Forest Run Influent Flow Peaking Factor Analysis

Date:	September 26, 2024
Client:	MetCom
Project Name:	Forest Run Wastewater Pump Station Flow Monitoring and Inflow & Infiltration Characterization Study
Client Project No:	5171MS
Jacobs Project No.:	E4X57600
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Background

Forest Run Wastewater Pump Station (WWPS) is the largest pump station in St. Mary's Metropolitan Commission (MetCom) Sanitary District (SD) #8. The WWPS is within the commercial area of Lexington Park with partial flows from residential users. Forest Run WWPS also receives flow from the Piney Point force main, Great Mills force main, Westbury WWPS, and Patuxent West WWPS. There are 42 major pump stations in SD #8 and all flow collected in SD #8 is pumped or drains to the Marlay-Taylor Wastewater Water Reclamation Facility (MTWRF).

To characterize inflow and infiltration to Forest Run WWPS, Jacobs metered sewer flows at two (2) inflow points near the Forest Run WWPS Influent Pump Station (IPS). The six (6) month monitoring period started in September of 2023 and ended in April of 2024.

MetCom has tasked Jacobs to develop preliminary wet weather peaking for Forest Run using the first six (6) months of flow monitoring data and four (4) calendar years of historical SCADA data spanning from January 2020 through March 2024. The SCADA data provides instantaneous data on pump cycling and wet well level changes at the influent pump station of Forest Run WWPS. The flow meters provide 5-minute flow rate readings.

The contents of this Technical Memorandum (TM) summarize the analysis, results, and key findings of wet weather peaking factors developed for Forest Run from the flow meter and SCADA data.

Data Analysis

Per Maryland Department of Environment (MDE) *Design Guidelines for Wastewater Facilities*[1], peaking factors are to be calculated independently for each full consecutive calendar year examined. Then, the highest peaking factor on either an hourly, daily, or monthly basis is selected using the following equation:

$$Peaking\ Factor\ (PF) = \frac{Peak\ flow\ for\ the\ calendar\ year\ (hourly, daily, or\ monthly)}{Average\ daily\ flow\ for\ the\ calendar\ year}$$

Historical SCADA data was used to develop peaking factors for calendar years 2020 to 2023 and part of 2024. Hourly, daily, and monthly flowrates were calculated by finding a rolling average of the estimated inflow volume at each timestep of the SCADA data. Inflow volume was calculated based on pump runtimes, estimate pump capacities for one and two pump operation, and active storage volumes. Then, the maximum value, or peak flow, from each rolling average at each temporal resolution was taken and divided by the average daily flow for the respective calendar year. The average daily flow was calculated from the estimated total inflow for the calendar year.

In addition to the SCADA data, flow monitoring data was recorded from September 20, 2023, to March 19, 2024. The flow meter records a flow rate in millions of gallons per day (MGD) every five minutes. Comprehensive flow meter data presented in the I/I Characterization Report for Piney Point, California Run, and Forest Run prepared by Jacobs. Peaking factors were calculated from the meter data based on hourly, daily, and monthly rolling averages similarly to what was done for the SCADA data. Because monitoring began part way through September, a monthly flow rate was not calculated only for the month of September and excluded from the summary statistics presented in Table 1 and Table 2. Similarly, peak hourly and daily flowrates were found only for complete hours and days and incomplete hours and days were excluded from summary statistics.

Results

Peaking factors found for the calendar years 2020 to 2023 and respectively flow rates are presented below:

Table 1. Calendar Years 2020 to 2023 Peaking Factors

Data			Peaking Factors		
Year	Duration	Source	Hourly	Daily	Monthly
2020	Calendar Year	SCADA	7.4	3.3	1.1
2021	Calendar Year	SCADA	5.9	2.2	1.2
2022	Calendar Year	SCADA	4.0	2.4	1.1
2023	Calendar Year	SCADA	4.4	2.9	1.1
2023-2024	9/21/2023-3/19/2024	SCADA	4.1	2.7	1.1
2023-2024	9/21/2023-3/19/2024	Meter	3.7	2.7	1.1

Table 2. Calendar Years 2020 to 2023 Flow Rate Summary

Flow Rates, gpm (mgd)						
Year	2020	2021	2022	2023	2023*	Meter*
Average	599 (0.86)	564 (0.81)	554 (0.80)	524 (0.75)	561 (0.81)	644 (0.93)
Hourly						
Peak	4,428 (6.38)	3,335 (4.80)	2,202 (3.17)	2,296 (3.31)	2,296 (3.31)	2,408 (3.47)
Min	169 (0.24)	62 (0.09)	135 (0.19)	75 (0.11)	132 (0.19)	142 (0.20)
Daily						
Peak	1,983 (2.86)	1,262 (1.82)	1,312 (1.89)	1,501 (2.16)	1,501 (2.16)	1,720 (2.48)
Min	375 (0.54)	301 (0.43)	425 (0.61)	370 (0.53)	419 (0.60)	454 (0.65)
Monthly						
Peak	681 (0.98)	700 (1.01)	607 (0.87)	602 (0.87)	603 (0.87)	710 (1.02)
Min	538 (0.77)	495 (0.71)	520 (0.75)	487 (0.70)	495 (0.71)	549 (0.79)

*Flow rate calculated from 9/21/2023 to 3/19/2024

Wet Weather Events

For calendar year 2020, the peak hourly flow rate was 4,428 gpm (6.38 mgd) and occurred on August 4th. The peak daily flow rate was 1,983 gpm (2.86 mgd) and occurred on November 12th. On November 12th, the peak daily rainfall was 4.78 inches, which is associated to an unnamed storm event. The peak hourly rainfall for the year was 1.18 inches and occurred on August 28th, which equates to a 1-year, 1-hour storm and is associated to Tropical Storm Laura. The peak daily rainfall for the year was 5.29 inches and occurred on August 4th, which equates to a 10-year, 24-hour storm and is associated to Tropical Storm Isaias.

For calendar year 2021, the peak hourly flow rate was 3,335 gpm (4.80 mgd) and occurred on July 9th. The peak daily flow rate was 1,262 gpm (1.82 mgd) and occurred on July 9th. The peak hourly rainfall for the year was 1.23 inches and occurred on July 8th, which equates to a 1-year, 1-hour storm. The peak daily rainfall for the year was 3.72 inches and occurred on July 9th, which equates to a 2-year, 24-hour storm. Rainfall during July 8th and 9th is associated to Tropical Storm Elsa, which was in the vicinity during this time.

For calendar year 2022, the peak hourly flow rate was 2,202 gpm (3.17 mgd) and occurred on January 16th. The peak daily flow rate was 1,312 gpm (1.89 mgd) occurred on March 24th. On January 16th, the peak daily rainfall was 1.50 inches. On March 24th, the peak daily rainfall was 0.71 inches. The peak hourly rainfall for the year was 1.97 inches and occurred on July 26th, which equates to a 5-year, 1-hour storm. The peak daily rainfall for the year was 2.88 inches and occurred on December 15th, which equates to a 1-year, 24-hour storm.

For calendar year 2023, the peak hourly flow rate was 2,296 gpm (3.31 mgd) and occurred on December 10th. The peak daily flow rate was 1,501 gpm (2.16 mgd) and occurred on December 18th. On December 10th, the peak daily rainfall was 2.56 inches. On December 18th, the peak daily rainfall was 0.32 inches. The peak daily rainfall also occurred on December 11th, with a total accumulation of 2.98 inches. The peak hourly rainfall for the year was 1.24 inches and occurred on August 14th, which equates to a 1-year, 1-hour storm. The peak daily rainfall for the year was 3.68 inches and occurred on December 11th, which equates to a 2-year, 24-hour storm.

Figure 1 shows the NOAA Atlas 14 precipitation frequency curves. From this, the frequency of peak rainfall events can be determined. Table 3 summaries the frequency of each peak rainfall event from 2020 to 2023 calendar years.

Figure 1. NOAA Atlas 14 Partial Duration Series (PDS)-Based Precipitation Frequency Curves

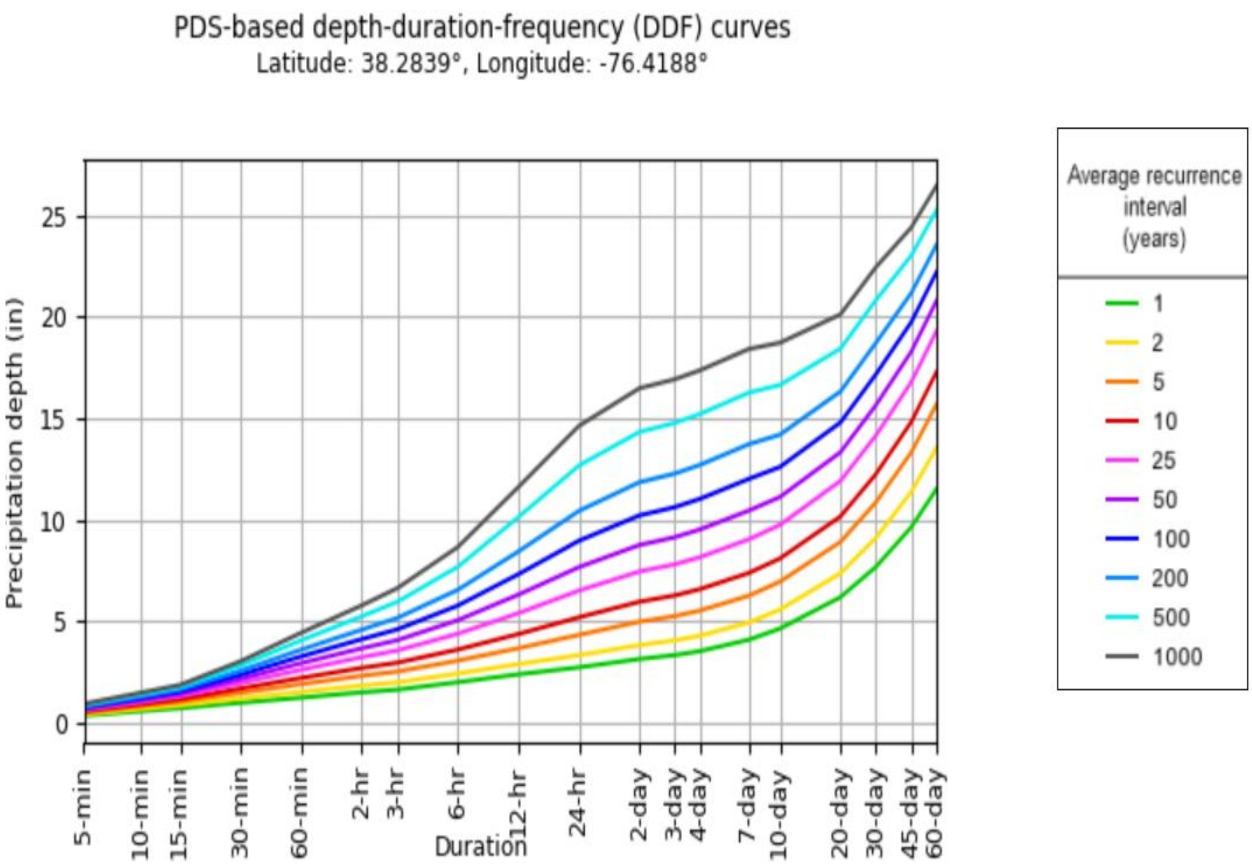


Table 3. NOAA Atlas 14 Peak Precipitation Frequency

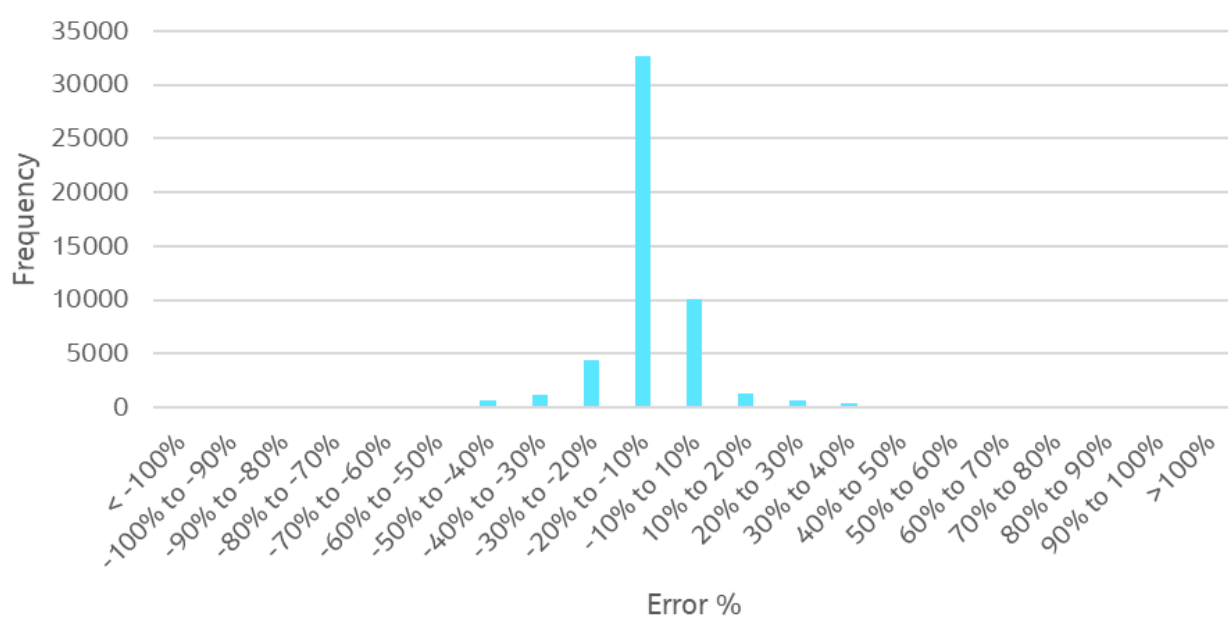
	2020	2021	2022	2023	2024*
Duration	(Inches / Frequency)				
1-hr	1.18 / **1-yr**	1.23 / **1-yr**	1.97 / **5-yr**	1.24 / **1-yr**	0.65 / **1-yr**
2-hr	1.77 / **2-yr**	2.11 / **5-yr**	2.19 / **5-yr**	1.29 / **1-yr**	1.11 / **1-yr**
3-hr	2.48 / **5-yr**	2.38 / **5-yr**	2.2 / **2-yr**	1.43 / **1-yr**	1.48 / **1-yr**
6-hr	3.57 / **10-yr**	2.91 / **5-yr**	2.2 / **2-yr**	2.27 / **2-yr**	2.07 / **1-yr**
12-hr	4.76 / **10-yr**	2.99 / **2-yr**	2.57 / **1-yr**	2.49 / **1-yr**	3.39 / **5-yr**
24-hr	5.29 / **10-yr**	3.72 / **2-yr**	2.88 / **1-yr**	3.68 / **2-yr**	3.51 / **2-yr**

*From 1/1/2024 to 3/19/2024

SCADA Validation

With having flow monitoring meter data, the SCADA dataset used to develop peaking factors can be validated against the meter data to assess accuracy. The overlapping period used for validation spans from September 21st, 2023, to March 19th, 2024. To measure accuracy, a histogram of the percent difference, or error, of the estimate flowrate from SCADA data to measured flowrate of the meter data was developed, which is shown in Figure 2.

Figure 2. SCADA Data Error Histogram



From **Figure 2**, the histogram shows that more than 63% of the data points have an error between -20% to -10% with the overall dataset overall skewing to negative errors, which suggests the SCADA data generally underestimates flowrates relative to the meter data. For the validation period, the meter measured a peak hourly flow of 2,408 gpm (3.47 mgd) on 12/18/2023 at 1:25 AM while the SCADA data estimated a peak hourly flow of 2,296 gpm (3.31 mgd) on 12/10/2023 at 11:45 PM. On 12/18/2023 at around 1:25AM, the SCADA data estimated the hourly flow rate to be 2,066 gpm (2.98 mgd).

Table 4 provides additional summary statistics of the flow rates and volumes found from the meter data and SCADA data for the monitoring period. **Figure 3** and **Figure 4** shows the overall trend of the meter and SCADA flow data for the validation period and the peak rainfall event, respectively.

Table 4. Flow Monitoring vs SCADA Data Estimates

Value	Meter	SCADA
	9/20/2023-3/19/2024	
Peak Hour Flow[1] (12/18/2023 1:25 AM) (gpm/mgd)	2,408 / 3.47	2,066 / 2.98
Average Flow (gpm/mgd)	644 / 0.93	561 / 0.81
Min Hour Flow (gpm/mgd)	142 / 0.20	132 / 0.19
Peak Daily Flow[2] (gpm/mgd)	1,720 / 2.48	1,501 / 2.16
Total Inflow Volume (Gallons)	167,865,780	146,312,525
October 2023 Total Volume (Gallons)	24,495,146	22,463,681
November 2023 Total Volume (Gallons)	23,890,406	21,368,093
December 2023 Total Volume (Gallons)	31,189,505	26,754,227

[1]Peak hour flow represents peak hourly flow observed by meter, which occurs on 12/18/2023, and the corresponding peak hourly flow from the SCADA data for the entire day

[2]The peak daily flow for both meter and SCADA data occurs on the same day on 12/18/2023

Figure 3. Meter and SCADA Flowrate Comparison Graph

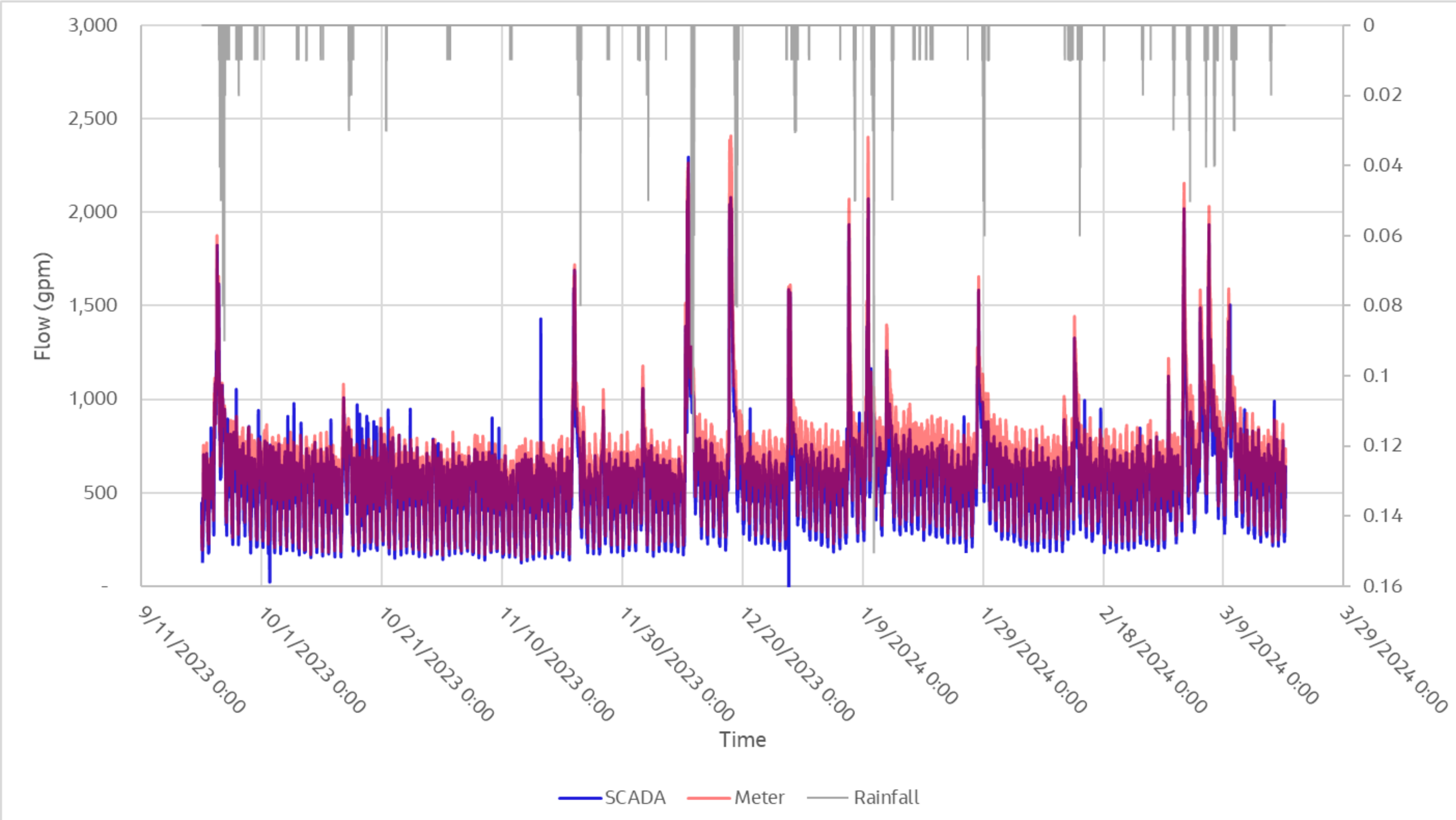
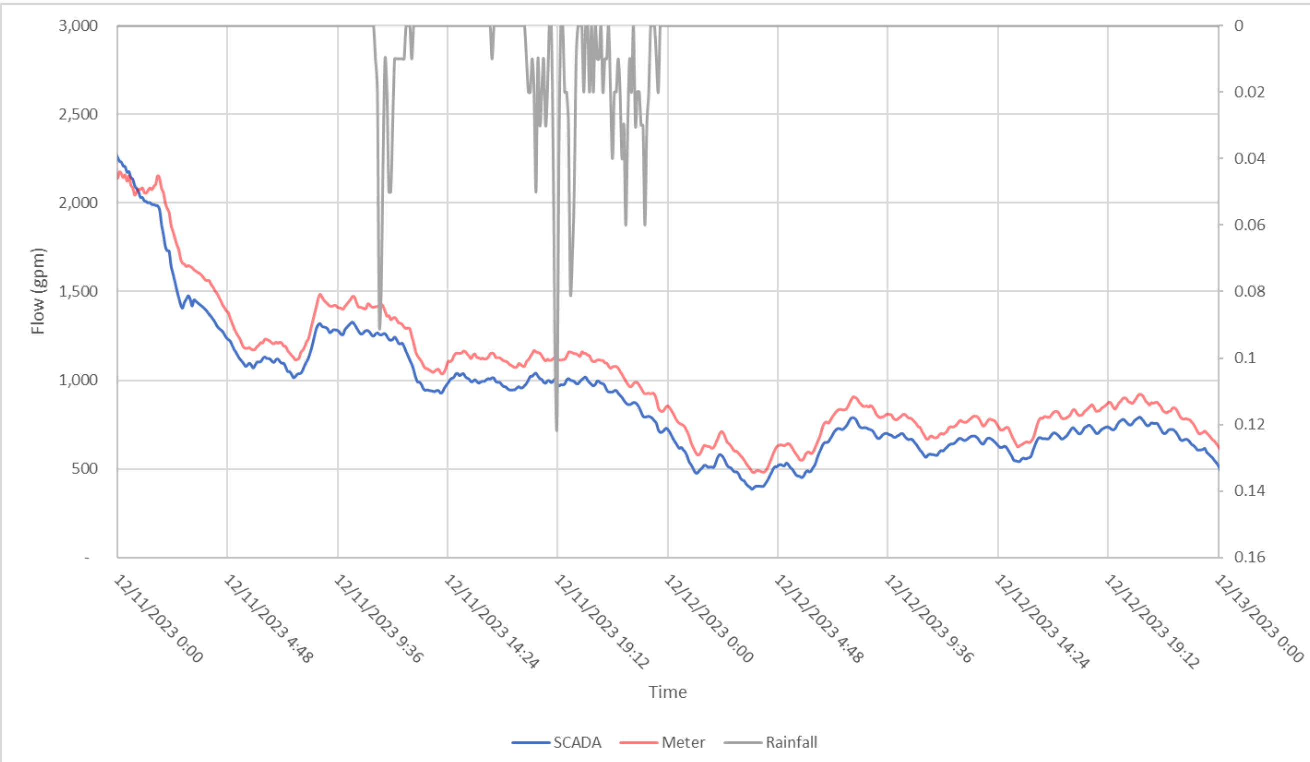


Figure 4. Flow Distribution on 12/18/2023 Rain Event



Overall, the SCADA data correlates well in response with the meter data for the validation period. As shown in Figure 2, metered flows are underestimated by SCADA with 32,644 of 51,934 (~63%) total data points falling within an error range of -10% to -20%. Overall, it is reasonable to use the previous years of SCADA data as representative for the purposes of developing peak factors and flow projections shown in Table 5. Because the SCADA is underreporting the metered flows, and since we have more confidence in the meter data, the meter results are being used as the starting point for the projected flow analysis (644 gpm for 2024 average daily flows). To calculate future peak wet weather flows, the peak factor calculated in the SCADA analysis is applied to the meter derived average daily flow. As shown in Table 1 above for the metering period, the estimated hourly peak factor of 4.1 for SCADA exceeds the estimated hourly peak factor of 3.7 for the metering data. While the estimated SCADA hourly peak factor exceeds the meter hourly peak factor, it is unknown how the meter may respond during higher intensity storms. We feel it is reasonable to apply the estimated SCADA hourly peak factor for 2020 to the metered average daily flows for the purpose of estimating peak flows to Forest Run.

Forest Run Upgrades

Firm capacity is defined as the maximum capacity of the pump station with the largest pump out of service. The basis of design for the firm capacity of the Forest Run WWPS has been evaluated on the following conditions:

1. **Minimum Peaking Factor:** Apply peaking factor of 4.25 to the projected average daily wastewater flows.

   As shown on **Table 5**, the projected average daily flow for 2024 based on the flow meter data is 0.93 mgd (644 gpm) which equates to a peak flow of 3.94 mgd (2,737 gpm). The projected average daily flow in 2045 is 1.41 mgd (976 gpm) which equates to a peak flow of 5.97 mgd (4,148 gpm).

2. **SCADA Peak Factor:** Apply highest observed peaking factor from past four (4) calendar years of SCADA data to the projected average daily wastewater flows.

   The highest peaking factor presented in **Table 1** from the SCADA data is 7.4. The projected average daily flow for 2045 is 1.41 mgd, as shown in **Table 5**, which equates to a peak flow of 10.43 mgd.

3. **Blended Peak Factor:** Apply a blended peaking factor to the projected average daily wastewater flows.

   To calculate future peak flows, we might suggest applying the maximum peak factor observed from the SCADA data to calendar year 2024 daily flows and applying the 4.25 minimum peak factor to future flows.

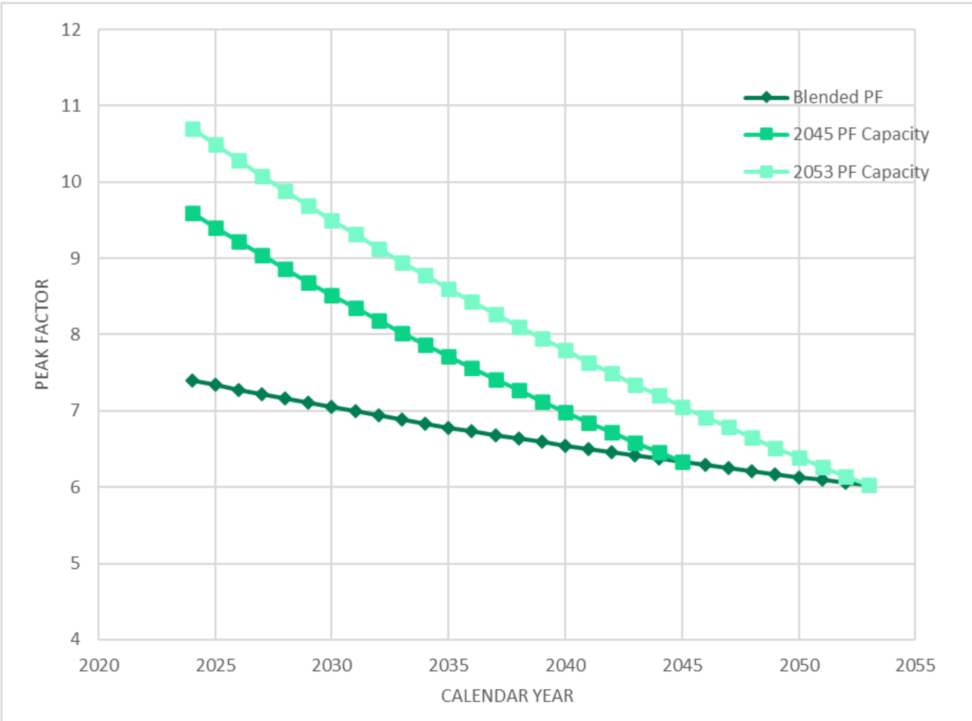
   As shown in **Table 5**, the average daily flow for 2024 is 0.93 mgd and the projected average daily flow is 1.41 mgd in the year 2045 based on an estimated flow increase of 2% per year. By applying a peak factor of 7.4 to calendar year 2024 flows of 0.93 mgd plus applying a peak factor of 4.25 to the future flows of 0.48 mgd, the total peak flow equals 8.89 mgd in the year 2045. This equates to a blended peak factor of 6.3 based on projected average daily flows. Peak flow at full buildout (1,625,400 gpd ADF) would occur in 2053 at a peak hourly rate of 9.92 mgd.

Table 5. Projected Flows and Peak Factors

Year	Average Daily Flow (GPM / MGD)		Peak Hourly Flow (GPM / MGD)		Blended PF	Pump Station PF Capacity (2045 Design)	Pump Station PF Capacity (2053 Design)
2024	644	0.93	4766	6.86	7.4	9.6	10.7
2025	657	0.95	4820	6.94	7.3	9.4	10.5
2026	670	0.96	4876	7.02	7.3	9.2	10.3
2027	683	0.98	4933	7.10	7.2	9.0	10.1
2028	697	1.00	4991	7.19	7.2	8.9	9.9
2029	711	1.02	5050	7.27	7.1	8.7	9.7
2030	725	1.04	5111	7.36	7.0	8.5	9.5
2031	740	1.07	5173	7.45	7.0	8.4	9.3
2032	755	1.09	5235	7.54	6.9	8.2	9.1
2033	770	1.11	5300	7.63	6.9	8.0	9.0
2034	785	1.13	5365	7.73	6.8	7.9	8.8
2035	801	1.15	5432	7.82	6.8	7.7	8.6
2036	817	1.18	5500	7.92	6.7	7.6	8.4
2037	833	1.20	5569	8.02	6.7	7.4	8.3
2038	850	1.22	5640	8.12	6.6	7.3	8.1
2039	867	1.25	5712	8.23	6.6	7.1	7.9
2040	884	1.27	5786	8.33	6.5	7.0	7.8
2041	902	1.30	5861	8.44	6.5	6.8	7.6
2042	920	1.32	5938	8.55	6.5	6.7	7.5
2043	938	1.35	6016	8.66	6.4	6.6	7.3
2044	957	1.38	6096	8.78	6.4	6.5	7.2
2045	976	1.41	6177	8.89	6.3	6.3	7.1
2046	996	1.43	6260	9.01	6.3	6.2	6.9
2047	1016	1.46	6345	9.14	6.2	6.1	6.8
2048	1036	1.49	6431	9.26	6.2	6.0	6.7
2049	1057	1.52	6519	9.39	6.2	5.8	6.5
2050	1078	1.55	6609	9.52	6.1	5.7	6.4
2051	1099	1.58	6700	9.65	6.1	5.6	6.3
2052	1121	1.61	6794	9.78	6.1	5.5	6.1
2053	1144	1.65	6889	9.92	6.0	5.4	6.0

In addition, and as shown by Figure 5, because the peak design capacity is calculated based on future conditions, the pump station peak factor capacity is greater than the calculated blended peak factor required for any given year, up to 2045. For the year 2025, the pump station would have a peak factor capacity of 9.4 versus 7.3 blended PF minimum.

Figure 5. Peak Factors Over Time



Conclusion

While applying the highest peak factor to average daily flows estimated at full build-out generates the highest theoretical peak flows, we recommend using a blended approach to determine the firm capacity requirements for the Forest Run WWPS. As discussed above, the firm capacity required would equal 8.89 mgd in 2045.

This approach provides a rational way to utilize the SCADA data for long term planning while providing spare capacity over an extended period. This approach provides a pump station peak factor capacity greater than 7.4 through the year 2037. Should average daily flows increase more than projected, or if future peak flows are not within the blended targets, corrective actions can be taken in advance of full build-out conditions. These activities include I/I reduction through SSES and rehabilitation, additional flow metering, modification to construction guidelines, construction inspection and testing, and connection restrictions if necessary.

The flow monitoring data does capture the peak storm event of the year, but it is not recommended to develop a basis of design around a small window of monitoring if other longer-term data, such as the SCADA data, can be supplemented and indicates peak factors higher than the meter data. **Similarly, it is noted that the 2045 firm capacity of 8.89 mgd is based around one data point and that flow projections may change if storm events similar in intensity and duration would have happened during the metering period.**

Since 2021, MetCom has completed several projects to help reduce inflow and infiltration, which directly impact peak factors. These projects include:

- Flood-proofed St. George's Island Lift Station electrical system - completed July 2021
- Replaced vented grinder pump lids with non-vented lids on 129 pumps in Piney Point which ultimately flow to this station - completed March 2022
- Fully replaced 14 grinder pump units (including vaults) in SD 5 identified as needing immediate repair - completed between July 2024 and September 2024
- Added a tri-plex grinder pump with SCADA at Camp Merryland on St. George's Island which flows into the St. George's Island Lift Station - completed March 2023
- Rehabilitated 67 manholes in Great Mills which feeds into (upstream) this station – completed August 2023
- Relining of 10,379 feet of sewer in Great Mills just upstream of this station – completed August 2023 (Phases 1& 2)
- Relining of an additional 1,778 feet of sewer in Piney Point just upstream of this station - completed September 2023 (Phase 3)
- Wet well rehabilitation (parged and epoxy coating) of the Sheehan Wastewater Lift station which eventually flows into this station - completed March 2024

While the I&I reduction due to these rehabilitation efforts has not been quantified, Table 1 shows that peak hourly and peak daily factors have decreased since 2020. This is likely due to the differences in storm intensity and duration (Table 3) and ongoing rehabilitation work.

Considering work completed and plans to complete SSES, additional flow monitoring could be performed to re-establish firm pump station capacity needs for Forest Run. The goal of the additional flow monitoring would be to capture storms of similar intensity and duration as the 2020 events (or greater), to see if there has been a reduction in peak factor due to rehabilitation. We recommend that SCADA and flow metering data continue to be reviewed on a scheduled basis for monitoring of peak and average flows.

Below ground flow equalization could be considered to limit the Forest Run sewer force main capacity to a set rate, while capturing the difference from peak weather flows in a below ground tank. The use of a equalization tank would reduce the need for downstream improvements to accommodate the peak hourly design flows.

Data from the top 5 peak flow events since 2020 was reviewed to estimate the volume of storage that would be required to avoid a sewer overflow would be required. As shown by Figure 6, three (3) storm events produced flow in excess of 4.75 mgd. Based on the duration of the events over 4.75 mgd, the 8/4/2020 event would require approximately 90,000 gallons and the 11/11/2020 event would require approximately 15,000 gallons. Table 6 lists the peak flows for the top 5 events and durations of flow above 4.75 mgd.

Figure 6. Top 5 Storm Events

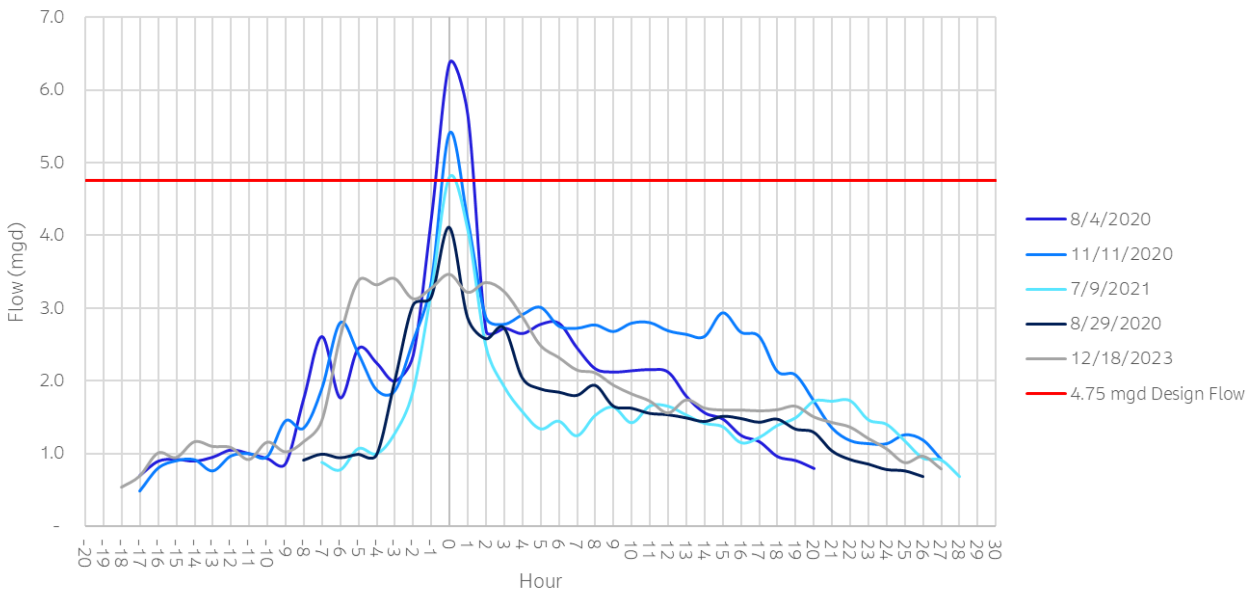


Table 6. Top 5 Storm Events Peak Flows

Event Date	8/4/2020	11/11/2020	7/9/2021	8/29/2020	12/18/2023
Peak Flowrate (mgd)	6.4	5.4	4.8	4.1	3.5
Duration Above 4.75 mgd (hrs.)	2.1	1.1	0.5	0	0

Recommendation

MetCom is in the design phase of upgrades to the Forest Run WWPS. The proposed design capacity of the upgraded pump station is 4.75 mgd. Considering rehabilitation work completed to date in upland areas and the data from the top 5 storm events, it is recommended to continue with the Forest Run WWPS upgrade, to bring the pump station capacity to 4.75 mgd as soon as possible, while planning for expandability of the pump station to meet future demands. Following startup of the upgraded pump station, additional flow monitoring could be performed to re-establish firm pump station capacity needs for Forest Run.

References

1. Maryland Department of the Environment, *Design Guidelines for Wastewater Facilities*, Engineering and Capital Projects Program, 2021. Available: https://mde.maryland.gov/programs/water/wwp/Documents/Wastewater%20Design%20Guidelines%20-%202021.pdf

2. National Oceanic and Atmospheric Administration's (NOAA) National Weather Service, "NOAA Atlas 14 Point Precipitation Frequency Estimates," *National Oceanic and Atmospheric Administration*, 2017. Available: https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html?bkmrk=md