ASSESSING WATER AFFORDABILITY

A Pilot Study in Two Regions of California

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August 2013

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The full report is available online at http://www.pacinst.org/publication/assessing-water-affordability/

ISBN 13: 978-1-893790-04-9

In collaboration with

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Acknowledgements

We would like to thank Francisco Diaz, Fresno State, for research assistance and preliminary analysis of Tulare Lake Basin data along with Kaitlin Toyama, Community Water Center, for research assistance and preliminary analysis of Sacramento data. We also gratefully acknowledge the valuable comments of the following reviewers: Rich Haberman (formerly with the California Department of Public Health); Phoebe Seaton (Leadership Council for Justice and Accountability); David Spath (formerly with the California Department of Public Health); and David Wallis (Rural Community Assistance Corporation). In addition, we would like to thank the following organizations for supporting this work: the S.D. Bechtel Jr. Foundation, the U.S. Environmental Protection Agency Region 9, the U.S. Department of Agriculture Internship Program through California State University San Bernardino, the Switzer Environmental Leadership Fellowship, and the University of California, Presidential Post-Doctoral Fellowship.

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1 Introduction

Water rate affordability is a central element to water access. Cost makes water excludable and inaccessible to those who cannot afford it. Water affordability is also a major concern to public welfare, safety, and security. When households are unable to make their water payments, consequences can include public health crises, social unrest, and lost revenue for water providers that can threaten their fiscal stability.

In California, water affordability has taken center stage since the passage of two landmark Assembly Bills in 2012: AB 685 and AB 2334. As the first state law in the United States to explicitly recognize the Human Right to Water, AB 685 notes that "every human being has the right to safe, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" as set forth in Section 106.3 of the California Water Code (CWC). Focused more explicitly on water affordability, AB 2334 requires the Department of Water Resources to include an analysis of water affordability and mechanisms to address lack of drinking water (and wastewater services) affordability in California's Water Plan. Specifically, it recognizes that (CWC Section 10004.8):

> (a) Throughout California, hundreds of thousands of low-income residents do not have access to potable drinking water and wastewater services without paying cost-prohibitive rates. Thus, reliable and potable drinking water is not affordable or accessible for many Californians.
>
> (b) It is in the public interest for all households to have access to safe and affordable water for basic needs and to have effective and affordable wastewater treatment.
>
> (c) While California has programs to ensure that low-income households have access to affordable and dependable basic energy and telecommunication services, the state has not adopted a similar program in what are the most basic and critical household utilities, water and wastewater.

While these recent legal successes bring water affordability into the limelight, much of the important work lies ahead. Which areas of the state have unaffordable water bills?[1] What are the different ways to analyze affordability? This pilot study is intended to explore how to measure

[1] Throughout the rest of the study we use the term "water bill" to represent the bill that customers pay to a water utility to cover water for domestic purposes, not including wastewater.

water affordability, the implications of using different measures, and how to understand the implications of results in both urban and rural regions. As a starting point, the study examines water affordability in two regions: the Sacramento metropolitan area and the Tulare Lake Basin (TLB).

Specifically, the study asks, “Where are water bills unaffordable?” and addresses the question using different affordability measures, at different scales, in different regions of the state. We used a combination of primary data collected from a survey of water systems in the two areas and publicly available water rate information, as well as a series of spatial analyses.

Typically, water affordability is measured by the percentage of median household income spent annually on water services. Households paying an amount for water that exceeds the affordability threshold are considered to be paying a cost that is unaffordable. In practice, the affordability threshold varies (see Table 1). For this study, we use 2% of median household income as the water affordability threshold. In addition, we calculate a second measure of affordability, based on individual household income as the evidence suggests that there may be many households, even within affluent communities, that exceed the affordability threshold. Therefore, it may be more important to consider household income rather than median income when assessing water affordability, and work is needed to address financing considerations for water systems facing affordability challenges and to develop “best practices.” These measures are described in further detail below.

2 Methods

Case Selection and Rationale

We conducted our study in two regions—one an urban area and one a rural area. The urban case focused on the Sacramento metropolitan region, and consisted of community water systems ("water systems")[2] that have at least a portion of their service areas within the City of Sacramento. Sacramento is the capital of California and is located in the northern portion of California's Central Valley. Sacramento is one of America's most diverse cities, based on U.S. Census data (Stodghill and Bower 2002), and its diverse socioeconomic make-up makes it an important case for looking at affordability within and across systems in urban areas of California.

The rural case focused on the Tulare Lake Basin (TLB), including Fresno, Tulare and Kings Counties, but excluding Kern County which is also in the TLB.[3] The TLB is located in one of the poorest areas of the state and has some of the worst water quality in the nation (Dubrovsky et al. 1998). Located in the southern San Joaquin Valley, the TLB is composed of a few major urban areas (e.g., Fresno, Bakersfield and Visalia) that supply drinking water to many of the residents in the TLB. However, most of the TLB is rural with many small, disadvantaged communities, and 86% of water systems serve fewer than 3,300 people (California Department of Public Health 2008), often residing in unincorporated, lower-income communities. In recent years, residents have highlighted the lack of affordable rates as a major issue, and although one study documented the costs of water in these communities (Moore et al. 2011), no comprehensive study of water rates has been conducted in the region.

In comparing these two cases we sought to explore the potential differences that urban and rural areas have in relation to water affordability. In urban areas, water systems serve more populous areas, and often cover multiple Census Block groups. While affordability may be assessed at the water system level, there may be widely varying income levels, and therefore, levels of affordability within a water service area. Including an urban area in the analysis allowed us examine water affordability at both the water system level and within the water system at the Census Block group scale. Contrary to urban water systems, the vast majority of the rural water systems in the TLB are contained within a single Census Block group.[4] Thus, for the rural case study we examine water affordability only at the water system scale.

[2] Community water systems refer to the EPA's definition of Public Water Systems (i.e., regulated by the Safe Drinking Water Act) that serve at least 25 people or 15 connections year-round. Throughout this study we use the term "water system" to refer to community water systems.

[3] Kern County is also part of the Tulare Lake Basin. At the time of this white paper, survey efforts were still collecting data in Kern County.

[4] Only three of the water systems in the TLB case study had significant area (i.e., 6% or more of their area) in more than one Census Block group.

In both regions, we attempted to survey the entire population of water systems that fit our criteria. This included all 21 water systems that serve the Sacramento metropolitan area. For the TLB, only community water systems serving fewer than 3,300 customers were included as we were interested in water affordability in the rural areas within the region, and among small systems. This included 130 systems, excluding mobile home parks. Mobile home parks were excluded from the total list of water systems to sample because after a few initial pilot calls, it was determined that these systems do not bill water rates separately from other general property-related fees. Of the 130 systems, however, only 93 had confirmed contact information. These became the target population that we attempted to survey.

The sample selection processes were slightly different for TLB rural water systems and the Sacramento urban water systems in order to highlight issues of water affordability in a more urban and a more rural setting. This, of course, means that our units of comparison (i.e., all urban systems versus only smaller water systems) are not altogether comparable, an issue examined further in the discussion section. As a pilot study, however, the main goal was to draw lessons learned from the two areas so as to offer considerations for future affordability research.

Calculating Water Affordability

In order to calculate water affordability, the following steps were taken: 1) calculation of average monthly water bill; 2) compilation of water system boundaries; 3) estimation of key demographic variables in order to calculate affordability (i.e., water bills in relation to demographic variables); and 4) calculation of affordability using different scales and measures.

Calculating Water Bills

The first step to calculate water bills was to obtain water rate data. These data were collected from existing water rate studies and via an online survey and by administering the survey to individual water systems in the two study areas, primarily via telephone. Data were recorded online, on a secure Survey Monkey website (https://www.surveymonkey.com/s/WaterSurveyTLB). Among other things, the survey asked water system managers to share monthly water bill information, rate sheets, and a description of water affordability programs.

For the Sacramento Region, water rate data was first compiled from the American Water Works Association Survey (AWWA and Rafetelis 2009). If the water system was not listed in this survey, it was sent an email invitation to participate in the survey, and a follow-up call was then placed. In sum, the study relied on water bill data for nine systems using the AWWA data; data for the remaining 12 was compiled using the survey. None of the systems of interest had recorded data within AWWA's survey, since this survey tends to focus on larger systems. Thus, in the TLB, each water system was sent an email invitation to participate in the survey, if email addresses were available. The system was then called three times at different times and days. When contact was made, the water system manager was given the option of being surveyed right away, setting up a time for a survey, or being sent the survey via a link to fill out on his/her own time. After three calls, a system was considered to be unreachable if the research team made no contact. In the Sacramento metropolitan region, water rate information was obtained for all 21 systems. In the TLB, 51 water systems fully participated; the rest did not provide complete information, declined to participate, or did not respond after three calls and one email attempt.

With water rate data compiled, we then calculated average monthly water bills. The water bill refers to the amount a household pays to use 1,500 cubic feet of water per month. To determine the water bill, the price per unit of water and the rate structure of each system was considered. For instance, where water rates are flat and all customers pay the same amount for water regardless of volume consumed, the monthly water bill was directly equal to the stated water rate. For flat rates billed bi-monthly, the bill was divided by two to calculate a monthly bill. In other cases, flat rates vary by meter size. In those cases, we assumed a 3/4 inch meter size, which is typical for residential water connections. For volume-based water rates, such as uniform rates, block rates, or tiered rates,[5] we assumed an average household's water use is 1,500 cubic feet per month or 368 gallons per day, and calculated a monthly water bill based on this volume of use.[6] These numbers may underestimate current residential water use, as recent data estimates average household use in the Sacramento River Hydrologic Region is 1,790 cubic feet per month and is even higher in the San Joaquin River Hydrologic Region (2,208 cubic feet per month).[7]

[5] For more information about the most common water rate structures, see the Pacific Institute publications *An Overview of the "New Normal" and Water Rate Basics* (www.pacinst.org/publication/water-rates-series).
[6] This is the average household water use estimate used in the American Water Works Association survey. This is also similar to estimates of per-capita residential use reported for the region in the 20x2020 Water Conservation Plan (DWR et al. 2010).
[7] The 20x2020 Plan estimates that per capita residential water use is 174 gallons per day in the Sacramento River Hydrologic Region and is 180 gallons per day and in the Tulare Lake Hydrologic Region (see Table A1 in the Appendix). Assuming an average household of 2.6 and 3.1 people, respectively, average monthly household water use is approximately 1,790 cubic feet per month in the Sacramento metropolitan region and 2,208 in the Tulare Lake Basin, which actually exceeds our assumption of 1,500 cubic feet per month.

Water System Boundaries and GIS Estimation of Demographic Parameters

In order to determine affordability we estimated the following demographic characteristics for each water system:

1. The median household income
2. The number of households within particular income ranges

To do this, we first identified the location of water systems in relation to U.S. Census Block groups. We obtained the boundaries for most participating water systems from a variety of sources. For the Sacramento region, we obtained an AutoCAD file from Sacramento County staff showing the service areas for water providers in the county, which we converted into a GIS shapefile. For the TLB, we obtained digitized boundaries from the TLB Disadvantaged Communities Study (Provost and Pritchard 2013). For some small water providers, where no service area boundary was provided, the TLB Study represented the system with a 0.5-mile diameter. In these cases, the general location of the water system's service area is assumed to be accurate though its boundaries are unknown. Figure 1 shows a subset of systems in the TLB.

To determine the demographic characteristics of the water provider's service area, we used data from the U.S. Census Bureau's American Community Survey (ACS). This dataset contains records on median household income, number of people below the poverty level, percent of the population below the poverty level, and other socio-economic characteristics at the Census Block group level. These data do not represent a single point in time, but rather a five-year average for the years 2007–2011.

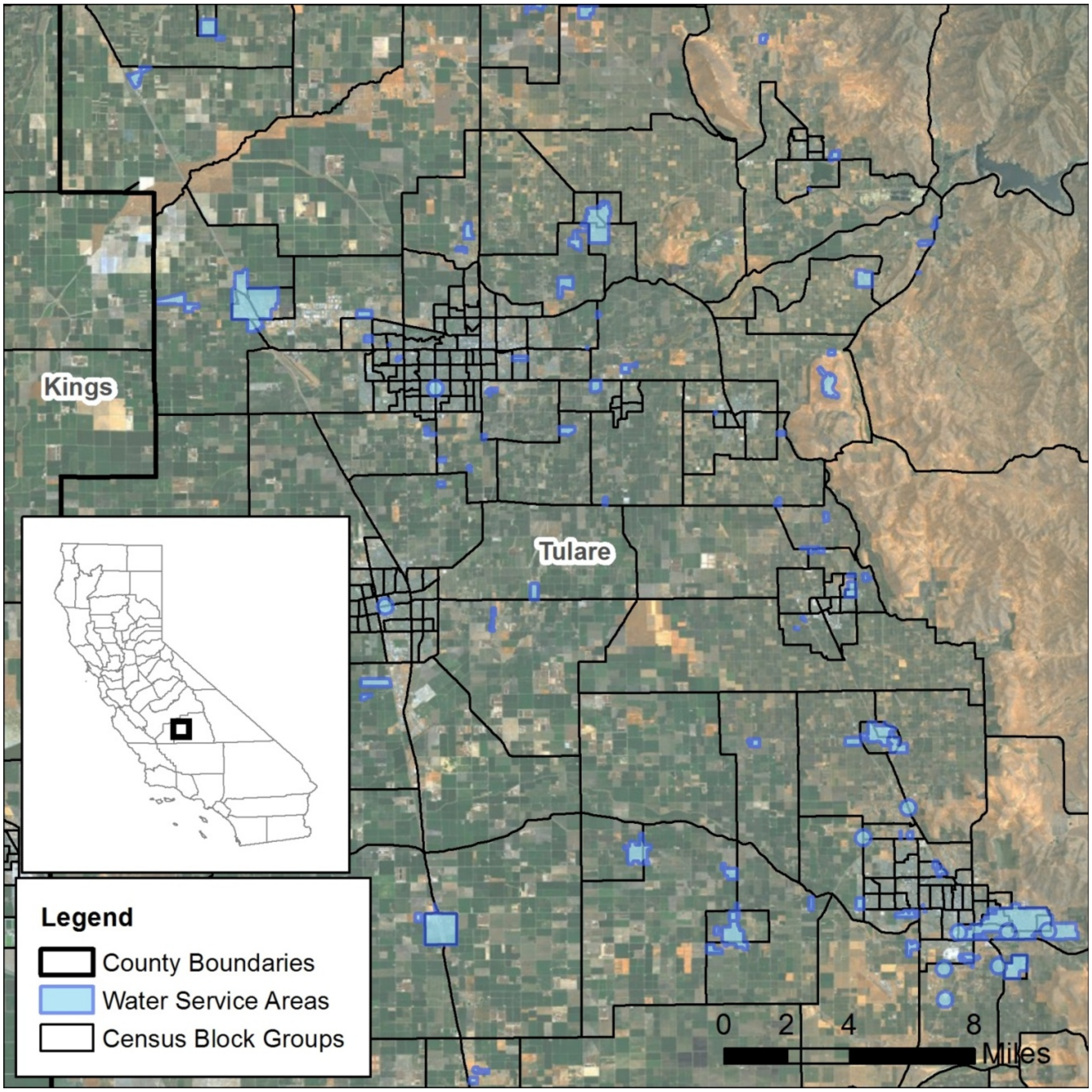


Figure 1. An example of the Census Block group boundaries and water service areas in Tulare County, California. Many water systems fall completely within one Census Block group, while other water systems intersect multiple Block groups.

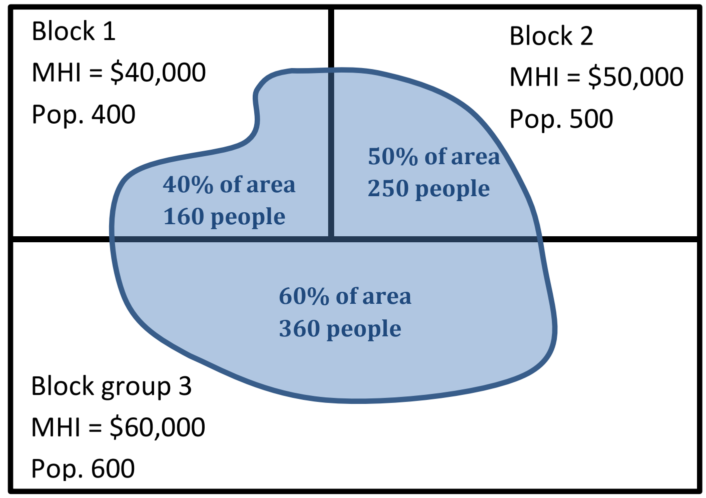
Census Block groups and water service areas do not usually share common boundaries, requiring us to do some spatial weighting using standard methods to apportion population characteristics to the water system level. In the TLB, a largely rural area, the Census Block groups are relatively large (i.e., on average 15 square miles), and most water systems have a relatively small service area (i.e., less than a few square miles) (see Figure 1).

In the more urban Sacramento metropolitan area, Census Block groups are smaller in size on average (i.e., 3.1 square miles), and the water systems serve larger areas.

To conduct this spatial weighting, we undertook the following steps:

1. Join the demographic field in question (i.e., Median Household Income (MHI) field from the ACS Summary File) to the attribute table of the Census Block group GIS layer, using each Block group's FIPS code as its unique identifier.
2. Disaggregate the MHI attribute to the Census Block group level by joining the Block group attributes to the Census Block attribute table.
3. Intersect Census Block groups and Water system boundary layers to calculate the fraction of each Census Block group's area that intersects a water system's service area.
4. Calculate the population-weighted average for the demographic variable in question for water systems. These steps assume the population with a Block group is homogeneously distributed.

As an example, Figure 2 shows a water system that overlaps three Census Block groups. Each Block group has a value representing its population and its median household income. For each overlapping area, we calculate the fraction of the Block group in the system. For example, in Block group 1, 40% of the Block group's area is in the system, so we assume 40% of its population resides there. For each overlapping area, we calculate the proportional population, and assign the MHI from its parent Block group. Then we calculate the population-weighted average MHI as shown in the example below. Because of the relatively large margin of error associated with the inputs (population and MHI), and the inherent imprecision of our methods, we round the result to the nearest thousand dollars.



Population in System:

Block group 1	40% × 400 =	160
Block group 2	50% × 500 =	250
Block group 3	60% × 600 =	360
Total:		770

$$\begin{aligned} &\mathit{Weighted\ MHI} \\ &= \frac{(\$40{,}000)(160) + (\$50{,}000)(250) + (\$60{,}000)(360)}{(160 + 250 + 360)} \\ &= \$52{,}597 \end{aligned}$$

Figure 2. Example Calculation of Population-weighted MHI in a Hypothetical Water System

Measures of Water Affordability

Next, we estimated water affordability using several different measures, described in detail below.

Measure 1a: Percent of Median Household Income, Water System Scale

Water affordability is most commonly measured as a percent of median household income. While this is a very common measure of affordability, organizations set different affordability thresholds, ranging, from 1.5% of median household income to 3% of median household income (Table 1). For the purposes of this report, we use the threshold of 2%, which is also the threshold used in recent legislation affirming a human right to water in California (AB 2334).

Table 1. Water Affordability Thresholds

Affordability Threshold	Organization
1.5% of MHI	California Department of Public Health
2% of MHI	AB 2334
2.5% of MHI	U.S. Environmental Protection Agency
3% of MHI	United Nations Development Program (UNDP)

Measure 1 divides a household's annual water bill for average household water use by the median household income (See Equation1a):

$$Eq. 1a = \frac{\text{Monthly bill for average water use * 12}}{\text{Median household income of water system}} * 100$$

Measure 1b: Percent of Median Household Income plus Water Replacement Cost, Water System Scale

In some areas of the state, including the TLB, many water systems are not able to supply clean and safe drinking water. In such cases, households often pay their monthly water bill and a "replacement cost" or the cost to purchase non-contaminated water supplies (typically bottled water or vended water). This has been documented in *The Human Cost of Nitrate-Contaminated Drinking Water* (Moore et al. 2011) and a report by the United Nations Special Rapporteur (UN General Assembly 2011). To take these additional costs into consideration, we *assumed* a scenario in which all households were paying a replacement cost for water in addition to their monthly water bill. In this variation on Measure 1a, an average replacement cost is added to the monthly bill for average water use.

To estimate replacement water costs, we used values established by previous research in Tulare County. Specifically, in 2011, the Pacific Institute, Community Water Center, California Rural Legal Assistance Foundation, and Clean Water Action conducted a household survey of four water systems in Tulare County with recent violations of nitrate limits to document the extent to which households undertake measures to avoid nitrate-contaminated water and the associated costs (Table A2). The results showed that, on average, households pay an additional $28.91 per month for replacement water supplies. Thus, Equation 1b adds $28.91 to the monthly water bill to reflect the average replacement costs for households with contaminated water supplies. Equation 1b was applied to all water systems in the TLB case study only.

$$Eq. 1b = \frac{\text{(Monthly bill for average water use + \$28.91) * 12}}{\text{Median household income of water system}} * 100$$

Measure 2: Percent Median Income, Census Block Group Scale

Water systems are a common unit of analysis for assessing affordability. However, averaging median household income across an entire water system can mask significant socio-economic heterogeneity. Thus, in the urban case study, we examined affordability with a second measure at a finer scale: affordability at the Census Block group level. Here, we disaggregated water system data (i.e., water bills) to Census Block group boundaries, and calculated the percentage of median household income that households spend on water at the Block group scale. Our hypothesis was that this would reveal more detail about where water affordability may be more of a concern *within* a water system's boundaries for larger systems.

$$Eq.2 = \frac{\text{Monthly bill for average water use * 12}}{\text{Median household income of Block group}} * 100$$

Measure 3a: Number of Households that Spend More than 2% of Annual Income on Drinking Water Service

Examining water affordability at the median household income only ensures that households at, or above, the median income have access to affordable water. Using the standard approach to measuring affordability, we overlook the reality of households with income below the median. Because the American Community Survey (2011) reports number of households within certain income brackets,[8] we were able to obtain a count of the number of households in a Block group that fall within various income ranges. Thus, our final measure of affordability examines water affordability at the household scale "range". Here, we used household income data, rather than median household income data, to determine how many households in the two case study regions spend 2% or more of their income on drinking water services.

We again used population weighting to estimate the number of households within a particular water system's boundaries that were in each income range. We then divided the annual household water bill by 2% to determine the income threshold at which water bills were exactly 2% of household income. Households with incomes below that threshold pay more than 2% of their income for drinking water services. Thus, we added up the number of households that were within income ranges that were below and/or did not encompass the 2% income threshold.

$$Eq.3a = \frac{\text{Monthly bill for average water use * 12}}{2\%}$$

Measure 3b: Number of Households that Spend More than 2% of Annual Income on Drinking Water Service plus Replacement Cost

As with Measure 1b, for the TLB we added replacement cost to this measure to reflect the costs to communities that are not only paying a monthly water bill but also a replacement cost to access non-contaminated drinking water supplies.

$$Eq.3b = \frac{\text{(Monthly bill for average water use + \$28.91) * 12}}{2\%}$$

[8] Specifically, the 2011 American Community Survey, which collected data over the five-year period of 2007-2011, provides a count of households within particular income ranges, such as up to $10,000; $10,000-15,000; $15,000-$20,000.

3 Results

Sacramento Metropolitan Area: An Urban Case Study

Water Affordability at the Water System Scale

The 21 water systems in the Sacramento region (Figure 3) serve 1.38 million people. Among these water systems, median household income within each system ranges from an estimated $33,000 to $102,000. Average monthly water bills in the region ranged from $20 to $78 per month. Using Measure 1, for the 21 water systems in the Sacramento metropolitan area, water affordability ranges from 0.4% to 1.5% Thus, there are zero water systems with unaffordable rates (Table 2).

Table 2. Water Affordability in the Sacramento Metropolitan Region, California

Measure	Number of Units Paying Unaffordable Rates: Count (Percentage)
Measure 1: Water systems with unaffordable rates	0 (0%)
Measure 2: Block groups with unaffordable rates	52 (6%)
Measure 3: Households with unaffordable rates	116,130 (23%)

Water Affordability at the Block Group Scale

For the Sacramento Region, Block-group-level median household income, rather than system-level income data, reveals different results, as it provides a better reflection of socio-economic variability within the relatively large water system boundaries. In Sacramento County, out of 912 groups in the county, 874 Block groups are served by one of the water systems in our study.9 Using Measure 2, of these 847 Block groups, 52 Block groups (within six systems) exceeded the affordability threshold of 2% of the Block group's median income (Figure 4).

Water Affordability at the Household Scale

Finally, using Measure 3, we examine water affordability at an even smaller unit: the household scale. At this scale, we find that there are over 100,000 households within the Sacramento metropolitan region that are spending 2% or more of their household income on drinking water services.

[9] To be included, the Block group must have the majority of its area inside of a water agency's service area; this prevents us from counting tiny slivers of overlap caused by imprecise geodata. Rural block groups do not overlap the water districts in our study.

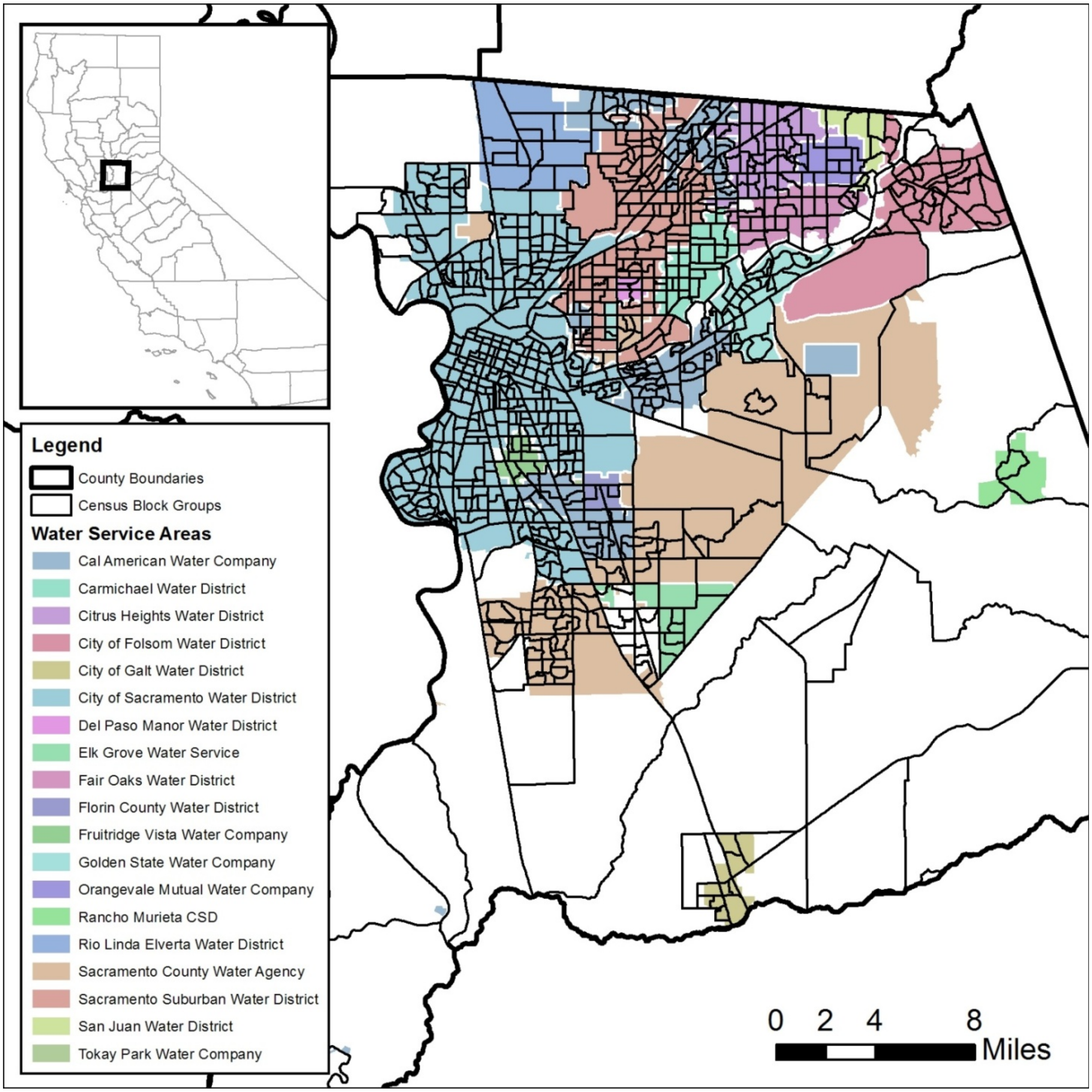


Figure 3. Census Block group boundaries and water service areas in the Sacramento Metropolitan Region. The water systems in this area cover multiple Census Block groups.

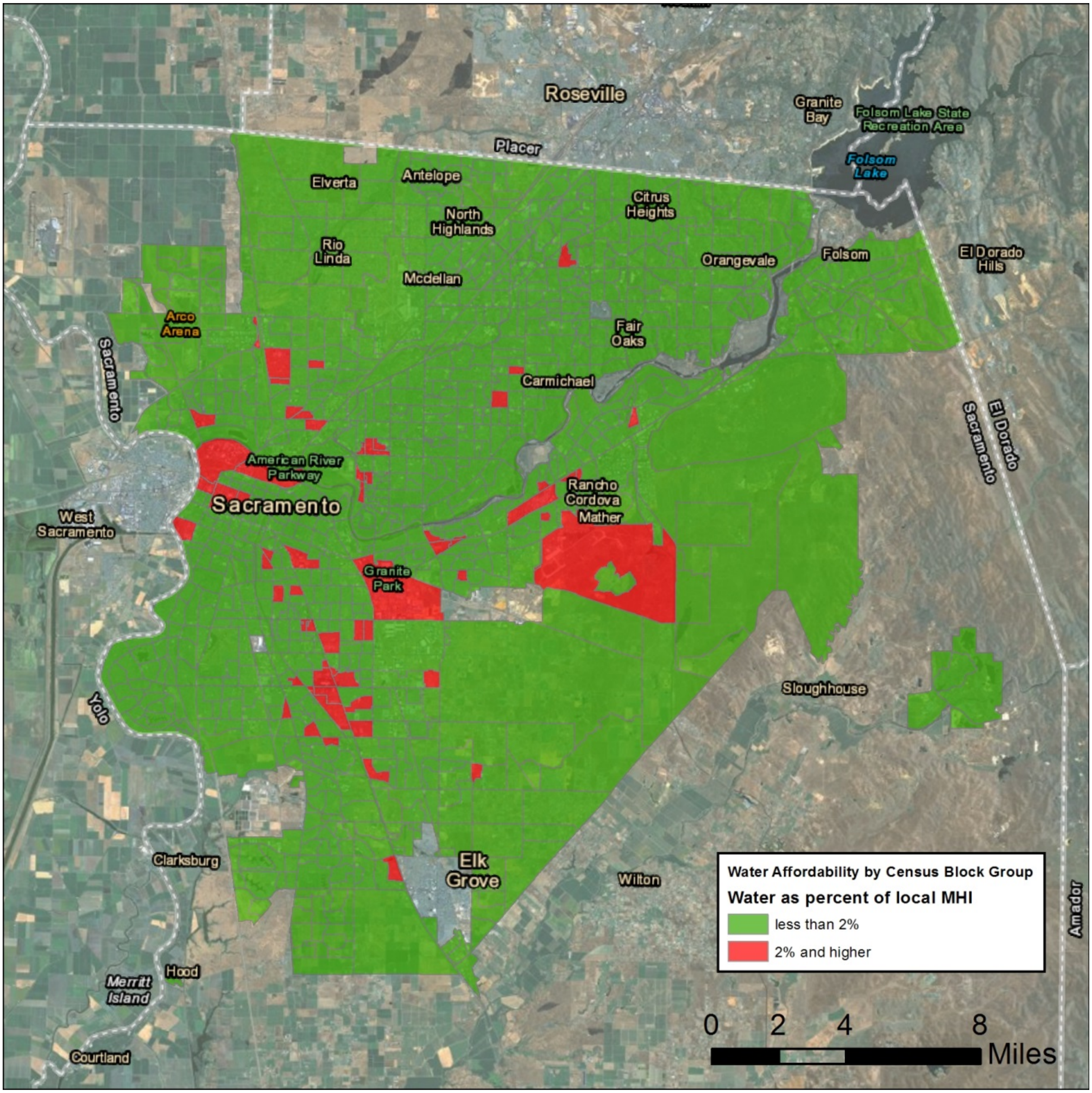


Figure 4. Water affordability at the Census Block group scale. Red areas indicate Block groups where a typical water bill exceeds 2% of the Block group's median household income.

Tulare Lake Basin: A Rural Case Study

Water Affordability at the Water System Scale

The 51 water systems in the TLB serve over 10,000 connections (approximately 38,000 people) and cover 406 Census Block groups. Among these water systems, median household income ranges from $18,851 to $108,665. Water rates range from $14 to $94 per month. Using Measure 1a to assess median household income at the water system scale, water affordability ranges from 0.5% to 3.4%, and nine systems exceed the water affordability threshold (Figure 5, Table 3).

Using Measure 1b, which considers water affordability that takes into account replacement costs (see equation 1b), 14 water systems exceed the affordability threshold.

Water Affordability at the Household Scale

Applying Measure 3, we find that there are almost 4,000 households (nearly one-third of all households) within our study sample that are spending 2% or more of their household income on drinking water services. If we add replacement costs to the water bill, over 7,000 households exceed the affordability threshold, or more than half of households served.

Table 3. Water Affordability in the Tulare Lake Basin Region, California

Measure	Number of Units Paying Unaffordable Rates: Count (Percentage)
Measure 1: Water systems with unaffordable rates	9 (17%)
Measure 1a: Water systems with unaffordable rates, considering replacement costs	14 (27%)
Measure 3a: Households with unaffordable rates	3,933 (29%)
Measure 3b: Households with unaffordable rates, considering replacement costs	7,021 (51%)

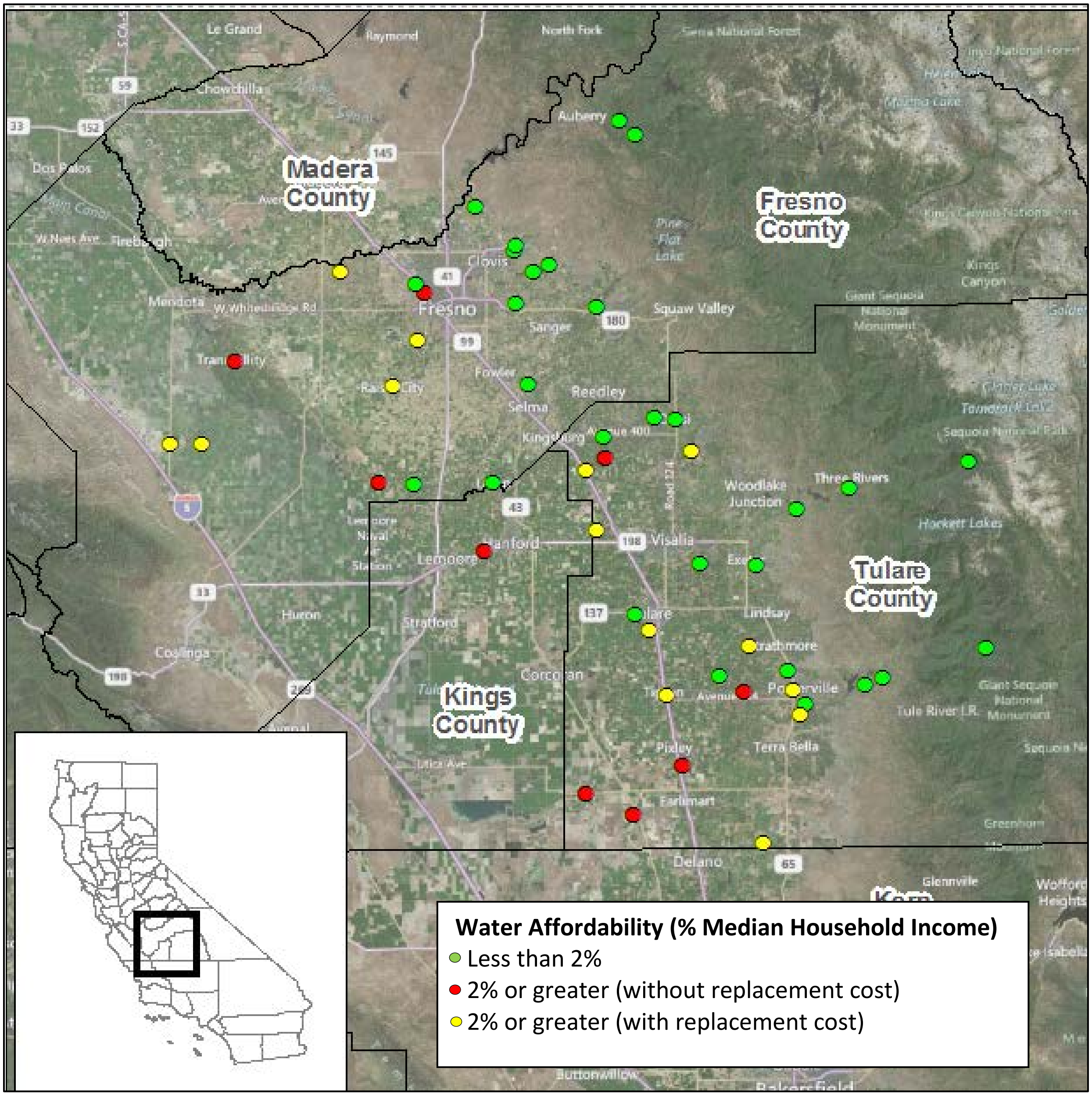


Figure 5. Water affordability for water systems in the Tulare Lake Basin Region, California highlighting which systems pay what percent of median household income in various variations. Systems are indicated with circles to simplify map.

4 Discussion

This study serves as a pilot for analyzing water affordability in California. A central conclusion is that, depending on the region and the affordability measures used, the results vary. In the urban case, using the annual water bill in relation to the percent of median household income at the water system scale, few water systems in either area appeared to suffer from unaffordable rates. In the urban case study, examining affordability at the Block group level reflected greater socio-economic diversity within the water system, and highlighted how a significant number of areas within water systems have unaffordable rates, even if the system as a whole does not. In the rural case, even with Measure 1, nearly one in five systems has unaffordable rates, but this percentage increases with the finer-scaled measures. In both the urban and rural case studies, analysis of actual household incomes rather than median household incomes revealed the highest levels of unaffordability.

In sum, affordability measures calculated at different scales of analysis yield different results. While water may be affordable at the state scale, it may not be affordable at the water system scale. And while water may be affordable at the water system scale, it may not be affordable at the Census Block group scale (when there are multiple block groups within a system) or the household scale. More fine-scale measures are able to better reflect socio-economic heterogeneity.

That the count of "unaffordable" systems varies by measure used has important implications for policy circles. When using Measure 1, a common approach to determining affordability, policy makers must be aware that this count masks areas within a system that have unaffordable rates (as shown in Block group analysis). Moreover, measures focused on the system level or using median income levels do not account for impacts on the most vulnerable populations within a system: those earning less than the median income. In this respect, using household level data is equally as important. This type of Measure (e.g., Measure 3) not only highlights the overall number of households with unaffordable water within a system, but can also be used to assess what types of affordability programs may be needed or are feasible, given financial requirements of the system.

Finally, as shown in the analysis of the TLB, replacement water costs associated with buying bottled water, vended water, or water filters to ensure safe drinking water supplies can dramatically increase unaffordability. Unfortunately, current laws do not include these additional replacement costs in assessments of water affordability. Thus, agencies charged with implementing a human right to water should consider using a measure that correctly assesses those members of the population who are most vulnerable.

A final point of discussion is in regard to economies of scale and the technical capacity of water systems. Small water systems often suffer from a lack of economies of scale. Even if a small rural system has good water quality, the lack of a strong revenue base at reasonable water rates makes it virtually impossible for the system to put funds aside to have an ongoing infrastructure maintenance and replacement program. For example, many rural utilities do not have funds to address future infrastructure replacements or emergencies and as result these systems have less reliable "water services." If these systems did have these accounts built into their rates, the rates would be even higher than they are currently, and more systems would have unaffordable rates. What's more, if more systems face the high costs of treating contaminated water (Moore et al. 2011), rates would further increase, likely impacting affordability even more.

Limitations and Assumptions

Several limitations must be acknowledged as part of this analysis. First, our results are likely an underestimate of unaffordability as we report on drinking water costs alone, rather than including wastewater costs; in essence we may underestimate the full cost of water services. Second, our demographic estimates may have resulted in an underestimate of the impact. In many communities, especially rural areas, the median household income of the Census Block group does not reflect the more poverty-stricken income levels of rural, unincorporated areas. It is likely that the incomes in these areas are much lower than those at the Block group level, thus resulting in a lower count of impacted systems. Given the potential for overestimating median household income, this would mask unaffordability in a smaller system within a Block group. That said, an informal comparison of Block- group-derived MHI estimates to on-the-ground classification of income levels in communities yielded very similar results as compared with those reported above.[10] Third, our population weighting techniques assume spatial homogeneity within each Block group. Fourth, were we to use a different affordability threshold level (i.e. 1.5% or 2.5%), the count of unaffordable systems would vary. Fifth, we assumed all systems in the TLB incurred replacement water costs, and used an average monthly replacement cost based on a fairly small household survey in Tulare County. While current evidence suggests this to be likely, more fine-tuned estimation of replacement water costs would need to be assessed on a community-by-community basis.

Finally, we also must note that the comparison between the urban and rural case are not meant to be strict comparison of "apples-to-apples," but rather serve to highlight patterns in two different types of areas. The fact that we focused only on small systems in the TLB means we cannot compare results directly to the urban area. Instead, the inclusion of the two case regions serves to highlight how affordability can vary within a region, and at different scales.

On the other hand, a few assumptions may have contributed to our results overestimating unaffordability. Throughout, we calculate total water bill based on average household water use (estimated at 1500 cubic feet) rather than non-discretionary water use (such as an estimate of indoor water use only). In reality, however, our results indicated unaffordable water bills where customers are billed based on a flat rate structure, which does not vary with the volume of water used and therefore the total bill is the same for all customers no matter if they only use water for human health and hygiene or if they have multiple discretionary water uses.

[10] For more information on this analysis, please consult with authors.

5 Conclusions

Water provision is a rising cost industry as much of the water infrastructure in the U.S. is at, or beyond, its useful life (EPA 2009). Infrastructure replacement costs will significantly contribute to the unaffordability unless these costs are significantly paid for by external funds. In addition, some water systems, such as many in the Tulare Lake Basin, are facing challenges as legacy nitrate pollution or other contaminants (e.g. arsenic, DBCP) continue to contaminate water supplies (Moore et al. 2011). As water quality worsens, water treatment costs will increase, and systems may be forced to increase their water rates. Unfortunately, this will likely lead to scenarios of increasing water bills in an area already plagued with high levels of unaffordability. Indeed, more and more water systems may find themselves in a difficult financial situation, torn between the need to upgrade or increase treatment to ensure safe drinking water while also keeping water bills low enough for customers to have access to affordable water.

Rural areas of California like the TLB represent a major challenge to ensuring the state's commitment to a human right to water. At a minimum, more specific discussion of developing affordability programs, whether within or across systems, will be important. This is in line with AB 2334's mandate that directs the Department of Water Resources to:

> (Section 2:d) Propose appropriate subsidization programs to make water affordable for high-cost communities. High-cost communities shall include the following:
>
> (1) Water systems serving disadvantaged communities, defined as communities with a median household income at or below 80 percent of the state median household income, where water rates are more than 2 percent of the median household income.
>
> (2) Water systems serving communities with a median household income no higher than 120 percent of the state median household income and where more than 10 percent of the population spends more than 2 percent of their income on water.
>
> (3) Other communities as determined to be appropriate by the department (Section 10004.8).

The evidence provided herein suggests that there may be many households, even within affluent communities, that exceed the affordability threshold and that it may be more important to consider household income rather than median income when assessing water affordability. In fact, there are already a number of well-established affordability programs based on household income data, including California

Alternate Rates for Energy (CARE); the Family Electric Rate Assistance Program (FERA); the Federal Low Income Home Energy Assistance Program (LIHEAP); the Low Income Energy Efficiency Program (LIEE); and the California LifeLine Program. In some cases, utilities or public welfare agencies may be able and willing to share this information with water service providers. In such cases, it can minimize administration costs to automatically enroll customers who are participating in programs with matching eligibility requirements. However, even if this information is not made available, a water service provider can allow customers to enroll themselves with proof of participation in a program with matching eligibility requirements.

Future work will need to address financing considerations for water systems, and their technical, managerial, and financial capacity. As part of this research effort, we will be analyzing the relationship between a system's technical, managerial, and financial capacity and their water rates to provide more information on which types of systems face particular affordability challenges. We see a need for additional research that will examine affordability across the state using different measures and scales in order to develop a "best practice" approach.

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Appendix

Table A1 Residential Water Use Estimates from the 20x2020 Water Conservation Plan

Hydrologic Region	Residential Water Use (GPCD in 2005)*	Average Household Size (# of people)**	Monthly Use (gal)	Monthly Use (cf)
Sacramento River	174	2.6	13,391	1,790
Tulare Lake	180	3.1	16,517	2,208

Notes:
*Estimated in DWR et al. 2010, pg. 13
**Calculated in DeOreo et al. 2010, pg. 253

Table A2 Socioeconomic and Water Quality Information for the Four Water Systems Surveyed in Tulare County (Moore et al. 2011)

Water System	Connections*	Population*	% Below / Near Poverty Level**	% Non-White**	In Violation of MCL Since***	Most Recent MCL Violation (nitrate concentration) ***
Beverly Grand Mutual Water Co.	28	108	45%	35%	2000	Apr. '10 (65 mg/L)
Lemon Cove Water Co.	50	250	24%	13%	1997	Aug. '10 (54 mg/L)
El Monte Village Mobile Home Park	49	100	40%	53%	2007	Sep. '10 (54 mg/L)
Soults Mutual Water Co.	36	100	57%	36%	1996	Mar. '10 (94 mg/L)

*Source: PICME Database **Source: U.S. Census 2000 ***Source: Tulare Co. Water Surveillance Program