Boston University Institute for Sustainable Energy

Measuring and Addressing Water and Waste Water Affordability in the United States

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Introduction

The United States is suffering a crisis of affordability, especially among low-income and marginalized communities. Efforts and attention to address this crisis have been increasing. However, one portion of the affordability crisis has received disproportionately little effort and attention, and that is the cost of water and sanitation services. These costs have increased so rapidly in recent years and can soon notably threaten access to this essential service, in turn threatening public and individual health. Providing affordable water and wastewater services is key to sustainable water management. The evidence available suggests that water and wastewater costs will keep rising, but the current solutions for these affordability issues are insufficient, as are the metrics to measure the scope of these problems. The contribution of this report is a more comprehensive set of metrics to measure the scope of the affordability problem in the United States, an affordability assessment tool for decisionmakers, and recommendations for how different stakeholders can take action to address affordability using the insights from this new set of affordability metrics.

The Cost of Living Paradigm

The economy of the United States is often characterized by several key metrics: the growth of gross domestic product, unemployment, wages, and inflation. The vast majority of discussions about the economy focus on growth of the gross domestic product, or growth in the aggregate value of all goods and services exchanged. If the amount of goods and services increases by at least a certain percentage (2-3%) this year compared to last year, then the economy is doing well. If the amount of goods and services increases by a lower percentage or even decreases, then the economy might be slowing down or even in a recession. Such reductive discussions implicitly presume that in a good economy, most households are doing well. However, the rising costs of several key goods and services can trap households in economic fragility, even in times of strong economic growth. In a time of crisis, this fragility can rear its head, exposing not just struggling low-income households, but also widespread struggles even among people in middle-income households.

This is the current paradigm in the United States economy: a cost of living that rises so fast, that even growing wages do not cover the new costs. The result is a growing number of households living paycheck to paycheck, even with relatively comfortable incomes. In 2018, 27% of adults would need to borrow or sell something to pay for an unexpected $400 expense, and

12% of adults would not be able to cover such an expense at all. In fact, 17% of adults cannot pay all of the current month's bills[i]. Clearly, the United States is facing a crisis of affordability.

The most critical form of this rising affordability crisis is in housing, which is the single largest expense of most households. The cost of shelter has risen on average 4.61% every year for 50 years according to the Bureau of Labor Statistics Consumer Price Index[ii]. Meanwhile, the first, second, and third income quintiles had income growth far lower than the rise in shelter costs[iii]. The rising costs of shelter that outpace income growth of at least 60% of Americans mean fewer and fewer people can afford to own homes: in 2004, the homeownership rate peaked at 69.4%, and today it has declined to 64.8%[iv]. Although homelessness has been on the decline since 2007, 552,830 people were homeless for at least one night in 2018[v].

Affordability problems in housing are known to have wide-ranging negative impacts on other aspects of life. Housing affordability issues may cause overcrowding[vi], reduced spending and access to other goods[vii] [viii], longer commutes[ix], poor health outcomes[x] [xi], lower housing quality, lower educational attainment for children[xii] [xiii] [xiv] [xv], and worse long-term labor market outcomes for children[xvi].

Shelter isn't the only good or service that has outpaced income growth over the last 50 years. Medical care has risen an average of 5.64% every year, water and sewer costs have risen 5.9% every year, and college tuition has risen an average of 6.65% every year (Figure 1). Focusing on just the past 10 years shows shelter costs grew at a rate of 2.46% per year, medical care grew 2.87% per year, and college tuition grew at 3.62% per year. Water and sewer service costs grew at 4.83% per year, outpacing all other costs and growth of every income quintile over these last 10 years. The negative consequences of housing unaffordability on other aspects of life also apply to unaffordability of these other rapidly growing expense categories, including water and sewer.

Within this group of goods and services with rapidly rising costs, water and sewer stand out as surprising. Water and sewer costs are often overlooked in discussions of fast-rising costs of goods and services, yet it is the fastest-growing cost for households. Moreover, programs for housing, medical care, and college tuition affordability exist on the federal level. Even electricity costs, which have grown more slowly than income growth at only 3.96% on average over the last 50 years and 1.02% over the last 10 years, have a federal affordability program. Rapidly rising water and sewer costs, on the other hand, do not have a federal affordability program, nor do any states have an affordability program.

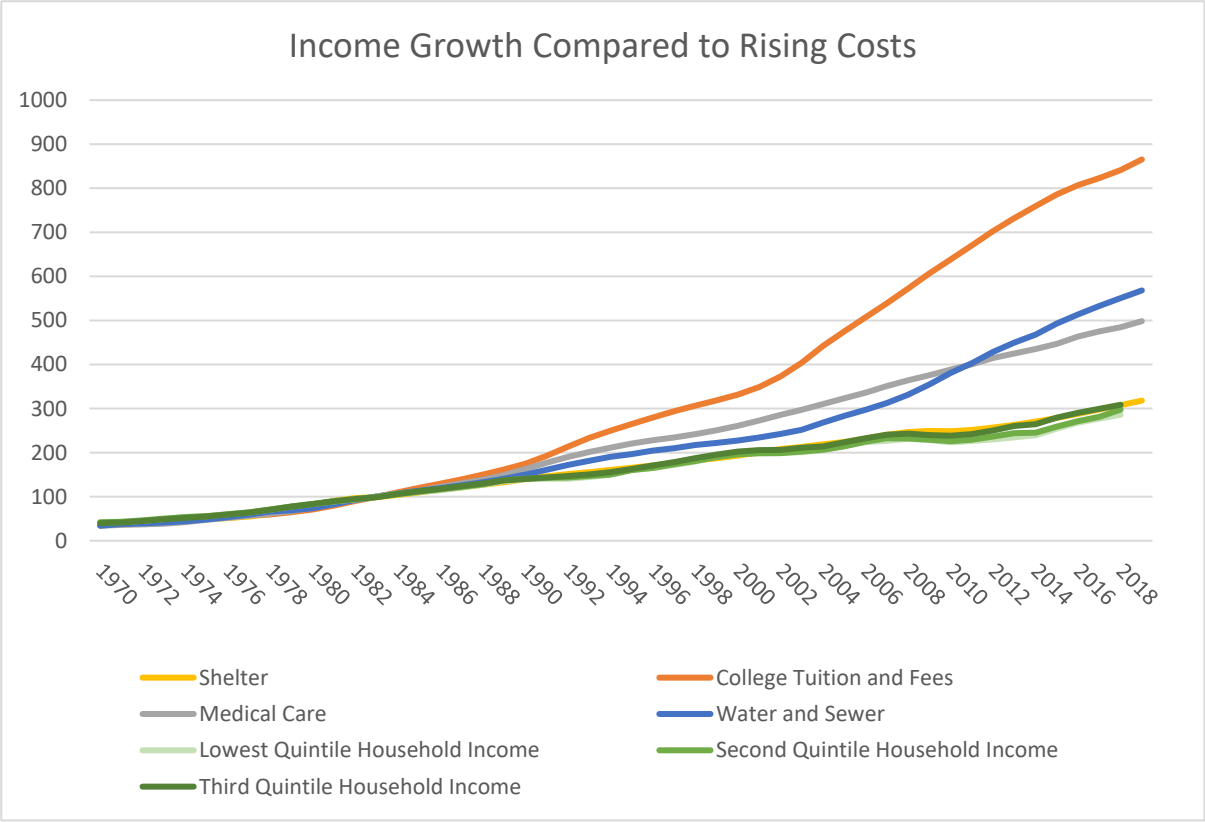

Figure 1: Comparison of Rising Costs and Income Growth

The lack of affordability programs and widespread water and sewer utility shutoffs are highlighted by the most recent crisis: the 2020 Coronavirus pandemic. This deadly pandemic has caused many states to order their citizens to stay at home and practice good hygiene: thorough washing of hands in particular. This crisis underscores the need for affordable housing and water and sewer services. In fact, many water and sewer utilities have moved to suspend utility shutoffs of water and sewer services. Some water and sewer utilities are even reconnecting previously shut off water and sewer connections to ensure that people can practice basic hygiene in their homes. Even the federal government has sprung into action, with some of the multi-trillion dollar stimulus and aid proposals including a $1.5 billion water affordability relief for low-income families administered through the Low-Income Home Energy Assistance Program (LIHEAP). No proposal with a federal relief program has been passed thus far. Yet it should not require a once-in-a-century public health crisis to force us to address access to a fundamental resource: affordable and clean water.

Causes of Rising Water and Sewer Costs

Potable water and wastewater services are essential to public health. Water services are essential for hydration, preparing food for sustenance, maintaining personal hygiene, and for many modern goods and services demanded from commercial and industrial entities. Water systems collect water from ground and surface water resources, remove pollutants and toxins, and distribute the water to where it is needed. Wastewater or sewage systems collect this used water and sewage, remove contamination, and return the water to lakes and rivers for use in the future. As the cost of these services rises, the infrastructure that provides them is aging and prone to failure. The American Society of Civil Engineers (ASCE) rate drinking water infrastructure at a D and wastewater infrastructure at a D+ [xvii] [xviii]. In a survey of water utility professionals, the American Waterworks Association (AWWA) found that for the last 5 years, "renewal and replacement of aging water and wastewater infrastructure" and "financing for capital improvements" were ranked the top two most important and urgent concerns out of 30 potential issues for water and wastewater utilities[xix].

The aging infrastructure of water and sewer is the primary driver of cost increases. The EPA estimates that water infrastructure needs $472.6 billion of investment over the 20 years from 2015-2035[xx]. This 20-year need has increased by 86% since 1995, even after accounting for inflation of construction costs. Two-thirds of the needs are in transmission and distribution of water through water mains, and the rest of the needs are primarily for treatment, storage, and new source water. The piped water main infrastructure in the US had a large boom of construction following World War II in the mid-20th century and through the 1970s after the Clean Water Act. The useful life of this infrastructure is estimated to be 75-100 years, meaning that water costs and needs will continue to rise as this aging infrastructure demands replacement. Meanwhile, water utilities only replace 0.5% of their water pipes every year, suggesting a total system replacement rate of 200 years or infrastructure used for more than double the estimated useful life. The result of this mismatch has already become evident: nearly 6 billion gallons or 14-18% of treated drinking water are lost each day due to leaking pipes from 240,000 water main breaks occurring every year (ASCE). Such failures in water infrastructure can cause service disruptions along with unsanitary conditions that could lead to public health issues, hinder emergency response, and cause damage to other infrastructure.

Sewer infrastructure also needs about $271 billion of investment according to the EPA[xxi]. 56 million new people will connect to centralized sewer systems that relied on private septic

systems previously, resulting in a 23% increase in demand by 2032[xxii]. These sewer systems require investment in water treatment, repair and expansion of conveyance systems, correction for combined sewer overflows (CSOs), expansion of stormwater management, and expansion of recycled water distribution. CSOs are especially pressing in the 772 communities with combined wastewater and stormwater drains which can overflow during heavy rain events. These CSOs release untreated human and industrial waste, toxic substances, debris, and other pollutants and contaminants into natural water resources. This can potentially cause public health issues and affect wildlife.

Other drivers of cost increases for water and sewer services include more extreme weather from climate change, fluctuating populations, declining federal funding, and regulatory compliance[xxiii]. Climate change can cause flooding and sea-level rise, which in turn can cause infrastructure to fail as it did during Superstorm Sandy in New Jersey and New York during 2012[xxiv]. Climate change can also lead to more rainfall, requiring the expansion of treatment capacity and possibly exacerbating CSOs. Meanwhile, some areas of the United States are experiencing rising populations and sprawl, requiring more water resources and distribution infrastructure that have higher marginal costs. Other areas of the United States have declining populations, causing higher per capita costs for water and wastewater services as utilities struggle to recover costs from a smaller population paying for the water and wastewater services. These shifts are occurring against a backdrop of federal funding for water and wastewater infrastructure declining by 74% since 1976; more recently, state and local funding has also declined[xxv]. Finally, regulatory compliance with water pollution standards from the Clean Water Act and the Safe Drinking Water Act have driven approximately $1 trillion of spending since 1972 from government and industry to abate water pollution[xxvi]. All of these factors contribute to the rising costs of water and wastewater.

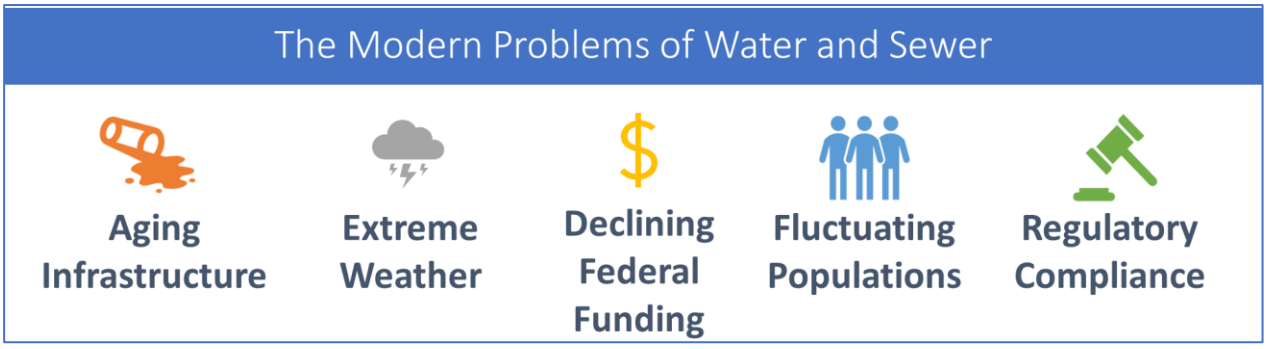

Figure 2: Modern problems of water and sewer

In fact, when considering the factors that are driving the cost increases in water and wastewater services, it is clear that the prices charged to consumers of these services are too low today and have been too low historically as well. Citizens in other developed countries pay twice as much as the average consumer in the United States for water and wastewater services[xxvii].

Aging infrastructure that is being replaced too slowly, climate change, fluctuating populations, and declining funding from state and local governments result in a need for utilities to charge even more for water and wastewater services while they were already slow to increase them. Rate increases for water and wastewater services are considered political, and by extension, funding the needs of water and wastewater systems is political. The result is chronically underfunded water and wastewater systems that are neglected all at once from federal, state, and local governments as well as customers unwilling to pay more. According to the AWWA, "public understanding of the value of water systems and services" and "public understanding of the value of water resources" have fluctuated between 3rd and 4th and 5th and 6th (respectively) most important or urgent issues (ranked by industry professionals) out of 30 issues the water and wastewater utilities face[xxviii]. AWWA recommends that utilities employ "full-cost pricing" in consumer rates and fees to reflect the cost of providing services as well as updating or expanding infrastructure, but typically, water bills only cover the cost of extracting and delivering water. AWWA found that only 15% of water and wastewater utilities believe that they are fully able to cover all costs of providing service.

The surprising conclusion that water and wastewater services remain underpriced means that rapidly rising costs of these services to consumers and the associated affordability issues are even more urgent to address.

The Current State of Water and Sewer Affordability Policy

The United Nations Sustainable Development Goals call for affordability as a key part of meeting the human right to water and sanitation[xxix]. The United States has extraordinarily little policy to advance this goal on the federal and state levels, and instead, affordability is considered a local matter.

While the United States has a federal affordability program to help low-income households with heating and cooling costs called the Low-Income Home Energy Assistance Program (LIHEAP), there is no comprehensive water and sewer affordability policy in the United States. On the federal level, there have been multiple attempts to pass water and sewer affordability policy. US Senator Kamala Harris introduced the Water Affordability Act in June 2018 to help low-income families pay their water and sewer bills[xxx]. Multiple versions of the Water Affordability, Transparency, Equity, and Reliability (WATER) Act have been introduced in both the house and the senate in 2018 and 2019[xxxi]. Finally, in 2020, some of the multi-trillion-dollar coronavirus stimulus proposals included $1.5 billion water affordability relief for low-income families administered through LIHEAP[xxxii]. None of these attempts at passing policy to support

water and sewer affordability at the federal level were successful. However, the EPA does grant variances to utilities to comply with Clean Water Act regulations based on their Financial Capability Assessment Framework that assesses a community's ability to comply with the regulations[xxxiii]. The EPA also actively encourages municipalities to provide lower rates and subsidies to low-income customers[xxxiv].

On the state level, California is the first and only state to legally recognize that "every human being has the right to safe, clean, affordable, and accessible water adequate for human consumption, cooking, and sanitary purposes" in 2013[xxxv]. Later in 2015, California passed a law requiring the State Board of Equalization to develop a plan for the funding and implementation of the Low-Income Water Rate Assistance Program[xxxvi]. After several years and multiple plans being released and public meetings and comments, California still has not implemented a statewide affordability program. California is the only state to attempt to develop a statewide affordability program, and even so, it has not yet been implemented. While statewide affordability programs are mostly non-existent, many states have legal barriers in place for ratepayer-funded customer assistance programs. According to a 2017 report from the University of North Carolina Finance Center, 5 states specifically prohibit ratepayer-funded customer assistance programs, and 35 states have potential legal challenges against them[xxxvii]. This is due to regulations that require rates to be "reasonable" and "non-discriminatory" that might be legally interpreted to mean that higher-income families cannot subsidize costs for lower-income families.

Almost all water and sewer affordability programs are found on the local level in a utility. These programs vary in who qualifies, how much assistance is provided, and the form of assistance provided. There are five types of customer assistance programs: bill discounts, flexible terms, lifeline rates, temporary assistance, and water efficiency programs. Due to legal challenges, costs, and other barriers, only 37% of utilities provided some form of assistance according to the 2019 AWWA State of the Water Industry report, with smaller utilities being less likely to offer assistance[xxxviii].

Sample	Small Utilities	Medium Utilities	Large Utilities	Very Large Utilities
Utilities surveyed that offer assistance to low-income customers	29%	37%	34%	49%

The affordability programs that do exist have several issues. First, these programs suffer from low participation rates among customers who are eligible due to the often-burdensome process to prove eligibility or the general lack of awareness of these programs. Another common

problem with these programs is the exclusion of renters. Most renters do not pay their water bills directly, and instead, the cost of water and sewer is included in their rent. Therefore, low-income renters who cannot afford expensive water and sewer services end up paying for them in their rent payment without any possibility for assistance because their landlord pays the actual bill to the utility.

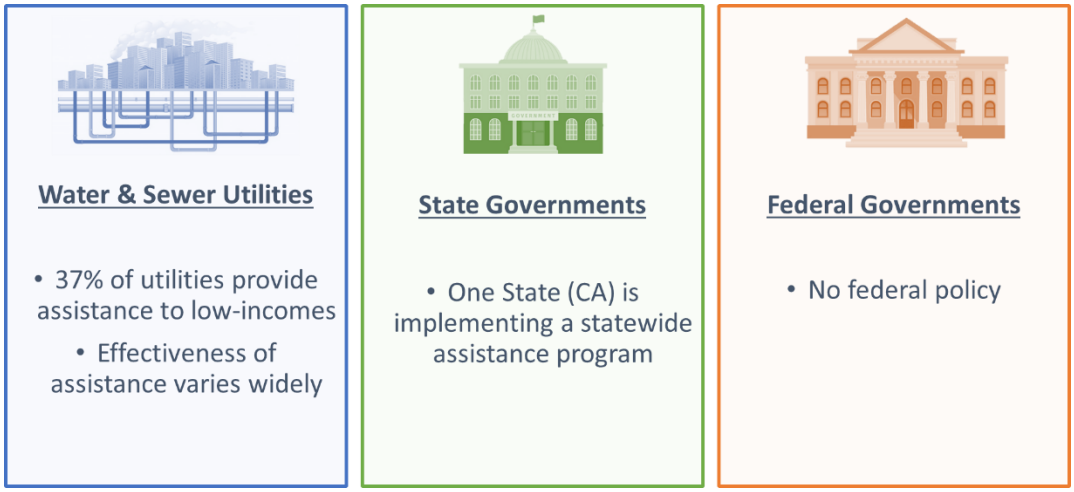

Figure 3: Current state of affordability policy

Affordability Metrics

One potential reason that affordability issues are not getting the attention and action that they require from utilities, states, and the federal government might be the poor measurement of the issue. The most widely used metric for water affordability is the EPA's metric which dictates that water charges in excess of 2.5% of a community's median household income for water and 2% for sewer (or 4.5% combined) are "unaffordable". This metric was designed to be used in combination with other community indicators to determine a community's financial ability to comply with water pollution regulations[xxxix]. However, this metric has been misapplied to measure household affordability and can lead to researchers, water and wastewater industry consultants, and utility and government decision-makers to underestimate the severity of the affordability problem. For instance, according to these metrics, only about 2% of water utilities and 8% of sewer utilities charge "unaffordable" rates by this metric in 2018[xl]. Meanwhile, a survey of water shutoffs in the US estimated that 15 million people (4.6%) experienced a water shutoff in 2016[xli]. People who experience a water shutoff are far from the only people struggling to afford their bills. There is an obvious disconnect between the actual experiences of communities with water and wastewater affordability and the metric that is claimed by some to measure these affordability struggles.

There are several issues with using the EPA's metric to measure household affordability. First, the use of the median household income as the benchmark ignores the bottom half of the

income distribution. Up to 49.9% of a community's households could be spending more than 4.5% of their income on water and wastewater costs and still, this metric would consider the combined charges "affordable" because the median household spends less than 4.5%. However, it is important to note what "affordable" in this context means. It means the community's water and wastewater costs are "affordable" in the sense that there is no determined need to grant a special compliance schedule from the EPA for federal water pollution standards due to a community's reduced ability to pay. This does not mean that a large number of households do not experience excessive financial burdens for water and wastewater bills. Second, the use of 2.5% of the median household income for water and 2% for sewer is entirely arbitrary. The reasoning for the choice of these percentages is unknown but some researchers claim that it originated from a government report about charges for telecommunication utilities in the 1970s. Any percentage that might have been chosen for this purpose would be somewhat arbitrary. In this case, the arbitrary percentage is particularly problematic because it is being applied to one household (the median household) to measure affordability for the entire community.

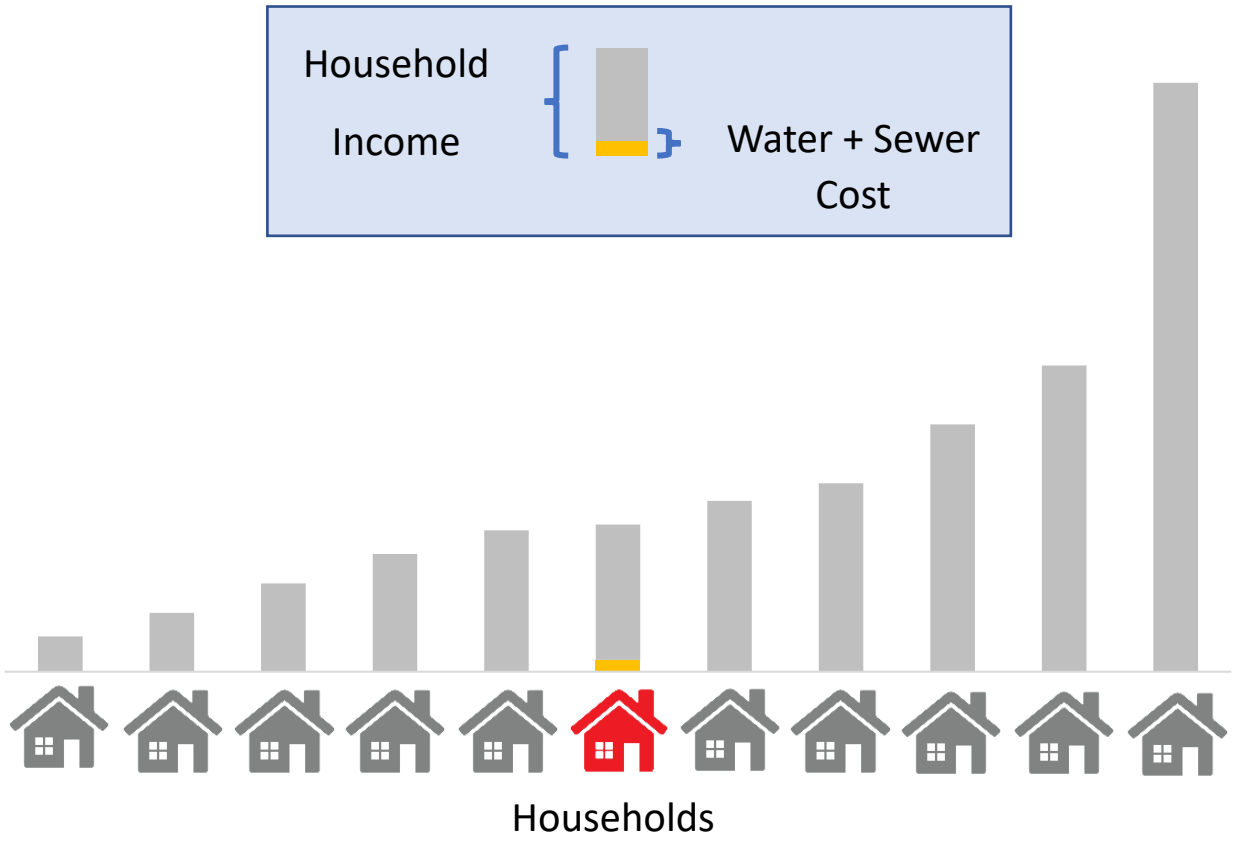

Figure 4: Illustration of EPA affordability metric

EPA's metric determines a community's household affordability for water and wastewater based only one median household (red), ignoring the lower end of the income distribution

Numerous alternative metrics for household water and wastewater affordability have been proposed, but these metrics do not distill information about affordability on the household level to an actionable and easy to understand number. Some of these alternative metrics are also computationally difficult to calculate. Stantec Consulting Services, a water consulting company, developed the Weighted Average Residential Index (WARi), which calculates an average percentage of household income spent over the whole income distribution rather than using the median income and applies the calculation to each census tract in a utility's territory and weights the metric by population in each census tract[xlii]. The primary issue with this metric is it produces an average for the percent of income spent on water and wastewater for the community, thus obscuring the struggling of lower incomes in a community average. The community average might lead a utility to believe it has no affordability issue when in fact it does. The metric is also problematic because it computationally difficult to calculate, and most likely would require utilities to hire consultants to calculate it.

Another proposed alternative set of metrics comes from Manuel Teodoro, a researcher at Texas A&M University. His proposed metrics are the affordability ratio (AR20) and the hours of minimum wage work required to pay the bill (HM)[xliii]. The affordability ratio calculates the percentage of disposable income (gross income minus essential costs) that is spent on water and wastewater services for the 20th percentile household. This metric does properly focus attention on the lower end of the income distribution. However, the metric does not inform a utility on how widespread the affordability issue might be. Moreover, the essential costs are computationally difficult to calculate because there is no authoritative source of data on these costs on a granular level. The methods to calculate these costs for a specific community are questionable and might introduce unnecessary error into the metric. The hours of minimum wage work required to pay the utility bill is a straightforward metric that also appropriately focuses attention on the lower end of the income distribution, but not everyone works a minimum wage job, so this metric does not reflect the affordability issue for a whole community.

Finally, some other proposed metrics are the percentage of delinquent bills and the prevalence of low incomes[xliv]. The percentage of delinquent bills does measure households who truly cannot afford to pay their bills, but it also measures households that simply forget to pay their bills and does not measure households that struggle to pay their water bills but still pay them – possibly by sacrificing spending on other core needs (e.g. food, heat, medical bills). Moreover, it relies on utilities to report this metric that is most often not publicly available, and this metric might be more reflective of the utility's collection practices and definition of

delinquency than actual affordability issues. This also means that this metric cannot be applied across utilities for comparison due to differing practices. Metrics that measure the prevalence of low incomes such as percentage of households below the federal poverty level, percentage of households receiving public assistance, percentage of households below a living wage, and others do focus on the right groups. However, these metrics are not connected to water and wastewater costs in any way and might miss middle-income households that may still struggle with the burden of very high water and wastewater service charges.

To develop better metrics, we must approach the issue from first principles. What might a utility or government decision-maker consider when deciding whether to implement water and wastewater affordability programs and policy? The intuitive questions to ask about affordability in a community are how many people are experiencing an excessive burden from their water and wastewater bills and how excessive is this burden? In other words, what is the prevalence of excessive burden or affordability issues, and what is the intensity? Metrics that can answer these questions can be more actionable and easier for decisionmakers and the general public to understand.

The prevalence of affordability issues can be measured by looking across the whole income distribution rather than just the median or any one household. Here, we can use EPA's 4.5% benchmark for excessive burden in a much less arbitrary way. It is also reasonable to use other percentages of income as the benchmark, but it would not change the interpretation of the metric drastically. Generally, benchmarks from the UN, OECD, World Bank, and advocacy groups range from 2.5% to 5% for affordable water and wastewater service, so EPA's 4.5% is a relatively conservative measure [xlv] [xlvi] [xlvii] [xlviii]. We can find out how prevalent affordability issues are by finding the percentage of households that spend more than 4.5% of their incomes on water and wastewater costs by using the water and wastewater charges and the income distribution. This metric shall be referred to as "water unaffordability prevalence".

The intensity of affordability issues can be measured by looking at the bottom portion of the income distribution and measuring what percentage of the household income is spent on water and wastewater. The higher the percentage of incomes spent on water and sewer at the bottom of the income distribution, the more intense the affordability issue is in a particular community. However, in order to measure this, we need not just the water and wastewater charges but also the denominator: the benchmark income to measure intensity against. The most straightforward way to do this is to use the 20^{th} percentile income in a community because it a readily available figure from the US Census. This metric shall be referred to as "water unaffordability intensity".

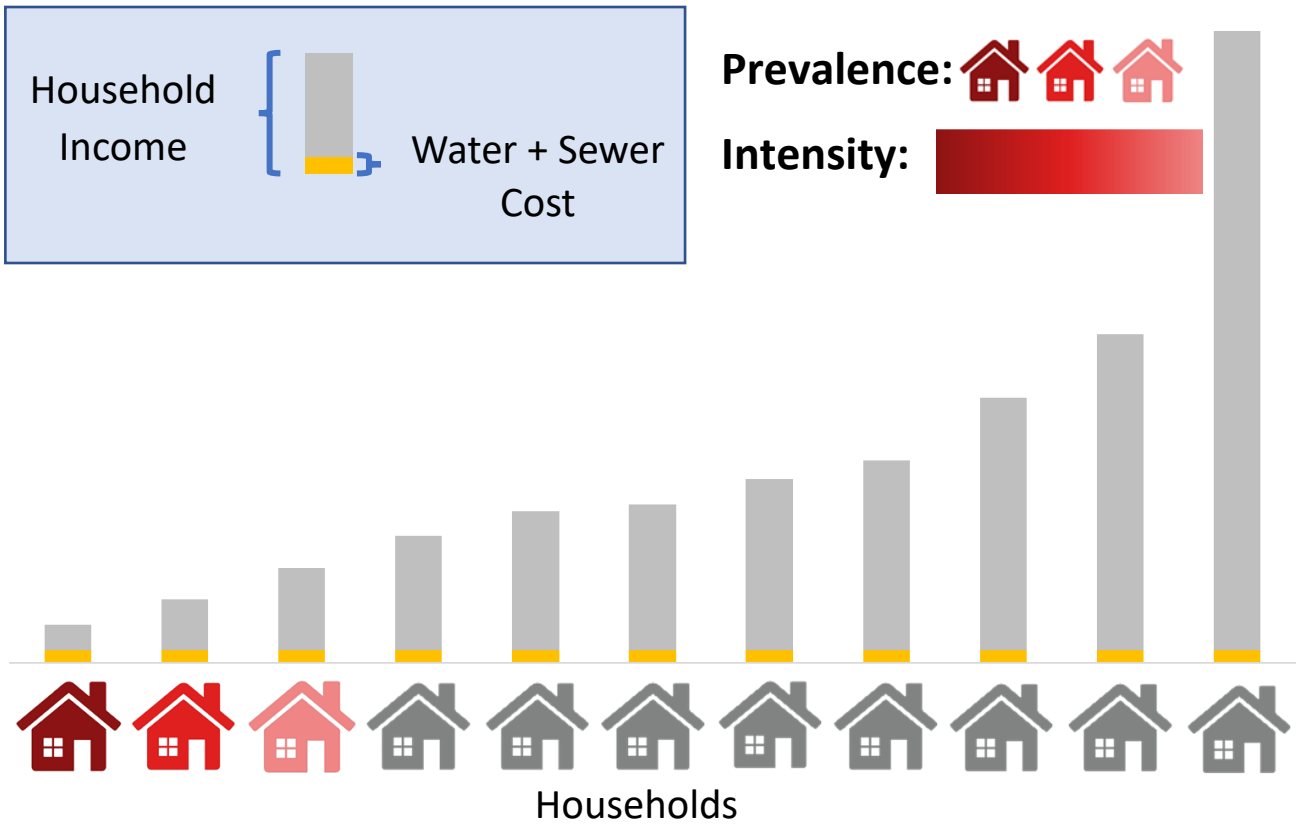

Figure 5: Water Unaffordability Prevalence and Intensity metrics illustrated (WUP, WUI)

Unaffordability prevalence and intensity metrics capture the households that are struggling to afford their water and wastewater bills and the intensity of their struggle.

The water unaffordability prevalence and intensity metrics are highly correlated with one another and with EPA's affordability metric (each metric can explain more than 90% of the variation in the other). However, they offer a distinct framing of affordability issues and provide insightful and actionable interpretations. The EPA metric only determines if a particular utility's rates are "affordable" or unaffordable" based on a somewhat arbitrary benchmark that is only useful for determining whether a utility needs an exceptional compliance schedule for water quality regulations. The water unaffordability prevalence metric shows how many households or people might be struggling with the affordability of water and wastewater services as a percentage of the population, thus answering questions about how many households would have

to be reached by an affordability program. The water unaffordability intensity metric shows how intensely households struggle with the affordability of water and wastewater services, thus answering questions about how much help households might need.

With the combination of metrics that measure the prevalence and intensity of affordability issues, a decision-maker and the public can easily understand how many people might be struggling with affordability issues and how much they are struggling. It is also relatively simple to calculate the dollar amount of the aggregate excess burden on households beyond 4.5% of their incomes from the income distribution from the same data that is needed for the prevalence and intensity metrics. This number represents the total burden that must be shifted to other ratepayers or otherwise mitigated through assistance programs to address affordability issues. In short, these metrics are very actionable and insightful on the extent of affordability issues with straightforward interpretations.

Insights from Data

To illuminate the affordability issue of water and wastewater in the United States, we analyzed data compiled by Manuel Teodoro's research team at the Department of Political Science at Texas A&M University[xlix]. The data is the only representative sample of water and wastewater utility charges identified in a review of the literature. This dataset is a stratified random sample of 327 water and wastewater utility communities that is stratified into the 4 population served categories (between 3,300 and 10,000; between 10,000 and 50,000; between 50,000 and 100,000; and more than 100,000) and into private and non-private stratum. To make this data suitable for our purposes, we also amended the billing data with income distribution data from the Census Bureau's 2018 American Community Survey (ACS) 5-year estimates. One caveat here is that utility service territory boundaries do not always align with municipal boundaries or might serve multiple cities, and the US census frequently provides different boundaries for the same place (i.e. census-designated place versus city versus county). When this occurred, census data from the community boundaries that most closely matched the population served for each utility was used. In the case that the most closely matched community was significantly smaller and therefore not representative of the utility's population, a broader community was used (e.g. county).

In order to measure the affordability of water and wastewater services, one must select a standard monthly water and wastewater usage amount to calculate the bills and compare it to incomes. For this analysis, we will use the EPA's minimum sanitary requirement of 6,000 gallons per month per household. This is based on a 4-person household using 50 gallons per person per

day. The amount of 50 gallons per capita per day is a standard in sewer system design[l] and is therefore an appropriate amount to use to estimate a benchmark usage for water and wastewater.

Applying EPA's metric to this random sample of water and wastewater utilities suggests that on a combined basis, only 1.5% of utilities charge "unaffordable" rates according to EPA's 4.5% of median household income affordability benchmark. The distribution of the EPA metric is illustrated below. However, this approach of identifying communities with excessively expensive water and wastewater charges for the median household does not tell the full picture, suggesting only a few utilities have reason to worry about the affordability of their services.

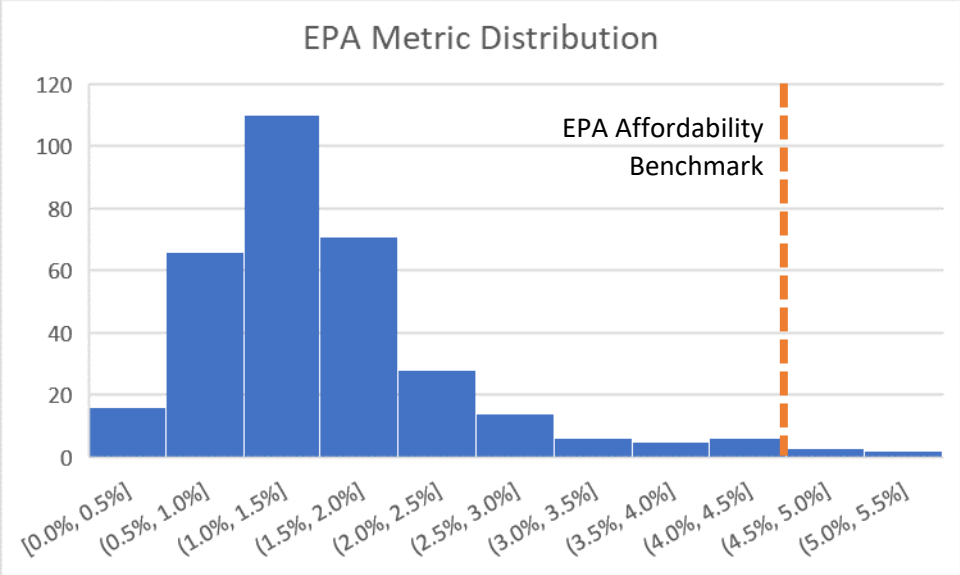

Figure 6: EPA metric distribution

Applying the water unaffordability prevalence metric described in the previous section on this stratified random sample and adjusting for the stratification shows an estimated 14.95% of the US population live in households with unaffordable combined water and sewer rates (where unaffordable is defined as in excess of 4.5% of household income). Previous research has estimated this metric to be 11.9% in 2014, but this research used an average from AWWA's rates survey and compared it to the national income distribution to produce this estimate, thus not accounting for variation in rates around the country[li].

Applying the water unaffordability intensity metric described in the previous section shows that on average, poor households at the 20th percentile of the income distribution spend 3.7% of their income on water and wastewater services. The distributions of the water unaffordability prevalence and intensity metrics are presented below.

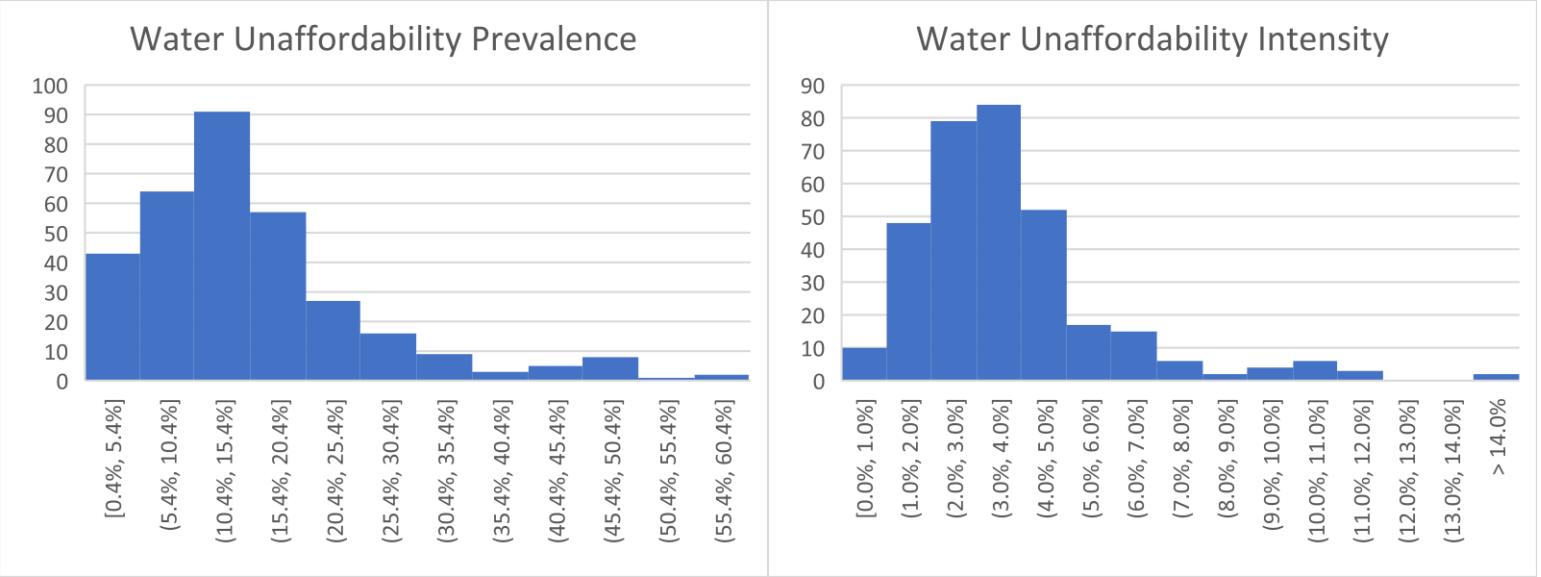

Figure 7: Water Unaffordability Prevalence (WUP) and Intensity (WUI) distributions

Both the unaffordability prevalence and intensity metrics showed more severe affordability issues for utilities serving smaller populations and utilities in the south, while utilities in the west had lower unaffordability prevalence and intensity. See the box and whisker plots of these data below for further detail.

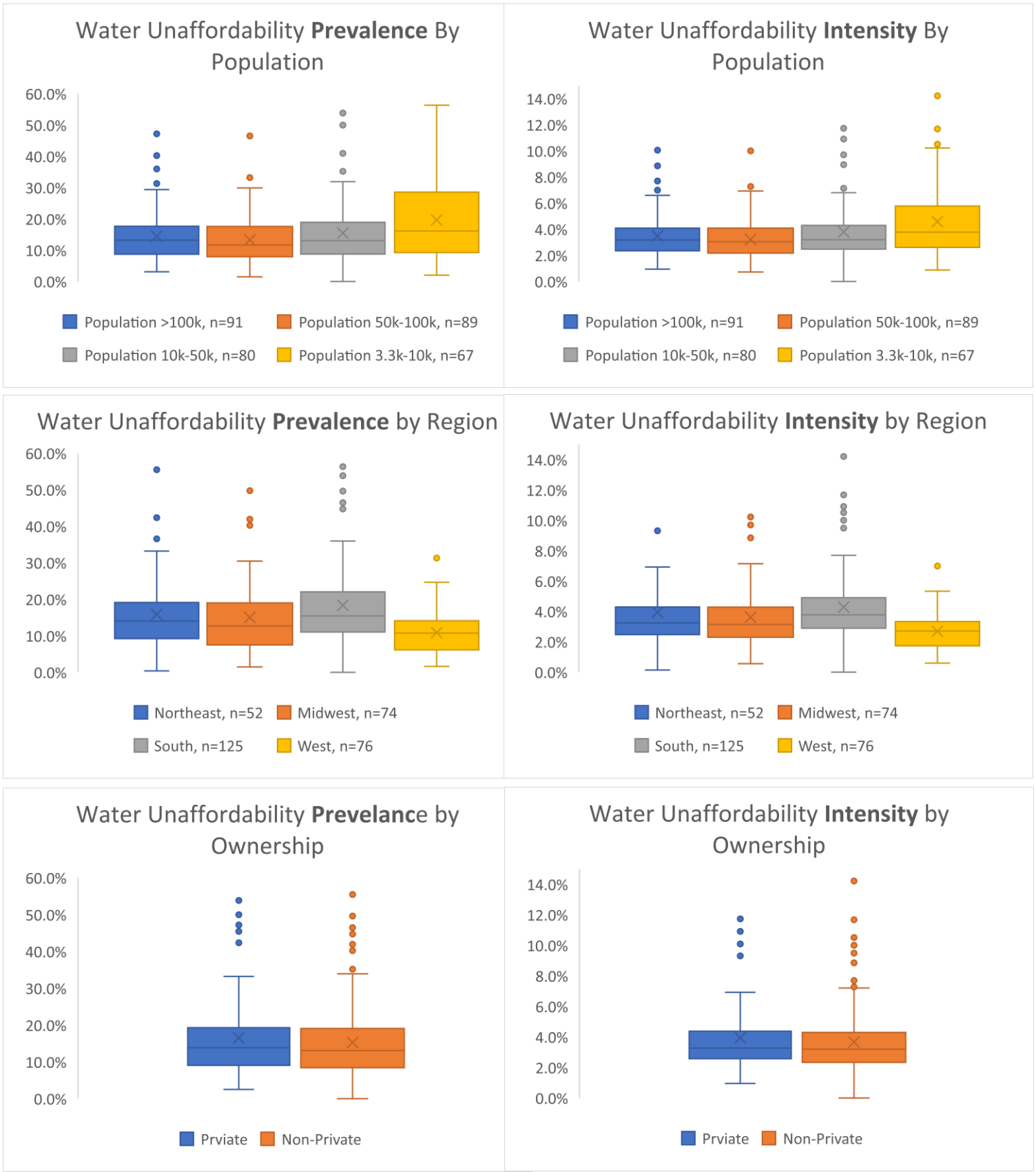

Figure 8: WUP & WUI by population, region, and utility ownership

Note: One outlier in the data is excluded from the 3 displays for water unaffordability intensity on the right. This utility is in the 10-50k population bucket in the northeast and is non-private. It has a water unaffordability intensity of 21% due to an exceptionally low 20th percentile income.

Using the income distribution, the water and sewer charges for each utility, and the 4.5% benchmark, it is also possible to calculate the total value of excess charges above 4.5% of each household's income. As mentioned previously, this value can be used to approximate the total burden that must be shifted to other ratepayers with higher incomes or otherwise mitigated through assistance programs. Extrapolating the aggregate value of burdensome charges from the representative sample based on population yields an estimate of $2.3 billion of excess charges for lower incomes in the entire United States for water and wastewater services.

Water and wastewater unaffordability prevalence, intensity, and excess burden on lower incomes will continue to rise. If the trends in water and wastewater costs and income growth of the 8 years leading up to 2017 continue, then by 2025, water unaffordability prevalence will rise from 15% to 20%. This means 1 in 5 people will live in households whose water and wastewater charges exceed 4.5% of their income and are therefore unaffordable. Water unaffordability intensity will rise from 3.7% to 4.9%, meaning poor households at the 20th percentile of the income distribution will spend 4.9% of their income on water and wastewater services. The aggregate excess burden of water and wastewater bills on low-income households would double from $2.3 billion to $4.6 billion. If the problem is not addressed soon, water and wastewater unaffordability will increasingly threaten public health.

	2017 Actual Estimate	**2025 Forecast**
Water Unaffordability *Prevalence*	14.95%	19.86%
Water Unaffordability *Intensity*	3.75%	4.92%
Excess Burden on Lower Incomes (Thousands)	$2,313,719	$4,642,385

Generally, water and wastewater unaffordability are more prevalent and intense in the largest cities in the US. In the 25 largest cities in the US, average water unaffordability intensity is 5.2% compared to 3.7% for the broader US. Water unaffordability prevalence is 22.6% compared to 15% for the broader US.

One important nuance with all the affordability calculations above is that it does not consider affordability programs implemented by each utility. While only 37% of all utilities have some sort of affordability program for low-income customers, 49% of the largest utilities have an affordability program[lii]. These programs are difficult to account for without detailed data from each utility. Each utility has a different program, and some programs that simply provide flexible terms for payment or temporary assistance would not change the numbers presented in this section. Moreover, affordability programs are notorious for having low participation rates among those who are eligible due to the often-burdensome process to prove eligibility or the general lack of awareness of these programs. Therefore, this nuance does not significantly change the overall picture of the prevalence and intensity of water and wastewater affordability issues in the United States.

A Tool for Measuring Affordability

To promote better measurement of affordability of water and wastewater services, an excel tool was developed to be used by decisionmakers. The tool is meant to be used to determine the affordability of water and wastewater rates. The excel tool utilizes a variety of metrics with the metrics proposed in the "Affordability Metrics" section emphasized. The inputs page of the tool is divided into 3 data entry steps with instructions for each: utility and local data, data from the US census, and other data. The local and utility data inputs are the name of the utility, the water and wastewater charges for 6,000 gallons of usage, the population served, and the local minimum wage. Data gathered from the US Census includes unemployment, income distribution, median household income, percentage of people receiving various government benefits, percentage of people in poverty, and the 20th percentile income. Finally, other data includes the local monthly rent for an efficiency unit from the Department of Housing and Urban Development (HUD) and the local living wage that reflects the local cost of living from MIT's Living wage calculator[liii] [liv]. The inputs page of the excel tool is pictured on the following page.

The metrics that the tool calculates and displays are divided into calculated affordability metrics that are calculated using the water and wastewater bill in addition to other data, and socioeconomic metrics. The calculated affordability metrics that the tool displays are as follows:

Calculated Affordability Metrics	Description
Percent of median household income spent on water and sewer costs	Annual 6,000-gallon water and wastewater bill divided by annual median household income
Percent of households above the affordability threshold water and sewer costs	Percentage of households spending more than 4.5% of their annual income on 6,000-gallon water and wastewater bills derived from income distribution (Water Unaffordability Prevalence)
Percent of households that are above the affordability threshold (adjusted for cost of living)	Same as above except 4.5% benchmark is adjusted based on the ratio of local cost of living to national cost of living (data from MIT Cost of Living Calculator)
Percent of lowest quintile income spent on water and sewer costs	Annual 6,000-gallon water and wastewater bill divided by annual 20th percentile household income (Water Unaffordability Intensity)
Percent of lowest quintile income (adjusted for housing costs) spent on water and sewer costs	Same as above except local efficiency rent from HUD is subtracted from income. This is a simplified version of Teodoro's AR20 metric
Hours of minimum wage work required to pay monthly water and sewer costs	Monthly 6,000-gallon water and wastewater bill divided by the local minimum wage. This metric is also proposed by Teodoro

Enter City/Town Here:	Select State from list:	Affordability Assessment	6/6/2020
Lowell	Massachusetts		

1) Utility/Local Data

Utility Name:	Lowell Water and Sewer
Total Water Bill for 6,000 Gallons:	$ 29.93
Total Sewer Bill for 6,000 Gallons:	$ 65.53
Population Served:	111,670
Local Minimum Wage Per Hour:	$ 12.75

2) US Census Data

2a) Total Population - (Instructions)

Unemployed:	4.6%	Percent	Median Household Income:	$ 51,987
Income and Benefits				
Less than $10,000	9.3%	Percent	With Social Security:	25.0% Percent
$10,000 to $14,999	8.2%	Percent	With Supplemental Security Income:	12.6% Percent
$15,000 to $24,999	11.1%	Percent		
$25,000 to $34,999	8.0%	Percent	With Cash Public Assisstance Income:	4.6% Percent
$35,000 to $49,999	11.7%	Percent		
$50,000 to $74,999	16.2%	Percent	With Food Stamp/SNAP benefits in the Past 12 months:	23.2% Percent
$75,000 to $99,999	13.1%	Percent		
$100,000 to $149,999	13.9%	Percent	Percentage of People Whose Income in the Past 12 Months is Below the Federal Poverty Level (ALL PEOPLE):	20.7% Percent
$150,000 to $199,999	5.1%	Percent		
$200,000 or more	3.4%	Percent		

2b) Lowest Quintile Income - (Instructions): $17,520

3) Other Data

3a) HUD FMR Efficiency Rent: $ 1,066 (Instructions)

3b) MIT Living Wage for 2 Working Adults and 2 Children $ 18.78 (Instructions)

Figure 9: Affordability assessment tool input page

The tool also compiles socioeconomic metrics for a community, which could also serve as indicators for potential affordability issues. Selected socioeconomic metrics include: percent of households below federal poverty level, percent of households below the local living wage, percent of households spending >30% on housing, percent of households receiving cash public assistance, percent of households receiving SNAP, percent of households receiving Social Security, and percent of households with supplemental security income. Both the calculated and socioeconomic affordability metrics are benchmarked against the 25 largest cities in the United States that contain approximately 11.5% of the US population. This benchmarking determines whether each metric is "Significantly above average" (>75th percentile), "Slightly above average" (>60th & <75th percentile), "Average" (40th to 60th percentile), "Slightly below average" (>25th & <40th Percentile), or "Significantly below average" (<25th percentile).

The excel tool emphasizes water unaffordability prevalence and intensity metrics on the outputs page with graphics to show what portion of the income distribution spends more than 4.5% of their income on water and wastewater bills and with a bar chart displaying how high the unaffordability intensity metric is. The tool also displays other useful information such as what percentile water and wastewater charges for the selected are for 6,000 gallons of usage in the United States and the estimated minimum assistance budget needed to reduce all bills to below 4.5% of each household's income. The outputs page of the excel tool is pictured on the following page.

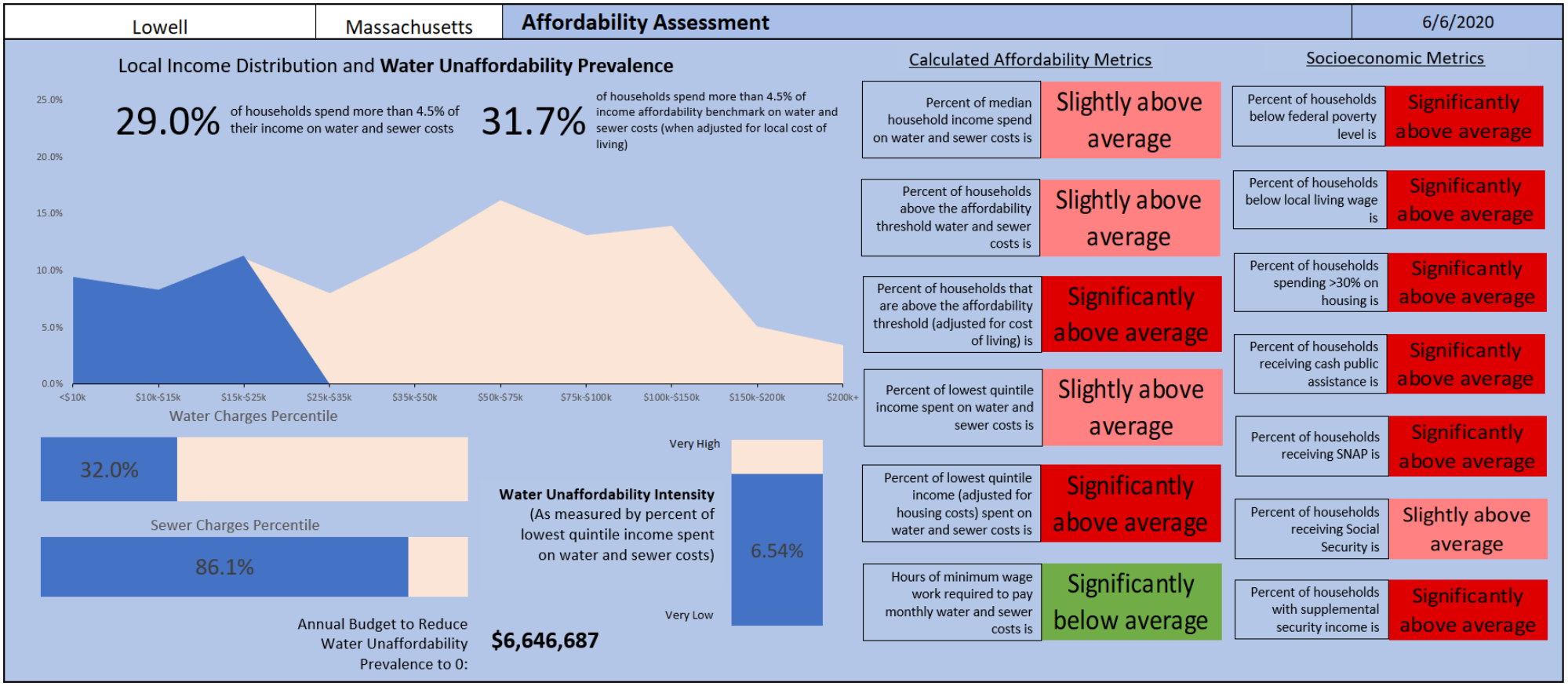

Figure 10: Affordability assessment tool outputs page

Potential Solutions for Water Affordability

Framing affordability metrics in terms of *prevalence* and *intensity* of unaffordability has implications for policy that can address water and wastewater affordability from utilities to states to the federal government. Observing the prevalence of water affordability issues focuses attention away from median households towards the households on the low end of the income distribution. Nationwide, approximately 15% of people cannot afford their water and wastewater services, and in the least affordable utilities in the country, this number can easily surpass 30% and even exceed 50%. This widespread prevalence emphasizes the need for a multi-pronged approach at every level: utility, state, and federal. Similarly, the intensity of the affordability issues emphasizes the wide variability in the need for assistance, with the most intense need for lower incomes. The average 20th percentile household spends 3.7% of their income on water and wastewater services in the US, but for some households, these water charges can easily exceed 9%, or double EPA's affordability benchmark of 4.5%, and even approach 20% in some parts of the United States.

Utility-Level Solutions

Utilities should be particularly interested in keeping their rates affordable, as unaffordable rates can result in less revenue and more costs from collection efforts[lv]. However, water and wastewater utilities are currently failing to address the affordability problem with only 37% providing customer assistance to low-income customers[lvi]. Moreover, certain kinds of assistance programs do not reduce the prevalence or intensity of unaffordability. Temporary bill assistance, flexible terms like payment plans will not reduce the unaffordability prevalence or intensity metrics at all because ongoing monthly charges will not change. These metrics reveal the nature of assistance that is needed to reduce struggles with affordability: the water and wastewater bill itself must be reduced for a basic level of usage. A truly comprehensive approach to affordability is required: water and wastewater rates must be structured conscientiously, the lowest income customers must have direct bill assistance, and water efficiency must be addressed.

The most important piece of a strategy to reduce affordability issues is the rate structure. Structuring rates and charges so that water and wastewater services are affordable for a basic level of service is critical because it is universal. This means that groups that are typically excluded from affordability programs such as renters who pay their water and wastewater bills indirectly in their rent payment can have more affordable water and wastewater service as well. A universal

approach to affordability is also desirable because affordability assistance programs regularly suffer from low participation rates among those eligible due to lack of awareness or excessive burden to prove eligibility.

The best rate structure to address affordability is an inclining block structure where higher levels of water and wastewater usage are charged at higher per-unit rates. Traditionally, this rate structure applied for conservation reasons to discourage higher usage with increasing prices. However, this rate structure can be an effective affordability strategy as well if the lowest usage block aligns with a minimum sanitary requirement (e.g. 6,000 gallons) and charges a sufficiently low per-unit rate for the first block and compensating to ensure sufficient revenue overall through higher unit rates for higher consumption blocks.

In fact, an inclining block was one of the primary recommendations by a commission of leading affordability experts to the Detroit Water and Sewer Department (DWSD), one of the most distressed water and wastewater utilities in the entire United States. Detroit is a troubled city due to the long-running population declines that eventually led to the city's bankruptcy in 2013. The water and sewer department of Detroit struggled as well, with declining populations leading to insufficient revenues to cover the utility's cost of operations. DWSD was forced to rapidly increase charges for water and wastewater services, resulting in nearly half of its customers becoming delinquent[lvii]. In 2013, Detroit started mass water and wastewater utility shutoffs. It is estimated that DWSD issued 142,953 water shut-off notices between 2010 and 2018[lviii]. Today, the water unaffordability prevalence and intensity metrics capture these issues, with unaffordability prevalence estimated to be near 40% and intensity near 10% before accounting for affordability programs, both exceptionally high. The backlash to these prevalent and intense affordability issues was numerous anti-water-shutoff advocacy campaigns, litigation, and international media attention that eventually led Detroit to convene a Blue Ribbon Panel on Water Affordability (BRPA) with affordability experts, consultants, and lawyers[lix]. As mentioned above, one of the primary recommendations of this panel, delivered in February 2016, was an inclining block structure. The other recommendations included enhanced billing options, enhanced shutoff avoidance practices and options, a focus on efficiency in retail operations, and expanded customer assistance that includes water conservation and plumbing repair.

While Detroit did implement almost all of these recommendations, an inclining block structure that is found at around half the utilities in the US has not yet been implemented. The targeted customer assistance program that allows for $25 monthly bill discounts for 12-24 months per household under 150% of the federal poverty level could potentially reduce water unaffordability prevalence metric from 39% to 29% with full enrollment of everyone eligible. The result of DWSD actions was an increase in the bill collection rate from 77% to 91% and a decline in water shutoffs. This is a significant improvement that could go further and reach more people (including renters, those who are eligible but do not participate in the customer assistance

program, and households who have exhausted their bill discount) if Detroit adopts an inclining block structure.

The second critical component of utility level affordability efforts is customer assistance programs. Detroit's program did lead to large improvements, but the most widely discussed affordability program is found in Philadelphia. Under Philadelphia's Tiered Assistance Program (TAP), residents who are under 150% of the federal poverty line or residents experiencing hardship such as unemployment or serious illness can pay a defined percentage of their income for water and wastewater services instead of usage-based charges. Customers must prove their income and document hardships to qualify. Philadelphia estimates that 60,000 customers representing 10% of the households would be eligible for the program and that the program will eventually reach a budget of $18 million[lx]. While this will help many households afford their water bill, the water unaffordability prevalence metric indicates that around 30.5% of households in Philadelphia cannot afford their water and the intensity metric indicates a 20th percentile household would have to pay 7.1% of their income under current rates in Philadelphia. The total estimated assistance required for all Philadelphia residents to spend less than 4.5% of their income is $99 million. Philadelphia's income-based billing approach for low incomes could reduce the water unaffordability metric by up to 10% if everyone who is eligible enrolls, but that would still leave 20.5% of households struggling, and the 20th percentile benchmark household would still pay 7.1% of their income for water and wastewater. This indicates that while Philadelphia's program can be effective in theory, it still needs supplemental strategies to fully address the affordability problem.

It is important to note that the success of the program depends on reaching the eligible population effectively. Philadelphia's early rollout of the program was significantly slower than initially anticipated[lxi]. One way to alleviate this issue is to adopt the approach of Seattle's Public Utilities. Seattle has one of the highest water and wastewater charges in the country, but the program offers a 50% discount on water and wastewater charges (along with drainage and garbage collection) for households with less than 70% of Washington state's median income. Seattle aimed to boost participation by auto-enrolling all income-eligible households of the Seattle Housing Authority in the affordability program[lxii]. Seattle's water unaffordability prevalence is about 30.2% and the 20th percentile household spends 6.81% of their income on water and wastewater before accounting for this assistance program. This program likely reaches a large portion of its eligible population due to the auto-enrollment of households in the Seattle Housing Authority that represent approximately 5% of the households. The income limitations on this program cast such a wide net that if everyone who is eligible enrolled, water unaffordability prevalence and intensity metrics would be cut approximately in half. Again, this emphasizes that a customer assistance program alone will not address the full scope of the affordability problem.

Finally, water conservation measures, fixing leaks, and generally efficient operation of retail water delivery and wastewater processing can lead to lower bills for low-income customers and lower costs for water and wastewater utilities. Although limited by how many people it can reach, such programs can mitigate the need for future rate increases and reduce the bills of some low-income households. This strategy alone would not affect water unaffordability prevalence and intensity dramatically, but it can effectively supplement conscientious ratemaking and customer assistance programs to form a comprehensive affordability strategy.

State-Level Solutions

States have a role in ensuring water and wastewater service affordability. The most obvious reform for states is to reduce legal barriers to customer assistance programs and limitations on rates that prevent affordability conscious ratemaking. The 5 states that specifically prohibit ratepayer-funded customer assistance programs and the 35 states with potential legal challenges must pass policy to allow utilities to implement customer assistance programs to maintain the affordability of their services without legal issues[lxiii].

Another piece of the solution is for states to pass laws recognizing the human right to water and sanitation, and along with these laws limit water and wastewater utility shutoffs or even eliminate them. These practices can have traumatic impacts on low-income households and can have negative public health implications. Reducing these practices can also reduce the most severe consequences of household water and wastewater unaffordability.

States can also pass policy to leverage their existing public utilities regulators to ensure that water and wastewater utilities have affordable rate structures and customer assistance programs to reduce water unaffordability prevalence and intensity. This would only apply to private utilities, but states can ensure public utilities charge affordable rates as well by conditioning some of the funding they provide for water and wastewater infrastructure on utilities implementing a comprehensive affordability strategy. This would push utilities to be more conscientious about household affordability.

The final potential piece of state-level solutions for water and wastewater affordability is implementing a statewide program for direct household assistance to lower unaffordability prevalence and intensity. California has passed laws to specifically create a statewide program for low-income households after passing a law acknowledging the human right to water. While California has not yet implemented such a program, the learnings from building such a program emphasize the benefits of creating a statewide program that specifically focuses on household assistance[lxiv]. Providing funding at the system level to reduce the impacts of rising water and

wastewater costs does not directly alleviate household affordability struggles, and rate structures designed for affordability can only go so far. Moreover, many other basic service sectors are subsidized or otherwise made affordable by state programs, further bolstering the case for statewide water bill assistance programs.

Federal-Level Solutions

The federal government also plays an important role in addressing affordability issues. First, the federal government can and should collect better data about water and wastewater shutoffs/liens, charges, and general affordability. Collecting data centrally and making it publicly available aids researchers in identifying the problems more clearly and can lead to more specific and effective solutions. Where states fail to implement measures to address affordability, the federal government can choose to help households struggling with affordability with similar tools as the states but applied at the federal level. Conditioning federal funds disbursed to utilities for infrastructure projects on those utilities implementing comprehensive affordability strategies can work to make affordability programs and conscientious ratemaking more widespread. Finally, the federal government can implement a version of the Low-Income Home Energy Assistance Program (LIHEAP) for water and wastewater services, which are just as essential if not more so than home energy. Such an affordability program might be easier to implement on a federal rather than the state level due to the federal government's significantly more lenient budget constraints. A federal affordability program of this size and scope could work to complement state and utility level efforts to reduce the burdens on the lowest incomes.

Summary

In summation, the prevalence and intensity of water and wastewater unaffordability issues demand coordinated action from water and wastewater utilities, state governments, and federal governments. The problem calls for the following actions:

1. Conscientious ratemaking through inclining blocks
2. Customer Assistance Programs from utilities
3. Water conservation measures
4. Legal reform to remove barriers to assistance programs and recognize the right to water
5. Policy change to condition state and federal funds on affordable water and wastewater charges
6. Direct bill assistance from state and federal governments

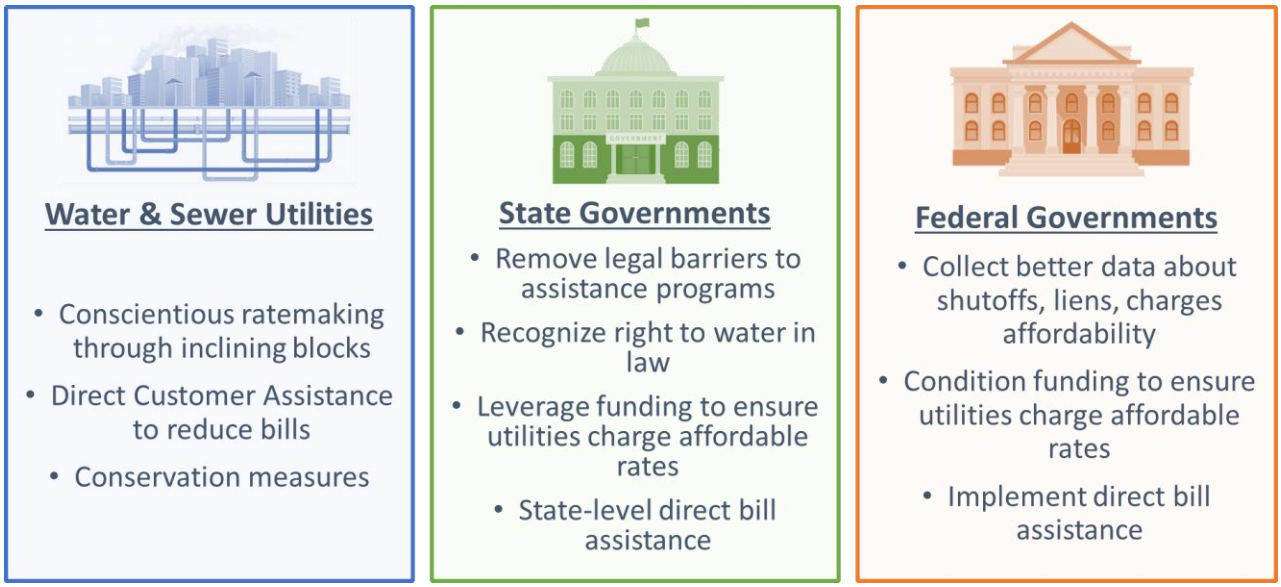

Figure 11: Affordability solutions

Conclusion

In a broad view of water and wastewater costs, it is clear that the costs of these services have been rising quickly, and that the rapid rise will continue due to aging infrastructure, extreme weather from climate change, fluctuating populations, declining federal funding, and regulatory compliance. Water and wastewater are still not priced to reflect the full cost of these services and will require dramatic increases in prices. Meanwhile, the current state of affordability assistance for water and wastewater services is far from sufficient and significantly less developed than affordability programs for other essential services. As affordability struggles increase, households will have to make difficult budget tradeoffs and in the millions of worst cases, they would have to face water and wastewater shutoffs and home liens that potentially lead to loss of shelter. In this report, we proposed two metrics that comprehensively capture the affordability issues: the water unaffordability prevalence and water unaffordability intensity metrics. These metrics can serve decisionmakers by better identifying the scope of the affordability problem than alternative metrics. These metrics were incorporated along with others into an affordability measurement excel tool, also designed for decisionmakers. Finally, applying these metrics to case studies about addressing affordability revealed insights about the scope of solutions needed from utilities, states, and the federal government to address the accelerating affordability issues. Overall, deeper analysis and generally more attention are needed in regards to the affordability of water and wastewater services, especially from a policy perspective, and the use of proper metrics to quantify affordability is crucial to this pursuit.

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