

MWDOC

2020 Residential Water Use Study



PREPARED FOR: The Municipal Water District of Orange County (MWDOC)

PREPARED BY: Flume Inc. and WaterDM

May 21, 2021

Revision 2

Table of Contents

Table of Contents	2
Summary	3
Flume and Customer Level Data	3
Additional Customer Information	5
End Use Disaggregation	6
Research Results	6
Participant Demographics and Household Characteristics	6
Geographic Distribution of Flume Devices	13
Indoor Water Use	15
Effect of COVID on Indoor Water Use	24
Outdoor Water Use	26
Effect of Weather and Watering Restrictions on Outdoor Water Use	35
Irrigation Requirement and Application Rate	39
Santa Margarita Irrigation Restrictions	44
Total Water Use	45
Demographic Analysis of Orange County 2020 Residential Water Use	57
Value of Home	57
Age of Home	59
Lot Size	61
Home Size	63
Demographic Analysis	65
Peer Comparison	66
Conclusions	70
References	71

Summary

Within the Municipal Water District of Orange County (MWDOC) service area, there are approximately 375 Flume devices (devices) currently installed at single-family residences (SFR). Flume devices record flows at high-frequency intervals which enables detailed analysis of water use.

This report presents results from data collected from active devices installed at SFRs within the MWDOC service area during all or part of calendar year 2020. The report includes the following analyses:

- Property Characteristics of Flume device users
- Indoor water use trends
- Impact of COVID-19 on indoor water use
- Outdoor water use trends
- Impact of weather on outdoor water use
- Total water use trends
- Analysis of the relationship between water use and home age, home value, lot size and home size
- Comparison of residential use of the Flume users in Orange County and neighboring counties

Flume and Customer Level Data

The data collected for this study were obtained from approximately 375 individual Flume devices installed at single-family homes in Orange County. To be included in this study, each device met the following criteria:

1. The Flume device was installed in or before 2020 and was active at some point in 2020;
2. The Flume device was installed within the MWDOC service area.

Flume data are collected unobtrusively, directly from the customer water meter. Flume collects and stores customer use data under the terms of the Flume customer agreement. Flume carefully protects customer personal information using strict security protocols and information that could be used to identify any individual customer or group of customers is never released or reported.

Customers who installed a Flume device also received the accompanying Flume smart phone application (app) which provides continuous leak detection and leak notification to customers. Continuous leak notification and detection is a proven approach for finding and reducing customer-side leakage. As a result of this feature of the Flume device, the approximately 375 customers that participated in this study are likely to have lower levels of leakage and greater

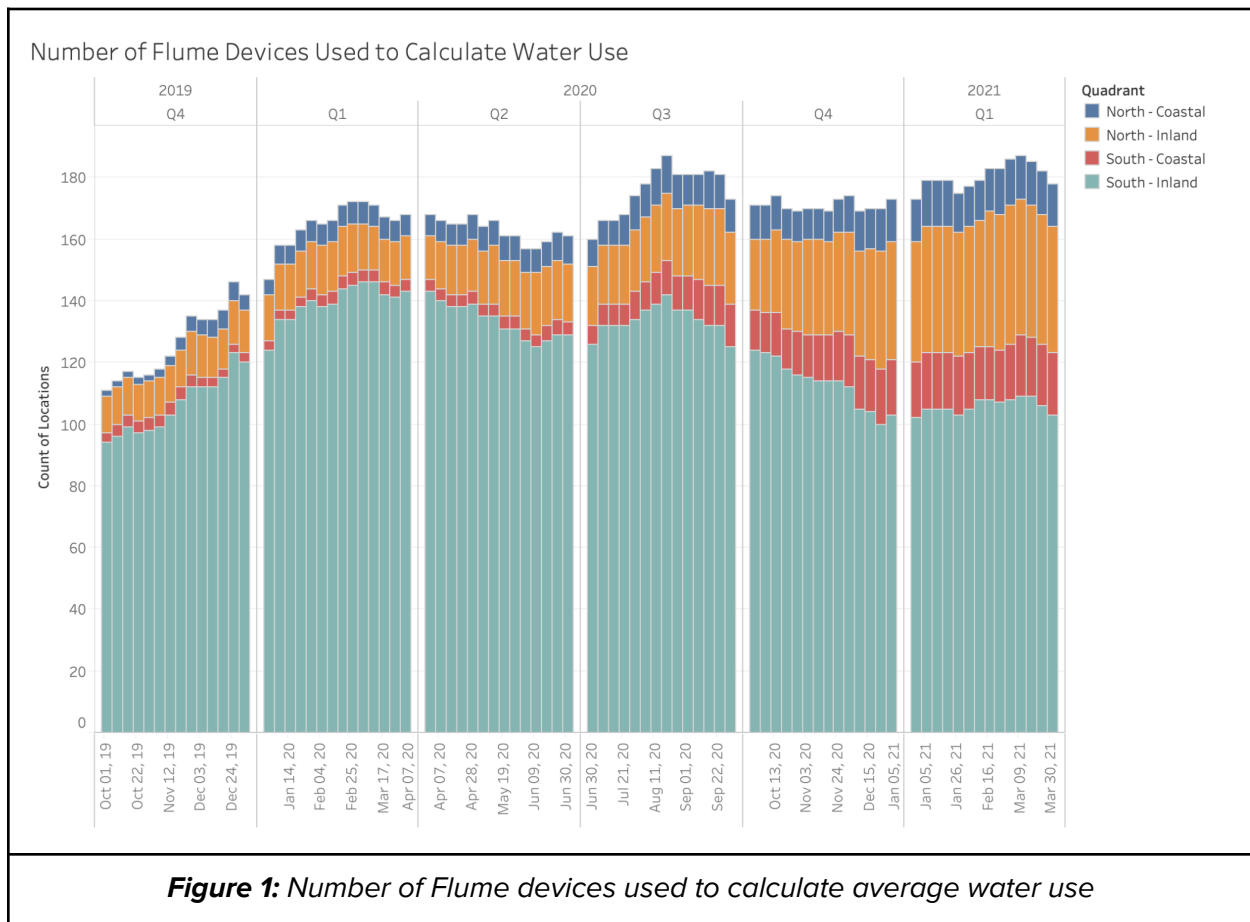
awareness of their overall water use than the general population in Orange County without Flume devices.

There are approximately 375 Flumes installed and active in the MWDOC service area in 2020. Only devices that were online recording data at homes where the number of residents was reported via the Flume app could be included in the final analysis.

In Q4 2019, there were approximately 100 Flume devices that were online with a reported number of residents in the MWDOC service area. By the end of Q1 2021, there were approximately 200 Flume devices that met this criteria. Significantly, if any devices were offline during a period of time, those missing data streams were excluded from the sample set. For example, while determining the water use on 12/1/2020 between 1:00 a.m. and 2:00 a.m., only devices that were active during that specific hour were used in the analysis.

Figure 1 below illustrates the number of devices that were used for this study by week and by service area region. Note that the number of devices included steadily increases throughout the year, but at no point was it less than 100.

Note that the number of devices in the “South - Inland” quadrant has far more Flume devices installed to date than any other MWDOC quadrant (please refer to Figure 8 for a definition of the MWDOC quadrants). This is because Santa Margarita Water District (SMWD) actively promoted a successful Flume rebate program in 2019. MWDOC intends to offer a similar Flume rebate program in the coming months to increase participation across the entire district.



Additional Customer Information

As part of the Flume installation process, within the Flume smart-device application, the customer is asked to enter information about their home, including:

- Number of residents;
- Number of bathrooms;
- Swimming pool - yes or no;
- Type of irrigation system (automatic inground, manual, none, etc.);
- Typical frequency of irrigation.

These questions are optional to fill out within the Flume app. However, 93% of the MWDOC Flume customers did answer these questions. Because the number of residents is necessary for GPCD calculations, only homes with this reported information were included in the study.

The following property-specific data were obtained independently from Flume partner [estimated.com](https://www.estimated.com):

- Property value;
- Home age;
- Lot size;
- Home size.

End Use Disaggregation

Data for this study were collected using both Flume 1 and Flume 2 devices. The Flume 1 devices collected flow data in one-minute intervals. For each day in 2020, every Flume 1 device recorded 1,440 measurements of flow, providing an extraordinarily detailed view of water use throughout the entire year. The Flume 2 devices collected data in 5-second intervals. Although 5-second resolution was not required for this study, these more granular data will be used for future end-use studies.

The 60-second or 5-second flow data from each household were disaggregated by Flume into indoor and outdoor use for each household for each day. The disaggregation was accomplished using Flume's proprietary water use analysis technology which uses machine learning and artificial intelligence to accurately assign end use classifications.

In general, Flume categorized the following uses as "outdoor":

- Irrigation (automatic timed irrigation sprinklers, drip, soaker hose, etc.);
- Garden hoses and manual sprinklers;
- Pool fillers (automatic swimming pool refilling).

The following uses are categorized as "indoor":

- Leaks;
- Any other use not categorized as outdoor or leakage.

Research Results

Participant Demographics and Household Characteristics

The following demographic and customer information data (Figure 2) were collected from study participants by Flume during the installation process. Approximately 93% of customers provided these data. The data in the Figure 2 below is self-reported by the study participants.

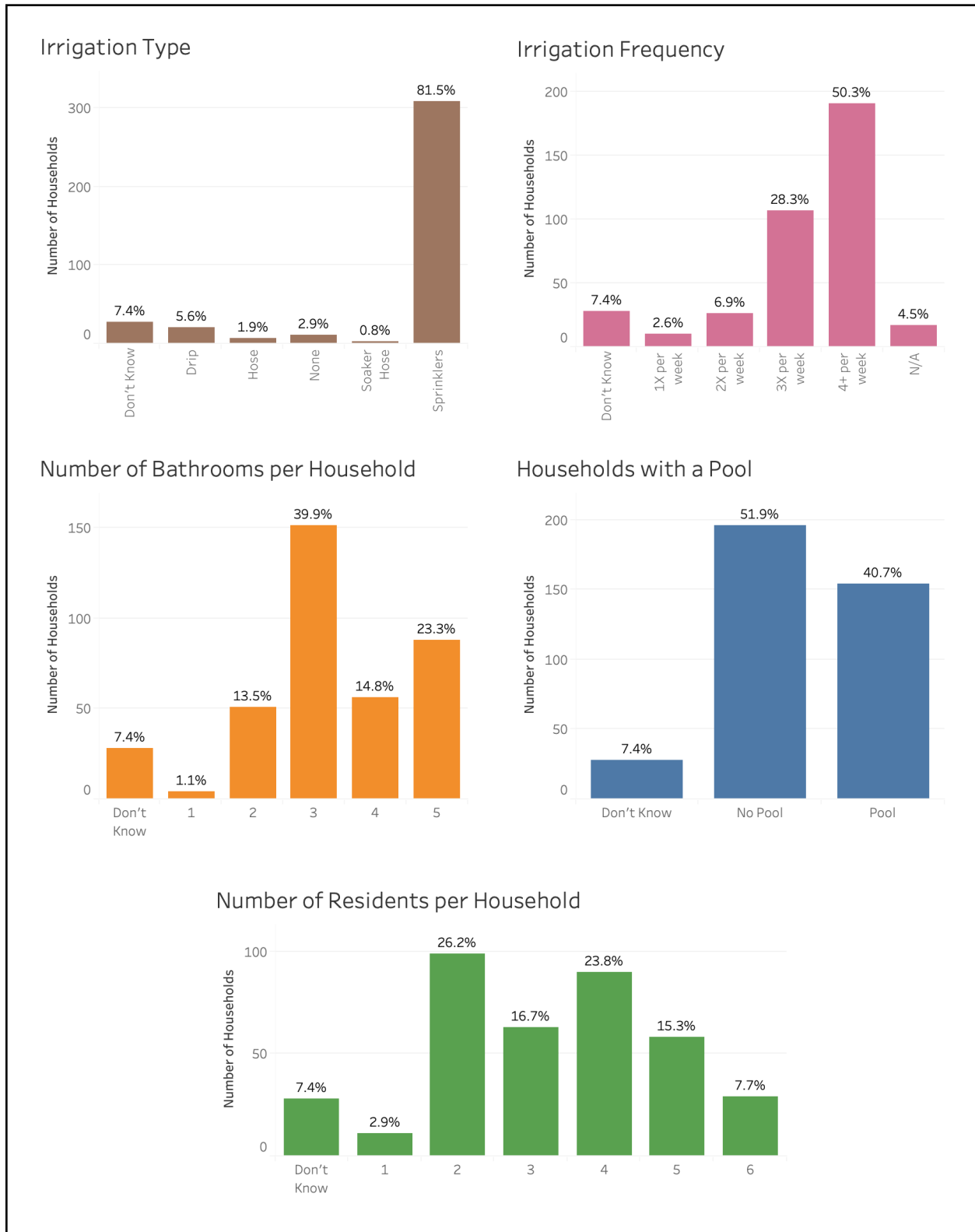
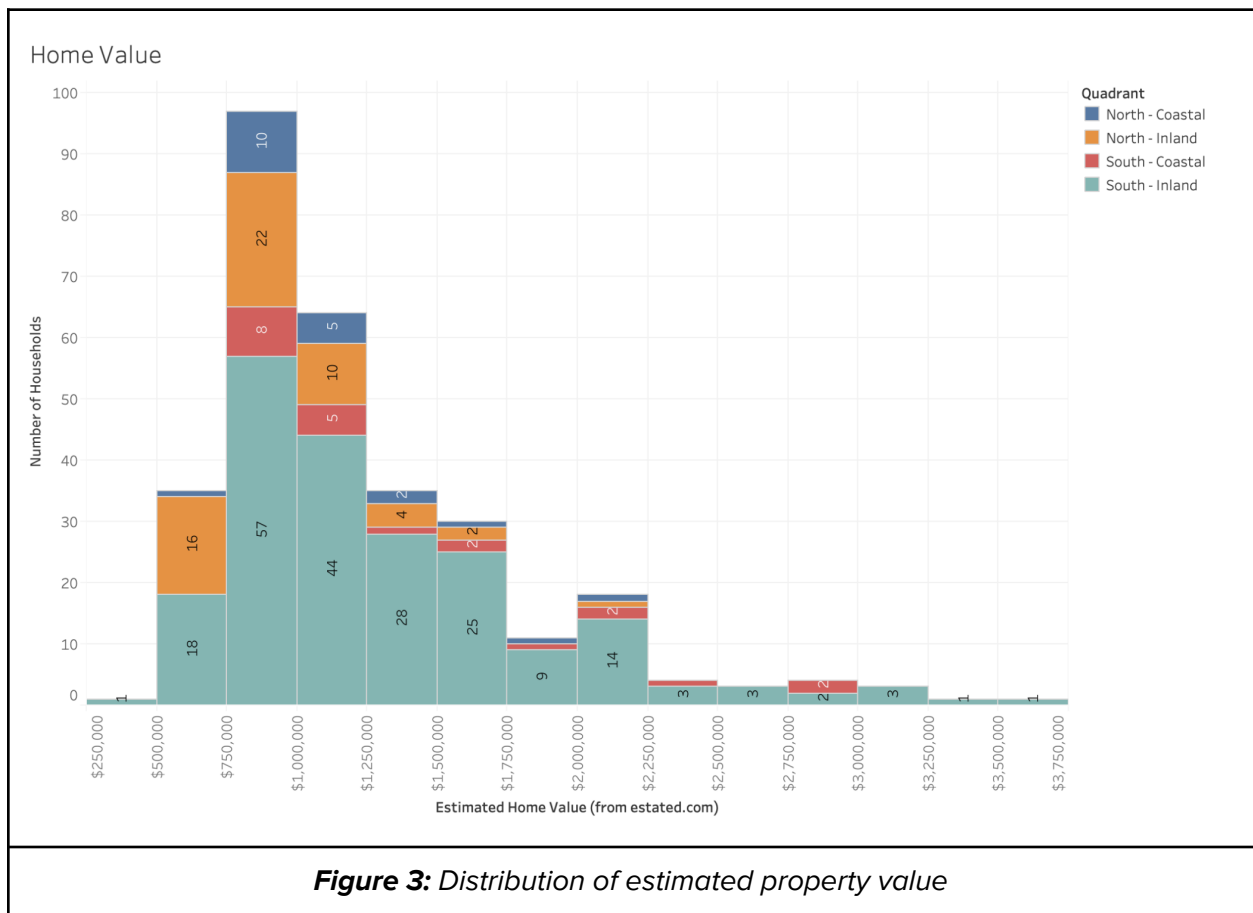
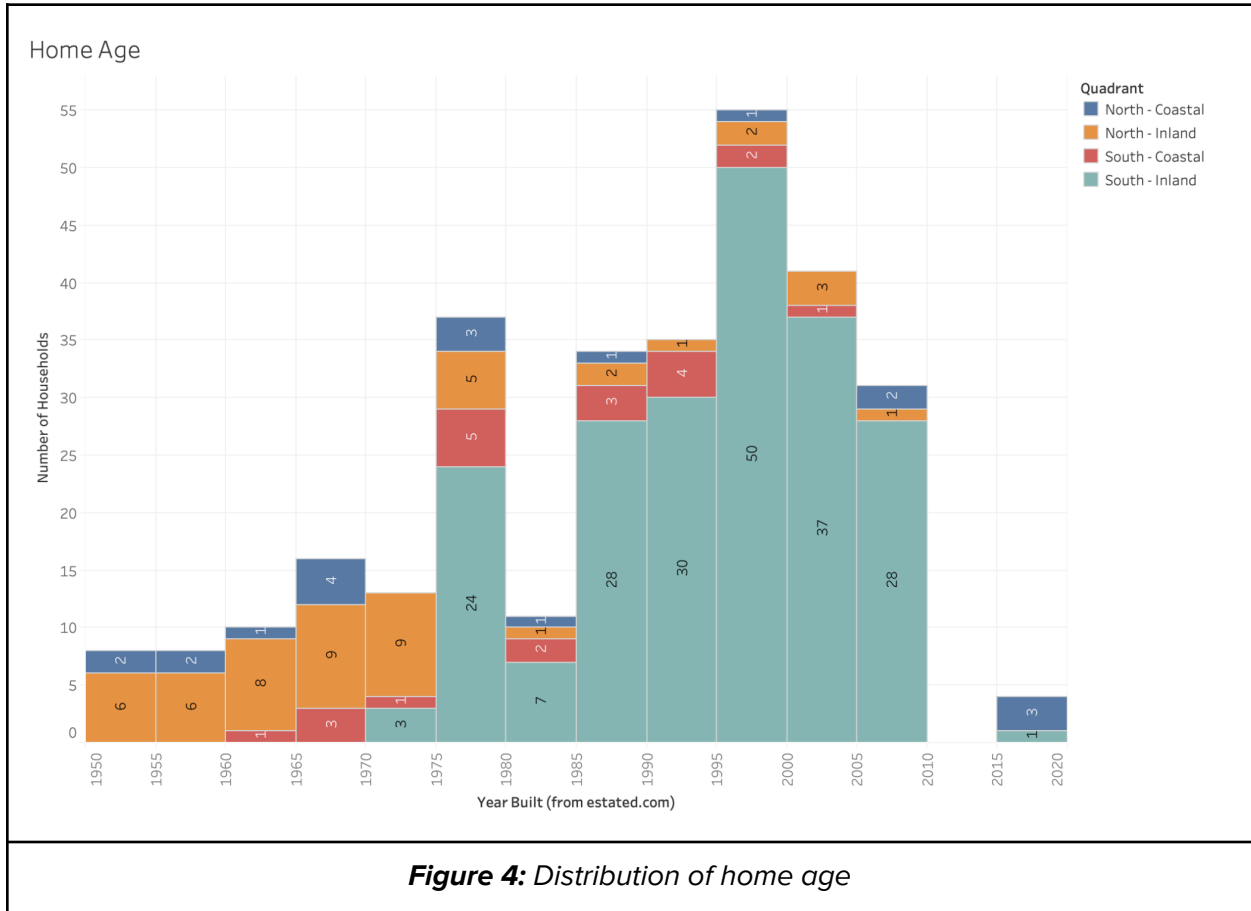
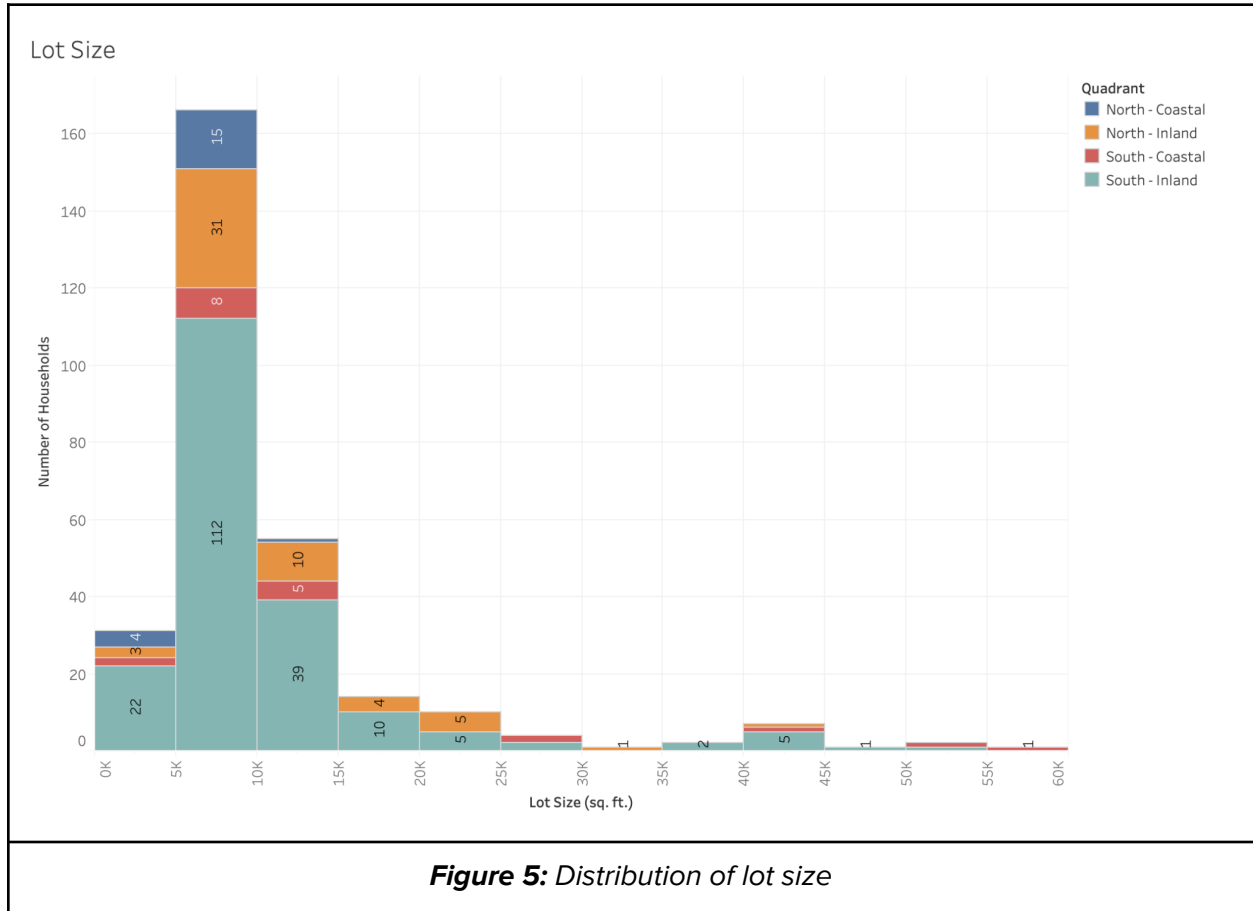


Figure 2: MWDOC 2020 Residential Water Use Study participant demographics and customer information. This data is self-reported by the study participants.

The following charts (Figures 3 through 6) show the distribution of home value, home age, lot size and home size for the households used in this study. Table 1 shows the average property value, home age, lot size and home size in the study compared with the entire Orange County average.







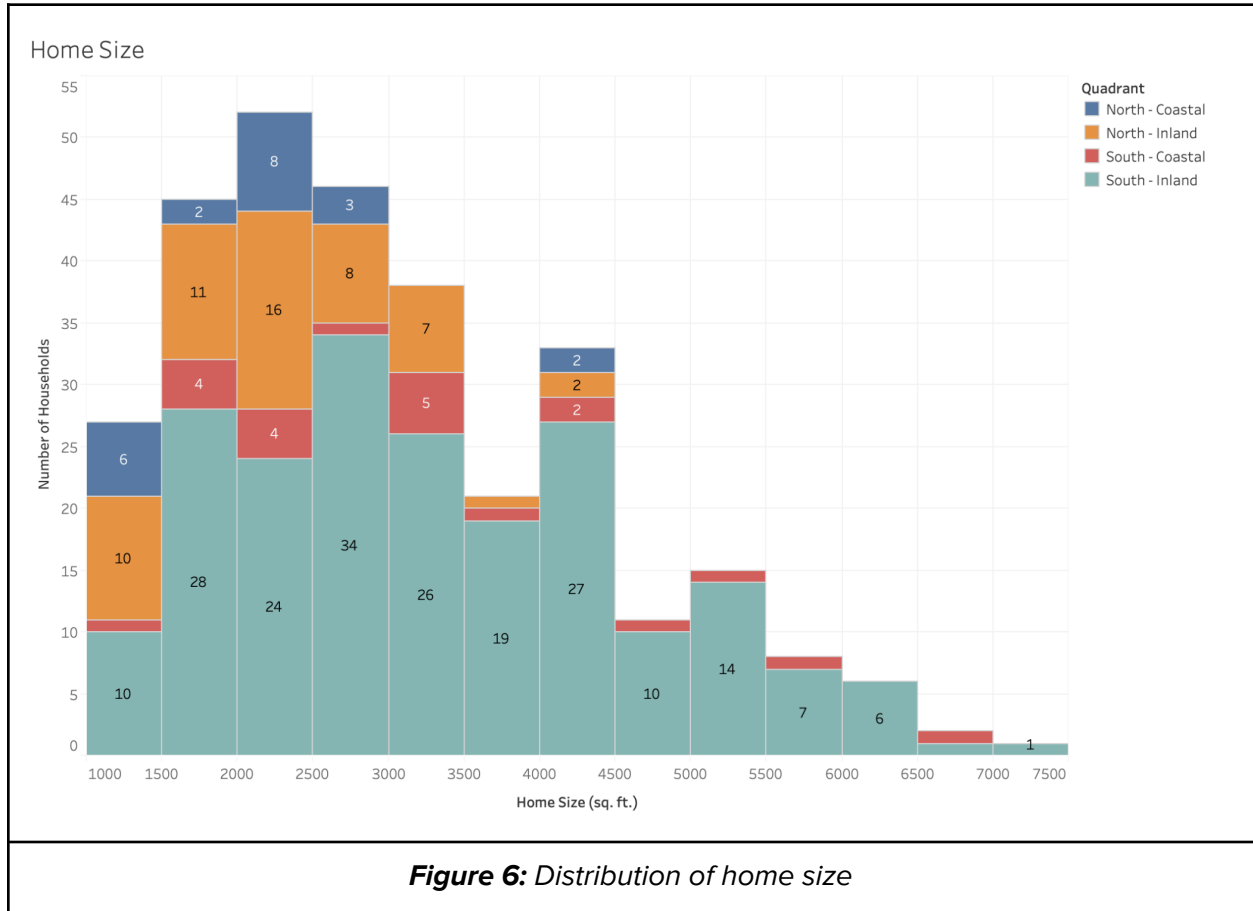


Table 1 indicates that the average home value of the Flume users in Orange County is higher than the average Orange County home value. In addition, the Median Household Income of Flume users in Orange County is also higher than the average. This implies that the sample of participants in this study may be wealthier than the average Orange County household. To account for this possibility, this report presents analyses of consumption data based on different property values and ages that may be more representative of the overall population economically.

Table 1: Average home value, age, lot size home size, and median household income

	Orange County Flume User Average	Orange County Average
Property Value	\$1,258,682	\$841,137*
Home Age	33 years old (built in 1988)	49 years old (built in 1972)**
Lot Size	12,637 sq. ft.	N/A
Home Size	3,085 sq. ft.	1,756 sq. ft.***
Median Household Income****	\$151,125	\$90,234

* zillow.com

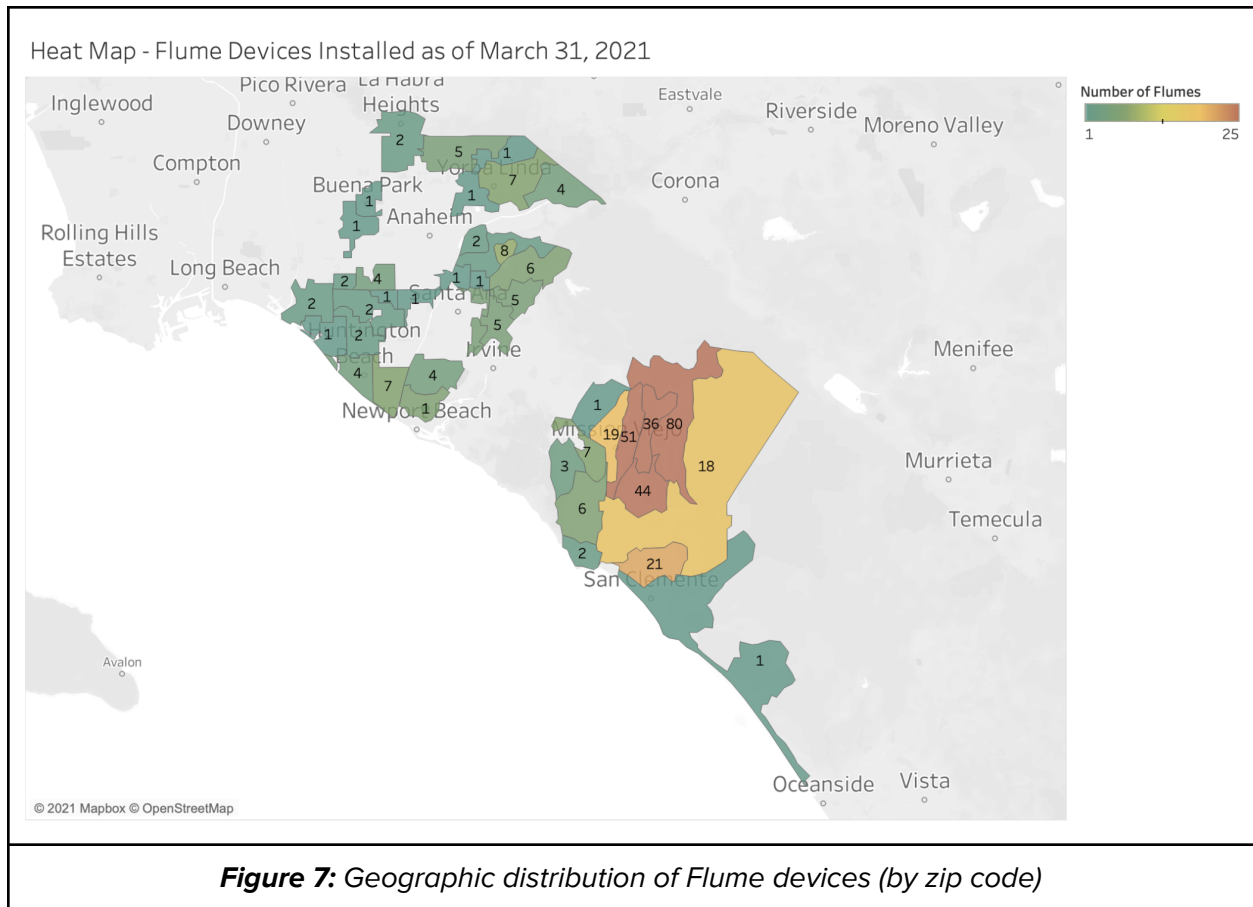
** point2homes.com

*** redfin.com

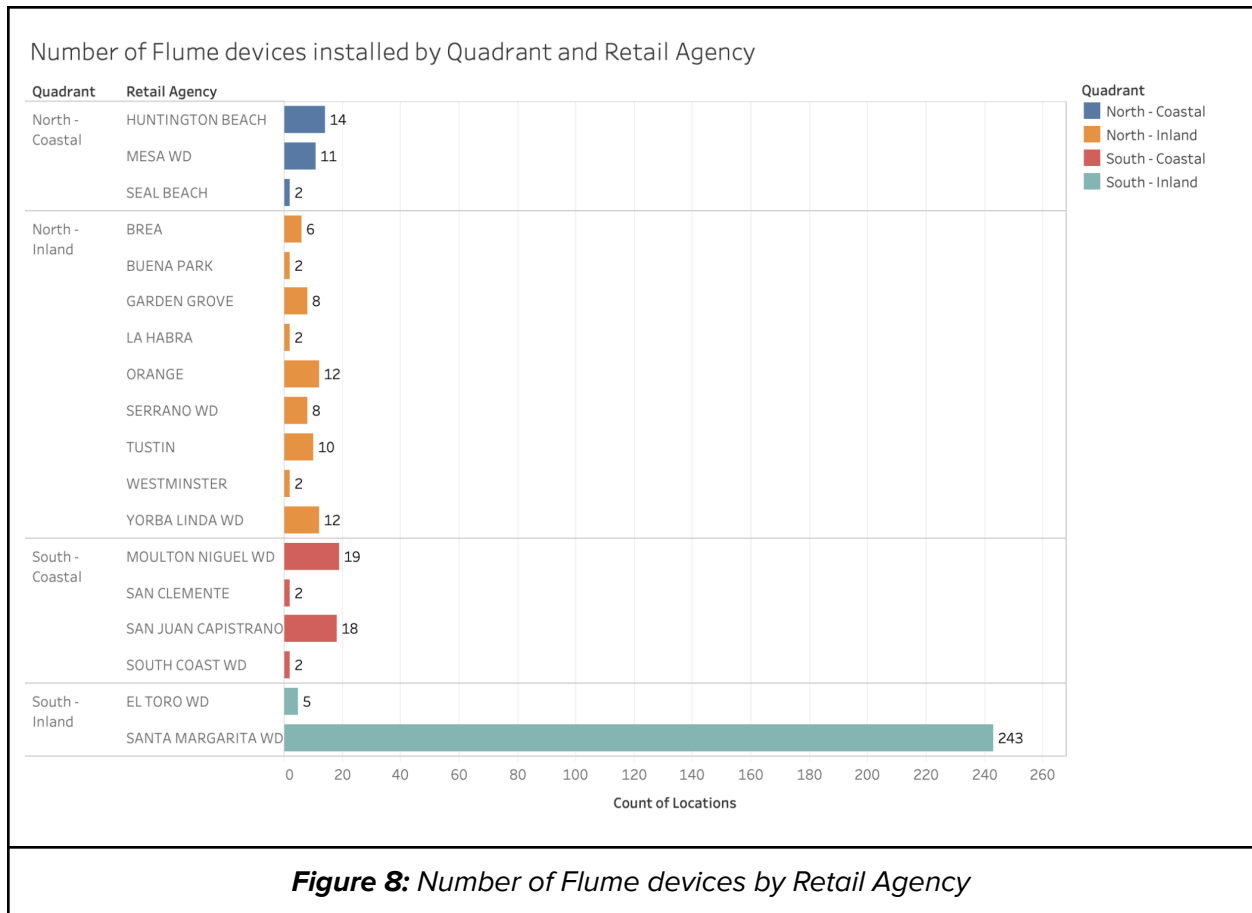
**** provided by MWDOC

Geographic Distribution of Flume Devices

Seventy-one percent of the Flume customers in Orange County reside in the zip codes that are shaded in red, orange and yellow below, with red representing the highest concentration of Flumes. As the project continues in 2021, there will be a concerted effort to add more Flume devices in neighborhoods with less representation in the 2020 analysis.



The distribution of Flumes by Retail Agency is shown in Figure 8 below.



Indoor Water Use

Table 2 represents a summary of indoor water use as average gallons household per day (GPHD) and average gallons per capita per day (GPCD), for the Flume users in Orange County in 2020 in each month of the year.

As discussed later in this report (see section entitled “Effect of COVID on Indoor Water Use”), 2020 indoor use was strongly influenced by COVID-19 stay-at-home restrictions, which resulted in higher indoor water use, particularly in April–September.

Table 2: 2020 Average monthly indoor use as GPCD and GPHD

Month	Avg. Indoor GPCD	Avg. Indoor GPHD
January	54.9	192.0
February	57.7	198.9
March	57.9	198.3
April	73.9	240.1
May	66.4	217.0
June	63.5	205.7
July	64.8	209.7
August	64.8	210.0
September	67.0	209.2
October	59.3	184.8
November	56.4	178.7
December	60.3	187.5
Annual Average	62.2	202.7

Figure 9 shows the average 2020 indoor GPCD across all Flume users in Orange County by month. In a normal year, it would be expected that this curve would be fairly flat. But 2020 was not a normal year for the world. Due to COVID-19 restrictions, average per capita indoor use increased dramatically in March and April as more people stayed home. The impact of COVID-19 on indoor water use is discussed in more detail later in this report (see section entitled “Effect of COVID on Indoor Water Use”).

Prior to COVID restrictions, average indoor use for the Flume users in Orange County averaged between 55 - 58 GPCD (as shown in January and February). The yearly average of 62.3 is most likely higher because of the significant demand increases that occurred in response to COVID-19. This is discussed in more detail later in this report (see section entitled “Effect of COVID on Indoor Water Use”).

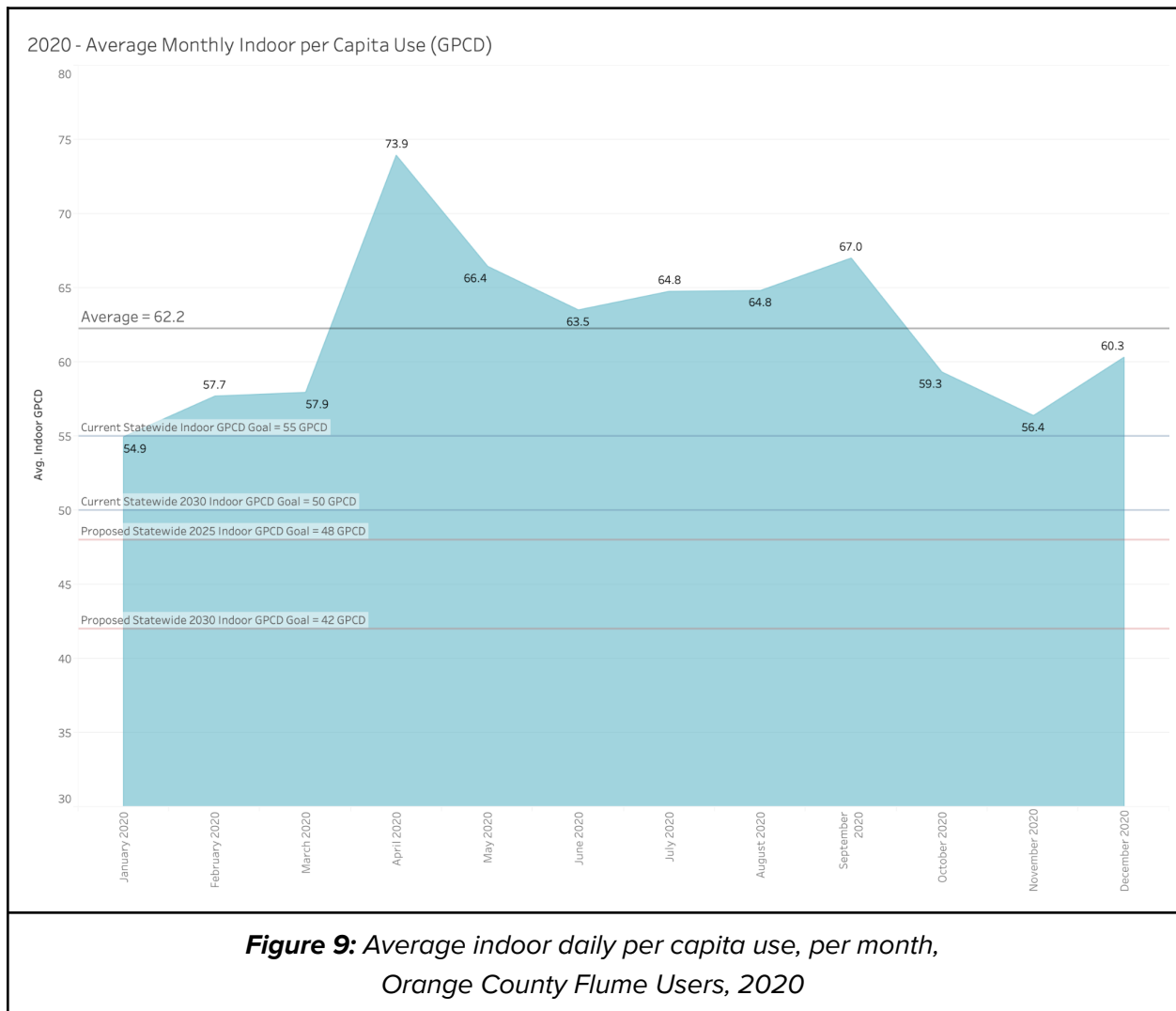
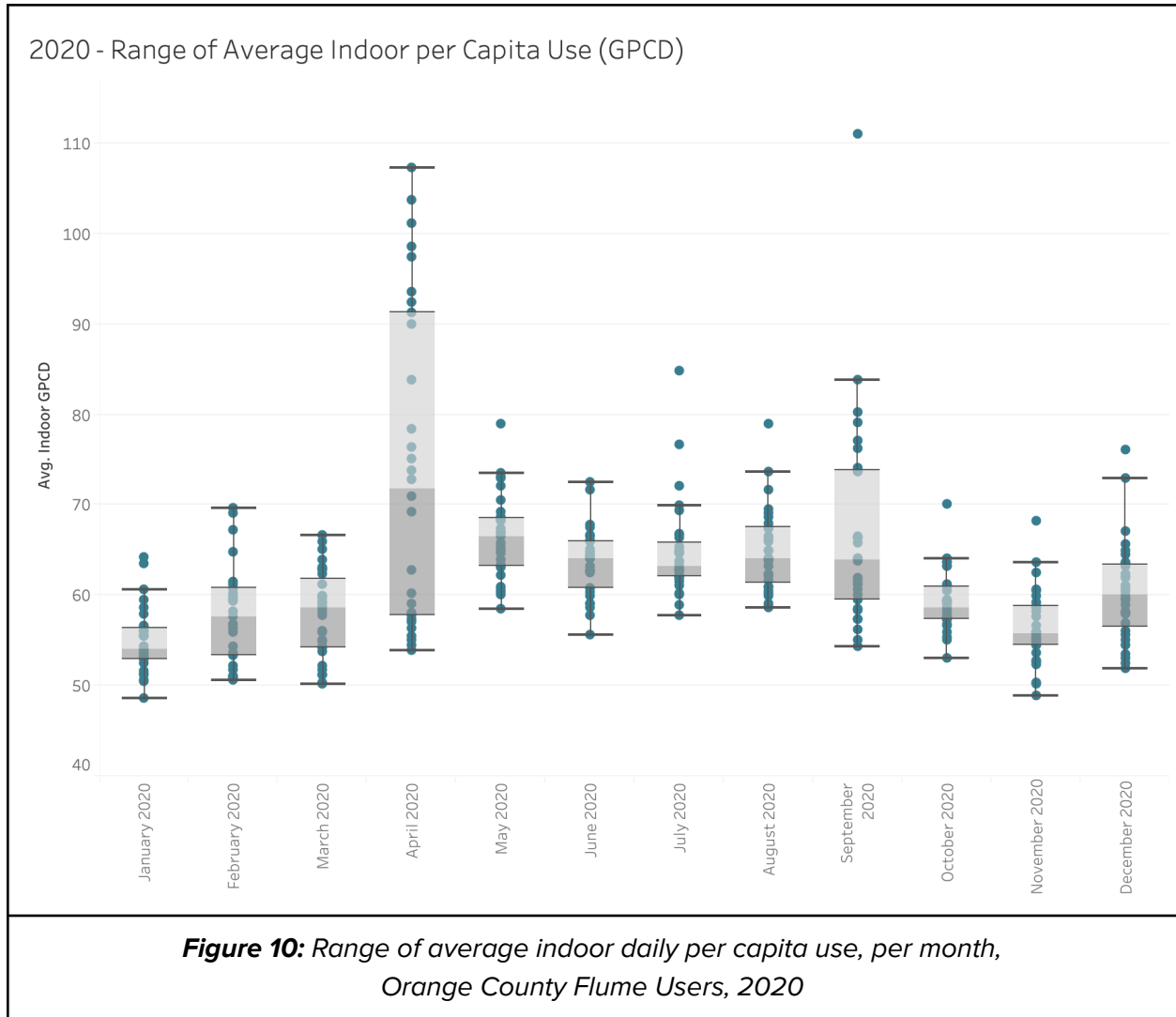


Figure 10 is a bar and whisker chart that shows the range and variability of per capita water use each month. The solid boxes represent all of the data points that fall between the first and the third quartiles (that is, the middle 50% of the data). The whisker lines show the minimum and the maximum (but disregard outliers). During 2020, indoor use for the Flume users in Orange County rarely dropped below 50 GPCD. In most months, typical indoor water use was between 55 and 65 GPCD. Water use in April 2020 was exceptionally high and variable due to COVID stay-at home orders.

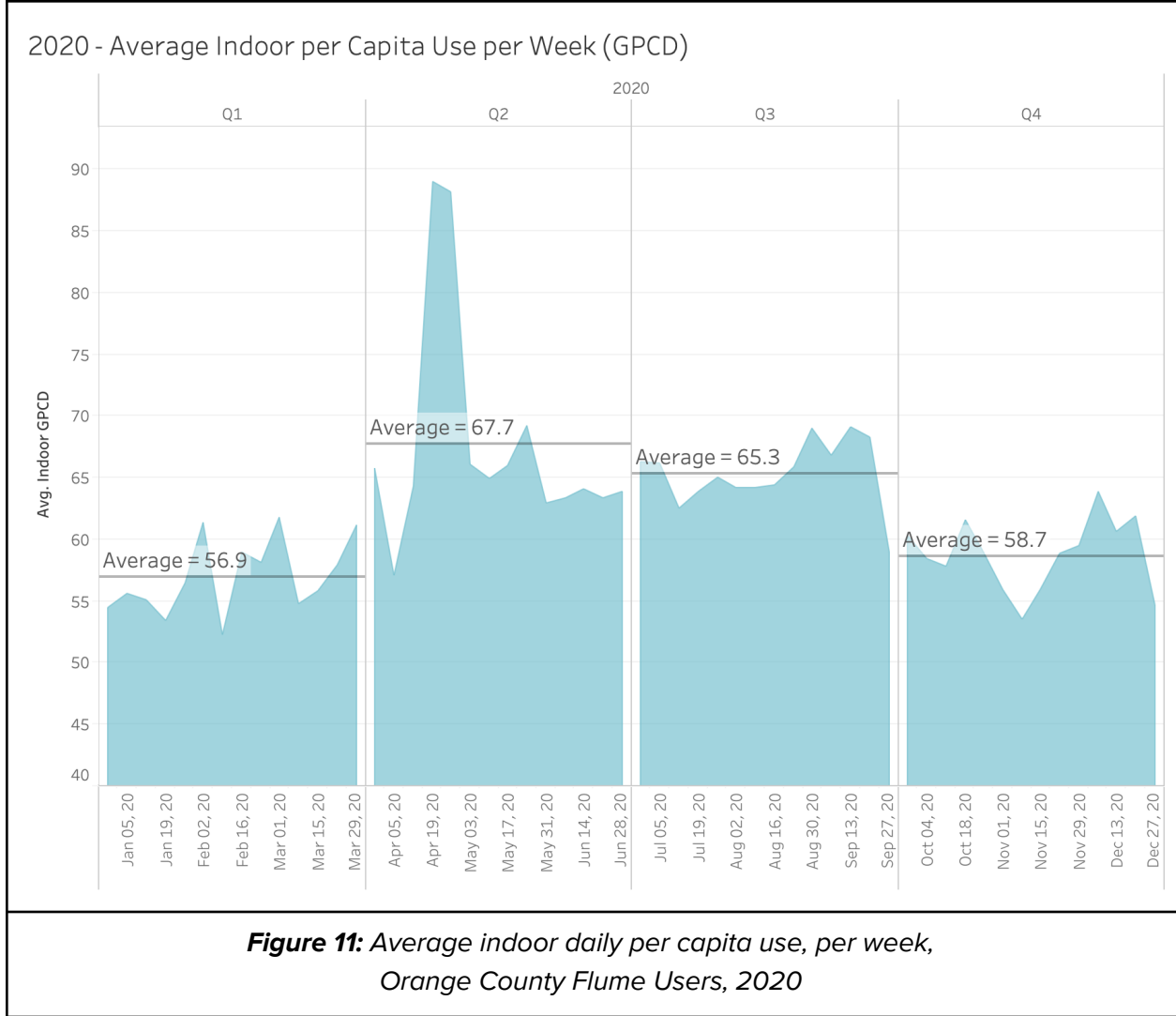


Figures 11 and 12 and Table 3 present the indoor GPCD data shown Figures 9 and 10 by the week (instead of by the month). An increase in use of more than 10 GPCD occurred in April, almost certainly due to COVID-19 stay-at-home orders. Indoor use declined in each of the following quarters in 2020, but did not fully return to pre-COVID levels.

In Q1, 2020, indoor use averaged 56.9 GPCD. In Q2, indoor use increased by a dramatic 19% to 67.7 GPCD, peaking close to 90 GPCD in April 2020. Indoor use declined in Q3 by just 4% to 65.3 GPCD, but reduced by another 10% in Q4, ending at 58.7 GPCD. Indoor use in Q4 was about 1.8 GPCD higher than in Q1 2020.

Table 3: Quarterly Change in Indoor GPCD in 2020

2020 Quarters	Avg. Indoor GPCD	% Change, Quarter to Quarter
Q1	56.9	
Q2	67.7	+19%
Q3	65.3	-4%
Q4	58.7	-10%



It is interesting to note in Figure 12 that the average weekly indoor GPCD never falls below 48 during 2020. It is lowest during the week of January 12, 2020 at 48.6 GPCD.

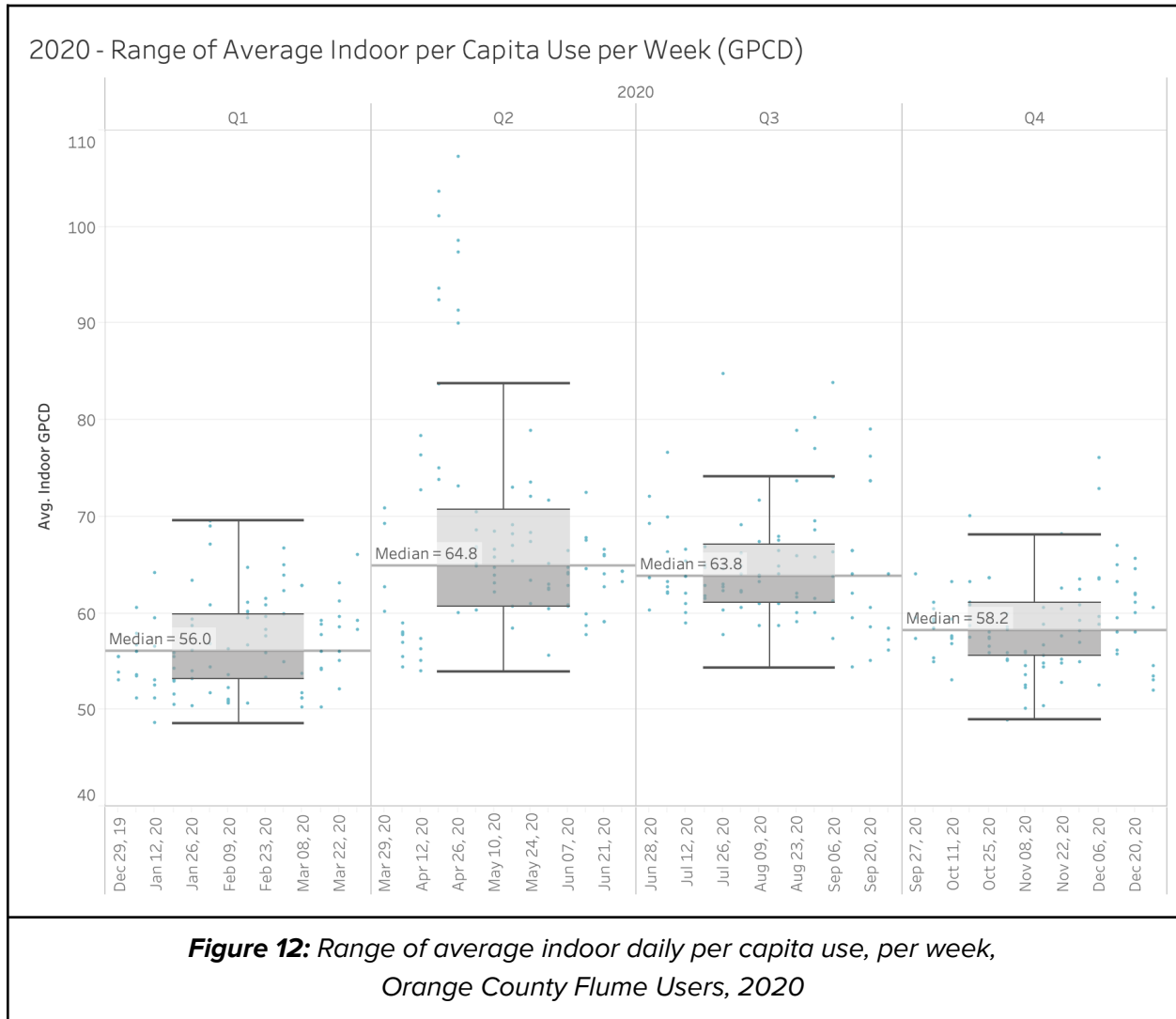
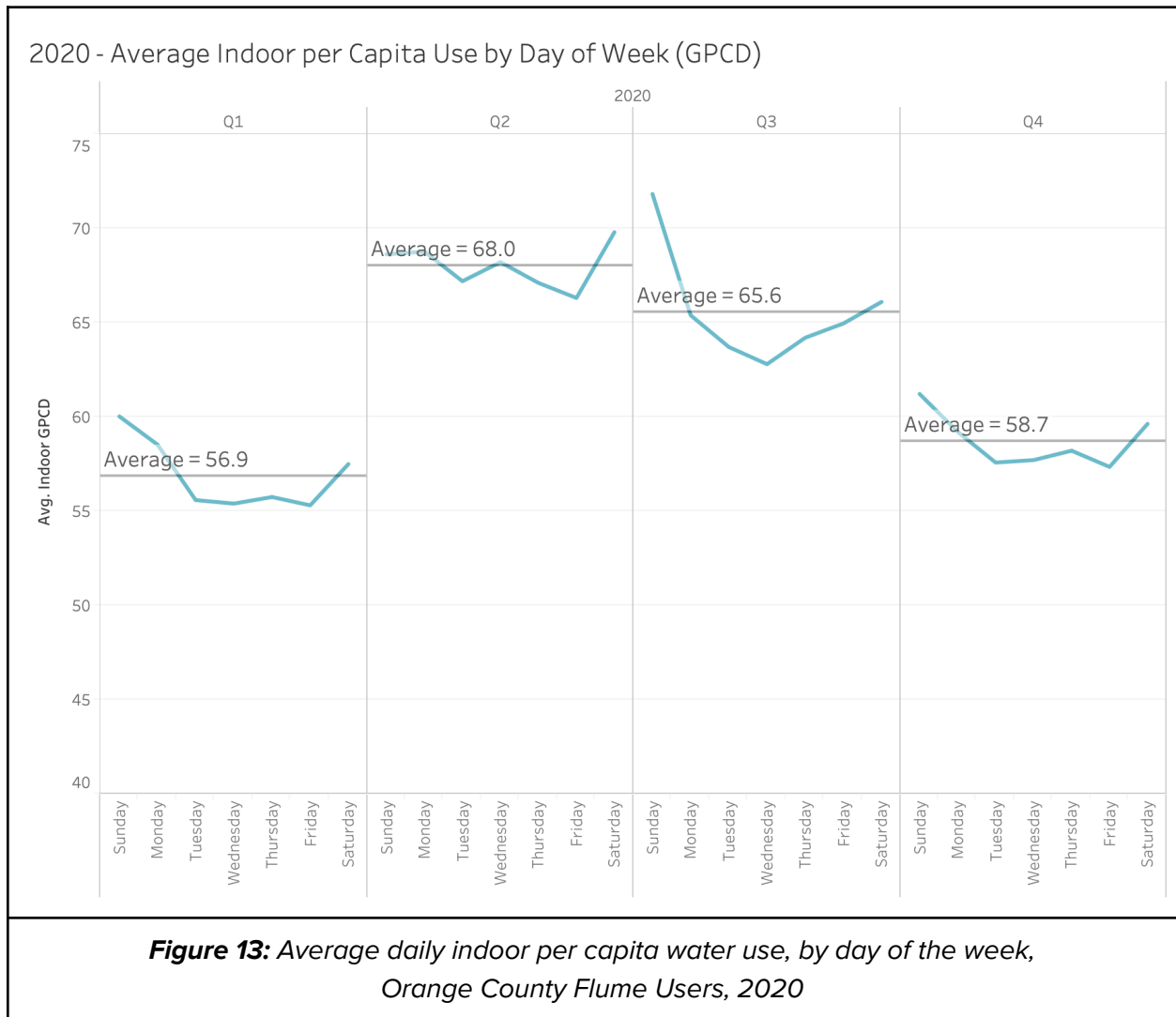


Figure 13 and Figure 14 show the average indoor GPCD for each day of the week for each quarter of 2020. Indoor water use is highest on Saturdays, Sundays and Mondays in all quarters of 2020. This may be attributed to more people being home on weekends and indoor water using activities, such as laundry, are done. Tuesday and Friday had the lowest average per capita indoor use. During the second quarter, when people stayed home more, the differences between weekend days and week days became less pronounced.



It is interesting to note in Figure 14 that the average daily indoor GPCD never falls below 48 during 2020. It reached its lowest level on Fridays in Q1 at 48.6 GPCD.

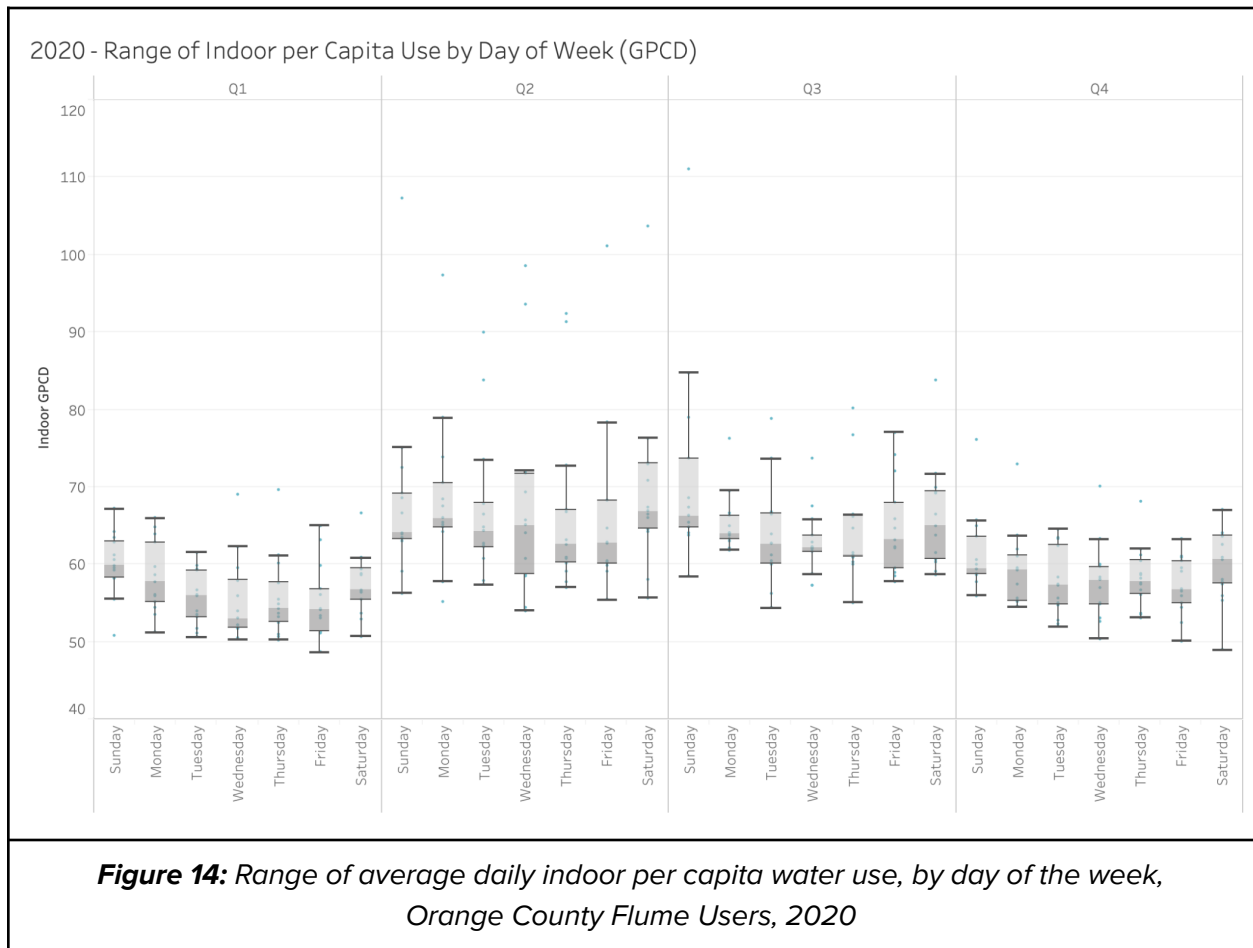
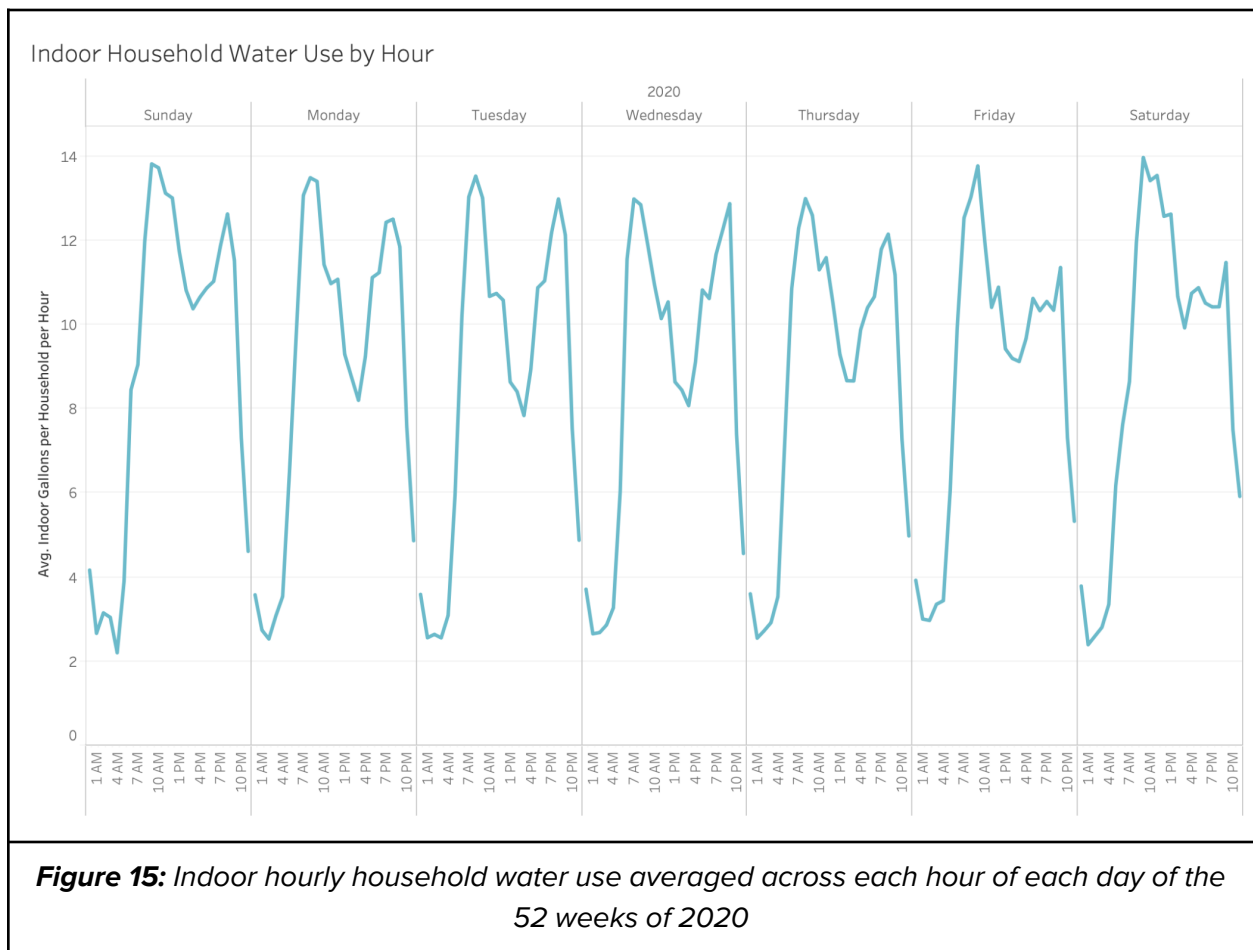


Figure 15 represents an entire year of indoor water use at high resolution. This figure shows the diurnal indoor use patterns across the week and is constructed from the average hourly indoor household water use from each household for each hour of the day in 2020. Table 4 identifies the timing of specific peaks that occur in Figure 15.

Table 4: Timing of indoor peak hourly use, shown in Figure 15

	Morning Peak	Evening Peak
Sunday	9AM	8PM
Monday	8AM	8PM
Tuesday	8AM	8PM
Wednesday	7AM	9PM
Thursday	8AM	8PM
Friday	9AM	9PM
Saturday	9AM	9PM



Effect of COVID on Indoor Water Use

COVID-19 restrictions in Orange County had a direct and immediate impact on indoor water use. Figure 16 correlates some key closure/reopening dates with indoor water use. The impacts of COVID-19 on indoor water use for the Flume users in Orange County was pronounced and substantial. In response to the first stay-at-home order in March 2020, indoor water use increased steeply and stayed elevated through the summer of 2020, including specific responses to public health announcements. Towards the end of 2020, indoor water use temporarily peaked again as new stay-at-home orders were enacted.

Specifically, in Q1, 2020, indoor use averaged 56.9 GPCD. In Q2, indoor use increased by a dramatic 19% to 67.7 GPCD, peaking close to 90 GPCD in April 2020 in response to COVID-19 restrictions. During this time people stayed at home and flushed the toilet, cooked, and used the faucet more frequently. On May 8, 2020, California moved to a new stage of response which allowed additional commerce. While not as high as the peak in April 2020, average indoor use stayed fairly high through Q3, declining by just 4% to 65.3 GPCD compared with Q2. Demand reduced further in Q4, ending at 58.7 GPCD. Average indoor use in Q4 2020 was about 1.8 GPCD higher than in Q1 2020.

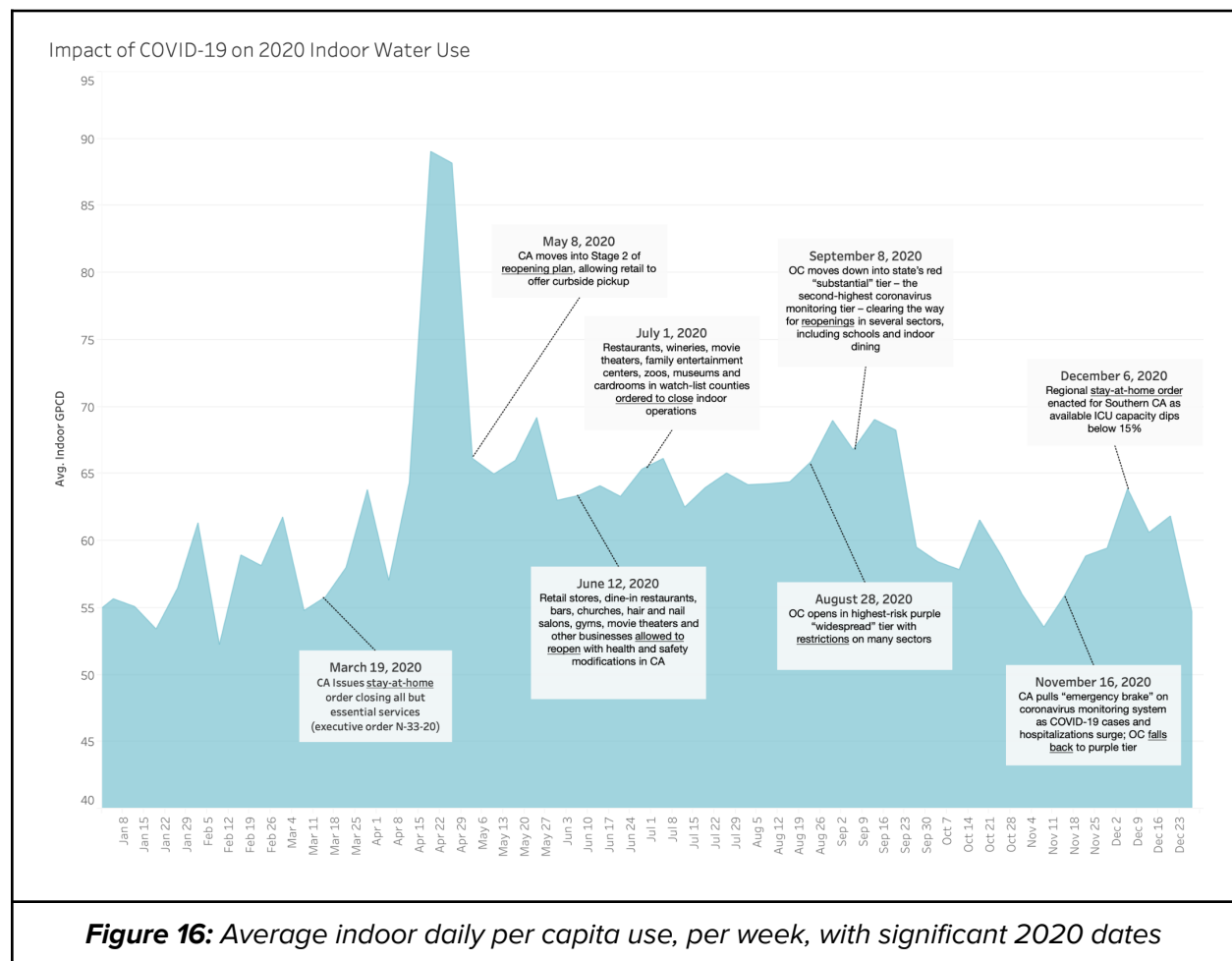
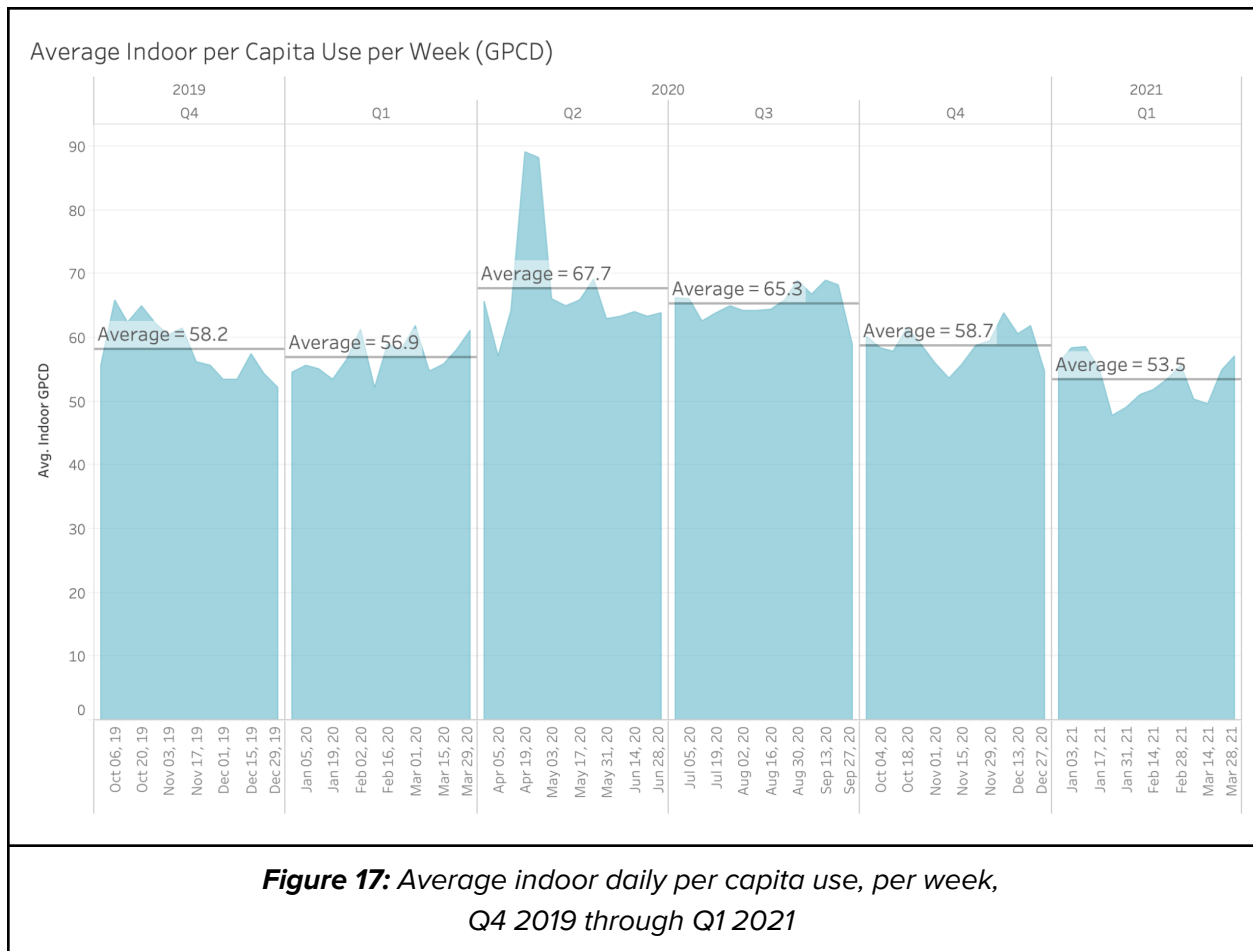


Figure 17 presents six quarters of indoor water use starting from Q4 2019 and going through Q1 2021. The number of Flume devices in Orange County grew steadily over this time. During the Q4 2019 and Q1 2020, prior to stay-at-home orders related to the COVID-19 pandemic indoor use averaged between 56.9 - 58.2 GPCD. However, the average indoor use increased by 10 GPCD during Q2 2020 and Q3 2020 (during the initial phases of COVID-19).

Notably, in Q1 2021 indoor use declined to an average of 53.1 GPCD, which is lower than any of the previous five quarters, perhaps returning closer to a more normal level for this group of customers, which has steadily grown over the six quarters shown in Figure 17. Future Flume reports will evaluate potential lingering impacts on COVID-19 on American work habits and indoor water use.



Outdoor Water Use

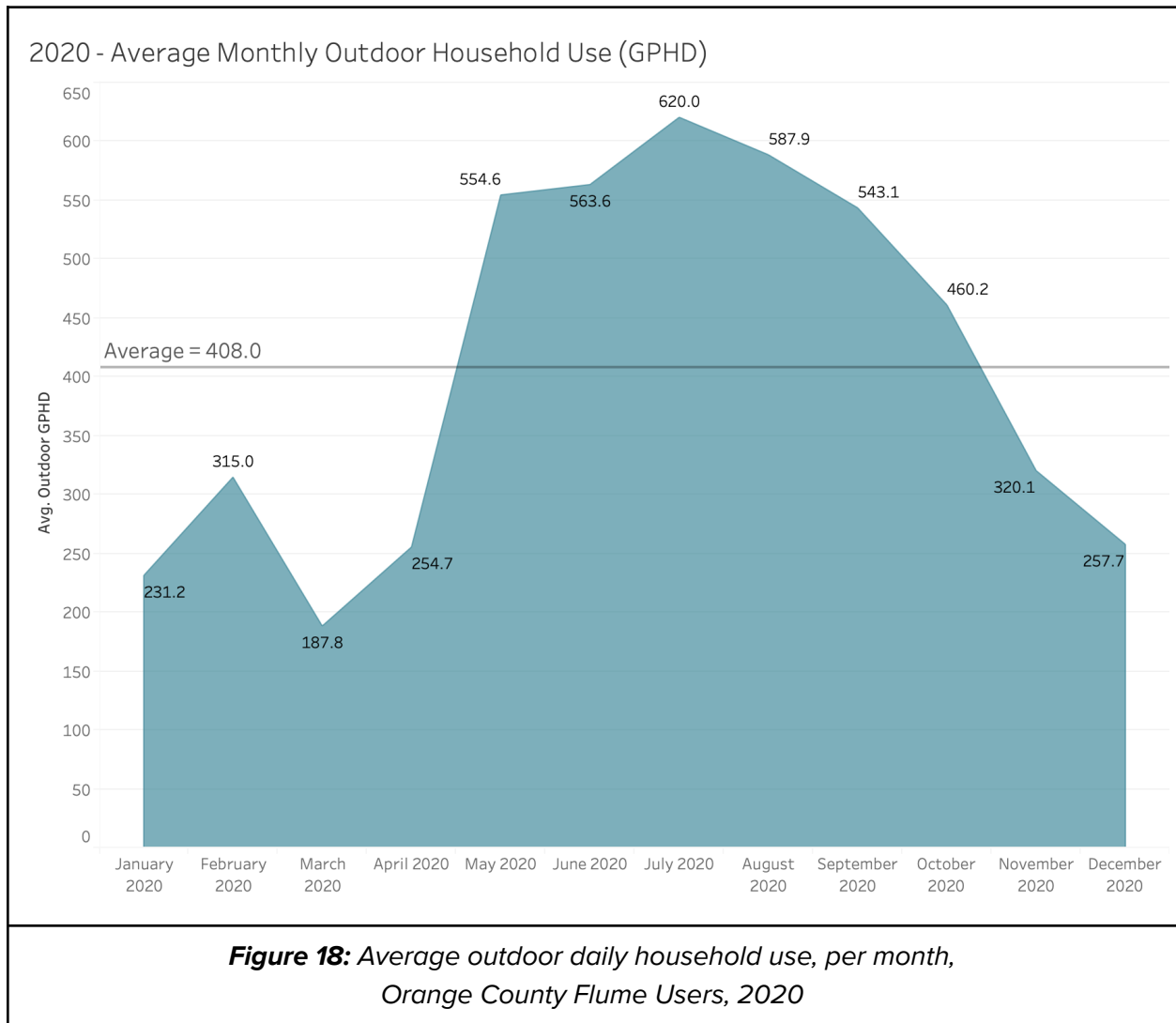
In 2020, 67% of the study participant’s total household residential water use was used outdoors and 33% indoors. Table 5 summarizes household and per capita outdoor use in each month of 2020 for the Flume users in Orange County. Outdoor use was highest from May–October, but still occurred in all months of the year for the Flume users in Orange County.

Table 5: Average daily household and per capita outdoor use in each month of 2020

Month	Avg. Outdoor (GPCD)	Avg. Outdoor (GPHD)
January	84.4	231.2
February	108.7	315.0
March	76.4	187.8
April	93.1	254.7
May	198.1	554.6
June	204.2	563.6
July	229.0	620.0
August	199.0	587.9
September	176.2	543.1
October	169.4	460.2
November	128.3	320.1
December	82.5	257.7
Annual Average	146.3	410.1

In subsequent Flume water use reports it will be possible to present outdoor water use data from the four geographic quadrants of Orange County which have distinct climate features. As of Q1 2021 there were not enough Flumes distributed across three of the four quadrants to make the analysis meaningful. As discussed earlier in this report, the majority of Flume devices are currently installed in a single quadrant, as shown in Figure 7.

Figure 18 and Figure 19 show the average daily household outdoor water use in each month of 2020. The annual average was 408.0 GPHD. At least some outdoor use was measured in all 12 months of the year. The maximum outdoor use occurred in the summer months and the minimum use occurred in the winter months. The maximum month in 2020 for outdoor use was July and the minimum month was March.¹



¹ Weather has a distinct impact on outdoor use in Orange County and will be discussed later in the report (see section entitled “Effect of Weather and Watering Restrictions on Outdoor Water Use”).

Figure 19 shows the tremendous range and variability in daily outdoor water use across all Flume users in Orange County and the coordinated response to seasonal changes.

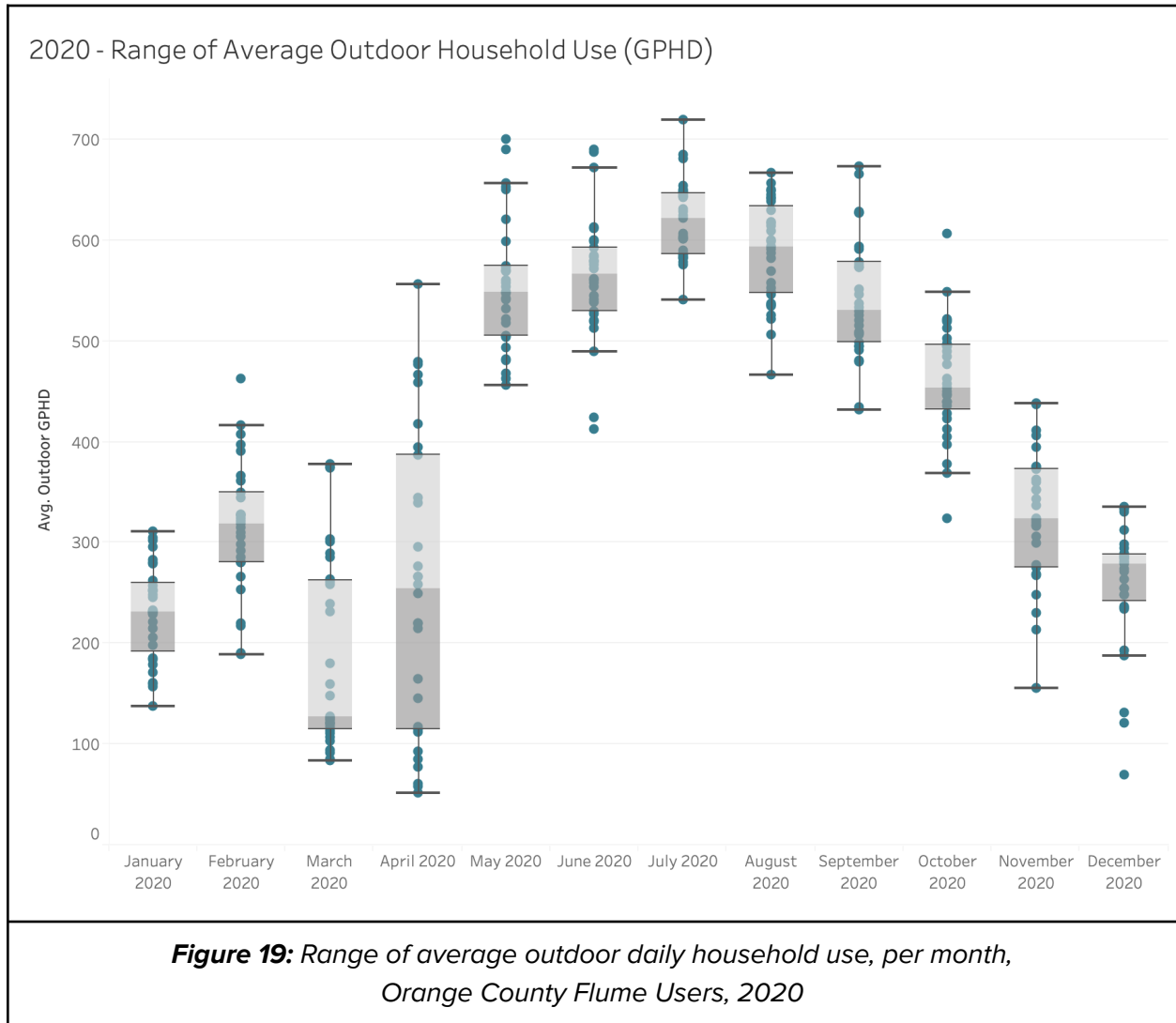
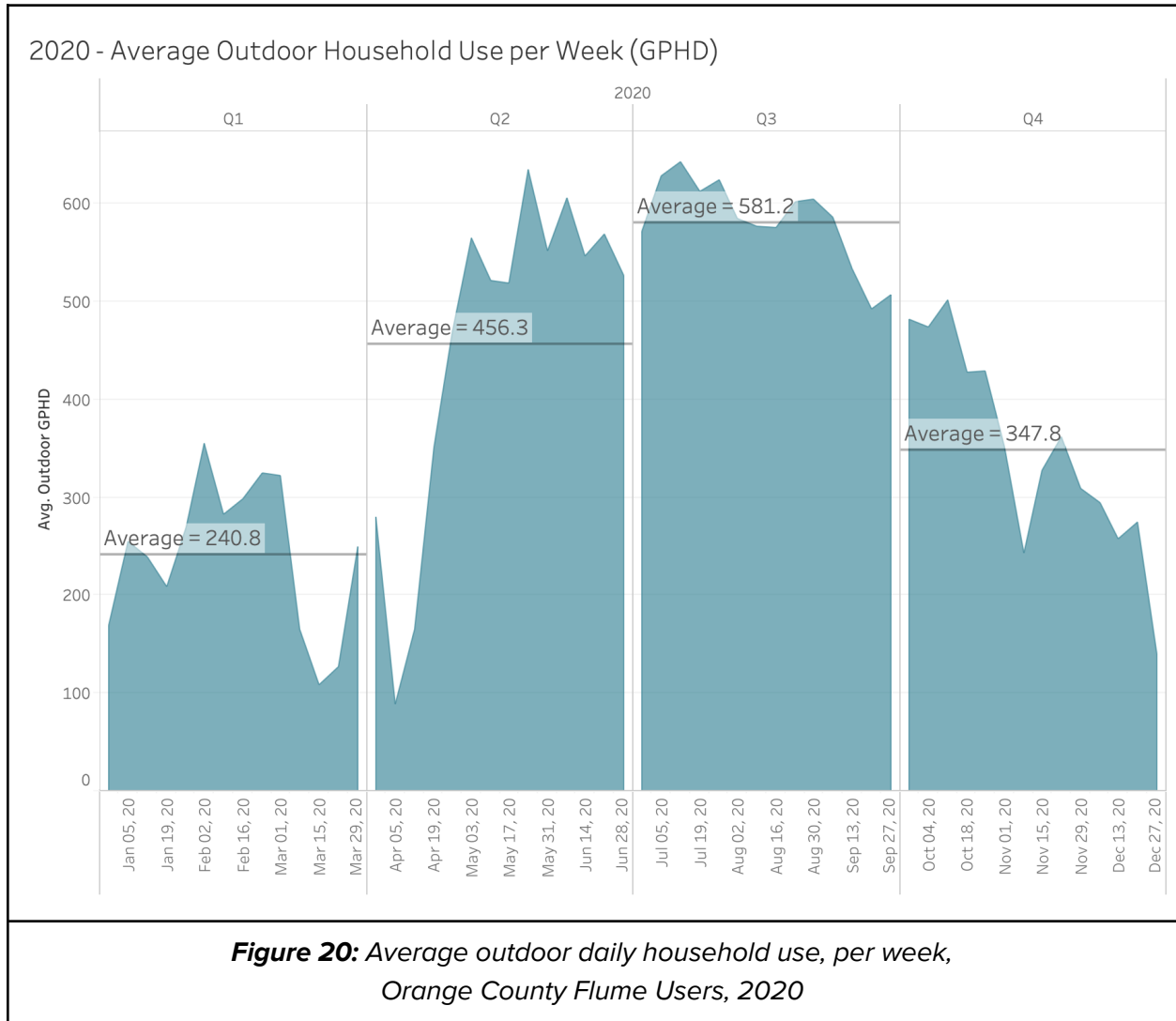


Figure 20 and Figure 21 visualize the same outdoor use data for each week of 2020. Outdoor use was lowest during Q1 and highest in Q3. The variability in outdoor use was most pronounced in Q2 and Q4, when precipitation events occurred. The impacts of weather are addressed later in this report (see section entitled “Effect of Weather and Watering Restrictions on Outdoor Water Use”).



2020 - Range of Average Outdoor Household Use per Week (GPHD)

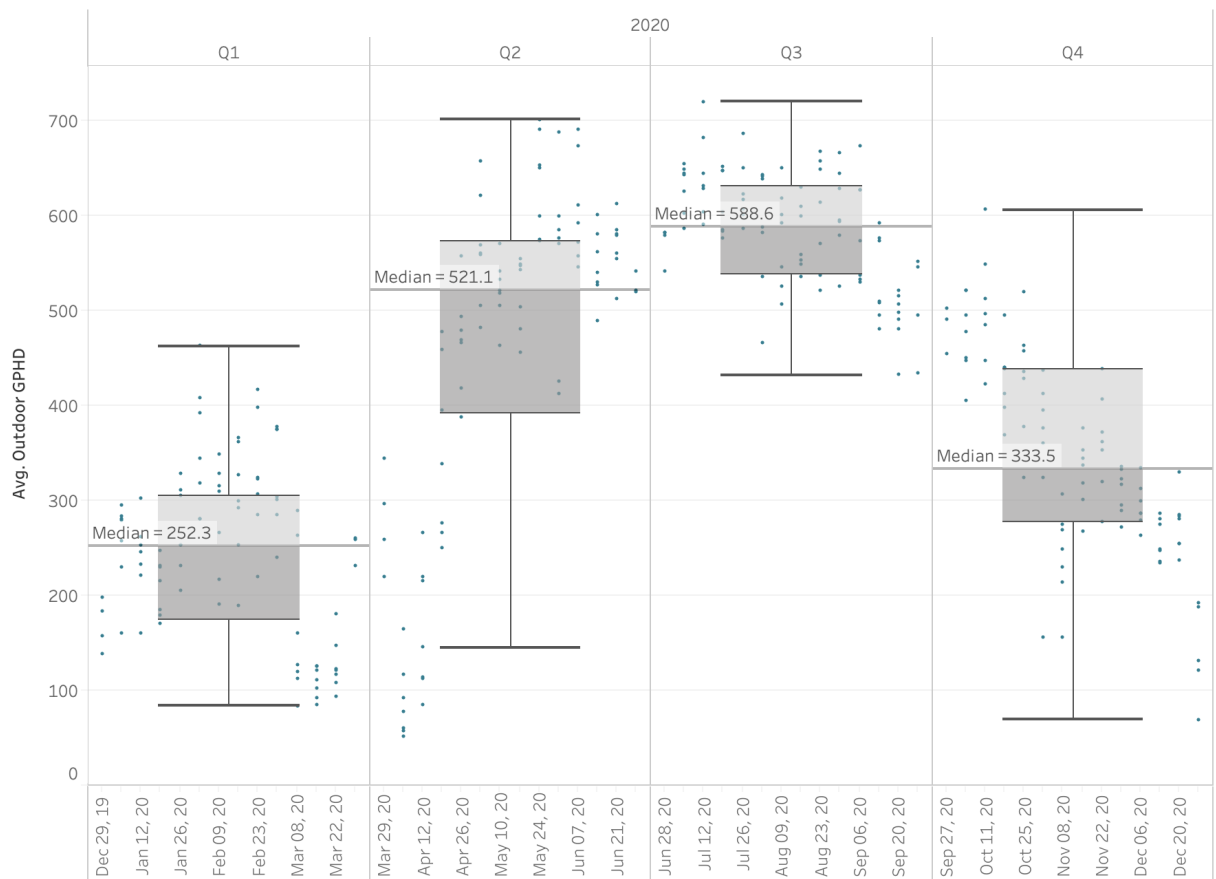
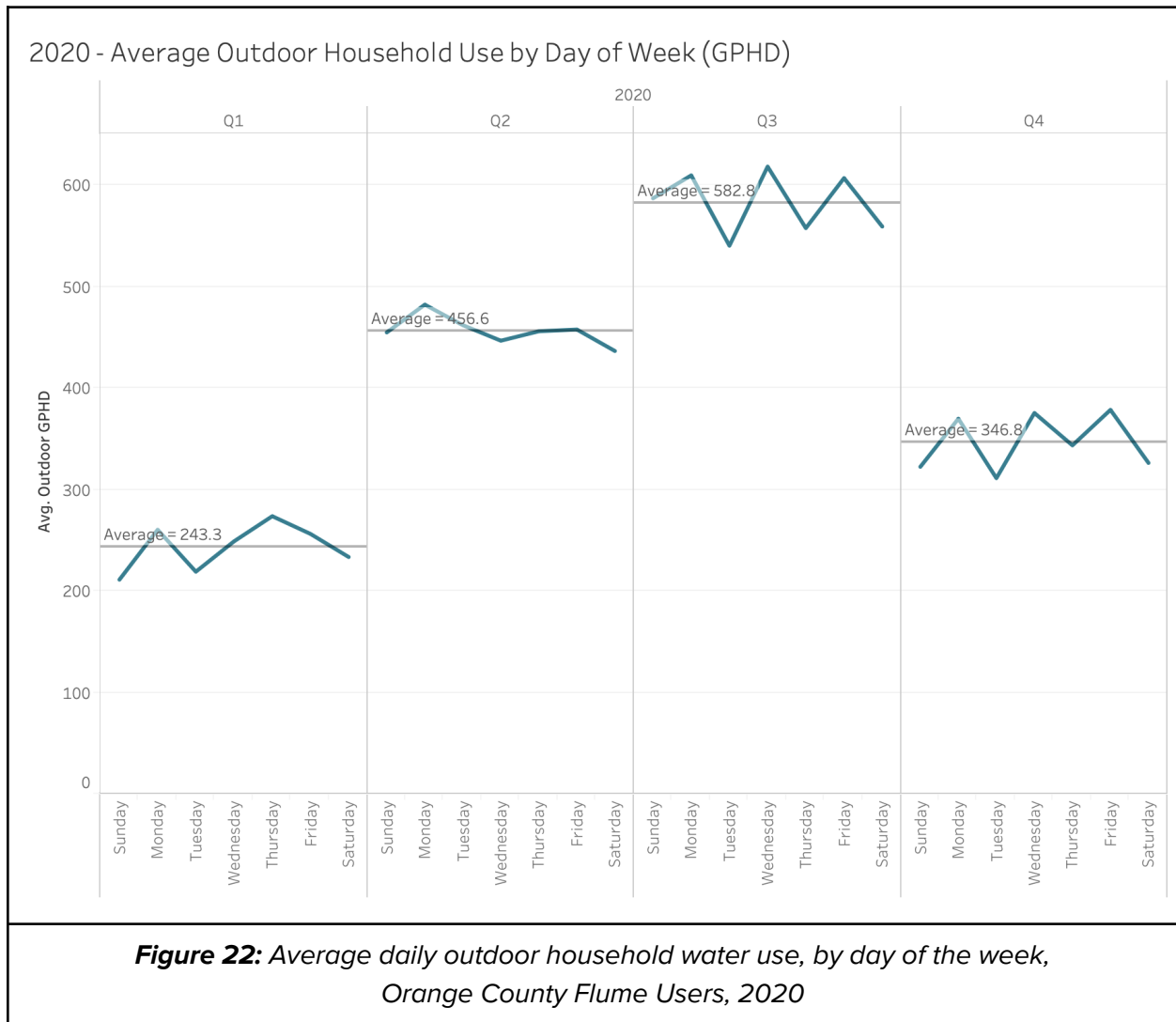


Figure 21: Range of average outdoor daily household use, per week, Orange County Flume Users, 2020

Figure 22 and Figure 23 represent outdoor use for each day of the week in 2020. During Q3, the highest outdoor use occurred. In this quarter, Mondays, Wednesdays and Fridays had the most outdoor use followed by Sunday. During Q3, Tuesdays, Thursdays, and Saturdays had less outdoor use. When measured across the entire year, there is tremendous variability in usage on each day of the week, but the average use and variability of each day is similar.



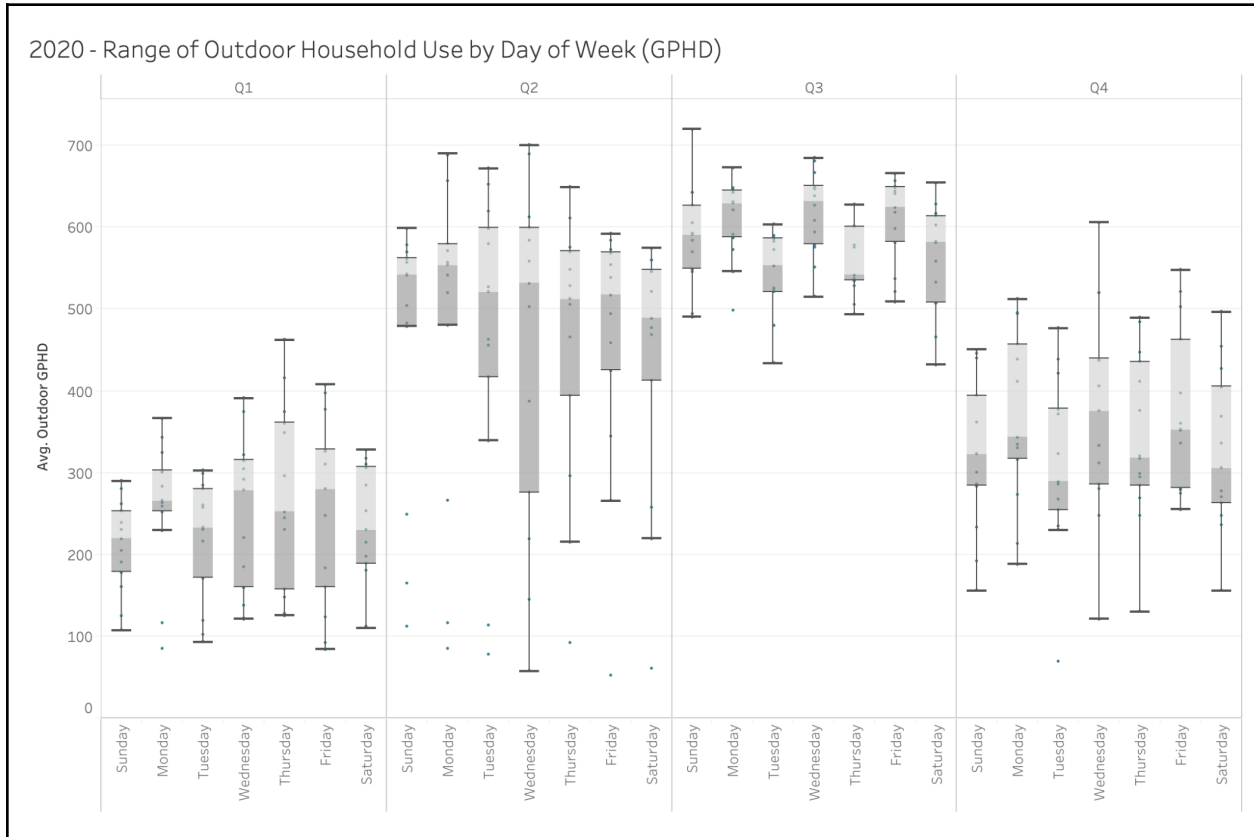


Figure 23: Range of average daily outdoor household water use, by day of the week, Orange County Flume Users, 2020

Table 6 and Figure 24 represent average outdoor household use summarized for each hour of the week in 2020. Table 6 identifies the two largest hourly peaks evident in Figure 24. Among these Flume customers in Orange County, outdoor use ramps up overnight and peaks at 5 a.m. and then declines through the morning. There appears to be trimodal pattern to outdoor use for the Flume users in Orange County with the larger, primary peak at 4 a.m., the secondary in the evening, and a small but consistent tertiary spike in the early afternoon about 1 p.m. each day, as shown in Figure 24. Public messaging encourages irrigation in the early morning and late evening hours.

Upon further investigation, a single irrigator in the sample set was found to be responsible for the small afternoon outdoor use spike. It was determined that this single irrigator used approximately 15 times the amount of water as a typical home, which was enough to become evident across the sample of Flumes.

Table 6: *Timing of hourly peaks, shown in Figure 24*

	Big Morning Peak	Small Evening Peak
Sunday	5AM	9PM
Monday	5AM	7PM
Tuesday	5AM	9PM
Wednesday	5AM	7PM
Thursday	5AM	9PM
Friday	5AM	9PM
Saturday	5AM	7PM

Outdoor Household Water Use by Hour

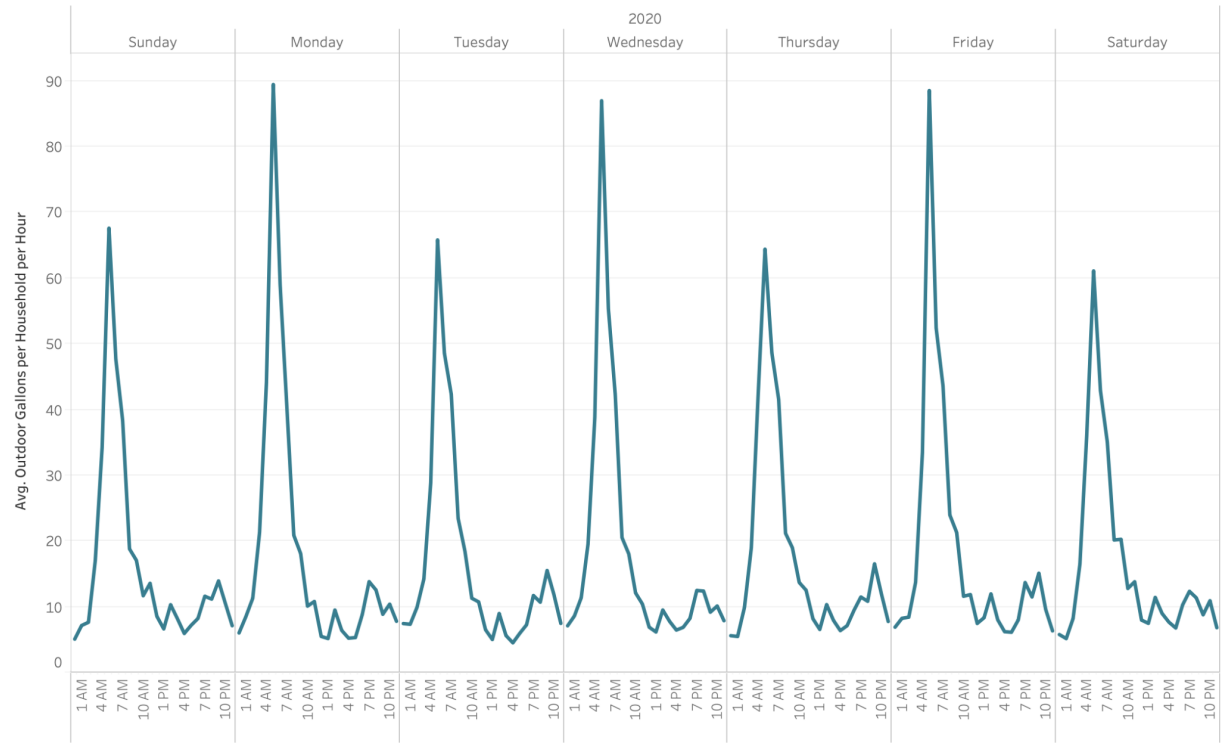


Figure 24: Outdoor hourly household water use averaged across each hour of each day of the 52 weeks of 2020

Effect of Weather and Watering Restrictions on Outdoor Water Use

Figure 25 shows the daily high temperature and the outdoor water use of Flume customers in Orange County for each week of 2020. Higher temperatures generally result in higher use in household outdoor water use. However, the temperature doesn't explain all of the dramatic dips evident in outdoor use in March, April, and November. These substantial changes in average household outdoor use are largely influenced by precipitation (as seen in Fig 26). Temperature data was sourced from the California Irrigation Management Information System (CIMIS) weather station #75 in Irvine.

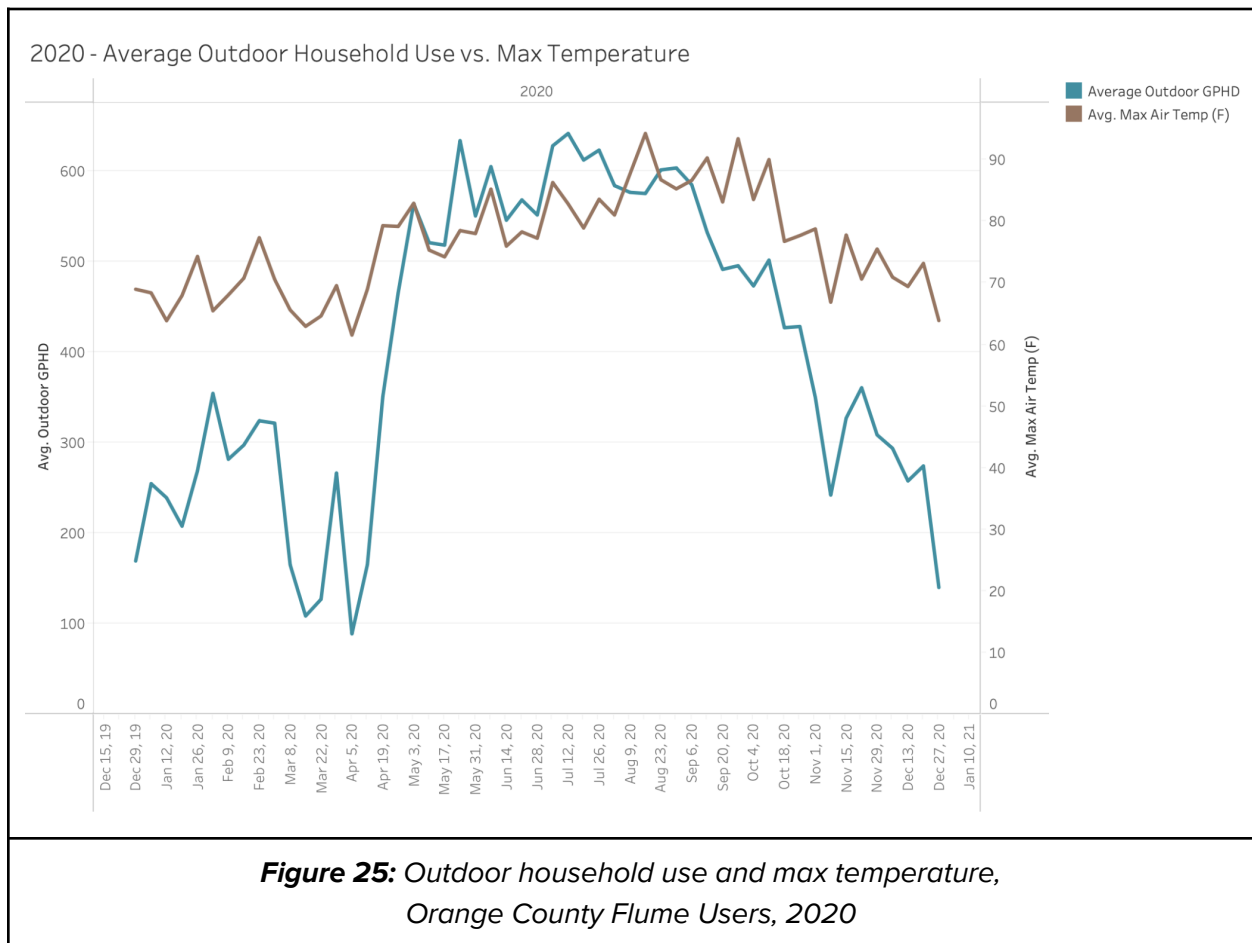


Figure 26 shows the weekly precipitation and average outdoor water use. At this timescale, a direct response in outdoor water use among these Flume customers in Orange County is evident in close proximity with rainfall. Rainfall that occurred in late March and early April reduced average outdoor use among Flume customers as did rainfall in early November as shown in Figure 26. Precipitation data was sourced from the CIMIS weather station #75 in Irvine.

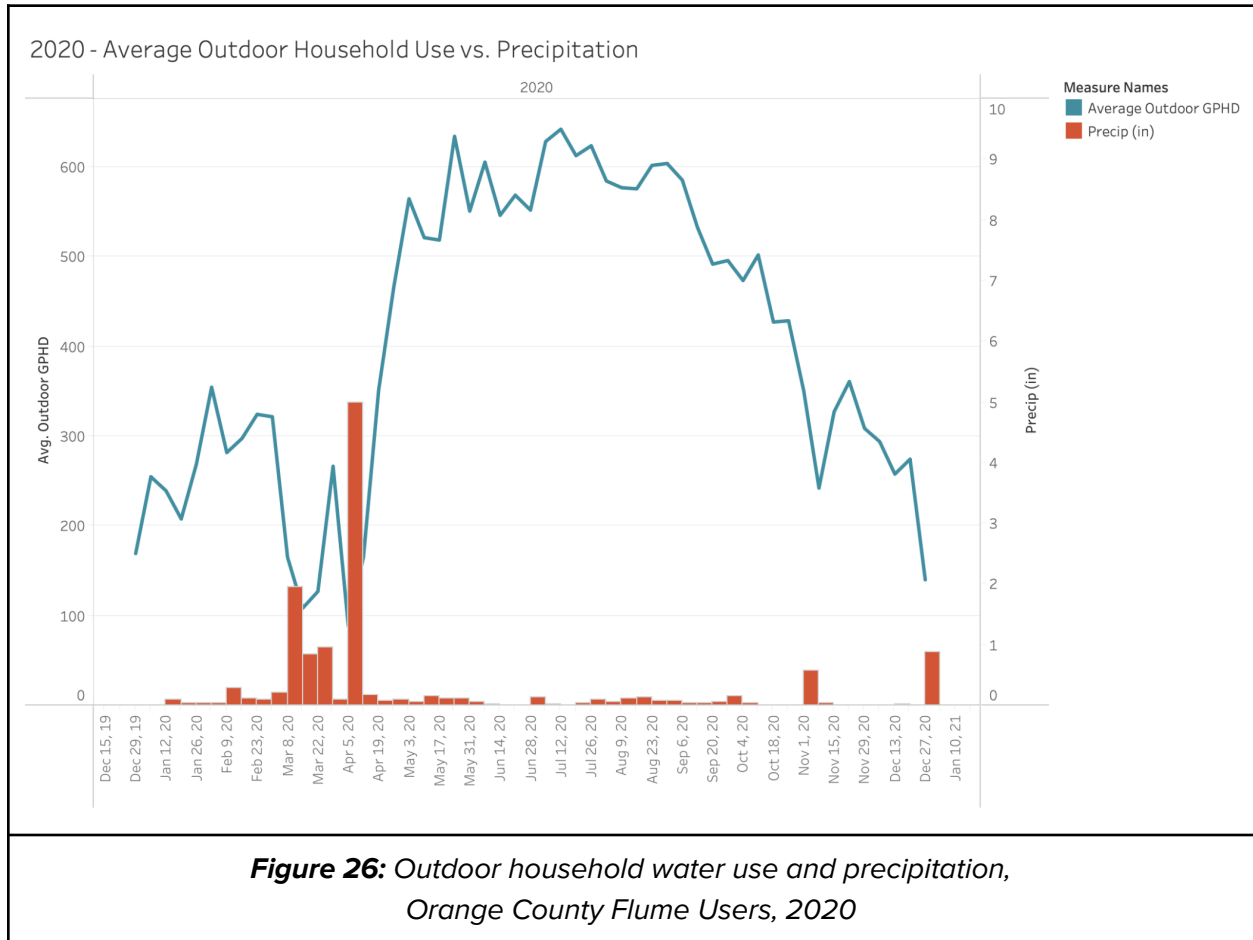
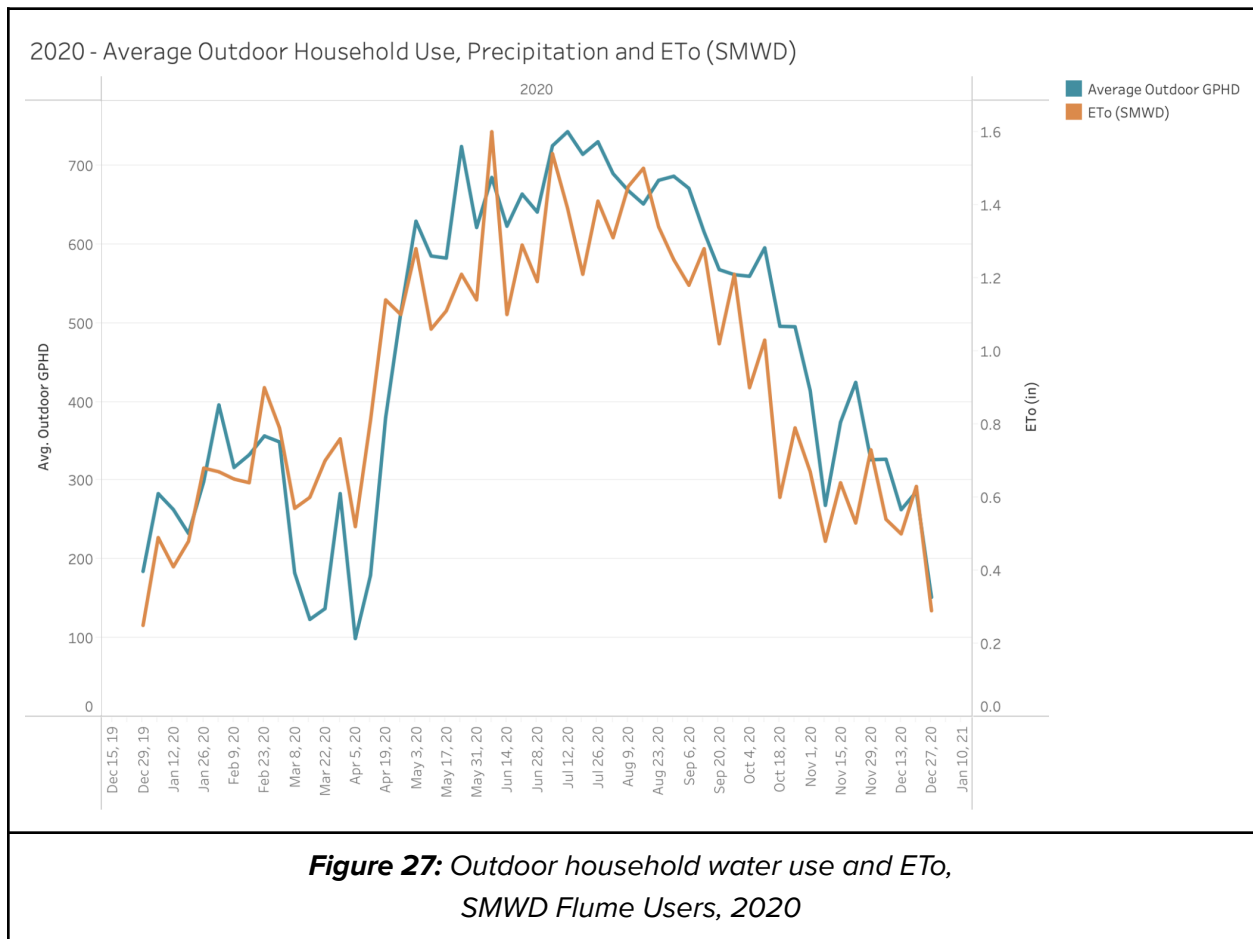


Figure 27 shows average outdoor water use and reference evapotranspiration (ET_o). Since the majority of the Flume users in Orange County are in the Santa Margarita Water District (SMWD), only Flumes in the Santa Margarita Water District were included in this particular analysis. ET data was sourced from CIMIS Spatial Reports, which provided interpolated ET_o for the Rancho Santa Margarita (RSM) area.

Water use across these Flume customers in SMWD changes proportionally in response to weather, including warming temperatures and measurable precipitation events (i.e. increases with higher temperatures and decreases with precipitation). Figure 27 shows the remarkably rapid response of a large number of water users to prevailing weather conditions. When viewed on a weekly time scale, changes in average daily outdoor water use are of similar magnitude to changes in average daily ET_o.



The relationship between daily ETo and daily average outdoor water use in 2020 in SMWD is shown in Figure 28 with ETo as the dependent variable and average daily outdoor use as the independent variable. This simple regression, fitted with a straight line model results in an R-Squared value of 0.94, indicating an extremely close fit and a clear, strong statistical correlation between ETo and average daily outdoor water use.



Irrigation Requirement and Application Rate

To evaluate the efficiency of outdoor use, Flume prepared a comparison of the monthly net evapotranspiration (ET_{net}) requirement in each region and the average outdoor water use each month. The formulae used for these calculations are shown below.

Measured landscape area data for most (but not all) Flume customers was provided by MWDOC. This included the turf area, tree area, and pool area in square feet. The irrigation requirement was calculated using the equation shown below for each day of the year for each customer in the Flume sample and then summarized by month. Crop coefficient and sprinkler efficiency values were provided by MWDOC. The irrigation requirement or “water budget” for each customer was then compared against the actual outdoor use to evaluate the overall efficiency of outdoor use.

$$Irrigation\ requirement = \frac{ET_{net} * \left[\left(\frac{K_{turf} * TurfArea}{SE_{turf}} \right) + \left(\frac{K_{trees} * TreeArea}{SE_{trees}} \right) + \left(\frac{K_{pool} * PoolArea}{SE_{pool}} \right) \right] * 7.48\ gal/cu.\ ft.}{12\ inches/ft.}$$

$$ET_{net} = ET_o - (15\% * Precipitation)$$

Table 7: Crop Coefficients and Sprinkler Efficiency used for Analysis

	K_c	Sprinkler Efficiency (SE)
<i>Turf</i>	85%	55%
<i>Trees</i>	30%	65%
<i>Pool</i>	85%	100%

Figure 29 shows the monthly irrigation water requirement (water budget) and the average per household outdoor use for the South Inland quadrant, where the most Flume devices were installed. Outdoor water use patterns of this set of Flume customers closely followed the irrigation requirement curve. Overall Flume customers in the South Inland irrigated below their water budget requirement in each month of the year and particularly during the summer months when the irrigation requirement was highest. On average in 2020 this set of Flume customers applied 87.7% of the irrigation requirement.

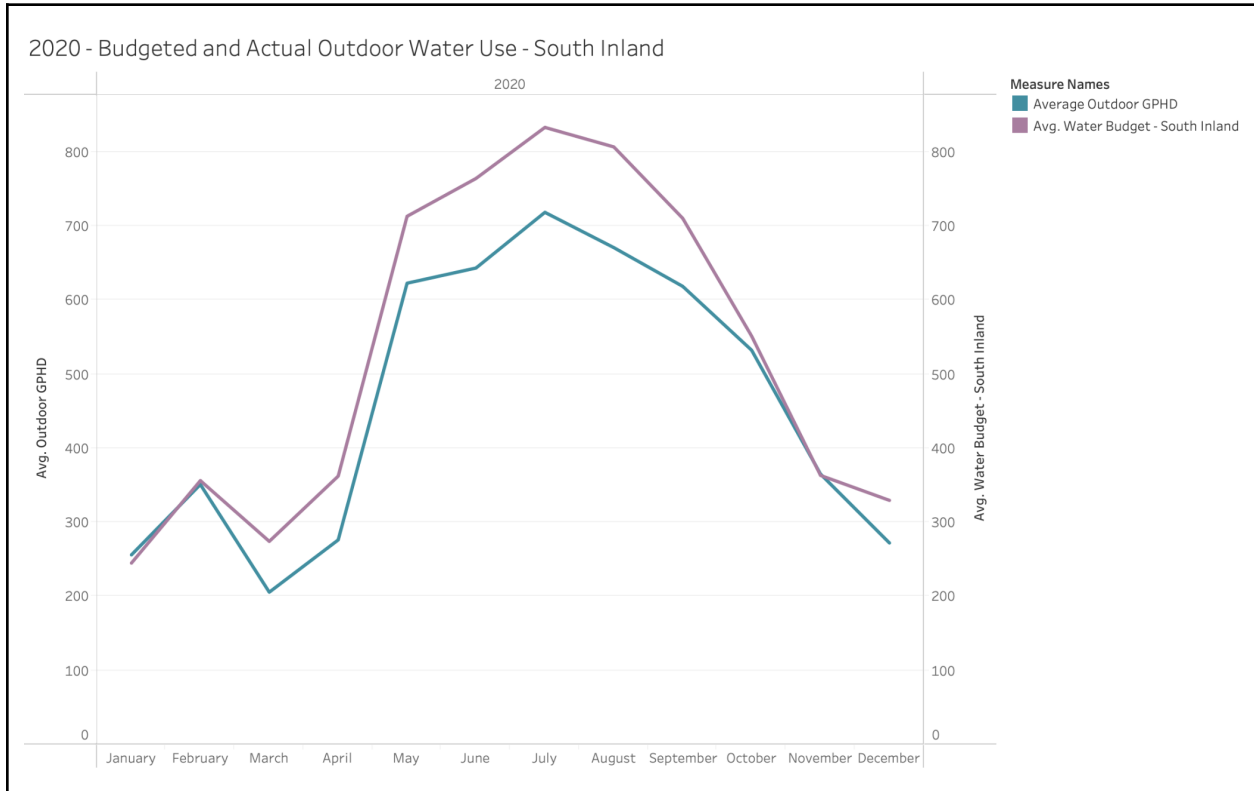


Figure 29: Budgeted and Actual Outdoor Water Use, South Inland Flume Users, 2020

Figure 30 shows the monthly irrigation water requirement (water budget) and the average per household outdoor use for the South Coast region. Outdoor water use patterns of this set of Flume customers closely followed, but were considerably lower than the irrigation requirement curve. Overall Flume customers in the South Coast irrigated below their water budget requirement in each month of the year and particularly during the first six months of the year. On average in 2020 this set of Flume customers applied 54.9% of the irrigation requirement.

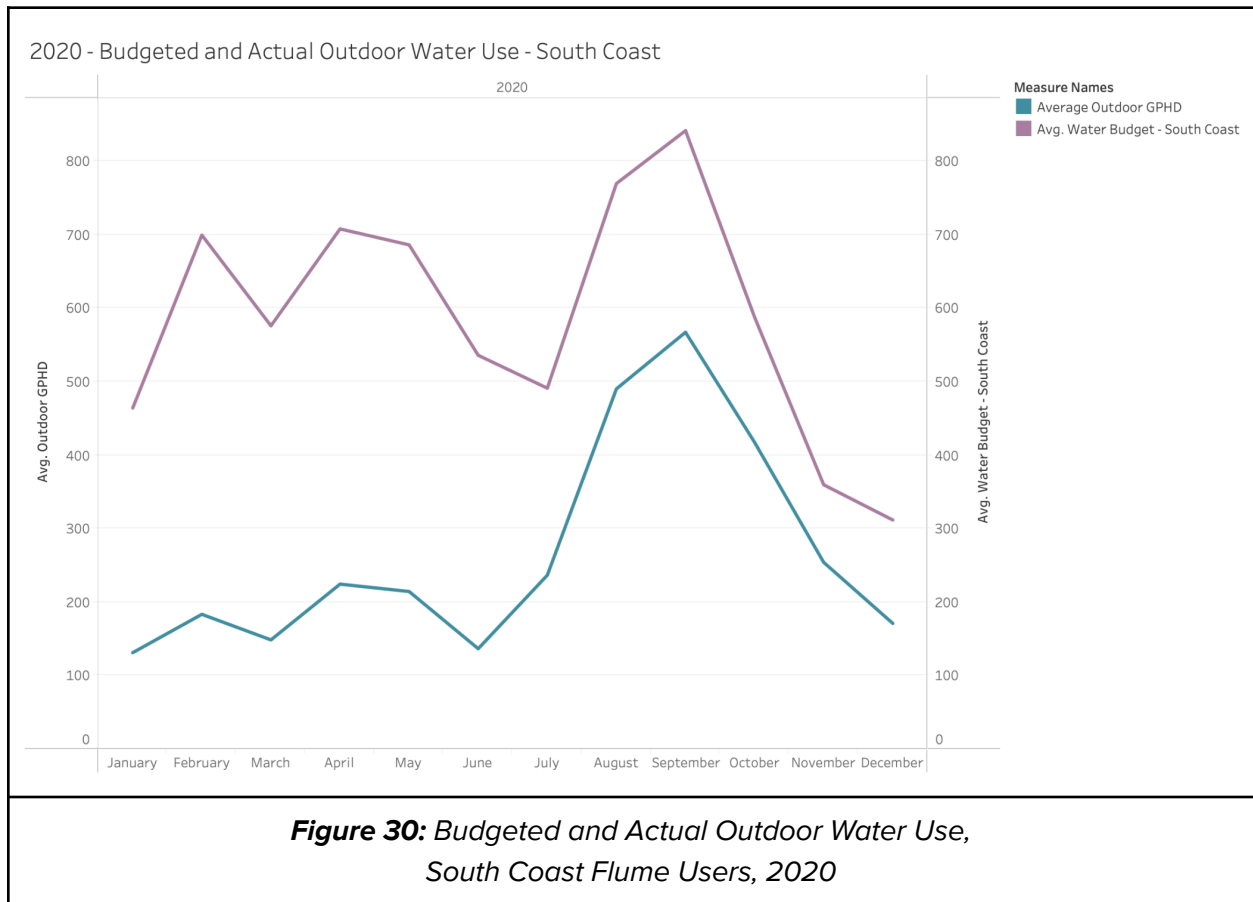


Figure 31 shows the monthly irrigation water requirement (water budget) and the average per household outdoor use for the North Inland quadrant. Outdoor water use patterns of this set of Flume customers closely followed the irrigation requirement curve for most of the year, but outdoor use exceeded the requirement in November and December. Overall Flume customers in the North Inland quadrant irrigated at a level close to their water budget requirement in most months of the year. On average in 2020 this set of Flume customers applied 95.5% of the irrigation requirement.

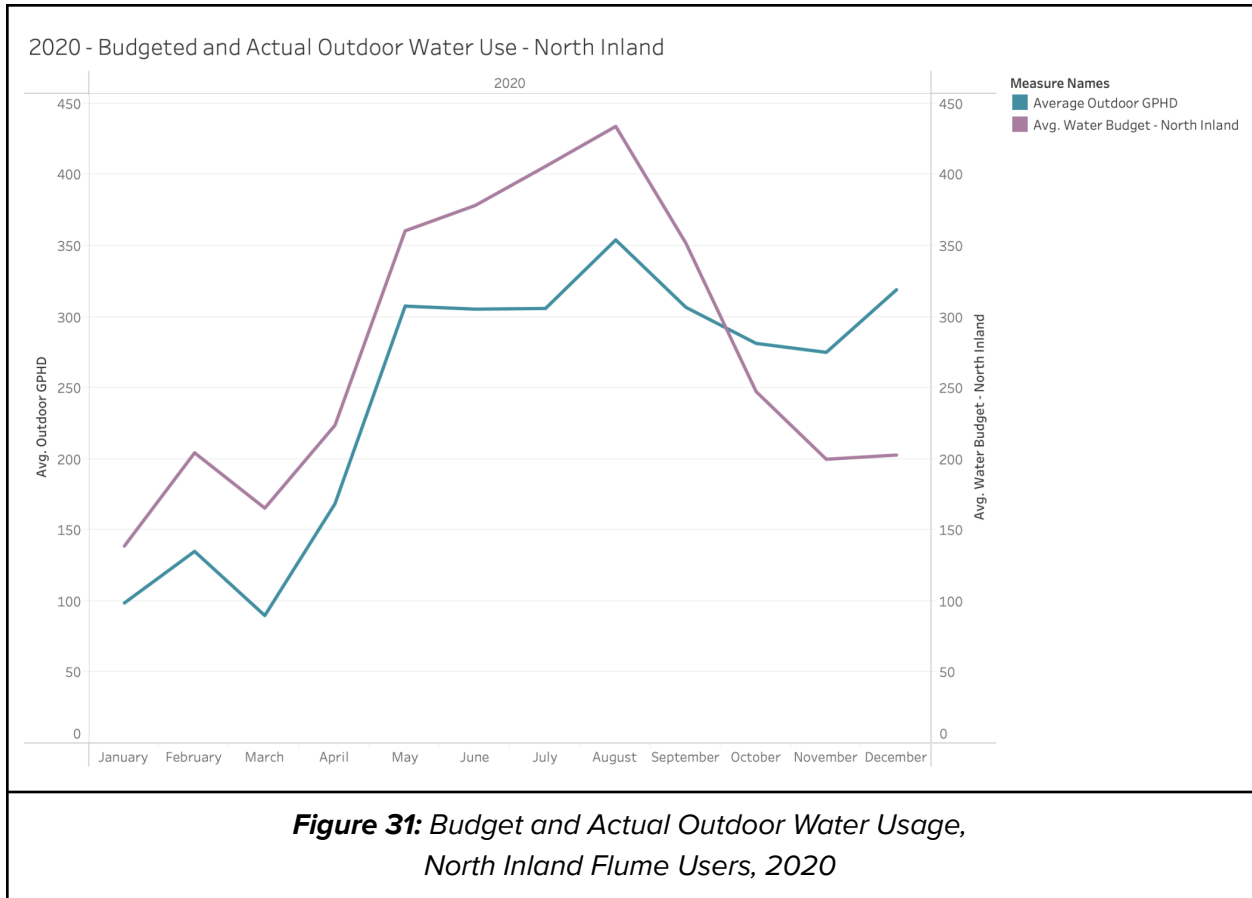


Figure 32 shows the monthly irrigation water requirement (water budget) and the average per household outdoor use for the North Coast quadrant. Outdoor water use patterns of this set of Flume customers closely followed the irrigation requirement curve for most of the year, but outdoor use exceeded the requirement in May and June. Overall Flume customers in the North Coast quadrant irrigated below their water budget requirement in most months of the year. On average in 2020 this set of Flume customers applied 89.3% of the irrigation requirement.

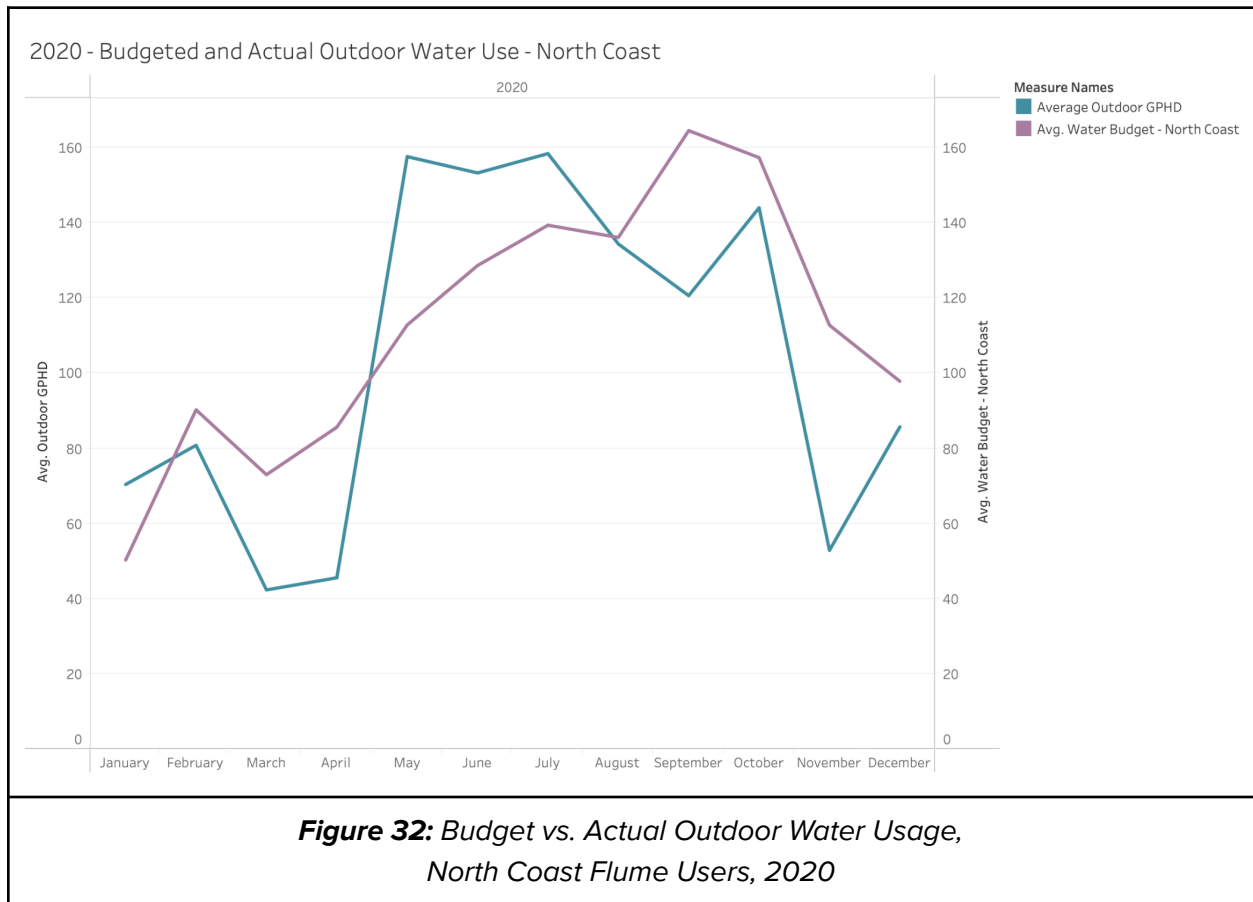


Table 8: Average of data presented in Figures 29 through 32

	Irrigated Sq. Ft.*	2020 Budget	2020 Actual	2020 % of Budget
South Inland	5,421	527.3	462.2	87.7%
South Coast	10,524	554.9	304.8	54.9%
North Inland	4,469	275.5	263.0	95.5%
North Coast	1,797	119.9	107.1	89.3%

*Irrigated area = turf area + tree area + pool area

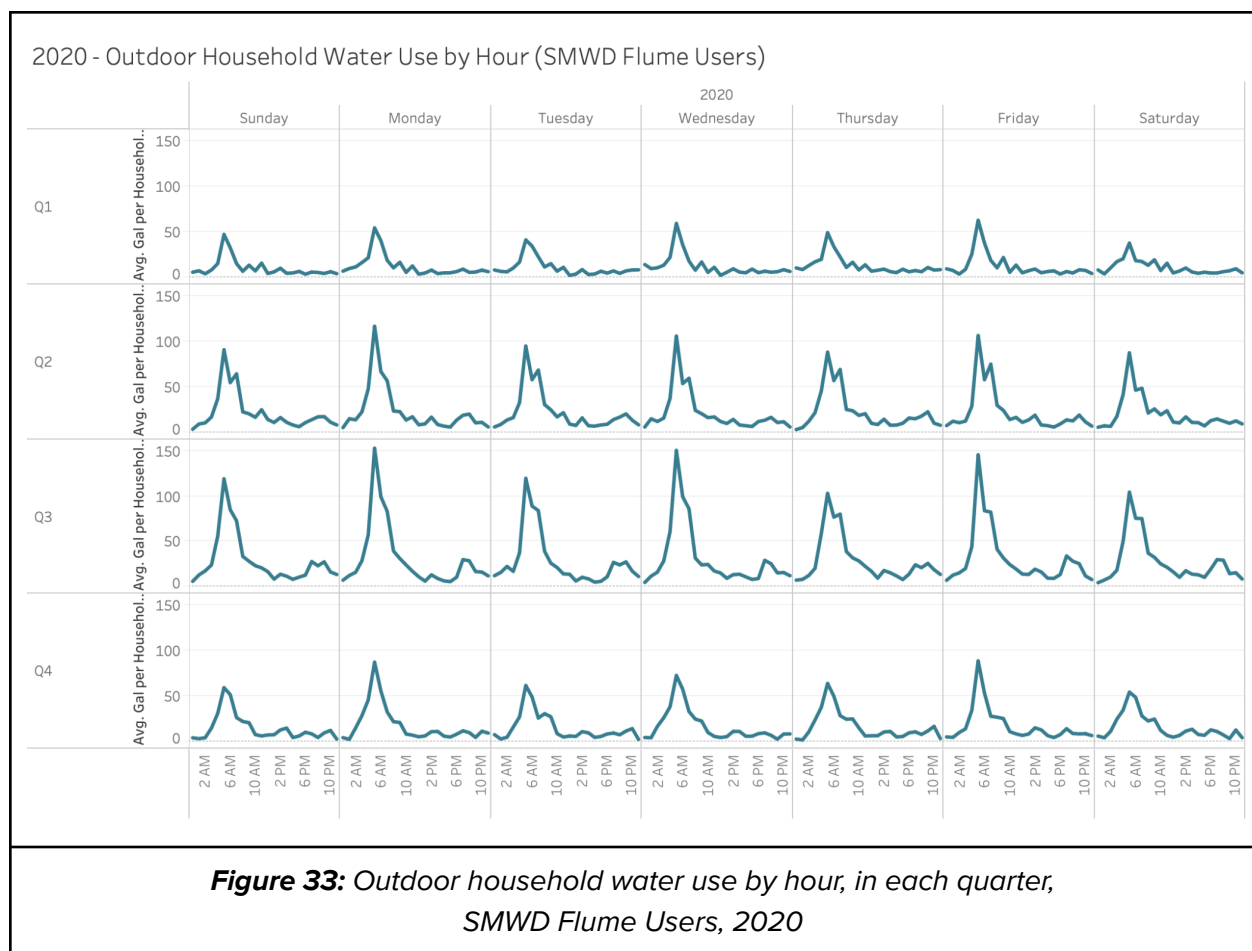
Santa Margarita Irrigation Restrictions

About 64% of the homes in this study were located in the Santa Margarita Water District (SMWD) which has the following voluntary and mandatory outdoor watering restrictions:

- Watering between 8 a.m. and 6 p.m. is prohibited.
- Residents are encouraged to water 1 day per week in the winter (Nov–March).
- Residents are encouraged to water 3 days per week in the summer (Apr–Oct).
- Even-numbered addresses should water Sunday, Tuesday, and Thursday.
- Odd-numbered addresses should water Monday, Wednesday, and Friday.

Figure 33 below analyzes outdoor watering patterns of just Flume users in SMWD. It is evident that most of these homes are irrigating early in the morning (usually between 4 - 6 am).

During peak irrigation season, many households water three times per week, and Monday, Wednesday and Friday typically had higher outdoor water use. It is also evident that irrigation is common during every quarter of the year, peaking in Q3. However, the magnitude of the irrigation changes based upon the season.



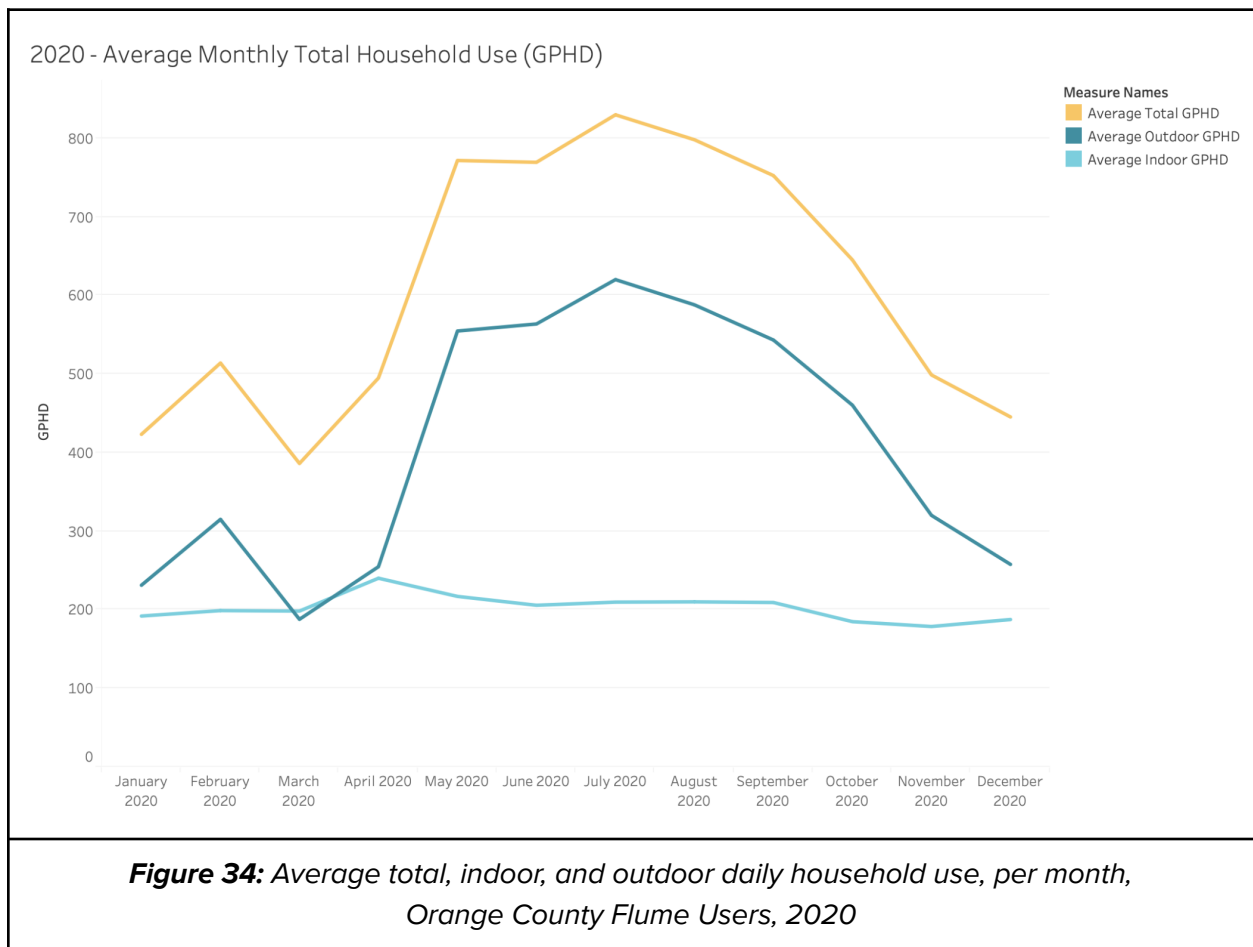
Total Water Use

The monthly averages of indoor, outdoor and total household and per capita use are shown in Table 9.

Table 9: Average indoor, outdoor and total use per month, Orange County Flume Users, 2020

Month	Avg. Indoor GPCD	Avg. Indoor GPHD	Avg. Outdoor GPCD	Avg. Outdoor GPHD	Avg. Total GPCD	Avg. Total GPHD	% Outdoor
January	54.9	192.0	84.4	231.2	139.4	423.2	54.6%
February	57.7	198.9	108.7	315.0	166.4	513.9	61.3%
March	57.9	198.3	76.4	187.8	134.4	386.1	48.6%
April	73.9	240.1	93.1	254.7	167.0	494.8	51.5%
May	66.4	217.0	198.1	554.6	264.5	771.6	71.9%
June	63.5	205.7	204.2	563.6	267.7	769.3	73.3%
July	64.8	209.7	229.0	620.0	293.7	829.7	74.7%
August	64.8	210.0	199.0	587.9	263.8	797.9	73.7%
September	67.0	209.2	176.2	543.1	243.2	752.3	72.2%
October	59.3	184.8	169.4	460.2	228.7	645.1	71.3%
November	56.4	178.7	128.3	320.1	184.7	498.7	64.2%
December	60.3	187.5	82.5	257.7	142.8	445.3	57.9%
Annual Avg.	62.3	202.6	146.3	410.1	208.6	612.7	66.9%

Figure 34, Figure 35, and Figure 36 represent the data from Table 9 in graphical format. When seen in comparison with seasonal changes in outdoor use, the changes in indoor household use, even during the April 2020 COVID-19 stay-at-home time periods, appear small. The shape of the total residential demand curve among Flume customers in Orange County is heavily influenced by the seasonal changes in outdoor use as discussed in the outdoor demand section of this report (Figures 25 - 27).



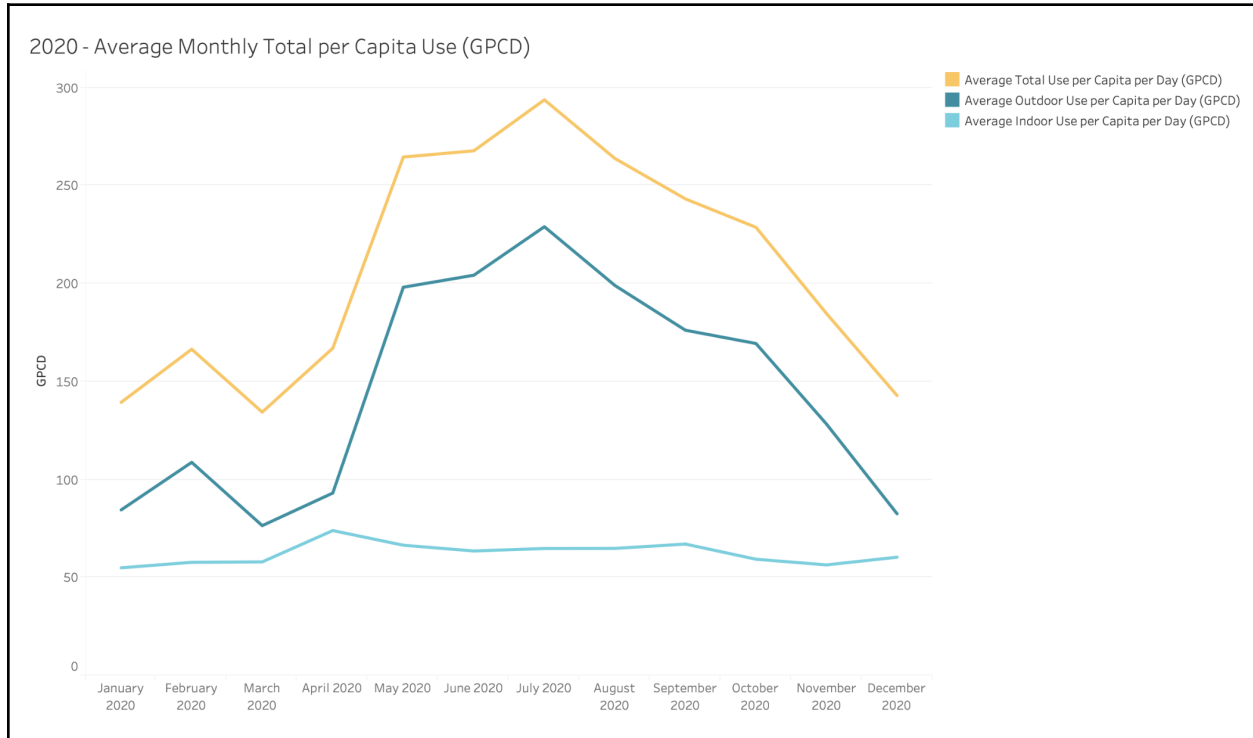


Figure 35: Average total, indoor, and outdoor daily per capita use, per month, Orange County Flume Users, 2020

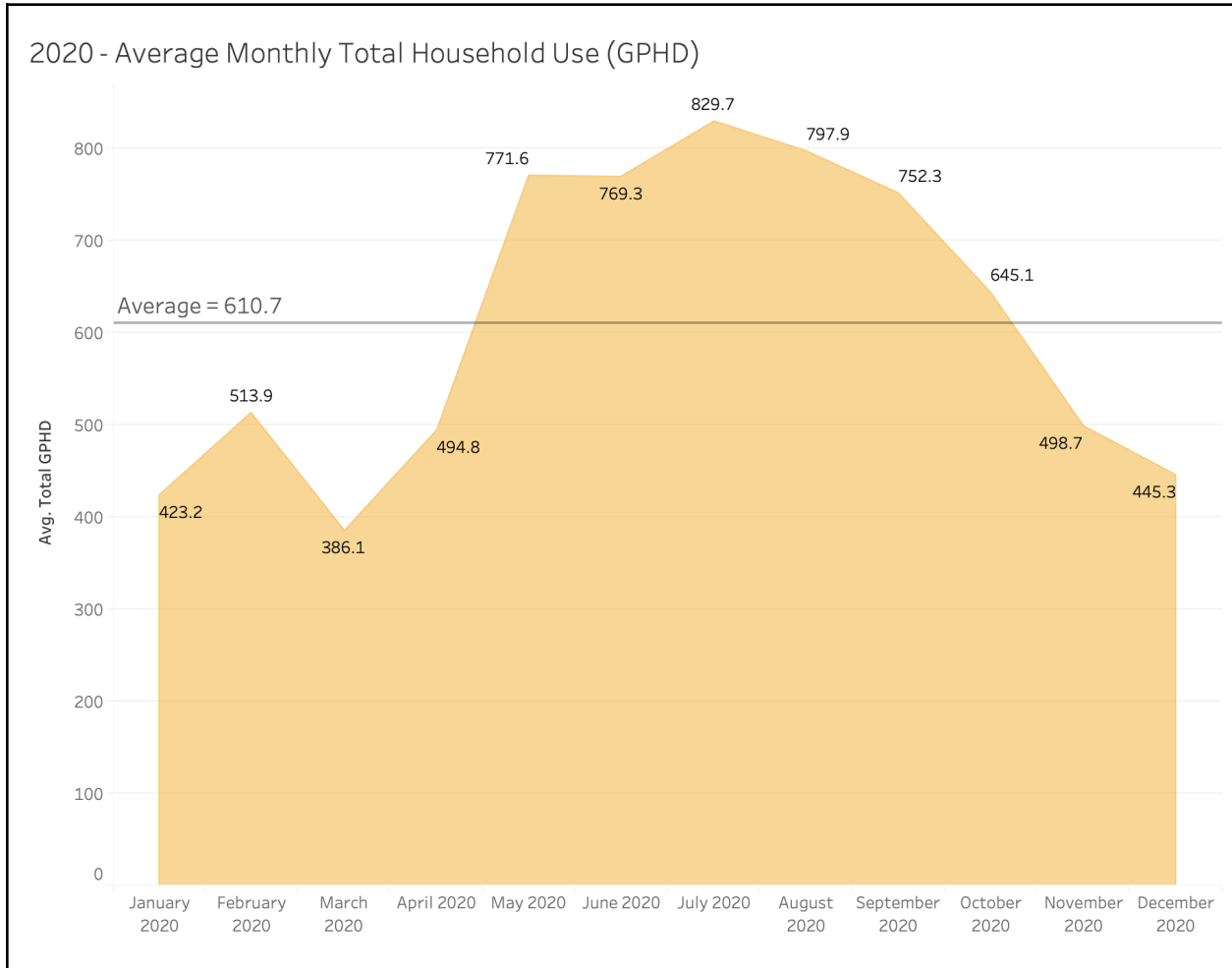


Figure 36: Average total daily household use, per month, Orange County Flume Users, 2020

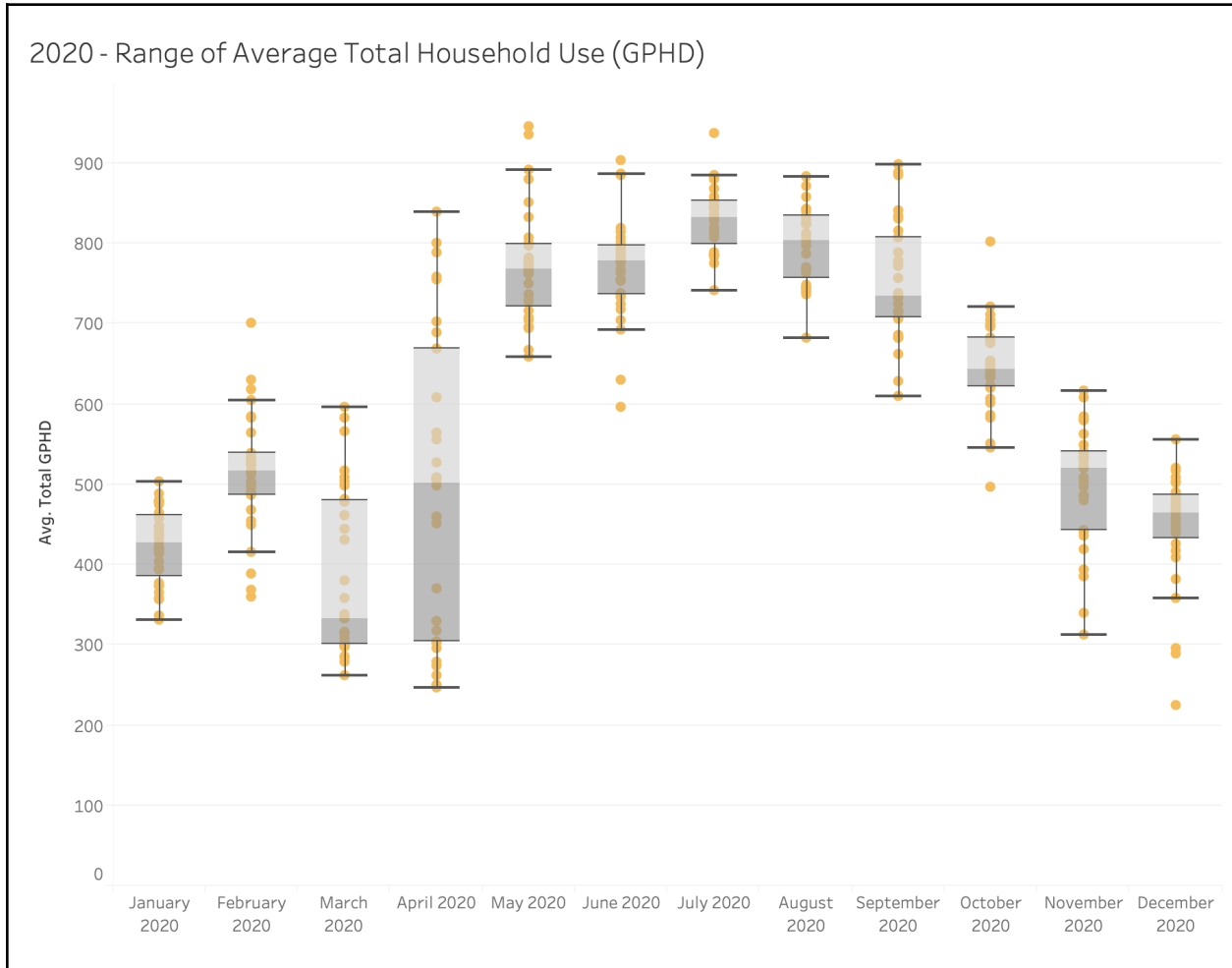
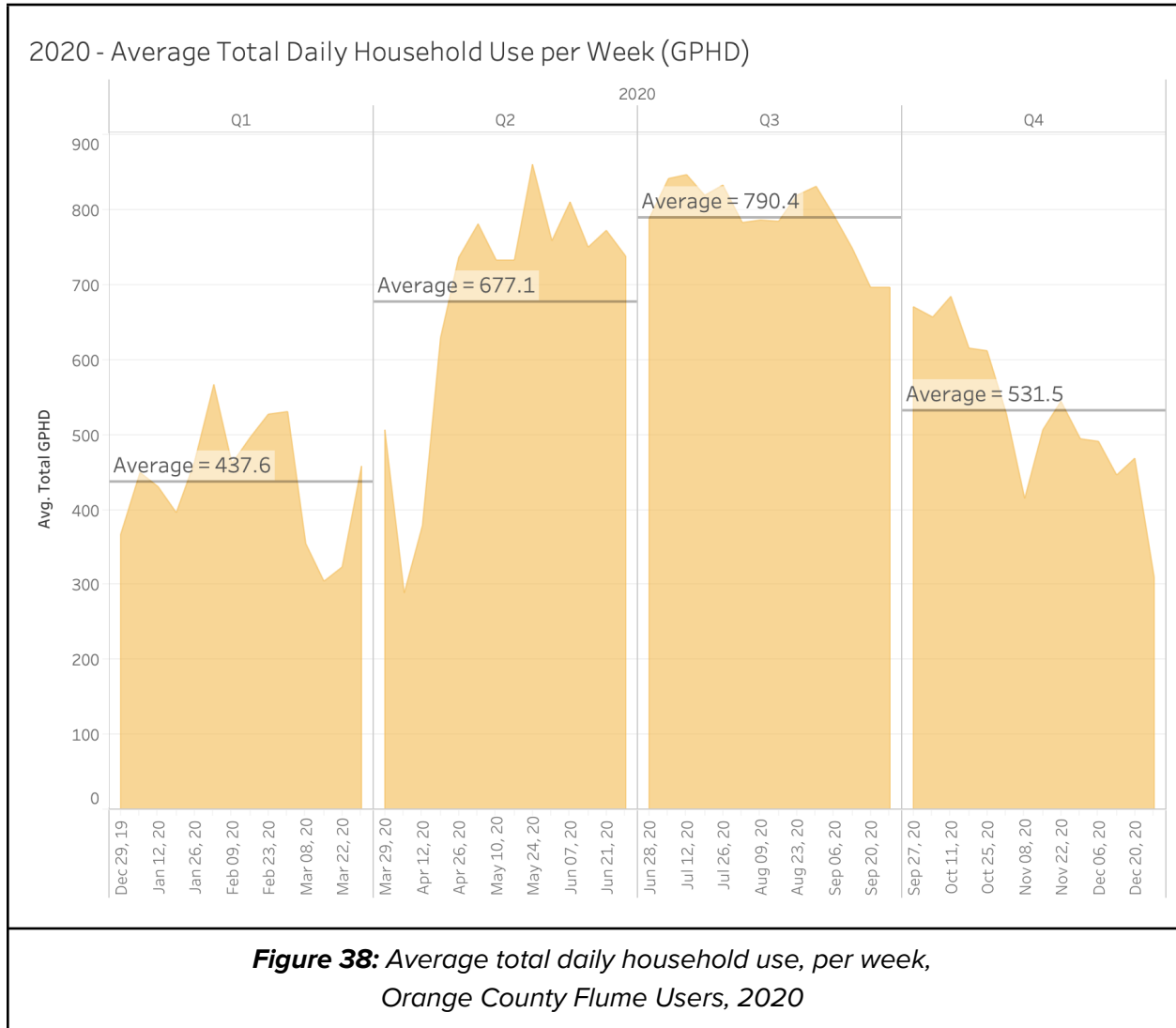


Figure 37: Range of average total daily household use, per month, Orange County Flume Users, 2020

Figure 38 and Figure 39 visualize average daily use calculated weekly for 2020, with quarterly summaries. Total use was lowest during Q1 and highest in Q3. The variability in total use was most pronounced in Q2 and Q4, largely influenced by outdoor use changes when precipitation events occurred.



2020 - Range of Average Daily Total Household Use per Week (GPHD)

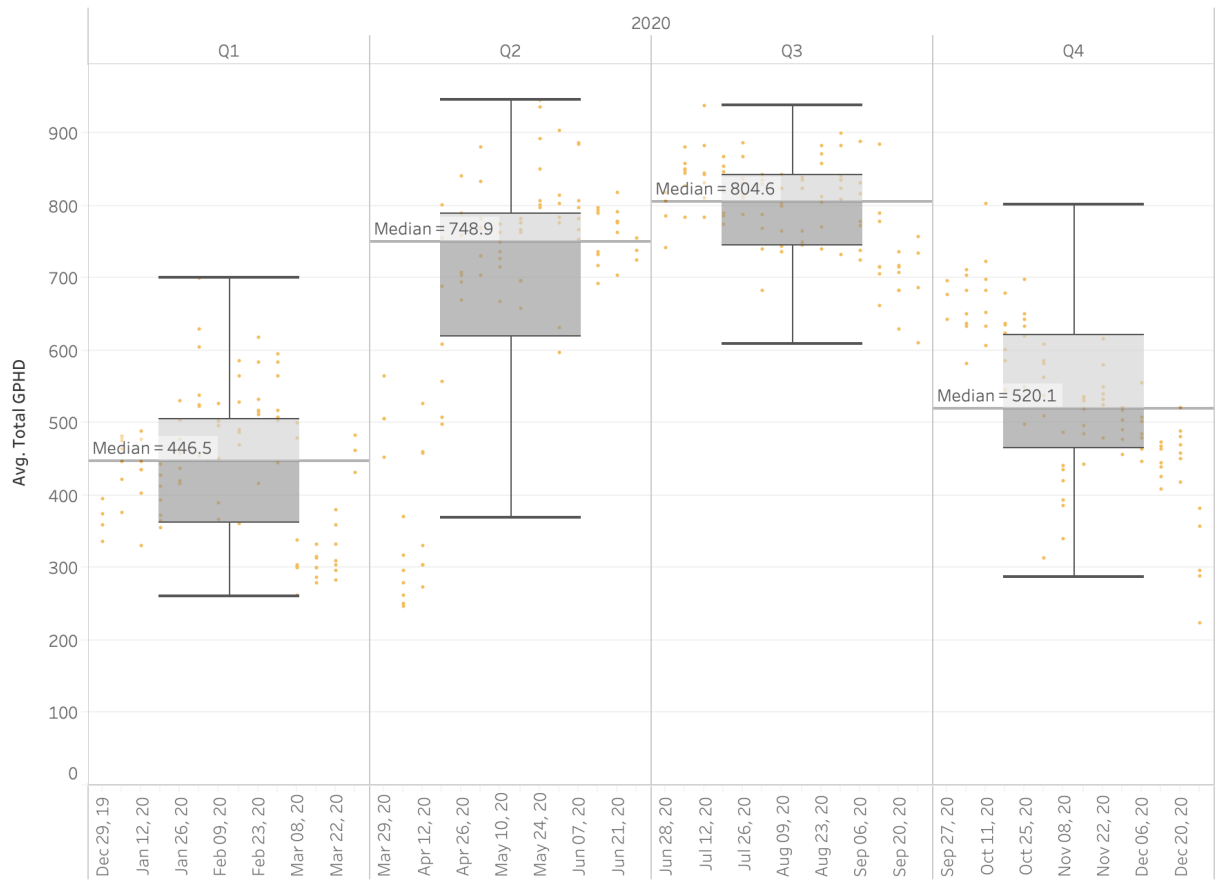


Figure 39: Range of average daily total household use, per week, Orange County Flume Users, 2020

2020 - Average Total Household Use by Day of Week (GPHD)

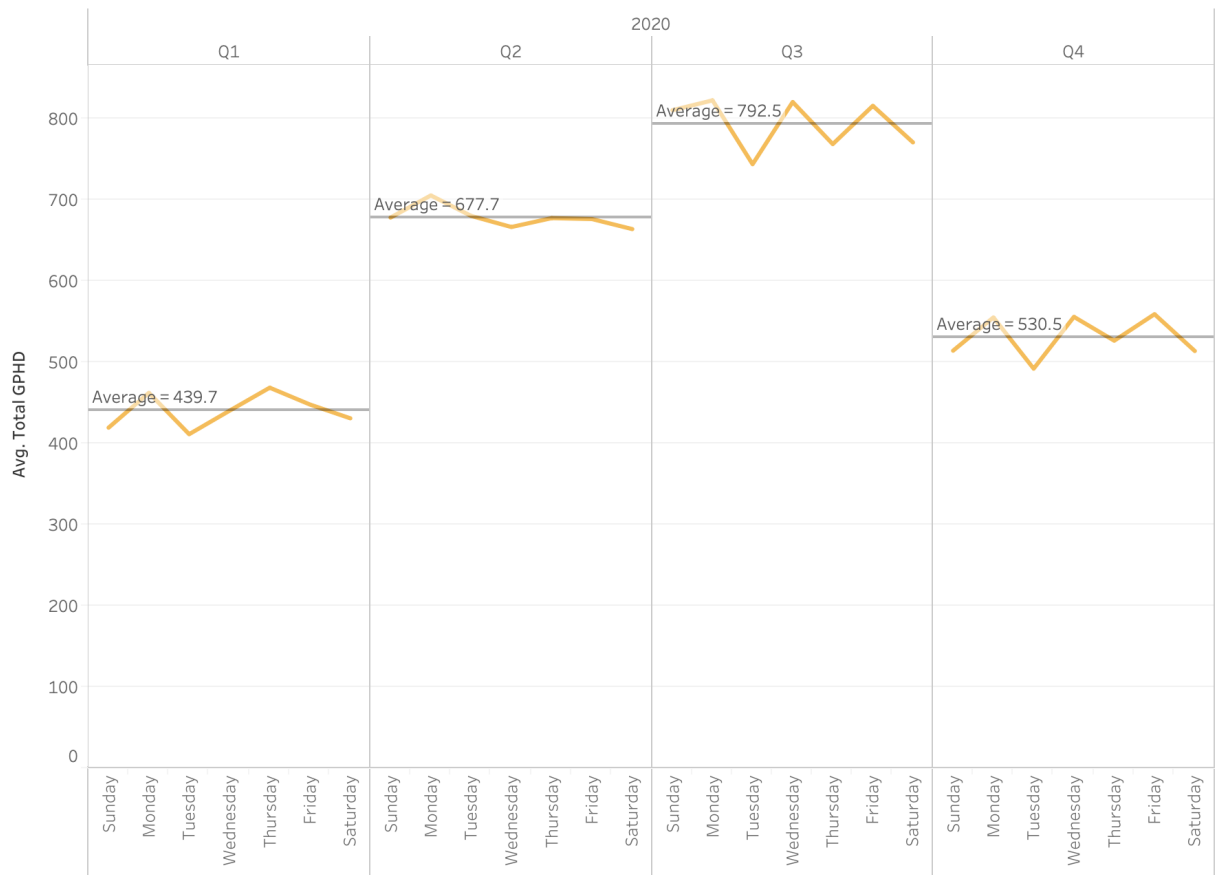


Figure 40: Average daily total household water use, by day of the week, Orange County Flume Users, 2020

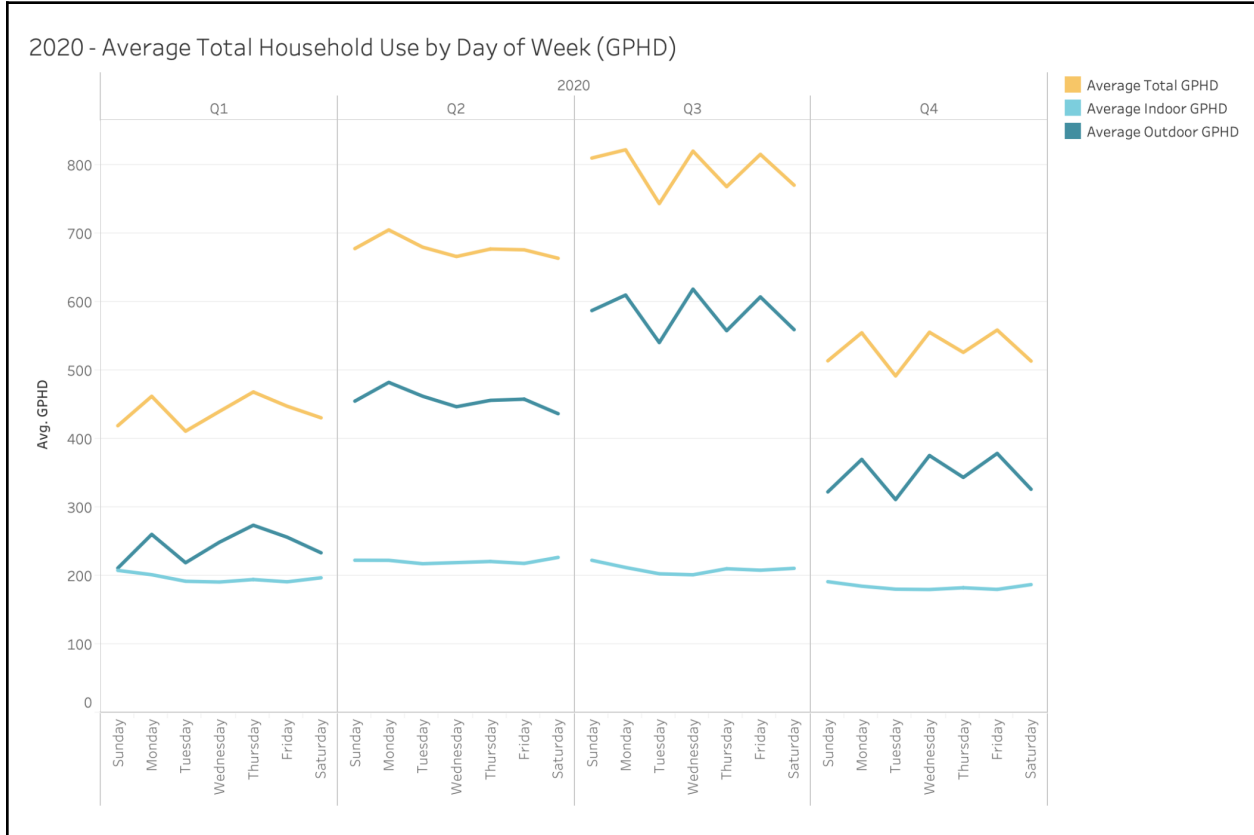


Figure 41: Average daily indoor, outdoor and total household water use, by day of the week, Orange County Flume Users, 2020

2020 - Range of Total Household Use by Day of Week (GPHD)

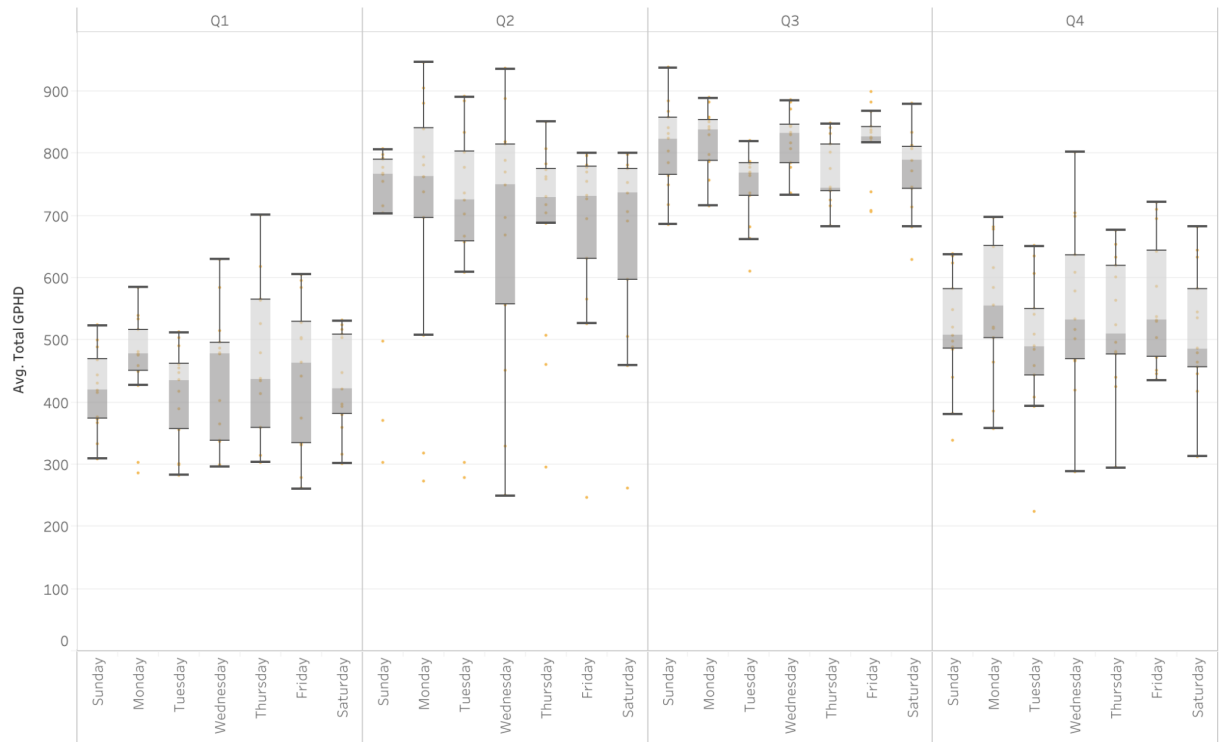
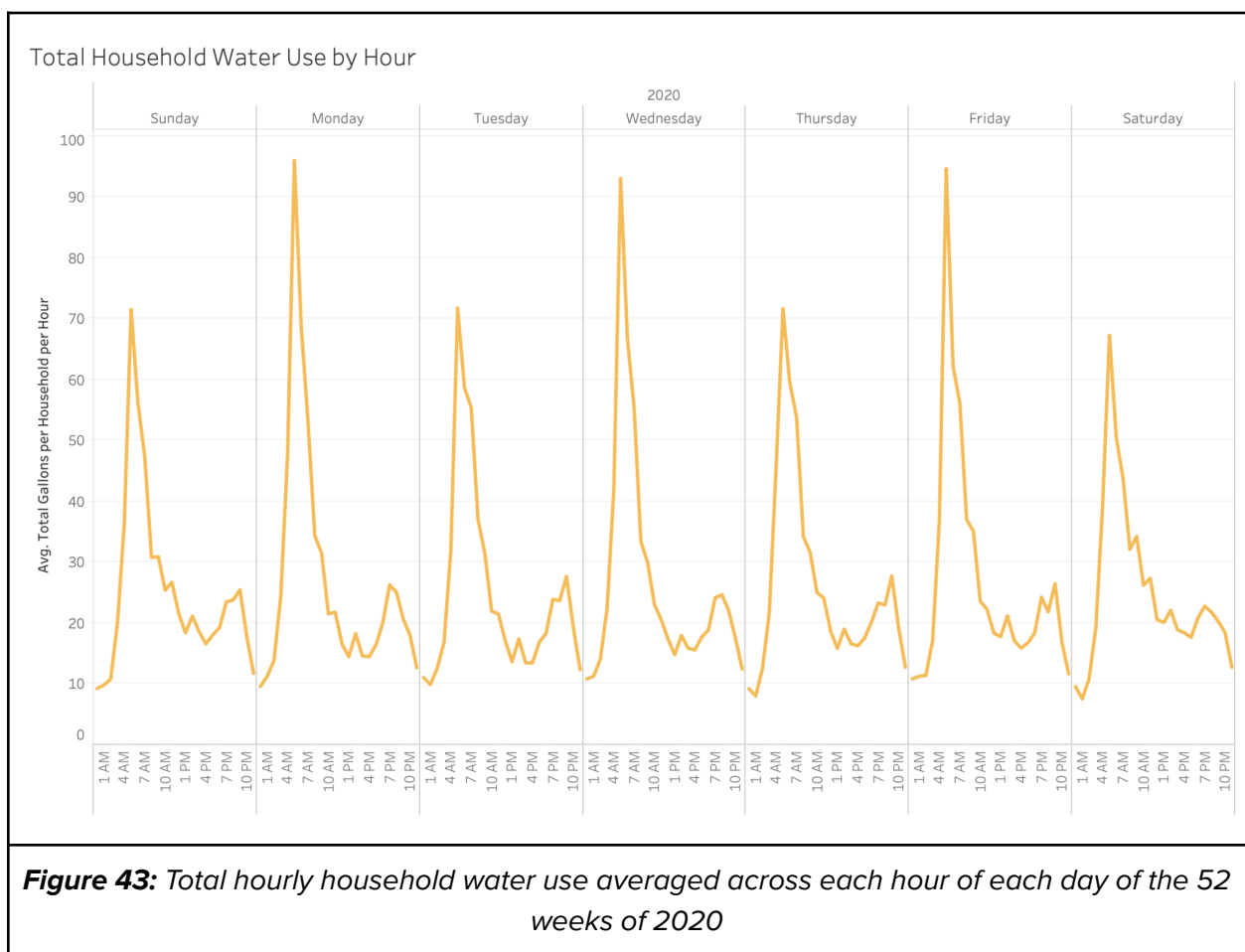
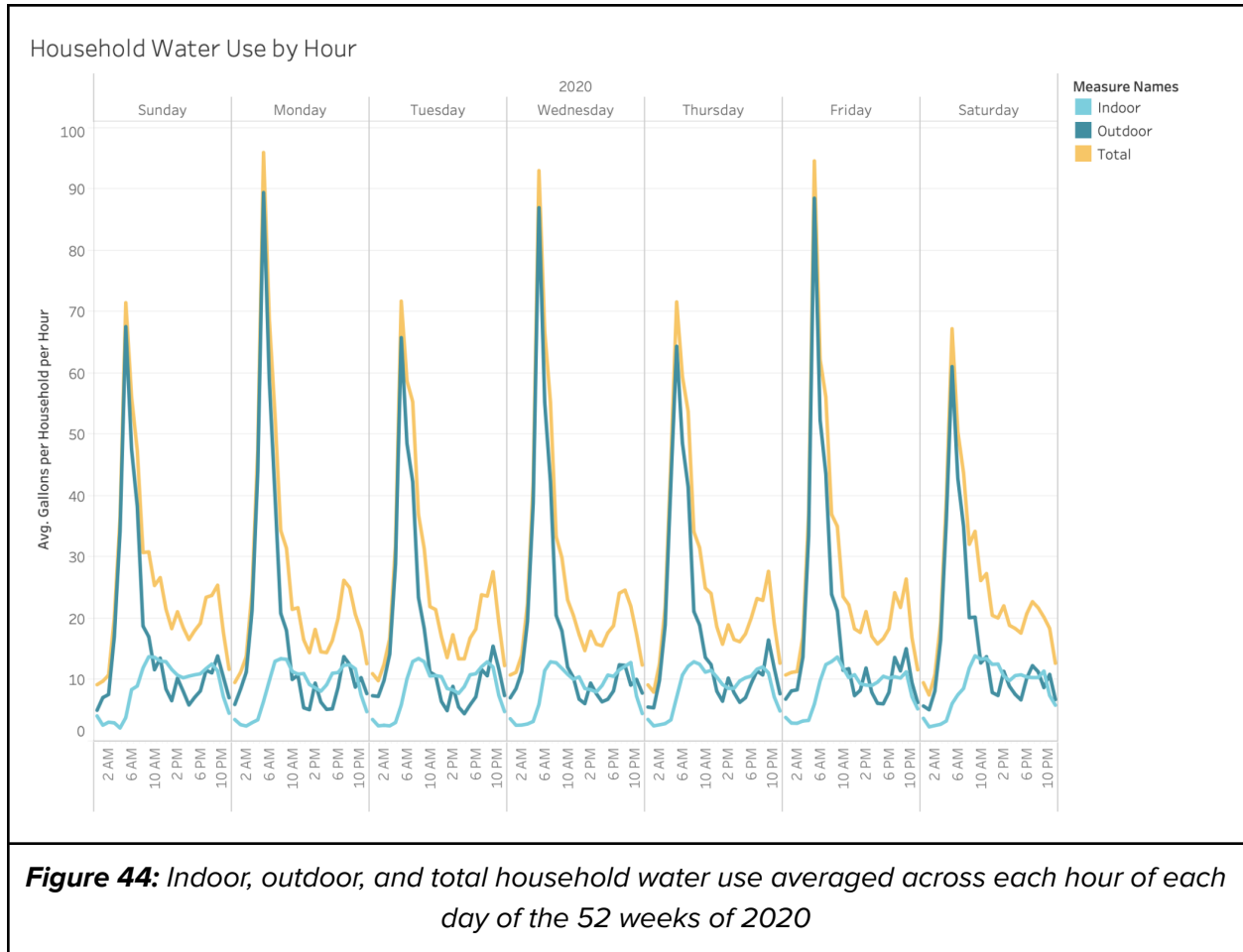


Figure 42: Range of average daily total household water use, by day of the week, Orange County Flume Users, 2020

Figure 43 and Figure 44 represent total household use, and indoor and outdoor use, by hour of the week in 2020. For the Flume users in Orange County, due to outdoor use, demand ramps up overnight and peaks at 5 a.m. and then declines through the morning. There appears to be a tri-peaking demand pattern to residential use for the Flume users in Orange County, as there are the typical high morning and evening peaks, but also a small, but consistent outdoor use spike in the early afternoon each day evident in Figure 44.

Upon further investigation, a single irrigator in the sample set was found to be responsible for the small afternoon outdoor use spike. It was determined that this single irrigator used approximately 15 times the amount of water as a typical home, which was enough to become evident across the sample of Flumes.





Demographic Analysis of Orange County 2020 Residential Water Use

In this section, indoor and outdoor use is analyzed in conjunction with home value, home age, lot size and home size.

Value of Home

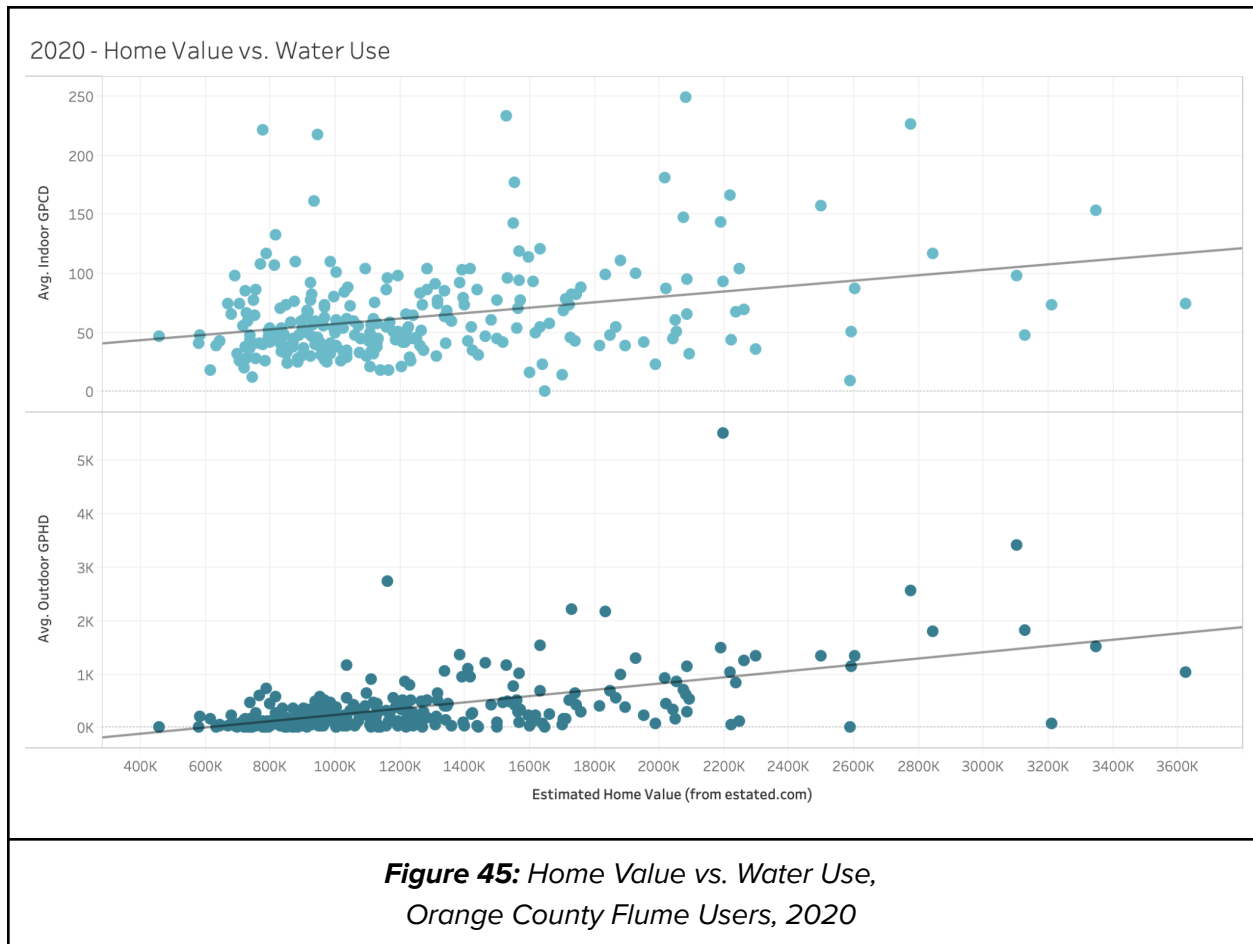
The following charts analyze indoor and outdoor water use based upon property value. For this analysis, the Flume homes in Orange County were separated into bins based upon estimated value (from estated.com). Table 10 shows the number of Flume-equipped homes included in each bin. The table also shows the average indoor GPCD and outdoor GPHD for each bin.

Table 10: Water Use by Value of Home

Home Value	# of Flume equipped Homes	Avg. Indoor GPCD	Avg. Outdoor GPHD
\$250 - 500K	1	47.2	0.0
\$500 - 750K	26	51.0	82.3
\$750K - 1M	78	56.0	195.3
\$1 - 1.25M	62	51.0	281.6
\$1.25 - 1.5M	30	66.0	421.0
\$1.5 - 1.75M	29	76.3	533.9
\$1.75M - 2M	10	56.7	614.6
\$2M - 2.25M	16	99.6	1164.9
\$2.25M - 2.5M	3	93.9	1292.8
\$2.5M - 2.75M	3	67.9	1223.2
\$2.75M - 3M	2	129.4	1875.8
\$3M - 3.25M	3	73.1	2310.9
\$3.25M - 3.5M	1	153.5	1516.8
\$3.5M - 3.75M	1	74.6	1040.7

The average estimated home price in this sample is \$1.26M, which was higher than the average home price of \$841K in Orange County. An important goal for Flume in 2021 is to increase participation from lower income households so that their water use patterns can be included in future studies.

Figure 45 presents estimated home value vs. average indoor GPCD and outdoor GPHD. There was not much of a relationship between indoor GPCD and home value as the Indoor GPCD R-Squared of the regression analysis was 0.10. The estimated value of the homes appears to have very limited (if any) impact on indoor use. There is a stronger relationship between home value and outdoor GPHD where the R-Squared of the regression analysis was 0.30. As home value increases, higher outdoor use becomes more likely.



Age of Home

The following charts analyze indoor and outdoor water use based upon home age. For this analysis, homes were separated into bins based upon the year that they were built (from estimated.com). Table 11 shows the number of Flume-equipped homes included in each bin. The table also shows the average indoor GPCD and outdoor GPHD for each bin.

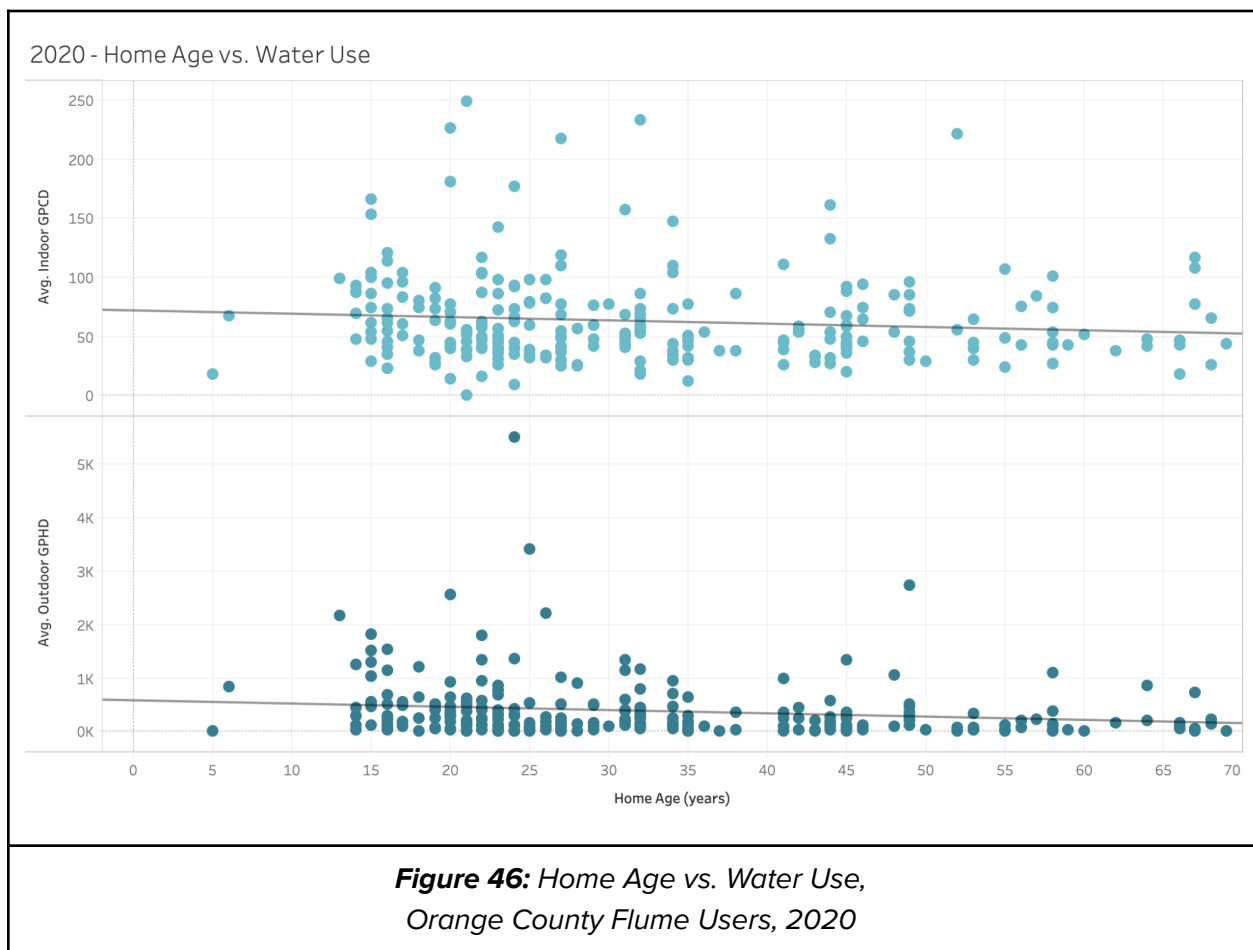
Table 11: Water Use by Age of Home

Year Built	# of Flume equipped Homes	Avg. Indoor GPCD	Avg. Outdoor GPHD
1905 - 1930	1	40.6	416.2
1930 - 1945	1	43.8	1.5
1945 - 1950	1	34.8	1171.7
1950 - 1955	6	72.1	214.0
1955 - 1960	6	37.3	228.7
1960 - 1965	10	64.0	128.9
1965 - 1970	11	50.9	96.5
1970 - 1975	11	62.3	400.8
1975 - 1980	30	65.4	189.7
1980 - 1985	8	45.5	195.9
1985 - 1990	32	55.3	288.6
1990 - 1995	31	61.5	329.8
1995 - 2000	49	66.7	647.0
2000 - 2005	37	57.4	370.1
2005 - 2010	28	70.2	684.7
2015 - 2020	2	63.8	773.4

Figure 46 presents home age vs. average indoor GPCD and outdoor GPHD. There is not any relationship between indoor GPCD and home value, as the Indoor GPCD R-Squared of the regression analysis was 0.01. The age of a home appears to have a little impact on indoor use, as older homes are now just as likely to be water efficient indoors as newer homes.

There is also no relationship between home age and outdoor GPHD, as the R-Squared of the regression analysis was 0.03.

Although the three oldest homes (i.e. homes older than 70 years) are not shown in the graph below, they were included in the analysis.



Lot Size

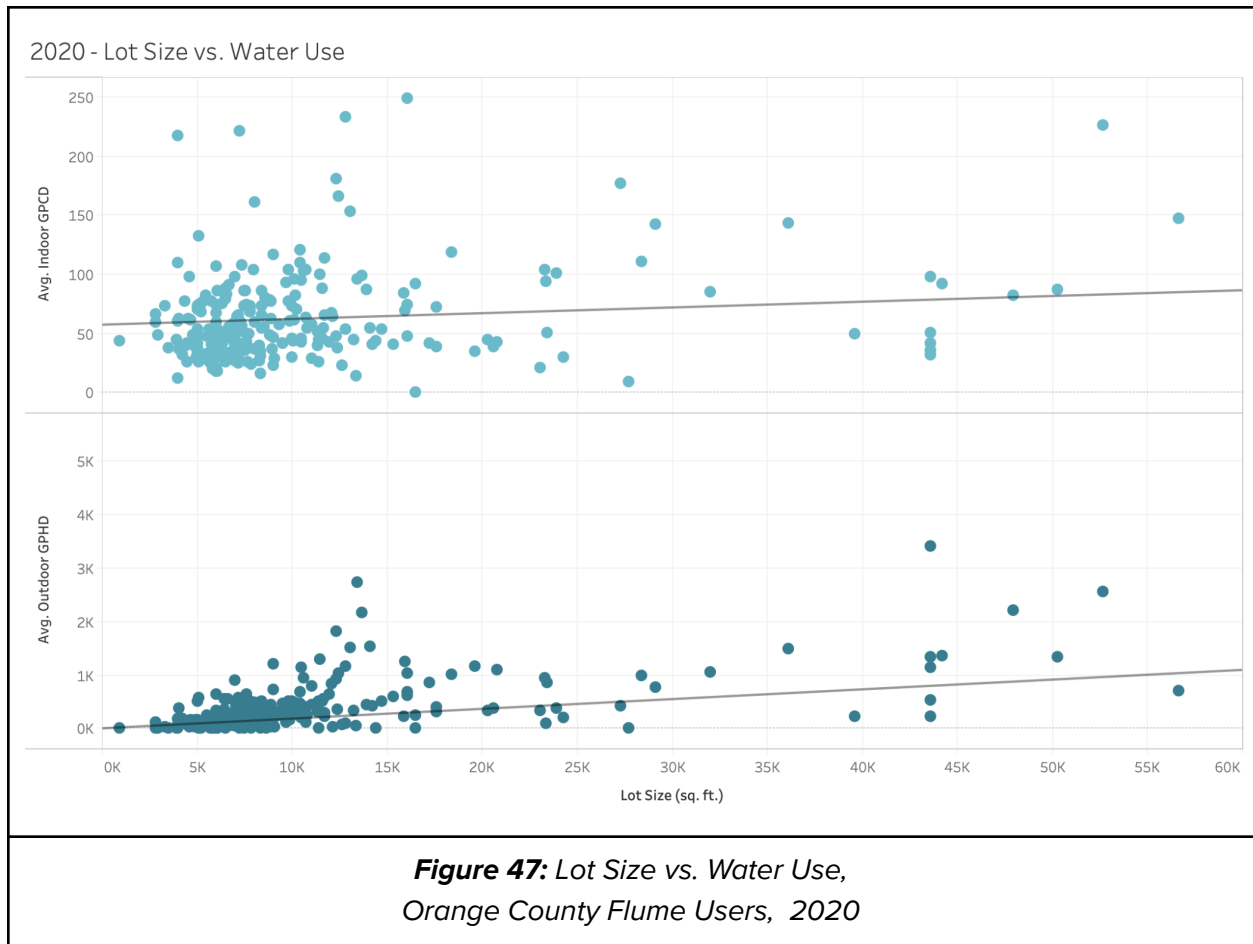
The following tables and charts analyze indoor and outdoor water use based upon lot size. For this analysis, homes were separated into bins based upon lot size (from estated.com). Table 12 shows the number of Flume-equipped homes included in each bin. The table also shows the average indoor GPCD and outdoor GPHD for each bin.

Table 12: Water Use by Size of Lot

Lot Size (sq. ft.)	# of Flume equipped Homes	Avg. Indoor GPCD	Avg. Outdoor GPHD
0 - 5,000	26	53.4	96.9
5,000 - 10,000	143	55.5	216.2
10,000 - 15,000	49	67.7	591.5
15,000 - 20,000	13	65.3	640.3
20,000 - 25,000	9	58.6	530.6
25,000 - 30,000	4	153.4	645.4
30,000 - 35,000	1	85.2	1059.2
35,000 - 40,000	2	138.3	1430.4
40,000 - 45,000	6	63.7	1612.3
45,000 - 50,000	1	82.7	2203.8
50,000 - 55,000	2	120.8	1628.9
55,000 - 60,000	1	147.6	704.9
70,000 - 75,000	1	117.2	1790.4
120,000 - 125,000	1	92.7	5510.5
290,000 - 295,000	1	157.4	1344.4

Figure 47 presents lot size vs. average indoor GPCD and outdoor GPHD. There was not much of a relationship between indoor GPCD and lot size as the Indoor GPCD R-Squared of the regression analysis was 0.07. Lot size appears to have very limited (if any) impact on indoor use. There is a stronger relationship between lot size and outdoor GPHD where the R-Squared of the regression analysis was 0.41. As lot size increases, higher outdoor use becomes more likely.

Although the three biggest lots (i.e. lots bigger than 60,000 sq. ft.) are not shown in the graph below, they were included in the analysis.



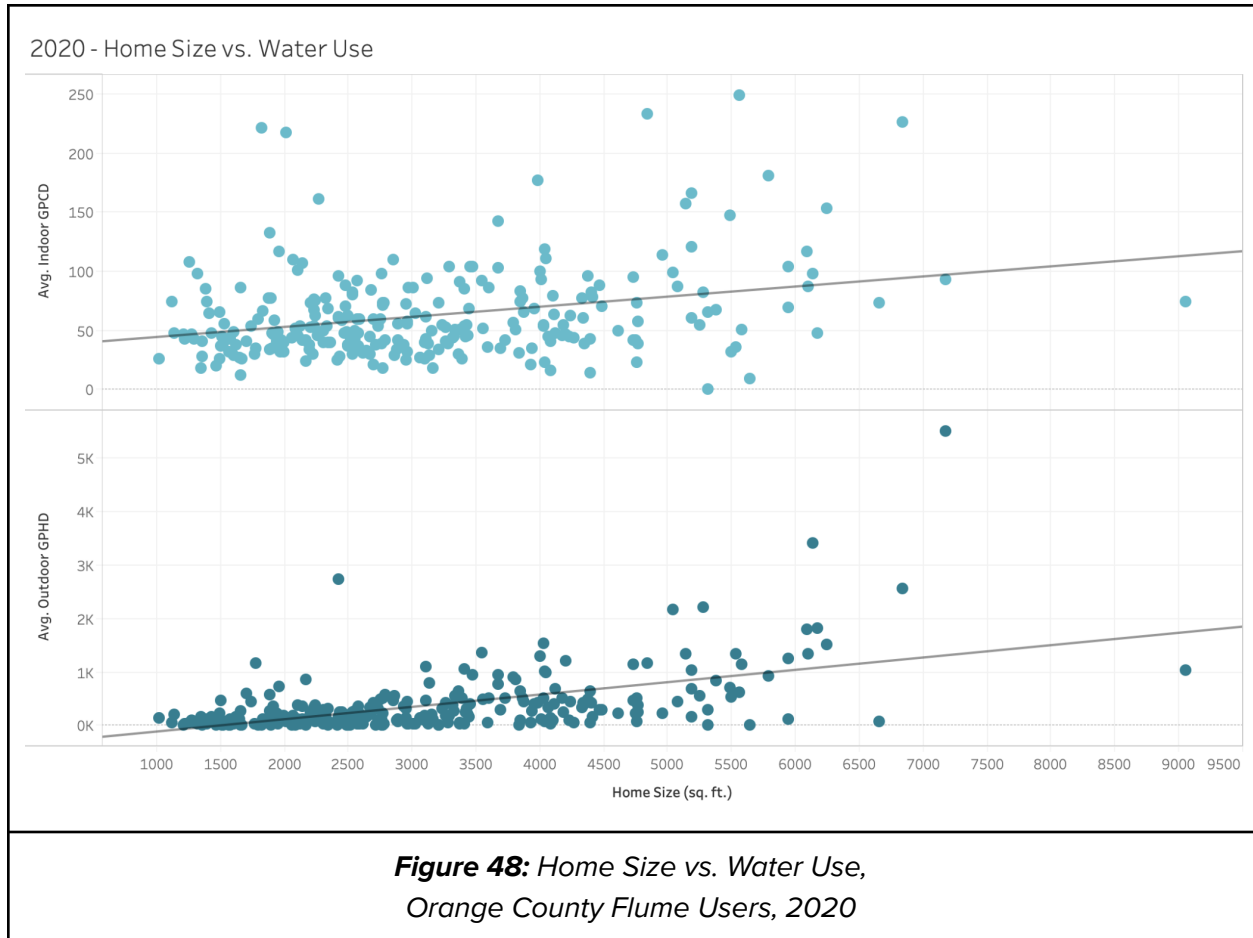
Home Size

Table 13 and Figure 48 represent indoor and outdoor water use based upon home size. For this analysis, homes were separated into bins based upon home square footage (from estimated.com). Table 13 shows the number of Flume-equipped homes included in each bin. The table also shows the average indoor GPCD and outdoor GPHD for each bin.

Table 13: Water Use by Size of Home

Home Size (sq. ft.)	# of Flume equipped Homes	Avg. Indoor GPCD	Avg. Outdoor GPHD
1,000 - 1,500	19	57.6	78.7
1,500 - 2,000	36	45.7	190.5
2,000 - 2,500	43	62.6	165.3
2,500 - 3,000	43	54.2	220.6
3,000 - 3,500	36	50.1	321.3
3,500 - 4,000	19	73.7	544.7
4,000 - 4,500	29	61.8	461.6
4,500 - 5,000	10	59.2	360.1
5,000 - 5,500	13	88.6	847.3
5,500 - 6,000	7	107.8	1067.2
6,000 - 6,500	5	92.0	2175.9
6,500 - 7,000	2	121.9	864.8
7,000 - 7,500	1	92.7	5510.5
9,000 - 9,500	1	74.6	1040.7

Figure 48 presents estimated home size vs. average indoor GPCD and outdoor GPHD. There was not any real relationship between indoor GPCD and home size as the Indoor GPCD R-Squared of the regression analysis was 0.09. The size of the homes appears to have very limited (if any) impact on indoor use. There is a stronger relationship between home size and outdoor GPHD where the R-Squared of the regression analysis was 0.29. This is likely because home size and lot size are themselves closely related. As home size increases, higher outdoor use becomes more likely.



Demographic Analysis

A summary of the regression analysis presented in Figures 45 - 48 is present in Table 14. These simple regression analyses show that among Flume users in Orange County, indoor water use is not well correlated with any of the home characteristics.

Average outdoor household use among Flume users in Orange County is more closely correlated with these home characteristics than indoor use. The strongest correlations were found between lot size, home value, and home size and outdoor use. Larger, more expensive homes, on large lots were more likely to use more water outdoors. There did not appear to be any correlation between home age and indoor or outdoor water use.

Table 14: Correlation between Home Characteristics and Water Use

Home Characteristics	Indoor GPCD R-Squared	Outdoor GPHD R-Squared
Home Value	0.10	0.30
Home Age	0.01	0.03
Lot Size	0.07	0.41
Home Size	0.09	0.29

Peer Comparison

The following charts and tables compare water use of Orange County Flume users with Flume users from the following counties: Los Angeles, Riverside, and San Diego. Table 15 shows the average number of Flume-equipped households that were included from each county in this analysis, as well as the average indoor GPCD and the average outdoor GPHD in each county.

Average indoor GPCD in 2020 across these four Southern California counties was quite similar, and the Flume users in Orange County average of 62.3 was in between LA (61.4), Riverside (61.5) and San Diego (65.7). The 2020 indoor per capita values have been shown to be higher than in past years due to COVID-19 stay-at-home orders. The 2016 Residential End Uses of Water, Version 2 study, reported an average of 58.6 GPCD indoors, based on research conducted in 9 cities in the US and Canada. This is quite similar to the Q1 2020 average indoor GPCD of 53.9 from across the four Southern California counties shown in Figure 49.

As expected, outdoor use was much more variable across the four Southern California counties because of differences in weather, lot size, economics, cost of water, and more. As shown in Table 15, in 2020, San Diego had the highest household outdoor use followed by the Flume users in Orange County, LA, then Riverside. It's also known that ETo varies considerably across these counties, but just a single value from a single weather station is presented for each county.

Table 15: Sample size and average 2020 residential water use, Southern California peer comparison

Flume Users in County	Total # Flume Households Analyzed	2020 Avg. Indoor GPCD	2020 Avg. Outdoor GPHD	2020 ETo (inches)*	Avg. Home Value	Avg. Home Age (years)	Avg. Home Size (sq. ft.)	Avg. Lot Size (sq. ft.)
Orange County	279	62.3	410.1	56.2	\$1,258,682	33	3,150	12,637
Los Angeles	671	61.4	378.8	53.8	\$1,480,475	53	2,752	14,264
Riverside	558	61.5	266.6	61.5	\$612,349	21	2,731	12,338
San Diego	900	65.7	523.2	49.0	\$1,068,233	36	2,781	48,407

* ET data was sourced from the following CIMIS weather stations: Irvine (Station 75), Los Angeles (Station 223), Riverside (Station 44), San Diego (Station 184).

Figure 49 compares quarterly indoor per capita water use for the Flume users in Orange County and the three neighboring counties. Indoor use was higher for the Flume users in Orange County during Q1 than the comparisons, but by Q4, indoor use for the Flume users in Orange County was lowest.

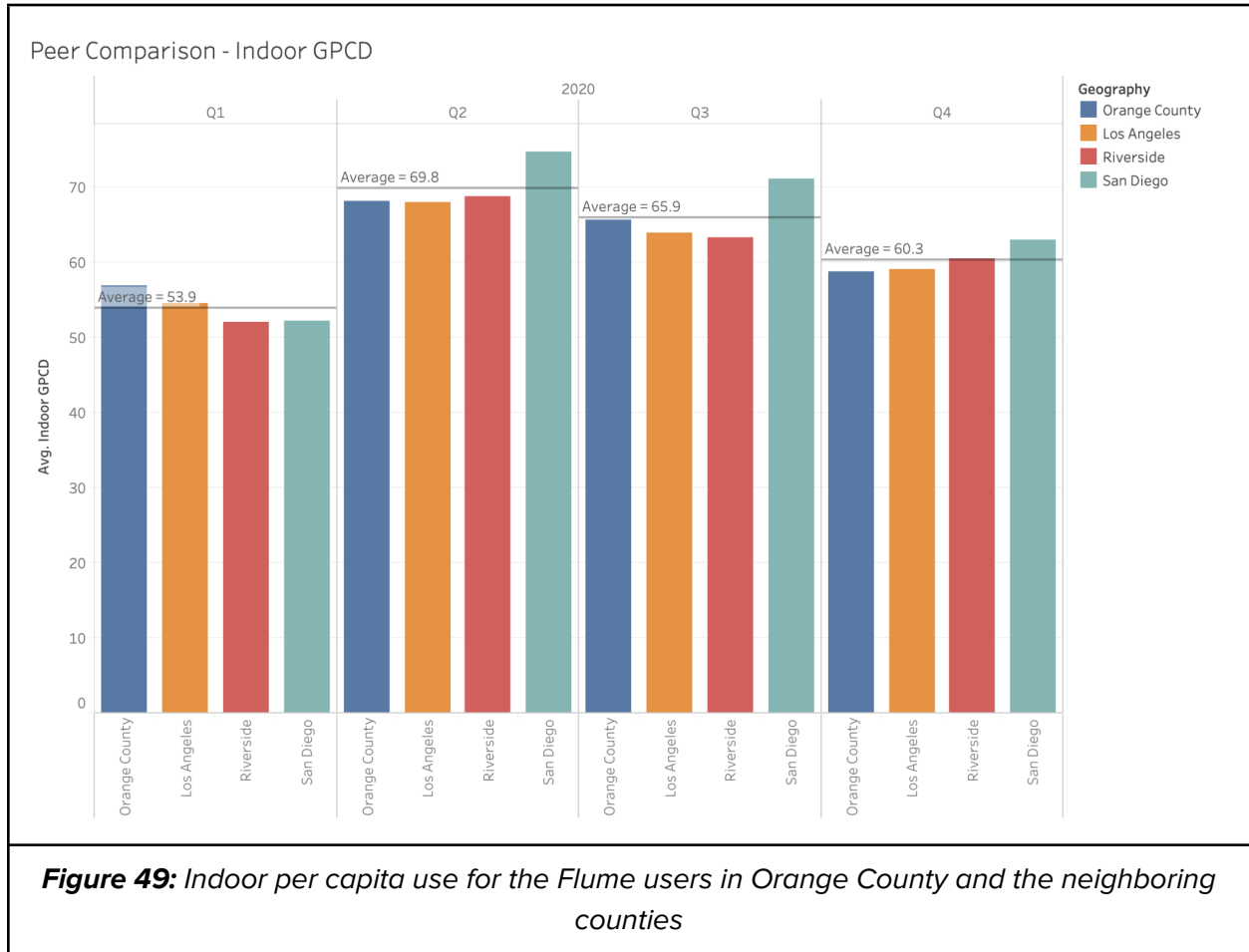
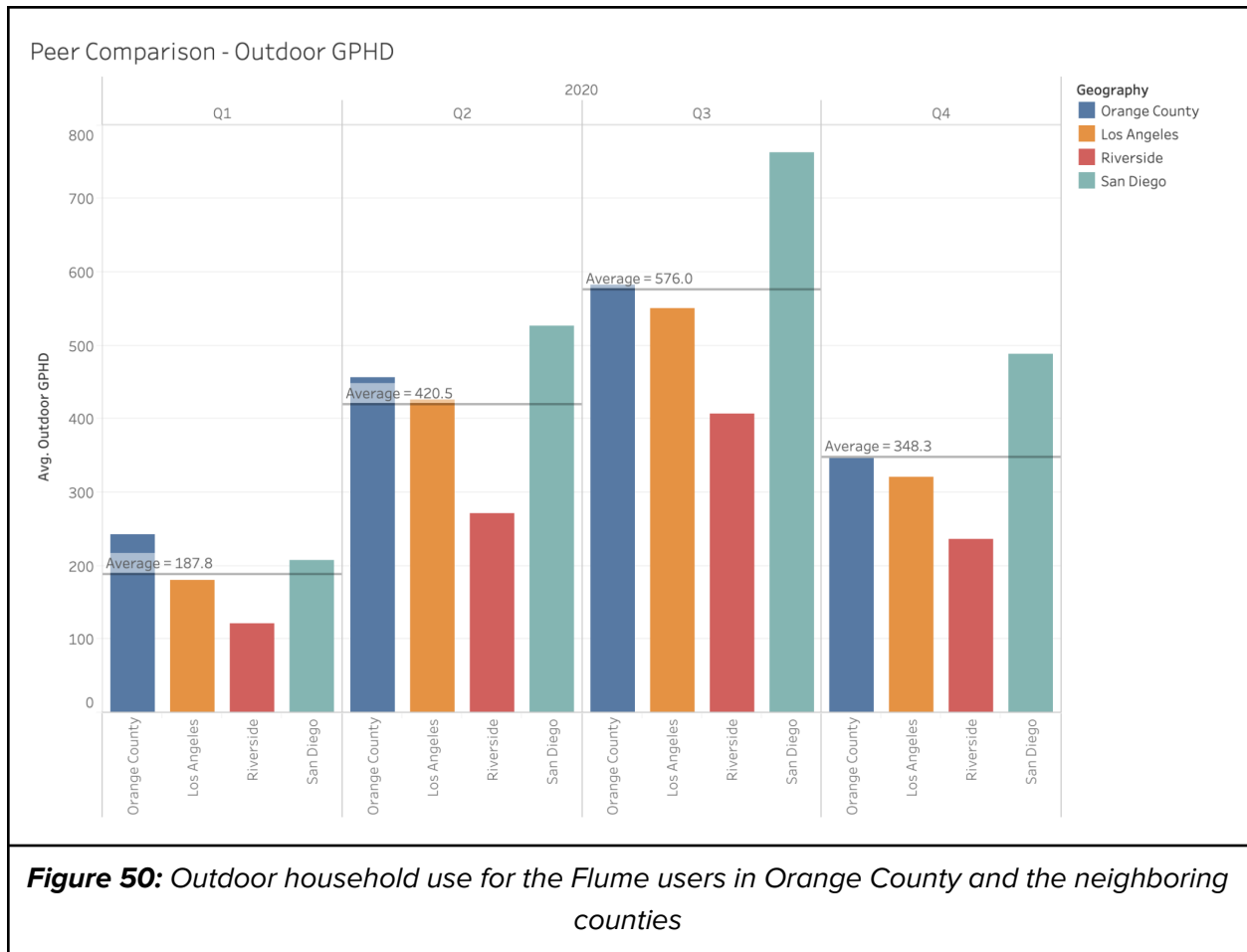


Figure 50 compares quarterly outdoor household water use for the Flume users in Orange County and the three neighboring counties. San Diego had the highest household outdoor water use in each quarter followed by the Flume users in Orange County, LA, and then Riverside.

As seen in Table 15, the average lot size in the San Diego County sample was just over an acre. This is due to a large number of Flume customers in the Fallbrook area, where the average lot size is four acres. This explains why the outdoor water used in the San Diego County sample was higher than the other three peer groups.



Both 2020 indoor and outdoor use of the Flume users in Orange County is compared with the three comparison utilities in Figure 51.

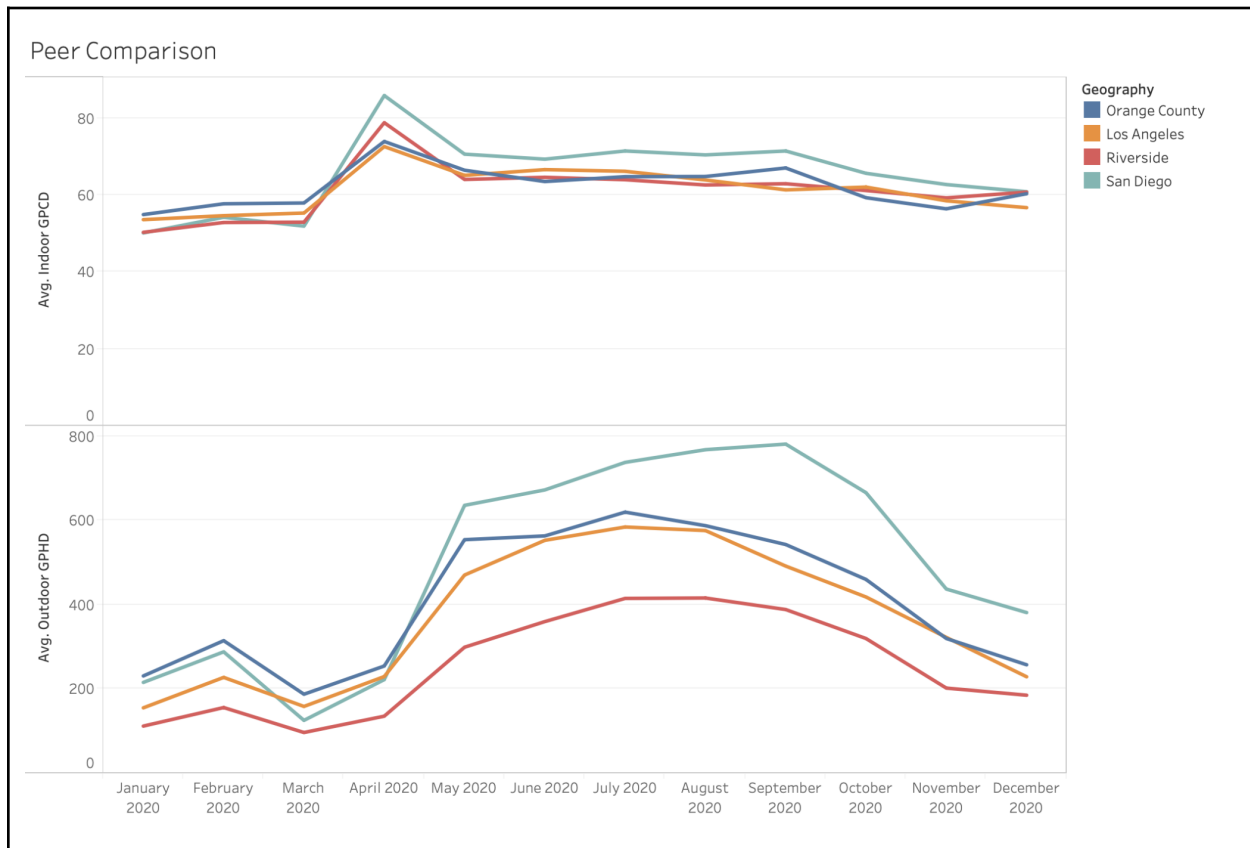


Figure 51: Indoor per capita use and outdoor household use for the Flume users in Orange County and the neighboring counties

Conclusions

This report presents results from data collected from active Flume devices installed at single-family homes within the MWDOC service area during calendar year 2020. The 2020 MWDOC Residential Water Use Study represents a major breakthrough in end use research and portends a future where high-resolution water use data can be analyzed and used for water management objectives as never before.

The following are significant findings and results from the 2020 MWDOC Residential Water Use Study:

- Across all monitored homes in Orange County in 2020, indoor use averaged 62.3 GPCD.
- Indoor water use varied from month to month and was impacted by COVID-19 stay-at-home orders, which resulted in increased indoor water use.
- COVID-19 impacts on indoor water use were most evident in the month of April.
- Over the 12 months of 2020, average daily indoor water use ranged from a low of 54.9 GPCD in January to a high of 73.9 GPCD in April.
- Despite the temporary surge in indoor water usage in 2020, indoor water use in Q1 2021 (53.5 GPCD) is now below the pre-COVID levels of Q4 2019 (58.2 GPCD).
- In 2020, on average, 33% of water was used indoors and 67% outdoors across all monitored homes.
- Across all monitored homes, outdoor water use averaged 409.9 GPHD.
- Outdoor water use occurred in every month of the year and was highest in the month of July when it averaged 620.0 GPHD.
- The correlation between daily ETo and outdoor household water found amongst Flume users in the Santa Margarita Water District and the proportional daily changes in average outdoor use and ETo implies that the SMWD Flume users responded promptly and effectively to change their irrigation patterns in response to weather events.
- The irrigation patterns of the Flume users in SMWD were influenced by water restrictions put in place in that district.
- Total single-family residential water use (indoor + outdoor) in 2020 averaged 612.5 GPHD across the sample of Flume users.
- Average indoor use was slightly correlated with home size, with demand increasing as home size increases. Indoor use was also slightly correlated with home value and lot size. Large homes on larger lots were more likely to use more water indoors.
- Average outdoor household use is moderately correlated with lot size, home value, and home size. Larger, more expensive homes, on large lots were more likely to use more water outdoors.
- Home age and outdoor use are weakly correlated with newer homes tending to use more water outdoors than older homes.

References

Mayer, P., W.B. DeOreo, E. Opitz, J. Kiefer, B. Dziegielewski, and J.O. Nelson. Residential End Uses of Water. American Water Works Association Research Foundation, Denver, Colorado.

DeOreo, W.B., P. Mayer, J. Kiefer, and B. Dziegielewski. 2016. Residential End Uses of Water, Version 2. Water Research Foundation. Denver, CO

Utah Water Research Laboratory. 2019. Performance Evaluation of Five Different Flow Monitoring Devices, Logan, Utah. (Barfuss, S.L., T. Ashby, A. Pack)