IMPROVING WATER-USE EFFICIENCY: FOCUS ON THE OUTLIERS

Eric Hirst
Bellingham WA
July 2017[1]

Although Whatcom County enjoys ample water supplies when averaged over the year, summer conditions are quite different. During the summer, water use is especially high (primarily because of agricultural irrigation), and streamflows and precipitation are especially low. The discrepancies between summer supply and demand will grow over the coming years as population continues to increase and the effects of global climate change continue to worsen.

Various supply and demand projects and programs can help improve the summer supply/demand balance. This paper focuses on water-use efficiency (WUE), in particular the benefits of concentrating on those who use the most water. To explore this idea of targeting high users, I obtained monthly water-use data for single-family residential customers of the City of Lynden for three years, 2014, 2015, and 2016. I used these data to compare monthly, summer, and annual water use for different groups of customers classified by usage. The bottom line is that focusing efficiency programs on, say, the top 10% of summer water users is likely to be especially productive, much more so than undifferentiated programs that address all customers.

DATA

The City of Lynden sent me spreadsheets with data on about 4,000 residential water customers.[2] To ensure a homogeneous population, I deleted accounts that were for multi-family units, where inconsistencies arose in account start dates, where households moved into or out of houses (which led to changes in the account numbers), and for accounts that had more than one missing value for each of the three years (to ensure that these accounts represented year-round occupants[3]). The resultant data set included 2,613 household accounts. This final data set is almost surely all single-family homes, and with the same year-round occupants across the full 3-year period.[4] Monthly results presented below are for the month during which the consumption occurred.[5]

[1] I thank Elisabeth Britt, Bill DeOreo, Mike Dexel, Tom Fox, and Hank Kastner for their very helpful comments on a draft of this paper.
[2] I thank Steve Banham, Laura Burford, and Jaimie Noteboom for sending me these data. I thank Jaimie Noteboom for patiently and fully answering my many questions about interpretation of these data.
[3] Some Lynden residents are "snowbirds" who live in Lynden during the summer but live elsewhere during the winter. These snowbirds were excluded from this analysis.
[4] I have no information on the number of occupants, the number and characteristics of water-using equipment, or of the property size (including lawns and gardens) associated with these single-family residential accounts.
[5] Lynden uses an automated-meter-reading system that allows it to read its water meters over a 2- or 3-day period near the end of every month. Water bills are then mailed early in the following month.

RESULTS

The month-to-month pattern of usage is consistent across the three years of analysis (Fig. 1). Summer[6] usage is roughly three times greater than winter usage.

Although baseline (i.e., non-summer) use is similar for all three years, summer usage is highest for 2015 (a drought year). In particular, summer usage averaged 400 gallons/day (gpd) in 2015, compared with about 350 gpd for the other two years.[7]

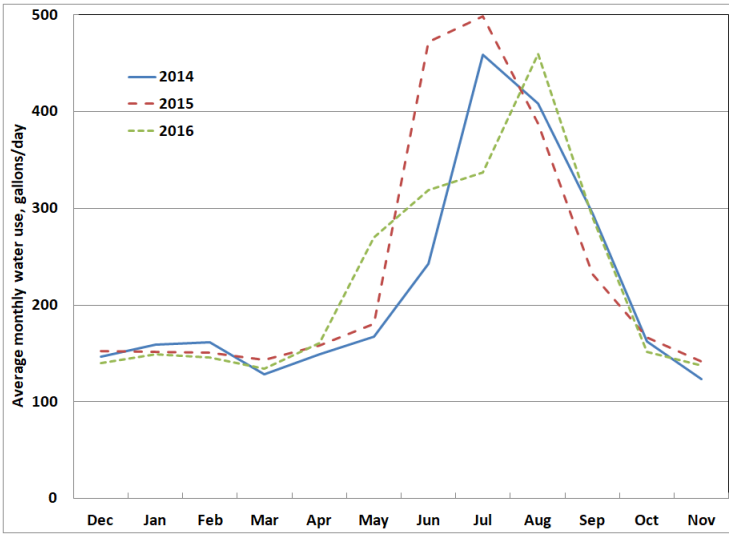

Fig. 1. Monthly water use for single-family residential customers in Lynden, 2014 through 2016.

The variation in monthly water use across households, the focus of this paper, is striking. Fig. 2 shows monthly water use for three sets of households – at the bottom 10% of the distribution, the median[8] (50%), and the top 10%. The low water users show relatively little variation in seasonal water use; their monthly outdoor water use is about two-thirds of their monthly base water use.[9] For the top 10%, however, the picture is very different. These high users show dramatic month-to-month differences, with outdoor water use almost double (180% of) base use.

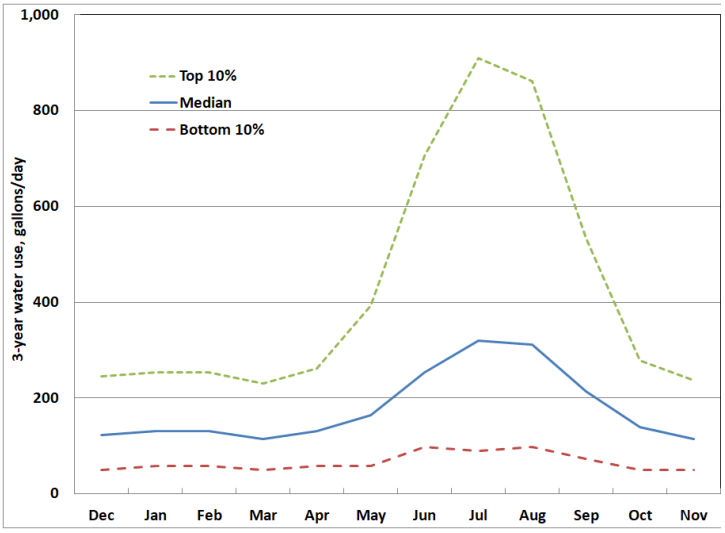

Fig. 2. Distribution of monthly water use averaged over three years showing top and bottom 10% and median.

[6] I define summer as the four months June through September, based on the patterns shown by the data. (In my prior studies of Whatcom County water use, I defined summer as July through September.)

[7] Lynden measures and bills customers for cubic feet of water. 1 cubic foot = 7.48 gallons.

[8] I use two measures of the average in this paper: the *mean* is the sum of all the numbers in the set divided by the amount of numbers in the set. The *median* is the middle point of a number set, in which half the numbers are above the median and half are below. When a distribution is skewed (i.e., asymmetrical) the median is a more useful measure of the average.

[9] I define base water use as the average over the seven months of November through May. Outdoor water use is defined as monthly water use in June, July, August, and September minus base use.

Examining additional details on the distribution of summer water use among these customers shows, once again, substantial variation. Fig. 3 shows average consumption for each decile,[10] i.e., the bottom 10% the next 10%, and so on. The top decile consumes an average of 920 gpd, about triple what the median customer uses and more than 10 times as much as the lowest decile consumes. The second highest decile (90%) also consumes a great deal of water in the summer, 660 gpd (more than double the median).

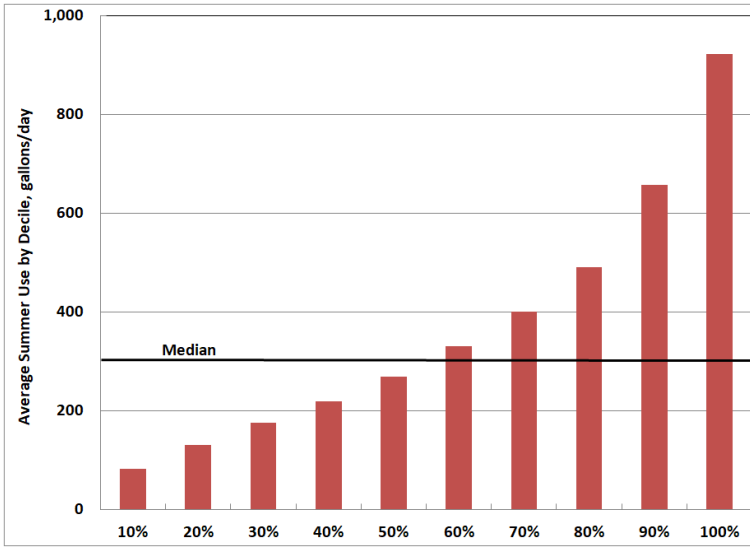

Fig. 3. Distribution of summer water use by decile.

Finally, those who use lots water during one summer are very likely to do the same during other summers. Consider those households in the top 10% of 2014 summer water use: 66% were in the same category for 2015 and 64% for 2016. In other words, households are consistent in their water use from year to year.

IMPLICATIONS FOR WUE PROGRAMS

Household water use is a function of two broad factors: equipment and behavior. Homes with more water-using fixtures and appliances that are inefficient will use more water than those with fewer, more efficient equipment. Similarly, households that take long showers and overwater their lawns will use more water than those that are more efficiency conscious.

Because I had no information on the household occupants, the water-using equipment in the house, and the size and type of lawn, garden, and yard, I was not able to separate the effects of these two factors on water use. Some of the differences observed here are due to family size, house age, equipment efficiency, and size of the yard. And some of the difference among accounts is due to consumer behavior and attitudes towards efficiency. A utility interested in sharpening its WUE program could conduct periodic surveys of its customers to better understand these characteristics.

The results presented here suggest that focusing on high users is likely to be much more effective and cost effective than undifferentiated efficiency programs that encompass all customers. And focusing on summer (primarily outdoor) water use is much more important than addressing

[10] A decile is one of 10 equal groups into which a population can be divided. Each decile here has 261 accounts.

overall water use. For example, cutting summer outdoor use by 10% across all homes would save about 14 gpd per household. However, reducing water use for the top 10% of homes down to the median level would save 30 gpd per household, more than double the savings for the average home. And the cost to run such a targeted program would be much less than for one that addresses all customers.

These results clearly show that not all households are created equal. Indeed, substantial variation in water use occurs among these nominally similar accounts. From an efficiency perspective, the differences in summer water use are especially dramatic and offer a major opportunity for efficiency gains. That is, programs that seek to reduce summer (outdoor) water use should focus on these high users.

These results also suggest important improvements in rate design. Inclining blocks (in which the price of water increases as you use more water) provide a strong economic incentive to use water efficiently. The initial price could be set low enough to cover base (indoor) water use for the median household. The second (higher) price could cover the estimated outdoor water use for the median household. And a third (still higher) price could cover all water use above that amount. Lynden's rates increase from 21 cents per 100 gallons to 28 cents at about 120 gpd, and then increase again to 42 cents at about 440 gpd (Fig. 4).

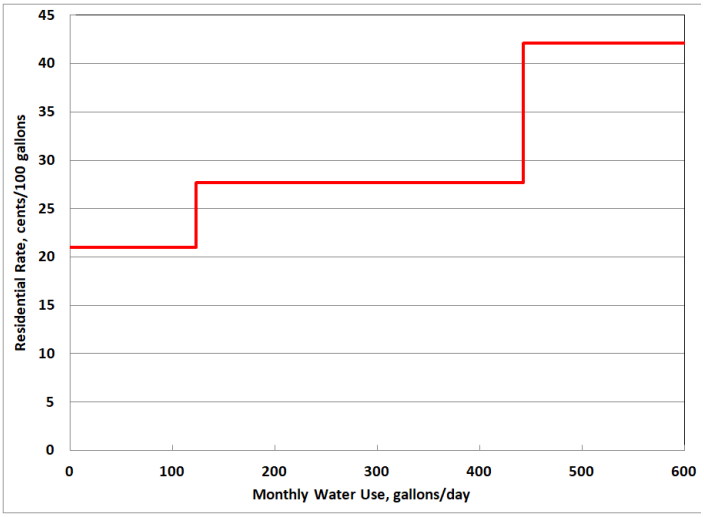

Fig. 4. City of Lynden residential water rates.

In addition to saving water, focusing on high users and peak summer demand will lower water and wastewater utility capital costs. That is, less money will need to be spent to increase capacity in pipes, pumping, water treatment and sewage treatment if peak demand is cut. Operating costs will also be cut.

Finally, these large variations in water use among customers in the same class likely apply to other sectors. That is, similar gains in efficiency programs could likely be achieved in the commercial, industrial, and agricultural sectors by focusing on the small number of very high users.