To: Philadelphia Water Department (PWD)	From: Black & Veatch Management Consulting, LLC
Task Name: Cost of Service Study	Project Number: 195603.1000
Document: Max Day and Max Hour Factors	Date: April 17, 2018

White Paper: Max Day and Max Hour Factors

INTRODUCTION

The Philadelphia Water Department (PWD) conducts a comprehensive cost of service analysis to identify the cost of service responsibilities of each customer type and recover these costs in a fair and equitable manner. The cost of service analysis incorporates four tasks:

1) Determine the net revenue requirements by cost categories;
2) Assign revenue requirements to functional costs;
3) Allocate functional costs to cost components;
4) Distribute costs to customer types.

For task 3, Black & Veatch utilized the base-extra capacity method to allocate the functional costs to the cost components. Under base-extra capacity, the cost components consist of base costs (i.e., annual average usage), extra capacity (i.e., maximum day and maximum hour demands), customer costs, and public fire protection.

This white paper provides an overview of the approach utilized to review the estimated maximum day and maximum hour customer peaking factors reflected in the cost of service analysis.

PURPOSE

The determination of peaking factors is difficult without a formal demand study. However, a formal demand study requires daily and hourly customer metering data which is not readily available based on the daily operations of the utility due to the current customer metering technology. As such, the peaking factor assumptions from the Fiscal Year (FY) 2017 and FY 2018 rate proceeding were evaluated using the methodology outlined in Appendix A (Appendix A Methodology) of the American Water Works Association (AWWA) Manual M-1, Principles of Water Rates, Fees and Charges (AWWA M-1). The Appendix A Methodology develops estimates of peaking factors based on the system peak demand data, customer billing data, and adjustments for weekly usage and maximum hour to maximum day usage patterns by customer type.

Peaking Factor Methodology

The development of peaking factors by customer type is difficult to obtain due the lack of the necessary data for such purposes. Daily and hourly customer metered demand data is not available to perform a sample analysis to determine the peak flow requirements of each customer type. Therefore, the ratemaking industry often relies on the Appendix A Methodology, which utilizes system-wide demand data and customer billing data records that are commonly available to utilities. The Appendix A

Methodology also incorporates general knowledge of the consumption patterns throughout the week and day by customer type.

The Appendix A Methodology makes use of the following system-wide demand and customer billing data components:

- System Maximum Day Ratio: The highest ratio of system maximum day volume of water delivered to system average day volume of water delivered. Many utilities track the hourly and daily amount of water delivered within their systems via their SCADA system and therefore can identify the average day and maximum day volume of water delivered and system maximum day ratio over several historical years.
- System Maximum Month Ratio: The highest ratio of system maximum monthly average daily flow of water delivered to system average flow of water delivered during the year in which the highest System Maximum Day Ratio occurs.
- System Maximum Hour Ratio: The highest ratio of system maximum hour volume of water delivered to system average day volume of water delivered. In the same manner as the System Maximum Day Ratio, data from several historical years serves as the basis for the maximum hour volume of water delivered and system maximum hour ratio.
- Customer Maximum Month Demand Ratio: The maximum month demand ratio by customer type based on the billing data from the year which corresponds to the highest System Maximum Day Ratio. The customer maximum month demand is the highest value of the monthly billed volumes by customer type for the year in which the highest System Maximum Day Ratio occurs. The use of the maximum month metered demand for each of the various customer types tends to recognize the month in which each class experiences its maximum day demand. It may or may not coincide with the month in which the system coincidental maximum day demand occurs.

Combining these datasets, we determine the estimated non-coincident peaking factors for each customer type. The estimated non-coincident peaking factors represent that peaking factors for each customer type regardless of the system-wide peaking factor. In examining the customer type consumption, not all customer type consumption peaks coincide with the system-wide peak. Some customer types will place a larger demand on the system on a different day and time than the system-wide peaks. Since utilities design systems to handle system-wide coincidental peak demands, there are benefits associated with the efficiencies, economies of scale, and cost savings in basing the system design and associated capital costs and operating expenses on the coincidental demands. The Appendix A Methodology uses the non-coincidental peaking factors to distribute costs equitably amongst customer types because they represent the true demand of each customer type. The use of the non-coincidental demands proportionately spreads the cost savings to each class of customer base on each classes' peak demands.

In almost all situations, the sum of all the non-coincidental peaks should exceed the system-wide peak (or coincidental peak). The ratio of the non-coincidental to coincidental peak is known as the system diversity factor. Based on industry standards, the diversity factor is often in the range of 1.1 to 1.4. The

more homogeneous the customer type consumption patterns are to each other, then the closer the diversity factor is to 1.0.

To reflect the diversity of the customer demands within the system, the Appendix A Methodology utilizes the following adjustments factors by customer type:

- Weekly Usage Adjustment. While the System Maximum Day Ratio represents the overall maximum day demand for the system, the potential to understate the actual maximum daily demand from various customer classes exists due to the daily variations of consumption and/or the number of days of operations/water use for each customer type. The consumption for a particular customer type could occur over a shorter timeframe (days) within a given month thus resulting in a higher maximum day demand. Therefore, the Appendix A Methodology recommends a weekly usage adjustment to account for these daily variations in demand from the different customer types. For example, some business and/or industrial customers only operate 5 or 6 days per week.
- Maximum Hour to Maximum Day Factor Adjustment. Similarly, to the Weekly Usage Adjustment, the Appendix A Methodology recommends the incorporation of the Maximum Hour to Maximum Day factor adjustment. The consumption could occur over a shorter timeframe (hours) thus resulting in a higher maximum hour demand. Therefore, the Appendix A Methodology recommends an hourly based adjustment to account for these hourly variations in demand from the different customer types. These adjustments can recognize variations in the number of operating hours within a peak day consumption period for various customer types.

SYSTEM-WIDE DEMAND

In performing the cost of service analyses, Black & Veatch obtains annual water production records from PWD which identifies the system's average day, maximum day and maximum hour demands. For the cost of service analysis, since maximum day demand serves as the basis for the allocation of the system raw water pumping and treatment costs, Black & Veatch is using the system raw water pumping delivered to the treatment plants as the basis for the system maximum day demand. Similarly, since maximum hour demand is the basis of the distribution system treated water storage and transmission costs, we use the system treated water delivered data for the system maximum hour demand. Based on an assessment of historical data, the system-wide maximum day ratio is 1.40, maximum month ratio is 1.06, and the maximum hour ratio is 1.90. Tables 1 to 3 show the determination of the System Maximum Day, Maximum Month, and Maximum Hour Demand Ratios.

Table 1: System Maximum Day Ratio

	Avg Day (MGD) (1)	Max Day (MGD) (2)	Max Day Ratio (3) = (2)/(1)
Raw Water Pumping			
FY 2010	244.9	346.1	1.30
FY 2011	271.7	339.8	1.25
FY 2012	257.9	362.7	1.41
FY 2013	259.8	338.6	1.30
FY 2014	260.1	343.5	1.32
FY 2015	250.9	305.3	1.22
FY 2016	243.2	276.8	1.14
Maximum Demand Ratio (FY 2012)			1.41
Maximum Demand Ratio (Rounded)			1.40

Table 2: System Maximum Month Ratio

	Volume (MG) (1)	Average Rate (MGD) (2)
FY 2012 Total Delivered Volume (All Treatment Plants)		
July	6,627	214
August	7,888	254
September	7,443	248
October	7,472	241
November	7,232	241
December	7,488	242
January	7,266	234
February	6,995	250
March	7,226	233
April	6,959	232
May	7,279	235
June	7,466	249
FY 2012 Annual	87,341	239
Maximum Month		254
Maximum Month Ratio		1.06

Table 3: System Maximum Hour Ratio

	Avg Day (MGD) (1)	Max Rate (MGD) (2)	Max Hour Ratio (3) = (2)/(1)
Total Delivered Volume			
FY 2010	244.5	365.0	1.49
FY 2011	250.0	433.8	1.74
FY 2012	237.1	421.4	1.78
FY 2013	238.3	394.1	1.65
FY 2014	239.5	428.4	1.79
FY 2015	230.8	365.5	1.58
FY 2016	223.8	430.8	1.92
Maximum Demand Ratio (FY 2016)			1.92
Maximum Demand Ratio (Rounded)			1.90

CUSTOMER BILLING RECORDS

In performing the cost of service analysis, Black & Veatch receives customer billing data from the PWD, sorted by customer type, month and fiscal year. Table 4 Column 1 and 3 show the total annual and maximum monthly consumption by customer type for FY 2012 as extracted from the PWD customer billing dataset. Table 4, Column 2 represents the average daily consumption, and Column 4 represents the average daily consumption during the maximum month. Consumption is measured in hundred cubic feet (CCF) (1 CCF = 748 gallons).

Table 4: Customer Billing Data

FY 2012	Total Annual Consumption (CCF) (1)	Average Daily Consumption (CCF/Day) (2)=(1)/365	Maximum Monthly Consumption (CCF) (3)	Maximum Monthly Avg Daily Consumption (CCF/Day) (4)=(3)/30.4
Customer Type				
Senior Citizens	1,063,324	2,913	94,986	3,125
General Service-Residential	34,206,008	93,715	3,122,600	102,717
General Service-Commercial	14,558,020	39,885	1,585,203	52,145
General Service-Industrial	1,064,019	2,915	122,028	4,014
General Service-Public Utilities	68,496	188	7,164	236
P.H.A	1,768,436	4,845	183,267	6,029
Charities & Schools	2,156,938	5,909	214,195	7,046
Hospital/University	2,708,627	7,421	302,550	9,952
Hand Bill	5,711,342	15,648	558,542	18,373
Scheduled	115	0	14	0
	63,305,325	173,439	6,190,549	203,636

PEAKING FACTORS

To derive the non-coincidental maximum day peaking factors the first step is to divide the daily consumption for the maximum month by the annual average daily consumption as shown in Column 5 of Table 5. Column 5 represents the minimum, maximum day factor by customer type. The values in Column 5 are then multiplied by the system-wide maximum day to maximum month ratio to reflect fluctuations in demand. The system-wide maximum day to maximum month ratio of 1.32 is based on the maximum day to annual average day ratio of 1.40 from Table 1 divided by the maximum month to average annual month during fiscal year 2012 of 1.06 from Table 2. The incorporation of the system-wide maximum day to maximum month ratio provides a relationship between coincident peak and non-coincident peaks of each customer type. Similarly, Table 5, Column 7 reflects the incorporation of a weekly adjustment for demand fluctuations. For example, the General Service – Commercial assumes that majority of the water demand throughout the week occurs in 6 out of 7 days. Therefore, the weekly adjustment factor is 1.17. Column 8 shows the number of days of consumption for each customer type. The multiplication of Table 4, Columns 5, 6 and 7 derive the estimated maximum day peaking factors by customer type.

Table 4: Non-Coincident Maximum Day Peaking Factors

FY 2012	Avg Day in Max Month/ Annual Avg Day Ratio	System-wide Max Day to Max Month Ratio	Weekly Usage Adjustment	Concentrated Usage Days	Estimated Max Day Factor
	(5)=(4)/(2)	(6)	(7) = 7/(8)	(8)	(9)=(5)x(6)x(7)
Customer Type					
Senior Citizens	1.073	1.32	1.35	5.2	1.91
General Service-Residential	1.096	1.32	1.35	5.2	1.95
General Service-Commercial	1.307	1.32	1.17	6.0	2.02
General Service-Industrial	1.377	1.32	1.17	6.0	2.13
General Service-Public Utilities	1.256	1.32	1.00	7.0	1.66
P.H.A	1.244	1.32	1.26	5.6	2.07
Charities & Schools	1.192	1.32	1.17	6.0	1.84
Hospital/University	1.341	1.32	1.17	6.0	2.07
Hand Bill	1.174	1.32	1.17	6.0	1.81
Scheduled	1.462	1.32	1.17	6.0	2.26

Notes:

- Column number references are a continuation from Table 4. Columns (2) and (4) refer to columns presented in Table 4.

The estimated maximum day peaking factors by customer type are multiplied by an hourly adjustment as shown in Table 6, Column 10 to produce the non-coincidental maximum hour peaking factor. For example, the General Service – Commercial assumes that majority of the water demand throughout the day occurs in only 14.5 out of 24 hours. Therefore, the weekly adjustment factor is 1.66. Column 11 shows the number of hours of consumption for each customer type. The multiplication of Table 6, Columns 9 and 10 derive the estimated maximum hour peaking factors by customer type.

Table 6: Non-Coincident Max Hour Peaking Factors

FY 2012	Estimated Max Day Factor	Hourly Usage Adjustment	Concentrated Usage Hours	Estimated Max Hour Factor
	(9)=(5)x(6)x(7)	(10)=24/(11)	(11)	(12)=(9)x(10)
Customer Type				
Senior Citizens	1.91	1.66	14.5	3.17
General Service-Residential	1.95	1.66	14.5	3.24
General Service-Commercial	2.02	1.66	14.5	3.35
General Service-Industrial	2.13	1.33	18.0	2.83
General Service-Public Utilities	1.66	1.33	18.0	2.21
P.H.A	2.07	1.66	14.5	3.44
Charities & Schools	1.84	1.66	14.5	3.06
Hospital/University	2.07	1.66	14.5	3.44
Hand Bill	1.81	1.66	14.5	3.01
Scheduled	2.26	1.66	14.5	3.75

Notes:

- Column number references are a continuation from Tables 3 and 4. Column (9) from Table 5 is repeated for ease of reference.

COMPARISON TO RATE CASE

Table 7 shows a comparison of calculated estimated peaking factors to the existing peaking factor assumptions used in the previous rate proceeding.

Table 7: Comparison of Peaking Factors

Customer Type	Estimated Max Day Factor	B&V Max Day Factor	Difference	Estimated Max Hour Factor	B&V Max Hour Factor	Difference
Senior Citizens	1.91	2.00	-0.09	3.17	3.60	-0.43
General Service-Residential	1.95	2.00	-0.05	3.24	3.60	-0.36
General Service-Commercial	2.02	1.80	0.22	3.35	2.65	0.70
General Service-Industrial	2.13	1.60	0.53	2.83	2.00	0.83
General Service-Public Utilities	1.66	1.60	0.06	2.21	2.00	0.21
P.H.A	2.07	1.90	0.17	3.44	3.13	0.31
Charities & Schools	1.84	1.80	0.04	3.06	2.70	0.36
Hospital/University	2.07	1.80	0.27	3.44	2.35	1.09
Hand Bill	1.81	1.80	0.01	3.01	2.70	0.31
Scheduled	2.26	2.00	0.26	3.75	3.60	0.15

SUMMARY

Based on the results of the peaking factor analysis utilizing the Appendix A Methodology, Black & Veatch recommends PWD continue using the current peaking factors by customer type for the cost of service analysis. The results demonstrate that the current peaking factors are reasonable, although some variations do exist. Black & Veatch believes that these variations are due to the use of typical weekly and hourly usage factor adjustments as presented in the example calculations included AWWA M-1 Appendix A. These weekly and hourly assumptions do not address unique circumstances of each system. For example, PWD does not experience seasonal peaking to the extent of some utility systems since the urban customer base does not have summer usage peaks for irrigation usage. Since the system experiences a lower maximum day peaking factor, the system experiences more diversity in the hourly usage adjustments than those reflected in the AWWA M-1. As stated in AWWA M-1 “Care must be taken to recognize the usage characteristics of each utility’s customers; the assumptions in this appendix are for illustrative purposes only.”

Black & Veatch recommends that PWD consider performing a formal demand study once it implements an Advanced Metering Infrastructure system, which will provide PWD with the ability to obtain the daily and hourly data necessary to perform the study.