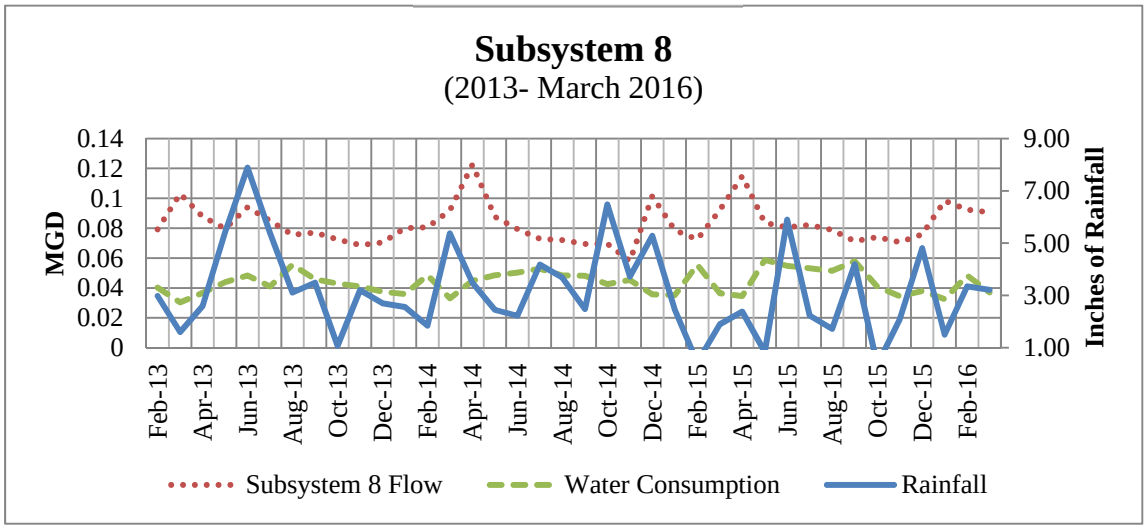
Town of Hudson, New Hampshire

INFILTRATION AND INFLOW STUDY UPDATE

June 2016



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2016
INFILTRATION/INFLOW REPORT UPDATE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.)

APPENDICES:

EXECUTIVE SUMMARY

A major challenge to confidence in the data generated by this study is that Hudson experienced a moderate drought during the evaluation period for this update of the Infiltration/Inflow (I/I) Study. Data shows a reduction of approximately 85,000 gallons per day of Infiltration and Inflow (615,000 vs. 700,000 GPD) from the Town of Hudson sewer system since the 2002 Study, a drop of over 12 percent. (Upon closer examination of the 2002 data from the report's Appendices, we noted that the interpretation of specific data did not match the current means of evaluation. Recalculation of the I/I for the 2002 report resulted in an average I/I of nearly 700,000 gallons, versus the 662,000 cited.) Through the lining and replacement of old sewer mains and the repair of breaks in piping and manholes, we believe that the Town's Sewer and Drain Division of the Hudson Highway Department has been able to achieve a significant reduction in I/I which has allowed capacity to accommodate all of the connections since 2002.

However; as noted above, the Town of Hudson was experiencing drought-like conditions during much of the current study period. Rainfall totals from 2001 used in the 2002 Study totaled 36.88 inches. Total rainfall for 2015 was 29.29 inches, more than 20% less than in 2001. While the percentage reduction in rainfall likely makes up a portion of the percentage drop in calculated I/I, there are many other factors which have contributed to the apparent reduced I/I volumes. Therefore, with drought conditions continuing into the present, it would not be prudent to recommend the reallocation of the majority of the calculated I/I volume to new or expanded development until additional I/I evaluation and elimination has occurred.

Aging Homes and Sewer System Piping

Sewer service laterals, especially those for older homes, are a leading cause of sewer system I/I. This is not just inflow from foundation drains, sump pumps, etc., but also infiltration from damaged/cracked piping and poor quality installation. Clay service piping is especially susceptible to root damage. The majority of homes in the Town of Hudson are of older vintage, with many that have drains and sump pumps connected directly to their sewer service outlet piping. A house-by-house inspection program could be implemented to quantify the number of homes with these types of connections. Inspection of service piping to evaluate root damage or other infiltration sources would be more difficult, but is an option the Town should consider as it might uncover some individual sources of infiltration, especially in those subsystems located near the Merrimack River.

Priority Evaluation

Subsystem #5 (Bordered by Lowell Road/Belknap Road/past Hilindale Drive/Pelham Road/Melendy Road intersection) is recommended as a priority for further evaluation of potential infiltration sources as this subsystem has some of the highest sewer flows of any subsystem. Sources of inflow are not as easily identified, but given that a portion of Subsystem #5 is made up of older homes, it is likely that inflow is at least a partial cause of the increased sewer flows. Subsystem #5 is centered on the intersection of Belknap Road and Melendy Road.

Continued efforts to remove Infiltration and Inflow from areas where high variations in flow remains will continue to result in capacity increases. Challenges to be overcome will require innovative design technologies to move stormwater away from low areas of Town where residents are adversely impacted by surface water and groundwater.

SECTION 1: PROJECT BACKGROUND AND OBJECTIVES

1.1 Overview

The Town of Hudson is located along the Merrimack River in the South Central area of New Hampshire as shown on Figure 1 in Appendix A-1. Hudson is made up of mixed-use neighborhoods that include residential, industrial, commercial, and educational facilities. Municipal water and sewer serve the majority of the Town. The wastewater generated in Hudson is collected via gravity sewers and a series of pump stations that discharge to a primary pump station located along the Merrimack River. Wastewater flows are also generated from the Pope Technical Park. However, these flows do not pass through the primary flume in the Town of Hudson. The storm drainage separation from the sanitary sewer in the Town of Hudson began in 1976 and took several years to complete.

Wastewater from the primary pump station in the Town of Hudson is pumped to the City of Nashua wastewater collection system and is ultimately treated at the City of Nashua Wastewater Treatment Facility (WWTF) under an Intermunicipal Agreement (Appendix A-2). Wastewater generated from the Pope Technical Park is discharged to the City of Nashua WWTF separately from the flows from the primary flume. The Town of Hudson has an allocation of 2 million gallons per day (mgd) based on an annual average from the City of Nashua. For purposes of this study, Pope Technical Park was not included as part of the infiltration/inflow analysis. The Town of Hudson has not exceeded the 2-mgd allocation based on an annual average. However, there have been isolated occasions when wastewater flows have exceeded the 2-mgd allocation during periods of rainfall and high groundwater.

The Town of Hudson has worked on various levels of infiltration/inflow studies since 1987. Television inspection was initiated during the 1989-1991 time period. Since then the Town has purchased its own wastewater flow meters and television inspection equipment. These studies were updated in 1998 and 2002. Based on the increased disparity between wastewater flows and water consumption, the Hudson Sewer and Drain Division and the Town Engineer recognized the need to continue previous work efforts with updated Infiltration/Inflow (I/I) documentation of the entire wastewater collection system to further refine prior I/I source evaluations.

There are several objectives associated with this I/I Study update including:

- Calculate an estimated volume of wastewater reduction to Nashua since the 2002 Study.
- Identify areas of Town where excessive I/I remains.
- Develop a plan of action to continue to eliminate non-wastewater discharges without creating hardships for the residents.
- Increase overall theoretical capacity for future development in the Town of Hudson.
- Develop a prioritization schedule for smoke testing; further television inspection; and correction of the problems identified.

1.2 Scope of Study

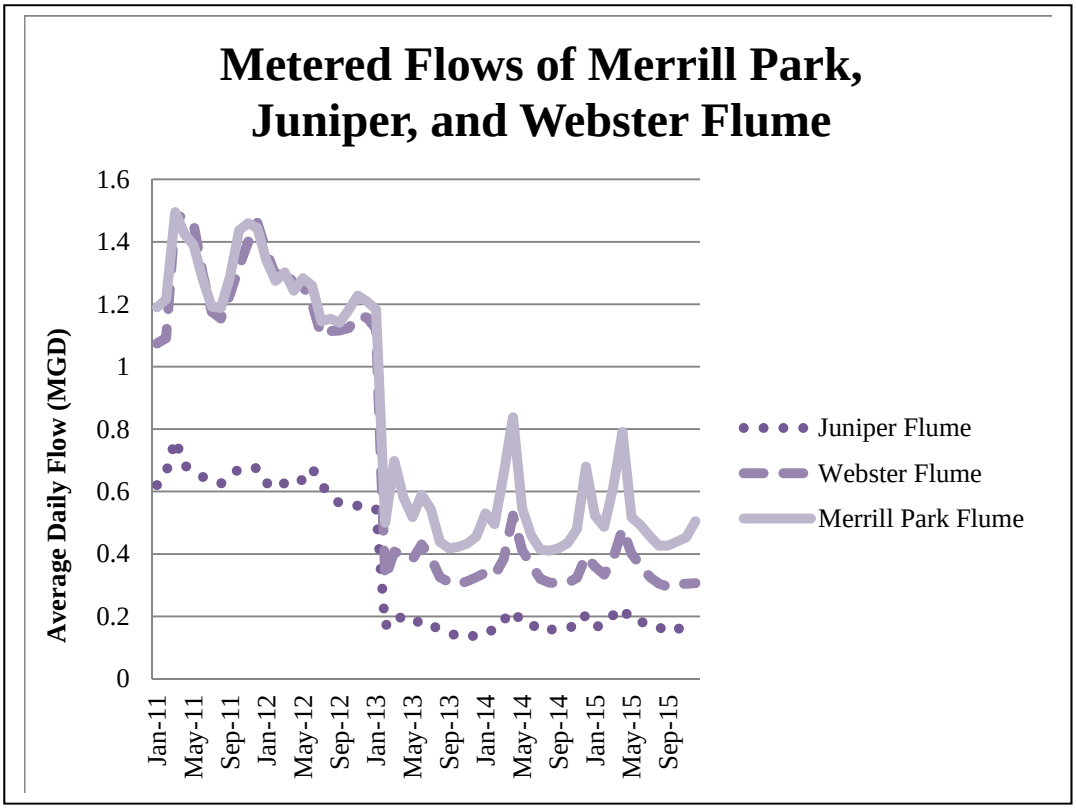
To accomplish the objectives of the project, the following tasks were completed:

Data Collection: The data reviewed and collected during the I/I Study update includes the following:

- Documents developed and used as part of the 2002 Study.
- Historical rainfall data.
- Historical flows for the flumes, which meter all wastewater to the Nashua Sewer System.
- Updated Town of Hudson Master Parcel Plan that includes GIS Data, including an inventory of pipe sizes, slopes, type, age, manhole locations, and depths.
- Electronic GIS data: Town of Hudson recently updated GIS data.
- List of projects completed by the Sewer and Drains Division of the Hudson Highway Department.
- Sewer service connection location files.
- Water consumption records from 2007 to present.
- Well usage water meter data.
- Water deduct meter data.

The final analysis was performed using available water and wastewater data provided by the Town of Hudson for the years of 2015 and 2016. It is important to note that after the water, rainfall, meter and flume data was entered for the time period between January 2011 and January 2013, it became apparent that there was a calibration issue with the three flume monitoring locations. Upon recalibration, it is noted that the calibration affected the recorded flume data between 300,000 and 800,000 gallons per day. Therefore, the data during that time period was determined to be invalid to use for further evaluation. The calibration issue is documented in the *Metered Flows of Merrill Park, Juniper, and Webster Flume* graph as **Figure 1-1**, below. Therefore, data prior to the calibration was not evaluated.

Figure 1-1



This study period is from March 2013 to March 2016 and includes the following:

Historical Wastewater Flow vs. Rainfall records were compared against wastewater flow records in attempts to draw parallels between periods of rainfall and periods of high I/I.

Historical Water Consumption Data and Wastewater Flow*:* Correlations were made between the water being consumed by the users in the Town and the wastewater being discharged to the sewer system.

Installation of Temporary/Permanent Flow Meters: The wastewater flow meters for the entire sewer system were strategically placed by the Town of Hudson with guidance from CLD, so that smaller areas could be evaluated for I/I.

This report summarizes findings and conclusions associated with the above-mentioned scope of work and are intended to assist the Town of Hudson in making informed decisions regarding improvements.

1.3 Definitions

Infiltration: ”Water other than wastewater that enters a sewer system (including sewer service connections and foundation drains) from the ground through such means as defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from, inflow” (*40 CFR Section 35.905*).

Inflow: "Water other than wastewater that enters a sewer system (including sewer service connections) from sources such as, roof leaders, cellar drains, yard drains, area drains, drains from springs and swampy areas, manhole covers, cross connections between storm sewers, and sanitary sewers, catch basins, cooling towers, storm waters, surface runoff, street wash waters, or drainage. Inflow does not include and is distinguished from, infiltration. Inflow does not include, and is distinguished from, infiltration." *(40 CFR, Section 35.905)*

Infiltration/Inflow (I/I): "The total quantity of water from both infiltration and inflow without distinguishing the source.”

Excessive I/I: Excessive I/I is that I/I quantity for which it has been shown, through economic analysis, that elimination from the subject sewer section by rehabilitation or replacement of sewer lines will be more cost-effective than handling the quantity through the treatment process.

Non-Excessive I/I: Non-excessive I/I is that quantity for which it has been shown, through economic analysis, that handling through the treatment process will be more cost-effective than elimination from the subject sewer section by rehabilitation or replacement of sewer lines.

Subsystem: The combination of a number of sewer segments that together constitute one of several major contributing areas to the main pump station in Hudson in this case.

1.4 Existing Wastewater Collection System

Wastewater from the Town of Hudson is collected and discharged to a main pumping station located at the foot of Sycamore Street that pumps the wastewater to the Nashua WWTF. The sewer collection system consists of various size pipes constructed of asbestos cement (AC), vitrified clay tile (VC), reinforced concrete pipe (RCP) and polyvinyl chloride (PVC). (A breakdown of the pipe sizes and estimated lengths are shown in **Figure 3-19** as part of the I/I evaluation calculation.)

The majority of the existing wastewater collection system for the Town of Hudson was constructed prior to 1978. The sewer materials prior to 1978 consisted primarily of VC and AC. After 1978, sewer materials primarily consisted of PVC with the exception of some AC pipe in industrial areas until 1984. The Town of Hudson also has some RCP in isolated instances. All new construction requires that sewer piping be PVC material.

In addition, the municipal wastewater collection system also includes three other significant pump stations located at Sagamore Park Road, Industrial Drive, and Federal Street located along the Merrimack River and several other smaller pump stations that transport wastewater within a subsystem.

As a result of meetings and discussions with Town personnel, CLD modified various aspects of our approach. Two such meetings are documented in Appendices A-4 and A-5. The detailed memo of documentation discussed during the April 2016 meeting is included in Appendix A-6. Information provided to CLD regarding new or replaced, or lined sewer pipes since 2002 is summarized in Figure 1-2. After 2002 many pipes have been replaced based on suggestions from the 2002 CLD I/I Study and many pipes have been added to accommodate new housing in Hudson.

Figure 1-2: New or CIPP Sliplined Sewer Location Since 2002

SUBSYSTEM	STREET	SUBSYSTEM	NEIGHBORHOOD/ STREET
Subsystem 1		Subsystem 5	
	Bradford Circle		Overlook Estates (Overlook Circle)
Subsystem 2			Oak Ridge Estates
	Belknap Street		Annie Court
	Bond Street		Brody Lane
	Chatham Street		Graham Court
	Clifton Street		Loren Court
	Greentree Drive		McEwen Court
	Hurley Street		Tiffany Circle
	Melendy Road		Charbonneau Drive
	Short Street		Gulf Street
Subsystem 4		Subsystem 6	
	Sparkling River Estates		Paula Circle
	Scenic Lane	Subsystem 7	
	Shoreline Drive		Andrews Avenue, Chase Street
	Vernon Street		Edgar Court, Winnhaven Drive, Wyeth Drive

Temporary Flow Meters (ISCO meters) were installed in the spring 2015 at four locations to delineate individual subsystem flows from downstream combined flows. Location information on these flow meters is summarized in the following **Figure 1-3**.

Figure 1-3: Temporary ISCO Flow Meters

Subsystem 1	Flow Meter Location: SMH TH-1, located on Route 111 between Greely Street (east) and Merrill Brook (west)
Subsystem 2 (Merrill Park)	Flow Meter Location: SMH EXC-3 on Maple Avenue
Subsystem 3	Flow Meter Location: SMH DE-26 on Derry Street, between Easy Street and Elm Avenue
Subsystem 5	Flow Meter Location: SMH BI-1 on Birch Street, 1 SMH west of Lowell Road

A detailed description of the various subsystems is provided in Section 3.4. A graphical representation of the sewer flow through the system and the meters (or measuring devices) is provided in **Appendix 3 (A-3).**

SECTION 2: DATA COLLECTION

2.1 Overview

Wastewater flow data and water consumption data during the I/I Study was provided by the Town of Hudson Sewer and Drain Division and the Hudson Sewer Utility, respectively. CLD separated the data by subsystem, and determined the classification of each user, such as; whether they were on public water or a well, or whether the user was on a subsurface disposal system and had public water.

The Sewer and Drain Division provided ongoing assistance to CLD throughout the course of the study. Their knowledge and understanding of the existing sewer collection system and the history of work performed was a very important part of accomplishing the goals of the study.

2.2 Overview of Data

The following data was obtained during the I/I Study and is summarized below:

Wastewater Flow Meter Data: Subsystem flows were measured at three flumes (Webster, Merrill Park, and Juniper); three subsystem pump stations (Industrial Drive, Federal Street and Sagamore); and within the four sewer manholes noted in **Figure 1-3** where temporary ISCO flow meters monitored flows. Flows were recorded on a continuous basis at five or fifteen-minute intervals. This sewer base flow is labeled as "Subsystem Flow" on the Subsystem graphs.

Meter Data: The Sewer and Drain Division provided ISCO flow meter data for Subsystems #1, #2, #3, and #5 to CLD to support our analysis. The additional ISCO meters began recording data in March of 2015.

Partial Town of Hudson Geographic Information System (GIS) Electronic File: A plan of Town sewer infrastructure data collated into an electronic format.

Pump Station Flow Records: The Sewer and Drain Division provided flow records for all four pump stations located within the sewer collection system.

Water Consumption: Monthly water bills were obtained from the Town and allocated into the corresponding Subsystem by address. The combined water quantity is shown as "Water Consumption" on each of the Subsystem graphs.

Rainfall Data (daily) was supplied by the City of Nashua on a monthly basis. The rainfall is summarized monthly and shown on the Subsystem graphs.

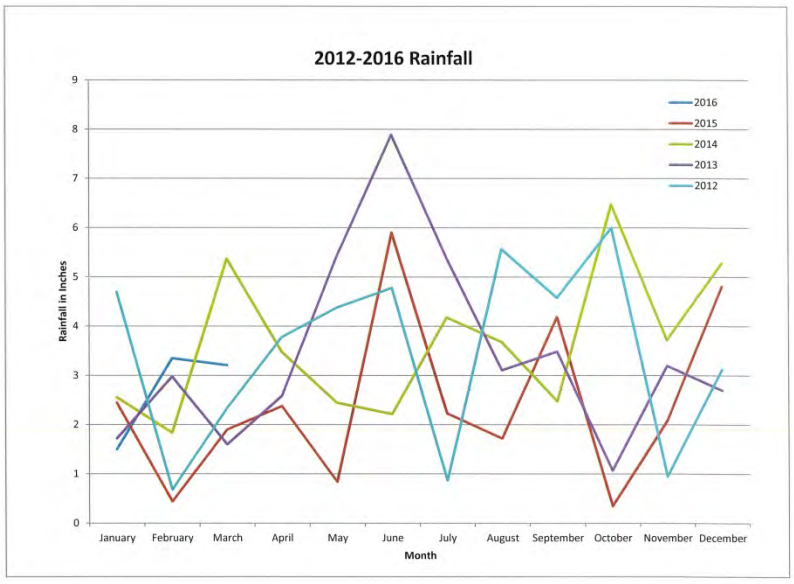
2.3 Rainfall Data

It is noted that overall rainfall totals for 2015 were lower than in previous years, and during various periods the Town of Hudson was considered to be experiencing abnormally dry conditions which can be defined as a moderate drought. These periods included:

- May 5-19, 2015 – Abnormally Dry
- May 19 – June 23, 2015 – Moderate Drought
- August 4 – September 29, 2015 – Abnormally Dry
- September 29, 2015 to present – Moderate Drought

(US Drought Monitor at http://droughtmonitor.unl.edu/MapsAndData/mapArchive.aspx).

Figure 2-1: 2012-2016 Rainfall Data



For comparison purposes, the annual rainfall totals for recent years are 41.76 inches for 2012, 41.15 inches for 2013, 43.74 inches for 2014, and only 29.29 inches for 2015. Despite this 25% drop in rainfall from previous years, there wasn't a corresponding decrease in sewer flows in 2015 that could be easily correlated to the lower rainfall total.

(**Figure 2-2** summarizes the data.)

Figure 2-2

Year	Total Sewer Flows at Main Flume (Gallons)	Rainfall (Inches)	Percent Change in Rainfall from Prior Year	Percent Change in Sewer Flow from Prior Year
2015	402,430,600	29.29	-33.0	-2.9
2014	414,322,016	43.74	+6.2	+2.4
2013	404,459,056	41.15	-0.01	N/A*
*N/A Due to Meter Calibration Issue				

There was a net increase of 16 sewer connections between 2014 and 2015 (5,355 vs 5,371) but the resultant new system flow from these connections does not offset a larger decrease in flow that could be attributed to rainfall related Infiltration/Inflow. The timing of rainfall when compared to groundwater elevations should be considered a leading indicator of the amount of Infiltration/Inflow experienced.

SECTION 3: INFILTRATION/INFLOW UPDATED ANALYSIS

3.1 Overview

The most effective method of evaluating I/I in a municipal wastewater collection system is to divide the entire sewer system into subsystems and evaluate the flows in each subsystem. For the 2002 evaluation, subsystems were established within the entire Hudson wastewater collection system on the basis of accessibility of gauging points and the ability to isolate distinct subsystems. Establishing these subsystems allowed for both the isolation of areas where excessive I/I may be occurring. The current I/I Study updated these same subsystems as a basis for study. Based upon the new GIS data available modifications were made to the limits of Subsystem #10 (Sagamore Pump Station) and Subsystem #6 (JU-1, EXC-3). A much less significant adjustment of the delineation of the border between Subsystem #7 (Flume) and Subsystem #2 (Merrill Park) was incorporated.

3.2 Infiltration/Inflow Evaluation Criteria

The following State and Federal regulations were reviewed to establish criteria for determining if the I/I found in the Town of Hudson sewer collection system is considered to be excessive or not.

The Environmental Protection Agency (EPA) considers I/I rates over 1,500 gallons per day per inch-diameter per mile (gpd/in-dia/mile) to be excessive. (USEPA, Quick Guide for Estimating Infiltration and Inflow, June 2014) EPA threshold was utilized in this evaluation to determine whether or not I/I found in the Town of Hudson sewer collection system is considered to be excessive.

We also understand that the New Hampshire Department of Environmental Services, State of New Hampshire requires that new sewers be designed to provide an I/I allowance of 300 gpd/in-dia/miles. However, exceeding this limit in old sewers is not considered excessive.

3.3 Method of Infiltration/Inflow Analysis

The I/I analysis update was conducted in a series of steps. The first step in updating the I/I information was to gather and manipulate available information on the existing sewer collection system. The next step was to reevaluate the sewer service areas to better isolate and define areas with significant I/I. The streets within each subsystem were identified. In addition, the pipe sizes and lengths were used to calculate how many in-dia/miles were in each subsystem.

Once the subsystems were defined, wastewater flow meter data was manipulated and recorded from a time period from January 2011 and January 2013. As previously mentioned, it became apparent that there was a calibration issue with the three flume monitoring locations. Upon recalibration, it is noted that the calibration affected the recorded flume data between 300,000 and 800,000 gallons per day. Therefore, the data prior to calibration was not valid to use for further evaluation. The flow data prior to recalibration of the flume which had been accumulated and graphed for evaluation was subsequently discounted and not used. The calibration issue is documented as part of the *Metered Flows of Merrill Park, Juniper, and Webster Flume graph* (**Figure 1-1**) on page 1-3.

To determine the amount of I/I associated with each subsystem, water consumption data was compared to the wastewater flow data. Metcalf and Eddy (Metcalf & Eddy, Wastewater Engineering, McGraw Hill, Inc., 1972, p.33) suggests that 60% to 80% of the water consumed becomes sewerage. However, a more conservative value of 90% was used for the determination of the I/I in the Town of Hudson sewer collection system during the 2002 evaluation. For comparison purposes, this same 90% value was used in the current study. The amount of I/I in each subsystem was determined by subtracting 90% of the water consumed from the wastewater flow for each subsystem.

3.4 Subsystems

In an effort to better isolate and define areas with significant I/I, the entire sewer service area was divided into several subsystems. These subsystems and the areas they encompass are shown on **Figure 1** in **Appendix A-1**. Based upon updated base plan data, some of the subsystem delineations were modified from the originally defined areas. The 2002 data was also updated so the comparison was representative of current conditions. A description of each subsystem is provided in the following text and summarized in **Appendix A-3**, *Subsystem Layout and Flow Discrepancy Documentation.*

3.4.1 Subsystem #1 (Site 111) - **Figure 2** in **Appendix A-1**

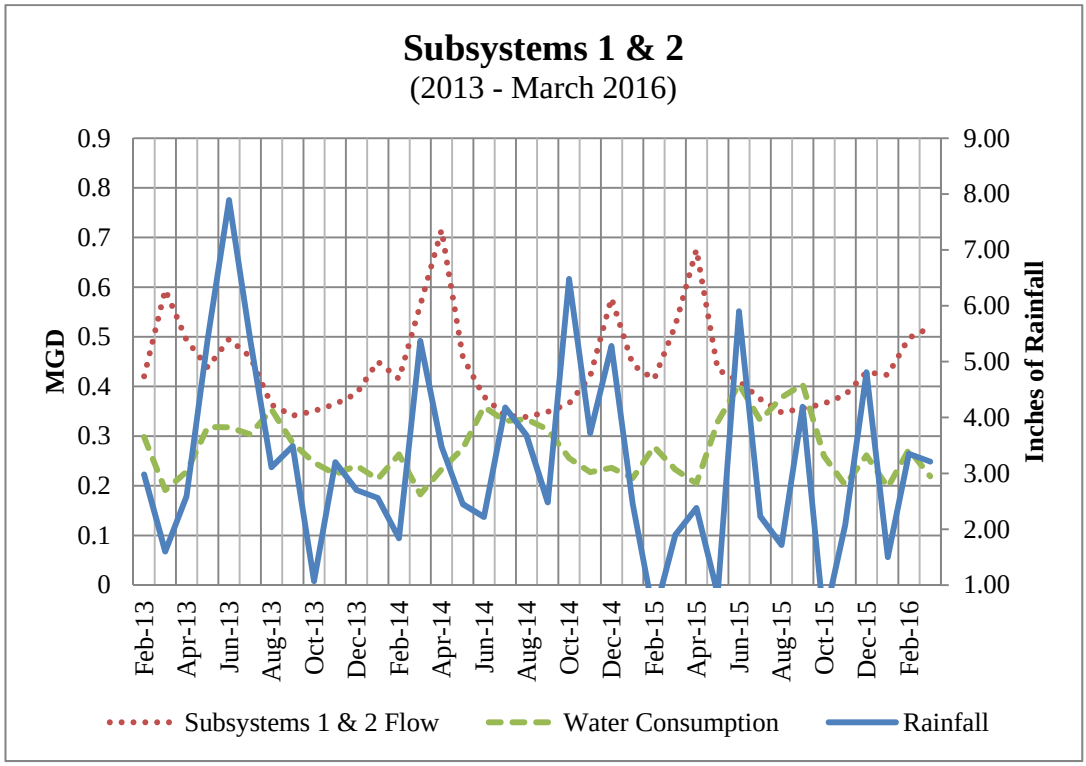
Subsystem #1 is identified as Site 111**.** This subsystem consists primarily of residential areas and is located on both sides of Route 111 (Central Street). It extends east to Lund Drive and extends west to approximately 600 feet beyond the Route 111/Greeley Street intersection. The wastewater flow meter for Site 111 is located on Route 111. Since this subsystem has been defined, new sewer piping has been added on Bear Path Lane.

3.4.2 Subsystem #2 (Merrill Park) – **Figure 3** in **Appendix A-1**

Subsystem #2 is identified as Merrill Park. This subsystem consists of a combination of industrial and residential uses. There are significantly large industries connected to this subsystem. Subsystem #2 extends north along Route 111 to approximately 450 feet east of the Merrill Brook crossing. It is bordered to the west by the Merrimack River, to the south by Belknap Road and the north by Highland Avenue. The wastewater flow meter for this subsystem is located near Maple Avenue. Since the 2002 I/I, many sewer pipes

in this area have been replaced in order to minimize any infiltration in this subsystem. Replaced sewer systems include Belknap Street, Chatham Street, Bond Street, Clifton Street, Greentree Drive, Short Street, and Hurley Street.

Figure 3-1:
2013-2016 Combined Water, Rainfall and Sewer Meter Data
That Includes Subsystem 2



3.4.3 Subsystem #3 - Towhee/Greeley/Derry (Site 3) – **Figure 4** in **Appendix A-1**

Subsystem #3 is identified as Site 3. Subsystem #3 is bordered to the north by Towhee Drive, located east of Subsystem #4 (Web-6) and extends south to the Public Service Company of NH right-of-way. This subsystem also extends east to Greeley Street/Marsh Road intersection and west to Derry Street. The wastewater flow meter for Site 3 is located on Derry Street. No sewer pipes have been added or replaced in this subsystem since the 2002 CLD Study.

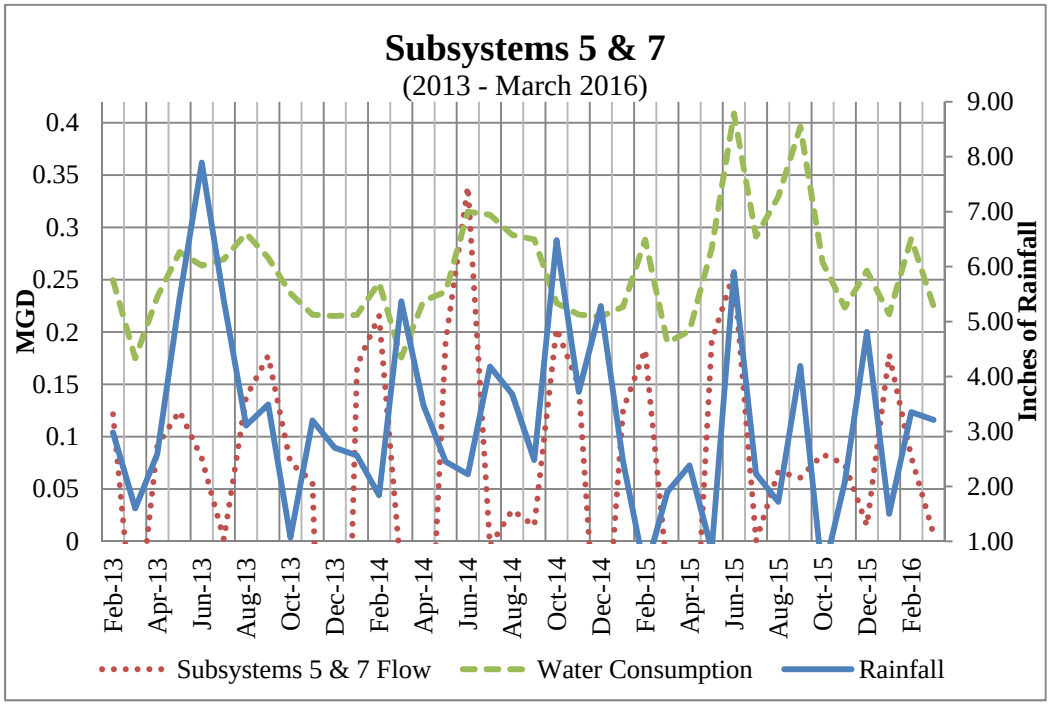
3.4.4 Subsystem #4 (Web-6) – **Figure 5** in **Appendix A-1**

Subsystem #4 is identified as Web-6 and is located in the northernmost portion of the Town bordered by the Merrimack River to the west, Adam Drive to the north, Ferry Street to the south and Derry Street to the east. This subsystem consists of a mixture of primarily residential use with some industrial uses. The wastewater flow meter for Web-6 is located in a manhole located on Webster Avenue. Three new sewer mains have been constructed and added onto this subsystem since the 2002 CLD Study, including Sparkling River Estates, Scenic Lane, and Shoreline Drive. Additionally, the piping on Vernon Street has been lined since the 2002 Study.

3.4.5 Subsystem #5 (Site 2) – **Figure 6** in **Appendix A-1**

Subsystem #5 is identified as Site 2 and serves primarily residential areas. It is bordered to the west by Lowell Road. It extends to the north on Belknap Road approximately 1,000 feet beyond the intersection with Hilindale Drive. This subsystem extends east to the Pelham Road/Melendy Road intersection. The wastewater flow meter for Site 2 is located on Birch Street. Many new housing developments have been added to this subsystem and new sewer pipes have been put in place in the following areas: Fox Hollow, Overlook Estates, Oakridge Estates, and Paula Circle. Additionally, a portion of Belknap Street (this street falls within both Subsystem #5 and Subsystem #2), and Charbonneau Drive have had their lining replaced. (Note that the data is not useful for evaluation due to the irregularity in flow meter reconciliation from flow surcharges in Subsystem #7.)

Figure 3-2:
2013-2016 Combined Water, Rainfall and Sewer Meter Data
That Includes Subsystem 5



3.4.6 Subsystem #6 (Ju-1, Exc-3) – **Figure 7** in **Appendix A-1**

Subsystem #6 is identified as Site Ju-1, Exc-3 and is made up of a mixture of residential, commercial and industrial uses. It is bordered to the west by the Merrimack River. It extends to the east to the Shelly Drive/Burns Hill Road intersection south to the Lowell Road/Wason Road Intersection. The wastewater flow meter for this subsystem is located on Juniper Street. No piping has been replaced or added since 2002 CLD Study.

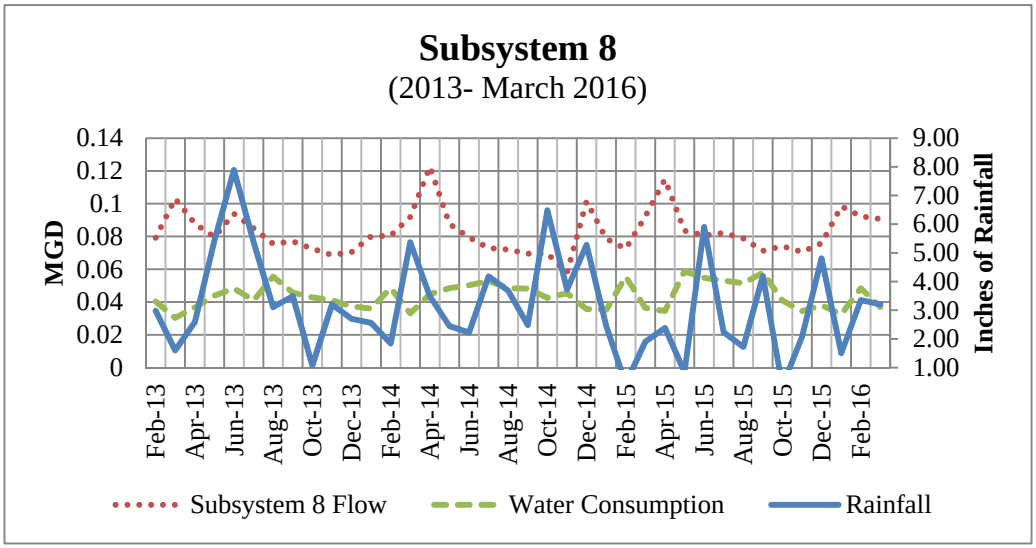
3.4.7 Subsystem #7 (Flume) – **Figure 8** in **Appendix A-1**

Subsystem #7 is identified as Flume. This subsystem, bordered to the east by Lowell Road, is located in a densely populated area of Hudson, consisting of various uses including residential, commercial, and industrial. Subsystem #7 is located immediately adjacent to the Merrimack River, and encompasses a large portion of the center of Town. It extends south to Hickory Street and north to Ferry Street. The wastewater flow meter for this subsystem is located upstream of the central pump station and measures all flows entering the central pump station and discharged to the Nashua WWTF. A portion of the subsystems sewer pipes have been lined since the 2002 Study. The replaced piping resides on the following streets: Chase Street, Winnhaven Drive, Wyeth Drive, Andrew Avenue, and Edgar Court.

3.4.8 Subsystem #8 (Industrial Drive Pump Station) – **Figure 9** in **Appendix A-1**

Subsystem #8 is identified as Industrial Drive Pump Station. This subsystem consists of industrial and residential uses. The Industrial Drive Pump Station collects wastewater from Industrial Drive, Lund Drive, Hedgerow Drive, Paget Drive and Park Avenue. Wastewater flow data for this subsystem was collected at the pump station located on Industrial Drive. New sewer has been installed at Bradford Circle.

Figure 3-3
2013-2016 Combined Water, Rainfall and Sewer Meter Data
That Includes Subsystem 8



3.4.9 Subsystem #9 (Federal Street Pump Station) – **Figure 9** in **Appendix A-1**

Subsystem #9 is identified as the Federal Street Pump Station. This subsystem consists of a combination of industrial and residential uses is bound by Subsystem #4 (Web-6) on the north, east and south and the west by the Merrimack River. This subsystem consists of primarily older houses. The Federal Street Pump Station collects wastewater from Federal Street, Merrimack Street, Kenyon Street, Gambia Street, Jones Street and Bank Street. Wastewater flow data for this subsystem is monitored at the pump station located on Federal Street.

3 .4.10 Subsystem #10 (Sagamore Pump Station) – **Figure 10** in **Appendix A-1**

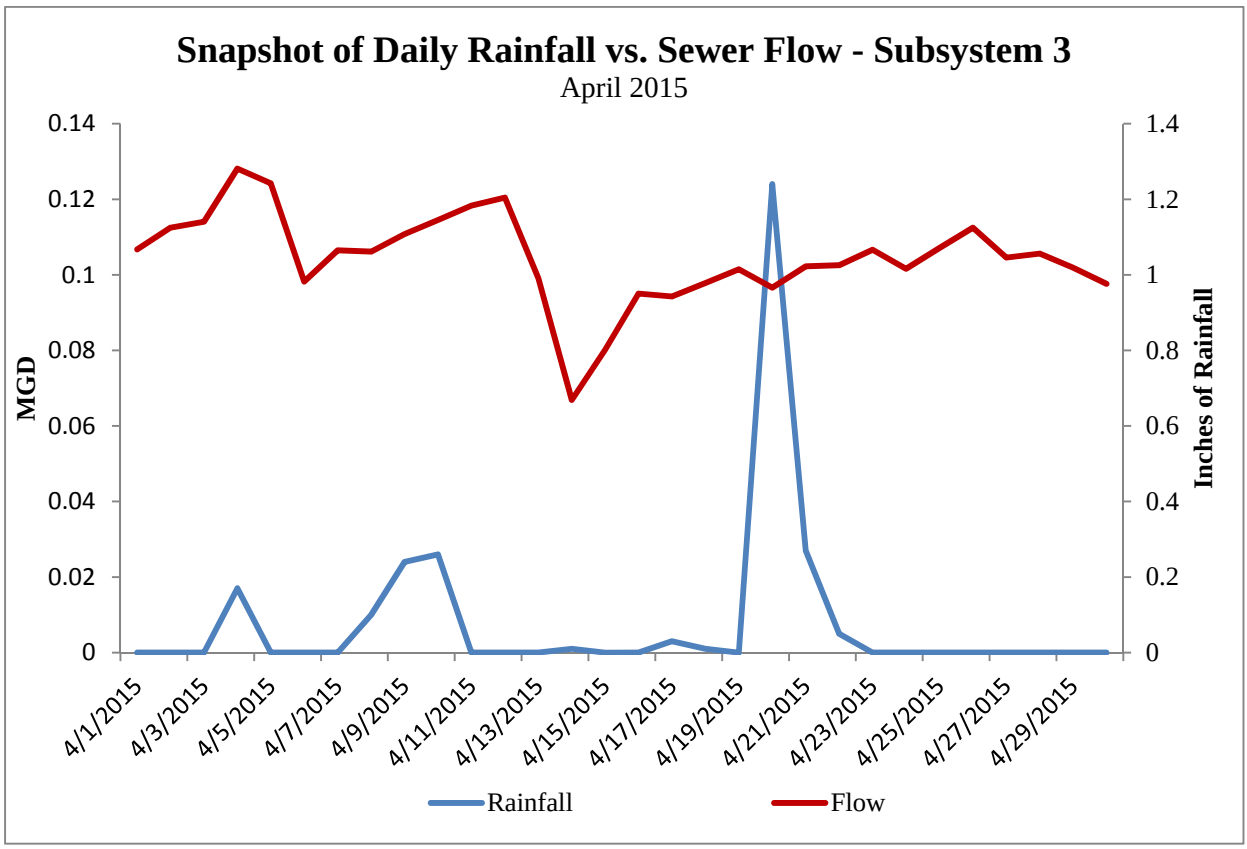
Subsystem #10 is identified as Sagamore Pump Station. The Sagamore Pump Station collects wastewater from a large industrial park located between Lowell Road and the Merrimack River. Wastewater flow data for this subsystem was collected at the pump station located on Sagamore Park Road.

3.5 Sewer Flow vs. Rainfall

The received flow meter data and rainfall data was compared in order to determine if periods of high rainfall correlated to periods of high flow. The daily rainfall and sewer flows were compared for each subsystem. Out of the ten subsystems, Subsystems with different characteristics (#3 and #5) were chosen to analyze more thoroughly. This approach better depicts the influence that rainfall has on sewer flows.

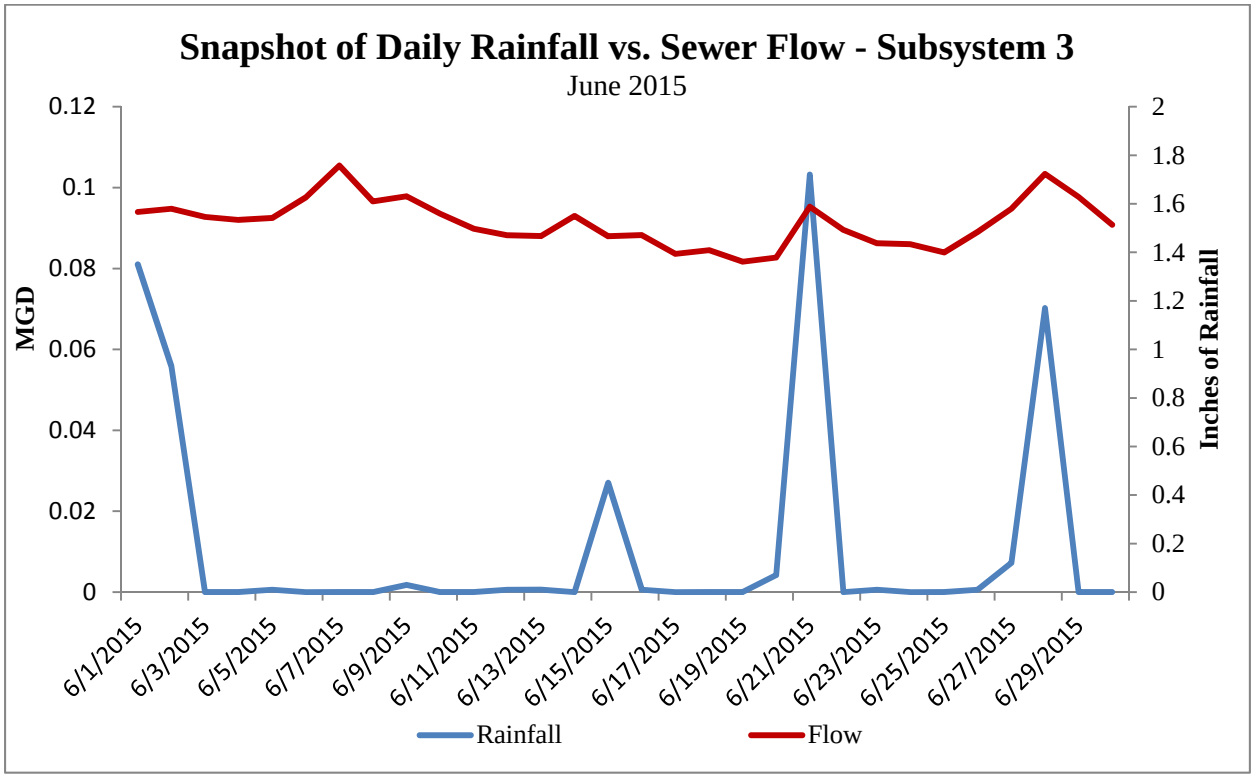
Daily comparisons of sewer flow vs. rainfall in Subsystems #3 and #5 show an increase in flow lagging several days behind rainfall during periods of assumed high groundwater levels (see April 2015 graphs below). During periods of lower groundwater levels (June 2015 graphs), the sewer flow spikes the same day as rainfall. These results, while not unexpected, are typical across all Subsystems and show the influence of infiltration and inflow on the sewer system.

Figure 3-4



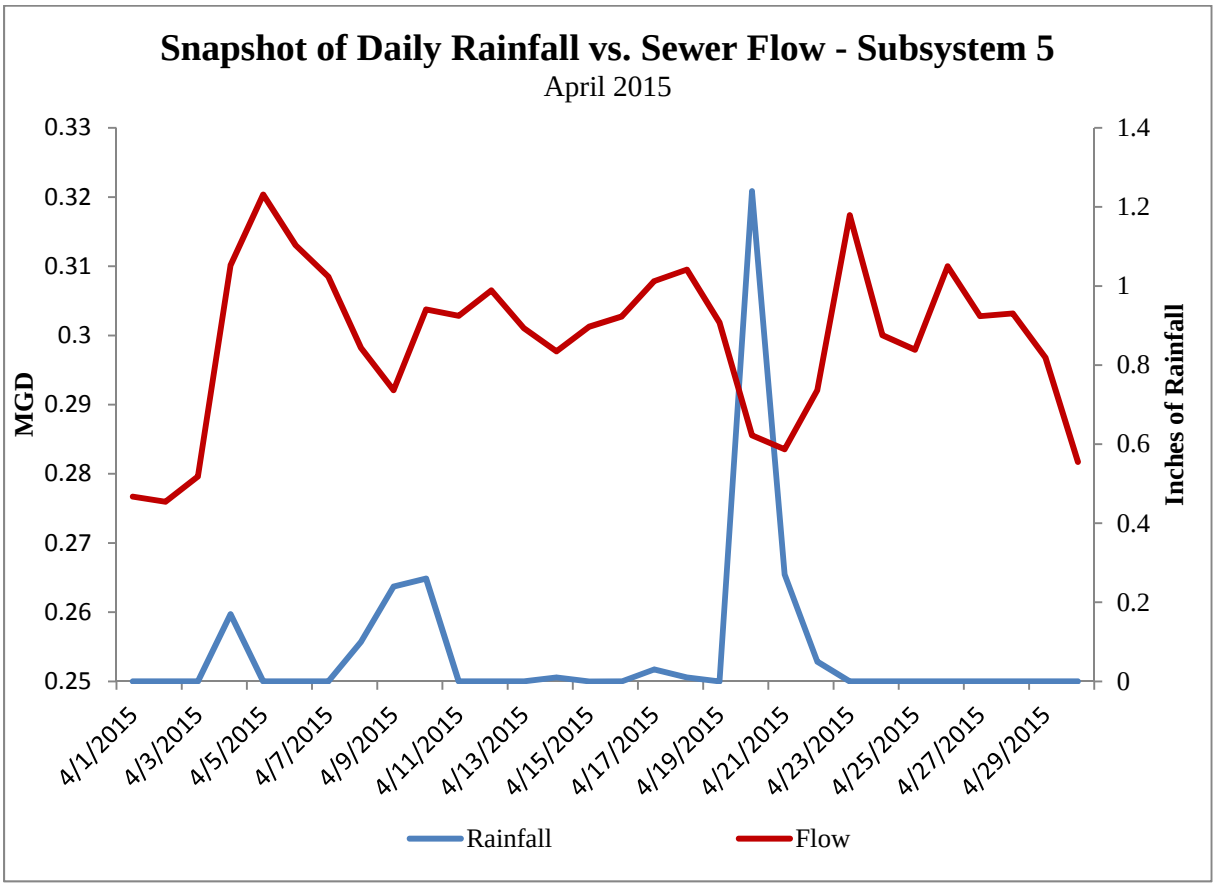
Note that the first two rain events in Subsystem #3 cause some correlation with I/I; however, the third event does not.

Figure 3-5



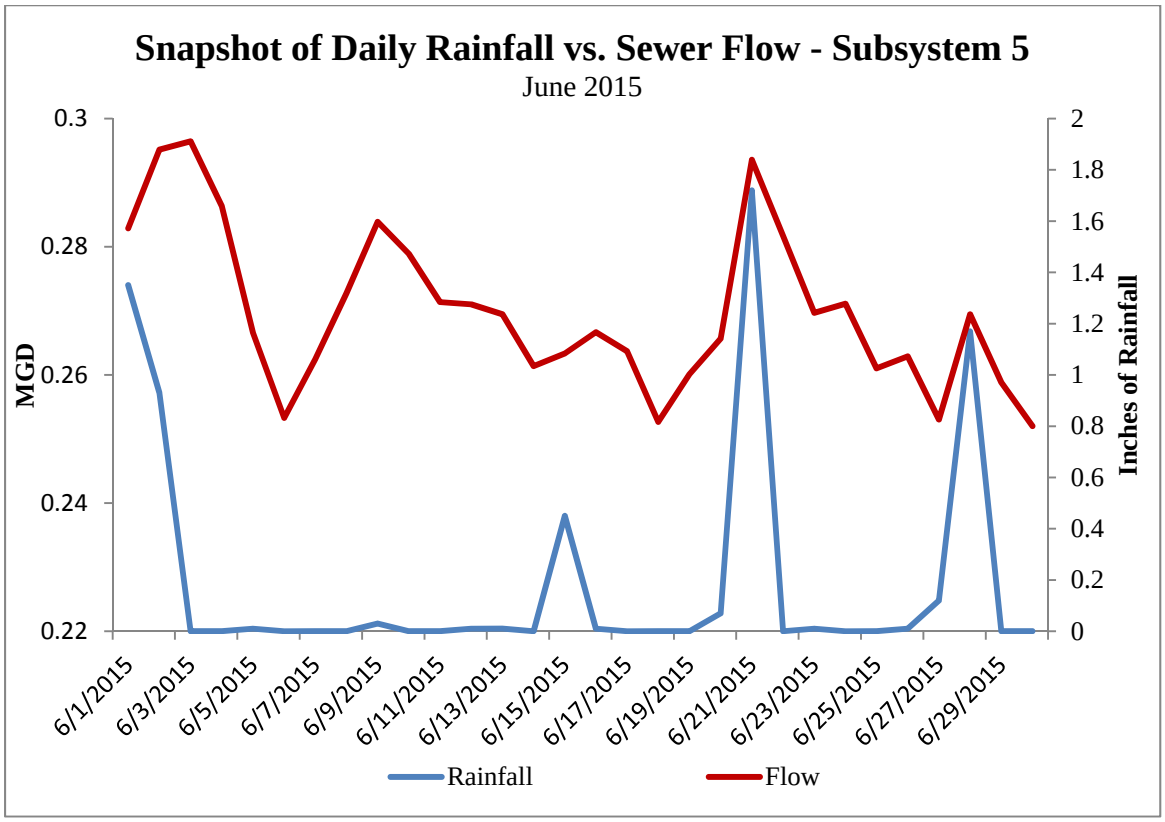
Note that the effect of I/I from rain events is relatively muted in June 2015. (Low groundwater situation.)

Figure 3-6



Subsystem #5 shows pronounced I/I correction in April and June (especially when the ground is saturated with groundwater).

Figure 3-7



Subsystem #5 shows pronounced I/I correlation in April and June (especially when the ground is saturated with groundwater).

As noted above 2015 was a relatively dry year for rainfall, even after the year's heavy winter snow accumulation. Enough variability exists across all subsystems when rainfall is evaluated against recorded flows that a direct correlation cannot be made (i.e. the most rain does not necessarily result in the highest system flows). When evaluated on a daily basis, it is evident that flows increase whenever there is a rainfall.

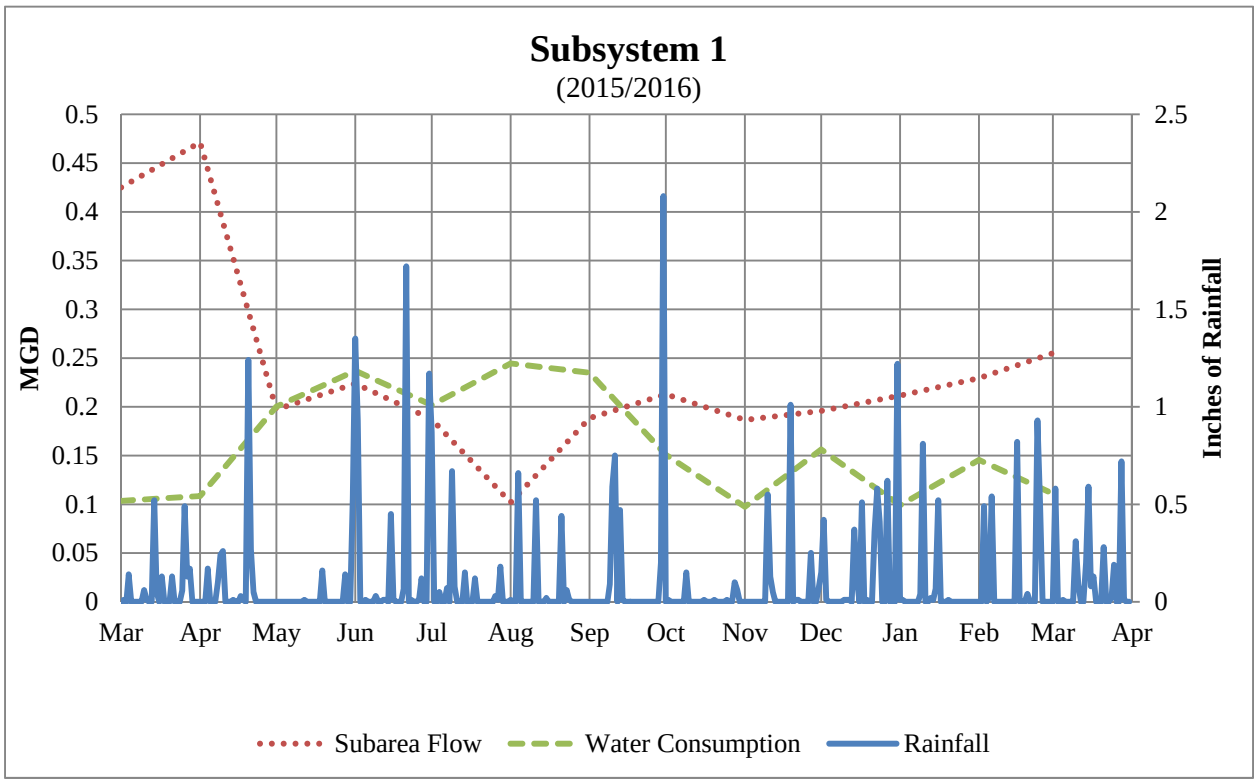
Basement sump pumps, foundation drains and roof drains (gutter systems) connected to a house's sewer service are a likely cause of inflow into the sewer system during a rain event. But the extent of any flow increase is tempered by the groundwater elevation at that time. For example, in May of 2015 Hudson received only 0.84 inches of rain, yet the total monthly flows measured at the Merrill Park, Juniper, and Webster flumes were all higher than the flows at the same locations measured in June of 2015 when there was 5.90 inches of rain. This variability reinforces the conclusion that groundwater elevations are the most critical element in inflow and infiltration into the sewer system. Data shows consistently higher flows in the spring months when groundwater elevations lie above many gravity sewers and when sump pumps and foundation drains contribute inflow into the public sewer mains. Contributions from inflow and infiltration are evident on the graphs for each subsystem.

3.6 Sewer Flow vs. Water Consumption

The flows for all subsystems were evaluated against the sewer account data received from the Town for the evaluation period. Several subsystems recorded flow amounts significantly greater than the water consumption for the same time period, which is a leading indication of inflow and infiltration. Even in summer months when water usage typically increases and groundwater elevations are lowest, several subsystems exhibited higher flow amounts than water consumed.

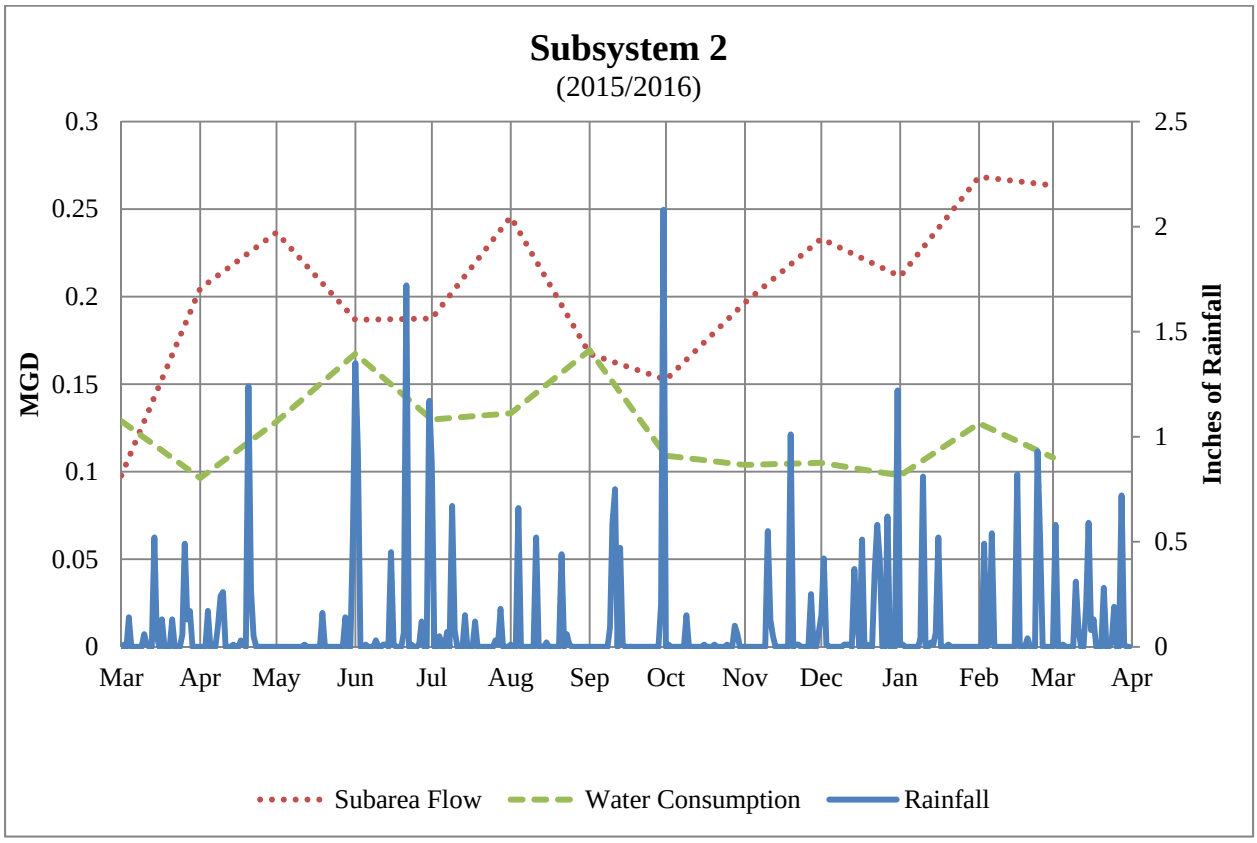
The following graphs depict the Subsystems flows compared against the water consumption data and rainfall data for a specific time period.

Figure 3-8



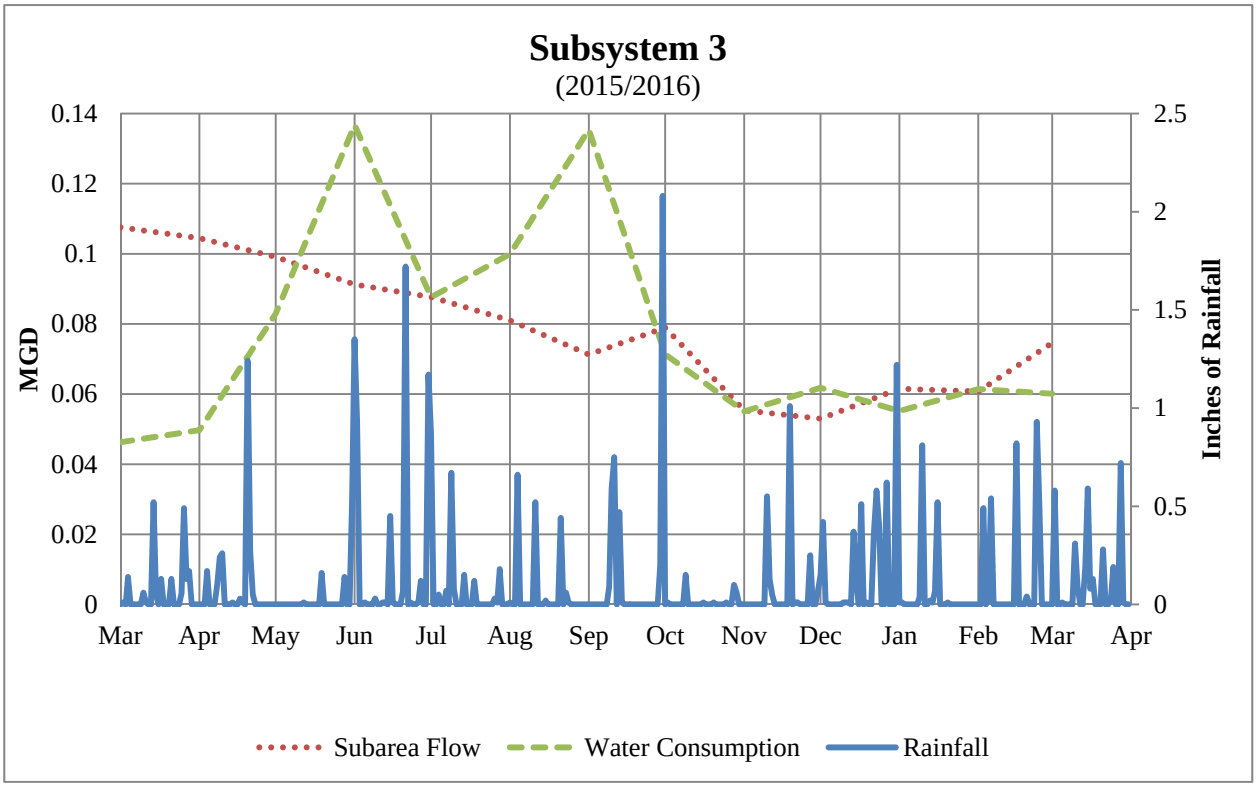
Note that in Subsystem #1 – Significantly higher sewer flow in March/April and October/ November.

Figure 3-9



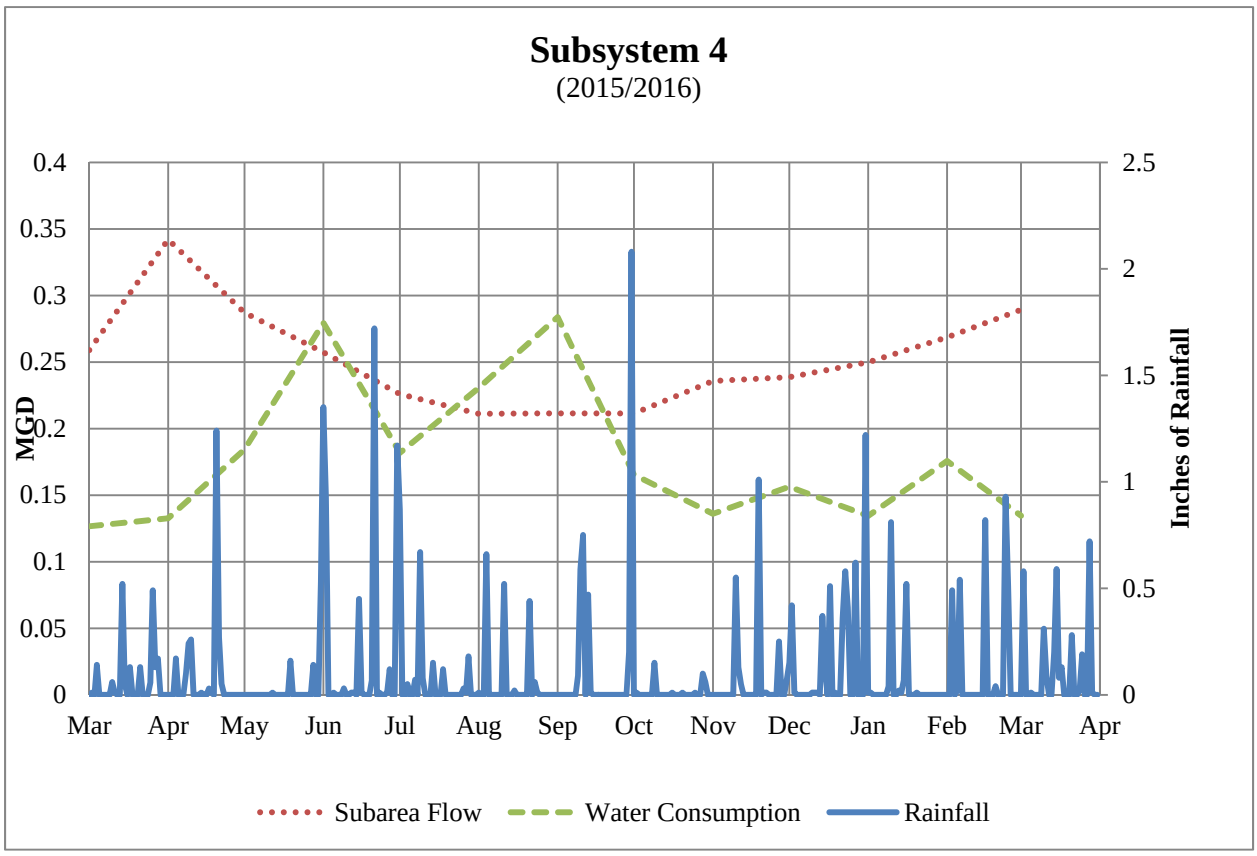
Subsystem #2 – Sewer flows are higher than water usage throughout the year.

Figure 3-10



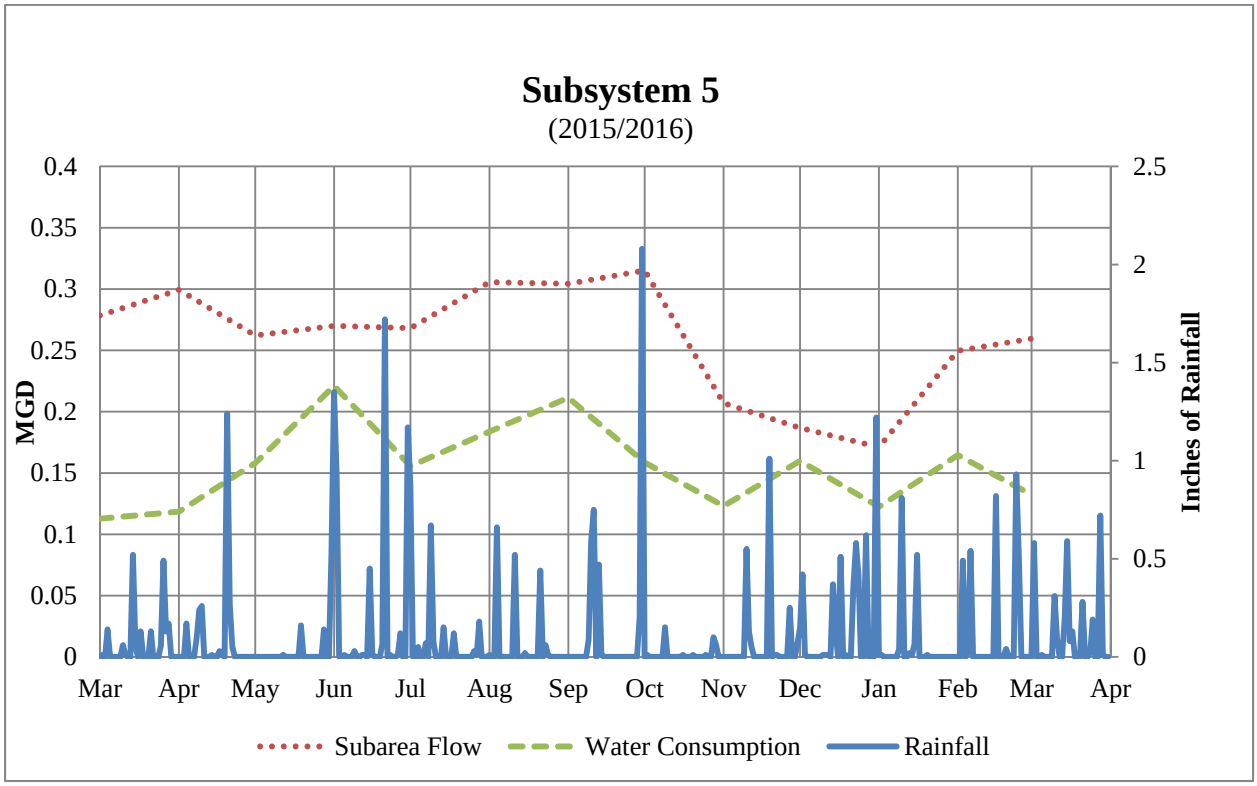
Subsystems #3 (and #6 and #10) exhibited some seasonally elevated sewer flows in spring and fall, most likely due to higher groundwater elevations. Sewer flows during the summer and winter months were below water usage amounts.

Figure 3-11



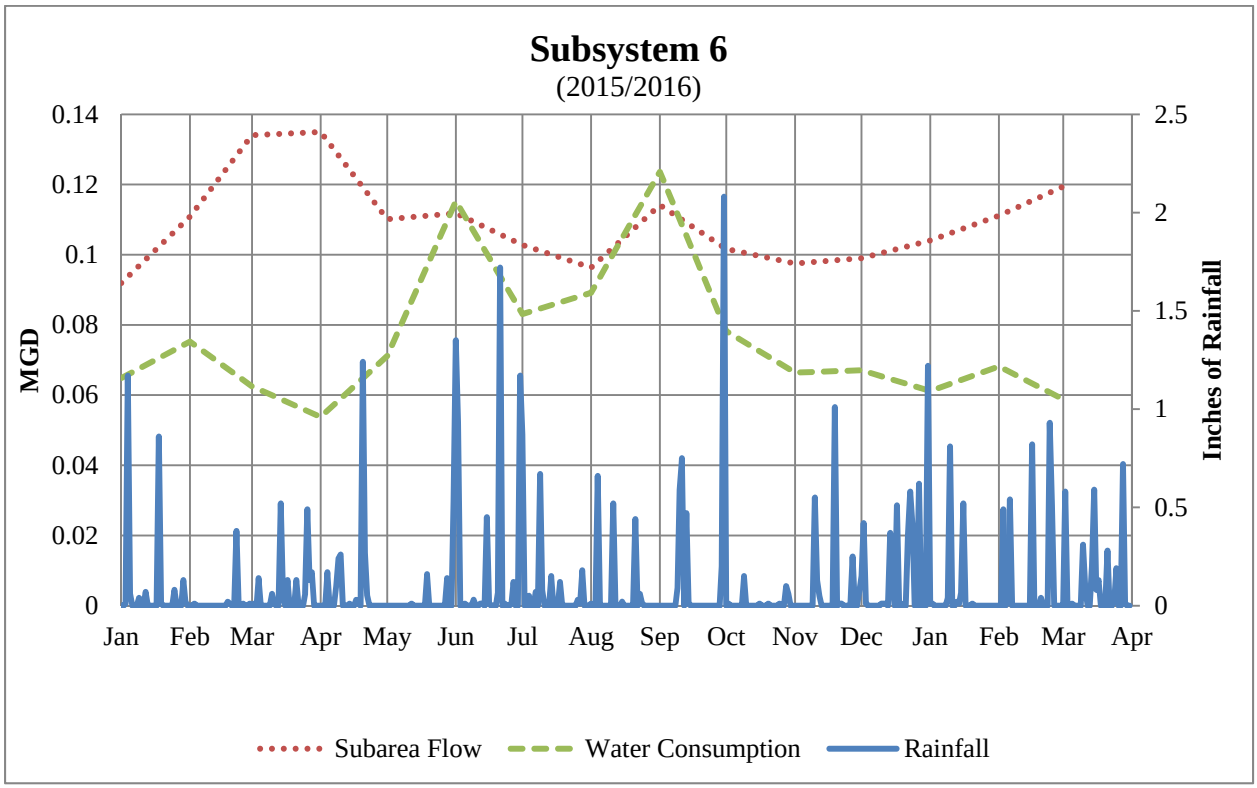
Subsystem #4 – Significantly higher sewer flow in March/April and November/ December.

Figure 3-12



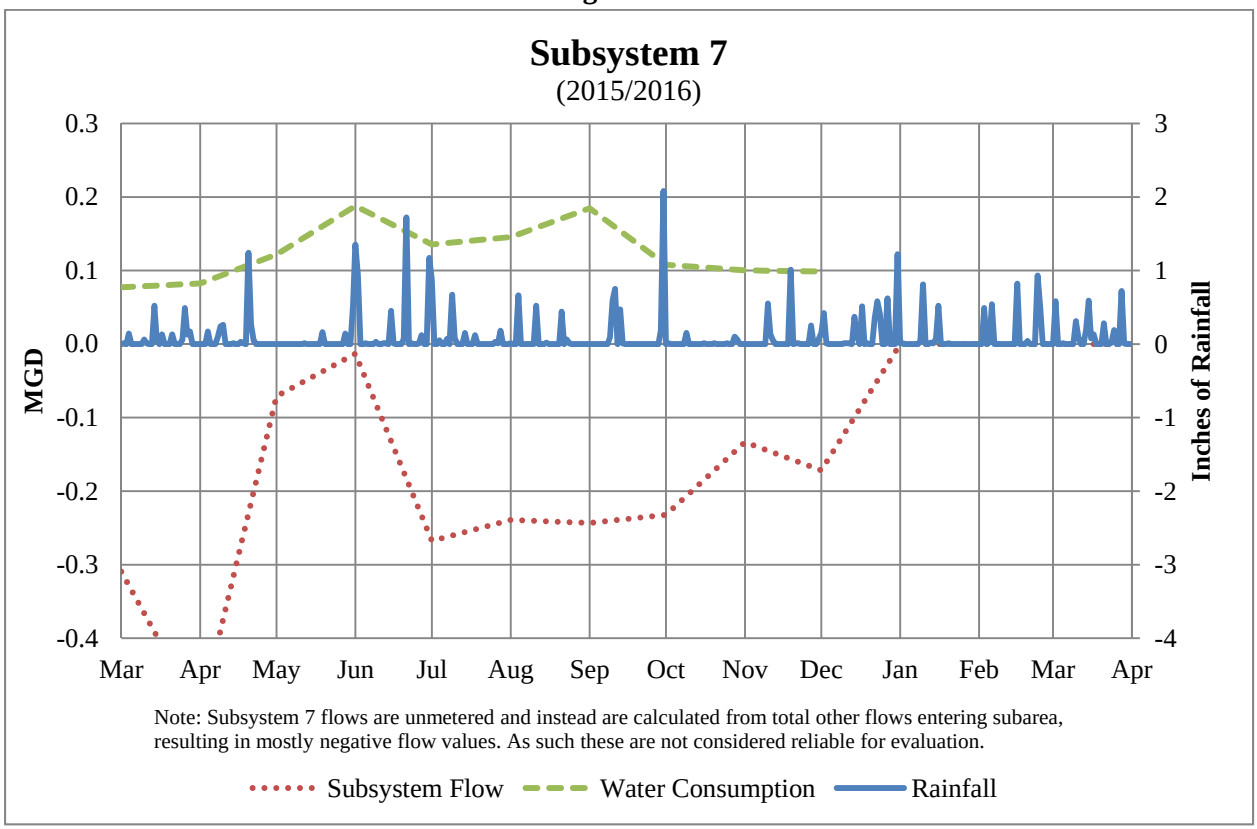
Subsystem #5 – Sewer flows are significantly higher than water usage throughout the year.

Figure 3-13



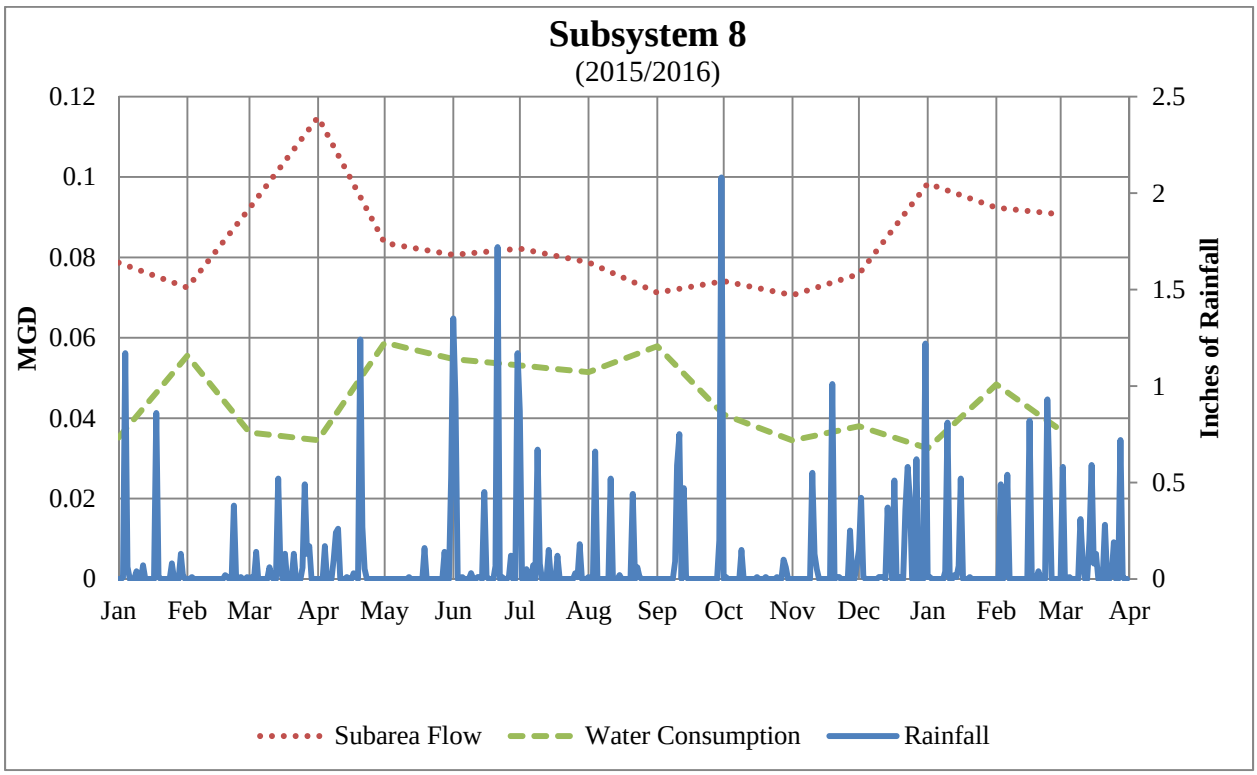
Subsystem #6 (and #3 and #10) exhibited some seasonally elevated sewer flows in spring and fall, most likely due to higher groundwater elevations. Sewer flows during the summer and winter months were below water usage amounts.

Figure 3-14



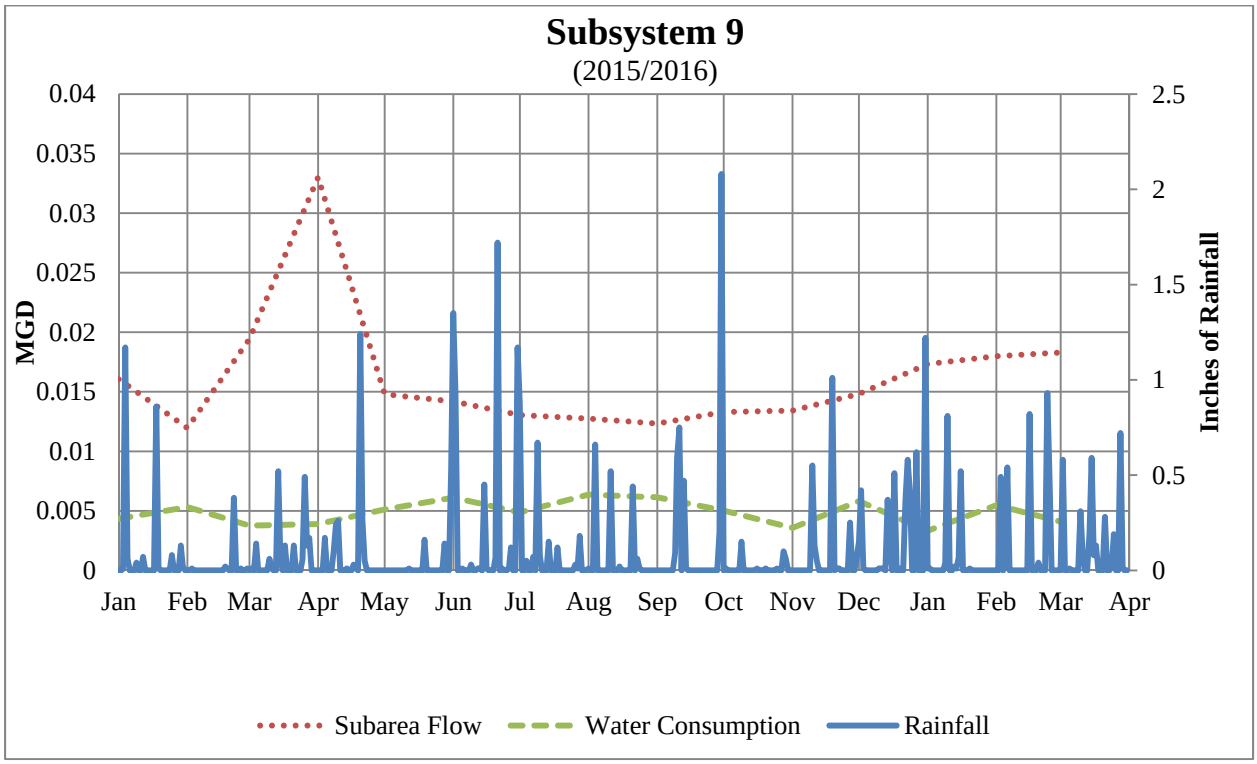
Subsystem #7 receives flows from all the other subsystems before conveying the flow to Nashua. As noted in Section 3.7.2, Subsystem #7 flow data was calculated by subtracting the flow data from all other subsystems from the total flow in the Main Flume crossing to the Nashua Wastewater Treatment Facility, as all other subsystems discharge into Subsystem #7 and there is no flow meter installed just for Subsystem #7. This resultant data shows multiple negative monthly flows for Subsystem #7, plus other very low positive flows that do not appear to be representative of the sanitary flows from the large number of homes within this subsystem. Therefore, this data was not used in the final analysis.

Figure 3-15



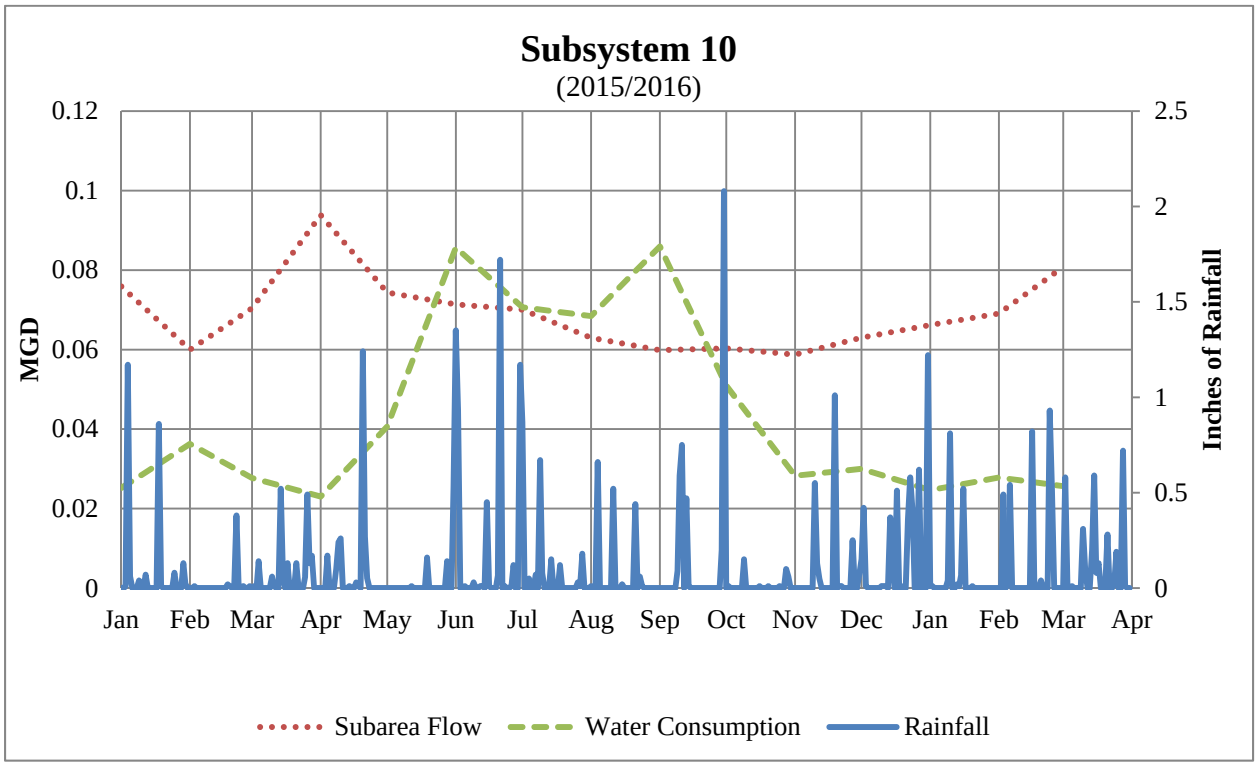
Subsystem #8 sewer flows were consistently above reported water usage.

Figure 3-16



Subsystem #9 sewer flows were consistently above reported water usage.

Figure 3-17



Subsystems #10 (and #3 and #6) exhibited some seasonally elevated sewer flows in spring and fall, most likely due to higher groundwater elevations. Sewer flows during the summer and winter months were below water usage amounts.

3.7 I/I Calculations

Infiltration and Inflow was calculated for each subsystem for the one-year period of April 2015 to March 2016. Although data was processed for the entire period beginning in 2012, this period was used because there was complete sewer flow data and water usage data available for each individual subsystem. Monthly average I/I values were calculated by subtracting 90% of the water usage data from the sewer flows, the same method used in the 2002 I/I Study.

Note that because the available sewer flow data for Subsystem #7 was determined to be unreliable (see 3.7.2), the I/I values for Subsystem #7 were estimated by adjusting the flow data from Subsystem #2 for the number of houses in Subsystem #7, then subtracting 90% of the Subsystem #7 water usage data from those values. Subsystem #2 was chosen for estimating purposes because it has a similar number of homes (668 vs. 671), both subsystems are made up of mostly older homes, and portions of both subsystems border on the Merrimack River so groundwater conditions could be assumed to be similar for both subsystems.

Figure 3-18:
Average Daily I/I Based Upon Water Usage and Metered Sewer

Average Daily I/I (MGD) based upon Water Usage and Metered Sewer										
	Subsystem 1	Subsystem 2	Subsystem 3	Subsystem 4	Subsystem 5	Subsystem 6	Subsystem 7	Subsystem 8	Subsystem 9	Subsystem 10
April	0.3781	0.1180	0.0597	0.2227	0.1927	0.0866	0.1162	0.0838	0.0295	0.0731
May	0.0275	0.1208	0.0245	0.1212	0.1200	0.0461	0.11901	0.0307	0.0102	0.0378
June	0.0275	0.0361	-0.0318	0.0058	0.0710	0.0080	0.0356	0.0314	0.0087	-0.0057
July	0.0198	0.0706	0.0088	0.0623	0.1280	0.0280	0.0702	0.0344	0.0087	0.0065
August	-0.0982	0.1256	-0.0090	0.0035	0.1403	0.0161	0.1249	0.0325	0.0070	0.0014
September	-0.0090	0.0148	-0.0506	-0.0438	0.1140	0.0029	0.0147	0.0191	0.0068	-0.0175
October	0.0854	0.0544	0.0147	0.0627	0.1724	0.0312	0.0540	0.0373	0.0088	0.0145
November	0.1020	0.1031	0.0058	0.1133	0.0961	0.0377	0.1025	0.0396	0.0102	0.0333
December	0.0608	0.1386	-0.0026	0.0949	0.0428	0.0386	0.1377	0.0417	0.0096	0.0360
January	0.1251	0.1234	0.0119	0.1287	0.0609	0.0490	0.1223	0.0691	0.0143	0.0440
February	0.1045	0.1536	0.0055	0.1104	0.1015	0.0498	0.15221	0.0488	0.0131	0.0440
March	0.1594	0.1663	0.0205	0.1681	0.1405	0.0665	0.16482	0.0574	0.0146	0.0577
Average Daily I/I per subsystem (MGD)	0.0819	0.1021	0.0048	0.0877	0.1150	0.0384	0.1011	0.0438	0.0118	0.0271
GPD	**81,909**	**102,113**	**4,791**	**87,748**	**115,012**	**38,386**	**101,193**	**43,803**	**11,788**	**27,086**

Alternatively as a means to coordinate the data gathered, CLD evaluated I/I based upon the Infiltration and Inflow as a measurement of in-dia/miles of sewer. That data is summarized below in **Figure 3-19.**

Figure 3-19:
Infiltration in GPD per Inch-Diameter-Mile by Subsystem

	Estimated Feet of Sewer	8" Diameter	10" Diameter	12" Diameter	15" Diameter	18" Diameter	Calculated Average Diameter (Inches)	Infiltration Gallons per Inch Diameter Mile per Day
Subsystem 1	77,000	85%	0%	0%	15%	0%	9.05	632
Subsystem 2	55,000	80%	0%	10%	10%	0%	9.1	**1,076**
Subsystem 3	30,500	100%	0%	0%	0%	0%	8	104
Subsystem 4	83,500	90%	10%	0%	0%	0%	8.2	677
Subsystem 5	54,500	85%	10%	5%	0%	0%	8.4	**1,325**
Subsystem 6	33,000	85%	0%	0%	0%	15%	9.5	644
Subsystem 7	66,500	90%	0%	0%	10%	0%	8.7	923
Subsystem 8	18,000	100%	0%	0%	0%	0%	8	**1,603**
Subsystem 9	4,500	100%	0%	0%	0%	0%	8	1,761
Subsystem 10	20,000	80%	10%	0%	10%	0%	8.9	796

3.8 Overall System Evaluation

The overall sewer system has varying degrees of infiltration and inflow. Some areas have been improved through work performed by Town forces, some areas are influenced by groundwater infiltration to a greater extent than others, and some areas with more older neighborhoods are believed to have more inflow from sources such as foundation drains, sump pumps, and roof drains connected to sewer service piping. I/I have been reduced since the previous study, and the Town is committed to eliminating as many sources of I/I as can be determined.

Aside from review of infiltration and inflow values generated for each subsystem, there were several additional factors that were considered during the evaluation. They include:

- Age and pipe material characteristics were another factor. The relatively new PVC plastic sewers should contribute only nominal infiltration if installed correctly and if found to be undamaged during future CCTV events.
- Review of graphical data identified some subsystems to have a more direct correlation between rainfall events and spikes in the flow data than others. If the peaks appeared close, this would suggest predominately inflow contributions (vs. infiltration).
- Relative flow quantity contributions of the subsystems were also considered.
- Lastly, I/I rates relative to the 1,500 GPD/in-dia/mile threshold established by the EPA were compared.

After looking at all collected and analyzed data, it was evident that specific evaluations needed to be done for both Subsystems #9 and #7 in order to further assess the ongoing inflow and infiltration in Hudson.

3.8.1 Subsystem #9 Evaluation

As noted above, Subsystem #9 (Federal Pump Station) sewer flows are consistently above water usage data. However, when compared against rainfall, sewer flows show significant correlations between precipitation and base sewer flow increases during spring and fall peaks. Further review of Subsystem #9 would be warranted based on these comparisons between sewer flow data and rainfall graphing. Subsystem #9 is located in a neighborhood of homes immediately adjacent to the Merrimack River where a high groundwater table is assumed to be present and a likely cause of both infiltration when groundwater levels are elevated and inflow during rain events. Sewer pipe in this subsystem is generally composed of asbestos cement pipe (ACP) that is generally more susceptible to joint leakage than modern SDR-35 PVC sewer pipe.

These flow/rainfall correlations suggest that Subsystem #9 should also be the focus of videotaping during the wet spring months when groundwater might be witnessed entering the sewer system. We know that conditions in this Subsystem have been evaluated before by the Town of Hudson, and we recommend that the Town perform video inspection of the sewer mains within this subsystem to review the condition of the existing system and locate any evident infiltration conditions (separated or damaged pipe joints, cracks in sewer piping, cracks in sewer manholes, etc.). It is noted that during this particular spring 2016, no stored precipitation is available from snowmelt to help raise the groundwater table and thus help to identify leaking pipe joints or other infiltration conditions.

3.8.2 Subsystem #7 Evaluation

Subsystem #7 receives upstream flows from all other subsystems, so a separate and distinct flow assessment is difficult to perform for Subsystem #7 internal flows only. Subsystem #7 flow data was calculated by subtracting the flow data from all other subsystems from the total flow in the Main Flume crossing to the Nashua Wastewater Treatment Facility, as all other subsystems discharge into Subsystem #7 and there is no flow meter installed just for Subsystem #7. This resultant data shows multiple negative monthly flows for Subsystem #7, plus other very low positive flows that don't appear to be representative of the sanitary flows from the large number of homes within this subsystem. The Town has noted that there are no areas within this subsystem where sewer flow is overflowing out of the system or being lost to runoff, and that during periods of heavy rain the sewer system at the Main Flume backs up, rendering flow data questionable. Therefore, we believe this data to be unreliable and have discounted it from our evaluation. A summary of the data is provided in **Appendix A-3**.

Subsystem #7 is made up of mostly older homes which could be the source of significant Infiltration/Inflow. The Town has lined sewer mains within this subsystem recently which helps reduce infiltration. In the absence of reliable flow data, we recommend the Town perform more video inspections of the remainder of the old sewer system to assess the condition of the piping and evaluate for potential infiltration. These video inspections would ideally be performed during the spring when infiltration through damaged/separated pipe joints or manhole deficiencies could be observed.

SECTION 4: FINDINGS AND RECOMMENDATIONS

4.1 Impacts of Infiltration/Inflow

The Town of Hudson has an allocation of 2 MGD from the City of Nashua Wastewater Treatment Facility based on an annualized average. This allocation is based upon 12.58% of the wastewater treatment facility capacity. This capacity was reduced from 2.7 MGD to 2 MGD in the early 1990's when the City of Nashua upgraded its treatment facility. The wastewater treatment facility was originally designed for 21 MGD. The upgrade added secondary treatment facilities with a capacity of 16 MGD. The lower design capacity was the controlling factor in determining the Town of Hudson's allocation per the Town's Intermunicipal Agreement with the City of Nashua for sewer treatment, the Town's share shall be in relation to the design capacity of the treatment plant, (originally 2.7 MGD for 21.45 MGD proportion), or a current total of 2.014 MGD (based upon 16 MGD capacity).

In Section 3 *Infiltration/Inflow Updated Analysis,* the overall system average I/I for the one year period between April 2015 and March 2016 was calculated to be approximately 615,000 gallons per day. The average daily wastewater flow for the same time period is approximately 1.1 MGD, demonstrating that a continued large portion of the flow to the NWWTF continues to be as a result of I/I. Although this conclusion is disheartening since the data closely resembles the data developed as part of the 2002 Study, it is important to note that the sewer collection system has continued to age, enlarge and for many reasons, including increased attention to water conservation by residents and industries, the water usage has decreased at a different rate than the infiltration.

Infiltration/inflow can cause several problems. In the Town of Hudson it takes away allocation that would otherwise be utilized for growth, congestion of the sanitation system, cause system overflows, and it results in higher treatment costs for treating essentially "clean" water.

4.2 Summary of Subsystems with Excessive I/I

Only two areas in Hudson meet the EPA-designated definition of excessive I/I (Subsystem #8 and Subsystem #9), since Subsystem's #9 neighborhood is the smallest contributor of I/I in gallons per day, it does not appear to be a good choice for the next phase of I/I reduction efforts. The second location, Subsystem #8, demonstrates that the area contributes an average total volume of I/I, so it should be considered.

In order to most effectively address the largest contributors of I/I, we will deviate off the prescribed standards used in evaluating areas to address first.

As illustrated in **Figure 3-18,** Subsystem #5 contributes the largest flow of I/I and appears to serve one of the older neighborhoods (with older sewers) in Hudson. Although the rate of I/I remains slightly less than the EPA threshold for increased scrutiny, mitigation measures here can offer an effective use of both evaluation and repair resources to find and reduce net sewer flows.

Merrill Park, Subsystem #2 also serves an older part of Town, but with a lower rate of I/I contributing to the sewer flows than Subsystem #5. It was noted that some lengths of the 15" ACP trunk sewer of Subsystem #2 likely lie below local groundwater tables. This trunk sewer conveys flows from the upstream Subsystems #8 and #1, as well.

Industrial Park Pump Station, Subsystem #8 has received Cured-In-Place-Pipe Lining repairs indicating additional sewers may benefit from these lining efforts. A portion of the sewer profile likely lies below the stream bisecting Park Avenue, which may contribute infiltration to nearby sewers. Also, this system serves predominantly industrial and light commercial businesses.

4.3 Recommendations

4.3.1 Video Inspection, Smoke Testing, and Inspection

Based on the evaluation of sewer flow vs. water usage, we recommend additional video inspection of Subsystems #1, #2, #4, #5, #8 and #9 to try to determine sources of infiltration into the system. Video inspections would ideally be performed during the spring when active infiltration through damaged/separated pipe joints or manhole deficiencies could be observed. Smoke testing and individual home inspection could be performed any time.

4.3.2 Flow Monitoring

It is recommended that wastewater flow monitoring continue so that each subsystem can be periodically evaluated. This data will be useful in establishing a history for each subsystem. In addition, it will be helpful to compare results as repair work continues.

4.3.3 Public Education and Outreach

In addition to measures to identify and correct I/I within individual subsystems, we recommend that the Town conduct a public outreach campaign to make all Town residents aware of the costs associated with I/I and detail specific steps homeowners can make to help reduce I/I. These steps include the disconnection of roof drains and gutters from a home's sewer service, homeowner identification of potential root growth into sewer service piping, and the relocation of sump pump discharges out of a home's sewer service and into an outdoor sheet flow area. CLD can assist the Town in preparing public outreach documents for Town-wide distribution.

4.3.4 Inflow Determination/Questionnaire

Another option that the Town could consider in the attempt to quantify inflow into the overall sewer system is by mailing a questionnaire to all Town residences and businesses that are connected to the sewer system. Questions that can be included in the mailing include:

- Does your dwelling/building currently have a sump pump?
- If yes, is the sump pump discharge connected to the sewer system service lateral?

- How often does your sump pump operate (every time it rains, only during the heaviest rains, nearly all the time during the spring, etc.)?
- Is your dwelling/building foundation drain connected to the sewer system service lateral?
- Does your dwelling/building have gutters or other roof drains? Are they connected to the dwelling/building foundation drain?

Sewer service laterals, especially those for older homes, are a leading cause of sewer system I/I. This is not just inflow from foundation drains, sump pumps, etc., but also infiltration from damaged/cracked piping and poor quality installation. Clay service piping is especially susceptible to root damage. The Town could include in the questionnaire a space for the homeowner/building owner to sketch the location of the sewer service where it leaves their building. This location could be compared to Town as-built records as well as to aboveground conditions including trees, plantings, or other items that could possibly create breaches in the service piping.

Responding to such a questionnaire would be voluntary and because connection of any drain water system to a sanitary sewer is prohibited by the Town of Hudson's Sewer Use Regulations, respondents may not be willing to divulge this information. However, those responses received would provide valuable data to help identify some of the causes and locations of inflow and infiltration into the sewer system. CLD would be happy to assist the Town in developing this questionnaire.

4.3.5 Priority of Subsystems for Further Evaluation

Of these subsystems, we recommend Subsystem #5 as the priority for further evaluation of potential infiltration sources as this subsystem has some of the highest sewer flows of any subsystem. Sources of inflow are not as easily identified, but given that a portion of Subsystem #5 is made up of older homes, it is likely that inflow is at least a partial cause of the increased sewer flows. Also, there are only a small number of well users within Subsystem #5 that are connected to the sewer (11 sewer-only vs. 926 sewer/water customers) so their contribution to overall sewer flow does not appear substantial enough to explain the variance between sewer flow and water usage. Subsystem #5 has approximately 19 auxiliary (sprinkler) meters in use, which contributes to the water usage data but also may contribute to sewer flow through infiltration/inflow.

Subsystem #2 would be the second priority for further review/inspection (16 sewer-only vs. 674 sewer/water customers, and 19 auxiliary (sprinkler) meters in use), followed by Subsystems #8 (which has a much smaller sewer flow compared to other Subsystems), #9, #4, and #1.

The list below shows the priority of subsystems for further evaluation:

1. **Subsystem #5**
2. **Subsystem #2**
3. **Subsystem #8**
4. Subsystem #9
5. Subsystem #4
6. Subsystem #1
7. Subsystem #7.

Subsystems #3, #6, #10 were not considered for further evaluation because it was found that the I/I in these areas was minimal (either by total volume or by in-dia/mile assessment) compared to the other subsystems.

These evaluations could include additional video inspection, smoke testing at sewer manholes, individual home inspections, and analysis of drainage systems in the subsystems to determine if stormwater flows and outfalls are impacting the sewer system in any capacity. These methods would be tailored for the particular subsystems depending on such factors as the age of the homes, the volume of I/I calculated, the age and condition of existing sewer infrastructure if known, and the general working knowledge of the various areas that Town personnel possess and can contribute to the evaluation.

Estimated costs for additional evaluation efforts if not performed by Town personnel are as follows:

- Video Inspection of Sewer Mains - $2.50 per foot
- Smoke Testing at Sewer Manholes - $1,200 per day
- Individual Lot/Basement Inspections - $1,200 per day

These evaluation activities would likely cost less if performed by Town personnel, but we recognize the demands on Town personnel time.

If the evaluations confirm suspicions laid by this update, costs for improvements may be estimated as follows:

Subsystem #5

We believe that due to the large volume of I/I that could potentially be eliminated from this subsystem, the most reduction of I/I will be found by improvements to Subsystem #5.

Subsystem #5 is a large subsystem, but the Town has already performed some video inspection of sewer mains. If an outside vendor performed the remainder of investigative efforts for Subsystem #5, the costs would likely be in the $25,000 range based on the estimated values above.

If the continued evaluation demonstrates that I/I reduction and elimination efforts for this subsystem would be best achieved by cured-in-place pipe lining of older sewer mains, estimated costs for this work could potentially be up to $525,000 ($70/linear foot of CIPP lining @ 7,500 linear feet of suspected problem areas).

Subsystem #2

We believe that there is also some merit to continuing the investigation in Subsystem #2.

The Town has already video-inspected and lined the worst of the sewer mains within Subsystem #2. A portion of Subsystem #2 is located along the Merrimack River which likely contributes more groundwater-caused I/I than to other subsystems located further east. Video inspection, smoke and dye testing, and home inspections would all be recommended for this subsystem. Costs for these continued investigation activities would likely be in the $25,000 vicinity.

In addition to these efforts and the associated costs noted above, we would recommend a drainage study be performed to analyze flows, elevations, and groundwater impacts to the existing system. This study could identify streets within the Subsystem which could benefit from the installation of new drainage systems to convey stormwater away from areas where there may be a higher groundwater table and also provide for outfalls further downstream that may help prevent system maximization during rain events. Costs for this drainage analysis would likely be approximately $10,000. Costs for drainage upgrades as a result of the drainage analysis would be approximately $285 per linear foot, a cost which includes among other things new structures, traffic control, trench patch, design and survey, and minor easement work. For 500 feet of new drain, permitting, and some minimal treatment measures, we would budget approximately $175,000.

If the continued evaluation demonstrates that I/I reduction and elimination efforts for this subsystem would be best achieved by cast-in-place pipe lining of older sewer mains, estimated costs for this work could potentially be up to $434,000 ($70/linear foot of CIPP lining @ 6,200 linear feet of suspected problem areas).

Subsystem #8

Once Subsystems #5 and #2 have been evaluated and methods of I/I reduction identified and/or implemented, then continuing investigations in Subsystem #8 may prove to be worthwhile.

We believe that video inspection, smoke and dye testing, and home inspections would provide the information needed to determine potential I/I sources and reduction/elimination efforts. This is a smaller subsystem area-wise but includes a large amount of suspect sewer piping, so costs for an outside vendor to perform these evaluation efforts would likely be in the $30,000 range.

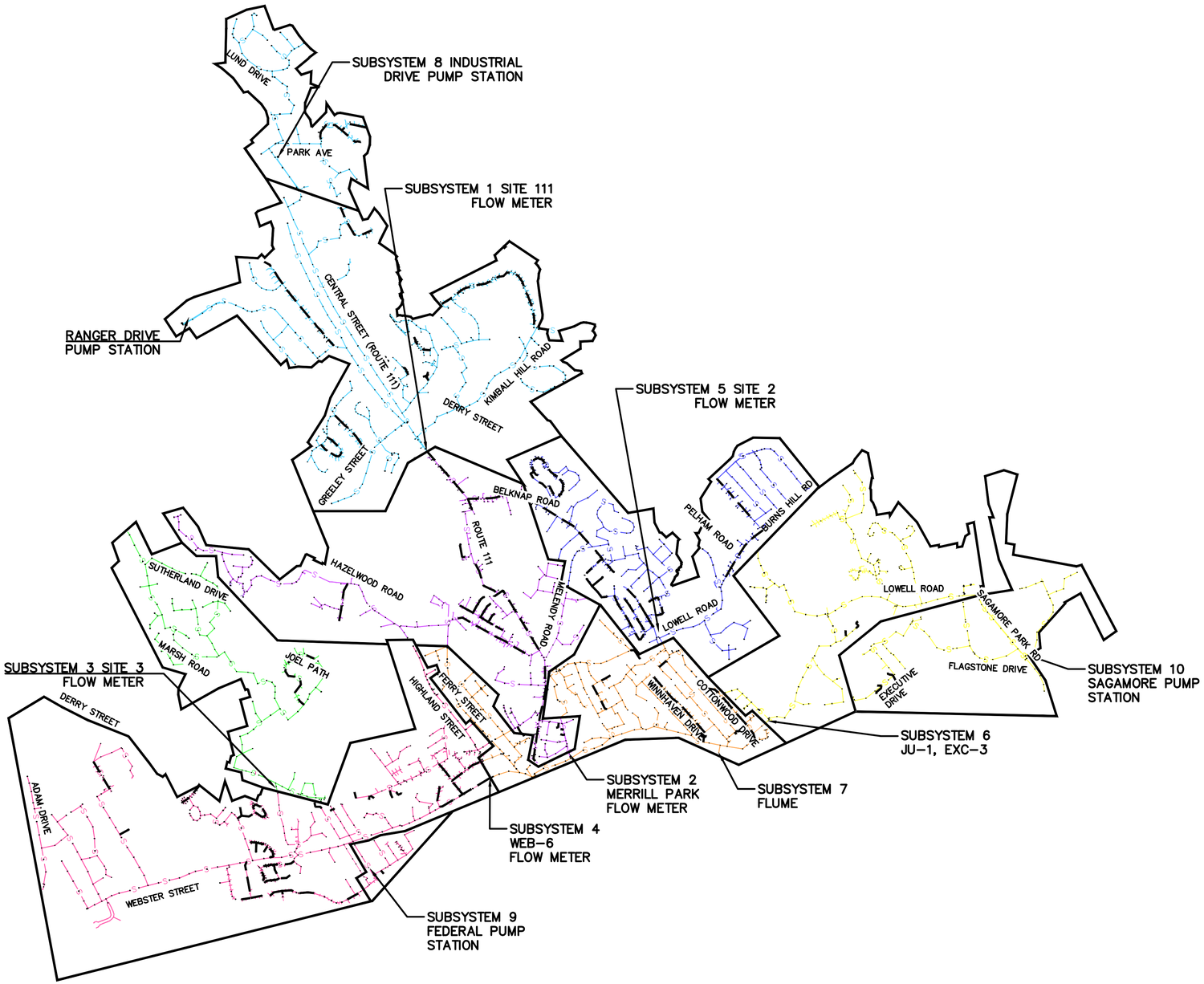
If the continued evaluation demonstrates that I/I reduction and elimination efforts for this subsystem would be best achieved by cured-in-place pipe lining of older sewer mains,

estimated costs for this work could potentially be up to $539,000 ($70/linear foot of CIPP lining @ 7,700 linear feet of suspected problem areas).

Subsystems #9, #4, #1 and #7

Due to the fact that the Town has limited resources, we believe that the Town is best positioned to attack Subsystems #5, #2 and #8 before moving on to Subsystems #9, #4 #1, or #7. Therefore, since technology and permitting requirements are changing at a rapid rate, we recommend that additional follow-up be performed in several years (or as efforts in Subsystems #5, #2, and #8 near completion) to determine the next step for reductions in Subsystems #9, #4, #1 and #7.

A-1: HUDSON GIS SEWER DATA (FIGURES 1 THROUGH 10)



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

1500 0 750 1500 3000 6000

(IN FEET)
1 inch = 1500 ft.

NO.	DATE	REVISION

DRAWN: TSP
DESIGNED: –
CHECKED: SWR
APPROVED: DAL

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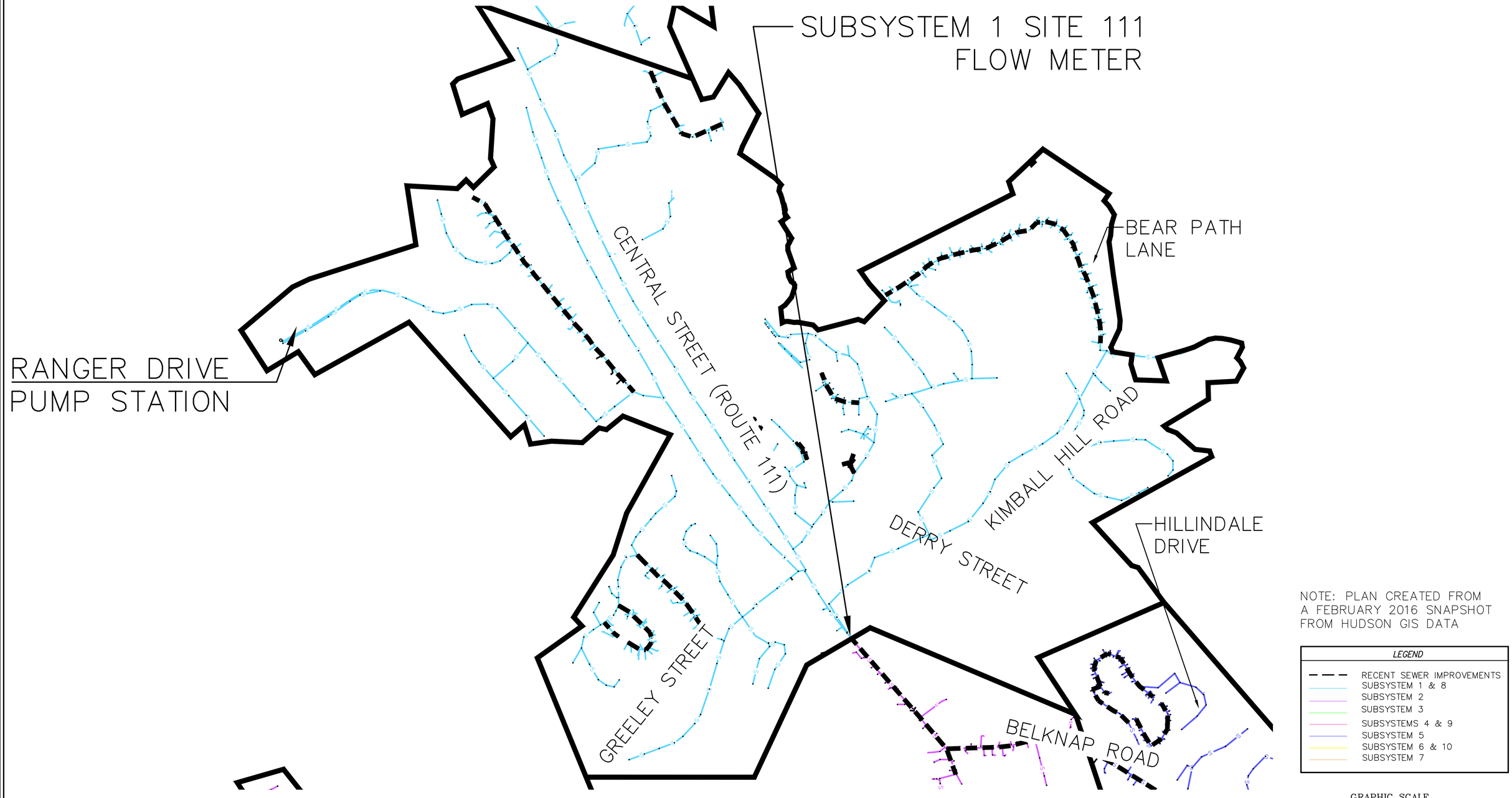
Client:
TOWN OF HUDSON
12 SCHOOL STREET 03051
HUDSON, NEW HAMPSHIRE

2016 INFILTRATION/INFLOW REPORT UPDATE

SEWER SYSTEM OVERVIEW

SCALE: 1"=1500'
JOB NO. 15-0116
DATE: JUNE 2016
DWG. OVERVIEW
FIGURE: 1



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

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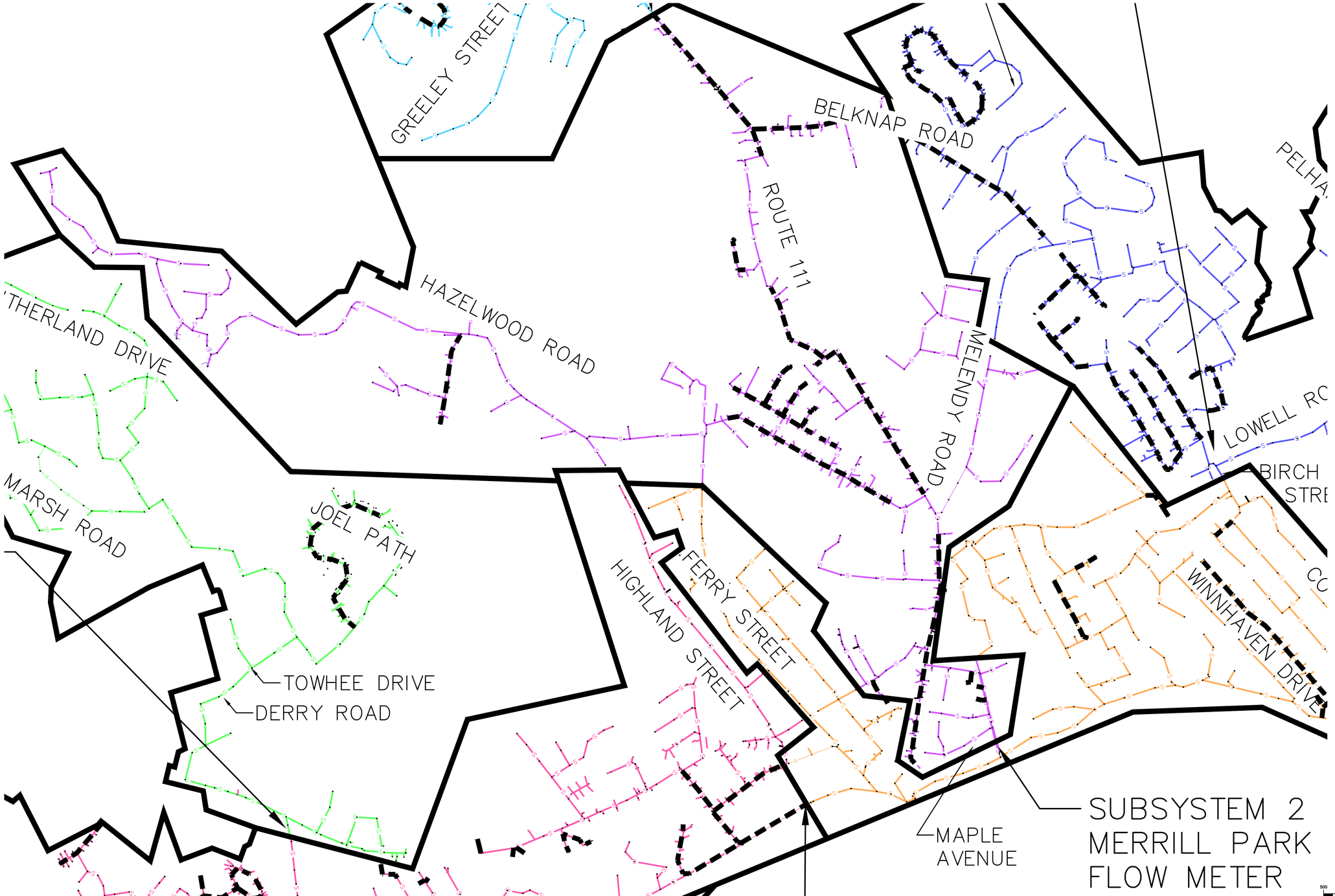
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 1 (SITE 111)

SCALE: 1"=500'
DWG. SUB-1
JOB NO. 15-0116
DATE: JUNE 2016
FIGURE: 2



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

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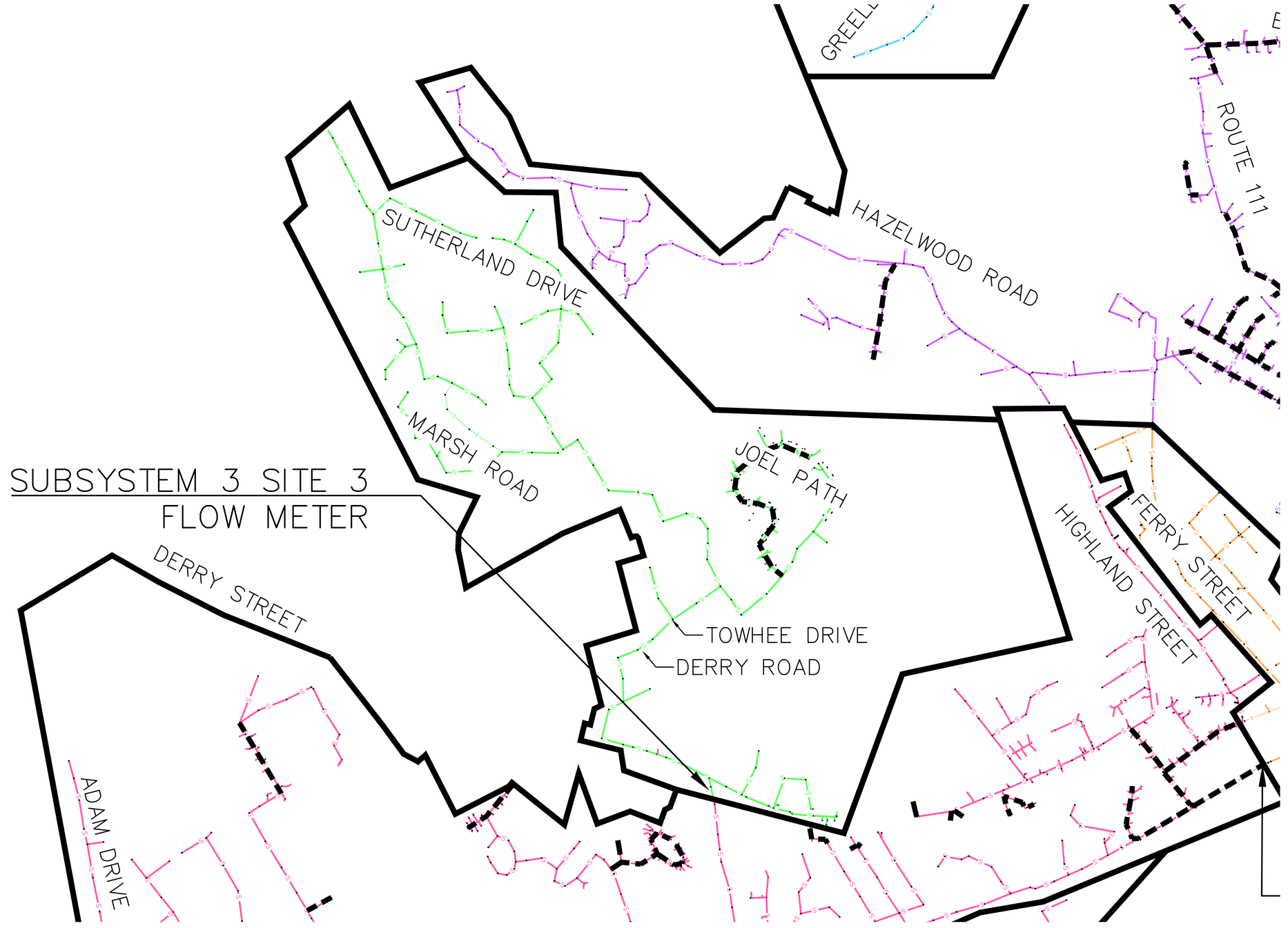
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 2
(MERRILL PARK)

SCALE: 1"=500'
DWG. SUB-2
JOB NO. 15-0116
DATE: JUNE 2016
FIGURE: 3



SUBSYSTEM 3 SITE 3 FLOW METER

NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

DRAWN: TSP
DESIGNED: –
CHECKED: SWR
APPROVED: DAL

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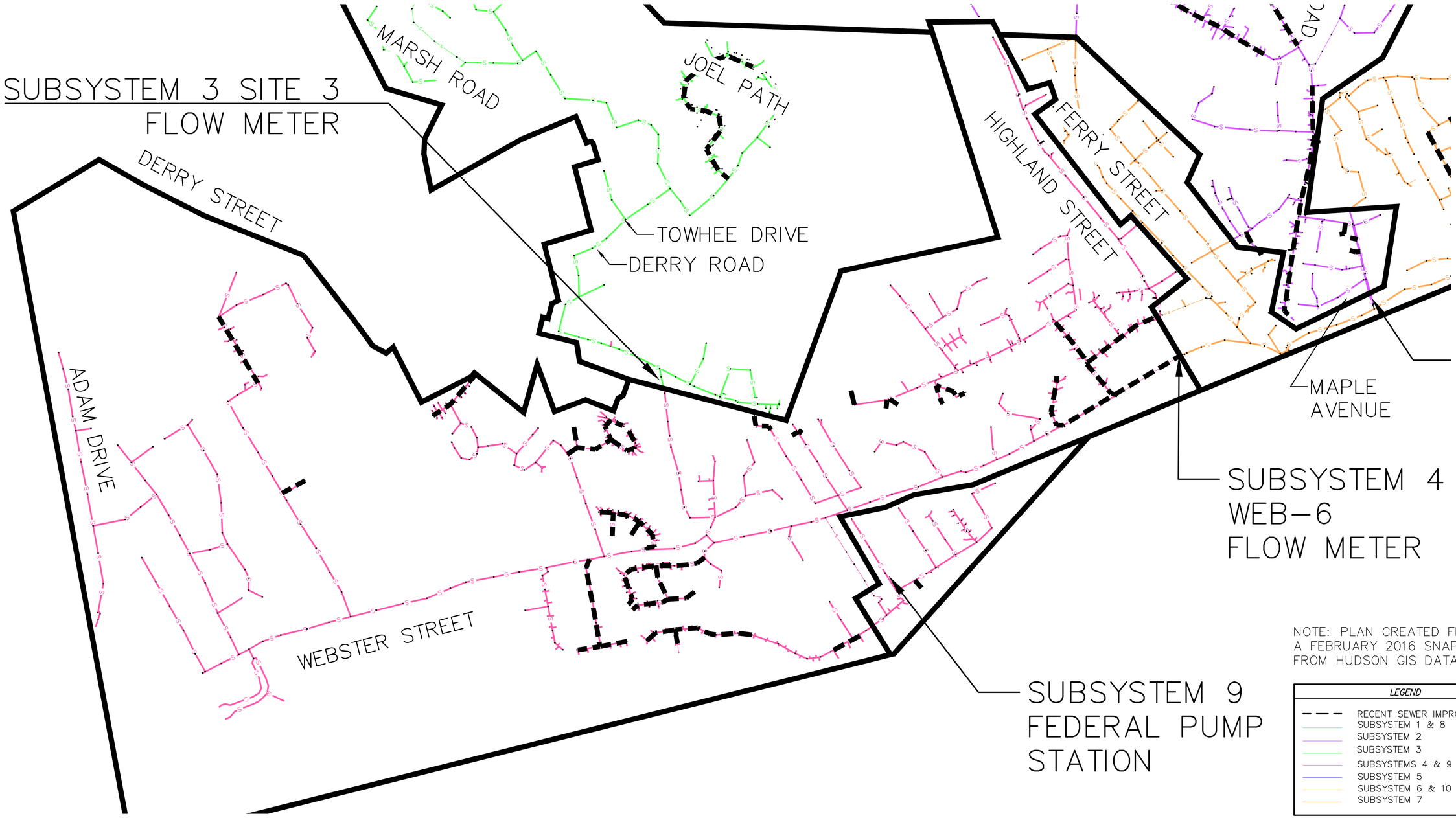
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 3 (SITE 3)

SCALE: 1"=500'
JOB NO. 15–0116
DATE: JUNE 2016
DWG. SUB–3
FIGURE: 4



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

DRAWN: TSP
DESIGNED: –
CHECKED: SWR
APPROVED: DAL

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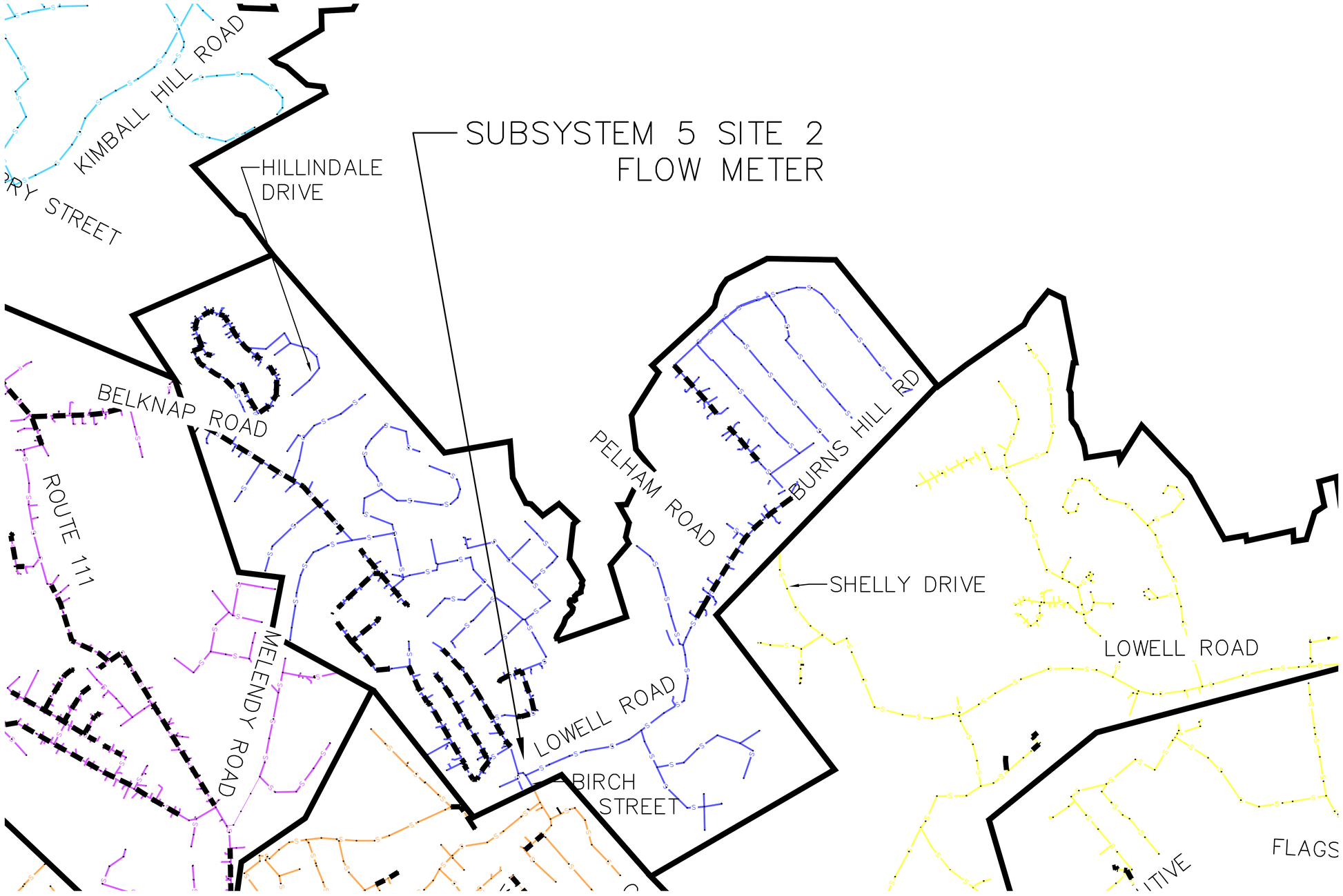
HUDSON, NEW HAMPSHIRE

2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 4 (WEB-6)

SCALE:	DWG.
1"=500'	SUB-4
JOB NO. 15-0116	
DATE: JUNE 2016	FIGURE: 5



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

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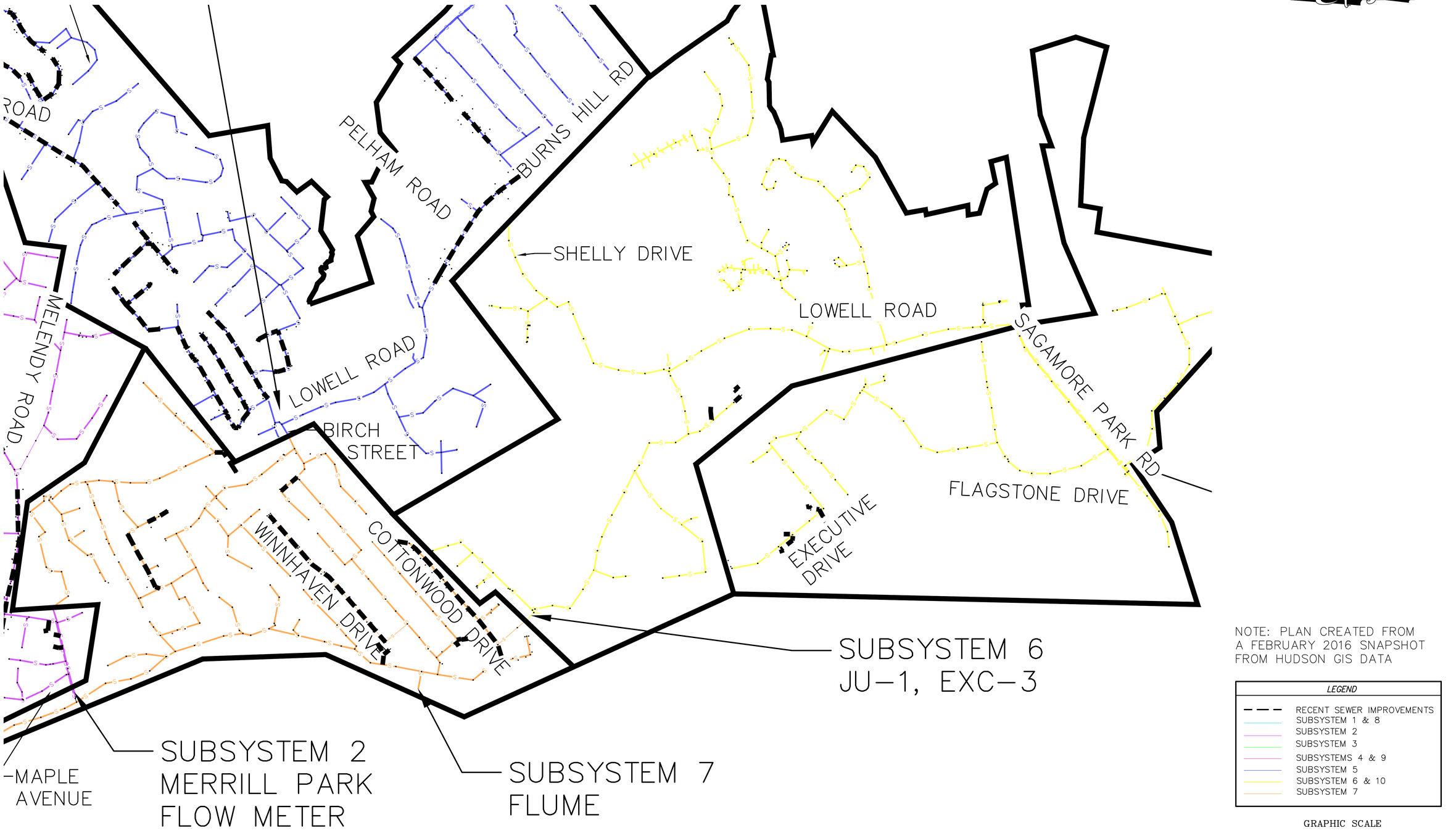
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 5 (SITE 2)

SCALE: 1"=500'
JOB NO. 15–0116
DATE: JUNE 2016
DWG. SUB–5
FIGURE: 6



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

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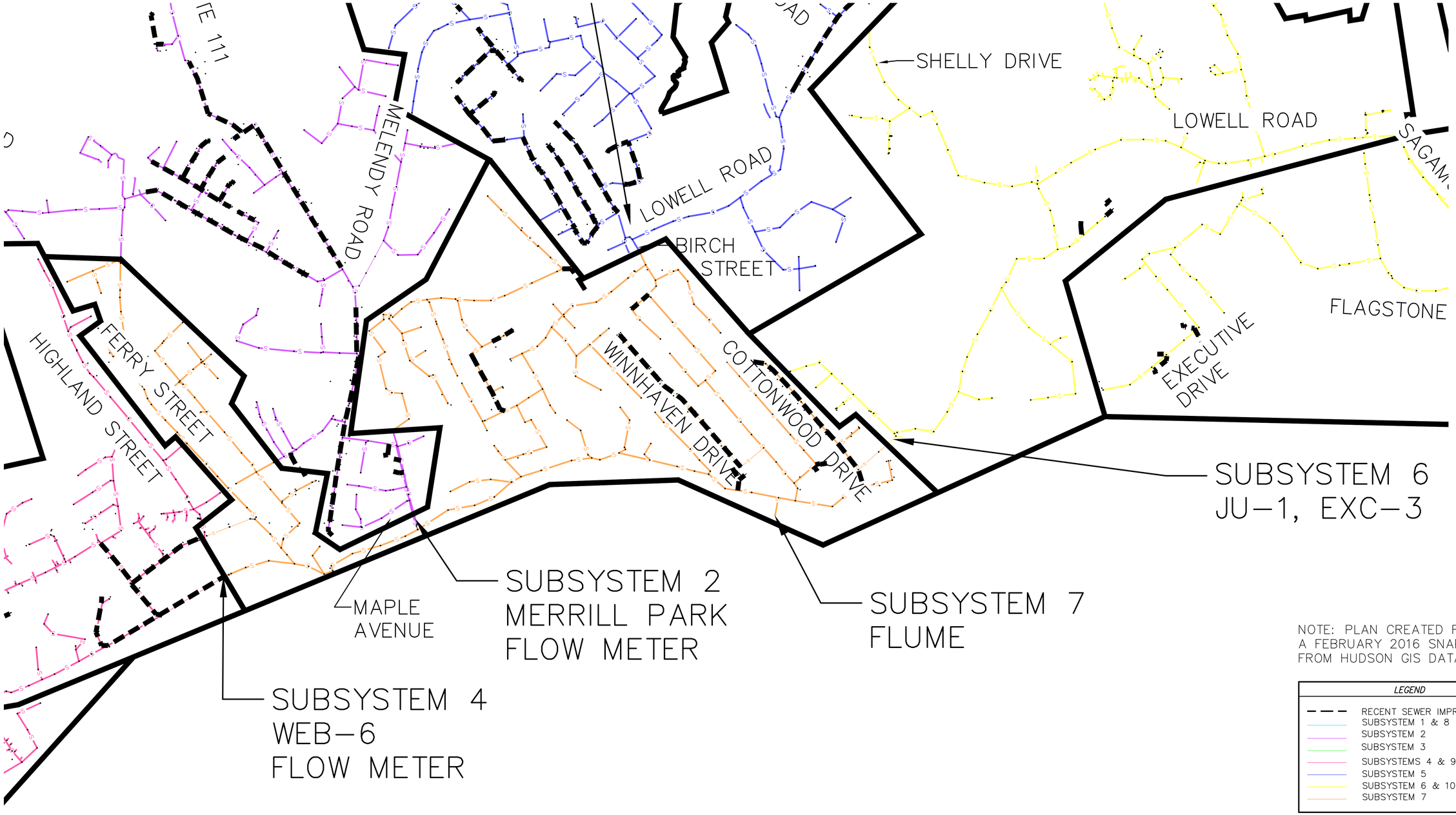
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 6
(JU-1, EXC-3)

SCALE:	DWG.
1"=500'	SUB-6
JOB NO. 15-0116	
DATE: JUNE 2016	FIGURE: 7



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

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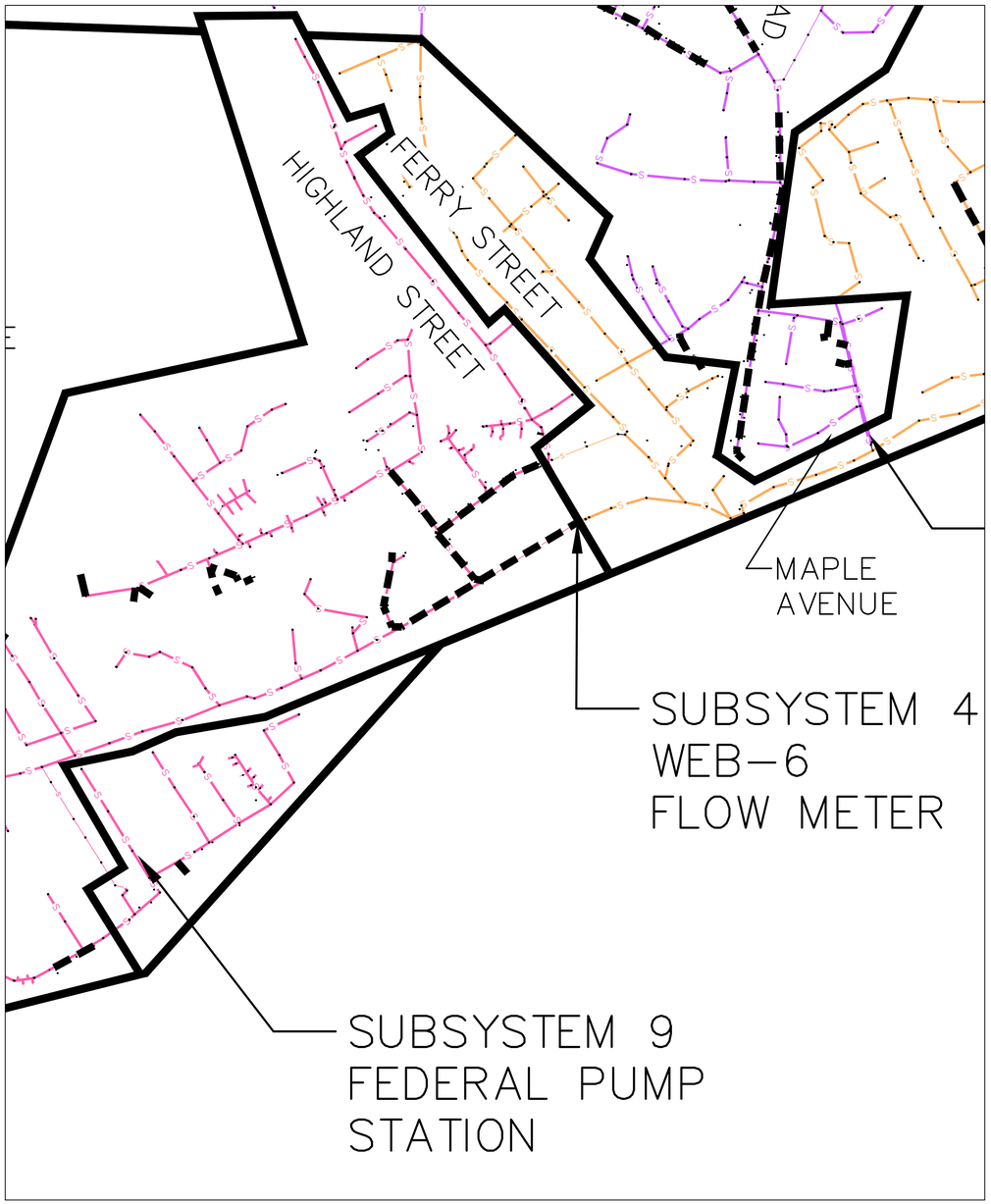
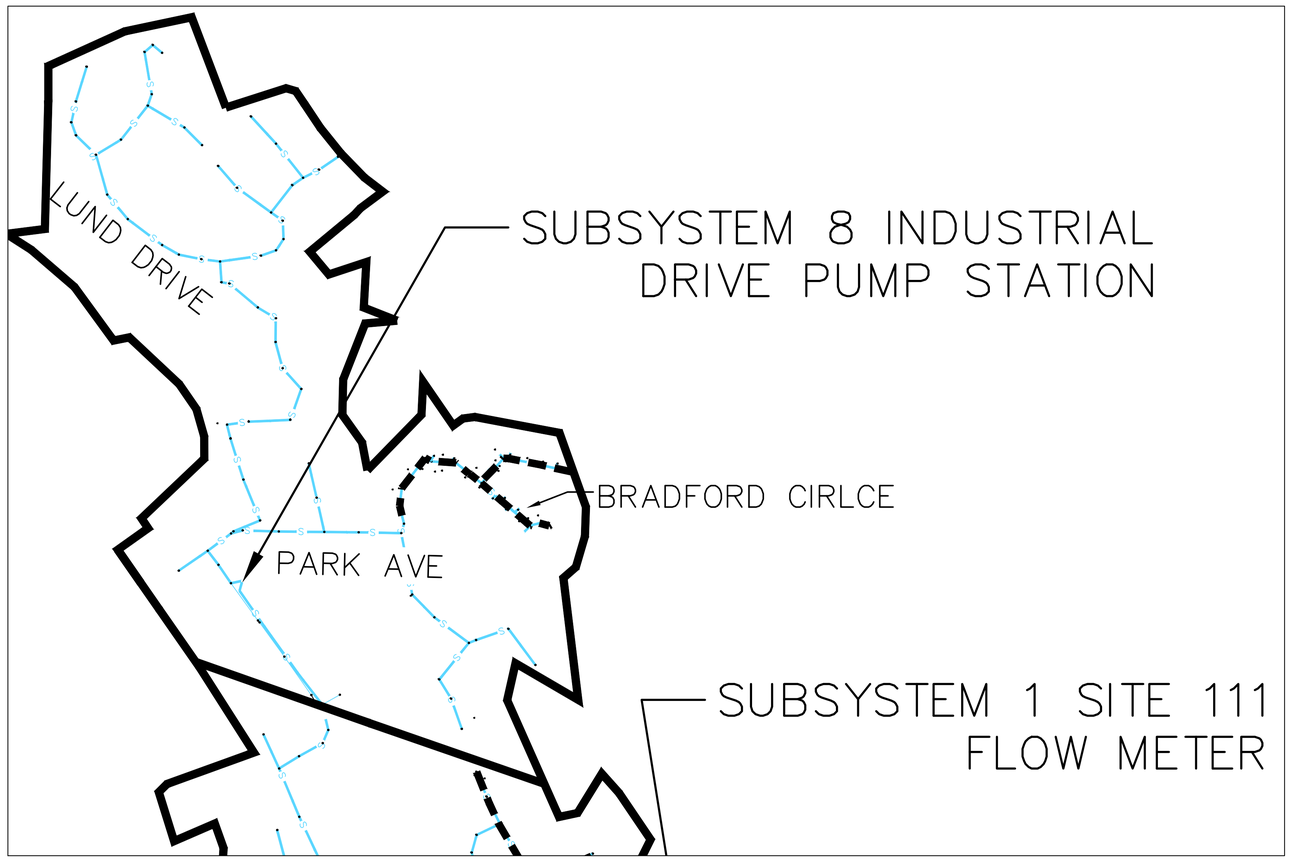
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 7 (FLUME)

SCALE: 1"=500'
JOB NO. 15-0116
DATE: JUNE 2016
DWG. SUB-7
FIGURE: 8





NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

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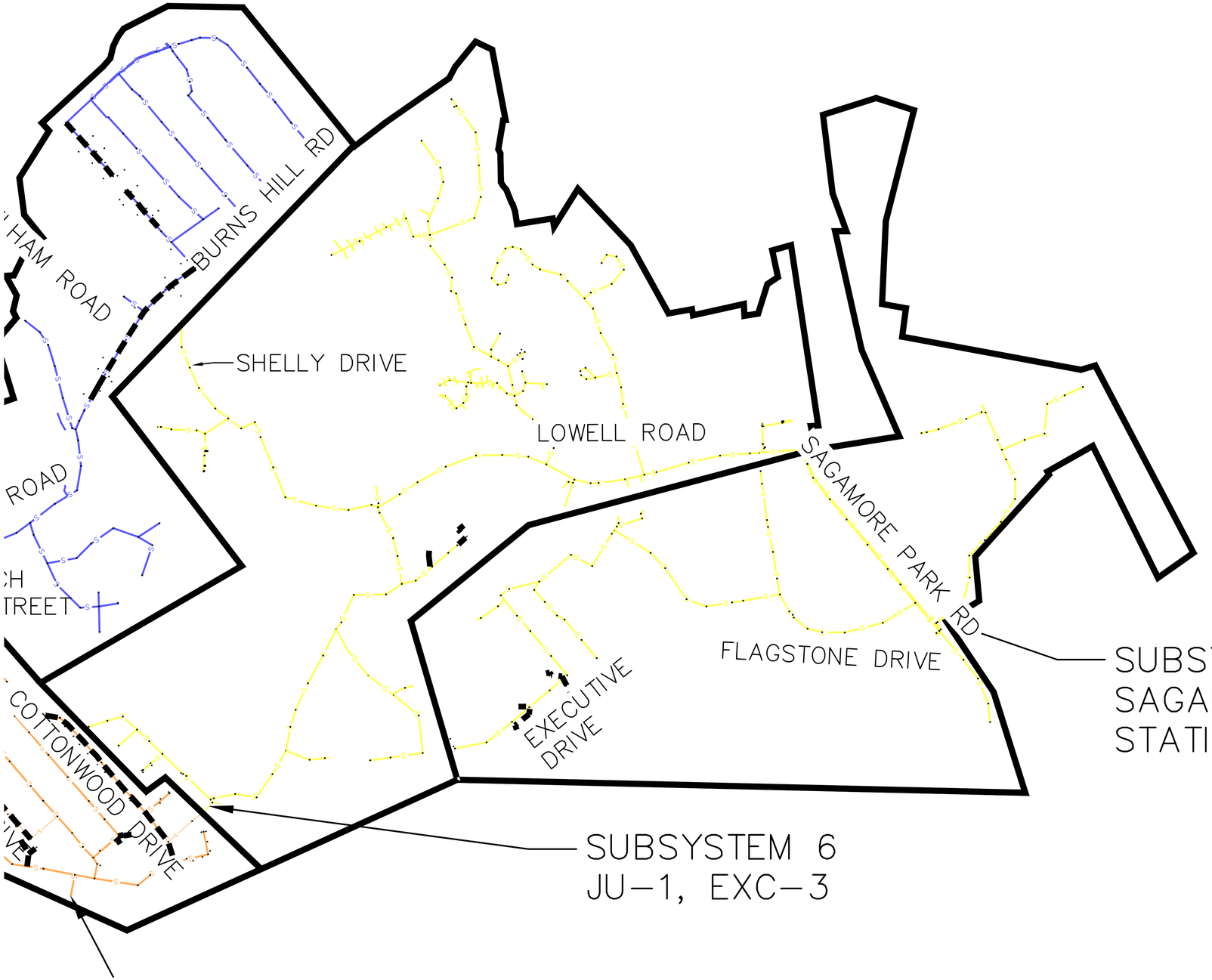
2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 8 & SUBSYSTEM 9

SCALE: 1"=500'
JOB NO. 15-0116
DATE: JUNE 2016
DWG. SUB-8, SUB-9
FIGURE: 9



NOTE: PLAN CREATED FROM A FEBRUARY 2016 SNAPSHOT FROM HUDSON GIS DATA

LEGEND

- RECENT SEWER IMPROVEMENTS
- SUBSYSTEM 1 & 8
- SUBSYSTEM 2
- SUBSYSTEM 3
- SUBSYSTEMS 4 & 9
- SUBSYSTEM 5
- SUBSYSTEM 6 & 10
- SUBSYSTEM 7

GRAPHIC SCALE

500 0 250 500 1000 2000

(IN FEET)
1 inch = 500 ft.

NO.	DATE	REVISION

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2016 INFILTRATION/INFLOW REPORT UPDATE

SUBSYSTEM 10
(SAGAMORE PUMP STATION)

SCALE: 1"=500'
JOB NO. 15-0116
DATE: JUNE 2016
DWG. SUB-10
FIGURE: 10

A-2: INTERMUNICIPAL AGREEMENT

TABLE OF CONTENTS

TABLE OF CONTENTS

THIS AGREEMENT made and entered into this 4th day of December, 1978, by and between the City of Nashua, a Municipal Corporation within the County of Hillsborough and State of New Hampshire, herinafter referred to as the "City", acting through its Mayor, and the Town of Hudson, a Municipal Corporation within the County of Hillsborough and State of New Hampshire, herinafter referred to as the "Town", acting through its Board of Selectmen

WITNESSETH

WHEREAS, the New Hampshire Water Supply and Pollution Control Commission has found both the City and Town to be discharging wastes into the waters of the State in contravention of the water quality standards, and

WHEREAS, the City and Town are authorized by law to enter into contracts and agreements for the purpose of aiding in the prevention or abatement of water pollution, and

WHEREAS, the City and Town deem it to be in the public interest to enter into a contract whereby the City would receive, treat, and dispose of the Town's wastewater through the City's Wastewater Treatment Works.

NOW, THEREFORE, in consideration of these premises and mutual benefits to be derived by the parties hereto, IT IS AGREED as follows:

1.1 For the purpose of the Agreement, the following terms are defined:

1.1.1 "Average Daily Flow" shall mean the total annual flow in millions of gallons, divided by the number of days in the year

1.1.2 "BOD" (denoting Biochemical Oxygen Demand) shall mean the quantity of oxygen utilized in the biochemical oxidation of the wastewater under standard laboratory procedure in five (5) days at 20° C, expressed in milligrams per liter.

1.1.3 "City" is the City of Nashua, a municipal corporation of the State of New Hampshire.

1.1.4 "Combined Sewer" shall mean a sewer receiving both wastewater and surface runoff from storms.

1.1.5 "Domestic Wastewater" shall mean the wastewater derived principally from dwellings, business buildings, institutions and the like. It may may not contain ground water, surface water, or stormwater.

1.1.6 "E.P.A." - Environmental Protection Agency of the United States Government or its successors.

1.1.7 "Industrial Wastewater" shall mean any and all wastewater discharged from any industry, other than domestic wastewater.

1.1.8 "Industry" shall mean any room, group of rooms, building or other enclosure used or intended for use in the operation of one (1) business enterprise for manufacturing, processing, cleaning, assembly or preparing any produce commodity or article, or from which any process waste, as distinct from domestic wastewater, shall be discharged.

1.1.9 "Operating Costs" shall mean the costs associated with operation of the Wastewater Treatment Works, including labor, chemical, power,

maintenance, material and equipment replacement costs, and consulting services related to plant operation of thos facilities used jointly. They shall also include the cost of sampling of wastes and the analysis of these samples, plus the cost accounting related to the distribution and invoicing of operating costs.

1.1.10 "pH" shall mean the reciprocal of the logarithm of the hydrogen ion concentration in grams per liter of solution.

1.1.11 "Peak Dry Weather Flow" shall mean the peak flow on the day of maximum 24-hour discharge.

1.1.12 "Septage" domestic or industrial wastewater which is collected in a septic tank or similar device

1.1.13 "Standard Methods for the Examination of Water and Wastewater" shall mean the latest edition of the said publication which is published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation.

1.1.14 "State" State of New Hampshire Water Supply and Pollution Control Commission, or its successors.

1.1.15 "Suspended Solids" (abbreviated SS) shall mean solids that either float on the surface of, or are in suspension in water, wastewater, or other liquids, and which are removable by laboratory filtering and are referred to as nonfilterable residue in the laboratory test prescribed in "Standard Methods for the Examination of Water and Wastewater

1.1.16 "Town" is the Town of Hudson, a municipal corporationof the State of New Hampshire.

1.1.17 "Wastewater" shall mean the spent water of the City and/or the Town and may be a combination of the liquid and water-carried wastes from residences, commercial buildings, industrial plants, and institutions together with any groundwater, surface water and stormwater that may

be present.

1.1.18 "Wastewater Treatment Works" shall mean any arrangement of devices and structures used for treating wastewater.

1.1.19 "Wastewater Works" shall mean all structures, equipment and processess for collecting, pumping, treating and disposing of wastewater.

ARTICLE II AGREEMENT TERM

The provision of this Agreement shall remain in full force f the useful life of the treatment facilities subject to the provision Article XI.

ARTICLE III OBLIGATIONS AND RESPONSIBILITIES

3.1 Acceptance of the Town's Wastewater by the City

The City shall receive, treat, and dispose of the Town's was water in accordance with all existing or future laws, regula tions, ordinances, water quality standards, orders, and decrees of any governmental authority having jurisdiction over the treatment and disposal of said wastewater.

3.2 Unacceptable Discharges from the Town

The Town will not connect any additional combined sewer with the City's system beyond those in existence on the date here and will not discharge into the Wastewater Works of the City any drainage substances or wastewater which is in violation of the latest revision of the City of Nashua's Sewer Use Ordinance at the time of signing this Agreement, or any futu revisions to the Ordinance.

In the event of the Town discharging wastewater to the City' Wastewater Works which is in violation of the City's Sewer Use Ordinance it shall be the Town's responsibility to locat and eliminate the source, or sources, of such wastewater.

3.3 Sewer Use Ordinance for the Town

Prior to connection of the Towns wastewater Works to the City's Wastewater Works the Town agrees to adopt and enforce a Sewer Use Ordinance which is at least as restrictive as the above referenced City Sewer Use Ordinance. The Town Ordinance, and proposed revision thereto, shall be sent to the State and Environmental Protection Agency for approval and to the City for review and concurrance. The City shall inform the Town of any changes in the City Sewer Use Ordinance. Both ordinances will be written to insure the efficient and effective operation of the Wastewater Treatment Works. The City will not require an ordinance of the Town more restrictive than that in force in the City.

3.4 Industrial Cost Recovery

The Town agrees to adopt an equitable system, acceptable to EPA and in accordance with EPA regulations, for recovery of industrial waste treatment costs. A draft of the proposed equitable cost recovery system will be submitted through the State for approval by EPA; a copy shall be sent to the City for information purposes.

The Town shall inventory and survey all the industries within the Town. The survey shall be conducted at least annually and shall produce all pertinent information required either by the City or to comply with EPA regulations. Based upon the Town's share of the firs costs of the joint facilities and the analysis of the industrial process wastes, the Town will compute the amount to be paid under the industrial cost recovery regulations by the industries involved. Cop of the computations and the back-up data will be transmitted to the City. The Town will collect the sums payable by the industry, pay 50% to the City for transmission to the Federal Government and invest the other 50% for later use as part of the Town's share in future

joint construction, all in conformance with P.L. 92-500 and such amendments as may be issued.

If so requested by the Town, the City will carry out the necessary analysis required for determination of industrial recovery payments as part of normal plant operation.

The Town shall turn over to the City at the time of the final payment for the fiscal year the amounts due the City for transmission to the Federal Government as established above.

3.5 Septic Tank Pumpage

All septic tank pumpage (septage) from within the Town shall be discharged at a designated location within the Town. No septage from within the Town shall be discharged within the City.

All septage shall conform to this agreement prior to discharge.

ARTICLE IV IMPLEMENTATION

4.1 Construction by the City

The City agrees to construct wastewater works for receiving treating and disposing of the Town's wastewaters within the limits of the City of Nashua. The major interceptor sewer has been constructed from the point of connection (a point where the North Merrimack Interceptor I angles away from its parallel route with the Merrimack River towards the Wastewater Treatment Works - a distance of approximately 1000 feet). The sewer has been sized to adequately handle the estimated peak dry weather flow of the users through the design period (2020). The pumping facilities and primary treatment facilities and primary treatment facilities have been constructed to handle the estimated peak dry weather flow through the design period 1995. Initial construction provides for primary treatment only.

Secondary Treatment is planned for the immediate future.

4.2 Construction by the Town

The Town agrees to independently construct a collection and interceptor system terminating at the point of connection described above. The Town will take the easements required in the City as necessary for connections to the Town. The costs of such easement will be borne by the Town.

ARTICLE V CAPITAL COSTS APPORTIONMENT

5.1 Bonding for the Existing Primary Works

The City has issued general obligation bonds (hereinafter called the "Bonds") in order to finance the project costs of the Primary Wastewater Treatment Works constructed in 1960, and expanded in 1963 and 1974. The project costs include all costs involved in the preliminary design, final design and construction phases of the Wastewater Works, and also include land costs, administration and legal costs, bond fees, interest and all other costs incidental to the completed projects for original construction and the two expansions. The bonds have been issued from time to time, either separately or as part of a larger issue of bonds by the City. Each issue or series of bonds is repayable in equal periodic principal amounts for 20 years after its date of issue, and the principal and interest are payable semi-annually.

5.2 Payment of Capital Costs for the Existing Primary Works for 1960 and 1963 Projects.

The Town shall pay to the City, within sixty (60) days of the effective date of this Agreement, a lump sum of $58,612 as the Town's share of the project cost-to-the-City, of

the original treatment plant constructed in 1960 and added t
in 1963. The Town's share shall be in the relation that the
design capacity for Hudson (2.70 MGD) bears to the total des
capacity of the exisitng Sewage Treatment Plant (21.45 MGD),
i.e., 12.58%. The "project cost" is defined in Section 5.1
1974 Project - The Town shall pay to the City, in yearly pay
ments over the remaining life of the bond issue used to fina
the project in accordance with a schedule furnished by the
City, the Town's share of the project cost-to-the-City of th
primary treatment plant constructed in 1974. The Town's sha
shall be the same proportion as for the 1960 and 1963 plants
12.5%. "Project Cost" is defined in 5.1 above, and includes
the intercepting sewer from the point of Hudson's Connection
to the Wastewater Treatment Works.

The City shall furnish the Town with a breakdown of the Town
share of the total project-cost-to-the City, and a schedule
indicating the dates payments are to be made, by the Town to
the City, and the amount thereof.

State and Federal Aid - Hudson will only participate in the
costs-to-the-city of the above projects; State and Federal A
received shall be substracted from the project costs to deter-
mine the cost-to-the-city.

5.3 Payment of Capital Costs for Secondary Treatment

When the City is required to provide secondary treatment, th
Town will pay to the City as its share of the additional pro
ject costs (exclusive of Federal and/or State contributions)
and amount equal to the summation of the cost determined by
applying the following formulae:

$$\frac{\text{Town's average flow for the design year}}{\text{Total plant average flow for the design year}} \times 0.26\ C$$

$$\frac{\text{Town's average BOD for the design year}}{\text{Total plant average BOD for the design year}} \times 0.61\ C$$

$$\frac{\text{Town's average Suspended Solids for the design year}}{\text{Total plant average Suspended Solids for the design year}} \times 0.13\ C$$

C = Total project cost of additional facilities (exclusive of Federal and/or State contributions) as defined in Article 5.1 (exclusive of Bond fees and interest).

The Town shall pay its portion of the estimated project cost of secondary treatment facilities by coordinating monthly payments to the City based on actual construction costs as approved for payment by the City to the Contractor. Payment for design costs will be billed to the Town 390 days after approval. Payment for construction costs will be billed to the Town immediately after approval. Any adjustments in overpayment or underpayment by the Town will be made when EPA makes final payment to the City on the project. Non-payment within 30 days of submission of a bill by the City to the Town for the Town's share of project costs shall result in a surcharge of 9% per annum being assessed. In the event of non-payment for 390 days after billing, the City may bring termination proceedings under Paragraph 11.2.

5.4 Treatment Levels Greater than Secondary Treatment

In the event that a degree of treatment greater than secondary treatment is required, the method of allocating costs to each party for the additional plant or facilities shall be negotiated by both parties.

5.5 Treatment Capacities Provided by the City

The City has provided the following capacities in the initial

construction of its Wastewater Treatment Works for the Town
Wastewater:

	Year 1995
Average Daily flow	2.7 mgd
Park Dry Weather flor	8.7 mgd
BOD (Average of 24-hour composites)	4500 ppd
SS (Average of 24-hour composites)	5700 ppd

For the purpose of this Article, the City's desing capacity (including the allowance for the Town) shall be as follows:

	Year 1995
Average Daily Flow	21.5 mgd
Park Dry Weather Flow	50.3 mgd
BOD (Average of 24-hour composites)	28,250 ppd
SS (Average of 24-hour composites)	29,650 ppd

Mgd = million gallons per day

ppd = pound per day

5.6 Sale of Capacity

If either party exceeds the flows and/or strengths specified, one party can sell its unused capacity to the other party with the sharing of costs to be negotiated.

5.7 Payment of Other Capital Costs

Other capital costs, not specifically treated herein, and whi are not treated as Operating Costs, shall be computed and pai for in the same manner as that for Secondary Treatment.

ARTICLE VI OPERATING COSTS APPORTIONMENT

6.1 Method of Apportionment

The operating cost, as defined in Article 1, to the Town shal

apportioned on a porportional basis; on the basis of average flow, BOD and suspended solids.

The annual net operating costs to the City for the Primary Wastewater Treatment Works, less any operations grants from any sources, shall be apportioned on the basis of flow and suspended solids as follows:

	Flow	SS
Labor	70	30
Power	90	10
Chemicals	60	40
Heat	70	30
Maintenance/Supplies	70	30

After the construction of secondary facilities, the annual net operating costs to the City for the primary and secondary facilities, less any operations grants from any sources, shall be apportioned on the basis of flow, BOD, and Suspended Solids at the following percentages:

	Flow	BOD	SS
Labor	40	35	25
Power	30	50	20
Chemicals	50	20	30
Heat	50	30	20
Maintenance/Supplies	20	40	40

6.2 Determination of Apportionment Parameters

Average daily flow rates shall be determined for the Town on the basis of the records obtained from metering equipment installed at the Town's metering and sampling station, and recording equipment installed at the Wastewater Treatment

Works. The average daily flow shall be determined for each quarterly period of the year by adding all of the total daily flow readings from the totalizer for each day of the quarterly period and dividing by the total number of days in said perio BOD and Suspended Solids from the Town shall be determined fr proportional, composite, 24-hour samples obtained at the Town metering and sampling station by the City. Composite samples shall be analyzed at the Wastewater Treatment Works by plant personnel. The average daily BOD, and SS, in pounds per day (ppd), shall be determined for each quarterly period of the year by a sampling and analyses program. A minimum number of seven 24-hour composite samples (composited as to flow) shall be collected and analyzed each month. The samples can be taken at any time during the month, but each sample shall represent a different day of the week. In lieu of the samplin program established hereinbefore, both parties may agree on the concentration of BOD and SS to use in computing the Town's share of the operating cost. The method of establishing the BOD and SS concentration and the period of time for which these concentrations shall be used to determine the Town's share of operating costs shall be mutually agreed upon by each party.

6.3 Method of Payment

Within three (3) working days after the end of the first quarterly period, the City will notify the Town in writing of the Town's share of estimated operating costs for said quarter period. The Town will make full payment to the City within thirty (30) days of receipt of said notification. Within three (3) working days after the end of each subsequent

quarterly period, the City will notify the Town in writing of the Town's share of estimated operating costs (the Town's share of estimated operating costs will be equal to the Town's share of actual operating costs for the second preceding quarter) and the City will adjust the share of estimated operating costs by subtracting any overpayment of or by adding any underpayment of actual costs of the second prec quarter. All of the aforementioned allocations are tentative and shall be as reasonable as circumstances will permit. If the Town fails to make payment to the City within thirty (30) days, the Town will pay a surcharge to the City of 9% per annum. The first quarterly statement after commencement of us by the Town will contain the actual cost to the Town for any time and expenses expended by the City for the new operator training and consulting services incurred after the date here This will include any time and expenses incurred by new perso who will supervise or operate the facility, who are hired in advance of start-up of the facility for the purpose of gainin advance knowledge of the facility, and shall also include any costs associated with operator training courses in which futu operator or operators take part. Their costs will be apportic to each participant on the basis of actual flows. Written verification of such cost expenditures shall be submitted to the Town for its review.

6.4 Cost Accounting

The City shall maintain an adequate cost accounting system which shall be the basis for the determination and allocation of costs. This accounting system shall be subject to review by the Town. The City will submit to the Town at the end of

and will supply, upon request, any supporting information. I the event that the Town disagrees with the accounting or all tion procedures used to arrive at such costs after consultin with the City, the matter shall be submitted to the respecti party's independent auditors for resolution.

6.5 Review of Apportionment Percentages

The City and Town both agree that the apportionment of costs forth in this Article shall be subject to review annually. A a review of the annual costs, if an adjustment to the costs appears to be necessary, said adjustment shall be made by th City in the forthcoming billing for services. The adjustment will be to the mutual satisfaction of the City and Town. Sho arbitration be necessary it shall be conducted in accordance with Article XIII.

6.6 Responsibility for Operation of the Wastewater Treatment Wor

The City shall have sole responsibility for operation of the Wastewater Treatment Works.

ARTICLE VII ADJUSTMENT CLAUSE

7.1 Pretreatment

The Town reserves the right at any time to pretreat and/or to reduce either or both the quantity and quality of its waste- water, or to otherwise give preliminary treatment to its wast water prior to discharge to the City's Wastewater Treatment Works. If the Town elects to reduce either or both the quant and quality of its wastewater, or to otherwise give prelimina treatment to wastewater it shall not relieve the Town from paying its share of the project costs as established under Article V.

ARTICLE VIII NOTICE OF CHANGES

The Town agrees to notify the City's Board of Public Works as far in advance as possible of any anticipated or planned significant increases or decreases in both the quantity and quality of the wastewater to be discharged to the City facil

ARTICLE IX MEASURMENT OF FLOW

9.1 Flow Metering and Sampling Station

The Town will construct a flow metering and sampling station the design and operation of which will be subject to the Cit approval. The station shall be located in the Town's system as close as practicable to the connection with the City's sy in a location accessible to the City on the Town's side of t Merrimack River. Equipment will be installed by the Town fo monitoring the agreed upon design flow set forth in Article and for the purpose of computing the charges set forth in Ar VI. The Town shall pay all costs required to furnish and ins the flow metering equipment, reduce by State & Federal Grant and all costs required to maintain said equipment in acceptal working condition. The flow meter will be designed and oper so as to transmit flow information to indicating, totalizing and recording equipment at the City's Wastewater Treatment W The Town shall do all of the work to install the necessary e ment for transmitting the flow information over leased teleph wires to the City's Wastewater Treatment Works, and will pay required costs including the leasing charges for use of Tele Company Equipment. Design and operation of the equipment wi subject to the City's approval to insure compatibility with City installations.

The City will be responsible for maintaining the recording e ment

accuracy and reliability of the flow metering and transmitting equipment. The Town will be advised of the results of any tests made on the equipment and the methods used to ascertain its accuracy and reliability. The City shall have reasonable access to the metering and sampling station.

9.2 Temporary Malfunction of Metering Equipment

In the event the metering equipment is temporarily out of order or service for any reason, the volume of wastewater will be estimated by the City and the Town on a mutually agreed upon basis.

ARTICLE X SAMPLING AND ANALYSIS OF WASTEWATERS

The City and the Town both agree that the determination of character and concentration of wastewater will be in accordance with the latest edition of "Standard Methods for the Examination of Water and Wastewater" as proposed, approved and published jointly by the American Public Health Association, the American Water Works Association and the Water Pollution Control Federation, or any other method mutually agreed upon by the City and the Town, and subject further to the following:

The sampling and determination of the character and concentration of the Town's wastewater for the purpose of computing the charges shall be the responsibility of the City or its authorized agent. The Town shall be furnished copies of all such determinations.

Samples shall be collected by the City at the Town's metering and sampling station, and in the manner described in Article VI so as to be representative of the actual quality of the wastewater, and shall be used as a basis for computing the distribution of operating costs. The Town may however, conduct its own sampling and analysis program and submit the results relating to the character and concen-

tration of its wastewater to the City. Portions of wastewate samples collected by the Town as part of a sampling and analy program will be made available to the City at no cost and in adequate quantities for analysis by the City for characterist and concentrations. In the event of discrepancy in results o analyses between the City and the Town, and said discrepancy cannot be satisfactorily resolved, then the parties will sub- mit the samples to a mutually acceptable disinterested qualif third party for determination of the wastewater characteristi

ARTICLE XI BREACH OF AGREEMENT AND TERMINATION

11.1 Breach of Agreement

a. In the event of breach of this Agreement by either party, (exclusive of events not within the control of the parties) t other party shall give written notice of the breach to the pa who has caused the breach. The party who has caused the brea shall correct the breach at once, and shall pay for any damage caused by the breach within 45 days after being sent a bill.

b. If the breach is not corrected at once, or if the damages are not paid as provided under (a) above, the issue shall be submitted to the Executive Director of the Water Supply and Pollution Control Commission for resolution. The Director shall decide the issue under rules of procedure established b the Attorney General of New Hampshire.

c. In the event either party rejects the Director's decision issue shall be submitted to the said Commission for resolutio The Commission's decision shall be subject to appeal only und RSA:541.

11.2 Termination

Either party may bring proceedings to terminate this Agreeme for continued material breach by the other party or any comm using its capacity. Termination shall be effected by mutual ment, or, if mutual agreement cannot be reached, by submitti a written request for termination to the said Executive Dire The Director shall decide the termination request and the te under which termination is to take place, under rules of pro cedure established by the Attorney General of New Hampshire. In the event either party rejects the Directors' decision, t issue shall then be decided by the said Commission. The Com mission's decision shall be subject to appeal only under RSA

ARTICLE XII REVISIONS TO STATE AND FEDERAL REGULATIONS

In the event of revisions to State and Federal Regulations having a material affect on this Agreement, the Agreement may be renegotiated.

ARTICLE XIII DISPUTES

The parties herto agree that if any dispute not covered under section 11.1 arising out of this Agreement and/or its continu tion cannot be resolved by the parties within 30 days, the di pute shall be resolved in the same manner as in Section 11.1

ARTICLE XIV APPROVAL AND FUNDING

This Agreement, including any funding required thereunder, sh become effective only upon approval by the requisite governin bodies.

ARTICLE XV GENERAL OWNERSHIP OF FACILITIES

General ownership of all wastewater works located in the City (other than the Town's interceptor located east of the point

connection in Section 4.1) shall remain in the City during the life of this Agreement. The Town shall have special ownership in all rights of use thereof as are specifically provided herein. The rights of the Town hereunder are assignable with the written consent of the City, which consent shall not be unreasonably withheld.

IN WITNESS WHEREOF, the City of Nashua has prepared this Agreement and causes it to be executed by its Mayor, and the Town of Hudson, has caused this Agreement to be executed by its Board of Selectmen thereunto duly authorized.

FOR THE CITY OF NASHUA, NEW HAMPSHIRE

Mayor

Approved as to Appropriation:

Approved as to Form and Properly Execut

Corp. Counsel

11/4/78

FOR THE TOWN OF HUDSON, NEW HAMPSHIRE

Board of Selectmen

Chairman

Approved as to Appropriation:

Approved as to Form and Properly Execut

AMENDMENT TO
NASHUA-HUDSON WASTEWATER TREATEMENT AGREEMENT
EXECUTED DECEMBER 4, 1978

The City of Nashua (City) and the Town of Hudson (Town) agree that the following provisions of the agreement between them, entitled "Nashua-Hudson Wastewater Treatment Agreement," executed December 4, 1978, are amended as follows:

I. ARTICLE IV, is amended by adding the following to Section 4.2:

The Town further agrees to independently construct or cause to be constructed an additional collection and interceptor system together with a point of connection all as shown on the plans entitled "Plan and Profile Sanitary Sewer Hudson, New Hampshire" prepared for Sanders Associates, Inc., dated 28 March 1983, Allan H. Swanson, Inc. consisting of eight (8) sheets, which plans are jointly on file with the office of the City Engineer of the City of Nashua, and with the Office of the Town Engineer of the Town of Hudson. Said plans are incorporated into this Amendment by this reference thereto, and are an integral part hereof. The Town will acquire the easements, river crossing rights and other interests in land as are necessary for the construction of said interceptor system, and as are necessary for connection to the City's existing interceptor system, as shown on said plans. The costs of acquiring said easements, river

crossing rights and other interests in land shall be borne by the Town or parties other than the City. The parties agree that the flow from the aforesaid additional collection and interceptor system into the aforesaid point of connection shall be limited to three hundred (300) gallons per minute unless otherwise approved by the Nashua City Engineer.

II ARTICLE IX is amended by deleting the present provisions of Section 9:1, and inserting in place thereof the following:

9.1. FLOW METERING AND SAMPLING STATIONS.

The Town will construct or cause to be constructed flow metering and sampling stations, the design and operation of which will be subject to the City's approval. The stations shall be located in the Town's system, as close as practicable to each connection with the City's system, in locations accessible to the City on the Town's side of the Merrimack River. Equipment will be installed by the Town for monitoring the agreed upon design flow set forth in Article V and for the purpose of computing the charges set forth in Article VI. The Town or parties other than the City shall pay all costs required to furnish and install the flow metering equipment, reduced by State & Federal Grants, and all costs required to maintain said equipment in acceptable working condition. The flow meters will be designed and operated so as to transmit flow information to indicating, totalizing and recording equipment at the City's Wastewater Treatment Works. The Town shall do or cause to be done all work to install the necessary equipment for

transmitting the flow information over leased telephone wires to the City's Wastewater Treatment Works, and will pay all required costs including the leasing charges for use of Telephone Company equipment. Design and operation of the equipment will be subject to the City's approval to site compatibility with the City's installations.

The City will be responsible for maintaining the recording equipment and checking the accuracy and reliability of the flow metering and transmitting equipment. The Town will be advised of the results of any tests made on the equipment and the methods used to ascertain its accuaracy and reliability. The City shall have reasonable access to the metering and sampling stations.

III. The parties agree that the City of Nashua shall not be obligated to accept sewage through any connection constructed pursuant to Section 4.2 above until all flow metering and sampling stations associated with said construction are fully completed and certified as operational by the Nashua City Engineer.

IV. The remaining provisions of the Agreement between the parties executed December 4, 1978 are fully applicable to all construction contemplated by this AMENDMENT, and are otherwise to remain in full force and effect.

V. The parties acknowledge that the New Hampshire Water Supply and Pollution Control Commission is not a party to this AMENDMENT, and that this AMENDMENT is not to become effective until it has been executed by both the City and the Town.

CITY OF NASHUA, NEW HAMPSHIRE

By its Mayor

Date: 7/6/93

TOWN OF HUDSON, NEW HAMPSHIRE

By its Board of Selectmen

Date:

TOWN OF HUDSON

Office of the Town Engineer

Robert A. Perreault, Jr. P.E.
Town Engineer

Denis M. Boisvert, EIT
Civil Engineer

12 School Street Hudson, New Hampshire 03051 603-889-1891

August 1, 1983

Steven A. Bolten, Esq.
229 Main Street
Nashua, N.H. 03060

RE: 7/21/83 Amendment to the Nashua-Hudson Wastewater Treatment Agreement

Dear Atty. Bolten:

This letter responds to your July 28, 1983 letter addressed to the Hudson Town Engineer,

On Page 3 of the original amendment, the last sentence of the carry-over paragraph from Page 2 contained an inadvertent typographical error. With this letter it is amended to read:

> "Design and operation of the equipment will be subject to the City's approval to insure compatibility with the City's installations."

Very truly yours,

Robert A. Perreault, Jr.

Robert A. Perreault, Jr.
Town Engineer

ACKNOWLEDGEMENT BY EXECUTORS OF THE ORIGINAL AMENDMENT:

TOWN OF HUDSON, NEW HAMPSHIRE

By its Board of Selectmen

Date: AUGUST 3, 1983

SECOND AMENDMENT TO
NASHUA-HUDSON WASTEWATER TREATMENT AGREEMENT

The City of Nashua (CITY) and the Town of Hudson (TOWN) hereby amend the Agreement, dated December 4, 1978, known as the Nashua-Hudson Wastewater Treatment Agreement, by addition of the following provisions:

Article XVI - INDUSTRIAL PRETREATMENT PROGRAM.

16.1 The TOWN shall develop and administer an Industrial Pretreatment Program meeting the requirement of the Federal Water Pollution Control Act, also known as the Clean Water Act, as amended, 33 U.S.C. 1251, et seq, and the regulations of the Environmental Protection Agency promulgated pursuant thereto, and in particular 40 CFR Part 403, including compliance and enforcement activities. TOWN and Town Officials shall be deemed representatives of the CITY for the purposes of this section and the Federal Act and regulations referenced herein.

16.2 As a part of the duties under Section 16.1 the TOWN shall adopt and enforce a Sewer Use Ordinance which at a minimum is as restrictive as the Sewer Use Ordinance adopted by the CITY and which requires immediate notification to the Superintendent of the Wastewater Treatment Plan in the event of any slug or spill. The CITY shall provide the TOWN with a copy of any amendment to the City Sewer Use

Ordinance. If necessary, the TOWN shall within a reasonable time not to exceed sixty (60) days amend its Sewer Use Ordinance to be as restrictive as the City Sewer Use Ordinance as amended.

16.3 The TOWN shall forward to the CITY copies of all permits and reports issued and received pursuant to the Industrial Pretreatment Program and the Sewer Use Ordinance. Upon reasonable notice CITY officials shall have the right to inspect all records of the TOWN relating to the Industrial Pretreatment Program or the Sewer Use Ordinance, including compliance and enforcement activities taken pursuant thereto.

16.4 The CITY and City officials are hereby deemed the agents and representatives of the TOWN for the purpose of undertaking compliance and enforcement actions, including civil, criminal, and equitable court proceedings, pursuant to the Industrial Pretreatment Program and the Sewer Use Ordinance. Such action may be undertaken by the CITY or City officials only after the TOWN has failed to take such action after reasonable notice by the CITY. Ten (10) days notice shall be considered reasonable in all cases and in case of emergency such lesser period of time as warranted by the circumstances shall be reasonable.

16.5 All costs and fees, including reasonable attorneys' fees, incurred by the CITY acting pursuant to Section 16.4 in any action against an alleged violator shall be reimbursed by the TOWN in the event that it is determined that the Town failed to act.

DATE: _____

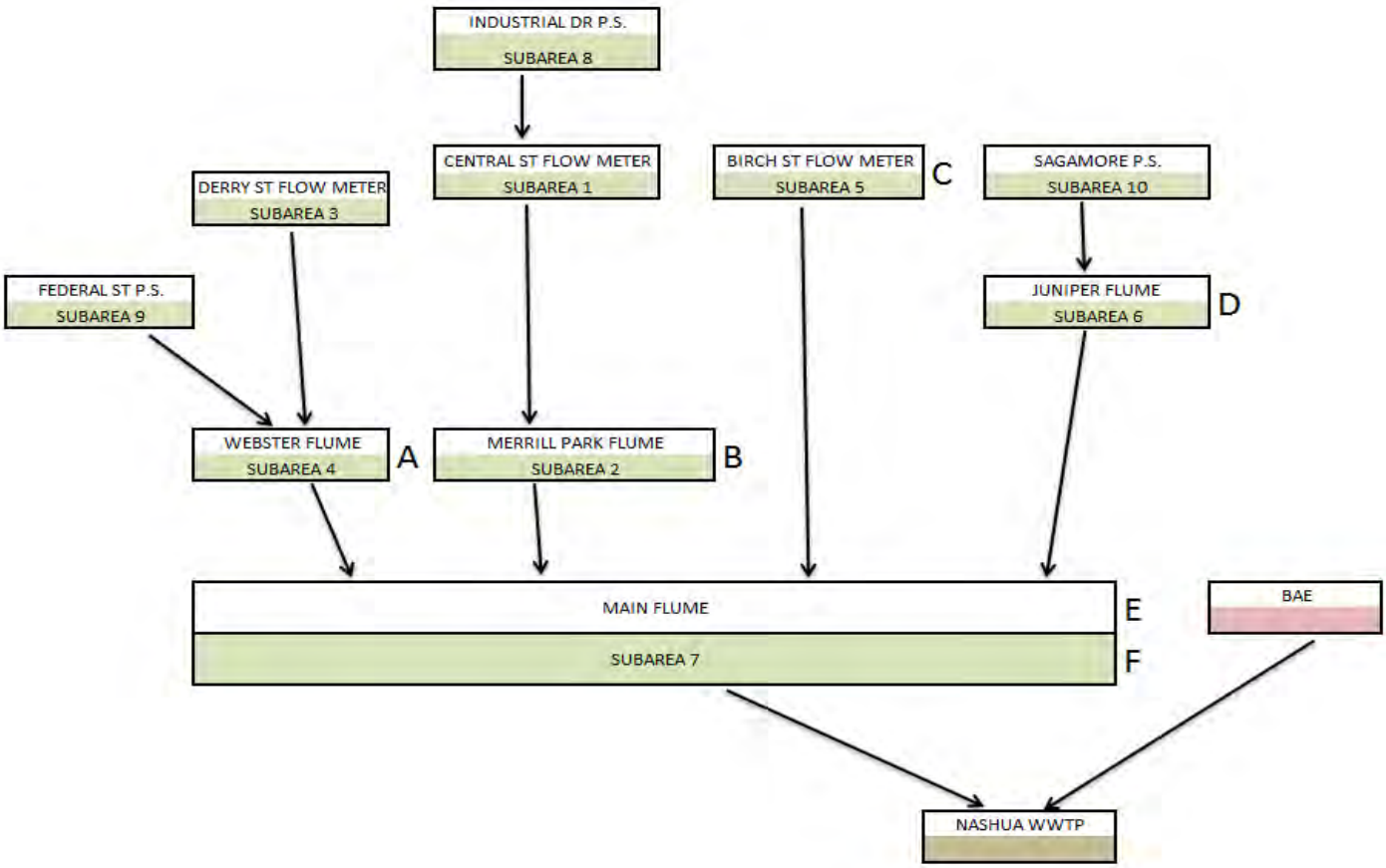
CITY OF NASHUA

_____

TOWN OF HUDSON

_____

A-3: SUBSYSTEM LAYOUT AND FLOW DISCREPANCY DOCUMENTATION



Month	2015/2016 FLOWS					
	Webster Flume Flow	**Merril Park Flume Flow**	**SUBSYSTEM 5 Flow** (Birch St_1)	**Juniper Flume Flow**	**Main Flume Flow**	**SUBSYSTEM 7 Flow**
	Average daily flow, MGD	Average daily flow, MGD	Average daily flow, MGD	Average daily flow, MGD	Average daily flow, MGD	Average daily flow, MGD
	A	B	C	D	E	F=E-A-B-C-D
January	0.358654	0.522199	*	0.167825	1.174533	*
February	0.333773	0.486752	*	0.170835	1.174533	*
March	0.385957	0.615082	0.278465	0.204480	1.174533	-0.309450
April	0.479543	0.790858	0.299358	0.228817	1.294077	-0.504500
May	0.401064	0.517419	0.262175	0.184477	1.294077	-0.071058
June	0.362771	0.491357	0.269923	0.183169	1.294077	-0.013142
July	0.326632	0.457025	0.268162	0.172843	0.957028	-0.267633
August	0.304810	0.426358	0.305649	0.159293	0.957028	-0.239082
September	0.295181	0.426870	0.304254	0.174026	0.957028	-0.243303
October	0.303649	0.439587	0.315146	0.161916	0.988207	-0.232091
November	0.304485	0.453818	0.206957	0.156236	0.988207	-0.133289
December	0.306451	0.504794	0.186695	0.161986	0.988207	-0.171720
January	0.328647	0.521433	0.171088	0.170256	1.198703	0.007280
February	0.347275	0.590265	0.249610	0.180223	1.198703	-0.168670
March	0.382169	0.609325	0.259594	0.200200	1.198703	-0.252584

* Not metered prior to Feb. 2015

A-4: DOCUMENTATION OF GUIDANCE/DISCUSSIONS (MARCH 2015)

CONSULTING ENGINEERS
540 Commercial Street Manchester, NH 03101
(603) 668-8223 • Fax: (603) 668-8802
cld@cldengineers.com • www.cldengineers.com
New Hampshire • Vermont • Maine

TO: File

FROM: David A. Lewis, P.E.

DATE: March 3, 2015

RE: Town of Hudson
I&I Update Memorandum
CLD Reference No. 15-0116

On this date, Heidi Marshall and the writer met with Jess Forrence and Derek Derochers, at the Town of Hudson Highway Department. CLD noted that the scope of our assignment was to compare 2000-2001 sewer flow data with 2013-14 flow data.

1. CLD's meeting goals:
    a. Obtain flows from the pump stations and 9 sewer subsystems
    b. Copy plans from the areas that were repaired, installed, or improved, per Jess' list (attached). There are no plans available for any of the slip-lined projects.
    c. Obtain flows from the flume that leads to Nashua.

2. The Town utilizes "FlowLink" software, developed by ISCO.
    a. Derek downloaded a ZIP file and supplied to CLD to compare new flow data.
    b. ISCO rep.: Dennis Vigliotte, New England Environmental Equipment dennis@he3inc.com
    c. The pump stations do not have telemetry. Typically, Derek tries to visit and manually read pump station data on Mondays and Thursdays.

3. The Town has six pump stations. Jess and Derek feel that only insignificant I&I would result from the three Gorman-Rupp sewered areas:
    a. Glen Drive
    b. Ottarnic
    c. Ranger Drive

4. Jess recalls that the Town transitioned from VCP to PVC pipe for sanitary sewers about 1986 or 1987.

5. The ten sewer subareas outlined on CLD's drawing set, dated 4/ 2002. Does subarea have a dedicated, permanent flowmeter?
    a. Flume on Webster St., includes Buttercup - Yes
    b. Juniper (JU) has flume - Yes
    c. Merrill Park Yes
    d. Industrial Park - Yes
    e. Sagamore P.S. Yes

f. Federal P.S.	Yes
g. Fox Hollow (Dwg. S-6)	No, needs a Temp. flowmeter

So Town needs 4 temporary flowmeters, as follows:

- Subsystem 2
- Site 3 Subsystem 3
- Subsystem 5
- Subsystem 1

I&I update work hopes to monitor April 2015 flows and April 2016 flows.

6. CLD will attempt to convert the ZIP file, export to Excel, and compare with 2001-02 flow data.

DAL:mjt

A-5: PRE-INTERIM MEMO REPORT SUMMARY MEETING MEMORANDUM (APRIL 2016)

CONSULTING ENGINEERS
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New Hampshire • Vermont • Maine

TO: File

FROM: David A. Lewis, P.E.

DATE: April 20, 2016

RE: Town of Hudson
Infiltration and Inflow (I/I) Meeting
CLD Reference No. 15-0116

On this date, a progress meeting was held at Hudson Highway Department. Present were:

- Elvis Dhima, P.E.
- Jess Forrence, Sewer and Drain Foreman
- Heidi J. Marshall, PE
- Steven W. Reichert, P.E.
- David A. Lewis, P.E.

The purpose of the meeting was to have a discussion prior to finalizing the Interim Memo outlined in the CLD scope of work.

Graphics attached to the draft memorandum were used during the discussion. Two documents were handed out: 1 page Study memo dated April 18, 2016 and 9 page Progress Memo, dated April 13, 2016.

1. Flume: CLD wondered if the flows backing up into Hudson during heavy rain events caused the negative flow values for Subsystem 7. Jess didn't think so. because the flume has two sensors that record when flat water conditions exist. He showed several weekly circular flow charts. Jess enters the data, subtracts out the peak flow from the backup, then sends the data to Donna Sommers and CLD.

2. Jess briefly reviewed the Subarea #5 listed street that CLD suggested might cause I/I (page 3). A Street, Belknap, Belknap Terrrace, C Street, and Melendy Road are dry when observed at night, so these do not produce I/I. DPW staff will view SMH flow conditions from 1-3 AM when residential flows are low.
    a. He offered to have CLD witness the ISCO meter calibration event.
    b. Jess added that the Belknap Terrace pipe joints were grouted in the past.
    c. SWR pointed out that the recommended street list developed for each subarea would need to be expanded for smoke testing, since the list focused on VCP and ACP pipe that might contribute Infiltration – i.e. not Inflow component.
    d. CLD will update the memo to show both components.

3. The mis-calibration of flow data before February 2013 was reviewed with the purple graph. Jess related that DPW used to have a staff member focused on calibration coordination, but that person left DPW.

4. Graph Trends
    a. The lag time from rain events to observed sewer flows peaks varies by season.
    b. Jess empirically finds that infiltration typically takes 7-8 hours to show up in sewer flows. Roof drain inflow shows up almost immediately.
    c. Flows from individual irrigation deduct meters was removed from the flow contributions manually. Jess related that he irrigates at his house but never got a deduct meter.

5. Smoke testing:
    a. DPW has the equipment and Jess exercises it annually to ensure operation.
    b. An information letter could be mailed out 1 month before work. CLD noted that if the neighborhood had a high minority population bilingual documents must be considered to ensure all residents could understand the upcoming operation.
    c. When the smoke testing schedule along a street segment is known, hang-tags could be placed to warn of impended smoke testing. CLD offered to develop the hang tag language. Elvis will send CLD the hang tag format.
    d. CLD's has scope to witness any smoke testing performed by the Town in CLD's 2015-2016 scope.
    e. Elvis wants to start smoke testing this June, but Jess related that the Highway Department is too busy this season, but perhaps next spring (2017). He informed Elvis that other work (e.g. portion of 2017 paving) would need to be deferred. Elvis will present options to the Selectmen of how to staff work.
    f. Jess recommends a cellar inspection to view sump pump and drain layouts be done in conjunction with the smoke testing program.
    g. Elvis noted that foundation perimeter drains without vents wouldn't be revealed. Jess advised that the smoke will take time to pass through the overburden soil, but it will show up.
    h. Garage Drains: Jess related that occasionally residents will complain of sewer gas. Jess will advise them to add water into the cellar drain to refill a likely dry trap.

6. Cost for Disconnection of Inflow from sanitary sewer.
    a. Elvis wondered if a fee could be added onto the sewer invoice to allow the storwater discharge to go to sewer? CLD responded that current regulations do not allow stormwater to enter the sewer

7. Questionnaire
    a. If the Town moves forward with a questionnaire, CLD will develop technical rationale narrative portion to ask residents to truthfully respond about known Inflow connections to the sewer system.
        i. basement drain
        ii. floor drains
        iii. sump pump

iv. roof drains
v. foundation drains

b. CLD recommended that a "carrot" be included, such as immunity from future fines if they answer truthfully. Documentation should inform residents that the intent is to reduce I/I andpoint out that ultimate disconnection will benefit the Town in capacity issue and save the Town money.
c. Although another system reported 50% response to a questionnaire program, that would be ambitious.
d. Elvis will forward a file that included the Town's logo to include on the form.

8. Capacity
    a. Currently, the Town only has 25,000 GPD of reserve capacity for new users on the sewer balance sheet.
    b. Only Hadco's former building has any sizeable unused capacity worth chasing. Another ~10 users only have less than 5,000 GPD unused individually.
    c. Elvis wants to know the decrease in I/I from 2001 to 2015 to be able to use this additional capacity for new allocation requests.

9. June 2016 Report
    a. Donna Sommers sent out the first quarter of water data (Jan – March 2016). No further water data will be forthcoming before the end of the CLD contract.
    b. Donna is now sending the data in a *csv file format that is really helpful
    c. Elvis wants to prioritize streets for smoke testing. Then propose "options" of how to fund work to present to the Selectboard.
    d. Jess thought the initial program would utilize 4 DPW staff for 4-6 weeks. The use of interns to perform or help was dismissed due to safety concerns.
    e. 2002 CLD I/I study outlined that Hudson had 64 miles of sewer.

10. Miscellaneous
    a. Jess has no plans to CIPP any sewers in 2016.
    b. Elvis calls a contractor to visit site and obtain pricing to fix the infiltration leak at Nan King, 222 Central Street.

DAL:mjt

A-6: INTERIM MEMO REPORT (APRIL 2016)

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New Hampshire • Vermont • Maine

TO: Elvis Dhima, PE, Town of Hudson
Jess Forrence, Town of Hudson

FROM: Heidi J. Marshall, PE

DATE: April 20, 2016

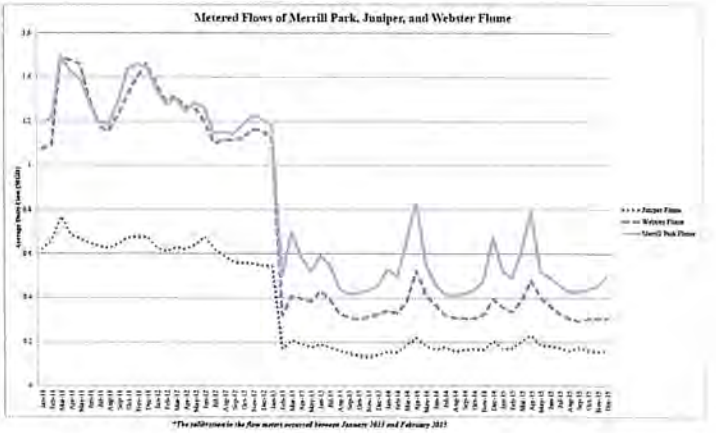
RE: Town of Hudson
Infiltration/Inflow Study Update
CLD Reference No. 15-0116

SUBJECT: Infiltration/Inflow Progress Memorandum

Following is CLD's summary of efforts to date. This memo is designed to prompt discussion for the purpose of compiling the final memo report.

This memo report documents progress and summarizes recent evaluations of and to review Subsystems to consider for further, focused review efforts.

The most important item to document is that after the water, rainfall, meter and flume data was entered for the time period between January 2011 and January 2013, it became apparent that there was a calibration issue with the three flume monitoring locations. Upon recalibration, it is noted that the calibration affected the recorded flume data between 300,000 and 800,000 gallons per day. Therefore, the data during that time period was not valid to use for further evaluation. In summary, the flow data prior to recalibration of the flume which had been accumulated and graphed for evaluation was subsequently discounted and not used. The calibration issue is documented as part of the *Metered Flows of Merrill Park, Juniper, and Webster Flume* graph next to this discussion.



Data/Information Used For Evaluation:

Early in the data collection phase, we also determined that additional temporary Flow Meters would be helpful to acquire additional data. Although using many meters would provide the most data, it was determined that four locations would be the most economical and efficient use of funds. Therefore, ISCO flow meters were installed in the spring of 2015 at four locations to delineate individual Subsystem flows from downstream combined flows. These flow meters were installed as follows:

Temporary Meter Locations:

Subsystem 1	Flow Meter Location: SMH TH-1, located on Route 111 between Greeley Street (east) and Merrill Brook (west)
Subsystem 2 (Merrill Park)	Flow Meter Location: SMH EXC-3 on Maple Avenue
Subsystem 3	Flow Meter Location: SMH DE-26 on Derry Street, between Easy Street and Elm Avenue
Subsystem 5	Flow Meter Location: SMH BI-1 on Birch Street, 1 SMH west of Lowell Road

Rainfall Data:

Rainfall data was supplied by the City of Nashua on a daily basis. This rainfall is summarized monthly and shown on the Subsystem graphs developed during this review.

Water Usage Data:

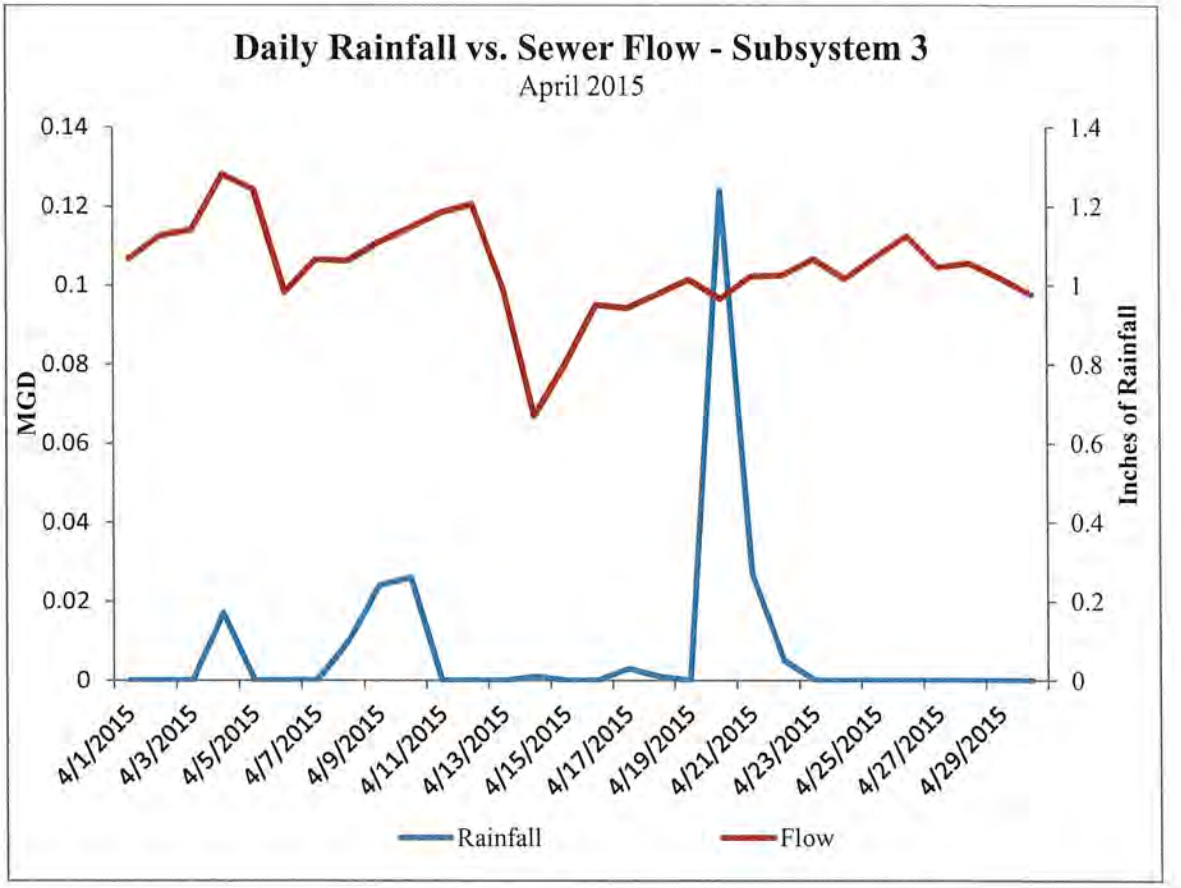
Monthly water bills were obtained from the Town and allocated into the corresponding Subsystem by address. The combined water quantity is shown as "Water Consumption" on each of the Subsystem graphs.

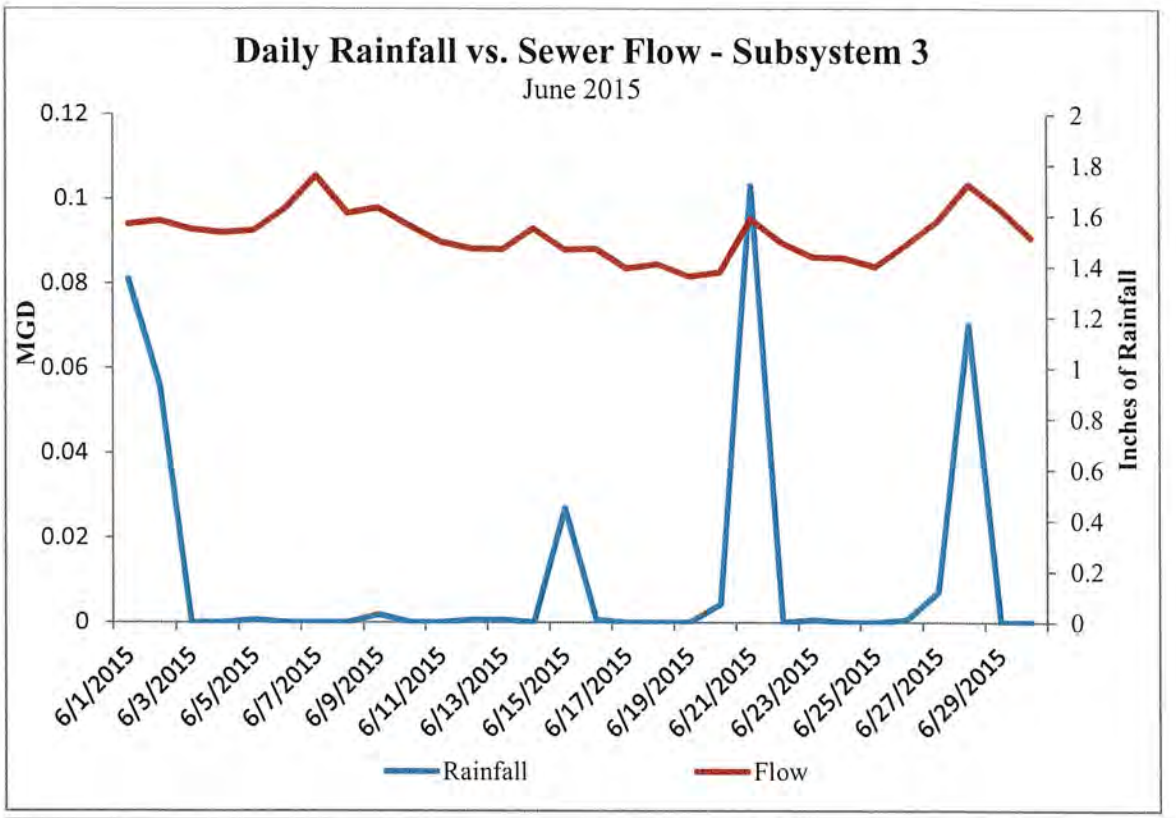
Sewer Base Flows:

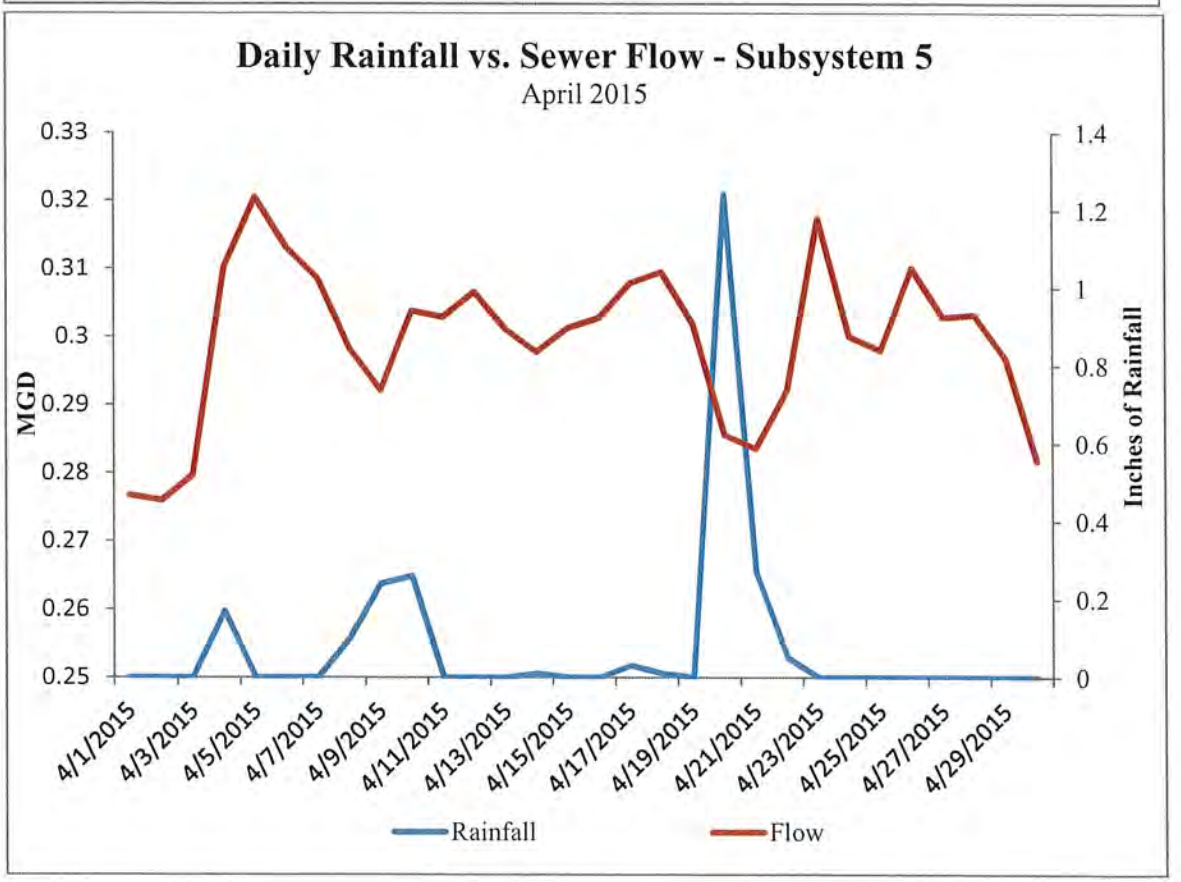
Sewer base flows were measured at three flumes (Webster, Merrill Park, and Juniper), three subsystem pump stations (Industrial Drive, Federal Street and Sagamore), and within the four sewer manholes noted above where temporary ISCO flow meters monitored flows. Flows were recorded on a continuous basis at five or fifteen-minute intervals. This sewer base flow is labeled as "Subsystem Flow" on the Subsystem graphs.

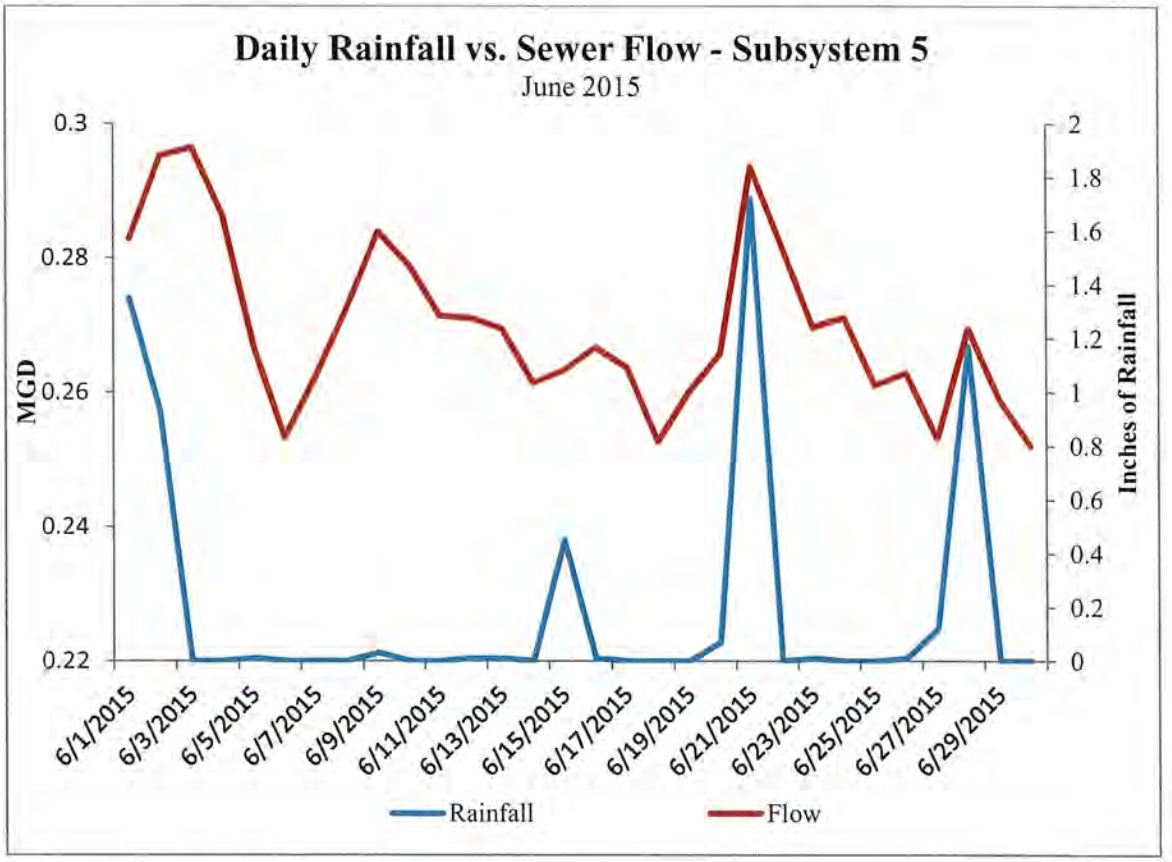
Sewer Flow vs. Rainfall:

Daily comparisons of sewer flow vs. rainfall in Subsystems #3 and #5 show an increase in flow lagging several days behind rainfall during periods of assumed high groundwater levels (see April 2015 graphs below). During periods of lower groundwater levels (June 2015 graphs) the sewer flow spikes the same day as rainfall. These results, while not unexpected, are typical across all Subsystems and show the influence of inflow and infiltration on the sewer system.




Daily Rainfall vs. Sewer Flow - Subsystem 3
June 2015
MGD
Inches of Rainfall
0.12
0.1
0.08
0.06
0.04
0.02
0
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
6/1/2015
6/3/2015
6/5/2015
6/7/2015
6/9/2015
6/11/2015
6/13/2015
6/15/2015
6/17/2015
6/19/2015
6/21/2015
6/23/2015
6/25/2015
6/27/2015
6/29/2015
Rainfall
Flow


Daily Rainfall vs. Sewer Flow - Subsystem 5
April 2015
MGD
Inches of Rainfall
0.33
0.32
0.31
0.3
0.29
0.28
0.27
0.26
0.25
1.4
1.2
1
0.8
0.6
0.4
0.2
0
4/1/2015
4/3/2015
4/5/2015
4/7/2015
4/9/2015
4/11/2015
4/13/2015
4/15/2015
4/17/2015
4/19/2015
4/21/2015
4/23/2015
4/25/2015
4/27/2015
4/29/2015
Rainfall
Flow



It is noted that 2015 was a relatively dry year for rainfall after the year's heavy winter snow accumulation. This is reflected to a certain extent in flow meter readings when compared to previous years' flow data. However, enough variability exists across all subsystems when rainfall is evaluated against recorded flows that a direct correlation cannot be made (i.e. the most rain does not necessarily result in the highest system flows). When evaluated on a daily basis, it is evident that flows increase whenever there is a rainfall.

Basement sump pumps, foundation drains and roof drains (gutter systems) connected to a house's sewer service are a likely cause of inflow into the sewer system during a rain event. But, the extent of any flow increase is tempered by the groundwater elevation at that time. For example, in May of 2015 Hudson received only 0.84 inches of rain, yet the total monthly flows measured at the Merrill Park, Juniper, and Webster flumes were all higher than the flows at the same locations measured in June of 2015 when there was 5.90 inches of rain. This variability reinforces the conclusion that groundwater elevations are the most critical element in inflow and infiltration into the sewer system. Data shows consistently higher flows in the spring months when groundwater elevations lie above many gravity sewers and when sump pumps and foundation drains contribute inflow into the public sewer mains. Contributions from inflow and infiltration are evident on the graphs for each subsystem.

New/Lined Sewers:

The Town identified new or lined sewers from the period of 2002 – 2014 that focused on Subsystems 2 and 5 with several projects in Subsystems 4 and 7.

New or Replaced Sewer Lines since 2003:

SUBSYSTEM	STREET	SUBSYSTEM	NEIGHBORHOOD/ STREET
Subsystem 1		Subsystem 5	
	Bradford Circle		Overlook Estates (Overlook Circle)
Subsystem 2			Oak Ridge Estates
	Belknap Street		Annie Court
	Bond Street		Brody Lane
	Chatham Street		Graham Court
	Clifton Street		Loren Court
	Greentree Drive		McEwen Court
	Hurley Street		Tiffany Circle
	Melendy Road		Charbonneau Drive
	Short Street		Gulf Street
Subsystem 4		Subsystem 6	
	Sparkling River Estates		Paula Circle
	Scenic Lane	Subsystem 7	
	Shoreline Drive		Andrews Avenue, Chase Street
	Vernon Street		Edgar Court, Winnhaven Drive, Wyeth Drive

Sewer Flow vs. Water Consumption:

The flows for all subsystems were evaluated against the sewer account data received from the Town for 2015. Several subsystems recorded flow amounts significantly greater than the water consumption for the same time period, which is a leading indication of inflow and infiltration. Even in summer months when water usage typically increases and groundwater elevations are lowest, several subsystems exhibited higher flow amounts than water consumed.

- Subsystem #1 – Significantly higher sewer flow in March/April and October/November.
- Subsystem #2 – Sewer flows are higher than water usage throughout the year (see graph below).
- Subsystem #4 – Significantly higher sewer flow in March/April and November/ December.

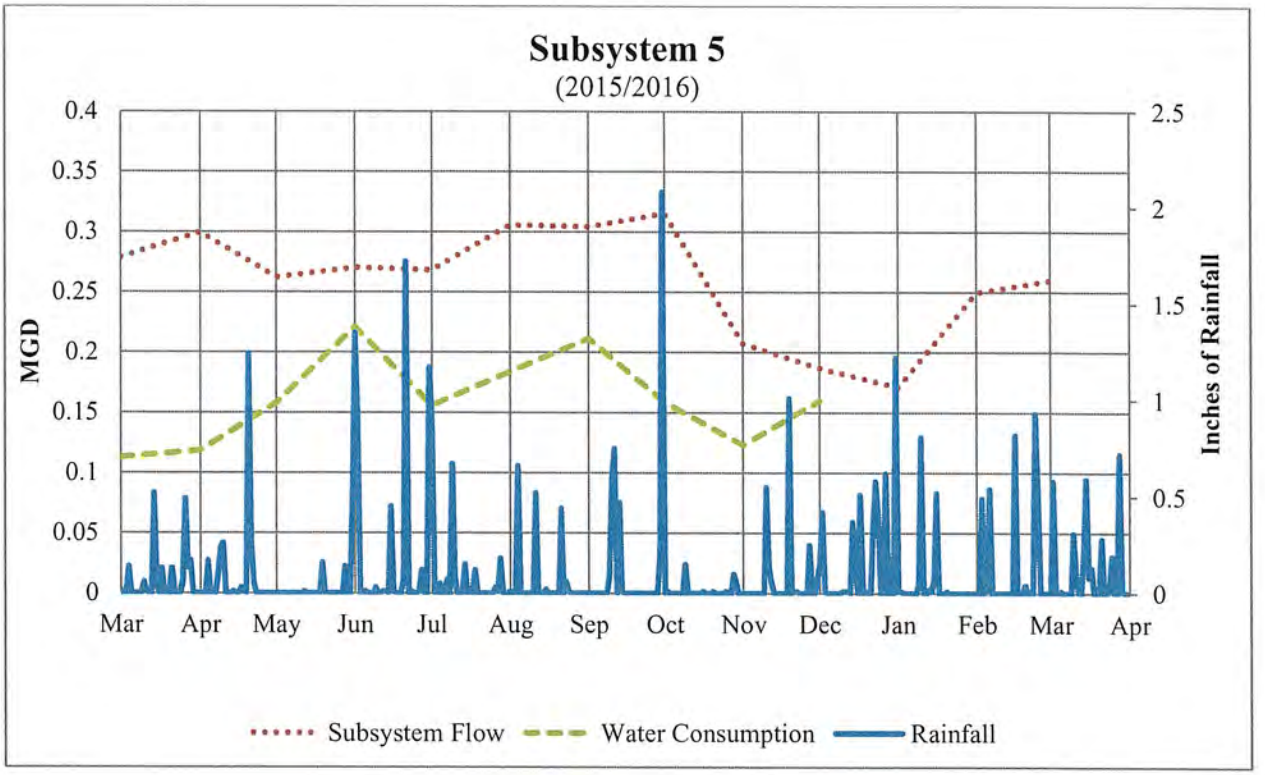
- Subsystem #5 – Sewer flows are significantly higher than water usage throughout the year (see graph below).
- Subsystems #8 and #9 sewer flows were consistently above reported water usage.
- Subsystems #3, #6, and #10 exhibited some seasonally elevated sewer flows in spring and fall, most likely due to higher groundwater elevations. Sewer flows during the summer and winter months were below water usage amounts.

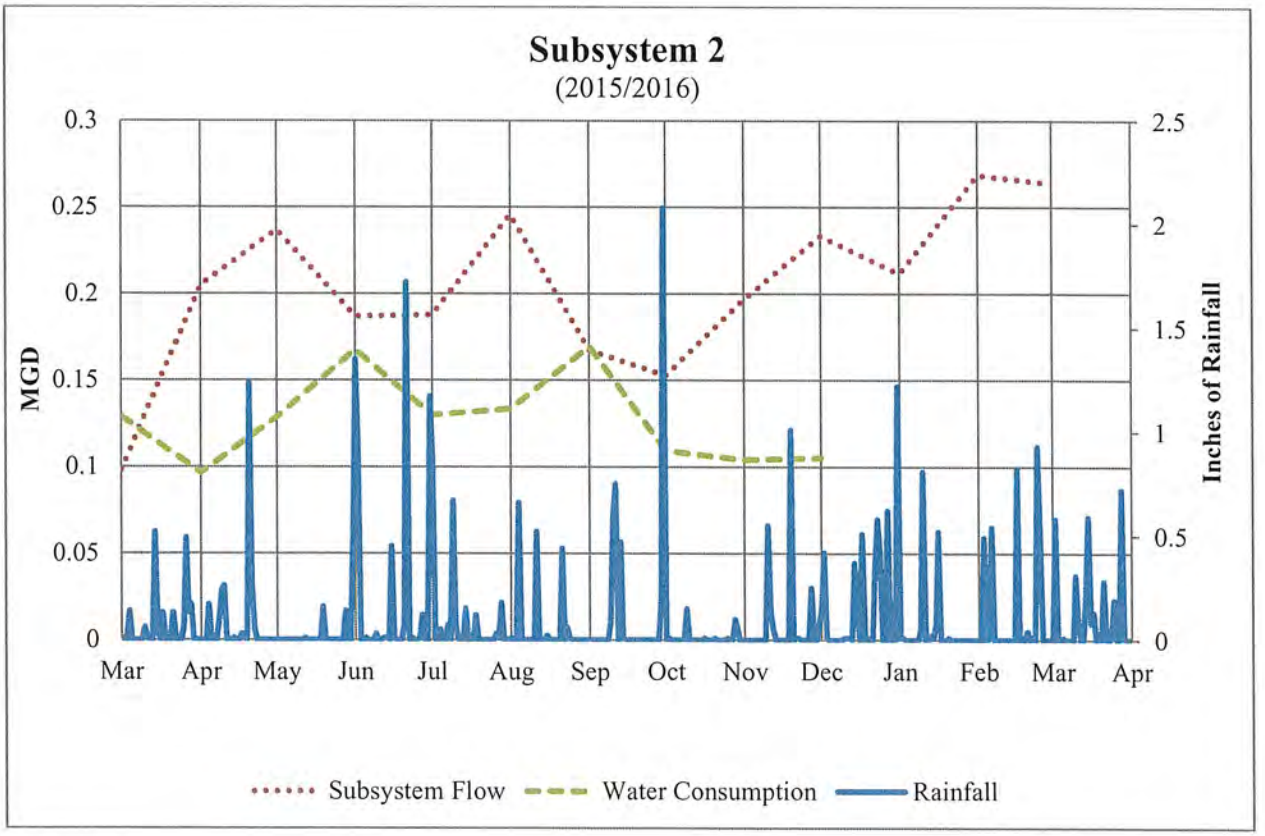
Based on the evaluation of sewer flow vs. water usage, we recommend additional video inspection of Subsystems #1, #2, #4, #5, #8 and #9 to try to determine sources of infiltration into the system. These video inspections would ideally be performed during the spring when active infiltration through damaged/separated pipe joints or manhole deficiencies could be observed.

Of these subsystems, we recommend Subsystem #5 as the priority for further evaluation of potential infiltration sources as this subsystem has some of the highest sewer flows of any subsystem. Sources of inflow are not as easily identified, but given that a portion of Subsystem #5 is made up of older homes, it is likely that inflow is at least a partial cause of the increased sewer flows. Also, there are only a small number of well users within Subsystem #5 that are connected to the sewer (11 sewer-only vs. 926 sewer/water customers) so their contribution to overall sewer flow does not appear substantial enough to explain the variance between sewer flow and water usage. Subsystem #5 has approximately 19 auxiliary (sprinkler) meters in use, which contributes to the water usage data but also may contribute to sewer flow through infiltration/inflow.

Based upon data collected to date, Subsystem #2 would be the second priority for further review/inspection (16 sewer-only vs. 674 sewer/water customers, and 19 auxiliary (sprinkler) meters in use), followed by Subsystems #8 (which has a much smaller sewer flow compared to other Subsystems), #9, #4, and #1.

Collected data for Subsystems #5 and #2 is summarized by the following graphs:


Subsystem 5
(2015/2016)
MGD
Inches of Rainfall
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2.5
2
1.5
1
0.5
0
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall


Subsystem 2
(2015/2016)
MGD
Inches of Rainfall
0.3
0.25
0.2
0.15
0.1
0.05
0
2.5
2
1.5
1
0.5
0
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall

Subsystem #9 Evaluation:

As noted above, Subsystem #9 (Federal Pump Station) sewer flows are consistently above water usage data. However, when compared against rainfall, sewer flows show significant correlations between precipitation and base sewer flow increases during spring and fall peaks. Further review of Subsystem #9 would be warranted based on these comparisons between sewer flow data and rainfall graphing. Subsystem #9 is located in a neighborhood of homes immediately adjacent to the Merrimack River where a high groundwater table is assumed to be present and a likely cause of both infiltration when groundwater levels are elevated and inflow during rain events. Sewer pipe in this subsystem is generally composed of asbestos cement pipe (ACP) that is generally more susceptible to joint leakage than modern SDR-35 PVC sewer pipe.

These flow/rainfall correlations suggest that Subsystem #9 should also be the focus of videotaping during the wet spring months when groundwater might be witnessed entering the sewer system. We know that conditions in this Subsystem have been evaluated before by the Town of Hudson, and we recommend that the Town perform video inspection of the sewer mains within this subsystem to review the condition of the existing system and locate any evident infiltration conditions (separated or damaged pipe joints, cracks in sewer piping, cracks in sewer manholes, etc.). It is noted that during this particular spring 2016, no stored precipitation is available from snowmelt to help raise the groundwater table and thus help to identify leaking pipe joints or other infiltration conditions.

Subsystem #7 Evaluation:

Subsystem #7 receives upstream flows from all other subsystems, so a separate and distinct flow assessment is difficult to perform for Subsystem #7 internal flows only. Subsystem #7 flow data was calculated by subtracting the flow data from all other subsystems from the total flow in the Main Flume crossing to the Nashua Wastewater Treatment Plant, as all other subsystems discharge into Subsystem #7 and there is no flow meter installed just for Subsystem #7. This resultant data shows multiple negative monthly flows for Subsystem #7, plus other very low positive flows that don't appear to be representative of the sanitary flows from the large number of homes within this subsystem. The Town has noted that there are no areas within this subsystem where sewer flow is overflowing out of the system or being lost to runoff, and that during periods of heavy rain the sewer system at the main flume backs up, rendering flow data questionable. Therefore, we believe this data to be unreliable and have discounted it from our evaluation.

Subsystem #7 is made up of mostly older homes which could be the source of significant infiltration and inflow. The Town has replaced sewer mains within this subsystem recently which helps reduce infiltration. In the absence of reliable flow data, we recommend the Town perform more video inspections of the remainder of the old sewer system to assess the condition of the

piping and evaluate for potential infiltration. These video inspections would ideally be performed during the spring when infiltration through damaged/separated pipe joints or manhole deficiencies could be observed.

Inflow Determination:

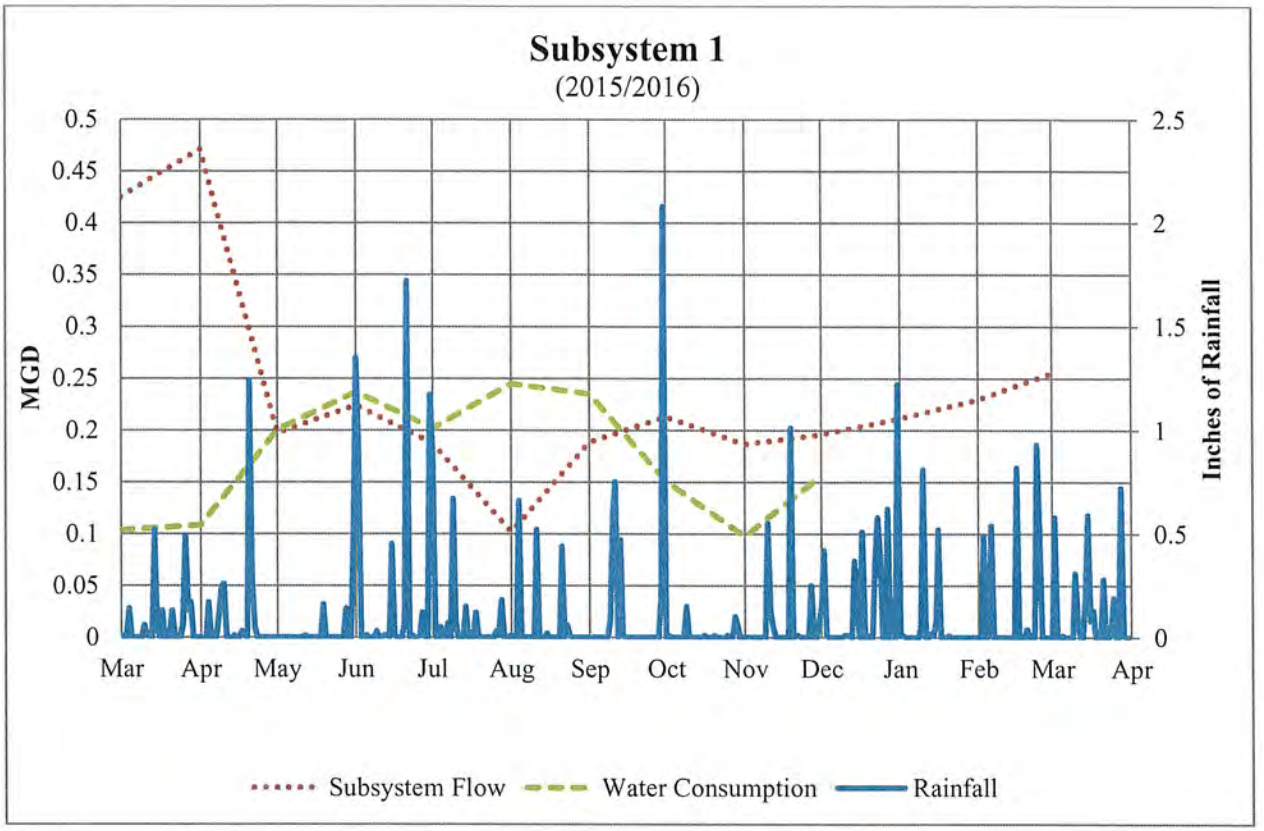
Another option that the Town could consider in the attempt to quantify inflow into the overall sewer system is by mailing a questionnaire to all Town residences and businesses that are connected to the sewer system. Questions that can be included in the mailing include:

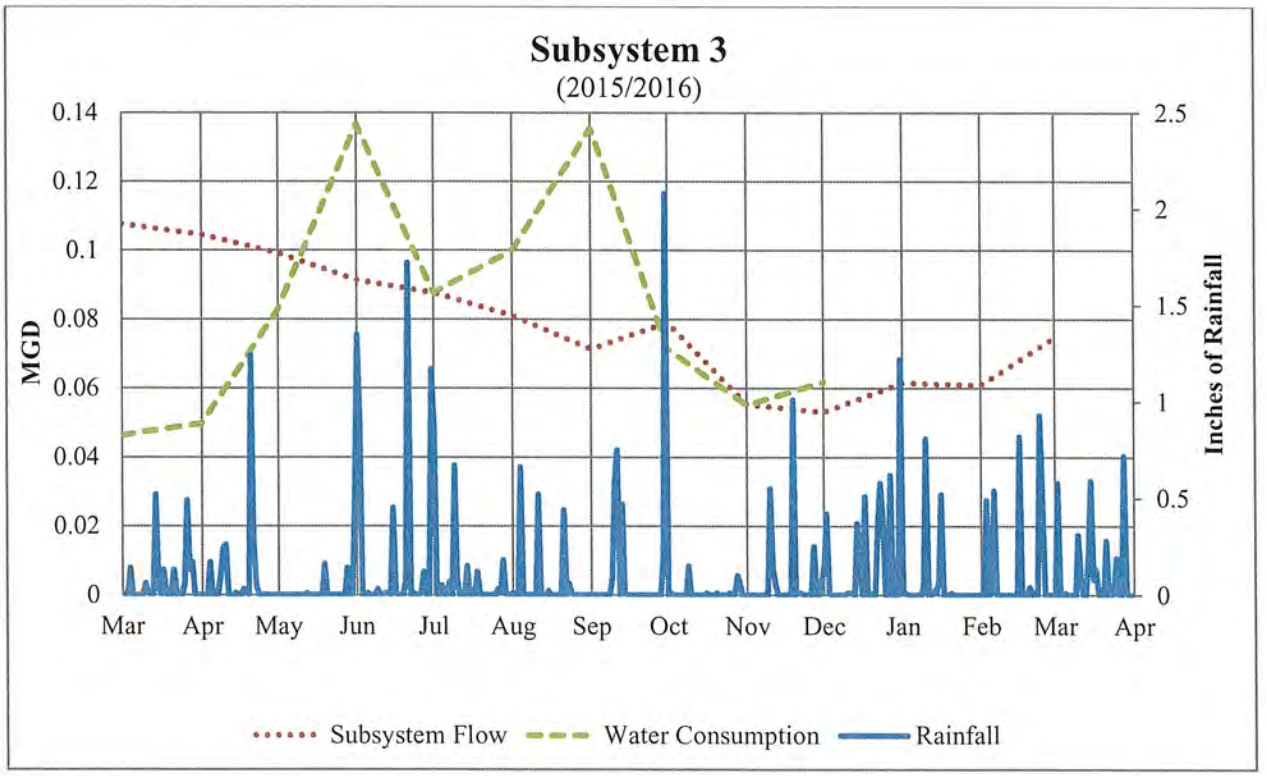
- Does your dwelling/building currently have a sump pump?
- If yes is the sump pump discharge connected to the sewer system service lateral?
- How often does your sump pump operate (every time it rains, only during the heaviest rains, nearly all the time during the spring, etc.)?
- Is your dwelling/building foundation drain connected to the sewer system service lateral?
- Does your dwelling/building have gutters or other roof drains? Are they connected to the dwelling/building foundation drain?

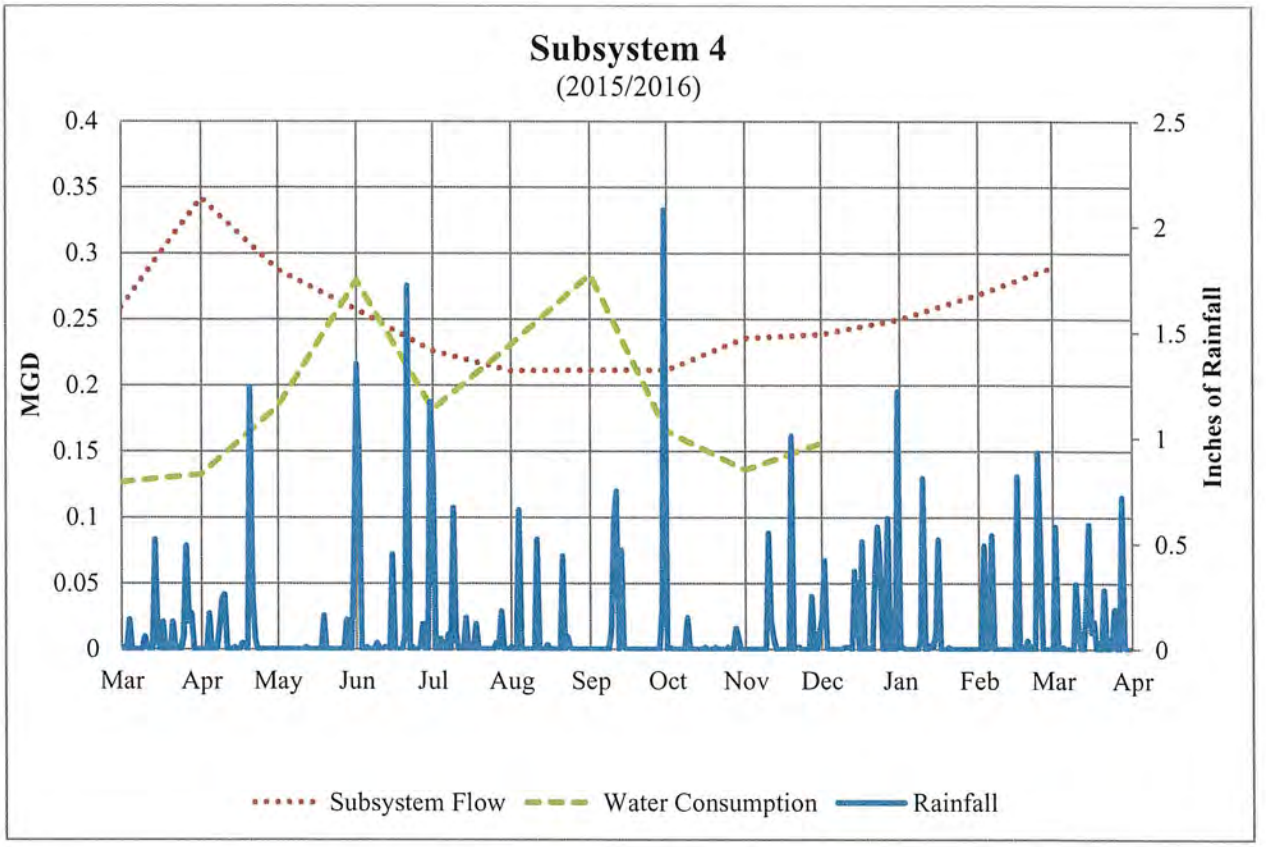
Sewer service laterals, especially those for older homes, are a leading cause of sewer system I/I. This is not just inflow from foundation drains, sump pumps, etc., but also infiltration from damaged/cracked piping and poor quality installation. Clay service piping is especially susceptible to root damage. The Town could include in the questionnaire a space for the homeowner/building owner to sketch the location of the sewer service where it leaves their building. This location could be compared to Town as-built records as well as to aboveground conditions including trees, plantings, or other items that could possibly create breaches in the service piping.

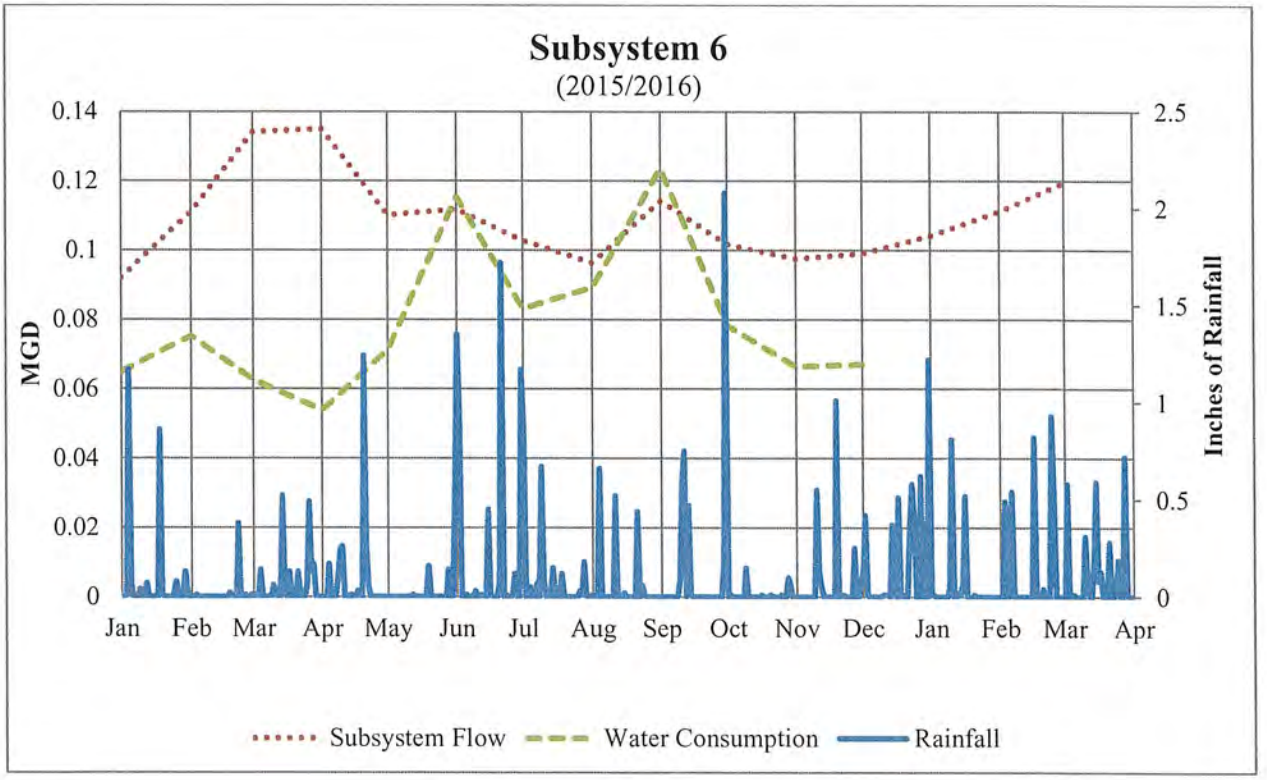
Responding to such a questionnaire would be voluntary and because connection of any drain water system to a sanitary sewer is prohibited by the Town of Hudson's Sewer Use Regulations, respondents may not be willing to divulge this information. However, those responses received would provide valuable data to help identify some of the causes and locations of inflow and infiltration into the sewer system.

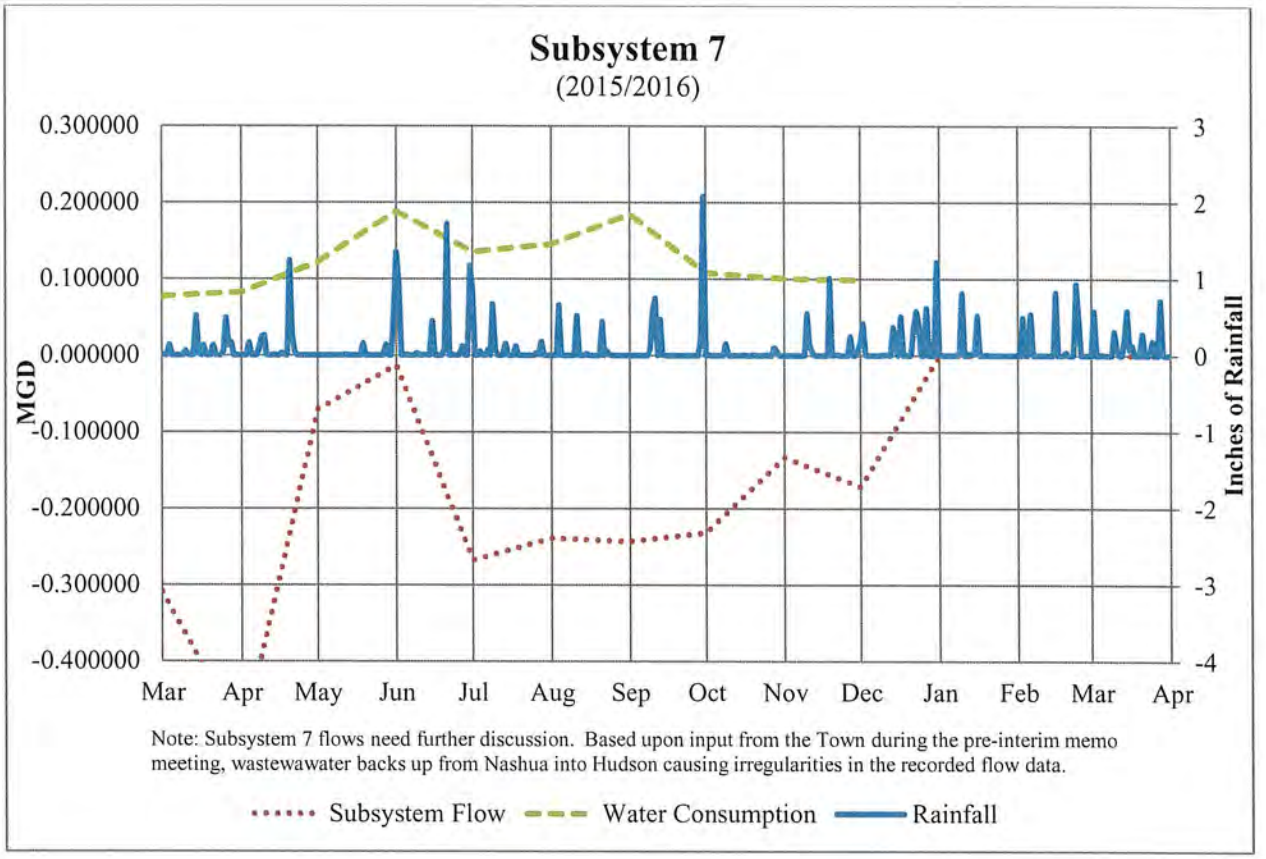
For documentation purposes, graphs of the remaining subsystems follow:

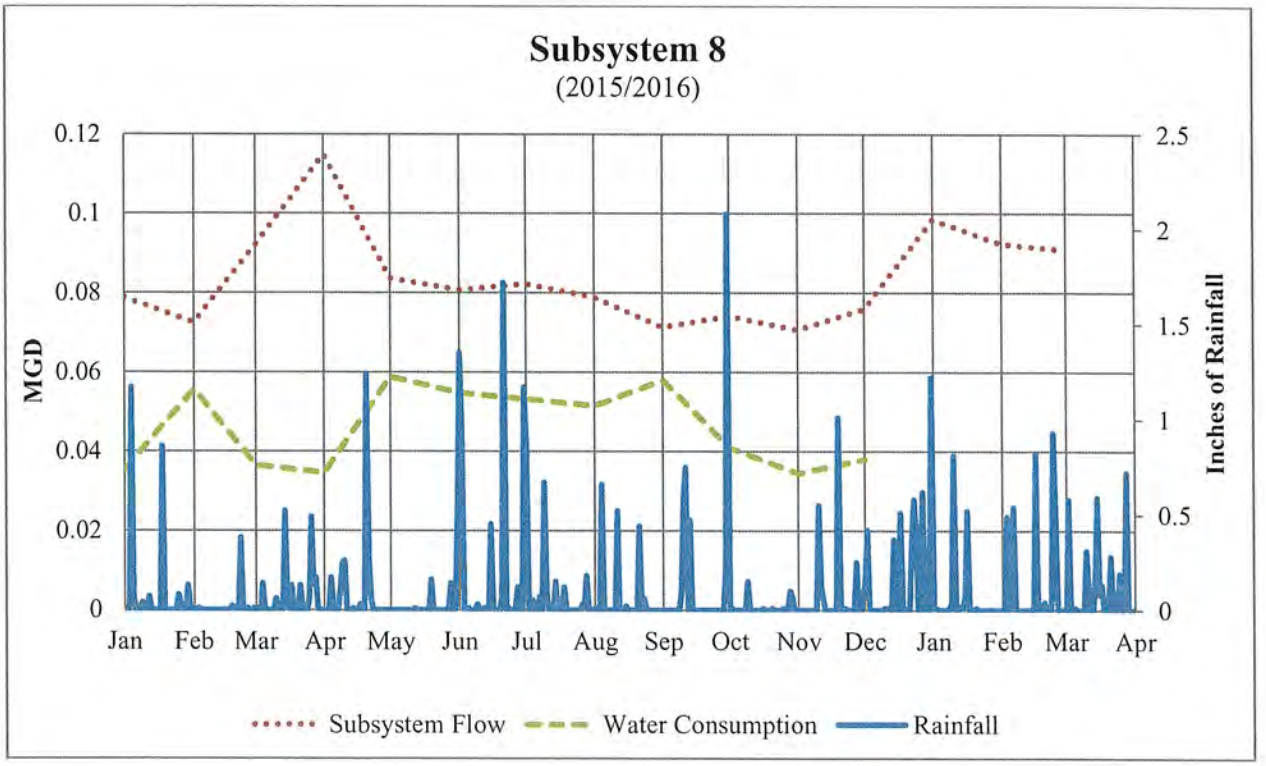

Subsystem 1
(2015/2016)
MGD
Inches of Rainfall
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2.5
2
1.5
1
0.5
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Subsystem Flow
Water Consumption
Rainfall

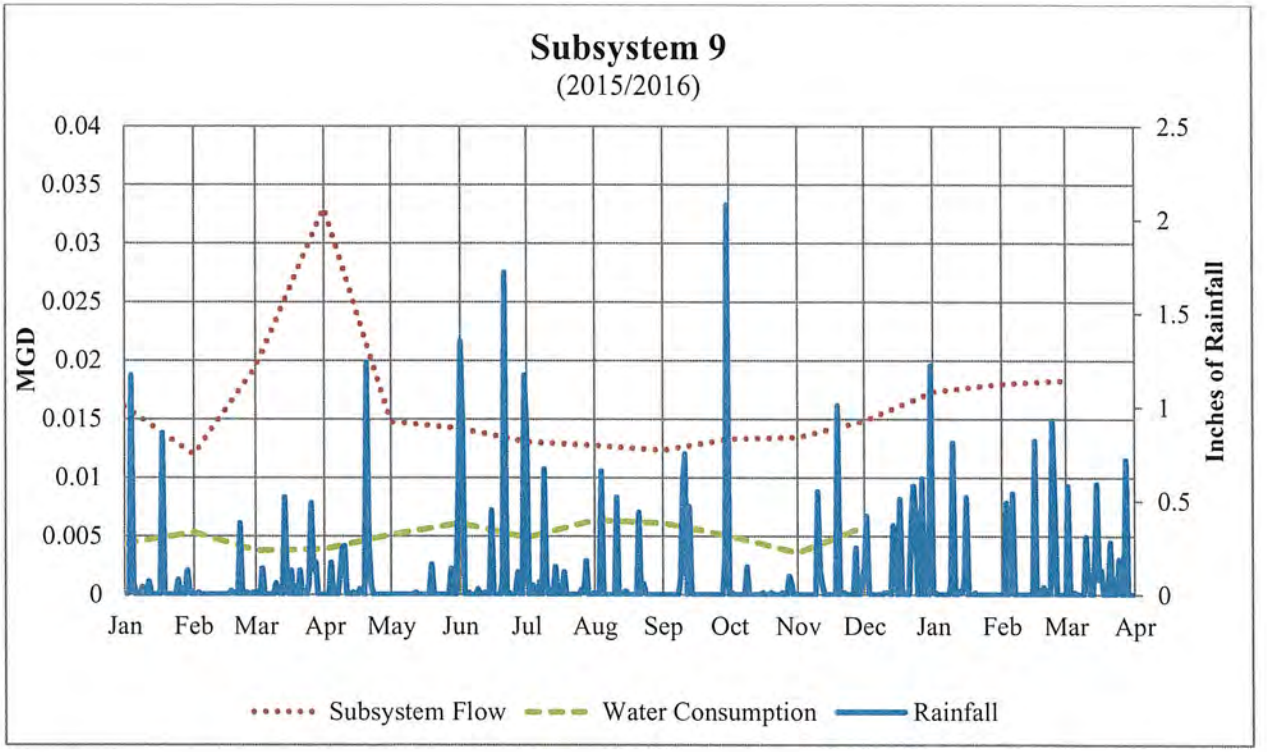

Subsystem 3
(2015/2016)
MGD
Inches of Rainfall
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2.5
2
1.5
1
0.5
0
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
Subsystem Flow
Water Consumption
Rainfall

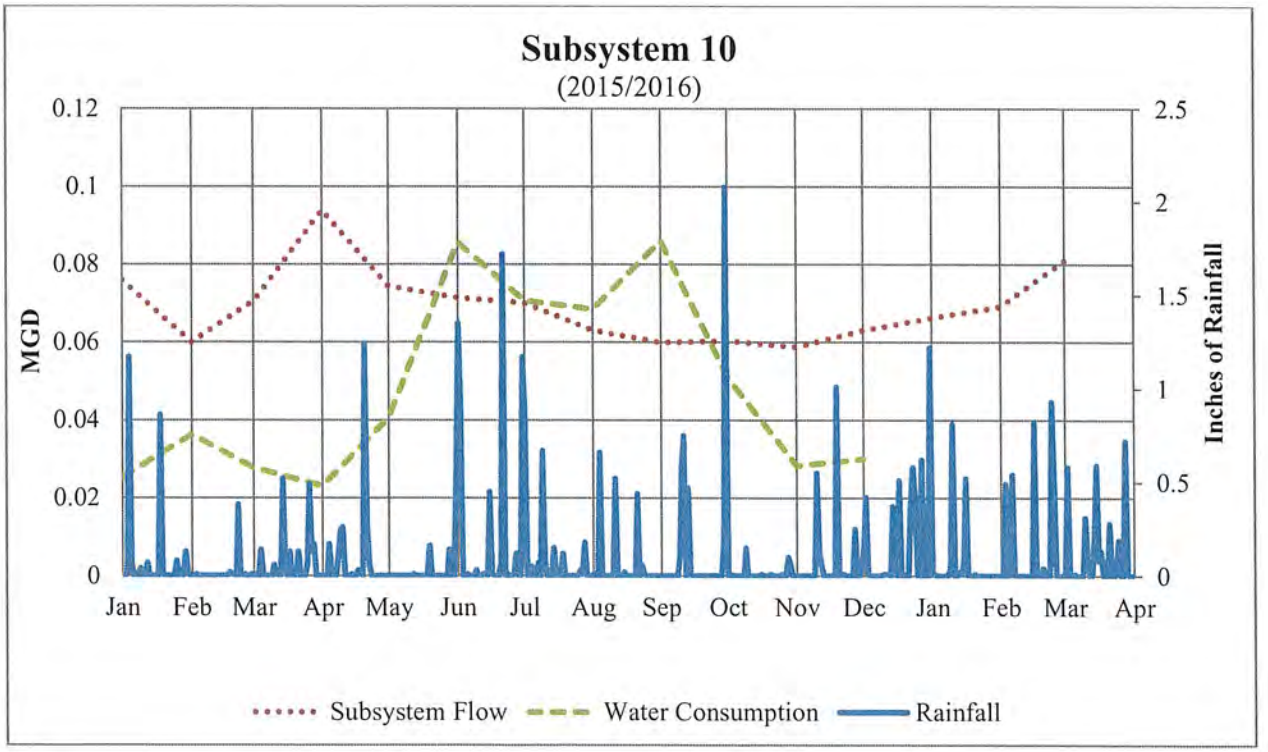

Subsystem 4
(2015/2016)
MGD
Inches of Rainfall
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2.5
2
1.5
1
0.5
0
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall


Subsystem 6
(2015/2016)
MGD
Inches of Rainfall
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall


Subsystem 7
(2015/2016)
0.300000
0.200000
0.100000
0.000000
-0.100000
-0.200000
-0.300000
-0.400000
MGD
3
2
1
0
-1
-2
-3
-4
Inches of Rainfall
Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Note: Subsystem 7 flows need further discussion. Based upon input from the Town during the pre-interim memo meeting, wastewawater backs up from Nashua into Hudson causing irregularities in the recorded flow data.
Subsystem Flow
Water Consumption
Rainfall


Subsystem 8
(2015/2016)
0.12
0.1
0.08
0.06
0.04
0.02
0
MGD
2.5
2
1.5
1
0.5
0
Inches of Rainfall
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall


Subsystem 9
(2015/2016)
MGD
Inches of Rainfall
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall


Subsystem 10
(2015/2016)
MGD
Inches of Rainfall
0.12
0.1
0.08
0.06
0.04
0.02
0
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr
Subsystem Flow
Water Consumption
Rainfall

Summary:

We recommend that the Town continue video inspection and evaluation of the sewer system within the various subsystems in this order:

- Subsystem #5
- Subsystem #2
- Subsystem #8
- Subsystem #9
- Subsystem #4
- Subsystem #1
- Subsystem #7.

Upon completion of the video inspection, additional actions may be recommended.

HJM:jt