How Important was Water Pricing in Achieving Conservation Goals During the California Drought?

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UNC SCHOOL OF GOVERNMENT
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Water pricing and residential water use data for hundreds of water agencies in California during the State-mandated conservation period (June 2015 - May 2016) were studied to find out if the water rates or rate structures that the agencies charged were a critical component in achieving greater conservation. This research revealed that the relationship between pricing and water use is not straightforward. Certain aspects of pricing—the rates and the rate structure design—were an essential aspect of some water agencies' success in maintaining long-term efficient water use or meeting short-term curtailment goals, but not for other agencies. There is no single pricing solution that works for all water agencies to encourage conservation. Pricing can encourage conservation, but should be customized to local conditions and in the context of non-pricing conservation programs.

About the Environmental Finance Center

The Environmental Finance Center at the University of North Carolina at Chapel Hill is part of a network of university-based centers that work on environmental issues, including water resources, solid waste management, energy, and land conservation. The EFC at UNC partners with organizations across the United States to assist communities, provide training and policy analysis services, and disseminate tools and research on a variety of environmental finance and policy topics.

The Environmental Finance Center at the University of North Carolina, Chapel Hill is dedicated to enhancing the ability of governments to provide environmental programs and services in fair, effective, and financially sustainable ways.

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The California Mandated Conservation Period and Promoted Pricing Strategies

Following the lowest snowpack ever recorded and with no end to the drought in sight, 2015 was a year of historic drought in California. In response, California Governor Jerry Brown signed Executive Order B-29-15 on April 1, 2015, directing the State Water Resources Control Board (Water Board) to implement a 25 percent overall reduction on the state's local water supply agencies over the next year[1]. The state-mandated conservation period lasted for 12 months, from June 2015 through May 2016. During this period, each local water agency was required to achieve a specific conservation standard, measured as a cumulative reduction in their potable water production relative to their equivalent production in 2013.

While the Water Board was responsible for setting each local water agency's conservation standard, individual agencies were largely free to choose their own strategies for meeting their particular reduction goals. Agencies employed a diverse range of pricing strategies and non-pricing programs throughout the state-mandated conservation period. Non-pricing measures, including limiting the use of water for lawn irrigation and increasing infraction enforcement for violators of conservation directives, among others, were common for many water agencies. In addition, many agencies used pricing as an important part of a suite of strategies to encourage customers to reduce water use. Some agencies employed water rate structures such as budget-based rates, which is an increasing block rate structure where the block sizes are determined by a water budget that defines an efficient level of water use for each customer based on their individual characteristics, such as household size or number of water fixtures in the home. Others implemented temporary drought surcharges on high levels of water use, while some agencies raised water rates for all uses.

The Water Board promoted pricing strategies, claiming that "conservation pricing is an effective tool to prevent wasteful water use,"[2] and listed various reports and examples as resources to water agencies seeking to learn more about using pricing as a strategy to curtail water use. The basic premise is that rate structures can be designed in ways to provide a financial incentive—a price signal—to customers to conserve water. In a staff presentation by the Water Board on July 8, 2015, several types of rate structure designs were shared as examples of conservation rates, including increasing block (tiered) rates, allocation-based rates (i.e. budget-based rates), seasonal rates, variable fixed rates, and dynamic rates that are applicable in the energy sector.[3] At around the same time, the California Urban Water Conservation Council published a *Water Shortage Pricing Primer* which describes variations of drought surcharges and fee structures that apply during water shortage periods that can "help send a stronger signal to customers to meet a water use reduction target while providing the utility some revenue stability."[4]

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[1] State of California Executive Department. 2015. Executive Order B-29-15. https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/docs/040115_executive_order.pdf

[2] California Water Boards State Water Resources Control Board. 2018. State Water Board Drought Year Water Actions: Conservation Pricing. https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/pricing/

[3] California Water Boards, Office of Research, Planning, and Performance. 2015. Conservation Rates and Pricing: Overview and Framework. https://www.waterboards.ca.gov/waterrights/water_issues/programs/drought/pricing/docs/workshop/070815_10_staff_pres.pdf

[4] California Urban Water Conservation Council. 2015. Jumpstart Water Shortage Toolkit: Tool #3 Water Shortage Pricing Primer. http://cuwcc.org/Portals/0/Document%20Library/Resources/Drought%20Resources/Tool%20Kit/Tool%203%20Water%20Shortage%20Rate%20Structure%20Primer.pdf

These recommendations all follow the basic economic theory that the more you charge, the less people use, and hence rate structures that charge higher rates for high levels of water use will incentivize customers to curtail their use. Water pricing, however, is more nuanced. Although water agencies may carefully consider how to send appropriate price signals to customers through certain types of rate structures, predicting how different price signals influence actual customer consumption is challenging.

Pricing signals might not come across clearly enough to bring about an incentive to reduce usage, or they may be ineffectual if not designed appropriately for the local conditions and characteristics of the customer base. Furthermore, water agencies may not be able to design water rate structures that strongly incentivize conservation, given some restrictions imposed on water rates under Proposition 218. For instance, under a cost of service rate model, a water agency with low treatment and delivery costs cannot charge high rates to encourage conservation if those rates exceed what is required to recover the costs of service. This water agency will find it more difficult to use pricing as a tool to encourage conservation than a water agency that has the ability to charge higher rates.

The Environmental Finance Center (EFC) at the University of North Carolina at Chapel Hill analyzed data on up to 398 California water agencies' water pricing, residential water use, and production data during the mandatory conservation period to examine the relationship between pricing and customer conservation. The data and study design are described later in this article. The EFC's research suggests that setting water rates is complex and there is no single, definitive pricing solution for reducing water consumption that is effective for all water agencies across the state.

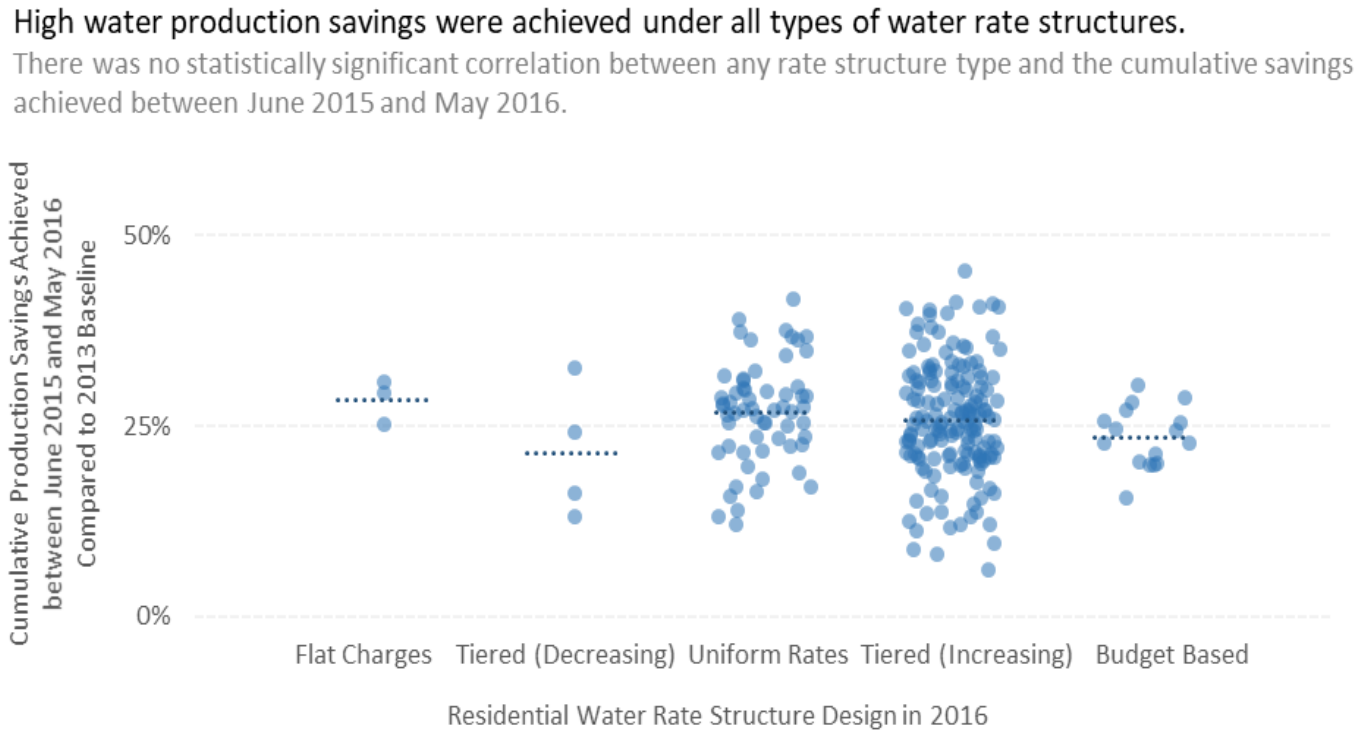
Pricing is Complicated, and there is No Single Pricing Solution for Conservation

Approaches to water pricing across California are diverse, each providing a unique set of pricing signals to customers. For example, the 2015 water rates for a quarter of the surveyed water agencies were priced in a way that a residential customer reducing their water use from 12 hundred cubic feet (ccf) in one month to 6 ccf in the next month would have saved more than $23 in their water bill. Yet, water rates for a different quarter of the surveyed agencies were priced in a way that their customers would have saved less than $9, providing a much lower price signal that financially incentivizes customers to conserve. To complicate matters, a significant number (nearly half) of the agencies that charged the lower price signals actually had increasing block rate structures or budget-based rate structures, both types described as examples of conservation rates in the Water Board's presentation. Furthermore, among the agencies with the higher price signals are a few that charge a total monthly water bill for average water use levels that are low relative to most other agencies in the state. Even though a rate structure might be designed in one way to encourage conservation, it may still provide a weaker incentive to conserve than another rate structure that was not designed with the same objective.

Hence, water agencies should be wary of being too focused on a simple interpretation of the relationship between rate structures and conservation. The strength of pricing signals is influenced by more than just whether a rate structure is classified as a uniform structure, increasing block rates, or budget-based rates. In fact, the analysis showed there was no statistically significant difference in the water savings achieved between different water rate structure types, and that high water production savings during the conservation period were achieved with all types of rate structures, as illustrated in Figure 1. None of the rate structure types was necessarily the dominant predictor of water savings. For example, when looking

just at those agencies that use increasing block rates, it is clear that some agencies achieved much higher water production savings (30 percent or higher) than others (savings of less than 15 percent), demonstrating that one rate structure design influences customer water usage dissimilarly in different agencies, based on a variety of factors. Furthermore, several agencies with uniform rate structures achieved the same level of high water production savings that agencies with increasing block rates achieved, illustrating that high levels of conservation can be influenced by different types of rate structures. To incentivize conservation, both the various elements of the rate structure as well as the rates themselves need to be intentionally designed.

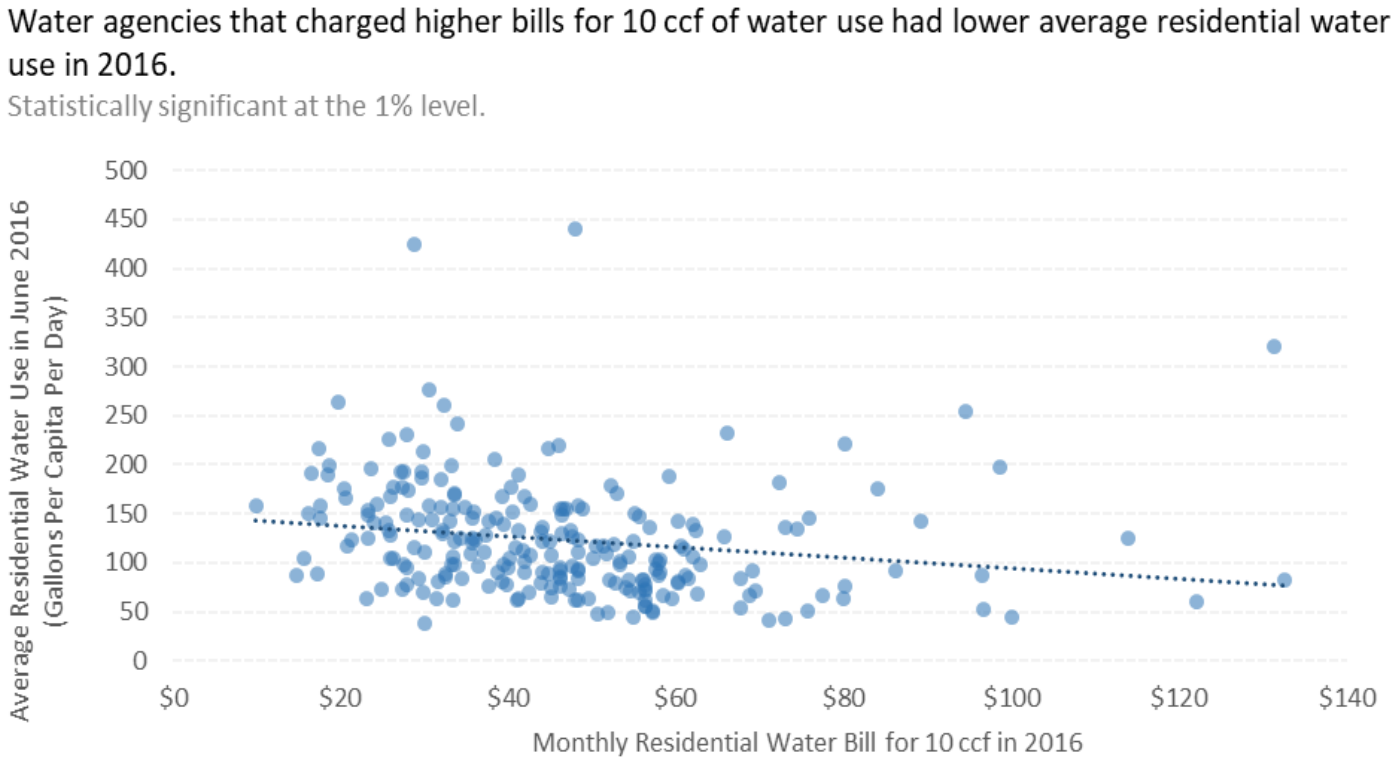
Figure 1: Water Production Savings under Various Water Rate Structure Types in California



Sources: California State Water Resources Control Board's May 2016 Supplier Conservation Compliance (June 21, 2016), and a survey of water rate structures by California-American Water Company. Savings were calculated by the Water Board using local water agencies' self-reported water production data. Dotted lines represent the average cumulative production savings between all water agencies using the same water rate structure type (differences were not statistically significant).

Pricing signals vary, and water agencies that incur higher costs to acquire, treat, and supply water typically set higher prices with higher conservation signals, regardless of the type of rate structure used. This is illustrated in Figure 2, which reveals a negatively correlated relationship between the total water price charged for a specific monthly consumption amount and the average residential water use. Agencies charging higher prices had, on average, lower average residential water use than agencies charging lower prices. Thus, agencies that charge the full cost of water service inherently send stronger pricing signals than if they underprice their services. For many agencies, the decision to charge the true cost of water service may be as important as whether to adopt an increasing block, budget-based, or uniform rate structure, as there is potential to have strong price signals with all of these approaches. Another way to look at this is that a water agency with higher costs and prices may not have to manipulate its rates or use complicated rate structures to send strong pricing signals to customers.

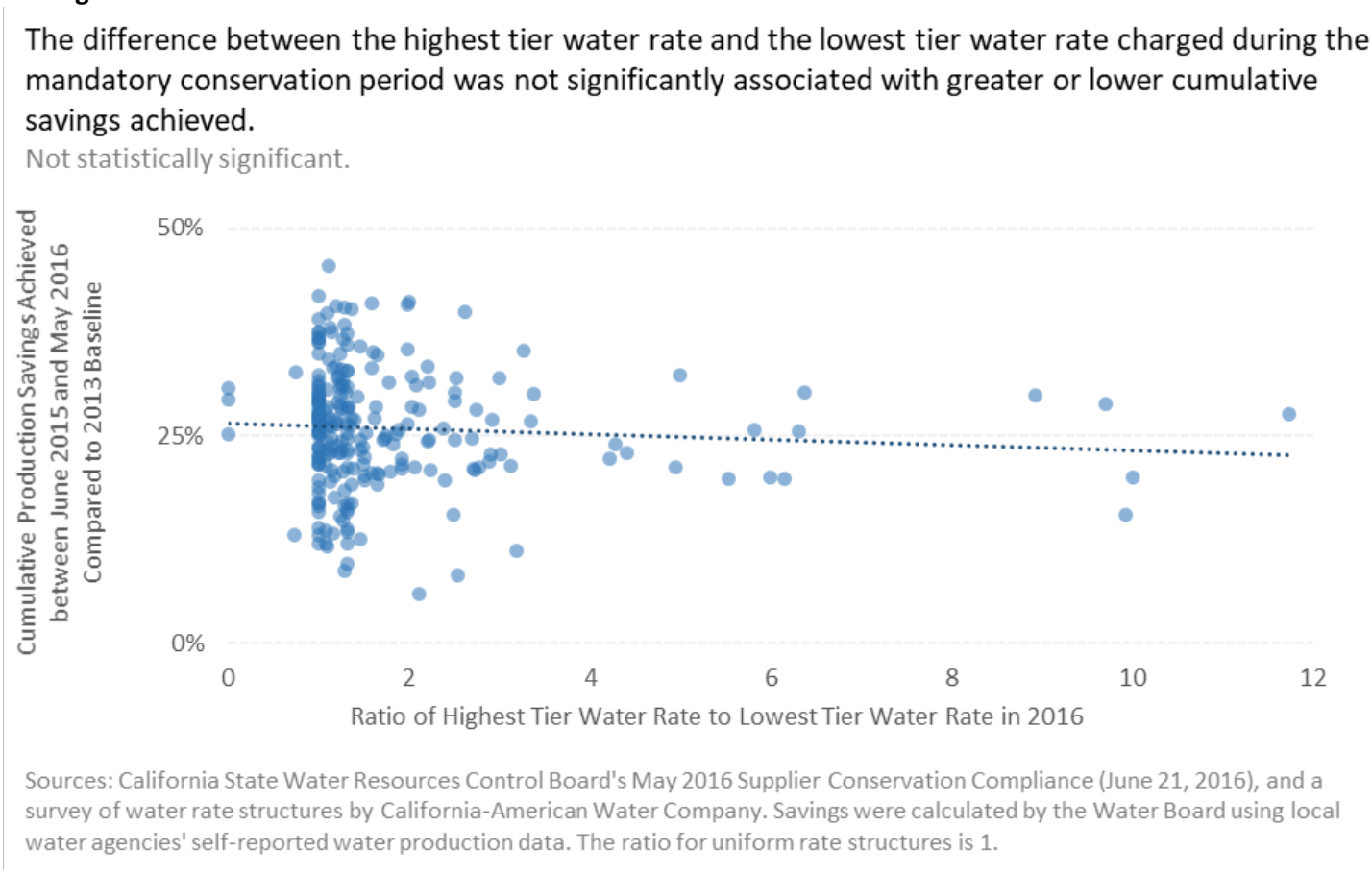
Figure 2: Water Prices and Average Residential Water Use in California in 2016



Sources: California State Water Resources Control Board's June 2014 - June 2017 Urban Water Supplier Report Dataset (August 1, 2017), and a survey of water rate structures by California-American Water Company. Residential gallons per capita per day was calculated by the Water Board using water agencies' self-reported water production data.

Increasing block rates or budget-based rates with steep differentials between blocks are often designed to encourage conservation. For example, one agency's volumetric water rate at the lowest tier was $1.95/ccf and at the highest tier was $16.97/ccf, making it 8.7 times higher than the lowest tiered rate. While the research found that larger differences between the highest and lowest tiered water rates is associated with lower average residential water use, it also revealed that those differences were not associated with greater water savings during the mandatory conservation period, shown in Figure 3. Similarly, while the prices charged at near-average consumption were associated with lower average water use, they were not associated with greater water savings achieved during the mandatory conservation period.

Figure 3: Water Production Savings in California under Rate Structures with Varying Differences between the Highest and Lowest Tiered Water Rates



Sources: California State Water Resources Control Board's May 2016 Supplier Conservation Compliance (June 21, 2016), and a survey of water rate structures by California-American Water Company. Savings were calculated by the Water Board using local water agencies' self-reported water production data. The ratio for uniform rate structures is 1.

In other words, water agencies with higher average prices or higher differentials between tiered rates did not achieve greater levels of conservation relative to their 2013 production levels, but did have lower average residential water use during the mandatory conservation period. Likewise, any type of rate structure is capable of producing high water savings, and no statistically significant correlation was found between any rate structure design and the cumulative savings achieved during the state-mandated conservation period.

Lastly, many water agencies raised rates in 2016, possibly as part of normal operations in response to increasing costs. Our analysis did not find a correlation between the amount of a rate increase and how much water savings was achieved during the mandatory conservation period. Large savings were achieved for agencies that raised their rates as well as agencies that did not raise rates, demonstrating that conservation can be promoted through various means.

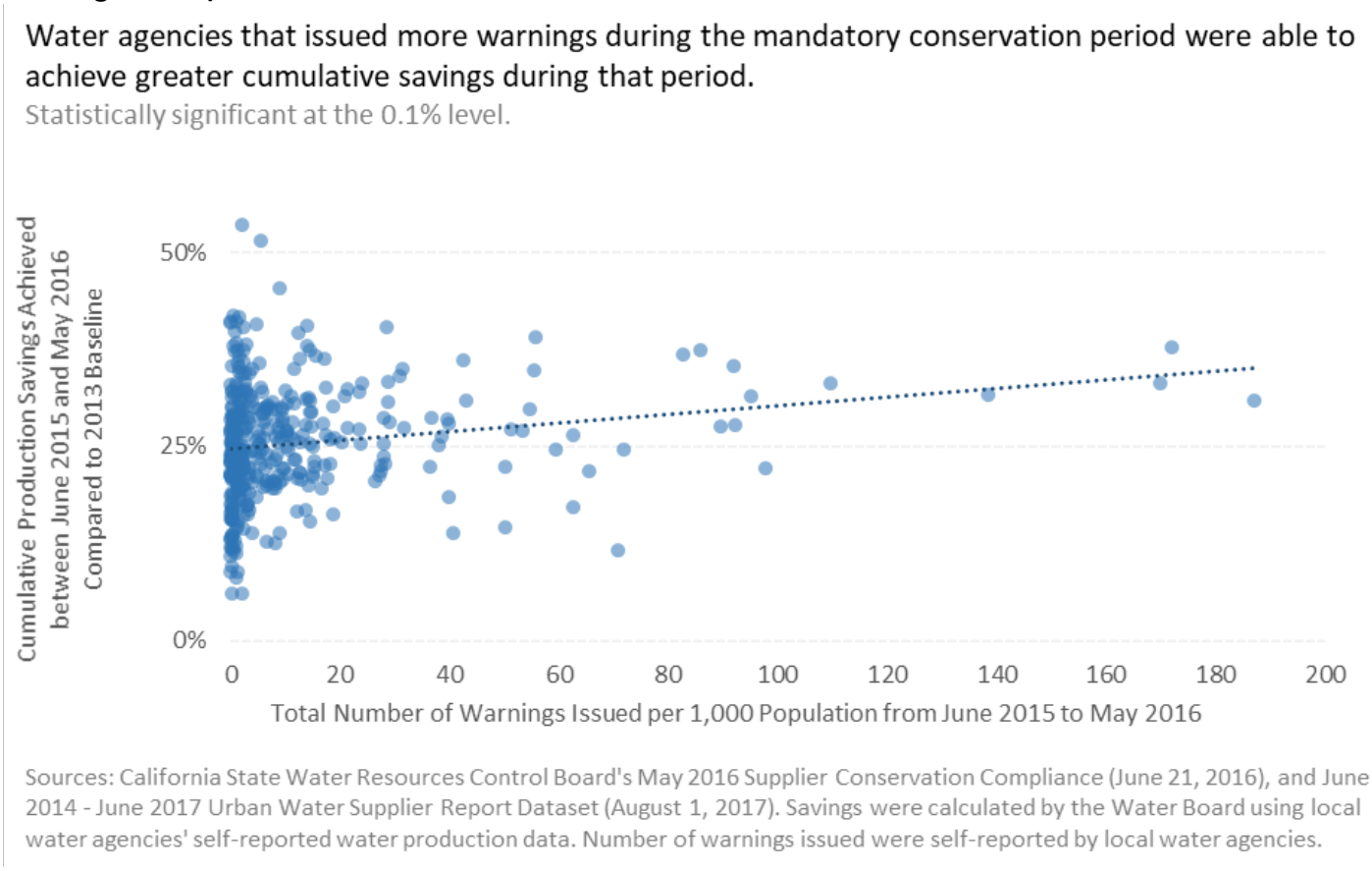
Water Agencies Achieved their Conservation Goals through a Variety of Effective Means

The analysis revealed that while rates and some elements of rate structure designs are associated with lower average residential water use, they were not associated with achieving greater conservation (i.e.

reductions in water use) during the mandatory conservation period. In other words, pricing does not appear to be the dominant tool that was used to generate short term curtailments. Yet, high levels of conservation were achieved during the 12-month period. The EFC's research also looked at the basic relationships between higher levels of short-term conservation, non-price conservation strategies, and several external drivers that are typically associated with water savings.

Based on a simple bi-variate analysis, one of the most successful strategies appears to have focused on strict local enforcement of conservation directives by issuing warnings to customers that violated them. Water agencies that issued a greater number of infraction warnings, normalized by service population size, achieved greater cumulative savings during the mandatory conservation period than those that did not issue as many warnings, as illustrated in Figure 4. A similar result was found when analyzing the number of penalties issued to customers, supporting the finding that greater local enforcement of conservation directives was an effective strategy on average across multiple water agencies in California.

Figure 4: Water Production Savings under Various Levels of Local Water Agency Enforcement (i.e. Warnings Issued) in California



Sources: California State Water Resources Control Board's May 2016 Supplier Conservation Compliance (June 21, 2016), and June 2014 - June 2017 Urban Water Supplier Report Dataset (August 1, 2017). Savings were calculated by the Water Board using local water agencies' self-reported water production data. Number of warnings issued were self-reported by local water agencies.

In an age of constant news streams, media coverage of the drought also played an important role during the conservation period. Water conservation advertising by Governor Brown and media coverage of the issue contributed heavily to the water agencies' savings. A recent Stanford study by Quesnel and Ajami, which developed an algorithm to quantify drought coverage by state and national news outlets, linked real water consumption data in California with the public attention garnered by the drought and subsequent

conservation period.[5] The study demonstrated that single-family residential customers reduced water consumption at the fastest rate following intense drought-related news media coverage.

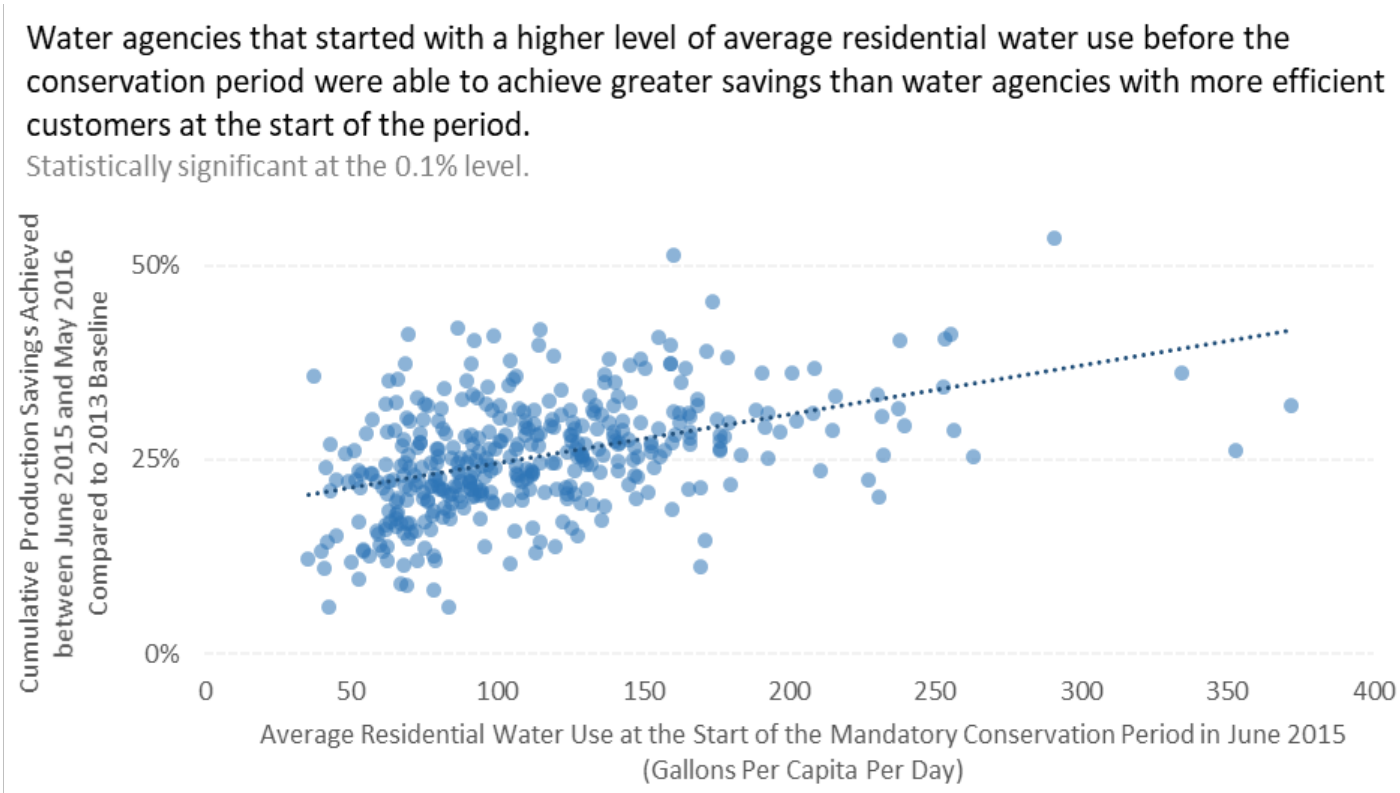
One reason why higher water rates were associated with lower average residential water use but not with greater cumulative water savings is probably because the agencies that had higher pricing signals already had lower water use before the conservation period began. Thus, they were not able to achieve greater levels of conservation than agencies that had lower pricing signals and higher average use at the start. This is supported by another result of the analysis: water agencies starting the conservation period with a higher level of average residential water use were able to achieve greater cumulative savings than water agencies with more efficient customers from the start. In other words, more room for improvement means greater opportunity for progress. This is shown in Figure 5.

However, it is important to remember that agencies with lower residential water use before the conservation period had lower conservation standards to achieve, reflective of their already-more efficient water demands. This result highlights another key point: as water use becomes more efficient over time under typical supply conditions, the flexibility that water agencies have in achieving significant short-term curtailment in demand during water shortage periods becomes limited. If Californians become more efficient water users in the long-term, they will find it harder to make short-term sacrifices and cut use even further during water shortage periods. The long-term water resources goal for water agencies is to encourage more efficient use among its customers, but it is not expected that customers will maintain their drought-time use levels constantly.

Beyond the control of the water agencies are external factors that affect how much water people use, and influenced the cumulative water savings during the conservation period, no matter the pricing signal or non-pricing conservation strategies employed. The EFC's analysis identified that weather patterns and household characteristics were important external factors. Average residential water use in June 2016 was, on average, higher in communities that had higher temperatures during that month than in other communities. Further, higher cumulative savings were achieved in communities with higher median household incomes and in communities with lower average household size.

[5] Quesnel, K.J., & Ajami, N.K. 2017. *Changes in water consumption linked to heavy news media coverage of extreme climatic events.* Science Advances. Vol. 3, no. 10. DOI: 10.1126. http://advances.sciencemag.org/content/3/10/e1700784

Figure 5: Water Production Savings Achieved after Different Starting Points in Average Residential Water Use before the Conservation Period in California



Sources: California State Water Resources Control Board's May 2016 Supplier Conservation Compliance (June 21, 2016) and June 2014 - June 2017 Urban Water Supplier Report Dataset (August 1, 2017). Residential gallons per capita per day was calculated by the Water Board using water agencies' self-reported water production data.

Water Agencies Should Customize Pricing to Local Conditions and Consider Non-Pricing Conservation Programs

Given the findings above on pricing, non-pricing strategies, local conditions, and their correlations with average water use and conservation, all of those factors need to be considered simultaneously at the local level to design effective pricing and non-pricing strategies to encourage conservation. What is effective for one water agency may not be as effective for another water agency with different customer characteristics.

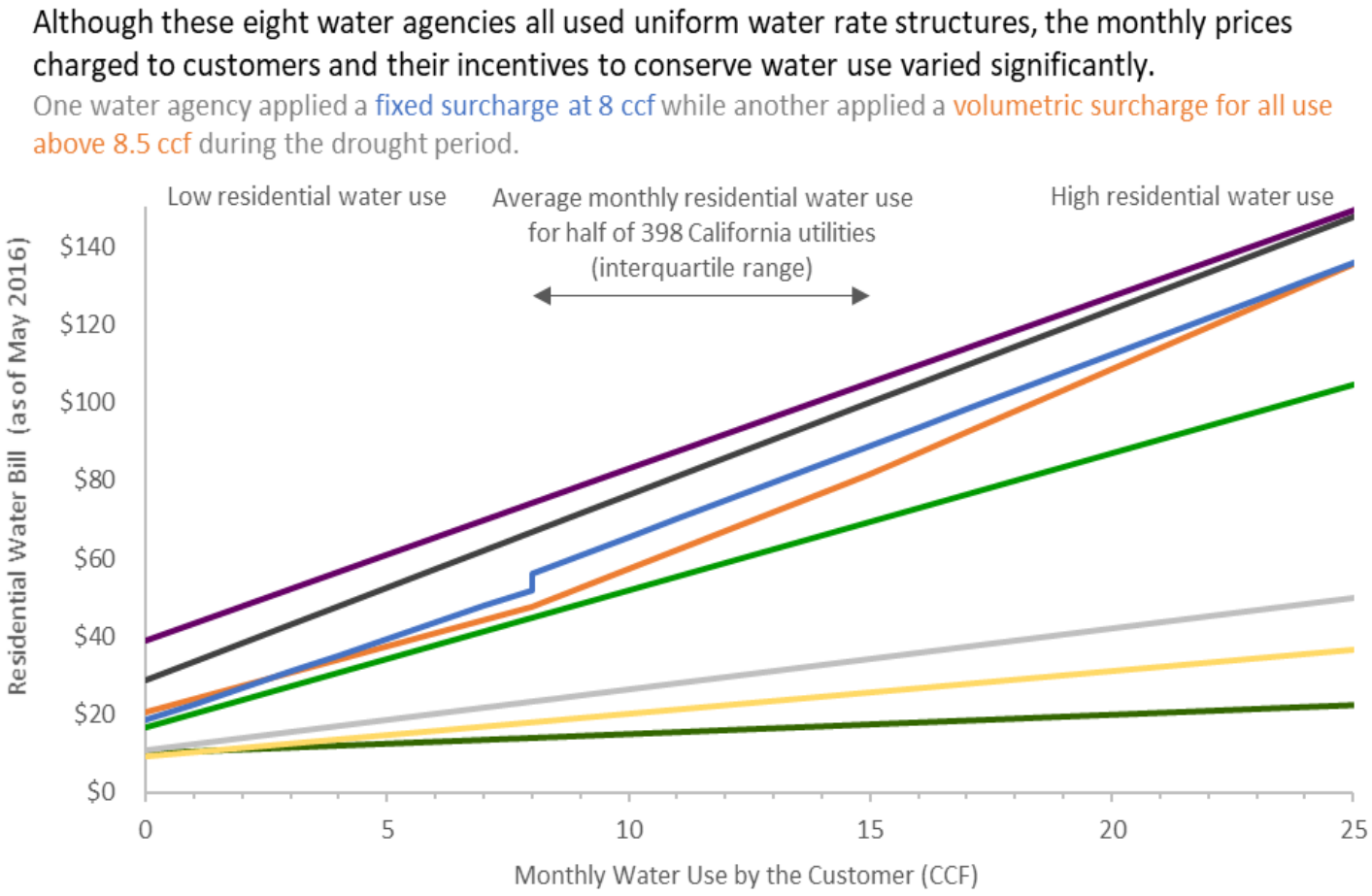
The diversity of local conditions and costs defy a one-size-fits-all approach to pricing and conservation strategies across the state. Some water agencies have high water rates and do not need complex rate structures to convey conservation price signals, while others might rely more on the rate structure design than high rates. Water agencies with inexpensive treatment and delivery costs, or those that have avoided rate increases to keep water rates low, will provide little incentive for customers to save water unless the rate structure has a design that signals an incentive to maintain low water use. It is also likely that these agencies will have to work harder with non-pricing conservation strategies to encourage water savings.

In using pricing as a strategy to encourage conservation or low water use, as stated above, water agencies can craft aggressive pricing signals with nearly any type of rate structure, and the rates themselves are as

important in influencing water use as the rate structure designs. A uniform rate structure with high volumetric rates could provide greater financial incentives for the customers to reduce water use than an increasing block rate structure with low rates and low price differentials between blocks. In addition, all rate structures could further encourage conservation by implementing drought-period pricing strategies such as temporary drought surcharges.

For example, Figure 6 displays the rate structures of eight California water agencies. Even though all eight agencies used uniform rate structures, the prices charged to customers provide very different financial incentives to reduce or maintain low water use.

Figure 6: Example of Eight Uniform Rate Structures Charged to Residential Customers in 2016



Furthermore, two of the water agencies in Figure 6 implemented drought surcharges to encourage conservation and to recoup revenue from the sharp decline in water use during the mandatory conservation period. Even without employing block pricing, these agencies were able to send very different price signals to their customers than the other agencies. One of these agencies (orange line) imposed a volumetric surcharge on water use above 8.5 ccf/month, thereby essentially creating a temporary increasing block rate structure. The other agency (blue line) implemented a drought surcharge of $0.50/ccf for all water use. However, customers with water use under 200 gallons per day (gpd) were given a full refund on that surcharge on the same bill. The drought surcharge and credit were distinct line items on the water bill. When the drought surcharge actually "kicked in" at any amount over 200 gpd, the drought charge then applied to all of the customer's water use. This means that the next gallon used above 200 gpd was the most expensive gallon purchased, at a total of $4.00. This price jump can be seen in Figure 6, at the

8 ccf mark. These two different approaches to implementing temporary drought surcharges created different price signals to the customers, particularly during the mandatory conservation period when the surcharges were in effect.

Data and Study Design

Each month during the mandatory conservation period, the local water agencies reported to the Water Board data on their water production, number of customers, enforcement metrics, number of days when outdoor watering was permissible, and various other statistics. In addition, the water agencies were required to report their pricing, rate structures, and water usage data, among other information, to the Water Board via the Electronic Annual Reporting System. About the same time, one of the state's largest water agencies completed its own statewide survey of water rate structures. Data from these sources provided an opportunity to study different pricing strategies and signals that agencies throughout the state used to influence usage during the mandatory conservation period.

In the wake of this unique opportunity, a group of California water agencies asked the EFC to collect and analyze information that could provide insight on how pricing, conservation measures, and a range of other factors might have influenced customer water consumption behavior. In particular, the EFC:

1) determined the variation in water pricing signals employed by water agencies across the State before and during the mandatory conservation period,
2) determined the significance of pricing and non-pricing strategies in reducing water use during the mandatory conservation period, and
3) assessed the relationship between water pricing and residential water use at the conclusion of the mandatory conservation period.

To conduct these analyses, the EFC explored the annual pricing data (including rate structure designs, rates, drought surcharges, and changes from one year to the next) and the monthly usage data reported by 398 water agencies to the Water Board. Statistical analyses were conducted to test the significance of the bivariate relationships between various elements of pricing and non-pricing strategies with the achieved conservation levels during the conservation period and with the average residential water use post-conservation period.

It is important to note that although extensive data cleaning was performed, some of the data reported by the water agencies to the Water Board may be prone to reporting errors not corrected by the data cleaning, or data may have been incomplete. At present, we performed exploratory analyses and tested bivariate correlations between pricing and non-pricing factors on water use and cumulative savings; the main results of which are described in this article. Future work will include more detailed explanatory analyses, including multivariate regressions of the data.

What this Means for Future Strategies

In the face of a changing climate, heightening water supply stress, and increasing population, conservation efforts are likely to be a trending topic for water agencies in California and across much of the country for the foreseeable future. As conservation efforts—and possibly mandates—continue, water agencies should

still focus on using pricing as a strategy and understand the signals their pricing structures send, but should also consider pricing in the context of other measures.

While the study did not show that pricing was correlated with higher levels of short-term curtailment/conservation, it did show that pricing was correlated with average water use, and that some agencies successfully employed pricing to meet reductions. In order for pricing to be effective, both the rates and elements of the rate structure need to be designed intentionally to provide appropriate price signals to encourage conservation. However, there is no evidence to suggest that any single approach employed by any water agency was effective across all of California in achieving water savings, or that pricing was the sole factor in reaching conservation goals. In fact, the research adds to the list of studies that identified non-pricing conservation programs as effective mechanisms to achieve short-term reductions in water use.

In future periods of conservation, water agencies should consider their demographic, geographic, and climate-related situations when making determinations about how to encourage conservation through pricing and non-pricing strategies.