Interruptible Irrigation Rates:

A Feasibility Study

This report explores the feasibility of an innovative business model for water utilities made possible with a smart water grid: interruptible irrigation rates. Overall, the "business case" for an interruptible irrigation rates program by a water utility is mixed and highly dependent on the structure of a utility and its customer base. Using a synthesis of interviews, research, data analysis, and program simulations, the report provides discussion, suggestions and recommendations for the implementation of an interruptible irrigation rates program.

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A FEASIBILITY STUDY

EXECUTIVE SUMMARY

The purpose of this report is to explore the feasibility and potential impact of an innovative business model for water utilities made possible with a smart water grid: interruptible irrigation rates. Interruptible rates have long been used in electricity demand to manage peak demand. A typical program allows a customer to opt-in to an interruptible rate program in which the customer is charged a lower variable rate for consumption, but gives the utility the ability to cut-off the customer's service when the utility approaches supply constraints.

Overall, the "business case" for an interruptible irrigation rates program for a water utility is mixed and highly dependent on the utility structure and customer base. It is imperative to take utility costs for comparable demand-management policies into account to determine the cost-effectiveness of an interruptible irrigation program, but a program of this sort gives the managing utility a useful and effective tool to control non-essential uses of water demand when capacity constraints arise.

The main findings of the report, from a synthesis of interviews, research, data analysis, and program simulations, are as follows:

- While the decision to install the necessary metering technology (AMI) at a utility-wide scale is not likely to be influenced by the desire to implement an interruptible irrigation rates program, the benefits of such a program would add to the cumulative benefits of investing in new water infrastructure.

- Water supply, treatment capacity, and wholesale water purchases are three of many possible constraints that could benefit from obtaining remote turn-on and turn-off capabilities for irrigation meters.

- Since customers tend to increase consumption when prices drop, which counteracts the utility's goals of water conservation, our analysis finds that irrigation rate decreases between 5-15% exhibit properties conducive to satisfying the program goals.

- Simulation results indicate that the utility should decrease rates just enough to induce customers to participate in the interruptible rates program (while also improving the cost-effectiveness of the interruptible rates program), though not so much so that it affects the utility's revenue goals from decreased income in non-interrupted months.

- The option of discounted variable rates for irrigation will incentivize customers who irrigate through a standard meter to install an irrigation meter. This will benefit the utility since a higher proportion of water volume flowing through an interruptible irrigation meter gives the utility more control over their distributional capacity in this type of program.

INTRODUCTION

Water utilities in the Southeast are increasingly considering the adoption of "smart" water meters to replace decades-old infrastructure and outdated technology. With increasing demand for clean drinking water in the US, the need for efficient management of water supplies is driving the upward trend in demand for advanced metering infrastructure (AMI).[1] New metering technology is attractive for a host of benefits well-known to those in the water management business: improved leak detection, reduced meter reading costs, enhanced customer service, remote service connections and disconnections, among others. AMI meters also provide an opportunity for better demand management by rethinking the way water is priced and distributed for different end-uses. The purpose of this report is to explore the feasibility of an innovative business model for water utilities made possible with a smart water grid: interruptible irrigation rates.

Interruptible rates have long been used by electricity utilities to manage peak demand. A typical program allows a customer to opt-in to an interruptible rate program in which the customer is charged a lower variable rate for electricity consumption, but gives the utility the ability to cut-off a portion of electricity service when the utility approaches its supply constraints. For an electric utility, there are significant benefits from managing peak demand. The corollary to peak demand in the water industry could include drinking water treatment plant capacity, supply contraints requiring an immediate demand reduction, and wholesale water purchases. The ability to better manage these capacity constraints by controlling the use of non-essential water demand (i.e., turf irrigation) is an attractive option for utility managers.

While the decision to install AMI technology at a utility-wide scale is not likely to be initiated by the desire to implement an interruptible irrigation rates program, the benefits of such a program would add to the cumulative benefits of investing in new water infrastructure, making it a potentially more attractive option for a utility. Those benefits, however, are not readily transparent. This report explores the "business case" for the adoption of an interruptible irrigation rates program for a large Southeastern utility.

[1] Rising Demand for Water to be a Key Driver for Smart Water Meter Adoption, Says Pike Research." BUSINESSWIRE. MAY 23, 2012. (Last accessed: 6/8/2012).

PROGRAM DRIVERS FOR RALEIGH AND CARY

In this report, the City of Raleigh and the Town of Cary are used as representative large utilities for a simulated case study. These utilities are ideal for studying the "business case" of interruptible irrigation rates for several reasons: 1) both utilities have recently invested in different types of new metering technology, which allows for unique comparisons of the technology; 2) each utility has a substantial amount of billed irrigation through irrigation meters (between 10-20% of total demand in summer months); and 3) both utilities already have rigid irrigation restrictions included on their mandated Water Shortage Response Plans. Additionally, the Research Triangle region of North Carolina is increasingly becoming recognized as the "Silicon Valley of smart meter technology[2]."

METHODS

The information contained in this report is a synthesized product of informal interviews with personnel of meter companies and utilities, media coverage of smart meter technology and adoption, published research in the field of water demand management, and original analysis of comprehensive customer billing data from Raleigh's and Cary's water utilities from July 2006 to May 2010 obtained by through a partnership with the NC Urban Water Consortium, the North Carolina Water Resources Research Institute, and the Environmental Finance Center at the University of North Carolina.

First, the motivation for an interruptible irrigation rates program is done so in light of the challenges and benefits of implementation. We focus on both the utility and the customer perspective, highlighting the key decision points for each stakeholder. Next, we assess the costs within a management partnership, both in terms of the relationship between the metering company and the utility, and the fixed monetary costs of installing a utility-wide smart grid system. In order to make an interruptible irrigation program feasible, it is important to understand the triggers that would warrant an instantaneous reduction in demand. We discuss three capacity constraints in turn: supply, treatment, and purchases.

Finally, billing data is used to simulate a representative interruptible irrigation rates program using historical billing data. In the simulation, we consider a program that mandates customers with irrigation meters enroll in the interruptible rates program but discuss the implications of making it optional. Then, we recalculate customer consumption and bills under the new rates in the program and assess both the demand and revenue impacts of the program under varying levels of "interruption" between fiscal years 2007 and 2010. We analyze the feasibility of interruptible rates to produce a demand response commensurate with conservation reductions outlined in each utility's Water Shortage Response Plan. In this framework, we pay close attention to the revenue impacts for each utility to make recommendations on whether there is a "business case" for interruptible rates relative to a business-as-usual scenario.

Lastly, we review the results of the analysis within the larger scope of the future of utility management to offer suggestions and recommendations on the potential for innovative business models for water utilities.

[2] "Research Triangle: The New Silicon Valley of the Smart Grid?" http://www.greentechmedia.com/articles/read/the-research-triangle-the-new-silicon-valley-of-the-smart-grid/. April 2, 2012. (Last Accessed: 6/8/2012).

RE-THINKING IRRIGATION RATES

Seasonal demand for irrigation end uses of water requires utilities to invest in distribution capacity expansions to meet the peak demands.[3] Additionally, it is municipal irrigation which is targeted first in times of acute scarcity. It is important, then, to re-think the way municipal utilities price water for irrigation use with the goals of demand projections and capacity planning. Currently in North Carolina, water use through an irrigation meter is charged at a lower rate than combined water and sewer rates for indoor uses.[4] Introducing interruptible irrigation rates into the equation allows for a potentially cost-effective solution to maintaining affordable irrigation while keeping a close eye on costly peak demand.

Benefits

The benefits of interruptible rates as a demand-management tool for the utility are straightforward: they garner more control over discretionary use of water. Interruptions of irrigation service can be used to induce a quantifiable reduction in demand instantaneously with a higher degree of certainty than conventional methods (i.e., watering restrictions). From the customer's perspective, there are benefits from interruptible rates as well. In essence, the utility is "paying" the customer for the ability to remotely control discretionary uses of water through lower volumetric rates for metered irrigation. Additionally, the improved management of a community's water resources allows for more accurate demand projections which, in turn, benefit both parties jointly through transparent and stable rate increases.

Downsides

The downsides of an interruptible irrigation program for the utility are largely financial in nature. The initial investment in the infrastructure and technology necessary to implement an interruptible service program are large. These costs are broken down in the following section. In terms of variable costs, each time the utility interrupts irrigation service for a customer, they lose potential revenue from that customer. Additionally, lowering rates for uninterrupted irrigation service would induce an increase in irrigation demand based on the sensitivity of customer demand to changes in price. Studies have shown that a 100% increase (decrease) in the price of water for discretionary uses, such as irrigation, will result in an approximately 51% decrease in quantity of water demanded.[5]

From the customer's perspective, the primary disadvantage is sacrificing ultimate control of irrigation decisions, and the accompanying costs of an unexpected interruption of service.

[3] Tiger et al., "Implications of residential irrigation metering for customers' expenditures and demand." Journal AWWA, December 2011, 103:12.
[4] Eskaf, Shadi & Chris Nida. "Water and Wastewater Rates and Ratestructures in North Carolina." Environmental Finance Center. March 2012.
[5] Espey et al. "Price elasticity of residential demand for water: A meta-analysis." Water Resources Research, June 1997, Vol. 33, No. 6.

AMI metering technology

Background and benefits For the purposes of this report, the "smart" meters necessary to implement interruptible irrigation rates are two-way AMI meters rather than automatic meter reading (AMR) technology which does not allow for the remote turn on/off ability. This ability is fundamental to this type of program. AMI meters possess a host of benefits for the utility and customer, which greatly improve the demand-management capabilities relative to conventional methods. Some of the primary benefits of a full smart-grid capable AMI system include: increased consumption readings (hourly, daily), improved leak detection and/or non-metered water loss, remote move-ins/move-outs, enhanced customer service benefits, functionality with a customer usage dashboard, out-of-town notifications, etc.[6] These examples alone have monetary benefits, as well as not easily quantifiable intrinsic benefits, that have led to increasing adoption of AMI metering systems for water utilities, though AMI has pervaded less than 10% of the water meter market. The utility's ability to implement programs such as interruptible irrigation is one of potentially many auxiliary benefits that can help shape innovative new business models for water utilities moving forward.

Costs of metering technology The biggest obstacle to implementing an interruptible irrigation program is the AMI hardware and meter data management (MDM) software requirements. Rough cost estimates and ranges for a large utility seeking to overhaul meters in their service area are presented in Table 1. The estimates should be good approximations for both Raleigh and Cary for irrigation meters only (both of which have roughly 6,000 irrigation meters). Hardware and installation of the meters themselves, including communication devices and cut-off valves with actuators, average around $290 per meter. Additionally, the network hardware and installation and MDM software for the smart grid average around $170 per meter. Annual software maintenance would add around $20 per meter per year.

While these are rough hypothetical estimates for a utility seeking to overhaul all of its meters, it provides a good snapshot of the up-front costs a utility should expect to face. In 2011, the Town of Cary began the installation of nearly 50,000 AMI meters with full smart grid technology for approximately $17.9 million.[7] The cost per meter compares favorably with the estimates presented in Table 1.

Capacity constraints

Interruptible irrigation has the potential to be a cost-effective tool to reduce peak demand when the utility requires an abrupt decrease in demand. There are many situations in which an interruption of service would be a viable choice for the utility, although we consider three options: 1) in lieu of, or in addition to, watering restrictions; 2) to decrease pressure on drinking water treatment systems when peak capacity is approached; and 3) when capacity is constrained to a point when the utility relies on

[6] "Advanced metering infrastructure: Drivers and benefits in the water industry." WaterWorld. http://www.waterworld.com/index/display/article-display.articles.waterworld.water-utility_management.2011.08.advanced-metering-infrastructure-drivers-and-benefits-in-the-water-industry.QP129867.dcmp=rss.page=1.html (Last Accessed: 6/11/2012)

[7] "Cary water customers will get new meters" News and Observer. Dec. 24, 2010. http://www.newsobserver.com/2010/12/24/880006/cary-water-customers-will-get.html#storylink=cpy (Last Accessed: 6/13/2012).

water purchases from interconnection agreements. In each of these situations, it is important for the utility to weigh the costs of each option relative to the costs of interrupting service.

Conservation

Implementing interruptible irrigation rates to replace, or augment, mandatory outdoor watering restrictions during drought is a transparent illustration of the potential effectiveness of such a program. Currently, both Raleigh's and Cary's Water Shortage Response Plans diagram a strategy to induce 13-15% reduction in summer water use that targets reductions in outdoor irrigation for Stage I triggers.[8,9] Specifically, both response plans limit the time or day during which the irrigation system can be used. Additionally, Raleigh has a non-drought watering schedule in place in which households are permitted to irrigate their lawn on particular days throughout the week. An interruptible irrigation program could cut-off irrigation meters during the periods when irrigation is prohibited, thus ensuring 100% compliance with restrictions. In this situation, the utility could avoid the majority of costs associated with communicating the watering schedule, including postal and material charges, marketing costs, administrative costs, and the personnel required for monitoring and enforcement.

Alternatively, rather than relying on compliance with watering restrictions, the utility could cut-off irrigation meters completely to produce an instantaneous drop in consumption. During drought, the reduction in costs associated with conventional water shortage response plans (i.e. personnel and materials expenses for outreach, monitoring and enforcement) could make an interruption of service an attractive option in this scenario.

Treatment

In addition to conservation, a utility's treatment capacity could be a potential trigger for the interruption of irrigation service. According to the provisional Local Water Supply Plans published by the Division of Water Resources (DWR) of the North Carolina Department of Environment and Natural Resources (NC DENR), the City of Raleigh's maximum daily demand reached over 80% of its daily permitted treatment capacity at least once each year between 2006 and 2009, prior to opening an additional treatment facility in 2010. Cary's maximum daily demand within that period remained around 60-70% of daily treatment capacity. With rising demand, both utilities project demand to over 90% of supply by 2030, future supply sources will require additional treatment capacity.

Using interruptible rates to cut-off irrigation meters when daily demand hits a certain percentage of treatment capacity will help to smooth the costly peaks and improve supply projections. In addition, with the rising costs of peak electricity demand, utilities can utilize service interruptions as a mechanism to minimize operational costs of treatment plants.

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[8] Town of Cary, Water Shortage Response Plan. January 21, 2010.
[9] City of Raleigh, Water Shortage Response Plan. 2010.

Purchases

The last scenario we consider is to employ interruptible irrigation service to replace water purchases through utility interconnection partnerships. Currently, in North Carolina, there are 635 utilities with an interconnection, which is 30% of all utilities, to supplement supply constraints.[10] During 2007-2011, the City of Raleigh did not make any water purchases from its interconnection partnerships. The Town of Cary, however, relied on water purchases 8.4 days per year, during the same time period with an average daily purchase of 1.13 million gallons per day.[11] This translates to approximately 5% of average daily consumption in the month of August for the Town of Cary. These water purchases could be avoided by interrupting roughly 1/3 of typical irrigation meters for eight days per year.

INTERRUPTIBLE IRRIGATION SIMULATIONS FOR REPRESENTATIVE LARGE UTILITIES

To analyze the cost-effectiveness of an interruptible irrigation rates program, we simulate several scenarios in lieu of a typical conservation program (i.e., watering restrictions) using historical billing data for both Raleigh and Cary. In this framework, we consider a program that assumes all customers with irrigation meters are enrolled in the interruptible rates program. We did this to illustrate the extreme case of implementation. Then, we recalculate customer usage and charges while varying the rates that customers pay for irrigation usage and the level of irrigation cut-offs during the peak irrigation months of July and August. By analyzing historical data in this way we can determine the cost, per thousand gallons of irrigation usage, of an interruptible rates program in terms of forgone revenue.

Details

When simulating usage, we vary two parameters: the percent decrease in irrigation rates and the percent of irrigation consumption that is cut-off. For the change in irrigation rates, we consider the impact of no change in price to a 25% decrease in price at 5% intervals. Due to the concept of price elasticity of demand, we make the assumption that irrigation demand will increase by half as much as the decrease in price. In other words, if price decreases by 10%, irrigation demand will increase by 5%. This means that if an irrigation rates program is in place with lower irrigation rates, though the utility decides not to cut-off irrigation meters at any point, there will be increased demand for irrigation relative to the "business-as-usual" baseline. Further, for the change in the percent of irrigation consumption that is cut-off, we analyze the effect of decreasing irrigation demand by 25% to 100%, at 25% intervals, in the months of July and August. Since the billing data is observed at the monthly level, we cannot determine the effect of irrigation cut-offs for shorter periods of time. We use the percent of irrigation consumption cut-off as an approximation of total usage reduction goals utilities might target through this program. We also make the assumption that all irrigation customers are billed on the hypothetical interruptible irrigation

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[10] Patterson, Lauren & Shadi Eskaf. "Assessment of Current and Potential Water System Interconnections in North Carolina." February 2011. Environmental Finance Center, University of North Carolina.
[11] NC DENR Provisional Local Water Supply Plan, 2007-2011.

rate program for ease of simulation and analysis. This is an assumption that is not realistically feasible, nor is it recommended to mandate participation in the interruptible rates program.

Results

Figures 1 and 2 present a graphical analysis of four different consumption and revenue simulations, respectively, relative to the baseline consumption and revenue for the Town of Cary. In Figure 1, the consumption in the cut-off simulations displays a significant drop in irrigation consumption in the peak irrigation months of July and August. This figure diagrams the potential for an interruptible irrigation rates programs to "shave" irrigation consumption when it is at its annual maximum. This reduction in irrigation consumption, however, does not come at zero cost. Figure 2 presents the simulated trends in revenue for the corresponding levels of consumption. In the off-peak months, simulated revenue tracks baseline revenue closely, though during the peak months, simulated revenue drops due to the discount in rates. Additionally, any time an irrigation meter is cut-off, the revenue from that meter is also reduced.

Based on the simulations, we are able to calculate a simple metric of the "cost" of different program simulations for fiscal years 2007-2009. Table 3 documents the cost of interruptible irrigation rates programs in terms of "forgone revenue" from irrigation cut-offs. We measure this in dollars per 1,000 gallons because it provides a good comparison to charges for metered irrigation. Naturally, this metric is highly dependent on the revenue gained from irrigation consumption. A scenario with a large decrease in irrigation rates provides the lowest-cost scenario for the utility, because the utility loses less revenue per meter cut-off, though this scenario would recoup very little revenue in the months where meters were not cut-off. In simulation scenarios, we find that as we move from no change in price to a 25% reduction in price, the cost to the utility in forgone revenue decreases. Since each unit of irrigation is charged at the same rate, the utility faces the same cost per cut-off regardless of the amount that is actually cut-off – this allows for easy analysis of whether interrupting irrigation consumption would be a cost-effective scenario relative to the cost of the utility's supply constraints.

Using fiscal year 2010 as an example, with a 0% decrease in prices, cutting off 100% of irrigation consumption in the summer months (which represents 2.4% and 4.5% of total annual consumption in Raleigh and Cary, respectively) costs Raleigh $2.82/1,000 gallons and Cary $7.08/1,000 gallons, which is slightly less than the volumetric rate for metered irrigation. A price decrease of 10% in the summer months however, costs the utility slightly less because the forgone revenue in a reduced-rates scenario is less than what it otherwise would have been. This result should be tempered by the results of the graphical analysis in different simulation scenarios in Cary (Figures 1 and 2). In months when large volumes of water are running through irrigation meters and meters are not interrupted, consumption increases slightly as prices decrease, but revenue also decreases in these months. So, despite the fact that lower rates will be more attractive to irrigation customers, as well as more cost-effective for utilities, each decrease in prices also affects revenue in the non-interrupted months. As a prescription, these results indicate that the utility should decrease rates just enough to induce customers to participate in the interruptible rates program (while also improving the cost-effectiveness of the interruptible rates program), though not so much so that it affects the utility's revenue goals from decreased income in non-interrupted months.

It is important to note that we model a scenario in which 100% of irrigation customers are participating in the interruptible rates program. This is likely not going to occur for several reasons, including the fact that some customers will not want to sacrifice control of their irrigation meter for any reduction in price.

Thus the reduction in prices is meant to give irrigation customers an incentive to participate in the program. The model simulations then provide an extreme scenario. If there are effectively two irrigation rates, the baseline rate and the new interruption discounted program rate, the effect of lowering the rates on revenue will be less severe. The flip side to this benefit is that the utility is able to control a smaller percentage of irrigation consumption through their interruptible meters, giving them less ability to cut-off a large amount of nonessential consumption during times when capacity constraints are approached.

Another interesting result that has a significant impact on program performance is found in comparing the irrigation customer base between Raleigh and Cary. The City of Raleigh had around 7.5% of total annual consumption coming from irrigation meters in FY10 whereas the Town of Cary had around 13.2%. In fact, Cary has more irrigation meters than Raleigh despite the fact that Cary has around two-thirds of the number of customers in Raleigh. Using fiscal year 2010 under a 15% rate reduction and 100% of July and August irrigation consumption cut-off, Cary is able to target 4.8% of total annual consumption with its simulated interruption while Raleigh is only able to target 2.6% of total annual consumption. This means that interruptible irrigation programs will be most effective for utilities with a large percentage of individually metered irrigation accounts. Additionally, the lowered rates for irrigation would provide even more incentive for customers who typically water their lawn through their indoor water meter, and pay water and sewer charges for their outdoor water use.

DISCUSSION, SUGGESTIONS, AND RECOMMENDATIONS

Overall, the “business case” for an interruptible irrigation rates programs is mixed and highly dependent on the structure of the utility and its customer base. It is imperative to take utility costs for comparable demand-management policies into account to determine the appropriateness of an interruptible irrigation program, but interruptible irrigation gives the managing utility a useful, and effective, tool to control non-essential uses of water demand when capacity constraints arise.

The necessary metering infrastructure to manage an interruptible irrigation rates program (including AMI meter hardware, software, and network connections) will cost the utility over $400 per meter in up-front costs, with an additional $15-20 per meter in additional annual management costs. This makes the investment in smart meter technology unrealistic if the only desired benefit is an interruptible irrigation program. An interruptible irrigation rates program makes the most sense when incorporated with the numerous benefits of investing in smart grid technology within a utility’s service area.

Constraints in supply and treatment capacity, as well as higher wholesale water rates, are just three of many possible constraints that could benefit from obtaining remote turn-on and turn-off capabilities for irrigation meters.

Due to the average customer’s response to price decreases, results from our simulation indicate that large decreases in irrigation rates can counteract the effectiveness of an interruptible irrigation program. Conversely, customers will need to have an incentive to opt into the program. Our analysis finds that irrigation rate decreases between 5-15% exhibit properties conducive to the satisfying the program goals when a program is fully subscribed.

While lower irrigation rates make the irrigation customers better off, they also have a perverse effect on a utility’s revenue stream. Simulated results show that an interruptible irrigation program becomes more cost-effective as prices decrease. It is important, though, to factor the reduction in revenue in non-interrupted months into utility planning decisions.

Many utilities have a large proportion of customers who irrigate through their regular meter and pay both water and sewer charges for their irrigation usage. A decrease in rates for consumption through an irrigation meter will incentivize the installation of an irrigation meter. This benefits the utility since a higher proportion of water volume flowing through an interruptible irrigation meter gives the utility more control over their distributional capacity.

APPENDICES – TABLES AND FIGURES

Table 1: Estimated costs for AMI meter transition in Large Utility

Cost Worksheet for Irrigation Meter Transition in a Large Utility							
	Number of Meters?	Cost of Meter:	Communication Device:	Cut-off valve w/ Actuator:	Installation:		
Metering Hardware and Installation:		(per meter)	(per meter)	(per meter)	(per meter)		
	6,000	[$90]	[$90]	[$50 - $100]	[$30 - $40]		
		$90	$90	$75	$35	**Sub-total A:**	**Per meter:**
		$540,000	$540,000	$450,000	$210,000	**$1,740,000**	**$290**
Network Hardware, Software, and Installation:		Network Hardware + Installation:	Meter Data Management (MDM) Software:				
		(% of sub-total A)	(Dollar Amount)				
		[15% - 20%]	[$500k - $1M]				
		15%	$500,000			**Sub-total B:**	**Per meter:**
		$261,000.00	$500,000			**$761,000**	**$127**
Annual Management Costs:		Software Maintenance:	"Cloud" AMI Software Service (Optional):				
		(Dollars/year)	(Dollars/year)				
		[$100k]	[$10k - $30k]				
		$100,000	$20,000			**Sub-total C:**	**Per meter:**
		$100,000	$20,000			**$120,000**	**$20**
		Initial Costs:	*Annual Costs (with "Cloud")*	*Annual Costs (without "Cloud")*			
		$2,501,000	**$120,000**	**$100,000**			
		$416.83 per meter	**$20 per meter**	**$16.67 per meter**			

* Typical cost estimates obtained from Sensus

Table 2: Summary statistics for billing data

Summary Statistics										
Fiscal Year	Total Irrigation Volume	Total Volume	Percent Irrigation Volume	Total Irrigation Charge	Total Charge	Percent Irrigation Revenue	Average Irrigation Charge	Number of Irrigators	Number of Customers	Percent Irrigators
City of Raleigh										
2007	866,014	12,514,282	6.92%	$ 2,256,309	$ 69,305,362	3.26%	$ 2.61	4,698	151,058	3.11%
2008	702,864	12,324,725	5.70%	$ 2,088,982	$ 72,304,350	2.89%	$ 2.97	5,430	167,662	3.24%
2009	749,230	11,932,185	6.28%	$ 2,384,732	$ 77,604,944	3.07%	$ 3.18	5,561	169,045	3.29%
2010	922,395	12,281,842	7.51%	$ 2,994,149	$ 88,673,191	3.38%	$ 3.25	5,533	169,852	3.26%
Town of Cary										
2007	547,634	4,465,295	12.26%	$ 3,926,506	$ 42,706,626	9.19%	$ 7.17	5,908	43,211	13.67%
2008	620,239	4,608,869	13.46%	$ 4,421,860	$ 45,222,285	9.78%	$ 7.13	6,632	45,445	14.59%
2009	562,041	4,431,945	12.68%	$ 3,988,132	$ 46,086,643	8.65%	$ 7.10	7,376	47,721	15.46%
2010	606,982	4,597,187	13.20%	$ 4,350,514	$ 51,187,375	8.50%	$ 7.17	7,693	49,313	15.60%

Figure 1: Simulated consumption under different cut-off scenarios for the Town of Cary

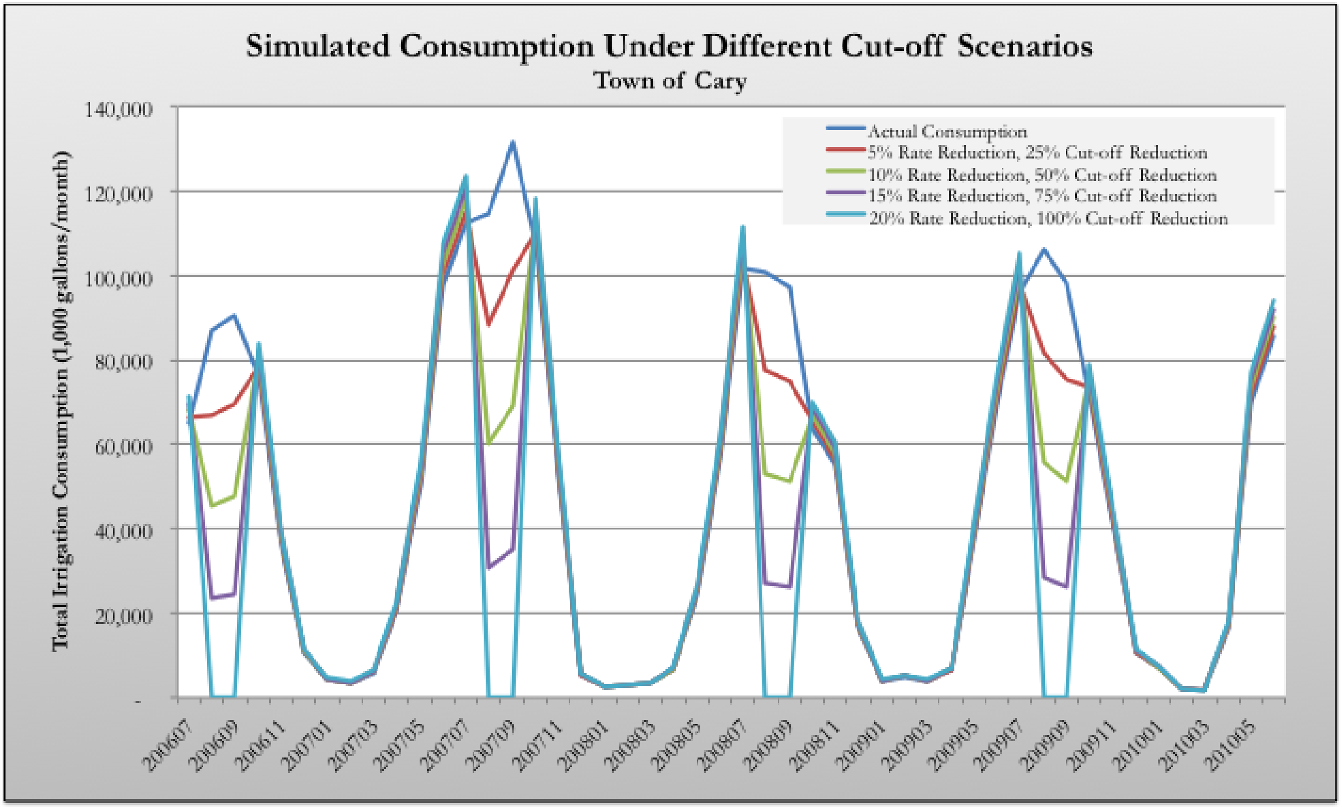

Figure 2: Simulated revenue under different cut-off scenarios for the Town of Cary

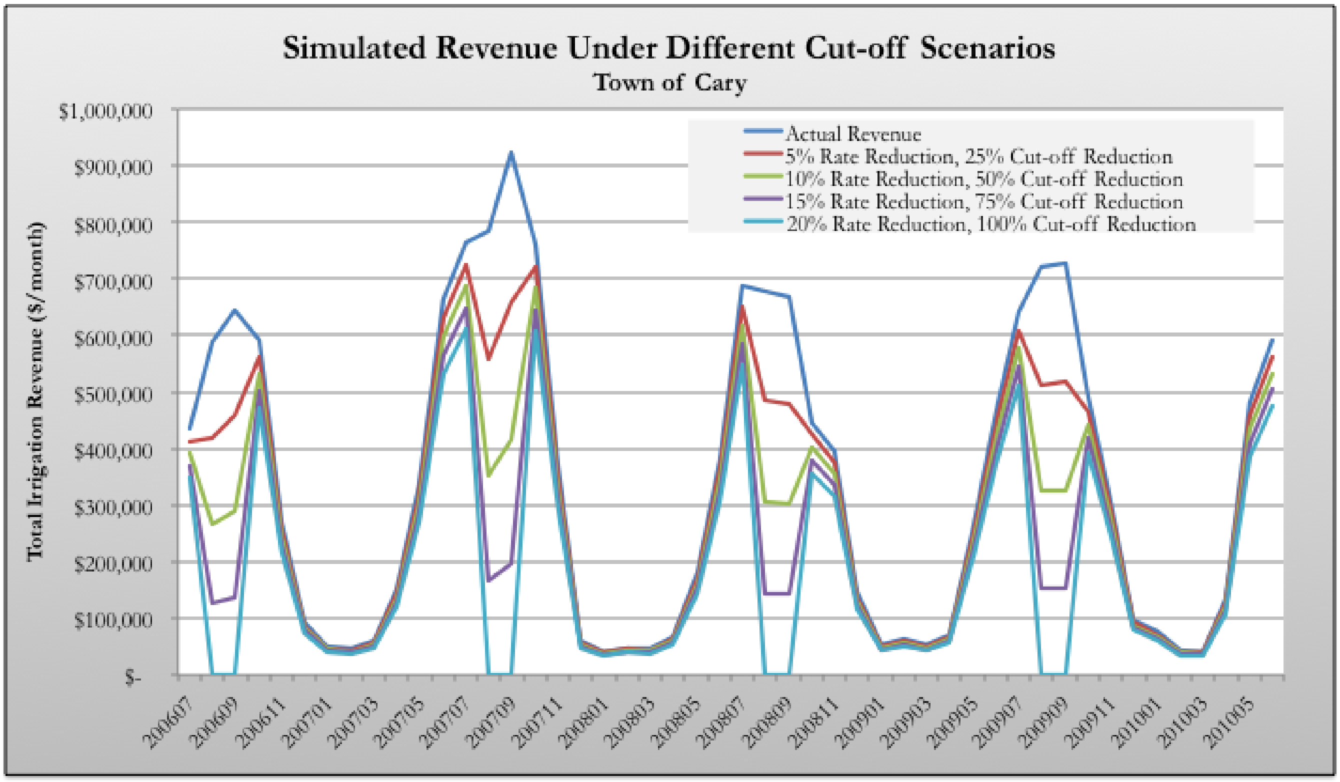

Table 3: Cost of Interruptible Irrigation Rates Program Under Different Scenarios

Panel A: City of Raleigh

Cost of Interruptible Irrigation Rates Program Under Different Scenarios (July & August Irrigation Cut-off)

(average charge for irrigation water/1,000 gallons of irrigation consumption avoided)

City of Raleigh

Rate reduction?	0%	0%	0%	0%	5%	5%	5%	5%	10%	10%	10%	10%	15%	15%	15%	15%	20%	20%	20%	20%	25%	25%	25%	25%
Cut-off Reduction?	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**
Fiscal Year 2007	$2.42	$2.42	$2.42	$2.42	$2.25	$2.25	$2.25	$2.25	$2.08	$2.08	$2.08	$2.08	$1.92	$1.92	$1.92	$1.92	$1.76	$1.76	$1.76	$1.76	$1.62	$1.62	$1.62	$1.62
2008	$2.71	$2.71	$2.71	$2.71	$2.51	$2.51	$2.51	$2.51	$2.32	$2.32	$2.32	$2.32	$2.14	$2.14	$2.14	$2.14	$1.97	$1.97	$1.97	$1.97	$1.81	$1.81	$1.81	$1.81
2009	$2.86	$2.86	$2.86	$2.86	$2.65	$2.65	$2.65	$2.65	$2.45	$2.45	$2.45	$2.45	$2.26	$2.26	$2.26	$2.26	$2.08	$2.08	$2.08	$2.08	$1.91	$1.91	$1.91	$1.91
2010	$2.82	$2.82	$2.82	$2.82	$2.61	$2.61	$2.61	$2.61	$2.42	$2.42	$2.42	$2.42	$2.23	$2.23	$2.23	$2.23	$2.05	$2.05	$2.05	$2.05	$1.88	$1.88	$1.88	$1.88

Note: The upper cell indicates that with a 5% rate reduction and 50% of irrigation meters cut off for July and August in fiscal year 2009, the cost of the cut-off to the utility is $2.65 per 1,000 gallons of water cut-off. This implies that the utility is "paying" (in forgone revenue) $2.65 for every 1,000 gallons of irrigation water that was not delivered to customers, but otherwise would have been used if the cut-off had not taken place. The lower cell indicates that 1.0% of total residential consumption (indoor + outdoor use) under the new rates and cut-off scenario in 2009 was interrupted in fiscal year 2009.

Percent Reduction of Total Residential Consumption from Cut-off Irrigation Annually

Fiscal Year																								
2007	0.5%	1.0%	1.5%	2.0%	0.5%	1.0%	1.6%	2.1%	0.5%	1.1%	1.6%	2.1%	0.5%	1.1%	1.6%	2.2%	0.6%	1.1%	1.7%	2.2%	0.6%	1.1%	1.7%	2.3%
2008	0.6%	1.2%	1.8%	2.4%	0.6%	1.2%	1.8%	2.4%	0.6%	1.2%	1.9%	2.5%	0.6%	1.3%	1.9%	2.5%	0.6%	1.3%	1.9%	2.6%	0.7%	1.3%	2.0%	2.7%
2009	0.5%	1.0%	1.4%	1.9%	0.5%	1.0%	1.5%	2.0%	0.5%	1.0%	1.5%	2.0%	0.5%	1.0%	1.6%	2.1%	0.5%	1.1%	1.6%	2.1%	0.5%	1.1%	1.6%	2.2%
2010	0.6%	1.2%	1.8%	2.4%	0.6%	1.2%	1.9%	2.5%	0.6%	1.3%	1.9%	2.5%	0.7%	1.3%	2.0%	2.6%	0.7%	1.3%	2.0%	2.7%	0.7%	1.4%	2.0%	2.7%

Panel B: Town of Cary

Cost of Interruptible Irrigation Rates Program Under Different Scenarios (July & August Irrigation Cut-off)

($/1,000 gallons of irrigation consumption avoided)

Town of Cary

Rate reduction?	0%	0%	0%	0%	5%	5%	5%	5%	10%	10%	10%	10%	15%	15%	15%	15%	20%	20%	20%	20%	25%	25%	25%	25%
Cut-off Reduction?	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**	**25%**	**50%**	**75%**	**100%**
Fiscal Year 2007	$6.94	$6.94	$6.94	$6.94	$6.43	$6.43	$6.43	$6.43	$5.95	$5.95	$5.95	$5.95	$5.49	$5.49	$5.49	$5.49	$5.05	$5.05	$5.05	$5.05	$4.63	$4.63	$4.63	$4.63
2008	$6.93	$6.93	$6.93	$6.93	$6.42	$6.42	$6.42	$6.42	$5.94	$5.94	$5.94	$5.94	$5.48	$5.48	$5.48	$5.48	$5.04	$5.04	$5.04	$5.04	$4.62	$4.62	$4.62	$4.62
2009	$6.80	$6.80	$6.80	$6.80	$6.30	$6.30	$6.30	$6.30	$5.83	$5.83	$5.83	$5.83	$5.37	$5.37	$5.37	$5.37	$4.94	$4.94	$4.94	$4.94	$4.53	$4.53	$4.53	$4.53
2010	$7.08	$7.08	$7.08	$7.08	$6.56	$6.56	$6.56	$6.56	$6.07	$6.07	$6.07	$6.07	$5.60	$5.60	$5.60	$5.60	$5.15	$5.15	$5.15	$5.15	$4.72	$4.72	$4.72	$4.72

Percent Reduction of Total Consumption from Cut-off Irrigation Annually

Fiscal Year																								
2007	1.0%	2.0%	3.0%	4.0%	1.0%	2.0%	3.1%	4.1%	1.0%	2.1%	3.1%	4.2%	1.1%	2.1%	3.2%	4.3%	1.1%	2.2%	3.3%	4.4%	1.1%	2.2%	3.4%	4.5%
2008	1.3%	2.7%	4.0%	5.3%	1.4%	2.7%	4.1%	5.5%	1.4%	2.8%	4.2%	5.6%	1.4%	2.9%	4.3%	5.7%	1.5%	2.9%	4.4%	5.9%	1.5%	3.0%	4.5%	6.0%
2009	1.1%	2.2%	3.4%	4.5%	1.1%	2.3%	3.4%	4.6%	1.2%	2.3%	3.5%	4.7%	1.2%	2.4%	3.6%	4.8%	1.2%	2.5%	3.7%	4.9%	1.3%	2.5%	3.8%	5.0%
2010	1.1%	2.2%	3.3%	4.4%	1.1%	2.3%	3.4%	4.6%	1.2%	2.3%	3.5%	4.7%	1.2%	2.4%	3.6%	4.8%	1.2%	2.4%	3.7%	4.9%	1.3%	2.5%	3.8%	5.0%