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An Assessment of Water Affordability and Conservation Potential in Detroit, Michigan



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Executive Summary

This report includes an assessment of the affordability of water and sewer service in Detroit, Michigan at the census tract level. It also contains an evaluation of water conservation potential associated with replacing inefficient toilets with new WaterSense® labeled high-efficiency toilets. This assessment utilized publicly available data from the U.S. Census Bureau for 2018 and can be readily replicated or modified. The results indicate the cost of water and sewer service represents a high burden for Detroit's single-family customers, but the burden varies in extent and by geography throughout the city. This assessment also found that there is a large opportunity for water savings through the replacement of inefficient toilets in Detroit. This is due to the large number of homes built before 1994, when the Energy Policy Act of 1992 took effect. The Energy Policy Act of 1992 set federal water efficiency standards for toilets at a maximum flush volume of 1.6 gallons per flush (gpf). This federal standard took effect in 1994 for residential toilets and in 1997 for commercial toilets.¹ Before 1994 toilet flush volumes were 3.5 gallons or greater.



In short, there is a great need for programs to help customers reduce their water bill in Detroit, and there is great opportunity for conservation to play a role in reducing customer bills. Based on average indoor water use statistics, this assessment suggests customers can reduce their water bill by 13.67 percent in Detroit when inefficient toilets are replaced with an efficient model.

This report first describes the water affordability assessment, which is followed by the water conservation potential evaluation. Each section contains a histogram and a map that capture and display the variability of the data. The report structure is as follows:

1. Water Affordability Assessment

- » Household Burden Indicator
- » Poverty Prevalence Indicator
- » Household Burden Indicator and Poverty Prevalence Indicator Combination Descriptors
- » Additional Socioeconomic Data
 - Percent of Population Below the Federal Poverty Level
 - Percent of Population Age 65 and Older Below the Federal Poverty Level

2. Evaluation of Single-Family Household Water Conservation Potential

- » Inefficient Toilet Stock Estimate
- » Estimate of Water Savings Potential via Inefficient Toilet Replacements
- » Water Conservation Impact on Water and Sewer Bills

The following are short descriptions and key findings related to each section of the assessment. More detailed information can be found in the body of the report.

¹ United States Department of Energy. (1992). Energy Policy Act of 1992. <https://www.afdc.energy.gov/pdfs/2527.pdf>

Water Affordability Assessment

Water affordability was assessed for Detroit at the census tract level using methods put forth in the 2019 paper by Raucher, et al., *Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector*.² These methods produce the Household Burden Indicator (HBI), Poverty Prevalence Indicator (PPI), and affordability descriptors that combine the HBI and PPI. Additional socioeconomic data are also presented to supplement the water affordability assessment.

Household Burden Indicator (HBI)

WHAT IT IS: The HBI is a measure of water affordability that divides the average annual cost of basic water service by the upper limit of the lowest income quintile (the highest income value of the lowest 20 percent of households in a specified geography). This focuses the affordability assessment on low-income households that may have difficulty paying their water and sewer bills.

WHAT WAS FOUND: Detroit has a city-wide HBI of 7.34, but a large range among census tracts. The minimum value found among census tracts was 1.54 and the maximum was 39.55. This means that at the city level, the cost of average indoor water use was at least 7.34 percent of annual income for households in the lowest income quintile in 2018, but it ranged from 1.54 to 39.55 percent among census tracts.



Poverty Prevalence Indicator (PPI)

WHAT IT IS: The Poverty Prevalence Indicator (PPI) is a measure of poverty within a given geography. This indicator is put forth by Raucher, et al., 2019 in addition to the HBI and can be calculated with data readily available from the U.S. Census Bureau. To calculate the PPI, the population below 200 percent of the federal poverty level (FPL) is divided by the population for whom poverty status is determined. In 2018 the federal poverty guideline (synonymous with poverty level) was \$20,780 for a 3-person household.

WHAT WAS FOUND: At the city level, the population below 200 percent of the federal poverty level in 2018 was estimated to be 415,795 and the population for whom poverty status was determined was 665,126. This calculates to a PPI of 62.51 for the city of Detroit, and fundamentally states that 62.51 percent of the population of Detroit has income that is below 200 percent of the federal poverty guideline. The minimum PPI value among Detroit census tracts was 13.09 and the maximum was 93.15.

2 Raucher, R., Clements, J., Rothstein, E., Mastracchio, J., & Green, Z. (2019). *Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector*. American Water Works Association, National Association of Clean Water Agencies, and Water Environment Federation.

Household Burden Indicator and Poverty Prevalence Indicator Combination Descriptors

WHAT IT IS: In addition to the HBI and PPI, Raucher, et al., 2019 present a matrix describing the level of water cost burdens based on a combination of the HBI and PPI. These descriptors put data into qualitative terms that may be easier to understand and communicate compared to ratios like the HBI and PPI. There are 5 descriptors based on the combination of HBI and PPI:

- 1 Low Burden
- 2 Moderate-Low Burden
- 3 Moderate-High Burden
- 4 High Burden
- 5 Very High Burden

WHAT WAS FOUND: The city-level HBI was calculated to be 7.34 and the PPI 62.51. This combination of HBI and PPI equates to a high burden for water and sewer costs. There is quite a bit of variability among census tracts, however. Only 2 percent of census tracts are classified as having a low burden, 3 percent as moderate-low burden, 35 percent as moderate-high burden, 44 percent as high burden, and 16 percent as a very high burden.



Additional Socioeconomic Data

Percent of Population Below the Federal Poverty Level

WHAT IT IS: While the PPI uses data related to the population that is 200 percent below the federal poverty level, this section also presents data measuring the percent of population in each census tract living below the federal poverty level.

WHAT WAS FOUND: At the city level, the population below the federal poverty level in 2018 was estimated to be 242,274 and the population for whom poverty status was determined was 665,126. This suggests that 36.43 percent of the population of Detroit lives below federal poverty level. The average poverty rate across the census tracts analyzed was 35.65. For comparison, the United States had a 2018 poverty rate of 14.05 percent, making Detroit's rate 2.59 times higher. The minimum poverty rate among Detroit census tracts in 2018 was 2.40 and the maximum was 75.30.

Percent of Population Age 65 and Older Below the Federal Poverty Level

WHAT IT IS: Elderly populations are particularly vulnerable if not financially secure. Water providers can utilize readily available U.S. Census Bureau data to gain insight into the prevalence of poverty among the elderly in their service area and identify where those populations are concentrated.

WHAT WAS FOUND: According to American Community Survey data, 19.94 percent of the population age 65 and older in Detroit, Michigan lived below the federal poverty level in 2018. This was more than twice the rate of 9.28 percent for the United States in 2018. There are some census tracts where a large portion of the population age 65 and older live below the federal poverty level. For 50 percent of the census tracts included in this assessment, 20 percent or more of the elderly population live in poverty.

Evaluation of Single-Family Household Water Conservation Potential

To evaluate water conservation potential for single-family households in Detroit, Michigan the remaining stock of inefficient toilets was calculated for each census tract. This was selected as the method because it is quantifiable with readily available data, and can be used to estimate savings with a higher degree of reliability than other water conservation measures. Knowing how many toilets there are by census tract and pairing it with an affordability assessment increase its usefulness and can help inform program design.

Inefficient Toilet Stock Estimate

WHAT IT IS: Detroit has an older housing stock, as many cities do. Homes built before 1994 (when the Energy Policy Act took effect) may still have older inefficient toilets that can be replaced. Inefficient toilets use 3.5 gallons per flush or greater, compared to the 1.28 gallons per flush of a WaterSense labeled high-efficiency toilet.

WHAT WAS FOUND: Based on this analysis, Detroit is estimated to have about 118,000 inefficient toilets remaining. Some tracts have more than others. The minimum census tract value was 3, the maximum value was 1,355, and the average was 407.

Estimate of Water Savings Potential via Inefficient Toilet Replacements

WHAT IT IS: The estimated stock of inefficient toilets was used to calculate the savings potential if all toilets were replaced.

WHAT WAS FOUND: If all the single-family inefficient toilets were replaced in Detroit, Michigan it would reduce indoor water use by an estimated 1,177 million gallons per year (MGY), or 1.18 billion gallons per year. While that is unlikely to occur anytime soon, it shows the potential for water use reductions in Detroit. Like inefficient toilet stocks, savings potential varied throughout the census tracts. The minimum estimate was 0.03 MGY, the maximum 13.58 MGY and the average of the census tracts was 4.05 MGY.



Water Conservation Impact on Water and Sewer Bills

WHAT IT IS: When customers are billed volumetrically for water and sewer service, like in Detroit, they can lower their bills by reducing their water use. In Detroit, a three-person household using 58.6 gallons per capita per day (gpcd) would have a monthly water and sewer bill of \$70.44. In 2018 every 1,000 gallons saved per month by a single-family household in Detroit, MI would have reduced the monthly household water bill by \$10.63.

WHAT WAS FOUND: In analyzing the bill impact of toilet replacements for the average household among the 291 census tracts, bill savings range from 7.26 to 16.17 percent with an average of 13.67 percent. This demonstrates that water conservation, in this case toilet replacements, can help lower water bills in a meaningful way. Homes with significant leaks will have high water bills and will benefit greatly from assistance programs.

Water affordability is a complex issue and involves both the cost of water and income. In Detroit, where there is a high level of poverty (2.59 times higher than the national rate), water and sewer customers have a high burden. However, the cost of water and sewer service is not above average when compared to other large cities in the United States. In a study including the 50 largest cities in the United States, Black and Veatch (2019) calculated the 50-city average combined water and sewer bill to be \$100 in 2018 (assumed 7,500 gallons used). A combined water and sewer bill based on 7,500 gallons used in Detroit, Michigan in 2018 would have been \$93.34, or 6.66 percent less than the reported average.

Affordability assessments can help water providers and communities quantify the financial impact the cost of water services has on households, particularly for lower-income customers. These assessments can provide insight into the magnitude of which customers are burdened by their water and sewer bills, and how that burden varies in both extent and geography. This can help determine the level of need for assistance programs and help with targeted outreach. Understanding conservation potential can help identify ways to help customers lower their bills. In addition to toilet and other fixture/appliance replacements, fixing leaks and education are critical components.

Introduction

The affordability of water and sewer service has become a prominent and pressing topic across the United States in recent years. Data collected by the American Water Works Association for its regular Water and Wastewater Rate Survey show that, between 1996 and 2018, water and wastewater charges have risen by 5.09 and 5.64 percent, respectively, compared to a 2.1 percent increase in the Consumer Price Index during the same period.³ The American Water Works Association adopted its first affordability policy statement on October 24, 2018.⁴ This statement acknowledges that low-income water customers may be burdened by the cost of water, even as utilities operate efficiently and sustainably, implement cost-effective water conservation measures, and prudently manage finances. AWWA recommends that utilities develop policies, programs, and procedures to reduce burdens on low-income customers that are feasible while maintaining the utility's financial stability.

Many water service providers in communities with low-income and other disadvantaged populations have already acted to create financial assistance programs. Detroit has several such programs, but the city's primary program for low-income water bill assistance is the Water Residential Assistance Program (WRAP), administered through the non-profit Wayne Metropolitan Community Action Agency. To qualify for assistance, participants must be at or below 150 percent of the federal poverty level. Approved customers receive a \$25 bill credit per month for 12 months. After making payments under this plan for 12 months, customers will have any past due balance frozen and will receive up to \$700 towards that balance. WRAP also offers water conservation audits to households that exceed 20 percent of average water consumption in the city and may provide up to \$1,000 in "water conservation and minor home plumbing repairs." Households that successfully participate in the plan for 12 months and that remain income-eligible can receive an additional 12 months of the \$25 bill credit and "financial assistance toward arrears up to \$700."⁵

Throughout the United States, there are other types of programs to assist customers in need. San Antonio Water System (SAWS) (San Antonio, Texas) runs its Uplift program with 14 different types of assistance to reduce bill burden for low-income and other customers requiring assistance. Recognizing that income status may not be the sole factor in determining need, SAWS offers assistance to senior citizens, people experiencing domestic violence, and people with disabilities.⁶ Portland Water Bureau (Portland, Oregon) has varied assistance offerings including yearly assistance vouchers for households experiencing temporary crises and assistance to renters in multi-family buildings, who are often overlooked in affordability programs because they do not receive a water bill in their own name.⁷ Prioritizing water affordability for a range of disadvantaged groups is a progressive strategy for addressing concerns throughout a community.



Many water service providers in communities with low-income and other disadvantaged populations have already acted to create financial assistance programs.

3 American Water Works Association. (2019). AWWA 2019 Water and Wastewater Rate Survey.

4 American Water Works Association. (2018). AWWA Policy Statement on Affordability.

5 Detroit Water & Sewerage Department. (2020). How Do I Keep My Water Flowing? <https://detroitmi.gov/departments/water-and-sewerage-department/bill-assistance-and-credits/how-do-i-keep-my-water-flowing>

6 San Antonio Water System. (2020). Uplift. <https://uplift.saws.org/>

7 Portland Water Bureau. (2020). Financial Assistance. <https://www.portlandoregon.gov/water/69504>

The question of how to quantify affordability is challenging, with little consensus developed despite extensive coverage and research by government agencies, national media, academia, and non-governmental organizations. Commonly cited in the United States is the Environmental Protection Agency's (EPA) calculation that the cost of combined water and sewer service should not exceed 4 to 4.5 percent of median household income (%MHI) in a given community.⁸ However, it has been pointed out that this figure was never intended to measure affordability at the household scale but rather to measure a utility's financial capability to institute combined sewer overflow management strategies.⁹ Furthermore, using a broad metric such as median household income as an indicator to determine affordability for individual households does not reflect the challenges faced by low-income customers, the likeliest to have trouble paying their bills. Despite these drawbacks, the EPA's %MHI indicator continues to represent a threshold for household-level water service affordability. Other indicators, however, have been proposed alongside %MHI to fill some of its perceived gaps.

The Affordability Ratio (AR) proposed by Teodoro (2018) is the "ratio of basic water and sewer costs to disposable household income for low-income customers." Removing what the author defines as "essential household expenses," including housing, food, and taxes, this metric compares the cost of water and sewer service to income remaining after other basic needs are accounted for. For a more focused analysis of low-income affordability, Teodoro recommends applying the AR equation to the lowest-income quintile for the service area. Teodoro proposes another metric for measuring household burden: HM, or, for a given service area, hours worked at the prevailing minimum wage required to pay for basic water and sewer service.⁸

The University of North Carolina's Water Affordability Assessment Tool uses a variety of data available from the U.S. Census Bureau, including income distributions, to evaluate the affordability of water for both average and low-income customers. This tool represents another alternative to the %MHI indicator.¹⁰

A 2017 report by the National Academy of Public Administration and the U.S. Environmental Protection Agency titled, *Developing a New Framework for Community Affordability of Clean Water Services*, critiqued the %MHI indicator and provided recommendations to improve on it, but did not specifically offer new methods.¹¹ A 2019 report prepared for AWWA, the National Association of Clean Water Agencies, and the Water Environment Federation titled, *Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector* sought to develop and offer a new framework for assessing household affordability.¹ The Household Burden Indicator (HBI) and Poverty Prevalence Indicator (PPI) were part of the recommended methods in the 2019 report and are used in this assessment of water service affordability in Detroit, Michigan.



8 U.S. Environmental Protection Agency. (1997). Combined Sewer Overflows — Guidance for Financial Capability Assessment and Schedule Development.

9 Teodoro, M. P. (2018). Measuring household affordability for water and sewer utilities. *Journal-American Water Works Association*, 110(1), 13-24.

10 University of North Carolina Environmental Finance Center. (2020). Water and Wastewater Residential Rates Affordability Assessment Tool. <https://efc.sog.unc.edu/resource/water-and-wastewater-residential-rates-affordability-assessment-tool>

11 National Academy of Public Administration and the U.S. Environmental Protection Agency. (2017). *Developing a New Framework for Community Affordability of Clean Water Services*.

As North America's only national non-profit specifically dedicated to promoting water conservation and efficiency, the Alliance for Water Efficiency (AWE) has conducted multiple research projects demonstrating that water conservation helps keep bills lower for not only customers that directly reduce their consumption, but all rate payers. It has been demonstrated that customer bills are lower than they would have been without conservation in Westminster, Colorado, Tucson, Arizona, Gilbert, Arizona, and Los Angeles, California.^{12,13,14,15}

Water conservation can help reduce the financial burden of water service costs for customers across the entire income spectrum. At the same time, reducing water use can have other benefits, such as increased community resiliency to water scarcity events, reduction in energy used to treat and supply water, and maintenance of environmental flows for flora and fauna.

Water conservation and efficiency help with water affordability in at least two ways:

1. Direct bill reductions for customers who reduce water use (assuming they are billed volumetrically), and;
2. Using collective water resources efficiently and potentially avoiding large costs for water system expansion or acquiring new supplies. If water use can be reduced for less than the cost of expansion and new supply development, then all rate payers benefit with lower bills. Rates will likely increase over time, but will rise less as a result of cost-effective water conservation implementation.

This report documents an assessment of water affordability and water conservation potential at the census tract level for Detroit, Michigan. It asserts that water savings achieved through replacing inefficient fixtures can generate meaningful and permanent bill reductions.



Water conservation can help reduce the financial burden of water service costs for customers across the entire income spectrum.

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- 12 Alliance for Water Efficiency. (2013). Conservation Helps Limit Rate Increases for a Colorado Utility. https://www.financingsustainablewater.org/sites/www.financingsustainablewater.org/files/resource_pdfs/AWE-Colorado-Article-FINAL-%28Ver7%29.pdf
 - 13 Alliance for Water Efficiency. (2017). Water Conservation Keeps Rates Low in Tucson, Arizona. https://www.financingsustainablewater.org/sites/www.financingsustainablewater.org/files/resource_pdfs/Final_AWE_tucson_cosnrates-az-web3.pdf
 - 14 Alliance for Water Efficiency. (2017). Water Conservation Keeps Rates Low in Gilbert, Arizona. https://www.financingsustainablewater.org/sites/www.financingsustainablewater.org/files/resource_pdfs/FINAL_AWE_gilbert-consrates-az-web2.pdf
 - 15 California Water Efficiency Partnership and the Alliance for Water Efficiency. (2018). Lower Water Bills: The City of Los Angeles Shows How Water Conservation and Efficient Water Rates Produce Affordable and Sustainable Use. https://www.financingsustainablewater.org/sites/www.financingsustainablewater.org/files/resource_pdfs/LADWP_Rates_Conservation_1.pdf

Overview of Data and Methods

This assessment of water affordability and conservation potential in Detroit, Michigan uses publicly available data from the United States Census Bureau, water and sewer rates from the Detroit Water and Sewerage Department, and references findings of the Water Research Foundation's 2016 Residential End Uses of Water study. Data were gathered from the American Community Survey 5-Year Data for 2018. Detroit water and sewer rates and charges from 2018-2019 were used to match to the year of the census data.

This assessment is at the census-tract level and is intended to take a more granular view of water affordability than a city-level assessment. There were 291 census tracts included in the analysis. Six census tracts were eliminated due to insufficient data. The reader may also notice a group of census tracts in the center of maps that are not included. This is technically not part of the city of Detroit but is made up of the cities of Highland Park and Hamtramck.

This analysis focuses on single-family households, because multifamily customers are rarely metered and billed individually.

Data are displayed in tables, histograms, and choropleth maps throughout this report.¹⁶ When there is a histogram and map presenting the same data, the values in the histogram bins and map legend intervals are identical.

In order to reduce clutter in the histograms and maps, the authors elected to leave out the less than (<), equal to (=), and greater than (>) symbols. For example, in Figure 1, the first histogram bin is 1-3, and the second bin is 3-5. The second bin includes values greater than 3, and less than or equal to 5 (>3<=5). This logic is applied to all histogram bins and map intervals. That is, the first number in a range should have ">" in front of it and the second number in a range should have "<=" in front of it.

Census tract shapefiles were obtained from U.S. Census Bureau TIGER/Line Shapefiles dataset and were clipped using a city of Detroit boundary shapefile obtained from the City of Detroit Open Data Portal.^{17,18}



16 Choropleth maps use shading, patterns, or symbols to display data for specified geographic areas. In this report the geographic area referenced is the census tract, and graduated colors are used to represent data ranges and geographic variability.

17 City of Detroit Open Data Portal. <https://data.detroitmi.gov/>

18 U.S. Census Bureau TIGER/Line Shapefiles. <https://www.census.gov/geographies/mapping-files/time-series/geo/tiger-line-file.2018.html>

Water Affordability Assessment in Detroit, Michigan

The primary methods employed in this paper to assess water affordability in Detroit, Michigan utilize indicators put forth by Raucher, et al. in the 2019 report, *Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector*.¹ Specifically, this assessment calculates the Household Burden Indicator (HBI), Poverty Prevalence Indicator (PPI), and assigns affordability descriptors created by the authors that combine the HBI and PPI. These indicators and descriptors are calculated for 291 census tracts in the city of Detroit, Michigan. Additionally, this report presents U.S. Census Bureau data related to poverty rates, and poverty rates among the population age 65 and older.

Household Burden Indicator

The Household Burden Indicator (HBI) described by Raucher, et al., 2019 is a metric that provides insight into water affordability for lower-income households. It was selected for this analysis, in part, because it offers the ability to calculate unique values for each census tract which provides greater insight than a service area, or city-level, assessment. The HBI is defined as, “basic water service costs (combined) as a percent of the 20th percentile household income (i.e., the Lowest Quintile of Income (LQI) for the Service Area).”²

More specifically, the HBI divides the average basic cost of water and sewer service by the upper limit of the lowest income quintile (the highest income value of the lowest 20 percent of households in a specified geography). Because the value representing the lowest income quintile is the upper limit, it is important to note that many households in the lowest income quintile will have a higher burden than what is indicated by the HBI. For example, an HBI of 7 would suggest that the cost of water and sewer services for households in the lowest income quintile represents 7 percent of their annual income, or greater.

Expressed another way:

$$HBI = \frac{\text{Total Annual Basic Water Sector Household Cost}}{\text{Upper Boundary of the Lowest Quintile Income}}$$

To calculate the HBI for each census tract the average annual household cost for water and sewer services was estimated for each census tract. This required estimating the average household consumption for each census tract, calculating costs based on Detroit Water & Sewerage Department (DWSD) rates and charges, and downloading income quintile data from the U.S. Census Bureau.

Average daily household water consumption was calculated by using persons per household (PPH) data for each census tract multiplied by 58.6 gallons, which was the average indoor gallons per capita per day (gpcd) in the Water Research Foundation’s 2016 Residential End Uses

of Water study.^{19,20} Persons per household were calculated by dividing census tract population by the number of occupied housing units. Because this assessment focuses on single-family households, the team did calculate single-family PPH, but the results included extremely high values (e.g., PPH>20) for several tracts. Because of these anomalies, total tract population and total occupied housing units were used to calculate PPH. Daily water use was converted to monthly by multiplying by the average number of days per month (30.42).

$$\text{Census Tract Estimated Average Monthly Single-Family Household Indoor Water Use} = 58.6 * \text{Census Tract PPH} * 30.42$$

As previously mentioned, the U.S. Census Bureau data used for this assessment were from the 2018 American Community Survey 5-Year Data. Data representing water and sewer rates and charges were from 2018 - 2019 for DWSD and are displayed in Table 1.

DWSD 2018-2019 Water and Sewer Rates and Charges

Water:

\$24.71 per 1,000 Cubic Feet (\$3.30/1,000 gallons)

\$7.30 - Monthly Meter Charge 5/8" Meter

Sewer:

\$54.84 per 1,000 Cubic Feet (\$7.33/1,000 gallons)

\$6.28 - Service Charge per bill

Table 1: *Water and Sewer Rates for Detroit DWSD Customers: 2018-2019*²¹

At the city level, the upper limit of the lowest income quintile in 2018 was \$10,120 and the PPH was 2.55. This calculates to an HBI of 7.34. Census tract-level values reveal a high degree of variability throughout the city. The minimum HBI value was 1.54, the maximum was 39.55, and the average of the 291 tracts was 8.11. Table 2 contains summary statistics related to the census tract-level HBI assessment. The lowest census tract-level HBI was 1.54, which suggests the cost of water and sewer service is rather insignificant as a portion of total income. However, one census tract had an HBI of 39.55 which would suggest the cost of water and sewer service represents an exceptionally high burden.

19 DeOreo, W. B., Mayer, P. W., Dziegielewski, B., & Kiefer, J. (2016). Residential end uses of water, version 2. Water Research Foundation.

20 Raucher, et al. 2019 and Teodoro, M. 2018 use 50 gpcd to represent indoor water use for affordability analysis.

21 Water and Sewer Rates for Detroit DWSD customers: 2018-2019. https://detroitmi.gov/sites/detroitmi.localhost/files/2018-10/Water%20Rate%20Card%202018-19_Detroit_Retail_Rates_COD_07312018_WEB.pdf

Census Tract-Level HBI Summary Statistics

Min	1.54
Max	39.55
Average	8.11
Median	7.67
Standard Deviation	4.69
Total Census Tracts	291

Table 2: Census Tract-Level HBI Summary Statistics in Detroit, MI

Figure 1 shows a histogram of HBIs by census tract, and Figure 2 illustrates the same data presented in a map. The largest group of census tracts (127 tracts or 44 percent) has an HBI of 7-10. Sixty percent of census tracts have an HBI of 7 or greater. Forty-six census tracts (16 percent) have an HBI greater than 10. There are 5 census tracts with an HBI greater than 25. The average cost of water in those census tracts is equal to at least 25 percent of the annual income for households in the lowest income quintile.

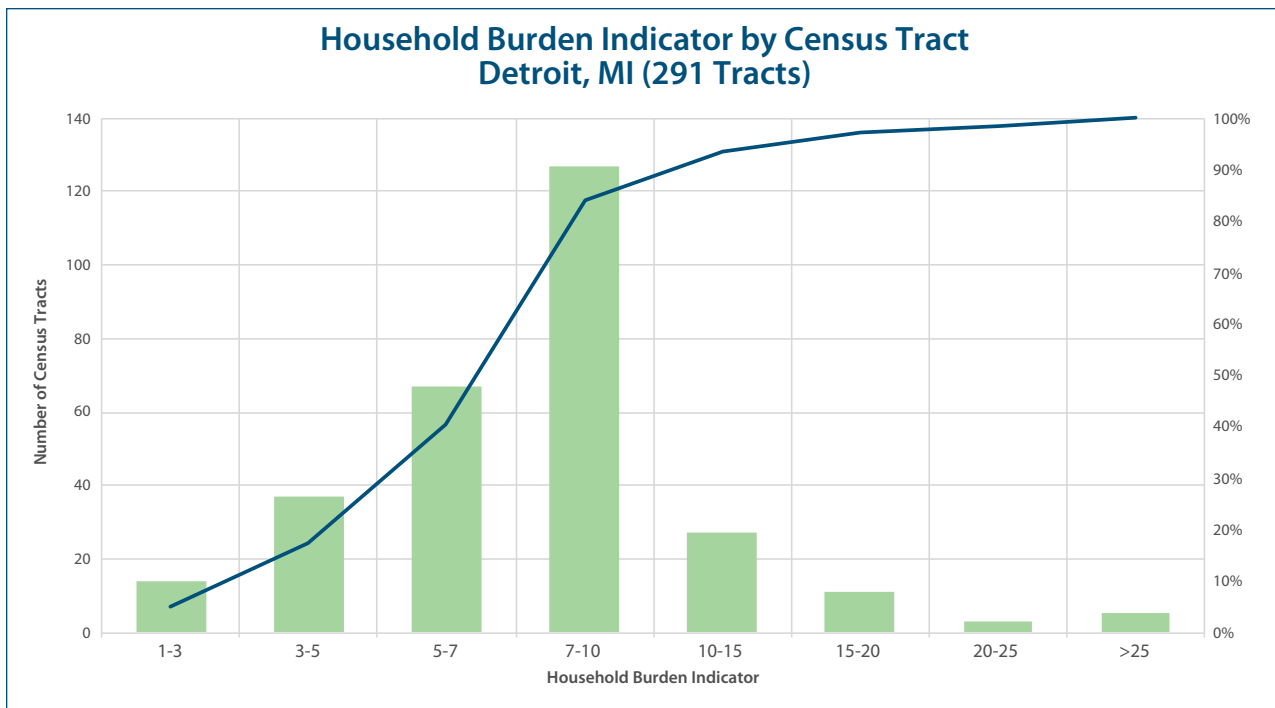


Figure 1: Household Burden Indicator Calculated by Census Tract, Detroit, MI

Figure 2 contains a map of census tract HBIs throughout the city of Detroit, Michigan. The map legend contains intervals that correspond to the bins in Figure 1. The darker the color, the higher the HBI. The histogram and map tell a much different story than the city-level HBI value of 7.34. Calculating the HBI at the census tract-level provides a range and distribution of the data. The map illustrates the geographic distribution and variability. For example, the histogram shows there are 5 census tracts that have an HBI greater than 25, and the map shows where those tracts are located in Detroit.

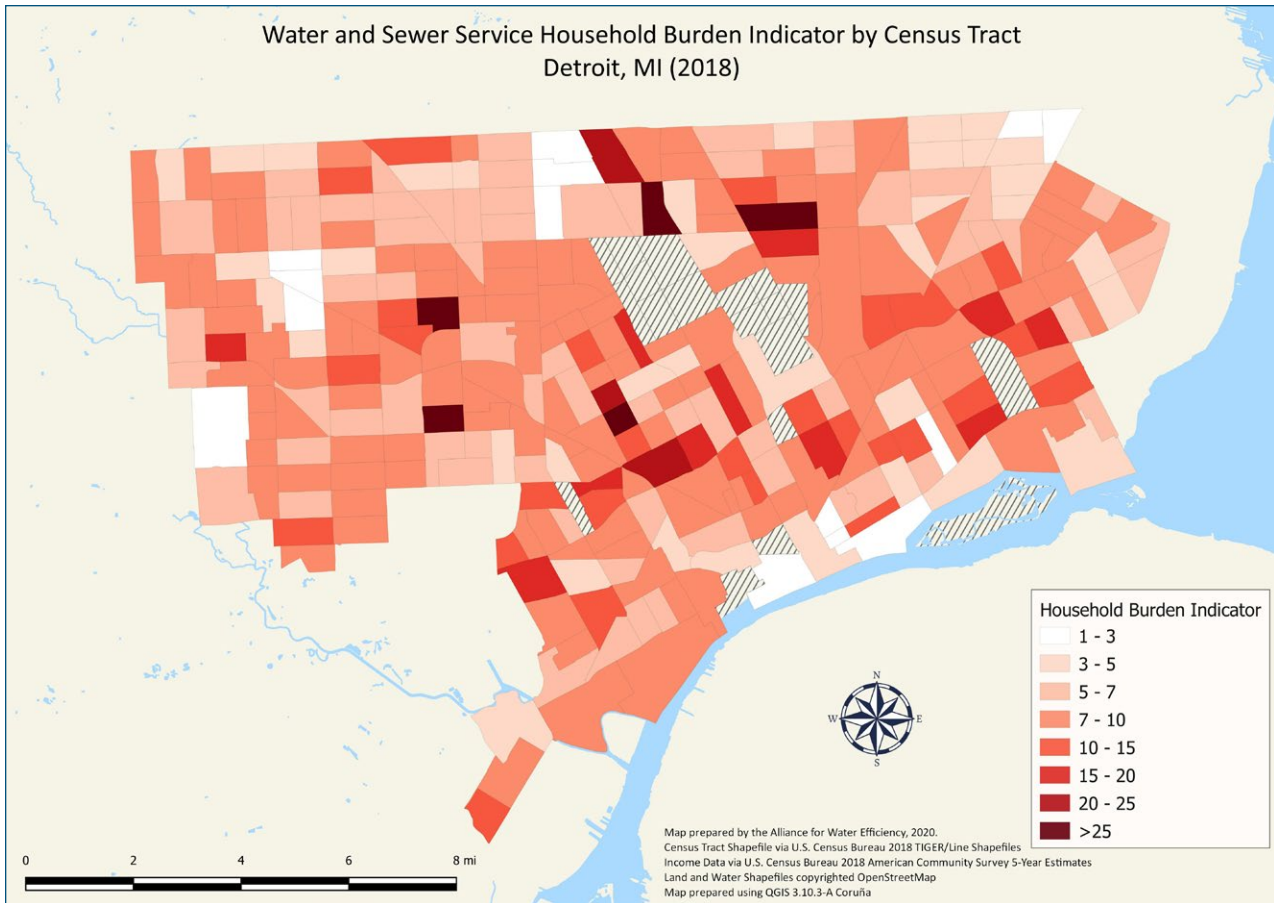


Figure 2: Map Showing the Household Burden Indicator by Census Tract in Detroit, MI

Poverty Prevalence Indicator

The Poverty Prevalence Indicator (PPI) is a measure of poverty within a given geography. This indicator is put forth by Raucher, et al., 2019 in addition to the HBI and can be calculated with data readily available from the U.S. Census Bureau. To calculate the PPI, the population below 200 percent of the federal poverty level (FPL) is divided by the population for whom poverty status is determined. According to Raucher, et al. 2019, many assistance programs use 150 or 200 percent of the FPL to determine eligibility. Detroit’s Water Residential Assistance Program (WRAP) uses 150% of Federal Poverty Guideline to determine eligibility. Detroit has a high rate of poverty as is illustrated in Figures 3 and 4, and again in Figures 7 through 10.

$$PPI = \frac{\text{Population Below 200\% of FPL}}{\text{Population for Whom Poverty Status is Determined}}$$

Terminology around federal poverty delineations can be confusing. Officially, there are federal poverty guidelines, and federal poverty thresholds. The term federal poverty level is often used to refer to the poverty guidelines, but according to the U.S. Department of Health and Human Services (the government organization charged with issuing poverty guidelines and poverty thresholds), “The poverty guidelines are sometimes loosely referred to as the “federal poverty level” (FPL), but that phrase is ambiguous and should be avoided, especially in situations (e.g., legislative or administrative) where precision is important.”²²

That said, the U.S. Census Bureau classifies data as federal poverty level, which is seemingly a reference to the federal poverty guidelines. To give perspective to the PPI as it is calculated in this report, the 2018 federal poverty guidelines are presented in Table 3.

2018 U.S. Federal Poverty Guidelines	
Persons Per Household	Poverty Guideline
1	\$ 12,140
2	\$ 16,460
3	\$ 20,780
4	\$ 25,100
5	\$ 29,420
6	\$ 33,740
7	\$ 38,060
8	\$ 42,380

Table 3: 2018 Federal Poverty Guidelines²³

At the city level, the population below 200 percent of the federal poverty level in 2018 was estimated to be 415,795 and the population for whom poverty status was determined was 665,126. This calculates to a PPI of 62.51 for the city of Detroit, and fundamentally states that 62.51 percent of the population of Detroit has income that is below 200 percent of the federal poverty guideline. The average PPI across the 291 census tracts analyzed is 63.59. For comparison, the United States had a 2018 PPI of 31.91. The city of Detroit’s PPI is almost double the U.S. value. The minimum PPI value among Detroit census tracts was 13.09 and the maximum was 93.15. Table 4 contains summary statistics related to the census tract-level PPI assessment.

22 U.S. Department of Health and Human Services. (January 2020). 2020 Poverty Guidelines. <https://aspe.hhs.gov/2020-poverty-guidelines>

23 Federal Register Vol. 83, No. 12. (January 2018). Department of Health and Human Services: Annual Update of the HHS Poverty Guidelines. <https://www.govinfo.gov/content/pkg/FR-2018-01-18/pdf/2018-00814.pdf>

Census Tract-Level PPI Summary Statistics

Min	13.09
Max	93.15
Average	63.59
Median	65.14
Standard Deviation	14.55
Total Census Tracts	291

Table 4: *Census Tract-Level PPI Summary Statistics in Detroit, MI*

Figure 3 shows a histogram of calculated PPIs for each of the 291 census tracts. Two hundred fifty-two (87 percent) of Detroit’s census tracts have a PPI of 50 or greater, with the largest number of census tracts having a PPI of 50-75. There are 56 (19 percent) census tracts with a PPI of greater than 75.

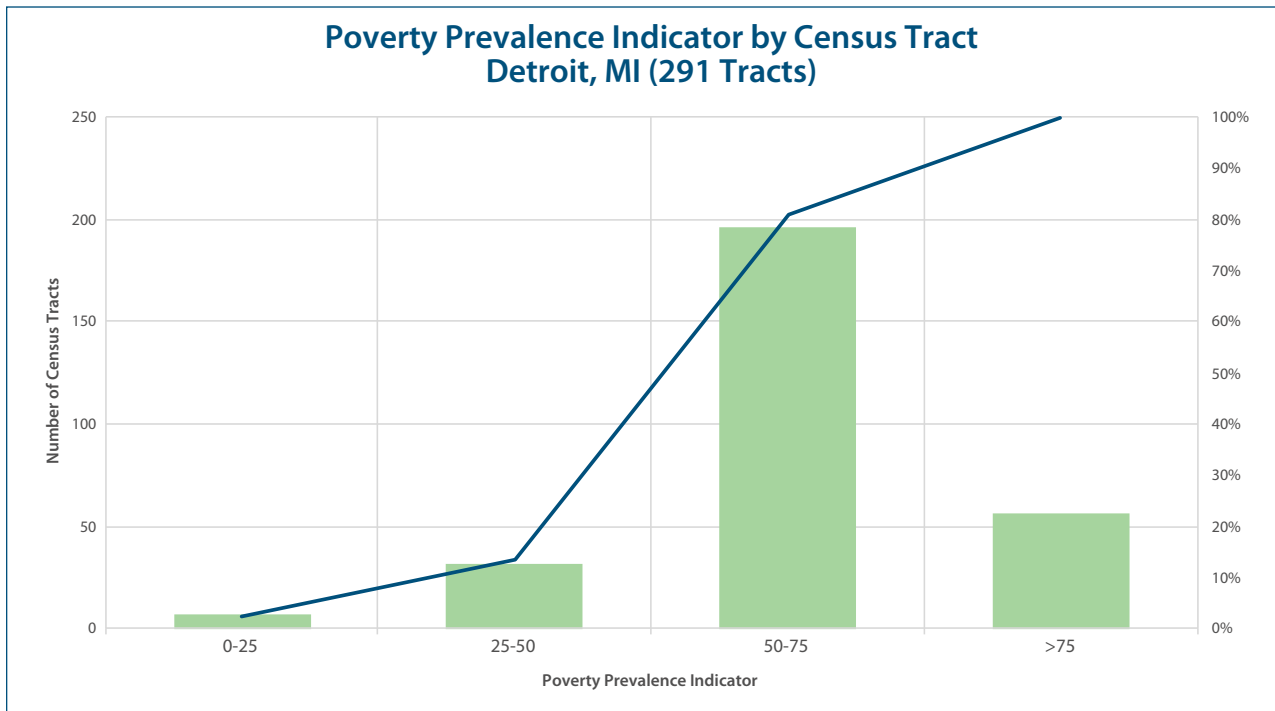


Figure 3: *Poverty Prevalence Indicator Calculated by Census Tract, Detroit, MI*

Figure 4 contains a map of census tract PPI ranges. There are four ranges that get progressively darker in color as values increase. As is suggested by Figure 3, 67 percent of the census tracts on the map are assigned the color of the 50 to 75 PPI range. Figure 4 is an unattractive map, as it should be, given the alarming data it is representing.

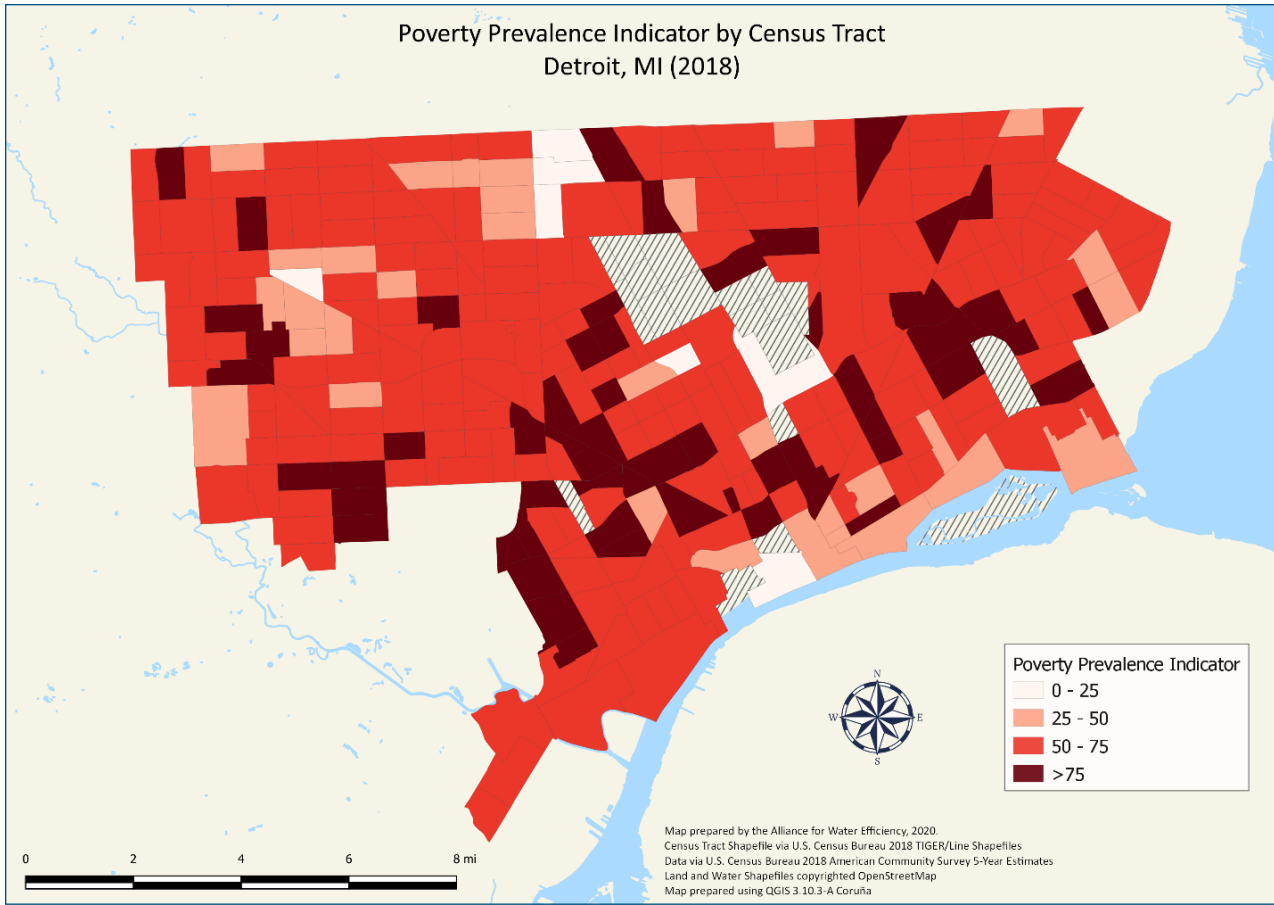


Figure 4: Map Showing the Poverty Prevalence Indicator by Census Tract in Detroit, MI

Household Burden Indicator and Poverty Prevalence Indicator Combination Descriptors

In addition to the HBI and PPI, Raucher, et al., 2019 present a matrix describing the level of water cost burdens based on a combination of the HBI and PPI. While not perfect, these descriptors put data into qualitative terms that may be easier to understand and communicate compared to ratios like the HBI and PPI. There are 5 descriptors based on the combination of HBI and PPI:

- 1 Low Burden
- 2 Moderate-Low Burden
- 3 Moderate-High Burden
- 4 High Burden
- 5 Very High Burden

Table 5 contains the matrix which was adapted from the report, *Developing a New Framework for Household Affordability and Financial Capability Assessment in the Water Sector*. Color shading was added to denote the different categories. The colors correspond to the map displayed in Figure 6.

HBI: Water Costs as a Percent of Income at LQI	PPI: Percent of Households Below 200% of FPL		
	≥ 35%	20 - 35%	< 20%
≥ 10%	Very High Burden	High Burden	Moderate-High Burden
7 - 10%	High Burden	Moderate-High Burden	Moderate-Low Burden
< 7%	Moderate-High Burden	Moderate-Low Burden	Low Burden

Table 5: Water Affordability Matrix Combining HBI and PPI. Table Adapted from Raucher, et al. 2019

The city-level HBI was calculated to be 7.34 and the PPI 62.51. Using the matrix provided in Table 5, this would suggest the city of Detroit has a high burden when it comes to water and sewer costs. Figures 5 and 6 illustrate how this varies throughout the 291 census tracts in this assessment. Based on this matrix, only six census tracts (2 percent) are classified as having a low burden, 9 (3 percent) as moderate-low burden, 103 (35 percent) as moderate-high burden, 127 (44 percent) as high burden, and 46 (16 percent) as a very high burden.

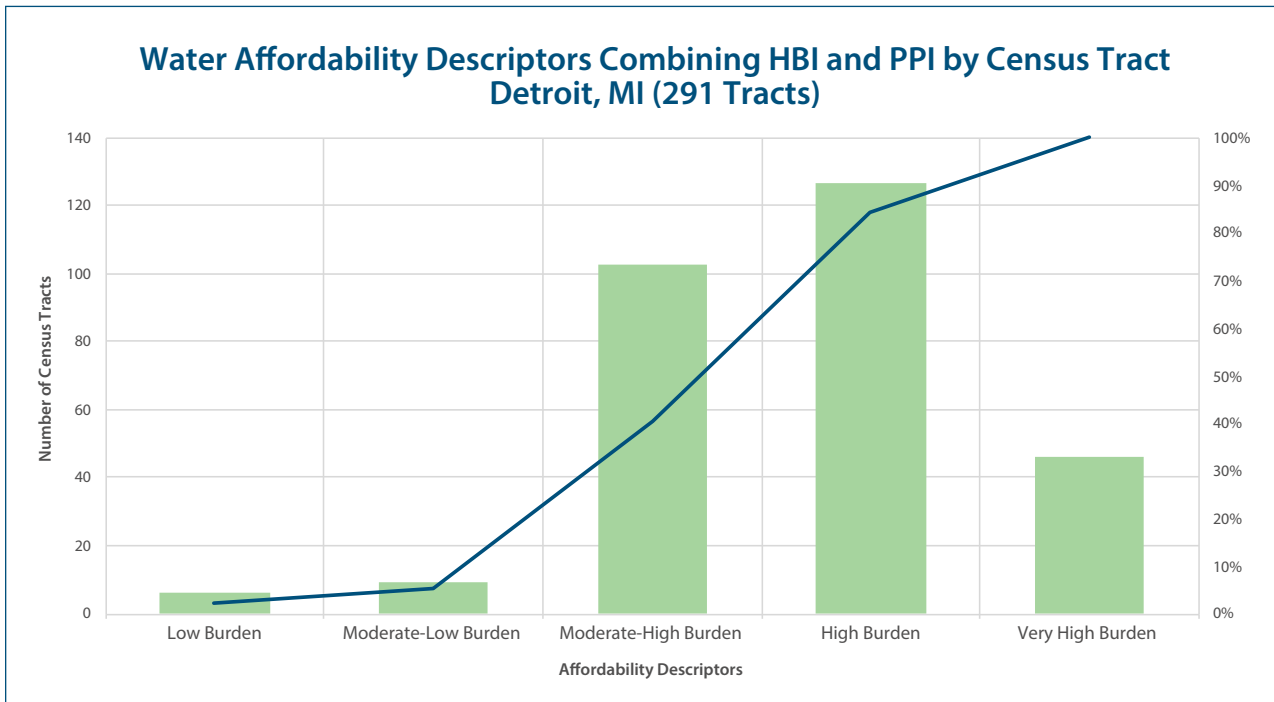


Figure 5: Water Affordability Descriptors Combining HBI and PPI in Detroit, MI

Figure 6 contains a map of the water affordability descriptors that combine the HBI and PPI. It shows how water affordability burdens vary throughout the city of Detroit and presents a geographic distribution of the data displayed in Figure 5.

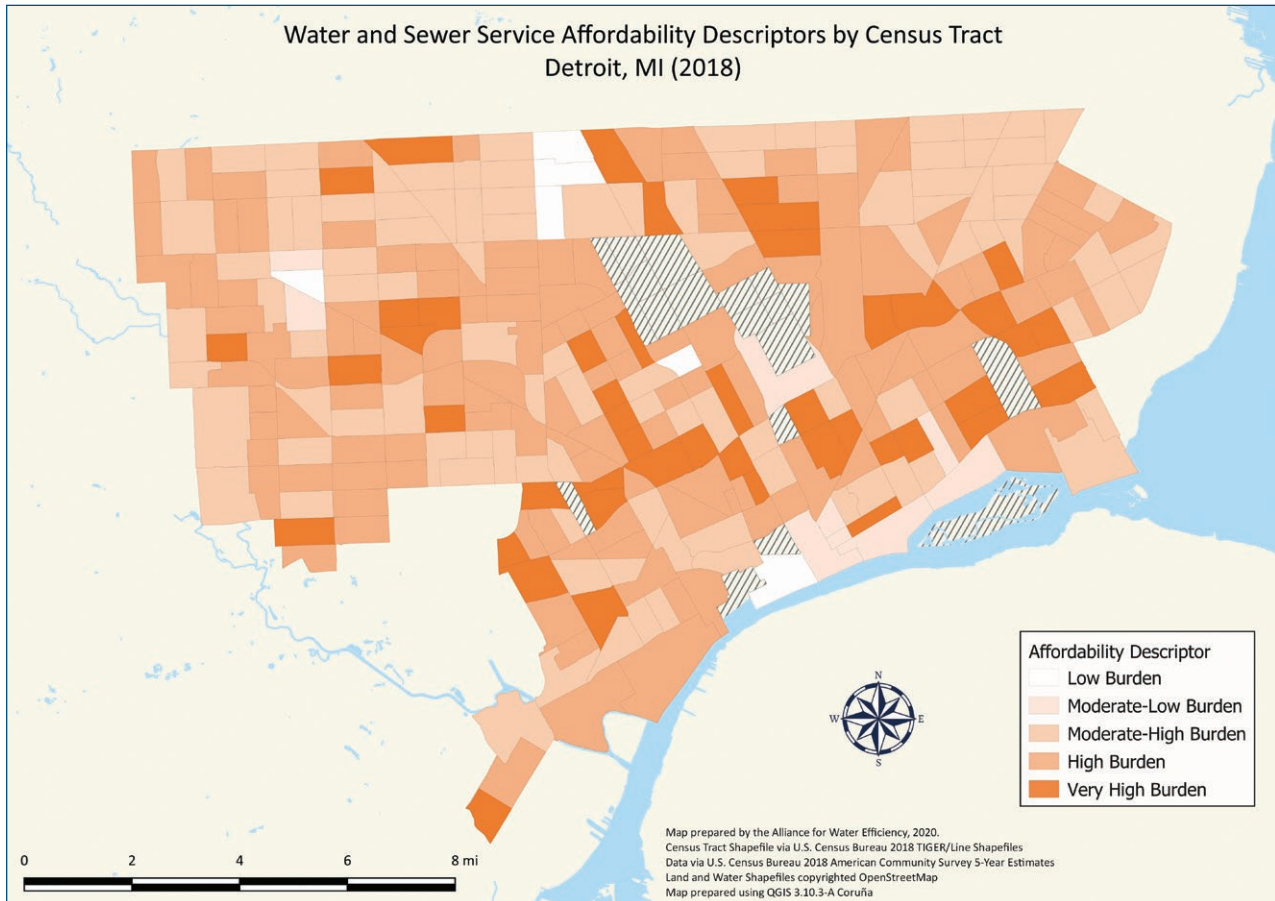


Figure 6: Map of Water Affordability Descriptors Combining HBI and PPI in Detroit, MI

Additional Socioeconomic Data

This section contains information related to the percent of population below the federal poverty level and percent of population age 65 and older below the federal poverty level. This is intended to provide additional insight into economic conditions in Detroit and better understand the financial state of elderly populations.

Percent of Population Below the Federal Poverty Level

While the PPI uses data related to the population that is 200 percent below the federal poverty level, this section also presents data measuring the percent of population in each census tract living below the federal poverty level. Documenting the rate of poverty is illustrative and helps provide an understanding of the economic conditions in Detroit, Michigan. It is important to note that this uses population-based data and not household-level data. Some of these individuals may not be living in single-family homes that are billed directly for water and sewer services.

At the city level, the population below the federal poverty level in 2018 was estimated to be 242,274 and the population for whom poverty status was determined was 665,126. This suggests that 36.43 percent of the population of Detroit lives below federal poverty level. The average poverty rate across the 291 census tracts analyzed is 35.65. For comparison, the United States had a 2018 poverty rate of 14.05 percent, making Detroit's rate 2.59 times higher. The minimum poverty rate among Detroit census tracts in 2018 was 2.40 and the maximum was 75.30.

Figure 7 displays census tract poverty rates in a histogram. Over 90 percent of census tracts in Detroit have a poverty rate greater than the national average of 14.05 percent. Seventy percent of census tracts in Detroit have a poverty rate greater than 30.

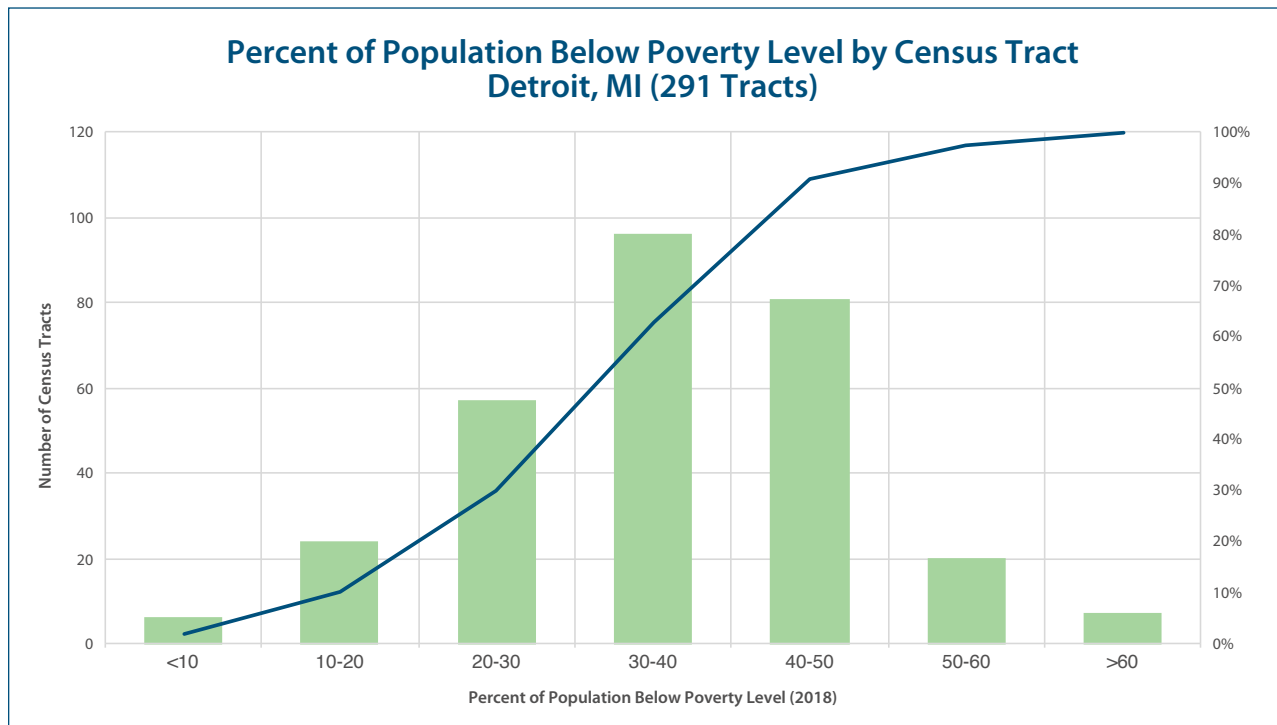


Figure 7: Percent of Population Below Poverty Level by Census Tract Detroit, MI

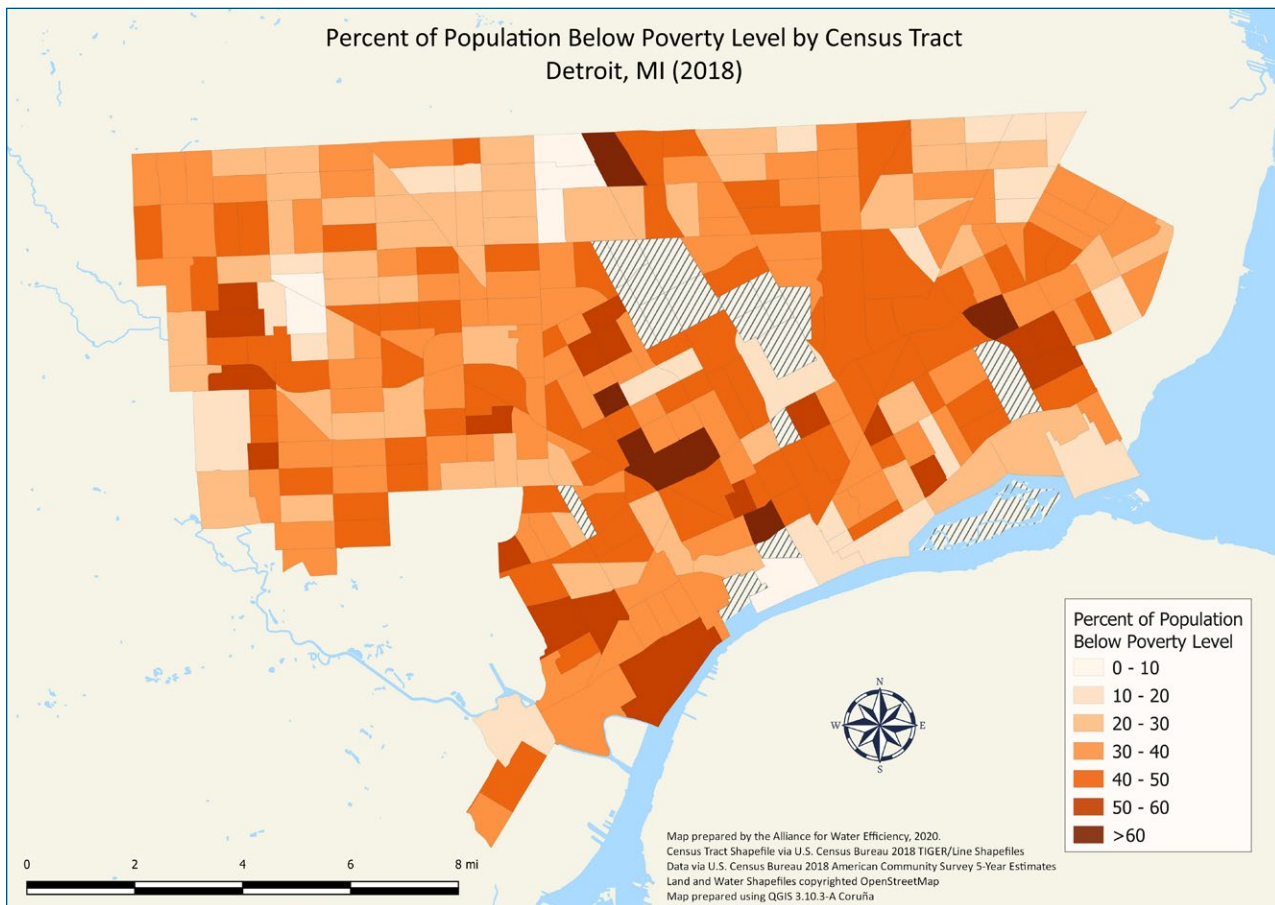


Figure 8: Map Showing the Percent of Population Below Poverty Level by Census Tract Detroit, MI

Percent of Population Age 65 and Older Below the Federal Poverty Level

Elderly populations are particularly vulnerable if not financially secure. Water providers can utilize readily available U.S. Census Bureau data to gain insight into the prevalence of poverty among the elderly in their service area and identify where those populations are concentrated. In this section, data is used to illustrate the prevalence of poverty among individuals age 65 and older. It is important to note that this uses population-based data and not household-level data. Some of these individuals may not be living in single-family homes that are billed directly for water and sewer services. They may be living in master metered apartment buildings, public housing, or assisted living centers.

According to American Community Survey data for 2018, 19.94 percent of the population age 65 and older in Detroit, Michigan lived below the federal poverty level. This was more than twice the rate of 9.28 percent for the United States in 2018. Table 6 contains summary statistics in Detroit pertaining to the percent of the population age 65 and older that are below the federal poverty level in each census tract. The minimum value was 0 (8 census tracts) and the maximum was 61.33.

A key takeaway from this data is that Detroit's population age 65 and older has more than twice the level of poverty than the population of the United States. There are some census tracts where

a large portion of the population age 65 and older live below the federal poverty level. For 50 percent of the census tracts included in this assessment, 20 percent or more of their elderly population live in poverty.

Data related to the percent of population age 65 and older below the federal poverty level by census tract are displayed in Table 6, Figure 9, and Figure 10.

Percent of Population Age 65 and Older Below Federal Poverty Level	
Min	0.00
Max	61.33
Average	21.91
Median	19.83
Standard Deviation	13.71
Total Census Tracts	291

Table 6: Summary Statistics of Percent of Population Age 65 and Older Below Poverty Level by Census Tract in Detroit, MI

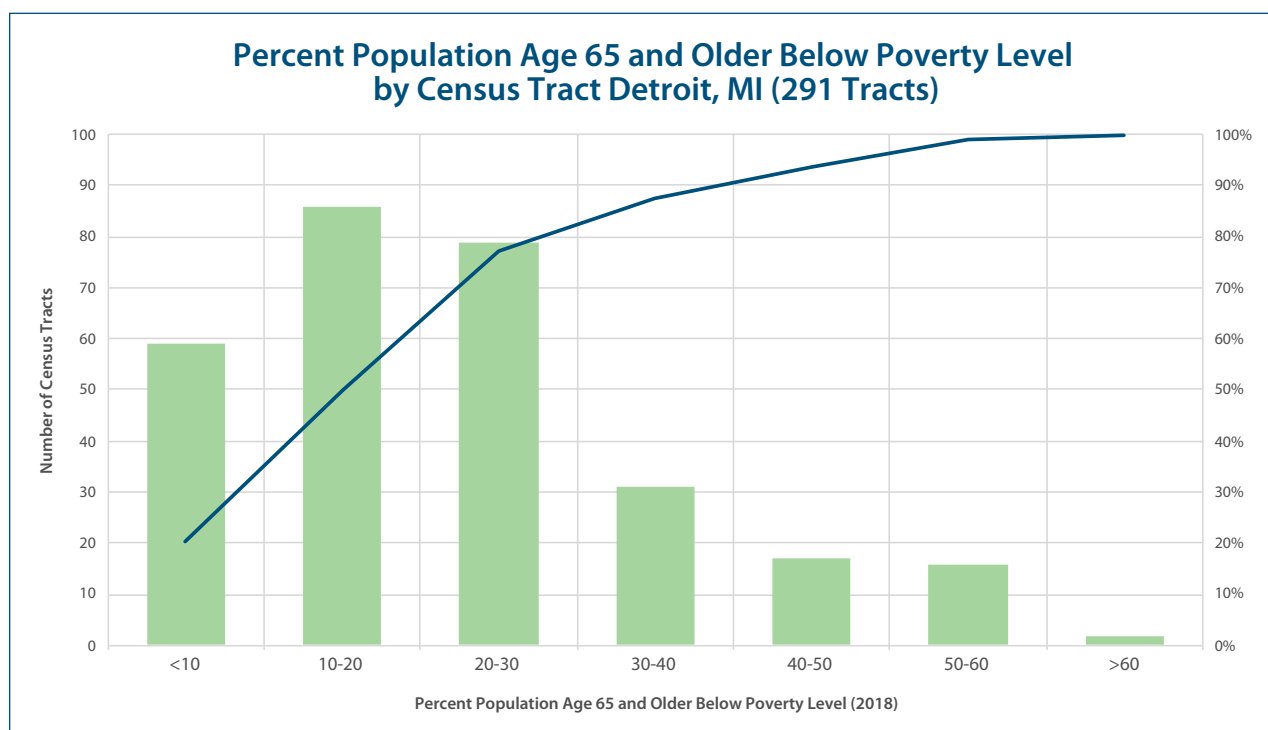


Figure 9: Percent Population Age 65 and Older Below Poverty Level in Detroit, MI

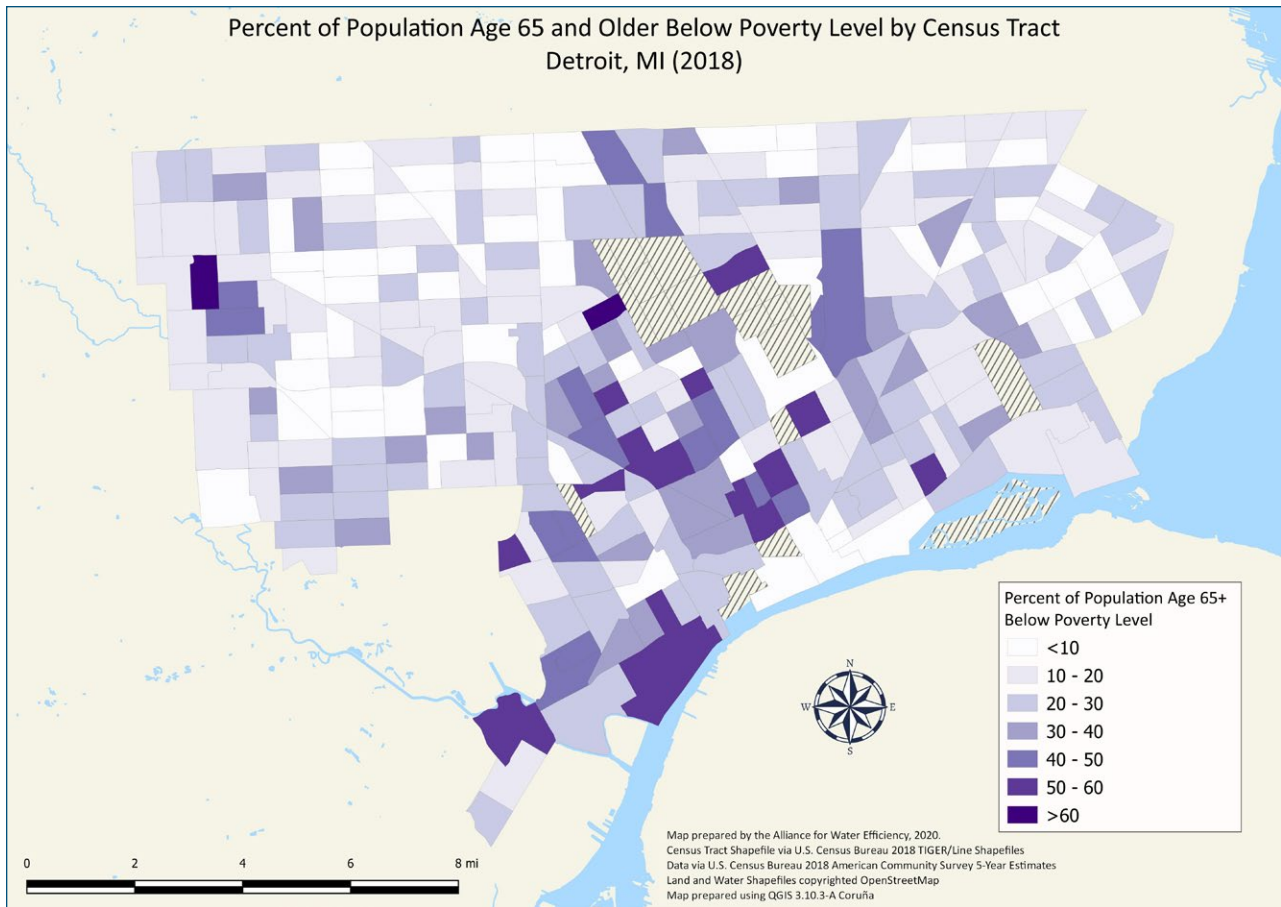


Figure 10: Map Showing the Percent of Population Age 65 and Older Below the Federal Poverty Level by Census Tract in Detroit, MI

Evaluation of Single-Family Household Water Conservation Potential in Detroit, Michigan

To evaluate water conservation potential for single-family households in Detroit, Michigan the remaining stock of inefficient toilets was calculated for each census tract. This was selected as the method because it is quantifiable with readily available data and can be used to estimate savings with a higher degree of reliability than other water conservation measures. Additionally, there are a large number of homes in Detroit built before the Energy Policy Act of 1992 took effect (1994). After 1994 the maximum flush volume for residential toilets became 1.6 gallons. Before 1994 toilet flush volumes were 3.5 gallons or greater. Replacing old inefficient toilets is one of the most cost-effective and certain ways to reduce indoor water use in the residential sector. It is also a theoretically permanent change as all future toilet replacements will continue to be efficient due to the Energy Policy Act's 1.6 gallon per flush standard. This section describes the methods and results for estimating the inefficient toilet stock, and the theoretical savings potential if all inefficient toilets were replaced. Having an estimate of the number of inefficient toilets remaining in the city of Detroit is valuable information. Knowing where those toilets are and pairing it with an affordability assessment increase its usefulness and can help inform program design. This section also looks at the potential impact of water conservation on customer bills.



Inefficient Toilet Stock Estimate

The project team utilized housing data from the U.S. Census Bureau's 2018 American Community Survey to estimate the stock of inefficient toilets in single-family homes for each census tract. Summing each of the 291 tracts resulted in a city-wide estimate of 118,526 remaining inefficient toilets in single-family households.

The number of inefficient toilets remaining in each census tract was calculated using the following steps:

- » Estimate the percent of occupied housing units that are single family by census tract.
- » Estimate the number of occupied housing units built before 1994 by census tract.
- » Multiply the percent of occupied housing units that are single family by the number of occupied housing units built before 1994 for each census tract.
- » Determine the average number of toilets per single-family housing unit. (This was a city-level estimate and was calculated to be 2.03 using 2017 American Housing Survey Data, which is the latest release as of this writing.)
- » Multiply the average number of toilets per single-family housing unit by number of occupied single-family housing units built before 1994 to estimate the installed base of inefficient toilets in 1994.

- » Apply an annual replacement rate of 4 percent to the installed base of inefficient toilets starting in 1994 through 2020.

As the age of housing and the number of housing units vary by census tract, so do the number of remaining inefficient toilets. Figure 11 contains a histogram showing inefficient toilet stock data at the census-tract level in five bins. The minimum value was 3, the maximum value was 1,355 and the average was 407.

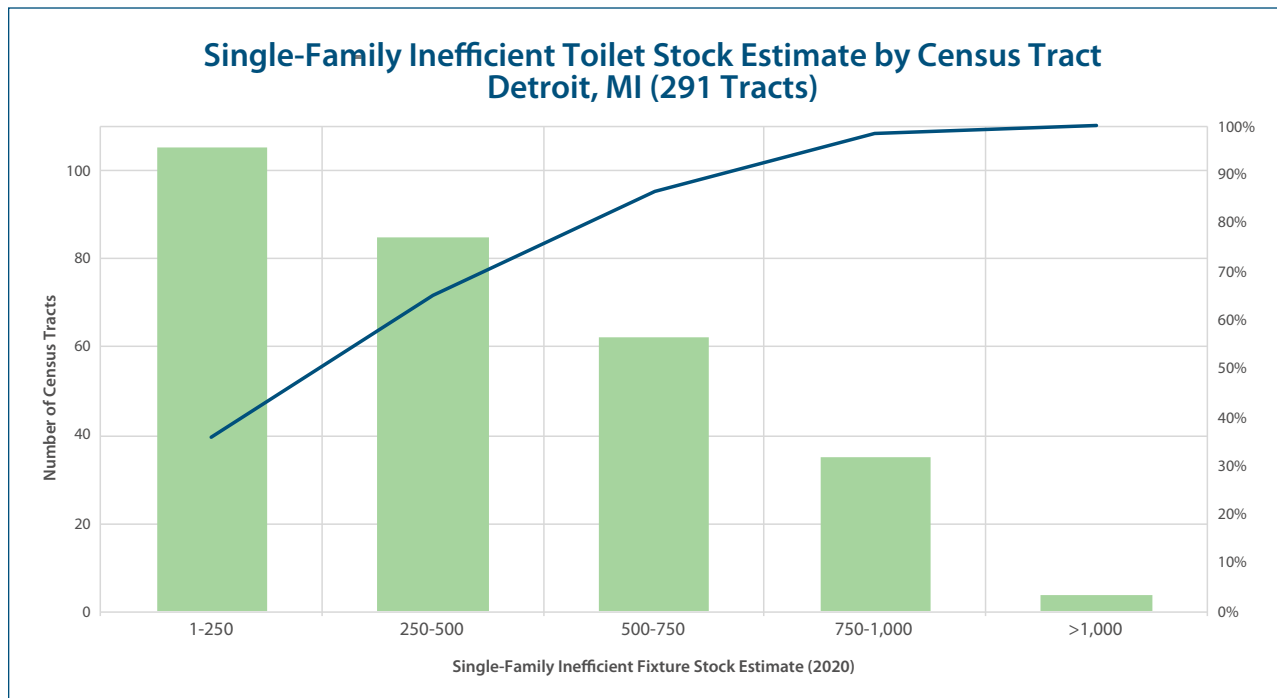


Figure 11: Single-Family Inefficient Toilet Stock Estimates by Census Tract in Detroit, MI

Figure 12 contains a map showing the geographic distribution of inefficient toilets in the city of Detroit. The darker green census tracts have larger stocks of inefficient toilets that can be replaced. Knowing the number and location of inefficient toilets can help understand savings potential and improve effectiveness of outreach efforts.

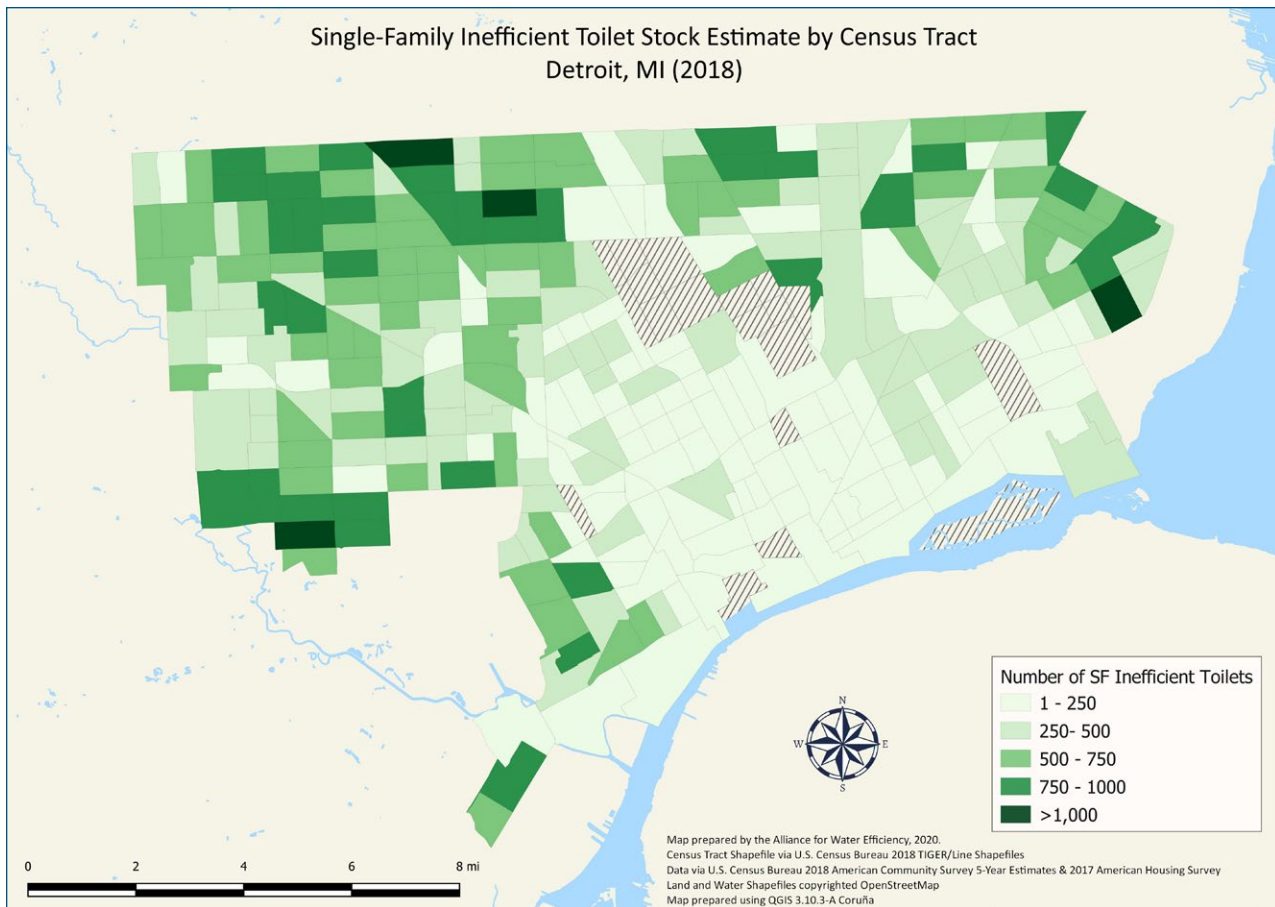


Figure 12: Map Showing Single-Family Inefficient Toilet Stock Estimates by Census Tract in Detroit, MI

Estimate of Water Savings Potential via Inefficient Toilet Replacements

The estimate of inefficient fixtures remaining in the city of Detroit was used to calculate potential water savings. The average savings for a toilet replacement was estimated for each census tract based on the census tract average persons per household. The following equation from the California Urban Water Conservation Council's (CUWCC) 2005 BMP Costs & Savings Study was used. It estimates water savings based on persons per household for replacing an inefficient toilet with a 1.6 gallon per flush toilet.²⁴

$$\text{Single-Family Toilet Replacement Water Savings} = (6.693 * PPH - 0.529 * (PPH)^2 + 7.826)$$

The values resulting from this formula were multiplied by 1.23 as this is the approximate increase in water savings from replacing a 3.5 gpf toilet with a 1.28 gpf toilet rather than a 1.6 gpf toilet. This is based on an analysis of data in the Residential End Uses of Water study.¹¹ Table 7 shows savings estimates based on the minimum, maximum and average PPH for the 291 census tracts.

²⁴ The California Urban Water Conservation Council (Now the California Water Efficiency Partnership). (2005). BMP Costs and Savings Study - 2.9 Ultra Low Flush Toilets (Residential). http://toolbox.calwep.org/w/images/8/87/2.9_Ultra_Low_Flush_Toilets_%28Residential%29-CSS-2005.pdf

Census Tract Stats	PPH	Savings Estimate per Toilet Replaced (gal/yr)
Min	1.34	7,113
Max	7.47	12,707
Average	2.65	9,808

Table 7: Example Toilet Replacement Savings Estimate Based on Persons Per Household.

For comparison and perspective purposes, Table 8 shows toilet use based on flush volume from the 1999 and 2016 Residential End Uses of Water studies (REUWS). The difference between the REUWS 1999 and WaterSense household toilet use is 10,472 assuming 2.6 persons per household. The method used in this assessment would estimate a savings value of 9,721 assuming 2.6 persons per household.

Source	Gallons per Household per Year (Toilet flushing)	Gallons Per Household Per Day (Toilet flushing)	Average Flush Volume
1999 Residential End Uses of Water Study (REUWS)	16,498	45.20	3.65
2016 Residential End Uses of Water Study (REUWS)	12,082	33.10	2.60
REUWS 2016 – Sample of 247 Homes with Efficient Fixtures	7,380	20.22	1.61
WaterSense Benchmark	6,026	16.51	1.28

Table 8: Annual Household Water Use from Toilet Flushing Based on Flush Volume from the 1999 and 2016 Residential End Uses of Water Studies³

If all the single-family inefficient toilets were replaced in Detroit, Michigan it would reduce indoor water use by an estimated 1,177 million gallons per year (MGY), or 1.18 billion gallons per year. While that is unlikely to occur anytime soon, it shows the potential for water use reductions in Detroit. Like inefficient toilet stocks, savings potential varied throughout the census tracts. The minimum estimate was 0.03 MGY, the maximum 13.58 MGY and the average of the 291 census tracts was 4.05 MGY.

Figure 13 shows the number of census tracts that fall within five different histogram bins.

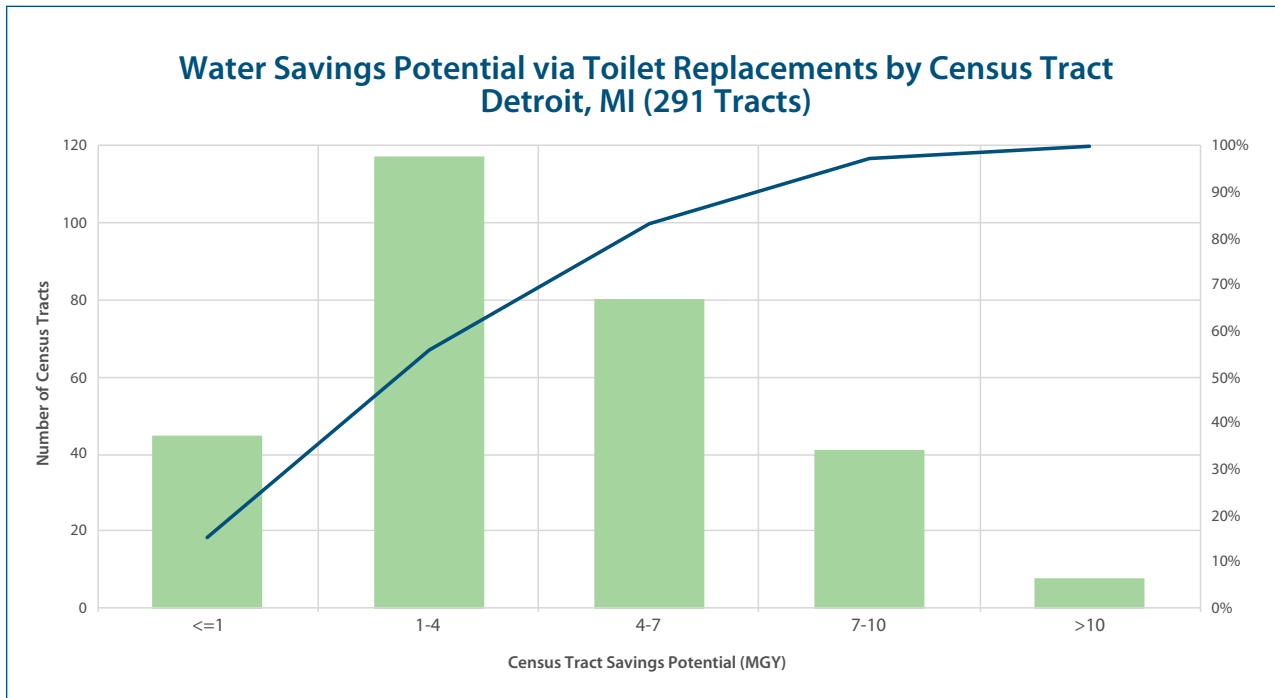


Figure 13: Water Savings Potential via Toilet Replacements by Census Tract in Detroit, MI

Figure 14 contains a map that shows the savings potential throughout the city at the census tract level in million gallons per year (MGY).

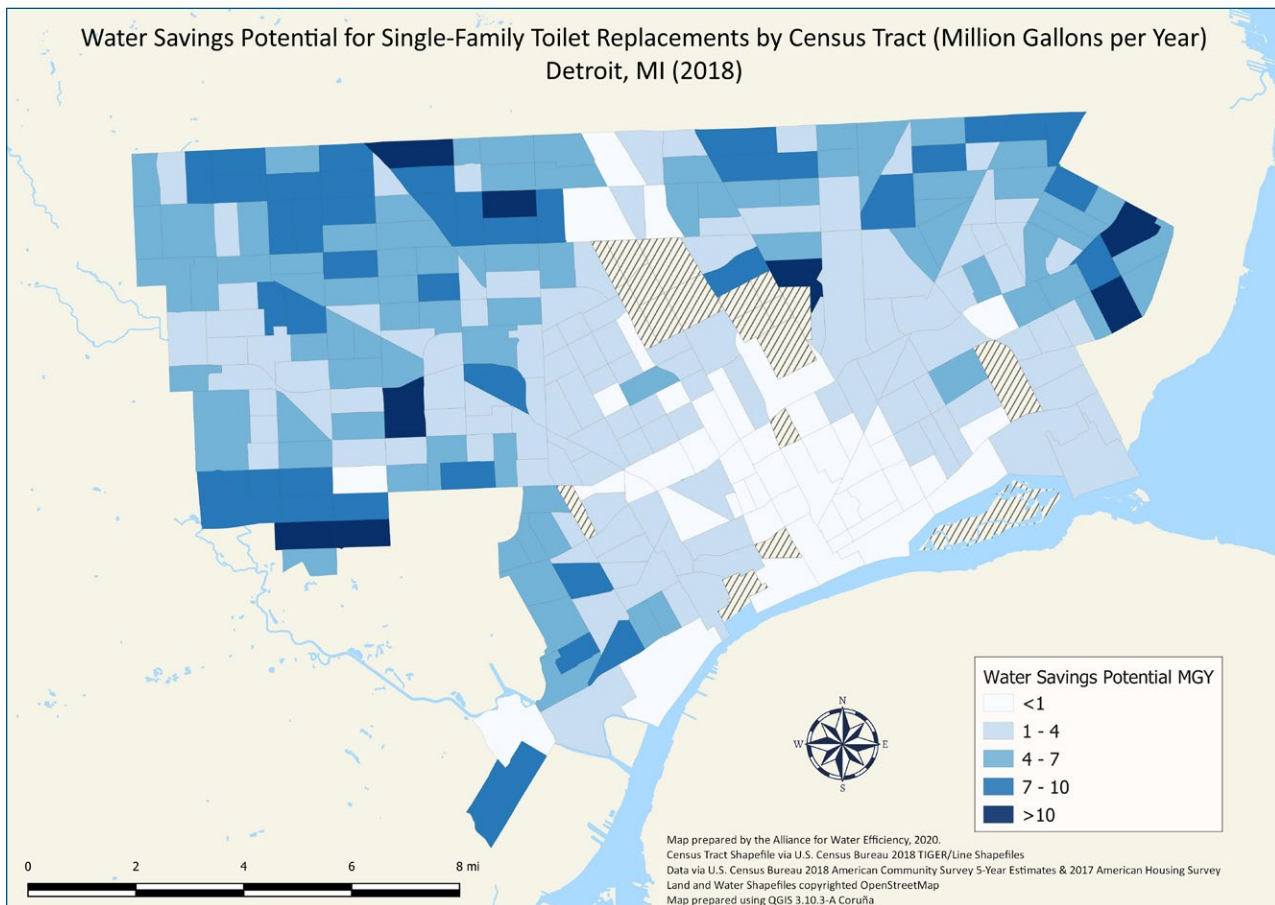


Figure 14: Map of Savings Potential via Toilet Replacements by Census Tract in Detroit, MI

Water Conservation Impact on Water and Sewer Bills

When customers are billed volumetrically for water and sewer service, like in Detroit, they can lower their bills by reducing their water use. In Detroit, a three-person household using 58.6 gpcd would have a monthly water and sewer bill of \$70.44 (based on 2018 rates). In 2018 every 1,000 gallons saved per month by a single-family household in Detroit, MI would have reduced the monthly household water bill by \$10.63. A toilet replacement in a three-person household is estimated to save 10,390 gallons per year, or 866 gallons per month. This would equal a \$9.21 water and sewer bill savings per month and \$110.49 savings per year. This equates to a monthly and annual bill reduction of 13.07 percent.

While the 2016 Residential End Uses of Water study found the average indoor gpcd to be 58.6, it estimated the indoor water use of an ultra-efficient household to be “about 37 gallons/person/day (pg. 214).”⁵ A gpcd of 37 in a 3 person household would equal a monthly water bill of \$49.48 in Detroit in 2018, which is 29.76 percent less than a bill based on 58.6 gpcd.

There are certainly opportunities beyond toilet replacements for water use reductions, like fixing leaks. Estimating savings from fixing leaks is difficult to quantify in a forward-looking assessment (and arguably imprudent). A factsheet on the 2017 water conservation impact of the Community Action Alliance’s Water Residential Assistance Program (WRAP) reported that 1,030 income-

eligible homes with high water usage received a home water audit. A pre-post water bill analysis of a sample of participants found an average bill savings of \$420 per year. The participants in this program had a high incidence of leaks. Fifty-one percent of homes that participated in the WRAP program in 2017 had leaks that cost more than \$100 per year.²⁵

In this assessment of conservation potential, an average household was characterized for each of the 291 census tracts that produced a unique water and sewer bill estimate based on indoor water use, and a unique savings potential via toilet replacements. In analyzing the bill impact of toilet replacements for the average household among the 291 census tracts, bill savings range from 7.26 to 16.17 percent with an average of 13.67 percent. Table 9 shows the minimum, maximum, and average estimated household bill savings among the 291 census tracts resulting from toilet replacements.

Census Tract Stats	Based on Toilet Replacement Savings Estimate		
	Average Monthly Bill Reduction	Average Annual Bill Reduction	Percent Bill Reduction
Min	\$ 6.31	\$ 75.67	7.26%
Max	\$ 11.26	\$ 135.16	16.17%
Mean	\$ 8.62	\$ 103.41	13.67%
Number of Census Tracts	291		

Table 9: *Estimated Average Household Bill Reductions Resulting from Inefficient Toilet Replacements by Census Tract in Detroit, MI*

This demonstrates that water conservation, in this case toilet replacements, can help lower water bills in a meaningful way. Homes with significant leaks will have high water bills and will benefit greatly from assistance programs. Additional, and significant, savings are almost certain for programs that combine toilet replacements with comprehensive home water audits that profile water use and identify savings opportunities, replace inefficient showerheads and faucet aerators, educate customers, and find and repair leaks.

²⁵ Community Action Alliance and EcoWorks. (2018). 2017 Water Conservation Impact Sheet.



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