



TECHNICAL MEMORANDUM FOR WES ADVISORY COMMITTEE

PREPARED BY: Ron Wierenga
Erin Blue

DATE: September 20, 2019

SUBJECT: Residential EDU Assignment Analysis

Introduction

WES' current System Development Charge (SDC) schedule assesses separate fees broadly based on Equivalent Dwelling Unit (EDU) assignments by class of service (e.g. residential, institutional, commercial, and industrial), and more specifically within each class of service based on other factors that serve as indicators of potential wastewater system demand, including: type, size, and use.

Residential EDU assignments differ by type of residence (e.g. single family, multi-family, etc.) and dwellings within each type are assigned the same number of EDUs. However, there is support that type may not be the only relevant distinction in the residential class. US Census Data demonstrates that occupancy increases with dwelling size (census.gov) and as population is a key driver of wastewater demand, consideration of dwelling size in assigning residential EDUs may result in a more accurate, indeed fair, fee schedule. In support of this notion, the Water Research Foundation report, Residential End Uses of Water, found, that among other factors, indoor water use was most significantly impacted by household size (DeOreo, Mayer, Dziegielewski, & Kiefer, 2014). While there are other variables that could be used as potential indicators of system demand, a 2010 analysis of single-family residential water consumption in Portland, OR drew the conclusion that "residential water consumption per household at the census block group scale is best explained by average building size" (Chang, Parandvash, & Shandas, 2010).

To better understand the impact on the wastewater system of residential connections, WES staff conducted an analytical review of available literature, research and local data. The following memo summarizes an analysis of the impact of dwelling size on residential indoor water use and considers whether dwelling size could be used to fine-tune WES' residential EDU assignment to more appropriately reflect potential system demand. This included a review of water consumption information from Clackamas River Water District and Sunrise Water Authority, which was then reconciled against County dwelling unit size information and census data.

Our review found a statistically significant correlation between the size of the dwelling and the number of people in a dwelling. This indicates that dwelling size is a reasonable and descriptive variable in estimating the amount of water consumption likely to occur in a dwelling over its' useful life, and therefore the amount of wastewater that will be contributed by that dwelling during its useful life. This information allows WES to better estimate the facilities needed to serve those residential customers, and therefore the infrastructure demands and concomitant financial impact of new connections to the wastewater system.

This memorandum provides a more detailed summary of this analytical review in support of a presentation that will be made to the WES Advisory Committee. The WES Advisory Committee will then provide recommended policy direction on revision of WES' Rules and Regulations with respect to incorporation, or not, of this approach.



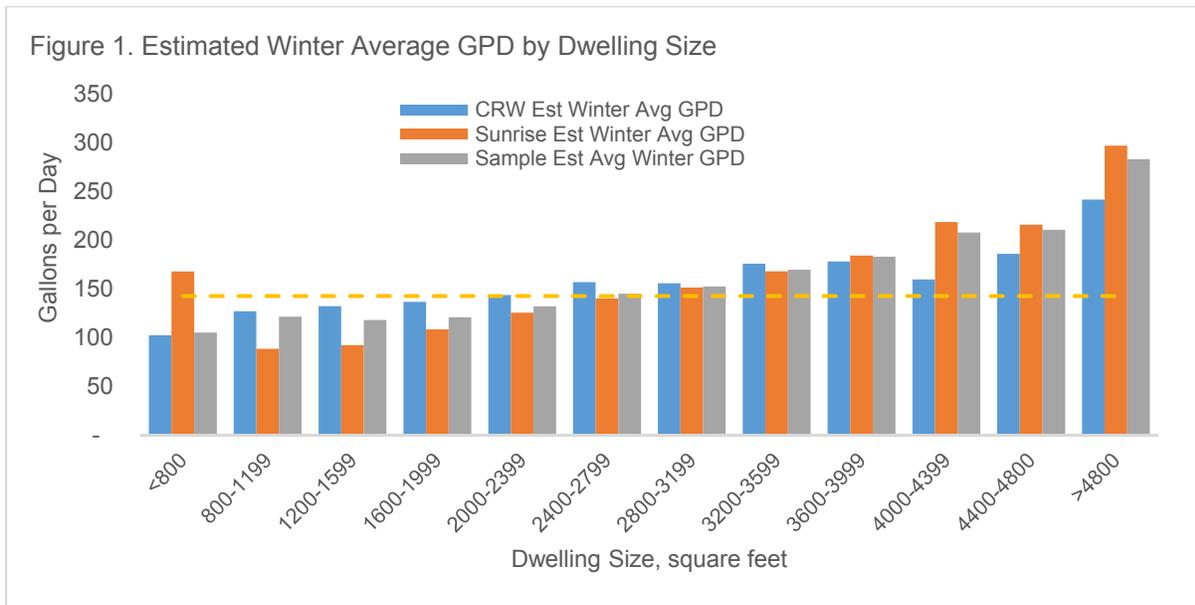
Summary of Results

Dwelling size and estimated indoor water use were examined for a sample of more than 23 thousand residential properties in Clackamas County with approximately 75% of properties in the sample inside WES' service area and the remaining 25% outside of WES' service area. Using estimated winter average gallons per day (GPD) calculated from water provider consumption records as a proxy for indoor water use and wastewater discharge, the sample average household indoor water use was calculated at approximately 143 GPD. As a measure of validity, this is comparable to the 138 GPD average household indoor water use calculated by the WRF (DeOreo, Mayer, Dziegielewski, & Kiefer, 2014). The relationship between dwelling size and water use within the Clackamas County water consumption sample data was analyzed by aggregating dwellings into size increments of 200 square feet and comparing each increment's (bin's) average indoor water use to the overall sample average. Bin averages ranged from a low of 69% of the sample average for dwelling sizes in the range of 600-799 square feet to a high of 198% of the sample average for dwelling sizes greater than 4,800 square feet with most 200 square foot increases in dwelling size corresponding to an increase in water use (see Table 1 on the following page).

Table 1. Estimated Winter Average GPD by 200 square foot bin

Dwelling Size Bin	Estimated Winter Average GPD	% of Sample Estimated Winter Average GPD	% Change from Prior Bin	% of Sample	Count
200-399	228	160%	N/A	0.0%	4
400-599	145	102%	-58%	0.1%	14
600-799	98	69%	-33%	0.6%	148
800-999	123	87%	18%	1.7%	386
1000-1199	120	85%	-2%	3.8%	882
1200-1399	124	87%	2%	5.5%	1,274
1400-1599	114	80%	-7%	8.6%	1,986
1600-1799	116	82%	1%	8.7%	2,005
1800-1999	125	87%	6%	10.0%	2,307
2000-2199	128	90%	3%	9.6%	2,219
2200-2399	136	95%	5%	9.1%	2,100
2400-2599	144	101%	5%	7.9%	1,826
2600-2799	146	103%	2%	6.6%	1,536
2800-2999	149	105%	2%	5.8%	1,354
3000-3199	156	110%	5%	5.0%	1,168
3200-3399	169	118%	9%	3.7%	866
3400-3599	170	119%	1%	2.7%	633
3600-3799	174	122%	2%	2.4%	549
3800-3999	197	138%	16%	1.6%	361
4000-4199	205	144%	6%	1.5%	354
4200-4399	211	148%	4%	1.0%	240
4400-4599	212	149%	1%	1.0%	236
4600-4800	208	146%	-3%	0.7%	161
>4800	283	198%	52%	2.4%	551
N	143			100.00%	23,160

Figure 1, below, illustrates the relationship between dwelling size and water use for the overall sample and for each of the two water providers using 400 square foot bin sizes.



Potential adjustments to WES’ residential EDU assignment methodology were explored by aggregating dwelling sizes into categories using the different approaches detailed in the following pages. Under the approaches considered in this analysis, relative adjustments range from 65% of 1 EDU at the lowest dwelling size range of <500 square feet to 171% of 1 EDU at the largest dwelling size range of >4,200 square feet.

Impact to revenue was estimated for each method using the proportion of dwelling size ranges from the Clackamas County consumption sample data, estimated annual new home construction of 500 dwellings within the WES Rate Zone 2 service area, and WES’ current residential sanitary sewer SDC charge of \$7,850 per EDU. Table 2, below, summarizes the estimated annual revenue which would be collected under WES’ current residential SDC fee schedule along with the estimated revenue collected under each of the different EDU assignment methods considered in this analysis for comparison. Variances with estimated annual residential wastewater SDC revenue under WES’ current EDU assignment methodology and the alternate methodologies considered in this analysis were minimal due to the reduction in revenue from fees for the smaller dwelling sizes offset by an increase from fees for the larger dwelling sizes. Variances were lowest for the methods that adjusted EDUs based on Clackamas County consumption sample data (methods 1 and 2) and highest for the method based on national Census data (method 3).

Table 2. Comparison of Estimated Annual SDC Revenue

Method	Estimated Annual RZ2 Residential Wastewater SDC Revenue	% Variance with Current
Current EDU Assignment Methodology	\$ 3,925,000	-
1A	3,907,400	-0.4%
1B	3,936,900	0.3%
2A	3,919,085	-0.2%
2B	3,922,625	-0.1%
3A	4,163,966	6.1%
3B	4,057,285	3.4%



Conclusion

The data for each method considered in this analysis supports an adjustment to residential EDU assignment based on dwelling size. However, as all of the methods reflect estimates and averages based on sample data, using either Clackamas County consumption sample data or national sample data, the percentage adjustments are subject to a margin of error and may be most valuable when viewed as evidence of trends rather than as exact representations. Viewing the data from a trend perspective, *any* consideration of dwelling size in residential EDU assignment will result in greater equity. The approach that most accurately and correctly allocates proportionate share as it relates to wastewater system impact is a matter of some judgment as it likely entails balancing accuracy of assigning impact on infrastructure with statutory requirements, community goals, development patterns, and public acceptance.

Recommendation

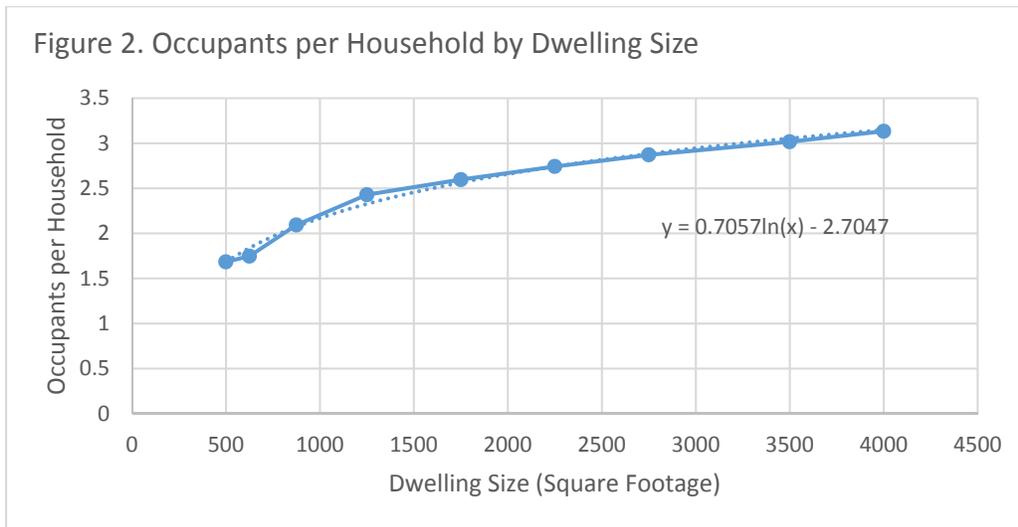
Each of the three methods considered for creating a residential EDU assignment schedule based on dwelling size has advantages and disadvantages. Methods 1 and 2 are more accurate representations of conditions in Clackamas County as they are based on Clackamas County water consumption sample data, however both these methods rely on estimated indoor water consumption, the variability of which may be influenced by characteristics other than dwelling size. Method 3 presents occupancy levels (as a proxy of potential water use) with dwelling size isolated from other variables but uses national dwelling size data rather than averages specific to Clackamas County dwellings, and relies solely on the relationship between occupancy and dwelling size rather than actual consumption data.

Barring additional analysis that may result in a more accurate Clackamas County consumption dataset, one potential recommendation for applying the current consumption and national average occupancy and dwelling size data to WES' residential EDU assignment methodology would be to set the relative percentage adjustments to EDUs based on national averages with the dwelling size categories most closely aligned with Clackamas County consumption data.

The limits of the dwelling categories could be established by identifying breaks in the data by the bins in Table 1 that correspond with the highest percentage changes as indicative of significant differences in system demand at the local level. As an example, from Table 1, the 18% difference from prior seen with the 800-999 square foot bin size and the 16% difference from prior seen with the 3,800-3,999 square foot bin size are significantly higher than the other differences in the table. Variations in estimated winter average GPD between dwelling size categories, as observed in method 1B, may support establishing more than three dwelling size categories, but if only three dwelling size categories were desired, the lowest would be 0 – 799 square feet, the middle would be 800 – 3799, and the upper would be ≥ 3800 square feet.

In order to isolate dwelling size from other characteristics that influence water demand, especially for the larger dwelling sizes, rather than relying on % of sample average winter GPD for determining EDU assignment adjustments, the adjustments could be derived from relative occupancy percentages from the national census data.

On a national level, the relationship between occupancy and household size can best be described as logarithmic (see figure 2).



While the dwelling size categories used in the national survey may not correspond to the limits of the dwelling size categories supported by the Clackamas County sample data, relative percentage adjustments for any dwelling size range within the minimum and maximum square foot designations in the national data can be calculated using the formula for the logarithmic regression trend line in Figure 2. This approach is used in the two tables below to calculate the amounts in the column “Relative % Adj based on Census data”.

Table 3. Recommended EDU assignment for residential developments using relative percentage adjustments based on national averages and dwelling size categories based on locally-derived Clackamas County water consumption data: 3 size categories; relative % adjustments normalized to 100% in middle category.

Dwelling size (Sq Ft)	Sample Winter Average GPD	% of Sample Avg Winter GPD	Relative % Adj based on Census Data	% of Sample (rounded)	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 800	105	74%	69%	1%	166	\$ 5,420	\$ 27,100
800 – 3,799	135	95%	100%	91%	21,091	7,850	3,571,750
≥ 3,800	228	160%	118%	8%	1,903	9,260	370,400
N	143			Totals	23,160		3,969,250



Table 4. Recommended EDU assignment for residential developments using relative percentage adjustments based on national averages and dwelling size categories based on locally-derived Clackamas County water consumption data: 5 size categories; relative % adjustments normalized to 100% in middle category.

Dwelling size (Sq Ft)	Sample Winter Average GPD	% of Sample Avg Winter GPD	Relative % Adj based on Census Data	% of Sample (rounded)	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 800	105	74%	69%	1%	166	\$ 5,420	\$ 27,100
800 – 1,799	118	83%	88%	28%	6,533	6,910	967,400
1,800 – 2,999	138	96%	100%	49%	11,342	7,850	1,923,250
3,000 – 3,799	165	116%	109%	14%	3,216	8,560	599,200
≥ 3,800	228	160%	118%	8%	1,903	9,260	370,400
N	143			Totals	23,160		3,887,350

Method Analysis:

Water use data was obtained from 2018 calendar year consumption records provided by Clackamas River Water (CRW) and Sunrise Water Authority (SWA). Dwelling size data was obtained from the Clackamas County Assessor’s database. The water use and dwelling size datasets were united using Jaccard similarity based on street address for each property (street address was the sole common field between the two datasets).

Winter average consumption (as a proxy for indoor-only water use) was calculated using CRW’s consumption records for the January through April billing periods. Gallons per day were computed for both calendar year consumption and winter consumption by multiplying the consumption in units for each period by 748 gallons/unit and dividing by the number of days. The multiplier for calendar year GPD versus winter average GPD was calculated for each CRW account in the dataset and then used to calculate an average multiplier for estimating Sunrise’s winter average GPD based on calendar-year consumption totals allowing average winter and calendar-year GPD to be estimated for each account in the dataset. Data was scrubbed following the steps outlined in the appendix. Dwelling sizes were divided into different categories based on various criteria, including: the sample size of each category, the average % variance from overall average winter GPD, statistical criteria based on sample means and standard deviations, and statistical criteria based on US Census/AHS Survey data. Each of the methods below outlines potential adjustments to WES’ residential SDC charge for the different dwelling size categories considered.

Explanation of Method Tables and Calculations

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Avg Winter GPD	% of Sample	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 1,400	121	85%	12%	2,708	\$ 6,670	\$ 400,200

Dwelling size (square feet): Dwelling size categories as developed from various sample data; these categories differ for each method and are described in detail on the following pages.

Winter Average GPD: Winter average GPD is calculated/estimated for each dwelling size category using the Clackamas County consumption sample data.



% of Sample Avg Winter GPD: Proportion of each dwelling size category's estimated winter average GPD to the winter average GPD calculated for the entire Clackamas County consumption sample. Example: $121 / 143 = 85\%$

% of Sample: % of the Clackamas County consumption sample that falls within the listed dwelling size category.

Count: Count of Clackamas County consumption sample that falls within the listed dwelling size category.

Adj. SDC Fee (rounded): An adjusted SDC fee based on multiplying the % of Sample Avg Winter GPD for the dwelling size category by WES' current residential SDC charge of \$7,850; rounded to the nearest \$10. Example: $85\% * \$7,850 = \$6,672.50$; rounded to nearest \$10 = \$6,670.

Est. Revenue: Estimated annual residential SDC revenue for each dwelling size category based on the adjusted SDC fee multiplied by the % of sample multiplied by an annual estimate of 500 new residential dwellings. This assumes the distribution of new homes' dwelling sizes will be proportionate to the distribution of dwelling sizes in the Clackamas County consumption sample. Example: $12\% \text{ of sample} * 500 \text{ new residential dwellings annual} * \$6,670 \text{ adj. SDC fee} = \$400,200$.

Data Limitations

Limitations with the Clackamas County consumption sample data are described below:

- Consumption data was scrubbed at only a limited level (see Appendix for scrubbing steps). High-use outliers were not scrubbed and are still present though are not a significant portion of the total sample. Additionally, while the data were scrubbed for winter average GPD that was likely to indicate partial or no vacancy for a period of time, there may still be low-use outliers.
- Approximately 25% of the dwellings in the sample are outside of WES' service area, most of which are in rural areas of CRW's service area. Characteristics other than dwelling size particular to the dwellings outside of WES' service area may have an impact on indoor water consumption which in turn impact the overall averages and percentage variances in the sample. Excluding dwellings outside WES' service area would reduce the sample size but may result in a more representative population.
- While winter average GPD could be calculated for each specific dwelling for CRW, winter average GPD was estimated for Sunrise based on total annual water consumption. CRW's data showed considerable variability between calendar year and winter water use at different dwelling levels (the calendar year vs. winter use proportion increased with increases in dwelling size); however, a consistent proportion equal to the average proportion calendar year use vs. winter use for CRW's entire dataset was applied to Sunrise's data. The decision to use a single average percentage was primarily due to significant differences in other dwelling characteristics (predominantly lot size) between the two water providers' datasets. The drawback of using a single percentage for estimating Sunrise's winter average GPD is that doing so may understate use in the lower dwelling size categories and overstate use in the higher dwelling size categories.

Method 1

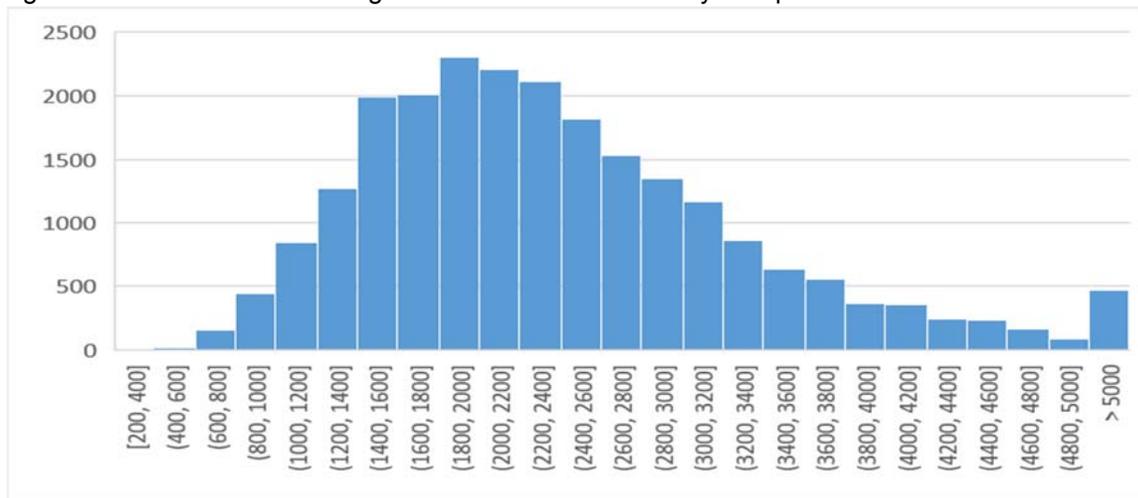
Method 1 approaches use Clackamas County water consumption sample data with dwelling size categories developed from statistical data for sample dwelling size (see Table 5). The breaks in categories for EDU assignments are based solely on dwelling size statistics not water use, and then the % of Sample Avg Winter GPD is used to determine the EDUs assigned for that category. The benefit of this approach is that it results in relatively similar sample sizes above and below a middle category centered on the mean dwelling size which represents a substantial portion of the overall sample.



Table 5. Dwelling Size Statistics (square feet)

Mean	2,402
Median	2,232
Mode	1,942
Standard Deviation	1,005
Minimum	200
Maximum	13,926

Figure 3. Distribution of Dwelling Sizes in Clackamas County Sample



Method 1A – 3 Levels

Method 1A divides dwelling size into three ranges with the middle category based on the dwelling size mean +/- 1 standard deviation (SD, ~1,000 sq ft) for a set of dwelling ranges with approximately equal sample size for the lower and higher dwelling size categories and a middle category which captures 75% of the residential dwelling sizes in the dataset. Mean and SD are rounded. The two outside categories represent dwelling sizes above or below 1 standard deviation from the mean.

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Avg Winter GPD	% of Sample	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 1,400	121	85%	12%	2,708	\$ 6,670	\$ 400,200
1,400 – 3,400	135	94%	75%	17,367	7,380	2,767,500
≥ 3,400	206	145%	13%	3,085	11,380	739,700
N	143		Totals	23,160		3,907,400

Method 1B - 5 Levels

Method 1B divides the data into five dwelling size categories with the middle range based on the dwelling size mean +/- 0.6 standard deviation (~600 sq ft), the next two dwelling size categories are +/- 1 standard deviation from the boundaries of the middle category and the two outer dwelling size categories represent the portion of the sample above or below 1.6 SD. This results in the middle category representing 49% of



the dataset. Mean and SD are rounded. The lower two dwelling size categories represent approximately 29% of the dataset and the upper two categories represent approximately 22% of the dataset.

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Avg Winter GPD	% of Sample	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 800	105	74%	1%	166	\$ 5,810	\$ 29,050
800 – 1,799	118	83%	28%	6,533	6,520	912,800
1,800 – 2,999	136	96%	49%	11,342	7,540	1,847,300
3,000 – 3,999	169	118%	15%	3,577	9,260	694,500
≥ 4,000	235	165%	7%	1,542	12,950	453,250
N	143		Totals	23,160		3,936,900

Method 1 Discussion

Method 1 approaches are aimed at dividing the sample into dwelling size categories with the goal that the sample size of each category is of sufficient size to be representative of trends in the general population. This is achieved to a greater degree with Method 1A where the lower and upper categories are closer to equally distributed. In Method 1B, while the middle category represents almost 50% of the sample, the two lower and upper categories reflect an uneven distribution with the lowest category representative of only 1% of the sample. The advantage of Method 1B over 1A is that it illustrates the relative variation in estimated winter average GPD for smaller and larger average dwelling size categories than Method 1A and shows the estimated winter average GPD for the lowest and highest categories are significantly different from the estimated winter average GPD for the other categories established using this method. While the sample sizes for the lowest and highest dwelling size categories in Method 1B are small, the significant variances suggest the choice of more than 3 levels of EDU assignment adjustments (as seen in Method 1A) *may* be justified.

Method 2

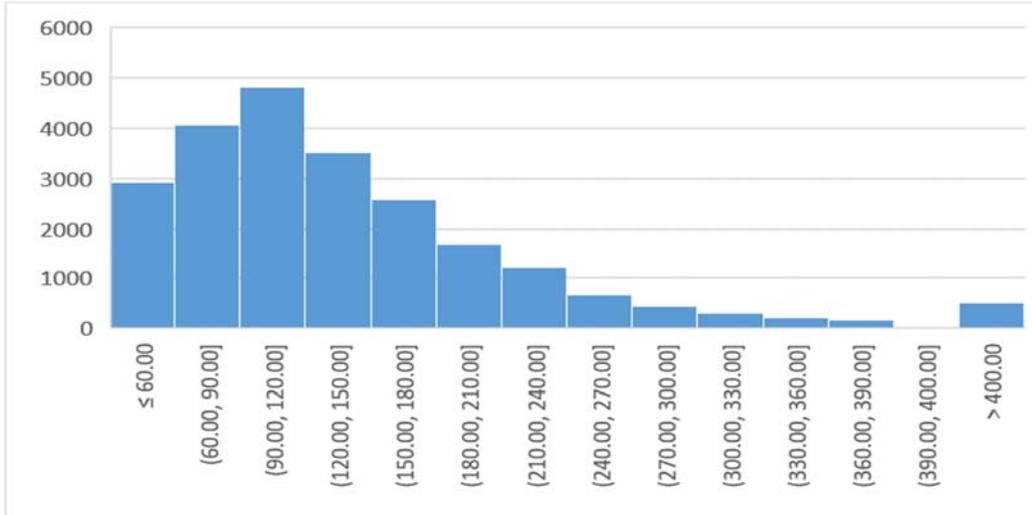
Method 2 approaches use Clackamas County consumption sample data with dwelling size categories developed from statistical data for estimated winter average GPD (see Table 6). These differ from Method 1 approaches in that the breaks in categories for EDU assignments are based on local water use, and then the % of Sample Avg Winter GPD is used to determine the EDUs assigned for that category. The use of estimated winter average GPD statistics aggregates dwelling sizes into categories based on similar indoor water use with less regard to the sample size of each dwelling size category.

Table 6. Winter Avg Gallons per Day Statistics

Mean	143
Median	120
Mode	107
Standard Deviation	113
Minimum	29
Maximum	4,427



Figure 4. Distribution of Estimated Winter Average GPD in Clackamas County Sample



Method 2A - 3 Levels

Method 2A divides the data into three dwelling size categories with the middle range based on the estimated winter average GPD mean for the entire Clackamas County consumption sample +/- approximately 0.25 standard deviation (~28 GPD). Lower and upper dwelling size categories represent estimated winter average GPD below 115 GPD and above 171 GPD, respectively. Mean and SD are rounded and category minimum and maximums are selected from the lower or upper bin value belonging to the 200 sq ft dwelling size bin in Table 1 with the closest estimated winter average GPD, as shown in the table below:

Selection of Dwelling Size Categories based on Sample Est. Winter Avg GPD +/- 0.25 SD

Sample Mean	Minimum Est. Winter Avg GPD for middle category	200 sq ft Dwelling Size bin from Table 1 closest to Min	Min Selected	Maximum Est. Winter Avg GPD for middle category	200 sq ft Dwelling Size bin from Table 1 closest to Max	Max Selected
143	$143 - 28 = 115$	1,600 – 1,799	1,600	$143 + 28 = 171$	3,400 – 3,599	3,599

This approach results in the middle dwelling size category representing approximately 69% of the dataset, the lower dwelling size category represents approximately 20% of the dataset and the upper two categories represent approximately 10% of the dataset.

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Avg Winter GPD	% of Sample	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 1,600	118	83%	20.3%	4,694	\$ 6,520	\$ 661,780
1,600 – 3,599	138	97%	69.1%	16,014	7,610	2,629,255
≥ 3,600	216	151%	10.6%	2,452	11,850	628,050
N	143		Totals	23,160		3,919,085

Method 2B - 5 Levels

Method 2B divides the data into five dwelling size categories with the middle range based on the estimated winter average GPD mean +/- approximately 0.10 standard deviation (~11 GPD). Lower and upper dwelling size categories represent estimated winter average GPD below 132 GPD and above 154 GPD,



respectively. Mean and SD are rounded and category minimum and maximums are selected from the nearest 200 sq ft dwelling size bin in Table 1, as shown in the table below:

Selection of Dwelling Size Categories based on Sample Est. Winter Avg GPD +/- 0.10 SD

Sample Mean	Minimum Est. Winter Avg GPD for category	200 sq ft Dwelling Size bin from Table 1 closest to Min	Min Selected	Maximum Est. Winter Avg GPD for category	200 sq ft Dwelling Size bin from Table 1 closest to Max	Max Selected
143	143 – 11 = 132	2,200 – 2,399	2,200	143 + 11 = 154	3,000 – 3,199	3,199

This approach results in a middle dwelling size category encompassing 1,000 square feet, ranging from 2,200 square feet to 3,199 square feet. Due to the high degree of variability in estimated winter average GPD observed in 200 square foot dwelling size bins above and below the boundaries of the middle category, the inner lower and upper dwelling size categories were selected for consistency with the 1,000 square foot range of the middle category, rather than by estimated winter average GPD standard deviation. The outer lower and upper categories represent dwelling sizes below or above the boundaries of the inner lower and upper dwelling size categories.

Under this approach, the middle category represents 34.5% of the dataset; the lower two dwelling size categories represent approximately 48.5% of the dataset and the upper two categories represent 17% of the dataset.

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Avg Winter GPD	% of Sample	Count	Adj. SDC Fee (rounded)	Est. Revenue
< 1,200	119	84%	6.2%	1434	\$ 6,590	\$ 204,290
1,200 – 2,199	122	85%	42.3%	9791	6,670	1,410,705
2,200 – 3,199	145	102%	34.5%	7984	8,010	1,381,725
3,200 – 4,199	178	125%	11.9%	2763	9,810	583,695
≥ 4,200	244	171%	5.1%	1188	13,420	342,210
N	143		Totals	23,160		3,922,625

Method 2 Discussion

Method 2 approaches are aimed at creating dwelling size categories that capture square foot ranges with similar patterns of water use. Using the Clackamas County consumption sample data, it is possible to select middle categories that exhibit relatively similar use by using the standard deviation for winter average GPD, however, due to the variation in estimated winter average GPD observed below and above the middle categories, utilizing statistical selection methods based on estimated winter average GPD isn't possible and alternate selection methods based on other criteria are necessary, such as the choice of the 1,000 square foot ranges employed in Method 2B. Using mixed selection criteria, the difference between the estimated average winter GPD for Method 2B's two lowest ranges is insignificant and suggests those categories could either be combined or split at a level other than 1,200 square feet to better capture variations in indoor water use. While Method 2A's dwelling size categories are more evenly distributed, utilizing only three categories does not capture the significant variations in estimated winter average GPD observed for the smallest or largest dwellings in the sample.



Method 3

Method 3 approaches use US census data for average number of occupants across different ranges of dwelling sizes and % adjustments that reflect the proportion occupancy of each size range from the average household occupancy. The benefit of method 3 approaches is the ability to isolate occupancy as the driver of wastewater system demand without potentially confounding variables present in the Clackamas County consumption sample data.

Method 3A

Method 3A uses US census data for average number of occupants across different ranges of square feet and % adjustments that reflect the proportion occupancy of each size range from the average household occupancy for Clackamas County of 2.58 (2013-2017 US Census Data).

Dwelling Size (square footage ¹)	Average Occupants per Household	% change in persons	% of Clackamas County Avg Household Occupancy	% of Sample	Adjusted SDC Fee (rounded)	Est. Revenue
Less than 500	1.68		65%	0.04%	\$ 5,100	\$ 1,020
500 to 749	1.75	3.8%	68%	0.48%	5,340	12,816
750 to 999	2.09	19.8%	81%	1.87%	6,360	59,466
1,000 to 1,499	2.43	16.0%	94%	13.41%	7,380	494,829
1,500 to 1,999	2.60	6.9%	101%	23.10%	7,930	915,915
2,000 to 2,499	2.74	5.6%	106%	22.57%	8,320	938,912
2,500 to 2,999	2.87	4.7%	111%	16.44%	8,710	715,962
3,000 to 3,999	3.02	5.1%	117%	15.44%	9,180	708,696
4,000 or more	3.13	3.9%	121%	6.66%	9,500	316,350
N	2.49			Total		4,163,966

Source: Adapted from US Census Bureau, 2017 American Housing Survey, National Household Demographics – All occupied units, Reported N = 107,478

¹ Dwelling Size excludes unfinished attics, carports, attached garages, porches that are not protected from weather (such as screened porches), and mobile home hitches. Both finished and unfinished basements are included.



Method 3B

Method 3B uses US census data for average number of occupants, aggregated square footage ranges and % adjustments that reflect the proportion occupancy of each aggregated size range from the average household occupancy for Clackamas County.

Dwelling Size (square footage ¹)	Average Occupants per Household	% change in persons	% of Clackamas County Avg Household Occupancy	% of Sample	Adjusted SDC Fee (rounded)	Est. Revenue
Less than 1,000	1.94		75%	2.4%	\$ 5,890	\$ 70,680
1,000 – 2,999	2.59	33.8%	100%	75.5%	7,850	2,963,375
3,000 or more	3.06	17.9%	118%	22.1%	9,260	1,023,230
N	2.49			Total		4,057,285

Method 3 Discussion

Method 3 approaches may be the most accurate in terms of reflecting the impact of dwelling size on indoor water use as they isolate occupancy from other variables present in the Clackamas County consumption sample data. However, dwelling size categories under this approach are limited to the categories included in national survey data and may not reflect square foot ranges that correspond with significant changes in impact at the Clackamas County level.

RW/EB



Appendix

Data Scrubbing/Matching Steps	CRW # of Accounts	Sunrise # of Accounts	Total
Consumption Lists, as received	10,606	16,150	26,756
# of Accounts with CY Consumption Readings of 0 or <10	N/A	736	736
# of Accounts with fewer than 6 bi-monthly billings for CY 2018 after 0 Consumption bi-monthly Readings removed	437	N/A	437
# of Accounts scrubbed for no match (Jaccard similarity coefficient = 0 or <0.8 and manually verified as no match)	148	155	303
Unified Dataset before Dwelling size considerations	10,021	15,259	25,280
# of Accounts scrubbed for "NULL" value for Dwelling size	407	124	531
# of Accounts scrubbed for low dwelling size (<200 square feet)	4	0	4
# of Accounts scrubbed for inability to calculate winter average (due to insufficient consumption data)	10	N/A	10
# of Accounts scrubbed for abnormally low winter average (<29.3 GPD; 50% of 58.6 WRF GPCD)	329	783	1,112
Accounts combined for duplicate Tax ID/Address Data	37	426	463
Remaining Dataset	9,234	13,926	23,160

References

- Chang, H. & Parandvash, G. & Shandas, V. (2010). Spatial Variations of Single-Family Residential Water Consumption in Portland, Oregon. *Urban Geography - URBAN GEOGR.* 31. 953-972. 10.2747/0272-3638.31.7.953. Retrieved from <https://www.researchgate.net>
- Mayer, P.W., DeOreo, W.B, Kiefer, J.K, & Dziegielewski, B. (2014). Residential End Uses of Water Study 2013 Update. Denver, CO. Water Research Foundation. Retrieved from <https://energy.mo.gov>
- Bowles, L.K., Nelson, A.C.. (2008). Impact Fees & Housing Affordability. Washington, DC. US Department of Housing and Urban Development. Retrieved from <http://huduser.org>

WES's Residential EDU Methodology



Residential EDU Determination

- Context: Estimate sewer system impact of a residential customer
- Current Policy: House-is-a-house, multifamily and mobile homes a fraction thereof

Element	District	Other Examples
Residential	<ul style="list-style-type: none">• Single Family 1 EDU• Multifamily 0.8 EDU• Mobile 0.8 EDU• Townhomes/ADU 0.8 EDU	<ul style="list-style-type: none">• Base-plus sf model (Eugene, OR)• Per sf & home size categories (Newport, OR)• By type with a small home category (MWMC, Sarasota, FL)• By type + per sf over certain size (Houston, TX)

Analysis

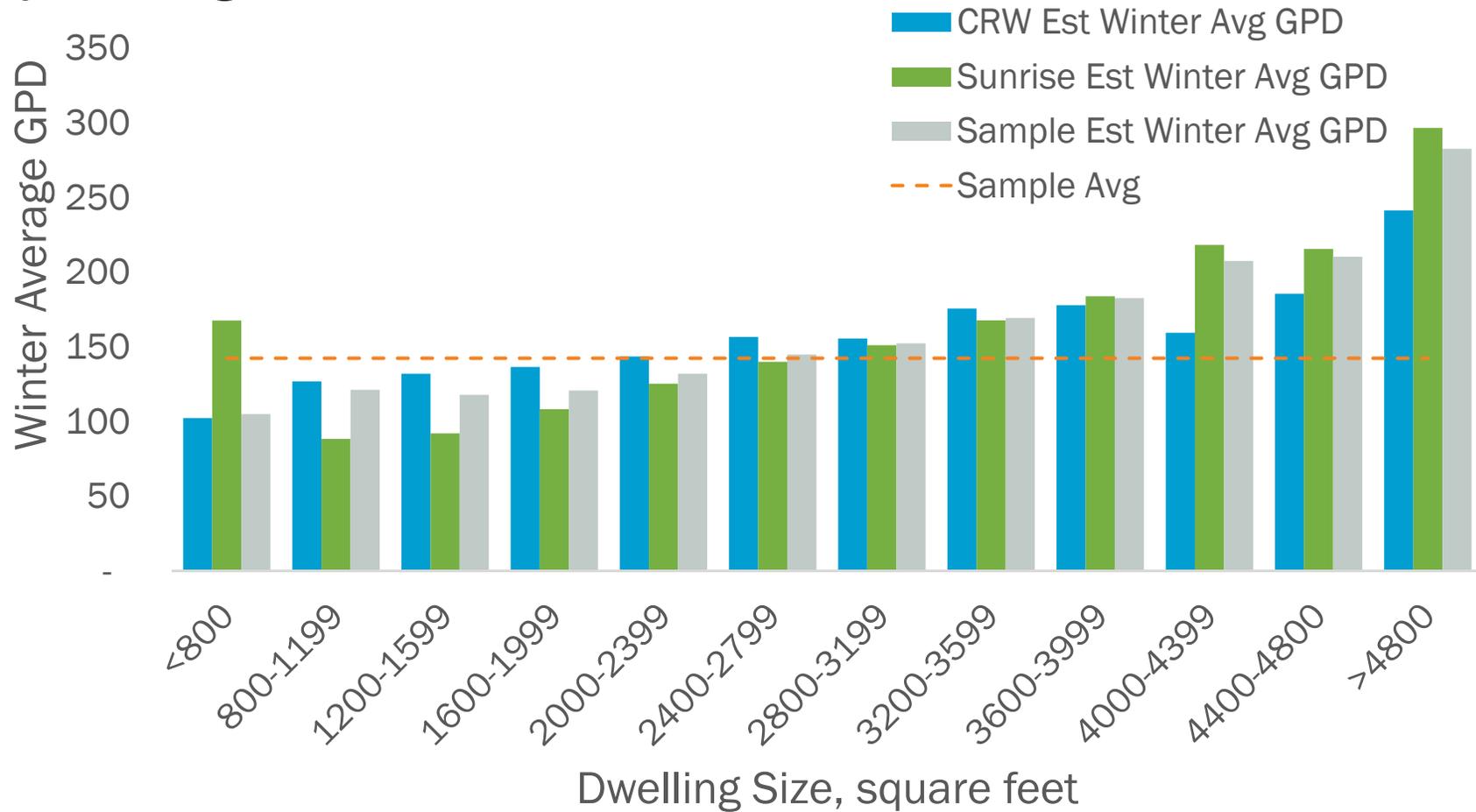
- Is there a relationship between dwelling size and wastewater system impact?
 - PSU/Portland Water Bureau Study
 - Water Research Foundation Report
 - US Census Data

Analysis

- What does Clackamas County water consumption data show?
 - Examined consumption and size data for a sample of >23 thousand households
 - Sample Estimated Winter Average GPD = 143
 - Estimated Winter Average GPD increases with increases with dwelling size

Analysis

Clackamas County Sample Estimated Winter Average GPD by Dwelling Size



Analysis

- 3 Approaches for modifying residential EDU assignment
 - Method 1 Approaches
 - Clackamas County Sample Dwelling Size Statistics
 - Method 2 Approaches
 - Clackamas County Sample Estimated Winter Average GPD Statistics
 - Method 3 Approaches
 - US Census Data

Analysis – Method 1B

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Winter Avg GPD	Count of Sample	Adj. SDC Fee ¹ (rounded)
< 800	105	74%	166	\$ 5,810
800 – 1,799	118	83%	6,533	6,520
1,800 – 2,999	136	96%	11,342	7,540
3,000 – 3,999	169	118%	3,577	9,260
≥ 4,000	235	165%	1,542	12,950
N	143		23,160	

¹ Based on WES' current residential SDC fee of \$7,850.

Analysis – Method 2A

Dwelling size (Sq Ft)	Winter Average GPD	% of Sample Winter Avg GPD	Count of Sample	Adj. SDC Fee ¹ (rounded)
< 1,600	118	83%	4,694	\$ 6,520
1,600 – 3,599	138	97%	16,014	7,610
≥ 3,600	216	151%	2,452	11,850
N	143		23,160	

¹ Based on WES' current residential SDC fee of \$7,850.

Analysis – Method 3A

Dwelling Size (Sq Ft)	Average Occupants per HH	% change in occupancy	Adj. to EDU (% of Clackamas Co. Avg HH Occupancy)	Adjusted SDC Fee ¹ (rounded)
Less than 500	1.68	-	65%	\$ 5,100
500 to 749	1.75	3.8%	68%	5,340
750 to 999	2.09	19.8%	81%	6,360
1,000 to 1,499	2.43	16.0%	94%	7,380
1,500 to 1,999	2.60	6.9%	101%	7,930
2,000 to 2,499	2.74	5.6%	106%	8,320
2,500 to 2,999	2.87	4.7%	111%	8,710
3,000 to 3,999	3.02	5.1%	117%	9,180
4,000 or more	3.13	3.9%	121%	9,500
N	2.49			

Source: Adapted from US Census Bureau, 2017 American Housing Survey, National Household Demographics – All occupied units, Reported N = 107,478

¹ Based on WES' current residential SDC fee of \$7,850.

Conclusions

- Each method supports connection
- *Any* consideration of dwelling size in residential EDU assignment would result in greater accuracy in reflecting impact on the wastewater system
- Demonstrate trends rather than exact representations

Recommended approach for residential EDU assignment

- Consider dwelling size
- Refine analysis
- Apply data using blended approach; 3 category example:

Dwelling size (Sq Ft)	Winter Average GPD from County Sample	Relative % Adj based on Census Data ¹	Adj. SDC Fee ² (rounded)	Count of County Sample
< 800	105	69%	\$ 5,420	166
800 – 3,799	135	100%	7,850	21,091
≥ 3,800	228	119%	9,260	1,903
N	143			23,160

¹ Relative adjustments are calculated from the logarithmic regression formula for occupants per household by dwelling size adapted from National Census Data. % adjustments are then normalized to reflect 100% in the middle dwelling size category.

² Based on WES' current residential SDC fee of \$7,850.

Recommended approach for residential EDU assignment

- Consider dwelling size
- Refine analysis
- Apply data using blended approach; 3 category example:

Dwelling size (Sq Ft)	Winter Average GPD from County Sample	Relative % Adj based on Census Data ¹	Adj. SDC Fee ² (rounded)	Count of County Sample
< 800	105	80%	\$ 5,420	166
800 – 3,799	135	100%	7,850	21,091
≥ 3,800	228	120%	9,260	1,903
N	143			23,160

¹ Relative adjustments are approximations based on values calculated from the logarithmic regression formula for occupants per household by dwelling size adapted from National Census Data. % adjustments are then normalized to reflect 100% in the middle dwelling size category.

² Based on WES' current residential SDC fee of \$7,850.

Recommended approach for residential EDU assignment

- Apply data using blended approach; 5 category example:

Dwelling size (Sq Ft)	Winter Average GPD from County Sample	Relative % Adj based on Census Data ¹	Adj. SDC Fee ² (rounded)	Count of County Sample
< 800	105	69%	\$ 5,420	166
800 – 1,799	118	88%	6,910	6,533
1,800 – 2,999	138	100%	7,850	11,342
3,000 – 3,799	165	109%	8,560	3,216
≥ 3,800	228	118%	9,260	1,903
N	143			23,160

¹ Relative adjustments are calculated from the logarithmic regression formula for occupants per household by dwelling size adapted from National Census Data. % adjustments are then normalized to reflect 100% in the middle dwelling size category.

² Based on WES' current residential SDC fee of \$7,850.

Recommended approach for residential EDU assignment

- Apply data using blended approach; 5 category example:

Dwelling size (Sq Ft)	Winter Average GPD from County Sample	Relative % Adj based on Census Data ¹	Adj. SDC Fee ² (rounded)	Count of County Sample
< 800	105	80%	\$ 5,420	166
800 – 1,799	118	90%	6,910	6,533
1,800 – 2,999	138	100%	7,850	11,342
3,000 – 3,799	165	110%	8,560	3,216
≥ 3,800	228	120%	9,260	1,903
N	143			23,160

¹ Relative adjustments are approximations based on values calculated from the logarithmic regression formula for occupants per household by dwelling size adapted from National Census Data. % adjustments are then normalized to reflect 100% in the middle dwelling size category.

² Based on WES' current residential SDC fee of \$7,850.