Literature Review of the influence of water rate structures and price on water usage and associated benefits

Executive Summary

This literature review is one of several products being developed by the Great Lakes Commission and its partners under the Value of Great Lakes Water Initiative. With funding from the Great Lakes Protection Fund, this initiative aims to guide and inform the Great Lakes states and provinces as they begin to implement the provisions of the Great Lakes-St. Lawrence River Water Resources Compact and Agreement.

The purpose of this literature view is to assess the current state of research related to the influence of water rate structures and pricing on water usage. This review also summarizes the associated benefits and limitations of various rate structures. Examples of how water pricing influences demand and how it can be implemented to achieve water resource management goals are highlighted. The literature is organized under the following content categories: effects price on water usage; watershed protection; pricing recommendations to government; utility revenue challenges and rate design; and price elasticity.

This literature review focuses on water pricing in the public supply sector. It does not include the effects of water pricing on water users who are not supplied by a public water system, such as self-supplied domestic users, agricultural users or industrial users.

Effects of Price on Water Usage

The literature reviewed indicates that the price of water can influence its usage and promotes water conservation. A study on consumption and conservation behavior within the three water districts of the San Francisco Bay area demonstrated that pricing had a particular effect on conservation during the annual dry season (Corral, Fisher, Hatch, 1999). On the eastern side of the United States, in Spalding County, Georgia, a study found that increasing block rate structures were effective in reducing consumption where no other conservation program was in place (Jordan, 1994). Furthermore, inclining block rate structures with more than 3 price blocks seem to create stronger incentives to conserve according to a study in Florida that analyzed the affects of a number of price blocks on residential customers (Rawls et al., 2010). Ultimately, the findings from the current literature conclude that conservation rates are best used to reduce peak demands that usually occur during the dry, summer months and are less effective in reducing base demand such as indoor uses (Jordan, n.d.).

To help educate utilities in designing rates to achieve better financial health and water conservation goals, Chesnutt and Beecher (1998) developed an abridged “how to” guide in alternative rate designs, weighing the pros and cons of various pricing methods. This publication discusses how conservation-oriented rates that reflect the true price of water can change consumers’ water use and reduce operating and development costs. Chesnutt and Beecher highlight some of the short-term benefits of conservation pricing: (1) reducing operating costs associated with pumping and treatment, (2) improving stream flow and slowing down groundwater depletion, and (3) improving drought management. Long-term benefits include avoided operating and capital costs to expand capacity for both the water and wastewater utilities.

Much of the literature is focused on regions that face limited water supplies. However, water conservation goals vary among utilities, especially in areas that are not limited in water supply. The use of certain pricing structures may be inappropriate or not worth the administrative resources in certain situations (e.g., a Great Lakes surface water utility with excess capacity and no expansion-related capital costs to avoid; aging infrastructure; and high water loss in the distribution system).

Price Elasticity

Related to the pricing impacts on conservation behavior are research studies that quantify the price elasticity of water as commodity. Many studies on price elasticity of household commodities such as water, natural gas and electricity show that they are all price inelastic. In other words, the price has a low influence on consumer demand (Dale, Fujita et al., 2009). Results from a 1998 study show a 10 percent increase in water price will reduce aggregate demand by 3.3 percent in the short-term and 3.9 in the long-term. Price responsiveness varied according to income and other household characteristics. Households with lower incomes responded more to higher water prices than wealthier households (Renwick and Archibald, 1998).

Despite this inherit inelasticity, other studies suggest that price could still be a good water demand management tool. A 2003 study by Olmstead, Hanemann and Stavins concluded that although the sensitivity of residential demand to price is quite low, price elasticity is higher and demand is lower among households facing block prices than among households facing uniform margin prices. A more recent study by Olmstead and Stavins (2007) shows strong empirical evidence for using prices to manage demand as more cost-effective than implementing non-price conservation programs. They found that on average in the United States, a 10 percent increase in the marginal price of water can be expect a decline in residential water demand by 3-4 percent, reflecting a similar elasticity demonstrated in the earlier 1998 study by Renwick and Archibald.

Watershed Protection

The relevance of utility pricing to achieve environmental benefits and watershed protection will depend on the mix of water users within a given watershed. In areas where public water systems only make up a small fraction of the total water use, water pricing may have little impact. In more urbanized areas, the price may have a larger impact on watershed protection.

The relationship between water pricing and watershed protection is not well studied. Most of the research consists of case studies of how local governments have successfully tied a portion of the price of public water to watershed protection. Examples include the city of San Carlos in the Philippines and New York City.

In the city of San Carlos, an additional environmental tax to residential water bills funds the city's multi-year watershed rehabilitation and conservation plan which aims to reforest 40 percent of the watershed (Villamor and Lasco, 2007). Historically, this watershed was covered in rainforest. Now only 5 percent of the rainforest remains in the watershed due to extensive logging in the 1950s and 1960s. As of 2005, a total of 7,014 seedlings of indigenous and fast growing species were planted. This financing scheme is now being replicated in other parts of the Philippines.

In the United States, New York City was able to opt out of the federal filtration requirements under the U.S. Safe Water Drinking Act by investing in a comprehensive watershed protection program in the Catskill-Delaware watershed which provides 90 percent of the city's drinking water. In signing a 1997 Memorandum of Agreement with local, state and federal officials, the city agreed to invest $1.5 billion over 10 years to restore and protect the watershed. Financing for this activity comes from additional taxes on residential water bills as well as from municipal bonds (Postel and Thompson, 2005). To advance watershed protection, Postel and Thompson make some noteworthy recommendations:

- Designate watershed protection to be a responsibility of water suppliers and bridge institutional divisions that separate watershed decisions from the provision of safe drinking water.
- Design water supply regulations that recognize the value of natural watershed services as cost-effective alternatives to technological treatment methods. In particular, institute water user fees or water-rate structures that build the costs of watershed protection into urban water supply systems.

Internationally, a couple of studies have assessed federal payment programs in Costa Rica and Mexico that aim to link water users to watershed protection activities (Munoz-Pina et al., 2008; Pagiola, 2008). An overarching finding

from both studies is the challenge of substantiating the benefits (e.g, improved water quality) of the watershed conservation activities to the water users in a federal program. This challenge is especially apparent when the watershed conservation activity is outside the watershed of water user who is paying into the program.

Pricing Recommendations to Government

Local, state and provincial governments as well as some non-profits have studied the issues of water supply and demand within regional areas of North America, from the arid Southwest to the water-abundant Great Lakes region. They have released reports and white papers on how governments can better manage their water resources using water rates. Many of the recommendations in these sources point to the need to price water in ways that reflects the full costs of providing water service to encourage efficiency and better reflect its scarcity. In the Great Lakes region, the Ontario Ministry of the Environment (2007) and the Chicago Metropolitan Agency for Planning (CMAP) (2010) have released reports with recommendations calling for the adoption of such a pricing scheme. Furthermore, in its 2010 Northeastern Illinois Regional Supply Demand Plan, CMAP recommends that the state natural resource agency encourage water use permittees to assess the feasibility of adopting seasonal water pricing and that county governments foster public acceptance and the political viability of conservation pricing.

To recover the full cost of providing water service, several forms of conservation-oriented pricing are recommended in the literature. American Rivers (2008) recommends a flat service fee that covers all utility fixed costs, a variable fee for the volume of water consumed, and higher fees associated with water waste that should fund conservation incentive programs. While most utilities follow this model, the volumetric charge may be minimal and may not send a very good price signal. In Wisconsin, some utilities have recovered some fixed costs through volumetric charges, providing a better price signal.

Similarly in a 2007 report published by the Pacific Institute and Western Resource Advocates, recommends a tiered blocked rate structure that incorporates low fixed costs and low rates for indoor needs yet a sharply increasing rate for outdoor uses. In another report, the New Hampshire Public Utilities Commission recommended a uniform rate and increased metered service as a first step in promoting conservation in its 2007 report, “Investigation into Water Conservation.”

Utility Revenue Challenges and Rate Design

Utility revenue challenges could be summed up in balancing environmental, political and equity concerns with the costs of providing the water. Affordability is a growing area of concern, and some conservation-oriented rate structures can disproportionately affect low-income persons or families. Gaur (2007) notes that with the rising social and environmental consciousness as well as the increasing cost of providing and delivering water, policymakers will need to implement more equitable and defensible rate structures.

Historically, water rates have been insufficient in covering long-run costs (Levin, Epstein et al., 2002). The literature suggests that this historic trend could be reversed by implementing alternative rate designs. A well designed pricing system can encourage conservation, reduce demand and requirements for future infrastructure expansion, and accommodate the long-run costs of the system. Chestnutt, Fisk et al. (2008) discuss how water use efficiency programs must be integrated in the overall economic picture of water system with consideration of the overall hydrologic cycle. Rawls and Brisova (2009) identify that conservation rates are a tool for utilities and regulatory agencies as part of a comprehensive, long-term planning approach in managing water resources. Both McCormick and Welser (2009) and Mitchell and Chesnutt (2009) discuss the effectiveness of rates designed to recover the cost of providing service. They conclude that more sophisticated rate designs that reflect long-run marginal costs and seasonality, and more equitably and efficiently allocate system costs will help an agency meet its water conservation policy objectives.

Another challenge for utilities is surviving the current economic downturn that has left some Great Lakes water utilities grappling with a declining customer base and increasing infrastructure needs. Beecher (2010) suggested a

variety of methods for utilities to overcome the declining sales and revenues while financing infrastructure needs. These coping methods include frequent rate adjustments; implementing forward-looking rates; and making demand-repression adjustments to programs and prices.

Annotated Bibliography

PRICING IMPACTS ON CONSERVATION

Chesnutt T. and Beecher, J. (1998). "Conservation Rates in the Real World." Journal AWWA 90(2):67.

This article summarizes the various alternative pricing approaches and their effects as presented in the California Urban Water Conservation Council sponsored "Designing, Evaluating and Implementing Conservation Rate Structures" handbook. The handbook advocates the use of long-run, marginal-cost pricing. Given resource constraints, prices based on marginal costs will encourage conservation more than prices based on historic costs. Additionally, it explores the relationship between water conservation and water rates. The article discusses both short-term and long-term benefits of conservation rates.

Corral. L., A.C., Fisher, N.W. Hatch. (1999). "Price and Non-Price Influences on Water Conservation: An Econometric Model Aggregate Demand under Nonlinear Budget Constraint." Dept. of Agriculture and Resource Economics, UCB, UC Berkely. http://escholarship.org/uc/item/3gx868tg

This paper describes a model used to study the influence of pricing and non-price conservation programs on consumption and conservation behavior in three water districts in the San Francisco Bay Area, over a 10-year period that includes both drought and normal years. Empirical results show that pricing can be effective in reducing water consumption, particularly during the annual dry season, and during longer drought episodes. Non-price conservation programs such as use restrictions and landscaping audits, appear to be particularly effective in inducing conservation.

Jordan, J. L. (1994). "The Effectiveness of Pricing as a Stand-Alone Water Conservation Program." Water Resources Bulletin, American Water Resources Association 30(5).

This paper examines the effectiveness of increasing rate structures in a situation where no other conservation program was introduced. The paper uses customer data from the Spalding County (Georgia) Water Authority where an increasing rate structure replaced a descending rate structure in January 1991. Since the imposition of the increasing rate structure, the number of customers has increased 21 percent while total water demand has gone up only 15 percent and per customer water use has declined 5 percent. The daily water use per connection has declined from 243 gallons in 1990 to 231 in 1993, and monthly use has gone from 7,381 gallons to 7,028 per connection over the same period. Statistical tests indicate that water consumption during the two periods was significantly different while weather factors were not.

Jordan, J. L. (n.d.). "Pricing to Encourage Conservation: Which Price? Which Rate Structure? University of Georgia." http://www.ucowr.siu.edu/updates/pdf/V114_A5.pdf

This paper reviews current literature on water price elasticities, impacts of billing information on consumer demand, and impacts of peak and seasonal pricing on demand. The author concludes that conservation rates can be best used to reduce peak demands. Conservation rates may be less effective in reducing "base level" or indoor water use. Simple uniform rates with excess or season charges may be more effective then increasing block rates, but the impact of peak charges on utility revenues are less predictable.

Rawls, C., T. Borisova, S. Berg, and J. Burkhardt. (2010). "Incentives for Residential Water Conservation: Water Price, Revenue, and Consumer Equity in Florida." Selected Paper prepared for presentation at the Southern Agricultural Economics Association Annual Meeting, Orland, FL, February 6-9, 2010. http://ageconsearch.umn.edu/bitstream/56510/2/Incetives%20for%20Residential%20Water%20Conservation%20a.pdf

This white paper describes a study to identify the tradeoffs faced by water utilities that implement conservation rates. To achieve this purpose, the study analyzed whether the number of price blocks affects the conservation incentives faced by residential customers; statistically tested the evidence that rate structure effects utility revenue and revenue variability; and analyzed the impact of different rate structures on consumer equity. The study results show that inclining block rate structures with more than 3 price blocks seem to create stronger incentives to conserve. However, uniform rate structures and rate structures with 3 or less blocks can also be designed to create strong conservation incentives. There may be a tradeoff between conservation and revenue variability, but further statistical analysis is needed. No evidence of a tradeoff between equity and water conservation objectives for water utilities was found.

WATERSHED PROTECTION

Brauman, K.A., G. Daily, T. Ka'eo Duarte, H. A. Mooney. (2007). "The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services." Annual Review of Environment and Resources. 32:67-98 (doi: 10.1146/annurev.energy.32.031306.102758).

This article provides an overview of ecosystem functions responsible for providing terrestrial hydrologic services. How hydrological services should be measured is discussed. Valuation and policy tools useful for ecosystem service protection are evaluated. The article notes that monetary valuation can be a powerful tool for decisionmaking because it organizes information about hydrologic services using a common metric. As a valuation tool, voluntary market-based payments are attractive because they allow conservation to occur outside a regulatory framework.

Munoz-Pina, C., A. Guevara, J. M. Torres, J. Brana. (2008). "Paying for the hydrological services of Mexico's forests: Analysis, negotiations and results." Ecological Economics. 65(4):725-736. DOI: 10.1016/j.ecolecon.2007.07.031.

This article discusses the Mexican federal Payment for Hydrological Environmental Services (PSAH) program that pays participating forest owners for the benefits of watershed protection and aquifer recharge in areas where commercial forestry is not currently viable. The funding comes from water users through the federal water fee which is set annually by Congress. The article describes the process of designing the PSAH program and the main stakeholder involved, and provides a preliminary evaluation. One of the main findings is that the payments are targeted in areas with low risk of deforestation. Areas that benefit directly the water users should be targeted.

Pagiola, S. (2008). "Payments for environmental services in Costa Rica." Ecological Economics. 65(4): 712-724. ISSN 0921-8009, DOI: 10.1016/j.ecolecon.2007.07.033.

This paper discusses the payments for environmental services (PES) employed in Costa Rica. This federal program run by the National Fund for Forest Financing (NFFF) charges users of environmental services for the services they receive. NFFF can sell interested water users environmental services certificates which pay for the conservation of one hectare of forest in a specified area. NFFF have made recent agreements with bottlers, municipal water systems, irrigators, and hotels to cover conservation costs over a five year period. In addition to the PES program, Costa Rica expanded its water tariff to water permittees to include a conservation fee earmarked for watershed conservation.

Postel, S.L. and B.H. Thompson, Jr. (2005). "Watershed protection: Capturing the benefits of nature's water supply services." Natural Resources Forum 29: 98-108
http://www.globalwaterpolicy.org/pubs/NRF_watershed05.pdf

This article presents a brief overview of the importance of natural water supply services, a typology of mechanisms for protecting those services, several cases where innovative mechanisms are under way to

increase such protection, and recommendations for achieving higher and sustainable levels of protection. New York City's (NYC) negotiated partnership with upstream landowners and communities in the watershed was highlighted as case study example of creating a unique link between ecosystem service providers and beneficiaries. NYC opted to seek a waiver of the U.S. Safe Water Drinking Act filtration requirement by investing in a comprehensive watershed protection program in the Catskill-Delaware watershed which supplies 90 percent of the city's drinking water. The city signed a MOA in 1997 with local, state and federal officials, committing the city to invest about $1.5 billion over 10 years to restore and protect the watershed. Financing comes from additional taxes on residents' water bills and from municipal bonds.

Selected recommendations from the paper include:

- Act early to integrate watershed protection and management into the provision of safe drinking water.
- Designate watershed protection to be a responsibility of water suppliers and bridge institutional divisions that separate watershed decisions form the provision of safe drinking water.
- Establish equitable partnerships between the land-holders providing watershed services and those benefiting from the services.
- Design water supply regulations that recognize the value of natural watershed services as cost-effective alternatives to technological treatment methods. In particular, institute water user fees or water-rate structures that build the costs of watershed protection into urban water supply systems.

Smith Jr., W.J. and Y.-D. Wang. (2007). "Conservation rates: the best 'new' source of urban water during drought." Water and Environment Journal. http://gis.unlv.edu/bismi/WEJ85.pdf

This study examines the effects of water conservation-oriented rates (WCOR) on water demands and secondarily stream flow through various models. The study models prove that one type of WCOR, drought demand rates can produce with minimal regulation the quadruple objectives of conservation rates: (1) improve efficiency; (2) provide revenue neutrality; (3) assure distributional equity and (4) guarantee the conservation of water. The study demonstrated that drought demand rates can make an immediate and powerful short-term, positive impact both in terms of supply and ecology. Such rates can reduce days that urban streams drop below critical flow levels.

Villamor, G.B. and R.D. Lasco. (2007). Water Levy as Financing Scheme for Watershed Protection – A City Government Initiative to Rehabilitate the Baticulan Watershed, Philippines." International Forum on Water Environmental Governance in Asia, March 2007, Bangkok.
http://www.worldagroforestrycenter.org/SEA/Publications/files/paper/PP0239-08.PDF

This paper presents a case study in the Philippines where the city of San Carlos played an important role in developing a financing scheme to rehabilitate their denuded watershed through a water levy. The levy is a small environmental fee (0.75 pesos) on every cubic meter of water billed. The revenue from the levy goes to the "Watershed Development and Environmental Protection Fund." This fund supports project under the city's multi-year watershed rehabilitation and conservation plan. The goal is to reforest 40% of the watershed.

PRICING RECOMMNEDATIONS TO GOVERNMENT

Adams, T. (2001). "Guiding and Controlling Ontario's Future Water and Wastewater Services: User Pay and Full Cost Pricing, Independent Economic Regulation, Strengthened Environmental Law Enforcement." Submission to the Walkerton Inquiry on behalf of the Energy Probe Research Foundation.

The purpose of this paper is to assist the Walkerton Inquiry in making recommendations to prevent reoccurrence of the tragedy that occurred in Walkerton in May 2000, and in finding permanent, effective solutions to the problem of unsafe drinking water and unsound waste water management practices in Ontario. This paper recommends that water services in Ontario be redesigned around the principle of user pay and overseen by an independent economic regulator of water utilities. To maximize efficiency and generate the funds necessary to support much-needed upgrades, rates for water service should be based on the principles of full cost pricing and "user pay." Full cost pricing would cover both the fixed and variable cost of supplying water, the environmental costs of its extraction, and the associated rent. The creation of the Ontario Water Board, a province-wide economic regulator to oversee water utilities, is also recommended.

American Rivers. (2008). "Hidden Reservoir: Why Water Efficiency is the Best Solution for the Southeast."

This report makes the case that water efficiency is the best source of affordable water and must be the backbone of water supply planning. By implementing the nine water efficiency policies outlined in this report, communities across the Southeast can secure cost-effective and timely water supply. To demonstrate the impact water efficiency could have in Southeastern communities, the authors have applied the nine policies to four cities and calculated the amount of water that could be secured.

One of the nine policies is pricing water to cover costs and encourage efficiency. The report recommends that utilities should adopt a two part fee system which establishes:

- A flat service fee that covers all utility fixed costs, such as pipe maintenance and pump station operations.
- A variable fee for the volume of water consumed, charging significantly higher rates as water consumption increases to discourage water waste, and lower rates for conserving households and low-fixed income customers.
- Higher fees associated with water waste should fund conservation incentive programs and alleviate the increased cost to lower and fixed income customers.

Chicago Metropolitan Agency for Planning (CMAP). (2010). Northeastern Illinois Regional Water Supply/Demand Plan: Looking Out to 2050.
http://www.cmap.illinois.gov/uploadedFiles/committees/watersupply/Documents/FY10-0079_RWSPG_PLAN_final_low_res.pdf
This report summarized the results of a survey of regional water rates and rate structures in Northern Illinois. About 5% of northeastern Illinois systems use decreasing block rates for residential accounts, while 29% of commercial and industrial accounts use decreasing block rate structures. The majority of water systems in Northeastern Illinois employ two-part rate schedules, which include a charge that does not vary with water use (fixed charge) and a charge that does vary with water use (commodity charge). Additionally, this reports presents water rate/conservation pricing recommendation to:

1. The state (ex., For the Lake Michigan service region, IDNR/OWR should encourage permittees to assess the feasibility of adopting seasonal water pricing),
2. County governments (ex., Foster public acceptance and political viability of conservation pricing.), and
3. Public water suppliers (ex., Implement rate structures based on full cost water price within a broader conservation program.)

Cooley, H., T. Hutchins-Cabibi, et al. (2007). "Hidden Oasis: Water Conservation and Efficiency in Las Vegas." Pacific Institute and Western Resource Advocates.
http://www.pacinst.org/reports/las_vegas/hidden_oasis.pdf

This report reviews Las Vegas' water conservation and efficiency efforts and potential. People respond to price signals, yet water agencies in Las Vegas underestimate the importance of proper water pricing. Las

Vegas has relatively high fixed rates and lower per-unit rates than many other arid and semi-arid cities in the West. This rate structure does not adequately encourage efficient water use. The report authors recommend expanding efforts to develop a tiered block rate structure that incorporates low fixed costs, low rates for water sufficient to meet basic indoor needs, and a sharply increasing rate for higher-volume outdoor uses.

New Hampshire Public Utilities Commission. (2003). "Investigation into Water Conservation." Report DW 01-253. http://www.puc.nh.gov/Water-Sewer/01-253Report.pdf

This report was in response to a recommendation from the New Hampshire Public Utilities Commission and the Department of Environmental Services to convene meetings with utilities and other stakeholders to consider water utility ratemaking structures, rate design approaches among other water conservation activities. The report documents the opinions of meeting participants and describes trends in ratemaking documented in other literature. The report discusses literature related to conservation rates and their impact on utility revenue. In conclusion, report authors recommend that New Hampshire water utilities use non-conservation rates first while eliminating unnecessary uses, unmeasured service and accompanying flat rates. Other non-pricing conservation measures such as leak detection and prevention and water restriction were also recommended.

Ontario Ministry of the Environment. (2007). "Toward Financially Sustainable Drinking Water and Wastewater Systems."

This paper recommends that water services in Ontario be redesigned around the principle of user pay and overseen by an independent economic regulator of water utilities. To maximize efficiency and generate the funds necessary to support much-needed upgrades, rates for water service should be based on the principles of full cost pricing and "user pay." If subsidies are deemed necessary to ensure social equity, disadvantaged individuals should be subsidized with direct payments, independent of their level of consumption, rather than resource prices below cost. This study suggests that, given consumers' low elasticity at current prices, price structure may be an important and cost-effective alternative to command-and-control approaches, and possibly a more effective alternative, in terms of its ability to reduce water consumption, than increases in the magnitude of marginal price, itself.

UTILITY REVENUE CHALLENGES AND RATE DESIGN

American Water Works Association. (2000). "Principles of Water Rates, Fees, and Charges." Manual 1. Fifth Edition. http://books.google.com

This manual is intended to help policymakers and rate analysts consider all relevant factors when evaluating and selecting rates, charges and pricing policies. It is a comprehensive collection of discussions and guidance on a variety of issues associated with designing and development of water rates and charges. It presents pricing alternatives related to specific customers or groups of customers. It discusses the recognition of demands, drought conditions and other considerations in establishing rates and charges.

Beecher, J.A. (2010). "The conservation conundrum: How declining demand affects water utilities." Journal AWWA 102:2

This article describes the challenge for utilities to remain financially sustainable when infrastructure costs are rising and a sales base is shirking due to the economic depression. Various coping methods were listed including long-term planning and scenario building with goals and performance metrics; more frequent rate adjustments; forward-looking rates; demand-repression adjustments to programs and prices; and periodic assessments of rate-design options.

Beecher, J.A., Mann, C.P., et al. (1994). "Revenue Effects of Water Conservation and Conservation Pricing: Issues and Practices." The Regulatory Research Institute. Ohio State University. http://ipu.msu.edu/research/pdfs/NRRI%20Revenue%20Effects%20of%20Water%20Conservation.pdf

This report explores the incentives and disincentives for water utilities to promote water conservation through their pricing rate structures. It notes that pricing is not always a sufficient way to motivate customers to conserve. It discusses the results of various water price elasticity studies which are often contradictory. Although demand for water is relatively price-inelastic, changes in price can result in changes in water usage. Variations in price elasticity of water demand may be due to the level and design of rates, customer class, geographic region, and type of use (such as indoor or outdoor, peak or off-peak). The report concludes that developing industry-specific policies on conservation pricing is a challenge. To meet this challenge, water utilities and regulators have begun to recognize efficiency as a viable resource option. A long-term efficiency-oriented perspective is needed to address concerns about the effects of conservation on water utility revenues.

Chesnutt, T.W., Fisk, G. et al. (2008). "Water Efficiency Programs for Integrated Water Management." Journal AWWA 100(5): 132-141

This article discusses the use of integrated water planning (IWP), an approach for water utilities to use systematic evaluation tools to select water resource management options and water-use efficiency (WUE) programs. The article refers often to the IWP evaluation tools that are available in the American Water Works Association Research Foundation report, "Water Efficiency Programs for Integrated Water Management." It further discusses how WUE programs should be integrated in the overall economic picture of a water system, including the hydrologic cycle. A simple accounting of water flows within a water utility's service area may be insufficient to understand all the potential costs and benefits of a WUE program. The ultimate goal of IWP is to provide the same or greater value from current and planned water supply systems while reducing the costs incurred. By reducing water use or altering patterns of use, WUE can reduce costs and improve total system efficiency.

Gaur, S. (2007). "Policy Objectives in Designing Water Rates." Journal AWWA 99(5): 112.

This article briefly describes the steps in developing a water rate structure, which the AWWA's Manual 1 fully documents in greater detail. The author compares six different rate types of rate structures (flat rate, declining rate, uniform rate, season rate, inclining rate and budget/individual) against four policy criteria (financially stable, social equitable, environmentally sound and administratively manageable). Finally, he notes some current trends in rate development. Inclining-block rates are growing in popularity in response to increasing environmental concerns. The author notes that with rising social and environmental consciousness, as well as the increasing cost of both water provision and delivery, policymakers will need to implement more equitable, defensible rate structures.

Jordon, J. L. and R. Albani. (1999). "Using Conservation Rate Structures." Journal AWWA 91(8).

This article discusses the results of a survey of water suppliers using conservation rate structures. The survey included questions about service characteristics, demand levels before and after implementation of conservation rates, rate structures and price levels, billing and revenue, other conservation measures, and the objectives and effectiveness of rates and conservation efforts. This article is intended to provide insight into the use of pricing as part of utility conservation efforts. Several conclusions based on the survey responses were made: 1) Rates used as part of a conservation program were most effective at reducing peak demands; 2) The use of permanent or complex increasing-block rate structures may be less effective than simple uniform rates with excess or seasonal charges; and 3) Although rates may affect peak usage, other conservation programs (e.g., low-flow fixtures, education) may be more successful at reducing base demand.

Levin, R.B., P.R. Epstein, et al. (2002). "U.S. Drinking Water Challenges in the Twenty-First Century." Evironmental Health Perspectives 100(1) 43-52.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1241146/pdf/ehp110s-000043.pdf

This paper presents an overview of trends in drinking water management in the U.S. The authors examine the areas of public water infrastructure, global climate effects, waterborne disease, land use, groundwater, surface water and the U.S. regulatory scheme. The pricing of water was noted as an unsustainable practice among local public water providers. Water rates have been insufficient to cover long-run costs. Furthermore, authors argue that water pricing should include the costs of watershed or aquifer management. Additionally they note that a well-designed pricing system can encourage conservation, which will not only reduce demands on the water resource, but also reduce future infrastructure requirements. They conclude that U.S. drinking water supplies will face challenges in these areas in this century and that solutions to at least some of them will require institutional changes.

McCormick, S. and W. Welser. (2009). "Measuring the Value of Water." Water & Wastes Digest.
www.wwdmag.com/lm.cfm/wd020912

This article describes the city of Ann Arbor, Michigan's approach to solving its water supply problems through its cost of service programs. The city has growth constraints to its groundwater and river water capacity and took a demand management approach to live within the existing capacity. Ann Arbor's cost-of-service rate structure allows it to distribute the costs of developing and maintaining the water system more fairly while incentivizing to conserve. The article further discussed how Automatic Meter Reader (AMR) technology enhanced its cost-of-service program. Customer's can view their usage, provided by AMR data taken twice daily and gauge how much their bills will be at the end of the current billing cycle. This helps customers understand the effect that specific types of usage such as lawn irrigation have on a bill. Future refinements to the program may include accounting for peaking factors for individual, residential users.

Mitchell, D. and T. Chesnutt. (2009). "White Paper: Water Rates and Conservation."
http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/rates/White-Paper-Rate-Structures-and-Conservation-March-13-2009.pdf

This paper provides a discussion of water rate structures and conservation. 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. It describes the various conservation-oriented rate designs and how they can be combined to further refine the price signal or meet other policy or financial objectives. It concludes with a discussion on how the cost-of-service should be integrated into rate design. More sophisticated rate designs reflecting long-run marginal costs and seasonality more equitably and efficiently allocate system costs while helping an agency meet its water conservation policy objectives.

Rawls, C. and T. Borisova. (2009). "Conservation and Drought Water Rates: State-of-the-art practices and their application." Prepared for Conserve Florida Water Clearinghouse Research. UF Water Institute.
http://library.conservefloridawater.org/publications/11759296.pdf

The overall purpose of this synthesis paper is to identify and summarize state of the art in conservation and drought pricing practices, and explore the challenges and opportunities associated with conservation pricing. Research gaps and needs for future research were also identified. For example, the paper recommends further research on the relationship between water conservation and utility revenue. It concludes that conservation rates are a useful tool for utilities and regulatory agencies as part of a

comprehensive, long-term planning approach. This study is based on a literature review and personal interviews with utility managers and agency representatives.

Stallworth, H. (2004). "Conservation Pricing of Water and Wastewater." U.S. Environmental Protection Agency. **http://www.epa.gov/OW-OWM.html/cwfinance/cwsrf/consrvprice.pdf**

This white paper addresses the role of price mechanisms in water and wastewater conservation. It describes the potential for water pricing strategies to be used to both stimulate conservation and raise revenue to meet clean water needs. This paper discusses how to internalize these impacts into a price mechanism that reflects underlying ecological costs of water use. Additionally, it reviews literature that document how price impacts water demand.

PRICE ELASTICITY

Dale, L., K. S. Fujita, et al. (2009). "Price Impact on the demand for water and energy in California Residences." California Climate Change Center. http://www.energy.ca.gov/2009publications/CEC-500-2009-032/CEC-500-2009-032-F.PDF

This paper summarizes research that estimates the household price elasticities for natural gas, electricity, and water in California. Preliminary estimates of the price elasticity of demand for natural gas, electricity, and water in California are presented. The paper concludes with a short discussion of the results, and their possible policy implications. The regression estimates reported in this paper suggest that the price elasticity of demand for natural gas, electricity, and water is slightly lower than is commonly reported in the literature. In other words, price has little influence on demand. Overall, the results highlight the general uncertainty surrounding estimates of the price elasticity of demand for household goods such as electricity, natural gas, and water. Coupled with global warming and rising electricity and water use, the price elasticity findings suggest a need for strong non-price and price conservation measures to effectively manage these resources.

Dziegielewski, B. and Chowdhury, F.J. (2008). Regional Water Demand Scenario for Northeastern Illinois: 2005-2050. Southern Illinois University Carbondale Dept. of Geography and Environmental Resources. http://www.geography.siu.edu/faculty_and_staff/Dzie/NE%20Demand%20Report%20August%2026%2008.pdf

This study presents future water-demand scenarios for geographical areas which encompass groundwater withdrawal points and surface water intakes in the 11-county regional planning area of Northeastern Illinois. For these water-demand scenarios the following price elasticity based on a 2004 study of 219 water systems in Illinois was used, "A 1 percent increase in marginal price of water is associated with a 0.1458 percent decrease in per capita water deliveries, and a 1 percent increase in median household income results in a 0.2845 percent increase in per capita water usage."

Olmstead, S.M., W.M Hanemann, R.N. Stavins. (2003). "Does Price Structure Matter? Household water demand under increasing-block and uniform prices." http://www.google.com/url?sa=t&source=web&ct=res&cd=15&ved=0CBgQFjAEOAo&url=http%3A%2F%2Fwww.esm.ucsb.edu%2Facademics%2Fcourses%2F595EE%2FReadings%2Folmstead_hanemann_stavins.pdf&rct=j&q=Measuring+the+Price+Responsiveness+of+Residential+Water+Demand+in+California%E2%80%99s+Urban+Areas.&ei=l06FS5y-CoG6NdK_7TM&usg=AFQjCNF3EOVhoGQNid5AkqO6w_7LgAYlmA

This white paper describes a study on the influence of the price of water and the structure of water prices on residential water demand. The study included the adaption of a model from the labor economics literature – the Hausman model of labor supply under progressive income taxation – to estimate water demand under increasing-block prices. This structural model was applied to the most price diverse,

detailed, household-level water demand data yet available to estimate the price elasticity of residential water demand. The results indicate that the sensitivity of residential water demand to price is quite low. However, that price elasticity is higher and demand is lower among households facing block prices than among households facing uniform marginal prices. The impact of the price structure on demand appears to be greater than the impact of marginal price itself. This study concludes that given consumers' low elasticity at current prices, price structure may be an important and cost-effective alternative to command-and-control approaches, and possibly a more effective alternative, in terms of its ability to reduce water consumption, than increases in the magnitude of marginal price, itself.

Olmstead, S.M. and R.N. Stavins. (2007). "Managing Water Demand: Price vs. Non-Price Conservation Programs." A Pioneer Institute White Paper.
http://www.hks.harvard.edu/fs/rstavins/Monographs_&_Reports/Pioneer_Olmstead_Stavins_Water.pdf

This white paper offers an analysis of the relative merits of price and non-price approaches. It notes strong empirical evidence that using prices to manage water demand is more cost-effective than implementing non-price conservation programs. The following are selected key conclusions of this analysis:

- On average in the U.S., a 10 percent increase in the marginal price of water can be expected to diminish demand in the urban residential sector by 3 to 4 percent.
- Price elasticity of residential water demand is similar to that of residential electricity and gasoline demand in the U.S.
- Utilities implementing price increase to reduce demand, at current estimates of price elasticity will experience increases in total revenue.

Olmstead, S.M. and E.T. Mansure. (2010). "The Value of Scarce Water: Measuring the Inefficiency of Municipal Regulations." http://www.som.yale.edu/faculty/etm7/papers/mansur_olmstead_water.pdf

Using unique panel data on residential end-uses of water, this study examines the welfare implications of typical drought policies. Using price variation across and within markets, end-use specific price elasticities were identified. The results suggest that current policies target outdoor water uses that households, themselves, are most willing to forgo. Nevertheless, use restrictions have costly welfare implications, primarily due to household heterogeneity in willingness-to-pay for scarce water. A price-based approach would result in welfare gains equal to 28 percent of what households spend each year on water. The paper concludes that in the long run, command-and-control regulations provide no incentive for the invention, innovation, and diffusion of water conserving technologies (outdoors or indoors). Water priced below marginal social cost also results in inefficient land-use patterns, like the establishment of large, lawn-covered lots and thirsty nonnative plant species where water is scarce. Further investigation of the welfare gains from water marketing within and across sectors is an important area for further research.

Renwick, M. E. and S. O. Archibald (1998). "Demand Side Management Policies for Residential Water Use: Who Bears the Conservation Burden?" Land Economics 74(3): 343-359.

This study assesses the potential for urban demand side management (DSM) policies as a water resource management tool. The extent to which price and alternative policy instruments (e.g., use and quantity restrictions and subsidies for water efficient technologies) reduce residential demand and their distributional implications by household types were examined. Using detailed household-level panel data for two California communities, the results suggest that the ultimate effects of DSM policies in terms of reduction in aggregate demand and distribution of water savings among household classes depend both on the policy instrument and the composition of the aggregate demand. Study results show a 10 percent increase in water price will reduce aggregate demand by 3.3 percent in the short-term and 3.9 in the long-term. Price responsiveness varied according to income and other household characteristics. Households with lower incomes responded more to higher water prices than wealthier households.