WHITE PAPER
WATER RATES AND CONSERVATION

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Introduction

This white paper provides a discussion of water rate structures and conservation, sometimes referred to as "conservation pricing". It addresses 1) the theoretical and empirical underpinnings for viewing rate structure design as a key tool for promoting efficient water use decisions, 2) alternative conservation-oriented water rate structures, and 3) cost-of-service considerations of rate design.

Linkages Between Rates and Water Use

Analysts have pointed out that water rates can be an extremely valuable public policy tool. Water rates can be more than a means of meeting utility revenue requirements. Water rates can be used to communicate to water users the private and social costs of water development. Water users can then base their consumption decisions on a more accurate accounting of the benefits and costs of using more or less water. If done correctly, the pricing of water can be a powerful means of signaling the cost and scarcity of the resource to water users, most of whom experience very little connection between their water usage and their total bill. In an era in which customer water demands are increasing while water supplies are constant or diminishing, it is important to apply economic tools to communicate the true value of fresh water.

The "Law of Demand" underpins the ability of conservation-oriented rate structures to promote water conservation. The "Law of Demand" derives from the empirical fact that, all else equal, as the price of a good or service increases, the quantity demanded tends to decrease. This relationship is why graphical depictions of demand curves are usually presented as downward sloping.

To be sure, some goods and services exhibit this tendency to a greater degree than others. Economists use the concept of "price elasticity" to measure the extent to which the demand for a good or service is sensitive to changes in its price. Price elasticity tells you the percentage change in demand for a one percent change in price. For example, if a good has an elasticity of magnitude 1.0, then a 10% increase in its price will produce a 10% decrease in its demand.[1] If instead, the good had an elasticity of magnitude 0.5, then the same 10% increase in price would produce only a 5% decrease in demand. A good or service with an elasticity of magnitude less than 1.0 is termed "inelastic,"[2] which means the percentage change in demand will be less than the percentage change in price. Conversely, an "elastic" demand is one with a price elasticity magnitude greater than 1.0. For an elastic demand, the percentage change in demand is greater than the percentage change in price.

Over the historic range of prices and consumption, urban demand for water has been relatively inelastic – generally the percentage change in customer water demand has been smaller than the percentage increase in water price. A large body of empirical research over the last 30 years has demonstrated this conclusively.[3] While the demand for water in urban settings is inelastic, its elasticity is not zero, as has been sometimes assumed by most water planning studies done over the past several decades. This distinction is crucial. If demand for water exhibited zero elasticity, what economists term "perfect inelasticity," water rates would have no relevance to consumer decisions about water use, and rate structure would prove an ineffective policy instrument for encouraging water conservation. But customer demand for water is not perfectly inelastic. It is relatively inelastic, yes, but not perfectly inelastic. This means that rates can be used strategically to influence the level of demand.

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[1] Price elasticity actually has a negative sign because price and quantity demanded move in opposite directions. To keep the discussion simple, we are presenting elasticity as a positive parameter. Technically, what we actually are presenting is the absolute value of the elasticity parameter.

[2] Note that many often read the label of "inelasticity" to mean "no elasticity". The authors are unaware how the label of "inelasticity" was chosen to mean "limited elasticity". Economists refer to a complete lack of demand responsiveness to price as "perfectly inelastic". This subtlety has been a longstanding and unfortunate source for misunderstanding between economists studying water demand and non-economists.

[3] Renzetti, Steven (2002). The Economics of Water Demands, Kluwer Academic Publishers, Boston.

Comprehensive reviews of the empirical evidence have suggested the following regarding the price elasticity of residential customers demand for water:[4]

- The majority of empirical studies have found the long-term residential price elasticity to range between 0.2 and 0.6. After reviewing the evidence, Griffin (2006) concluded that price elasticity for annual residential water use is likely to lie in the range of 0.35 to 0.45, meaning a 10% rate increase may produce a 3.5% to 4.5% reduction in demand over time.[5]
- Outdoor residential demand is more elastic than indoor residential demand. All else equal, residential water users will reduce outdoor consumption more readily than indoor consumption. The corollary of this finding is that summer demand tends to be more elastic than winter demand, because most outdoor use occurs during the summer.
- Residential customer demand for water is more responsive to price over the long-term than over the short-term. Another way of stating this is that it takes time for price changes to fully influence the demand for water. Right after a price increase, consumers are mostly locked into their water using appliances and landscaping. While they can modify their water using behavior in response to the price increase or change in rate structure, they may not be able to adjust their stock of water using capital, at least not right away. Over time, as this stock of capital wears out and is replaced, improvements in the efficiency of the capital can be realized. Thus, long-run demand tends to be less inelastic than short-run demand. Griffin (2006) estimates that long-run demand elasticity is typically on the order of 0.2 points higher than short-run elasticity (e.g. if long-run elasticity is 0.4, then short-run elasticity is probably around 0.2). These are broad generalizations, however. Demand responses are often specific to the time and circumstances in which the price adjustment occurs, and therefore can significantly vary by region and time period.

Far fewer studies have been completed for commercial and industrial customer demand for water than for residential customers and the heterogeneity of commercial and industrial water

[4] Epsey, M., J. Epsey, and W. Shaw (1997). *Price Elasticity of Residential Demand for Water: A Meta-Analysis*. Water Resources Research 33 (June) 1369-1374. Also see Dalhuisen, J., et. al. (2003). *Price and Income Elasticities of Residential Demand: A Meta-Analysis.* Land Economics 79 (May): 292-308.

[5] Griffin, Ronald C. (2006). Water Resource Economics: The Analysis of Scarcity, Policies, and Projects. The MIT Press, Cambridge, MA.

uses can make generalizations more difficult. Some industrial uses, such as flow through cooling, have been found to be very elastic – probably because of the relatively low cost involved in switching to more water efficient cooling practices once cost for water begins to increase. Process water uses are generally less elastic than cooling uses. Commercial and office uses, which are primarily related to sanitation, space cooling, and landscape irrigation, also have been shown to be relatively inelastic. The empirical evidence suggests the following about commercial and industrial price elasticity:

- Industrial demand tends to be less price inelastic than commercial demand, though demand for certain industrial processes requiring very high quality water can be very inelastic.
- Commercial demand tends to be inelastic, though empirical estimates span a wide range. Commercial water demand studies reviewed by Renzetti (2002) reported price elasticities ranging from 0.1 to 0.9. Elasticity varied considerably by commercial sector.
- As with residential customer demand for water, commercial and industrial demands are less inelastic in the long-run than in the short-run.

Using Rates to Influence Customer Demand for Water

Different rate structures have different types of effects on customer demand for water. Water agencies use rates to help manage water demand—throughout the year, during periods of seasonal peak demand, or in specific geographical zones.

> **Goal 1 - Reduce average system load.** Conservation rates can reduce total annual water use, that is, reduce average day demand. This goal may be particularly appropriate if the agency faces a supply source constraint that could necessitate the importing or purchasing relatively costly supplies. Demand management through pricing can help utilities avoid these costs.
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> **Goal 2 - Reduce peak system load**. A related goal for a water agency in implementing conservation rates can be to reduce seasonal water demand. This objective may be particularly appropriate for agencies facing costly capacity expansion. Again, these costs may be avoidable through effective demand management.
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> **Goal 3 - Reduce system diseconomies**. Finally, agencies may want to ensure that customers in expensive-to-serve areas, absorb the cost of this capacity through rates.

Agencies should also recognize, however, that customers willing to pay more for expensive types of water service are communicating a willingness to pay for additional investments to provide additional water service. Rather than a failing of conservation pricing, customer preferences for additional water service should be viewed as a form of desirable two-way price signaling.

The evidence on how residential, commercial, and industrial customer demands for water typically respond to changes in the cost of water can be used to structure rates to promote conservation. Before discussing the advantages and limitations of specific conservation-oriented rate designs, some general principals are presented. These are as follows:

- Conservation-oriented rates are likely to have the most impact on outdoor water uses because these uses are more responsive to price than indoor uses. Thus, rate structure can play an important role in promoting efficient landscape water use. As we will see in the case study section, combining a well-designed rate structure with landscape budgets or other landscape conservation programs can be particularly effective.
- Because customer demand for water exhibits strong seasonality, as do many water system costs, differentiating rates by season can both promote more efficient outdoor water use and more equitably allocate water system costs among water users.
- Water rates can influence the choice of landscaping, water-using appliances, fixtures, and processes. These are decisions that can affect regional water demands for many years into the future. Rate structures can be designed to promote water efficient capital investments. They can also be paired with conservation programs promoting replacement of inefficient water using appliances, irrigation systems, and landscaping materials.
- Water agencies need rates primarily to recover the costs of providing water service, not just to promote conservation. Sometimes the concern is expressed that using rates to promote conservation will result in lower water sales and jeopardize the financial integrity of the utility. As a factual matter, the evidence strongly suggests that this concern is misplaced. When customer demand for a good is inelastic, as is the case for urban water uses, the

positive effect on revenue of the higher price will outweigh the negative effect of lower sales. The net effect will be an increase, not a decrease, in sales revenue.[6]

Variable Charges Are Where the Action Is

A typical water bill consists of two types of charges – a fixed service charge that is invariant to the amount of water used, and a variable charge that is the product of the water rate and the amount of water consumed. Fixed charges are attractive to utility finance departments because they provide the enterprise with dependable and very stable revenue. Unfortunately, they provide no incentive to use water efficiently because they are completely disconnected from a customer's water use decisions. In the extreme case, where a bill consists only of a fixed charge, the incremental cost of water to the customer is zero, and it is economically rational for a customer in this situation to consume water to the point where the incremental benefit of additional water use is also zero. Under this situation, customers have no economic incentive to fix leaks or reduce wasteful uses unless those leaks or uses are imposing costs on them in some other way.

The variable charge, on the other hand, relates directly to customer water use decisions. Higher water use increases the variable charge, and lower water use decreases it. Customers can therefore control to some degree whether they pay more or less for water service through their consumption choices. Of course, the extent to which customers will be motivated depends on how much they can influence their overall bill. A water bill consisting of 90% fixed charges and 10% variable charges is unlikely to provide the same degree of behavioral motivation as one where the percentages were reversed.

This simple point is reflected in California's Best Management Practice (BMP) for Water Conservation Pricing.[7] California's conservation pricing BMP establishes the goal of having water suppliers recover the maximum amount of water sales revenue from volumetric rates that is consistent with utility costs, financial stability, revenue sufficiency, and customer equity.

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[6] Because rate increases sometimes follow periods of mandatory, non-price rationing during droughts, the effect on utility revenues of the non-price rationing and the rate increase are sometimes confused. Non-price rationing results in lower water use and lower system revenue. Price rationing, on the other hand, results in lower water use but higher system revenue.

[7] As codified in the *Memorandum of Understanding Regarding Urban Water Conservation in California,* administered by the California Urban Water Conservation Council.

This goal is based on the recognition that recovering volume-related system costs through fixed service charges can mask from water users the true cost of using more water, and can result in bills that are not proportionate to cost responsibility. Empirical studies have shown conclusively that under-pricing water resources in this way can lead to economically wasteful water use. In addition to setting the goal of recovering the maximum amount of water sales revenue from volumetric rates consistent with basic ratemaking principles, the BMP sets minimum thresholds of the percent of total water sales revenue that is derived from volumetric versus fixed consumption charges. The main features of California's conservation pricing BMP are as follows:

a. Water suppliers agree to either (1) recover not less than 70% of sales revenue from volumetric consumption charges; or (2) determine a lower volumetric revenue threshold by applying their own financial and system information to a standardized rate model designed to identify the incremental cost of water service.

b. Water suppliers retain their same latitude in selecting rate designs. Water suppliers can choose to implement uniform rates, increasing-block rates, seasonal rates, and budget-based rates, provided they meet the variable sales revenue requirement.

c. Water suppliers are provided a minimum of four years to transition their volumetric rates in order to meet the revenue threshold requirement. If, during the four-year transition period, a water supplier's rates would have to increase by more than 10% in a single year to achieve compliance, the water supplier can opt to extend the transition period.

d. Because weather and other factors cause water sales to vary unpredictably, compliance with the revenue threshold requirement is based on average performance over the previous three years of BMP implementation.

Shifting more sales revenue into the variable component has the potential to save significant amounts of water. For example, if California's conservation pricing BMP resulted in one-quarter of its retail water utilities increasing their residential variable charges by 10%, the California Urban Water Conservation Council has estimated that residential water demands statewide could decrease by 37.5 to 50.0 MGD in the near-term, and 62.5 to 75.0 MGD in the long-term.

Conservation-Oriented Rate Designs

Water rates have been designed in a variety of ways to promote water conservation. Three of the most commonly employed designs are: (1) increasing-block rates, (2) seasonally adjusted rates, and (3) budget-based rates. This section describes each of these approaches as well as how they can be combined to further refine the price signal or meet other policy or financial objectives.

Increasing-Block Rates

With an increasing-block rate, the price of water increases with the quantity of water consumed. The rate structure defines two or more consumption blocks (or tiers) and the price for water in each block. For example, a 3-block structure might define the first block as monthly consumption between 0 and 6 CCF; the second block as monthly consumption between 6 and 10 CCF; and the third block as anything more than 10 CCF. A customer consuming 7 CCF in a month would pay the lower first block price for the first six CCF and the higher second block price for the seventh. A customer consuming 12 CCF would pay the first block price for the first six CCF, the second block price for the next four CCF, and the third block price for the last two CCF.

Water agencies typically use increasing-block rate designs to send a price signal to their customers that higher amounts of consumption require the agency to acquire, treat, and distribute more expensive water supplies. Ideally this is done by setting the price for water equal to the marginal cost of supply. However, this can result in the water agency collecting too much revenue. Agencies can use a block-rate design to avoid over collecting revenue. The upper-block rates are set to approximate the marginal cost of water supply. The lower-block rates are set so the agency does not exceed its revenue requirement.

The effectiveness of increasing block-rates as a conservation tool depends on the design of the blocks and block-prices. As previously noted, upper-block prices should reflect long-run system marginal costs. The blocks should be such that transitions between blocks are attainable through reasonable modifications in water using behavior and capital. For example, designing a block-rate so the top 25% of residential water users fall within the upper block and could through modest to moderate investments in water use efficiency move into the lower block would be more effective than a block-rate structure where 75% of residential water users fall into the upper-block and only a small percentage would be expected to move into the lower block through moderate to extraordinary investments in water use efficiency. In all cases, designing a good block-rate structure requires thoughtful analysis of customer water usage patterns and water system costs.

Seasonal Rates

Seasonal rates can be used to reflect temporal differences in the cost of providing water service. For many water agencies, costs increase during the summer months because of the need for extra capacity to serve increased outdoor demand. Some water agencies may also have to increase their reliance on more expensive sources of water during summer periods. A seasonal rate design can be used to signal to water users that the resource they are demanding costs more to provide in some periods than others. This is a type of peak-load pricing; a pricing structure commonly used in the electricity, gas, communication, and transportation industries.

Seasonal pricing can be especially effective in promoting outdoor water conservation. As discussed previously, empirical studies have shown outdoor water use tends to be more responsive to rates. Partly this is because at historic prices water users have not placed much emphasis on landscape water use efficiency. As price rises, relatively easy changes in irrigation scheduling and maintenance can result in significant changes in water use. Also, a seasonal rate increase provides water users with a bigger financial incentive to fix outdoor leaks. Given that outdoor water uses typically account for almost two-thirds of residential water demand, using a rate structure that signals to customers the full cost of meeting these demands is a good way to promote more efficient water use. Seasonal rate designs can be an effective way to do this.

Budget-Based Rates

Budget-based rates combine a water use budget (typically for landscape-only water uses) with a schedule of rates. Rates are tiered to provide a financial incentive to stay within the water use budget. Exceeding the budget results in a higher rate or surcharge. Charges for exceeding the budget can be on a sliding scale, increasing as the amount the budget is exceeded increases. Budget-based rates are a requirement of BMP 5 for accounts with dedicated landscape meters.

Budget-based rates have several key advantages for promoting landscape water use efficiency. First, they establish for customers the correct amount of landscape water usage designed to keep both landscape healthy and water use reasonable. This is important because a surprisingly large proportion of water users really have no idea how much water their landscape requires to stay healthy and vibrant. Given this lack of knowledge, many water users adopt a "more is better" approach to watering. Second, the budget allows the water agency to identify customers with excessive outdoor water usage and provide direct assistance to them to become more water efficient. Third, the budget provides information about whether landscape water usage is excessive to the person responsible for paying the water bill. This is useful because for accounts with large landscaped areas it is frequently the case that the person responsible for paying the water bill is not the same as the person managing the landscape. In these cases, the person paying the bill learns whether they are using too much water for landscape and need to work with their landscape manager to curb usage.

A study of four southern California water agencies with budget-based rates found they reduced landscape water use by about 20%.[8] The study also found that the rates were effective at reducing seasonal peak demand and that customers became more responsive to information about evapotranspiration and plant water needs.[9]

Drought Pricing

The concept of drought pricing is to incorporate water rates into drought/shortage planning. Water agencies in California currently develop drought management plans that call for coordinated response to water shortages. Part of the coordination needs to include planning

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[8] A&N Technical Services (1997), "Landscape Water Conservation Programs: Evaluation of Water Budget Based Rate Structures," prepared for the Metropolitan Water District of Southern California, September.

[9] Budget-based rates have been criticized as less than perfectly conservation-oriented because they primarily aim to improve water use efficiency of current landscape (short run efficiency). Budget-based rates may provide insufficient incentive to change to a more efficient landscape mix (long run efficiency). These rates represent an informative tradeoff that communities have made between administrative costs, equity of water shortage allocations, and short and long run water efficiencies.

for water rates. The AWWA M1 Manual of Rates includes a section on Drought Pricing. The basic idea is as follows: when a water agency declares a shortage emergency and requests voluntary or mandatory customer curtailment of water use, a corresponding change in water rates for the duration of the drought emergency will accomplish several things:

- Customers are sent a higher price signal to indicate the scarcity value of water during a drought emergency.
- Water agencies avoid the inevitable “unexpected” revenue shortfall that follows a successful citizen response to calls for curtailed water use.
- Water agencies can avoid the political backlash that occurs when water rates are increased after customers have heeded the call to perform a civic duty by curtailing use.

Hybrid Designs

Different rate designs can be combined to better tailor the price signal to specific policy objectives. Seasonally differentiated rates, for example, can also incorporate block- or budget-based components. Existing rates can be combined with excess use surcharges or discounts to discourage wasteful water uses and reward efficient practices. In San Francisco, for example, customers that retrofit their homes or businesses with low water using fixtures are eligible for a lower rate than those that do not. Water budgets have been very successfully married to drought pricing in areas that have experience severe water shortages.[10]

Cost-of-Service Considerations

It is practically a truism to say that higher water rates will result in lower water use. One could thus conclude that in terms of promoting water conservation, the higher the rate the better. But this would be wrong. Rates should be designed to accurately transmit to water users the cost of providing water service. This is a fundamental requirement for economically efficient pricing policies and a legal requirement in many parts of the country.[11] A detailed cost-of-service study should be at the core of every rate design. Rates should be designed to allocate

[10] See the recent AwwaRF study by Mayer, DeOreo, Chesnutt, Pekelney, and Summers, *Water Budgets and Rate Structures–Innovative Management Tools*, 2007.

[11] For example, the passage or Proposition 218 in 1996 amended the California Constitution to require a strong nexus between cost-of-service and the fees charged to property owners for a property-related service. A recent decision by the California Supreme Court (Bighorn-Desert View Water Agency v. Beringson) affirmed that water service is subject to these requirements.

and recover system costs in a way that closely approximates the causation of those costs. Simple rates based on average system costs often fail to do this because they ignore important temporal, spatial, and volume differences in daily, monthly, and annual demands that drive system capacity and operating requirements. More sophisticated rate designs that reflect long-run marginal costs and include seasonality can do a better job at equitably and efficiently allocating system costs while simultaneously helping to meet an agency's water conservation policy objectives.