Detroit Water and Sewerage Department

Wastewater Master Plan

DWSD Project No. CS-1314

Wastewater Generation

Technical Memorandum
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Wastewater Generation

1. Overview

The Detroit Water and Sewerage Department (DWSD) serves 77 communities in southeast Michigan. The Wastewater Master Plan called for an analysis of both residential wastewater generation and commercial/industrial wastewater generation in the area serviced by the Greater Detroit Regional Sewer System (GDRSS).

Existing GDRSS CS-1249 estimates of these unit flows were reviewed. Also, additional residential and commercial/industrial water usage information was collected and evaluated from several communities. This was accomplished by measuring winter quarter water usage. Recommended unit flows for residential and commercial/industrial are made.

2. Existing GDRSS Estimates

The GDRSS estimate of residential water usage was 85 gallons per person per day (gpcd). This value was determined based on a three-year history of residential water usage, which was obtained from five communities including Dearborn, Detroit, Farmington, Melvindale, and Sterling Heights. This data have been separated by quarter; the average is illustrated in Figure 1.

The GDRSS estimate of commercial and industrial water usage was 50 gallons per employee per day (gped). This value was determined based on a three-year history of commercial and industrial water usage, which was obtained from six communities including Dearborn, Detroit, Farmington, Melvindale, Plymouth Township, and Sterling Heights. This data have been separated by quarter; the average is illustrated in Figure 2.

Figure 3 contains the data for all commercial and industrial water usage less flows and employee for significant industrial users (wastewater). Wastewater flows for significant industrial users are, for the most part, estimated from water use records.

The final GDRSS values of 85-gpcd for residential wastewater generation and 50-gped for commercial/industrial wastewater generation were selected using Figures 1 and 3, respectively, as well as achieving a workable fit with billing data.

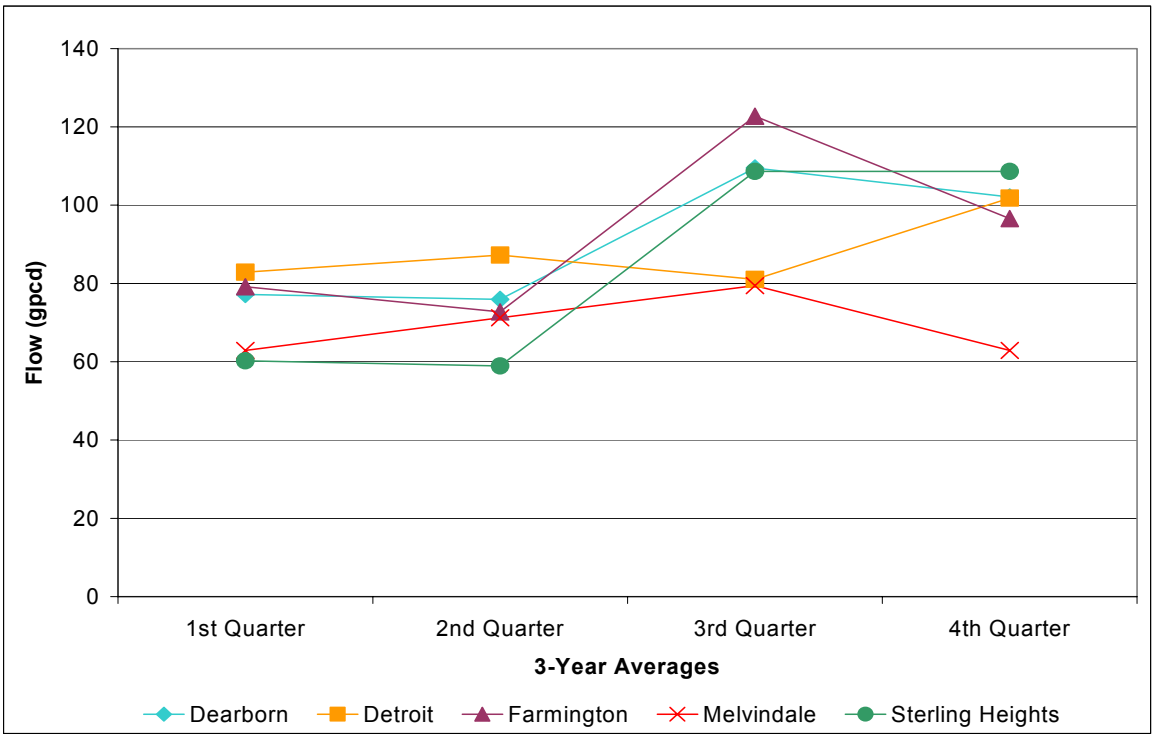

Figure 1. Residential Unit Flow (gpcd)

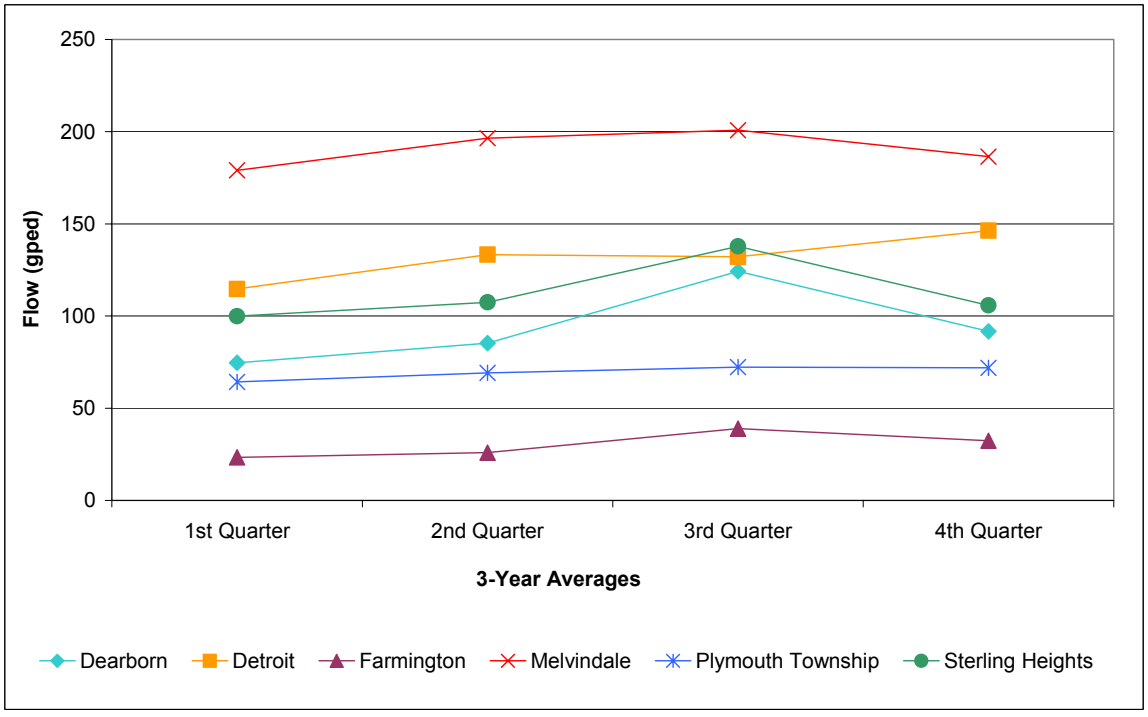

Figure 2. Commercial/Industrial Flow (gped)

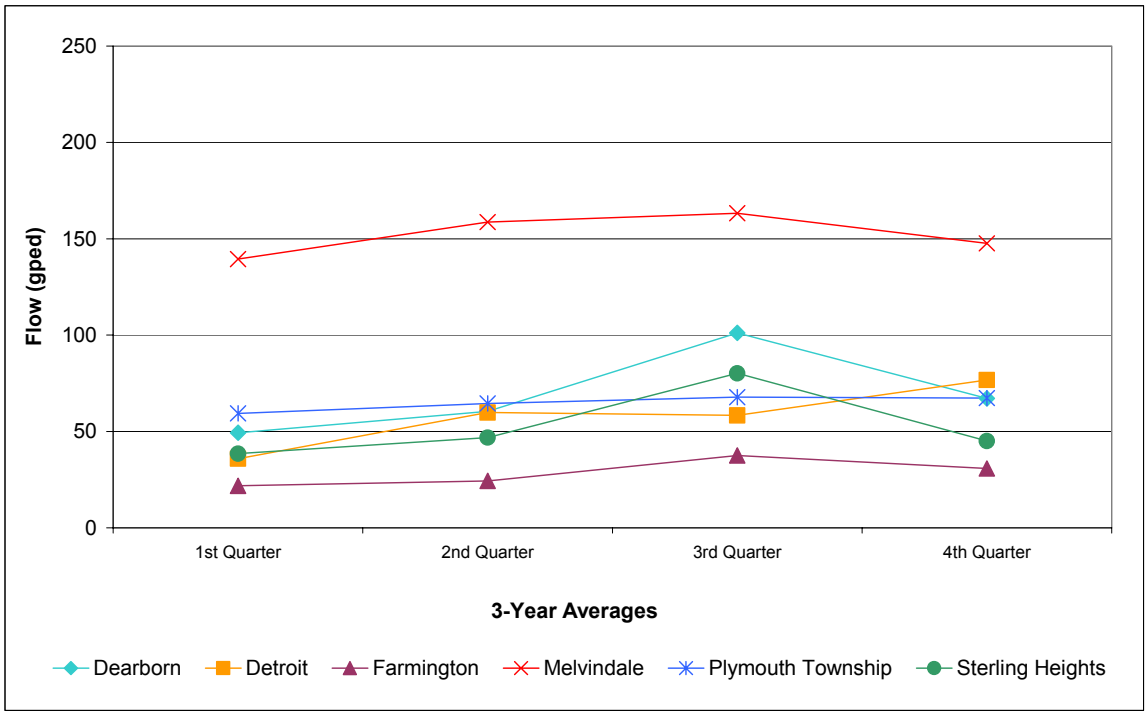

Figure 3. Commercial/Industrial Flow without Significant Industrial Users (gped)

3. Residential Water Use

To determine a per capita residential water usage, all 76 suburban communities were asked to provide billing records for 20-30 random residential accounts for the past three winter quarters. Winter quarter was chosen to minimize lawn and garden watering and other water uses that are not related to wastewater.

The Southeast Michigan Council of Governments (SEMCOG) provided data on population and number of households for each community. By dividing the population by the number of households, population per household could be determined for each community. Water use per household and water use per person could also be calculated.

Out of the 76 communities asked to participate, 66 communities provided information, four had information but did not respond, and seven communities had no information available or charged a fee to provide information. In addition to the 66 communities that provided information, the City of Detroit was added to the study using the residential water use value of 80 gallons/person/day from the GDRSS data (Figure 1).

The average residential water consumption was calculated for each community that provided information. A statistical analysis was performed on the data. Any values greater than two standard deviations from the mean were not considered. Center Line,

Madison Heights, and Oak Park provided average data, not individual account data. Therefore, no statistical analyses were performed for those communities.

The average residential water consumption was calculated using two methods. The first gave each community equal weight. The second weighted each community by the number of households.

When each community receives equal weight, the residential water usage value is 71.32 gallons/person/day. The per capita residential water usage value when communities are weighted by number of households is 74.88 gallons/person/day.

Table 1 illustrates the information provided by the 66 communities and the City of Detroit, with each community receiving equal weight. Table 2 illustrates the information provided by the 66 communities and the City of Detroit, weighted by number of households.

Table 1. Residential Water Use (Each Community Receiving Equal Weight)

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Population per Household	Average Residential Consumption (gal/person/day)
Allen Park	168.57	29,593	12,087	2.45	68.85
Auburn Hills	132.90	20,414	8,615	2.37	56.09
Berkley	150.28	16,819	6,695	2.51	59.82
Bingham Farms	273.30	942	412	2.29	119.53
Birmingham	167.82	20,203	9,383	2.15	77.94
Bloomfield	232.87	4,337	1,624	2.67	87.20
Bloomfield Hills	291.01	42,400	16,691	2.54	114.56
Canton	175.66	71,642	24,873	2.88	60.99
Center Line	166.90	8,116	3,927	2.07	80.75
Chesterfield	141.47	33,644	12,026	2.00	70.73
Clawson	173.86	13,052	5,620	2.32	74.86
Clinton Township	180.22	96,266	39,279	2.45	73.53
Dearborn	158.01	90,685	35,916	2.52	62.58
Detroit	214.04	934,509	349,288	2.68	80.00
Eastpointe	138.64	34,504	13,512	2.55	54.29
Farmington	129.24	10,052	4,755	2.11	61.14
Farmington Hills	221.94	78,991	33,058	2.39	92.88
Ferndale	128.34	24,756	9,841	2.52	51.02

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Population per Household	Average Residential Consumption (gal/person/ day)
Fraser	152.31	14,871	6,005	2.48	61.50
Grosse Pointe	201.11	5,745	2,391	2.40	83.70
Grosse Pointe Farms	185.52	9,965	3,866	2.58	71.97
Grosse Pointe Park	216.95	12,858	4,877	2.64	82.29
Grosse Pointe Shores	244.46	2,835	1,065	2.66	91.83
Grosse Pointe Woods	163.84	17,376	6,598	2.63	62.21
Harper Woods	155.18	14,593	6,590	2.21	70.08
Harrison Township	200.96	25,954	10,930	2.37	84.63
Hazel Park	157.79	19,521	7,230	2.70	58.44
Huntington Woods	166.37	6,441	2,362	2.73	61.01
Independence	190.68	32,162	11,115	2.89	65.90
Inkster	157.65	28,570	11,151	2.56	61.53
Keego Harbor	209.81	2,892	1,231	2.35	89.31
Lake Orion	158.31	2,927	1,297	2.26	70.15
Lathrup Village	168.10	4,222	1,572	2.69	62.59
Lenox Township	190.20	4,703	1,507	3.12	60.95
Livonia	197.96	98,203	38,259	2.57	77.12
Macomb Township	213.19	38,969	12,354	3.15	67.59
Madison Heights	162.93	30,074	12,904	2.33	69.91
Melvindale	141.77	10,301	4,534	2.27	62.40
New Haven	137.07	2,923	957	3.05	44.88
Northville	147.45	6,570	2,758	2.38	61.90
Northville Township	190.50	20,558	8,149	2.52	75.51
Novi	235.66	48,481	19,098	2.54	92.83
Oak Park	192.64	30,977	10,911	2.84	67.85
Oakland Charter Township	218.01	11,664	3,912	2.98	73.12
Orchard Lake Village	231.16	2,148	758	2.83	81.57
Orion Township	164.73	28,532	9,837	2.90	56.79
Oxford	152.78	3,400	1,316	2.58	59.13
Oxford Township	204.47	11,066	3,815	2.90	70.49
Pleasant Ridge	172.62	2,754	1,097	2.51	68.76

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Population per Household	Average Residential Consumption (gal/person/ day)
Plymouth	140.82	9,084	4,306	2.11	66.75
Plymouth Township	151.45	28,102	11,036	2.55	59.48
Redford	182.87	53,039	20,238	2.62	69.78
Rochester	158.69	8,335	3,848	2.17	73.26
Rochester Hills	191.34	68,766	25,773	2.67	71.71
Roseville	187.89	49,626	20,508	2.42	77.65
Royal Oak Township	107.32	5,169	2,455	2.11	50.97
Shelby Township	203.11	64,629	24,240	2.67	76.18
Southfield	244.18	73,641	32,397	2.27	107.42
St. Clair Shores	162.30	64,833	27,413	2.37	68.62
Sterling Heights	239.59	118,606	44,183	2.68	89.25
Utica	177.77	5,004	1,926	2.60	68.42
Van Buren	178.13	24,238	9,578	2.53	70.39
Washington Township	188.22	16,984	6,141	2.77	68.06
Waterford Township	202.27	69,071	27,777	2.49	81.34
Wayne	137.90	19,525	7,479	2.61	52.82
West Bloomfield	173.52	59,002	22,268	2.65	65.49
Westland	159.98	88,100	36,931	2.39	67.06
Average Residential Consumption (gallons/person/day)					**71.63**

* In Chesterfield, the SEMCOG estimate of 2.80 persons per household was replaced with 2.00 persons per household, based on advice from the community for the limited number of accounts that was looked at.

Table 2. Residential Water Use (Weighted by Number of Households)

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Household Weighted Consumption (gallons/day)
Allen Park	168.57	29,593	12,087	2,037,506
Auburn Hills	132.90	20,414	8,615	1,144,934
Berkley	150.28	16,819	6,695	1,006,125

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Household Weighted Consumption (gallons/day)
Bingham Farms	273.30	942	412	112,600
Birmingham	167.82	20,203	9,383	1,574,621
Bloomfield	232.87	4,337	1,624	378,181
Bloomfield Hills	291.01	42,400	16,691	4,857,248
Canton	175.66	71,642	24,873	4,369,256
Center Line	166.90	8,116	3,927	655,406
Chesterfield	141.47	33,644	12,026	1,701,313
Clawson	173.86	13,052	5,620	977,093
Clinton Township	180.22	96,266	39,279	7,078,857
Dearborn	158.01	90,685	35,916	5,675,114
Detroit	214.04	934,509	349,288	74,760,720
Eastpointe	138.64	34,504	13,512	1,873,304
Farmington	129.24	10,052	4,755	614,542
Farmington Hills	221.94	78,991	33,058	7,336,893
Ferndale	128.34	24,756	9,841	1,262,994
Fraser	152.31	14,871	6,005	914,625
Grosse Pointe	201.11	5,745	2,391	480,854
Grosse Pointe Farms	185.52	9,965	3,866	717,220
Grosse Pointe Park	216.95	12,858	4,877	1,058,065
Grosse Pointe Shores	244.46	2,835	1,065	260,351
Grosse Pointe Woods	163.84	17,376	6,598	1,080,984
Harper Woods	155.18	14,593	6,590	1,022,636
Harrison Township	200.96	25,954	10,930	2,196,487
Hazel Park	157.79	19,521	7,230	1,140,844
Huntington Woods	166.37	6,441	2,362	392,973
Independence	190.68	32,162	11,115	2,119,408
Inkster	157.65	28,570	11,151	1,757,903
Keego Harbor	209.81	2,892	1,231	258,276
Lake Orion	158.31	2,927	1,297	205,324
Lathrup Village	168.10	4,222	1,572	264,249
Lenox Township	190.20	4,703	1,507	286,631
Livonia	197.96	98,203	38,259	7,573,855

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Household Weighted Consumption (gallons/day)
Macomb Township	213.19	38,969	12,354	2,633,749
Madison Heights	162.93	30,074	12,904	2,102,431
Melvindale	141.77	10,301	4,534	642,794
New Haven	137.07	2,923	957	131,176
Northville	147.45	6,570	2,758	406,654
Northville Township	190.50	20,558	8,149	1,552,423
Novi	235.66	48,481	19,098	4,500,623
Oak Park	192.64	30,977	10,911	2,101,843
Oakland Charter Township	218.01	11,664	3,912	852,855
Orchard Lake Village	231.16	2,148	758	175,219
Orion Township	164.73	28,532	9,837	1,620,449
Oxford	152.78	3,400	1,316	201,058
Oxford Township	204.47	11,066	3,815	780,053
Pleasant Ridge	172.62	2,754	1,097	189,369
Plymouth	140.82	9,084	4,306	606,371
Plymouth Township	151.45	28,102	11,036	1,671,368
Redford	182.87	53,039	20,238	3,700,923
Rochester	158.69	8,335	3,848	610,639
Rochester Hills	191.34	68,766	25,773	4,931,309
Roseville	187.89	49,626	20,508	3,853,248
Royal Oak Township	107.32	5,169	2,455	263,471
Shelby Township	203.11	64,629	24,240	4,923,293
Southfield	244.18	73,641	32,397	7,910,699
St. Clair Shores	162.30	64,833	27,413	4,449,130
Sterling Heights	239.59	118,606	44,183	10,585,773
Utica	177.77	5,004	1,926	342,385
Van Buren	178.13	24,238	9,578	1,706,129
Washington Township	188.22	16,984	6,141	1,155,852
Waterford Township	202.27	69,071	27,777	5,618,454
Wayne	137.90	19,525	7,479	1,031,354
West Bloomfield	173.52	59,002	22,268	3,863,894
Westland	159.98	88,100	36,931	5,908,387

Community	Average Household Consumption (gal/house/day)	Population	Number of Households	Household Weighted Consumption (gallons/day)
TOTALS		**2,908,934**	**1,126,545**	**220,170,765**
Household Weighted Residential Consumption (gal/household/day)				**195.44**
Household Weighted Residential Consumption (gal/person/day)				**75.69**

The residential water use data for the 67 communities that provided information is plotted in Figure 4.

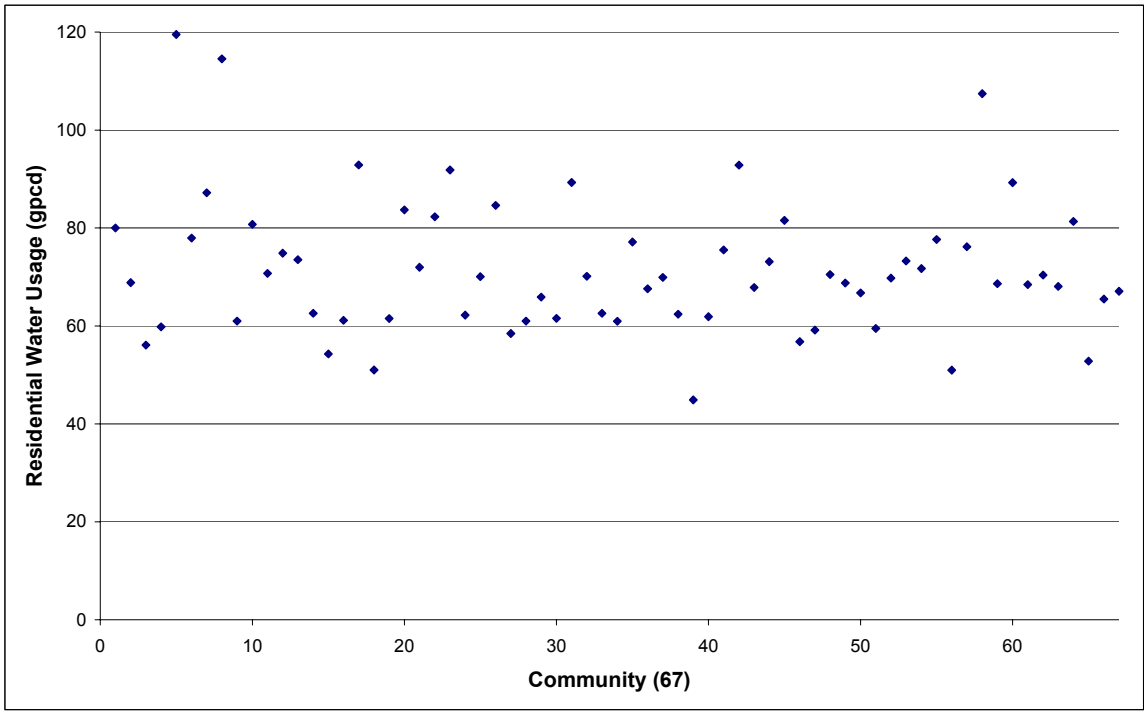

Figure 4. Residential Water Usage by Community

A review was then made of how these consumption values compare with other communities.

The American Water Works Association Research Foundation (AWWRF) conducted a study "Residential End Uses of Water, 1999", which presented data for 12 study sites pertaining to per capita daily indoor water use (Table 3). The mean indoor per capita use in each study site ranged from 57.1-gpcd (Seattle, Washington) to 83.5-gpcd (Eugene,

Oregon). The mean indoor per capita for all 12 sites was 69.3-gpcd which included leakage.

The 12 sites include four sites in California, two sites in Arizona, two sites in Colorado, and one site each in Oregon, Washington, Florida and Ontario, Canada. The study indicated that the values presented include a 5% reduction in water consumption resulting from the use of water conservation devices. This would increase the mean per capita consumption to 72.5-gpcd.

Of the 12 sites, three sites were above 75.69-gpcd (including conservation). These sites were Eugene, Oregon, Scottsdale/Tempe, Arizona, and Phoenix, Arizona. Increasing the daily consumptions for the 12 sites by applying the 5% reduction for water conservation, Phoenix, Arizona would be above 80-gpcd and Eugene, Oregon and Scottsdale/Tempe, Arizona would both be above 85-gpcd.

Table 3. Residential End Uses of Water Study, AWWRF, 1999

Study Site	Mean Daily Indoor Use (gpcd)
Waterloo/Cambridge, Ontario, Canada	70.6
Seattle, Washington	57.1
Tampa, Florida	65.8
Lompoc, California	65.8
Eugene, Oregon	83.5
Boulder, Colorado	64.7
San Diego, California	58.3
Denver, Colorado	69.3
Phoenix, Arizona	77.6
Scottsdale/Tempe, Arizona	81.4
Walnut Valley WD, California	67.8
Las Virgenes MWD, California	69.6
Mean of Study Sites	**69.3**

This study also presented data on the mix of indoor and outdoor usage rates of water. For all 12 of the study sites 42% of the annual water usage was for indoor usage and 58% was for outdoor usage. The mix of usage also varied according to the climate conditions. In hotter areas such as Phoenix, Arizona and Scottsdale/Tempe, Arizona, the outdoor usage rate were 59-67%, while in cooler and wetter climates such as Seattle, Washington, Tampa, Florida, and Waterloo/Cambridge, Ontario, Canada, the outdoor usage rates were 22%-38%.

The AWWA Research Foundation also identified the different uses of water in the household. This information is shown graphically in Figure 5.

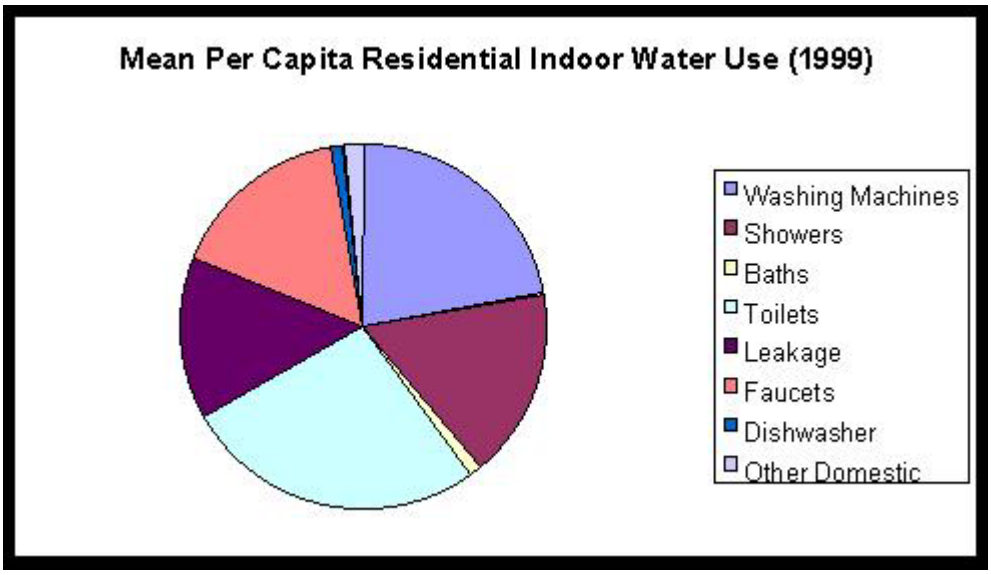

Figure 5. Mean Per Capita Residential Indoor Water Use (1999)

The general allocation of the type of uses identified in the AWWRF study is presented in Table 4. This data is compared to similar data presented in a 1984 United States Department of Housing and Urban Development (USHUD) study.

Table 4. Indoor Water Use Per Capita Per Day 1999 and 1984

Activity	AWWRF – 1999	USHUD – 1984
Washing Machines	21.7%	22%
Showers	16.8%	21%
Baths	1.7%	9%
Toilets	26.7%	28%
Leakage	13.7%	5%
Faucets	15.7%	12%
Dishwasher	1.4%	3%
Other Domestic	2.2%	N/A

As shown in the Table 4, the largest uses of water are toilets and washing machines, followed by showers. Attention is called to the general reduction in the areas of usage of showers, baths and toilets.

Historically, the water usage by device in the household is presented in Table 5. This data is summarized to better understand how the trend to the reduction of water consumption is being achieved.

Table 5. Historical Water Usage by Device in Household

Activity	Usage (gallons)
Shower (10-minutes)	40
Bath	35
Toilet Flush	5
Dishwasher (load)	15
Clothes Washer (load)	30-60
Tooth Brushing	1-2
Hand Washing	1-2
Shaving (face/leg)	1-3
Cooking	5-10
Washing Vegetables	5-20

Since 1984, there have been changes in plumbing codes and an increase in public awareness of how to achieve the conservation of water usage in the household. For toilet flushing, usage rates such as 5 gallons per flush (gpf) or more was not uncommon prior to 1984. Initially there was a trend to use toilets with 3.5-gpf. In 1992, Congress required all new houses to be fitted with ultra low flush capability, 1.6-gpf.

The construction of new housing in addition to remolding in bathrooms in households has resulted in a trend of reducing the amount of water usage due to toilet flushing. This trend is expected to continue.

For shower usage, showerheads have been installed which reduce the water usage to 2.2-gpm maximum. This is a significant reduction to the older showerheads, which had allowed 4-gpm. The trend reduction of water usage in baths can most likely be attributed to a change in personal preference by users in the home to shower rather than take baths.

As there is a continuation of public awareness in water conservation, and the change to more water conserving devices in the household, it is expected that the trend to reducing water consumption in the household will continue.

Data collected in the State of Florida indicates that the 1995 per capita consumption including commercial accounts was 169-gpcd. Adjusting this for indoor use only by applying a factor of 45% for indoor use (AWWARP data) results in a value of 76-gpcd.

The actual residential consumption rate would be less when adjusting for the commercial usage. Data for Harnett County, North Carolina indicates that a value of 85-gpcd represents household consumption and in some cases can be as high as 100-gpcd.

The use of a value between 75 and 80-gpcd for the Greater Detroit area represents a 6-12% decrease from the current value of 85-gpcd. This represents a decrease between 9 and 18-MGD of water consumption based on the current population. As the use of water conservation devices has become prevalent and continues to increase, the use of a value between 75 and 80-gpcd does not appear unreasonable and is in line with other communities.

4. Commercial/Industrial Water Use

To determine a per employee commercial/industrial water usage, 25 communities were asked to provide a total commercial/industrial billing record for the past three winter quarters. (Winter quarter was chosen to minimize lawn and garden watering and other water uses that are not related to wastewater.)

The Southeast Michigan Council of Governments (SEMCOG) provided data on the employment population for each community. By dividing the average daily commercial/industrial consumption by the employment population, the average per employee commercial/industrial consumption could be calculated for each community.

Out of the 25 communities asked to participate, 11 communities provided information, eight communities had no information available, and six communities did not respond.

In addition to the 11 communities that provided information, the City of Detroit was added to the study using the commercial/industrial water use value of 50 gallons/employee/day from the GDRSS data (Figure 3).

The average commercial/industrial water consumption was calculated using two different methods. The first method gave each community equal weight. The second method weighted each community by the number of employees.

When each community receives equal weight, the commercial/industrial water usage value is 64.98 gallons/employee/day. The average commercial/industrial water usage for communities weighted by employment population is 49.72-gped.

Table 6 illustrates the information provided by the 11 communities and the City of Detroit, with each community receiving equal weight. Table 7 illustrates the information provided by the 11 communities and the City of Detroit, weighted by number of households.

Table 6. Commercial/Industrial Water Use

Community	Average Daily Commercial/Industrial Consumption (gallons/day)	Employment Population	Average Commercial/Industrial Consumption (gallons/employee/day)
Canton	979,800	21,091	46.46
Center Line	476,249	10,000	47.62
Clinton Twp.	198,867	33,690	5.90
Detroit	18,443,950	368,879	50.00
Farmington	173,058	8,155	21.22
Livonia	3,086,753	107,438	28.73
Madison Heights	2,789,304	27,939	99.84
Melvindale	980,025	3,618	270.87
Novi	985,397	28,822	34.19
Plymouth Twp.	1,008,590	23,726	42.51
Rochester Hills	1,319,805	28,343	46.57
Sterling Heights	5,851,785	68,200	85.80
Average Commercial/Industrial Consumption (gallons/employee/day)			64.98

Table 7. Commercial/Industrial Water Use (Weighted by Employment Population)

Community	Average Daily Commercial/Industrial Consumption (gallons/day)	Employment Population
Canton	979,800	21,091
Center Line	476,249	10,000
Clinton Township	198,867	33,690
Detroit	18,443,950	368,879
Farmington	173,058	8,155
Livonia	3,086,753	107,438
Madison Heights	2,789,304	27,939
Melvindale	980,025	3,618
Novi	985,397	28,822
Plymouth Township	1,008,590	23,726
Rochester Hills	1,319,805	28,343
Sterling Heights	5,851,785	68,200
Total	**36,293,582**	**729,901**
Average Commercial/Industrial Consumption (gallons/employee/day)		49.72

The commercial/industrial water use data was plotted in Figure 6. The data was studied for any geographical or population trends. It can be observed from the figure that no spatial trends could be discerned.

However, it can be noted in Figure 6 that there is a data outlier. The commercial/ industrial water usage value for the City of Melvindale is nearly three times higher than the next highest value.

When removing the City of Melvindale from the calculations, the average found in Table 8 changes from 64.98-gped to 46.26-gped. The average found in Table 7 changes from 49.72-gped to 48.62-gped.

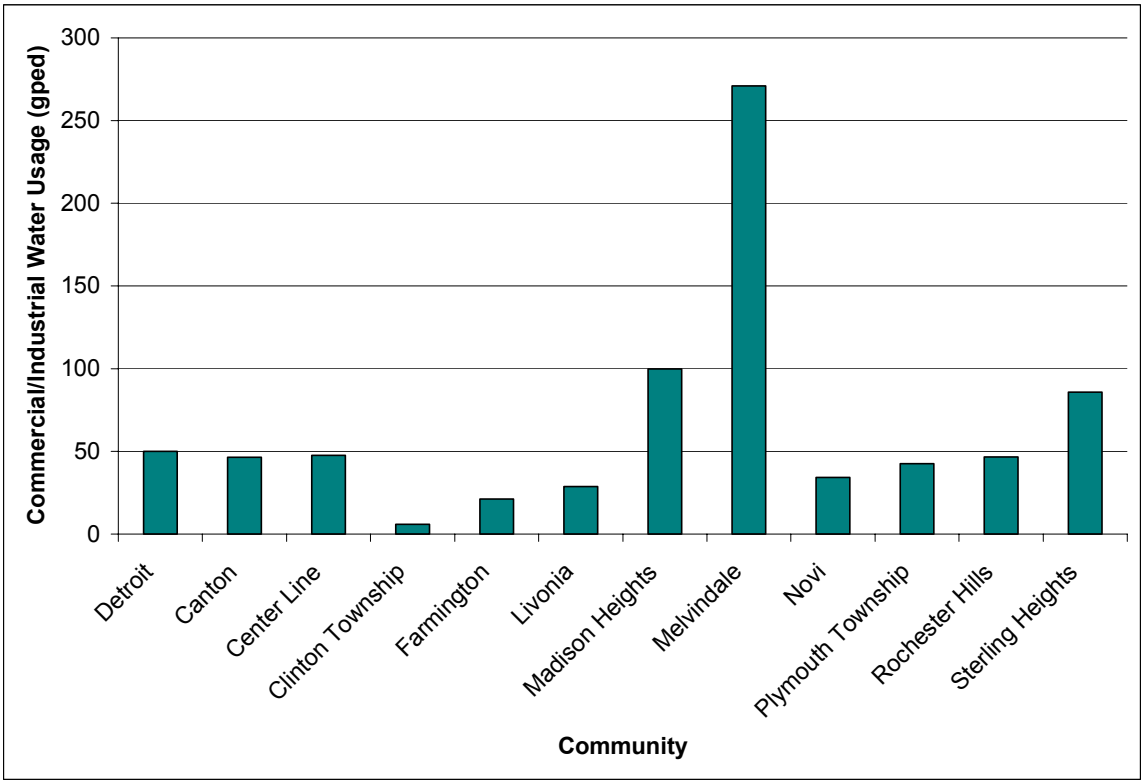

Figure 6. Commercial/Industrial Water Usage by Community

5. Recommendations

For residential water usage, the GDRSS existing data, the new residential water usage study data, and the geographical and historical study results appear to agree. The study of communities was a good balance between older industrial communities and newer rapidly-growing residential and business communities. The average water usage in that study was almost 72 gallons/person/day when each community was weighted equally, and nearly 76 gallons/person/day when each community weighted by number of households.

The GDRSS existing data concluded that the number to for residential water usage was 85-gpcd. However, it appears that in Figure 1, the average value in the first and second quarter is closer to the 75-80-gpcd range. This difference is based on ultimate incorporation into the DWSD note tables. The Wastewater Master Plan has used a value of 77-gpcd for all modeling. The use of 77-gpcd appears to be an accurate estimate in light of the results of these studies.

For commercial/industrial water usage, the new commercial/industrial data and the GDRSS existing data appears also appears to agree using both methods, provided the outlier is eliminated.

The community study, minus the City of Melvindale, resulted in an average commercial/industrial water usage value of 46.26-gped. When weighted for employment population, the average commercial/industrial water usage value was 48.62-gped. The GDRSS existing data concluded that commercial/industrial water usage was 50-gped. Therefore, the recommended value for commercial/industrial water usage is 50-gped.

It is important to note that both the residential water usage and the commercial/ industrial water usage values are for the entire DWSD system. This is because in both cases, no spatial trends could be discerned from the GDRSS data or the new data presented in this report.