Localized Residential Demands Study

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Introduction

Residential fixtures, appliances, and other end uses have become significantly more efficient in recent decades. The original goal of this task was to gain a better understanding of localized water and sewer demands from new single-family, townhome, and mid-rise multifamily development (~5 stories), which use the latest water efficient technologies. This understanding could be used in local decision making related to sizing meters, water mains, sewer lines, and related pump stations at the scale of the new development and the adjacent supporting water and sewer infrastructure. This understanding may also be relevant to sizing water and sewer impact fees for new residential development and for local water and sewer expansion planning. However, as work progressed on this task, and learnings were obtained, the focus of this task shifted to analysis and data collection and development of next steps. This memorandum summarizes that effort.

If water demands and sewer flows for new developments are overestimated, there is the potential for the design and implementation of oversized water and sewer infrastructure. In some cases, this can be a good thing, for example if additional growth is expected to occur to fill the additional capacity needs. However, oversizing can have negative consequences related to high water age and water quality issues on the drinking water side, and low flows in oversized water meters have the potential for great inaccuracy. Oversized sewer lines can create excessive odor and operational problems at pump stations. In addition, there is excessive cost spent on unnecessary infrastructure using customer fees and public funds. Therefore, it is important to use appropriate values for estimating future water and sewer flows, with reasonable safety factors. The fact is that new construction residential users (especially indoor) will use less water on a per person/household basis than existing residential users in aggregate. Therefore, the existing per capita use should not be used to plan for new users.

In Georgia, the International Plumbing Code (IPC) is used to size water service lines and premise plumbing. The issue with this practice is that it is based on a "peak water use" principle developed in the 1940's called Hunter's Curve. Obviously, since the 1940's there have been significant improvements in water efficiency for plumbing fixtures and appliances, resulting in less water needed to perform the same tasks. These Hunter's Curves have not been updated and do not fully apply current water use rates. In response to this, industry professionals are developing new tools for sizing water service lines and premise plumbing. The International Association of Plumbing & Mechanical Officials (IAPMO) have developed a tool called the Water Demand Calculator for residential and multi-family housing, which is free to the public. In addition, The Water Research Foundation (WaterRF) has a research project discussing this issue and proposing solutions for future research efforts, including updating Hunter's Curve with current fixtured units (Project 4689). Finally, the American Water Works Association (AWWA) has a discussion on this in the current version of Manual M22 Sizing Water Service Lines and Meters, which will continue to be updated every 5 to 10 years or so and will include future developments on this topic.

The Metro District has also started development of an Excel-based estimating tool that could be used for determining demands from new residential developments based on current standards for water fixtures and appliances. As part of this task, the tool was developed further, but has not been fully tested or validated, and needs future work before it can be applied by water utilities and developers.

One potential obstacle to reducing the size of water mains is minimum flow standards at fire hydrants for fire protection. The domestic flows are much smaller than these larger minimum flow requirements for fire protection and will usually dictate and define the size of the water mains in developments and further into the water distribution system. Below is a discussion of the current fire protection standards and codes in Georgia.

Fire Protection Standards and Codes in Georgia

The State of Georgia had adopted several codes that have been made mandatory with applicable local amendments that must be implemented and followed for all new building construction, including but limited to:

- International Building code (IBC), 2018 edition
- International Residential Code for one- and Two-Family Dwellings, 2018 edition
- International Fire code (IFC), 2018 edition
- International Plumbing code (IPC), 2018 edition

These building standards and codes were researched for One- and Two-family dwellings. The IFC 2018 which establishes the minimum requirements for fire prevention and fire protection systems categorizes residential one- and two-family dwellings under the residential Group R-3, which is the focus of this study. Additionally, while residential fire sprinkler systems are not required by the State of Georgia for One- and Two-family dwellings, if sprinkler systems are incorporated into this type of structures, it must be done per IFC 2018 and the National Fire Protection Association (NFPA) 13D standards which is specifically for residential sprinkler design focused on these types of residential dwellings.

Per AWWA M31 standards, there are four methods used to develop fire flow requirements in distribution systems. These are developed by the Insurance Services Office Inc. (ISO), Iowa State University (ISU), the National Fire Academy, and the Illinois Institute of Technology Research Institute (IITRI).

The ISO method involves determination of class of construction, occupancy, exposure hazard and communication hazard of adjacent buildings.

The ISU method is based on research conducted at the Fire Extension Service at Iowa State University. It references several Danish studies for its theoretical and statistical basis and involved performing experiments of small fires in rooms.

The National Fire Academy method is a modification of the ISU method and is used as a quick calculation formula at the scene of the incident or for pre-planning fire flow requirements of major structures.

The IITRI method was developed from statistical data collected for 134 fires in the Chicago area. Water application rates for the studied fires were calculated through a knowledge of length and diameter of hose and calculated nozzle pressure.

The National Fire Protection Agency (NFPA) 1142 standard establishes minimum requirements for water utilities for suburban and rural firefighting. The minimum water supply requirements are calculated based on the enclosed volume, occupancy, construction classification, and exposure hazards present.

Fire flow requirements for One- and Two-family Dwellings from nearby fire hydrants are shown in Figures 1 and 2 below.

According to the 2018 IFC, the minimum fire flow required for group R-3 dwellings under 3,600 sf, with no sprinkler system in place, require a minimum of 1,000 gpm from a nearby fire hydrant for a duration of 1-hour. However, if the dwelling is equipped with a sprinkler system, then the required fire flow demand at that same fire hydrant is reduced to 500 gpm for a duration of 30 minutes.

Similarly, if the dwelling is 3,601 sf or greater, the minimum required fire flow would be 1,500 gpm for a duration of 2 hours if a sprinkler system is not installed within the dwelling. However, if a sprinkler system is present then the minimum required fire flow is reduced to 750 gpm for a duration of 1-hour.

TABLE B105.1(1)
REQUIRED FIRE FLOW FOR ONE- AND TWO-FAMILY DWELLINGS, GROUP R-3 AND R-4 BUILDINGS AND TOWNHOUSES

FIRE-FLOW CALCULATION AREA (square feet)	AUTOMATIC SPRINKLER SYSTEM (Design Standard)	MINIMUM FIRE FLOW (gallons per minute)	FLOW DURATION (hours)
0–3,600	No automatic sprinkler system	1,000	1
3,601 and greater	No automatic sprinkler system	Value in Table B105.1(2)	Duration in Table B105.1(2) at the required fire-flow rate
0–3,600	Section 903.3.1.3 of the *International Fire Code* or Section P2904 of the *International Residential Code*	500	$^1/_2$
3,601 and greater	Section 903.3.1.3 of the *International Fire Code* or Section P2904 of the *International Residential Code*	$^1/_2$ value in Table B105.1(2)	1

For SI: 1 square foot = 0.0929 m^2, 1 gallon per minute = 3.785 L/m.

Figure 1- Table B105.1(1) of the IFC

TABLE B105.1(2)
REFERENCE TABLE FOR TABLES B105.1(1) AND B105.2

FIRE-FLOW CALCULATION AREA (square feet)					FIRE FLOW (gallons per minute)[b]	FLOW DURATION (hours)
Type IA and IB[a]	Type IIA and IIIA[a]	Type IV and V-A[a]	Type IIB and IIIB[a]	Type V-B[a]		
0-22,700	0-12,700	0-8,200	0-5,900	0-3,600	1,500	2
22,701-30,200	12,701-17,000	8,201-10,900	5,901-7,900	3,601-4,800	1,750	
30,201-38,700	17,001-21,800	10,901-12,900	7,901-9,800	4,801-6,200	2,000	
38,701-48,300	21,801-24,200	12,901-17,400	9,801-12,600	6,201-7,700	2,250	
48,301-59,000	24,201-33,200	17,401-21,300	12,601-15,400	7,701-9,400	2,500	
59,001-70,900	33,201-39,700	21,301-25,500	15,401-18,400	9,401-11,300	2,750	
70,901-83,700	39,701-47,100	25,501-30,100	18,401-21,800	11,301-13,400	3,000	3
83,701-97,700	47,101-54,900	30,101-35,200	21,801-25,900	13,401-15,600	3,250	
97,701-112,700	54,901-63,400	35,201-40,600	25,901-29,300	15,601-18,000	3,500	
112,701-128,700	63,401-72,400	40,601-46,400	29,301-33,500	18,001-20,600	3,750	
128,701-145,900	72,401-82,100	46,401-52,500	33,501-37,900	20,601-23,300	4,000	4
145,901-164,200	82,101-92,400	52,501-59,100	37,901-42,700	23,301-26,300	4,250	
164,201-183,400	92,401-103,100	59,101-66,000	42,701-47,700	26,301-29,300	4,500	
183,401-203,700	103,101-114,600	66,001-73,300	47,701-53,000	29,301-32,600	4,750	
203,701-225,200	114,601-126,700	73,301-81,100	53,001-58,600	32,601-36,000	5,000	
225,201-247,700	126,701-139,400	81,101-89,200	58,601-65,400	36,001-39,600	5,250	
247,701-271,200	139,401-152,600	89,201-97,700	65,401-70,600	39,601-43,400	5,500	
271,201-295,900	152,601-166,500	97,701-106,500	70,601-77,000	43,401-47,400	5,750	
295,901-Greater	166,501-Greater	106,501-115,800	77,001-83,700	47,401-51,500	6,000	
—	—	115,801-125,500	83,701-90,600	51,501-55,700	6,250	
—	—	125,501-135,500	90,601-97,900	55,701-60,200	6,500	
—	—	135,501-145,800	97,901-106,800	60,201-64,800	6,750	
—	—	145,801-156,700	106,801-113,200	64,801-69,600	7,000	
—	—	156,701-167,900	113,201-121,300	69,601-74,600	7,250	
—	—	167,901-179,400	121,301-129,600	74,601-79,800	7,500	
—	—	179,401-191,400	129,601-138,300	79,801-85,100	7,750	
—	—	191,401-Greater	138,301-Greater	85,101-Greater	8,000	

For SI: 1 square foot = 0.0929 m^2, 1 gallon per minute = 3.785 L/m, 1 pound per square inch = 6.895 kPa.
a. Types of construction are based on the *International Building Code*.
b. Measured at 20 psi residual pressure.

Figure 2- Table B105.1(2) of the IFC

Approach

In order to supplement the water use estimating tool and analyze water use rates for new construction residential developments, data was collected from some District water providers for analysis. This data was targeted to be the water billing data for newer construction residential developments that would be in compliance with the latest plumbing code and fixture standards. This data would be analyzed by provider, and by development type to evaluate trends and identify any common water use rates by development type.

The data requested from select District water providers included monthly billing data for residential customer accounts. Three types of residential developments were requested as follows:

1. Single-family, detached, separately metered.
2. Townhomes (multi-family), attached, separately metered.
3. Apartments (multi-family), attached, multi-story, master metered, with number of units known.

Data Collection

Data was collected from six water providers (Douglasville-Douglas County Water and Sewer Authority, Forsyth County, Gwinnett County, Henry County, Paulding County and the City of Gainesville.) This data consisted of monthly water usage for newer construction residential properties spanning from January 2016 to December 2021. The year built was also collected for each property.

Single-family water use data was collected for 148 new residential accounts and included number of bedrooms, number of bathrooms, lot sizes, square footage and tax values as shown in Figure 3.

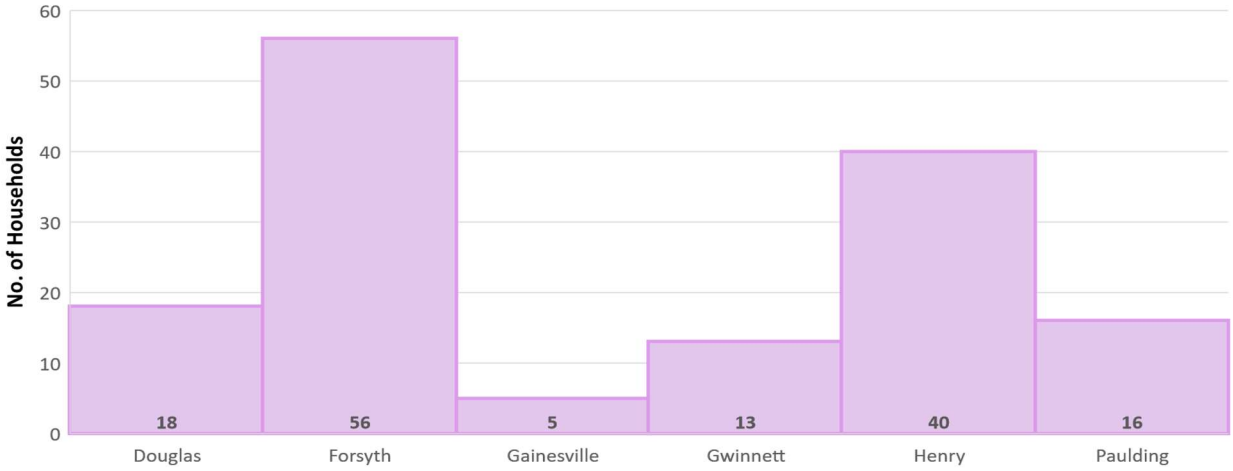

Figure 3- Single-family residential housing water use data collected

Multi-family addresses were verified to distinguish between townhome and apartments. Other properties such as nursing homes were omitted from the data set.

Multi-family water use data was collected for 237 new residential accounts as shown in Figure 3, of which 13 were apartment buildings with multiple units, and 224 were individual townhome units. Data collected included number of units, meter types, lot sizes, and tax values. For apartments, the total water usage was divided by the number of units to get the average water usage per household.

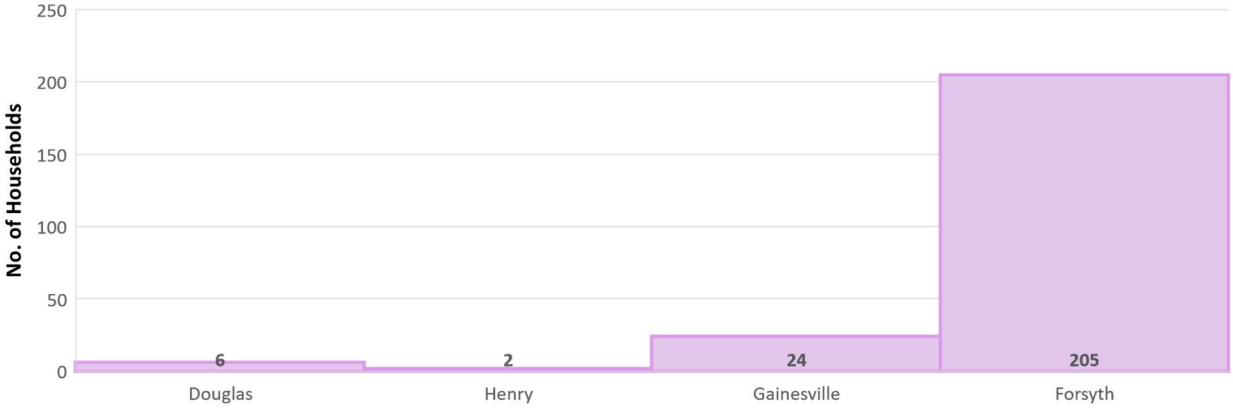

Figure 4- Multi-family Residential housing water use data collected

Water use data greater than 50,000 gal per month per household was deemed to be very high. These were considered as outliers and were excluded in some of the analyses performed. Figure 5 and Figure 6 show the histograms of average water usage by number of households for single family and multi-family residential housing.

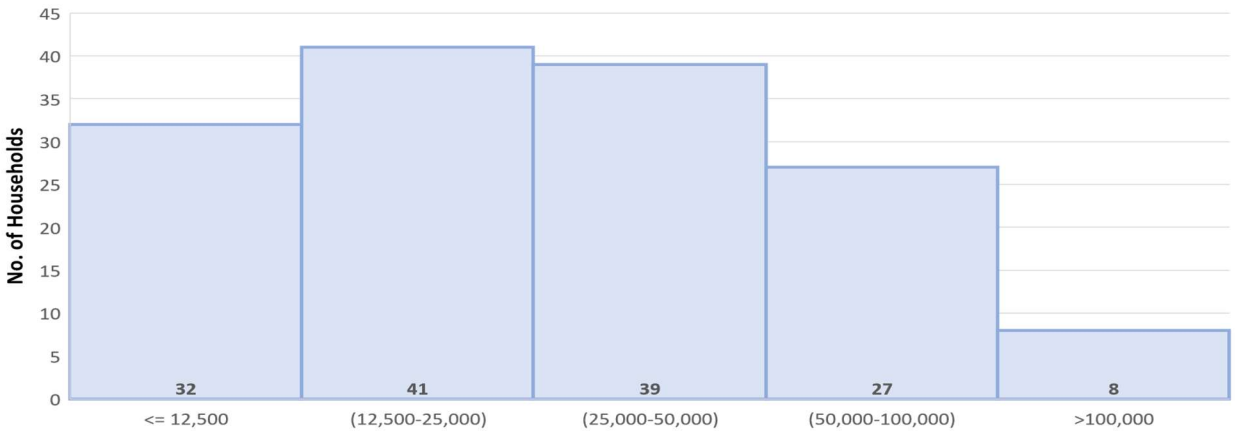

Figure 5- Average water use by household for Single Family Residential housing (gal/month)

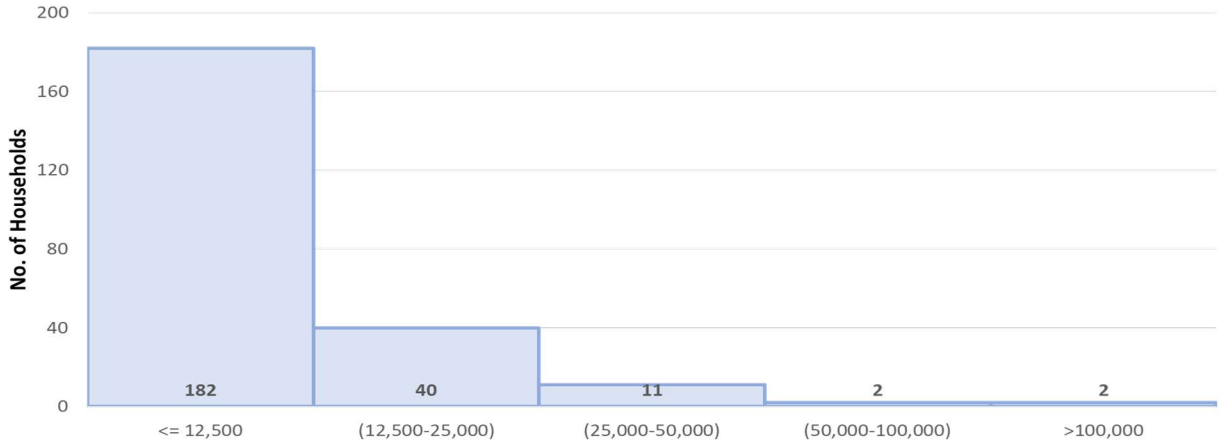

Figure 6- Average water use by household for Multi-family Residential housing (gal/month)

Analysis and Findings

Data was collected by the District as monthly water usage per residential account. This was modified to get the average daily water use per account (gpd). As explained previously, the water usage more than 50,000 gallons per month was excluded from some of the findings presented herein.

Single Family Residential Analysis:

Figure 7 shown below depicts the average, and range of average daily household water usage for single family residential housing between 2017 and 2021. Figure 8 shown below depicts the same data but excludes water usage greater than 50,000 gallons per month. It is unknown why there is high usage in 2019 that creates the difference in Figures 7 and 8. It is possible that high outdoor use during a very dry August 2019 (flash drought lasting through October 2019) was the reason. Average household use for single family use is around 200 gpd, As shown in Figure 8.

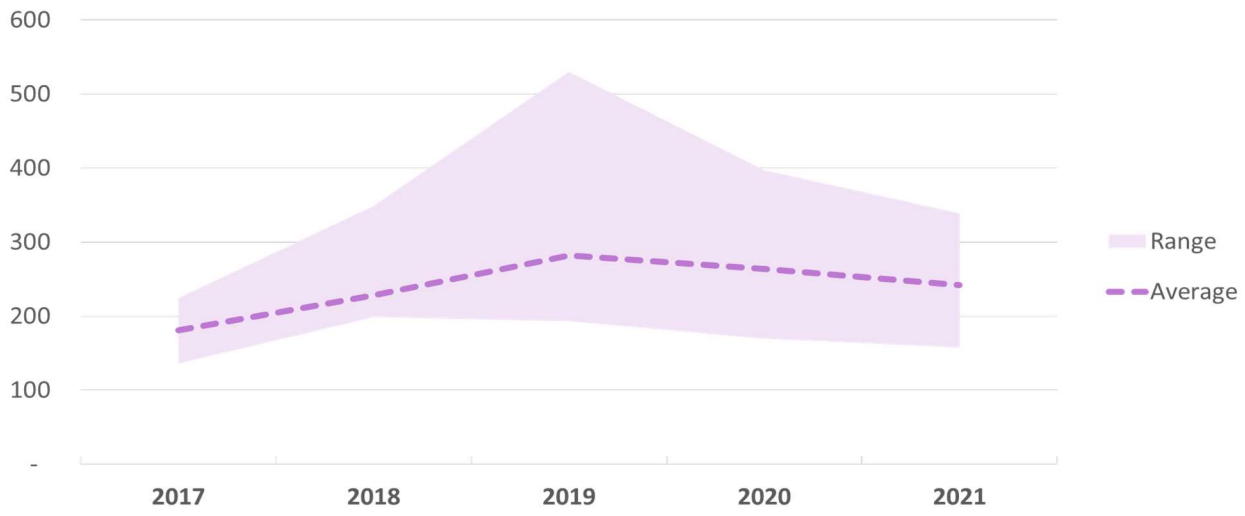

Figure 7- Average Daily Household Water Usage (gpd)

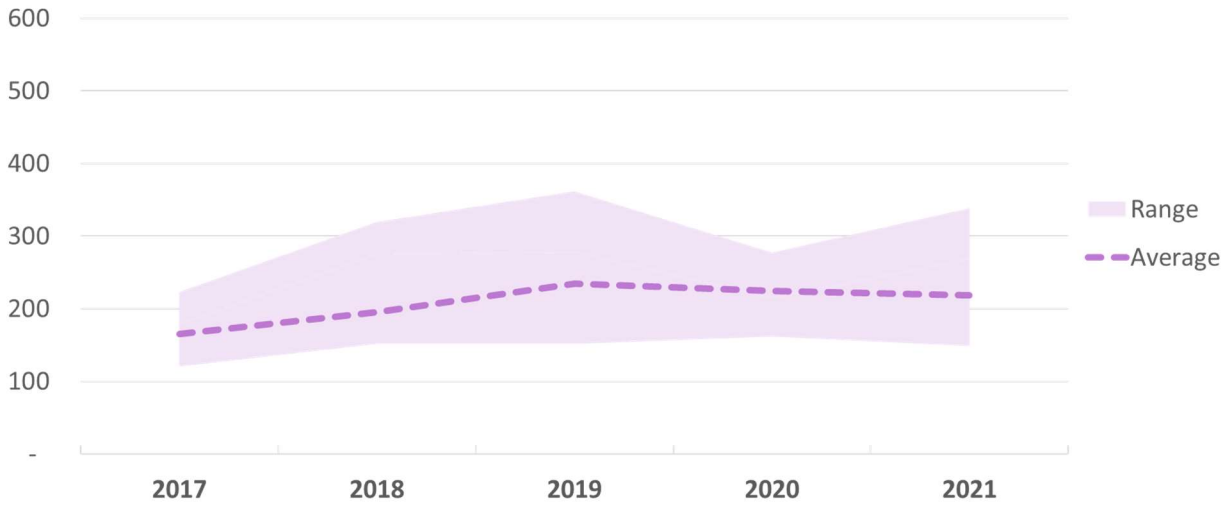

Figure 8- Average Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 9 shown below depicts the peak period average, and range of average daily household water usage for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. This peak usage fluctuates from year-to-year, most likely due to weather and high outdoor use in response to dry weather. The peak averages between 200 and 250 gpd.

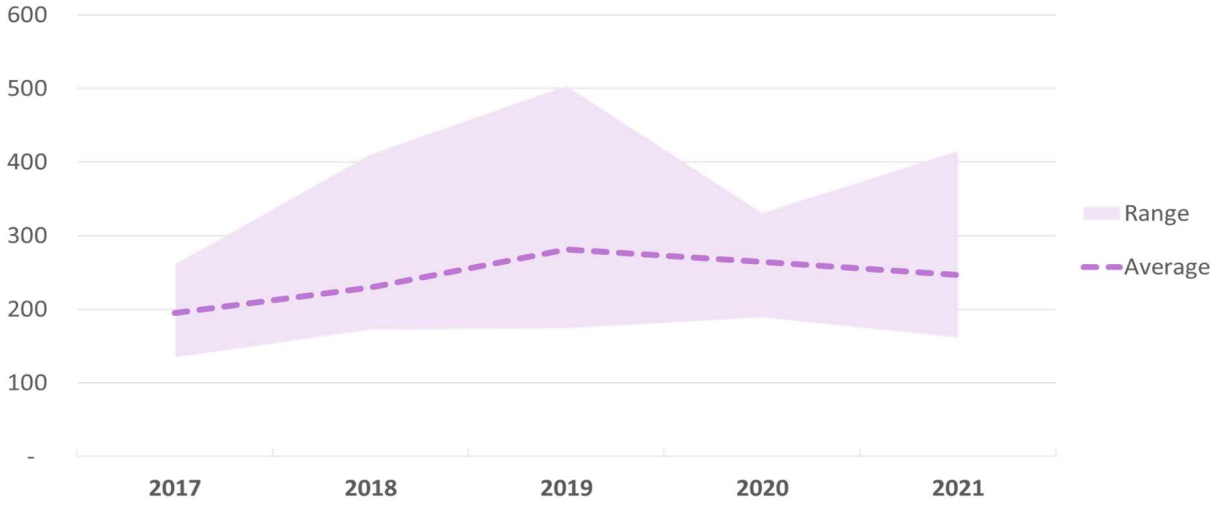

Figure 9- Average Peak Period (Mar-Oct) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 10 shown below depicts the winter period average, and range of average daily household water usage for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The winter use has much less fluctuation from year to year with the range staying close to the average. This should represent indoor use, which ranges between 100 and 150 gpd. It is unknown why the average use goes up consistently between 2017 and 2021 however plausible increases in leaky toilets as flappers age, and increased indoor water usage following the COVID-19 pandemic of 2020 and 2021 could play a part in these patterns.

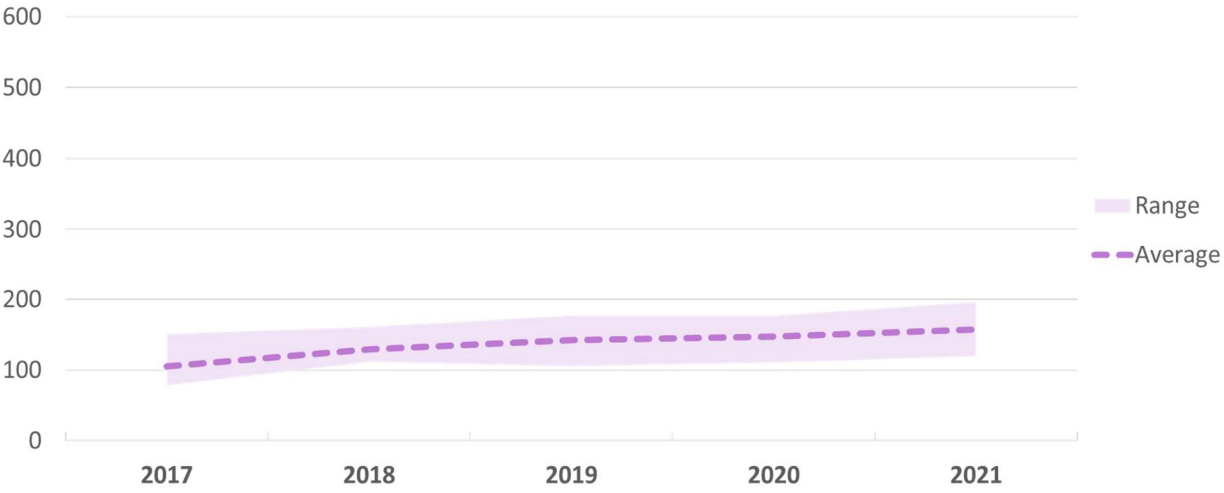

Figure 10- Average Winter (Nov-Feb) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 11 shown below depicts the peak period average, winter average, and overall average daily household water usage by tax value for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The data points show the number of households for each category of tax value. There is a clear trend that higher tax value homes have higher peak and average uses. The lower tax value homes have much lower indoor and outdoor uses, which is probably a result of lower family members and lower landscape. It is unknown why there is a dip in usage in the $800,000 - $1,000,000 range but it could be due to the relatively low number of homes in the top two categories.

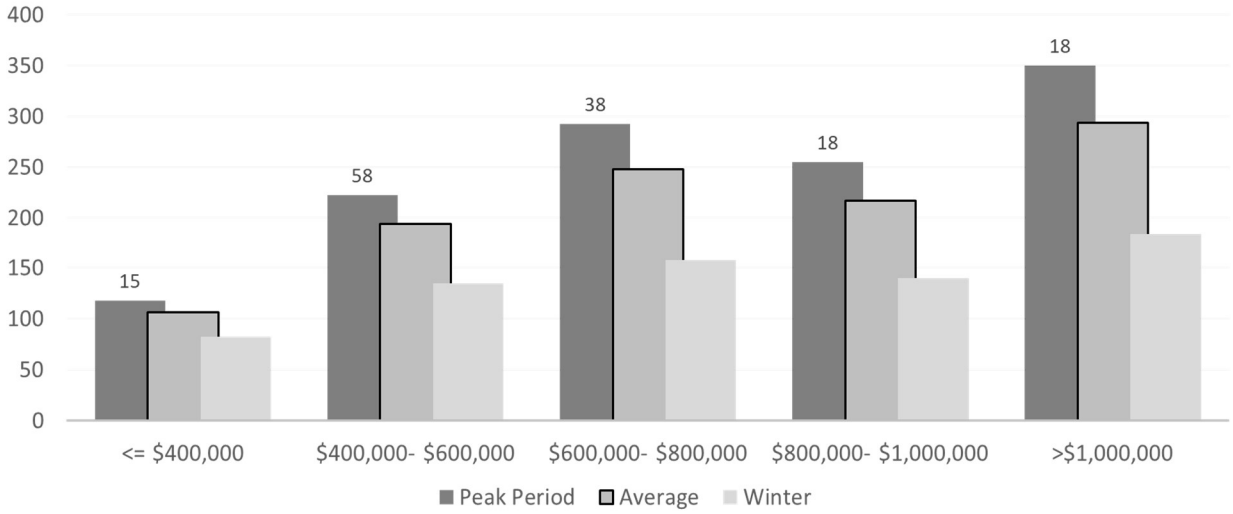

Figure 11- Average Daily Household Water Usage (gpd) by Tax Value - Excludes Water Usage greater than 50,000 gal/month

Figure 12 shown below depicts the peak period average, winter average, and overall average daily household water usage by number of bedrooms for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The data points show the number of households for each category of number of bedrooms. It can be seen that as the number of bedrooms increase from 2 to 6, the indoor water use increases dramatically, and the peak use increases at a slower rate. This is likely due to the number of people per household going up as the number of bedrooms increase, where the peak usage is probably due to outdoor use so would not vary depending on the number of people.

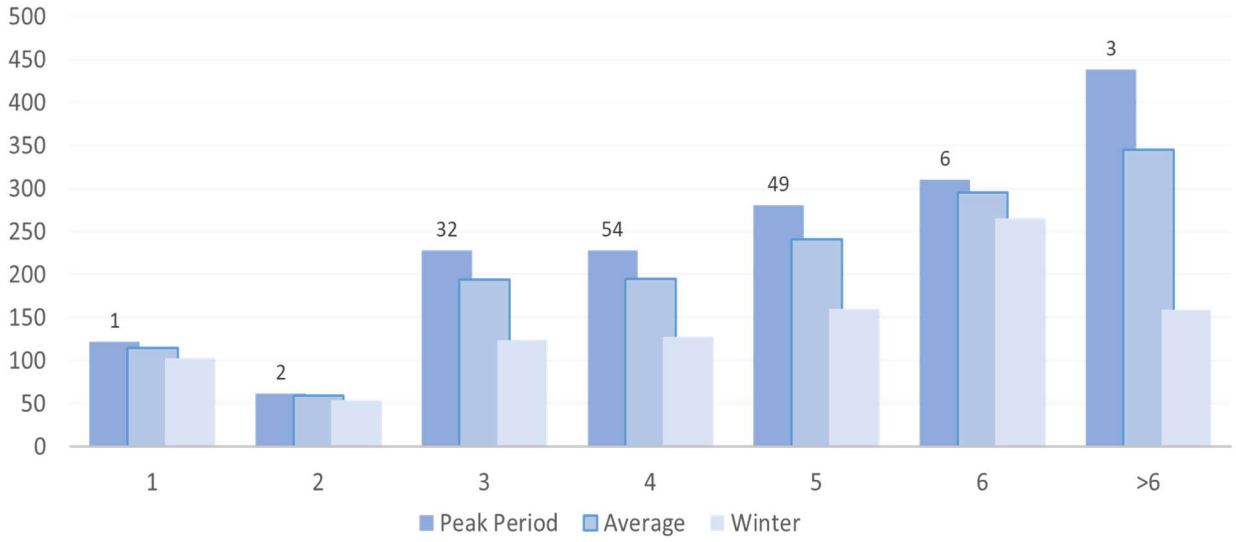

Figure 12- Average Daily Household Water Usage (gpd) by Number of Bedrooms - Excludes Water Usage greater than 50,000 gal/month

Figure 13 shown below depicts the peak period average, winter average, and overall average daily household water usage by number of bathrooms for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The data points show the number of households for each category of number of bathrooms. The trend is similar to the bedrooms shown above, as the number of bathrooms increase, the indoor and peak use increases.

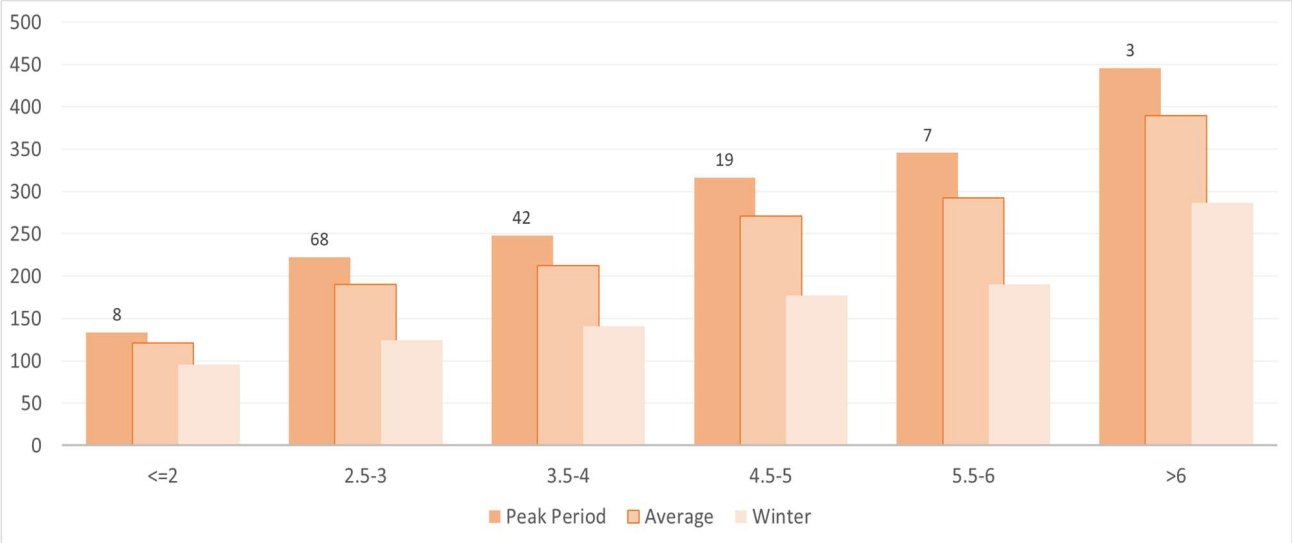

Figure 13- Average Daily Household Water Usage (gpd) by Number of Bathrooms - Excludes Water Usage greater than 50,000 gal/month

Figure 14 shown below depicts the peak period average, winter average, and overall average daily household water usage by lot size for single family residential housing between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The data points show the number of households for each category of lot size. This appears to show little difference in peak usage between a lot size that is 0.33 acre and 1.5 acres.

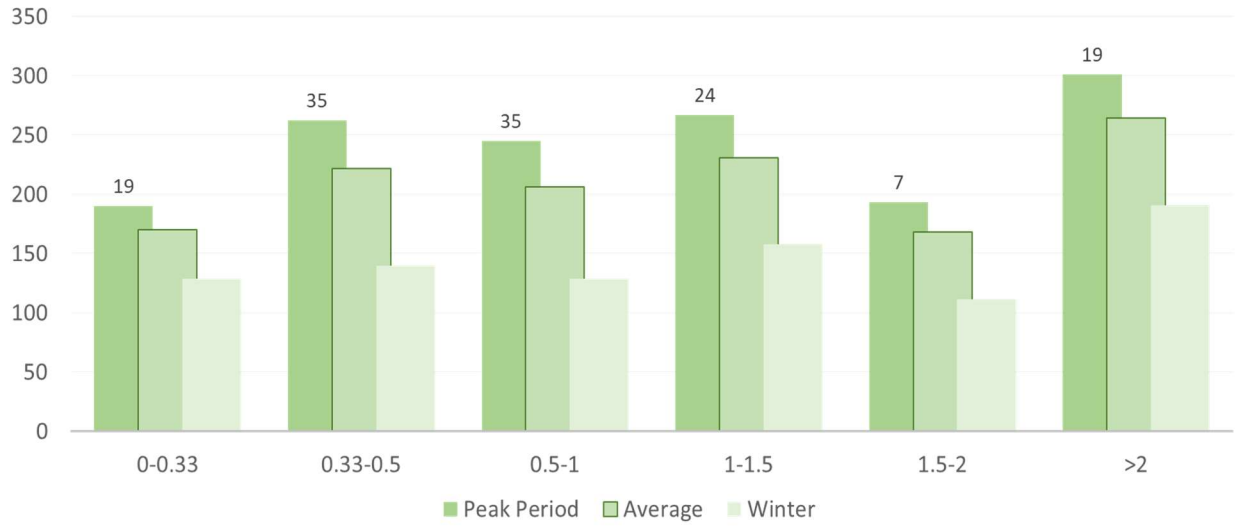

Figure 14- Average Daily Household Water Usage (gpd) by Lot Size (acres) - Excludes Water Usage greater than 50,000 gal/month

Multi-family Residential Analysis:

Multi-family housing is classified into apartments and town homes in this study. The data was separated and analyzed in these two categories of developments.

Apartments:

Figure 15 shown below depicts the average, and range of average daily household water usage for apartments between 2017 and 2021. Data was collected for 13 apartment buildings with multiple units. Figure 16 shown below depicts the same data but excludes water usage greater than 50,000 gallons per month. There is very little difference between the two which indicates a low number of high-water users. The average usage is consistently less than 100 gpd, which is much lower than single family. This is likely due to less people per household, and less overall fixtures and appliances, as well as lower outdoor use due to smaller yards.

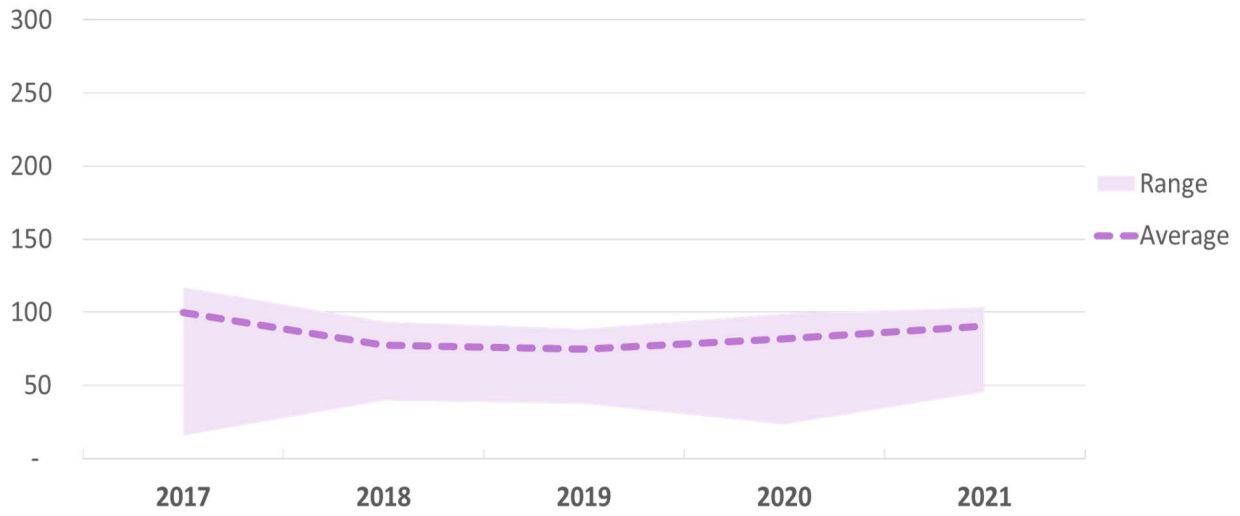

Figure 15- Average Daily Household Water Usage (gpd)

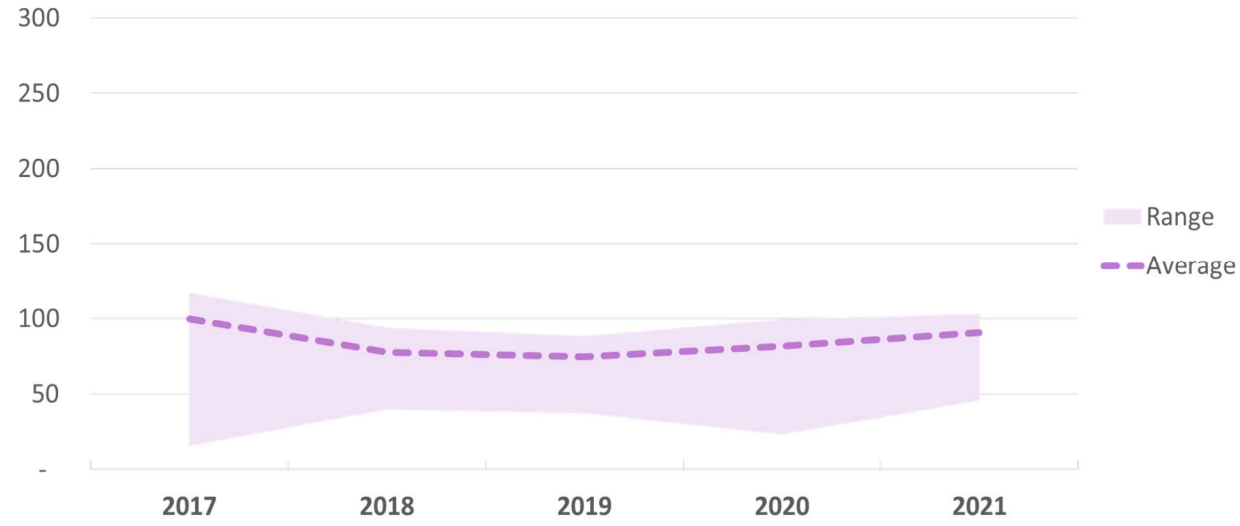

Figure 16- Average Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 17 shown below depicts the peak period average, and range of average daily household water usage for apartments between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The water use during this peak period only shows a moderate increase from the annual average, indicating lower outdoor use.

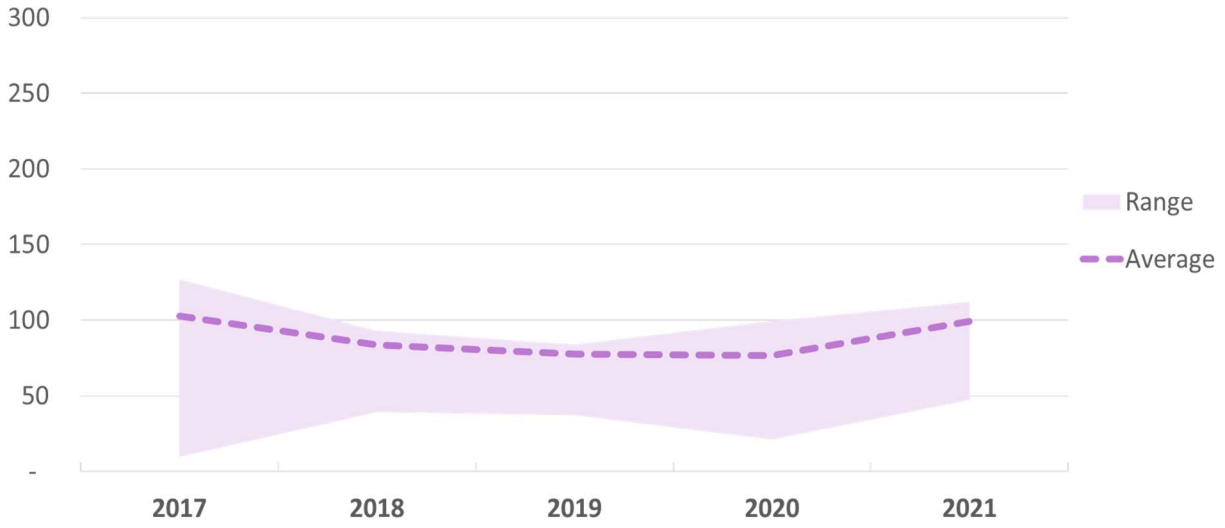

Figure 17- Average Peak Period (Mar-Oct) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 18 shown below depicts the winter period average, and range of average daily household water usage for apartments between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. This winter use is lower than the average, but not by a large amount, and represents the indoor use. It is much lower than single family, probably because of the lower residents per household in a multi-family apartment.

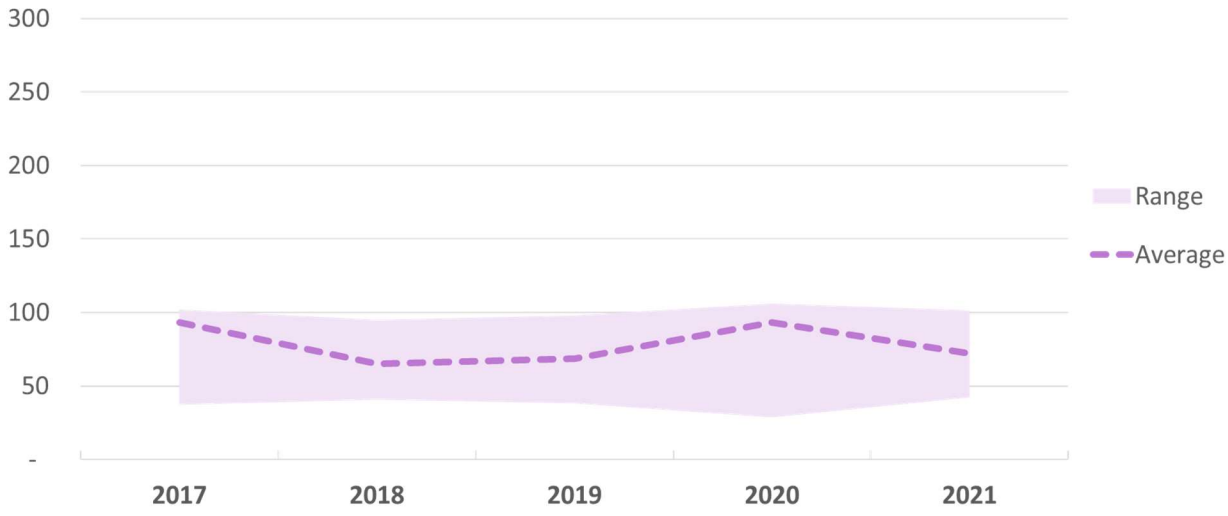

Figure 18- Average Winter (Nov-Feb) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Townhomes:

Figure 19 shown below depicts the average, and range of average daily household water usage for townhomes between 2017 and 2021. Data was collected for 224 individual townhome units. Figure 20 shown below depicts the same data but excludes water usage greater than 50,000 gallons per month. It is unknown why there is an increasing trend in water use from 2017 to 2021, however plausible increases in leaky toilets as flappers age, and increased indoor water usage following the COVID-19 pandemic of 2020 and 2021 could play a part in these patterns.

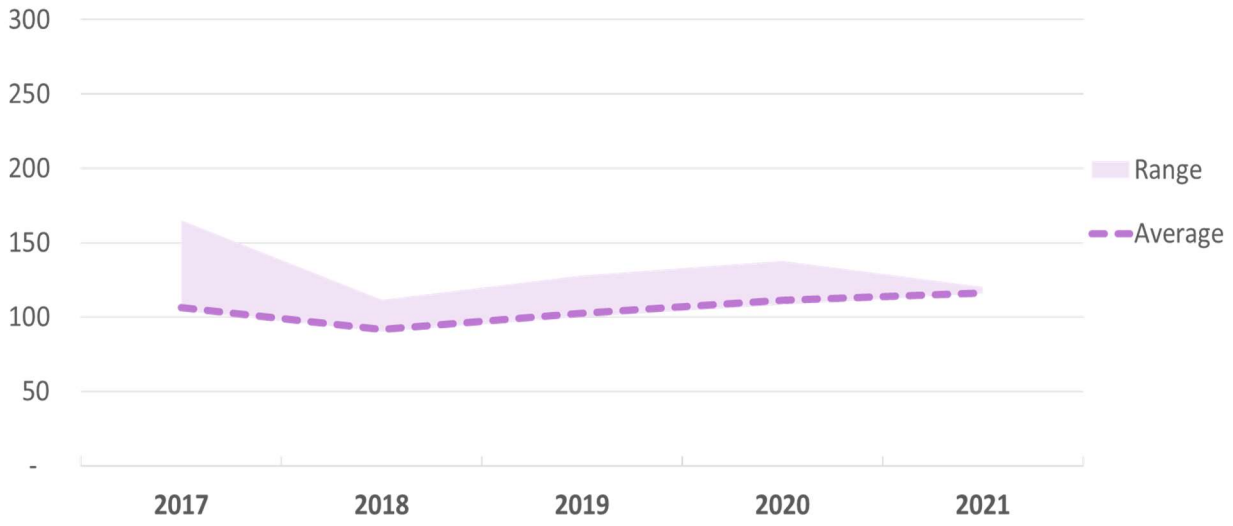

Figure 19- Average Daily Household Water Usage (gpd)

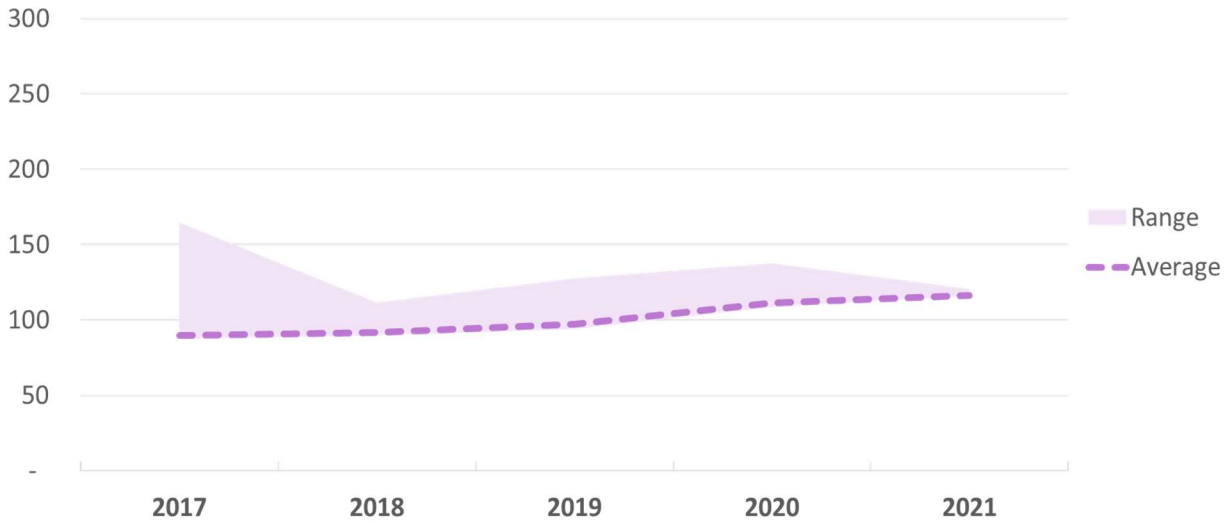

Figure 20- Average Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 21 shown below depicts the peak period average, and range of average daily household water usage for townhomes between 2017 and 2021. It excludes water usage more than 50,000 gallons per month.

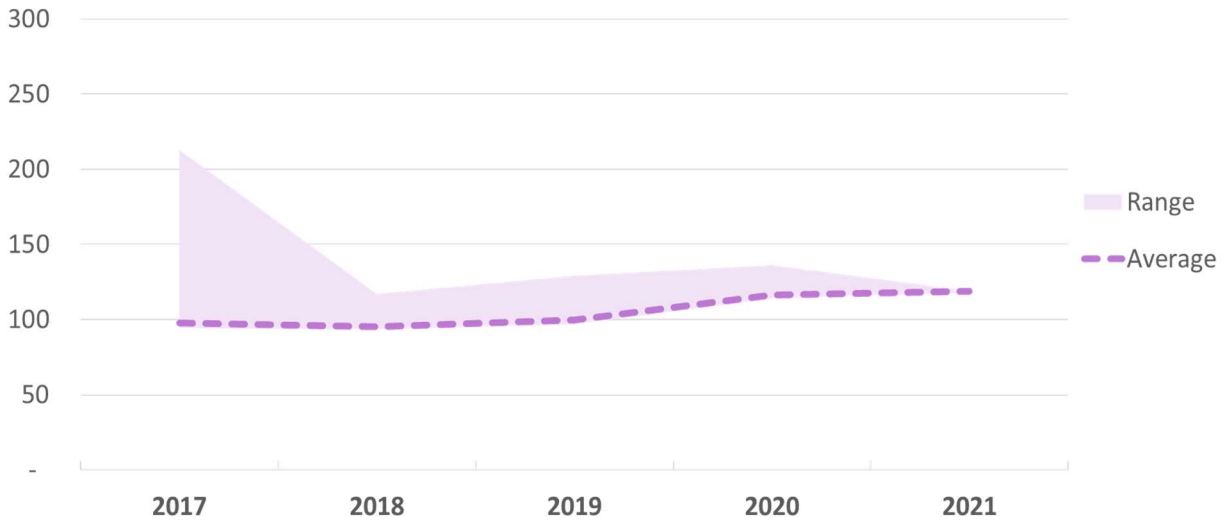

Figure 21- Average Peak Period (Mar-Oct) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 22 shown below depicts the winter period average, and range of average daily household water usage for townhomes between 2017 and 2021. It excludes water usage more than 50,000 gallons per month.

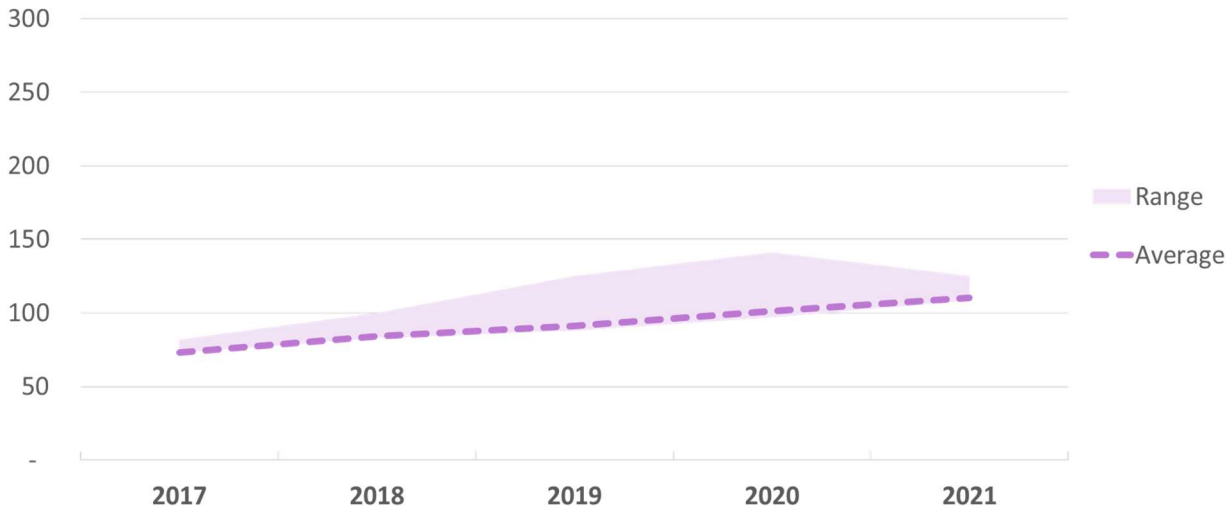

Figure 22- Average Winter (Nov-Feb) Daily Household Water Usage (gpd) - Excludes Water Usage greater than 50,000 gal/month

Figure 23 shown below depicts the peak period average, winter average, and overall average daily household water usage by tax value for townhomes between 2017 and 2021. It excludes water usage more than 50,000 gallons per month. The data points show the number of households for each category of tax value. Peak use increases in the third and fourth categories of tax value, which may indicate more people in the household using more water. There may also be more luxury water-using features, such as pools and outdoor landscaping with irrigation. The drop in usage for accounts over $1,000,000 could be due to the small sample size or inaccurate tax parcel data.

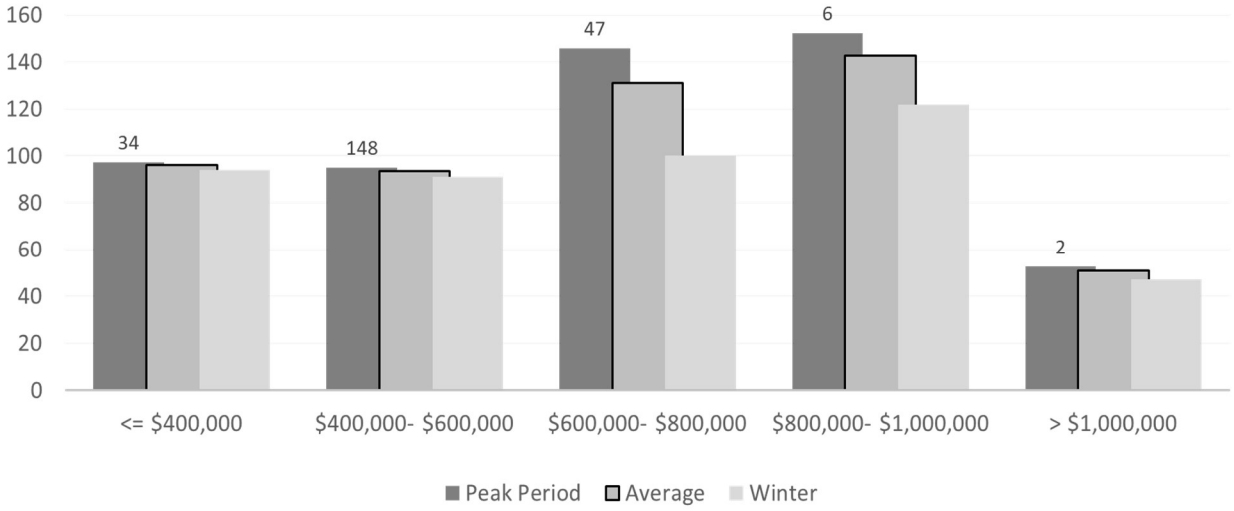

Figure 23- Average Daily Household Water Usage (gpd) by Tax Value - Excludes Water Usage greater than 50,000 gal/month

Summary of Development Standards in Georgia

The Environmental Protection Division (EPD) of the Georgia Department of Natural Resources provides minimum design criteria and establishes standards in the development and construction of public water systems. These are described in the Minimum Standards for Public Water Systems (Rev. March 2021). The average daily water usage for single family residential housing is 100 gallons per person or 400 gallons per household. The average daily water usage for multi-family housing is 120 gallons per bedroom.

Individual District utilities use their own design standards and specifications for water distribution and wastewater collection systems planning. Some of the current standards of the larger counties within the District are presented below.

For water main and service line sizing, Clayton County Water Authority (CCWA) uses 300 gallons per day per household for single family housing and 233 gallons per day per household for multi-family housing. For developing fire flow requirements, Cobb County Water System (CCWS) uses 1000 gpm for 60 minutes for single family housing, and 1600 gpm for 60 minutes for multi-family housing.

For sewer gravity main sizing, Gwinnett County Department of Water Resources (GCDWR) uses 400 gallons per day per household for single family housing, and 100 gallons plus 100 gallons for every bedroom per household per day for multi-family housing. For developing peak wastewater flows, a peaking factor of 2.5 is added atop the average value. DeKalb County Department of Watershed Management (DWM), on the other hand, uses 150 gallons per bedroom per household for both single family housing and multi-family housing.

The State of Georgia adopts the International Plumbing Code, edition 2018 as a basis for the design of plumbing systems and components for residential dwellings. Water and sanitary waste line sizing and demand is typically determined by the sum of water supply fixture units within a dwelling and the maximum flow rate through the supply lines. Water fixture units can be found in the IPC 2018 tables for each fixture type. If an exact fixture being installed is not listed in the plumbing code tables, then a fixture with similar water usage is selected. Water supply fixture units are then converted to flow rates in gpm for supply line sizing and a similar approach is used for sanitary waste lines.

Recommendations for Future Study

It is recommended that the following additional activities be performed to continue the original intent of this study.

Collect additional water consumption data from District utilities for analysis. This could benefit District water utilities through a larger dataset to calculate and understand the average water use and range of water uses for new residential developments. Examples of additional data to collect and analyze includes the following:

- More new residential accounts to supplement the existing analysis where the sample size was low
- Residential irrigation meters to understand the average and range of water use by irrigation systems for new construction, and determine if there is any correlation with weather
- AMI data from new residential developments would likely need big data analytics to study and look for trends in the data
- Data from participants using leak detection devices could provide even more data on residential water use, indoor/outdoor, fixture types, etc.

This additional data could be used to develop a District Excel tool for potential use by District Utilities. The processes outlined in this memo could also be replicated by any water utility looking to update their assumptions for new residential water use when undergoing financial planning and master planning for capital infrastructure. A robust sample size of local account data is the preferred method for creating new customer water use assumptions. This could be used to plan for the water and sewer impact of new residential developments, and plan for sizing of water and sewer infrastructure. The results of this study clearly indicate that as the size and value of new home increases, a direct pattern of increased water usage emerges.

Continued experimentation with the current and future versions of the Water Demand Calculator by IAPMO. Future developments include application to commercial developments.

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