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MEMORANDUM

TO: Gary J. Schneider – Director of Public Works for Town of Groton

FROM: Matthew M. Jermine, P.E. – Fuss & O'Neill

Cc: Virgil J. Lloyd, P.E. – Fuss & O'Neill

DATE: October 17, 2019

RE: Northeast Interceptor Capacity Analysis

Summary of Findings

A mixed use redevelopment project is proposed for the former Oral School property. Approval of an increase in sewer use for as a result of this redevelopment requires review of any impacts (existing and long term) to downstream sewer infrastructure.

The results of the pump station flow meter evaluation and sewer capacity analysis evaluated during the January 5th, 2018 storm with 2.21-inch of precipitation determined:

- Redevelopment of the **former Oral School** property:
  - Will add approximately 152,000 GPD average wastewater flow to the Northeast Interceptor.
  - Does not create any sewer capacity constraints in new pipe segments beyond what already occurs during existing peak flow conditions within the Northeast Interceptor.
  - Does not create a bottleneck in the existing sewer serving the parcel nor the sewer crossing below Interstate 95.
  - Will generally decrease the available capacity of the downstream pipes by 5% to 10%.

- For existing conditions, a bottleneck exists along the **Northeast Interceptor** from the Beebe Cove Pump Station force main discharge to the entrance of the Mumford Cove Pump Station due to extremely flat pipe slopes.
  - During heavy rainfall, the extremely high volume of infiltration and inflow surcharges the interceptor pipes and wastewater rises slightly up the manhole chimneys.
  - This condition is expected to become progressively more serious as the precipitation increases beyond the 2.21-inch storm event that was modeled through the Northeast Interceptor.

- The **Mumford Cove Pump Station** for existing conditions
  - The base sanitary sewage generated by actual sewer customers was only 25% of the total flow.
  - The other 75% of the total flow was from infiltration and inflow entering the tributary area draining into the Northeast Interceptor.
  - Even during the dry summer months, approximately 300,000 gallons per day of groundwater leakage (or 48% of the total flow) enter this part of the sewer system.

- The inflow rate, inflow volume, and total infiltration volume were the highest of the four pump station tributary areas.

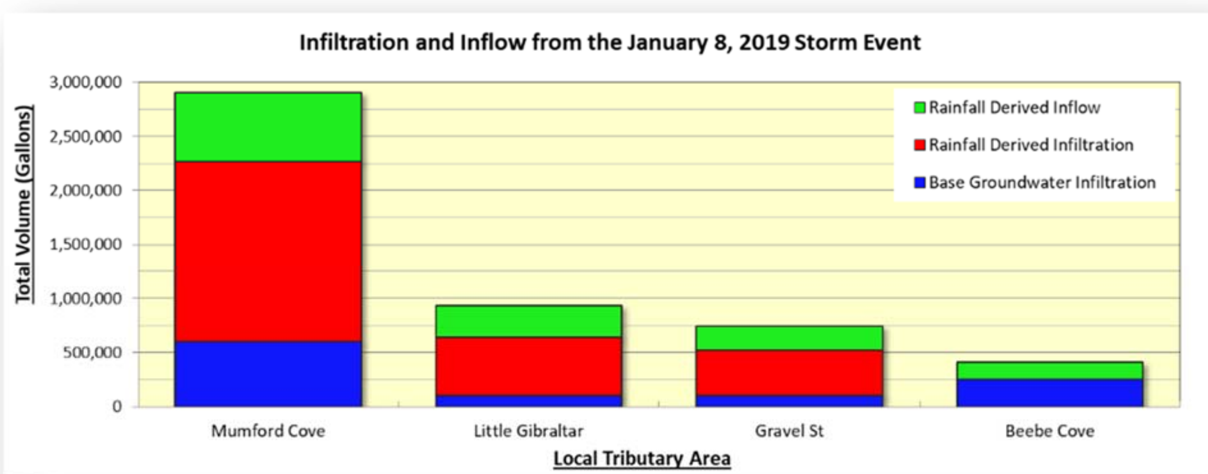
- For existing conditions, the **Little Gibraltar Pump Station** experiences:
  - The inflow rate, inflow volume, and total infiltration volume were the second highest of the four pump station tributary areas.
  - The inflow and infiltration from this tributary area has a significantly higher impact to the Northeast Interceptor because this extraneous flow must pass through three of the four pump stations before entering Groton's Water Pollution Control Facility. The long travel distance of the wastewater not only causes hydraulic capacity losses, but also significant increases mechanical equipment wear and unnecessary energy consumption at three pump stations.

- For existing conditions, the **Beebe Cove Pump Station** experiences:
  - 54% of the total generated flow from the sewer customers, with the remaining 46% of total flow from I/I sources.
  - This pump station has the highest percentage of sewer customer generated flow, which at 54% during wet weather conditions, is poor in comparison to other communities.

- For existing conditions, the **Gravel Street Pump Station** experiences:
  - 22% of the total flow is generated from the customer base, with the balance of flow from I/I sources.

- This evaluation is based upon analysis of high wet weather flows experienced over the past two years (April 2018 to August 2019). Should an extreme wet weather even be experienced in the future which exceeds the storms noted of the period of record, then the **capacity limits of the pump stations** may be challenged.

- At the Town's **Wastewater Treatment Facility**, there is reportedly an abundant amount of available hydraulic and treatment capacity.



Data Analysis and Modeling Results

The tabulated results of the analysis are provided at the end of the report text recorded as part of an in-set table on the pump station flow data graphs (attached).

The hydraulic model of the Groton sewer system was prepared based on the January 5th, 2019 storm event with 2.21 inches of total precipitation. This was the highest intensity storm event of the four that were analyzed in the preliminary calculations. Based on the hydraulic model, the sewer infrastructure between Beebe Cove Pump Station and Mumford Cove Pump Station appears to be approaching the limits of their max pumping capacity under existing conditions. Many sections of this run have a pipe capacity use exceeding 90% for the 2.21-inch storm event, as show in *Figure 1*.

The hydraulic model showed that the proposed flows from the Oral School redevelopment project would cause a 5% to 10% increase in pipe capacity use, as shown in *Figure 1*. There are no new capacity limitations issues that result from the proposed redevelopment flow.

Data Analysis Calculations

Flow data was taken from each of the four main pump stations along the Northeast Sewer Interceptor: Gravel Street, Little Gibraltar, Beebe Cove, and Mumford Cove. For each pump station, the flow from the upstream pump station meter was subtracted out (with the exception of Gravel Street which is the most upstream of the four pump stations evaluated). The resulting flow represents what is collected from the tributary area surrounding the pump station, whereas the flow readings collected directly from the meter represent the cumulative flow of the tributary area <u>and</u> the cumulative upstream sewersheds. The calculated regional flows were then graphed over time in conjunction with daily precipitation. These graphs are attached and were used to determine base infiltration, base sanitary flow, and wet weather infiltration/inflow.

Base infiltration comes from groundwater seeping into the sewer and is unrelated to rainfall. To determine the base infiltration rate for each pump station a period of dry weather was identified. The period used was July through August of 2018 because this period provided the lowest and steadiest flow patterns. A line was then drawn along the lowest points of the "Flow Volume" line, denoting the base infiltration. The area under this line is highlighted in blue on each of the graphs, where applicable. The lowest points of the "Flow Volume" line for the Little Gibraltar Pump Station reached no flow conditions, thus indicating that there is no base infiltration in the sewers discharging to this pump station.

The **base sanitary flow** was determined using the same dry weather period as the base infiltration, because wet weather has too many contributing factors to flow. The base sanitary flow was determined by drawing a straight line through the approximate average of the "Average Daily Rate" and subtracting the base infiltration from this value. The area between the base infiltration and this new line representing base sanitary flow is highlighted in yellow on each of the graphs.

Wet weather infiltration occurs when periods of frequent and/or high intensity storms raise the groundwater table over an extended period of time, allowing groundwater to seep into the sewer at higher elevations than base infiltration. To determine the wet weather infiltration rate for each pump station, a period of wet weather was identified for evaluation. The periods used varied between pump stations because each storm event effects each pump station differently. Periods where wet weather infiltration effects the flow will appear elevated. Not all of the wet weather conditions were highlighted, but the wet weather infiltration was highlighted on the graphs in violet related to the four storm events that were evaluated.

Once these three conditions were determined, four significant storm events were identified for evaluation: January 5, 2019, January 24, 2019, May 12, 2019, and June 25, 2019. These storm events produced 2.21 inches, 1.23 inches, 1.27 inches, and 1.92 inches of total precipitation, respectively. Peaks in the flow graph that occur above the base infiltration, base sanitary flow, and wet weather infiltration, and correspond with storm events, makeup storm related inflow and infiltration.

The **wet weather inflow** is assumed to occur for 24 hours from the start of the storm since inflow occurs as a result of stormwater runoff entering the sewers. **The total volume of inflow** is determined in millions of gallons (MG) by calculating the area under the peak (and above the base infiltration, base sanitary flow, and wet weather infiltration) for that 24 hour period. This area under the curve is highlighted in red on each of the graphs. The remaining area under the peak is assumed to be the total volume of storm related infiltration.

As previously mentioned, infiltration is caused by groundwater entering the sewers. **Infiltration related to storm events** is caused by the increase in the elevation of the groundwater table as a result of precipitation entering the ground. Because it takes time for the stormwater to make its way to the groundwater table, infiltration tends to have a delayed effect, which is why it is assumed that the infiltration doesn't start until after the 24 hour inflow period. The remaining area under the curve is calculated as the total storm event infiltration volume in millions of gallons (MG) and is highlighted in orange on each of the graphs. The **peak infiltration volume** is assumed to be the area under the peak for the 24 hours proceeding the inflow period, as this is when the infiltration will occur at its highest rate. After the storm has ceased, the groundwater table slowly stabilizes.

The **peak inflow rate** is determined by identifying the highest point of the "Flow Volume" on the graph associated with the storm related peak. While the flow meters collected data in millions of gallons per day (MGD), the peak inflow was converted to cubic feet per minute (CFM). These high points are labeled on each of the graphs.

Methods Used

Fuss & O'Neill modeled the Town of Groton's sewer collection system in Hydra sanitary sewer modeling software. The software calculates the resulting hydraulics within the collection system and provides tools for visualizing capacity impacts from wastewater flows, infiltration, and future development under various flow conditions.

The Town's sewer collection system, wastewater flows, infiltration, and inflow have been inputted and calibrated in the Hydra software. The model was run to quantify the hydraulic capacity impacts to the downstream sewer piping and pump station(s) based on 24-hour diurnal flow patterns recorded at each pump station.

The hydraulic analysis model was then updated and run again to include future proposed wastewater flow from redevelopment of the former Oral School. The proposed residential use for the redevelopment includes approximately 755 two-bedroom units with a flow of 50 gallons per bedroom, resulting in a total proposed flow of 75,500 gallons per day. The proposed total flow for the commercial uses is approximately 76,000 gallons per day. The results of the sewer model were exported into a GIS geodatabase for further analysis.

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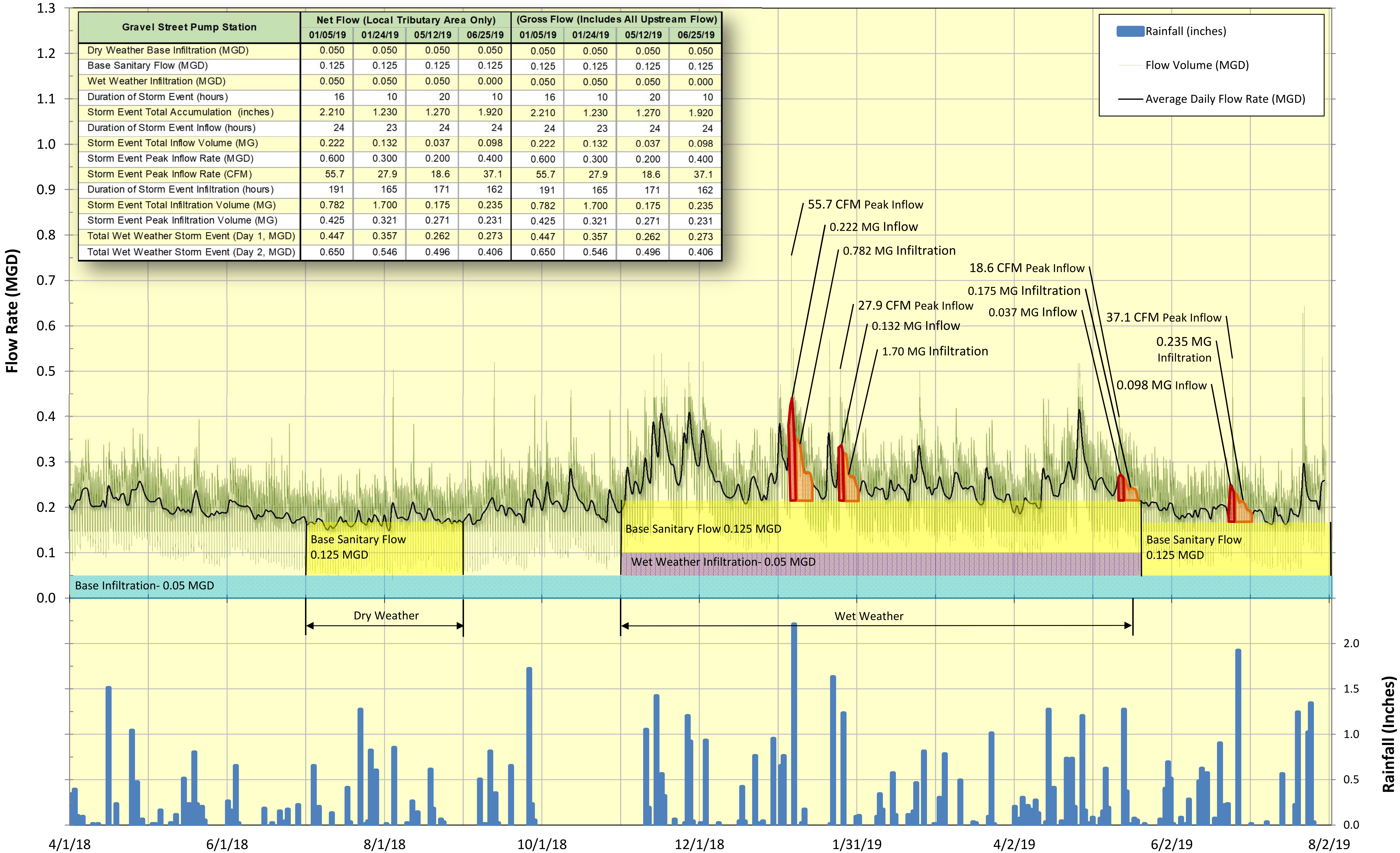
Gravel Street Pump Station Net Wastewater Flow

Gravel Street Pump Station	Net Flow (Local Tributary Area Only)				(Gross Flow (Includes All Upstream Flow)			
	01/05/19	01/24/19	05/12/19	06/25/19	01/05/19	01/24/19	05/12/19	06/25/19
Dry Weather Base Infiltration (MGD)	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Base Sanitary Flow (MGD)	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Wet Weather Infiltration (MGD)	0.050	0.050	0.050	0.000	0.050	0.050	0.050	0.000
Duration of Storm Event (hours)	16	10	20	10	16	10	20	10
Storm Event Total Accumulation (inches)	2.210	1.230	1.270	1.920	2.210	1.230	1.270	1.920
Duration of Storm Event Inflow (hours)	24	23	24	24	24	23	24	24
Storm Event Total Inflow Volume (MG)	0.222	0.132	0.037	0.098	0.222	0.132	0.037	0.098
Storm Event Peak Inflow Rate (MGD)	0.600	0.300	0.200	0.400	0.600	0.300	0.200	0.400
Storm Event Peak Inflow Rate (CFM)	55.7	27.9	18.6	37.1	55.7	27.9	18.6	37.1
Duration of Storm Event Infiltration (hours)	191	165	171	162	191	165	171	162
Storm Event Total Infiltration Volume (MG)	0.782	1.700	0.175	0.235	0.782	1.700	0.175	0.235
Storm Event Peak Infiltration Volume (MG)	0.425	0.321	0.271	0.231	0.425	0.321	0.271	0.231
Total Wet Weather Storm Event (Day 1, MGD)	0.447	0.357	0.262	0.273	0.447	0.357	0.262	0.273
Total Wet Weather Storm Event (Day 2, MGD)	0.650	0.546	0.496	0.406	0.650	0.546	0.496	0.406



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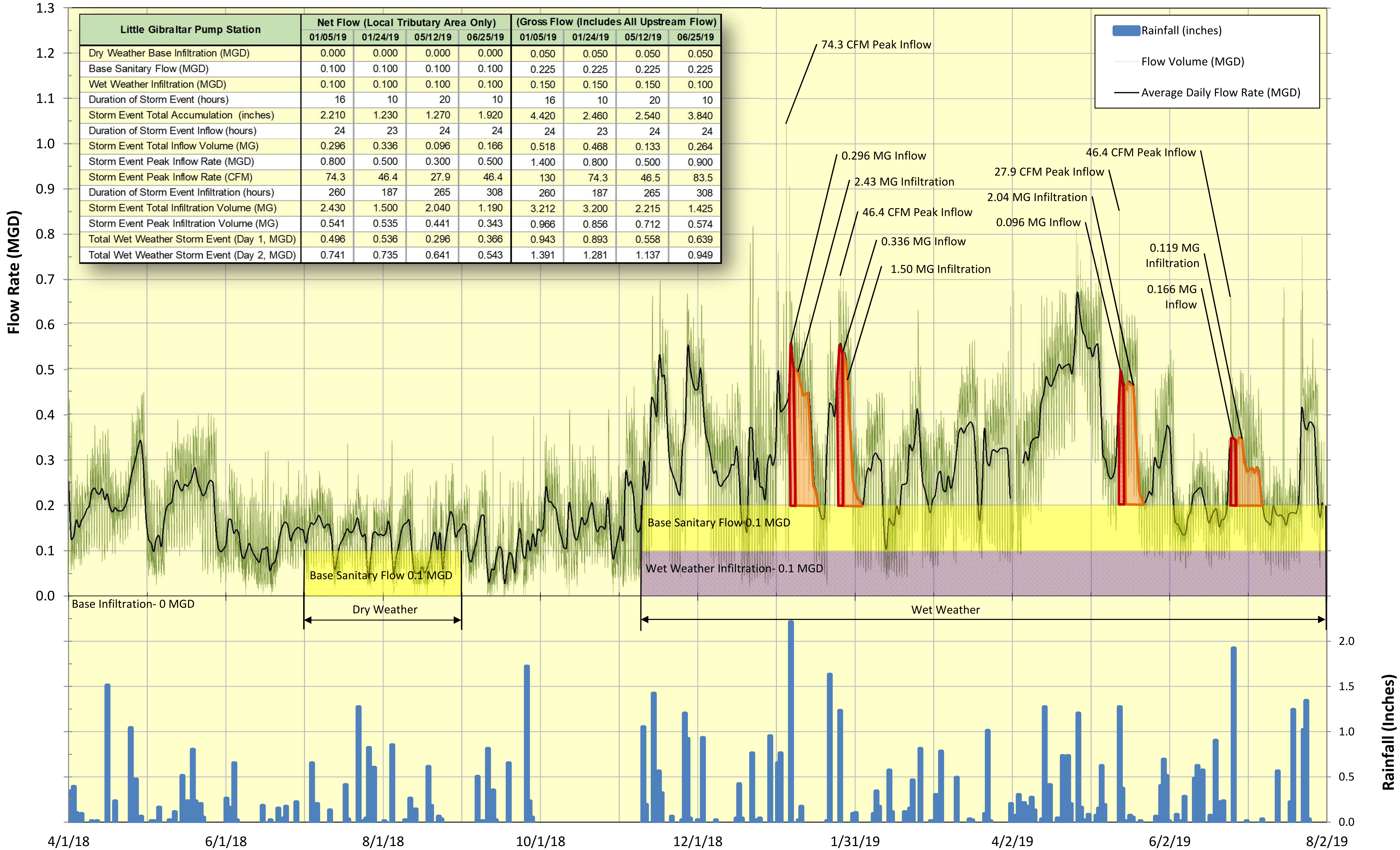
Little Gibraltar Pump Station Net Wastewater Flow



Little Gibraltar Pump Station	Net Flow (Local Tributary Area Only)				(Gross Flow (Includes All Upstream Flow)			
	01/05/19	01/24/19	05/12/19	06/25/19	01/05/19	01/24/19	05/12/19	06/25/19
Dry Weather Base Infiltration (MGD)	0.000	0.000	0.000	0.000	0.050	0.050	0.050	0.050
Base Sanitary Flow (MGD)	0.100	0.100	0.100	0.100	0.225	0.225	0.225	0.225
Wet Weather Infiltration (MGD)	0.100	0.100	0.100	0.100	0.150	0.150	0.150	0.100
Duration of Storm Event (hours)	16	10	20	10	16	10	20	10
Storm Event Total Accumulation (inches)	2.210	1.230	1.270	1.920	4.420	2.460	2.540	3.840
Duration of Storm Event Inflow (hours)	24	23	24	24	24	23	24	24
Storm Event Total Inflow Volume (MG)	0.296	0.336	0.096	0.166	0.518	0.468	0.133	0.264
Storm Event Peak Inflow Rate (MGD)	0.800	0.500	0.300	0.500	1.400	0.800	0.500	0.900
Storm Event Peak Inflow Rate (CFM)	74.3	46.4	27.9	46.4	130	74.3	46.5	83.5
Duration of Storm Event Infiltration (hours)	260	187	265	308	260	187	265	308
Storm Event Total Infiltration Volume (MG)	2.430	1.500	2.040	1.190	3.212	3.200	2.215	1.425
Storm Event Peak Infiltration Volume (MG)	0.541	0.535	0.441	0.343	0.966	0.856	0.712	0.574
Total Wet Weather Storm Event (Day 1, MGD)	0.496	0.536	0.296	0.366	0.943	0.893	0.558	0.639
Total Wet Weather Storm Event (Day 2, MGD)	0.741	0.735	0.641	0.543	1.391	1.281	1.137	0.949

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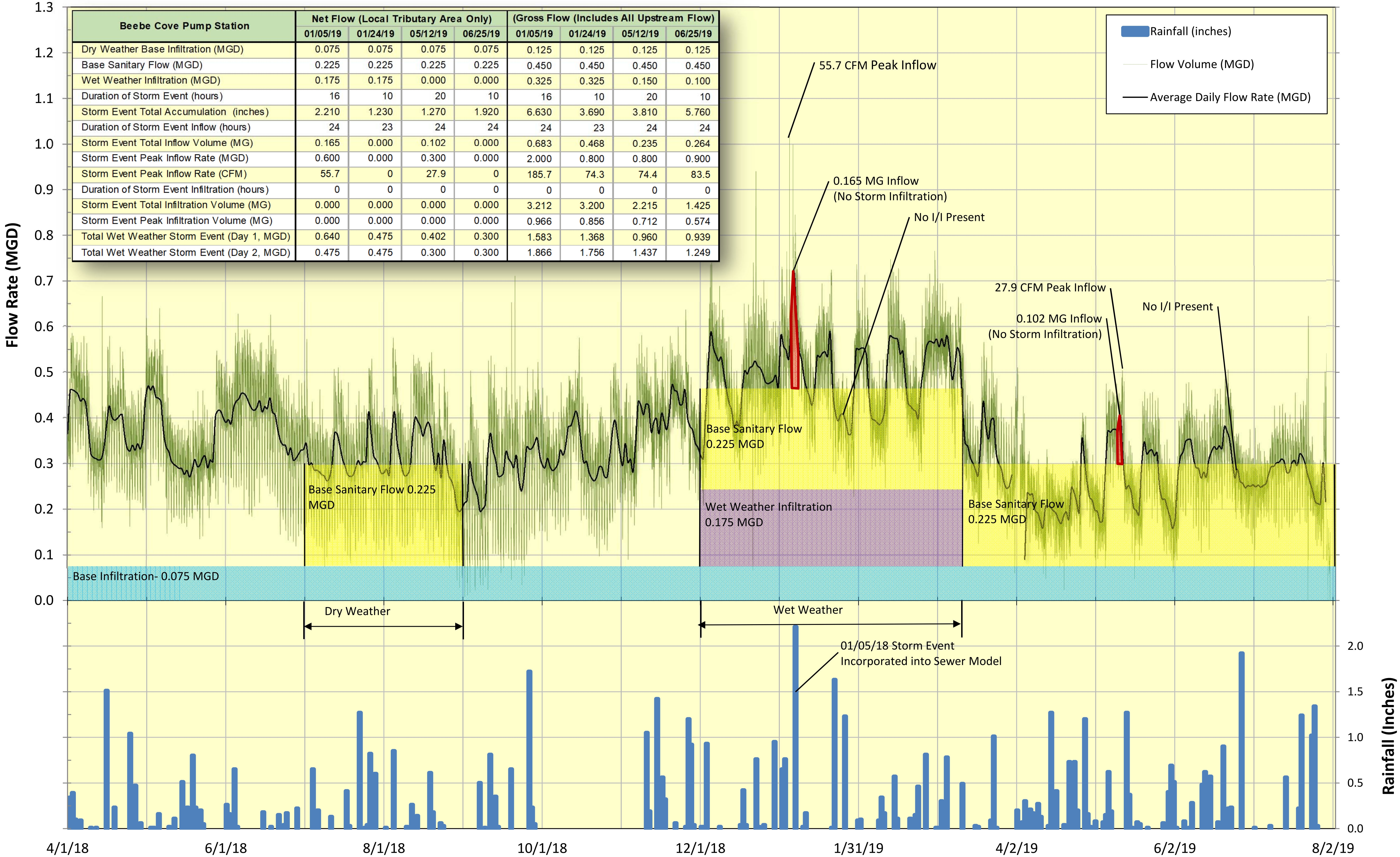
Beebe Cove Pump Station Net Wastewater Flow

Beebe Cove Pump Station	Net Flow (Local Tributary Area Only)				(Gross Flow (Includes All Upstream Flow)			
	01/05/19	01/24/19	05/12/19	06/25/19	01/05/19	01/24/19	05/12/19	06/25/19
Dry Weather Base Infiltration (MGD)	0.075	0.075	0.075	0.075	0.125	0.125	0.125	0.125
Base Sanitary Flow (MGD)	0.225	0.225	0.225	0.225	0.450	0.450	0.450	0.450
Wet Weather Infiltration (MGD)	0.175	0.175	0.000	0.000	0.325	0.325	0.150	0.100
Duration of Storm Event (hours)	16	10	20	10	16	10	20	10
Storm Event Total Accumulation (inches)	2.210	1.230	1.270	1.920	6.630	3.690	3.810	5.760
Duration of Storm Event Inflow (hours)	24	23	24	24	24	23	24	24
Storm Event Total Inflow Volume (MG)	0.165	0.000	0.102	0.000	0.683	0.468	0.235	0.264
Storm Event Peak Inflow Rate (MGD)	0.600	0.000	0.300	0.000	2.000	0.800	0.800	0.900
Storm Event Peak Inflow Rate (CFM)	55.7	0	27.9	0	185.7	74.3	74.4	83.5
Duration of Storm Event Infiltration (hours)	0	0	0	0	0	0	0	0
Storm Event Total Infiltration Volume (MG)	0.000	0.000	0.000	0.000	3.212	3.200	2.215	1.425
Storm Event Peak Infiltration Volume (MG)	0.000	0.000	0.000	0.000	0.966	0.856	0.712	0.574
Total Wet Weather Storm Event (Day 1, MGD)	0.640	0.475	0.402	0.300	1.583	1.368	0.960	0.939
Total Wet Weather Storm Event (Day 2, MGD)	0.475	0.475	0.300	0.300	1.866	1.756	1.437	1.249



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Mumford Cove Pump Station Net Wastewater Flow

Mumford Cove Pump Station	Net Flow (Local Tributary Area Only)				(Gross Flow (Includes All Upstream Flow)			
	01/05/19	01/24/19	05/12/19	06/25/19	01/05/19	01/24/19	05/12/19	06/25/19
Dry Weather Base Infiltration (MGD)	0.300	0.300	0.300	0.300	0.425	0.425	0.425	0.425
Base Sanitary Flow (MGD)	0.325	0.325	0.325	0.325	0.775	0.775	0.775	0.775
Wet Weather Infiltration (MGD)	0.300	0.300	0.200	0.100	0.625	0.625	0.350	0.200
Duration of Storm Event (hours)	16	10	20	10	16	10	20	10
Storm Event Total Accumulation (inches)	2.210	1.230	1.270	1.920	8.840	4.920	5.080	7.680
Duration of Storm Event Inflow (hours)	24	23	24	24	24	23	24	24
Storm Event Total Inflow Volume (MG)	0.630	0.373	0.132	0.192	1.313	0.841	0.367	0.456
Storm Event Peak Inflow Rate (MGD)	1.500	0.800	0.500	0.700	3.500	1.600	1.300	1.600
Storm Event Peak Inflow Rate (CFM)	139	74.3	46.4	65	324.7	148.6	120.8	148.5
Duration of Storm Event Infiltration (hours)	314	190	218	162	314	190	218	162
Storm Event Total Infiltration Volume (MG)	3.510	1.580	0.820	0.650	6.722	4.780	3.035	2.075
Storm Event Peak Infiltration Volume (MG)	1.670	1.250	1.000	0.850	2.636	2.106	1.712	1.424
Total Wet Weather Storm Event (Day 1, MGD)	1.555	1.298	0.957	0.917	3.138	2.666	1.917	1.856
Total Wet Weather Storm Event (Day 2, MGD)	2.595	2.175	1.825	1.575	4.461	3.931	3.262	2.824

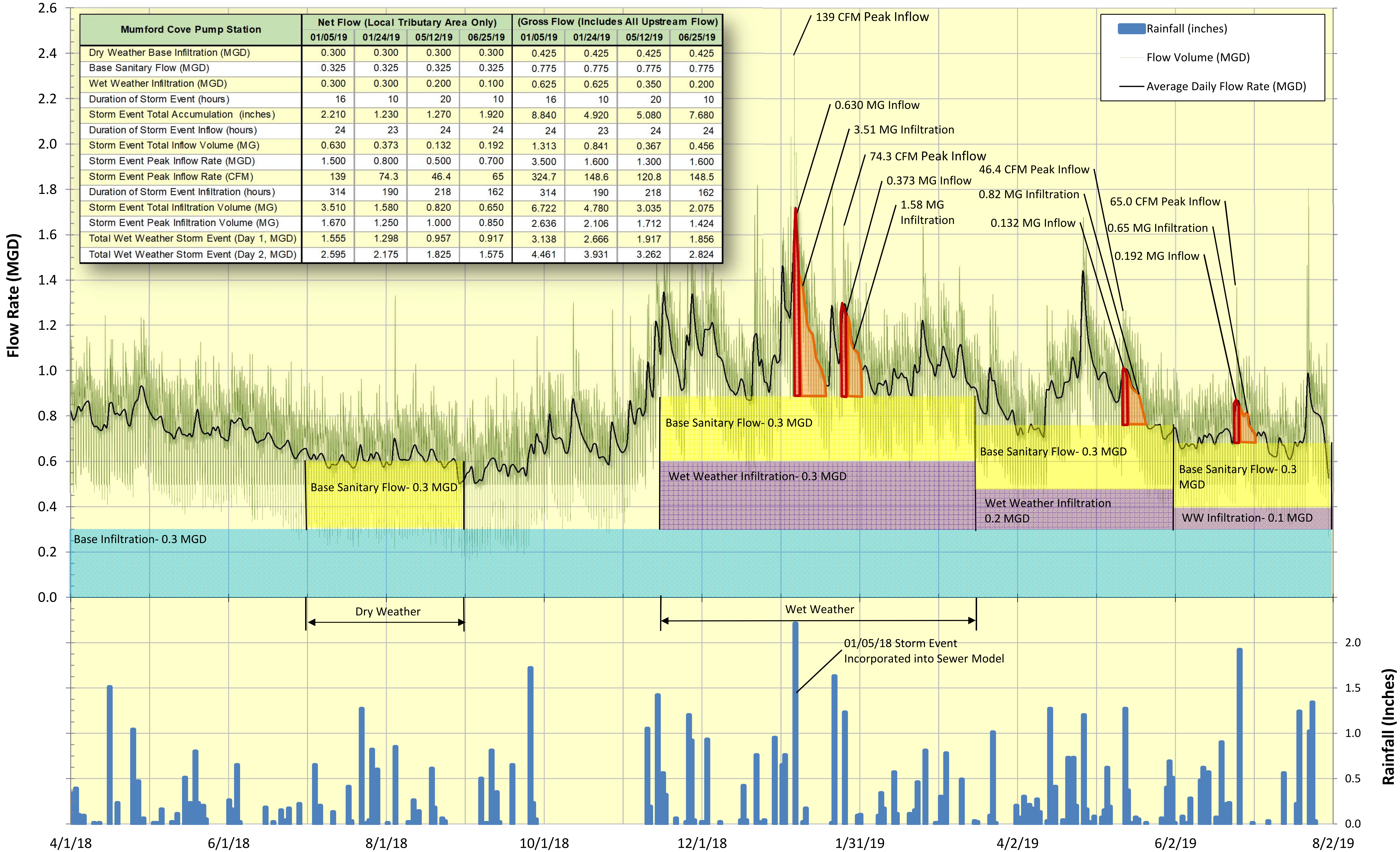

FIGURE 1

October 17, 2019

Pipe Capacity Used

- Less than 50%
- 50% to 75%
- 75% to 90%
- More than 90%
- Pump Stations
- Collector Sewers
- Manholes

The wastewater flows routed through the sewer system hydraulic model based on the pump station flow meter data from the last 3 years broken down into:

(1) Existing base sanitary wastewater flows (2) 2-Year 24-Hour rainfall induced inflow (3) Spring wet weather base infiltration.

The future development of the former Oral School site was apportioned 76,000 GPD of commercial and 75,500 GPD of residential sewer flow.

The wastewater flows were modeled through the system with 24-hour diurnal flow patterns matching the actual hourly flow meter data.

600 0 600 1,200 1,800

Feet

Pipe Capacity Analysis of the Northeast Interceptor

Town of Groton

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