

Measuring Household Affordability for Water and Sewer Utilities¹

- Working Paper -

Manuel P. Teodoro, PhD
Texas A&M University
mteodoro@tamu.edu

Revised September 2017

ABSTRACT

Rising costs and recent high-profile crises have brought renewed and increasing attention to the affordability of water and sewer service. Meaningful, accurate assessment of affordability is critical as utility leaders seek to serve low-income customers while simultaneously raising the revenue necessary to maintain and advance public health and conservation. Unfortunately, the predominant conventional method of measuring household affordability is fundamentally flawed and often misleading. This article advances a more accurate and meaningful methodology for measuring the affordability of water and sewer service for low-income households. The proposed method accounts for essential household water needs, income disparities, and core non-water/sewer costs. After detailing the method, the new approach is used to measure water and sewer service affordability in the 25 largest U.S. cities. The article concludes with a discussion of the new method's limits and general guidelines for its use in policymaking and rate design.

¹ This paper is work in progress. Thanks to Jon Davis, Rick Giardina, Jason Mumm, anonymous reviewers from *Journal AWWA*, and several Twitter followers for useful discussion in the development of this paper. Errors remain the responsibility of the author. Comments and criticisms are welcome.

EXECUTIVE SUMMARY

Rising costs and recent high-profile crises in Flint and Detroit, Michigan have brought renewed and increasing attention to the affordability of water and sewer service. Accurate assessment of affordability is critical as utility leaders seek to serve low-income customers while raising the revenue necessary to maintain and advance public health and conservation. Unfortunately, the predominant conventional method of measuring household affordability—combined average bill as a percentage of median household income (%MHI), with a value less than 4.0 or 4.5 designated as “affordable”—is fundamentally flawed and often misleading. Specifically, the %MHI method:

- Uses average water consumption as its basis for gauging affordability, rather than basic water consumption;
- Evaluates affordability based on a community’s median income, rather than on low-income households;
- Fails to account for essential non-water/sewer related costs, such as housing, food, health care, and home energy; and
- Applies an arbitrary affordability standard (typically 4.0%) that may not reflect community priorities.

A better method. A more meaningful and accurate methodology for measuring the affordability of water and sewer service at the household level is proposed here: the *Affordability Ratio* (AR) and *Hours’ Labor at Minimum Wage* (HM). Unlike the conventional approach, the proposed metrics account for basic household water needs (at 50 gallons per person per day) and essential non-utility costs:

$$\text{Affordability Ratio} = (\text{Cost of Basic Water} + \text{Sewer Service}) / (\text{Household Income} - \text{Essential Costs})$$

This AR effectively captures basic water and sewer costs as a share of disposable income. With a concern for low-income households, the proposed method also assesses affordability at the 20th-income percentile (AR₂₀), rather than at median income. Basic household water and sewer costs expressed in the number of hours worked at minimum wage (HM) is offered as useful complementary metric. Together these metrics offer a more defensible and practically useful way of assessing utility affordability for purposes of rate-setting and policy design.

Applications & limitations. The new metrics promise utility leaders, policy makers, and citizens more accurate information about the state of water and sewer affordability in their communities. Cross-utility comparison of AR₂₀ and HM values is not recommended as a basis for policy for any specific utility. Rather, these metrics can help frame local discussions about affordability and serve as useful tools or reference points in rate-setting and the development of customer assistance programs. Instead of an arbitrary affordability standard, AR₂₀ less than 10% and HM less than 8.0 are offered as “rules of thumb” to facilitate policy development.

A Big-City Snapshot. The new metrics are used to create an affordability profile for the largest 25 U.S. cities in the Spring of 2017. Household income at the 20th percentile and essential

expenditures for each city were estimated using data on community demographics and consumer expenditures. These estimates and minimum wage data were combined with water and sewer rates in place during the first half of 2017 to evaluate affordability for a hypothetical four-person household at the 20th income percentile and/or earning minimum wage.

The resulting AR₂₀ values average 11.4% across the top-25 cities, ranging from a low of 4.8% in Phoenix to a high of 26.9% in San Francisco. In terms of labor, basic monthly water and sewer service in the top-25 cities average 9.0 HM, from a low of 4.0 (Phoenix) to a high of 13.6 (San Francisco). Not surprisingly, these results indicate substantial variation across large U.S. cities, and suggest that affordability challenges in some places are driven by rate structures, while in other places underlying economic conditions may play a greater role.

Affordability in Largest 25 U.S. Cities in 2017

Pop Rank	City	Monthly Basic Service Cost	Affordability Ratio, 4-Person Household			Minimum Wage	Hours at Min. Wage (HM)
			20th Percentile Annual income	Est. Disposable Monthly Income	AR ₂₀		
1	New York, NY	\$ 81.78	\$ 18,085	\$ 579	14.1%	\$ 12.00	6.8
2	Los Angeles, CA	73.11	19,063	888	8.2%	10.50	7.0
3	Chicago, IL	47.27	17,386	576	8.2%	10.50	4.5
4	Houston, TX	74.87	19,109	642	11.7%	7.25	10.3
5	Phoenix, AZ	39.68	21,401	825	4.8%	10.00	4.0
6	Philadelphia, PA	58.54	13,546	524	11.2%	7.25	8.1
7	San Antonio, TX	55.16	19,517	933	5.9%	7.25	7.6
8	San Diego, CA	108.71	26,381	636	17.1%	11.50	9.5
9	Dallas, TX	59.82	18,585	685	8.7%	7.25	8.3
10	San Jose, CA	104.47	33,342	1,188	8.8%	10.50	9.9
11	Austin, TX	91.20	24,438	1,105	8.3%	7.25	12.6
12	Jacksonville, FL	68.23	19,817	873	7.8%	8.05	8.5
13	San Francisco, CA	176.85	24,946	658	26.9%	13.00	13.6
14	Columbus, OH	106.36	18,784	840	12.7%	8.15	13.1
15	Indianapolis, IN	97.60	17,395	724	13.5%	7.25	13.5
16	Fort Worth, TX	66.67	21,817	831	8.0%	7.25	9.2
17	Charlotte, NC	68.84	23,135	1,044	6.6%	7.25	9.5
18	Seattle, WA	180.70	27,290	961	18.8%	15.00	12.0
19	Denver, CO	64.91	21,698	884	7.3%	9.30	7.0
20	El Paso, TX	54.45	17,879	787	6.9%	7.25	7.5
21	Washington, DC	112.51	22,526	785	14.3%	11.50	9.8
22	Boston, MA	99.51	14,913	618	16.5%	11.00	9.0
23	Detroit, MI	92.68	9,436	379	24.4%	8.90	10.4
24	Nashville, TN	65.95	21,153	926	7.1%	7.25	9.1
25	Memphis, TN	39.53	14,913	618	6.4%	7.25	5.5
25-city Avg		\$ 83.58	\$ 20,262	\$ 780	11.4%	9.19	9.0

**Does not include low-income assistance programs.*

INTRODUCTION

This article advances a new methodology for measuring the affordability of water and sewer service for low-income households. Rising costs and recent high-profile crises have brought renewed and increasing attention to the affordability of water and sewer service for utilities that rely upon rate revenue to meet operating and capital needs. Consequently, communities across the United States and elsewhere are under increasing pressure to ensure that the most economically vulnerable can afford to pay for these essential services in an era of rising costs. Meaningful, accurate assessment of affordability is more critical than ever, as utility leaders seek to serve low-income customers while simultaneously raising the revenue necessary to maintain and advance public health and conservation (LaFrance 2017).

As with any organizational goal, getting affordability right requires measuring affordability accurately; unfortunately, the predominant method of measuring household water and sewer affordability is fundamentally flawed. The conventional approach measures affordability as a community's average cost of water and sewer service as a percentage of that community's Median Household Income (%MHI), with values less than 2.0 or 2.5 percent—4.0 or 4.5 percent combined—deemed “affordable” (Mack and Wrasse 2017). Originally intended as a means of gauging a community's overall financial capability for purposes of negotiating regulatory compliance, this standard has been widely misapplied to household affordability. As a result, evaluations of household water and sewer utility affordability are inaccurate at best, and misleading at worst.

This article advances a more meaningful and accurate methodology for measuring the affordability of water and sewer service at the household level. Unlike the conventional

approach, the proposed *Affordability Ratio* (AR) accounts for essential household water needs and core non-water/sewer costs. Further, since the main concern for affordability in the United States and other developed countries is for low-income households, the proposed method assesses affordability at the 20th-income percentile (AR₂₀), rather than at median income. Basic household water and sewer costs expressed in terms of hours' labor at minimum wage (HM) is offered as useful complementary affordability measure. Together these two metrics offer a more defensible and practically useful way of assessing utility affordability for purposes of budgeting, planning, rate-setting, and policy design.²

This article begins by summarizing the current conventional %MHI approach to measuring affordability and the ways in which it fails. The proposed new and improved methodology is then presented, along with a discussion of its advantages over the conventional approach. As an illustration, the new method is used to measure water and sewer affordability in the 25 largest U.S. cities. The article concludes with a discussion of the new method's applicability, limitations, and general guidelines for use in budgeting and rate design.

THE CONVENTIONAL APPROACH AND WHY IT'S WRONG

As noted earlier, the most widely applied method of measuring water and sewer affordability in the United States is to calculate the average residential water and sewer bill for a given utility as a percentage of the community's median household income. Usually this percentage is calculated for an entire utility, but sometimes it is calculated for a subset of customers, such as a neighborhood or a census tract. Typically, this percentage is compared

² Significant portions of this article draw on Davis and Teodoro (2014), which first introduced the Affordability Ratio methodology.

with a set affordability standard, most often 2.0 percent, or more recently 2.5 percent. A simple binary declaration follows this standard: if a utility's average bill as %MHI is less than this standard, then it is deemed "affordable;" if it is greater, then it is "unaffordable." Sometimes these %MHI standards are applied separately to water and sewer rates, other times they are combined water-plus-sewer costs. Often employed but rarely considered carefully, the 2.0 or 2.5%MHI (4.0 or 4.5%MHI combined) standard has become the default basis for analyzing water and sewer affordability in recent published research (see e.g., Janzen et al. 2016; Mack and Wrase 2017), with no other rationale than that it is convenient and conventional.³ Utility rate analysts typically follow suit; the University of North Carolina Environmental Finance Center's "Water and Wastewater Rates Dashboard" employs the %MHI method to guide rate design, for example.⁴

Despite its widespread use, the %MHI approach is seriously flawed. The main trouble with using %MHI as a measure of affordability is that *it does not measure affordability*—at least not at the household level, in the way that most interested observers typically think of affordability. The %MHI method and accompanying 2.0 percent standard as developed by the EPA were intended as a gauge of a community's *financial capability* for purposes of negotiating regulatory compliance by its utilities. The idea of %MHI as a measure of financial capability can be traced at least to the EPA's 1984 *Financial Capability Guidebook* (EPA 1984). The idea of identifying specific %MHI thresholds for determining financial capability appears to emerge

³ Janzen et al. (2016) discuss the analytical shortcomings of the 2.0 %MHI at length, but opt to use it anyway because of its wide application and convenience: "it was one of the few pieces of data that is commonly available for all systems" (E293).

⁴ <https://efc.sog.unc.edu/reslib/item/north-carolina-water-and-wastewater-rates-dashboard>

from the agency's 1995 guidelines on Water Quality Standards (EPA 1995) and Combined Sewer Overflow compliance schedule (EPA 1997). For purposes of assessing financial capability, %MHI values for water and sewer would be calculated separately, with the sum of the two held up against the standard. For example, a 2.0%MHI standard for water and 2.0%MHI standard for sewer implies a 4.0%MHI combined standard. None of these EPA documents offers a theoretical rationale for the 1.0, 2.0, or 2.5%MHI standards.

It is not clear when or how analysts began to conflate these utility-level financial capability metrics with household-level affordability, but as noted earlier, %MHI is now widely used as a household affordability metric. Unfortunately, as a method of measuring household affordability, the %MHI method is fundamentally flawed in at least four ways.

Average vs. essential water use. Using average residential demand as a basis for affordability analysis inflates the cost of water and sewer service for purposes of affordability analysis. In nearly all utilities of significant size in the United States, average residential water consumption is considerably higher than its median—that is, relatively conservative customers greatly outnumber high-volume customers. Consequently, in most utilities a minority of high-volume customers drive up the average demand that the conventional method uses as the basis for affordability analysis. Further, most American water utilities exhibit significantly greater demand during summers due to residential outdoor irrigation, indicating that much of the “average” water bill is for usage that is not serving basic health needs. Public policy discussions of water and sewer affordability seldom are concerned with the cost of maintaining large lawns, swimming pools, or other discretionary outdoor use. Rather, affordability is typically thought of as the ability of customers to pay for water and sewer services that are adequate to meet their

basic needs for drinking, cooking, health, and sanitation. For most American utilities, then, evaluating affordability as a function of average consumption implies an unduly high demand.

Median vs. low income. Perhaps the most frequent criticism of the %MHI standard is that its focus on median income misses the real subject of affordability concerns: poor households (Rubin 2001; Baird 2010; Stratus Consulting 2013). The median-income household is unlikely to face serious water and sewer affordability problems in any but the smallest or most desperately poor communities. For low-income households, however, water and sewer services may force important economic tradeoffs. Measuring affordability as a function of an entire community's median household income obscures the impacts of rate setting on low-income customers, for whom utility leaders presumably have the greatest affordability concerns. Certainly the tenor of public policy debates surrounding utility affordability suggests that low-income residential customers are the focus of alarm. As income stratification in a community increases, the degree to which %MHI masks potential affordability problems increases.

Essential costs of living. Water and sewer services are vital, but are not the only vital goods and services that customers must purchase. Housing, food, health care, home energy, and other essential goods and services also affect water and sewer affordability to the extent that they constrain households' financial flexibility. These non-water/sewer costs vary widely across utilities. Water and sewer bills may be low as a percentage of income, but much higher as a percentage of disposable income if the costs of housing or health care are high, for example. In such cases, water and sewer bills that are nominally low or a small percentage of MHI may force serious sacrifices for low-income customers. The conventional approach to affordability measurement is insensitive to these differences in costs of living.

An arbitrary, binary standard. Whether the affordability standard is set at 1.0, 2.0, 2.5, or any other %MHI, the standard represents a value of water and sewer service that is rarely (if ever) rooted in any philosophical reasoning or as a result of a deliberative process. Instead, analysts simply cite precedent and invoke the standard. Whatever its origins, the 2.0 (or 2.5) %MHI affordability threshold has evolved into a “golden number” (Socolow 1976), now held up as a definitive measure of household-level affordability, apparently for no other reason than its familiarity and convenience.

The simple binary nature—either “affordable” or “unaffordable”—of the %MHI standard is also problematic. The affordability of anything is rarely a strictly yes/no phenomenon—in microeconomics, things are more or less affordable relative to the costs of other things. Although informal “rules of thumb” can be useful, the %MHI standard has become a crutch that causes simplistic and misleading analysis. For example, simplistic application of the %MHI standard to census tracts led one recent study to declare that “water rates are currently unaffordable for an estimated 11.9% of households” (Mack and Wrasse 2017, 13), with no attention to the validity of %MHI standard or the distribution of water consumption within the census tracts where water was declared “unaffordable.” By the same token, leaders of a utility that satisfies the %MHI threshold can use the standard as an excuse not to address affordability, even if many of its customers struggle to pay their bills.

A BETTER WAY

This article offers an improved methodology for measuring water and sewer utility affordability. The method proceeds from an understanding of affordability as the ability of individual customers to pay for water and sewer services to meet their basic needs, while

maintaining the ability to pay for other essential costs (Davis and Teodoro 2014).⁵ The method aims to retain the intuitive appeal of the conventional approach while remedying its shortcomings. Specifically, the proposed method: 1) measures household-level affordability (rather than the entire utility’s financial capability); 2) provides for basic water needs (rather than average consumption); 3) focuses on low-income households (not average or median customers); and 4) accounts for essential costs other than water and sewer. The proposed method is “double-barreled” in the sense that it involves two complementary metrics: the *Affordability Ratio* and basic costs expressed as *hours of labor at minimum wage*.

The Affordability Ratio (AR). Household-level affordability (sometimes called “micro-affordability”) can be measured as the percentage or ratio of basic water and sewer costs to disposable household income for low-income customers. This measure may be calculated for an individual customer, or aggregated statistically for any defined group of customers. For a given customer c , the Affordability Ratio (AR_c) is:

$$AR_c = \frac{p_c(W + S)}{I_c - E_c} \quad (1)$$

where I is household income, E is essential household expenses (other than water and sewer services), p is the number of persons in the household, and W and S are the per-capita cost of essential water and sewer services, respectively. The relevant timeframe for calculating AR depends on the billing cycle employed by the utility (e.g., monthly, bimonthly, or quarterly).

The numerator in eq. 1 is the price of basic service to customer c , which varies according

⁵ This definition is similar to what EPA’s National Drinking Water Advisory Council called “household relative affordability” (NDWAC 2003).

to the water volume considered necessary to maintain health, the utility's rates, and the number of people in the household. The denominator is c 's disposable income, which depends upon the customer's income and the cost of essential non-water/sewer household expenses. The definitions of basic water needs and essential household expenses may vary from one utility to another, depending on local values and conditions. The resulting AR_c reflects the economic tradeoffs that customer c faces due to the costs of basic water and sewer service.

AR can be calculated for any customer, group of customers, or hypothetical customer. An assessment of AR at the 20th income percentile (AR_{20}) provides a meaningful look at affordability for low-income customers. This focus on the 20th percentile household aligns the analysis of water and sewer affordability with mainstream assessments of welfare economics, which typically identify the 20th percentile as the lower boundary of the middle class. At this income level, "working poor" households have very limited financial resources, but may not qualify for many income assistance programs. Public assistance programs vary considerably across the United States and across the world, and the absolute income level at the 20th percentile may qualify for significant assistance in some places. Still, the 20th percentile standard is a useful benchmark level for assessing the economic conditions of lower-middle class and working poor households. Analysts might choose to focus on a different income percentile when assessing affordability, depending on the economic conditions or distribution of incomes in a particular community.

The ease and precision with which the AR can be calculated depends on the availability of household-level customer data. Calculating the numerator is straightforward, requiring only information about the utility's rates (or proposed rate). Ideally, the AR's denominator would be

calculated using a comprehensive household-level consumer survey of the utility's customer base. Since such data are unlikely to be readily available, in most cases analysis will depend on estimates of household income and expenditures. Those estimates can draw from a variety of sources; the analysis presented in this article uses regression-based estimates, but a simpler approach could be to use more readily-available data on local housing, food, medical, home energy, and tax costs for a given community.

Basic Service Costs as *Hours at Minimum Wage* (HM). A complementary way to measure affordability is to calculate the number of hours of labor at minimum wage that would be necessary to pay for basic water and sewer service. As with the AR, the *HM* may be calculated for an individual customer, or aggregated statistically for any defined group of customers. For a given customer c , basic service costs as Hours at Minimum Wage (HM_c) is:

$$HM_c = \frac{p_c(W + S)}{A} \quad (2)$$

where p is the number of persons in the household, W and S are, respectively, the per-capita cost of essential water and sewer services, and A is the minimum wage in the c 's labor market. *HM* represents in very meaningful terms the cost of basic water and sewer service for low-income households, many of which labor at or near the minimum wage. *HM* is not sensitive to other essential costs the way that the AR is, but it is intuitively appealing because minimum wage is a familiar economic touchstone.

Analytical assumptions. The AR and *HM* are generally applicable metrics that are flexible enough to accommodate the specific conditions that apply in any given utility. In particular, the definitions of *basic service* and (non-water/sewer) *essential expenses* may vary

depending on local community values, and the analyst should adjust assumptions as necessary. *Basic service* is a moving target, as consumption patterns vary considerably across utilities and are broadly trending downward in the United States (Rockaway, et al. 2011). For purposes of this analysis and as a guideline for affordability analysis in the United States, basic service is defined as 50 gallons per person per day (gpcd). This 50 gpcd standard is a typical assumed minimal residential wastewater flow for purposes of sewer system design (Bowne, Naret and Otis 1994), and is meant to reflect indoor, non-discretionary water use to maintain health in a contemporary American home. In a similar vein, 2004 the Texas Water Development Board recommended 50 gpcd as its standard for indoor water use in crafting a water conservation implementation plan. Significantly less than average consumption of 91 gpcd (DeOreo, et al. 2016) but greater than the 35.6 gpcd standard that Chenoweth (2008) identifies as the “minimum water requirement for social and economic development,” the 50 gpcd assumption represents a reasonable, conservative level of basic service for purposes of evaluating affordability across large numbers of utilities. Values of AR can be calculated for any household size, but four-person household is assumed for purposes of this analysis.⁶

Essential household expenses in the present analysis include the costs of taxes, housing, food, medicine, health care, and home energy. These categories are considered essential because they are either inevitable (taxes) or at least as important as water for maintaining health. As noted earlier, any of these elements may be adjusted to reflect local conditions and values. For example, if the analyst believes that 50 gpcd is too high or too low a standard for basic service,

⁶ A four-person household is significantly greater than the average household size in the United States (2.64 persons according to the 2015 American Community Survey). As such, an assumed four-person household yields a conservative measure of affordability.

then the AR₂₀ formula can be adjusted accordingly. Similarly, essentially household costs may be expanded to include other expenses (e.g., child care, transportation, or telephone service) as appropriate according to local preferences and conditions. In particular, the definition and measurement of essential costs should be based on the needs of low-income households locally. Local organizations that provide assistance to low-income households can provide useful information about these costs.

AFFORDABILITY IN MAJOR U.S. CITIES

Water and sewer utility affordability in the 25 most populous U.S. cities are analyzed here with the new affordability measurement methodology as an empirical demonstration of the method and to provide a descriptive profile of affordability in the country's largest cities. Capital costs, operational expenses, rate structures, demographics, and economic conditions change frequently within and across utilities, and so the following information should be considered a "snapshot" of affordability in early 2017.

Data. To calculate basic service costs, water and sewer rates were gathered from utility websites during the Spring of 2017. Rate structures vary considerably across utilities in ways that affect the prices that individual customers pay. To maintain comparability and capture affordability, basic service costs were calculated assuming a single-family residential customer with a 5/8-inch meter connection, billed monthly.⁷ A four-person household and 50 gpcd were assumed. In cases where rates vary seasonally or across geographic zones, the highest seasonal and/or zone rates were assumed. Although it might be argued that these assumptions lead to

⁷ For utilities that bill bimonthly or quarterly, volumes and charges were converted to monthly to maintain comparability across utilities.

unduly high basic costs, they result in a conservative, “worst-case scenario” test of affordability.⁸ Because basic service is assumed to include only indoor use, the same volume is applied to both water and sewer charges. As noted earlier, this basic demand level can be adjusted for analysis of specific utilities; the four person household and 50 gpcd assumed here are for illustrative purposes.

In most cases, water and sewer services are provided by a single organization (e.g., a city government). In cases where different entities provide water and sewer services, costs were calculated using the rate structures from both organizations. Some of the utilities analyzed here calculate bills in thousand gallon (kgal) units, while others use hundred cubic foot (ccf) units; in each case, bills were calculated in the appropriate units for the utility being analyzed.

Many utilities (including several analyzed here) offer discount, subsidy, or other assistance programs aimed at improving affordability. Crucially, *the present analysis does not account for such assistance programs in assessing affordability* because the analytical goal is to measure affordability in absence of any policy intervention. In this sense, accurate affordability measurement helps gauge the need for assistance programs. As a practical matter, inclusion of assistance programs would complicate tremendously any attempt to measure affordability across large numbers of utilities because such programs vary widely in scope, structure, and implementation. When using AR₂₀ and HM to analyze rates in a specific utility, calculations can be made with and without assistance programs in order to understand their potential effects.

Income data—including the 20th percentile household income—were drawn from the

⁸ Utilities that use seasonal and/or zone rates might opt to calculate basic costs by averaging across time and/or space. However, the present analysis uses a “worst-month” scenario to calculate affordability because a low-income household are most likely to be stressed by single high bill than its average bill.

2015 American Community Survey's (ACS) five-year estimates. Essential non-water/sewer expenses were estimated based on the Bureau of Labor Statistics' 2015 Consumer Expenditure Survey (CEX). The CEX includes a probability-weighted national sample of 23,683 households that reported several categories of expenditures, as well as income and demographic information. Usefully for present purposes, both the ACS and CEX data include public assistance programs in determining net income. These data were used to develop regression models that estimate essential expenditures—that is, taxes, health care, food, housing, and home energy—for low-income households. The CEX includes intentional over-samples of several metropolitan areas. Where the CEX included more than 200 households from a given utility's service area, those data were used to calculate essential expenditures for that utility. For all other utilities, the full national sample was used to estimate essential expenditures.⁹ Coefficients from these models were combined with parameters for each individual city, and then essential expenditures were estimated at each city's 20th income percentile, assuming a four-person household and a single-family home. The legal minimum wages in each utility's political jurisdiction that was in effect on June 1, 2017 were used to calculate HM.

An example: Dallas, TX. Analysis of affordability in Dallas, Texas provides an illustration of how these affordability metrics are calculated. Table 1 shows the monthly basic water and sewer cost calculation for Dallas. Dallas bills water service using 1,000 gallon (kgal) units; at 50 gpcd, basic service for a four-person household is 6.2 kgal monthly. Water rates in

⁹ These regression models are reported in the appendix. CEX sampling is based on metropolitan areas, while the present affordability analysis is based on cities. This sampling unit mismatch limits the accuracy of the essential expenditure estimates used here, as expenses can vary considerably within metropolitan areas. However, metropolitan area subsamples are used when available because they are likely to be more representative for their respective cities than are the full national sample.

Dallas include a fixed monthly charge of \$5.25 for a 5/8" meter and increasing block volume charges of \$1.90/kgal for the first 4 kgal and \$4.25/kgal for volumes from 4-10 kgal.¹⁰ The city's sewer rates include a fixed monthly charge of \$4.70 and a uniform \$5.31/kgal winter average volume. These rates generate a basic cost of \$59.82 per month.

Table 1: Basic Monthly Water & Sewer Costs in Dallas, TX
Based on 2017 rates.

Monthly basic volume (kgal)	6.20
<u>Water charges</u>	
Fixed	\$5.25
Volume (4.0kgal at \$1.90/kgal, 2.2kgal at \$4.25/kgal)	16.95
<u>Sewer charges</u>	
Fixed	\$4.70
Volume (6.2kgal at \$5.31/kgal)	32.92
Total water & sewer charges	\$59.82

Table 2 combines this basic monthly cost with income, essential expenditure, and minimum wage information to illustrate the calculation of AR₂₀ and HM values for Dallas, where the 20th percentile household annual income is \$18,585 (\$1,549 monthly) and minimum wage is \$7.25 per hour. A four-person household in Dallas at that income level would have estimated essential expenses of \$883.60 per month, leaving \$665.15 as disposable income. The basic water and sewer cost of \$59.82 thus translates into an AR₂₀ of 8.74% and a HM of 8.25. In plain language, this result indicates that *basic water and sewer service costs a lower-middle class, four-person household in Dallas about nine percent of its disposable income, or about eight hours of labor*

¹⁰ Dallas water rates include additional blocks that apply for volumes beyond the basic demands analyzed here.

at minimum wage. Whether these figures represent “affordable” rates is a normative question that is addressed in the conclusion.

Table 2: Affordability Metrics for Dallas, TX
Based on 2017 rates.

(a) Monthly basic water & sewer cost	\$59.82
<u>Affordability Ratio (AR)</u>	
<u>Income</u>	
(b) 20 th Percentile Annual Income	\$18,585.00
(c) Monthly income (b ÷ 12)	1,548.75
(d) Estimated monthly essential expenses*	864.11
(e) Monthly disposable income (c-d)	684.64
AR₂₀ (a ÷ e)	8.74%
<u>Hours at Minimum Wage</u>	
<u>Wages</u>	
(f) Minimum wage per hour	\$7.25
HM (a ÷ f)	8.25

**Estimates based on regression analysis of 2015 Consumer Expenditure Survey. See appendix.*

A big city snapshot. The results of this affordability analysis for the top-25 U.S. cities are reported in Table 3, which is arranged by population. The average single-family residential bill at 6.2 kgal (8.3 ccf) across these cities is \$83.58 per month, although costs and rate structures vary considerably across these cities, from a low of \$39.68 (Phoenix, AZ) to a high of \$180.70 (Seattle, WA). Incomes also vary widely, with 20th percentile household incomes ranging from \$9,436 (Detroit, MI) to \$33,342 (San Jose, CA) annually. After accounting for essential non-water/sewer expenses, disposable income averages \$780 monthly. Hourly minimum wages vary from the federally-mandated \$7.25 to Seattle’s \$15.00.

Table 3: Affordability in Largest 25 U.S. Cities in 2017

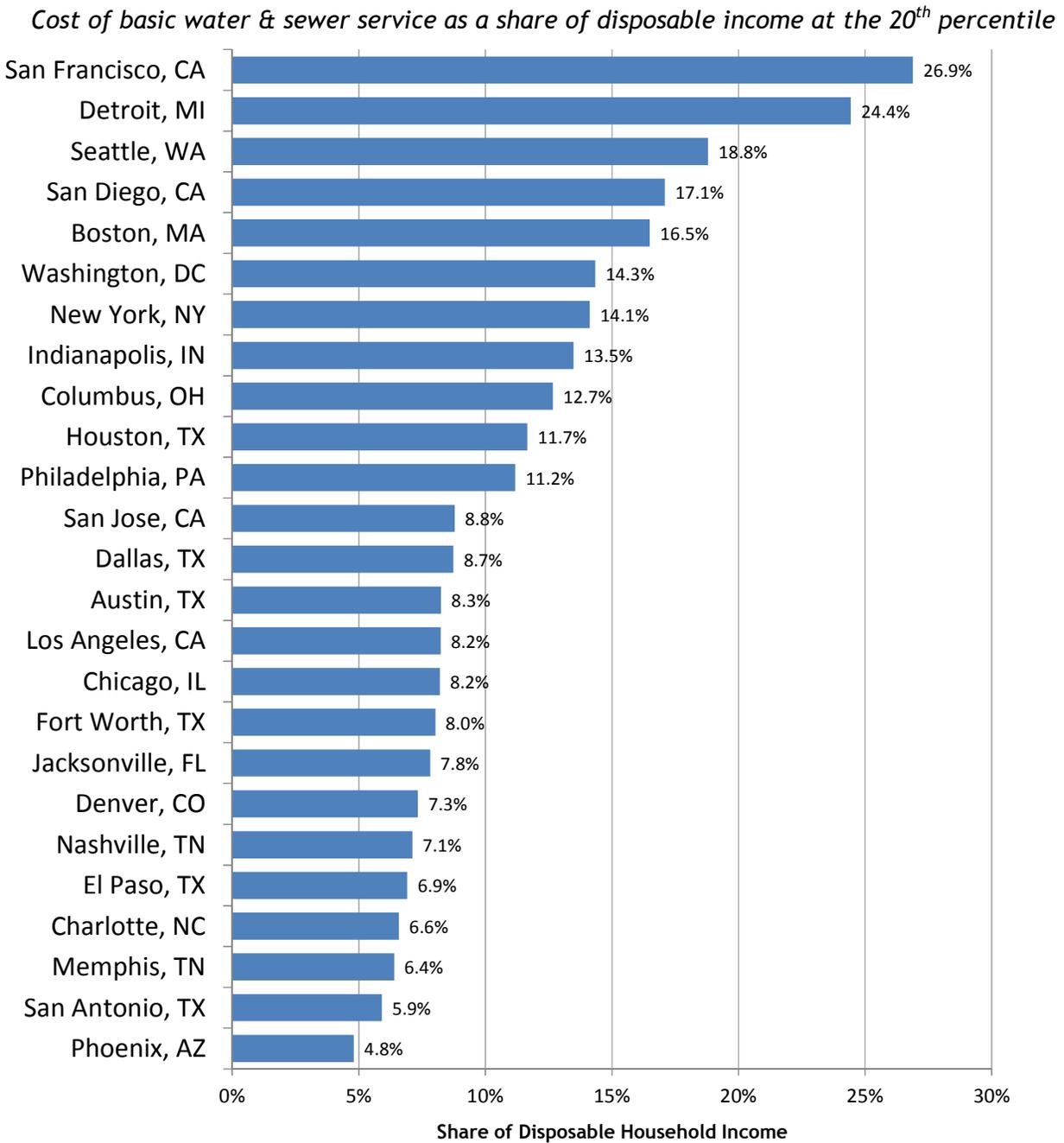
Pop Rank	City	Monthly Basic Service Cost	Affordability Ratio, 4-Person Household			Minimum Wage	Hours at Min. Wage (HM)
			20th Percentile Annual income	Est. Disposable Monthly Income	AR ₂₀		
1	New York, NY	\$ 81.78	\$ 18,085	\$ 579	14.1%	\$ 12.00	6.8
2	Los Angeles, CA	73.11	19,063	888	8.2%	10.50	7.0
3	Chicago, IL	47.27	17,386	576	8.2%	10.50	4.5
4	Houston, TX	74.87	19,109	642	11.7%	7.25	10.3
5	Phoenix, AZ	39.68	21,401	825	4.8%	10.00	4.0
6	Philadelphia, PA	58.54	13,546	524	11.2%	7.25	8.1
7	San Antonio, TX	55.16	19,517	933	5.9%	7.25	7.6
8	San Diego, CA	108.71	26,381	636	17.1%	11.50	9.5
9	Dallas, TX	59.82	18,585	685	8.7%	7.25	8.3
10	San Jose, CA	104.47	33,342	1,188	8.8%	10.50	9.9
11	Austin, TX	91.20	24,438	1,105	8.3%	7.25	12.6
12	Jacksonville, FL	68.23	19,817	873	7.8%	8.05	8.5
13	San Francisco, CA	176.85	24,946	658	26.9%	13.00	13.6
14	Columbus, OH	106.36	18,784	840	12.7%	8.15	13.1
15	Indianapolis, IN	97.60	17,395	724	13.5%	7.25	13.5
16	Fort Worth, TX	66.67	21,817	831	8.0%	7.25	9.2
17	Charlotte, NC	68.84	23,135	1,044	6.6%	7.25	9.5
18	Seattle, WA	180.70	27,290	961	18.8%	15.00	12.0
19	Denver, CO	64.91	21,698	884	7.3%	9.30	7.0
20	El Paso, TX	54.45	17,879	787	6.9%	7.25	7.5
21	Washington, DC	112.51	22,526	785	14.3%	11.50	9.8
22	Boston, MA	99.51	14,913	618	16.5%	11.00	9.0
23	Detroit, MI	92.68	9,436	379	24.4%	8.90	10.4
24	Nashville, TN	65.95	21,153	926	7.1%	7.25	9.1
25	Memphis, TN	39.53	14,913	618	6.4%	7.25	5.5
25-city Avg		\$ 83.58	\$ 20,262	\$ 780	11.4%	9.19	9.0

**Does not include low-income assistance programs.*

The resulting AR₂₀ values average 11.4%, ranging from a low of 4.8% in Phoenix to a high of 26.9% in San Francisco. In terms of labor, basic monthly water and sewer service in the top-25 cities average 9.2 HM, with Phoenix and San Francisco again at the ends of the distribution (4.0 and 13.6 HM, respectively). Figures 1 and 2 depict these AR₂₀ and HM results, with cities arranged from most to least affordable. These results should be considered with

some caution, as the assumptions underlying the AR₂₀ and HM calculations may not be appropriate for all 25 cities and, as noted earlier, they do not reflect low-income assistance programs that some utilities provide.

Figure 1: AR₂₀ for Largest 25 U.S. Cities in 2017



The results appear to follow from several factors. Although discussions of utility

affordability frequently focus on costs and revenue requirements, cursory review of these 25 cities suggests that rate structures — particularly the level of fixed charges and rates paid for the first few units of water — also significantly affect affordability for low-income households. Put another way, from a low-income affordability perspective, *how* a utility collects rate revenue can be as important as *how much* total revenue it collects. The method applied here reveals the less obvious but critical ways that income distributions and essential non-water/sewer expenses affect affordability — variation that is not reflected in the conventional %MHI metric.

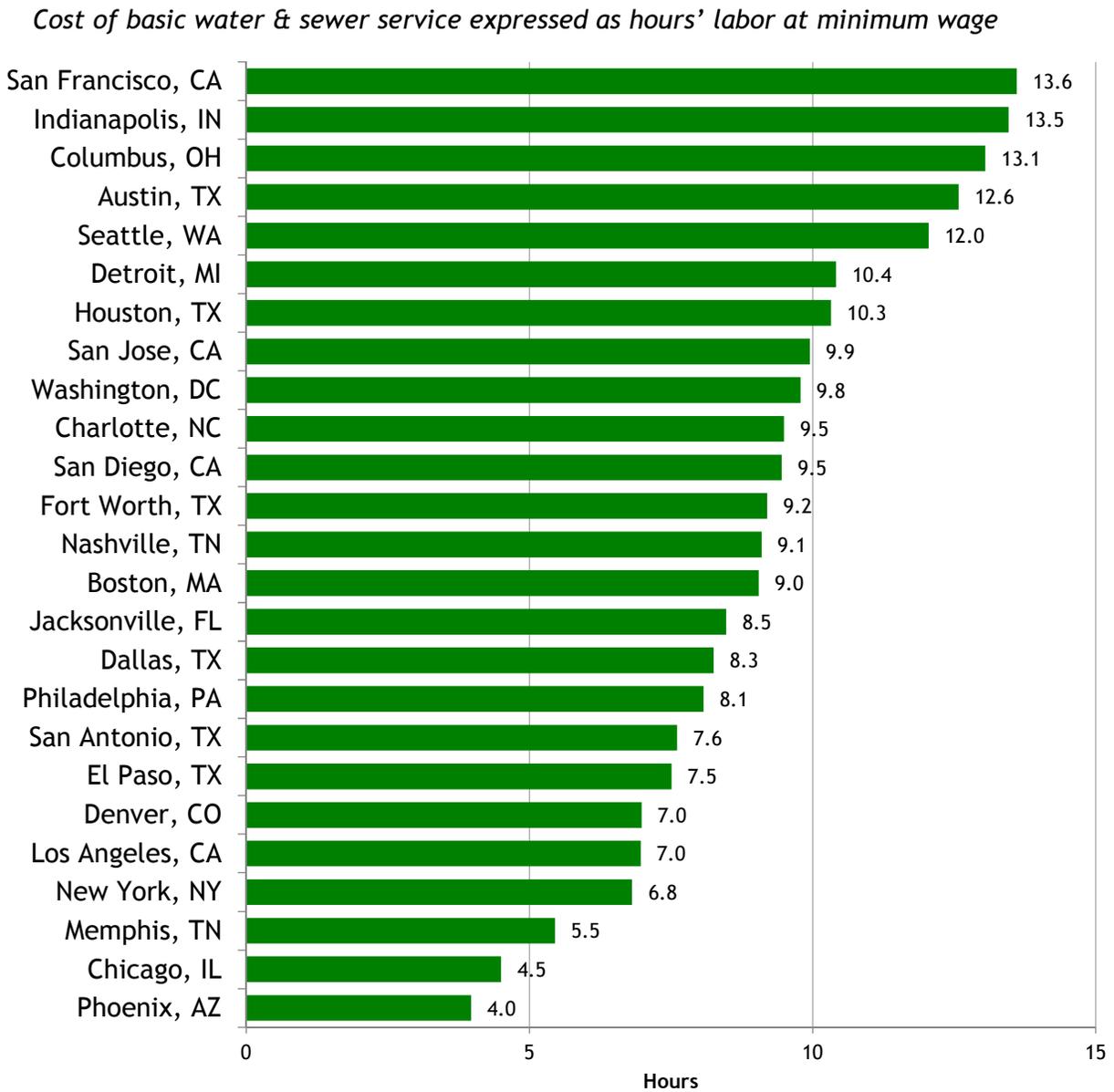
The significance of these metrics becomes clearer when compared with the conventional %MHI approach to measuring affordability. Consider Dallas (AR₂₀=8.7, HM=8.3) and Boston (AR₂₀=16.5, HM=9.0), for example. Average single-family residential water consumption in Dallas is 8.3 kgal, with billed sewer volume at 5.5 kgal, resulting in an average bill of \$65.04.¹¹ With a median annual income of \$43,781, the conventional metric puts Dallas' water rates at 1.8%MHI — well below typical affordability thresholds. Boston's average combined monthly average water and sewer bill \$87.83 and its median income is \$62,775, making its average water and sewer cost just 1.7%MHI.¹² Naïve application of the conventional standard to Dallas and Boston would lead to the conclusion that these two cities' water and sewer rates are affordable according to "EPA standards," and that they are roughly comparable in terms of affordability. The AR₂₀ and HM metrics indicate that the real economic burden of these services is markedly greater for low-income households in Boston than in Dallas.¹³

¹¹ http://dallascityhall.com/government/Council%20Meeting%20Documents/bfa_3_dallas-water-utilities-water-and-wastewater-retail-cost-of-service-rate-study_combined_120516.pdf

¹² <http://www.bwsc.org/SERVICES/Rates/rates.asp>

¹³ Data necessary for calculation of average sewer bills were not available for all 25 cities.

Figure 2: HM for Largest 25 U.S. Cities in 2017



DISCUSSION

Improved affordability metrics and a snapshot of affordability in major U.S. cities established, discussion now turns to their limitations, implications, and applications.

Limitations. Although AR₂₀ and HM offer major improvements over the conventional method of assessing affordability, they are not perfect. A clear drawback of the AR₂₀ is the

relative complexity of estimating it with the data typically available to analysts. While AR₂₀ is intuitive, estimating disposable household income in a given community requires a level of effort and/or technical sophistication beyond what is required of the conventional method. For all of its drawbacks, %MHI enjoys the virtue of back-of-the-envelope simplicity (even if that simplicity is misguided and misleading). Complexity is not an insurmountable barrier to use of these metrics for any specific utility, however. Regression analysis of CEX data is not necessary for AR₂₀ calculations in a single utility, and for most, income distribution and reasonably accurate essential household estimates are possible with locally available data.

Two additional limitations are more serious for purposes of advancing the cause of affordability, and should be kept in mind when using AR₂₀ and HM. First, the metrics advanced here focus on single-family residential customers. Theoretically, the same metrics could be applied to any class of customer, but measuring affordability for households in multi-family or rental housing is difficult or impossible if those households do not pay their own water and sewer bills. Assessing and addressing affordability for these “hard to reach” customers is a perennial, vexing challenge for utilities (Raucher, et al. 2017); unfortunately, the metrics advanced here offer little leverage on that challenge.

Second and more fundamentally, AR₂₀ and HM *measure* affordability; they do not *define* it. The metrics advanced here can significantly clarify the scope of the water and sewer affordability issues that utilities face, but they cannot in themselves define affordability.

So what’s affordable? Water and sewer affordability is a matter of community priorities. When confronting affordability questions, utility leaders and policymakers are really asking: how much is it reasonable to expect households of limited means to pay for these

essential services? What economic sacrifices are reasonable to expect low-income households to make in order to pay water and sewer bills?

These are fundamentally normative questions. No metric, however well-conceived and executed, can in itself define what is “affordable;” there is no scientific answer to a philosophical question. Just as incomes and essential expenditures vary from one community to another, so can social and political values—what one community considers affordable may not be considered affordable elsewhere. In a democratic society, these are matters for public deliberation and decision-making.

As noted earlier, one of the main weaknesses of conventional affordability analysis is that it declares utility rates “unaffordable” or “affordable” because they fall above or below a combined 4.0 or 4.5%MHI threshold—golden numbers with no underlying rationale. In the public policy arena, these arbitrary standards tend to preclude or pre-empt meaningful discussion over the meaning of affordability in a community. Better measurement of affordability can facilitate clearer thinking and more meaningful discussion of affordability. The metrics introduced here can help frame such thinking and discussion.

Beware of cross-utility comparisons. The affordability snapshot of the 25 utilities developed here is interesting in its own right, since it depicts the general state of affordability in large U.S. cities. However, this snapshot is not especially useful for setting affordability policy in any given utility. There is a common (perhaps innate?) human tendency to think about performance in comparison with others, and so it is tempting to think about a utility’s affordability relative to others when developing policy. This kind of comparison distracts from the core issue of affordability. As a metaphor, consider water treatment: no responsible engineer

would recommend a treatment technology for Boston based on measurements of average source water quality in the other top-25 cities; for purposes of designing treatment processes, the only relevant measurement is of Boston's source water. Developing affordability policy according to other utilities' affordability metrics is like designing a treatment plant for other communities' average source water. Utility rates and affordability programs ought to reflect their own communities' needs and values, not the metrics observed elsewhere.

For these reasons, utility leaders and policymakers should resist the temptation to make decisions about affordability in their own communities based on affordability conditions nationally or in neighboring communities. The relevant question is not: *how affordable are our water and sewer rates compared with other communities' rates?* Rather, the critical question is: *are our water and sewer rates consistent with the value that our community places on affordability?*

Rules of thumb. Bearing in mind the dangers of "golden numbers" and cross-utility comparison, some simple rules of thumb for evaluating water and sewer affordability are suggested here. They are offered in response to repeated queries from professionals and policymakers who are grappling with affordability in their utilities. These guidelines are not rooted in any theory of welfare economics, law, or philosophy; they simply reflect the author's intuitive answer to the question: *what trade-offs should low-income households be expected to make in order to pay for basic water and sewer service?* A double-barreled standard is suggested:

1. *An AR₂₀ value of no more than ten percent*, so that a four-person household at the 20th income percentile pays no more than ten percent of its disposable income on water and sewer service; and
2. *An HM value of no more than 8.0*, so that a four-person household's basic monthly water and sewer bill requires no more than eight hours of labor at minimum wage.

These two rules of thumb have some visceral appeal (“ten percent, one day”), but the intuition behind them is that water and sewer are essential services, and so it is reasonable to ask low-income customers to pay up to ten percent of disposable income and/or work up to one full day at minimum wage to pay for them. Beyond these levels, water and sewer costs may begin to constrain severely the welfare and economic opportunities of low-income households.

Reasonable people can disagree about the merits of these rules of thumb; the author makes no claim that they are objective, revealed truths.¹⁴

Analysts, utility leaders, policymakers, and interested observers are urged to use these rules of thumb not as new golden numbers to supplant the conventional %MHI standard, but as starting points for discussion and development of affordability policies for their own utilities. These rules can help frame efforts to define affordability locally. Mumm and Ciaccia’s (2017) pairwise comparison approach offers promising means of inferring community values about affordability, for example.

Based on the present analysis, fourteen of the 25 largest U.S. cities meet the first rule of thumb; only eight satisfy the second. Do these findings indicate that the cities that fail to meet these standards utilities have an affordability problem? Not necessarily. Several utilities fall just above or below the 10 percent / 8 hour thresholds, and so it would be simplistic to declare them “affordable” or “unaffordable” based on rules of thumb. In some cases—most conspicuously, Detroit—high AR₂₀ figures are driven more by very low 20th percentile incomes than by utility rates, and so may not reflect the range of public assistance programs that are available to

¹⁴ The conventional 4.0 or 4.5%MHI standards have no theoretical or scientific basis, either.

extremely low-income households. In other cases, 50 gpcd indoor water use may be an unrealistically high level of water use. Many of these utilities employ assistance programs to help address affordability concerns in ways that are not captured in AR₂₀ or HM. Moreover, utility rates that exceed the rules of thumb may nevertheless be consistent with their communities' understandings of affordability. On the other hand, it is possible that some of these utilities have serious affordability challenges that are underappreciated because they satisfy a %MHI convention. The best solutions for any affordability problems identified with these metrics will vary from one utility to another.

Implications for practice. Better measurement can facilitate better decisions. Utility leaders, policymakers, and regulators should abandon %MHI as a measure of household water and sewer affordability. Instead, better metrics like AR₂₀ and HM should be employed when setting rates or developing affordability programs because these metrics capture the kinds of welfare tradeoffs that utility rates force low-income households to make. When considering alternative rate structures, budgets, and affordability programs, policymakers should tailor the AR₂₀ and HM metrics to reflect local conditions, compare the AR₂₀ and HM that would result under various alternatives, and then set policies to align those results with their communities' priorities. Abandoning the flawed historical convention in favor of the metrics advanced here can greatly strengthen the way that the utility community thinks about and responds to affordability concerns.

References

- Baird, Gregory M. 2010. "Water Affordability: Who's Going to Pick Up the Check?" *Journal AWWA* 102(12): 16-23.
- Bowne, William C., Richard C. Naret, and Richard J. Otis. 1994. *Alternative Wastewater Collection Systems Manual*. Washington, DC: EPA Office of Wastewater Enforcement and Compliance.
- Chenoweth, Jonathan. 2008. "Minimum water requirement for social and economic development," *Desalination* 229: 245-256.
- Davis, Jon P. and Manuel P. Teodoro. 2014. "Financial Capability and Affordability," in *Water and Wastewater Finance and Pricing, Fourth Edition*, ed. by George Raftelis. New York: Taylor & Francis, 443-465.
- DeOreo, William, Peter Mayer, Benedykt Dziegielewski and Jack Kiefer. 2016. *Residential End Uses of Water, Version 2*. Denver, CO: Water Research Foundation.
- Environmental Protection Agency (EPA). 1997. "Combined Sewer Overflows—Guidance for Financial Capability Assessment and Schedule Development," EPA Office of Water (EPA 832-B-97-004).
- EPA. 1995. "Interim Economic Guidance for Water Quality Standards," EPA Office of Water (EPA 832-B-95-002).
- EPA. 1984. "Financial Capability Guidebook," EPA Office of Water (EPA 000-R-84-101).
- Janzen, Aaron, Gopal Achari, Mohammed H.I. Dore and Cooper H. Langford. 2016. "Cost Recovery and Affordability in Small Drinking Water Treatment Plants in Alberta, Canada," *Journal AWWA* 108(5): E290-298.
- LaFrance, David B. 2017. "Affordability Mega-steps," *Journal AWWA* 109(6): 10.
- Mack, Elizabeth A. and Sarah Wrase. 2017. "A Burgeoning Crisis? A Nationwide Assessment of the Geography of Water Affordability in the United States," *PLoS ONE* 12(1): e0169488.
- Mumm, Jason and Julius Ciaccia. 2017. "Improving the Narrative on Affordability and the Measurements We Need to Take Us There," *Journal AWWA* 109(5): 42-48.
- National Drinking Water Advisory Committee (NDWAC). 2003. "Recommendations of the National Drinking Water Advisory Council to the U.S. EPA on its National Small Systems Affordability Criteria," report to the EPA. https://www.epa.gov/sites/production/files/2015-11/documents/report_ndwac_affordabilitywg_final_08-08-03.pdf

- Raucher, Robert, Janet Clements, Lorine Giangola and Roger Colton. 2017. *Customer Assistance Programs for Multi-Family Residential and Other Hard to Reach Customers*. Project #4557. Denver, CO: Water Research Foundation.
- Rockaway, Thomas D., Paul A. Coomes, Joshua Rivard and Barry Kornstein. 2011. "Residential Water Use Trends in North America," *Journal AWWA* 103(2): 76-89.
- Rubin, Scott J. 2001. "Affordability of Water Service," white paper, National Rural Water Association.
- Stratus Consulting. 2013. "Affordability Assessment Tool for Federal Water Mandates," report to the United States Conference of Mayors, American Water Works Association, and Water Environment Federation.
- Socolow, Robert H. 1976. "Failures of Discourse," Failures of discourse. *Bulletin of the American Academy of Arts and Sciences*, 11-32.
- Texas Water Development Board. 2004. *Water Conservation Implementation Task Force Report to the 79th Legislature*. Austin, TX: Texas Water Development Board.