APPENDIX I

Sewer System Evaluation Study

Narragansett Bay Commission

Town of Johnston, Rhode Island
Sewer System Evaluation Survey

June 2009

Prepared by:

PARE CORPORATION

8 BLACKSTONE VALLEY PLACE
LINCOLN, RI 02865

and

BETA Group, Inc.
Engineers • Scientists • Planners
6 Blackstone Valley Place, Lincoln, RI 02865 401.333.2382 fax: 401.333.9225
Email: BETA@BETA-Inc.com

TABLE OF CONTENTS

Page No.

Appendices

CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND SCOPE

The objective of this survey was to assess the condition of the Narragansett Bay Commission (NBC)-owned sewers located within the Town of Johnston and identify areas within the Town that are contributing excessive infiltration and inflow (I/I) to the NBC-owned interceptors.

The condition assessment and potential inflow source identification portions of the survey were limited to the interceptor sewers, both owned and operated by the NBC and did not extend into the portions of the sewer system owned and operated by the Town of Johnston. The NBC owns and operates two interceptor sewers within the Town: the Johnston-North Interceptor and the Johnston-South Interceptor. The study was conducted in conjunction with a Facilities Plan being prepared for the Town of Johnston.

In an effort to identify areas contributing infiltration/inflow to the system, a two-part approach was employed.

- Flow Metering, to assist in identifying areas of elevated flows during wet weather events and excessive infiltration during dry weather periods, attributed either to NBC's sewer system or community sewers discharging to the NBC's interceptor
- Pipeline/Manhole Condition Assessment, to identify and correlate areas of elevated infiltration with pipeline and manhole conditions, as well as identifying potential inflow sources.

The ultimate goal of the SSES project is to identify meter basins that contribute excessive I/I so that the NBC can coordinate SSES and I/I reduction efforts with the Town of Johnston. For purposes of this report, a meter basin is defined as the area contributing wastewater to a given meter location.

1.2 BACKGROUND – JOHNSTON-NORTH INTERCEPTOR

The Johnston-North Interceptor consists of approximately 7.9 miles of sewer pipe, ranging in size from 8" to 24" in diameter. The interceptor collects sanitary flow from the northeastern portion of Johnston, east of Interstate 295 and north of Route 6. The primary interceptor branch begins on Putnam Pike (Route 44) at the intersection of Hebdeen Street. The interceptor proceeds east on Putnam Pike, then runs south along the Johnston – North Providence boundary. The branch discharges to the Woonasquatucket Interceptor immediately over the Johnston – Providence boundary at Manton Avenue in Providence.

The first secondary branch begins on Riverside Avenue in Johnston and extends south, connecting with the primary interceptor branch at Putnam Pike, just east of George Waterman Road (4,600 feet of pipe). This branch was installed in 1955 and consists of asbestos cement pipe ranging in size from 8" to 12".

The next secondary branch begins on George Waterman Road, between Garner Avenue and Vine Street. The branch flows south to Irons Avenue and eventually connects to the primary interceptor branch near Lyman Avenue (5,300 feet of pipe). This branch was originally installed in 1955. NBC's GIS records imply that a major portion of this branch was replaced in 1996. All pipe installed in 1955 was 10" asbestos cement, while the pipe installed in 1996 is 10" and 12" PVC. As part of the 1996 contract, about 1,400 feet of pipe were lined with a cured-in-place liner.

The third secondary branch begins on Greenville Avenue at Salina Avenue. The branch flows east along Greenville Avenue eventually connecting to the primary interceptor branch near Newman Avenue (4,100 feet of pipe). This branch was originally installed in 1955. NBC's GIS records imply that a major portion of this branch was replaced in 1996. All pipe installed in 1955 was 8" asbestos cement, while all the pipe installed in 1996 is PVC ranging in size from 8" to 12".

The fourth secondary branch begins on Borden Avenue, just north of Hartford Avenue. The branch extends along Borden Avenue, Killingly Street, Dyerville Avenue, Merino Street and Hedley Avenue, eventually connecting with the primary interceptor branch at the intersection of Greenville and Traver Avenues. The fifth secondary branch begins on Greenville Avenue, east of Lee Street, and connects to the primary interceptor branch at the intersection of Greenville and Traver Avenues.

The Johnston-North Interceptor system and service area are shown in Figure 1-1.

1.3 BACKGROUND – JOHNSTON-SOUTH INTERCEPTOR

The Johnston-South Interceptor consists of approximately 8.8 miles of sewer pipe (6.9 miles within Johnston), ranging in size from 8" to 36" in diameter (up to 30" in diameter within Johnston). The interceptor collects sanitary flow from the southeastern portion of Johnston, east of Interstate 295 and south of Route 6. The interceptor also collects combined sewer flow from the southwestern portion of Providence; however, that portion of the interceptor was not evaluated as part of this survey.

The Johnston-South Interceptor consists of four branches. The primary interceptor branch begins at the intersection of Atwood Avenue and Cherry Hill Road. The sewer flows south along Atwood Avenue to Plainfield Pike (Route 14). The sewer proceeds east along Route 14, eventually discharging to the Woonasquatucket Interceptor near Glenbridge Avenue in Providence.

The first secondary branch begins on Hartford Avenue at the intersection of Borden Avenue. The sewer extends west along Hartford Avenue and connects to the primary interceptor branch at the intersection of Hartford Avenue and Atwood Avenue

The next secondary branch also begins on Hartford Avenue between Memorial Avenue and Parkview Drive. The sewer proceeds east along Hartford Avenue and connects to the primary interceptor branch at the intersection of Hartford Avenue and Atwood Avenue

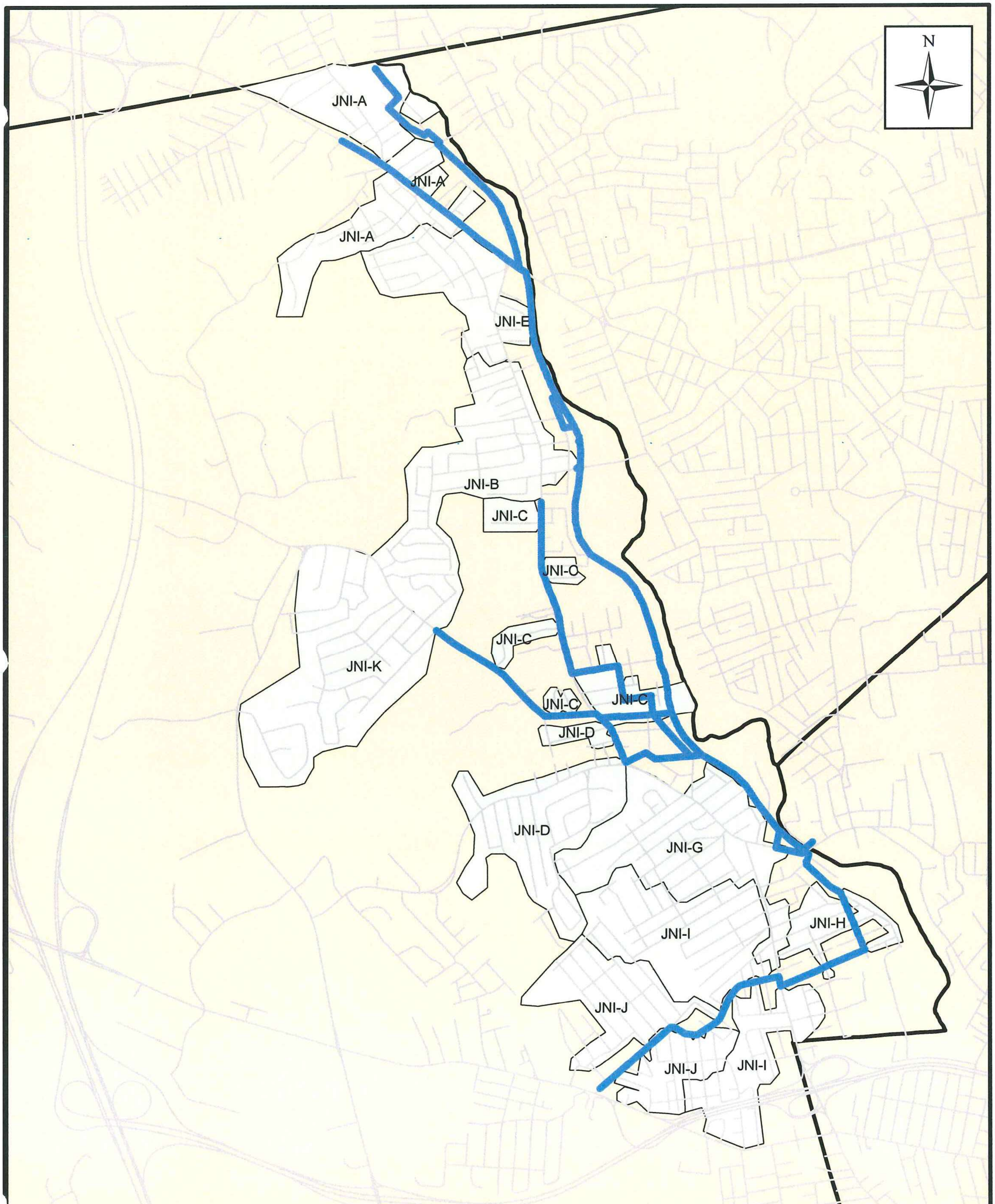
The third secondary branch begins at the intersection of Ashby Street and Pasadena Drive. The sewer flows north on Ashby Street to Boundary Avenue, east on Whittlesey Road, and north on Harding Avenue to Hartford Avenue. The interceptor then proceeds east along Hartford Avenue, connecting with the primary interceptor branch at the intersection of Hartford and Glenbridge Avenues.

As part of a previous study, the Interceptor Capacity Analysis (ICA) project, completed by BETA Group, Inc. in February 2007, inflow reduction measures were recommended in one meter basin (JSI-5T) to alleviate wet weather capacity issues within the Johnston-South Interceptor.

The Johnston-South Interceptor system and service area are shown in Figure 1-2.

FIGURE 1-1

JOHNSTON-NORTH INTERCEPTOR SERVICE AREA



PARE CORPORATION

BETA

NARRAGANSETT BAY COMMISSION
TOWN OF JOHNSTON, RI
SEWER SYSTEM EVALUATION SURVEY

JOHNSTON-NORTH INTERCEPTOR SERVICE AREA

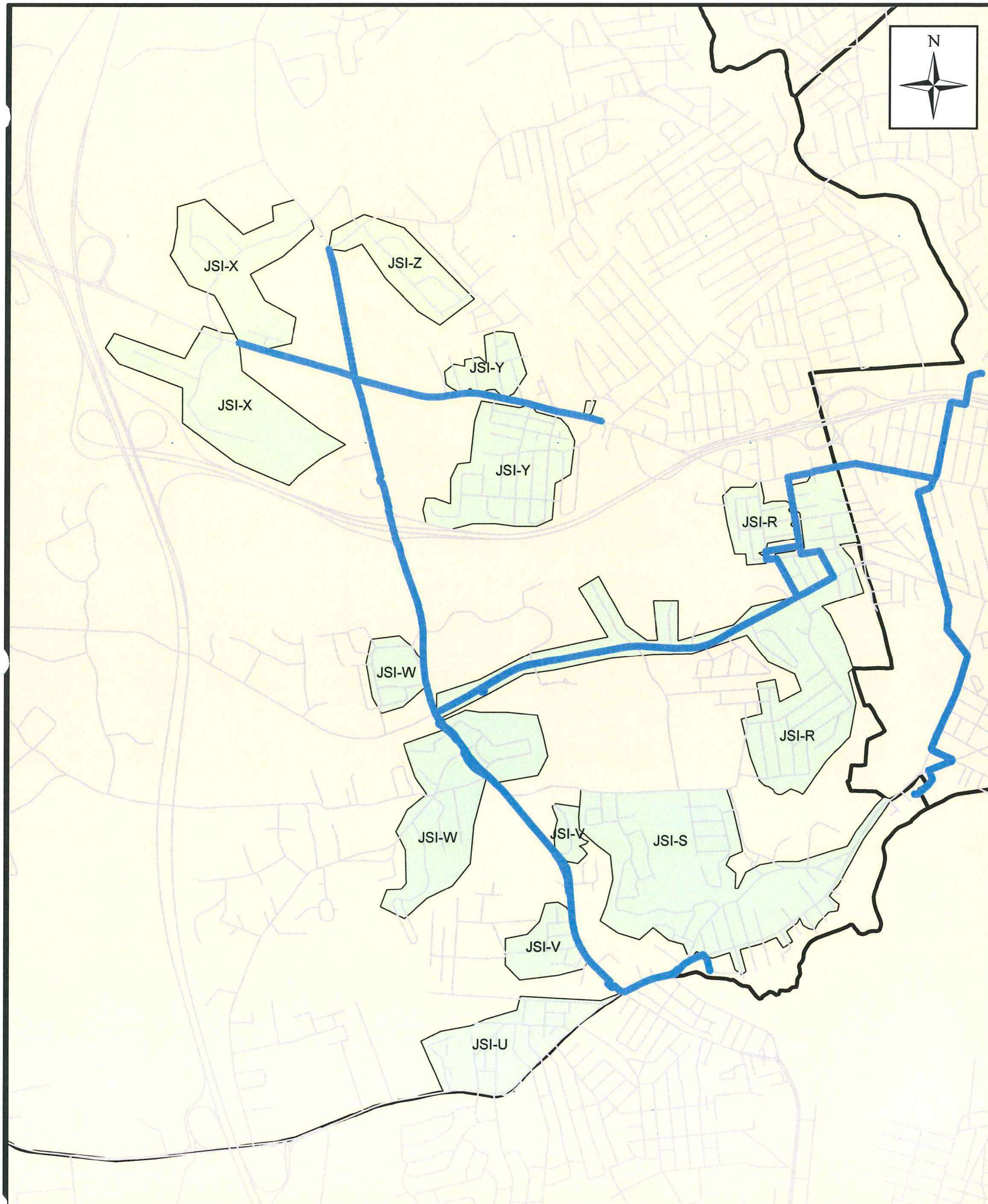
FIG. 1-1

SCALE: N.T.S.

DATE: JUNE, 2009

FIGURE 1-2

JOHNSTON-SOUTH INTERCEPTOR SERVICE AREA



PARE CORPORATION | BETA

NARRAGANSETT BAY COMMISSION
TOWN OF JOHNSTON, RI
SEWER SYSTEM EVALUATION SURVEY

JOHNSTON-SOUTH INTERCEPTOR SERVICE AREA

FIG. 1-2

SCALE: N.T.S.

DATE: JUNE, 2009

CHAPTER 2
FLOW METERING PROGRAM

2.1 GENERAL

The flow metering component of the previously completed ICA project entailed the installation and maintenance of seventy (70) meters throughout the NBC system to monitor flow in the interceptors for a 10-month period. Eight (8) of those meters directly monitored flow within the Johnston-North and Johnston-South Interceptors: three (3) meters in the Johnston-North Interceptor and five (5) meters in the Johnston-South Interceptor. While data collected from these flow meters indicated that large amounts of I/I were entering these interceptors through various meter basins, the size of the service areas contributing to those meters were too large to identify specific areas of high inflow.

Under this Town of Johnston Sewer System Evaluation Survey (SSES), the flow metering program included the installation and maintenance of nineteen (19) flow meters to measure flow within the Johnston-North and Johnston-South Interceptors over a two-month period, from October 1st, 2008 to December 1st, 2008.

- Eleven (11) of the meters were associated with the Johnston-North Interceptor, with ten (10) meters located directly on the NBC sewer and one (1) meter located on Allendale Avenue on a sewer maintained by the Town of Johnston.
- Eight (8) of the meters were located on the Johnston-South Interceptor.
- Groundwater gauges were installed at seven (7) meter locations to identify the presence of groundwater during the metering period.
- Two (2) tipping bucket-style rain gauges were installed within the service area at the NBC's Central Avenue Pumping Station and the Johnston Department of Public Works garage on Irons Avenue to record precipitation.

Figure 2-1 depicts the flow meter locations in relation to the NBC interceptor system, while Figure 2-2 shows the System Flow Diagram for this flow metering program.

2.2 METHODOLOGY

The flow meter locations identified for this project were based on both the flow meter locations used during the ICA project and community sub-basin discharge points to the interceptors. Ideally, each community discharge point to the interceptor would be monitored individually. While this situation occurred in some areas, it was not feasible in other areas due to the number of connections and the subsequent number of meters required. However, the 19 meters installed provide a good expansion of the previous metering efforts. The goal of this metering project was to capture flow data during significant storm events and evaluate the inflow response at the meters to isolate and prioritize sub-basins contributing significant inflow under storm conditions.

Infiltration

Infiltration is defined as extraneous groundwater flow that enters the sewer system through pipe joints, sewer line defects (including main sewer lines and service laterals), and defective manhole walls, benches, and pipe seals. Typically, an infiltration flow metering program would take place in March-April, when groundwater is at its highest elevation, to capture peak annual infiltration conditions as well as springtime, wet-weather flow conditions. However, due to time constraints, the flow metering period occurred during non-peak groundwater conditions (October-December). Infiltration to the system, as reflected in the flow data, increases from the beginning of the metering period to the latter stages of the period as groundwater levels rise. The large storm event that occurred at the beginning of the metering period temporarily raised groundwater levels at most of the gauge sites to levels coincident with high groundwater infiltration levels.

Infiltration at each meter location was determined by averaging the lowest flow value recorded (15-minute intervals) within four separate dry weather periods (four values total) and multiplying that value by 90% to allow for the fact that even during nighttime hours, there is a small percentage of sanitary flow present. The flow data was compared against the pipe lengths and sizes within each meter basin to calculate an infiltration rate for each basin. Information regarding sewer lengths and sizes for the Johnston-owned sewer system was obtained by Pare Corporation as part of the mapping effort associated with the Facilities Planning portion of the project. Information regarding sewer lengths and sizes for the NBC sewers was obtained through the NBC's GIS. The infiltration rates were evaluated to determine if any meter basin contributes excessive infiltration to the system. Rhode Island currently does not offer any guidance regarding excessive I/I. According to infiltration /inflow (I/I) guidance published by the Massachusetts Department of Environmental Protection (MADEP), an infiltration rate greater than 4,000 gallons per day per inch-diameter mile (gpd/idm) is considered excessive.

Inflow

Inflow in a sanitary sewer system is defined as extraneous flow that is a direct result of storm water runoff from a storm event. Inflow may enter the sanitary sewer through numerous sources from private property such as downspouts, area drains, service lateral cleanouts and foundation drains. From public property, inflow enters the sewer system through sources such as cross connections between the sanitary sewers and storm sewers, catch basins, and storm ditches; and sources such as manhole defects at the cover, frame seal, and corbel area. Inflow cannot be directly defined for combined sewers due to its inherent design to transport storm runoff.

To evaluate inflow at multiple meter locations, it is desirable to evaluate flow conditions during a number of storm events of varying volume and peak intensity. The resulting data would then be analyzed via linear regression to estimate peak inflow rates for various storm events, even if such a storm event did not occur within the metering period. Due to the limited number of significant storm events that occurred during the 2-month flow metering period, the aforementioned analysis could not be performed to any degree of reliability. However, this analysis was completed as part of the ICA project and already identified portions of the NBC system as contributing significant amounts of inflow.

The inflow analysis completed as part of this SSES project is intended to divide the Johnston-North and Johnston-South service areas into smaller meter basins than those defined in the ICA, and to identify specific areas of high inflow for further study.

- Four storms of varying volume and intensity were identified during the flow metering period. Two of these storm events occurred too close in time to the previous storm events and could not be evaluated on an individual storm basis.

- Flow data was plotted and compared against dry weather flow data from like days (weekdays to weekdays, weekends to weekends, and like time periods). The data was plotted from the beginning of the storm event to the point where the wet weather flow data stabilized. The point at which the wet weather flow data stabilizes is marked by either the point where the wet weather and dry weather equivalent flow data meet on a consistent basis or where the difference between the wet weather and dry weather flow remains consistent for an extended period of time (approximately 6 hours or more). The latter case occurs where the contributing meter basins have extensive RDII (rain-derived infiltration/inflow) contributions.

- The difference between the storm flow data and the dry weather equivalent flow data was calculated throughout the storm period and summed to yield the total volume of inflow evidenced at the meter during that particular rain event.

- The inflow volumes were evaluated to identify those meter basins that contributed the highest volume of inflow. Inflow volumes were also evaluated on a pipe length basis (gallons per day per inch diameter mile of sewer).

- Peak Inflow (mgd) and Peak Inflow Rates (gpd/lf) were evaluated to determine those meter basins that had the greatest inflow during the most intense period of the storms. These values were then compared to the dry weather flow rates to obtain a ratio (Q_{WP}/Q_D) to indicate the sensitivity of that basin to inflow during the highest intensity.

A sample calculation for determining inflow volume for a given storm event is provided at the end of this chapter.

Information relative to defining inflow as "excessive" is limited. The U.S. Environmental Protection Agency (USEPA) published I/I Analysis guidance in 1985 associated with their Construction Grants program. In this guidance document, the USEPA states, "If the average daily flow during periods of significant rainfall (i.e. any storm event that creates surface ponding and surface runoff; this can be related to a minimum rainfall amount for a particular geographic area) does not exceed 275 gpcd, the amount of inflow is considered non-excessive".

Manual of Practice FD-6 (MOP FD-6) entitled “Existing Sewer Evaluation & Rehabilitation”, published by the Water Environment Federation (WEF) states “Even in well-constructed, separate systems, the ratio of wet maximum [daily flow] to dry average (Q_{WM}/Q_D) usually ranges from 2 to 3, and the wet peak to dry average (Q_{WP}/Q_D) from 3 to 4; higher values indicate a more pronounced problem.”

Other state agencies consider any inflow to be excessive. The purpose of flow metering and inflow analysis is to determine which meter basins have the highest inflow contributions, since it assumed that it is easier and more cost effective to identify and remove inflow sources in areas with high inflow volumes and rates.

The purpose of the inflow analysis conducted as part of this SSES was to determine whether the amount of inflow from each meter basin is large enough to justify follow-up investigation. These areas will be referred to as having excessive inflow.

To determine which meter basins will be recommended for follow-up investigation, values for the following parameters will be calculated and used as a basis for comparison.

1. Peak inflow rate (mgd)
2. Peak inflow rate expressed as a rate per length of sewer (gpd/LF of sewer)
3. Inflow volume expressed as volume per length of sewer (gal/LF of sewer)
4. Ratio of wet weather peak flow to average dry weather flow (Q_{WP}/Q_D), per MOP FD-6. Severity of inflow problem is considered high if ratio > 4 and low if < 3. Note that the ratio is dependent on storm intensity and duration.
5. Ratio of wet weather maximum daily flow to average dry weather flow (Q_{WM}/Q_D). Severity of inflow problem is considered high if ratio > 3 and low if < 2. As stated above, the ratio is dependent on storm intensity and duration.

These parameters (or components of these parameters) are defined below:

- Peak Inflow Rate: the highest rate of inflow entering the system during a given storm event. The Peak Inflow Rate is calculated by obtaining a wet weather flow data value (15-minute measurement) and subtracting from it the dry weather equivalent flow data value of corresponding times and days. The greatest difference between the two values is the Peak Inflow Rate for that storm event and usually occurs at the highest recorded flow measurement during the storm event.

- Wet Peak Flow Rate: Q_{WP}; the highest flow rate during a given storm event, calculated as the Peak Inflow Rate plus the Dry Average Daily Flow (Q_D) Rate.

- Dry Average Flow: Q_D; the average daily flow rate during dry weather periods (i.e. excluding wet weather events), calculated as the average of all the 15-minute flow measurements recorded, excluding those measurements occurring during a storm event. Due to the limited number of storm events during this metering period, the difference between Q_D and the average daily flow (ADF) (including wet weather events) is negligible. Therefore, the ADF is used as Q_D in all calculations.

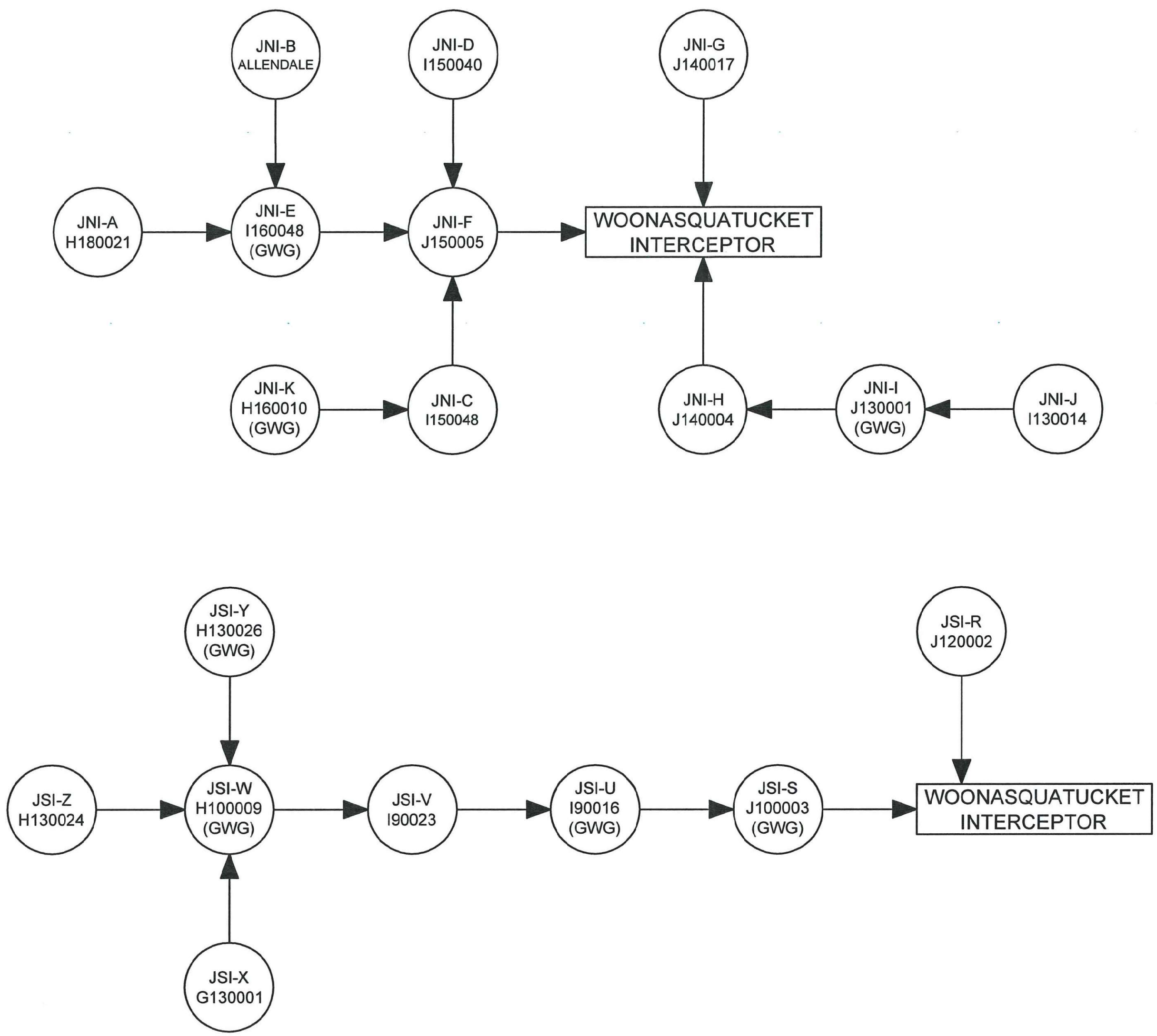
- Wet Maximum Daily Flow: Q_{WM}; the average daily flow rate occurring during a storm event (reported in MGD), calculated as the average of all the 15-minute flow measurements recorded during the storm event (for this project, beginning of rainfall to wet weather flow stabilization).

- Inflow Volume: the volume of inflow entering the system during a storm event. The inflow volume is calculated as the sum of the differences between 15-minute flow measurements recorded during the storm event (for this project, beginning of rainfall to wet weather flow stabilization) and the dry weather equivalent flow measurements of corresponding times and days.

$$InflowVolume(MG) = \sum \begin{pmatrix} WetWeatherFlowMeasurement(MGD) \\ - DryWeatherEquivalentFlowMeasurement(MGD) \end{pmatrix}$$

For the meter basins included in the Interceptor Capacity Analysis project, values for items one, two, and four above will be defined for both the 5-year and 1-year storms. As a minimum, follow-up investigations for inflow are recommended for all meter basins whose calculated Q_{WP}/Q_D ratio equals or exceeds a value of 4, for the 5-year storm event. Since the flow data for these storms is extrapolated from the inflow rate/rainfall intensity graphs, inflow volumes and Q_{WM}/Q_D cannot be reliably determined and are not presented in Tables 2-3 and 2-6.

For the meter basins included in the SSES, all of the above information will be included for all significant storm events observed. Values will be used to compare the various "sub-meter" basins to each other, to determine where the highest "concentration" of inflow is occurring within the meter basin, thus resulting in a more cost-effective approach to locating and removing the inflow sources.



PARE CORPORATION
8 BLACKSTONE VALLEY PLACE
LINCOLN, RI 02865

BETA Group, Inc.
Engineers • Scientists • Planners
6 Blackstone Valley Place
Lincoln, RI 02865
401.333.2382
email: BETA@BETA-inc.com

NARRAGANSETT BAY COMMISSION

TOWN OF JOHNSTON, RI

SEWER SYSTEM EVALUATION SURVEY

Scale: NONE

Figure No. 2-2

SYSTEM FLOW DIAGRAM

2.3 SUMMARY OF FINDINGS – JOHNSTON-NORTH INTERCEPTOR

Overall Flow Data Observations

In general, the data collected during the flow metering period appears to be of good quality. The daily flow patterns appear consistent and repeatable for most meters along this interceptor for both weekday and weekend flows. This allows average daily flow curves to be generated with a high degree of confidence. It also allows data anomalies to be quickly identified, such as holiday and special event flows (e.g. Thanksgiving, Columbus Day, Election Day, etc.), and removed from the average.

There does appear to be some data inconsistencies with meter data in specific basins. The data pattern for Meter JNI-J appears to be sporadic and does not subscribe to the strict diurnal flow pattern exhibited by other flow meters. Review of the flow data pattern and system mapping indicates that a pumping station upstream of the meter, located within the community-owned collection system, is influencing the recorded flow. The pumping station collects approximately half the flow contributions from the meter basin, so while one can loosely see the diurnal flow pattern on a hydrograph, the flow pattern appears indistinct, marred by flow spikes coincident with periods of pumped flow. Meter JNI-J is upstream of two other flow meters: JNI-I and JNI-H. A review of the hydrographs for each of these meters also showed evidence of the pump station influence, but to a continually lesser degree proportional to the distance away from the pumping station. The flow spikes at JNI-I were less frequent and shorter intensity; flow spikes at JNI-H even further dampened. The ultimate effect of these flow spikes and indistinct flow pattern is that the average flow curves were generated with a lesser degree of confidence than other meters in this basin. When averaged over a long time frame (weeks), the error effects are minimal. However, when conducting inflow analyses for storm events lasting for periods of a few hours, these effects can lead to decreased accuracy of inflow volume estimates.

There also appears to be some data discrepancies with two other meters along this interceptor. Data and analysis results for meters JNI-E and JNI-F indicated that the meters recorded near zero net flows or negative net flows after flow balancing. After reviewing the system mapping, the two meters are located on a section of interceptor located on a cross-country easement along the Woonasquatucket River. The amount of sanitary flow entering the interceptor upstream of either of these meters that is not recorded in an upstream meter is minimal. As such, near zero net flows and negative net flows at these meters are not surprising.

Infiltration Analysis

Basic data regarding average daily flow and infiltration for the Johnston-North Interceptor are presented in Table 2-1. The gross average daily flow (ADF) is the calculated average of all the flow measurements during the metering period for a given flow meter. The net average daily flow is the ADF contributions from the meter area subtracting flow contributions recorded at upstream meters. The “Pipe Length” represents a pipe size and length estimate typically used in infiltration estimates, measured in inch-diameter miles of pipe.

Table 2-1 – Infiltration Estimates: Johnston-North Interceptor

Meter	Gross ADF (MGD)	Net ADF (MGD)	Gross Infiltration (MGD)	Net Infiltration (MGD)	Pipe Length (IDM)	Percent of NBC Sewers (%)	Net Infiltration Rate (gpd/in-mi)
JNI-A	0.157	0.157	0.029	0.029	53.825	30.5%	548
JNI-B	0.133	0.133	0.043	0.043	32.653	0.0%	1330
JNI-C	0.341	0.149	0.160	0.071	25.943	68.9%	2732
JNI-D	0.202	0.202	0.085	0.085	28.179	9.8%	3018
JNI-E	0.307	0.017	0.072	-0.001	31.475	86.5%	-43
JNI-F	0.878	0.028	0.325	0.008	16.287	98.1%	511
JNI-G	0.140	0.140	0.027	0.027	36.071	3.2%	761
JNI-H	0.395	0.008	0.093	0.015	23.210	31.4%	640
JNI-I	0.387	0.152	0.079	0.021	51.610	6.5%	410
JNI-J	0.235	0.235	0.057	0.057	30.466	13.5%	1883
JNI-K	0.192	0.192	0.090	0.090	26.857	2.9%	3334

ADF: Average Daily Flow

The total volume of infiltration was determined to be approximately 0.45 mgd. However, groundwater elevations were likely not at their highest elevations during the metering period. Higher elevations would typically be seen in the late winter and spring seasons. Therefore, infiltration rates are likely higher during the higher groundwater period.

Based on the infiltration rates, the system appears to be in reasonably good condition. None of the meter basins investigated recorded infiltration rates greater than 4,000 gpd/in-mi, which was previously described as the benchmark for determining excessive infiltration. The only data anomaly is the negative net infiltration rate for Meter Basin JNI-E. Flow meter JNI-E is downstream of two other flow meters, JNI-A and JNI-B. As such, the net infiltration rate is calculated by estimating the gross infiltration rate at meter JNI-E and subtracting the gross infiltration rates from the upstream meters. The data indicates that the infiltration entering the system within the JNI-E meter basin is minimal and the negative net infiltration rate is attributed to normal flow balancing deviation.

The highest infiltration rate is 3,334 gpd/in-mi and enters the system from meter basin JNI-K. Meter basin JNI-D has the second-highest infiltration rate at 3,018 gpd/in-mi. While the infiltration rates in both meter basins are not considered excessive under groundwater conditions during the metering period, the rates may increase under higher groundwater conditions. Therefore, meter basins JNI-K and JNI-D may warrant further investigations. It is important to note that the Town of Johnston owns the majority of the sewers in these two meter basins.

Inflow Analysis

Projected inflow rates from the previous Interceptor Capacity Analysis report are presented in Table 2-2 for both the five-year and one-year storm event. Flow information is "net" per meter basin unless otherwise noted. Average daily flows are for dry-weather, high-groundwater conditions.

Table 2-2 – Inflow Summary (ICA – Johnston-North Interceptor)

Meter	Gross ADF (MGD)	Net ADF (MGD)	Street CL (mi)	Gross Peak Inflow Rate (MGD)	Net Peak Inflow Rate (MGD)	Peak Inflow Rate (gpd/LF)	Gross $Q_{WP}Q_D$	$Q_{WP}Q_D$
5-Year, 60-Minute Storm				**Peak Rainfall Intensity:**			**(1.55 in./hr.)**	
JNI-3T	0.56	0.56	6.42	1.61	1.61	47.5	3.875	3.875
JNI-2T	1.27	0.72	12.52	3.62	2.01	30.4	3.850	3.792
JNI-1T	0.49	0.49	11.11	1.52	1.52	25.9	4.102	4.102
1-Year, 60-Minute Storm				**Peak Rainfall Intensity:**			**(0.98 in./hr.)**	
JNI-3T	0.56	0.56	6.42	1.02	1.02	30.1	2.821	2.821
JNI-2T	1.27	0.72	12.52	2.29	1.27	19.2	2.803	2.764
JNI-1T	0.49	0.49	11.11	0.96	0.96	16.4	2.959	2.959

For the 5-year storm event, the Q_{WP}/Q_D ratio for JNI-1T is slightly greater than 4 indicating a high degree of inflow. The Interceptor Capacity Analysis report identified meter basins JNI-2T and JNI-3T as basins potentially subject to wet weather surcharging and meter basin JNI-1T as a basin potentially subject to dry weather overflows. The ICA report did not recommend that follow up investigation be conducted for the areas within any basins, but did acknowledge that inflow reduction for basins JNI-2T and JNI-3T were viable alternatives.

The results of the Inflow Analysis conducted as part of this SSES are presented in Table 2-3. Gross flow data (as recorded at each meter) and net flow data (per meter basin) are displayed to help understand flow through the system. Note that flow balancing by deducting upstream meter flows from downstream meter flows results in a negative value for some meter basins.

Table 2-3
Narragansett Bay Commission
Johnston SSES
Johnston-North Interceptor - SSES Inflow Analysis

		(Gross)			(Gross)			(Gross)			(Gross)		
Meter	**ICA Basin**	**Dry ADF (Q_D) (MGD)**	**Dry ADF (Q_D) (MGD)**	**Pipe Length (IDM)**	**Peak Inflow Rate (MGD)**	**Peak Inflow Rate (MGD)**	**Peak Inflow Rate (gpd/IDM)**	**Wet Max Daily Rate (Q_{WM}) (MGD)**	**Inflow Volume (MG)**	**Inflow Volume (gal./IDM)**	**Q_{WP}/Q_D**	**Q_{WP}/Q_D**	**Q_{WM}/Q_D**
October 25-26, 2008 Storm				*Peak Rainfall Intensity: 0.66 in./hr.*						*Total Rainfall: 1.27 in.*			
JNI-A	JNI-3T	0.130	0.130	53.825	0.595	0.595	11054	0.212	0.042	788	5.563	5.563	1.626
JNI-B	JNI-2T	0.123	0.123	32.653	0.185	0.185	5666	0.134	0.013	400	2.502	2.502	1.088
JNI-C	JNI-2T	0.301	0.154	25.943	0.134	0.056	2159	0.290	0.000	2	1.445	1.364	0.962
JNI-D	JNI-2T	0.173	0.173	28.179	0.173	0.173	6139	0.176	0.011	392	1.997	1.997	1.015
JNI-E	JNI-2T/JNI-3T	0.303	0.050	31.475	0.604	-0.176	-5592	0.340	-0.012	-383	2.992	-2.541	1.121
JNI-F	WI-5T	0.742	-0.036	16.287	0.881	-0.030	-1842	0.801	0.011	705	2.187	1.829	1.080
JNI-G	WI-5T	0.130	0.130	36.071	0.415	0.415	11505	0.176	0.031	853	4.184	4.184	1.350
JNI-H	JNI-1T	0.325	0.031	23.210	0.488	-0.208	-8962	0.323	0.002	76	2.503	-5.736	0.995
JNI-I	JNI-1T	0.294	0.105	51.610	0.696	0.444	8603	0.297	0.023	446	3.369	5.248	1.011
JNI-J	JNI-1T	0.189	0.189	30.466	0.252	0.252	8272	0.167	0.003	105	2.331	2.331	0.882
JNI-K	JNI-2T	0.147	0.147	26.857	0.078	0.078	2904	0.151	0.004	135	1.529	1.529	1.024
November 25, 2008 Storm				*Peak Rainfall Intensity: 0.20 in./hr.*						*Total Rainfall: 1.81 in.*			
JNI-A	JNI-3T	0.130	0.130	53.825	0.591	0.591	10980	0.280	0.147	2735	5.532	5.532	2.147
JNI-B	JNI-2T	0.123	0.123	32.653	0.169	0.169	5176	0.206	0.080	2454	2.372	2.372	1.672
JNI-C	JNI-2T	0.301	0.154	25.943	0.208	0.046	1773	0.411	0.000	12	1.690	1.299	1.364
JNI-D	JNI-2T	0.173	0.173	28.179	0.149	0.149	5288	0.258	0.080	2848	1.859	1.859	1.487
JNI-E	JNI-2T/JNI-3T	0.303	0.050	31.475	0.511	-0.249	-7911	0.500	-0.054	-1727	2.685	-4.010	1.649
JNI-F	WI-5T	0.742	-0.036	16.287	0.806	-0.062	-3807	1.236	0.102	6291	2.086	2.713	1.666
JNI-G	WI-5T	0.130	0.130	36.071	0.209	0.209	5794	0.234	0.098	2705	2.604	2.604	1.795
JNI-H	JNI-1T	0.325	0.031	23.210	0.723	-0.132	-5687	0.589	-0.028	-1215	3.227	-3.275	1.814
JNI-I	JNI-1T	0.294	0.105	51.610	0.855	0.549	10637	0.587	0.169	3269	3.910	6.253	1.998
JNI-J	JNI-1T	0.189	0.189	30.466	0.306	0.306	10044	0.306	0.110	3607	2.616	2.616	1.616
JNI-K	JNI-2T	0.147	0.147	26.857	0.162	0.162	6032	0.255	0.108	4009	2.099	2.099	1.730

** All Flow Information is "Net" unless otherwise noted.*

Results indicate the following:

- Based on peak inflow rate (gpd/IDM), meter basins JNI-A, JNI-I, and JNI-J consistently have the highest peak inflow rates. For the October 25-26 storm event, JNI-G had the highest peak inflow rate.

- Based on inflow volume (gal/IDM), none of the meter basins for the October 25-26 storm exhibited unusually high volumes of inflow. For the November 25 storm event, meter basin JNI-F had the highest inflow volume, although the actual volume may be slightly overestimated, as evidenced by a negative inflow net inflow volume at an upstream meter. Also, meter basins JNI-K and JNI-J have moderate inflow volumes for the November 25 storm.

- Based on the Q_{WP}/Q_D ratio, JNI-A and JNI-I are consistently greater than 4, indicating a high severity of inflow. JNI-G is greater than 4 for the October 25-26 storm event.

- Based on the Q_{WM}/Q_D ratio, only meter basin JNI-A exceeds a ratio value of 2 in any given storm event.

- The results indicate further investigation is not necessary in meter basins JNI-B, JNI-C, JNI-D, and JNI-E.

- Review of the wet weather hydrographs confirms extensive and immediate system response to rainfall conditions in meter basins JNI-A and JNI-I. Elevated inflows identified at these meters appear during most storm events, regardless of intensity.

A summary of inflow finds is as follows:

Parameter	Meter Basin Exhibiting High Inflow
Peak inflow rate (gpd/IDM)	JNI-A, JNI-I, JNI-J, and JNI-G
Inflow volume (gal/IDM)	JNI-F, JNI-K, and JNI-J
Q_{WP}/Q_D ratio	JNI-A and JNI-I
Q_{WM}/Q_D ratio	JNI-A

Based on the above summary, it is recommended that further inflow investigation be conducted in meter basins JNI-A, JNI-I, JNI-J and JNI-G.

2.4 SUMMARY OF FINDINGS – JOHNSTON-SOUTH INTERCEPTOR

Overall Flow Data Observations

Similar to the Johnston-North Interceptor observations, the data collected during the flow metering period appears to be of good quality. The daily flow patterns appear consistent and repeatable for most meters along this interceptor for both weekday and weekend flows.

Also similar to the Johnston-North Interceptor observations, some data inconsistencies with meter data in specific basins exists. Review of the flow data patterns and system mapping indicates that pumping stations discharging upstream of the meter, is influencing the recorded flow in meter basins JSI-R, JSI-X, and JSI-Z. For meter basin JSI-R, the influencing pumping station is the NBC's Central Avenue Pumping Station. While the flow data is noticeably influenced by this station, it is assumed that the discharge occurs far enough away from the flow meter to significantly affect the analysis when comparing average flows to storm flows (i.e. comparisons to short –duration flows). The flow data for meter basin JSI-Z appears to be particularly more erratic than the other two pump-influenced basins. Based on the system mapping, the contributing basin appears to be small with the majority of the flow passing through the pumping station. This theory is evidenced by the wide swings in recorded flow from near zero flows during non-pumping times and significant flow spikes during pumping times.

The flow data for meter basin JSI-X also appears to be heavily influenced by the effects of the upstream pumping station. However, the effects of the station do not appear to be greatly influencing the flow from a "range of flow" perspective as evidenced at the meter. The effects appear to be based more on the frequency of pump cycles, which is greater than the other pump-influenced basins. Due to the frequency of the pump cycles, it is anticipated that the pumping station is small. As a result, the average flow curve for this meter is smoother and less erratic than the other pump-influenced basins.

Infiltration Analysis

Basic data regarding average daily flow and infiltration for the Johnston-South Interceptor are presented below in Table 2-4.

Table 2-4 – Infiltration Estimates: Johnston-South Interceptor

Meter	Gross ADF (MGD)	Net ADF (MGD)	Gross Infiltration (MGD)	Net Infiltration (MGD)	Pipe Length (IDM)	Percent of NBC Sewers (%)	Net Infiltration Rate (gpd/in-mi)
JSI-R	0.228	0.228	0.052	0.052	43.843	21.7%	1180
JSI-S	1.041	0.054	0.423	-0.011	73.281	53.7%	-147
JSI-U	0.987	0.240	0.434	0.184	25.823	19.6%	7127
JSI-V	0.747	0.046	0.250	-0.007	23.282	79.6%	-300
JSI-W	0.701	0.240	0.257	0.155	49.736	80.3%	3121
JSI-X	0.215	0.215	0.035	0.035	19.634	18.8%	1788
JSI-Y	0.166	0.166	0.042	0.042	19.478	32.5%	2160
JSI-Z	0.080	0.080	0.025	0.025	8.992	35.1%	2752

ADF: Average Daily Flow

Based on the infiltration rates, most of the system appears to be in reasonably good condition. One meter basin investigated (JSI-U) recorded infiltration rates greater than 4,000 gpd/in-mi, which was previously described as the benchmark for determining excessive infiltration. The rate from JSI-W may also warrant further investigation since infiltration rates may be higher during the high groundwater season than those determined during this metering period. There are two data anomalies, realized in the form of negative net infiltration rates for Meter Basin JSI-S and JSI-V. Both flow meters are located downstream of other flow meters, meaning that the net infiltration rate is calculated estimating the gross infiltration rate from upstream meters. The data indicates that the infiltration entering the system within the meter basins are minimal and the negative net infiltration rate is attributed to normal flow balancing deviation.

Review of the CCTV inspection logs for the NBC interceptor in meter basin JSI-U indicates that the NBC sewer is in good condition with no major defects. The NBC owns approximately 19.6% of the sewers (on an IDM basis) within this basin, meaning that the Town of Johnston owns the majority of the sewers in this basin. Based on the apparent condition of the NBC-owned interceptor and the fact that the Town of Johnston owns most of the sewers, it is likely that the majority of infiltration within this basin is entering the system from local sewers. CCTV inspection of the Johnston-owned sewers would be necessary to confirm the presence of deficiencies contributing to the excessive infiltration. CCTV inspection logs for the NBC interceptor in meter basin JSI-W indicates that the NBC sewer is in reasonably good condition, but does exhibit signs of minor infiltration throughout the sewer. The NBC owns approximately 80% of the sewers (on an IDM basis) within this basin

Inflow Analysis

The inflow results of the Interceptor Capacity Analysis are presented in Table 2-5 for both the five-year and one-year storm events. Flow information is "net" per meter basin unless otherwise noted. Average daily flows are for dry-weather, high-groundwater conditions. Meter JSI-1T is located in the City of Providence and measures flow contributions from Providence sources exclusively (on a net meter basis). The data for

JSI-1T was intentionally omitted from the table below because it is located outside the project area.

Table 2-5 – Inflow Summary (ICA – Johnston-South Interceptor)

Meter	Gross ADF (MGD)	Net ADF (MGD)	Street CL (mi)	Gross Peak Inflow Rate (MGD)	Net Peak Inflow Rate (MGD)	Peak Inflow Rate (gpd/LF)	Gross $Q_{WP}Q_D$	$Q_{WP}Q_D$
5-Year, 60-Minute Storm				**Peak Rainfall Intensity: (1.55 in./hr.)**				
JSI-5T	0.53	0.53	10.94	2.77	2.77	48.0	6.226	6.226
JSI-4T	0.89	0.36	3.77	4.86	2.09	105.0	6.461	6.806
JSI-3T	1.16	0.27	6.23	5.08	0.22	6.7	5.379	1.815
JSI-2T	0.36	0.36	4.53	1.34	1.34	56.0	4.722	4.722
1-Year, 60-Minute Storm				**Peak Rainfall Intensity: (0.98 in./hr.)**				
JSI-5T	0.53	0.53	10.94	1.75	1.75	30.3	4.302	4.302
JSI-4T	0.89	0.36	3.77	3.07	1.32	66.3	4.449	4.667
JSI-3T	1.16	0.27	6.23	3.21	0.14	4.3	3.767	1.519
JSI-2T	0.36	0.36	4.53	0.85	0.85	35.5	3.361	3.361

For the five-year storm event, the Q_{WP}/Q_D ratios for JSI-2T, JSI-4T, and JSI-5T are all greater than 4 indicating a high degree of inflow. The Interceptor Capacity Analysis recommended that follow up inflow investigation be conducted for the areas within JSI-5T to alleviate wet weather capacity issues through the interceptor.

The results of the Inflow Analysis conducted as part of this SSES are presented in Table 2-6. Gross flow data (as recorded at each meter) and net flow data (per meter basin) are displayed to help understand flow through the system.

Table 2-6
Narragansett Bay Commission
Johnston SSES
SSES Inflow Analysis - Johnston-South Interceptor

		(Gross)			(Gross)			(Gross)			(Gross)		
Meter	**ICA Basin**	**Dry ADF (Q_D) (MGD)**	**Dry ADF (Q_D) (MGD)**	**Pipe Length (IDM)**	**Peak Inflow Rate (MGD)**	**Peak Inflow Rate (MGD)**	**Peak Inflow Rate (gpd/IDM)**	**Wet Max Daily Rate (Q_{WM}) (MGD)**	**Inflow Volume (MG)**	**Inflow Volume (gal./IDM)**	**Q_{WP}/Q_D**	**Q_{WP}/Q_D**	**Q_{WM}/Q_D**
October 25-26, 2008 Storm				*Peak Rainfall Intensity: 0.74 in./hr.*						*Total Rainfall: 1.34 in.*			
JSI-R	JSI-2T	0.201	0.201	43.843	0.997	0.997	22740	0.295	0.050	1139	5.960	5.960	1.468
JSI-S	JSI-3T	0.795	-0.151	73.281	3.793	2.181	29762	1.66	0.178	2432	5.773	-13.417	2.089
JSI-U	JSI-3T	0.946	0.329	25.823	1.612	-0.302	-11695	1.230	-0.071	-2737	2.704	0.081	1.300
JSI-V	JSI-4T	0.617	-0.025	23.282	1.914	0.301	12928	0.792	0.098	4229	4.101	-10.964	1.283
JSI-W	JSI-4T/JSI-5T	0.642	0.234	49.736	1.613	-0.285	-5730	0.880	-0.037	-749	3.511	-0.216	1.370
JSI-X	JSI-5T	0.192	0.192	19.634	1.092	1.092	55618	0.45	0.098	4979	6.702	6.702	2.350
JSI-Y	JSI-5T	0.139	0.139	19.478	0.747	0.747	38351	0.269	0.054	2766	6.373	6.373	1.935
JSI-Z	JSI-5T	0.077	0.077	8.992	0.059	0.059	6561	0.067	0.000	-6	1.762	1.762	0.865
November 25, 2008 Storm				*Peak Rainfall Intensity: 0.21 in./hr.*						*Total Rainfall: 1.69 in.*			
JSI-R	JSI-2T	0.201	0.201	43.843	0.271	0.271	6181	0.368	0.156	3566	2.348	2.348	1.831
JSI-S	JSI-3T	0.795	-0.151	73.281	1.433	0.495	6755	1.687	0.464	6336	2.803	-2.272	2.123
JSI-U	JSI-3T	0.946	0.329	25.823	0.938	-0.236	-9139	1.408	-0.129	-5001	1.992	0.282	1.488
JSI-V	JSI-4T	0.617	-0.025	23.282	1.174	0.177	7602	1.161	0.147	6303	2.902	-6.035	1.881
JSI-W	JSI-4T/JSI-5T	0.642	0.234	49.736	0.997	-0.259	-5207	1.035	0.025	507	2.552	-0.105	1.611
JSI-X	JSI-5T	0.192	0.192	19.634	0.843	0.843	42936	0.42	0.215	10925	5.402	5.402	2.193
JSI-Y	JSI-5T	0.139	0.139	19.478	0.327	0.327	16788	0.268	0.124	6346	3.352	3.352	1.928
JSI-Z	JSI-5T	0.077	0.077	8.992	0.086	0.086	9564	0.087	0.006	682	2.111	2.111	1.124

** All Flow Information is "Net" unless otherwise noted.*

Results indicate the following:

- Based on peak inflow rate (gpd/IDM), meter basins JSI-X and JSI-Y consistently have high peak inflow rates. Meter Basins JSI-R and JSI-S also have high peak inflow rates for the October 25-26 storm.

- Based on inflow volume (gal/IDM), meter basins JSI-X has the highest amount of inflow. JSI-S, JSI-V, and JSI-Y also have high inflow volumes for the November 25th storm.

- The Q_{WP}/Q_D ratio for meter basin JSI-X is greater than 4 for both storms, indicating a high severity of inflow. For the October 25-26 storm, JSI-R and JSI-Y both have values greater than 4, indicating a high severity of inflow likely associated with higher intensity rainfall. (Peak rainfall intensity = 0.74 in./hr. for October storm versus Peak rainfall intensity = 0.21 in./hr. for November storm).

- Based on the Q_{WM}/Q_D ratio, meter basins JSI-S and JSI-X exceeds a value of 2 for both storm events, indicating a moderate severity of inflow for a prolonged period of time.

- Further investigation is not recommended in JSI-U, JSI-W, and JSI-Z.

- The wet weather hydrographs show extensive and immediate system response to rainfall conditions in meter basins JSI-X, JSI-Y, JSI-R, and JSI-S.

A summary of inflow findings is as follows:

Parameter	Meter Basin Exhibiting High Inflow
Peak inflow rate (gpd/LF)	JSI-X, JSI-Y, JSI-R, and JSI-S
Inflow volume (gal/LF)	JSI-X, JSI-S, JSI-V, and JSI-Y
Q_{WP}/Q_D ratio	JSI-X, JSI-R, and JSI-Y
Q_{WM}/Q_D ratio	JSI-X and JSI-S

Based on the above summary, it is recommended that further inflow investigation be conducted in meter basins JSI-X, JSI-Y, JSI-R, JSI-S, and JSI-V.

Narragansett Bay Commission					
Johnston SSES					
Inflow Volume Calculation					
Flow Meter: JSI-X					
Storm Date: 10/25/2008-10/26/2008					
DateTime	**Storm Flow**	**DW Equiv.**	**Rainfall**	**Inflow Rate**	**Inflow Vol.**
M/d/yyyy h:mm:ss tt	***MGD***	***MGD***	***inches***	***MGD***	***MG***
10/25/2008 21:15	0.217	0.23	0.02	-0.013	-0.0001
10/25/2008 21:30	0.167	0.147	0.02	0.020	0.0002
10/25/2008 21:45	0.137	0.182	0.02	-0.045	-0.0005
10/25/2008 22:00	0.265	0.176	0	0.089	0.0009
10/25/2008 22:15	0.146	0.211	0	-0.065	-0.0007
10/25/2008 22:30	0.497	0.166	0	0.331	0.0034
10/25/2008 22:45	0.092	0.169	0	-0.077	-0.0008
10/25/2008 23:00	0.076	0.094	0	-0.018	-0.0002
10/25/2008 23:15	0.312	0.235	0	0.077	0.0008
10/25/2008 23:30	0.104	0.119	0.01	-0.015	-0.0002
10/25/2008 23:45	0.086	0.113	0.04	-0.027	-0.0003
10/26/2008 0:00	0.373	0.11	0.07	0.263	0.0027
10/26/2008 0:15	0.298	0.114	0.08	0.184	0.0019
10/26/2008 0:30	0.725	0.166	0.08	0.559	0.0058
10/26/2008 0:45	0.541	0.144	0.07	0.397	0.0041
10/26/2008 1:00	0.561	0.065	0.18	0.496	0.0052
10/26/2008 1:15	0.64	0.106	0.28	0.534	0.0056
10/26/2008 1:30	1.271	0.179	0.21	1.092	0.0114
10/26/2008 1:45	0.831	0.106	0.05	0.725	0.0076
10/26/2008 2:00	1.068	0.077	0.15	0.991	0.0103
10/26/2008 2:15	0.71	0.091	0.05	0.619	0.0064
10/26/2008 2:30	0.885	0.123	0	0.762	0.0079
10/26/2008 2:45	0.702	0.122	0	0.580	0.0060
10/26/2008 3:00	0.427	0.094	0	0.333	0.0035
10/26/2008 3:15	0.518	0.136	0	0.382	0.0040
10/26/2008 3:30	0.421	0.147	0.01	0.274	0.0029
10/26/2008 3:45	0.414	0.097	0	0.317	0.0033
10/26/2008 4:00	0.405	0.102	0	0.303	0.0032
10/26/2008 4:15	0.4	0.174	0	0.226	0.0024
10/26/2008 4:30	0.209	0.118	0	0.091	0.0009
Inflow Volume =	***0.0978***	***MG***			
Peak Flow Rate =	***1.271***	***MGD***			
Peak Inflow Rate =	***1.092***	***MGD***			
DateTime:	Date/Time data point was recorded (flow & rainfall)				
Storm Flow:	Flow Meter reading during storm event, expressed in MGD				
DW Equiv.:	Average Flow Meter reading for the same time period based on a series of dry weather days (no rainfall on day or two days prior), expressed in MGD.				

	Note that the date presented does not coincide with the date of the				
	measurement				
Rainfall:	Rainfall, as recorded at rain gauge, expressed in inches				
Inflow Rate:	Rate at which inflow is being measured at the flow meter; calculated				
	value based on the difference between the storm flow and the dry weather				
	equivalent flow, expressed as MGD				
Inflow Volume:	Estimated volume of inflow based on the calculated inflow rate and				
	assumes that the Inflow Rate is constant between flow meter readings.				
Inflow Volume Example:					
DateTime	**Storm Flow**	**DW Equiv.**	**Rainfall**	**Inflow Rate**	**Inflow Vol.**
M/d/yyyy h:mm:ss tt	***MGD***	***MGD***	***inches***	***MGD***	***MG***
10/26/2008 0:30	0.725	0.166	0.08	0.559	0.0058
10/26/2008 0:45	0.541	0.144	0.07	0.397	0.0041
	Inflow Vol. = (Inflow Rate * 15 min) / 1440 min/day				
	0.0058 MG represents the volume of inflow that entered the system between 0:30 and 0:45 on 10/26/2008. 0.0041 MG represents the volume of inflow that entered the system between 0:45 and 1:00 on 10/26/2008. The sum of all the volumes between the start of the storm event and the time where the storm flow stabilizes represents the total inflow volume for the storm event at that meter. Please note that the time in which the storm flow "stabilizes" does not necessarily coincide with approximately matching the dry weather equivalent flow. If the system is subject to large amounts of RDII (rain-dependent infiltration/inflow), this point in time may not occur until hours or even days after the "inflow" period has ended.				

CHAPTER 3
PIPELINE/MANHOLE INSPECTION PROGRAM

3.1 GENERAL

Part of the Sewer System Evaluation Survey entailed examining and evaluating the existing conditions of the NBC's sewer system for the Johnston-North and Johnston-South Interceptors. The purpose of this evaluation is to define specific areas where the NBC's pipe and manhole assets are in poor or deteriorating conditions. Assets in poor condition can lead to elevated infiltration and inflow flows, decreased carrying capacity of the interceptors (due to I/I and obstructions), and subsequently leading to a higher potential for system failure in the form of sewer surcharging and service backups.

3.2 PIPELINE INSPECTION PROGRAM

Outside the scope of this project, the NBC has been employing an aggressive program to inspect all of their pipeline assets. The Johnston-North and Johnston-South Interceptors were recently (within the last 5 years) inspected by means of internal closed-circuit television. The Johnston-North Interceptor was inspected by New England Pipe Cleaning Company between September 2006 and November 2006. The Johnston-South Interceptor was inspected by Inland Waters, Inc. between March 2007 and June 2007.

BETA reviewed the inspection reports from these contracts as part of this SSES project to assess the general condition of the pipes and to identify potential inflow sources. Potential inflow sources were identified from the reports as connections that did not appear to be associated with building services by size (i.e. connections other than 4" or 6" connections). It is recommended that these connections be investigated by the NBC to determine their source. A listing of these potential inflow sources is provided in Table 3-1 located at the end of this chapter.

Summary results of the condition assessment review, grouped by meter basin, are provided later in this chapter.

3.3 MANHOLE INSPECTION PROGRAM

As part of this project, BETA reviewed manhole inspection reports completed for the Johnston-North and Johnston-South Interceptors. The Johnston-North Manhole Inspections were completed in September 2006 by New England Pipe Cleaning Company The Johnston-South Manhole Inspections were completed in conjunction with the CCTV pipe inspections by Inland Waters, Inc. Similar to the Pipeline Inspection Program, BETA reviewed the available manhole inspection reports to assess the manhole conditions as well as identify potential inflow sources discharging to the manholes.

The two interceptors were inspected by different contractors, using different assessment methodologies. The Johnston-North Interceptor, inspected by the New England Pipe Cleaning Company (NEPCCO), utilized a condition rating system for each manhole component, typical for manhole condition assessments. The NEPCCO system also identified sources of infiltration within each manhole (if applicable) and identified each pipe within the manhole by size, depth, material, and assumed source. The Johnston-South Interceptor, inspected by Inland Waters, Inc., employed the MACP methodology for defect coding as established by NASSCO. The MACP methodology assesses the manhole as a single unit and notes specific deficiencies with the manhole, as opposed to rating the condition of the individual components.

The information contained within the Johnston-North manhole inspection reports appears to be reasonably thorough. The Johnston-South manhole inspection reports only contain data related to the type of pipe (inlet/outlet), shape, and clock position entering or exiting the manhole. BETA identified all manholes that possessed multiple inlets. BETA then compared the inspection reports against the system map prepared by Pare Corporation and was able to eliminate inlets to manholes from lateral sewers as potential inflow sources. The remaining unaccounted for inlets have been identified as potential inflow sources. No further information is currently available about these connections. It is recommended that the NBC investigate these connections to determine their source. A listing of potential inflow sources discharging to manholes is provided in Table 3-2. A deficiency log of all defects identified in the manhole inspection reports is provided in Table 3-3. Both tables are located at the end of this chapter.

3.4 RESULTS OF PIPELINE INSPECTIONS

The results of the pipeline inspections are provided below, separated by the meter basin in which the pipe resides.

JNI-A

The interceptor in this area appears to be in generally good condition. Defects along these pipe segments are predominantly minor instances of infiltration, roots, and attached deposits (grease, mineral encrustations, etc.) Multiple instances of break-in and intruding service connections also exist, but do not appear to have observed infiltration associated with them.

JNI-B

No interceptor sewers exist within this meter basin. The flow meter JNI-B was located on a sewer line owned by the Town of Johnston.

JNI-C

The interceptor in this area appears to be in generally good condition. Defects in these pipe segments include minor instances of attached deposits. There are also an unusually high number of break-in connections. Most of these connections are associated with a cured-in-place rehabilitated section of interceptor on George Waterman Road between Rice Street and Irons Avenue. It is anticipated that many of these break-in connections may simply be associated with the re-establishment of service connections after lining and may not truly be "break-in" connections. The only major problem was encountered on I150067:I150031 (8" PVC pipe on Lafayette Street) and consisted of a root ball barrel near the downstream manhole. According to the NBC, this root ball barrel was removed upon completion of the inspection.

JNI-D

The interceptor in this area appears to be in generally fair condition. The interceptor consists of two clearly distinct sections: presumably older 8" asbestos cement (AC) pipe and presumably newer 10" polyvinyl chloride (PVC) pipe. No major issues were encountered within the PVC pipe segments. However, most of the segments of AC pipe are marred with instances of surface spalling and attached deposits of varying degrees.

JNI-E

The interceptor in this area appears to be in generally good condition. There are no major defects identified in the CCTV inspection logs. One pipe segment (I170005:I170006) has a varying water level, indicating a potential sag within this pipe segment. Most of the pipes in this area are located within a cross-country easement, which is evidenced by a limited number of service connections along these pipe segments.

JNI-F

The interceptor in this area appears to be in generally good condition. There are no major defects noted along this stretch of interceptor. There are a few instances of break-in connections, but do not appear to have observed infiltration associated with them.

JNI-G

There are only two NBC-owned pipe segments in this basin. (The majority of the sewers in this area are community-owned.) Of the two pipe segments, one pipe segment is in good condition (12" AC, J140011:J140017) and has no identified defects. The other pipe segment (12" VC, J140008:J140011) is in fair condition, possessing defects of fine root barrels and longitudinal cracking.

JNI-H

The interceptor in this area appears to be in generally good condition. No major defects were identified in this area. There are a few pipes where varying water levels may indicate minor areas of sagging, however these instances appear to be minor and infrequent.

JNI-I

The interceptor in this area appears to be in generally good condition. No major defects were identified in this area. There are a few pipes where varying water levels may indicate minor areas of sagging. One such pipe (I130022:J130003) has multiple instances of varying water levels throughout the segment.

JNI-J

The interceptor in this area appears to be in generally fair condition. Upstream segments appear to be in worse conditions than downstream segments. Predominant defects identified include holes in the pipe (severity not identified on the logs), surface spalling within many of the AC pipe segments, intruding break-in service connections, and varying water levels. For some pipes, the varying water levels occur multiple times within the same pipe segment.

JNI-K

There is only one NBC-owned pipe in this basin, so the majority of the sewers in this area are community-owned. The only identified issues with this 12" PVC pipe are one instance of running infiltration and a minor instance of varying water levels.

JNI-Other Pipes

There are other pipe segments of the Johnston-North Interceptor located within the Town of Johnston downstream of all the meters. CCTV inspection logs of these pipes were reviewed and determined that the pipe are all in generally good condition with no major issues associated with any of the pipe segments.

JSI-R

The interceptor in this area is generally in fair condition based on the CCTV Inspection logs. Defects noted in the area are predominantly surface roughness conditions of the pipe and grease buildup. There are also several instances of the inspection camera going underwater, indicative of sagged sections of pipe in segments (I120005:I120004).

JSI-S

The interceptor in this area appears to be in generally good condition. Defects noted in this area are mainly surface roughness condition in segments (I90009:I90035). Minor infiltration exists and the pipe appears to be in good structural condition

JSI-U

The interceptor in this area appears to be in generally good condition. No major defects were noted along these pipe segments. The pipe appears to be in good structural condition.

JSI-V

The interceptor in this area appears to be in generally good condition. Defects noted in this are mainly surface roughness condition in segments (H100026:I90033). The pipe appears to be in good structural condition.

JSI-W

The interceptor in this area appears to be in generally good condition. Defects noted in this area are mainly surface roughness condition in segments (H100021:H100025) and (H110027:H110016). There is an instance of the inspection camera going underwater, indicative of sagged sections of pipe (G130008:G130001). Minor infiltration exists throughout the section and the pipe appears to be in good structural condition. It is important to note that the infiltration rate for this basin is greater than 3,000 gpd/IDM and that the NBC owns approximately 80% of the sewers on an IDM basis.

JSI-X

The interceptor in this area appears to be in generally good condition. Infiltration exists in several segments of this interceptor with the severity of infiltration being only minor. There is an instance of the inspection where the water level increases to about 50% of the cross sectional area, indicative of sagged sections of pipe in segments (G130002:G130008)

JSI-Y

The interceptor in this area appears to be in generally fair condition. Defects noted in this area are predominantly surface corrosion in the asbestos cement pipe in the downstream segments. Infiltration exists in all segments of this interceptor with the severity increasing from the upstream manhole to the downstream manhole (I130003:H130026). There are also several instances of the inspection camera going underwater, indicative of sagged sections of pipe (H130023:H130025).

JSI-Z

The interceptor in this area appears to be in generally fair condition. Defects noted in this area are predominantly surface roughness conditions of the pipe. Infiltration exists in several segments of this interceptor with the severity of infiltration ranging from minor to major.

Table 3-1
Narragansett Bay Commission
Johnston SSES
Pipeline Inspection Review - Potential Inflow Sources

Meter Basin	NBC Pipe ID	Street	Size	Location (ft.)	From MH
JNI-A	H180007:H180014	Putnam Pike	3	38.7	US
JNI-C	H160004:H160005	George Waterman Road	10	119.7	US
JNI-C	I150067:I150031	Lafayette Street	8	0	DS
JNI-E	I170004:I170005	Electrical Easement	8	34.1	US
JNI-E	I170063:I170001	Electrical Easement	8	16.1	US
JNI-F	I150050:I150059	Springfield Avenue	10	124.4	US
JNI-J	I130007:I130006	Borden Avenue	8	153.4	US
JNI	DMH-4A:OUTFALL	River Street ROW	12	87.7	US
JNI	MH-1:MH-2	Sundin Road ROW	8	77.4	US
D/S JSI-S	J100010:J100009	Farmington Avenue	10"	41.1	US
JSI-R	J120012:I120002	Alden Street	4"[2]	95.3	US
JSI-R	J120018:J120017	Harding Street	4"[2]	76.7	US
JSI-S	I90016:I90015	Plainfield Pike	1"	71.5	US
JSI-W	G130001:G130008	Hartford Avenue	6"[1]	316	US

*Potential Inflow Connections are any connections to the existing sewer main that are not 4" or 6" in diameter.
[1]Connection was only 6" connection on line, with various 4" connections around it.
[2]Connection was only 4" connection on line, with various 6" connections around it.

Table 3-2
Narragansett Bay Commission
Johnston SSES
Manhole Inspection Review - Potential Inflow Sources

Johnston-North Interceptor

Meter Basin	NBC Manhole ID	Street	Source	Reason for Identification
JNI-A	H180020	Putnam Pike ROW	4" Service	Depth appears shallow (?)
JNI-E	I160045	Irons Avenue ROW	4" Service	Depth appears shallow - 3'-2" deep for 13'-8" deep MH
JNI-E	I170056	Railroad Avenue	10" Service	Depth appears shallow - 1'-4" deep for 8'-7" deep MH
JNI-F	I150059	Springfield Avenue	6" Service	Material (RCP service)

Johnston-South Interceptor

Meter Basin	NBC Manhole ID	Street	Clock	
JSI-R	J120003	Hartford Avenue	3	No lateral sewer identified
JSI-R	J120004	Hartford Avenue	3	No lateral sewer identified
JSI-R	J120005	Hartford Avenue	9	No lateral sewer identified
JSI-R	J120009	Hartford Avenue	12	No lateral sewer identified
JSI-S	I100001	Plainfield Pike	4	No lateral sewer identified
JSI-S	I90006	Plainfield Pike	9	No lateral sewer identified
JSI-U	I90020	Atwood Avenue	12	No lateral sewer identified
JSI-V	I100002	Atwood Avenue	2, 3	No lateral sewer identified
JSI-V	I90023	Atwood Avenue	3	No lateral sewer identified
JSI-V	I90030	Atwood Avenue	9	No lateral sewer identified
JSI-V	I90031	Atwood Avenue	9	No lateral sewer identified
JSI-V	I90033	Atwood Avenue	3	No lateral sewer identified
JSI-W	H100023	Simmonsville Avenue	9	No lateral sewer identified
JSI-W	H110009	Atwood Avenue	10	No lateral sewer identified
JSI-W	H110010	Atwood Avenue	4	No lateral sewer identified
JSI-W	H110020	Atwood Avenue	9	No lateral sewer identified
JSI-W	H110026	Atwood Avenue	3	No lateral sewer identified
JSI-W	H120003	Atwood Avenue	9	No lateral sewer identified
JSI-W	H120011	Atwood Avenue	9	No lateral sewer identified
JSI-X	G130001	Hartford Avenue	9	No lateral sewer identified
JSI-Y	H130007	Hartford Avenue	3	No lateral sewer identified
JSI-Y	H130008	Hartford Avenue	9	No lateral sewer identified
JSI-Y	H130009	Hartford Avenue	3	No lateral sewer identified
JSI-Y	H130014	Hartford Avenue	9	No lateral sewer identified
JSI-Y	H130018	Hartford Avenue	9	No lateral sewer identified
JSI-Y	H130019	Hartford Avenue	3, 9	No lateral sewer identified
JSI-Y	H130021	Hartford Avenue	3, 9	No lateral sewer identified
JSI-Y	I130003	Hartford Avenue	2, 4, 9	No lateral sewer identified
JSI-Z	G140001	Atwood Avenue	10, 12, 3	No lateral sewer identified
JSI-Z	G140003	Atwood Avenue	10	No lateral sewer identified
JSI-Z	H130020	Atwood Avenue	9	No lateral sewer identified

*Note: Different methodologies were used during the manhole inspection of the Johnston-North and the Johnston-South Interceptors. See report text for detailed description of the methodologies.

Table 3-3
Narragansett Bay Commission
Johnston SSES
Manhole Inspection Review - Condition Assessment and Deficiency Log

Johnston-North Interceptor

Meter Basin	NBC Manhole ID	Street	Deficiencies
JNI-A	H190015	Alfred Ave.	Wall Infiltration
JNI-A	H200001	Riverside Ave.	Riser needs cement
JNI-A	H200003	Riverside Ave.	Bench/Invert - Heavy Roots
JNI-F	I150011	Newman Ave.	Bench/Invert Defective
JNI-F	I150018	Lyman Ave./Elec. Easement	Infiltration from connection
JNI-C	I150051	Lyman Ave.	Cracked cover
JNI-C	I150053	Lyman Ave.	Bench Defective/Wall Infiltration
JNI-F	I150059	Springfield Ave.	Wall Infiltration
JNI-F	I150060	Springfield Ave.	Wall Infiltration
JNI-C	I150062	Springfield Ave.	Bench Infiltration
JNI-E	I170057	Railroad Ave.	Infiltration from connection
JNI-J	*I180009	Borden Ave.	Steps Defective
JNI-H	J140019	Dyerville Ave.	Cover Defective

*Manhole identified as I180009 believed to be typographic error. Assumed MH ID is 130009.

Johnston-South Interceptor

Meter Basin	NBC Manhole ID	Street	DefCode	Deficiency	Notes
JSI-0	J130016	RT.6 Underpass	SWI3	manhole walls covered with deposits, medium	
JSI-0	J130017		SWI3	manhole walls covered with deposits, medium	
JSI-R	J120001	Hartford Ave.	SWI3	manhole walls covered with deposits, medium	
JSI-R	J120002	Hartford Ave.	EUA3	pipe leaking at exit connection, medium	
JSI-R	J120004	Hartford Ave.	SWI2	manhole walls covered with deposits, light	
JSI-R	SMH#4	Ashby	SDM		rim broken
JSI-R	SMH#5	Ashby	SDM		rim broken
JSI-R	SMH#6	Ashby	EUI3	pipe leaking at entrance connection, medium	
JSI-S	I90009	Plainfield Pike	SDM	manhole lid defective	paved over
JSI-S	**J90001	Evergreen	EUI1	pipe leaking at entrance connection, very light	
JSI-S	**J90005	Plainfield Pike	SDM	manhole lid defective	Can not locate
JSI-V	H100002	Atwood Ave.	SDM	manhole lid defective	to small, rocks
JSI-V	H100005	Atwood Ave.	SDM	manhole lid defective	Rim broken

Table 3-3 (cont'd.)
Narragansett Bay Commission
Johnston SSES
Manhole Inspection Review - Condition Assessment and Deficiency Log

Johnston-South Interceptor (cont'd.)

Meter Basin	NBC Manhole ID	Street	DefCode	Deficiency	Notes
JSI-V	I90027	Atwood Ave.	SDM	manhole lid defective	Rim busted
JSI-W	G130008	Hartford Ave.	SDM	manhole lid defective	Infiltration
JSI-W	G130008	Hartford Ave.	SDM	manhole lid defective	Ring broken
JSI-W	H110025	Atwood Ave.	SDM	manhole lid defective	Rim has chunk missing
JSI-W	H110029	Atwood Ave.	SEM	steps incorrectly positioned	
JSI-W	H120001	Atwood Ave.	SDM	manhole lid defective	Cracked
JSI-W	H120001	Atwood Ave.	SWK2	manhole walls defective, light	
JSI-W	H120001	Atwood Ave.	EUA4	pipe leaking at exit connection, heavy	
JSI-W	H120001	Atwood Ave.	EUI3	pipe leaking at entrance connection, medium	
JSI-W	H120002	Atwood Ave.	EUA2	pipe leaking at exit connection, light	
JSI-W	H120003	Atwood Ave.	SDM	manhole lid defective	Rim defective
JSI-W	H120004	Atwood Ave.	SDM	manhole lid defective	Small crack on rim
JSI-W	H120007	Atwood Ave.	SWI2	manhole walls covered with deposits, light	
JSI-W	H120008	Atwood Ave.	EUA1	pipe leaking at exit connection, very light	
JSI-W	H120013	Atwood Ave.	EUI2	pipe leaking at entrance connection, light	
JSI-W	H130001	Atwood Ave./Hartford Ave.	EUI2	pipe leaking at entrance connection, light	
JSI-W	H130001	Atwood Ave./Hartford Ave.	SDM	manhole lid defective	Rocks
JSI-W	H130002	Atwood Ave.	EUI2	pipe leaking at entrance connection, light	
JSI-W	H130027	Atwood Ave.	SDM	manhole lid defective	Cracked
JSI-W	H130029	Atwood Ave.	SDM	manhole lid defective	Rim broken
JSI-X	G130001	Hartford Ave.	SDM	manhole lid defective	Cant open/ cracked
JSI-X	G130002	Hartford Ave.	SDM	manhole lid defective	paved over
JSI-X	G130004	Hartford Ave.	SDM	manhole lid defective	paved over1/2
JSI-Y	H130007	Hartford Ave.	SGM2	invert defective, light	infiltration
JSI-Y	H130008	Hartford Ave.	SDM	manhole lid defective	Rim broken
JSI-Y	I130003	Hartford Ave.	SDM	manhole lid defective	Cracked @ 6 postion
JSI-Z	G130011	Atwood Ave.	SDM	manhole lid defective	Rim broken

**NBC Manhole IDs not identified as active in GIS. Meter basins estimated from street address.

CHAPTER 4
CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

Infiltration

Interceptor	Excessive or High Levels of Infiltration
Johnston-North Interceptor Metering Basins	JNI-K, JNI-D (both high)
Johnston-South Interceptor Metering Basins	JSI-U (excessive), JSI-W (high)

Johnston-North Interceptor

Based on the flow metering results and infiltration analysis, none of the basins in the Johnston-North Interceptor contributed excessive infiltration. However, two basins (JNI-K and JNI-D) exhibited elevated levels of infiltration that may be excessive under seasonal high groundwater conditions.

Johnston-South Interceptor

Based on the flow metering results and the infiltration analysis, it was determined that one meter basin (JSI-U) is contributing excessive infiltration. However, one basin (JSI-W) exhibited elevated levels of infiltration that may be excessive under seasonal high groundwater conditions.

Inflow

Interceptor	High Levels of Inflow
Johnston-North Interceptor Metering Basins	JNI-A, JNI-F, JNI-G, JNI-I, JNI-J, JNI-K
Johnston-South Interceptor Metering Basins	JSI-R, JSI-S, JSI-V, JSI-X, JSI-Y

Johnston-North Interceptor

Based on the inflow analysis, six basins (JNI-A, JNI-F, JNI-G, JNI-I, JNI-J, and JNI-K) all presented high levels of inflow, on either a peak rate basis, volumetric basis, or both. Review of the wet weather hydrographs confirm extensive and immediate system response to rainfall conditions in meter basins JNI-A and JNI-I as indicated by their high peak inflow ratios. Meter basin JNI-G also presented with high peak inflow rates during a rainfall event with high peak intensity, but did not display excessive inflow properties during a lower intensity event with a comparable rainfall volume. Meter basin JNI-F contributed a high volume of inflow for the November 25th storm event, but it is believed that the net basin volume is skewed due to flow balancing, as presented by the negative net inflow volume upstream. Meter basins JNI-K and JNI-J contributed moderate inflow volumes during the November 25th storm event, though considerably less than the volume calculated in meter basin JNI-F.

Johnston-South Interceptor

Based on the inflow analysis, five basins (JSI-R, JSI-S, JSI-V, JSI-X, and JSI-Y) all presented high levels of inflow, on either a peak rate basis, volumetric basis, or both. Review of the wet weather hydrographs confirms extensive and immediate system response to rainfall conditions in meter basins JSI-X and JSI-Y as indicated by their high peak inflow ratios. Meter basins JSI-R and JSI-S also presented with high peak inflow rates during a rainfall event with high peak intensity, but did not display excessive inflow properties during a lower intensity event with a comparable rainfall volume. Meter basin JSI-X contributed the highest volume of inflow for both storm events, followed by JSI-S, JSI-V, and JSI-Y for the November 25th storm event. The wet to dry maximum daily rate ratio (Q_{WM}/Q_D) identified both meter basins JSI-S and JSI-X as having a moderate severity of inflow during both storm events, indicating that both basins are sensitive to high volumes of inflow for a prolonged period of time.

4.2 RECOMMENDATIONS

Based on the results of the investigations conducted for this SSES, it is recommended that:

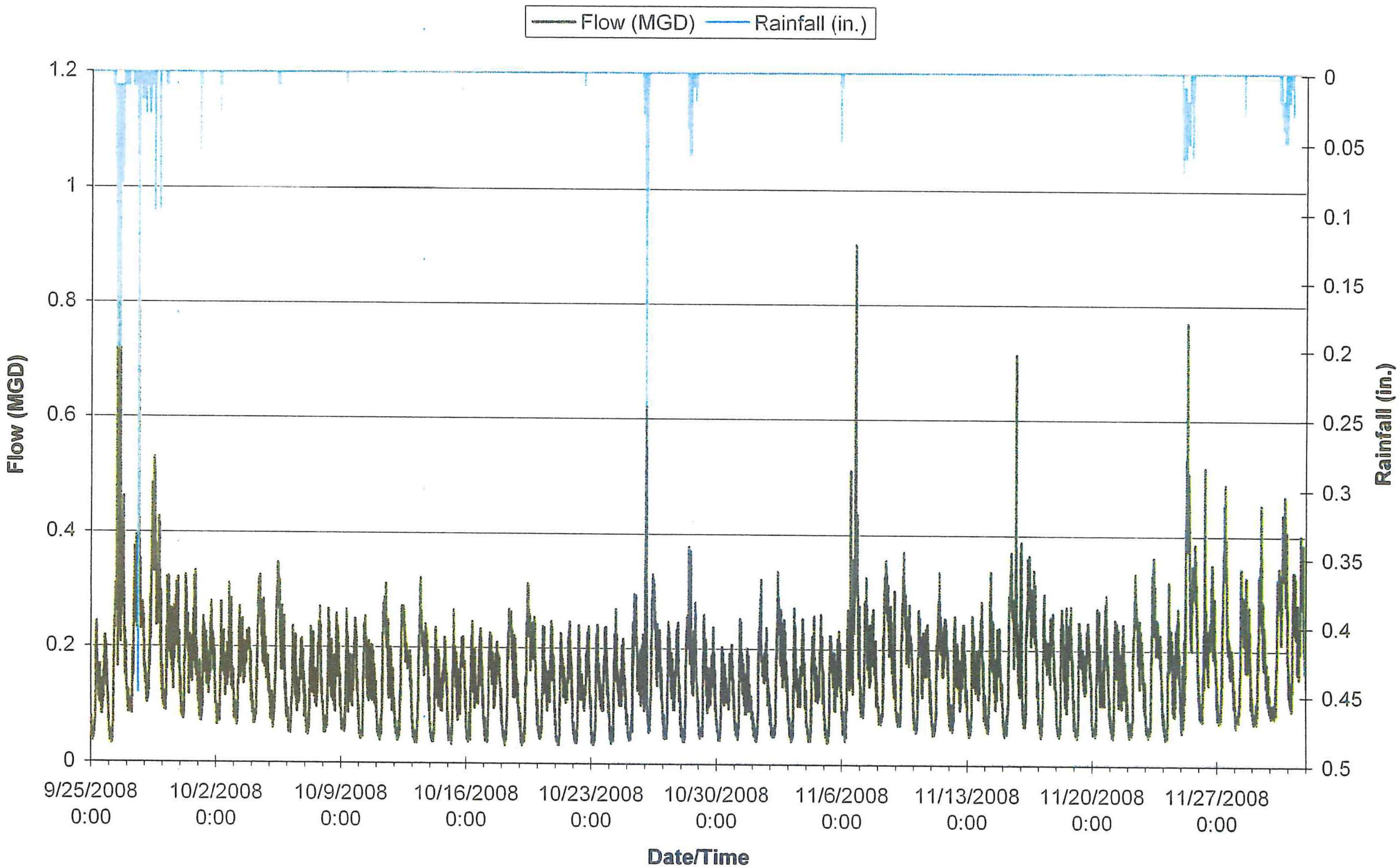
- Closed-circuit television (CCTV) inspections be conducted in **JSI-U, JNI-D, JNI-K, and JSI-W** to further evaluate excessive and high infiltration contributions from these basins. CCTV inspections should be isolated to local sewers within these basins since NBC-owned interceptors have been inspected and appear to be in good condition.

- Focused inflow investigations be conducted first in Johnston-South Interceptor meter basins **JSI-X, JSI-Y, JSI-V, JSI-R, and JSI-S** and then in the Johnston-North Interceptor meter basins **JNI-A, JNI-G, JNI-I, and JNI-J.** Preliminary inflow investigations should consist of field investigations to determine if catch basins and downspouts are connected to storm drains or sanitary sewers. Potential inflow sources identified on Table 3-1 should also be included in this preliminary investigation. Based on the findings of the preliminary investigation, a decision will be made as to whether or not further investigation using smoke testing should be conducted.

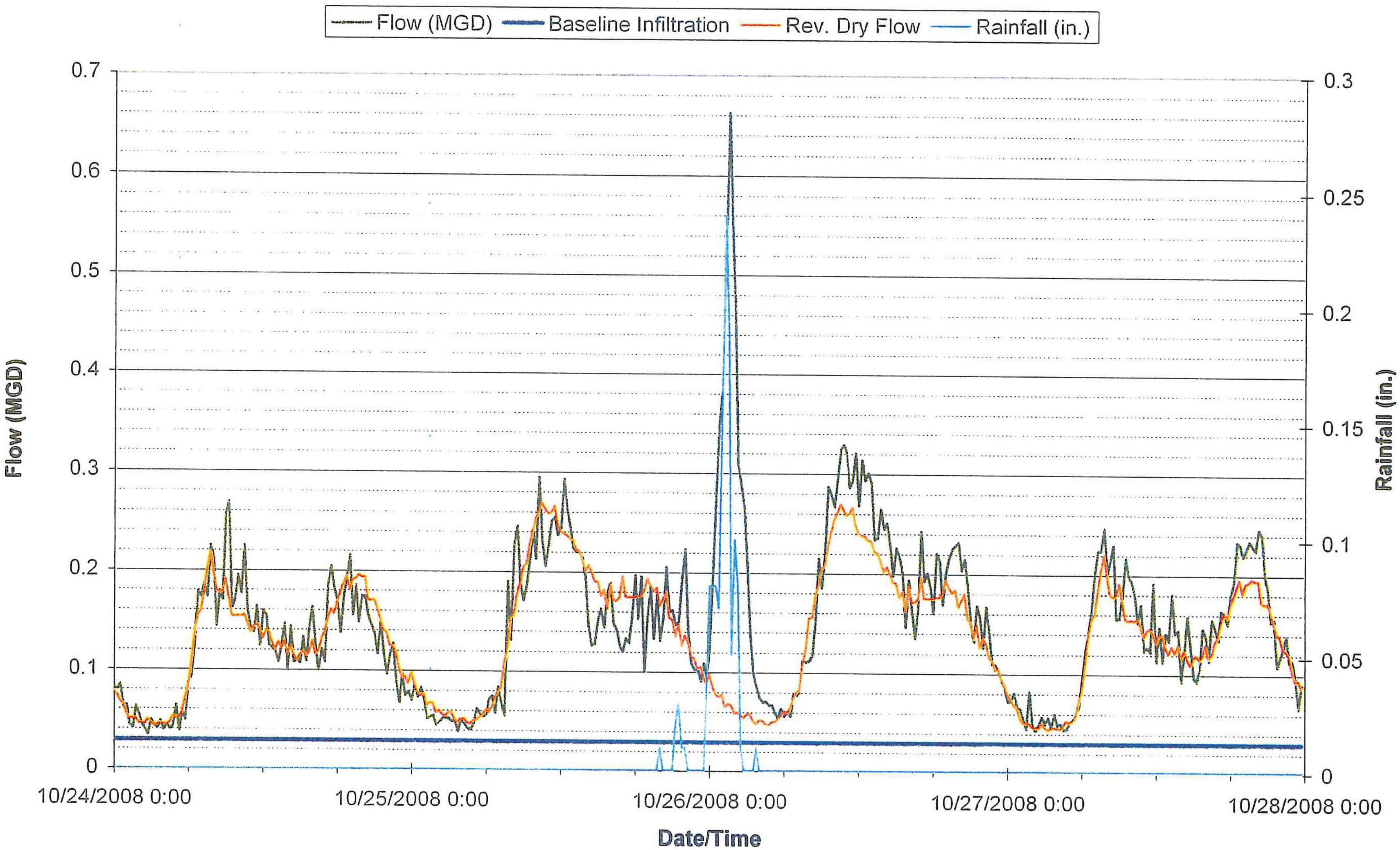
- Damaged or leaking manholes identified in Chapter 3 be repaired.

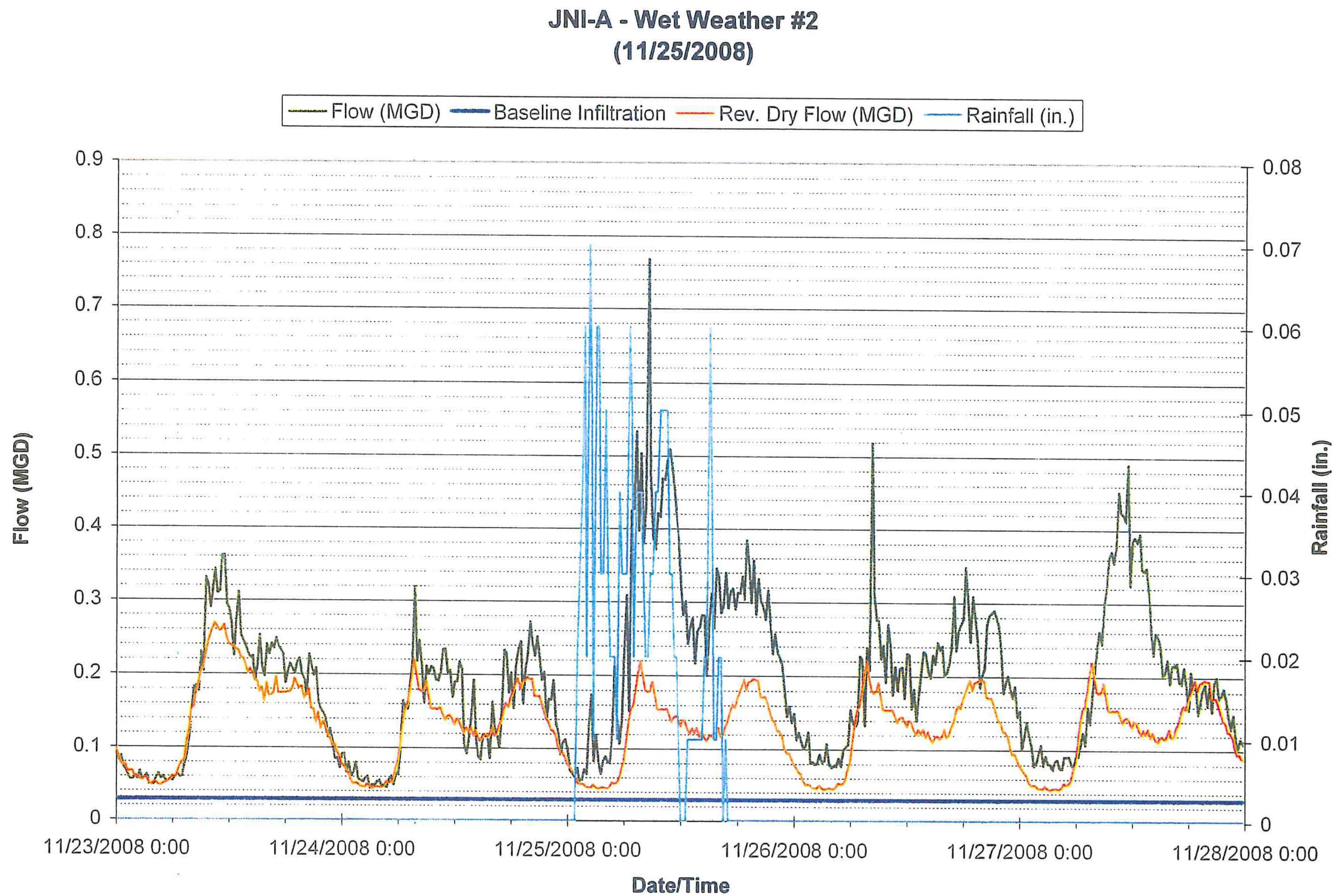
- No further investigation be required in **JNI-B, JNI-C, JNI-E, JNI-H, and JSI-Z**.

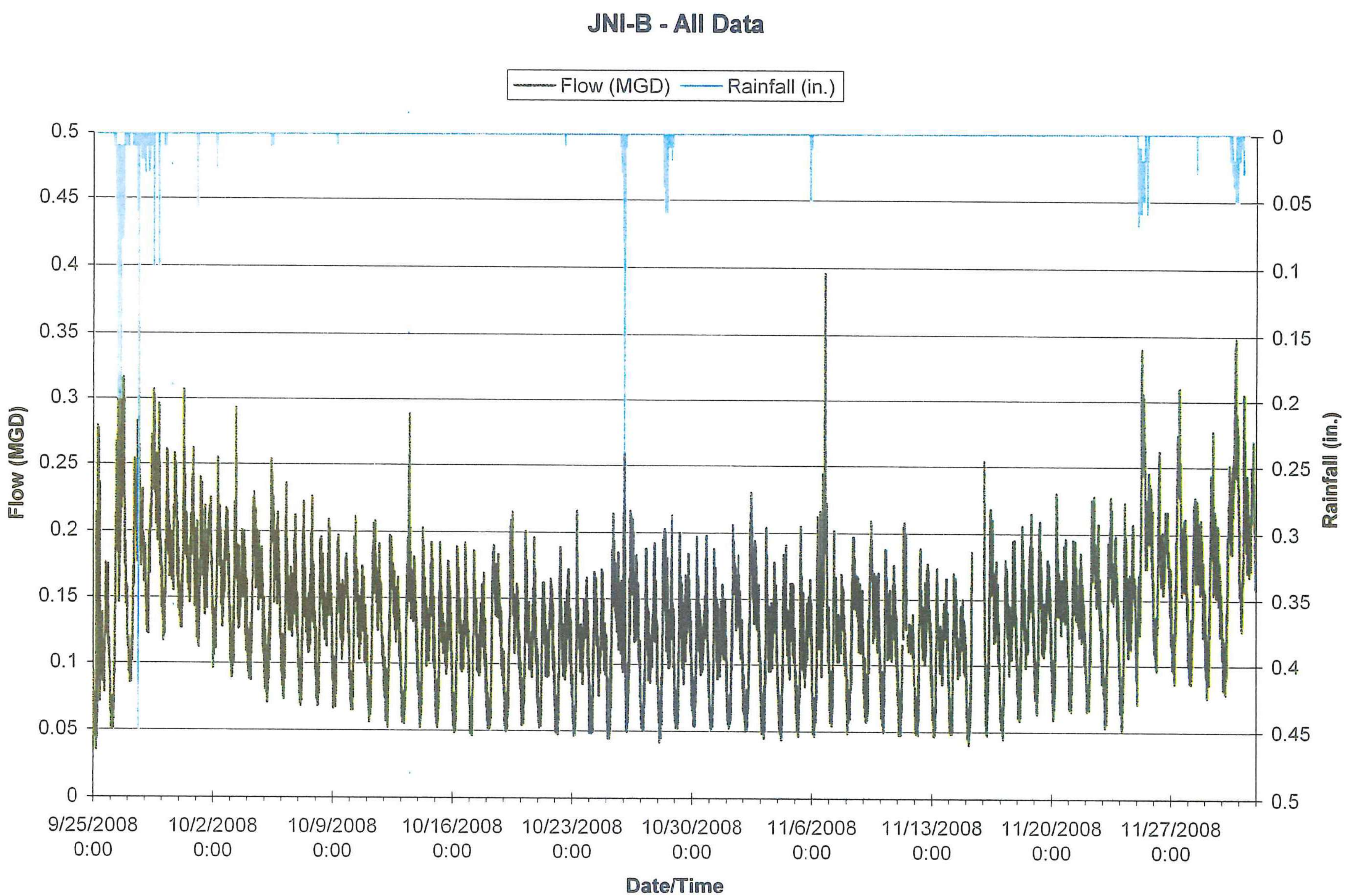
JNI-A - All Data



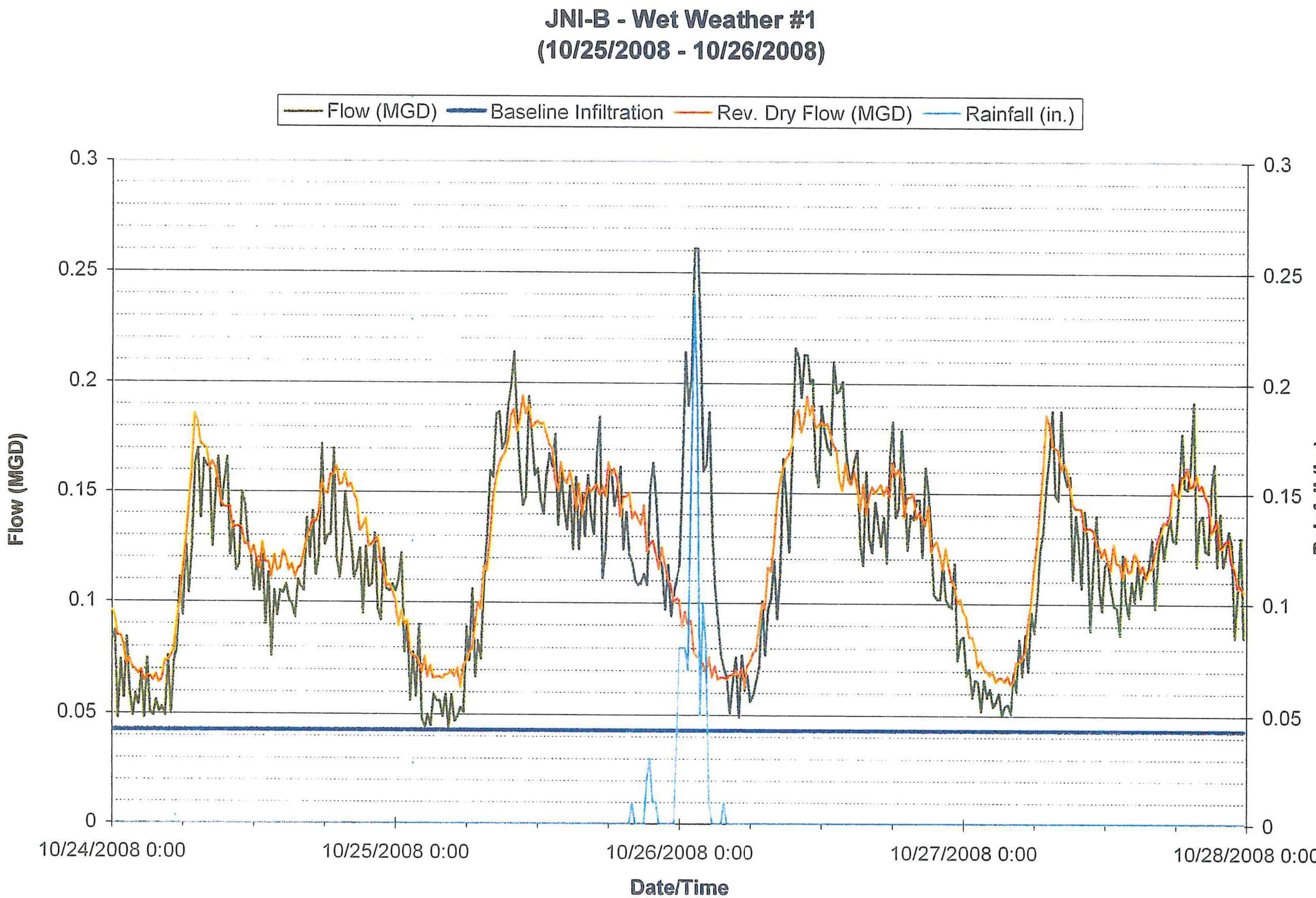
JNI-A - Wet Weather #1
(10/25/2008 - 10/26/2008)

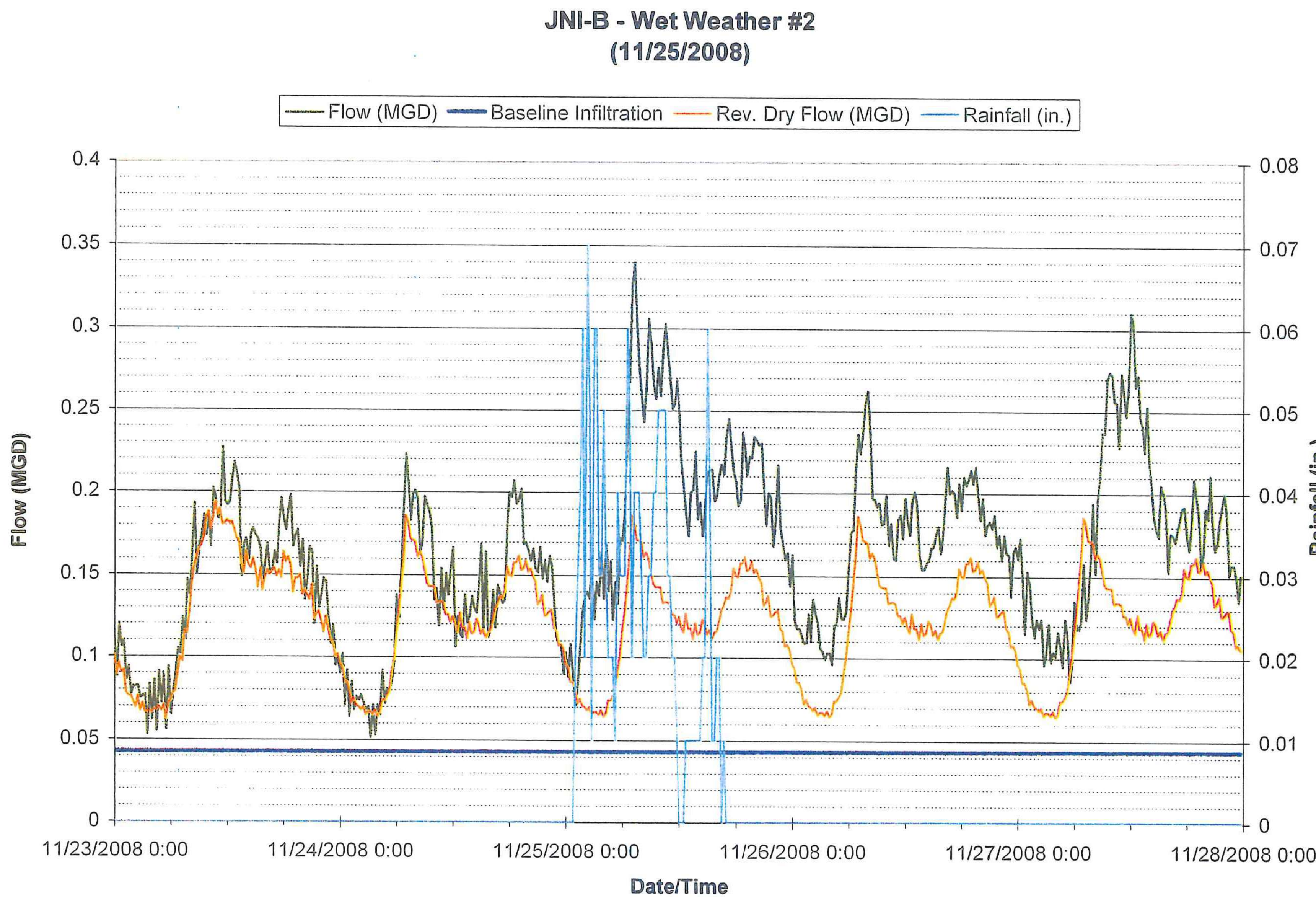



JNI-A - Wet Weather #2
(11/25/2008)
Flow (MGD)
Baseline Infiltration
Rev. Dry Flow (MGD)
Rainfall (in.)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Flow (MGD)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Rainfall (in.)
11/23/2008 0:00
11/24/2008 0:00
11/25/2008 0:00
11/26/2008 0:00
11/27/2008 0:00
11/28/2008 0:00
Date/Time

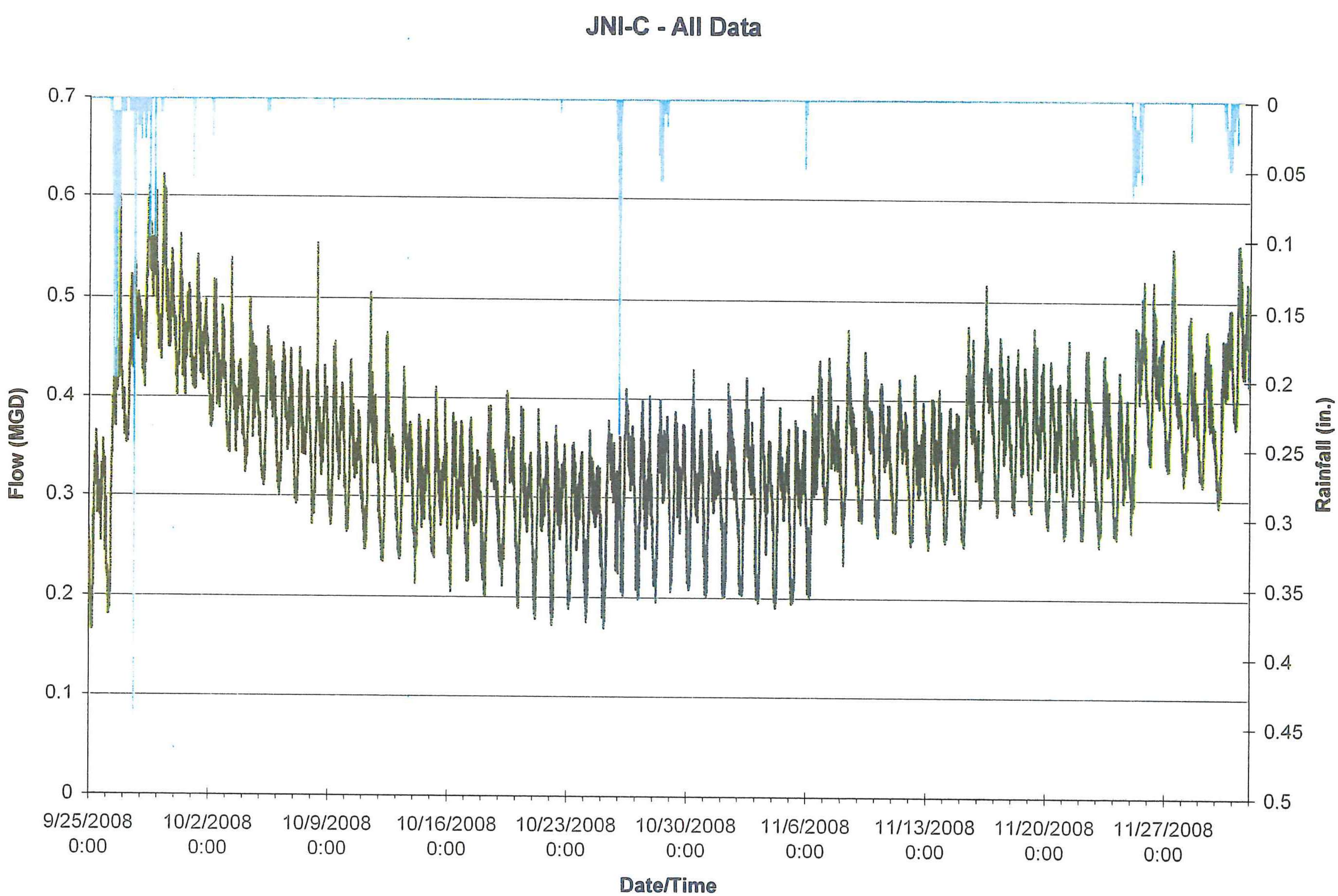


JNI-B - All Data
Flow (MGD)
Rainfall (in.)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
Rainfall (in.)
9/25/2008 0:00
10/2/2008 0:00
10/9/2008 0:00
10/16/2008 0:00
10/23/2008 0:00
10/30/2008 0:00
11/6/2008 0:00
11/13/2008 0:00
11/20/2008 0:00
11/27/2008 0:00
Date/Time

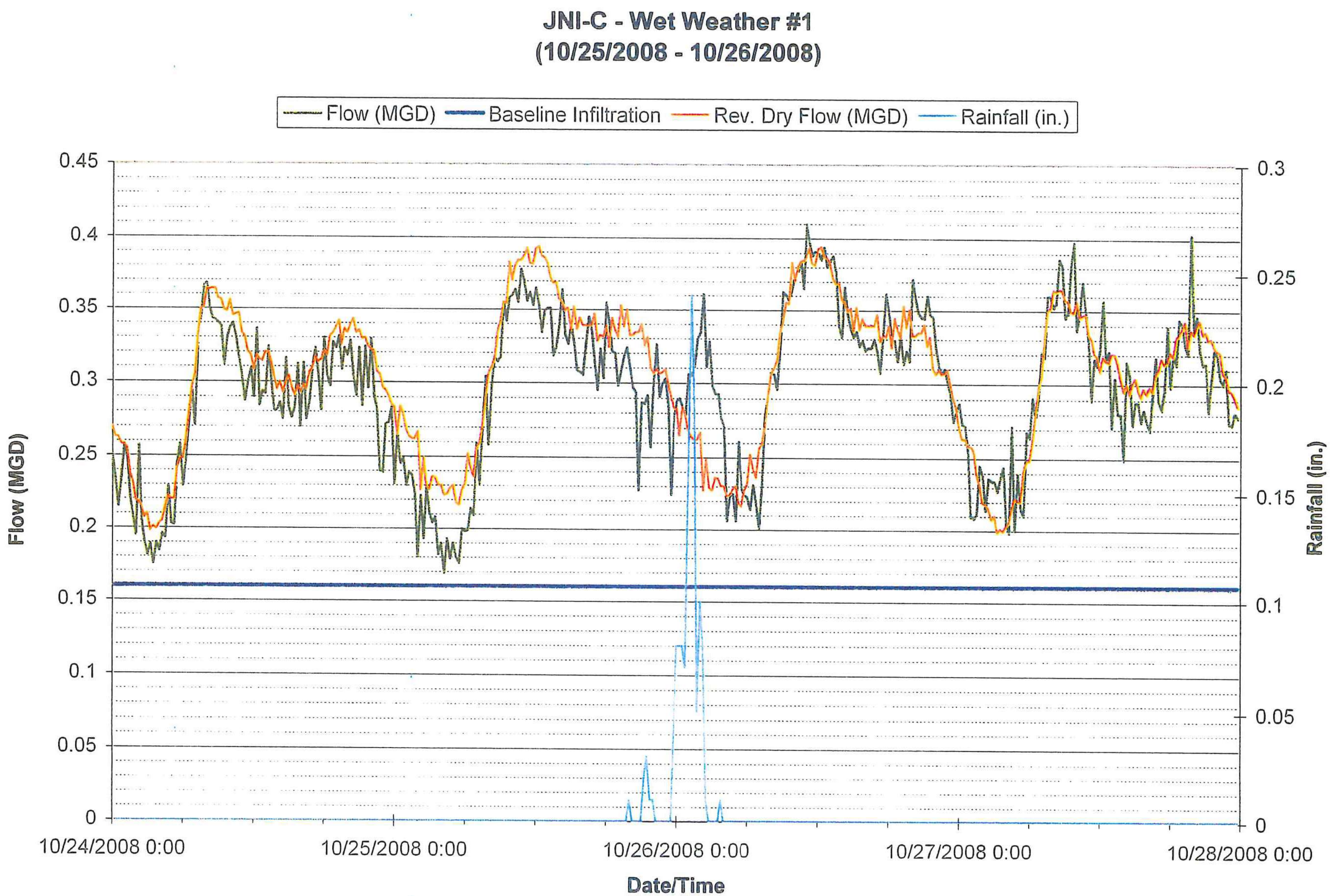

JNI-B - Wet Weather #1
(10/25/2008 - 10/26/2008)
Flow (MGD)
Baseline Infiltration
Rev. Dry Flow (MGD)
Rainfall (in.)
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow (MGD)
Rainfall (in.)
10/24/2008 0:00
10/25/2008 0:00
10/26/2008 0:00
10/27/2008 0:00
10/28/2008 0:00
Date/Time



JNI-B - Wet Weather #2
(11/25/2008)
Flow (MGD)
Baseline Infiltration
Rev. Dry Flow (MGD)
Rainfall (in.)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Flow (MGD)
Rainfall (in.)
11/23/2008 0:00
11/24/2008 0:00
11/25/2008 0:00
11/26/2008 0:00
11/27/2008 0:00
11/28/2008 0:00
Date/Time



JNI-C - All Data
Flow (MGD)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Rainfall (in.)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
9/25/2008 0:00
10/2/2008 0:00
10/9/2008 0:00
10/16/2008 0:00
10/23/2008 0:00
10/30/2008 0:00
11/6/2008 0:00
11/13/2008 0:00
11/20/2008 0:00
11/27/2008 0:00
Date/Time


JNI-C - Wet Weather #1
(10/25/2008 - 10/26/2008)
Flow (MGD)
Baseline Infiltration
Rev. Dry Flow (MGD)
Rainfall (in.)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Flow (MGD)
0.3
0.25
0.2
0.15
0.1
0.05
0
Rainfall (in.)
10/24/2008 0:00
10/25/2008 0:00
10/26/2008 0:00
10/27/2008 0:00
10/28/2008 0:00
Date/Time