is that they are easy for utilities to administer and easy for customer to understand. Their disadvantage is that they provide no incentive for customers to conserve water.

With volumetric rates (also referred to as "variable charges"), consumers are charged in proportion to their water usage. For example, a volumetric rate for residential users might be $5 for every 1000 gallons. Volumetric rates are generally charged on a monthly basis, depending on billing software and frequency of reading dates. The precondition for a utility to use a volumetric rate is the ability to meter customer water usage.

Most utilities use a combination of fixed fees (also referred to as "base charges") and volumetric rates. These "hybrid" charges are appealing to utilities because the fixed component can be used to cover fixed costs, such as infrastructure costs and capital expenses, while the volumetric component can be used to cover variable costs, such as labor and pumping costs. A residential hybrid rate structure can, for example, charge each household $10 a month regardless of usage and $5 for every 1,000 gallons used. Some utilities include a minimum amount of water consumption with their base charge. That is, volumetric rates take effect only when a customer uses more than the minimum included in the base charge. Table 1 lists different water rate structures and briefly explains them.

Table 1. Summary of alternative water rate structures

Rate	**Definition**
Fixed	Each user pays a fixed fee each month that does not change with the volume of water use
Declining block	Unit price for the last unit of water used decreases as usage increases from one water usage block to the next
Drought or Water Shortage	Water rates are higher during the times of drought or water shortage
Inclining Block	Unit price for the last unit of water used increases as usage increases from one water usage block to the next
Indoor-Outdoor	Prices for indoor use are lower than prices for outdoor use (does require separate metering)
Excess-Use	Price are higher for above-average use
Hybrid	Combination of several designs, most commonly inverted block and fixed; some utilities employ a hybrid of increasing and decreasing blocks where rates increase or decrease for specific targeted blocks of consumption
Marginal Cost Pricing	Rates that represent the marginal cost of water production
Marginal Opportunity Cost Pricing	Rates that represent the marginal cost of water production, plus the expected cost of water supply capacity expansion
Penalties	Charges customers pay for exceeding allowable limits of water use
Reclaimed	Separate rate for reclaimed water
Seasonal	Water rates are higher during the season of higher demand (usually during peak outdoor usage) than during the off-peak season
Sliding-Scale	Unit price for all water use increases as water usage increases
Spatial Pricing	Users pay for the actual cost of supplying water to their establishment. Customers “inside” a utility’s political jurisdiction usually pay less.
Scarcity Pricing	Cost of developing new supplies is paid by existing users
Time-of-Use	Water rates are higher during peak hours or days of the week
Uniform	A volumetric rate that is constant regardless of usage.
Water Budget	Inverted block rate structure in which the blocks are defined uniquely for each customer, based on an efficient level of water use for that customer

Source: Beecher et al. 1994; Mayer et al. 2008; Nida and Eskaf 2009; Raftelis 2005; Stallworth 2003

In addition to base and volumetric water charges, many utilities in Florida use separate base and/or volumetric sewage/wastewater charges to cover those services. These charges are different from water rates; however, they are often included on customer water bills based on water usage.

B. Conservation Water Rate Structures

B1. Definition of "Conservation Water Rate Structure"

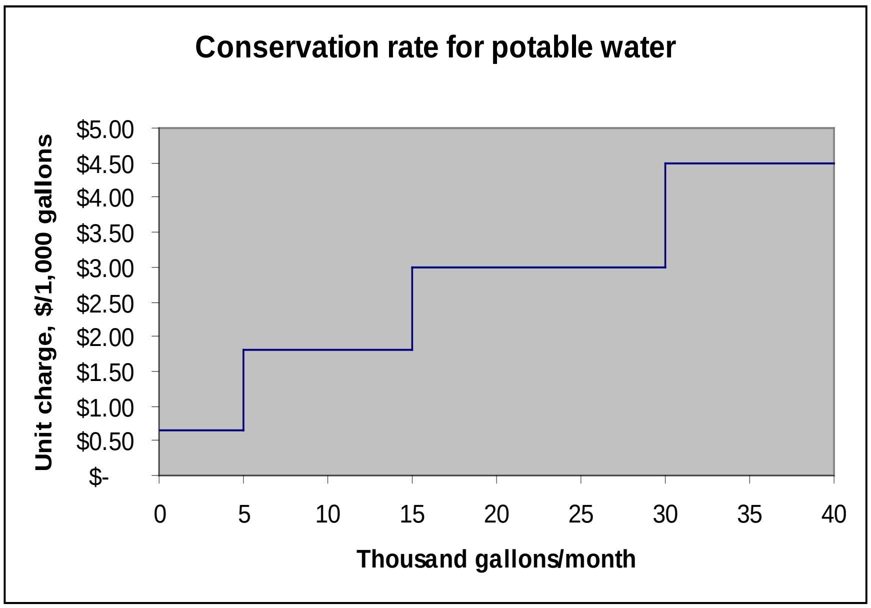
Generally, any rate structure that provides an economic incentive to conserve water is considered a conservation rate structure. On a more technical level, studies present different requirements to conservation rate structures, focusing on the following main characteristics: (1) the structural form of the volumetric water rates; (2) the proportion of volumetric charge in the total customer bill; (3) the proportion of utility revenues recovered through fixed fees versus volumetric rates; (4) effective communication of the price signal through consumer billing (see, for example, AWE 2008, Beecher et al. 1994, and Minnesota DNR 2008).

Structural form of the volumetric rates. By their structural form, conservation rates are usually associated with uniform, declining block, inclining block, and seasonal volumetric rate structures (often referred to as uniform, declining block, inclining block, or seasonal rates) (see Table 1). With a uniform rate, the user pays a set charge for each unit of water used. Uniform rates have the advantage of being relatively simple to administer and easy for the customers to understand. Uniform rates also send the customers a usage price signal, since the total water bill increases with increase in water consumption (AWWA 2000).

With declining block rates (also known as descending or decreasing block rates), the charge paid per unit of water decreases at certain usage thresholds. For example, the rate may be $3.00 per 1000 gallons for the first 10,000 gallons used, and only $2.00 per 1000 gallons for all additional usage. Usage volumes up to such threshold form a "price block" (also referred to as "tier"). The declining block rate volumetric structures are often used by utilities that need to develop a single rate schedule for various customer classes served. Such structure can allow utilities take into account the different costs and usage characteristics of all customers while remaining equitable to all of them. For example, an initial block can be designed to recover costs associated with the volumetric use of residential and small commercial customers, and subsequent blocks can be selected to encompass the water use and associated demand costs of industrial customer class (AWWA 2000). Declining block rates can be used when utilities costs decline with increasing water usage (due to economies of scale), and when it is important to provide price incentives to encourage large-volume customers to remain on the system (instead of developing their own source of supply by drilling a well, for example) (AWWA 2000). Declining block rate may also be used by utilities that need to encourage economic development (Childs and Kramer 2008).

With an inclining block volumetric rate structure (also known as increasing, inverted, ascending block rates), price for additional units of water increases at certain water use thresholds (Figure 1). For example, the rate may be $2.00 per 1000 gallons for the first 10,000 gallons used, and only $3.00 per 1000 gallons for all additional usage.

Figure 1. Example of an Inclining Block Rate Structure



Source: McLarty and Heaney (2008).

Inclining block volumetric rate structures provide stronger disincentive to use large quantities of water in comparison with uniform and declining block rate structures, and as a result, this structural form is most commonly presented as a "conservation rate structure". However, inclining block rate structures are difficult to design and administer, since they require analysis of the water volumes sold per price block and demand responses to price differentials between the blocks (AWWA 2000). Utility-wide application of inclining block rate structures can also result in "…cost-of-service inequities, especially to commercial and industrial customers… These customers may not impose costs on a water system proportional to the costs implied by increasing block rates" (AWWA 2000, p. 99-100). Furthermore, if significant cost-recovery depends on those consuming in the higher blocks, changes in demand (due to unusual weather patterns, changes in population demographics, or changes in income) can lead to revenue shortfalls. Advantages and disadvantages of conservation water rates will be discussed in more details in the following sections.

Economic incentives to conserve water created for the customers by an inclining block rate structure depend on the size and the number of the price blocks. The literature provides limited recommendations for the design of inclining block rate structures. Chestnutt and Beecher (1998), focusing on efficiency as the focus of rate design, recommend selecting rate structure in such a way that the price of the last unit of the water consumed is equal to the additional (i.e. marginal) costs of new supplies. Minnesota DNR (2008) recommends the increase in price between the price blocks to be 25% or more, with 50% increase between the last two blocks. Alliance for Water Efficiency (2008) recommends selecting the first price block such that minimum water usage is provided to a typical household at a minimum reasonable price, and setting the price increase between the blocks to be greater than 50%. Further, "an effective rate design will have more than half of residential customers exceeding the first tier when the new rate structure is first implemented, and at least 30% and 10% of customers using water in the 3rd or 4th tiers respectively (at least during seasonal peak demand)" (AWE 2008). However, Nida and Eskaf (2009) examined the rate structures used by North Carolina utilities and showed that for majority of utilities, the first price block exceeds typical residential use. That is, the rates are effectively uniform for the water usage below 15,000 gallons per month, and majority of customers are unaffected by the higher price blocks. Similarly, in Georgia, Environmental Finance Center (2007) reports that "a customer that reduces their consumption by 40% from 10,000 to 6,000 gallons/month is likely to receive the same reward, both in terms of total bill reduction and percent bill reduction, whether they are being charged increasing block or uniform rates" (p. 3).

With respect to the number of price blocks, Alliance for Water Efficiency (2008) suggests that 3 to 4 blocks are adequate for an effective residential rate design, and a nation-wide survey of water utilities by AWWA and Raftelis (2006) shows that for the surveyed utilities that use increasing block rate structures for residential water supply, the average number of blocks is 3.8.

Nation-wide surveys of water utilities indicate the drop in the use of declining block rate structures for residential water services, and an increase in the use of inclining and especially uniform rates (Table 2). In Florida, out of 16 utilities surveyed by Whitcomb (2005), 6 utilities used uniform and 10 used inclining block rates for residential customers in 1998 (Whitcomb 2005). In 2008, from the same sample of utilities, 3 used uniform, and 13 used inclining block rate structures (see table A1 in Appendix A).

Table 2. Water Rate Structures for Residential Water Services: Results from Nation-Wide Surveys.

	1996	1998	2000	2002	2004	2006
Declining block	36%	35%	35%	31%	25%	24%
Uniform	32%	34%	36%	37%	39%	40%
Increasing block	32%	31%	29%	32%	36%	36%

Source: AWWA and Raftelis (2006).

In the 2006 survey conducted by AWWA and Raftelis (2006), over 73% of the responding water utilities indicated that they have the same volumetric structure for residential and non-residential customers. The authors note that even under the same volumetric rate structure, the exact rates are not necessarily identical for residential and non-residential customers. Utilities that reported different volumetric rate structures generally shift from an increasing block rate structure for residential customers to a uniform or declining block rate structure for non-residential customers. For example, 36% of utilities have an increasing block rate structure for residential customers, but only 23% have an increasing block rate structure for non-residential customers (AWWA and Raftelis 2006). Wang *et al*. (2005) describe two utilities that experiment with conservation pricing for their non-residential customers. In Cleveland (OH), inclining block rate structure is used for industrial consumers, nearly doubling the price from the first block to the next. Louisville Water Company (KY) uses a “pyramid block structure” that includes a low rate per thousand gallons for both relatively small customers and very large customers, while intermittent heavy users (such as restaurants) face higher water rates. “It is likely not accurate, however, to consider pyramid block rates to be water conservation-oriented rates, as they result in the highest consumers within the commercial class paying less per unit that those who use less” (Wang *et al*. 2005).

Some utilities increase their rates or implement a new rate structure during specific seasons of peak use (seasonal rates) or times of droughts (drought tares), to provide additional incentives for water conservation. Of the 231 utilities surveyed by AWWA and Raftelis (2006), 36 reported that they use seasonal rates. More in-depth discussion of drought rates is presented in section 4.7.

Some utilities are also experimenting with rate structures based on individual household water budgets. "Water budget-based rate structures are also very effective in promoting conservation, though more difficult to implement. In this design, each residence has an inclining block rate structure designed according to its individual needs. The tiers are usually set based upon the quantity of occupants and the square footage of landscape; known to be the two most significant factors in residential water use. The prices of the tiers increase significantly (greater than 50%) after the base usage tier is established. This rate system requires a robust billing system to accommodate the quantity of individual rate structures (possibly equal to the quantity of customers); and the system requires a formal process to establish each homes base water usage, and respond to the many customers likely to appeal their base tier allotment " (AWE 2008). Establishing base water usage requires a judgment on what is equitable for each household, and how to define base tire allotment without "penalizing" customers who already use low water volumes (due to investments into water efficient home fixtures or due to house characteristics such as the lack of ground irrigation system) (source: based on D. Bracciano, personal communications).

Publically available modeling tools are being used to help utilities make informed rate design decisions. See "Decision Support Tools" in Appendix B for more information.

The proportion of volumetric water charges in the total customer bill. In addition to volumetric rates, almost all utilities charge fixed fees (also referred to as base, minimum, monthly, or meter fee or charge) that are the same each billing period regardless of usage. The fixed fee is almost always based on meter reading, billing, and collection costs. Many utilities also include meter repair and replacement costs and a capacity charge in their fixed fee (AWWA and Raftelis 2006). The Alliance for Water Efficiency suggests that conservation rates should be designed so that a large portion (two-thirds or more) of the water charges are based on the quantity of water the customer consumes (AWE 2008). According to the data from the nation-wide survey by AWWA and Raftelis (2006), the monthly fixed fee for the median customer

($5.84) comprises 29.3% of the total water bill (1000 cubic feet or 7.5 thousand gallon of water usage).

In addition to water charges, many utilities include wastewater charges in the total customer bill. Wastewater charges are typically based on a percentage of a customer's monthly water use (AWWA and Raftelis 2006). As a result, wastewater charges make the customers pay more for the non-discretionary water uses in comparison with the discretionary uses (effectively converting an inclining block into a declining block rate structure), and distort the economic incentives to conserve water created by conservation water rates. For example, Gainesville Regional Utilities (Florida) assess residential customers a wastewater charge of $4.94 per thousand gallons, based on average monthly water usage or winter maximum water use, whichever is lower. Consider a hypothetical household that uses 6 thousand gallons per month in winter. This household would pay $6.53 per thousand gallons for their first six thousand gallons ($4.94 of wastewater charge plus $1.59 of water charge), and only $1.59 per thousand gallons for any additional water use. If this household's consumption exceeds nine thousand gallons, the water rate would still be only $3.11 per thousand gallons (up to twenty five thousand gallons), much below the rate for the non-discretionary water use (GRU 2008a, GRU 2008b).

The proportion of utility revenues that is recovered through fixed versus volumetric charges. In 2007, the California Urban Water Conservation Council established specific guidelines for what constitutes a conservation rate (McLarty and Heaney 2008).   To meet California's conservation rate criteria, at least 70% of monthly utility revenue must come from volumetric rates (McLarty and Heaney 2008).

Effective communication of the price signal through consumer billing. To influence water demand, the conservation pricing must be understood by customers. Households should be able to estimate changes in their water bills corresponding to increases (or decrease) in water usage. The estimates of the effects of information campaign on consumer response to price signal varies from study to study. For example, Gaudin (2006) report increase in consumer responsiveness to price signals by up to 30%. In contrast, Carter and Milon (2005) found that the knowledge of the rates for additional units of water (i.e., marginal price) result in the increase in monthly water consumption. The authors hypothesize that the households tend to over-estimate their marginal water rates, and hence, they increase water consumption in response to the knowledge of the accurate marginal rates.

The survey of customers of sixteen Florida utilities conducted by Whitcomb (2005) showed that 39% of respondents are not knowledgeable about water rate structures (i.e., number, size, and prices of the blocks). At the time of the survey, only five of the sixteen participating utilities printed their water rates on their bills; this practice partially explains this lack of customer knowledge (Whitcomb 2005). Analysis of 1997 survey of customers of three North-Central Florida utilities by Carter and Milon (2005) shows that higher monthly income, larger household size, home ownership, larger lawn area, and awareness of nonprice conservation programs increase the likelihood of knowing the marginal price. Households facing block rate structures, however, are less likely to know the marginal price.

B2. Effectiveness of Conservation Rates

Price elasticity of demand. Responsiveness of the water use to rate is measured through the price elasticity of demand. Price elasticity is defined as the percent change in water consumption in response to the certain percent change in price (rate). "The most likely price elasticity range for long-term overall (indoor and outdoor) residential demand is -0.10 to -0.30, with price elasticity coefficients for long-term industrial and commercial demand ranging up to -0.80" (AWWA 2000, p. 158). This means that for residential customers, a 10% increase in rate (given current rate level) will most likely result in reductions in water usage within the range of 1% - 3%.

Price elasticity depends on a variety of factors, such as: the value of subsidies available to consumers; the size of wastewater and fixed charges in customer bills; percent of total income spent on water; price of water from alternative water sources (such as private wells); length of time over which rates and water demands are evaluated; climate and weather events; initial water rates against which the elasticity is measured; customer class (e.g., residential, commercial, or industrial); type of water use (indoor vs. outdoor); season and time of the day (peak vs. off-peak periods); geographical region; customers' knowledge of their water rates; presence of other conservation programs; and customer education programs (AWWA 2000; Carter and Milon 2005; Cavanaugh, *et al*. 2002, Dalhuisen *et al*. 2003, Espey *et al*. 1997; Howe 2002; Howe and

Goemans 2002, Wang *et al.* 2005). Price elasticity appears to rise with an increase in rate levels (AWWA 2000). Also, water use is more responsive to the change in real prices (adjusted for inflation), than in nominal prices (not adjusted for inflation) (AWWA 2000). The rates for the additional unit of water (i.e., marginal water price) are low in US (e.g., Cavanagh *et al*. (2002) cite the marginal price of $0.50 to $5.00 per thousand gallons). The average monthly bill for an "average" US customer (with about 7500 gallons of monthly usage) is $20.24 (AWWA and Raftelis 2006), which is a small portion of average US household income. Such low rates explain (at least partially) the small response in household water consumption to price increase (Cavanagh *et al*. 2002). However, "price levels sufficient to induce significant water savings are politically and socially controversial" (Cavanagh *et al*. 2002, p. 6).

Generally, water demand for outdoor discretionary uses (such as lawn watering, car washing, and swimming pools) is more elastic than the demand for non-discretionary indoor water uses. In Florida, there is less outdoor discretionary water use during late fall and winter when water use for irrigation decreases and the demand for water may be less responsive to price changes during that season. Further, "peak usage is more price-sensitive than off-peak usage" (AWWA 2000, p. 159). Customers who know their marginal price are more responsive to changes in prices (Carter and Milon 2005). Price elasticity is greater when measured over the long period of time (more than 3 to 5 years) (e.g., Carter and Milon 2005). The presence of marginal price information on the bill next to quantity consumed increases price elasticity (by a factor of 1.4, according to Gaudin 2006). Further, when water restrictions are implemented, consumers can be less responsive to rate changes (Kenney *et al.* 2008). High water users are generally more responsive to price than low water users (Kenney *et al*. 2008). Low income households are significantly more price responsive in comparison to the relatively wealthy households reflecting the larger share of water bills in the low income household budget (Agthe and Billings 1987, Dalhuisen *et al*. 2003, Renwick and Archibald 1998). Based on the analysis of 64 studies and 314 price elasticities, Dalhuisen *et al*. (2003) shows that price elasticity estimates vary depending on geographical regions of US, so that "price elasticities are greater in absolute value in the arid West" (p. 306), which may be related to more significant water use for discretionary purposes (irrigation).

Rate structures themselves can affect consumer responsiveness to rate changes (Kenny *et al.* 2008). Cavanagh *et al.* (2002) and Nieswiadomy and Molina (1989, cited by Nauges and Thomas 2000) found that price elasticity among households facing uniform marginal prices appears to be significantly smaller than among households facing block structure. "If a household knows that higher levels of use result in higher prices, it will be more sensitive to price" (Cavanagh *et al.* 2002, p. 27).

The differences in price elasticity estimates reported in existing studies can also be partially explained by the differences in the methodologies employed by the authors, specifically, the spatial and temporal level of data aggregation, period of time over which the elasticity is evaluated, price of water considered (average or marginal), and specific econometric estimation procedures employed (Cavanagh *et al.* 2002, Dalhuisen *et al*. 2003; Espey *et al*. 1997; Michelsen, *et al*. 1998). Studies also note that it is difficult for consumers to distinguish the actual water rate from wastewater and fixed charges included in the water bills, which complicates the estimation of price elasticity of water demand (e.g., Whitcomb 2005).

Empirical evaluation of the effectiveness of conservation pricing. Based on the responses to the nation-wide survey of utilities conducted by Wang *et al*. (2005), many utilities do not consider elasticities in designing water rates. An exception is Tucson (AZ), where utilities believe that for some customers, a 10% increase in price will result in 4% reduction in water usage (elasticity = -0.4), but more common response is 2% decrease in usage (elasticity = -0.2). Further, San Antonio (TX) responded that it is difficult to isolate impacts of individual conservation programs (focused on the Edwards Aquifer); however, it believes that water conservation rates had the main impact on the 25% reduction in per capita consumption between 1998 and mid-1980s. El Paso (TX) reported that its water conservation rates, along with other conservation programs, led to the drop in per capita consumption from 220 gallons to 165 gallons per day. This number would be even lower if non-residential consumers would have been excluded from estimations. Corpus Christi (TX) reported low amount of per capita consumption (130 gal per person per day) and attributed this record to education, planning, ordinances, aggressively pursuing irrigation leaks, and conservation rates (Wang *et al*. 2005).

Clunie (2004) reports the results of two case studies from Hawaii. In Kauai County, average monthly single-family residential water use (normalized for whether) dropped by 3.7%

in the year following the change in the water rate structure from uniform to inclining 3-block (with an average 32% rate increase). In contrast, in Hawaii County, average monthly single-family residential water use (normalized for whether) increased by 3.7% in the year following the change in the water rate structure from inclining 3-block to inclining 4-block structure (with an average 29% rate increase). The author suggests that increase in the number of blocks and the steepness of rate blocks may have impacted relatively few customers. Also, "customers with long-standing inverted block rates may have already changed their water use patterns" (Clunie 2004, p. 23), which may have reduced their ability to react to the higher water prices.

B3. Utilities' perspective: balancing competing objectives with rate design.

In addition to water conservation, the literature suggests the following criteria for rate design and evaluation: revenue level and stability; equity, fairness, and impacts on customers; economic efficiency; transparency; ease of understanding and implementation (simplicity); accountability; and coordination (AWWA 2000, Raftelis 2005).

Utility revenue. While the objectives listed above are not mutually exclusive, they can conflict with each other. The most common example is the potential tradeoff between water conservation and utility revenue. Any program or pricing strategy that decreases water consumption has the potential to decrease utility revenue. However, National Regulatory Research Institute (NRRI 1994) concludes that conservation rates can be designed to avoid revenue shortfalls. "The fact that water demand is relatively price inelastic means that price increases do not necessarily decrease utility revenues. In fact, under certain circumstances, price increases for conservation or other purposes can substantially increase utility revenues." (NRRI, 1994, p. 3). Among the 23 utilities nationwide responded to the survey by Wang *et al*. (2005), 9% of utilities responded that conservation rates increased their revenues, while 26% reported that revenues decreased (30% considered conservation rates to be revenue-neutral, and 35% did not know or gave no response).

The literature also discusses the potential for conservation rates to increase revenue variability (AWWA 2000, Chestnutt 1993). "This revenue volatility is because an increasing block rate anticipates recovering a proportionately greater percentage of the customer class's revenue requirement at higher levels of consumption. These higher levels of consumption tend to be more subject to variations in seasonal weather and, when coupled with a higher unit pricing, customers tend to curtail consumption in these higher consumption blocks" (AWWA 2000, p. 100). Generally, revenue streams from inclining block structures are more variable than revenue streams from declining block structures (AWWA, 2000, p. 100). Smaller utilities may be more affected by revenue variability than larger utilities. In a survey of North Carolina utilities, Nida and Eskaf (2009) observed larger fixed fees in smaller utilities and hypothesized that "smaller utilities may, on average, have less stable customer consumption and therefore decide to shift greater proportion of their operating costs into the base charge." (p. 5).

A revenue stabilization fund can be used to balance the need for conservation and the need for revenue stability (AWWA, 2000, p. 100). A certain percentage of surplus revenue can be allocated to the fund each month with surplus revenue; and the funds can be withdrawn from the fund when revenues fall below projections. A number of utilities in Florida, including Gainesville Regional Utilities, have adopted this strategy of revenue stabilization (GRU, personal communications). Excess revenues can also be used to retire bonds in order to keep future rates low, to improve infrastructure, or to educate public about water rates and water conservation. Deficit in revenues can also be addressed through increase in rates or taxes, through issuing bonds, inclusion of a risk margin in the calculation of revenue requirements, and developing a mechanism for more frequent rate adjustments (Wang *et al*. 2005).

Economic efficiency. Economists have recommended that water prices should reflect the marginal cost of providing water, i.e. the cost of providing the next additional unit of water (AWWA 2000). Economic costs of water include utility's operation and maintenance costs, costs of additional water supply to meet growing demands, and the social and environmental opportunity costs of losing other benefits that the water can provide (such as ecological and recreational values of water pumped for consumption from river basins) (Western Resource Advocates *et al*. 2004). Economic efficiency requires setting rates to each customer according to the customer's specific marginal costs, and adjusting rates as the opportunity costs or the water infrastructure use change (OECD 2009). Even if true marginal cost pricing is impossible, the literature strongly suggests that water rates reflect costs of water provision (Griffin 2001). When water rates are used for alternative purposes, economic inefficiency and inequity are the likely result, including “underpricing (requiring a transfer from the governing body), overpricing (providing a transfer to the governing body), or subsidizing some customers at the expense of others” (Griffin 2001, NRRI, 1994). In other words, water rates should be used to recover costs, and not as a tool to redistribute wealth (like a progressive income tax), subsidize development, or as source of additional city revenue.

Equity, fairness, and impacts on customers. Poorly designed conservation rate structures can potentially lead to an inequitable billing of different customer groups (AWWA 2000). Renwick and Archibald (1998) find that water use of low income customers is more responsive to price increase than the water use of high income customers. “These results suggest that price policy will achieve a larger reduction in residential demand in a lower income community than in a higher income community, all other factors held constant. Results also suggest that if price policy is the primary DSM [demand side management] instrument in a particular locale, lower income households will bear a larger share of the conservation burden” (p. 357).

However, Agthe and Billings (1987) demonstrate that with proper design of the inclining block rate structures, steeper price blocks will actually lead to greater distributional equity. The authors show that by making price blocks steeper, a utility could increase the incentive to conserve without adding any price burden to low income users. This conclusion is important; it means that when equity is a high priority of rate design, steeper price blocks can be a better option than increased fixed or uniform rates.

To address the impact of conservation rates on low-income / low use customers, several utilities surveyed by Wang *et al.* (2005) charge minimum rates for the minimum amount of water necessary to meet basic needs (“lifeline rate”), which often constitute the fist block in the inclining block rate structures. The Kentucky Public Service Commission and several largest utilities in Texas support a lifeline rate of 2,000 gal per household per month. San Antonio, TX, uses the lifeline rate of 7,000 gal per month (Wang *et al*. 2000). Utilities focus on keeping the rates for the lifeline rate low to avoid setting excessive burden on low-income customers. Some utilities forgive service charge to low-income customers, offer fixing water leaks for free, distribute free water-efficient home appliances, offer 50% discounts on the bills, or do not charge for water consumption within the first price block (Wang *et al*. 2005).

To achieve utilities' financial objectives, "social tariffs" (i.e., low rates) for low income / low use customers are often subsidized by other customer groups (e.g., by customers from other regions, or by customers with other water use levels and/or higher income). Discussions of affordability and social tariffs should be open to all the stakeholders. Also, social tariffs should be based on precise definition of "affordability" and on reliable data on income distribution and water use. "In the absence of such objective bases, there is a risk that the process be driven by 'political affordability'" (OECD 2009, p. 86).

Fairness is somewhat intangible, because it is related to public perception. An inequitable rate structure will probably be viewed as "unfair" by the public. Also, rate changes should be instituted in a proactive way, rather than in a way that could be viewed as punitive or reactionary. For example, utilities can be proactive by making rate changes in anticipation of future droughts rather than after a drought (source: personal communications).

Transparency and accountability. In Florida, there is no mandated rate design methodology. As a result, each utility has the authority to decide which rate structure to use based on its own criteria. This allows great flexibility in rate design across the state. But, it also can present a public relations challenge. If the public does not consider the rate design process to be transparent and accountable, rate hikes could lead to resentment among customers.

A rate process is transparent if the public understands why a rate change is necessary before the change is implemented. Information about rate changes should be made available to the public via meetings, workshops, websites, or other means. Further, public involvement in rate design enhance public acceptance of the rates (AWWA 2000, Cuthbert and Lemoine 1996, Saarinen 1993). For example, Saarinen (1993) suggested a "citizen's forum" to represent the needs and concerns of the community. Such a forum could take place in the context of government sponsored workshops, interactive websites, or civic group meetings. Wang *et al.* (2005) reports that in Tucson AZ citizen advisory committees are set up to review rate design that have memberships that are proportional to customer class (residential, commercial, and industrial).

Coordination. Rate changes should be coordinated with other demand management efforts and any supply expansion efforts. In several states surveyed by Wang *et al.* (2005), conservation rates are supplemented by outreach programs such as conservation displays in schools, demonstration of low flow water use landscaping, and public service announcements. For example, in San Antonio (TX), the fee set to the fourth of the four residential rate blocks is used to fund provision for low flow toilets and rebates for efficient washing machines, free repairs of leaks for low-income customers, and outreach efforts (Wang *et al.* 2005).

B4. Benefits of conservation rates

Some key benefits of implementing conservation rates include (AWE 2008, AWWA 2000, Cavanagh *et al.* 2002, Wang *et al.* 2005):

- Communicating general water conservation need, rewarding efficient users that contain water usage in the lower tiers, and penalizing non-efficient water use;

- Reduction in operating costs and delay in the need for system expansion and acquiring additional water supplies and storage capabilities. For example, Seattle Public Utilities found that water conservation rates allowed it to defer the acquisition of its next source of water supply by 10 years (Wang et al. 2005);

- Drought preparedness - Conservation programs that are implemented during periods of normal conditions prepare public utilities and customers alike by forcing them to consider consumption behavior and by conditioning them to be responsive to severe water scarcity;

- Environmental benefits - by reducing the amount of water that must be withdrawn from watersheds and aquifers, more natural water is kept in-stream, and wastewater discharges and thermal pollution are mitigated as ecosystems are buoyed.

- Customers' flexibility to choose their own approach to increase water use efficiency and conserve water. There can be a substantial difference in the costs of achieving greater water use efficiency or water conservation among households, for example, depending on the age and design of their houses. Traditional utilities' conservation programs target specific water uses (such as irrigation or toilet flushing) and establish single water efficiency target for all households, which is similar to "command and control approach". In contrast, price increase and changes in price structure allow households to take into account the difference in the costs of achieving water use efficiency target across households, and hence, . "…may be more cost-effective in practice …" (Cavanagh *et al*. 2002, p. 34).

B5. Pitfalls of conservation rate design

There are a number of barriers to successful implementation of conservation water rates (AWE 2008, AWWA 2000, Whitcomb 2005, Wang *et al.* 2005), many of which are discussed below:

- Possible effects of conservation rate on utility revenue (discussed in section 4.4 of this paper).
- Political considerations. When water rates are used to subsidize commercial development or as a redistributive tax, conservation price signals will probably be missed by the consumer.
- Difficulty in implementation (for inclining block rate structures, as discussed above);
- Possible reluctance on the users' side to accept increasing rates.
- Source substitution by utility customers. For example, in Florida, homeowners in many cities are legally allowed to dig their own irrigation wells. Substitution of well-supplied water for tap water in response to introduction of conservation rate structure can reduce the effectiveness of conservation rates.

C. Drought rates

Drought rates (or drought demand rates) are special surcharges that are implemented during times of severe drought. They are often discussed in the same context as conservation rates, but they differ from conservation rates in one important respect: they are temporary. While conservation rates are typically in force all year long, drought rates are used to manage demand before or during severe droughts and associated water shortages. Several communities in Florida, including Hernando County, Punta Gordo, and Englewood, have applied drought rates in recent years.

Drought rates are not as frequently used as inclining block rate structures. Drought rates differ among states and utility companies. For example, the East Bay Municipal Utility District (EBMUD), CA, imposes a 10 percent increase in volumetric rates for all customers and a $2 surcharge for each 100 cubic feet (748 gallons) of water used above individual customers' allocations. "Residential customers using less than 100 gallons per day are exempt from the increased rates and surcharges" (EBMUD 2009). Olivehain Municipal Water District (OMWD), CA, proposes increase in water rate structure during the times of drought depending on the drought alert level. For the drought alert level 1 ("drought watch"), no changes in water rates is proposed to the first block of the inclining block rate structure for residential customers. Increases in the second and third blocks are 5% and 15%. At the times of drought alert level 4 ("emergency"), water rates are proposed to increase by 35%, 65%, and 75% for the first, second, and third rate blocks respectively (in comparison with non-drought rates) (OMWD 2009).

Drought rates are often included into drought plans of state, regional, or local authorities. The first step in initiation of drought rates is drought declaration. The authority and responsibility to declare drought varies from state to state. Usually, the authority rests with districts or municipalities. For example, in Connecticut and Kentucky, droughts are declared by local governments (towns and municipalities) that may reflect spatial variation of physical conditions throughout the state. In California and Florida, water districts have declaring authority, and in Massachusetts, the state government declares a drought (Wang *et al.* 2005).

Drought is usually declared based on the results of monitoring of water resources. In Arizona, drought restrictions can be declared when population growth exceeds water capacity in an area. Wang *et al.* (2005) also report that there has been "some successes" using protection of endangered species as a justification of drought rate application. In Texas, "pass-through rates" can be used when a utility needs to purchase water from another utility, which can be the case in the times of drought. Pass-through rate allows the purchaser to pass along aspects of the lending utility's rate structure to avoid possible losses from obtaining water from the alternative source. Utilities in Texas are also allowed to apply high "temporarily rates" if a court orders mandatory reduction in pumping that result in losses of utilities' revenues (Wang *et al.* 2005).

Barriers to drought rates (Wang *et al.* 2005):

- Higher rates during droughts may yield little change in these customers' water use due to "demand hardening", which refers to the diminished capacity of some consumers to reduce consumption during the course of drought because of the characteristics of their demand (e.g., water use in hospitals) or past investments in water conservation that limit opportunities for discretionary use reduction (e.g., low-flow shower heads).

- The interface between drought, water use metering and water billing cycles create problems for some consumers who receive a price signal out of sync with the onset of drought. For example, if a drought where to only last one month while the billing cycle is two months, customers may find themselves paying drought rates under normal conditions.

- Drought is not always caused by local hydrologic conditions, given cross-basin transfers of water. In some areas, considering local conditions is no longer sufficient in the drought analysis; however, implementing drought rates because of drought conditions outside the locality is difficult to defend to customers. This can be true in Florida, where many communities often rely on water supply from the same aquifer, and where water use by one party can affect water availability to other users.

- Differences in elasticities between various socio-economic groups of customers impact the way in which people react to drought rates. Theoretically, less wealthy families may already be consuming at or near minimum level, and despite conservation rates, have little room to cut their consumption. And wealthier customers may regard landscaping losses as more costly that higher water bills.

- It takes time for the consumers to adjust their water consumption in response to rate increase. Droughts may last short time, and by the time consumers respond to drought rate, hydrologic conditions may return to normal.

Customers' education is important for the success of drought rates. In the survey conducted by Wang *et al.* (2005), utilities report putting advertisements in newspapers, notices in bills, sending special mailing, conducting workshops and town-hall style meetings, and hiring field consultants to educate customers about water rates. Effective communication strategies can help public understand measurable social and ecological benefits of drought rates, and thus to help promote customer support (Smith Jr. 2003 a, b, cited by Wang *et al*.).

D. International Rate Design Practices

D1. OECD Countries. This section is based on the publication by OECD (2009). The Organization for Economic Cooperation and Development (OECD) includes 30 member counties from North America (Canada, Mexico, and United States), Asia (Japan and Korea), Europe, as well as Turkey, Australia and New Zealand. Overall, between 1999 and 2008, the use of flat fees and declining block rates structures for residential customers decreased in OECD countries, while the use of uniform and inclining block rate structures increased. For industrial customers, only a few OECD counties used declining block rate structures. The Global Water Intelligence survey of 184 utilities in OECD countries conducted in 2007-2008 showed that about a half of utilities used uniform rate structure for residential water consumption (usually coupled with fixed fees), and another half used increasing block rates (with only two utilities coupling volumetric and fixed fees). Only seven utilities used declining block rate structures. "The use of flat fees, however, is still reported in Canada, Mexico, New Zealand, Norway and the United Kingdom" (p. 78). The number and size of blocks among the utilities using the inclining block rate structures varies significantly. For example, in Mexico, water rate structure is set by municipalities, and in most cases inclining block rate structures with large number of blocks (more than five) are used. In the city of Monterrey, Mexico, different rates are set for each cubic meter (264 gallons) used. In Mexico, industrial water rates are usually set higher than residential rates.

Domestic prices for water and wastewater vary depending on costs of water supply, water resources available and their quality, and percent of utilities' costs recovered through tariffs (OECD 2009). Among the 21 OECD countries examined, two reported average domestic rates for water and wastewater (including taxes) below US$3.8 per thousand gallon, eight countries reported rates between US$3.8 and $7.6 per thousand gallon, nine were clustered around US$11.4 per thousand gallon; while Denmark and Scotland reported even higher rates.

To address the concern of water affordability for low income customers, donors and international financial institutions often define the benchmark of affordability as the water bill equal to 3-5% of a household income. However, it is recommended to set the benchmark based on local conditions. Also, several countries (such as Greece, Luxembourg, Portugal and Spain) developed rate structures that take into the account the number of people in the household. Such structures address the issue that low income households can consume more water than high income households, just because of the larger household size. However, rate structures that take into account the number of people in the household are very data-intensive and costly to administer. Also, such structures require households to declare their destitution, and some households may be reluctant to do that. Income support in the form of subsidies is suggested as a mean to compensate low-income household for rate increases.

D2. Australia. Long term severe drought in Australia has forced policy makers to confront the issue of water allocation among different users with a great sense of urgency. To do this, institutional reform has been necessary (Dinar 2000). The national and regional governments in Australia have adjusted prices to reflect the true cost of production and distribution. "Upper bound pricing" have been defined as a maximum water rate level at which water utilities can recover operational, maintenance and administrative costs, externalities, taxes, and cost of capital, without deriving monopoly rents (NWC 2009). Also, regulators have made a coordinated effort to eliminate cross subsidization in water pricing (Dinar 2000). For example, in many areas residential and commercial users no longer subsidize the agricultural sector (Dinar 2000). These more efficient pricing strategies have helped regulators manage demand and mitigate severe water shortages.

In general, residential water rates in Australia tend to be somewhat more conservation oriented than American rates. For example, in Florida, monthly fixed fees vary between $2.00 and $14.00 (Rawls 2009); in Australia they tend to be comparable, often between $4.00 and $12.00 (O'Dea and Cooper, 2008, p. 30). But, in Australia, volumetric fees are usually higher. Average volumetric fees in Florida vary from about $1.00 to $3.00 per thousand gallons (Rawls 2009), while in Australia, they are usually between 3.50 and $5.00 per thousand gallons (O'Dea and Cooper, 2008, p. 30). The higher volumetric fees are not surprising, given the country's recent history of severe drought.

D3. Europe. Based on a review of existing studies, Dalhuisen *et al*. (2003) shows that responsiveness of water consumption to price (i.e., price elasticity) tends to be smaller in Europe in comparison with US. However, in Denmark, a survey-based study found that a water use tax has resulted in 40 percent decline in water usage (ECOTEC 2001 cited by PRI 2005). EEA

(2009) reports that in Estonia, steady increases in water rates over time contributed to a significant reduction in average household use. In England and Wales, widespread implementation of water metering has also lead to decreased water use (EEA 2009). Currently, in those two countries, metered households use, on average, 13% less water than non-metered households (EEA 2009).

According to the European Union (EU) Water Framework Directive (Article 9), by 2010, water rates in EU should cover the cost of water service, including financial cost of supply (operational, maintenance, and capital cost), opportunity costs of losing other benefits that the water can provide, as well as the costs to public or ecosystem "health" (OECD 2009). The directive allows states "to diverge from full cost recovery after accounting for the social impacts of cost recovery" (OECD 2009, p. 55). It is expected that the water rates will increase in many European countries to meet the EU Directive requirements (Schleich and Hillenbrand 2009).

V. Research Needs

Based on the review of related studies, we identified the following gaps in the literature and the following research needs:

- Estimation of the effectiveness of conservation rate. For many utilities, strong evidence may be needed to justify rate changes, especially in cases where drought rates or steeper price blocks are politically controversial. Future studies need to provide empirical, Florida-specific data to explore this issue. Currently, the only Florida study focused on price elasticity of water demand is Whitcomb (2005).

- Analysis of the factors that determine effectiveness of conservation rates; developing strategies to increase effectiveness. For example, survey-based studies may focus on consumers' understanding of their bills and water rates. If the customers' understanding is limited, then more effective billing procedure should be developed. Alternatively, future studies can focus on effectiveness of different conservation rate structures. For example, a working hypothesis for such a study could use a rate structure to separate indoor and outdoor usage, utilities may become more successful at encouraging conservation.

- Florida needs to adopt a consensus definition about what constitutes a conservation rate. Currently, the regulatory concept of conservation rate structures is too vague for consistently successful implementation. This is discussed further in the Appendix C.

- Further research is also needed to further explore the relationship between water conservation and utility revenue. Although a fairly large body of literature already exists on the topic, few Florida studies address the issue empirically. Negative revenue effects are still cited as one of the major pitfalls of conservation oriented rate structures. Utility managers must be confident that implementation of conservation or drought rates can be "revenue neutral".

- Recommendations are needed on rate structures and other demand and supply management strategies that can be used by utilities to achieve different objectives (including water conservation, revenue generation, fairness, etc). Such recommendations can be based on extensive consultations with policy makers and field professionals. An prototype of recommendation matrix is presented in Appendix D.

- Analysis of institutional factors affecting rate design. More research is needed to examine the decision-making process related to water rate design, and the role of politics, public relations, local history and other factors in this process. For example, utility managers may be under political pressure to keep rates low or uniform. Interest groups, such as specific commercial sectors, may historically have preferential treatment, and may oppose development of conservation rates. Utility ownership may also influence rate design. Most Florida utilities are publicly owned, and may be under more pressure to protect revenue and revenue stability, especially if the utility shares revenue with the city. Utilities' management structure can also play a role in rate design.

- Analysis of the synergetic effects of price and nonprice programs on water usage. Some researchers believe that a combination of price and nonprice programs can achieve the goal of water conservation more effectively. For example, Moncur (1987) suggests that the presence of nonprice programs enhances the price elasticity, thus lowering the price increase necessary to induce the desired reduction in water use. It is difficult to deduce the synergetic effects of price and nonprice programs, and there is little evidence to support claims because information essential for an accurate assessment is typically not available. Information about nonprice programs is often not recorded by utilities (Michelsen *et al*. 1998).

- Effects of specific designs of conservation rates on customers' water usage. The literature does not provide much guidance on the design on conservation rates. Utilities have the freedom to experiment with different rate structures (inclining block, seasonal, drought, water budgets, etc), different levels of inclining block rate structures, various price differentials between price blocks, and different consumption breakpoints between price blocks. Guidance is needed to lead water utilities through the process of conservation rate design.

- Potential effect of conservation rates on water use in residential sector -other than single family homes. For example, in most cases, water use by individual apartments in apartment complexes is not metered. The possibility of metering water use and the possible effects of conservation rates on residents of individual apartments needs to be examined (Rui Marques - personal communications).

- Relative costs and effectiveness of price and non-price conservation programs, as well as leakage detection programs, in comparison with investment to increase supplies, or update infrastructure to handle increased demands (Damian Adams, Rui Marques - personal communications).

- Issues of cross-subsidization between tap water and reclaimed water, as well as and reclaimed water ownership issued (Rui Marques - personal communications).

- Benchmarking of conservation programs implemented by various utilities in Florida, in the US, and internationally (Rui Marques - personal communications).

- Additional information on the advantages and disadvantages of alternative rate structures. Inclining block rates have been studied extensively, but others have not, including: marginal cost pricing, spatial pricing, and marginal opportunity cost pricing. Rate structures used in other industries and their applicability to water utilities can also be examined (see Appendix E).

VI. Conclusion

This paper provides an overview of water rate design and "state-of-the-art" conservation and drought rate practices. We conclude our literature analysis with two citations from Wang *et al*. (2005):

> Implementing conservation rates is a learning experience, which requires "finding the appropriate tariff structure, creating a community education program that enables users to make informed choices, and crafting the policy tools needed to address equity concerns and real-time financial impacts" (Wang *et al.* 2005, p. 39).
>
> "There are many conservation strategies available to water resource managers. … the most successful long-term programs focus on building conservation as a viable choice of informed customers. Those jurisdictions that have experienced the greatest success have designed multifaceted programs with long-term visions. This includes water resource education, taking into account equity and other socioeconomic considerations, anticipating utility revenue impacts and addressing them in a positive way, and providing users with ready access to practical and cost-effective technologies, as well as enlisting the power of market signals to encourage conservation." (Wang *et al*. 2005, p. 40).

Conservation water rates do not represent a complete solution to Florida's water allocation challenges. However, the results of this study strongly suggest that they will be part of the solution in the future. The literature and the experiences of those in the industry indicate that conservation rates are a useful tool for utilities and regulatory agencies. Where possible, this tool can be part of a comprehensive, long-term planning approach. Conservation rate design should also be an important subject for further study. Hopefully, the knowledge gaps outlined in section 4.10 can be incorporated into the Conserve Florida research agenda.

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Appendix A. Water Rate Design in Florida

The water regulatory structure in Florida is unique. The Florida Department of Environmental Protection cedes much authority to the five water management districts (WMDs). WMDs manage the water resources on the regional level. However the WMDs do not have the regulatory authority to dictate pricing schemes to utilities. Instead, they monitor and regulate groundwater extraction through Consumptive Use Permits. All pricing authority is left to the individual utility companies. The Florida Public Service Commission (PSC) monitors the profits of the utility companies, since they exist as regulated monopolies. Still, the PSC does not mandate how revenue is raised, as long as the revenue is not considered "excessive" based on production costs.

Water rate design in Florida varies dramatically between individual cities and utilities. Individual utilities have a fairly large degree of authority and flexibility to design rates for commercial and residential users. When it comes to conservation rates, inclining block rates are fairly popular, especially for larger utilities. (McLarty and Heany 2008). But, unlike California, Florida utilities usually include relatively high fixed fees in their rate designs (McLarty and Heany 2008). An exception is the Tampa Bay Water Department, which has no fixed charges at all. This remarkable rate design practically ensures that users have an incentive to conserve water.

In addition to variation in pricing strategy, Florida utilities developed more complex rates, in which water is priced differently depending on its use. This is sometimes referred to as "price specification." For example, some utilities have different rates established for indoor and outdoor use. Others set different rates for the customers inside and outside the city limits. As Florida utilities continue to experiment with more specified rates, they have an opportunity to more specifically target price signals. This is important because sometimes the costs vary dramatically across various factors. For example, even though reclaimed water is more expensive to produce than purified groundwater, many utilities provide significant discounts for reclaimed use. In this case, wastewater utilities save significant disposal costs if wastewater is reused. There may be a risk of designing rates that are too complicated and confusing to provide clear incentives. Nevertheless, price specification can be an effective way to distribute costs more efficiently.

One type of price specification in Florida that is particularly promising is special pricing for reclaimed water. A number of utilities charge a separate rate for reclaimed water use. In most cases, a significant discount is offered for using reclaimed water. For example, the City of Tallahassee offers a 70% discount for residential consumers willing to use reclaimed water.

A few Florida utilities have experimented with drought rates. Ft. Lauderdale, for example has implemented them on a wide scale with measurable effectiveness. As droughts become more common, drought rate designs like these will probably become more attractive.

In 2005, John Whitcomb published a report on water demand that was commissioned by the water management districts. Whitcomb's sample included 16 utility companies. In 1998, the first year data was collected, eight of the utilities had inclining block rates. Ten years later, in 2008, all but two of them had inclining block rates (Rawls 2009) which suggests that inclining block structures are becoming more popular. The most common number of price blocks is three, perhaps because more than three is too complicated. Almost all of them continue to have at least some fixed charges.

Like much of the country, Florida utilities appear to be moving away from declining block rates and uniform rates. Due to increased attention on conservation, inclining block rates are becoming more popular. Table 3 illustrates the trend.

Table A1. Trends in Florida Rate Design based on a sample of 16 utilities

Utility	1998 Rate Structure	2003 Rate Structure	2008 Rate Structure
Escambia County	Uniform	Uniform	Increasing with 2 blocks
City of Tallahasse	Uniform	Uniform	Uniform
City of Melbourne	Uniform	Uniform	Uniform
City of Ocoee	Uniform	Uniform	Increasing with 6 blocks
City of Palm Coast	Uniform	Uniform	Increasing with 4 blocks
Hernando County	Uniform	Uniform	Increasing with 5 blocks
Palm Beach County	Increasing with 3 blocks	Increasing with 3 blocks	Increasing with 4 blocks

City of Lakeland	Increasing with 3 blocks	Increasing with 3 blocks	Uniform
Miami Dade	Increasing with 5 blocks	Increasing with 5 blocks	Increasing with 4 blocks
Indian River County	Increasing with 4 blocks	Increasing with 4 blocks	Increasing with 4 blocks
Hillsborough County	Increasing with 5 blocks	Increasing with 5 blocks	Increasing with 4 blocks
City of St. Petersburg	Increasing with 4 blocks	Increasing with 4 blocks	Increasing with 4 blocks
Toho Water (Osceola County)	Increasing with 5 blocks	Increasing with 5 blocks	Increasing with 5 blocks
Sarasota County	Increasing with 5 blocks	Increasing with 5 blocks	Increasing with 5 blocks
City of Tampa	Increasing with 3 blocks	Increasing with 5 blocks	Increasing with 5 blocks
Seminole County	Increasing with 5 blocks	Increasing with 6 blocks	Increasing with 6 blocks

Source: Rawls, 2009.

Appendix B. Decision Support Tools

Several studies focus on decision support tools to help utilities design water rates. For example, the WateRate computer simulation model was developed by the five water management districts, and allows utilities to simulate the effects of changes in their rate design (SWFMD 2008). The model has four output tables, which include rate structure, bill distribution, elasticity, and several others. It has four output tables, which include projected usage and revenue up to five years in the future. The model also has default settings for data gaps. In short, it is powerful tool for utilities interested in exploring demand management options.

Another computer model is the University of Florida Simplified Aggregate Urban Water Conservation Guide (UF 2008). This interactive program allows utilities to explore the cost effectiveness of various conservation Best Management Practices. It also allows users to conduct comprehensive water audits to identify problems and inefficiencies. Currently, the Guide does not deal explicitly with rate design. However, future versions of the program probably will.

Outside of Florida, other interactive tools have been developed to assist utilities in long term planning. The publically available "Rate Dashboards", developed by the Environmental Finance Center at the University of North Carolina, can be used to simulate the effect of various rate structures by taking into account a variety of factors including utility finances and system characteristics (EFC 2009).

Chesnutt (1996, cited by Wang *et al.* 2005) created a method of quantifying uncertainty of utility revenues. His simulated water demand model "factors in parameters like season, climate, and customer characteristics. This model is used to map the rate structure onto expected revenues. The model also produces a measure of risk in future revenues. Given the estimate of risk, utilities can design a number of revenue copying strategies" (Wang *et al*. 2005, p. 34).

Appendix C. Legal aspects of defining conservation rates in Florida

Currently, there is no consensus on what exactly constitutes a conservation rate in Florida. The state government's only official definition is as follows: "**conservation rate structure** means a schedule of utility water rates designed to promote efficient use of water using economic incentives" (FDEP 2006, p.5). The Department of Environmental Protection states that "a water management district will afford a utility wide latitude in adopting a rate structure, and shall limit its review to whether the utility has provided reasonable assurance that the rate structure contains schedule of rates designed to promote efficient use of water using economic incentives" (FDEP 2006, p.5). In other words, the final decision rests with the Water Management Districts. Without clear minimum standards, the precise definition of conservation rates remains highly uncertain.

The South Florida Water Conservation District has taken steps establish minimum standards. In District's Water Conservation Program Plan, Strategy 1-A includes the following action step: "work with utilities and the Florida Chapter of the American Water Works Association (AWWA) to define minimum standards in water use permit criteria for conservation rates" (SFWMD 2008). These efforts to define and coordinate minimum standards should be continued.

Appendix D. Prototype matrix for water rate structure recommendations

Type of Rate Structure	Examples of Advantages	Examples of Implementation Challenges	Disadvantage mitigation strategies
Fixed Rates (base charges)	Highly predictable, stable revenue stream; easy to implement; easy for customers to understand	No incentive to conserve water; creates equity issues- average prices are higher for low use customers	Can easily be used with non-price conservation measures; despite equity issues, may be viewed as "fair" because everyone pays the same monthly bill
Declining block rates	Can be used by utilities that need to develop a single rate schedule for various customer classes; can be used when utilities costs decline with increasing water usage, and when it is important to provide price incentives to encourage large-volume customers to remain on the system; block rate may also be used by utilities that need to encourage economic development	very weak incentive to conserve water; may be difficult for some customer to understand; creates equity issues- marginal and average prices are higher for low use customers	Can be used with non-price conservation measures; transparent billing procedures and interactive tools such as “rate calculators” may increase customer understanding
Uniform Rates	Greater stability of stable revenue stream in comparison with inclining block; easy to implement; easy for customers to understand; provides some incentive to conserve water	provides less incentive to conserve water than inclining block rates	Can easily be used with non-price conservation measures
Inclining block rates	Provides strong incentive to conserve; may have customer equity advantages- average and marginal prices are higher for high-use customers	may make revenue stream more variable; may be difficult for some customers to understand; can be difficult to administer	Long term planning, revenue stabilization funds, and small base charges can help utilities deal with revenue variability; Transparent billing procedures and interactive tools such as “rate calculators” may increase customer understanding
Drought Rates	Provides strong incentive to conserve water in times of drought	May be viewed as unfair or punitive by customers	By implementing drought rates before or during droughts (rather than after the fact) utilities may increase consumer acceptance; public awareness efforts can also increase acceptance

Water Budget Rates	Provides very strong incentive to conserve; has significant customer equity advantages; highly flexible	difficult to implement- has high information requirements; may make revenue stream more variable; may be difficult for customers to understand	Initial expenses can be offset by future rate precision and water savings; Transparent billing procedures and interactive tools such as “rate calculators” may increase customer understanding; Long term planning, revenue stabilization funds, and small base charges (in addition to the uniform rate) can help utilities deal with revenue variability

Appendix E. Examples of Rate Design in Other Industries.

Water regulators can also learn from other industries (NRRI,1991, p. iii). For example, the electricity industry has dealt with some of the same pricing issues as water. In general, the energy sector makes use of infrastructure with high fixed costs and large distribution requirements. Some innovative conservation pricing strategies from the energy sector include:

- Peak-Load Pricing: Different rates are charged for "peak" usage times. In other words, consumers pay a premium during certain key hours when usage peaks. To be effective, peak-load pricing schemes need to take capacity expansion costs and various time horizons into account. (Lecing 1997).

- Time of Use (TOU) Rates: Different rates are charged at specified time intervals on a consistent basis (Barkett 2004).

- Real Time Pricing (RTP): Different rates are charged based on wholesale prices and infrastructure conditions (Barkett 2004). This pricing strategy allows for great precision in cost allocation. Unfortunately though, it requires high frequency metering, which is usually not available in the water industry.