BETA
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June 29, 2018

David Burns
Municipal Services
Department of Environmental Protection – Southeast Region
20 Riverside Drive
Lakeville, MA 02347

Re: Phase 2 - Infiltration and Inflow (I/I) Report
Town of Wareham, MA

Dear Mr. Burns:

Attached herewith is submission of the Phase 2 – Infiltration and Inflow (I/I) Report for the Town of Wareham's wastewater collection system. The Phase 2 I/I Report has been prepared in general accordance with 314 CMR 12.04 (2) and MassDEP Guidance document "*Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys,* dated May 2017".

Should you have any questions pertaining to this correspondence, please contact us at our office.

Very truly yours,
BETA Group, Inc.

Brian K. Wrigley, P.E.
Senior Project Engineer

cc: Guy Campinha Sr. – Wareham Director of Water Pollution Control

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Town of Wareham, Massachusetts

Phase 2 – Infiltration and Inflow (I/I) Report

June, 2018

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Executive Summary

ES.1 Purpose of Report

The purpose of this report is to present the findings of the Phase 2 Infiltration and Inflow (I/I) investigation that was conducted on the Town of Wareham's wastewater collection system. The work was performed by BETA Group, inc. (BETA), via professional services agreement with the Town of Wareham, with assistance from the Town of Wareham Water Pollution Control Department (WPCD). The infiltration and inflow investigation and evaluation was conducted in general accordance with the Massachusetts Department of Environmental Protection (MassDEP) Guidance document "*Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys*, revised/dated May 2017". This report shall serve to supplement and also to verify the results of the Phase 1 Infiltration and Inflow Report, completed in 2006 for the Town by engineering consultant, Camp, Dresser & McKee Inc. (CDM).

The goal of the I/I analysis is to make recommendations for further study to develop preliminary recommendations to implement a Sewer System Evaluation Survey (SSES). The goal of the SSES is to identify I/I sources and their flow contribution and propose a plan for remediation.

This report summarizes the results of the I/I investigation performed by BETA and includes details of field studies, data analysis, conclusions, and recommendations for further studies. In an effort to further demonstrate the relevance of the above evaluation, results have been compared to the Phase 1 Infiltration and Inflow investigation/analysis performed by CDM in 2006.

ES.1.1 Wastewater Collection System / Water Pollution Control Facility

The Town of Wareham's existing wastewater collection system consists of:

- 44 Pumping Stations
- Approx. 65 miles of gravity pipe
- Approx. 14.5 miles of force main pipe
- Approx. 1,900+ manholes

Gravity sewer pipe ranges in diameter from 8-inches to 21-inches and force main pipe ranges in diameter from 2-inches to 18-inches. Pipe materials vary and include polyvinyl chloride (PVC), vitrified clay (VC), asbestos cement (AC), cast iron (CI), ductile iron (DI), and reinforced concrete (RC).

Maps depicting the existing collection system, including delineated pumping station collection basins, pumping station locations, manholes and pipes have been provided in *Appendix A* of this report for reference.

The wastewater collection system is not subject to wet-weather sanitary sewer overflows or system surcharging that result in basement back-ups.

The Wareham Water Pollution Control Facility (WPCF) has an average daily (24-hour) influent flow of approximately 1.0 MGD. In March 2018, a maximum daily (24-hour) influent flow of 1.85 MGD was recorded at the facility.

ES.1.2 Alternative Approach

BETA, on behalf of the Town, met with representatives from MassDEP on January 19, 2017 to present an alternative approach to the I/I investigation than that described in the MassDEP Guidance. BETA proposed utilizing wastewater pumping station pump run-time data to identify areas that are subject to I/I influence in lieu of the continuous flow metering methodology that is included in the MassDEP Guidance document for the analysis.

The Town of Wareham has 44 pumping stations of varying size and configuration and operation of the pumping stations is continuously tracked by the Mission monitoring and data management system. The Mission system is a cellular based supervisory control and data acquisition (SCADA) system that provides the Town with a secure website for reviewing operating conditions and storing data for remote pumping station sites. Data includes general station information such as name, location, and pump capacity as well as operating data such as wet well level, pump status and daily pump run-times. Pump run-time data is stored for as long as the service has been maintained. Individual pumping stations are not equipped with flow meters but total daily flow volumes can be determined by comparing pump run-times and associated pump capacities.

One of the focuses in this data review was to look for evidence of extended run-times during wet-weather events and high groundwater conditions. Extended run-times would be an indication of I/I impacts to the collection system. The remote pumping stations on the perimeter of the collection system are ideal for making this correlation because their influence is limited to their smaller tributary collection system as opposed to a station which receives flow from multiple upstream pumping stations. Comparing the pump run-time data for different time periods and identifying trends provides the information required to determine when the stations manage additional flow. The service areas for those pumping stations that require pump operation for longer periods of time during periods of wet-weather and high groundwater will be targeted for additional investigations.

Through recommendation from MassDEP and as stipulation for the agency's approval of the alternative approach to the I/I investigation and analysis, levels of QA/QC were conducted at select pumping stations to validate the Mission data accuracy. Mission data is included in *Appendix C* of this report.

ES.2 Project Scope and Sources of Data

The scope of the I/I Study included the following tasks:

- Evaluation and analysis of pumping station operation data collected from the Town's Mission monitoring and data management system. The Town's Mission data was compared to local historical rainfall data for purpose of analysis.

- Wet well drawdown testing and limited flow metering of select pumping station discharges to validate station operation data collected within the Town's Mission monitoring and data management system, specifically verification of pump capacities.

- Research and review of investigations, studies and sewer rehabilitation previously completed within the Town's wastewater collection system. Findings and recommendations from these previous efforts have been incorporated into this report for comparison purposes and serve as a basis for focusing additional investigation efforts and recommending further studies within the collection system.

- Limited manhole inspections were performed for the purpose of searching for and identifying specific sources of groundwater infiltration within the Town's wastewater collection system.

- Limited pipeline CCTV inspections were conducted for the purpose of searching for and identifying specific sources of groundwater infiltration within the Town's wastewater collection system.

This study evaluated the wastewater collection system by distinct pumping station drainage basins. As described in the report, review and analysis of continuous pumping station operation data can provide indication of impacts to the collection system from wet-weather events and high groundwater conditions. Following evaluation of the Town's pumping stations monitored by the Mission system, pumping station drainage basins that were identified to be directly impacted by wet-weather, high groundwater conditions were then selected for further analysis.

Further analysis included quantifying the extraneous flows managed by the select pumping stations. Evaluating the Mission data through comparison of pump run-times during dry-weather conditions to pump run-times during wet-weather conditions

provided the extraneous flow volume estimates. A relative ranking of each targeted pumping station drainage basin was then developed based on the level of impact to the particular basin.

Table #ES-1 summarizes eighteen (18) pumping station collection basins that are suspected of being influenced by wet-weather.

Table #ES-1:
Pumping Station Collection Basins Influenced by Wet-Weather (Pump Run-Time Evaluation)

Pumping Station Name	Approx. Pump Capacity (gpm)*	Spring 2017 (Mar. - Apr.)			Winter/Spring 2018 (Jan. - Mar.)		
		Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Avg.	Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Avg.
Apple Street	130	20	45	125%	23	139	504%
Arnold Street	270	56	98	75%	60	98	63%
Briarwood	235	44	114	159%	60	158	163%
Cromesett	110	64	112	75%	70	166	137%
French-Canedy	140	32	94	194%	40	87	118%
Hathaway	460	82	128	56%	93	171	84%
Leonard	Pump 1: 60 gpm Pump 2: 30 gpm	77	133	73%	77	163	112%
Mattapoisett	230	10	26	160%	12	38	217%
North Boulevard	670	50	98	96%	70	339	384%
Onset Pier	Pump 1: 1,000 Pump 2: 1,100	66	209	217%	66	139	111%
Peter Cooper Drive	40	120	295	146%	120	662	452%
Pinehurst	345	55	79	44%	50	145	190%
Ruggles	230	80	240	200%	90	393	337%
Salt Works Road	245	62	129	108%	61	112	84%
Smith	1,265	93	177	90%	110	430	291%
South Water Street	1,060	60	120	100%	60	297	395%

Pumping Station Name	Approx. Pump Capacity (gpm)*	Spring 2017 (Mar. - Apr.)			Winter/Spring 2018 (Jan. - Mar.)		
		Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Avg.	Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Avg.
Terry Lane [Pine Tree Estates]	225	265	353	33%	270	466	73%
13th Ave	Pump 1: 60 Pump 2: 110	83	157	89%	40	212	430%

*Pump capacities as selected from Tables #3-11 & #3-12 within this report

Operation of the Town's larger pumping stations was also evaluated but given the influence of upstream pumping stations in each of these locations, determination of wet-weather impacts to the associated, individual collection basins would prove challenging and unreliable using pump run-time data and metering would pose similar challenges. The following is a list of six (6) pumping station collection basins (with year of construction) that also exhibited measureable increases in pump run-times as directly related to the occurrence of wet-weather events but were not evaluated further due to their upstream influence:

- Narrows (1970)
- Kennedy (1970)
- Hynes Field (1970)
- Dick's Pond (1988)
- Cohasset Narrows (1988)
- Depot Street (1988)

Information collected for these pumping stations can be found in later sections of this report.

ES.3 Wet-Weather Impacts

Infiltration Impacts

Determination of infiltration rates utilizing pumping station data is not straightforward. When reviewing typical meter data, infiltration is often determined by comparing night time flows during dry-weather, wet season conditions to dry-weather, dry season conditions. This is a difficult task in Wareham due to the seasonal variation in population. When comparing dry-weather / dry season and dry-weather / wet season data, uncertainty presents itself due to potential impacts by population swings.

All subareas that were analyzed, utilizing meter data, during the 2006 Phase 1 analysis exhibited an infiltration rate less than the MassDEP threshold of 4,000 gpd/in-mi (considered "excessive" for a sanitary sewer). Therefore, it was determined that the amount of groundwater entering the sewer system was within acceptable limits and additional studies for identification of infiltration sources were not recommended.

Based on previous studies and our understanding of the collection system, initial focuses should be directed toward removal of inflow sources. However, infiltration within the collection system should not be ignored and efforts such as routine pipeline CCTV inspection and/or manhole inspections can facilitate identification and subsequent removal of infiltration sources.

Inflow Impacts

As stated in this report, portions of the Town's wastewater collection system appear to be influenced by sources of inflow during wet-weather, high groundwater conditions. Based on the Phase 2 analysis, first-hand account of Wareham WPCD personnel, previous findings through smoke testing efforts and general understanding of the local geography, it is suspected that inflow sources may be from private property discharges.

Analysis results indicate the presence of inflow within several collection basins that were constructed in the last 15 to 30 years using PVC pipe. This provides further indication that sources of inflow likely exist within those respective collection basins, as infiltration is typically less of an issue in systems constructed with PVC pipe material as compared to those constructed of vitrified clay or asbestos cement pipe materials.

The defects identified during the smoke testing effort conducted in 2006 and later presented in the CDM document titled, "*Smoke Testing Letter Report (Follow Up To: Phase 1 – Infiltration/Inflow (I/I) Report*, dated August 2007", are summarized within Table #3-6 in Section 3.2.6 of this report. The Town's understanding is that the majority of the identified defects have been corrected since they were discovered and reported in 2007. The redirection of the identified sources of I/I and repair of observed system defects successfully removed approximately 150,000 gpd of peak extraneous flow, as calculated using the standard storm (1-year, 6-hour duration) peak intensity of 0.87 in/hr.

Table #ES-2 provides a comparison of results from previous I/I studies for the Wareham wastewater collection system since 2006. The table identifies the isolated locations that are suspected of being influenced by wet-weather flows, including when and how many times a particular location was studied. Table #ES-2 further demonstrates the relevance of the pump run-time analysis performed as part of the Phase 2 effort. As can be seen from review of the table, BETA's analysis provides confirmation of previously determined wet-weather flow impacts to specific locations and also identifies other locations that were not analyzed prior to this effort. Locations are depicted on a figure included within *Appendix A*.

Table #ES-2:
Wet-Weather Flow Impact Findings – Comparison of Multiple I/I Analysis Efforts

Sewershed #	Pumping Station Collection Basin	Number of Pumping Stations Upstream	Subarea # (2006 Phase 1 I/I Study)	Wet-Weather Flow Impact Y = Yes N = No " - " = Not Applicable or Not Studied		
				CDM Findings (2006)	OSD Findings (2014-15)	BETA Findings (2017-18)
3	Apple St.	0	-	-	-	Yes
6	Peter Cooper Dr.	0	-	-	-	Yes
10	Ruggles	0	11	Yes	Yes	Yes
11	Smith	1	11 & 12	Yes	No	Yes
12	Mattapoisett Rd.	0	-	-	-	Yes
13	Briarwood Dr.	0	-	-	-	Yes
14	Arnold St.	2	-	-	-	Yes
15	French-Canedy St.	0	-	-	-	Yes
16	Leonard St.	0	-	-	-	Yes
17	13th Ave.	0	-	-	-	Yes
18	Hathaway	5	-	-	-	Yes
19 & 20	Cromesett	1	-	-	-	Yes
21	Terry Lane	2	10	No	-	Yes
22	Narrows	19	8 & 9	Yes	-	Yes
23	Pinehurst	0	9	Yes	Yes	Yes
24	Kennedy	12	8 & 10	Yes	-	Yes
25	Depot St.	7	-	-	-	Yes
26	Dick's Pond	6	7	Yes	-	Yes
28	Salt Works Rd.*	1	6	Yes	-	Yes
29	Hill St.	0	7	Yes	-	No
30	Cohasset Narrows**	4	7	Yes	-	Yes
32	South Water St.	4	1 & 2	Yes	Yes	Yes
35	Onset Heights	0	1	No	-	No
36	Onset Pier	5	-	-	-	Yes
37	East Blvd.	0	4B	Yes	Inconclusive	No
38	South Blvd.	0	3A	No	-	No
39 & 41	Hynes Field	9	3A & 4A	No	Yes	Yes
40	North Boulevard	1	4B	Yes	Yes	Yes

*Receives flow from Town of Plymouth, MA
**Receives flow from Town of Bourne, MA

Table #ES-3 contains a summary of the eighteen (18) pumping station collection basins that were identified as part of the Phase 2 analysis as being influenced by potential sources of inflow. The collection basins have been ranked (from highest to lowest), relative to one another, based on the expected volumetric impact to the basin from the standard storm (1-year, 6-hour duration storm event).

Table #ES-3:
Pumping Station Collection Basins – Standard Storm Total Inflow Volumes

Ranking	Sewershed #	Pumping Station Collection Basin	No. Pumps	Approx. Pump Capacity (gpm)	Gravity Sewer Length (LF)	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	2	1,265	33,672	220,000	29.3	29.3
2	36	Onset Pier	2	1,000 / 1,100	5,121	122,000	16.3	45.6
3	32	South Water Street	2	1,060	17,520	105,000	14.0	59.6
4	40	North Boulevard	2	670	7,488	100,000	13.3	72.9
5	10	Ruggles	2	230	7,541	60,000	8.0	80.9
6	18	Hathaway	2	460	16,840	31,000	4.1	85.0
7	21	Terry Lane	2	225	15,432	25,000	3.3	88.3
8	23	Pinehurst	2	345	12,003	16,000	2.1	90.4
9	13	Briarwood	2	235	11,351	15,000	2.0	92.4
10	14	Arnold Street	2	270	8,954	10,000	1.3	93.7
11	20	Cromesett	2	110	6,332	10,000	1.3	95.0
12	6	Peter Cooper Drive	2	40	1,568	8,000	1.1	96.1
13	28	Salt Works Road	2	245	11,153	6,700	0.9	97.0
14	3	Apple Street	2	130	2,762	6,000	0.8	97.8
15	15	French-Canedy	2	140	2,903	5,800	0.8	98.6
16	17	13th Avenue	2	60 / 110	3,183	4,500	0.6	99.2
17	12	Mattapoisett	2	230	1,412	3,000	0.4	99.6
18	16	Leonard	2	60 / 30	4,157	2,850	0.4	100.0

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

ES.4 Conclusions

The Wareham wastewater collection system is not subject to wet-weather sanitary sewer overflows (SSOs) or bypasses and is not subject to surcharging that result in basement back-ups. Portions of the system appear to be influenced by infiltration and inflow, and based upon previous smoke testing results, the majority of sources may be private property sources such as sump pumps. Based on the information reviewed and analysis of pumping station flow data, problem areas already known to the Town have been substantiated and in addition, it has been demonstrated that other areas are not significantly impacted by I/I. Although the Town has not experienced wet-weather SSOs, the Town has a practical interest in removing sources of I/I to restore capacity to their collection systems and treatment facility to allow future sewer system expansion. Sufficient data exists to make recommendations for focusing future investigative efforts that will aid in developing preliminary remediation concepts. Recommendations have been summarized in the following sections of this Executive Summary.

ES.5 Recommended Additional Work and Investigations

Recommendations are as follows:

- Further Development of the Town's wastewater and storm water collection system mapping
- Smoke testing
- Private property inspections (including dyed water testing) to identify sources of inflow
- Pipeline CCTV inspection
- Manhole inspections and salinity testing
- Town ordinance review, including required additions and modifications
- Establishing an I/I Fee for sewer service connections

The recommendations can be completed as part of a Sewer System Evaluation Survey (SSES). An SSES is completed as a follow-up to an I/I analysis in order to locate and identify specific sources of infiltration and inflow in the collection system. The focus of the SSES is on the areas identified in the I/I analyses as containing excessive I/I. Sources of I/I are identified, quantified, and appropriate rehabilitation methods are determined as part of the SSES. A determination can then be made on the cost-effectiveness of the removal of each identified source. The results and recommendations are then summarized in an SSES report.

Maps depicting investigative work completed to date along with the future work recommended in Section 5 of this report have been provided in *Appendix A*. The following subsections provide details of the recommended work.

ES.5.1 Collection System Mapping

Wastewater Collection System

The Town's wastewater collection system mapping is developed electronically within Utility Cloud and includes the following attributes:

- Sewer manholes with unique identification numbers
- Pipes with length and connectivity
- Pumping Station locations with names

The Town has a good framework completed for the wastewater collection system. Additional useful data that can be incorporated into the system include pipe size, age, and material, as well as rim elevations and manhole depths. Identifying pipe size, age and material in a central, accessible location can be a powerful planning tool as the Town reviews and prioritizes what areas of the collection system to focus rehabilitation efforts.

Storm Water Collection System

The Town has not developed their electronic storm water collection system mapping to the same extent as their wastewater collection system mapping. Storm water mapping is GIS based and limited to the general location of catch basins. Similar to development of the wastewater collection system mapping, further development of the storm water collection system mapping will benefit the Town as they look for opportunities to remove and redirect sources of inflow from the wastewater collection system and plan for future sanitary expansion. Additional useful data that can be incorporated into the system include pipe connectivity, pipe size, age, and material, outfall locations, as well as structure rim, inlet, and outlet elevations. Mapping of the storm water collection system will also facilitate compliance with the MS4 storm water program requirements.

ES.5.2 Smoke Testing

It is recommended that smoke testing be performed within the following pumping station collection basins to identify potential sources of inflow:

Table #ES-4:
Recommended Primary Smoke Testing – Areas Identified as Being Influenced by I/I (Not Previously Smoke Tested)

Ranking	Sewershed #	Pumping Station Collection Basin	Linear Footage of Gravity Sewer Pipe in Smoke Testing Area	Number of Sewer Manholes in Smoke Testing Area	Phase 1 I/I Study Subarea #'s (2006 CDM)
1	11 (Portion)*	Smith [Shore Ave to east including Hamilton Beach Area]	19,164	124	12
2	36	Onset Pier	5,121	30	N/A
3	32 (Portion)*	South Water St. [North of Onset Ave]	8,383	55	1
NR	22 (Portion)*	Narrows [Main St]	3,450	17	9
NR	24 (Portion)*	Kennedy Lane [South of Marion Rd]	8,722	32	8 & 10
NR	25	Depot Street	4,287	17	N/A
NR	26 (Portion)*	Dick's Pond [West of Pump Station & Main Ave]	4,813	17	7
NR	39 & 41	Hynes Field	24,531	136	3A & 4A
		Totals:	78,471	428	

NR = Not Ranked
*Portion of area previously smoke tested in 2006.

The pumping station collection basins (or portions thereof) listed in the above table were identified during this analysis as being impacted by I/I during wet-weather events and high groundwater conditions. The linear footages of sewer recommended for smoke testing listed in Table #ES-4 were not previously smoke tested during the 2006 effort completed by Flow Assessment Services LLC, mentioned in Section 3.2.6 of this report.

All of the North Boulevard (Ranking #4), Ruggles (Ranking #5) and Cohasset Narrows (NR) collection basins and portions of the Smith, Narrows, Kennedy Lane, Dick's Pond and South Water Street Pumping Station collection basins were smoke tested in 2006 based on the metered subarea boundary delineations in the Phase 1 analysis. The recommendation is to conduct additional smoke testing in the remaining portions of those pumping station collection basins. It is recommended that smoke testing be

performed within these collection basins since I/I impacts were identified through measurable increases in pump run-times during wet-weather events.

ES.5.3 Private Property Inspections / Dyed Water Testing

Direct inflow sources may not always be detected during smoke testing efforts due to flooded traps in building services, active pumping of sump pumps, or clogged drains. Most of the time, inflow sources with these conditions must be sought out through physical inspection and dye testing where necessary. Dyed water testing is performed by introducing dyed water into a suspected inflow source and then observing flow at a downstream sanitary sewer manhole in search of the dyed water. Possible connections may include catch basins, downspouts, sump pumps and drains from yards, patios, window wells, stairwells, and driveways.

It is recommended that the Town conduct inspection and dyed water testing of private properties in areas identified within this analysis. Key aspects per MassDEP guidelines for successful completion of the effort are summarized below:

- Property owner notification (public and individual notification)
- Achieving property owner cooperation (make improvements as necessary)
- Development of a standard property inspection form(s) to ensure consistent and complete documentation of information
- Transparent communication and professional interaction of inspectors toward property owners
- Thorough interior and exterior inspection, including dyed water testing (with owner permission) of potential sources and documentation of known and suspected sources of inflow
- Development of protocol to handle inspection refusals and alternative inspection schedules (nights and weekends) to accommodate property owners. This may include review and modification of existing Town ordinances and non-compliance penalty schedules.

For the purpose of this effort, it is recommended to conduct inspection and dyed water testing of private properties in areas which account for a combined 80% of the total inflow based on the I/I analysis. Therefore, the following five (5) pumping station collection basins should be targeted accordingly (from Table #4-3):

Recommended Private Property Inspections / Dyed Water Testing (list from Table #4-3):

Ranking	Sewershed #	Pumping Station Collection Basin	Approx. # of Properties Within Basin	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	853	220,000	29.3	29.3
2	36	Onset Pier	157	122,000	16.3	45.6
3	32	South Water Street	455	105,000	14.0	59.6
4	40	North Boulevard	185	100,000	13.3	72.9
5	10	Ruggles	219	60,000	8.0	80.9
		Total:	1,869			

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

ES.5.4 Pipeline CCTV Inspection

The condition of the majority of the Town's wastewater collection system is unknown and the Town does not currently have a formal sewer pipeline CCTV program. As mentioned in Section 3.4 of this report, the Town has completed approximately 26,000 linear feet of sewer pipeline CCTV inspection since 2015, which equates to approximately 8% of the gravity sewer collection system. Through this effort, the Town discovered an 80 linear foot section of severely deteriorated 21-inch diameter RCP sewer between MH 001013 and MH 001012. The Town is taking immediate action for its repair. A summary table of the completed inspections and associated findings has been included in *Appendix D* of this report for reference.

It is recommended that the Town conduct additional CCTV inspection, starting within the oldest sections of the wastewater collection system which contain vitrified clay and asbestos cement pipe materials (constructed between 1970 and 1980). Inspection should be conducted in spring months (March 1 – June 30), when high groundwater conditions are typically experienced and active infiltration sources are more likely to be observed. It is noted that some of the areas recommended for CCTV inspection are within pump station collection basins that were identified as being influenced by wet-weather / high groundwater conditions and also contain older pipe materials (VC, AC,

etc.). It is recommended that the Town complete pipeline CCTV inspection within the following areas:

Table #ES-5:
Recommended Pipeline CCTV Inspection

Ranking	Sewershed #	Pumping Station Collection Basin	Total Linear Footage of Gravity Sewer Pipe	Pipe Size (Dia.) Range/Known Materials	Number of Sewer Manholes	Phase 1 I/I Study Subarea #'s (2006 CDM)
1	11	Smith	33,672	8" – 12" (VC, DI)	207	11 & 12
2	36	Onset Pier	5,121	8" – 15" (VC, RCP)	30	N/A
3	32	South Water St.	17,520	8" – 12" (VC)	113	1 & 2
4	40	North Boulevard	7,488	8" – 10" (VC)	39	4B
5	10	Ruggles	7,541	8" (AC, DI)	41	11
8	23	Pinehurst	12,003	8" – 10" (VC, DI)	79	9
		Primary Subtotal:	83,345			
NR	22	Narrows*	14,900	8" – 12" VC 21" RCP*	71	8 & 9
NR	24	Kennedy*	23,563	8" – 10" VC 18" - 21" RCP*	110	8 & 10
NR	39 & 41	Hynes Field	24,531	8" – 12" (VC)	136	3A & 4A
		Secondary Subtotal:	62,994			
		Total:	146,339			

NR = Not Ranked

*As mentioned in Section 3.4 of this report, the 18" & 21" RCP interceptors within the Kennedy and Narrows Pumping Station collection basins were inspected in 2017. A summary table of the completed inspections and associated findings has been included in *Appendix D* of this report for reference.

The pumping station collection basins listed in Table #ES-5 contain non-PVC pipe materials and were constructed between 1970 and 1980.

The Pinehurst Pumping Station collection basin was constructed in 1977 and also contains non-PVC pipe materials including vitrified clay and ductile iron. It is recommended that pipeline CCTV inspection be performed within this collection basin since I/I impacts were identified through measurable increases in pump run-times during wet-weather events and also because of Wareham WPCD personnel account of the presence of sand within sections of the pipelines.

The Narrows, Kennedy and Hynes Field Pumping Station collection basins were all constructed in 1970 and consist of non-PVC pipe materials such as vitrified clay and asbestos cement. These three basins were not evaluated further as part of this I/I analysis due to upstream influences and thus would be lower priority than the other ranked basins listed in the table. However, the Town should prioritize conducting structural evaluation via pipeline CCTV inspection in locations where there is asbestos cement or reinforced concrete pipe immediately downstream of pump station force main discharges.

ES.5.5 Manhole Inspections / Salinity Testing

As mentioned in Section 3.4 of this report, the Town has completed 266 limited sewer manhole inspections since 2015, which equates to approximately 14% of the total sewer manholes in the collection system. The intent of the limited inspection is to obtain an overall perspective of the condition of the system. A summary table of the completed inspections and associated findings has been included in *Appendix E* of this report for reference.

Extensive manhole inspections are typically recommended as the next step in the process as part of an SSES, to determine the quantity of infiltration entering the system from the manholes in the areas where I/I was determined to be excessive during the I/I analysis. Infiltration rates were not determined to be in excess of the MassDEP threshold of 4,000 gpd/in-mi during the 2006 Phase 1 I/I analysis. However, extensive manhole inspections are recommended by the MassDEP Guidelines in areas which account for a combined 80% of the total inflow based on the I/I analysis. It is therefore recommended to conduct extensive manhole inspections in the following five (5) pumping station collection basins to identify sources of inflow and infiltration (from Table #ES-3):

Recommended Manhole Inspections (list from Table #4-3):

Ranking	Sewershed #	Pumping Station Collection Basin	Total # of Sewer Manholes in Basin	Gravity Sewer Length (LF)	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	207	33,672	220,000	29.3	29.3
2	36	Onset Pier	30	5,121	122,000	16.3	45.6
3	32	South Water Street	113	17,520	105,000	14.0	59.6
4	40	North Boulevard	39	7,488	100,000	13.3	72.9
5	10	Ruggles	41	7,541	60,000	8.0	80.9
		Totals:	430	71,342			

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

Tidal I/I

Tidal influence was evaluated as part of this effort but results were inconclusive. However, analysis previously completed by CDM in 2006 as part of the Phase 1 report identified slight to moderate tidal influence within the thirteen subareas that were studied. Salinity testing of manholes is therefore recommended. This should be accomplished during high tides within manholes that are within close proximity to the shoreline and are constructed at depths below sea level elevations. This can be completed concurrently with the extensive manhole inspections where applicable.

ES.5.6 Town Ordinance Additions / Modifications

In preparation for inspection of private properties, it is recommended that the Town review and evaluate the existing Town sewer use ordinances and determine whether modifications to existing ordinances, or creation of new ordinances, will be required to aid in the Town's future I/I removal efforts. Considerations should include the following at a minimum and if applicable:

- Right-of-entry access to private property to conduct inspections and dye testing
- Regulations governing the discharge of groundwater or storm water runoff to the Town's separate sanitary sewer system
- Town enforcement schedules and non-compliance penalty matrices

ES.5.7 Establishment of I/I Fees

The Town has interest in pursuing the establishment of an I/I fee. Due to recent proposals for future land development and subsequent sewer collection system

expansion, and given the limited existing capacity at the Town's wastewater treatment facility, an I/I fee could be established and assessed to new construction with planned sewer connection and discharge of wastewater to the Town's collection system. Fees collected could be used to fund future studies and construction projects within the collection system aimed at identification and removal of known sources of infiltration and inflow. Removal of I/I will improve capacity limitations within the collection system and at the wastewater treatment facility.

It is recommended that the Town research and review procedures that other local communities have previously adopted for development and management of an I/I fee. The Town can obtain helpful information from this research that will assist in the development of their own fee structure should they decide to establish one.

Table #ES-6 summarizes the recommended (Primary Only) SSES work presented above in this Section.

Table #ES-6:
Summary of Recommended SSES Work – Top Ranked Pumping Station Collection Basins

Ranking	Sewershed #	Pumping Station Collection Basin	Smoke Testing	Private Property Inspection / Dyed Water Testing	Pipeline CCTV Inspection	Manhole Inspection / Salinity Testing
1	11	Smith	✓ (Portion)	✓	✓	✓
2	36	Onset Pier	✓	✓	✓	✓
3	32	South Water St.	✓ (Portion)	✓	✓	✓
4	40	North Boulevard	*	✓	✓	✓
5	10	Ruggles	*	✓	✓	✓
8	23	Pinehurst	*	N/A	✓	N/A

*Smoke Testing of pumping station collection basin completed in 2006.

In addition to the above, it is also recommended that the Town complete smoke testing in the service areas of the larger pump stations including Narrows (portion), Kennedy (portion), Depot Street, Dick's Pond (portion) and Hynes Field. Smoke testing is a relatively simple and low cost tool that may result in identification of major sources of

inflow. Among others, the North Boulevard, Ruggles, Pinehurst and Cohasset Narrows pumping station collection basins were completely smoke tested in 2006.

ES.6 Probable Costs and Schedule

Smoke testing is ideally conducted during dry-weather, low groundwater conditions (July 1 – November 15) to allow successful travel of the smoke throughout the system, whereas sewer manhole and pipeline inspections are ideally conducted during high groundwater conditions (March 1 – June 30) to identify sources of active infiltration within the system. Since the Town of Wareham experiences seasonal fluctuations in population with higher concentrations of residents and visitors in the summer months, it is recommended that the sewer manhole and pipeline inspections be completed in the spring months (March – May) and the smoke testing be completed in the fall months (September – November) to minimize disruptive impacts to the community.

Private property inspections and dyed water testing can be conducted concurrently with smoke testing efforts; however, due to seasonal population, access to private property will likely be limited. Property inspections will likely be a multi-year effort based on the recommended scope or work. A 5-year implementation schedule has been presented in this report as an example. Once a formal private property inspection program has been established, the Town should develop their own prioritized schedule for conducting property inspections.

It is recommended that the Town begin the SSES phase as early as March/April 2019 or as soon as funding is secured. An aggressive implementation schedule will serve to benefit the Town's future endeavors as related to restoring capacity to the collection system and treatment facility. A proposed implementation schedule for completion of SSES investigative work has been included within *Appendix F* of the report.

An opinion of probable cost (in 2018 dollars) for the related work has also been provided below in Table #ES-7 and Table #ES-8. Unit costs shall be adjusted as necessary to account for future inflation.

Table #ES-7:
2018 Opinion of Probable Cost – Recommended SSES Investigative Work
(An opinion of probable cost for Private Property Inspections and Dyed Water Testing has been provided separately in Table #ES-8)

SSES (Primary) - Work Description	**Quantity**	**Unit Cost**	**Extended Cost***
Smoke Testing – Primary Areas	79,000 LF	$1.00	$79,000.00
Pipeline CCTV Inspection – Primary Areas	84,000 LF	$3.00	$252,000.00
Extensive Manhole Inspection – Primary Areas	430 EA	$200.00	$86,000.00
		Subtotal:	*$420,000.00*
		Engineering & Contingencies (30%):	*$130,000.00*
		SSES Primary Total:	**$550,000.00**
SSES (Secondary) - Work Description	**Quantity**	**Unit Cost**	**Extended Cost***
Smoke Testing – Secondary Areas	113,000 LF	$1.00	$113,000.00
Pipeline CCTV Inspection – Secondary Areas	63,000 LF	$3.00	$189,000.00
		Subtotal:	*$310,000.00*
		Engineering & Contingencies (30%):	*$100,000.00*
		SSES Secondary Total:	**$410,000.00**
Development of Storm Water and Wastewater Collection System Mapping:			**$100,000.00**

*Extended Costs have been rounded up to the nearest thousand dollars. Subtotals, Engineering and Contingencies, and Total Costs have been rounded up to the nearest ten thousand dollars.

Table #ES-8:
2018 Opinion of Probable Cost – Recommended Property Inspection / Dyed Water Testing of Private Properties

SSES (Primary) - Work Description	**Quantity**	**Unit Cost Per Property**	**Extended Cost***
Private Property Inspection / Dyed Water Testing (All Recommended Properties)	1,870 EA	$750.00	$1,403,000.00
5-Year Implementation Schedule (Example)			
Year 1 Property Inspections	375 EA	$750.00	$282,000.00
Year 2 Property Inspections	375 EA	$750.00	$282,000.00
Year 3 Property Inspections	375 EA	$750.00	$282,000.00
Year 4 Property Inspections	375 EA	$750.00	$282,000.00
Year 5 Property Inspections	370 EA	$750.00	$278,000.00
Private Property Inspection Total:			**$1,410,000.00**

* Extended Costs have been rounded up to the nearest thousand dollars. Total Cost has been rounded up to the nearest ten thousand dollars.

Note: The opinions of probable costs presented in Table #ES-7 and Table #ES-8 do not include the development of an SSES Report. Development of an SSES Report will be contingent on the successful completion of and findings from identified recommended tasks. The scope of required collection system repairs will be developed based on the findings of the recommended investigation work. An estimate for development of the SSES Report can be generated at that time once the scope of work is determined.

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Section 1
Introduction

1.1 Purpose of Report

The purpose of this report is to present the findings of the Phase 2 Infiltration and Inflow investigation that was conducted on the Town of Wareham's wastewater collection system. The work was performed by BETA Group, Inc. (BETA), via professional services agreement with the Town of Wareham, with assistance from the Town of Wareham Water Pollution Control Department (WPCD). The infiltration and inflow investigation and evaluation were conducted in general accordance with the Massachusetts Department of Environmental Protection (MassDEP) Guidance document "*Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Surveys*, revised/dated May 2017".

The goal of the I/I analysis is to make recommendations for further study to develop preliminary recommendations to implement a Sewer System Evaluation Survey (SSES). The goal of the SSES is to identify I/I sources and their flow contribution and propose a plan for remediation.

BETA, on behalf of the Town, met with representatives from MassDEP on January 19, 2017 to present an alternative approach to the I/I investigation than that described in the MassDEP Guidance. BETA proposed utilizing wastewater pumping station pump run-time data to identify areas that are subject to I/I influence in lieu of the continuous flow metering methodology that is included in the MassDEP Guidance document for the analysis.

The Town of Wareham has 44 pumping stations of varying size and configuration and operation of the pumping stations is continuously tracked by the Mission monitoring and data management system. The Mission system is a cellular based supervisory control and data acquisition (SCADA) system that provides the Town with a secure website for reviewing operating conditions and storing data for remote pumping station sites. Data includes general station information such as name, location, and pump capacity as well as operating data such as wet well level, pump status and daily pump run-times. Pump run-time data is stored for as long as the service has been maintained. Individual pumping stations are not equipped with flow meters but total daily flow volumes can be determined by comparing pump run-times and associated pump capacities.

One of the focuses in this data review was to look for evidence of extended run-times during wet-weather events and high groundwater conditions. Extended run-times would be an indication of I/I impacts to the collection system. The remote pumping

stations on the perimeter of the collection system are ideal for making this correlation because their influence is limited to their smaller tributary collection system as opposed to a station which receives flow from multiple upstream pumping stations. Comparing the pump run-time data for different time periods and identifying trends provides the information required to determine when the stations manage additional flow. The service areas for those pumping stations that require pump operation for longer periods of time during periods of wet-weather and high groundwater will be targeted for additional investigations.

Through recommendation from MassDEP and as stipulation for the agency's approval of the alternative approach to the I/I investigation and analysis, levels of QA/QC were conducted at select pumping stations to validate the Mission data accuracy.

This report summarizes the results of the I/I investigation performed by BETA and includes details of field studies, data analysis, conclusions, and recommendations for further studies. In an effort to further demonstrate the relevance of the above evaluation, results have been compared to Wareham's Phase 1 Infiltration and Inflow investigation/analysis performed by Camp Dresser & McKee Inc. (CDM) in 2006.

1.2 Study Area

The Town of Wareham is situated in the southern end of Plymouth County, Massachusetts. Wareham lies approximately 55 miles southeast of Boston and approximately 45 miles east of Providence, Rhode Island. The Phase 2 Infiltration and Inflow Study area consisted of evaluation of nearly the entire sewered portion of Wareham (data analysis of all pumping stations tracked by the Mission system) with primary focus on select pumping station drainage basins as described further in this report. A more detailed description of the Town's collection system is included within Section 2 of this report.

1.3 Project Scope

The scope of the I/I Study included the following tasks, which are described in more detail in later sections of this report.

- Evaluation and analysis of pumping station operation data collected from the Town's Mission monitoring and data management system. The Town's Mission data was compared to local historical rainfall data for purpose of analysis.

- Wet well drawdown testing and limited flow metering of select pumping station discharges to validate station operation data collected within the Town's Mission monitoring and data management system, specifically verification of pump capacities.

- ❖ Research and review of investigations, studies and sewer rehabilitation previously completed within the Town's wastewater collection system. Findings and recommendations from these previous efforts have been incorporated into this report for comparison purposes and serve as a basis for focusing additional investigation efforts and recommending further studies within the collection system.

- ❖ Limited manhole inspections were performed for the purpose of searching for and identifying specific sources of groundwater infiltration within the Town's wastewater collection system.

- ❖ Limited pipeline CCTV inspections were conducted for the purpose of searching for and identifying specific sources of groundwater infiltration within the Town's wastewater collection system.

This study evaluated the wastewater collection system by distinct pumping station drainage basins. As described above in Section 1.1 of this report, review and analysis of continuous pumping station operation data can provide indication of impacts to the collection system from wet-weather events and high groundwater conditions. Following evaluation of the Town's pumping stations monitored by the Mission system, pumping station drainage basins that were identified to be directly impacted by wet-weather, high groundwater conditions were then selected for further analysis.

Further analysis included quantifying the extraneous flows managed by the select pumping stations. Evaluating the Mission data through comparison of pump run-times during dry-weather conditions to pump run-times during wet-weather conditions provided the extraneous flow volume estimates. A relative ranking of each targeted pumping station drainage basin was then developed based on the level of impact to the particular basin.

1.4 Definitions and Abbreviations

1.4.1 Definitions

Building Service Connection – Where a building service lateral connects to the public sewer; typically made using a wye or tee, with a chimney for deep public sewers.

Defect – A potential source of infiltration/inflow.

Dyed Water Testing – A detection technique in which dyed water is introduced into a suspected public or private source of inflow (i.e., downspouts, area drains, driveway drains, sump pumps, etc.) in order to confirm direct or indirect connections to the sanitary sewer.

Extraneous Flow – The excess water in the sewer collection system from sources of infiltration and inflow that is not intended to be in the system.

Infiltration – Water other than sanitary flow that enters a sewer system (including sewer service connections and foundation drains) from the ground through means which include, but are not limited to, defective pipes, pipe joints, connections, or manholes. Infiltration does not include, and is distinguished from inflow.

Inflow – Water other than sanitary flow that enters a sewer system (including sewer service connections) from sources which include, but are not limited to, 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, sump pump discharges, or drainage. Inflow does not include, and is distinguished from, infiltration. The total amount of inflow is equal to the sum of the delayed inflow and direct inflow.

Infiltration/Inflow Analysis – A study of the sewer collection system to identify specific portions of the system that exhibit measurable influence from infiltration and/or inflow during wet-weather and high groundwater conditions.

Pump Run-Time – The minutes per day that a particular sewage pump, located at a remote pumping station within the sewer collection system, was recorded as actively pumping.

Pumping Station Collection Basin – The isolated, individual portion of the overall gravity sewer collection system that conveys wastewater to a particular pumping station located at the most downstream point of the collection area, excluding the areas upstream and downstream from the basin that convey flow to a different pumping station or treatment facility. Also referenced as a "sewershed".

Salinity Testing – The sampling and testing of the wastewater stream within the sewer collection system, typically taken from specific manhole entry points near a body of salt water, to identify the salinity concentration of the wastewater. Concentrations of salt within the wastewater would indicate a potential tidal influence of the salt water body on the sewer collection system (potential source of infiltration and/or inflow).

Sanitary Flow – The component of wastewater which includes domestic, commercial, institutional, and industrial sewage, and specifically excludes infiltration/inflow.

Sanitary Sewer – A sewer intended to carry sanitary flow.

Sanitary Sewer Overflow or SSO – Any overflow, spill, release, discharge or diversion of untreated or partially treated wastewater from a sanitary sewer system to ground or surface waters. The discharge of sewage into a building is not considered an SSO if the discharge was not the direct result of problems in the public sewer system.

Sewer Interceptor – A sewer that receives flow from multiple lateral sewers and conveys wastewater to a facility for additional transmission or directly to a facility for treatment.

Sewer System – Pipelines or conduits, pumping stations, force mains, and all other structures, devices, appurtenances, and facilities used for collecting and transporting wastes to a site or works for treatment or disposal.

Sewer System Evaluation Survey – The detailed review and analysis of a sewer collection system conducted to identify specific locations and estimated volumes of extraneous flow sources within the collection system and determining scope and estimating costs for rehabilitation and repair of the identified defects within the system aimed at removal of the extraneous flow sources.

Smoke Testing – A procedure used to identify sources of inflow within the sewer collection system. The testing involves blowing a combination of air and non-toxic smoke into the sewer collection system at various manhole entry points. The pressurized air/smoke follows the sewer pipe network in reverse and reveals sources of inflow that are exposed at the surface.

Storm Water – All water running off from the surface of a drainage area after a period of rain.

Subarea - The isolated, individual portion of the overall gravity sewer collection system that conveys wastewater to a particular downstream point of the collection area, typically associated with flow meter placement within a sewer collection system for study purposes. The collection system areas upstream and downstream from the isolated basin are excluded and make up separate subareas.

Tidal I/I – Infiltration and inflow caused by tide cycles that elevate groundwater levels or introduce water as inflow to the sewer collection system via system defects.

Wastewater – Sanitary flow, along with any infiltration and inflow present in the sewer system.

Wet Well Drawdown Test – The process involves the measurement of time required for a specific sewage pump to “drawdown” or pump a known volume of liquid from the respective sewer pump station wet well. The instantaneous rate (at the time of the drawdown test) at which the influent wastewater flow is entering the station’s wet well is also measured and factored into the calculation. The resultant calculation then

provides an accurate flow rate that can be attributed to the pump's pumping capacity under the given system conditions.

1.4.2 Abbreviations

AC	Asbestos Cement
CCTV	Closed-Circuit Television (inspection)
CI	Cast Iron
CWMP	Comprehensive Wastewater Management Plan
DI	Ductile Iron
ft^2	Square Feet
GIS	Geographic Information System
gpd	gallons per day
gpd/in-mi	gallons per day per inch diameter mile of pipe
gpm	gallons per minute
I/I	Infiltration and Inflow
in	inches
in/hr	inches per hour
lf	linear feet
LP	Low Pressure
MACP	National Association of Sewer Service Companies' (NASSCO) Manhole Assessment and Certification Program
MassDEP	Massachusetts Department of Environmental Protection
mg	million gallons
mgd	million gallons per day

MH	Manhole
NASSCO	National Association of Sewer Service Companies
PACP	National Association of Sewer Service Companies' (NASSCO) Pipeline Assessment and Certification Program
PS	Pumping Station
PVC	Polyvinyl Chloride
RC	Reinforced Concrete
SCADA	Supervisory Control and Data Acquisition
SSES	Sewer System Evaluation Survey
SSO	Sanitary Sewer Overflow
VC	Vitrified Clay
VFD	Variable Frequency Drive
WPCD	Water Pollution Control Department
WPCF	Water Pollution Control Facility

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Section 2
Existing Wastewater Collection System

2.1 Collection System

The Town of Wareham's existing wastewater collection system consists of:

- 44 Pumping Stations
- Approx. 65 miles of gravity pipe
- Approx. 14.5 miles of force main pipe
- Approx. 1,900+ manholes

Gravity sewer pipe ranges in diameter from 8-inches to 21-inches and force main pipe ranges in diameter from 2-inches to 18-inches. Pipe materials vary and include polyvinyl chloride (PVC), vitrified clay (VC), asbestos cement (AC), cast iron (CI), ductile iron (DI), and reinforced concrete (RC).

Maps depicting the existing collection system, including manholes, pipes, pumping stations, and isolated pumping station collection basins have been provided in *Appendix A* of this report for reference.

The wastewater collection system is not subject to wet-weather sanitary sewer overflows or system surcharging that result in basement back-ups.

2.2 Pumping Station Collection Basins / Subareas / Sewersheds

Phase 2 of the Town's I/I investigations focused on individual pumping station collection basins. Data from the Town's pumping stations was reviewed, and the areas that appear to be influenced by wet-weather and high groundwater conditions (based on historical pump run-time data recorded at the stations) were selected for additional evaluation. Phase 1 I/I investigations, conducted in 2006 by CDM, focused on metered subareas delineated throughout the collection system. For comparison purposes and to validate the analysis results of BETA's investigations, a correlation will be made in this report between the pumping station collection basins and the subareas delineated as part of the 2006 effort.

Operation of the Town's larger pumping stations was also evaluated but given the influence of upstream pumping stations in each of these locations, determination of wet-weather impacts to the associated, individual collection basins would prove challenging and unreliable using pump run-time data and metering would pose similar challenges. Information collected for these pumping stations can be found in later

sections of this report. A flow schematic depicting the connectivity of the Town's pumping stations is included within *Appendix B*.

Eighteen (18) of the forty-four (44) pumping stations were determined to be influenced by wet-weather flows. The collection basins for these areas were analyzed further and are depicted on the figures included within *Appendix A*. Table #2-1 includes an inventory listing of the eighteen (18) pumping station collection basins.

Table #2-1:
Pumping Station Collection Basins Evaluated Further (Inventory)

Sewershed #	Pumping Station Collection Basin	Total Linear Footage of Gravity Sewer Pipe	Pipe Size (Dia.) Range/Known Materials	Number of Sewer Manholes	Phase 1 I/I Study Subarea #'s (2006 CDM)
3	Apple Street	2,762	8" (PVC)	18	N/A
6	Peter Cooper Dr.	1,568	8" (PVC)	5	N/A
10	Ruggles	7,541	8" (AC, DI)	41	11
11	Smith	33,672	8" – 12" (VC, DI)	207	11 & 12
12	Mattapoisett	1,412	8" (PVC)	7	N/A
13	Briarwood	11,351	8" – 12" (PVC)	57	N/A
14	Arnold Street	8,954	8" – 10" (PVC)	48	N/A
15	French-Canedy	2,903	8" (PVC)	12	N/A
16	Leonard	4,157	8" (PVC)	20	N/A
17	13th Ave	3,183	8" (PVC)	18	N/A
18	Hathaway	16,840	8" – 12" (PVC)	74	N/A
19 & 20	Cromesett	6,332	8" (PVC) 2" (PVC L.P.)	28	N/A
21	Terry Lane [Pine Tree Estates]	15,432	8" (PVC)	82	10
23	Pinehurst	12,003	8" – 10" (VC, DI)	79	9
28	Salt Works Rd.	11,153	8" – 10" (PVC, DI)	65	6
32	South Water St.	17,520	8" – 12" (VC)	113	1 & 2
36	Onset Pier	5,121	8" – 15" (VC, RCP)	30	N/A
40	North Boulevard	7,488	8" – 10" (VC)	39	4B
	Totals:	169,392		943	

Apple Street (Sewershed #3)

The Apple Street Pumping Station was constructed after 2003 and services a small, predominantly residential neighborhood that borders the Agawam River to the northeast, Sandwich Road to the south and the Avenue A Pumping Station collection basin to the west. The collection basin contains 2,762 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the Apple Street Pumping Station to the Avenue A Pumping Station via Sandwich Road and Oakdale Street. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with each having a capacity of approximately 130 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Peter Cooper Drive (Sewershed #6)

The Peter Cooper Drive Pumping Station was constructed in 1986 and services a small, residential neighborhood situated in the center of Town east of the Wareham River and Crab Cove and south of Minot Ave and the Agawam River. The collection basin contains 1,568 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the Peter Cooper Drive Pumping Station in a northwesterly direction where it connects to the Narrows Pumping Station force main along Minot Avenue. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with each having a capacity of approximately 40 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Ruggles (Sewershed #10)

The Ruggles Pumping Station was constructed in 1977 and services a residential neighborhood that borders the Wareham River to the south and includes 7,541 linear feet of 8-inch AC and DI gravity sewer pipe. The Ruggles Pumping Station pumps wastewater to the Smith Pumping Station to the north. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two dry-pit submersible pumps with each having a capacity of approximately 230 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Smith (Sewershed #11)

The Smith Pumping Station was constructed in 1977 and services a residential neighborhood that borders the Ruggles collection basin to the south, the Wareham River to the southeast, and the Broad Marsh River to the northeast. The Smith collection basin contains 33,672 linear feet of 8-inch to 12-inch VC and DI gravity sewer pipe and flow is pumped from the Smith Pumping Station to the Kennedy Lane Pumping Station to the north via Swifts Beach Road. The Smith Pumping Station receives flow from the Ruggles Pumping Station. The station contains two dry-pit submersible pumps with each having a capacity of approximately 1,265 gpm. One pump serves as the

primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Mattapoisett (Sewershed #12)

The Mattapoisett Pumping Station was constructed after 2003 and services a small, residential neighborhood that borders the Wareham River to the east and the Cromesett Pumping Station collection basins to the north, south and west. The collection basin contains 1,412 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the Mattapoisett Pumping Station to the Cromesett Pumping Station via Mattapoisett Road and Cromesett Road. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with each having a capacity of approximately 230 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Briarwood (Sewershed #13)

The Briarwood Pumping Station was constructed after 2003 and services a residential neighborhood in a location referred to as "Briarwood Shores" that borders the Weweantic River to the south and Marion Road (Route 6) to the northwest. The collection basin contains 11,351 linear feet of 8-inch to 12-inch PVC gravity sewer pipe and flow is pumped from the Briarwood Pumping Station to the Hathaway Pumping Station via Briarwood Drive, Old Marion Road, and Hathaway Street. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with each having a capacity of approximately 235 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Arnold Street (Sewershed #14)

The Arnold Street Pumping Station was constructed after 2003 and services a residential neighborhood in a location referred to as "Rose Point" that borders the Weweantic River to the east, Route 195 to the northwest, and the Sippican River to the west. The collection basin contains 8,954 linear feet of 8-inch to 10-inch PVC gravity sewer pipe and flow is pumped from the Arnold Street Pumping Station in an easterly direction, crossing the Weweantic River, to the Hathaway Pumping Station collection basin. The Arnold Street Pumping Station receives flow from the Leonard Pumping Station and the French-Canedy Pumping Station. The station contains two submersible pumps with each having a capacity of approximately 270 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

French-Canedy (Sewershed #15)

The French-Canedy Pumping Station was constructed after 2003 and services a small residential neighborhood in a location referred to as "Rose Point" that borders the Arnold Street Pumping Station collection basin and the Weweantic River to the east,

Route 195 to the northwest, and the Sippican River to the south. The collection basin contains 2,903 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the French-Canedy Pumping Station to the Arnold Pumping Station via Rose Point Avenue, Winter Street, Barlow Avenue and Gordon Street. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with each having a capacity of approximately 140 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Leonard (Sewershed #16)

The Leonard Pumping Station was constructed after 2003 and services a residential neighborhood in a location referred to as "Rose Point" that borders the Weweantic River to the east, Route 195 to the northwest, and the Arnold Pumping Station collection basin to the south. The collection basin contains 4,157 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the Leonard Pumping Station to the Arnold Pumping Station via Barlow Avenue. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with pump 1 having a capacity of approximately 60 gpm and pump 2 having a capacity of approximately 30 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

13th Ave (Sewershed #17)

The 13th Ave Pumping Station was constructed in 2003 and services a small, residential neighborhood in a location referred to as "Weweantic Shores" that borders the Weweantic River to the west and the Hathaway Pumping Station collection basin to the east. The collection basin contains 3,183 linear feet of 8-inch PVC gravity sewer pipe and flow is pumped from the 13th Ave Pumping Station to the Hathaway Pumping Station via 13th Ave and Hathaway Street. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two submersible pumps with pump 1 having a capacity of approximately 60 gpm and pump 2 having a capacity of approximately 110 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Hathaway (Sewershed #18)

The Hathaway Pumping Station was constructed in 2003 and services a residential neighborhood in a location referred to as "Weweantic Shores" that borders the Weweantic River to the west and Marion Road (Route 6) to the east. The collection basin contains 16,840 linear feet of 8-inch to 12-inch PVC gravity sewer pipe and flow is pumped from the Hathaway Pumping Station to the Kennedy Lane Pumping Station via Windsor Drive, Melwood Drive, Marion Road (Route 6), and Swifts Beach Road. The Hathaway Pumping Station receives direct pumped flow from three pumping stations: Briarwood, Arnold, and 13th Avenue Pumping Stations. The Arnold Pumping Station also

receives pumped flow from the French Avenue and Leonard Street Pumping Stations for a total of five (5) pumping stations that contribute flow to the Hathaway collection basin. The station contains two submersible pumps with each having a capacity of approximately 460 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Cromesett (Sewershed #19 & 20)

The Cromesett Pumping Station was constructed after 2003 and services a residential neighborhood that borders the Wareham River and Marks Cove to the east, the Weweantic River to the south and west, and the Terry Lane (Pine Tree Estates) Pumping Station collection basin to the north. The collection basin contains 6,332 linear feet of 8-inch PVC gravity sewer pipe and approximately 500 linear feet of 2-inch PVC low-pressure sewer pipe. The Cromesett Pumping Station pumps flow to the Terry Lane Pumping Station via Cromesett Road and receives flow from the Mattapoisett Pumping Station. The station contains two submersible pumps with each having a capacity of approximately 110 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Terry Lane [Pine Tree Estates] (Sewershed #21)

The Terry Lane Pumping Station was constructed in 1989 and services a residential neighborhood called "Pine Tree Estates" that is located inland in the southwest portion of the collection system and contains 15,432 linear feet of 8-inch PVC gravity sewer pipe. The basin is bordered by Marion Road (Route 6) to the west and the Cromesett collection basin to the south. Flow is pumped from the Terry Lane Pumping Station to the Kennedy Lane Pumping Station to the north via Swifts Beach Road. The Terry Lane Pumping Station receives flow from the Cromesett Pumping Station. The station contains two submersible pumps with each having a capacity of approximately 225 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Pinehurst (Sewershed #23)

The Pinehurst Pumping Station was constructed in 1977 and services a residential neighborhood that borders the Broad Marsh River to the west, the Wareham River and Mirror Cove to the east, and the Narrows Pumping Station collection basin to the north. The Pinehurst collection basin contains 12,003 linear feet of 8-inch to 10-inch VC and DI gravity sewer pipe and flow is pumped from the Pinehurst Pumping Station to the Narrows Pumping Station to the north. The collection basin is "isolated" and does not receive flow from other pumping stations. The station contains two dry-pit submersible pumps with each having a capacity of approximately 345 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Salt Works Road (Sewershed #28)

The Salt Works Road Pumping Station was constructed in 1988 and services a residential neighborhood that borders Buttermilk Bay to the east, Red Brook Road to the north and the Cohasset Narrows Pumping Station collection basin to the south. The collection basin contains 11,153 linear feet of 8-inch to 10-inch PVC and DI gravity sewer pipe and flow is pumped from the Salt Works Road Pumping Station to the Cohasset Narrows Pumping Station to the south via Choctaw Drive and Cranberry Highway (Route 6). The Salt Works Road Pumping Station receives pumped flow from the Town of Plymouth to the north. The station contains two submersible pumps with each having a capacity of approximately 245 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

South Water Street (Sewershed #32)

The South Water Street Pumping Station was constructed in 1972 and services a predominantly residential neighborhood in East Wareham that borders Onset Bay to the south, Broad Cove to the west, Onset Heights Pumping Station collection basin to the north and the Green Street and Bay Street Pumping Station collection basins to the east. The collection basin contains 17,520 linear feet of 8-inch to 12-inch VC gravity sewer pipe and flow is pumped from the South Water Street Pumping Station in a westerly direction, crossing Broad Cove, to the Onset Pier Pumping Station collection basin. The South Water Street Pumping Station receives direct pumped flow from the Onset Heights and Green Street pumping stations. The Green Street Pumping Station is an ejector style station and also receives pumped flow from two additional ejector style stations, the Woodbury Street and Bay Street pumping stations. A total of four (4) pumping stations contribute flow to the South Water Street collection basin. The station contains two dry-pit submersible pumps with each having a capacity of approximately 1,060 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

Onset Pier (Sewershed #36)

The Onset Pier Pumping Station was constructed in 1972 and services a mixture of residential and commercial buildings in Onset and the neighborhood is bordered by Onset Bay to the south, Broad Cove to the east, and several pumping station collection basins to the north and west. The collection basin contains 5,121 linear feet of 8-inch to 15-inch VC and RCP gravity sewer pipe and flow is pumped from the Onset Pier Pumping Station to the Hynes Field Pumping Station collection basin via Onset Avenue. The Onset Pier Pumping Station receives direct pumped flow from the South Water Street Pumping Station. The South Water Street Pumping Station also receives pumped flow from the Onset Heights Pumping Station and three ejector style stations including the Green Street, Woodbury Street and Bay Street pumping stations. A total of five (5) pumping stations contribute flow to the Onset Pier collection basin. The station contains two dry-pit submersible pumps with pump 1 having a capacity of approximately 1,000 gpm and pump 2 having a capacity of approximately 1,100 gpm.

One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

North Boulevard (Sewershed #40)

The North Boulevard Pumping Station was constructed in 1972 and services a residential neighborhood that borders Broad Cove and Muddy Cove to the northeast, the Hynes Field Pumping Station collection basins to the southwest, and the East Boulevard Pumping Station collection basin to the southeast. The collection basin contains 7,488 linear feet of 8-inch to 10-inch VC gravity sewer pipe and flow is pumped from the North Boulevard Pumping Station to the Hynes Field Pumping Station via Wareham Avenue. The North Boulevard Pumping Station receives flow from the East Boulevard Pumping Station, which is an ejector style station. The station contains two dry-pit submersible pumps with each having a capacity of approximately 670 gpm. One pump serves as the primary pump while the other pump serves as the standby pump. Pump operation is alternated between the two pumps.

2.3 Wareham, MA Water Pollution Control Facility

The Town of Wareham's Water Pollution Control Facility (WPCF) has been in operation since 1972 as a conventional activated sludge facility. In 2005, the Town completed construction of an upgrade to the facility. The 1.56 MGD advanced wastewater treatment facility is designed to handle a maximum daily flow of 3.48 MGD and a peak hourly flow of 5.39 MGD. Existing average daily flow to the WPCF is approximately 1.0 MGD. Wastewater for the entire sewerage system is collected and enters the WPCF through two 18-inch force mains. Preliminary treatment is provided by a cylindrical fine screen, a hand-cleaned bypass screen, vortex grit removal chamber, a grit classifier, and a septage receiving package plant. Two offline, open-air equalization basins were constructed to dampen peak flows during the 2005 improvements to the facility. Wastewater is diverted to the equalization basins during peak flows with an adjustable weir gate. When elevated flows to the WPCF subside, two pumps are available to pump wastewater from the equalization basins back into the main treatment facilities. Following preliminary treatment, flow passes through secondary treatment comprised of: two (2) anoxic selector tanks; three (3) aeration tanks; three (3) 55-foot diameter clarifiers; three (3) denitrifying filters; and UV disinfection. Flow is discharged through a pipe to the Agawam River.

The Wareham WPCF accepts septage from within the Town as well as from the towns of Bourne, Carver, Marion, Rochester, and Sandwich.

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Section 3
Data Collection / Previous Studies

3.1 General

This section includes a summary description of the data collection process utilized for preparation of this report, including gathering and reviewing information previously reported as a result of former I/I studies, investigations and related evaluations completed by/for the Town. The following subsections also include summaries of sewer rehabilitation and repair previously completed within the Town's wastewater collection system related to the removal of I/I. Findings and recommendations from these previous efforts serve as a basis for focusing additional investigation efforts and for providing recommendation for further studies within the collection system.

3.2 Sources of Data / Previous Studies & Completed Work

The various sources of information that were used in preparation of this report are as follows:

- Available system mapping, plans, reports, and other documents provided by the Town were obtained and reviewed
- Wastewater flow records (pumping stations and WPCF)
- Supplemental information provided by the Town WPCD through meetings and other correspondences
- Swifts Beach I/I Study (August 2000)
- Comprehensive Wastewater Management Plan / Single Environmental Impact Report (March 2002)
- Phase 1 - Infiltration and Inflow Report (March 2006)
- Smoke Testing Letter Report (August 2007)
- 2014-2015 OSD Engineering I/I Studies
- Previously completed inflow removal and repairs
- Previously completed sewer rehabilitation
- Mission data – Pumping Station monitoring information
- Precipitation data / Groundwater Levels
- Water consumption data
- SmartCover® Monitoring System
- Manhole inspections / Pipeline CCTV Inspections
- Pumping Station Wetwell Drawdown Testing
- Wareham Capital Improvement Plan
- Flow Metering

Data review, collection procedures, calculation methods and analysis preparation are discussed further in this section.

3.2.1 System Inventory

The Town's wastewater collection system is mapped in electronic format and includes general location and connectivity of manholes, pipes, and pumping stations. System mapping was obtained from the Town for use in this analysis. The Town's collection system mapping is developed within Utility Cloud and was brought into GIS for the purpose of review. The mapping was utilized to delineate the service area for each pumping station. Existing record drawings of the collection system and various pumping stations were reviewed and supplemental information was obtained through discussion with Town WPCD personnel. Information collected during the review process included pipe size and material, age and depth of installation, location of off-road easements and coastal alignments, pumping station construction, and identification and understanding of known areas of concern.

The Town has not developed their storm water collection system mapping to the same extent as the wastewater collection system. Storm water infrastructure is GIS based and limited to catch basin locations.

Maps depicting the existing collection system, including manholes, pipes, pumping stations, and isolated pumping station collection basins have been provided in *Appendix A* of this report for reference.

3.2.2 WPCF Flow Data

Daily wastewater flows are recorded at the Town's wastewater treatment facility from a Parshall flume at the influent to the WPCF and again from a Parshall flume at the effluent to the WPCF. The history of flows is available for review at the WPCF. The plant relies upon equalization basins to manage peak flow conditions. Incoming flow is diverted to the equalization basins during peak flows. Therefore, the effluent flow meter will not see the peak conditions. Influent flow meter data is more representative of maximum flows managed by the facility. Table #3-1 summarizes WPCF influent flow meter data for 2017 and 2018 through March.

Table #3-1:
2017 and 2018 (through March) WPCF Influent Flow Meter Data

Year	Month	Avg. Daily Flow (MGD)	Max. Daily Flow (MGD)
2017	JAN	0.901	0.985
	FEB	0.940	0.980
	MAR	0.852	0.945
	APR	1.031	1.249
	MAY	0.900	0.975
	JUN	0.957	----
	JUL	1.006	1.105
	AUG	0.923	1.063
	SEP	0.863	0.963
	OCT	0.810	1.006
	NOV	0.855	0.978
	DEC	0.825	0.908
2018	JAN	0.937	1.066
	FEB	1.039	1.166
	MAR	**1.389**	**1.850**

The greatest maximum daily (24-hour) influent flow to the Wareham WPCF was recorded in March 2018 as 1.850 MGD, which is approximately 100% higher than the typical average daily (24-hour) flow recorded in previous months in 2017-2018. Also, the average daily (24-hour) flow for the month of March 2018 was 1.389 MGD, which is approximately 50% higher than the typical average daily flow recorded in previous months in 2017-2018.

As can be seen in Table #3-11 in Section 3.2.10 of this report, the months of January through March 2018 have been wetter than average with monthly rainfall totals near or above 6.5-inches. A monthly rainfall total of close to 7.5-inches was recorded for the month of March 2018, compared to a monthly rainfall total of 3.8-inches recorded in March 2017. Additionally, the region experienced rapid snowmelt in the months of January and March 2018 as a direct result of wet-weather events and warmer than average temperatures for this time of year. This information would confirm that the Town's wastewater collection system is being impacted by I/I.

3.2.3 Swifts Beach I/I Study (August 2000)

This 2000 study was referenced in later reports but documentation was not available for review at the time of this analysis.

3.2.4 Comprehensive Wastewater Management Plan / Single Environmental Impact Report (March 2002)

In 2002, CDM assisted the Town with development of a Comprehensive Wastewater Management Plan (CWMP). At the time the CWMP was completed, the Town's collection system consisted of approximately 45 miles of sewer pipe and 29 pumping stations. The Town's wastewater collection system was evaluated as part of the overall Plan. It was determined that the existing collection system, including the pumping stations, was adequate to handle both present and projected future flows in the Town. Following analysis, it was estimated that approximately 203,000 gpd of infiltration was present in the system during winter months. It was also determined that inflow within the collection system appeared to be negligible at the time.

Recommendations included conducting a continuous flow monitoring program followed by flow isolation and pipeline television inspection to identify system deficiencies and reduce infiltration. Recommendations also included development of a routine cleaning and inspection program of the gravity sewer (pipelines and manholes) for identifying existing leaks and deficiencies in the system.

3.2.5 Phase 1 - Infiltration and Inflow Report (March 2006)

The 2006 Phase 1 Infiltration and Inflow Report was completed for the Town of Wareham by CDM in accordance with MassDEP guidance document "*Guidelines for Performing Infiltration/Inflow Analyses and Sewer System Evaluation Survey*, dated January 1993". The study area for this report included the majority of Wareham's sewer collection system and involved the following data collection efforts and analysis:

- Wastewater flow monitoring (March 16, 2005 through June 14, 2005) at 13 strategically selected metering locations
- Rainfall monitoring in two locations within Town
- Groundwater monitoring in four locations within Town (select flow meter locations)
- Tidal I/I analysis

The goal of the Phase 1 effort was to quantify the amount of I/I being conveyed to the Wareham WPCF and to develop recommendations for further studies to identify specific sources of I/I. The results of the investigations and analyses are summarized and presented in the paragraphs to follow. Table #3-2 summarizes the peak rates of I/I (by type) that were calculated for the entire study area during the Phase 1 investigations.

Table #3-2:
Quantity of Infiltration, Inflow and Tidal I/I (2006 Phase 1 Infiltration and Inflow Report)

Peak Infiltration Rate (gpd)	**Standard Storm Peak Inflow Rate (gpd)**	**Standard Dry Weather Tidal I/I Rate (gpd)**
331,500 (0.33 mgd)	5,860,000 (5.86 mgd)	673,000 (0.67 mgd)

Infiltration

All metered subareas that were analyzed exhibited an infiltration rate less than the MassDEP threshold of 4,000 gpd/in-mi (considered "excessive" for a sanitary sewer). Therefore, it was determined that the amount of groundwater entering the sewer system was within acceptable limits and additional studies for identification of infiltration sources were not recommended. Table #3-3 summarizes the peak infiltration rates calculated for the isolated study areas.

Table #3-3:
Peak Infiltration Rates (2006 Phase 1 Infiltration and Inflow Report)

Ranking	**Metering Subarea**	**Gravity Sewer Length (lf)**	**Inch-Mile**	**Peak Infiltration (gpd)**	**Peak Infiltration Rate (gpd/in-mi)**	**Flow Isolation Warranted**
1	4B	12,248	18.8	50,000	2,665	NO
2	11	21,578	34.2	70,000	2,046	NO
3	8	25,176	52.6	80,000	1,520	NO
4	1	13,095	20.6	25,000	1,216	NO
5	4A	9,255	15.2	16,000	1,053	NO
6	9	17,609	28.0	25,000	894	NO
7	12	19,374	30.8	25,000	811	NO
8	3A	12,444	19.1	15,000	784	NO
9	2	20,114	32.2	18,000	559	NO
10	6	15,859	24.7	5,000	203	NO
11	5	9,876	17.1	2,500	146	NO
12	7	23,600	45.0	-	-	-
13	10	23,457	44.3	-	-	-
Totals:		***223,685***		***331,500***		

Inflow

The inflow analysis was conducted using flow gaging data collected during the continuous flow monitoring program. The inflow analysis correlated the gaged peak inflow rates, as defined by the MassDEP guidelines, to the estimated flow for the "standard" 1-year, 6-hour duration storm. A peak inflow rate within the collection system of approximately 5.86 mgd was estimated for the standard 1-year, 6-hour duration storm. Table #3-4 summarizes the standard storm inflow rates calculated for the isolated study areas for the 1-year, 6-hour duration storm.

Table #3-4:
Standard Storm Inflow Rates (2006 Phase 1 Infiltration and Inflow Report)

Ranking	Metering Subarea	Gravity Sewer Length (lf)	Inch-Mile	Standard Storm Peak Inflow Rate (gpd)	Standard Storm Peak Inflow Rate (gpd/in-mi)	Percent of Total Inflow	Cumulative Percent	Gravity Sewer Length Targeted for Additional Investigation (lf)
1	11	21,578	34.2	1,600,000	46,769	27%	27%	21,578
2	7	23,600	45.0	1,180,000	26,231	20%	47%	23,600
3	6	15,859	24.7	402,000	16,301	7%	54%	15,859
4	9	17,609	28.0	450,000	16,094	8%	62%	17,609
5	4B	12,248	18.8	290,000	15,455	5%	67%	12,248
6	8	25,176	52.6	630,000	11,968	11%	78%	25,176
7	2	20,114	32.2	340,000	10,564	6%	84%	20,114
8	4A	9,255	15.2	142,000	9,350	2%	86%	-
9	12	19,374	30.8	249,000	8,076	4%	90%	-
10	10	23,457	44.3	322,000	7,274	5%	95%	-
11	3A	12,444	19.1	98,000	5,124	2%	97%	-
12	5	9,876	17.1	74,000	4,321	1%	99%	-
13	1	13,095	20.6	81,000	3,940	1%	100%	-
Totals:		***223,685***		***5,858,000***				***136,184***

In accordance with MassDEP guidelines, the metered subareas in the study that accounted for 80% of the total system inflow volume were targeted for additional investigations. Metered subareas 2, 4B, 6, 7, 8, 9 & 11 accounted for 84% of the total calculated inflow for the studied collection basins and were specifically recommended for smoke testing to identify direct and indirect inflow connections to the sewer system. It was also recommended that all subareas be studied to locate inflow sources, if feasible. In addition to smoke testing, dye water tracing was also recommended for identification of sources of inflow.

The MassDEP guidance states that subareas shall be prioritized for additional investigation work based on the total inflow per day in gpd when all subarea lengths of pipe are similar in size. However, since Wareham's collection system could not be evenly divided, peak inflow rates were ranked based on gpd/in-mi.

Tidal I/I

Since the vast majority of sewered areas in Wareham are bordered by inlets of Buzzards Bay, all subareas were analyzed for the presence of tidal I/I. Dry weather flow was compared to tidal fluctuations. Peaks in dry weather wastewater flow recorded during typical low-flow timeframes that also correspond with a high tide can indicate the presence of tidal I/I. Table #3-5 summarizes the dry weather tidal I/I rates calculated for the isolated study areas.

Table #3-5:
Standard Dry Weather Tidal I/I Rates (2006 Phase 1 Infiltration and Inflow Report)

Ranking	Metering Subarea	Pipe Length (lf)	Pipe Length (Inch-Mile)	Standard Dry Weather Tidal I/I Rate (gpd)	Standard Dry Weather Tidal I/I Rate (gpd/in-mi)	Percent of Total Tidal I/I	Cumulative Percent
1	8	25,176	52.6	260,000	4,939	39%	39%
2	7	23,600	45.0	99,000	2,201	15%	54%
3	10	23,457	44.3	71,000	1,604	11%	65%
4	11	21,578	34.2	49,000	1,432	7%	72%
5	9	17,609	28.0	36,000	1,287	5%	77%
6	2	20,114	32.2	30,000	932	4%	81%
7	6	15,859	24.7	28,000	1,135	4%	85%
8	12	19,374	30.8	24,000	778	4%	89%
9	3A	12,444	19.1	22,000	1,150	3%	92%
10	4B	12,248	18.8	16,000	853	2%	94%
10	4A	9,255	15.2	16,000	1,053	2%	97%
12	1	13,095	20.6	14,000	681	2%	99%
13	5	9,876	17.1	8,000	467	1%	100%
Totals:		***223,685***		***673,000***			

All thirteen of the metered subareas that were studied exhibited slight to moderate tidal influence. Increases in wastewater flows between the hours of 10:00 pm and 5:00 am were observed during high tides. Additional field studies were recommended to

attempt to locate possible sources of tidal I/I. The following additional investigations were recommended in the Phase 1 Report:

- Smoke testing
- Dye testing
- Manhole inspections with salinity testing

Metered subareas 2, 7, 8, 9, 10 & 11 account for 81% of the total estimated tidal I/I flow for the studied collection basins and were specifically recommended for a future smoke testing program.

Locating Additional Sources of I/I

A few small areas of the sewer collection system could not be studied during the Phase 1 effort. In particular, flow monitoring could not be performed upstream of the Hynes Field Pumping Station as the manholes chosen for flow monitoring were under water during the monitoring period. These areas were recommended to be included in a future smoke testing program and were also recommended for additional studies such as dyed water tracing.

3.2.6 Smoke Testing Letter Report (August 2007 [Dec. 2006 Work])

In December of 2006, under contract with CDM, Flow Assessment Services LLC conducted smoke testing investigations within approximately 160,000 linear feet of Wareham's wastewater collection system in the following metered subareas (associated pumping station[s] collection basin):

- Metering Subarea 2 (South Water Street / Green Street / Woodbury Street / Bay Street)
- Metering Subarea 4B (North Boulevard / East Boulevard)
- Metering Subarea 6 (Salt Works Road)
- Metering Subarea 7 (Dick's Pond / Hill Street / Cohasset Narrows)
- Metering Subarea 8 (Industrial Park I & II / Springbourne / Kennedy Lane / Narrows)
- Metering Subarea 9 (Pinehurst)
- Metering Subarea 10 (Terry Lane [Pine Tree Estates])
- Metering Subarea 11 (Ruggles & Smith)

The subareas listed above were selected by CDM following analysis of flow monitoring data collected during the Phase 1 I/I Study and were recommended for smoke testing investigation within the associated report to identify sources of I/I. The results of the 2006 smoke testing effort have been summarized in Table #3-6 and additional details of the effort can be reviewed in the CDM document titled, "*Smoke Testing Letter Report (Follow Up To: Phase 1 – Infiltration/Inflow (I/I) Report*", dated August 2007.

Table #3-6:
Summary of 2006 Smoke Testing Results

Metering Subarea	Location	Source/Defect Identified	Calculated Drainage Area (ft^2)	Estimated Inflow* (gpd)	Recommended Rehabilitation
11	8 - 12 Grant Street	Four (4) Catch Basins**	12,250	142,317	Disconnect from sewer and redirect discharge
7 & 11	Roby Street parking lot / 3236 Cranberry Highway	Five (5) Constructed Holes in Concrete (Open Pipes)	298	3,462	Plug ends of pipes or other means as necessary (abandon)
2	Mason Street Extension and Barnes Street	Two (2) Roof Leaders	359	4,171	Disconnect from sewer and redirect discharge
4B & 8	Thatcher Lane / North Boulevard / Oceanside Drive	Three (3) Holes in Brush and Vegetated Areas	272	1,053	Plug ends of pipes or other means as necessary (abandon)
11	Barnes Street and Greenwood Avenue	Two (2) Outdoor Shower Drains	48	558	Construct small roof over each shower drainage area
10	Harkins Way Easement and Cromesett Road	Two (2) Cracked Cleanout Covers	19	74	Replace cleanout covers
2, 4B & 11	Mason Street / Florence Street / Crescent Place	Three (3) Miscellaneous Sources (Undetermined)	Unknown	Unknown	Further Investigation Required
			Total:	***151,634***	

*Inflow calculated by CDM using the rational method with a storm of 0.87 in/hr
**Source previously identified in the August 2000 Swifts Beach I/I Study (CDM)

3.2.7 2014-2015 OSD Engineering I/I Studies

In 2014 and 2015, OSD Engineering Consultants (OSD) contracted with the Town to conduct I/I analysis in seven wastewater pumping station collection basins. In 2014, the Swifts Beach area was analyzed, which includes the collection basins for the Smith and Ruggles Pumping Stations. In 2015, OSD analyzed the collection basins for the Pinehurst, South Water Street, East Boulevard, North Boulevard and Hynes Field Pumping Stations.

OSD's analysis of each collection basin consisted of combining estimated sanitary flows (using water billing data [assuming 70% consumption] and record plan analysis) along with an 'excessive infiltration rate' (equal to the 4,000 gpd/idm standard threshold) and plotting the values against actual pumping station operational data provided by the Town (pump capacities, pump run-time logs, etc.). Comparing this information, a study area was considered to be influenced by 'excessive flows' if the pumped flow exceeded the estimated excessive flow limit at any given time over the study period.

The OSD studies concluded that at least five of the seven collection basins periodically exhibited peak flow rates that exceeded the excessive flow marks established within the respective basins for comparison purposes. Table #3-7 summarizes the results of OSD's analyses and incorporates the CDM subareas identified in the Phase 1 I/I Study.

Table #3-7:
Summary Results of OSD I/I Studies

Pumping Station Collection Basin	**Subarea # (CDM 2006 Phase 1 I/I Study)**	**Gravity Sewer Length (lf)**	**Excessive Wet-Weather Flows**
Smith	11 & 12	41,300	No
Ruggles	11	7,600	Yes
Pinehurst	9	12,000	Yes
South Water Street	1 & 2	17,600	Yes
East Boulevard*	4B	4,700	Unknown*
North Boulevard	4B	7,500	Yes
Hynes Field	3A & 4A	24,400	Yes

*Area could not be fully analyzed due to lack of pumping station operational data

Study results, including OSD's recommendations, are described in more detail below for each individual location.

3.2.7.1 Swifts Beach (Smith & Ruggles)

This 2014 study was referenced in later reports but documentation was not available for review at the time of this analysis.

3.2.7.2 Pinehurst

The study examined flows within the Pinehurst Pumping Station collection basin during the years of 2011 through 2015. On numerous occasions during the analysis period, measured flow from the Pinehurst Pumping Station exceeded the total flow considered excessive for the collection area. OSD concluded that the recorded exceedances appeared to indicate that the system is influenced by large precipitation events and spring tides. A groundwater analysis of the collection basin was inconclusive. As a result, recommendations were made for additional data collection and analysis to be conducted as follows:

OSD Recommendations:

- Inspect all sewer manholes in collection basin
- Smoke testing
- Private Property inspections
- Salinity testing
- Flow monitoring
- Flow isolation followed by prioritized CCTV inspection

3.2.7.3 South Water Street

The study examined flows within the South Water Street Pumping Station collection basin during the year 2012. On multiple occasions during the analysis period, measured flow from the South Water Street Pumping Station exceeded the total flow considered excessive for the collection area. OSD concluded that the recorded exceedances appeared to indicate that the system is influenced by large precipitation events and spring tides. A groundwater analysis of the collection basin was inconclusive. As a result, recommendations were made for additional data collection and analysis to be conducted as follows:

OSD Recommendations:

- Conduct flow tests at the Green Street, Bay Street, and Woodbury Street compressor-ejector Pumping Stations to determine pump station flow capacities.
- Investigate the Onset Heights Pumping Station collection area. On two occasions during the study period, flows from the upstream Onset Heights Pumping Station exceeded pumped flow recorded from the downstream South Water Street Pumping Station. It should be determined if surcharging

occurs downstream on these occasions or if the data from the Town's Mission SCADA system is inaccurate.

- Re-evaluate the South Water Street Pumping Station collection area and upstream basins once the above recommendations have been completed to identify priority locations for further I/I assessment.

3.2.7.4 East Boulevard

The study examined flows within the East Boulevard Pumping Station collection basin during the years of 2011 through 2015. The capacity of the East Boulevard Pumping Station could not be determined. A flow test at the station is required to determine the pumping capacity. The station relies on air compressors to pump flow. Run-time data for the compressors are recorded but flow information is not available. OSD observed a correlation between groundwater levels and compressor run-times in this location. Increased groundwater levels at a local monitoring well appeared to result in increased run-times of the pump station. On several occasions, station run-times were also increased immediately following a large precipitation event. A tidal analysis of the collection basin was inconclusive. Absent pump station capacity information, excessive I/I could not be estimated for the collection basin.

OSD Recommendations:

- Conduct a flow test at the East Boulevard compressor-ejector Pumping Station to determine pump station flow capacities.
- If the flow tests indicate that excessive I/I is present in the collection basin, the following is recommended:
    - Inspect all sewer manholes in collection basin
    - Smoke testing
    - CCTV inspection
    - Private Property inspections

3.2.7.5 North Boulevard

The study examined flows within the North Boulevard Pumping Station collection basin during the year 2012. During the 2012 analysis period, the flow considered excessive for this collection area was exceeded on three consecutive days immediately following a precipitation event which produced more than 3 inches of rainfall. No other exceedances were observed in 2012. The analysis did not reveal a correlation between spring tides and excessive flows but did show a slight influence from high groundwater conditions. Recommendations were made for additional data collection and analysis to be conducted as follows:

OSD Recommendations:

- Conduct a flow test at the East Boulevard compressor-ejector Pumping Station to determine pump station flow capacities.
- The following investigative work is recommended:
  - Extensive sewer manhole inspections
  - Flow isolation
  - Smoke testing
  - CCTV inspection

3.2.7.6 Hynes Field

The study examined flows within the Hynes Field Pumping Station collection basin during the year 2012. The Hynes Field Pumping Station receives pumped flow from three pumping stations – North Boulevard PS, Onset Pier PS and South Boulevard PS. Flow balancing was performed to determine the isolated flow within the Hynes Field collection basin. However, flow from the South Boulevard Pumping Station was estimated since the actual capacity of the pump station could not be determined. A flow test at the station is required to determine pumping capacity. The station relies on air compressors to pump flow. Run-time data for the compressors are recorded but flow information is not available.

Over half of the 2012 year, particularly between January and July, measured flow from the Hynes Field Pumping Station exceeded the total flow considered excessive for the collection area. Flows decreased significantly in the second half of the year. OSD concluded that the recorded exceedances appeared to indicate that the system is influenced by large precipitation events and spring tides. The analysis also showed a possible influence from high groundwater conditions. Recommendations were made for additional data collection and analysis to be conducted as follows:

OSD Recommendations:

- Conduct a flow test at the South Boulevard compressor-ejector Pumping Station to determine pump station flow capacities.
- The following investigative work is recommended:
  - Extensive sewer manhole inspections
  - Flow isolation
  - Smoke Testing
  - CCTV inspection

3.2.8 Completed Source Removal, Rehabilitation, and Repairs

This section includes a summary of work previously completed by the Town related to the removal of I/I from the wastewater collection system.

3.2.8.1 Inflow Removal and Repairs

The defects identified during the smoke testing effort conducted in 2006 and later presented in the CDM document titled, "*Smoke Testing Letter Report (Follow Up To: Phase 1 – Infiltration/Inflow (I/I) Report*", dated August 2007, were previously summarized in Table #3-6 in Section 3.2.6 of this report. The defects have reportedly been corrected since they were discovered and reported in 2007. This includes redirection of the four (4) catch basins that were found to be connected to the sewer on Grant Street.

The redirection of the identified sources of I/I and repair of observed system defects reportedly removed approximately 150,000 gpd of peak extraneous flow, as calculated using the standard storm (1-year, 6-hour duration) peak intensity of 0.87 in/hr.

3.2.8.2 Sewer Rehabilitation

The Town previously completed sewer rehabilitation through trenchless methods such as installation of cured-in-place pipe liners and epoxy coating of manholes. Additional detail of trenchless sewer rehabilitation that the Town has completed to date is provided below.

Swifts Beach

The following sewer rehabilitation was completed in 2016 by Warren Environmental under contract with the Town:

- Approx. 1,600 linear feet of 8-inch diameter cured-in-place pipe liner along Bayview Street and Wankinquoah Ave
- Epoxy coating of nine (9) manhole shelves/inverts including the first vertical foot of the manhole walls (upstream and downstream of pipe liner installation)

Viking Drive Easement (Adjacent to High School)

The following sewer rehabilitation was completed in December 2016 by Warren Environmental under contract with the Town:

- 315 linear feet of 21-inch diameter cured-in-place pipe liner
- Epoxy coating of two (2) manhole shelves/inverts including the first vertical foot of the manhole walls (upstream and downstream of pipe liner installation)

3.2.9 Mission Data – Pumping Station Monitoring Information

As previously discussed in Section 1 of this report, an alternative approach to evaluation of flow data was presented to and approved by MassDEP. This alternative approach includes the review and analysis of the Town's wastewater pumping station run-time data to identify areas that are subject to I/I influence in lieu of the continuous flow metering methodology that is outlined in the MassDEP Guidance document for performing an I/I analysis.

As previously stated, the Town of Wareham's pumping stations operations are continuously tracked by the Mission monitoring and data management system. The Mission system provides the Town with a secure website for reviewing real-time operating conditions and storing data for the remote pumping station sites. Data includes general station information such as name, location, and pump capacity as well as operating data such as wet well level, pump status and daily pump run-times. Pump run-time data is stored for as long as the service has been maintained.

Individual pumping stations are not equipped with flow meters but total daily flow volumes can be determined by comparing pump run-times and associated pump capacities. One of the focuses in this data review was to look for evidence of extended run-times during wet-weather events and high groundwater conditions. Extended run-times would be an indication of I/I impacts to the collection system. The remote pumping stations on the perimeter of the collection system are ideal for making this correlation because their influence is limited to their tributary collection system. Comparing the pump run-time data for different time periods and identifying trends provides the information required to determine when the stations manage additional flow. The service areas for those pumping stations that require pump operation for longer periods of time during periods of wet-weather and high groundwater were targeted for additional investigations. The pumping station run-time data analysis figures have been included within *Appendix C* of this report.

3.2.10 Precipitation Data / Groundwater Levels

Precipitation data collected for use in the Phase 2 infiltration and inflow analysis was obtained from U.S. Climate Data (www.usclimatedata.com) for the Town of Wareham (2015 & 2016 data) and from a rain gauge that is installed at the Pinehurst Pumping Station, which is monitored by the SmartCover® Monitoring System (2017 & 2018 data). Precipitation data obtained from Weather Underground (www.wunderground.com) was also used for verifying accuracy of the previously mentioned data sources, providing supplemental rainfall information for missing 2016 U.S. Climate Data, and for comparison of historical storm events for use in the sewer system overflow risk assessment described in Section 4.3 of this report.

Following evaluation of the historical precipitation data for the area, it was determined that data collected during the 2015 calendar year, specifically the months of March and April, would be useful for the initial analysis based on the amount of precipitation (both rainfall and snowfall) that was recorded leading up to and during that timeframe.

The 2016 calendar year was considered dry overall, and while rainfall was recorded during the springtime months, appreciable impacts related to infiltration and inflow on the Town's wastewater collection system are potentially limited as a result. However, 2016 springtime (March - April) precipitation data was used for comparison purposes.

In spring of 2017, the area experienced moderate rainfall with an approximate 3.5-inch rain event (2-year return frequency, 24-hour duration event) specifically occurring between March 31st and April 1st.

Additional rainfall data recorded during two 24-hour storm events on January 12th and 13th, 2018 and on March 2, 2018 were also used in the analysis. The January 12-13th storm produced approximately 2.60 inches of rainfall (1-year return frequency, 24-hour duration event) and the March 2nd storm produced approximately 3.30 inches of rainfall (2-year return frequency, 24-hour duration event). Also, approximately 1-foot of snow depth was on the ground prior to the January 12-13th event with the majority of the snow cover melting during and as a direct result of the storm due to warm temperatures and heavy rainfall.

Groundwater level information was not measured for the Phase 2 effort. However, analysis of wastewater flows and associated pumping station operation was conducted during timeframes in which the groundwater table was believed to be elevated due to the locally-recorded moderate precipitation and significant snowmelt. The combination of moderate precipitation and snowmelt provide ideal conditions for conducting analysis in search of potential impacts of infiltration and inflow on the wastewater collection system.

Local precipitation data (including daily snow depth groundcover where available) recorded for March and April of 2015, 2016 and 2017 and January through March 2018 has been summarized in Table #3-8, Table #3-9, Table #3-10 & Table #3-11, respectively.

Table #3-8:
2015 Wareham, MA Precipitation Data (March – April)
Source: U.S. Climate Data (www.usclimatedata.com)

Day	Precip. (in.)	Snowfall (in.)	Snow Depth (in.)	Day	Precip. (in.)	Snowfall (in.)	Snow Depth (in.)
3/1/2015	0	0	20.98	4/1/2015	0	0	0
3/2/2015	0.48	4.80	25.98	4/2/2015	0	0	0
3/3/2015	0	0	24.02	4/3/2015	0.05	0	0
3/4/2015	0.56	1.42	24.02	4/4/2015	0.30	0	0
3/5/2015	0.41	1.50	22.99	4/5/2015	0	0	0
3/6/2015	0.33	7.99	29.02	4/6/2015	0.15	0	0
3/7/2015	0	0	27.01	4/7/2015	0	0	0
3/8/2015	0	0	25.00	4/8/2015	0.32	0	0
3/9/2015	0	0	22.99	4/9/2015	0.25	0	0
3/10/2015	0	0	17.99	4/10/2015	0.06	0	0
3/11/2015	0.39	0	15.98	4/11/2015	0.05	0	0
3/12/2015	0	0	14.02	4/12/2015	0	0	0
3/13/2015	0	0	12.99	4/13/2015	0	0	0
3/14/2015	0.02	0	12.01	4/14/2015	0	0	0
3/15/2015	1.17	0	9.02	4/15/2015	0	0	0
3/16/2015	0.18	2.52	12.01	4/16/2015	0	0	0
3/17/2015	0.10	0	10.98	4/17/2015	0.09	0	0
3/18/2015	0.08	0	7.99	4/18/2015	0.14	0	0
3/19/2015	0	0	7.99	4/19/2015	0	0	0
3/20/2015	0	0	7.99	4/20/2015	0	0	0
3/21/2015	0.17	1.81	10.00	4/21/2015	0.33	0	0
3/22/2015	0.03	0	9.02	4/22/2015	0	0	0
3/23/2015	0	0	7.99	4/23/2015	0	0	0
3/24/2015	0	0	7.99	4/24/2015	0	0	0
3/25/2015	0	0	5.98	4/25/2015	0	0	0
3/26/2015	0.07	0	4.02	4/26/2015	0	0	0
3/27/2015	1.57	0	0.98	4/27/2015	0	0	0
3/28/2015	0.10	0	0.98	4/28/2015	0.05	0	0
3/29/2015	0.25	0.31	0	4/29/2015	0	0	0
3/30/2015	0	0	0	4/30/2015	0	0	0
3/31/2015	0	0	0				
TOTALS	**5.91**	**20.35**		**TOTALS**	**1.79**	**0**	

Table #3-9:
2016 Wareham, MA Precipitation Data (March – April)
Source: U.S. Climate Data (www.usclimatedata.com)

Day	Precip. (in.)	Snowfall (in.)	Snow Depth (in.)	Day	Precip. (in.)	Snowfall (in.)	Snow Depth (in.)
3/1/2016	0	0	0	4/1/2016*	0.14	-	-
3/2/2016	0.07	0	0	4/2/2016*	0.64	-	-
3/3/2016	0.10	0	0	4/3/2016*	0.37	-	-
3/4/2016	0	0	0	4/4/2016	0	2.01	-
3/5/2016	0.19	0.98	-	4/5/2016	0.58	5.79	5.98
3/6/2016	0	0	0	4/6/2016	0	0	2.99
3/7/2016	0	0	0	4/7/2016	0	0	0
3/8/2016	0	0	0	4/8/2016	1.09	0	0
3/9/2016	0	0	0	4/9/2016	0	0	0
3/10/2016	0	0	0	4/10/2016	0	0	0
3/11/2016	0.16	0	0	4/11/2016	0	0	0
3/12/2016	0	0	0	4/12/2016	0	0	0
3/13/2016	0	0	0	4/13/2016	0.51	0	0
3/14/2016	0	0	0	4/14/2016	0	0	0
3/15/2016	1.16	0	0	4/15/2016	0	0	0
3/16/2016	0.27	0	0	4/16/2016	0	0	0
3/17/2016	0.05	0	0	4/17/2016	0	0	0
3/18/2016	0.02	0	0	4/18/2016	0	0	0
3/19/2016	0	0	0	4/19/2016	0.04	0	0
3/20/2016	0	0	0	4/20/2016	0	0	0
3/21/2016	0.25	2.72	-	4/21/2016	0	0	0
3/22/2016	0.05	0.31	-	4/22/2016	0	0	0
3/23/2016	0	0	0	4/23/2016	0.22	0	0
3/24/2016	0	0	0	4/24/2016	0	0	0
3/25/2016	0	0	0	4/25/2016	0	0	0
3/26/2016	0.31	0	0	4/26/2016	0	0	0
3/27/2016	0	0	0	4/27/2016	0.26	0	0
3/28/2016	0.02	0	0	4/28/2016	0	0	0
3/29/2016	0.46	0	0	4/29/2016	0	0	0
3/30/2016	0	0	0	4/30/2016	0	0	0
3/31/2016	0	0	0				
TOTALS	**3.11**	**4.01**		**TOTALS**	**3.85**	**7.80**	

*Precipitation data obtained from Weather Underground to supplement missing data

Table #3-10:
2017 Wareham, MA Precipitation Data (March – April)
Source: Rain Gauge Located at Pinehurst PS – (SmartCover® Monitoring System)

Day	Precip. (in.)	Day	Precip. (in.)
3/1/2017	0.17	4/1/2017	2.37
3/2/2017	0	4/2/2017	0
3/3/2017	0	4/3/2017	0
3/4/2017	0	4/4/2017	1.20
3/5/2017	0	4/5/2017	0
3/6/2017	0	4/6/2017	1.13
3/7/2017	0.04	4/7/2017	0.01
3/8/2017	0.10	4/8/2017	0
3/9/2017	0	4/9/2017	0
3/10/2017	0.30	4/10/2017	0
3/11/2017	0	4/11/2017	0
3/12/2017	0	4/12/2017	0
3/13/2017	0	4/13/2017	0
3/14/2017	1.47	4/14/2017	0
3/15/2017	0	4/15/2017	0.03
3/16/2017	0	4/16/2017	0.02
3/17/2017	0	4/17/2017	0
3/18/2017	0	4/18/2017	0
3/19/2017	0	4/19/2017	0.06
3/20/2017	0	4/20/2017	0.08
3/21/2017	0	4/21/2017	0.37
3/22/2017	0	4/22/2017	0.05
3/23/2017	0	4/23/2017	0
3/24/2017	0.02	4/24/2017	0
3/25/2017	0.01	4/25/2017	1.10
3/26/2017	0	4/26/2017	0.12
3/27/2017	0.25	4/27/2017	0.02
3/28/2017	0.53	4/28/2017	0.02
3/29/2017	0.18	4/29/2017	0
3/30/2017	0	4/30/2017	0
3/31/2017	0.73		
TOTALS	**3.80**	**TOTALS**	**6.58**

Table #3-11:
2018 Wareham, MA Precipitation Data (January – March)
Source: Rain Gauge Located at Pinehurst PS – (SmartCover® Monitoring System)

Day	Precip. (in.)	Day	Precip. (in.)	Day	Precip. (in.)
1/1/2018	0	2/1/2018	0	3/1/2018	0.03
1/2/2018	0	2/2/2018	0.28	3/2/2018	3.14
1/3/2018	0	2/3/2018	0	3/3/2018	0.08
1/4/2018	1.88	2/4/2018	1.01	3/4/2018	0.07
1/5/2018	0	2/5/2018	0.06	3/5/2018	0.15
1/6/2018	0	2/6/2018	0	3/6/2018	0
1/7/2018	0	2/7/2018	0.75	3/7/2018	1.59
1/8/2018	0.02	2/8/2018	0	3/8/2018	0.30
1/9/2018	0	2/9/2018	0	3/9/2018	0
1/10/2018	0	2/10/2018	0.40	3/10/2018	0
1/11/2018	0	2/11/2018	1.31	3/11/2018	0
1/12/2018	1.56	2/12/2018	0.02	3/12/2018	0.02
1/13/2018	1.01	2/13/2018	0	3/13/2018	1.24
1/14/2018	0	2/14/2018	0.01	3/14/2018	0
1/15/2018	0.04	2/15/2018	0.15	3/15/2018	0
1/16/2018	0	2/16/2018	0.33	3/16/2018	0
1/17/2018	0.36	2/17/2018	0.36	3/17/2018	0
1/18/2018	0	2/18/2018	0.42	3/18/2018	0
1/19/2018	0	2/19/2018	0.04	3/19/2018	0
1/20/2018	0	2/20/2018	0	3/20/2018	0
1/21/2018	0	2/21/2018	0	3/21/2018	0.34
1/22/2018	0.04	2/22/2018	0.05	3/22/2018	0.26
1/23/2018	1.42	2/23/2018	0.17	3/23/2018	0
1/24/2018	0	2/24/2018	0.16	3/24/2018	0
1/25/2018	0	2/25/2018	0.82	3/25/2018	0.11
1/26/2018	0	2/26/2018	0	3/26/2018	0
1/27/2018	0	2/27/2018	0	3/27/2018	0
1/28/2018	0.16	2/28/2018	0	3/28/2018	0
1/29/2018	0.01			3/29/2018	0
1/30/2018	0.29			3/30/2018	0.06
1/31/2018	0			3/31/2018	0
TOTALS	**6.79**	**TOTALS**	**6.34**	**TOTALS**	**7.39**

3.2.11 Water Consumption Data

The Wareham WPCD requested and obtained historical potable water consumption information for the Town from Northern Data Systems for planned use in this analysis. The Town's water consumption data is collected and recorded on a semi-annual basis.

A portion of the Town's wastewater collection system is located in the Onset Bay area, which is under jurisdiction of its own potable water district, separate from that of Wareham's water district. Water consumption information from the Onset water district was not readily available at the time of this effort. In lieu of having actual consumption data, reasonable water consumption estimates could be generated based on population density for these areas.

For the purpose of this analysis, it was planned that a portion or all of the recorded and estimated water consumption data would be attributed to sanitary sewer base flow. However, the data could not be used for comparison of flows for the following key reasons, proving difficult to pinpoint actual water consumption, and consequently baseline sanitary sewer flow for a specific monitoring period:

- Large seasonal fluctuations in population are typical in Wareham
- Water consumption data is collected infrequently (semi-annually vs. monthly, etc.)

3.2.12 SmartCover® Monitoring System

The Town purchased four (4) SmartCovers® and installed the equipment in select manhole locations in the wastewater collection system. The SmartCover® device is a self-contained, wireless level monitoring system with instant alarming and historical data logging capabilities. The device is designed to be mounted to the underside of a manhole cover and utilizing an ultrasonic sensor, measures the water depth within the manhole as referenced from the manhole's invert elevation. The device is supported by a software package that provides remote real-time access and monitoring of device activity and the water level within the manhole. Trends can also be viewed in chart form through customizable views controlled by the user. Alarm set-points can be established and alarm notification can be customized in order to alert the user of surcharging conditions at the specific manhole location.

The SmartCovers® are installed in the following locations:

- Cottage Street / Pinehurst Drive *[Pinehurst PS collection basin]*
- Bayview Street / Wankinquoah Avenue *[Ruggles PS collection basin]*
- Point Independence Yacht Club *[South Water PS collection basin]*
- Point Road / Pilgrim Ave *[Smith PS collection basin]*

A rain gauge was also purchased as part of the SmartCover® package and is installed at the Pinehurst Pumping Station. Rainfall data collected by this device is also managed by and can be remotely viewed via the SmartCover® software package. Data collected by this rain gauge was reviewed for comparison purposes but was not used for the analysis.

It was initially thought that review of the data collected and stored by the SmartCover® devices could be used for further evaluation and verification of I/I influence within the respective pumping station collection basin. Unfortunately, a comparison of the data collected provided inconclusive results, and therefore could not be used for the analysis.

The general location of the SmartCover® devices at the time of this study have been depicted on a map included within *Appendix A* of this report.

3.3 Mission Data Reliability Evaluation

As previously stated in Section 1 of this report, through recommendation from MassDEP and as stipulation for the agency's approval of the alternative approach to the Phase 2 I/I investigation and analysis described earlier, levels of QA/QC were to be conducted at select pumping stations to validate the Town's Mission data accuracy. This quality control process is described in more detail below.

3.3.1 Methodology

In accordance with MassDEP direction, BETA, with assistance from Town WPCD personnel, conducted wet well drawdown testing of select pumping station discharges to validate station operation data collected within the Mission monitoring and data management system, specifically for the purpose of pump capacity verification. This pumping station testing effort was also essential for the accurate calculation of flow pumped from each location, which was then used for the basis of comparison of flows under dry weather conditions to flows under wet-weather conditions.

The wet well drawdown process involves the measurement of time required for a specific pump to "drawdown" or pump a known volume of liquid from the respective pump station wet well. The instantaneous rate (at the time of the drawdown test) at which the influent wastewater flow is entering the station's wet well is also measured and factored into the calculation. The resultant calculation then provides an accurate flow rate that can be attributed to the pump's pumping capacity under the given system conditions. The calculated pumping flow rate is considered the pump's "actual" capacity and may not necessarily match the pump's reported rated capacity. Since the individual pumping stations are not equipped with flow meters, the drawdown test provides the optimal estimation of pump capacity for use in the analysis.

An alternative method of verifying pump capacities through use of continuous flow monitoring of pump station force main discharges was also considered. However,

several aspects associated with this approach were considered impediments to its success and as a result, flow monitoring of the station force main discharges was not pursued as a primary means of determining pump capacity. As described below, limited flow metering of pumping station force main discharges was strictly used as a quality control measure to verify some wet well drawdown results.

Continuous flow monitoring involves selection of scheduled sampling intervals (measure flow every 5 minutes, 10 minutes, etc.) for when the metering equipment will record instantaneous flow information. Operation of a pumping station is typically intermittent, whereas a pump is not operating continuously but is turning on and off dependent on the rate at which influent wastewater flow is entering the station's wet well and the set point elevations of the pumps' on/off operation levels. The notion of the flow metering device recording an instantaneous flow measurement at a preset recurring time interval may or may not result in the successful capture of peak pumping flow rates (necessary for I/I flow analysis) from an upstream pumping station discharge. Furthermore, and dependent upon the meter installation location downstream of the force main, there is a potential to record "zero" flows when the pumping station is not operating. These conditions can create a level of uncertainty in the recorded flow data, thus reducing the data's reliability.

The wet well drawdown testing procedure that was conducted at select pumping stations provided a higher data confidence level than that of the continuous flow monitoring approach discussed above. The drawdown testing process is described in more detail in the following subsections.

3.3.2 Equipment

The equipment used during the pumping station wet well drawdown testing included a water level indicator, a stopwatch, and a tape measure. The battery-powered water level indicator (*Solinst Water Level Meter – Model 101*) contains a probe on the end of graduated vinyl tape for reference measurement of liquid surface depth from above. The probe sensitivity is adjustable and contains an audible alarm to indicate the probe's contact with the liquid surface being measured. Once a reference point is established by the user, the probe is slowly lowered into the pumping station wet well until contact with the water surface is indicated by the audible notification on the unit. Measurement of the distance (depth) from the established reference point to the water surface elevation at instantaneous timed intervals is then recorded for each test. Flow rates for each time interval are calculated and then averaged over the testing period per individual pump.

The stopwatch was used for measuring the time duration of filling a known volume (influent flow) and similarly for drawdown of a known volume (pumped flow) within the wet well. The tape measure was used to verify wet well dimensions to facilitate accurate calculation of flow rates and capacities.

Wareham WPCD personnel provided assistance with the drawdown testing through access to the pumping stations and manual operation of the pumps during the tests. The pumps were operated by the Town for this testing effort in order to acquire pumping capacity data.

3.3.3 Data Analysis / Pump Capacity Determination

The results of the pumping station wet well drawdown testing were reviewed and compared to the related pump capacity information listed in the Town's Mission data monitoring system. Also, a recently completed pumping station evaluation performed by GHD, an engineering consultant, provided pump information within a comprehensive capital improvement plan (CIP) which was reviewed for comparison purposes. Manufacturer's pump performance curves were also included within the CIP for some of the pump stations and were reviewed if pump capacity was not provided on the site inspection form within the CIP. Table #3-11 below summarizes the pump capacity information from the multiple sources.

3.3.4 Quality Control

In accordance with MassDEP's request, BETA, with assistance from Flow Assessment Services and Town WPCD personnel, conducted limited flow metering to verify the accuracy of the methodology utilizing Mission data and pumping station capacity to determine flow information.

Flow meters were installed downstream of the force main discharge for Smith, Pinehurst, Onset Pier, and North Boulevard pumping stations in late January 2018. The four meters were initially left in place for two weeks. Readings were taken every minute to account for low flow conditions and short pump run times. This approach was successful and flow volumes were confirmed for the Smith and Pinehurst pumping stations. Meters installed at the Onset Pier and North Boulevard pumping stations collected inconsistent data so it was decided to relocate the meters. The original Onset Pier meter was relocated just upstream to the influent manhole to South Water pumping station where the flow conditions were more favorable. Similarly, the North Boulevard meter was removed and two meters were installed in two influent manholes to the station. The results from theses relocations were consistent with flows measured in the Town's Mission data monitoring system.

Table #3-11:
Pump Capacity Information Summary

Pumping Station Name	Pump Nameplate Capacity (gpm)	Calculated Drawdown Capacity (gpm)		Mission System Listed Capacity (User Input) (gpm)		GHD CIP Report Design Capacity (gpm)	
		Pump 1	Pump 2	Pump 1	Pump 2	Pump 1	Pump 2
Apple Street	----	128	-	128	128	128	128
Arnold Street	----	N/A	N/A	330	330	333	333
Briarwood	----	-	246 223	270	270	355	355
Cromesett	----	110 110	109	324	324	123	123
French-Canedy	----	N/A	N/A	270	270	398	398
Hathaway	----	450	467	418	446	-	-
Leonard	----	62	29	329	329	326	361
Mattapoisett	----	229	-	-	-	160	160
North Boulevard	----	672 655	684	439	528	-	-
Onset Pier	Pump 1: 1,200 Pump 2: 1,350	1,012	1,099	960	1,147	-	-
Peter Cooper Drive	----	N/A	N/A	6	17	42	42
Pinehurst	300	321	371	353	304	-	-
Ruggles	----	227	234	147	132	300	300
Salt Works Road	----	241	246	143	221	-	-
Smith	1,200	1,240	1,290	767	790	1,200	1,200
South Water Street	1,000	1,058	1,060	568	423	1,000	1,000
Terry Lane [Pine Tree Estates]	----	223 232	220	96	94	169	169
13th Ave	----	N/A	N/A	60	108	-	-

N/A – Not Applicable / Drawdown not performed

For the purpose of the I/I analysis, the pump capacities were determined by averaging the values of each pump's flow rate calculated during the pumping station drawdown testing. At pumping stations where drawdowns were not performed, pump capacities were carefully selected based on the available Town records.

Table #3-12 contains the average pump capacities for each pumping station that were selected for the analysis.

Table #3-12:
Pump Capacities Selected for Analysis

Pumping Station Name	**Pump Capacity Selected* (gpm)**
Apple Street	130
Arnold Street	270
Briarwood	235
Cromesett	110
French-Canedy	140
Hathaway	460
Leonard	Pump 1: 60 / Pump 2: 30
Mattapoisett	230
North Boulevard	670
Onset Pier	Pump 1: 1,000 / Pump 2: 1,100
Peter Cooper Drive	40
Pinehurst	345
Ruggles	230
Salt Works Road	245
Smith	1,265
South Water Street	1,060
Terry Lane [Pine Tree Estates]	225
13th Ave	Pump 1: 60 / Pump 2: 110

*Pump capacity rounded to the nearest 5 gpm

The inflow/infiltration analysis is described in detail within Section 4 of this report.

3.4 Manhole Inspections / Pipeline CCTV Inspections

Manhole Inspections

Since 2015, the Town WPCD, with additional assistance from Watershed Maintenance Corporation in 2017, has completed **266** limited sewer manhole inspections within the collection system (approximately **14%** of the total sewer manholes in the collection system). The intent of the limited inspection is to obtain an overall perspective of the condition of the system. The manhole inspections were conducted in accordance with the National Association of Sewer Service Companies' (NASSCO) Manhole Assessment and Certification Program (MACP).

BETA reviewed and organized the associated information collected during the inspections and created a summary table which includes the specific findings. The summary table has been included in *Appendix E* of this report for reference. Table #3-13 further summarizes the Town's manhole inspection efforts within each respective pumping station collection basin and also identifies whether or not active sources or indications of previous infiltration were identified during the inspection process.

Table #3-13:
Summary of Sewer Manhole Inspections Completed since 2015

Sewershed #	Pumping Station Collection Basin	Total Number of Sewer Manholes in Basin	Number of Sewer Manholes Inspected	% of Manholes Inspected in Basin	Infiltration Identified
14	Arnold Street	48	5	10%	No
34	Bay Street	49	1	2%	Yes
13	Briarwood	57	3	5%	No
30	Cohasset Narrows	116	35	30%	Yes
19 & 20	Cromesett	28	2	7%	No
26	Dick's Pond	41	4	10%	No
37	East Boulevard	35	7	20%	No
18	Hathaway	74	5	7%	No
39 & 41	Hynes Field	136	36	27%	No
8	Indian Neck	40	1	3%	No
24	Kennedy Lane	110	12	11%	Yes
16	Leonard	20	4	20%	Yes
22	Narrows	71	19	27%	No
40	North Boulevard	39	13	33%	Yes
36	Onset Pier	30	2	7%	No
7	Parkwood Beach	104	7	7%	No
23	Pinehurst	79	1	1%	No
10	Ruggles	41	15	37%	Yes
28	Salt Works Road	65	21	32%	Yes
11	Smith	207	41	20%	Yes
38	South Boulevard	14	8	57%	No
32	South Water Street	113	7	6%	Yes
21	Terry Lane	82	17	21%	No
		Total:	266		

Pipeline CCTV Inspections

Since 2015, the Town WPCD, with additional assistance from Watershed Maintenance Corporation in 2017, has completed approximately **26,000** linear feet of sewer pipeline CCTV inspections of sewer main within the collection system (approximately **8%** of the total length of gravity sewer pipe in the collection system). The pipeline inspections were conducted in accordance with NASSCO PACP.

BETA reviewed and organized the associated information collected during the inspections and created a summary table which includes the specific findings. The detailed summary table has been included in *Appendix D* of this report for reference. Table #3-14 further summarizes the Town's sewer pipeline CCTV inspection efforts within each respective pumping station collection basin and also identifies whether or not active sources or indications of previous infiltration were identified during the inspection process.

Table #3-14:
Summary of Sewer Pipeline CCTV Inspections Completed since 2015

Sewershed #	**Pumping Station Collection Basin**	**Total Linear Footage of Gravity Sewer Pipe in Basin**	**Linear Footage of Gravity Sewer Pipe Inspected**	**% of Pipeline Inspected in Basin**	**Infiltration Identified**
13	Briarwood	11,351	292	3%	Yes
37	East Boulevard	4,776	232	5%	Yes
24	Kennedy Lane	23,563	6,549	27%	Yes
22	Narrows	14,900	2,456	17%	Yes
40	North Boulevard	7,488	1,109	15%	Yes
23	Pinehurst	12,003	3,739	31%	Yes
10	Ruggles	7,541	5,325	71%	Yes
11	Smith	33,672	4,302	13%	Yes
32	South Water Street	17,520	590	3%	Yes
21	Terry Lane	15,432	1,289	8%	Yes
		Total:	25,883		

During the Town's 2017 pipeline CCTV inspection efforts, an immediate area of concern was identified on High Street which is located within the Narrows Pumping Station collection basin. The 21-inch diameter reinforced concrete gravity interceptor pipe was found to be in a severely deteriorated condition with the pipe's steel reinforcement exposed within the pipe interior, likely caused by the presence of hydrogen sulfide gas within the pipe network. The discovery of this condition prompted additional CCTV inspection of the remainder of the approximately 2,500 linear foot 21-inch RCP interceptor, which runs along High Street, Sawyer Street, Main Street and Merchants Way before discharging to the Narrows Pumping Station. Similar deteriorating conditions of varying severity were observed throughout the interceptor with exposed aggregate identified on the surface of the pipe's interior wall. The interceptor is a critical component of the system as it receives direct pumped flow from the Kennedy Lane Pumping Station force main discharge on High Street as well as servicing Tobey Hospital. The interceptor is also adjacent to the Wareham River.

The Town then decided to inspect the approximately 6,600 linear foot 18-inch and 21-inch RCP gravity interceptor that runs along Swifts Beach Road, through Ripley's Mobile Home Park and along multiple off-road easements before reaching Viking Drive where it eventually discharges to the Kennedy Lane Pumping Station. Following inspection, this RCP interceptor was also discovered to be in a deteriorating condition with exposed aggregate identified on the interior pipe wall. This interceptor is also a critical component of the system as it receives direct pumped flow from the Hathaway, Terry Lane, and Smith Pumping Stations as well as servicing the Town's Middle School and High School.

Specific to High Street, the Town took immediate action by soliciting proposals from three (3) contractors for repair of 80 linear feet of severely deteriorated 21-inch diameter RCP sewer between MH 001013 and MH 001012. The proposed repair will include lining 21-inch diameter RCP to stop the degradation of the pipe's interior wall, provide structural stability to prolong the life of the interceptor, and improve overall system reliability. The Town is currently in the process of securing funding to complete repair of the remaining RCP interceptor.

Section 4
Inflow/Infiltration Analysis

4.1 Mission Data - Overview

Pumping station data downloaded from the Town's Mission monitoring and data management system for use in the I/I analysis included the following:

- Daily pump run-times for each pump installed at the respective pumping stations
- Approximate gallons pumped per day per pump (based on pump capacity information)
- Number of pump starts per day per pump
- Combined daily pump run-times (Pump 1 + Pump 2) and approximate gallons pumped for the pump station (based on pump capacity information)

As previously stated, one of the focuses in this data review was to look for evidence of extended run-times during wet-weather events and high groundwater conditions. Extended run-times would be an indication of I/I impacts to the collection system. Comparing the pump run-time data for different time periods and identifying trends provides the information required to determine when the stations manage additional flow. The service areas for those pumping stations that require pump operation for longer periods of time during periods of wet-weather and high groundwater were targeted for additional investigations.

4.2 Pump Run-Time Evaluation and Results

As discussed in the previous section, the Mission data was used for evaluation of individual pumping station collection basins to determine whether or not the basin was influenced by wet-weather. Daily pump run-times were plotted against simultaneously collected rainfall data and then compared to average pump run-times for the particular location. Average pump run-times were calculated based on "typical" dry-weather pump station operation during the study period and were then compared to the peak pump run-times recorded during and as a direct result of wet-weather events. This analysis was performed for all pumping stations for which data is monitored and collected within the Town's Mission system. If the data indicated a moderate to significant influence on the basin caused by wet-weather, high groundwater conditions (resultant increased pump run-times), that particular pumping station collection basin was further evaluated. If the data analysis did not provide conclusive evidence of wet-weather impacts, the collection basin was no longer analyzed. This process served to streamline the focus of the I/I analysis and prioritize locations for further evaluation. The pumping station collection basins that were selected for further analysis were those that exhibited measureable increases in pump run-times as directly related to the

occurrence of wet-weather events. This correlation between rainfall data and simultaneously recorded pump activity is best analyzed graphically. Graphs depicting pump run-time versus rainfall data during the study period for each collection basin listed below in Table #4-1 have been included within *Appendix C* for reference.

Table #4-1 provides a comparison of results from previous I/I studies for the Wareham wastewater collection system since 2006. The table identifies the isolated locations that are suspected of being influenced by wet-weather flows, including when and how many times a particular location was studied. Table #4-1 further demonstrates the relevance of the pump run-time analysis performed as part of the Phase 2 effort. As can be seen from review of the table, BETA's analysis provides confirmation of previously determined wet-weather flow impacts to specific locations and also identifies other locations that were not analyzed prior to this effort. Locations are depicted on a figure included within *Appendix A*.

Table #4-1:
Wet-Weather Flow Impact Findings – Comparison of Multiple I/I Analysis Efforts

Sewershed #	Pumping Station Collection Basin	Number of Pumping Stations Upstream	Subarea # (2006 Phase 1 I/I Study)	Wet-Weather Flow Impact Y = Yes N = No " - " = Not Applicable or Not Studied		
				CDM Findings (2006)	OSD Findings (2014-15)	BETA Findings (2017-18)
3	Apple St.	0	-	-	-	Yes
6	Peter Cooper Dr.	0	-	-	-	Yes
10	Ruggles	0	11	Yes	Yes	Yes
11	Smith	1	11 & 12	Yes	No	Yes
12	Mattapoisett Rd.	0	-	-	-	Yes
13	Briarwood Dr.	0	-	-	-	Yes
14	Arnold St.	2	-	-	-	Yes
15	French-Canedy St.	0	-	-	-	Yes
16	Leonard St.	0	-	-	-	Yes
17	13th Ave.	0	-	-	-	Yes
18	Hathaway	5	-	-	-	Yes
19 & 20	Cromesett	1	-	-	-	Yes
21	Terry Lane	2	10	No	-	Yes
22	Narrows	19	8 & 9	Yes	-	Yes
23	Pinehurst	0	9	Yes	Yes	Yes
24	Kennedy	12	8 & 10	Yes	-	Yes
25	Depot St.	7	-	-	-	Yes
26	Dick's Pond	6	7	Yes	-	Yes
28	Salt Works Rd.*	1	6	Yes	-	Yes
29	Hill St.	0	7	Yes	-	No
30	Cohasset Narrows**	4	7	Yes	-	Yes
32	South Water St.	4	1 & 2	Yes	Yes	Yes
35	Onset Heights	0	1	No	-	No
36	Onset Pier	5	-	-	-	Yes
37	East Blvd.	0	4B	Yes	Inconclusive	No
38	South Blvd.	0	3A	No	-	No
39 & 41	Hynes Field	9	3A & 4A	No	Yes	Yes
40	North Boulevard	1	4B	Yes	Yes	Yes

*Receives flow from Town of Plymouth, MA
**Receives flow from Town of Bourne, MA

Operation of the Town's larger pumping stations was also evaluated but given the influence of upstream pumping stations in each of these locations, determination of wet-weather impacts to the associated, individual collection basins would prove challenging and unreliable using pump run-time data and metering would pose similar challenges. The following is a list of six (6) pumping station collection basins (with year of construction) that also exhibited measureable increases in pump run-times as directly related to the occurrence of wet-weather events but were not evaluated further due to their upstream influence:

- Narrows (1970)
- Kennedy (1970)
- Hynes Field (1970)
- Dick's Pond (1988)
- Cohasset Narrows (1988)
- Depot Street (1988)

Table #4-2 summarizes the remaining eighteen (18) pumping station collection basins that are suspected of being influenced by wet-weather.

Table #4-2:
Pumping Station Collection Basins Influenced by Wet-Weather
(Pump Run-Time Evaluation)

Pumping Station Name	Approx. Pump Capacity (gpm)*	Spring 2017 (Mar. - Apr.)			Winter/Spring 2018 (Jan. - Mar.)		
		Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Dry-Weather Avg.	Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Dry-Weather Avg.
Apple Street	130	20	45	125%	23	139	504%
Arnold Street	270	56	98	75%	60	98	63%
Briarwood	235	44	114	159%	60	158	163%
Cromesett	110	64	112	75%	70	166	137%
French-Canedy	140	32	94	194%	40	87	118%
Hathaway	460	82	128	56%	93	171	84%
Leonard	Pump 1: 60 Pump 2: 30	77	133	73%	77	163	112%
Mattapoisett	230	10	26	160%	12	38	217%

Pumping Station Name	Approx. Pump Capacity (gpm)*	Spring 2017 (Mar. - Apr.)			Winter/Spring 2018 (Jan. - Mar.)		
		Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Dry-Weather Avg.	Avg. Daily Dry-Weather Run-Time (min.)	Max. Daily Wet-Weather Run-Time (min.)	Increase Above Dry-Weather Avg.
North Boulevard	670	50	98	96%	70	339	384%
Onset Pier	Pump 1: 1,000 Pump 2: 1,100	66	209	217%	66	139	111%
Peter Cooper Drive	40	120	295	146%	120	662	452%
Pinehurst	345	55	79	44%	50	145	190%
Ruggles	230	80	240	200%	90	393	337%
Salt Works Road	245	62	129	108%	61	112	84%
Smith	1,265	93	177	90%	110	430	291%
South Water Street	1,060	60	120	100%	60	297	395%
Terry Lane [Pine Tree Estates]	225	265	353	33%	270	466	73%
13th Ave	Pump 1: 60 Pump 2: 110	83	157	89%	40	212	430%

*Pump capacities as selected from Tables #3-11 & #3-12 within this report

As previously discussed, BETA, with assistance from Town WPCD personnel, conducted wet well drawdown testing of several of the pumping station discharges to validate station operation data collected within the Mission monitoring and data management system. Also as previously discussed, BETA, with assistance from Flow Assessment Services and Town WPCD personnel, conducted limited flow metering downstream of several pumping station force main discharges as a means of additional quality control of the Mission data. This data was then used for the basis of comparison of flows under dry-weather conditions to flows under wet-weather conditions. Calculation of flows and determination of impacts from wet-weather are described in further detail in Section 4.2.2 below.

4.2.1 Rainfall Information

As previously stated in Section 3.2.10 of this report, precipitation data collected for use in the Phase 2 infiltration and inflow analysis was obtained from U.S. Climate Data (www.usclimatedata.com) for the Town of Wareham (2015 & 2016 data) and from a rain gauge that is installed at the Pinehurst Pumping Station, which is monitored by the SmartCover® Monitoring System (2017 & 2018 data). Precipitation data obtained from Weather Underground (www.wunderground.com) was also used for verifying accuracy of the previously mentioned data sources and for comparison of historical storm events for use in the sewer system overflow risk assessment described in Section 4.3 of this report.

4.2.2 Wet-Weather Impacts

The influence of wet-weather events within the isolated pumping station collection basins identified in Table #4-2 was determined for each location. Since infiltration and inflow could not be differentiated as part of this analysis and infiltration has been previously considered to be within acceptable amounts throughout the Town's collection system, calculated excessive wet-weather flows used for the analysis were identified strictly as inflow. Infiltration is therefore assumed to be part of the average daily flow values.

The total inflow volume (in gallons) was calculated for each storm event within the respective pumping station collection basin and correlated with the total rainfall (in inches) produced from the storm. Total inflow volumes were calculated using pump capacities, associated wet-weather pump run-times, and deduction of base, dry-weather sanitary flows, and is more simply defined as the area between the storm event hydrograph and the dry-weather hydrograph.

The MassDEP Guidelines state that total inflow volume shall be established for all storm events having an average rainfall of approximately 0.20 inches per hour and for any other storms for which an inflow response is readily observable during the study period. This correlation of total inflow volume to rainfall is performed graphically with inches of rainfall along the X-axis and total inflow volume along the Y-axis. The graph produced by the rainfall/total inflow volume correlation for storm events recorded during the study period can then be used to estimate the total inflow volume expected to be produced within a respective collection area from the standard storm (1-year, 6-hour duration storm event), as defined by MassDEP. The estimated total inflow volumes for the standard storm are then used as the basis for comparison and for ranking of the study areas relative to one another based on the volumetric wet-weather impact to the collection basins.

Table #4-3 contains a summary of the eighteen (18) pumping station collection basins that were identified as part of the Phase 2 analysis as being influenced by potential

sources of inflow. As stated above, the collection basins have been ranked (from highest to lowest), relative to one another, based on the expected volumetric impact to the basin from the standard storm.

Table #4-3:
Pumping Station Collection Basins – Standard Storm Total Inflow Volumes

Ranking	Sewershed #	Pumping Station Collection Basin	No. Pumps	Approx. Pump Capacity (gpm)	Gravity Sewer Length (LF)	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	2	1,265	33,672	220,000	29.3	29.3
2	36	Onset Pier	2	1,000 / 1,100	5,121	122,000	16.3	45.6
3	32	South Water Street	2	1,060	17,520	105,000	14.0	59.6
4	40	North Boulevard	2	670	7,488	100,000	13.3	72.9
5	10	Ruggles	2	230	7,541	60,000	8.0	80.9
6	18	Hathaway	2	460	16,840	31,000	4.1	85.0
7	21	Terry Lane	2	225	15,432	25,000	3.3	88.3
8	23	Pinehurst	2	345	12,003	16,000	2.1	90.4
9	13	Briarwood	2	235	11,351	15,000	2.0	92.4
10	14	Arnold Street	2	270	8,954	10,000	1.3	93.7
11	20	Cromesett	2	110	6,332	10,000	1.3	95.0
12	6	Peter Cooper Drive	2	40	1,568	8,000	1.1	96.1
13	28	Salt Works Road	2	245	11,153	6,700	0.9	97.0
14	3	Apple Street	2	130	2,762	6,000	0.8	97.8
15	15	French-Canedy	2	140	2,903	5,800	0.8	98.6
16	17	13th Avenue	2	60 / 110	3,183	4,500	0.6	99.2
17	12	Mattapoisett	2	230	1,412	3,000	0.4	99.6
18	16	Leonard	2	60 / 30	4,157	2,850	0.4	100.0

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

The pumping station collection basins in the above table all exhibit a level of influence from wet-weather in the form of increased wastewater flows. Prioritization of recommended improvements and additional investigations within a specific collection basin should be focused on the higher of the estimated total inflow volumes calculated for the standard storm, as presented in the table. The priority ranking system should be used as a planning tool only and shall not preclude efforts to correct any previously identified or known significant sources of I/I to the collection system, wherever they may exist. Significant sources, when identified, shall be addressed in an urgent manner, especially if the source(s) leads to system surcharging and/or SSOs or private property backups. Otherwise, the rankings above can be used for capital planning purposes to conduct work within the respective pumping station collection basins on a prioritized basis, addressing first the isolated areas contributing the largest total wet-weather inflow volumes to the overall collection system.

4.3 Sewer System Overflow Risk Assessment

Massachusetts Division of Water Pollution Control Standards 314 CMR 12.04 requires all sewer system authorities to develop a plan for long-term I/I control which at a minimum must specifically assess the risk of sewer system overflows from a 5-year, 24-hour duration storm event. MassDEP has defined the 5-year, 24-hour duration storm as an event with a total rainfall depth of 4.61 inches, a peak intensity of 0.73 in/hr and an average intensity of 0.19 in/hr.

MassDEP has established a baseline for comparison of inflow rates and volumes to which projected responses shall be evaluated against. The baseline storm event for the area is the 1-year, 6-hour duration storm which produces 1.72 inches of rainfall, a peak intensity of 0.87 in/hr and an average intensity of 0.29 in/hr. This storm event was used to calculate comparative inflow rates and volumes in the Phase 1 analysis performed by CDM in 2006 and was also used in the comparison of total inflow volumes for this effort, per the MassDEP Guidelines.

Since the Town does not have a calibrated sewer system model to project flows and system response, including resultant hydraulic grade lines, system surcharging and SSOs cannot be predicted. A review of historical rainfall events equal to and/or in excess of the 5-year, 24-hour duration storm defined above and Wareham WPCD reports of associated system response can also be used as a basis for risk assessment of SSOs from the collection system. However, the Town of Wareham has not experienced an event of this magnitude or greater in recent history.

Six local springtime storm events recorded since 2010 that produced moderate rainfall in Wareham, occurred on the following dates:

- March 13-15, 2010 *(Max. 24-Hr Rainfall: 3.45 in.)*
- March 29-30, 2010 *(Max. 24-Hr Rainfall: 3.50 in.)*
- June 7-8, 2013 *(Max. 24-Hr Rainfall: 3.82 in.)*
- March 29-30, 2014 *(Max. 24-Hr Rainfall: 3.56 in.)*
- March 30-April 1, 2017 *(Max. 24-Hr Rainfall: 3.54 in.)*
- March 2, 2018 *(Max. 24-Hr Rainfall: 3.31 in.)*

A rainfall amount of at least 3.5-inches was recorded within a 24-hour period for five of the six events listed above. The rainfall data was recorded at the Plymouth Municipal Airport, approximately 15 miles north of Wareham (source: www.wunderground.com). After review of *Technical Paper No. 40*, five of the six listed storm events had a recurrence interval of 2 years for a 24-hour duration storm event. Accordingly, the June 7-8, 2013 storm event can be classified between a 2-year and a 5-year return frequency, 24-hour duration storm event. Based on MassDEP SSO/Bypass Notification reporting records on file as well as firsthand accounts from Wareham WPCD personnel, neither of the above storm events led to system surcharging that resulted in SSOs or basement backups within the collection system. Furthermore, the Town has reportedly never experienced SSOs as a result of wet-weather events. This provides verification that the Town's wastewater collection system has sufficient capacity to convey elevated wet-weather flows during moderate to significant rainfall events and therefore is a low risk for system surcharging and resultant SSOs.

4.4 Conclusions

The Wareham wastewater collection system is not subject to wet-weather sanitary sewer overflows (SSOs) or bypasses and is not subject to surcharging that result in basement back-ups. Portions of the system appear to be influenced by infiltration and inflow, and based upon previous smoke testing results, the majority of sources may be private property sources such as sump pumps. Based on the information reviewed and analysis of pumping station flow data, problem areas already known to the Town have been substantiated and in addition, it has been demonstrated that other areas are not significantly impacted by I/I. Although the Town has not experienced wet-weather SSOs, the Town has a practical interest in removing sources of I/I to restore capacity to their collection systems and treatment facility to allow future sewer system expansion. Sufficient data exists to make recommendations for focusing future investigative efforts that will aid in developing preliminary remediation concepts. Associated recommendations have been summarized in Section 5 of this report.

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Section 5
Summary of Findings and Recommendations

5.1 Wet-Weather Impacts

5.1.1 Infiltration Impacts

Determination of infiltration rates utilizing pumping station data is not straightforward. When reviewing typical meter data, infiltration is often determined by comparing night time flows during dry-weather, wet season conditions to dry-weather, dry season conditions. This is a difficult task in Wareham due to the seasonal variation in population. When comparing dry-weather / dry season and dry-weather / wet season data, uncertainty presents itself due to potential impacts by population swings.

All subareas that were analyzed, utilizing meter data, during the 2006 Phase 1 analysis exhibited an infiltration rate less than the MassDEP threshold of 4,000 gpd/in-mi (considered "excessive" for a sanitary sewer). Therefore, it was determined that the amount of groundwater entering the sewer system was within acceptable limits and additional studies for identification of infiltration sources were not recommended.

Based on previous studies and our understanding of the collection system, initial focuses should be directed toward removal of inflow sources. However, infiltration within the collection system should not be ignored and efforts such as routine pipeline CCTV inspection and/or manhole inspections can facilitate identification and subsequent removal of infiltration sources.

5.1.2 Inflow Impacts

Portions of the Town's wastewater collection system appear to be influenced by sources of inflow during wet-weather, high groundwater conditions. Based on the Phase 2 analysis, first-hand account of Wareham WPCD personnel, previous findings through smoke testing efforts and general understanding of the local geography, it is suspected that inflow sources may be from private property discharges.

Analysis results indicate the presence of inflow within several collection basins that were constructed in the last 15 to 30 years using PVC pipe. This provides further indication that sources of inflow likely exist within those respective collection basins, as infiltration is typically less of an issue in systems constructed with PVC pipe material as compared to those constructed of vitrified clay or asbestos cement pipe materials.

The most recent analysis of pump run-time data provides confirmation of previously determined wet-weather inflow impacts to specific locations throughout the collection

system and also identifies other locations with potential impacts that were not analyzed prior to this effort.

5.2 Recommended Additional Work and Investigations

Recommendations are as follows:

- Further Development of the Town's wastewater and storm water collection system mapping
- Smoke testing
- Private property inspections (including dyed water testing) to identify sources of inflow
- Pipeline CCTV inspection
- Manhole inspections and salinity testing
- Town ordinance review, including required additions and modifications
- Establishing an I/I Fee for sewer service connections

The recommendations can be completed as part of a Sewer System Evaluation Survey (SSES). An SSES is completed as a follow-up to an I/I analysis in order to locate and identify specific sources of infiltration and inflow in the collection system. The focus of the SSES is on the areas identified in the I/I analyses as containing excessive I/I. Sources of I/I are identified, quantified, and appropriate rehabilitation methods are determined as part of the SSES. A determination can then be made on the cost-effectiveness of the removal of each identified source. The results and recommendations are then summarized in an SSES report.

Maps depicting investigative work completed to date along with the future work recommended in this Section have been provided in *Appendix A*. The following subsections provide details of the recommended work.

5.2.1 Collection System Mapping

5.2.1.1 Wastewater Collection System

The Town's wastewater collection system mapping is developed electronically within Utility Cloud and includes the following attributes:

- Sewer manholes with unique identification numbers
- Pipes with length and connectivity
- Pumping Station locations with names

The Town has a good framework completed for the wastewater collection system. Additional useful data that can be incorporated into the system include pipe size, age,

and material, as well as rim elevations and manhole depths. Identifying pipe size, age and material in a central, accessible location can be a powerful planning tool as the Town reviews and prioritizes what areas of the collection system to focus rehabilitation efforts.

5.2.1.2 Stormwater Collection System

The Town has not developed their electronic storm water collection system mapping to the same extent as their wastewater collection system mapping. Storm water mapping is GIS based and limited to the general location of catch basins. Similar to development of the wastewater collection system mapping, further development of the storm water collection system mapping will benefit the Town as they look for opportunities to remove and redirect sources of inflow from the wastewater collection system and plan for future sanitary expansion. Additional useful data that can be incorporated into the system include pipe connectivity, pipe size, age, and material, outfall locations, as well as structure rim, inlet, and outlet elevations. Mapping of the storm water collection system will also facilitate compliance with the MS4 storm water program requirements.

5.2.2 Smoke Testing

It is recommended that smoke testing be performed within the following pumping station collection basins to identify potential sources of inflow:

Table #5-1:
Recommended Primary Smoke Testing – Areas Identified as Being Influenced by I/I (Not Previously Smoke Tested)

Ranking	Sewershed #	Pumping Station Collection Basin	Linear Footage of Gravity Sewer Pipe in Smoke Testing Area	Number of Sewer Manholes in Smoke Testing Area	Phase 1 I/I Study Subarea #'s (2006 CDM)
1	11 (Portion)*	Smith [Shore Ave to east including Hamilton Beach Area]	19,164	124	12
2	36	Onset Pier	5,121	30	N/A
3	32 (Portion)*	South Water St. [North of Onset Ave]	8,383	55	1
NR	22 (Portion)*	Narrows [Main St]	3,450	17	9
NR	24 (Portion)*	Kennedy Lane [South of Marion Rd]	8,722	32	8 & 10
NR	25	Depot Street	4,287	17	N/A
NR	26 (Portion)*	Dick's Pond [West of Pump Station & Main Ave]	4,813	17	7
NR	39 & 41	Hynes Field	24,531	136	3A & 4A
		Totals:	78,471	428	

NR = Not Ranked
*Portion of area previously smoke tested in 2006.

The pumping station collection basins (or portions thereof) listed in the above table were identified during this analysis as being impacted by I/I during wet-weather events and high groundwater conditions. The linear footages of sewer recommended for smoke testing listed in Table #5-1 were not previously smoke tested during the 2006 effort completed by Flow Assessment Services LLC, mentioned in Section 3.2.6 of this report.

All of the North Boulevard (Ranking #4), Ruggles (Ranking #5) and Cohasset Narrows (NR) collection basins and portions of the Smith, Narrows, Kennedy Lane, Dick's Pond and South Water Street Pumping Station collection basins were smoke tested in 2006 based on the metered subarea boundary delineations in the Phase 1 analysis. The recommendation is to conduct additional smoke testing in the remaining portions of those pumping station collection basins. It is recommended that smoke testing be

performed within these collection basins since I/I impacts were identified through measurable increases in pump run-times during wet-weather events.

In addition, considering the relatively low cost of smoke testing and the potential discoveries resulting from it, the Town may want to consider smoke testing within the remaining pumping station collection basins. The secondary scope includes those areas that have not previously been smoke tested and those that are also not listed previously in Table #5-1. The table below summarizes the recommended secondary smoke testing:

Table #5-2:
Recommended Secondary Smoke Testing – Remaining Areas that have not been Smoke Tested Previously

Ranking	Sewershed #	Pumping Station Collection Basin	Total Linear Footage of Gravity Sewer Pipe in Study Area	Number of Sewer Manholes in Study Area	Phase 1 I/I Study Subarea #'s (2006 CDM)
6	18	Hathaway	16,840	74	N/A
7	21 (Portion)	Terry Lane [East of Camardo Dr]	1,340	11	10
9	13	Briarwood Drive	11,351	57	N/A
10	14	Arnold Street	8,954	48	N/A
11	19 & 20	Cromesett Road	6,332	28	N/A
12	6	Peter Cooper Drive	1,568	5	N/A
14	3	Apple Street	2,762	18	N/A
15	15	French-Canedy	2,903	12	N/A
16	17	13th Ave	3,183	18	N/A
17	12	Mattapoisett Road	1,412	7	N/A
18	16	Leonard Street	4,157	20	N/A
NR	1	Spring Bourne	3,783	17	8
NR	4	Avenue A	4,845	26	N/A
NR	5	Linwood Avenue	1,587	13	N/A
NR	7	Parkwood Beach	20,162	107	N/A
NR	8	Indian Neck	5,913	40	N/A
NR	9	Oak Street	2,846	18	N/A
NR	27	Riverside	6,576	35	5
NR	35	Onset Heights	6,205	38	1
		Totals:	112,719	592	

NR = Not Ranked

If smoke testing is completed within the areas mentioned in Tables #5-1 & #5-2 above, the Town's entire wastewater collection system will have been smoke tested.

5.2.3 Private Property Inspections / Dyed Water Testing

Direct inflow sources may not always be detected during smoke testing efforts due to flooded traps in building services, active pumping of sump pumps, or clogged drains. Most of the time, inflow sources with these conditions must be sought out through physical inspection and dye testing where necessary. Dyed water testing is performed by introducing dyed water into a suspected inflow source and then observing flow at a

downstream sanitary sewer manhole in search of the dyed water. Possible connections may include catch basins, downspouts, sump pumps and drains from yards, patios, window wells, stairwells, and driveways.

It is recommended that the Town conduct inspection and dyed water testing of private properties in areas identified within this analysis. Key aspects per MassDEP guidelines for successful completion of the effort are summarized below:

- Property owner notification (public and individual notification)
- Achieving property owner cooperation (make improvements as necessary)
- Development of a standard property inspection form(s) to ensure consistent and complete documentation of information
- Transparent communication and professional interaction of inspectors toward property owners
- Thorough interior and exterior inspection, including dyed water testing (with owner permission) of potential sources and documentation of known and suspected sources of inflow
- Development of protocol to handle inspection refusals and alternative inspection schedules (nights and weekends) to accommodate property owners. This may include review and modification of existing Town ordinances and non-compliance penalty schedules.

For the purpose of this effort, it is recommended to conduct inspection and dyed water testing of private properties in areas which account for a combined 80% of the total inflow based on the I/I analysis. Therefore, the following five (5) pumping station collection basins should be targeted accordingly (from Table #4-3):

Recommended Private Property Inspections / Dyed Water Testing (list from Table #4-3):

Ranking	Sewershed #	Pumping Station Collection Basin	Approx. # of Properties Within Basin	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	853	220,000	29.3	29.3
2	36	Onset Pier	157	122,000	16.3	45.6
3	32	South Water Street	455	105,000	14.0	59.6
4	40	North Boulevard	185	100,000	13.3	72.9
5	10	Ruggles	219	60,000	8.0	80.9
		Total:	1,869			

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

Once sources of private property inflow have been identified, a systematic plan should be developed for removal and relocation of the discharges from the wastewater collection system to the storm water collection system or other alternative locations.

5.2.4 Pipeline CCTV Inspection

The condition of the majority of the Town's wastewater collection system is unknown and the Town does not currently have a formal sewer pipeline CCTV program. As previously mentioned in Section 3.4 of this report, the Town has completed approximately 26,000 linear feet of sewer pipeline CCTV inspection since 2015, which equates to approximately 8% of the gravity sewer collection system. A summary table of the completed inspections and associated findings has been included in *Appendix D* of this report for reference.

It is recommended that the Town conduct additional CCTV inspection, starting within the oldest sections of the wastewater collection system which contain vitrified clay and asbestos cement pipe materials (constructed between 1970 and 1980). Inspection should be conducted in spring months (March 1 – June 30), when high groundwater conditions are typically experienced and active infiltration sources are more likely to be observed. It is noted that some of the areas recommended for CCTV inspection are within pump station collection basins that were identified as being influenced by wet-weather / high groundwater conditions and also contain older pipe materials (VC, AC, etc.). It is recommended that the Town complete pipeline CCTV inspection within the following areas:

Table #5-3:
Recommended Pipeline CCTV Inspection

Ranking	Sewershed #	Pumping Station Collection Basin	Total Linear Footage of Gravity Sewer Pipe	Pipe Size (Dia.) Range/Known Materials	Number of Sewer Manholes	Phase 1 I/I Study Subarea #'s (2006 CDM)
1	11	Smith	33,672	8" – 12" (VC, DI)	207	11 & 12
2	36	Onset Pier	5,121	8" – 15" (VC, RCP)	30	N/A
3	32	South Water St.	17,520	8" – 12" (VC)	113	1 & 2
4	40	North Boulevard	7,488	8" – 10" (VC)	39	4B
5	10	Ruggles	7,541	8" (AC, DI)	41	11
8	23	Pinehurst	12,003	8" – 10" (VC, DI)	79	9
		Primary Subtotal:	83,345			
NR	22	Narrows*	14,900	8" – 12" VC 21" RCP*	71	8 & 9
NR	24	Kennedy*	23,563	8" – 10" VC 18" - 21" RCP*	110	8 & 10
NR	39 & 41	Hynes Field	24,531	8" – 12" (VC)	136	3A & 4A
		Secondary Subtotal:	62,994			
		Total:	146,339			

NR = Not Ranked

*As previously mentioned in Section 3.4 of this report, the 18" & 21" RCP interceptors within the Kennedy and Narrows Pumping Station collection basins were inspected in 2017. A summary table of the completed inspections and associated findings has been included in *Appendix D* of this report for reference.

The pumping station collection basins listed in Table #5-3 contain non-PVC pipe materials and were constructed between 1970 and 1980.

The Pinehurst Pumping Station collection basin was constructed in 1977 and also contains non-PVC pipe materials including vitrified clay and ductile iron. It is recommended that pipeline CCTV inspection be performed within this collection basin since I/I impacts were identified through measurable increases in pump run-times during wet-weather events and also because of Wareham WPCD personnel account of the presence of sand within sections of the pipelines.

The Narrows, Kennedy and Hynes Field Pumping Station collection basins were all constructed in 1970 and consist of non-PVC pipe materials such as vitrified clay and asbestos cement. These three basins were not evaluated further as part of this I/I analysis due to upstream influences and thus would be lower priority than the other ranked basins listed in the table. However, the Town should prioritize conducting structural evaluation via pipeline CCTV inspection in locations where there is asbestos cement or reinforced concrete pipe immediately downstream of pump station force main discharges.

It is recommended that the Town consider development of a cleaning and inspection program for the gravity sewer system (pipelines and manholes) in order to identify existing leaks and deficiencies within the system. A cleaning and inspection program can provide many benefits including prevention of blockages and resultant sanitary sewer overflows and back-ups, identification of structural defects and sources of infiltration within the collection system, as well as a detailed inventory of the system for asset management and capital improvement planning purposes.

5.2.5 Manhole Inspections / Salinity Testing

As previously mentioned in Section 3.4 of this report, the Town completed 266 limited sewer manhole inspections since 2015, which equates to approximately 14% of the total sewer manholes in the collection system. The intent of the limited inspection is to obtain an overall perspective of the condition of the system. A summary table of the completed inspections and associated findings has been included in *Appendix E* of this report for reference.

Extensive manhole inspections are typically recommended as the next step in the process as part of an SSES, to determine the quantity of infiltration entering the system from the manholes in the areas where I/I was determined to be excessive during the I/I analysis. Infiltration rates were not determined to be in excess of the MassDEP threshold of 4,000 gpd/in-mi during the 2006 Phase 1 I/I analysis. However, extensive manhole inspections are recommended by the MassDEP Guidelines in areas which account for a combined 80% of the total inflow based on the I/I analysis. It is therefore recommended to conduct extensive manhole inspections in the following five (5) pumping station collection basins to identify sources of inflow and infiltration (from Table #4-3):

Recommended Manhole Inspections (list from Table #4-3):

Ranking	Sewershed #	Pumping Station Collection Basin	Total # of Sewer Manholes in Basin	Gravity Sewer Length (LF)	Standard Storm Total Inflow Volumes* (gal)	% of Total Inflow	Cumul-ative %
1	11	Smith	207	33,672	220,000	29.3	29.3
2	36	Onset Pier	30	5,121	122,000	16.3	45.6
3	32	South Water Street	113	17,520	105,000	14.0	59.6
4	40	North Boulevard	39	7,488	100,000	13.3	72.9
5	10	Ruggles	41	7,541	60,000	8.0	80.9
		Totals:	430	71,342			

*Calculated based on the MassDEP Standard Storm (1-year, 6-hour duration storm event)

Tidal I/I

Tidal influence was evaluated as part of this effort but results were inconclusive. However, analysis previously completed by CDM in 2006 as part of the Phase 1 I/I report identified slight to moderate tidal influence within the thirteen subareas that were studied at that time. Salinity testing of manholes is therefore recommended. This should be accomplished during high tides within manholes that are in close proximity to the shoreline and are constructed at depths below sea level elevations. This can be completed concurrently with the extensive manhole inspections where applicable.

5.2.6 Town Ordinance Additions / Modifications

In preparation for inspection of private properties, it is recommended that the Town review and evaluate the existing Town sewer use ordinances and determine whether modifications to existing ordinances, or creation of new ordinances, will be required to aid in the Town's future I/I removal efforts. Considerations should include the following at a minimum and if applicable:

- Right-of-entry access to private property to conduct inspections and dye testing
- Regulations governing the discharge of groundwater or storm water runoff to the Town's separate sanitary sewer system
- Town enforcement schedules and non-compliance penalty matrices

5.2.7 Establishment of I/I Fees

The Town has interest in pursuing the establishment of an I/I fee. Due to recent proposals for future land development and subsequent sewer collection system

expansion, and given the limited existing capacity at the Town's wastewater treatment facility, an I/I fee could be established and assessed to new construction with planned sewer connection and discharge of wastewater to the Town's collection system. Fees collected could be used to fund future studies and construction projects within the collection system aimed at identification and removal of known sources of infiltration and inflow. Removal of I/I will improve capacity limitations within the collection system and at the wastewater treatment facility.

It is recommended that the Town research and review procedures that other local communities have previously adopted for development and management of an I/I fee. The Town can obtain helpful information from this research that will assist in the development of their own fee structure should they decide to establish one.

Table #5-4 summarizes the recommended (Primary Only) SSES work presented above in this Section.

Table #5-4:
Summary of Recommended SSES Work – Top Ranked Pumping Station Collection Basins

Ranking	Sewershed #	Pumping Station Collection Basin	Smoke Testing	Private Property Inspection / Dyed Water Testing	Pipeline CCTV Inspection	Manhole Inspection / Salinity Testing
1	11	Smith	✓ (Portion)	✓	✓	✓
2	36	Onset Pier	✓	✓	✓	✓
3	32	South Water St.	✓ (Portion)	✓	✓	✓
4	40	North Boulevard	*	✓	✓	✓
5	10	Ruggles	*	✓	✓	✓
8	23	Pinehurst	*	N/A	✓	N/A

*Smoke Testing of pumping station collection basin completed in 2006.

In addition to the above, it is also recommended that the Town complete smoke testing in the service areas of the larger pump stations including Narrows (portion), Kennedy (portion), Depot Street, Dick's Pond (portion) and Hynes Field. Smoke testing is a relatively simple and low cost tool that may result in identification of major sources of

inflow. Among others, the North Boulevard, Ruggles, Pinehurst and Cohasset Narrows pumping station collection basins were completely smoke tested in 2006.

5.3 Probable Costs and Schedule

Smoke testing is ideally conducted during dry-weather, low groundwater conditions (July 1 – November 15) to allow successful travel of the smoke throughout the system, whereas sewer manhole and pipeline inspections are ideally conducted during high groundwater conditions (March 1 – June 30) to identify sources of active infiltration within the system. Since the Town of Wareham experiences seasonal fluctuations in population with higher concentrations of residents and visitors in the summer months, it is recommended that the sewer manhole and pipeline inspections be completed in the spring months (March – May) and the smoke testing be completed in the fall months (September – November) to minimize disruptive impacts to the community.

Private property inspections and dyed water testing can be conducted concurrently with smoke testing efforts; however, due to seasonal population, access to private property will likely be limited. Property inspections will likely be a multi-year effort based on the recommended scope or work. A 5-year implementation schedule has been presented in this report as an example. Once a formal private property inspection program has been established, the Town should develop their own prioritized schedule for conducting property inspections.

It is recommended that the Town begin the SSES phase as early as March/April 2019 or as soon as funding is secured. An aggressive implementation schedule will serve to benefit the Town's future endeavors as related to restoring capacity to the collection system and treatment facility. A proposed implementation schedule for completion of SSES investigative work has been included within *Appendix F* of the report.

An opinion of probable cost (in 2018 dollars) for the related work has also been provided below in Table #5-6 and Table #5-7. Unit costs shall be adjusted as necessary to account for future inflation.

Table #5-5:
2018 Opinion of Probable Cost – Recommended SSES Investigative Work
(An opinion of probable cost for Private Property Inspections and Dyed Water Testing has been provided separately in Table #5-6)

SSES (Primary) - Work Description	**Quantity**	**Unit Cost**	**Extended Cost***
Smoke Testing – Primary Areas	79,000 LF	$1.00	$79,000.00
Pipeline CCTV Inspection – Primary Areas	84,000 LF	$3.00	$252,000.00
Extensive Manhole Inspection – Primary Areas	430 EA	$200.00	$86,000.00
		Subtotal:	*$420,000.00*
		Engineering & Contingencies (30%):	*$130,000.00*
		SSES Primary Total:	**$550,000.00**
SSES (Secondary) - Work Description	**Quantity**	**Unit Cost**	**Extended Cost***
Smoke Testing – Secondary Areas	113,000 LF	$1.00	$113,000.00
Pipeline CCTV Inspection – Secondary Areas	63,000 LF	$3.00	$189,000.00
		Subtotal:	*$310,000.00*
		Engineering & Contingencies (30%):	*$100,000.00*
		SSES Secondary Total:	**$410,000.00**
Development of Storm Water and Wastewater Collection System Mapping:			**$100,000.00**

*Extended Costs have been rounded up to the nearest thousand dollars. Subtotals, Engineering, Contingencies, and Total Costs have been rounded up to the nearest ten thousand dollars.

Table #5-6:
2018 Opinion of Probable Cost – Recommended Property Inspection / Dyed Water Testing of Private Properties

SSES (Primary) - Work Description	**Quantity**	**Unit Cost Per Property**	**Extended Cost***
Private Property Inspection / Dyed Water Testing (All Recommended Properties)	1,870 EA	$750.00	$1,403,000.00
5-Year Implementation Schedule (Example)			
Year 1 Property Inspections	375 EA	$750.00	$282,000.00
Year 2 Property Inspections	375 EA	$750.00	$282,000.00
Year 3 Property Inspections	375 EA	$750.00	$282,000.00
Year 4 Property Inspections	375 EA	$750.00	$282,000.00
Year 5 Property Inspections	370 EA	$750.00	$278,000.00
Private Property Inspection Total:			**$1,410,000.00**

* Extended Costs have been rounded up to the nearest thousand dollars. Total Cost has been rounded up to the nearest ten thousand dollars.

Note: The opinions of probable costs presented in Table #5-5 and Table #5-6 do not include the development of an SSES Report. Development of an SSES Report will be contingent on the successful completion of and findings from identified recommended tasks. The scope of required collection system repairs will be developed based on the findings of the recommended investigation work. An estimate for development of the SSES Report can be generated at that time once the scope of work is determined.

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APPENDIX A

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Sewershed	Pumping Station Name	Sewershed	Pumping Station Name
1	Springbourne	23	Pinehurst
2	Kendrick (Industrial Park I)	24	Kennedy Lane
2	Thatcher (Industrial Park II)	25	Depot Street
3	Apple Street	26	Dick's Pond
4	Avenue A	27	Riverside
5	Linwood Avenue	28	Salt Works Road
6	Peter Cooper Drive	29	Hill Street
7	Parkwood Beach	30	Cohasset Narrows
8	Indian Neck	31	Woodbury Street
9	Oak Street	32	South Water
10	Ruggles	33	Green Street
11	Smith Avenue	34	Bay Street
12	Mattapoisett Road	35	Onset Heights
13	Briarwood Drive	36	Onset Pier
14	Arnold	37	East Boulevard
15	French-Canedy	38	South Boulevard
16	Leonard Street	40	North Boulevard
17	13th Avenue	39, 41	Hynes Field
18	Hathaway	–	Minot Avenue
19, 20	Cromesett Road	–	Police Station
21	Terry Lane (Pine Tree Estates)	–	Tremont Nail
22	Narrows	–	Redwood Park

WAREHAM
PLYMOUTH
BOURNE
MARION
WWTF
MAYFLOWER RIDGE
AGAWAM RIVER
HIDEAWAY VILLAGE
SAND POND
DICK'S POND
BUTTERMILK BAY
EAST WAREHAM
BROAD MARSH RIVER
WAREHAM RIVER
BUTLER COVE
TAYLOR POINT
AGAWAM BEACH
SHELL POINT BAY
ONSET
MASS MARITIME ACADEMY
CAPE COD CANAL
ONSET BAY
ONSET ISLAND
LITTLE HARBOR
BOURNE COVE
WEWEANTIC RIVER
PHINNEYS HARBOR
STONEY POINT
HAMMETT COVE
MUDDY COVE
BROAD COVE
FERRO HILL ROAD
MAIN STREET
TREMONT ROAD
GLEN AVENUE
SANDWICH ROAD
NARROWS ROAD
MINOT AVENUE
MARION ROAD
WAREHAM STREET
HEAD OF THE BAY ROAD
RED BROOK ROAD
OAKDALE AVENUE
GREEN AVENUE

Town of Wareham Massachusetts

Phase 2 - I/I Report

Sewer Collection System Phase 2 I/I Analysis Study Areas & Findings

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Sewer Pump Station
- WWTF Outfall
- Sewer Manhole
- SmartCover Location
- Sewershed/Pump Station Collection Basin

Study Area

- I/I Impacts Observed (80% of Total Inflow Measured)
- I/I Impacts Observed (20% of Total Inflow Measured)
- I/I Impacts Observed Area Not Studied Further
- I/I Insignificant/ Data Inconsistent

Planimetric Data

- Roadway
- Railway
- Rain Gauge Location

μ

June, 2018

Scale: 1" = 1,250'

BETA
IMPROVING COMMUNITIES TOGETHER

Sewershed	Pumping Station Name	Sewershed	Pumping Station Name
1	Springbourne	23	Pinehurst
2	Kendrick (Industrial Park I)	24	Kennedy Lane
2	Thatcher (Industrial Park II)	25	Depot Street
3	Apple Street	26	Dick's Pond
4	Avenue A	27	Riverside
5	Linwood Avenue	28	Salt Works Road
6	Peter Cooper Drive	29	Hill Street
7	Parkwood Beach	30	Cohasset Narrows
8	Indian Neck	31	Woodbury Street
9	Oak Street	32	South Water
10	Ruggles	33	Green Street
11	Smith Avenue	34	Bay Street
12	Mattapoisett Road	35	Onset Heights
13	Briarwood Drive	36	Onset Pier
14	Arnold	37	East Boulevard
15	French-Canedy	38	South Boulevard
16	Leonard Street	40	North Boulevard
17	13th Avenue	39, 41	Hynes Field
18	Hathaway	--	Minot Avenue
19, 20	Cromesett Road	--	Police Station
21	Terry Lane (Pine Tree Estates)	--	Tremont Nail
22	Narrows	--	Redwood Park

Recommended Tests/Inspections
– Smoke Testing
– Private Property Inspection/Dyed Water Testing
– Pipeline CCTV Inspection
– Manhole Inspection/Salinity Testing

WAREHAM

PLYMOUTH

BOURNE

MARION

WWTF

Town of Wareham Massachusetts

Phase 2 - I/I Report

Recommended Additional Work & Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Sewer Pump Station
- WWTF Outfall
- Sewer Manhole
- SmartCover Location
- Sewershed/Pump Station Collection Basin

Recommended Tests/Inspections
(Refer to Recommendation Table This Sheet)

- All
- All (Except Smoke Testing)
- CCTV Only
- Smoke Test (Primary Area)
- Smoke Test (Secondary Area)
- Smoke Test Completed (2006)

Planimetric Data

- Roadway
- Railway
- Rain Gauge Location

μ

June, 2018

Scale: 1" = 1,250'

This map is intended to support the inventory of real property of the Town of Wareham. Map data should not be interpreted as the actual field survey data. This data should not be used for legal description or conveyance purposes.

BETA
IMPROVING COMMUNITIES TOGETHER

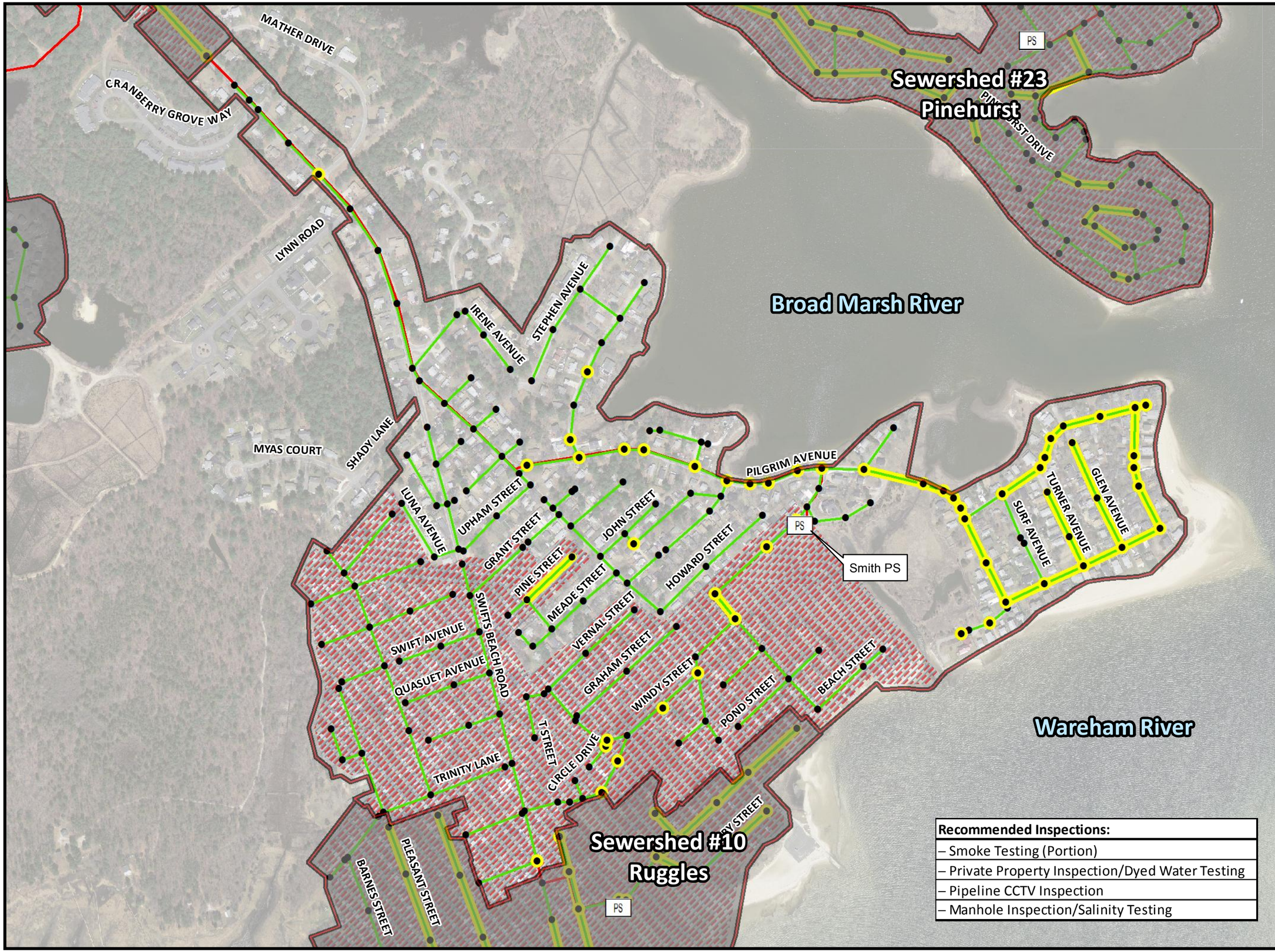
Town of Wareham
Massachusetts

Phase 2 - I/I Report

Sewershed #11
Smith
(Ranking #1)

Completed & Recommended Work / Investigations

Locus Map



Recommended Inspections:

– Smoke Testing (Portion)
– Private Property Inspection/Dyed Water Testing
– Pipeline CCTV Inspection
– Manhole Inspection/Salinity Testing

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed
- Smoke Testing Completed

N
W E
S

June, 2018

Scale: 1" = 400'

BETA
IMPROVING COMMUNITIES TOGETHER

Sewershed #41
Hynes Field

Sewershed #37
East Boulevard

Sewershed #38
South Boulevard

Onset Bay

HIGHLAND AVENUE
EAST CENTRAL AVENUE
TENTH STREET
C.W.BISHOP AVENUE
UNION STREET
UNION AVENUE
WABAN PLACE
WABAN AVENUE
ELEVENTH STREET
EAST BOULEVARD
MOBIL HOME PARK
OCEAN AVENUE
HOTEL STREET
ONSET AVENUE
PLEASANT AVENUE
PROSPECT AVENUE
SOUTH BOULEVARD

PS
PS
Onset Pier PS

Recommended Inspections:
– Smoke Testing
– Private Property Inspection/Dyed Water Testing
– Pipeline CCTV Inspection
– Manhole Inspection/Salinity Testing

Town of Wareham Massachusetts

Phase 2 - I/I Report

Sewershed #36
Onset Pier
(Ranking #2)

Completed & Recommended Work / Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed

N
W E
S

June, 2018

Scale: 1" = 150'

This map is intended to support the inventory of real property of the Town of Wareham. Map data should not be interpreted as the actual field survey data. This data should not be used for legal description or conveyance purposes.

BETA
IMPROVING COMMUNITIES TOGETHER

Town of Wareham
Massachusetts

Phase 2 - I/I Report

Sewershed #32
South Water
(Ranking #3)

Completed & Recommended Work / Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS — Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed
- Smoke Testing Completed

N
W E
S

June, 2018

Scale: 1" = 250'

This map is intended to support the inventory of real property of the Town of Wareham. Map data should not be interpreted as the actual field survey data. This data should not be used for legal description or conveyance purposes.

BETA
IMPROVING COMMUNITIES TOGETHER

Recommended Inspections:
– Smoke Testing (Portion)
– Private Property Inspection/Dyed Water Testing
– Pipeline CCTV Inspection
– Manhole Inspection/Salinity Testing

Sewershed #35
Onset Heights

Sewershed #36
Onset Pier

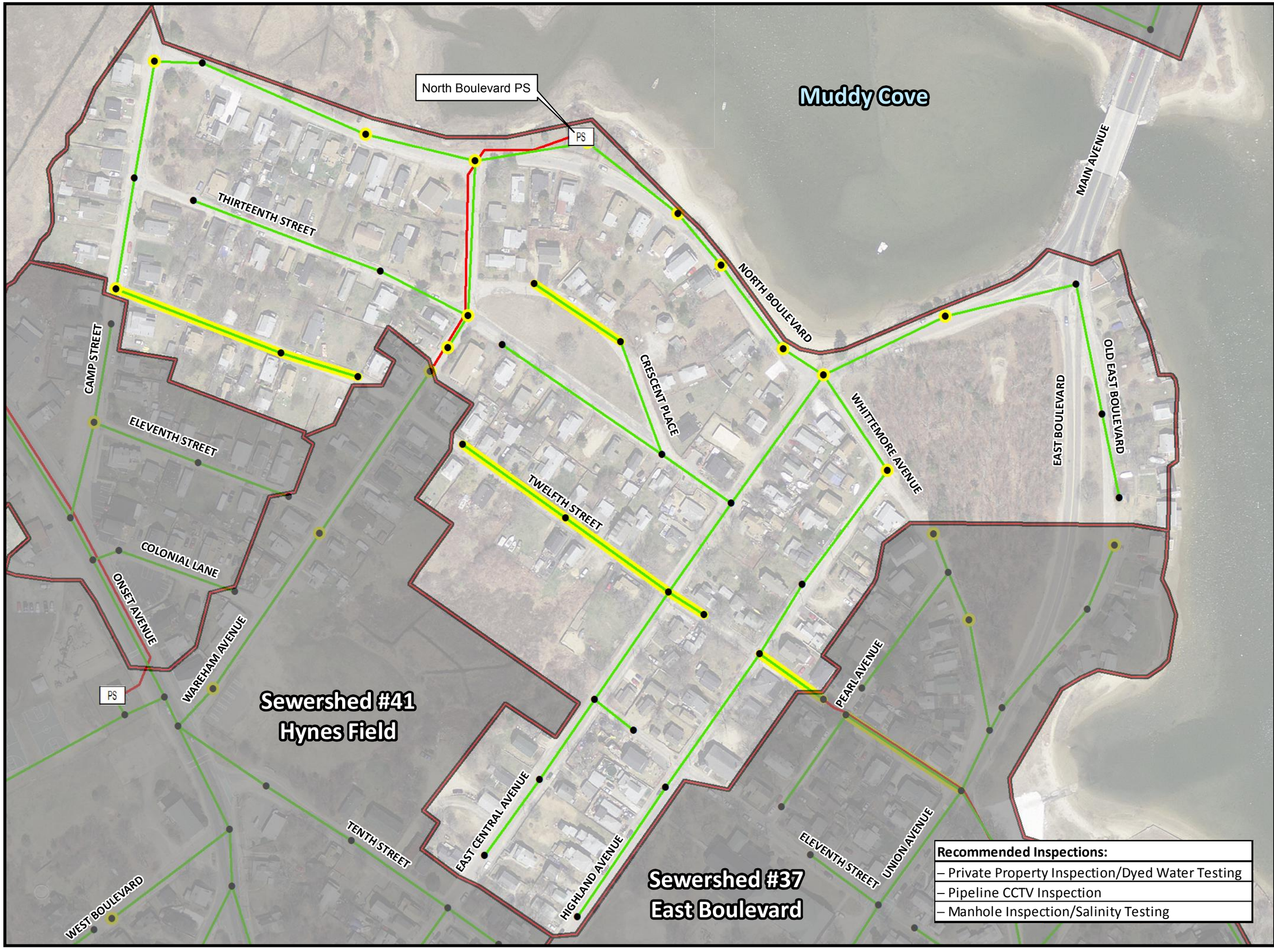
Sewershed #34
Bay Street

Onset Bay

South Water PS

PS

OLD EAST BOULEVARD
EAST BOULEVARD
ELEVENTH STREET
OCEAN AVENUE
COVE STREET
UPLAND ROAD
ACORN AVENUE EAST
NORTH WATER STREET
SANDLEWOOD LANE
DALE AVENUE
DOGWOOD LANE
FERN AVENUE
GROVE STREET
LOCUST STREET
CARLETON PLACE
HOLLY STREET
SYCAMORE STREET
MYRTLE STREET
HAMMOND STREET
PECAN STREET
EAGLE WAY
PEQUOD LANE
ADMIRALS WAY
ONSET BAY LANE
CLEARWATER DRIVE
INDEPENDENCE LANE
PRIVATE DRIVEWAY
MAPLE STREET
CAMERON STREET
GRAY STREET
NANUMETT STREET
ONSET AVENUE
CHARLIE AVENUE
ARTHUR STREET
ONSET STREET EXTENSION



Town of Wareham Massachusetts

Phase 2 - I/I Report

Sewershed #40
North Boulevard
(Ranking #4)

Completed & Recommended Work / Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS — Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed

N W E S

June, 2018

Scale: 1" = 150'

BETA
IMPROVING COMMUNITIES TOGETHER

Town of Wareham
Massachusetts

Phase 2 - I/I Report

Sewershed #10
Ruggles
(Ranking #5)

Completed & Recommended Work / Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS — Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed

N
W E
S

June, 2018

Scale: 1" = 200'

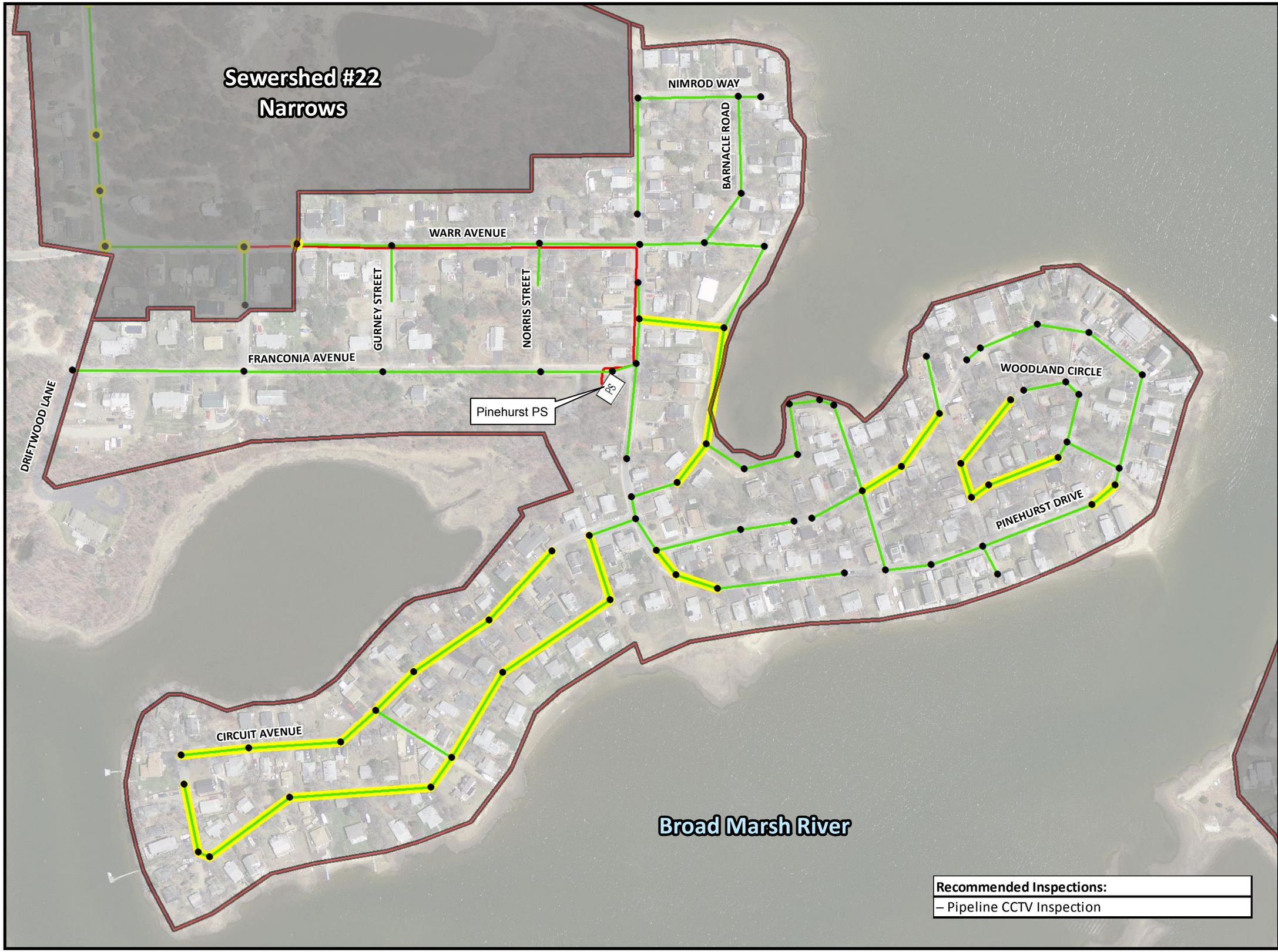
This map is intended to support the inventory of real property of the Town of Wareham. Map data should not be interpreted as the actual field survey data. This data should not be used for legal description or conveyance purposes.

BETA
IMPROVING COMMUNITIES TOGETHER

Sewershed #11
Smith

SWIFT AVENUE
QUASUET AVENUE
GREENWOOD AVENUE
VERNAL STREET
GRAHAM STREET
WINDY STREET
BELMONT STREET
POND STREET
BEACH STREET
T STREET
SWIFTS BEACH ROAD
CIRCLE DRIVE
TRINITY LANE
GALAVOTTI AVENUE
EVERETT AVENUE
OCEANSIDE DRIVE
ROBY STREET
COLUMBIA STREET
BARNES STREET
PLEASANT STREET
BAYVIEW STREET
WANKINCO AVENUE
MURPHY STREET
PS
Ruggles PS
Wareham River

Recommended Inspections:
– Private Property Inspection/Dyed Water Testing
– Pipeline CCTV Inspection
– Manhole Inspection/Salinity Testing



Recommended Inspections:

– Pipeline CCTV Inspection

Town of Wareham Massachusetts

Phase 2 - I/I Report

Sewershed #23
Pinehurst
(Ranking #8)

Completed & Recommended Work / Investigations

Locus Map

Wastewater

- Force Main Sewer
- Gravity Sewer Pipe
- Gravity CIPP Sewer Pipe
- PS — Sewer Pump Station
- Existing WWTF Outfall
- Existing Manhole
- Existing Sewershed

Completed Inspection Summary

- Inspected Manhole (SMH)
- Pipe Inspection Completed

June, 2018

Scale: 1" = 200'

BETA
IMPROVING COMMUNITIES TOGETHER

APPENDIX B

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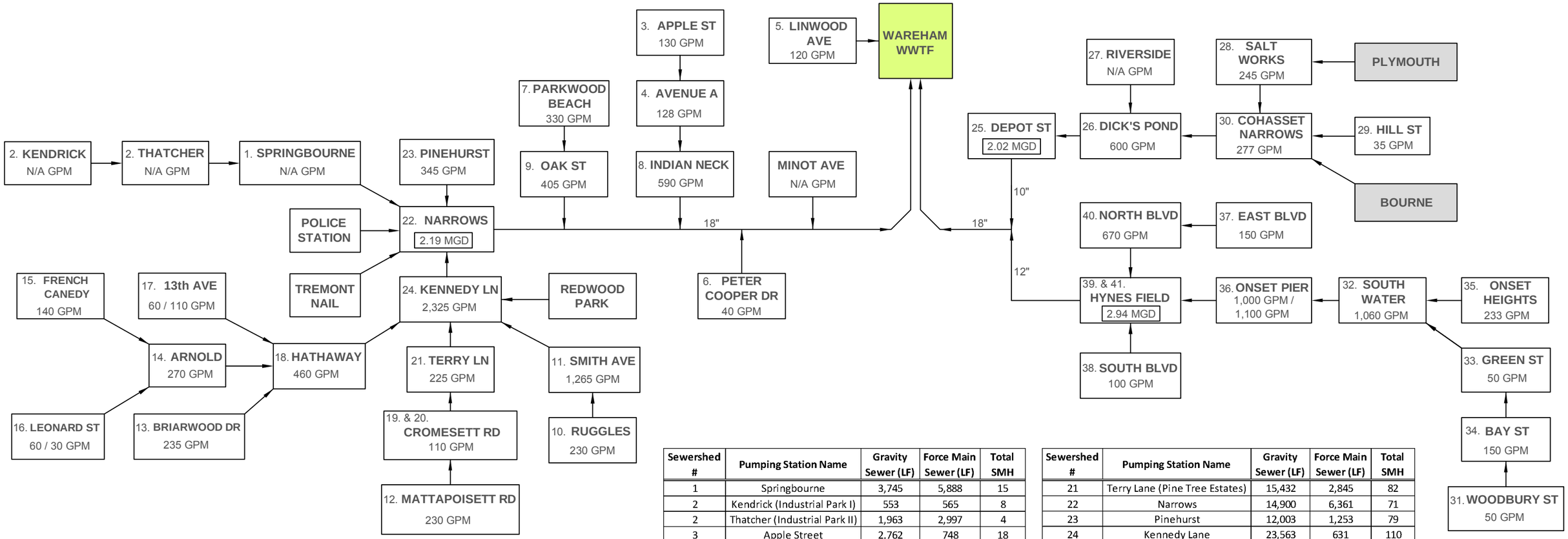

Sewershed #	Pumping Station Name	Gravity Sewer (LF)	Force Main Sewer (LF)	Total SMH
1	Springbourne	3,745	5,888	15
2	Kendrick (Industrial Park I)	553	565	8
2	Thatcher (Industrial Park II)	1,963	2,997	4
3	Apple Street	2,762	748	18
4	Avenue A	4,845	858	26
5	Linwood Avenue	1,587	216	13
6	Peter Cooper Drive	1,568	3,691	5
7	Parkwood Beach	20,162	2,709	104
8	Indian Neck	5,913	316	40
9	Oak Street	2,846	994	18
10	Ruggles	7,541	587	41
11	Smith Avenue	33,672	4,075	207
12	Mattapoisett Road	1,412	33	7
13	Briarwood Drive	11,351	2,298	57
14	Arnold	8,954	1,727	48
15	French-Canedy	2,903	1,117	12
16	Leonard Street	4,157	518	20
17	13th Avenue	3,183	460	18
18	Hathaway	16,840	4,859	74
19, 20	Cromesett Road	6,332	3,781	28

Sewershed #	Pumping Station Name	Gravity Sewer (LF)	Force Main Sewer (LF)	Total SMH
21	Terry Lane (Pine Tree Estates)	15,432	2,845	82
22	Narrows	14,900	6,361	71
23	Pinehurst	12,003	1,253	79
24	Kennedy Lane	23,563	631	110
25	Depot Street	4,287	1,597	17
26	Dick's Pond	10,401	1,534	41
27	Riverside	6,576	450	35
28	Salt Works Road	11,153	328	65
29	Hill Street	3,478	1,139	41
30	Cohasset Narrows	21,344	5,673	116
31	Woodbury Street	1,663	625	9
32	South Water	17,520	369	113
33	Green Street	536	117	6
34	Bay Street	8,808	1,814	49
35	Onset Heights	6,205	750	38
36	Onset Pier	5,121	1,207	30
37	East Boulevard	4,777	537	35
38	South Boulevard	2,702	203	14
39, 41	Hynes Field	24,531	8,064	136
40	North Boulevard	7,488	563	39
–	Minot Avenue	–	2,322	–
–	Police Station	–	–	–
–	Tremont Nail	–	–	–
–	Redwood Park	–	–	–

= FLOWS FROM ADJACENT TOWN

J:\WAREHAM\INFILTRATION AND INFLOW\AUTOCAD\WAREHAM PS SCHEMATIC (REPORT).DWG

BETA
www.BETA-Inc.com

PHASE 2 INFILTRATION & INFLOW REPORT

WAREHAM, MA

Plot Date: 6/28/2018 5:27 PM

WAREHAM PUMP STATION FLOW SCHEMATIC

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APPENDIX C

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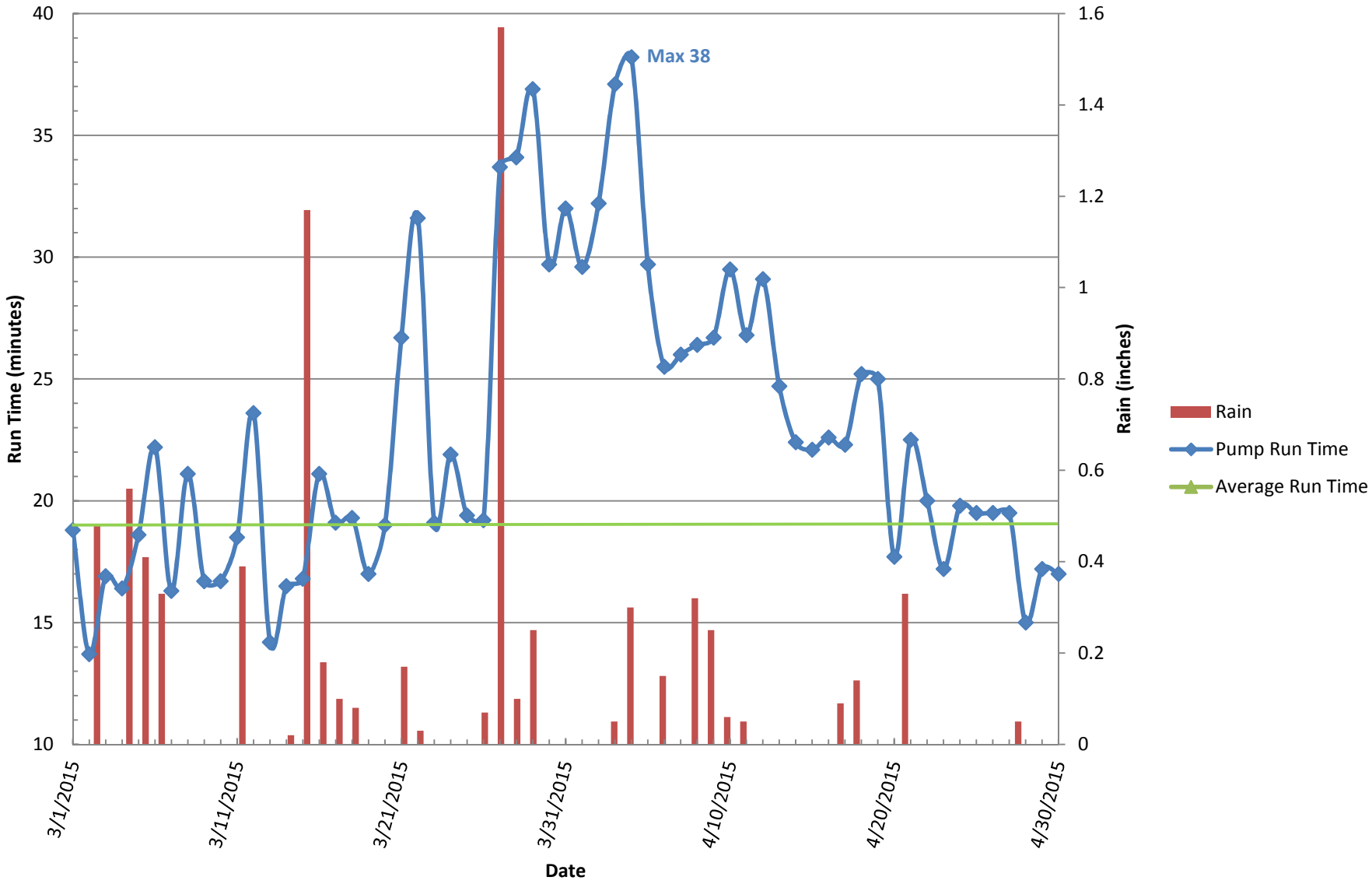
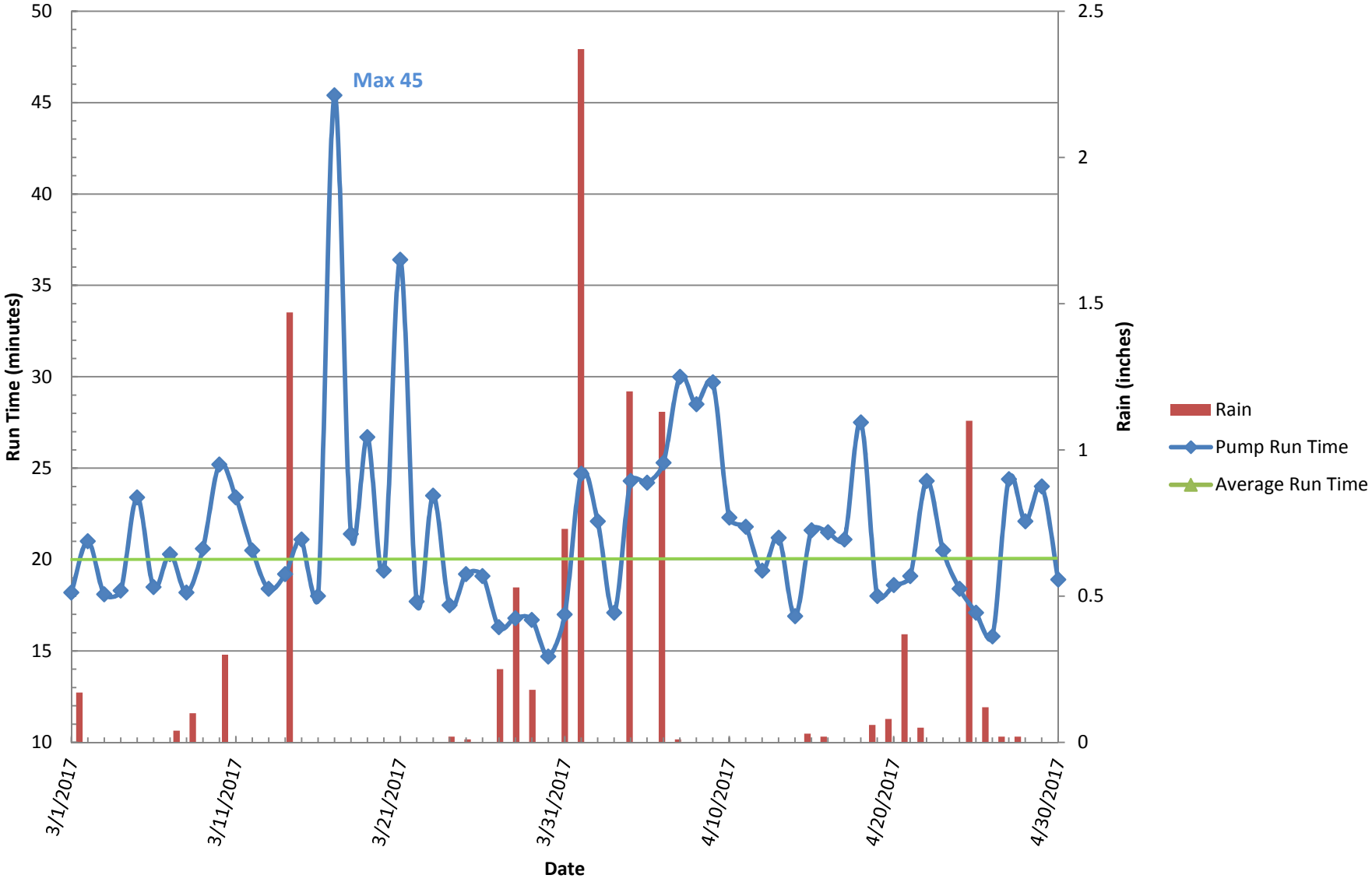
-Sewershed: 3 (2,762 LF pipe)
-Capacity: ± 130 gpm
-Average Dry-Weather Run-Time: 19 min

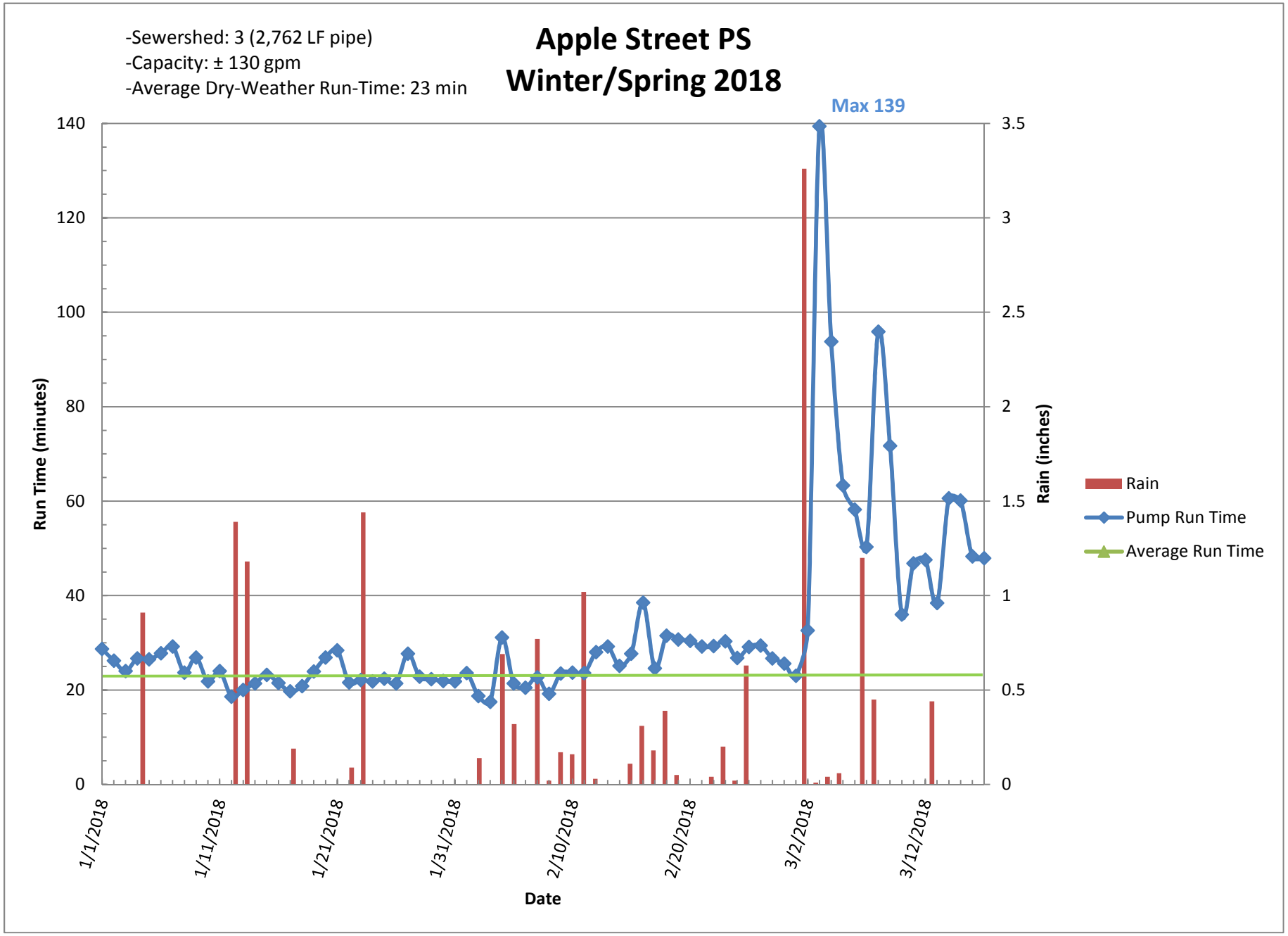
Apple Street PS
Spring 2015



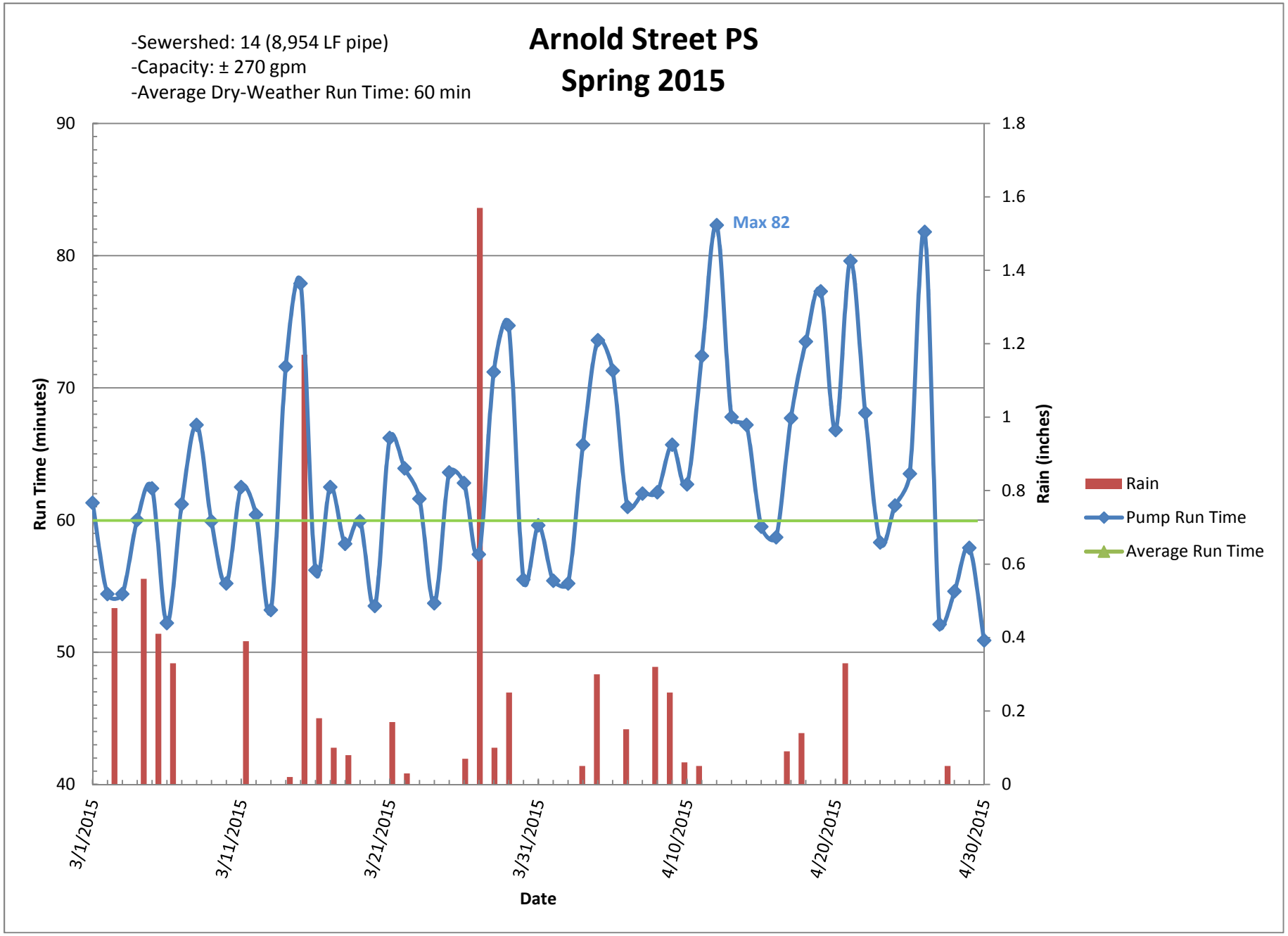
-Sewershed: 3 (2,762 LF pipe)
-Capacity: ± 130 gpm
-Average Dry-Weather Run-Time: 20 min

Apple Street PS
Spring 2017



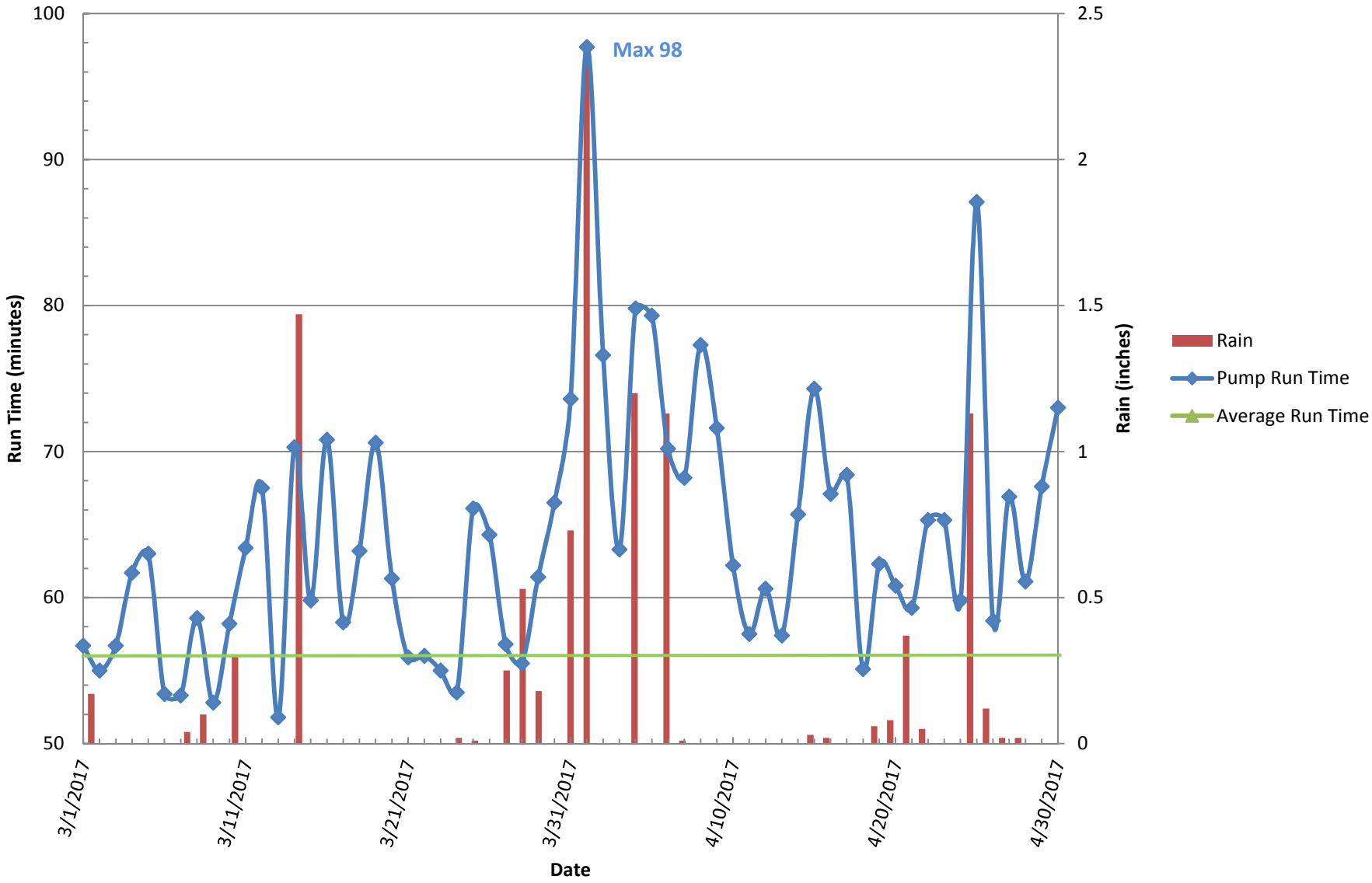

-Sewershed: 3 (2,762 LF pipe)
-Capacity: ± 130 gpm
-Average Dry-Weather Run-Time: 23 min
Apple Street PS
Winter/Spring 2018
Max 139
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
0
20
40
60
80
100
120
140
0
0.5
1
1.5
2
2.5
3
3.5
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018

-Sewershed: 14 (8,954 LF pipe)
-Capacity: ± 270 gpm
-Average Dry-Weather Run Time: 60 min



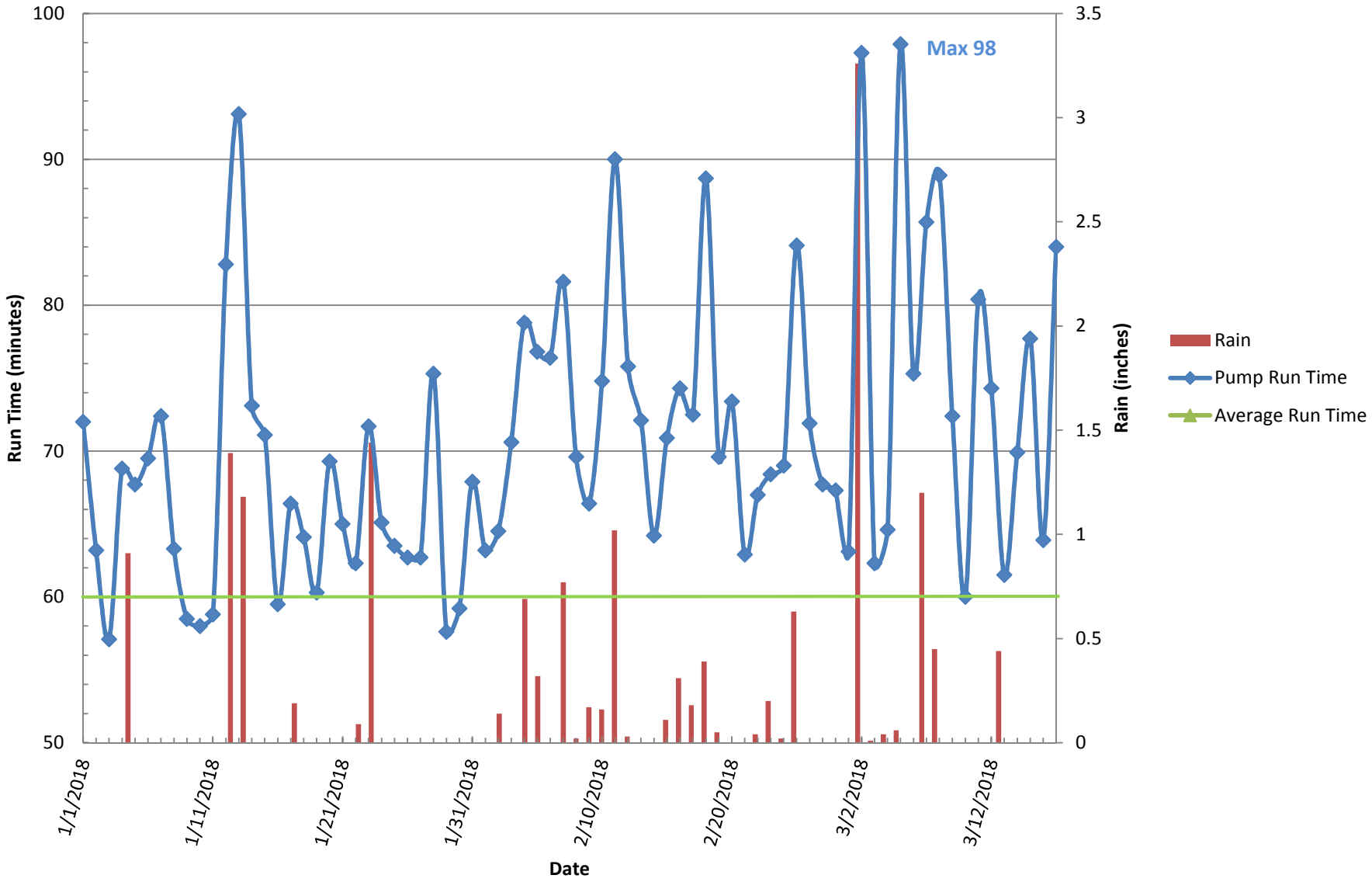
-Sewershed: 14 (8,954 LF pipe)
-Capacity: ± 270 gpm
-Average Dry-Weather Run Time: 56 min

Arnold Street PS
Spring 2017



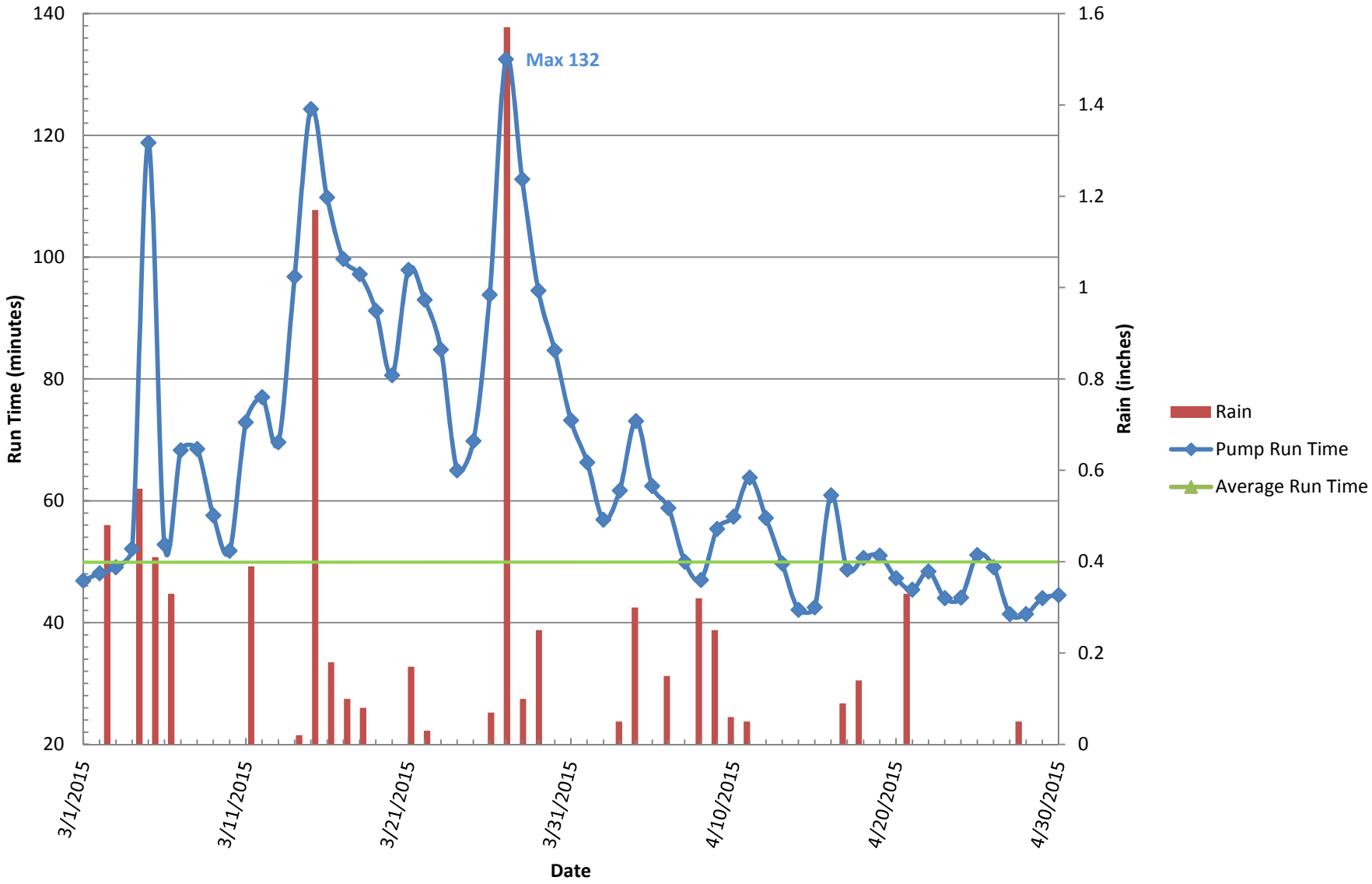
-Sewershed: 14 (8,954 LF pipe)
-Capacity: ± 270 gpm
-Average Dry-Weather Run Time: 60 min

Arnold Street PS
Winter/Spring 2018

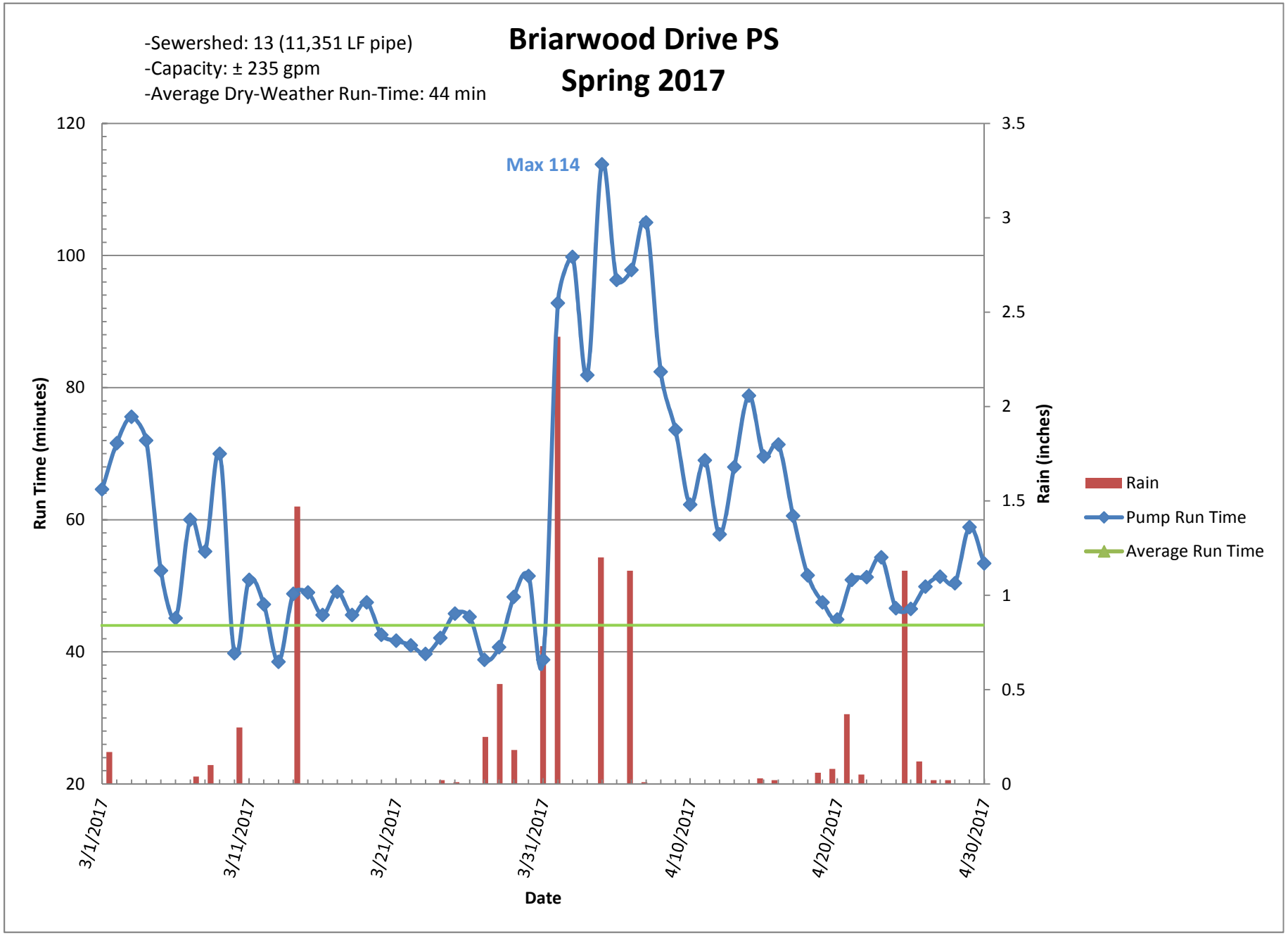


-Sewershed: 13 (11,351 LF pipe)
-Capacity: ± 235 gpm
-Average Dry-Weather Run-Time: 50 min

Briarwood Drive PS
Spring 2015

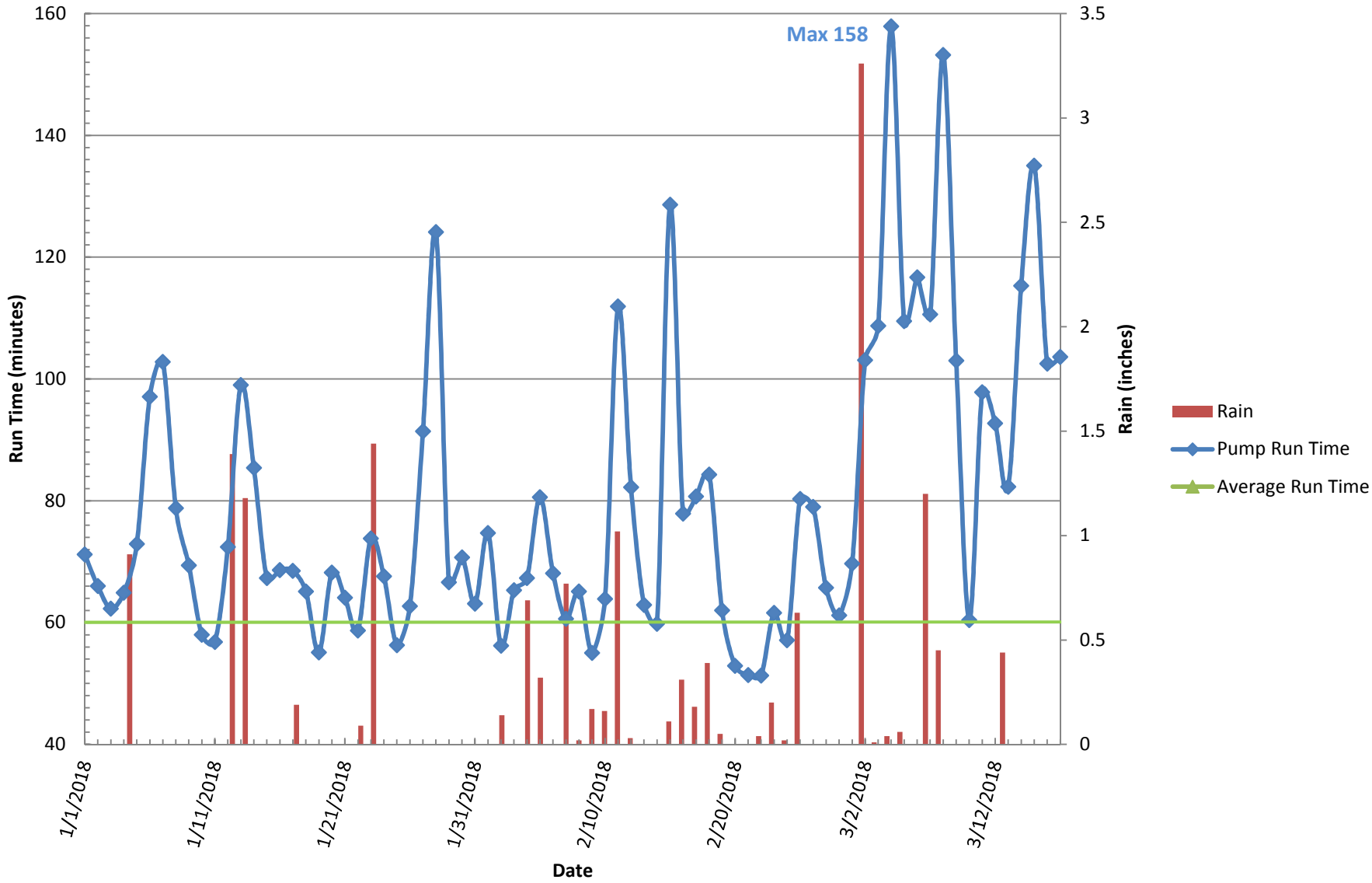


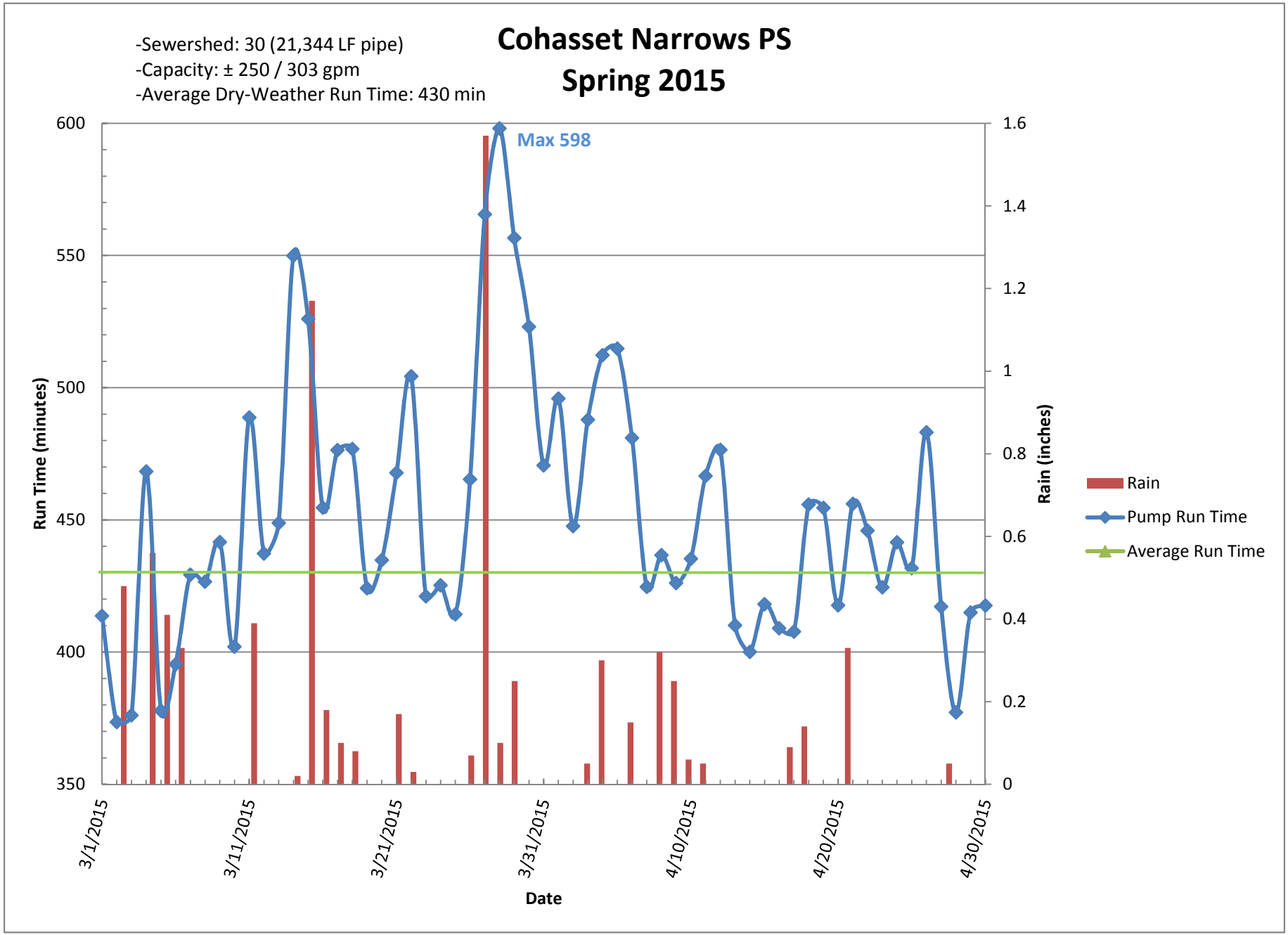
-Sewershed: 13 (11,351 LF pipe)
-Capacity: ± 235 gpm
-Average Dry-Weather Run-Time: 44 min

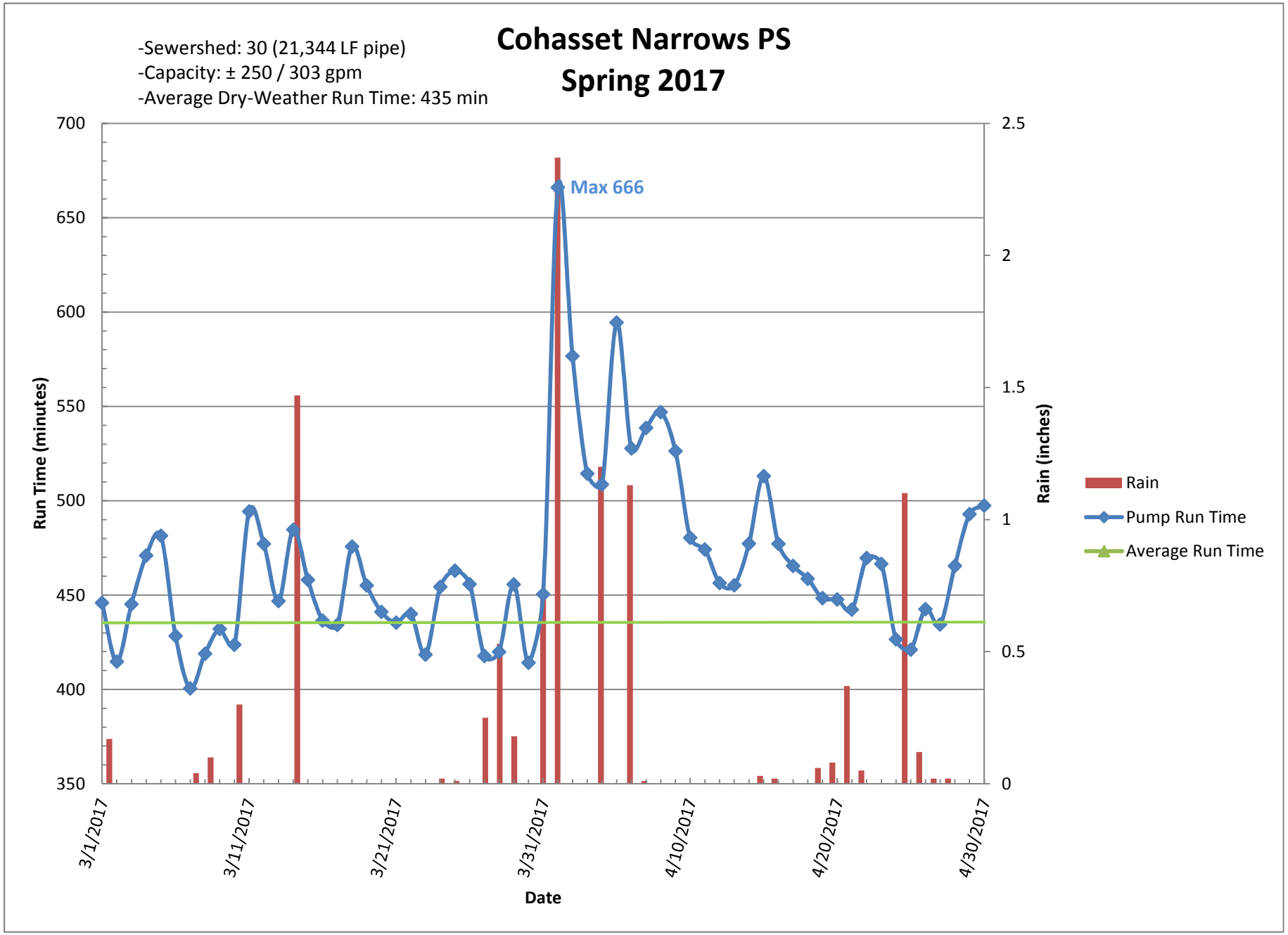


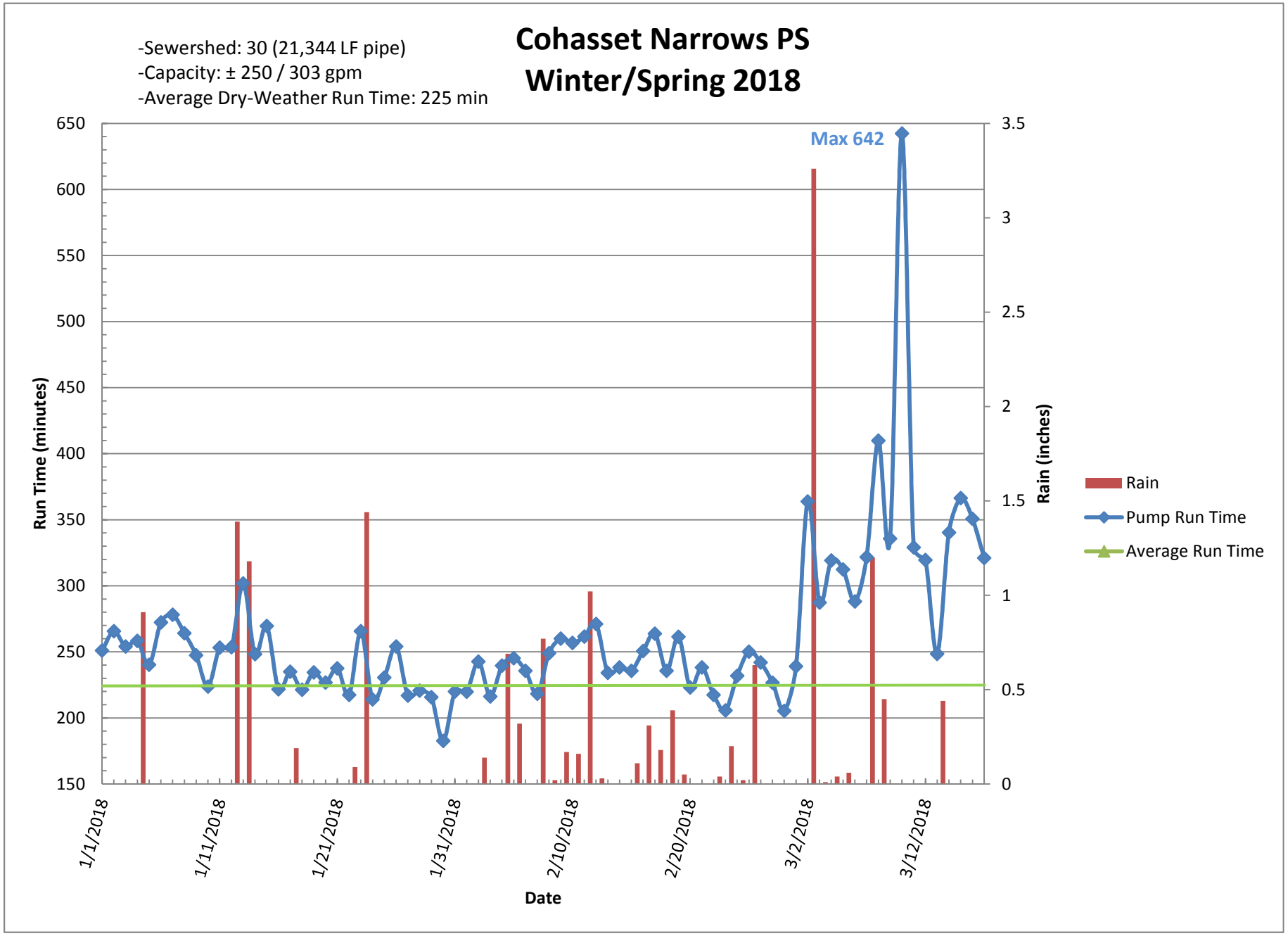
-Sewershed: 13 (11,351 LF pipe)
-Capacity: ± 235 gpm
-Average Dry-Weather Run-Time: 60 min

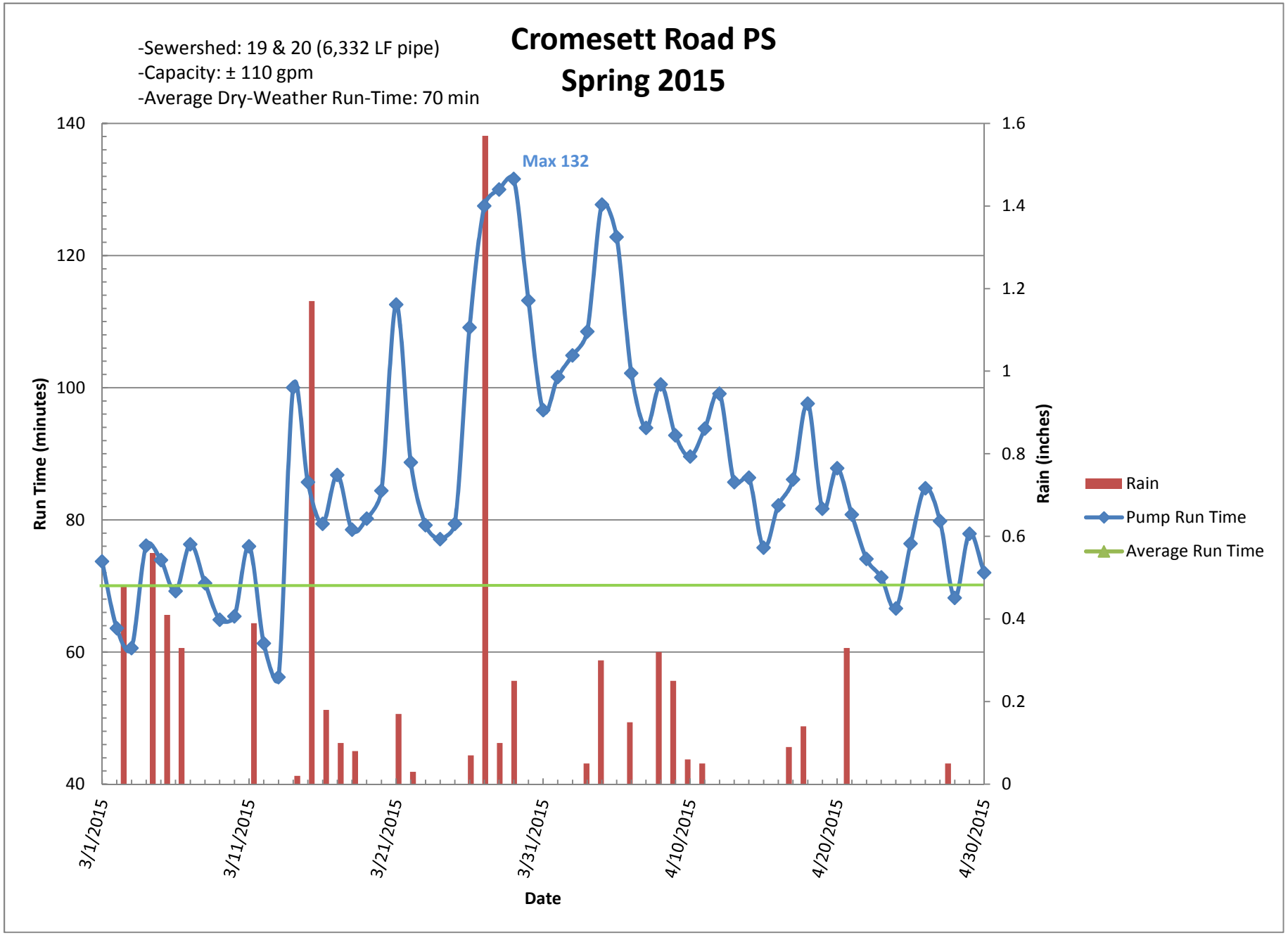
Briarwood Drive PS
Winter/Spring 2018

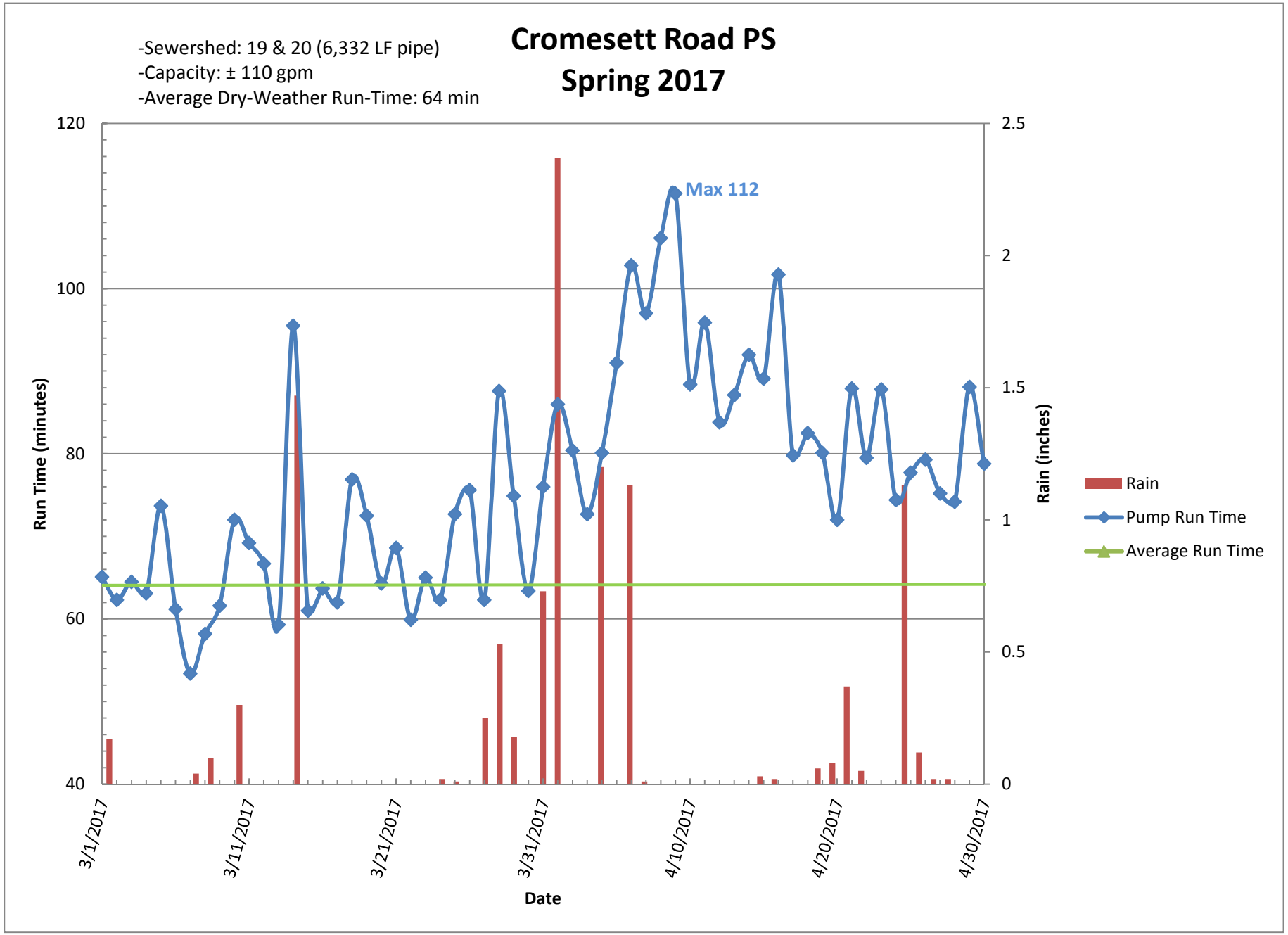


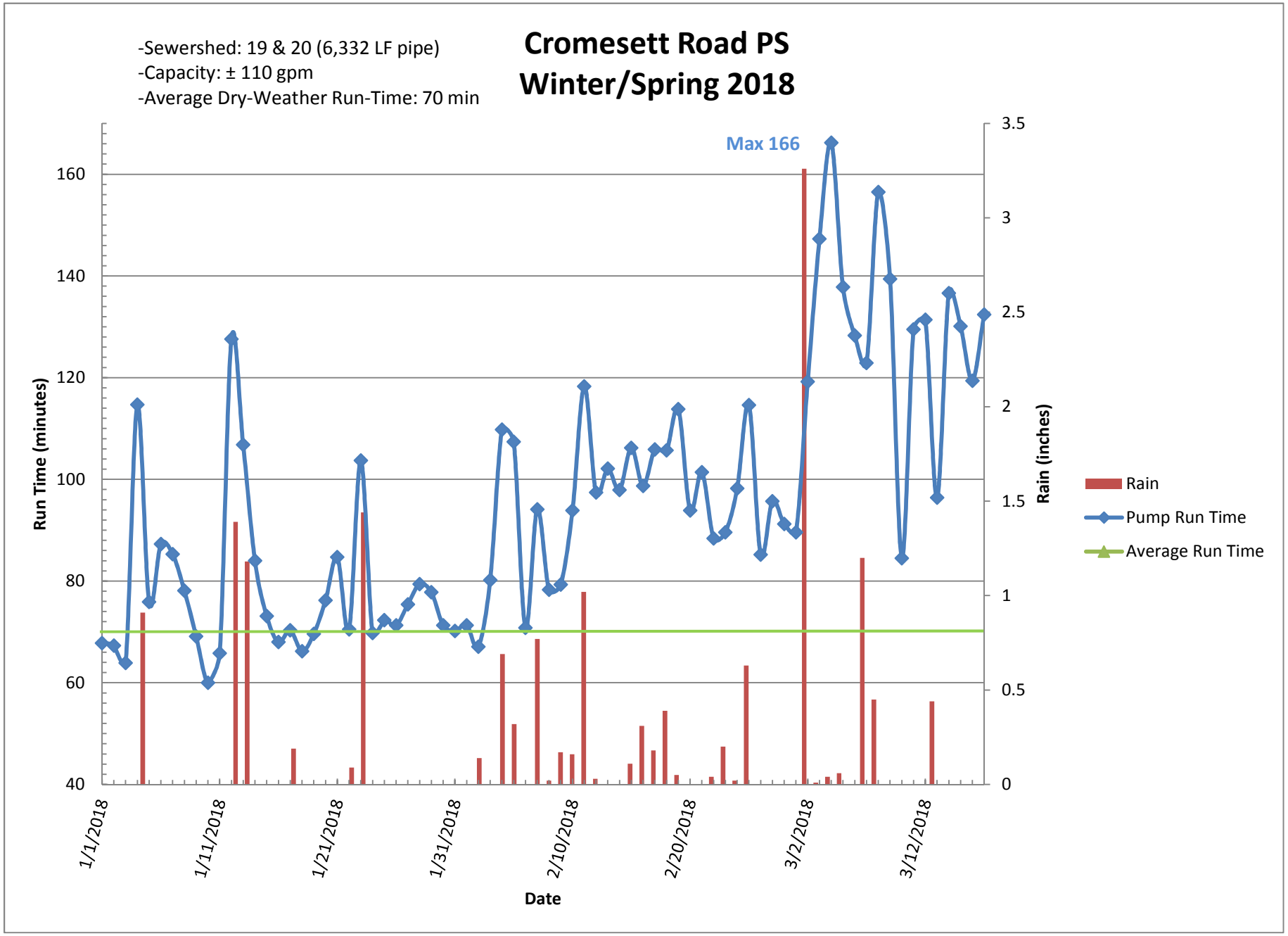

Cohasset Narrows PS
Spring 2015
-Sewershed: 30 (21,344 LF pipe)
-Capacity: ± 250 / 303 gpm
-Average Dry-Weather Run Time: 430 min
Max 598
Run Time (minutes)
Rain (inches)
600
550
500
450
400
350
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015
Date
Rain
Pump Run Time
Average Run Time


Cohasset Narrows PS
Spring 2017
-Sewershed: 30 (21,344 LF pipe)
-Capacity: ± 250 / 303 gpm
-Average Dry-Weather Run Time: 435 min
Max 666
Run Time (minutes)
Rain (inches)
Date
700
650
600
550
500
450
400
350
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Rain
Pump Run Time
Average Run Time


Cohasset Narrows PS
Winter/Spring 2018
-Sewershed: 30 (21,344 LF pipe)
-Capacity: ± 250 / 303 gpm
-Average Dry-Weather Run Time: 225 min
Max 642
Run Time (minutes)
Rain (inches)
Date
650
600
550
500
450
400
350
300
250
200
150
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018
Rain
Pump Run Time
Average Run Time

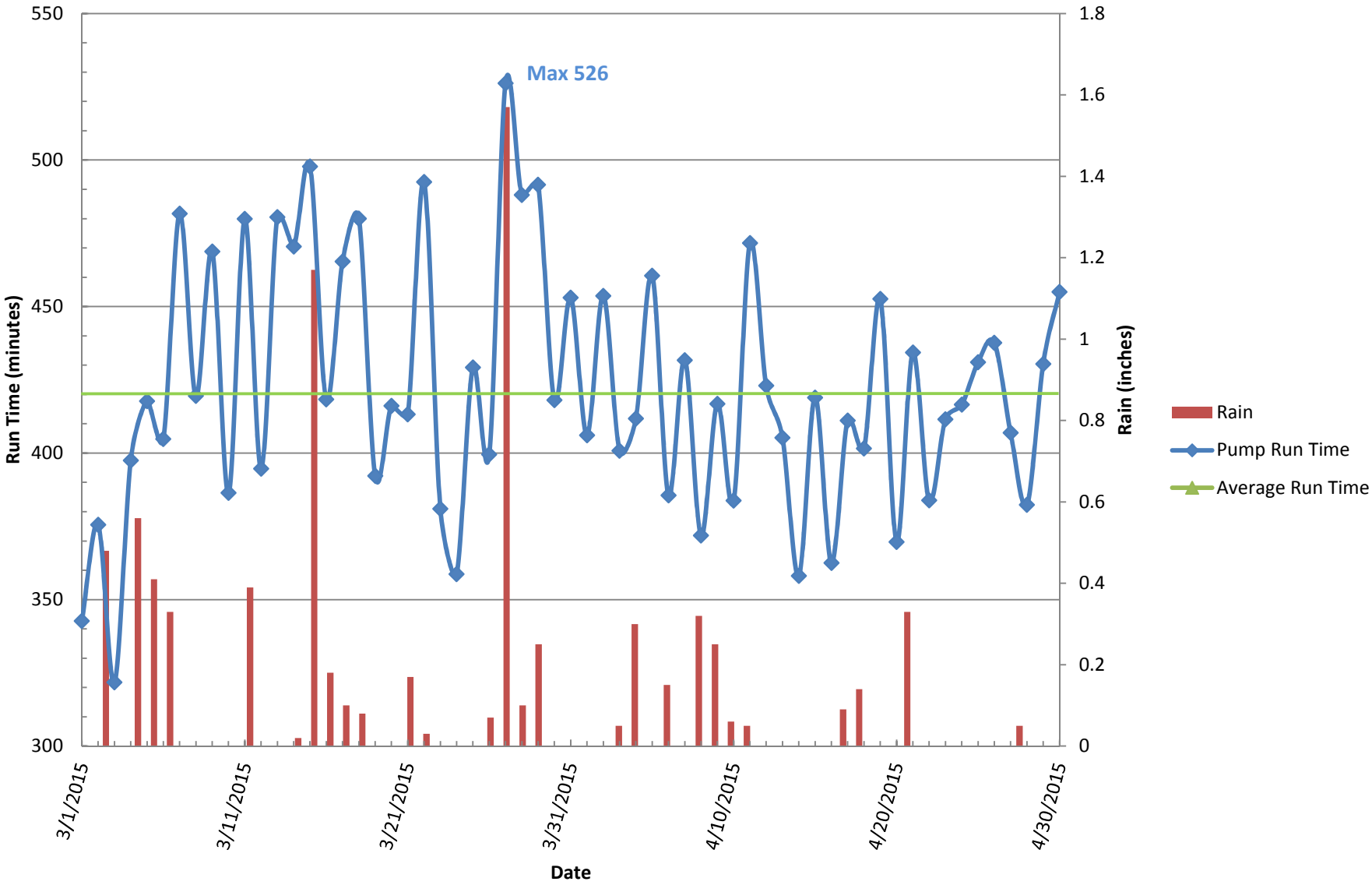

Cromesett Road PS
Spring 2015
-Sewershed: 19 & 20 (6,332 LF pipe)
-Capacity: ± 110 gpm
-Average Dry-Weather Run-Time: 70 min
Max 132
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
140
120
100
80
60
40
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015

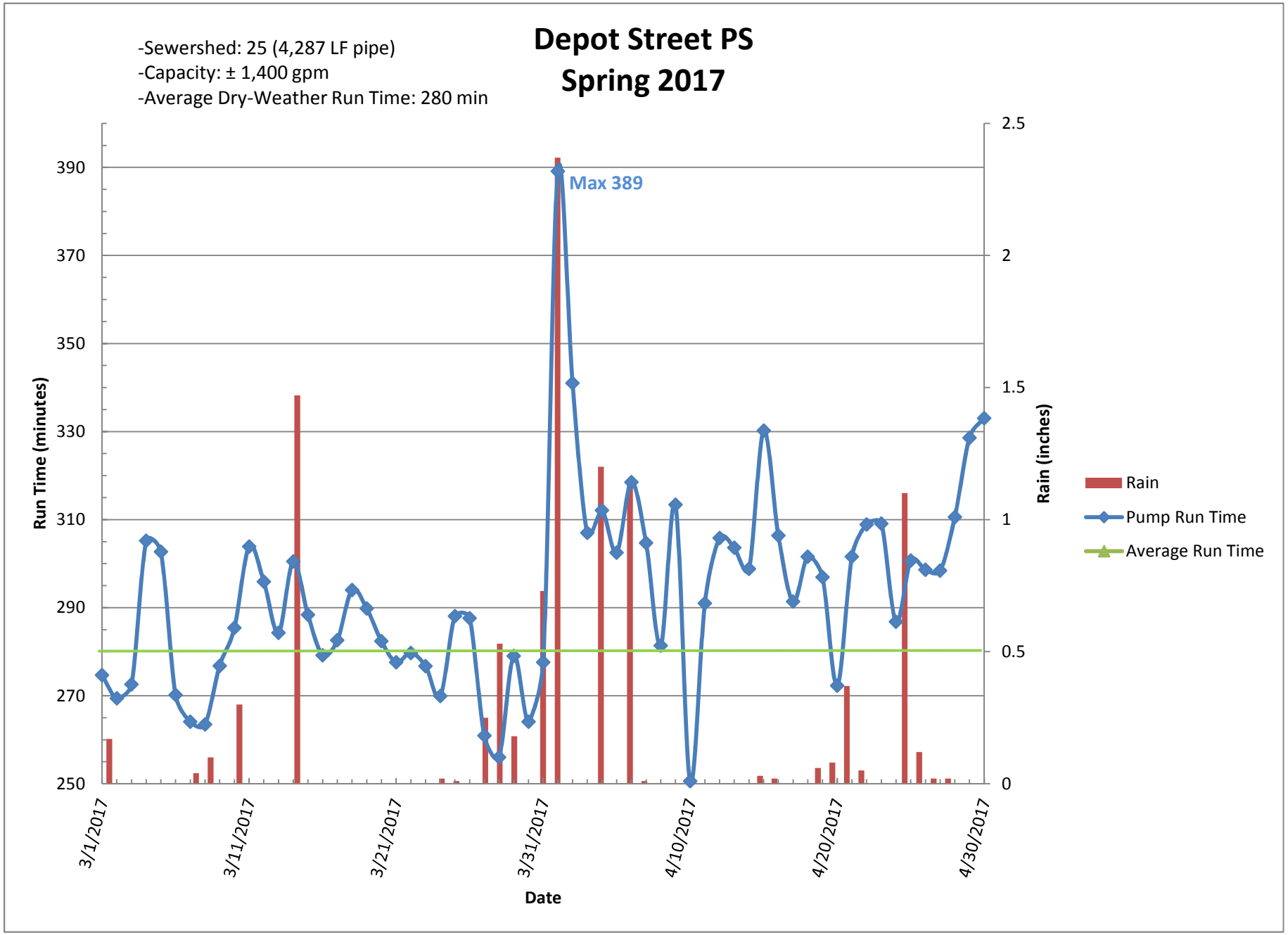

Cromesett Road PS
Spring 2017
-Sewershed: 19 & 20 (6,332 LF pipe)
-Capacity: ± 110 gpm
-Average Dry-Weather Run-Time: 64 min
Max 112
Run Time (minutes)
Rain (inches)
Date
120
100
80
60
40
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Rain
Pump Run Time
Average Run Time

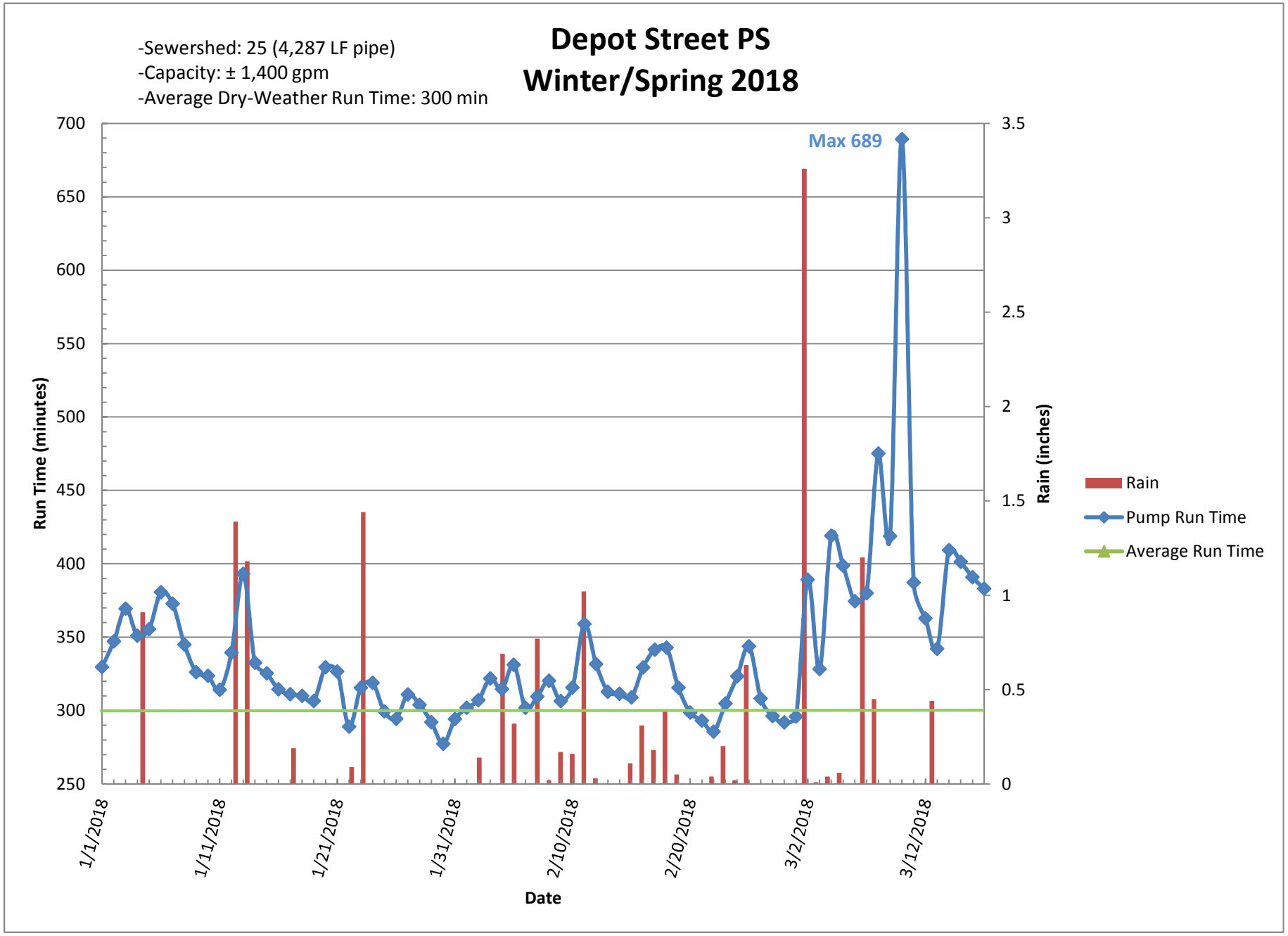

-Sewershed: 19 & 20 (6,332 LF pipe)
-Capacity: ± 110 gpm
-Average Dry-Weather Run-Time: 70 min
Cromesett Road PS
Winter/Spring 2018
Max 166
Run Time (minutes)
Rain (inches)
160
140
120
100
80
60
40
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018
Date
Rain
Pump Run Time
Average Run Time

-Sewershed: 25 (4,287 LF pipe)
-Capacity: ± 1,400 gpm
-Average Dry-Weather Run-Time: 420 min

Depot Street PS
Spring 2015

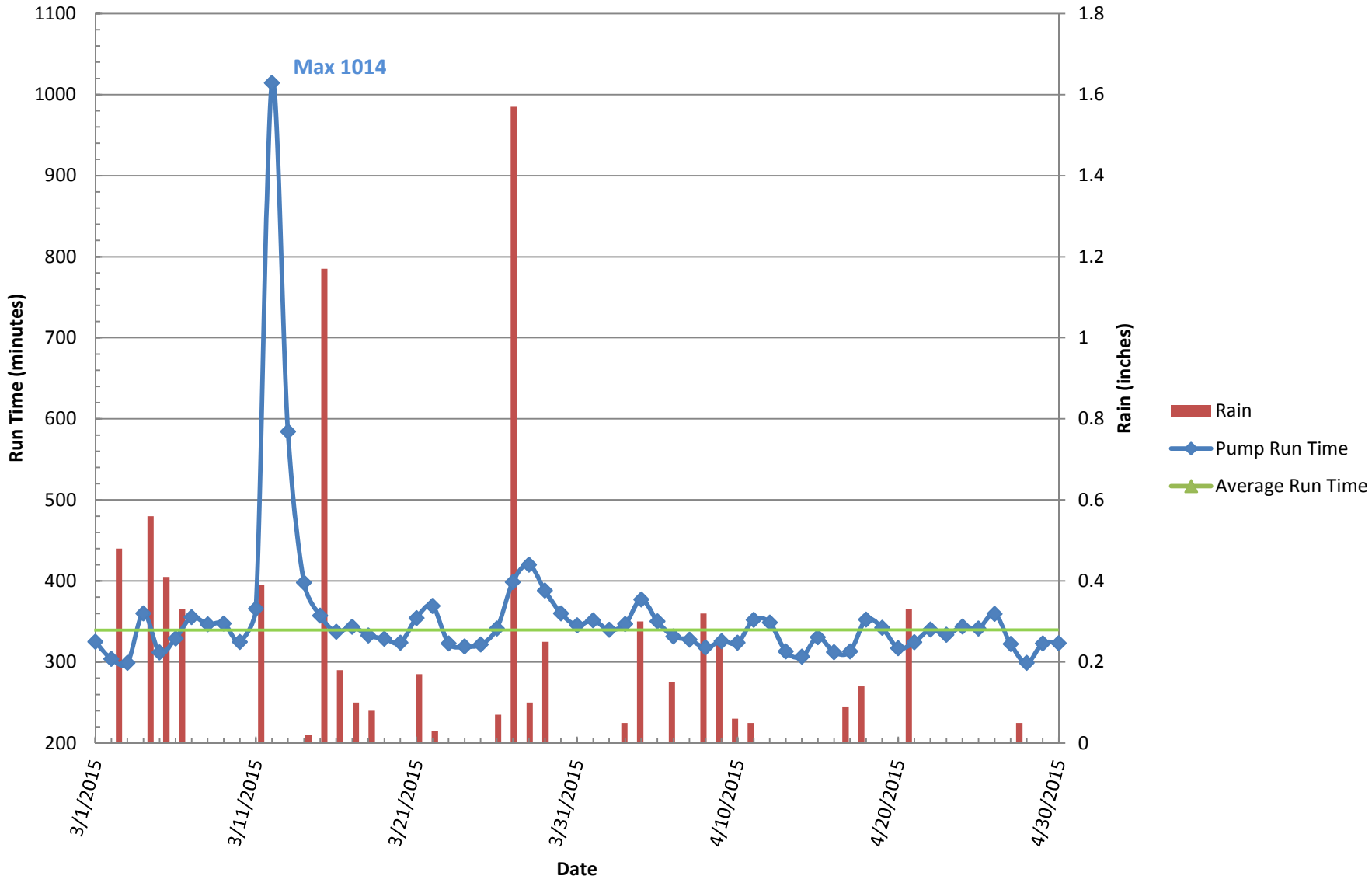


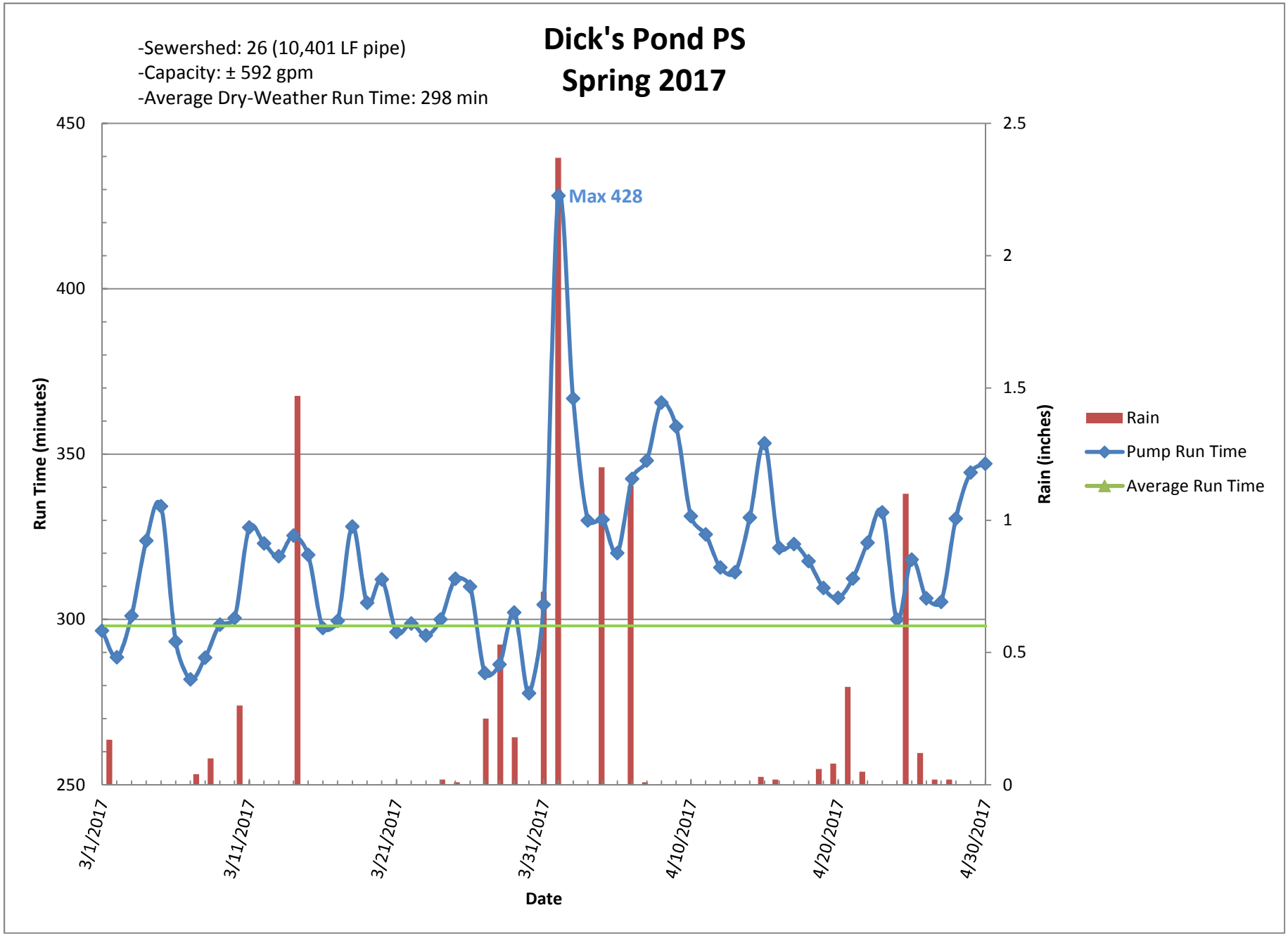

Depot Street PS
Spring 2017
-Sewershed: 25 (4,287 LF pipe)
-Capacity: ± 1,400 gpm
-Average Dry-Weather Run Time: 280 min
Max 389
Run Time (minutes)
Rain (inches)
Date
390
370
350
330
310
290
270
250
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Rain
Pump Run Time
Average Run Time

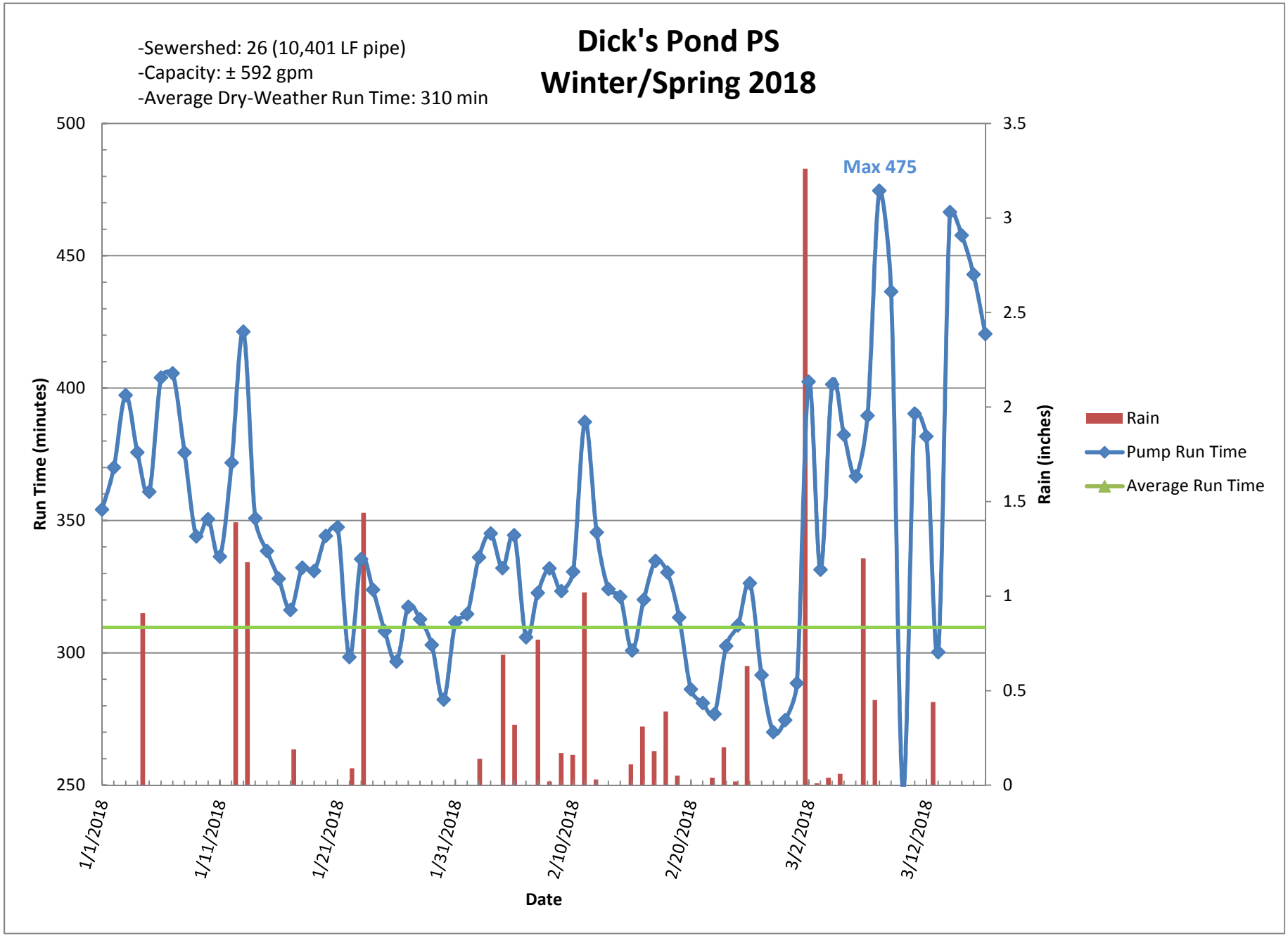

Depot Street PS
Winter/Spring 2018
-Sewershed: 25 (4,287 LF pipe)
-Capacity: ± 1,400 gpm
-Average Dry-Weather Run Time: 300 min
Max 689
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
700
650
600
550
500
450
400
350
300
250
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018

-Sewershed: 26 (10,401 LF pipe)
-Capacity: ± 592 gpm
-Average Dry-Weather Run-Time: 340 min

Dick's Pond PS
Spring 2015

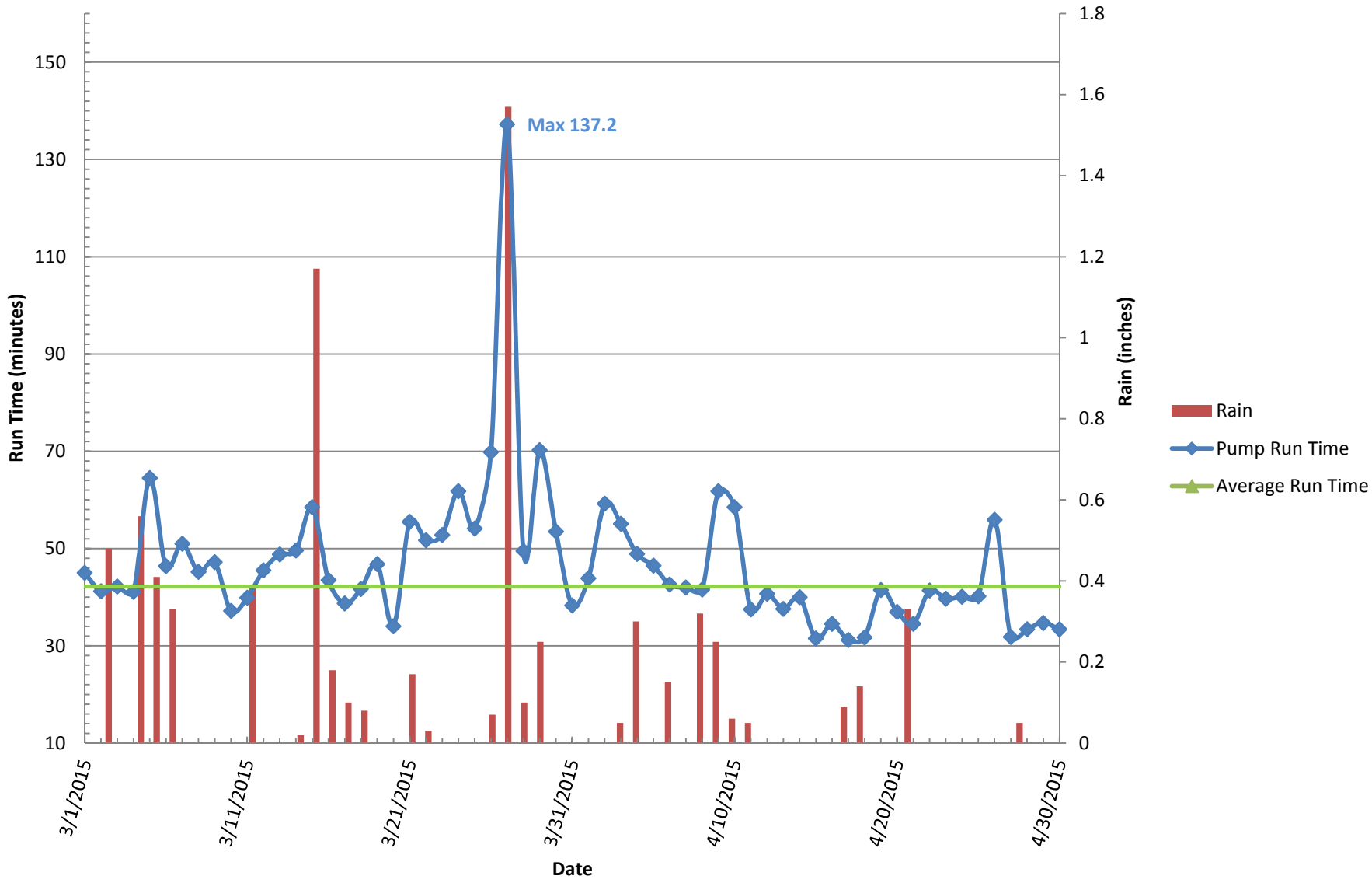


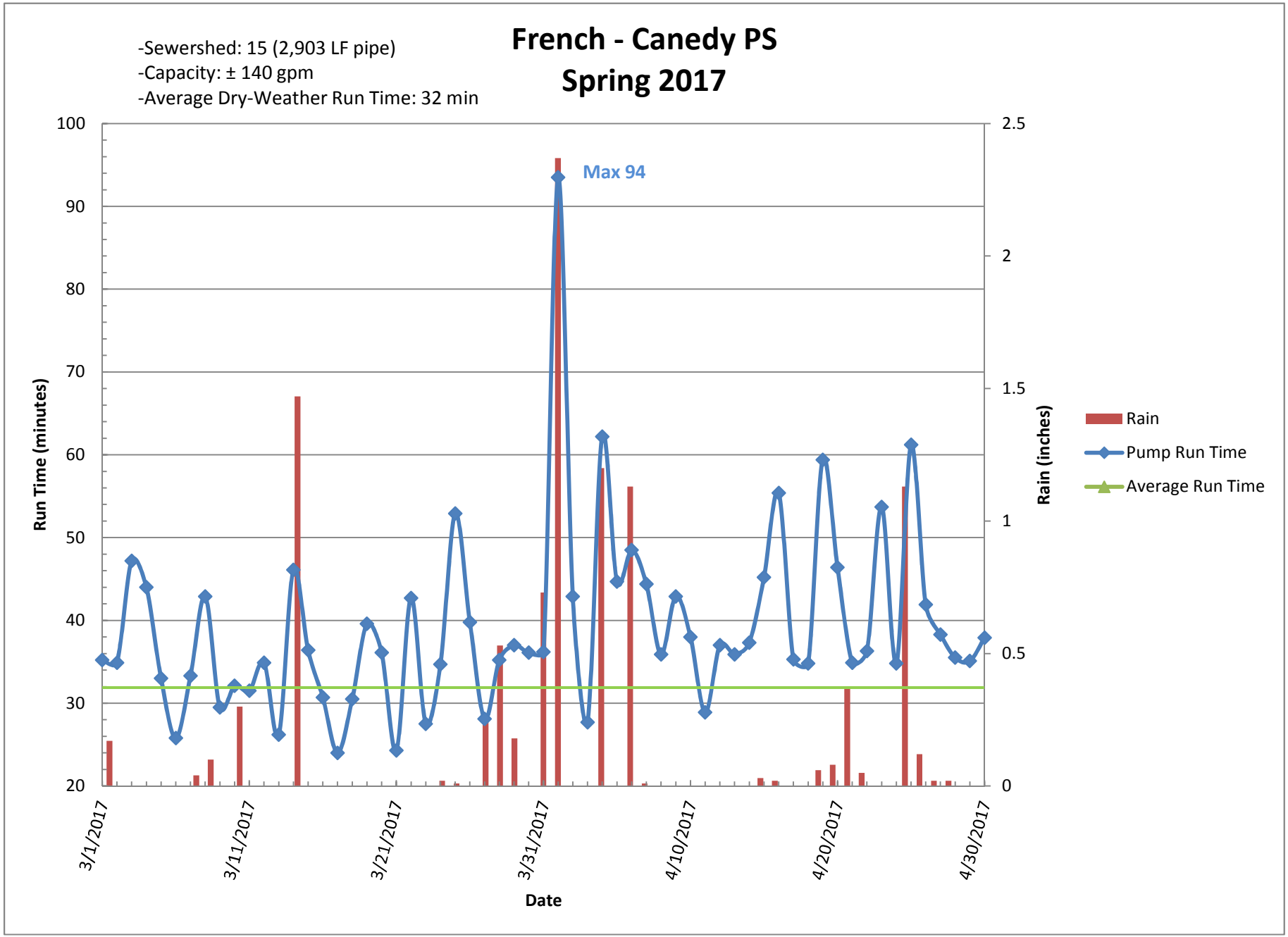

Dick's Pond PS
Spring 2017
-Sewershed: 26 (10,401 LF pipe)
-Capacity: ± 592 gpm
-Average Dry-Weather Run Time: 298 min
Max 428
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
450
400
350
300
250
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017

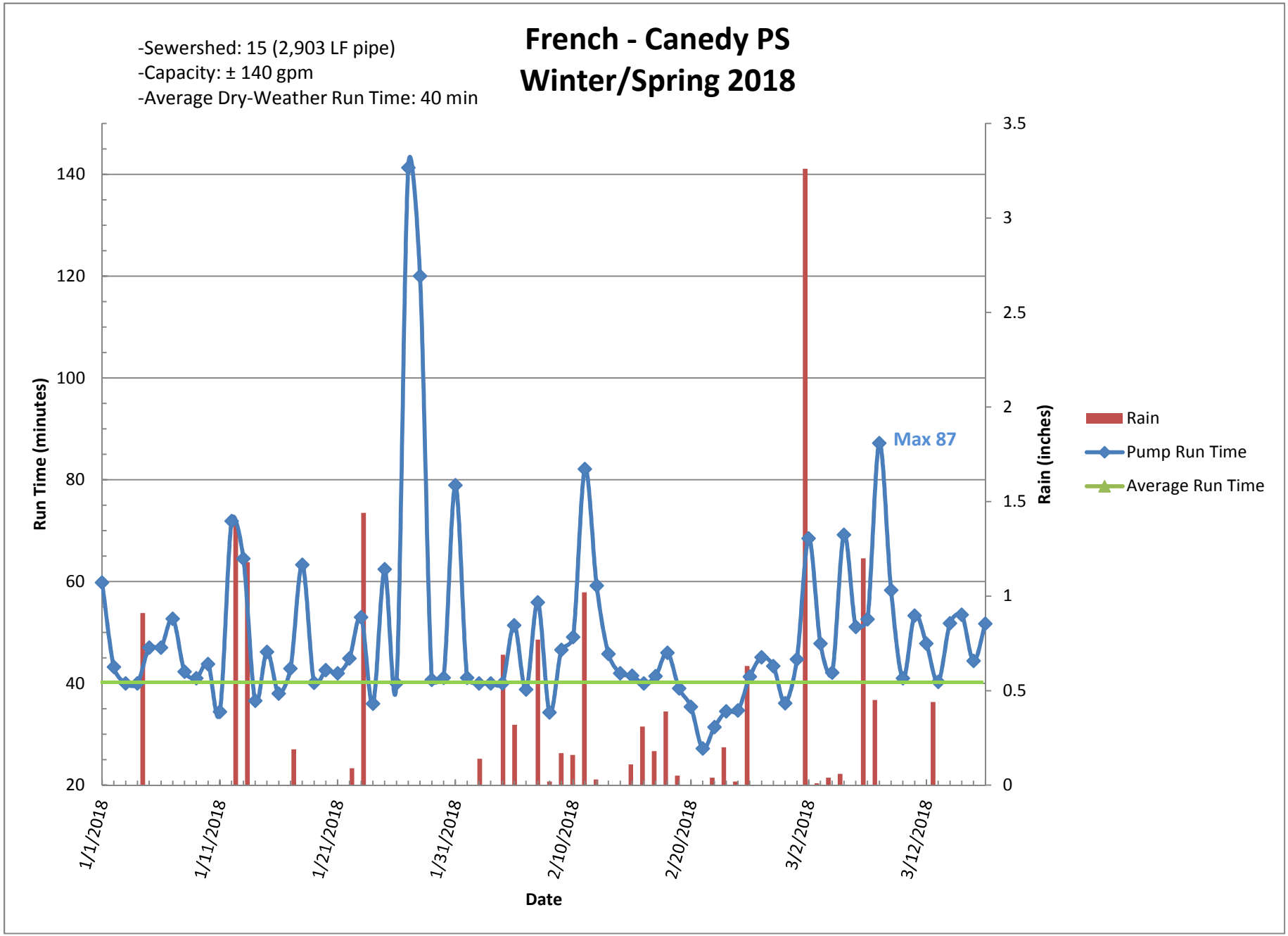

-Sewershed: 26 (10,401 LF pipe)
-Capacity: ± 592 gpm
-Average Dry-Weather Run Time: 310 min
Dick's Pond PS
Winter/Spring 2018
Max 475
Run Time (minutes)
Rain (inches)
Date
500
450
400
350
300
250
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018
Rain
Pump Run Time
Average Run Time

-Sewershed: 15 (2,903 LF pipe)
-Capacity: ± 140 gpm
-Average Dry-Weather Run Time: 42 min

French - Canedy PS
Spring 2015

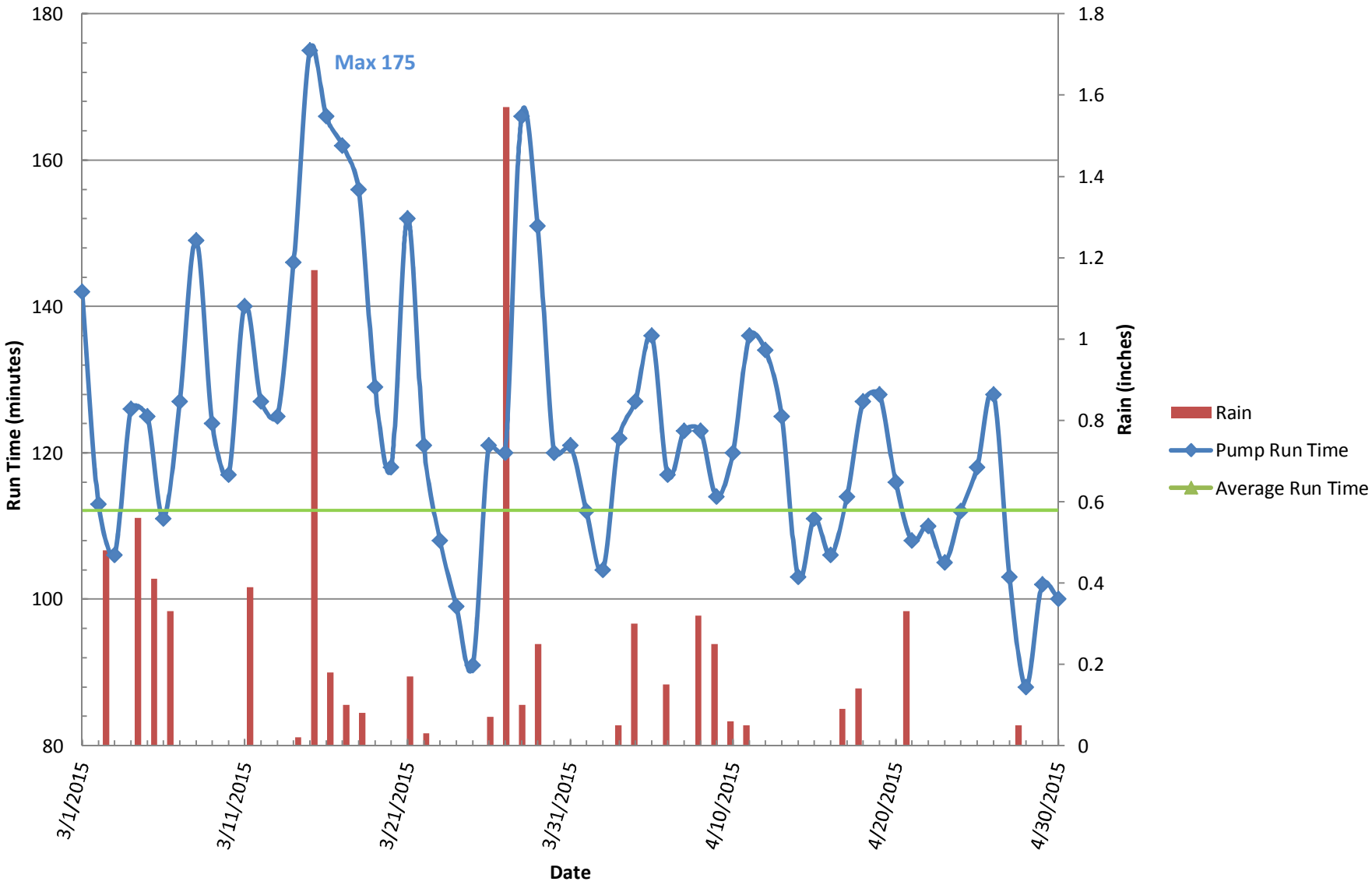



French - Canedy PS
Spring 2017
-Sewershed: 15 (2,903 LF pipe)
-Capacity: ± 140 gpm
-Average Dry-Weather Run Time: 32 min
Max 94
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
100
90
80
70
60
50
40
30
20
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017

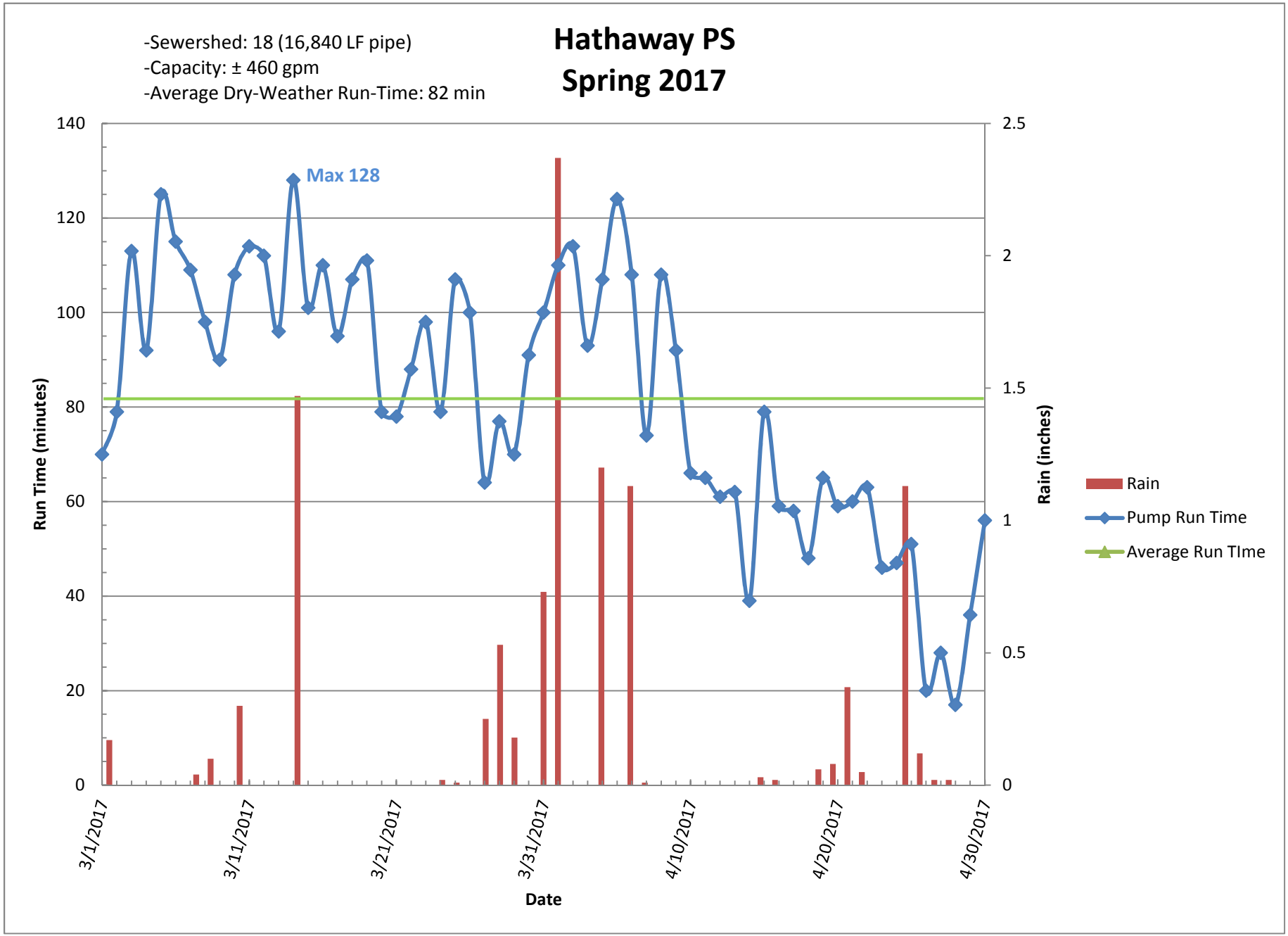

French - Canedy PS
Winter/Spring 2018
-Sewershed: 15 (2,903 LF pipe)
-Capacity: ± 140 gpm
-Average Dry-Weather Run Time: 40 min
Run Time (minutes)
Rain (inches)
Date
Max 87
Rain
Pump Run Time
Average Run Time
140
120
100
80
60
40
20
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018

-Sewershed: 18 (16,840 LF pipe)
-Capacity: ± 460 gpm
-Average Dry-Weather Run-Time: 116 min

Hathaway PS
Spring 2015

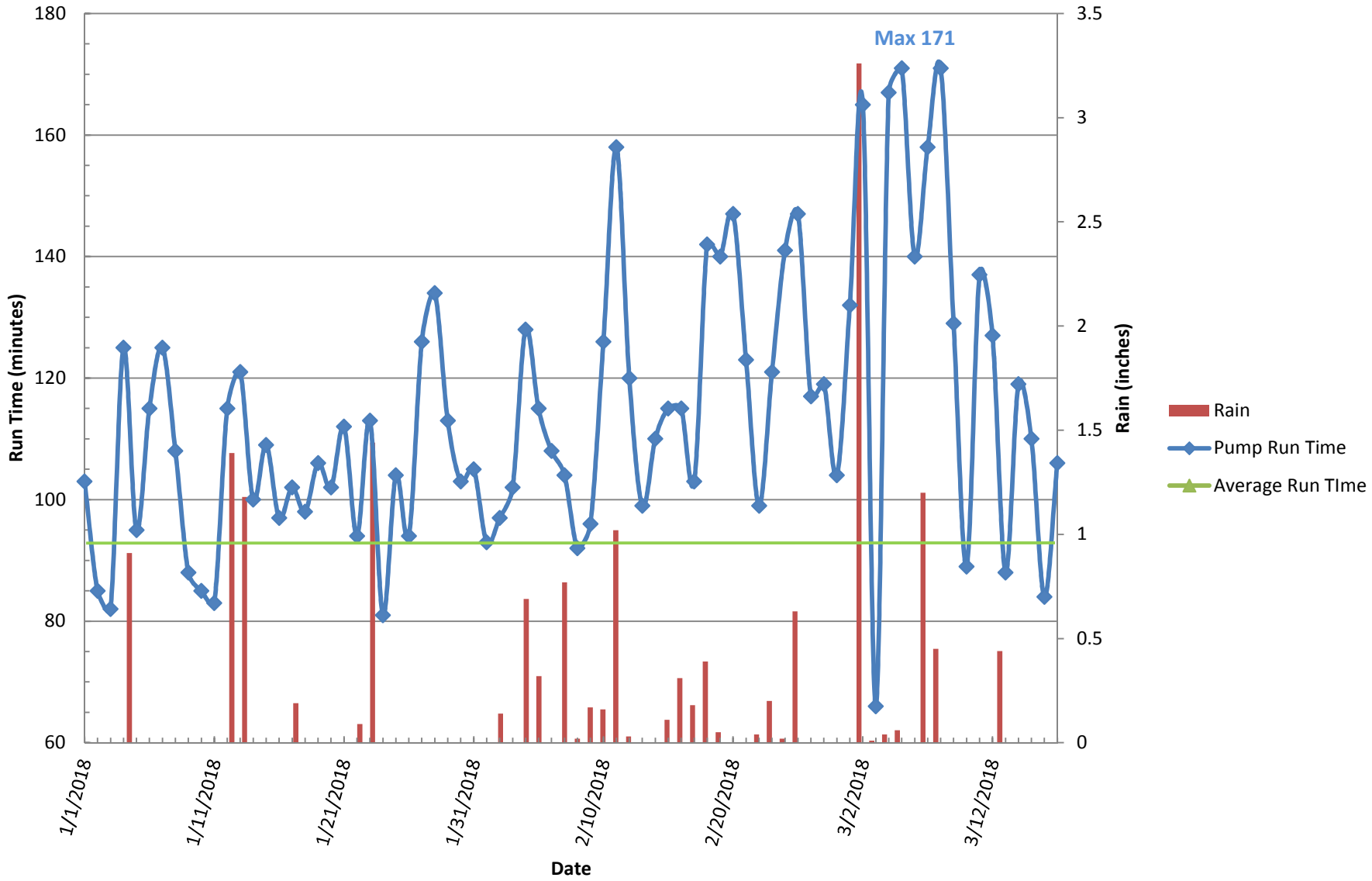


-Sewershed: 18 (16,840 LF pipe)
-Capacity: ± 460 gpm
-Average Dry-Weather Run-Time: 82 min



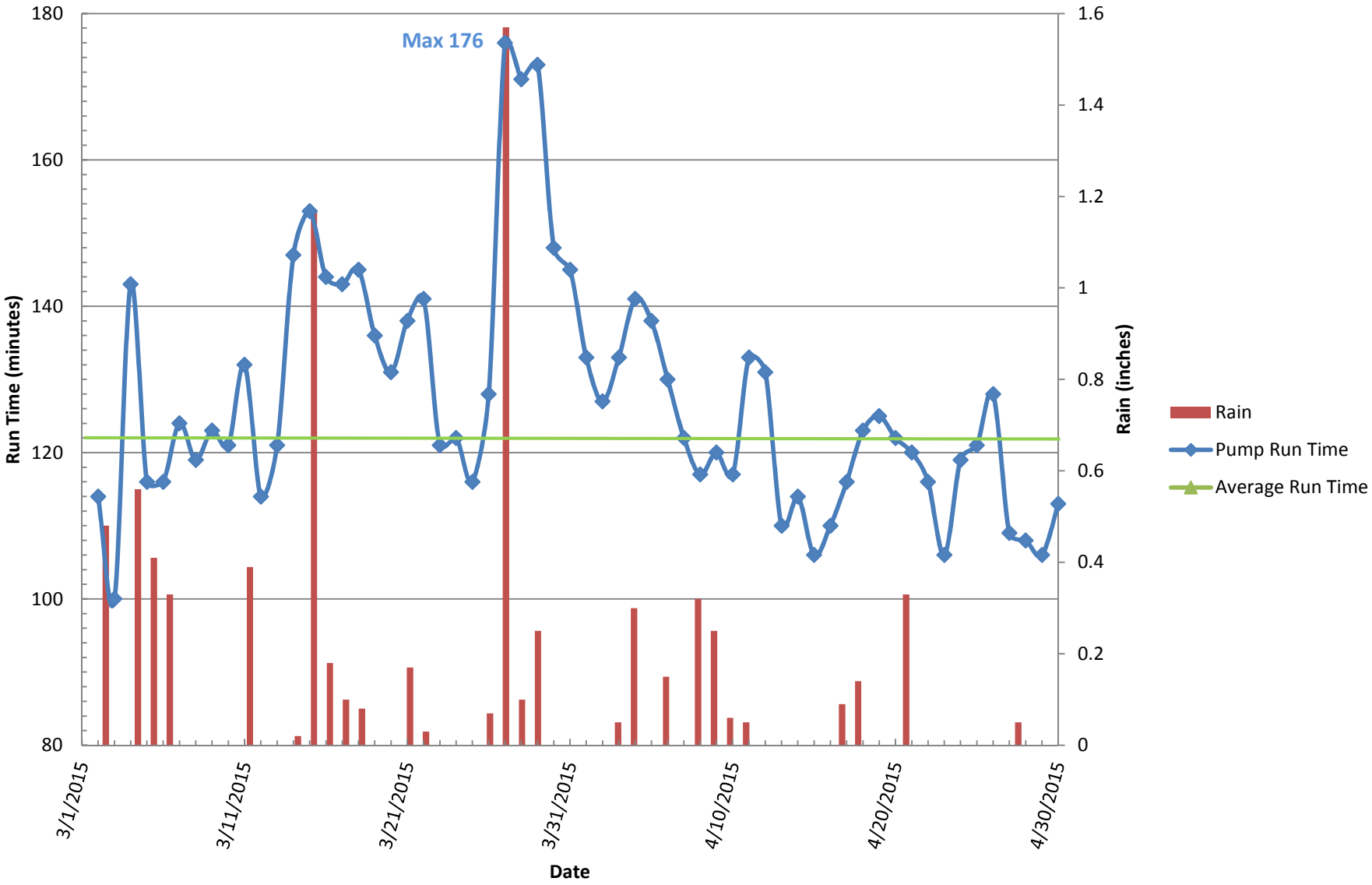
-Sewershed: 18 (16,840 LF pipe)
-Capacity: ± 460 gpm
-Average Dry-Weather Run-Time: 93 min

Hathaway PS
Winter/Spring 2018



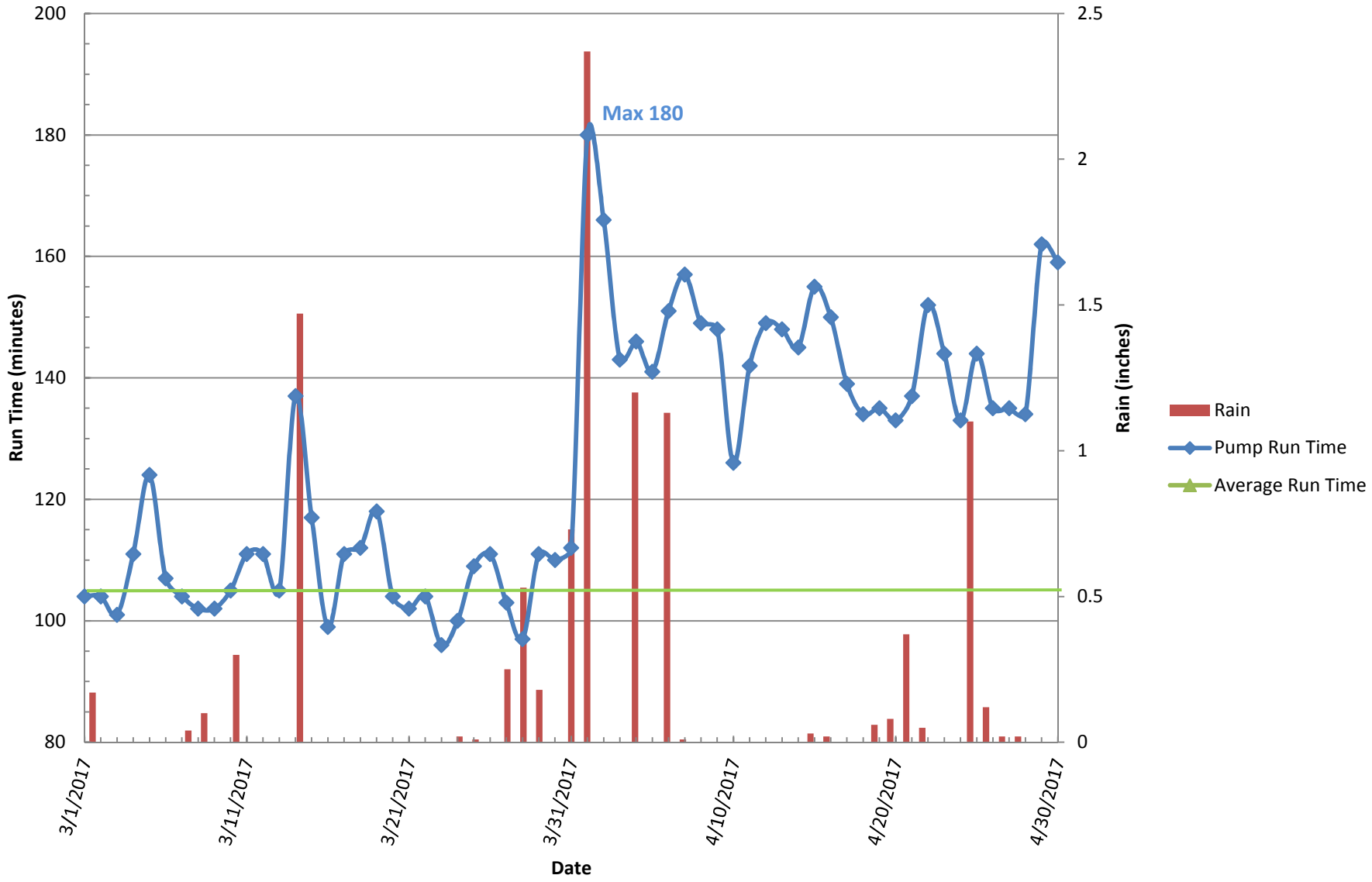
-Sewershed: 39 & 41 (24,531 LF pipe)
-Capacity: ± 1972 / 2117 gpm (VFDs)
-Average Dry-Weather Run-Time: 122 min

Hynes Field PS
Spring 2015



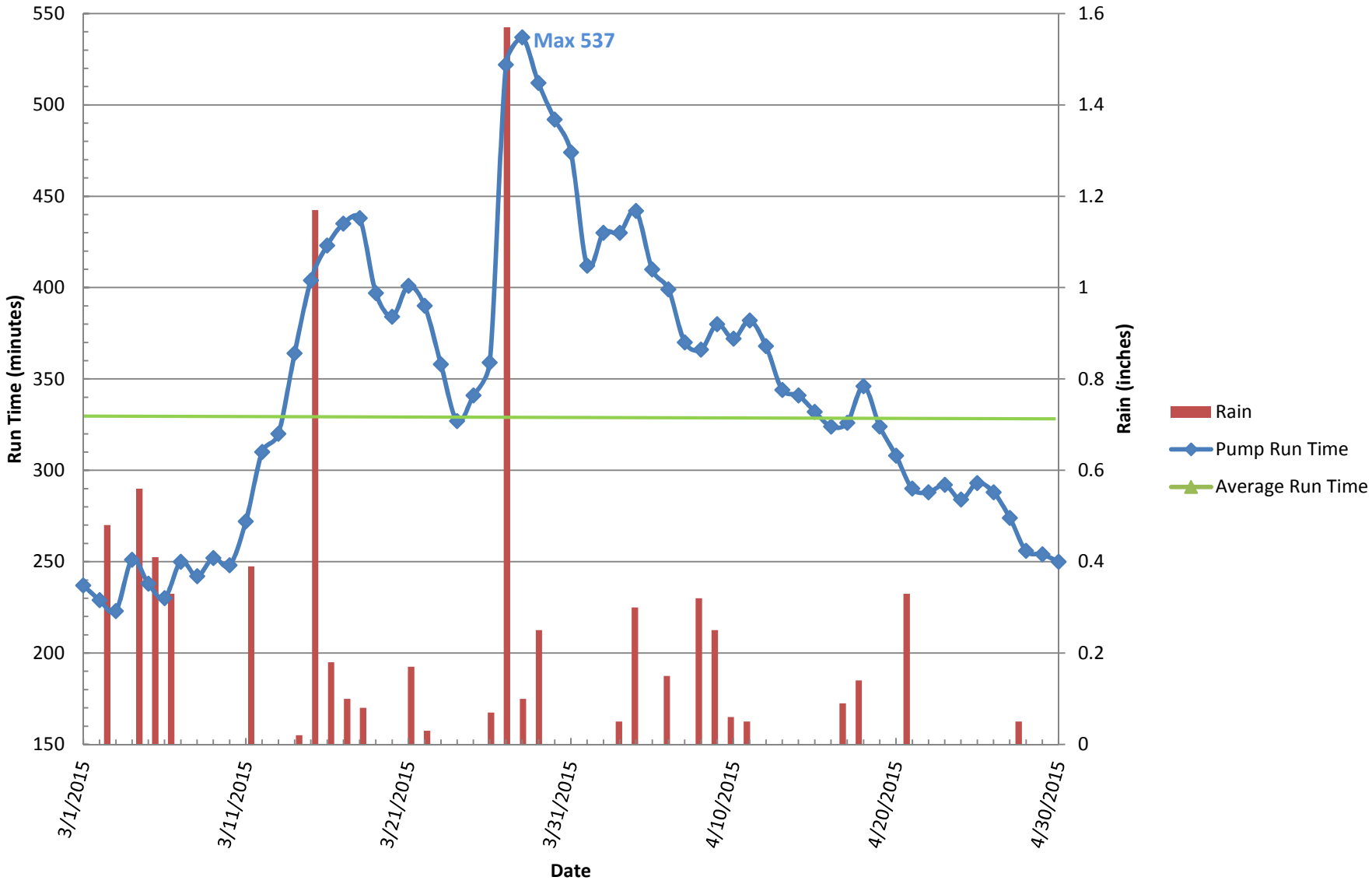
-Sewershed: 39 & 41 (24,531 LF pipe)
-Capacity: ± 1972 / 2117 gpm (VFDs)
-Average Dry-Weather Run-Time: 105 min

Hynes Field PS
Spring 2017



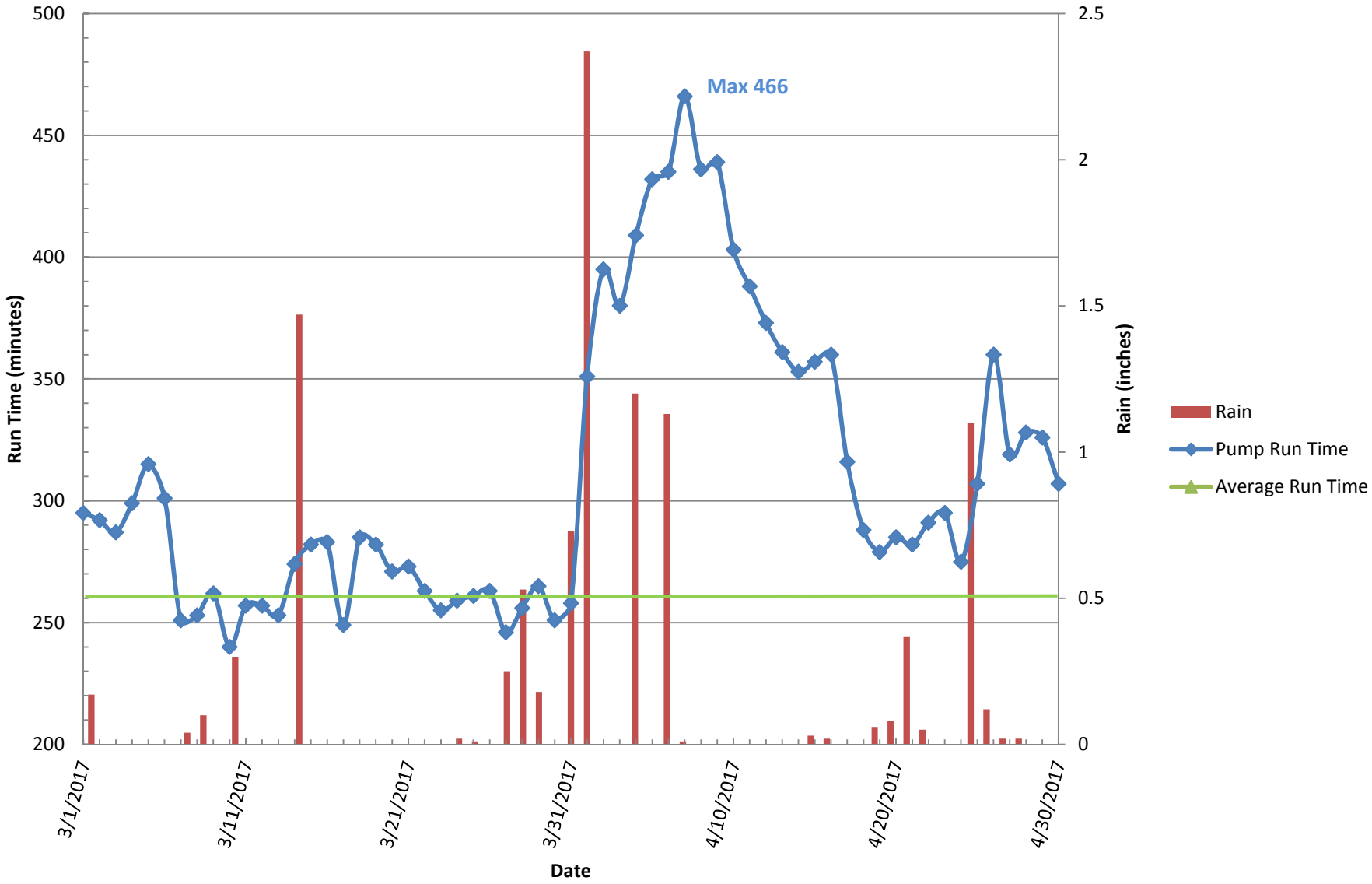
-Sewershed: 24 (23,563 LF pipe)
-Capacity: ± 2,325 gpm
-Average Dry-Weather Run Time: 330 min

Kennedy Lane PS
Spring 2015



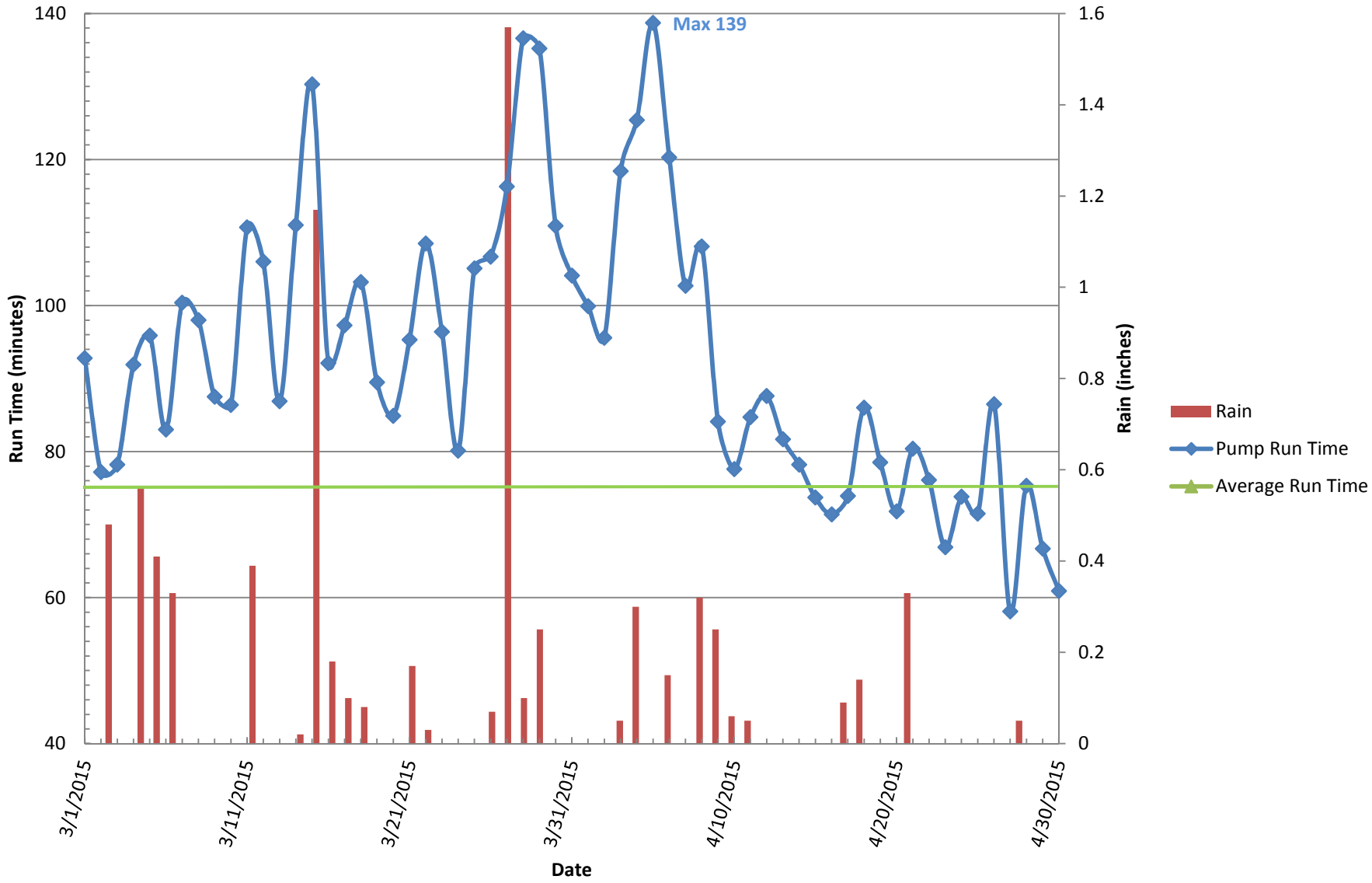
-Sewershed: 24 (23,563 LF pipe)
-Capacity: ± 2,325 gpm
-Average Dry-Weather Run Time: 260 min

Kennedy Lane PS
Spring 2017



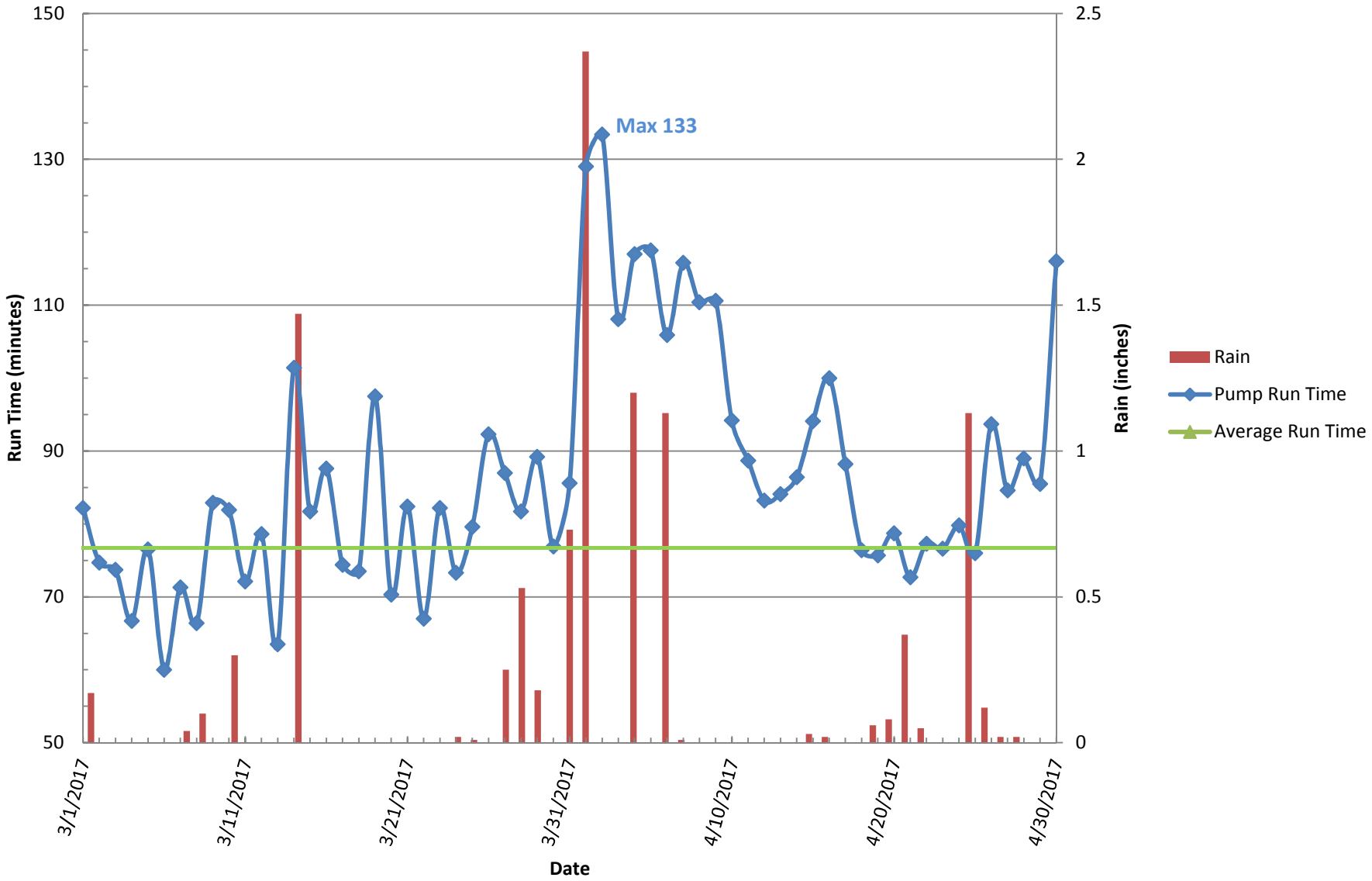
-Sewershed: 16 (4,157 LF pipe)
-Capacity: Pump 1: ± 60 gpm / Pump 2: ± 30 gpm
-Average Dry-Weather Run-Time: 75 min

Leonard Street PS
Spring 2015



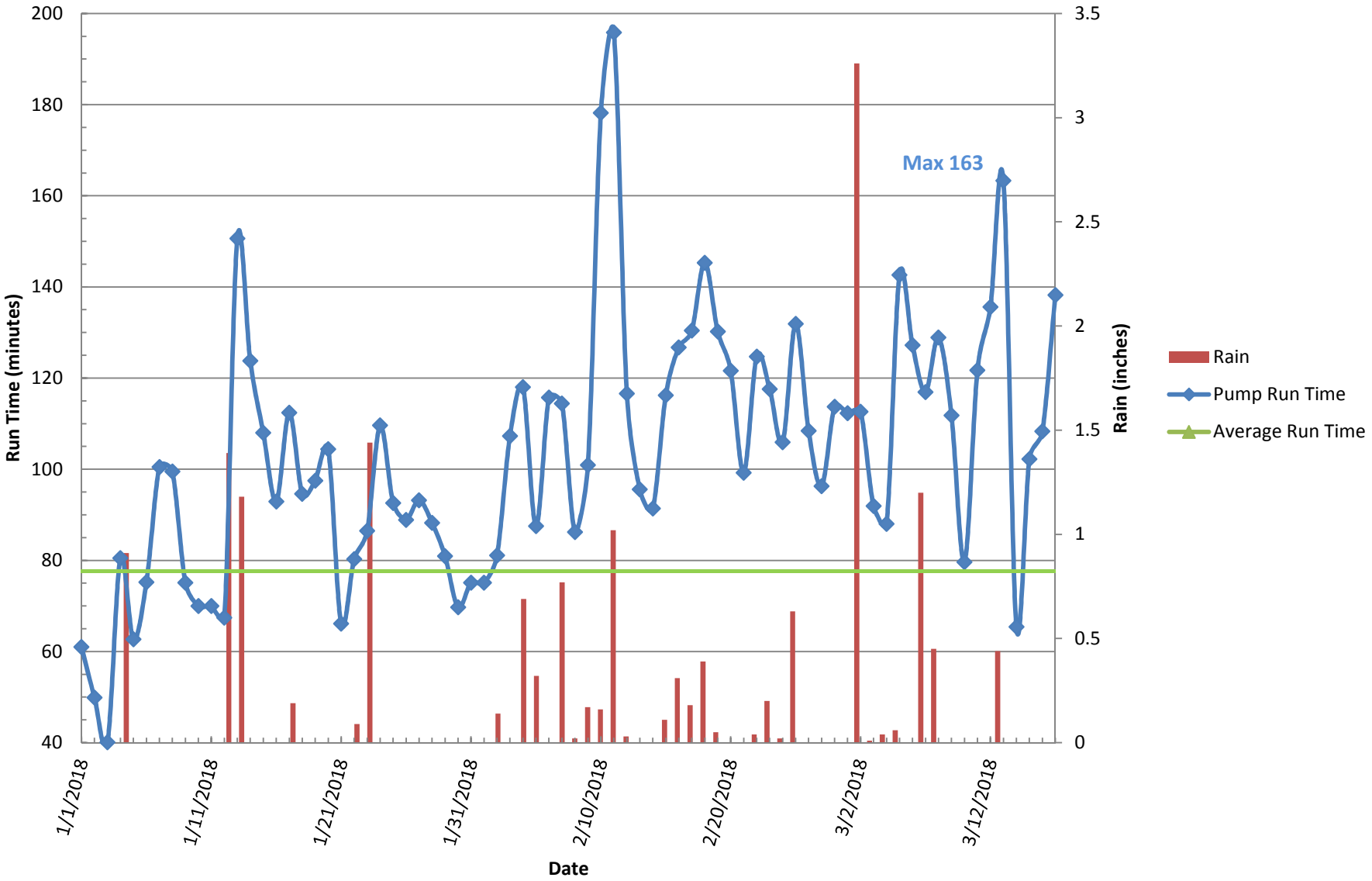
-Sewershed: 16 (4,157 LF pipe)
-Capacity: Pump 1: ± 60 gpm / Pump 2: ± 30 gpm
-Average Dry-Weather Run-Time: 77 min

Leonard Street PS
Spring 2017



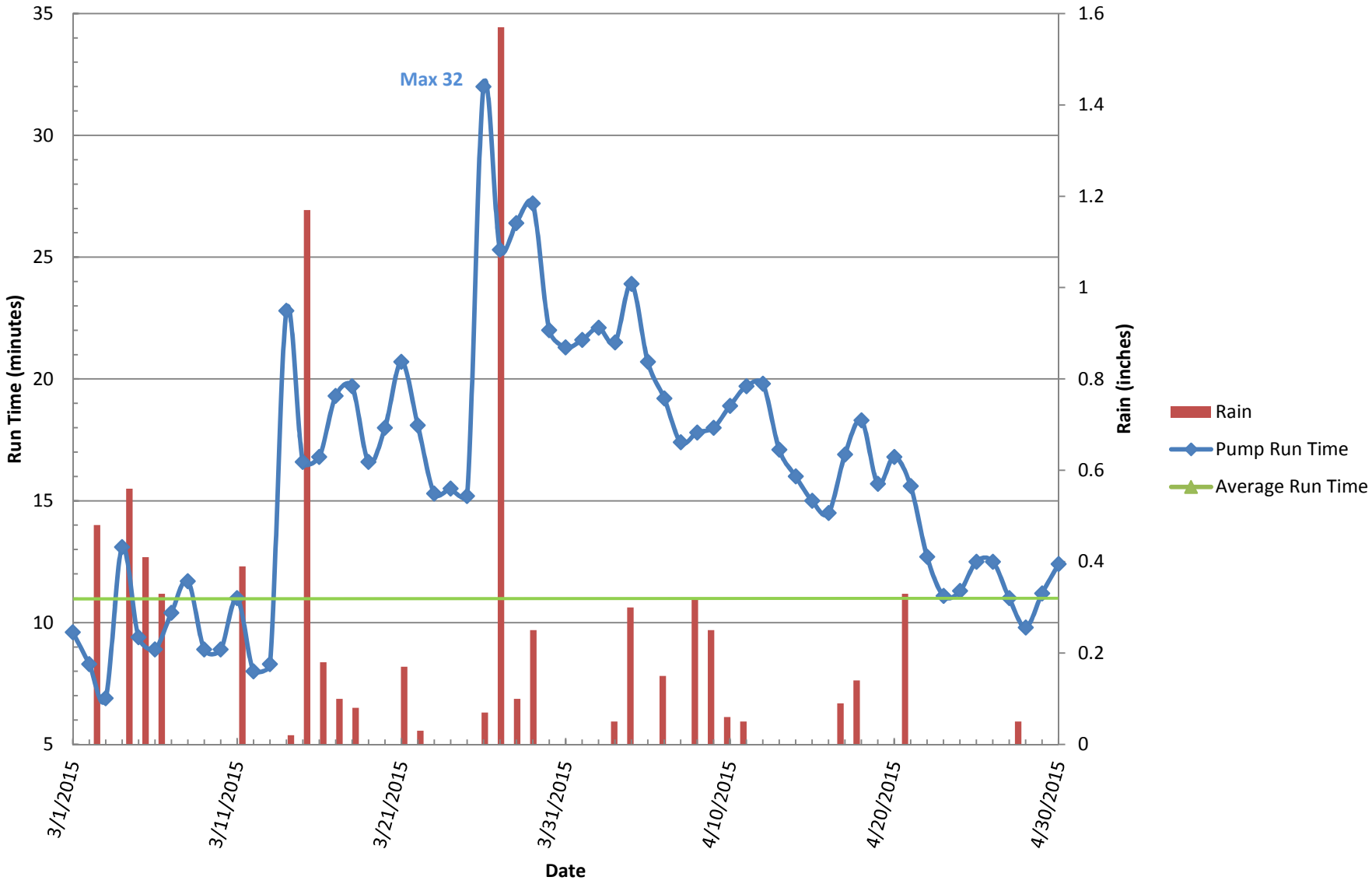
-Sewershed: 16 (4,157 LF pipe)
-Capacity: Pump 1: ± 60 gpm / Pump 2: ± 30 gpm
-Average Dry-Weather Run-Time: 77 min

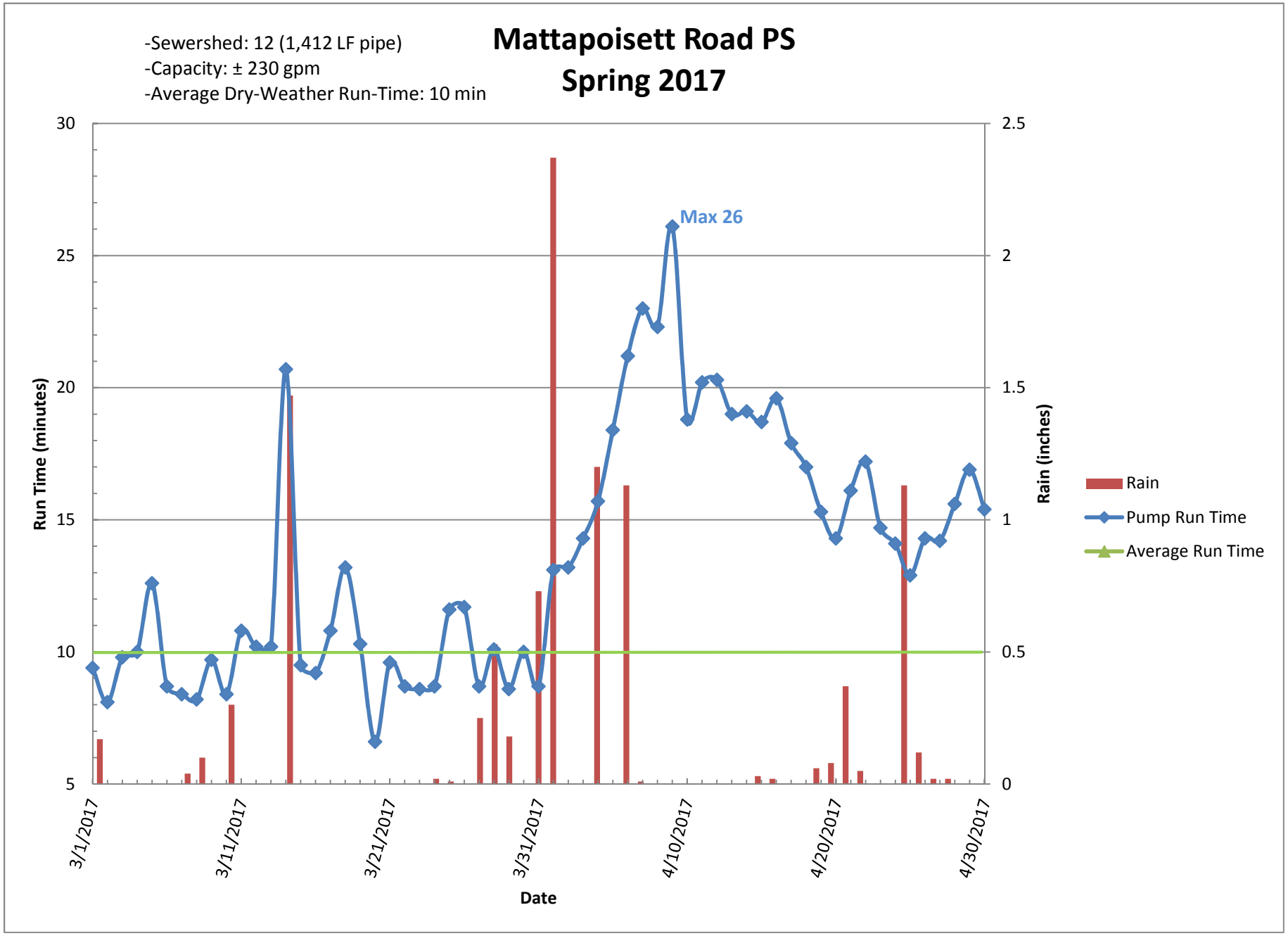
Leonard Street PS
Winter/Spring 2018



-Sewershed: 12 (1,412 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 11 min

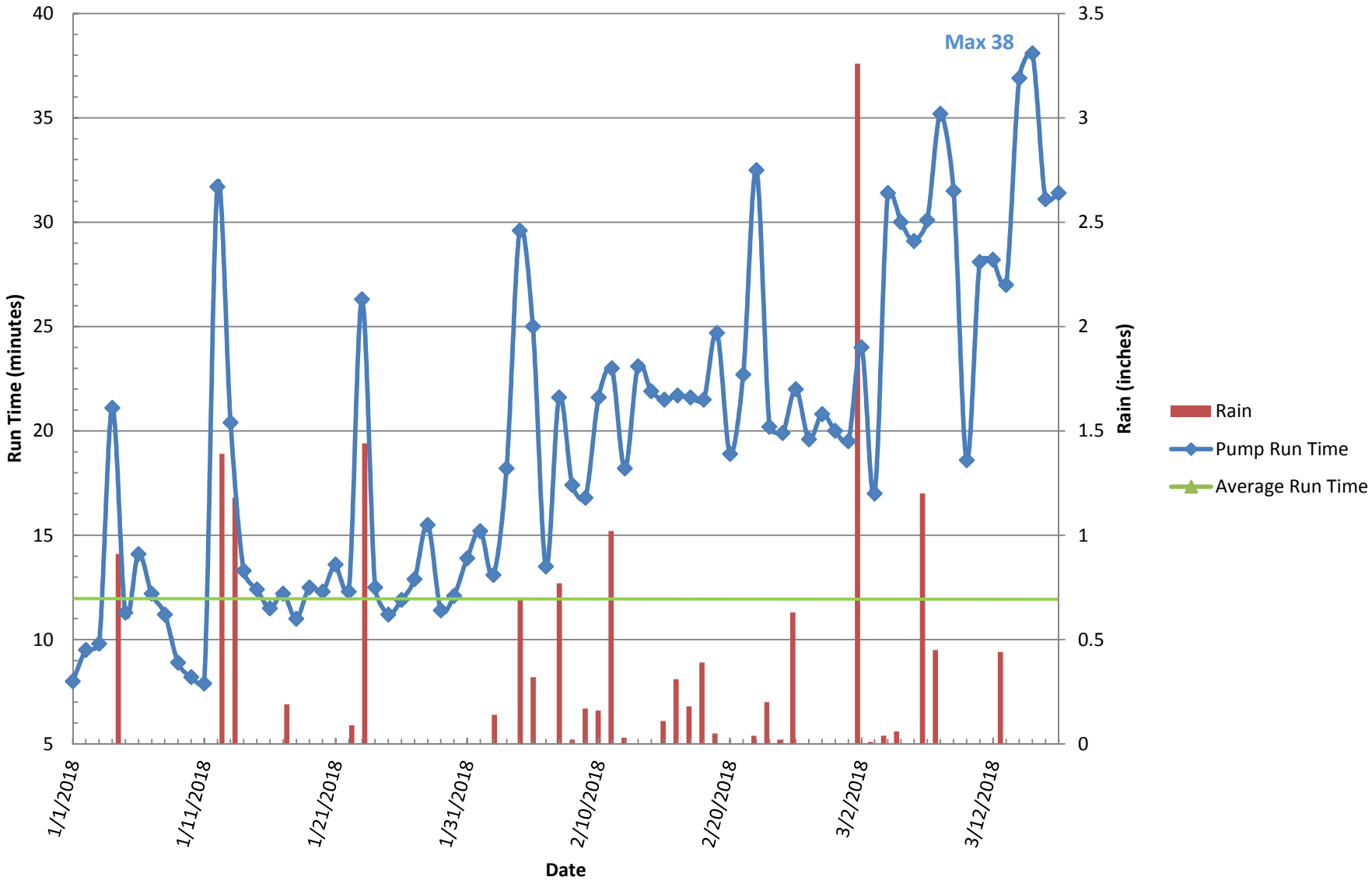
Mattapoisett Road PS
Spring 2015




-Sewershed: 12 (1,412 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 10 min
Mattapoisett Road PS
Spring 2017
Max 26
Run Time (minutes)
Rain (inches)
Date
30
25
20
15
10
5
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Rain
Pump Run Time
Average Run Time

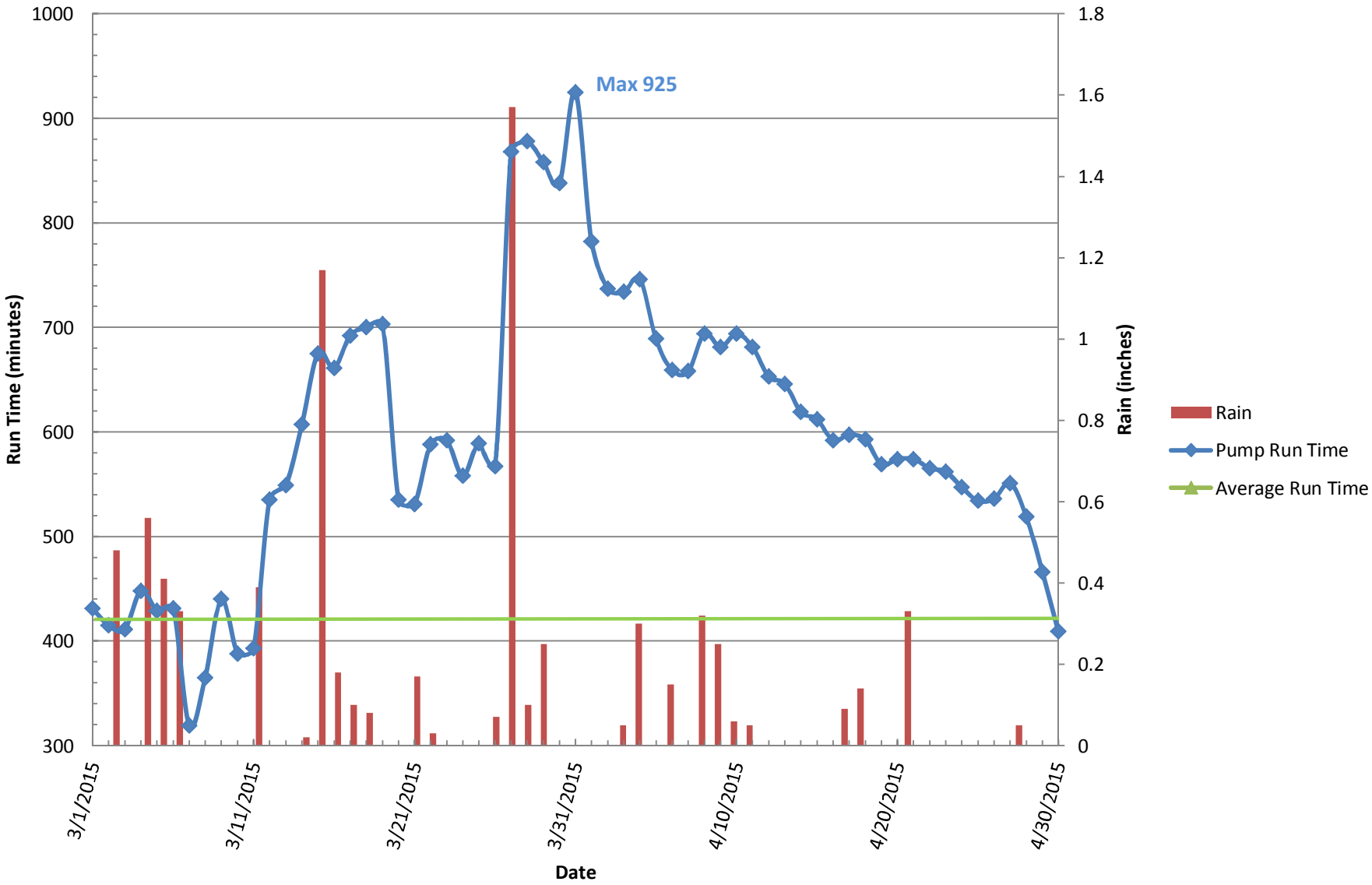
-Sewershed: 12 (1,412 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 12 min

Mattapoisett Road PS
Winter/Spring 2018

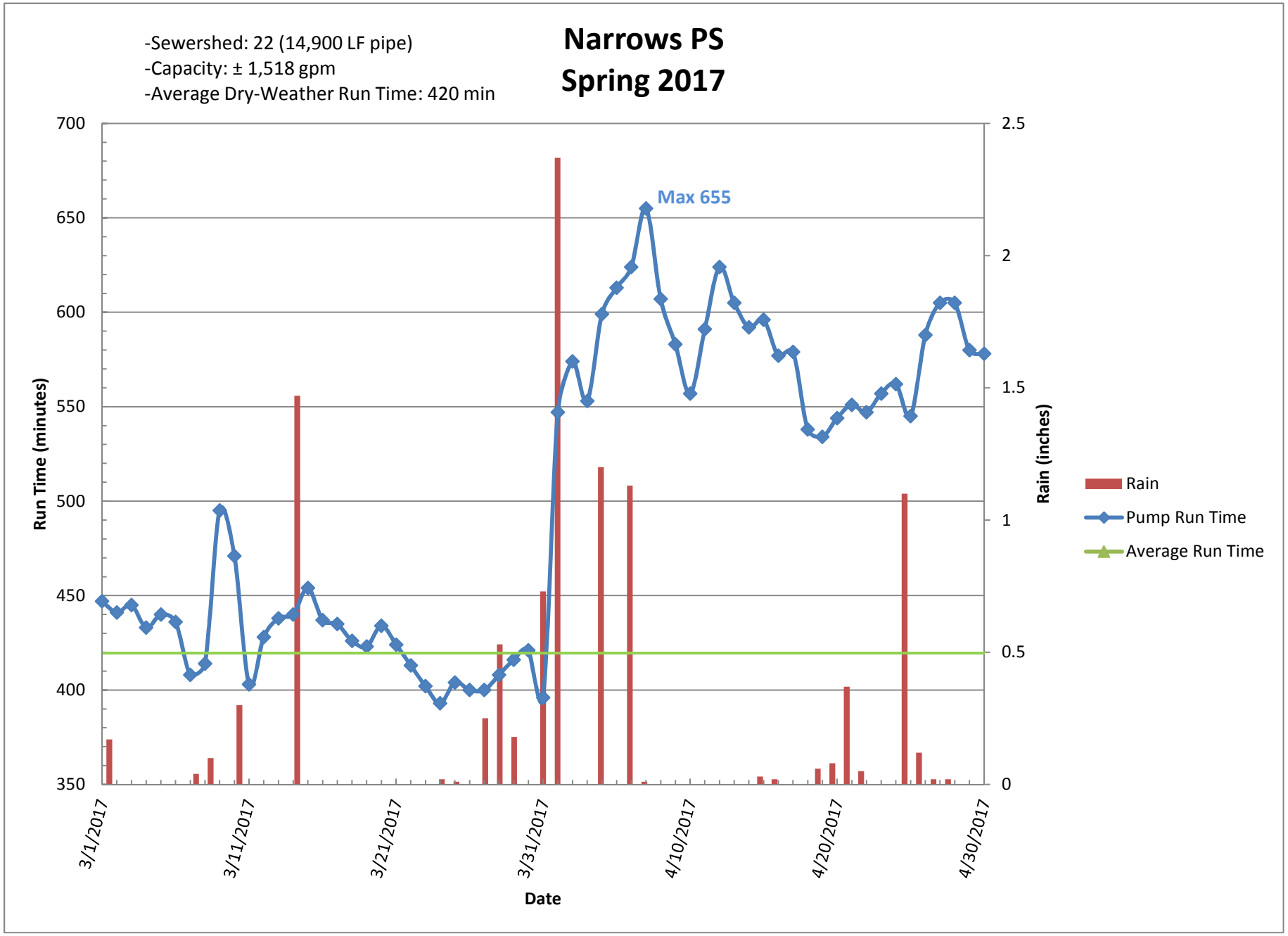


-Sewershed: 22 (14,900 LF pipe)
-Capacity: ± 1,518 gpm
-Average Dry-Weather Run-Time: 420 min

Narrows PS
Spring 2015

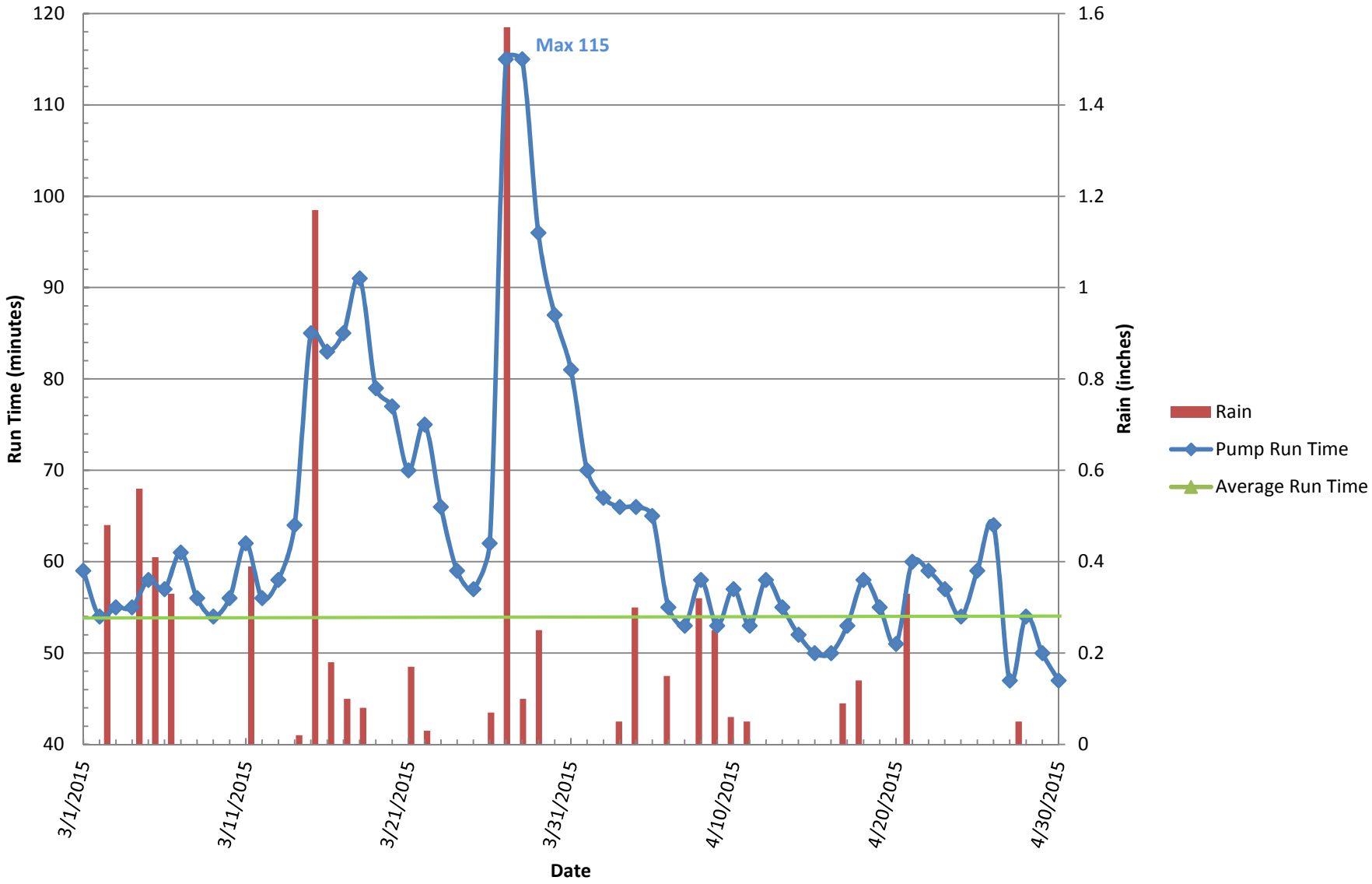


-Sewershed: 22 (14,900 LF pipe)
-Capacity: ± 1,518 gpm
-Average Dry-Weather Run Time: 420 min

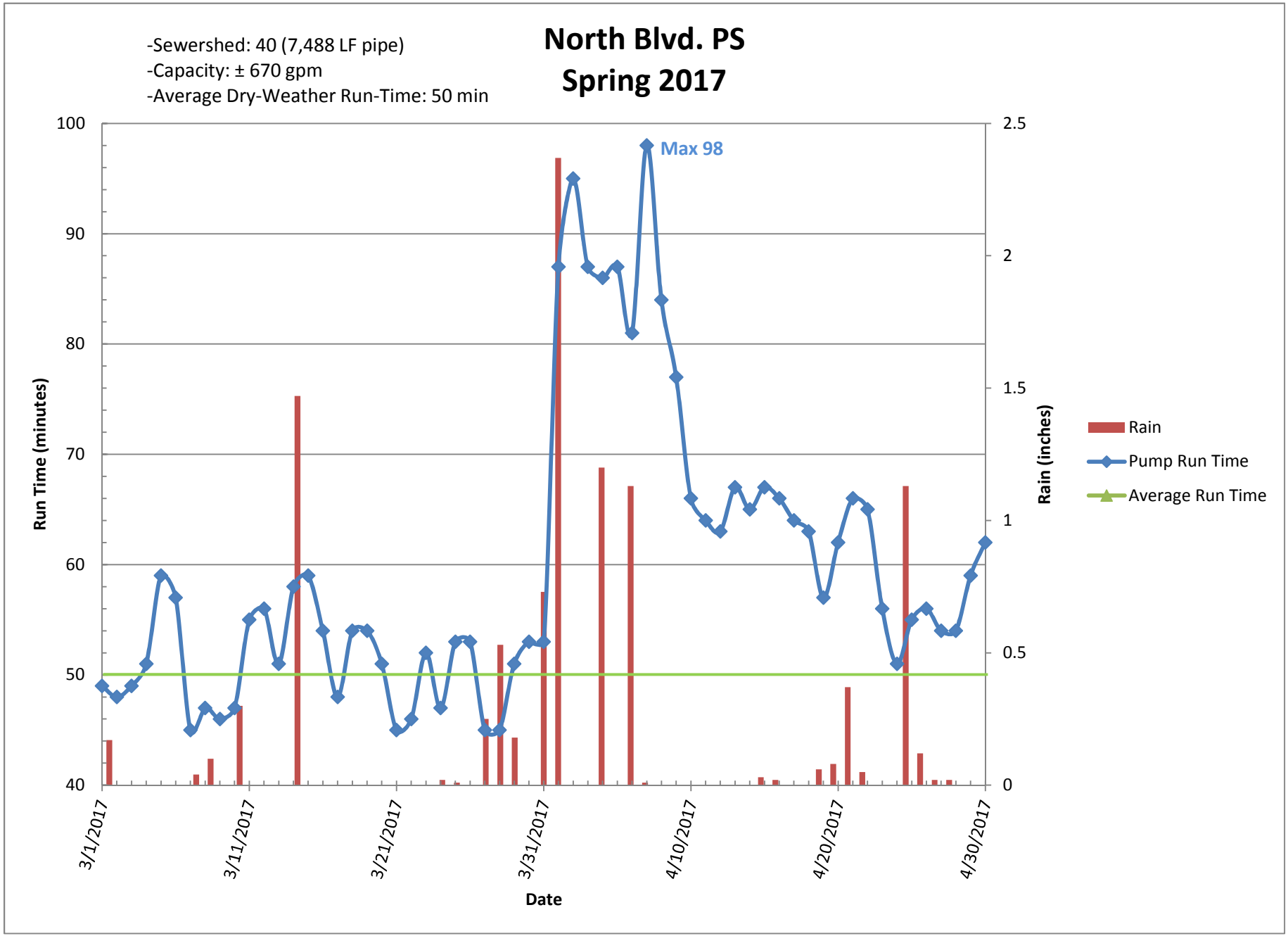


-Sewershed: 40 (7,488 LF pipe)
-Capacity: ± 670 gpm
-Average Dry-Weather Run-Time: 54 min

North Blvd. PS
Spring 2015

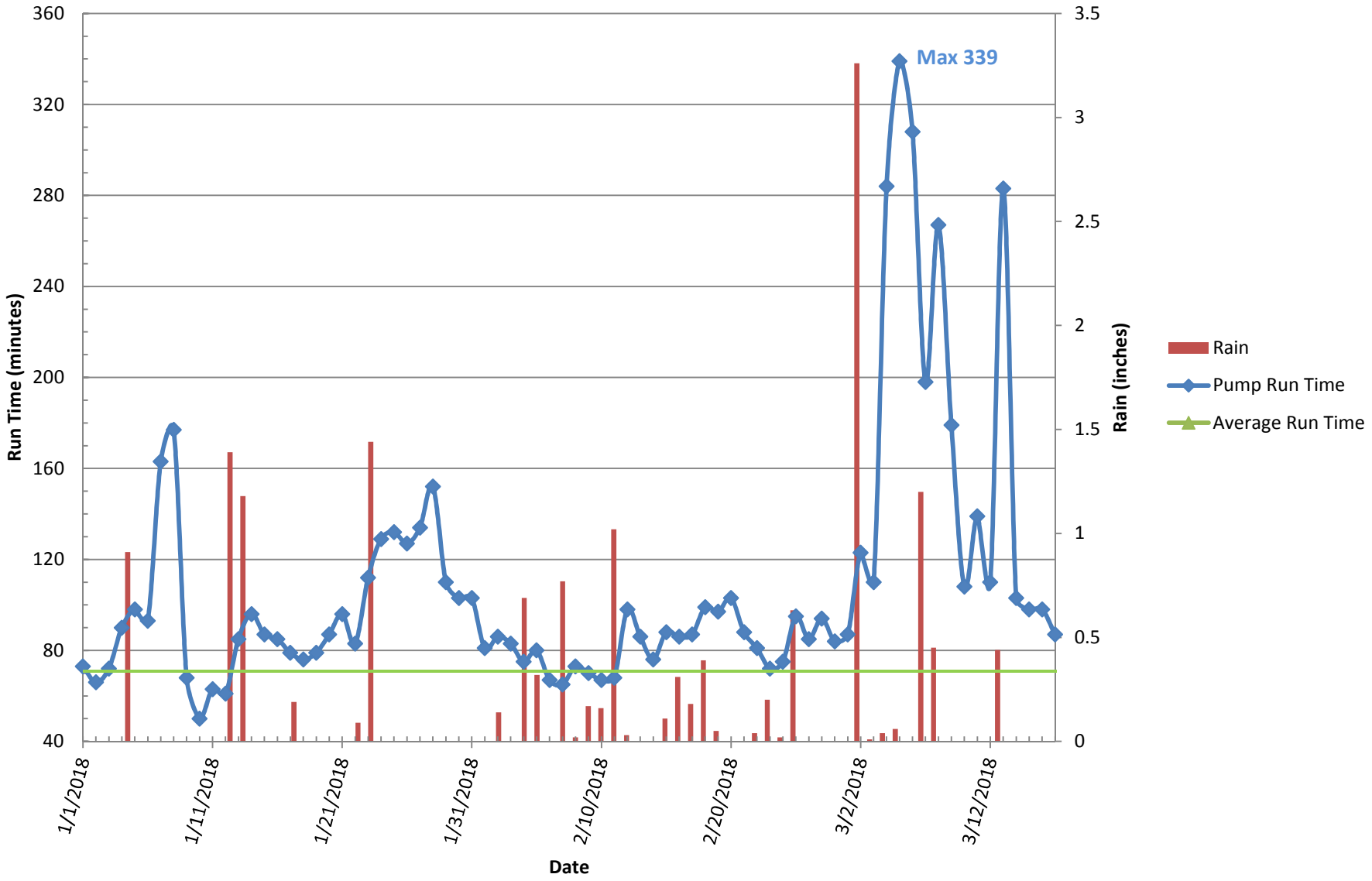


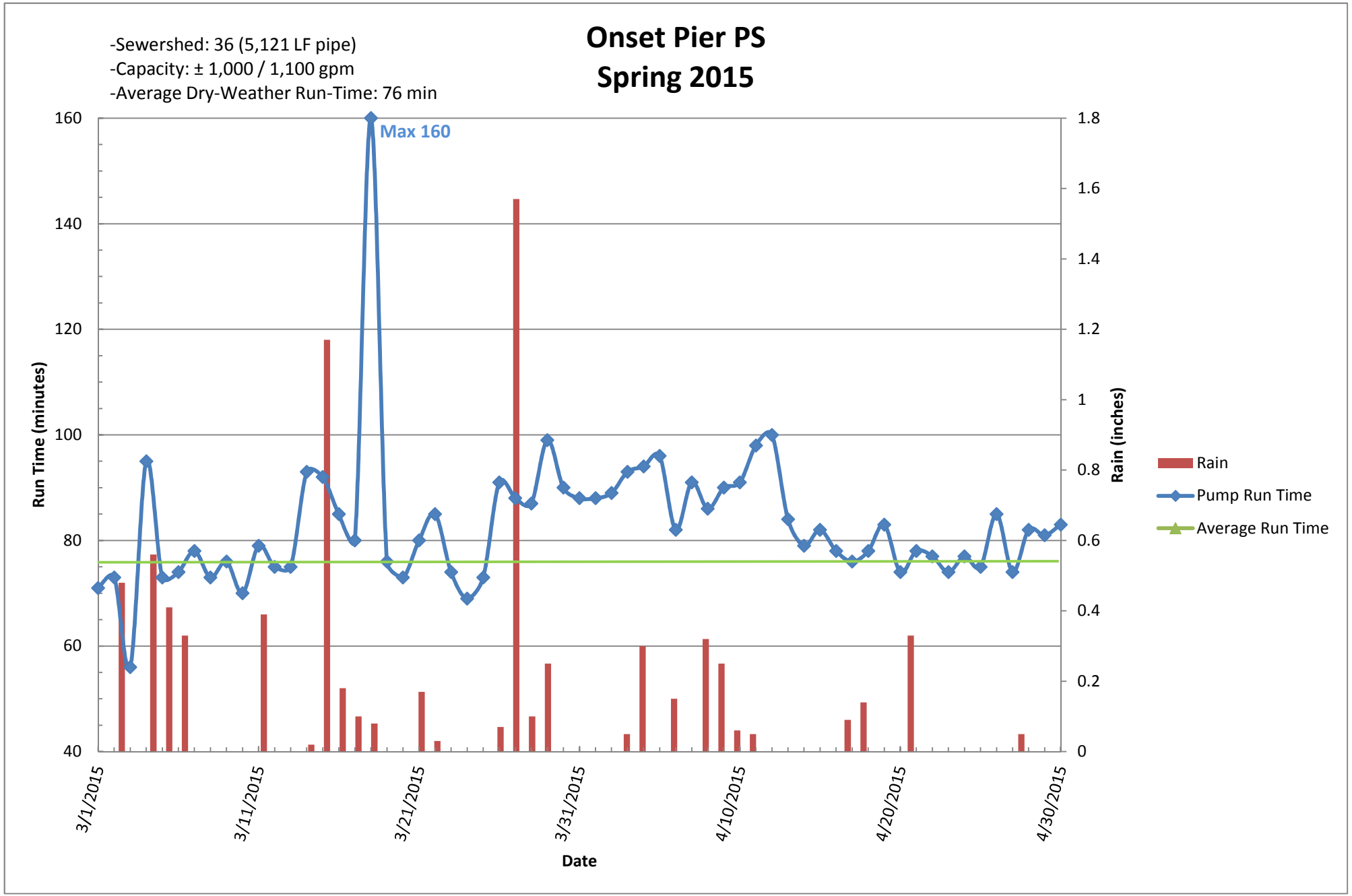
-Sewershed: 40 (7,488 LF pipe)
-Capacity: ± 670 gpm
-Average Dry-Weather Run-Time: 50 min

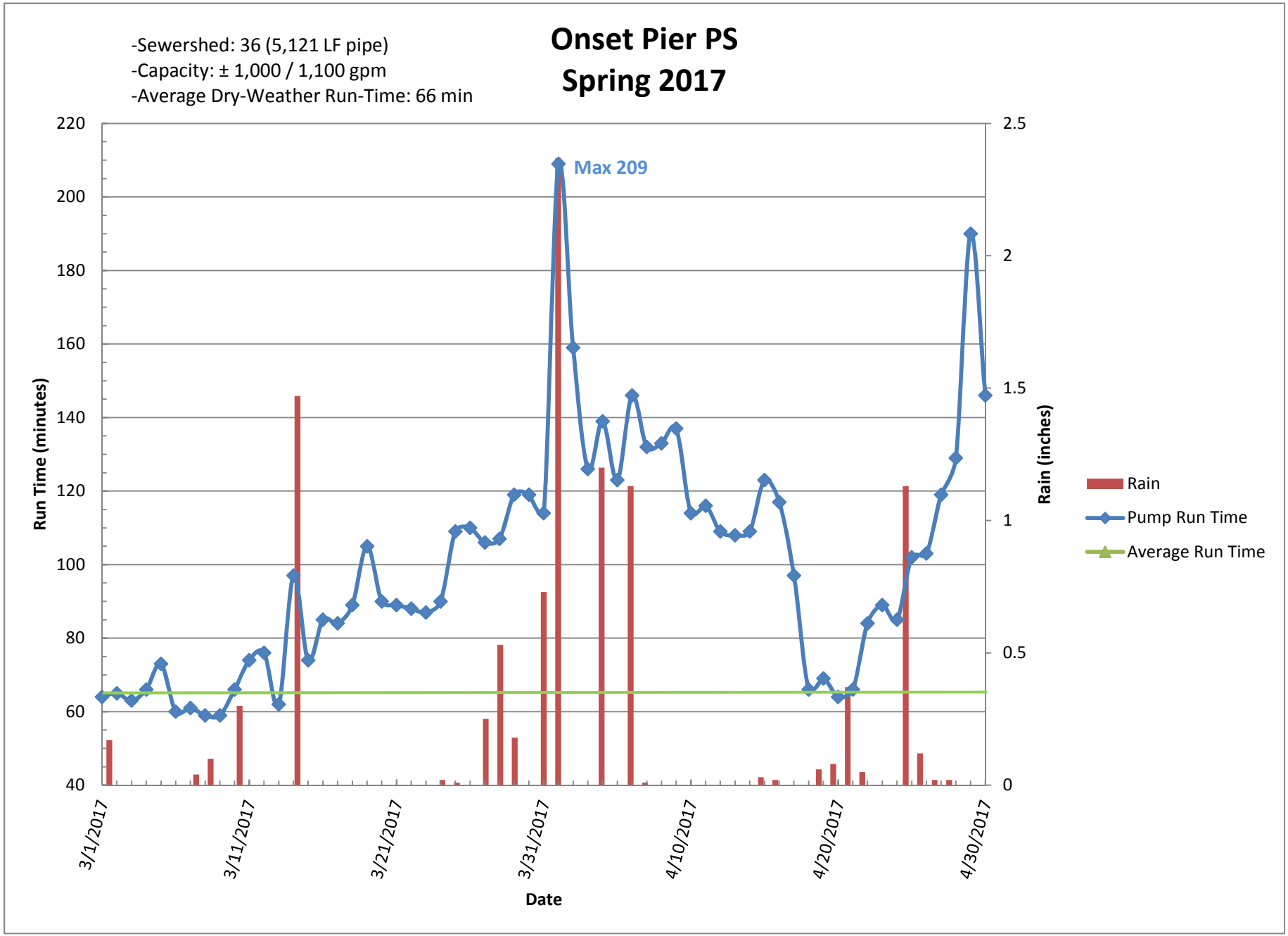


-Sewershed: 40 (7,488 LF pipe)
-Capacity: ± 670 gpm
-Average Dry-Weather Run-Time: 70 min

North Blvd. PS
Winter/Spring 2018

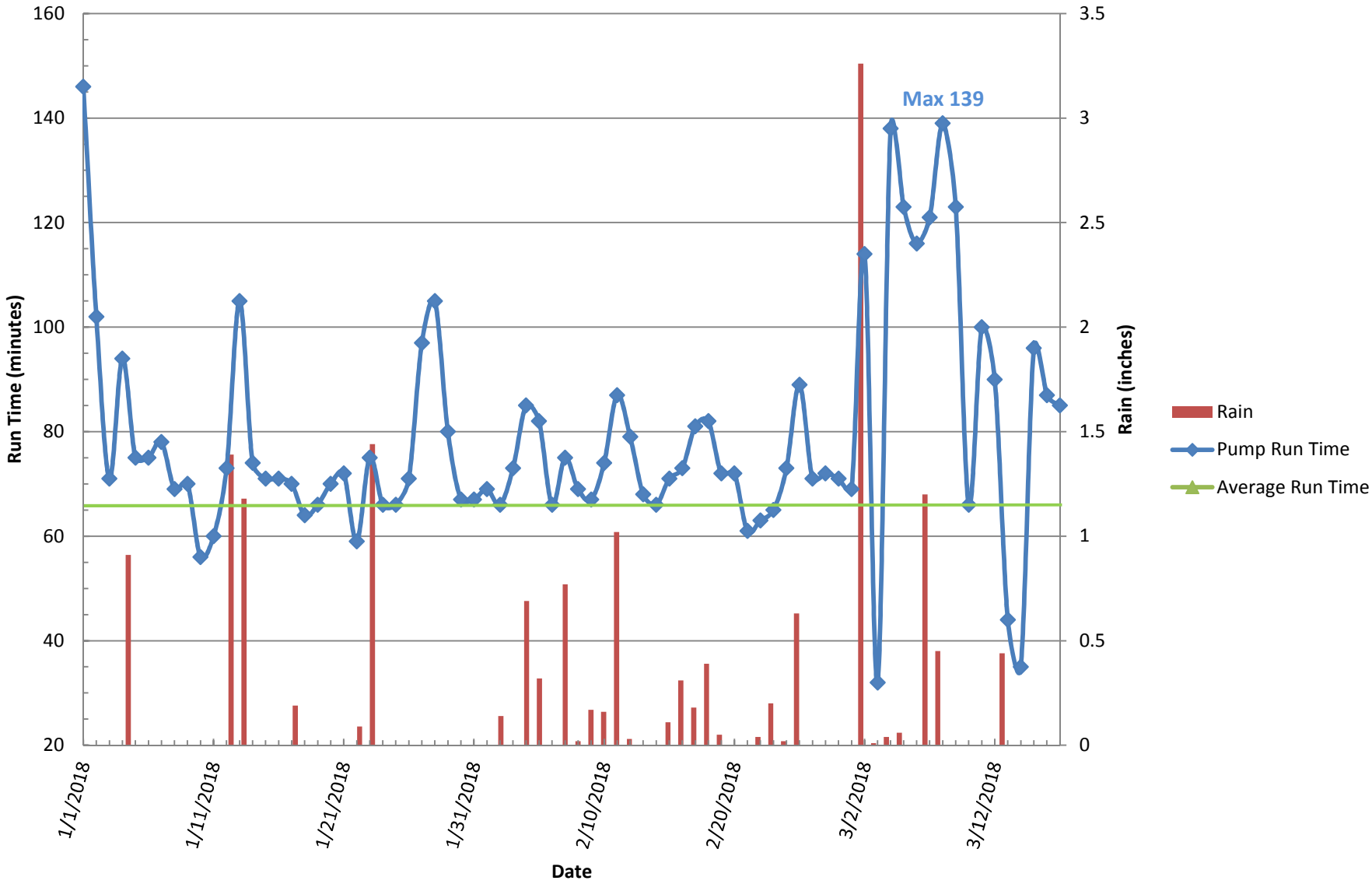



Onset Pier PS
Spring 2015
-Sewershed: 36 (5,121 LF pipe)
-Capacity: ± 1,000 / 1,100 gpm
-Average Dry-Weather Run-Time: 76 min
Max 160
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
160
140
120
100
80
60
40
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015


-Sewershed: 36 (5,121 LF pipe)
-Capacity: ± 1,000 / 1,100 gpm
-Average Dry-Weather Run-Time: 66 min
Onset Pier PS
Spring 2017
Max 209
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
220
200
180
160
140
120
100
80
60
40
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017

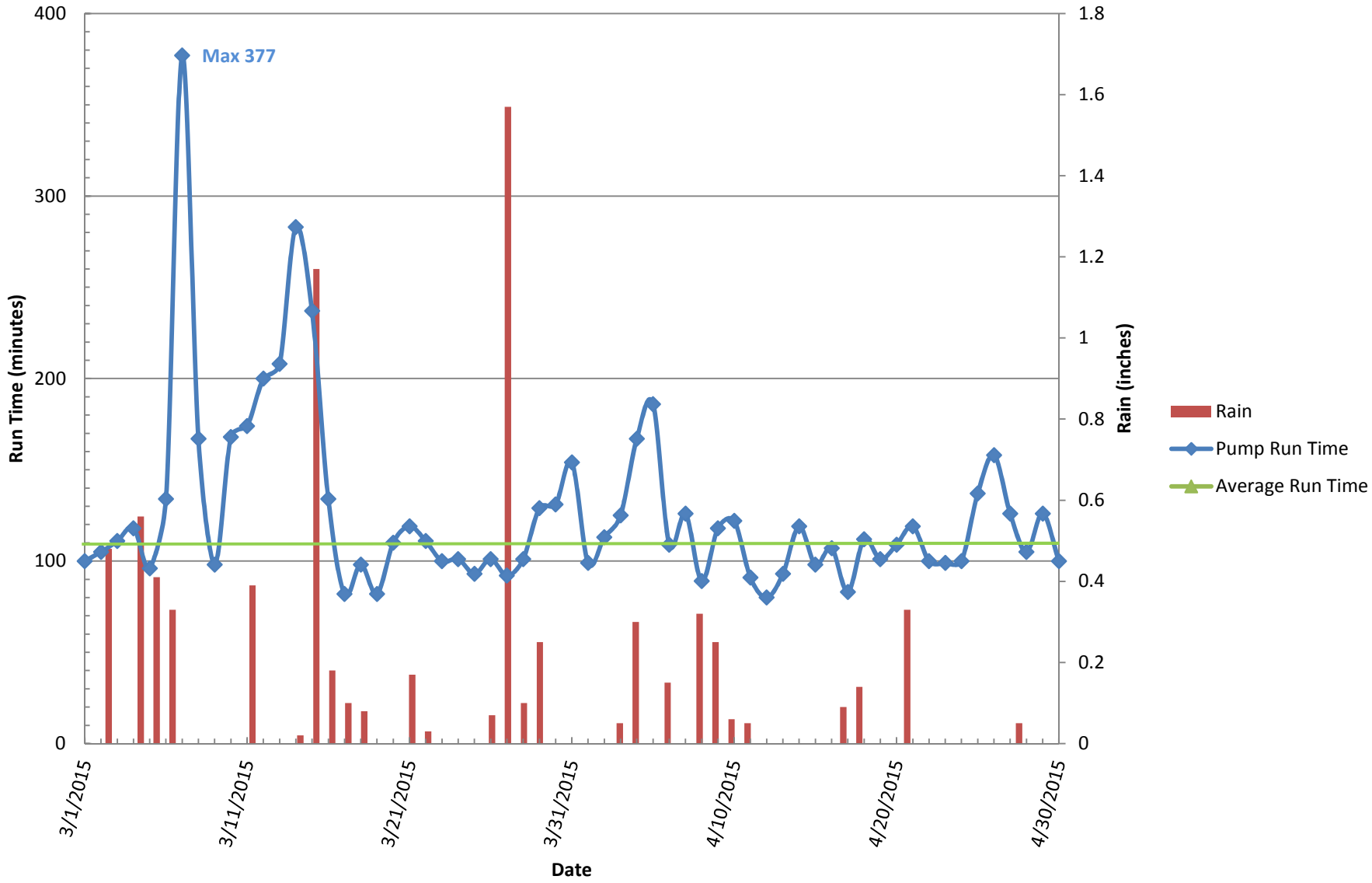
-Sewershed: 36 (5,121 LF pipe)
-Capacity: ± 1,000 / 1,100 gpm
-Average Dry-Weather Run-Time: 66 min

Onset Pier PS
Winter/Spring 2018



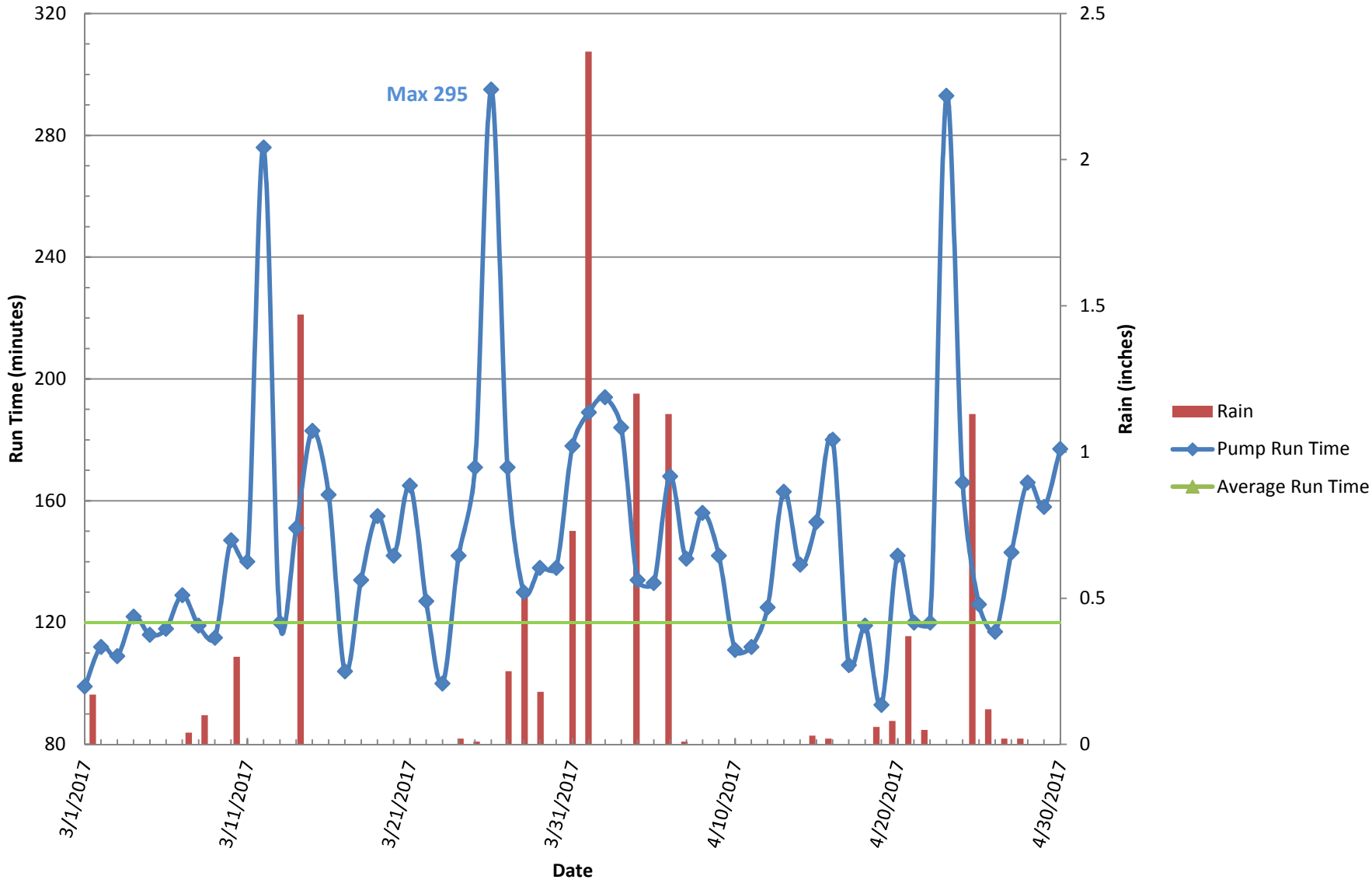
-Sewershed: 6 (1,568 LF pipe)
-Capacity: ± 40 gpm
-Average Dry-Weather Run Time: 110 min

Peter Cooper Drive PS
Spring 2015



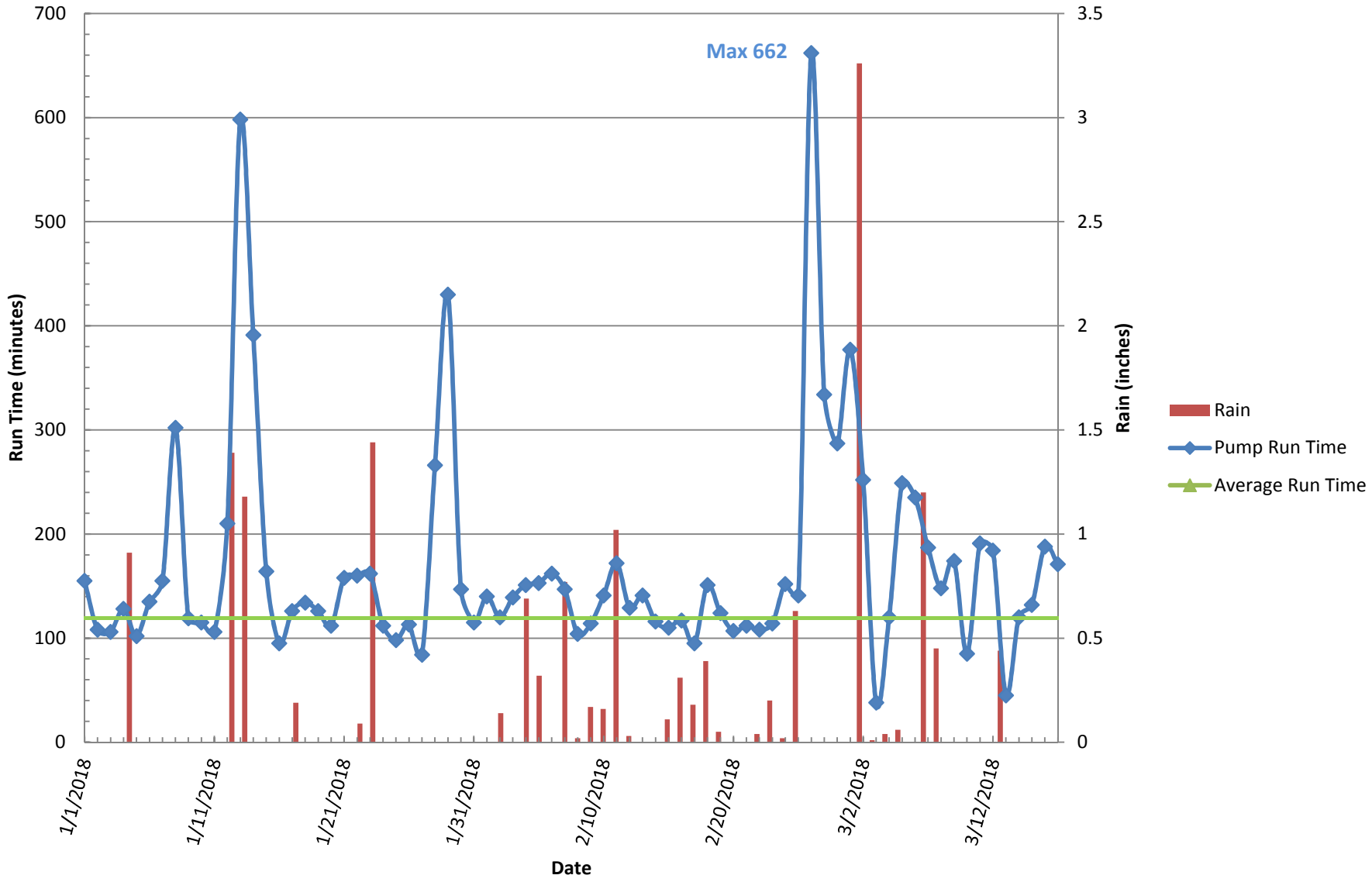
Peter Cooper Drive PS
Spring 2017

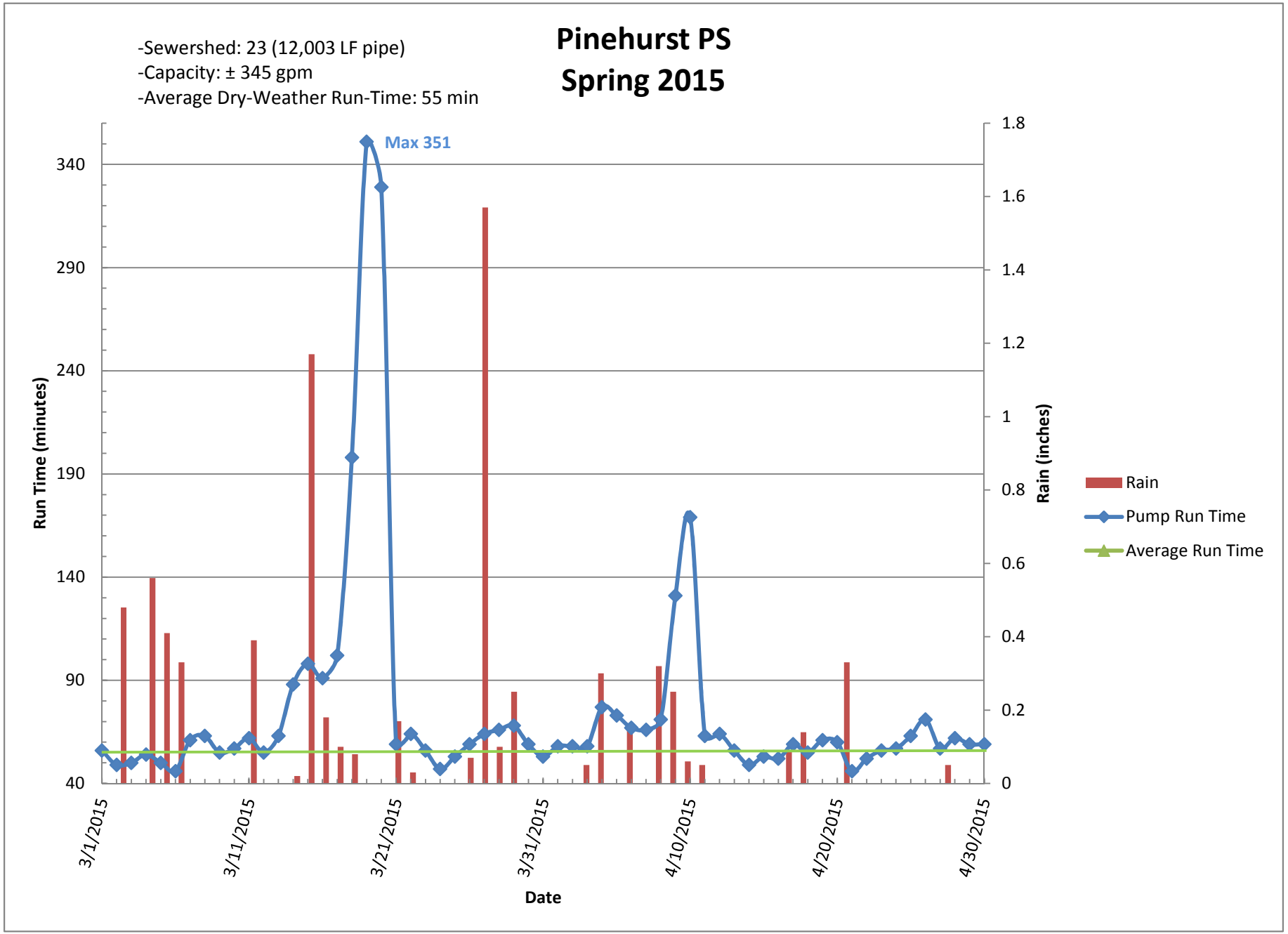
-Sewershed: 6 (1,568 LF pipe)
-Capacity: ± 40 gpm
-Average Dry-Weather Run Time: 120 min



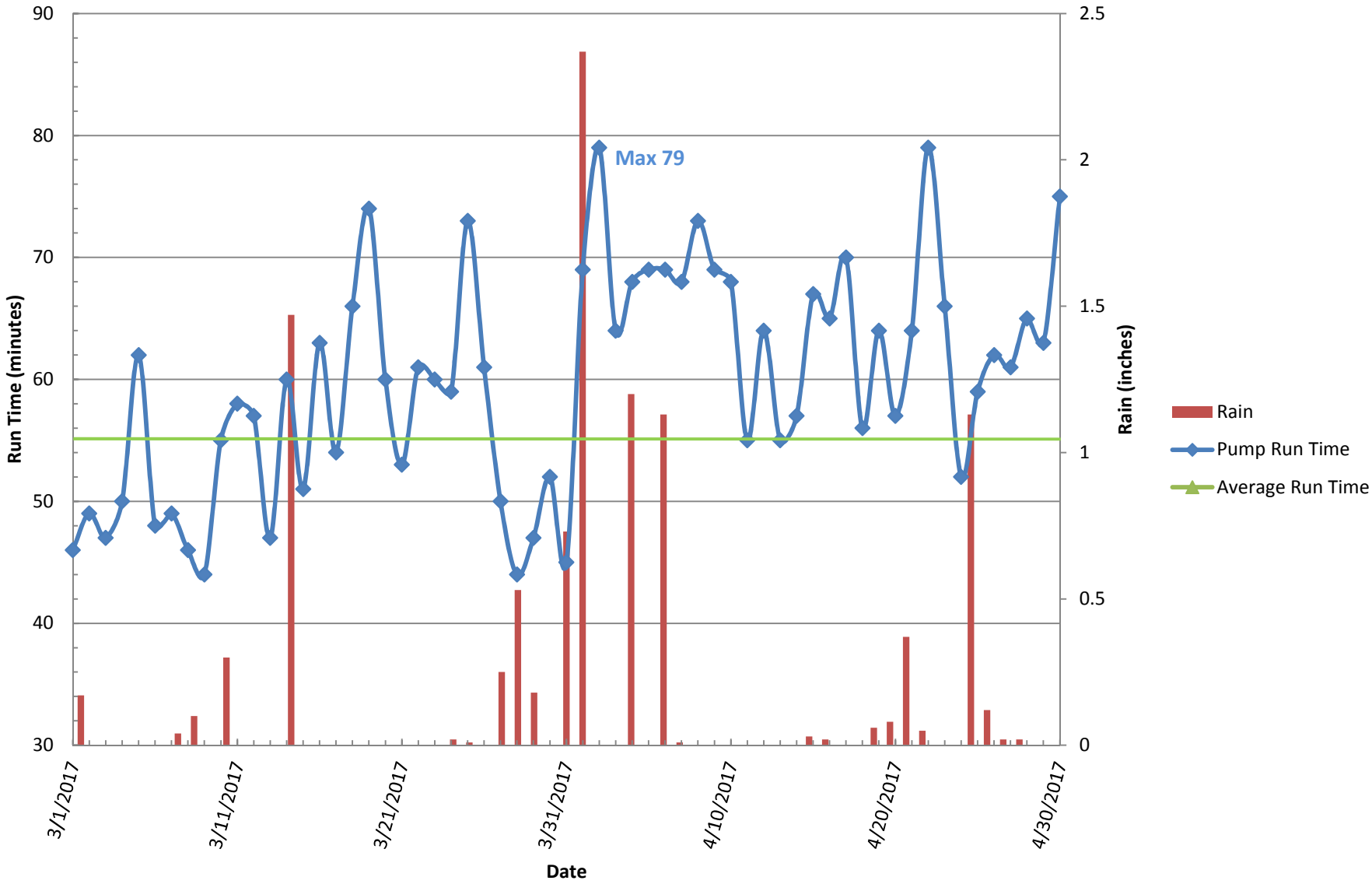
-Sewershed: 6 (1,568 LF pipe)
-Capacity: ± 40 gpm
-Average Dry-Weather Run Time: 120 min

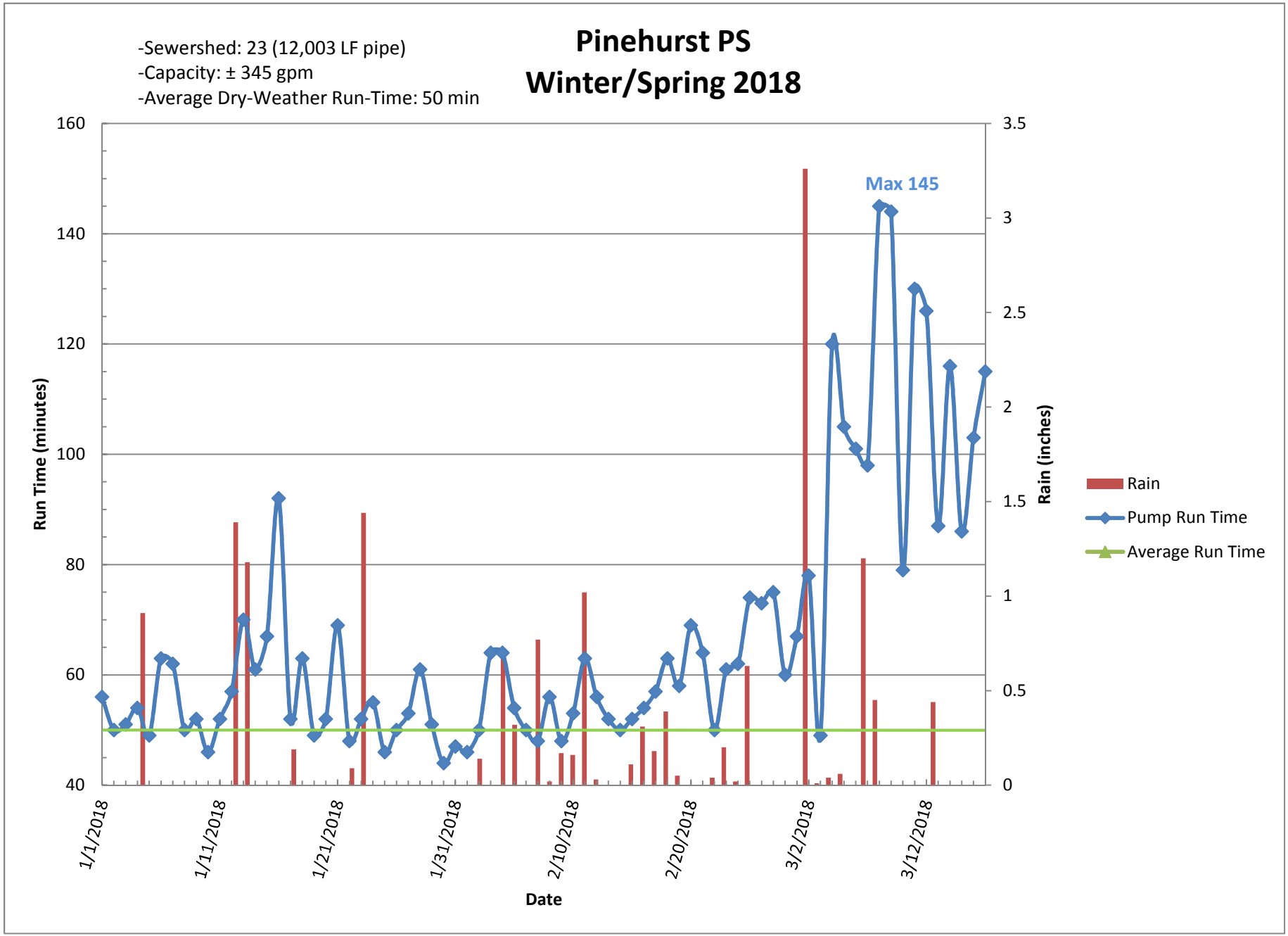
Peter Cooper Drive PS
Winter/Spring 2018




Pinehurst PS
Spring 2015
-Sewershed: 23 (12,003 LF pipe)
-Capacity: ± 345 gpm
-Average Dry-Weather Run-Time: 55 min
Max 351
Run Time (minutes)
Rain (inches)
340
290
240
190
140
90
40
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015
Date
Rain
Pump Run Time
Average Run Time

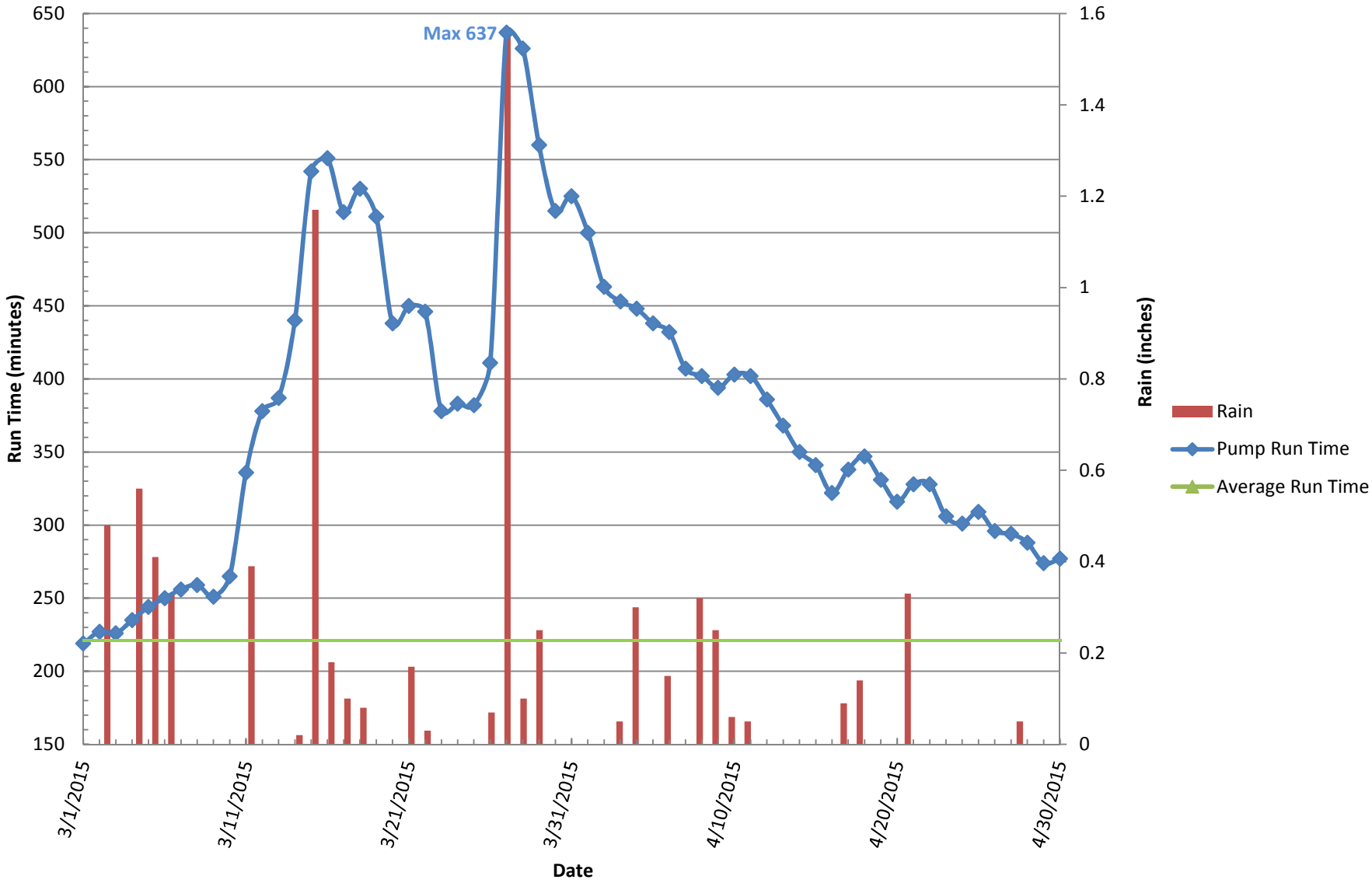
-Sewershed: 23 (12,003 LF pipe)
-Capacity: ± 345 gpm
-Average Dry-Weather Run-Time: 55 min




-Sewershed: 23 (12,003 LF pipe)
-Capacity: ± 345 gpm
-Average Dry-Weather Run-Time: 50 min
Pinehurst PS
Winter/Spring 2018
Max 145
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
160
140
120
100
80
60
40
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018

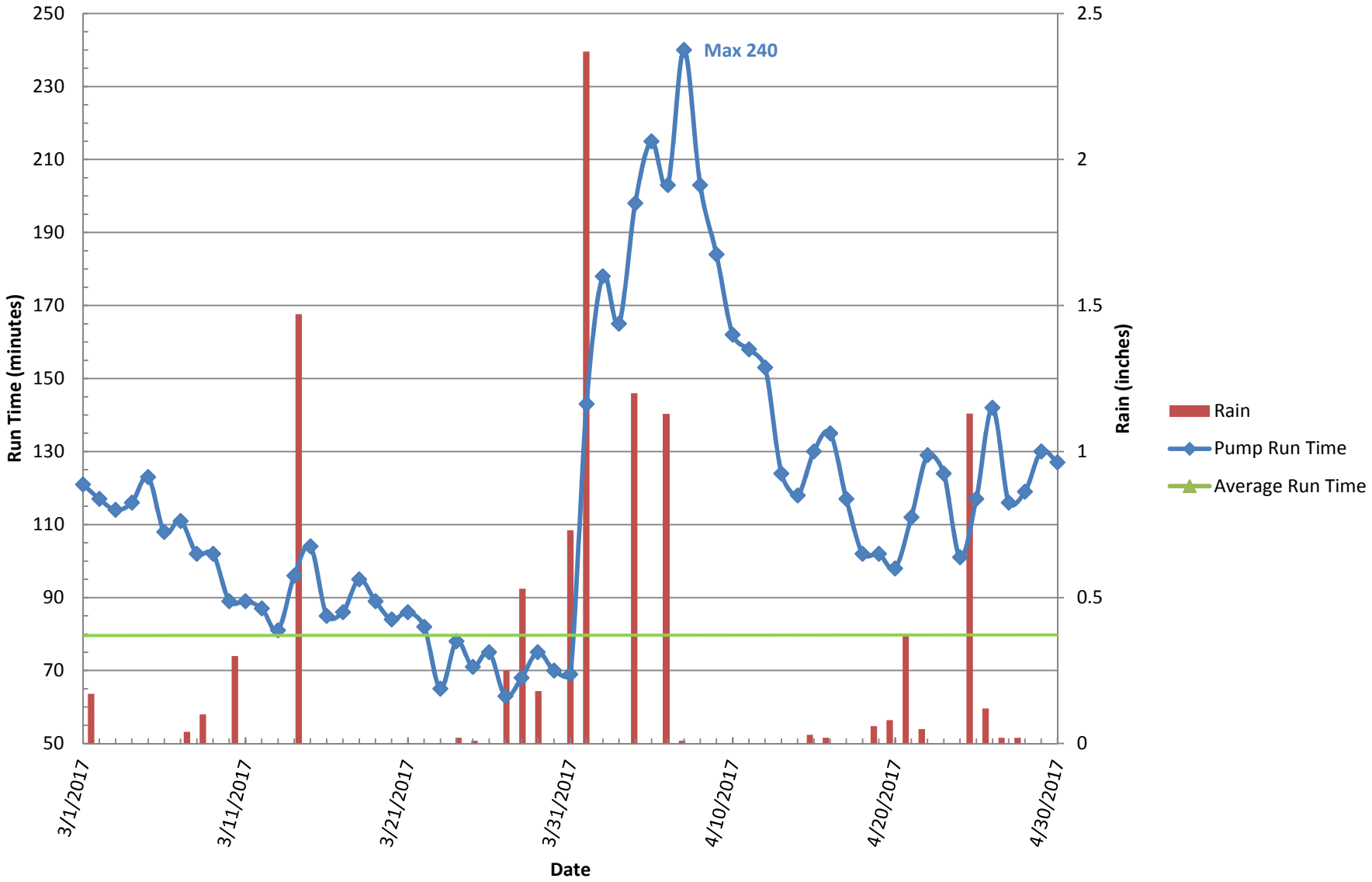
-Sewershed: 10 (7,540 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 220 min

Ruggles PS
Spring 2015



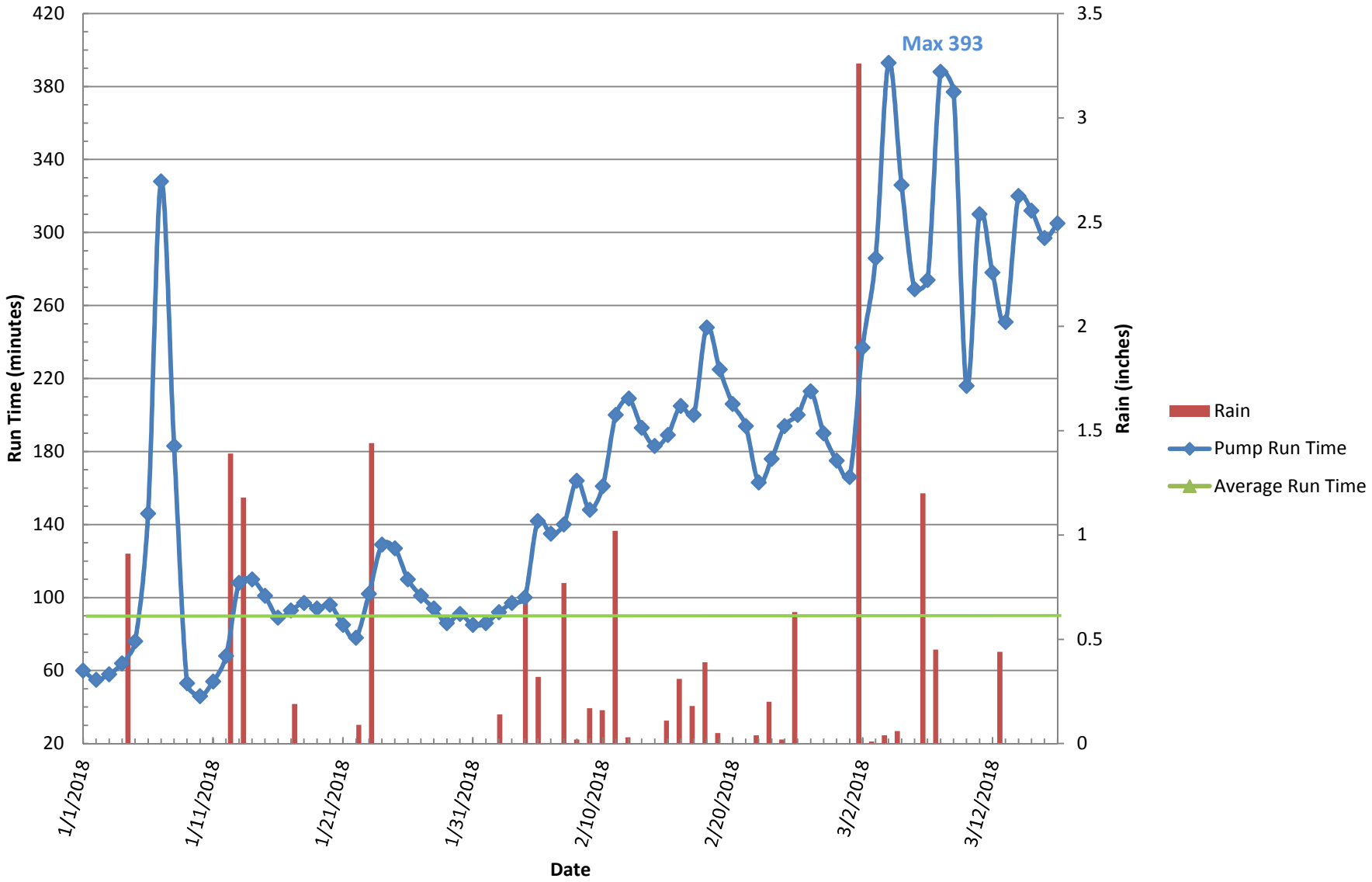
-Sewershed: 10 (7,541 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 80 min

Ruggles PS
Spring 2017



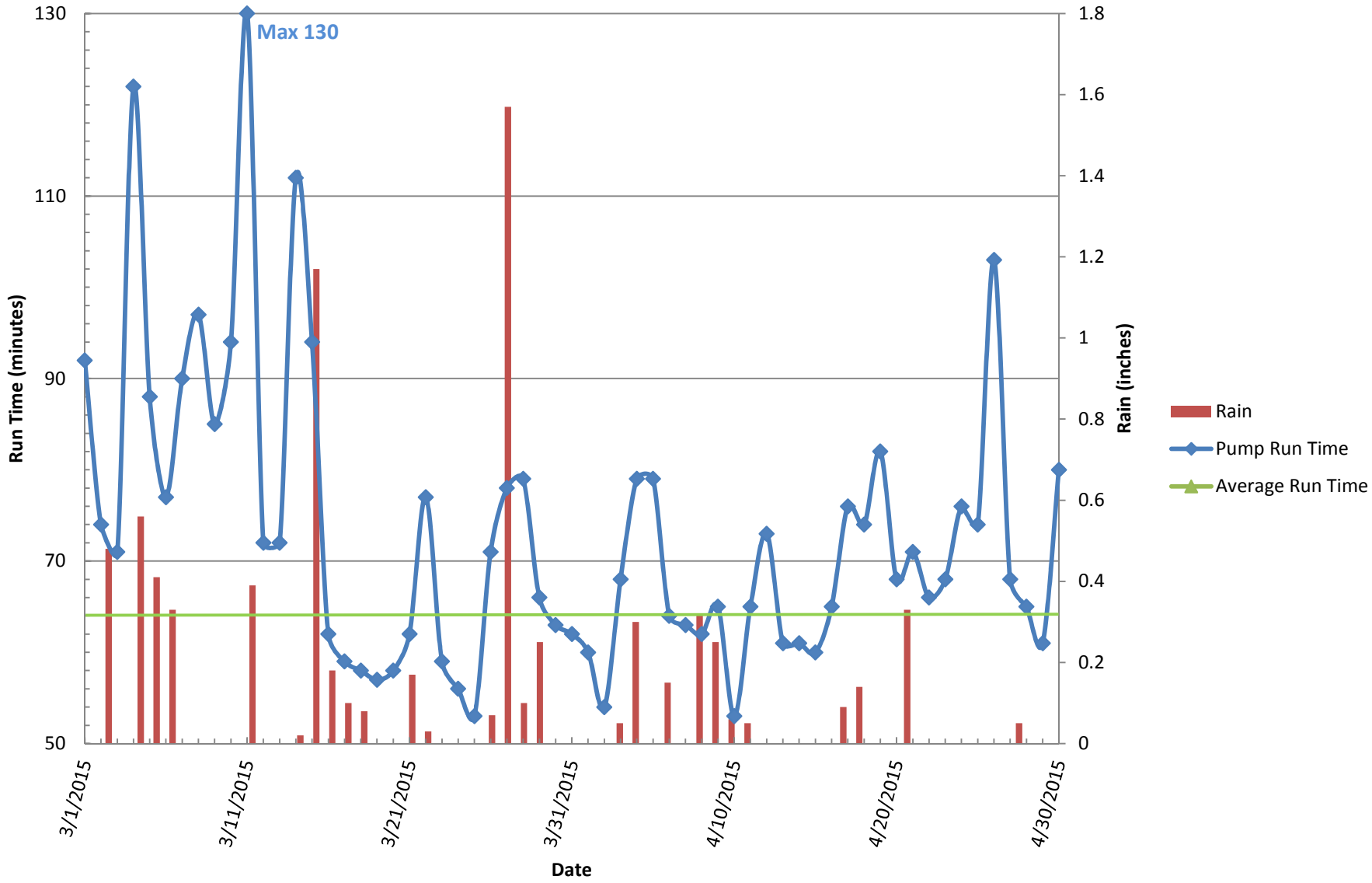
-Sewershed: 10 (7,541 LF pipe)
-Capacity: ± 230 gpm
-Average Dry-Weather Run-Time: 90 min

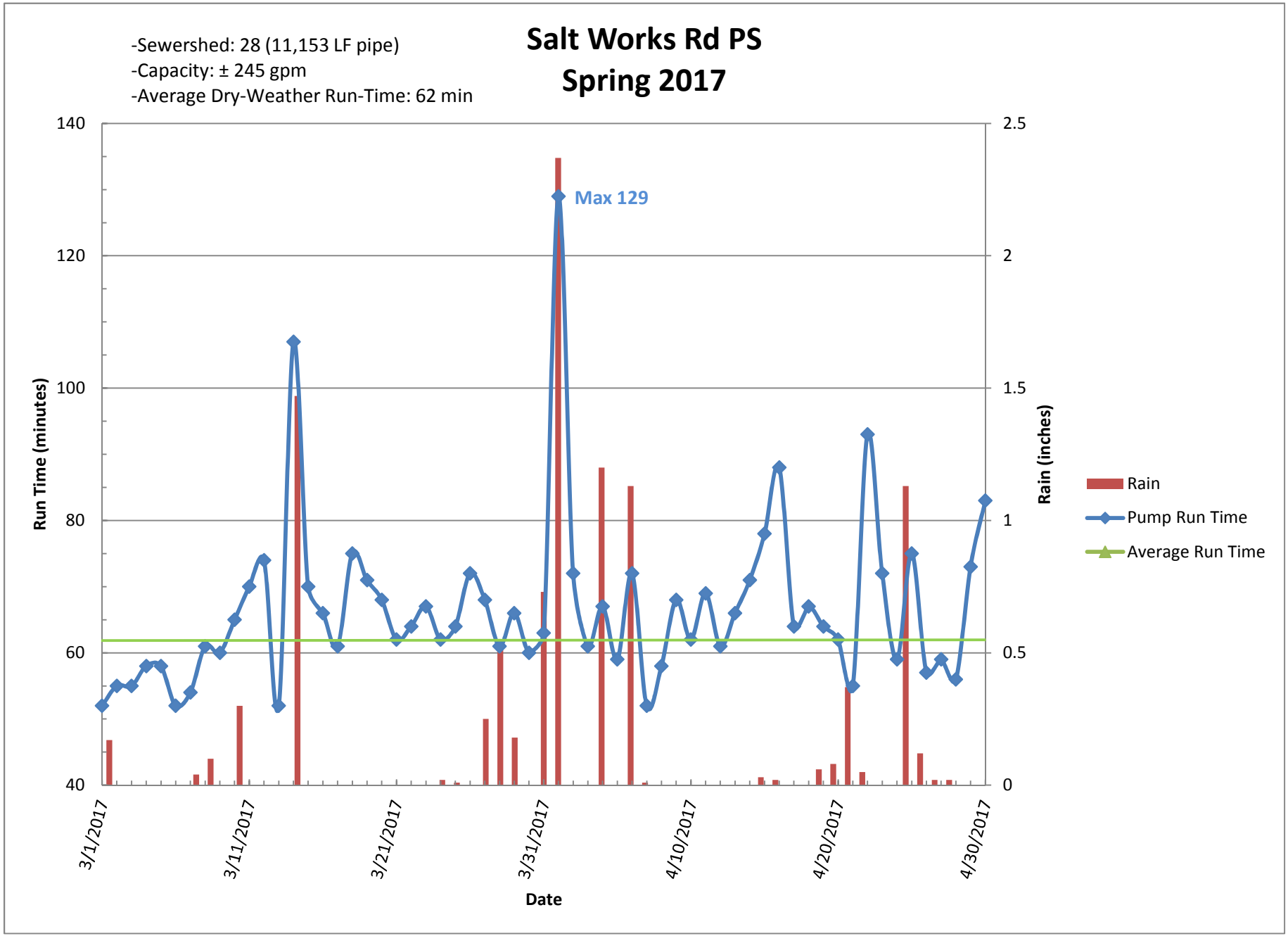
Ruggles PS
Winter/Spring 2018



-Sewershed: 28 (11,153 LF pipe)
-Capacity: ± 245 gpm
-Average Dry-Weather Run Time: 64 min

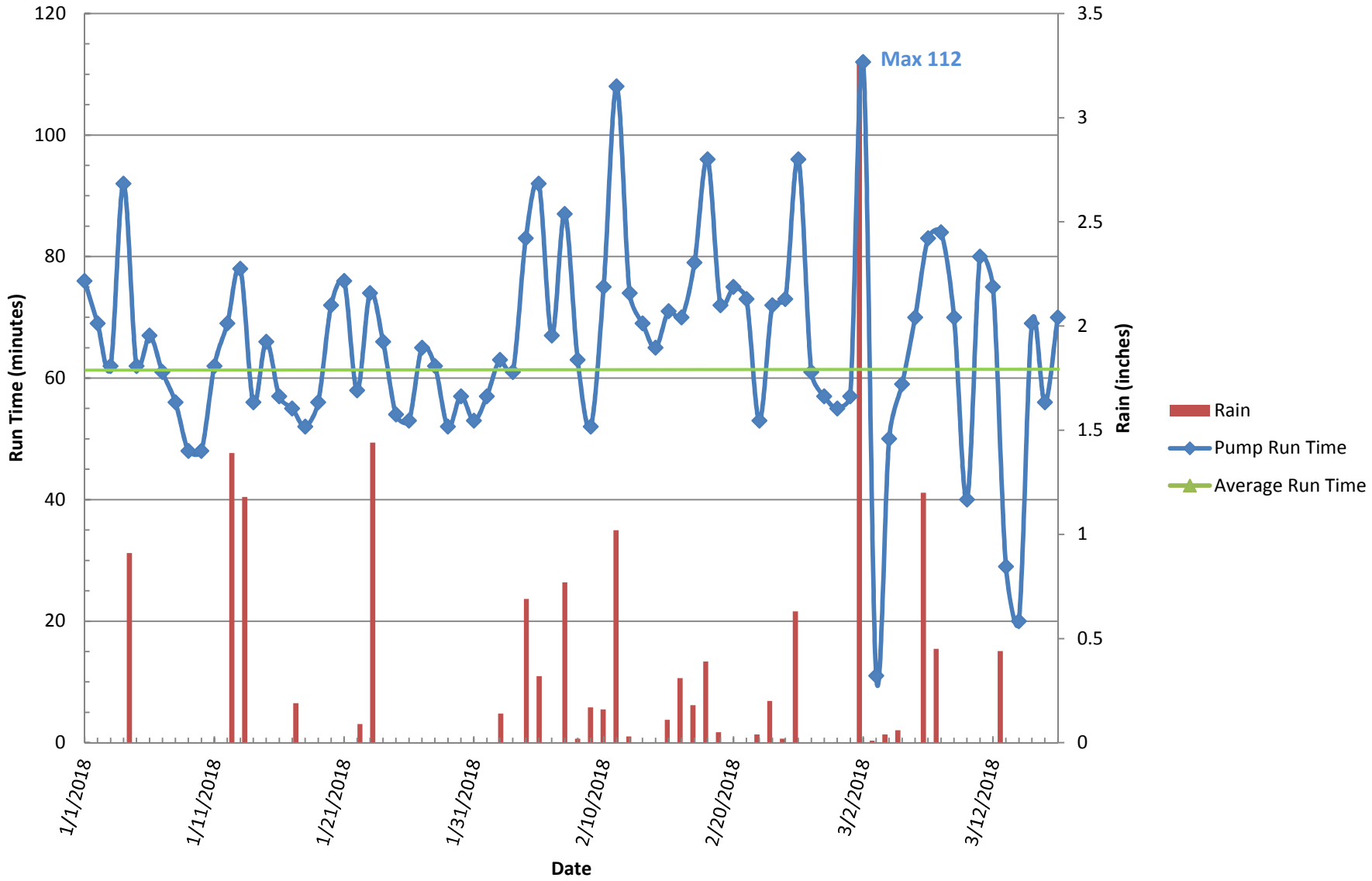
Salt Works Rd PS
Spring 2015

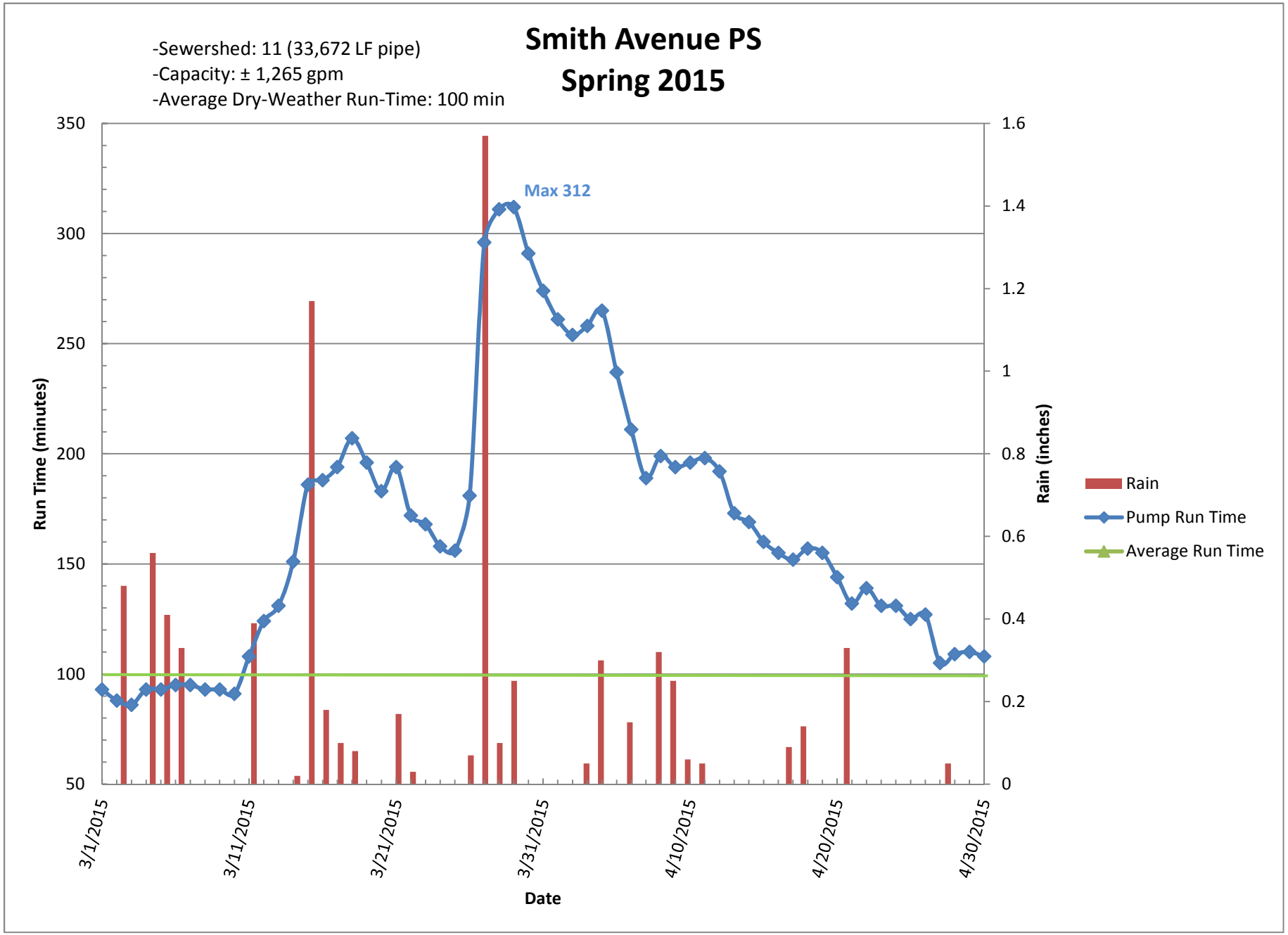



-Sewershed: 28 (11,153 LF pipe)
-Capacity: ± 245 gpm
-Average Dry-Weather Run-Time: 62 min
Salt Works Rd PS
Spring 2017
Max 129
Run Time (minutes)
Rain (inches)
Date
Rain
Pump Run Time
Average Run Time
140
120
100
80
60
40
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017

-Sewershed: 28 (11,153 LF pipe)
-Capacity: ± 245 gpm
-Average Dry-Weather Run-Time: 61 min

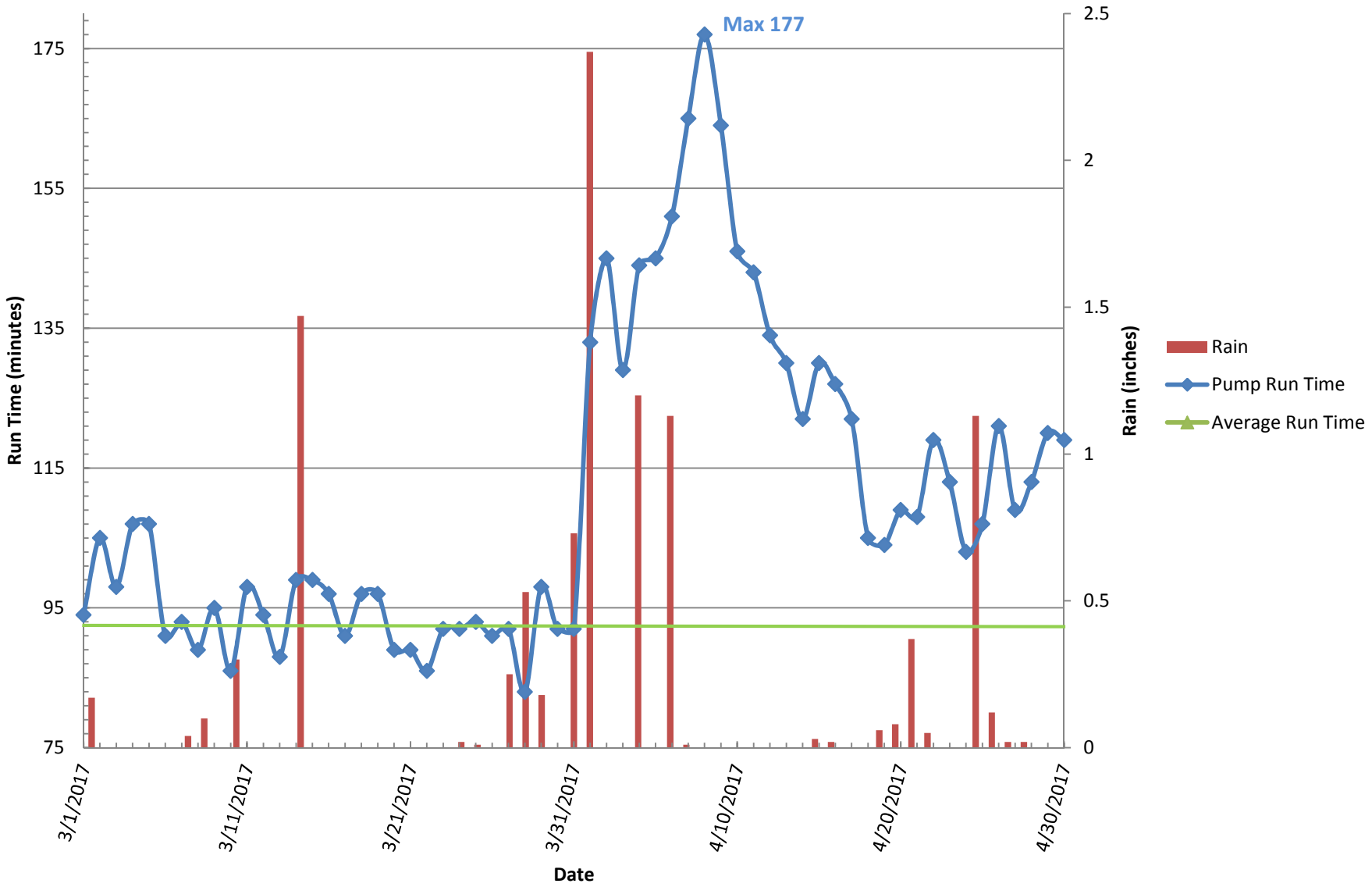
Salt Works Rd PS
Winter/Spring 2018




Smith Avenue PS
Spring 2015
-Sewershed: 11 (33,672 LF pipe)
-Capacity: ± 1,265 gpm
-Average Dry-Weather Run-Time: 100 min
Max 312
Run Time (minutes)
Rain (inches)
Date
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015
Rain
Pump Run Time
Average Run Time

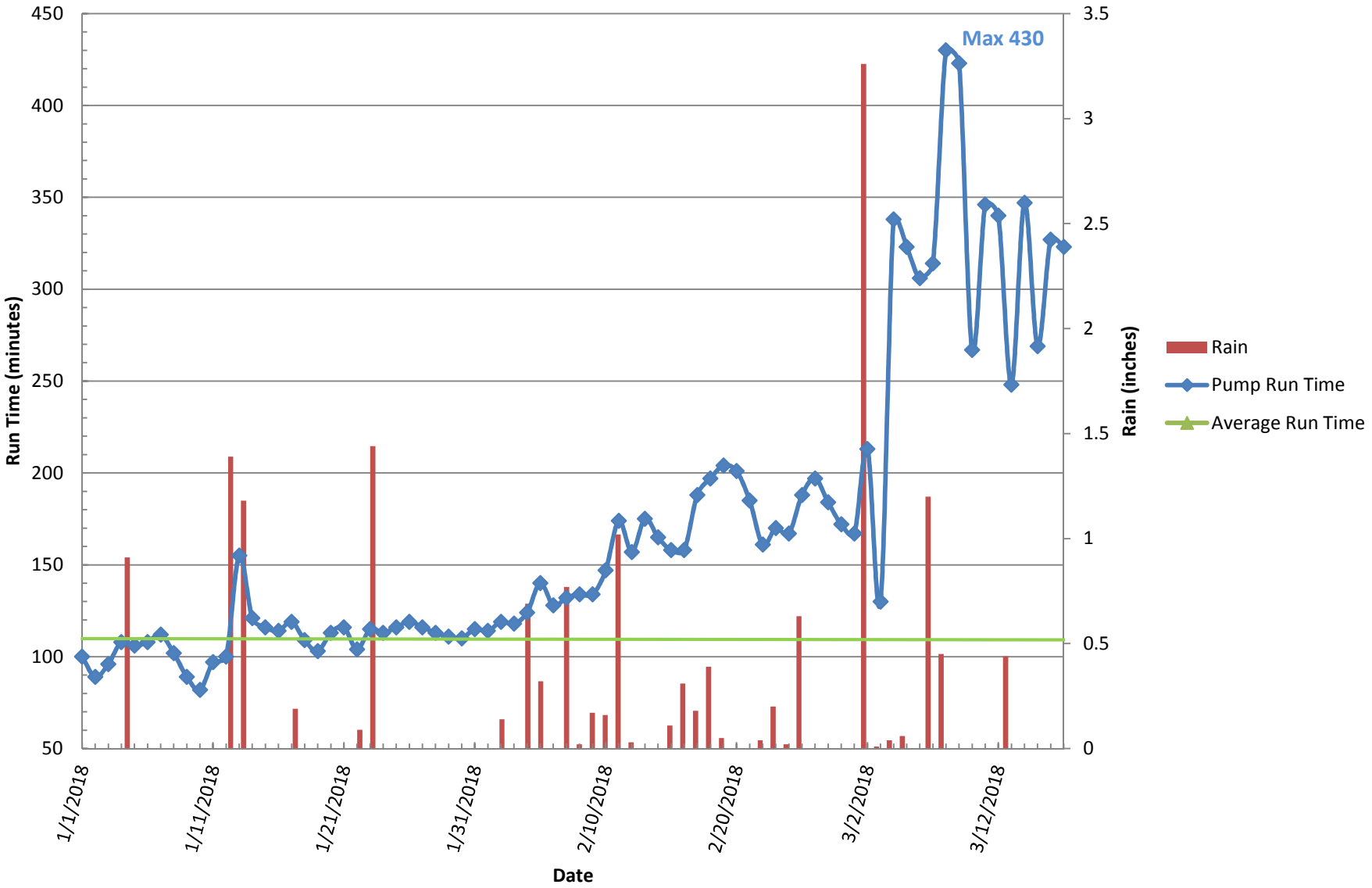
-Sewershed: 11 (33,672 LF pipe)
-Capacity: ± 1,265 gpm
-Average Dry-Weather Run-Time: 93 min

Smith Avenue PS
Spring 2017



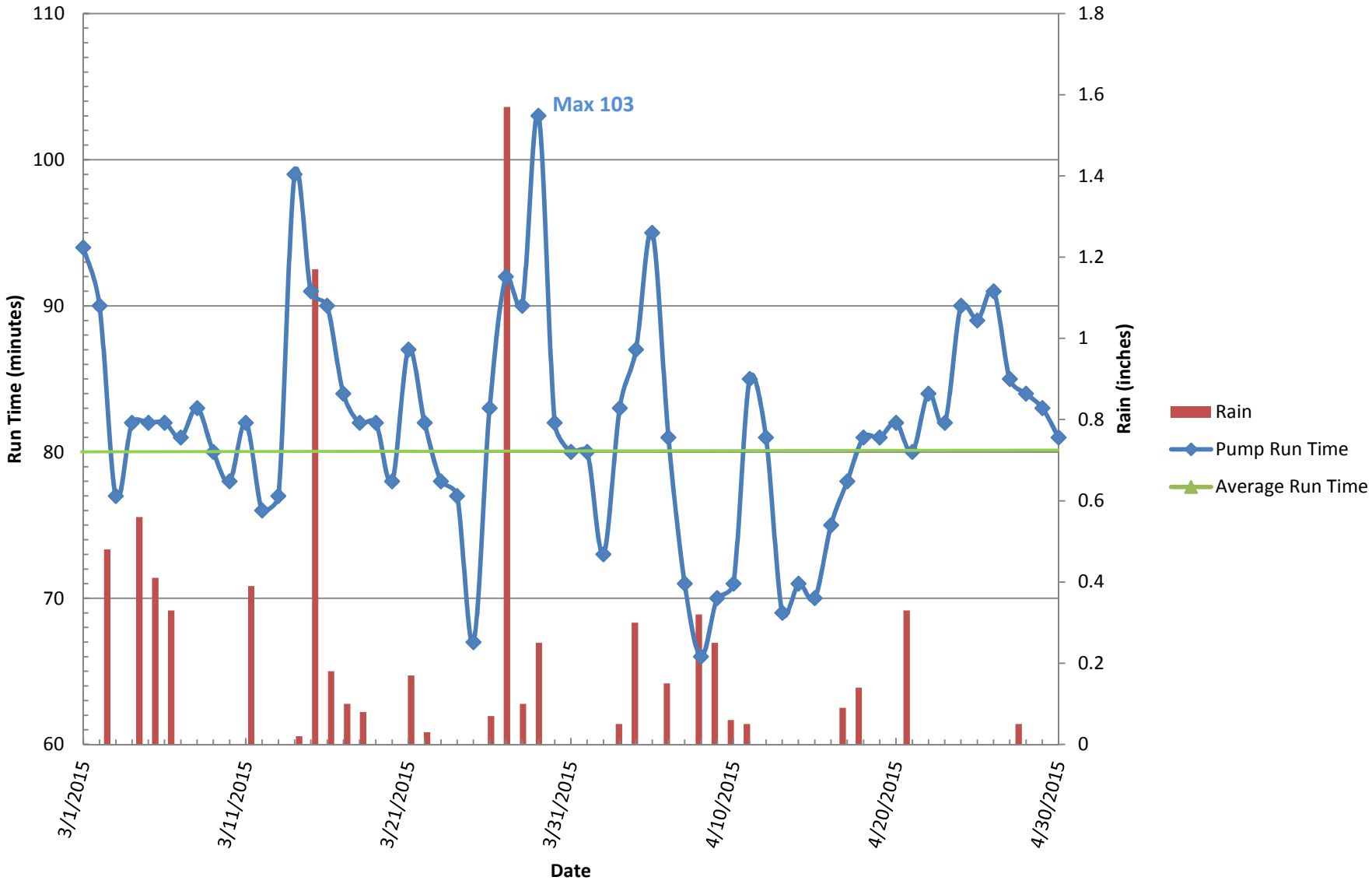
-Sewershed: 11 (33,672 LF pipe)
-Capacity: ± 1,265 gpm
-Average Dry-Weather Run-Time: 110 min

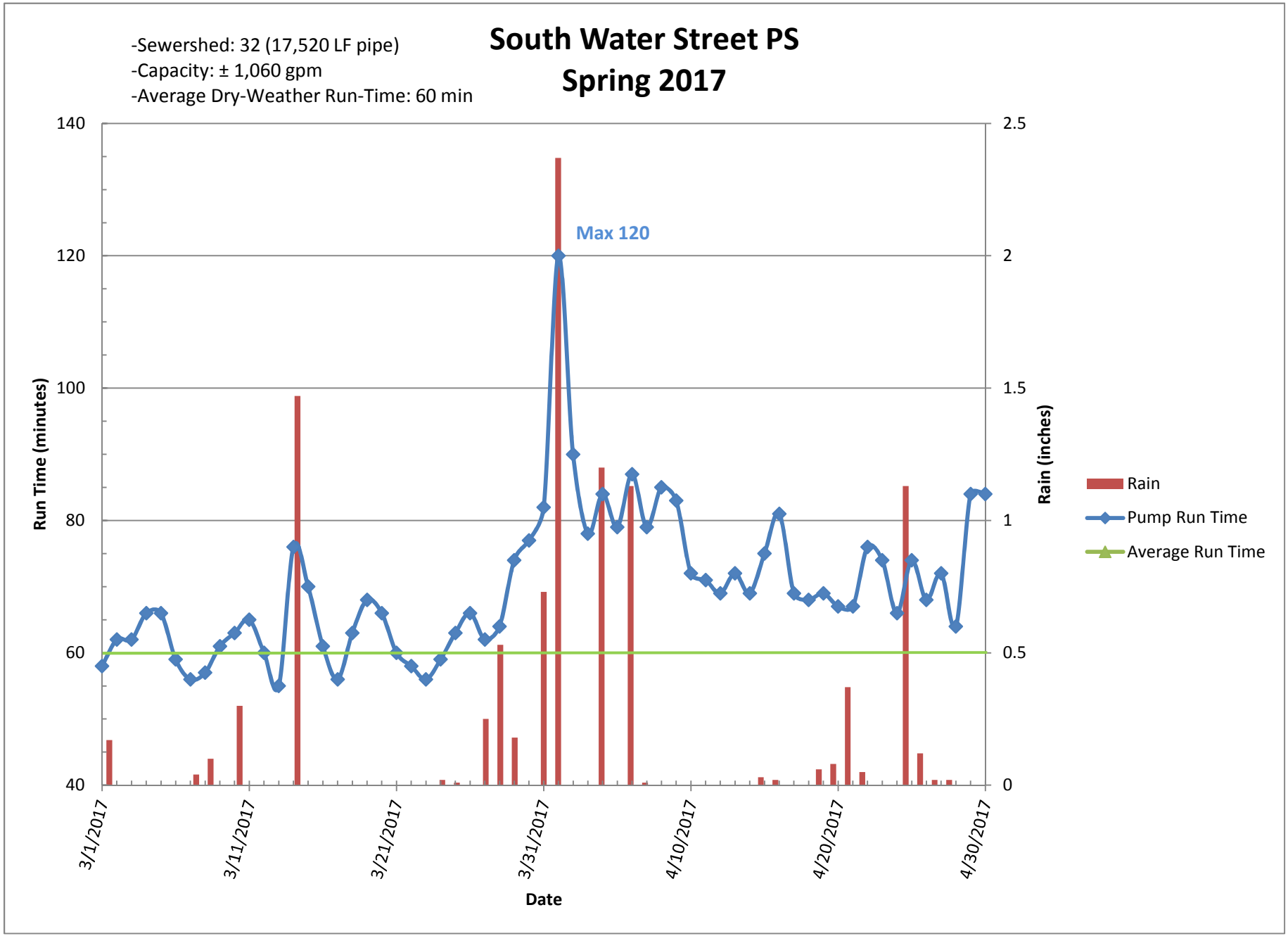
Smith Avenue PS
Winter/Spring 2018

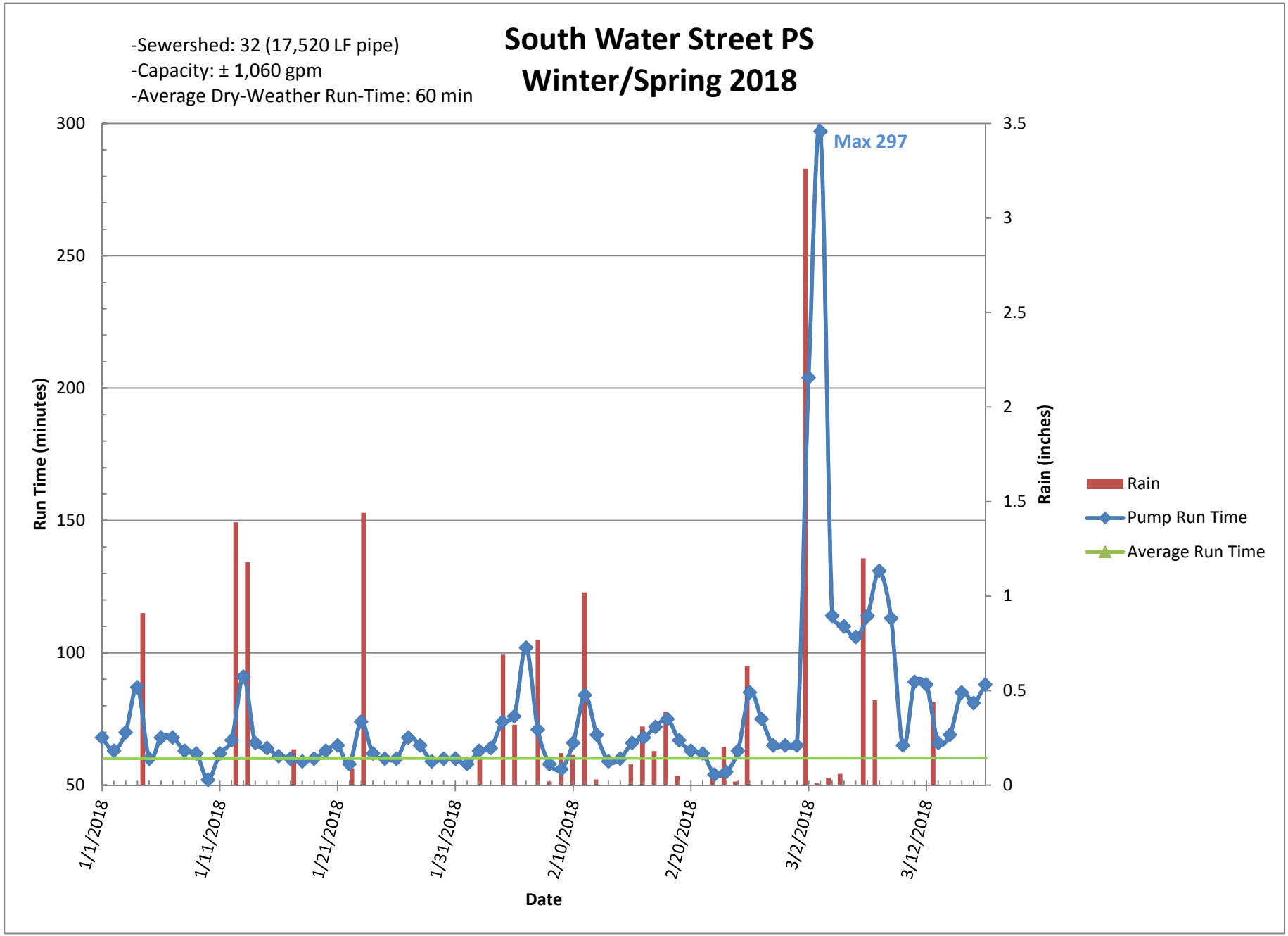


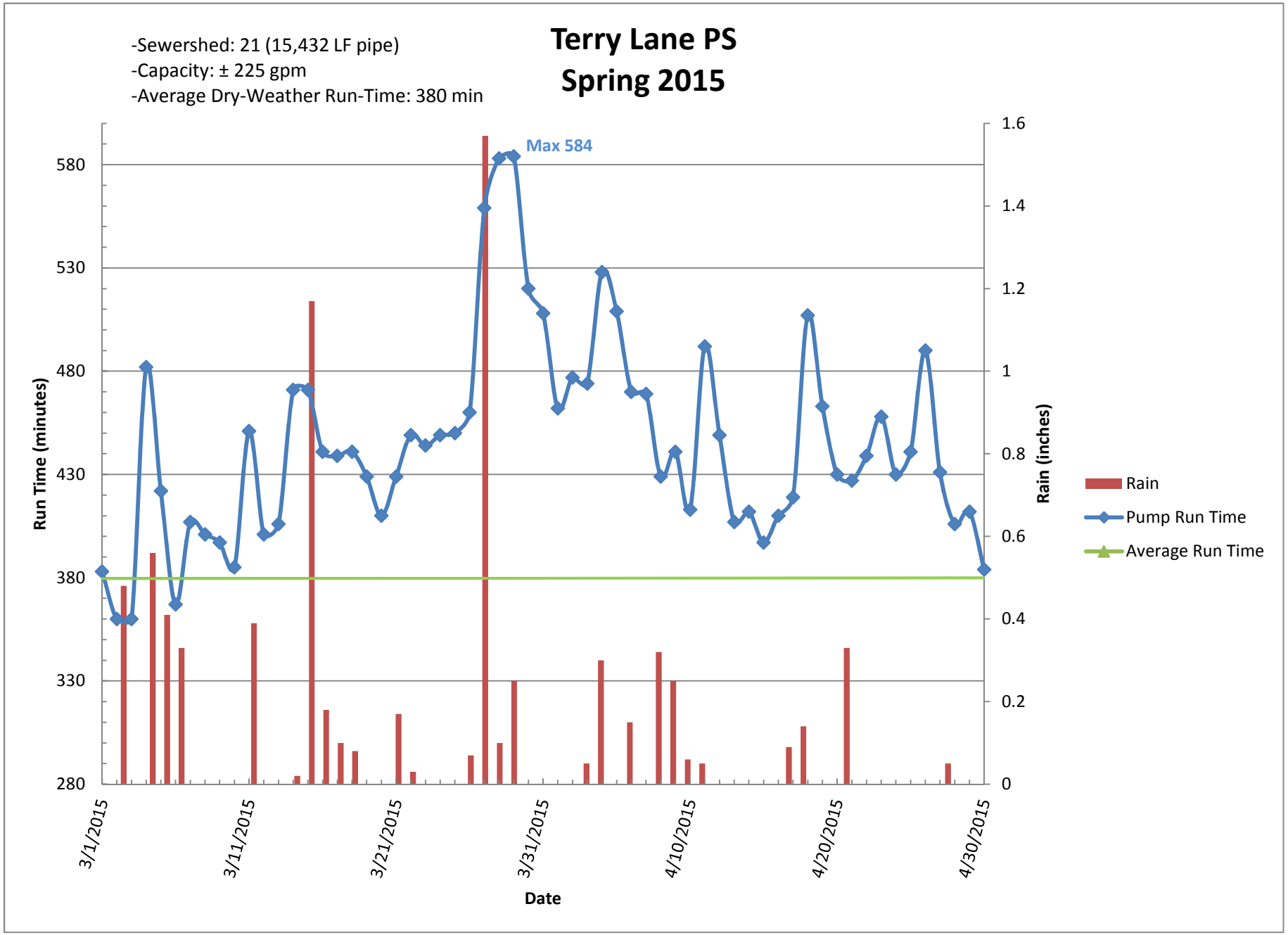
-Sewershed: 32 (17,520 LF pipe)
-Capacity: ± 1,060 gpm
-Average Dry-Weather Run Time: 80 min

South Water Street PS
Spring 2015



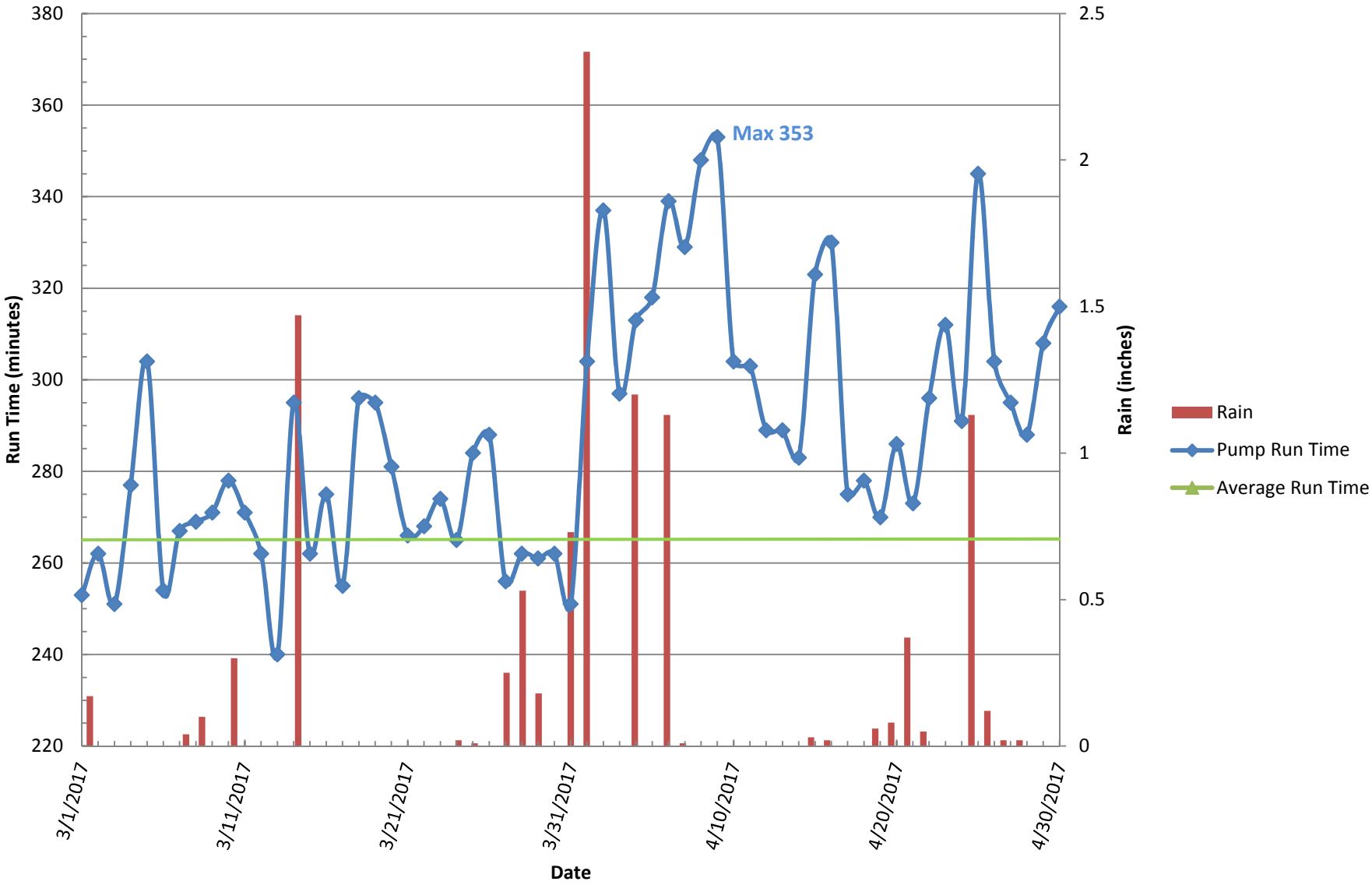

South Water Street PS
Spring 2017
-Sewershed: 32 (17,520 LF pipe)
-Capacity: ± 1,060 gpm
-Average Dry-Weather Run-Time: 60 min
Max 120
Run Time (minutes)
Rain (inches)
Date
140
120
100
80
60
40
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Rain
Pump Run Time
Average Run Time


South Water Street PS
Winter/Spring 2018
-Sewershed: 32 (17,520 LF pipe)
-Capacity: ± 1,060 gpm
-Average Dry-Weather Run-Time: 60 min
Max 297
Run Time (minutes)
Rain (inches)
Date
300
250
200
150
100
50
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018
Rain
Pump Run Time
Average Run Time


-Sewershed: 21 (15,432 LF pipe)
-Capacity: ± 225 gpm
-Average Dry-Weather Run-Time: 380 min
Terry Lane PS
Spring 2015
Max 584
Run Time (minutes)
Rain (inches)
580
530
480
430
380
330
280
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
3/1/2015
3/11/2015
3/21/2015
3/31/2015
4/10/2015
4/20/2015
4/30/2015
Date
Rain
Pump Run Time
Average Run Time

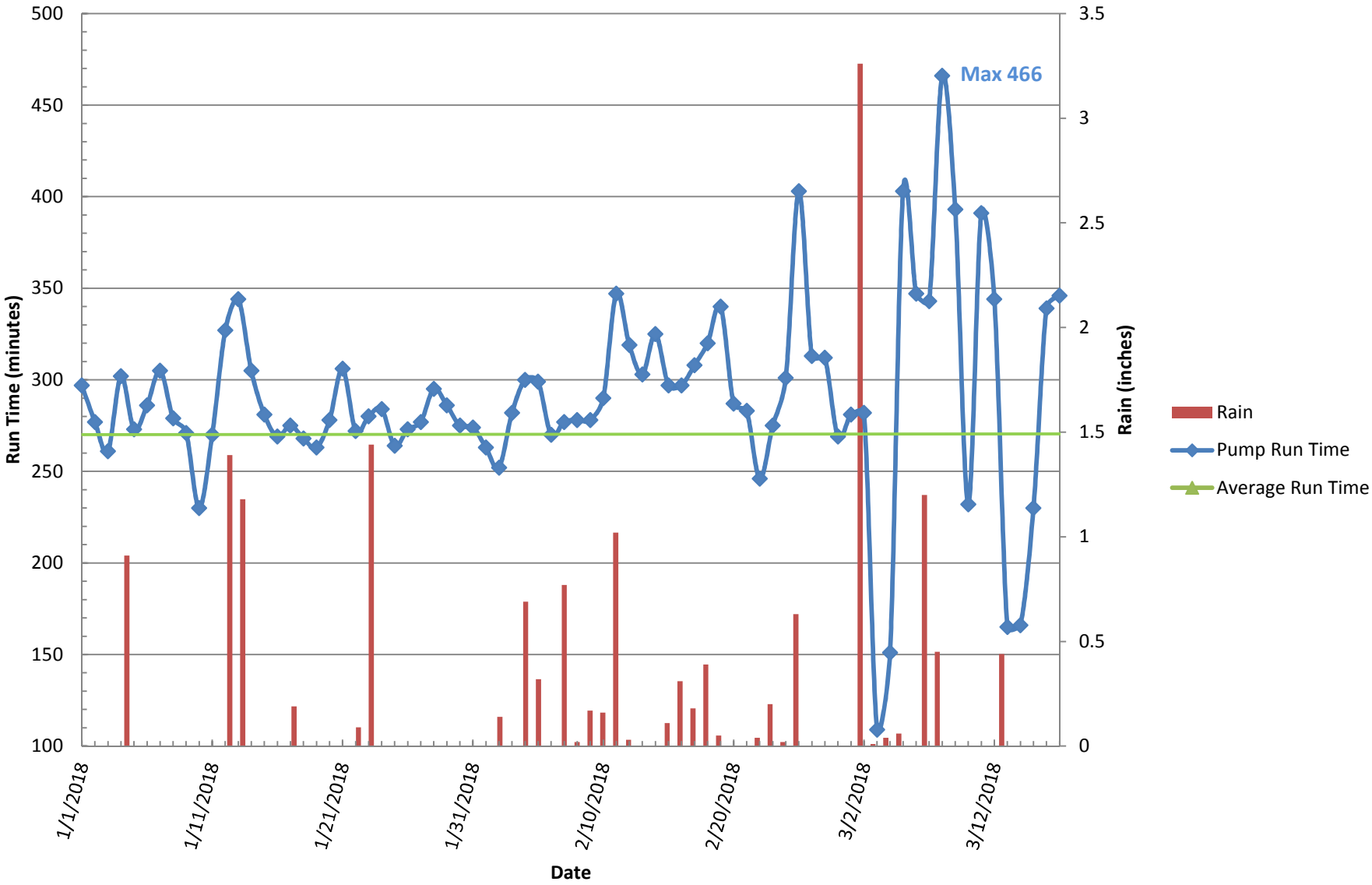
-Sewershed: 21 (15,432 LF pipe)
-Capacity: ± 225 gpm
-Average Dry-Weather Run-Time: 265 min

Terry Lane PS
Spring 2017



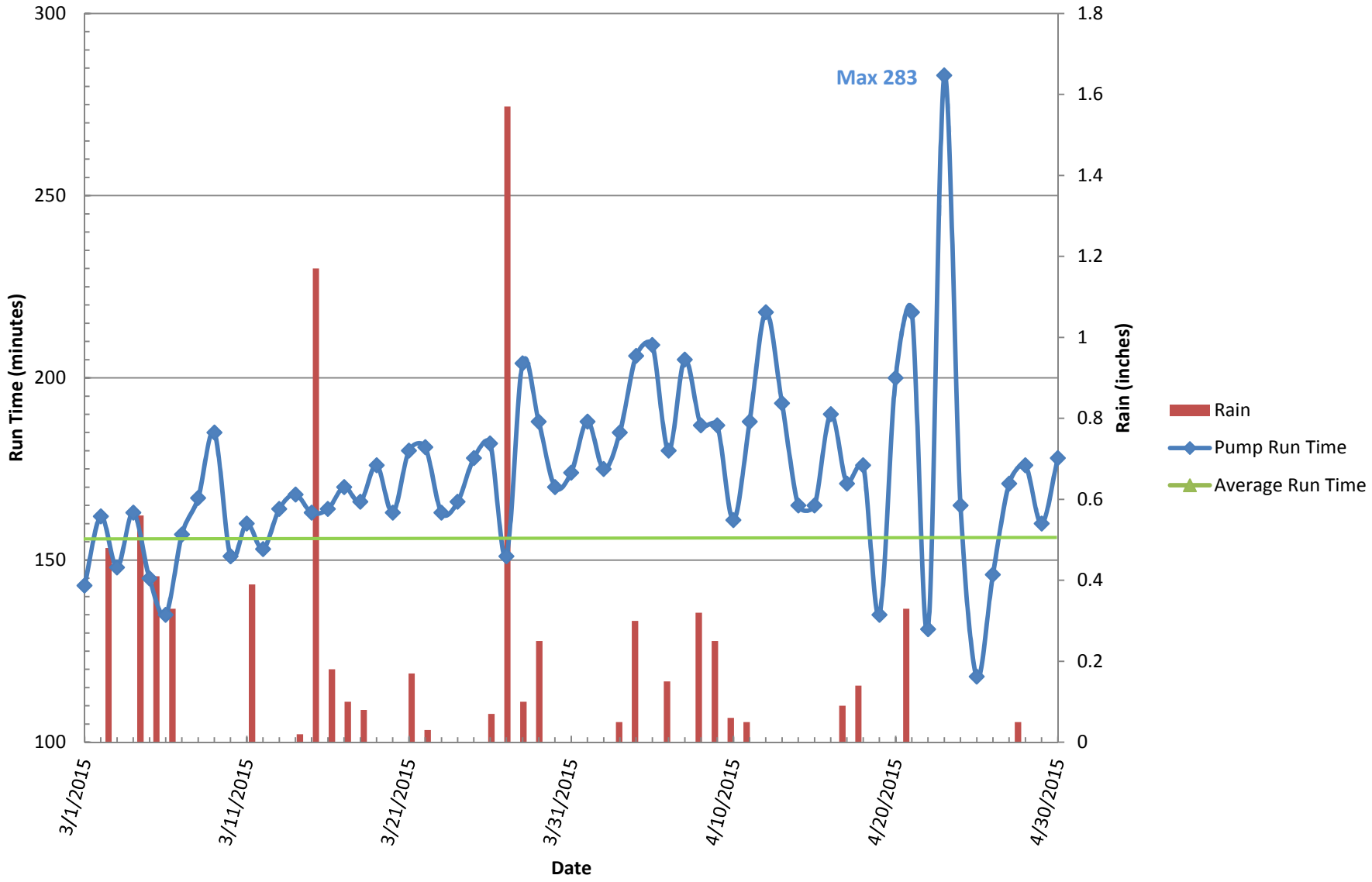
-Sewershed: 21 (15,432 LF pipe)
-Capacity: ± 225 gpm
-Average Dry-Weather Run-Time: 270 min

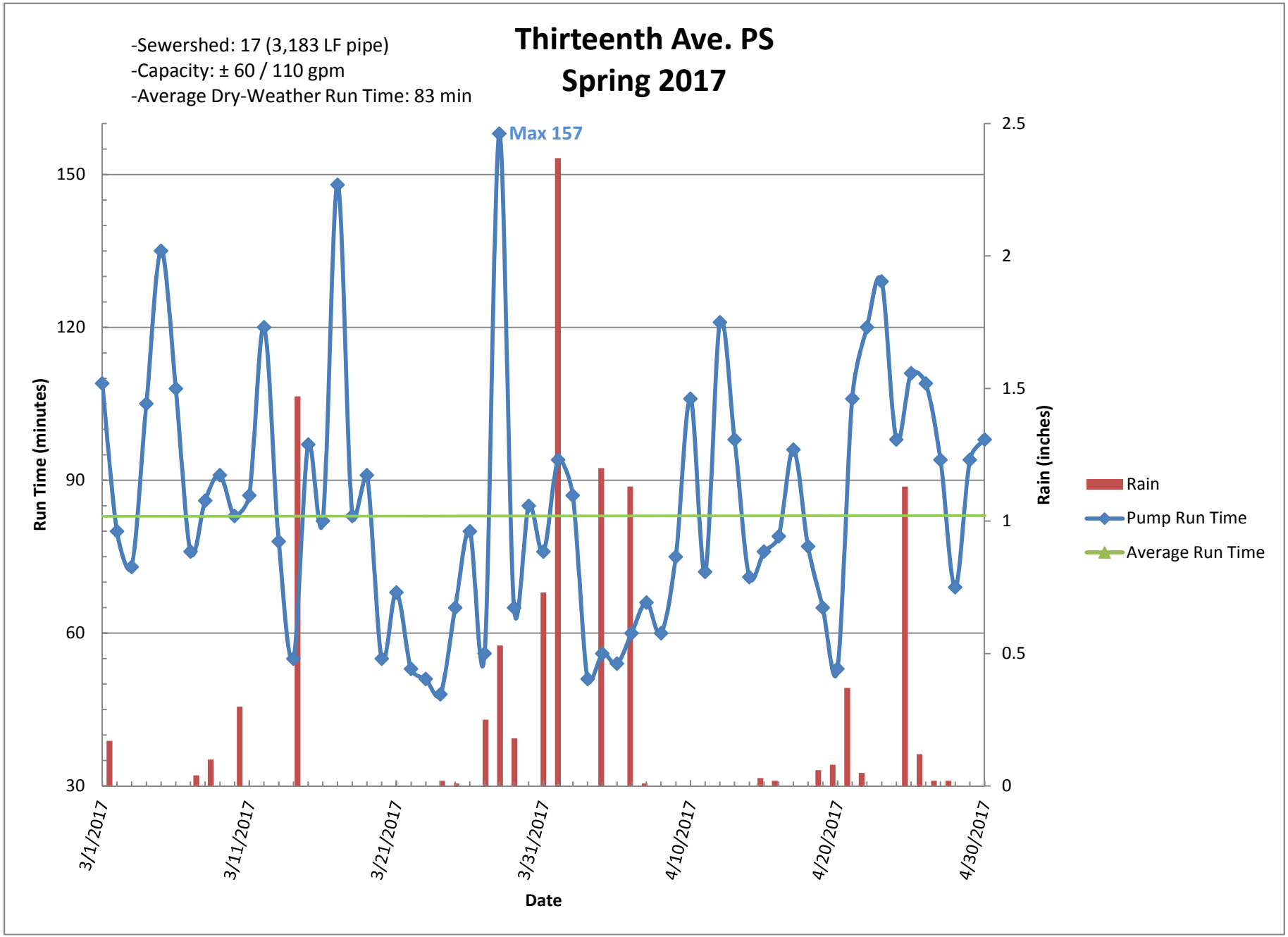
Terry Lane PS
Winter/Spring 2018

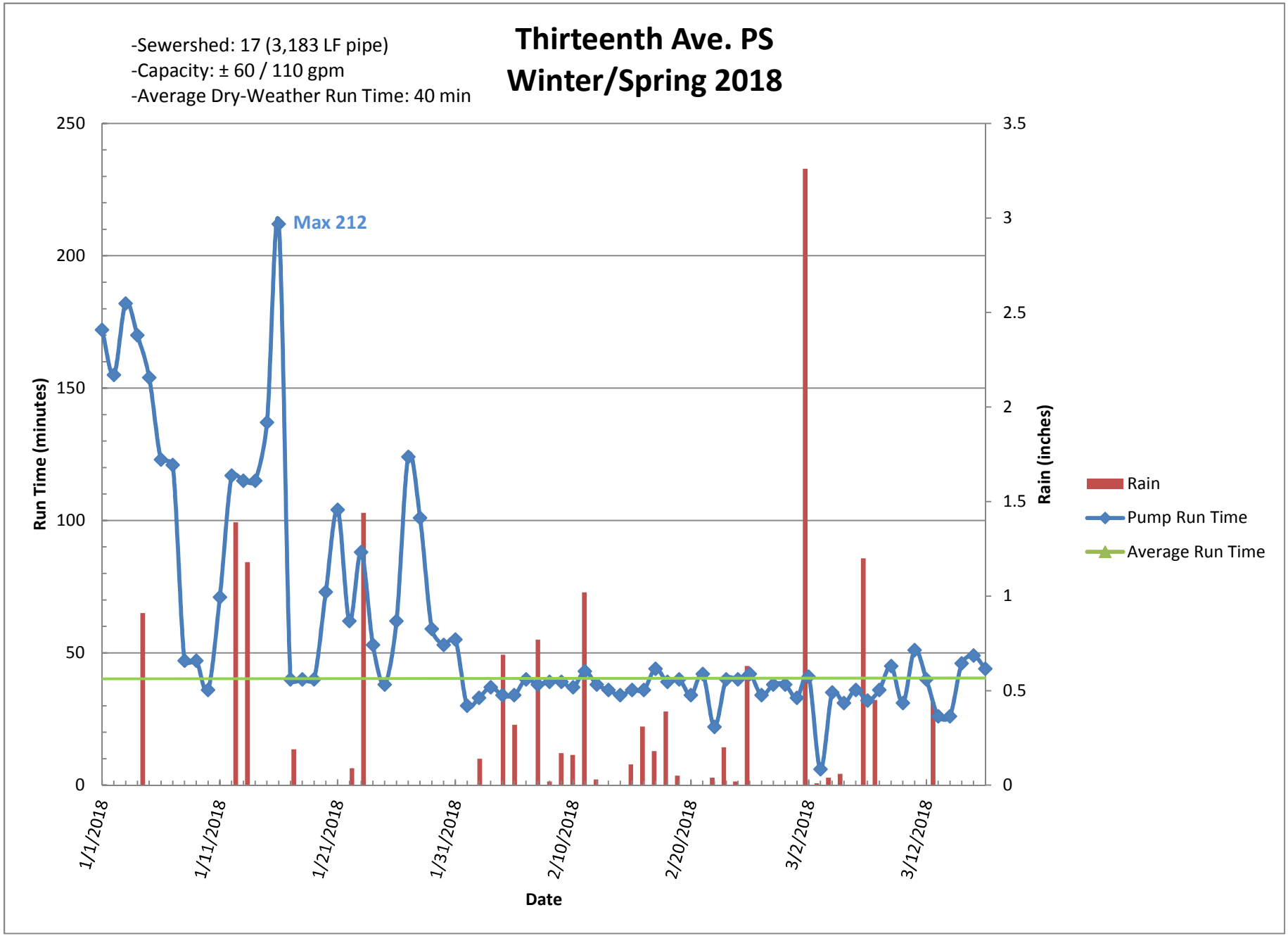


-Sewershed: 17 (3,183 LF pipe)
-Capacity: ± 60 / 110 gpm
-Average Dry-Weather Run-Time: 156 min

Thirteenth Ave. PS
Spring 2015




Thirteenth Ave. PS
Spring 2017
-Sewershed: 17 (3,183 LF pipe)
-Capacity: ± 60 / 110 gpm
-Average Dry-Weather Run Time: 83 min
Max 157
Run Time (minutes)
Rain (inches)
150
120
90
60
30
2.5
2
1.5
1
0.5
0
3/1/2017
3/11/2017
3/21/2017
3/31/2017
4/10/2017
4/20/2017
4/30/2017
Date
Rain
Pump Run Time
Average Run Time


-Sewershed: 17 (3,183 LF pipe)
-Capacity: ± 60 / 110 gpm
-Average Dry-Weather Run Time: 40 min
Thirteenth Ave. PS
Winter/Spring 2018
Max 212
Run Time (minutes)
Rain (inches)
Date
250
200
150
100
50
0
3.5
3
2.5
2
1.5
1
0.5
0
1/1/2018
1/11/2018
1/21/2018
1/31/2018
2/10/2018
2/20/2018
3/2/2018
3/12/2018
Rain
Pump Run Time
Average Run Time

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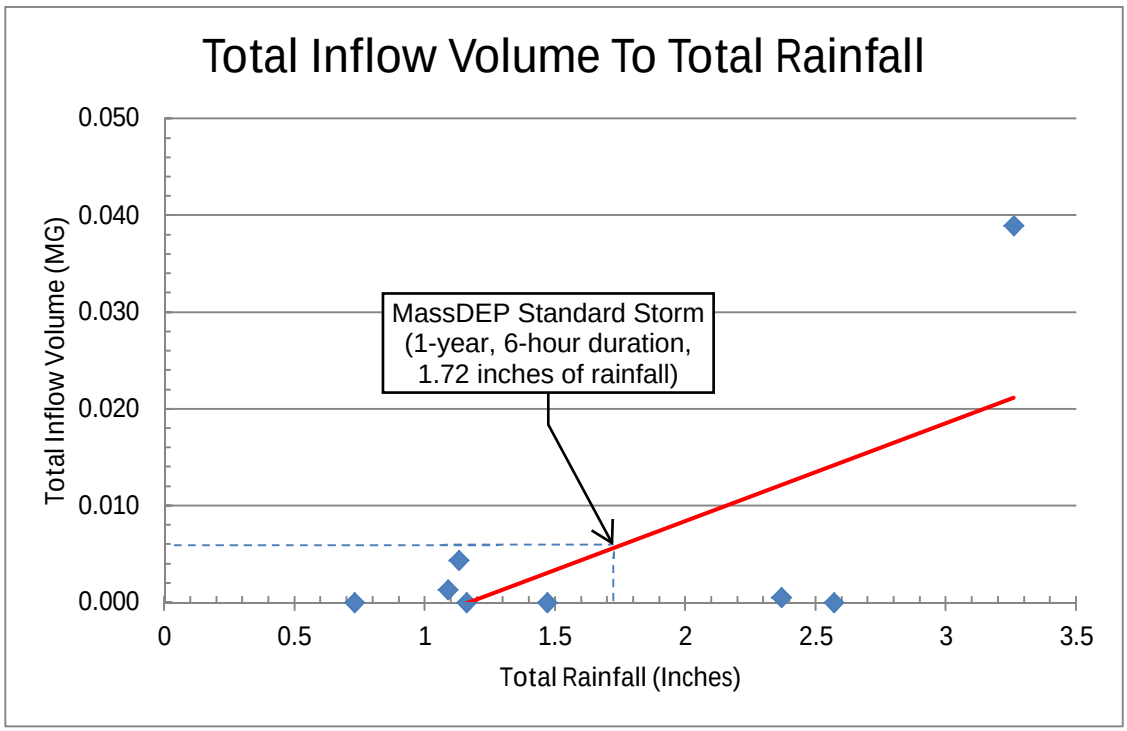
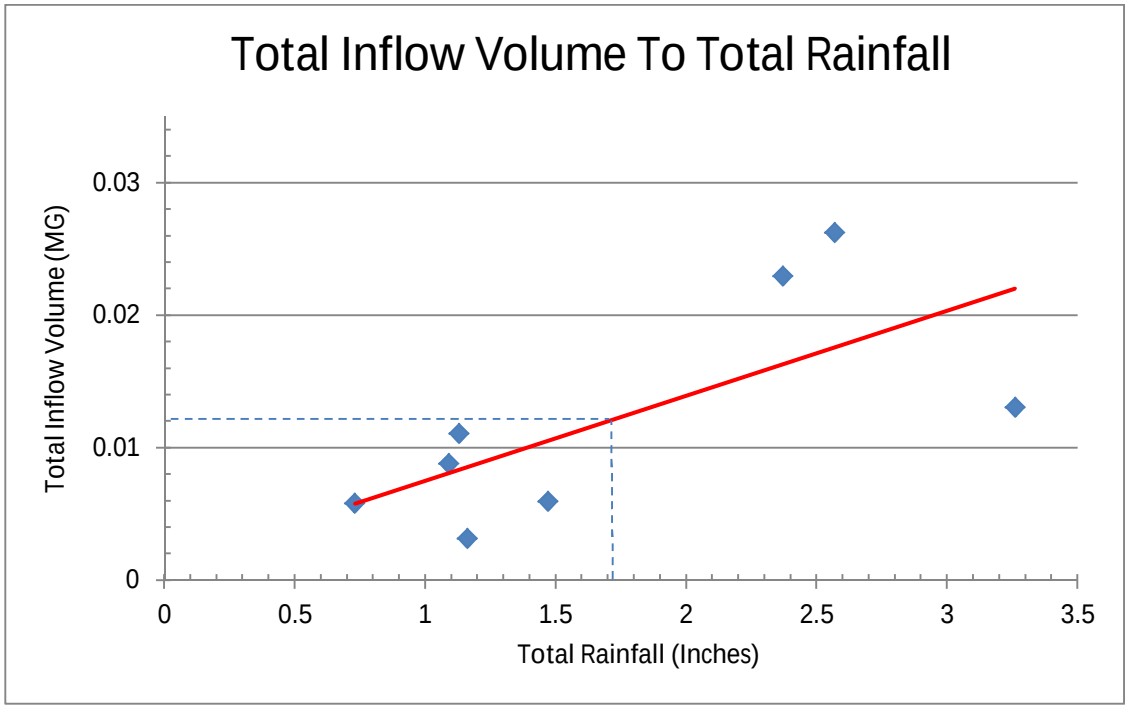
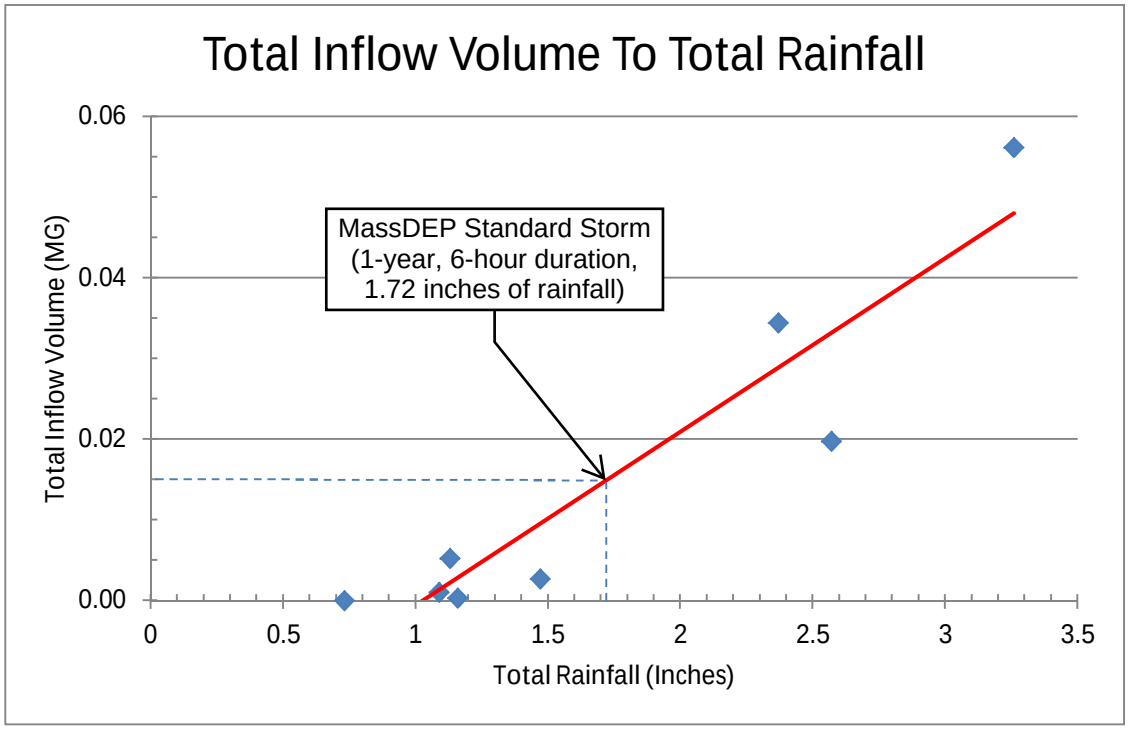
Apple Street:



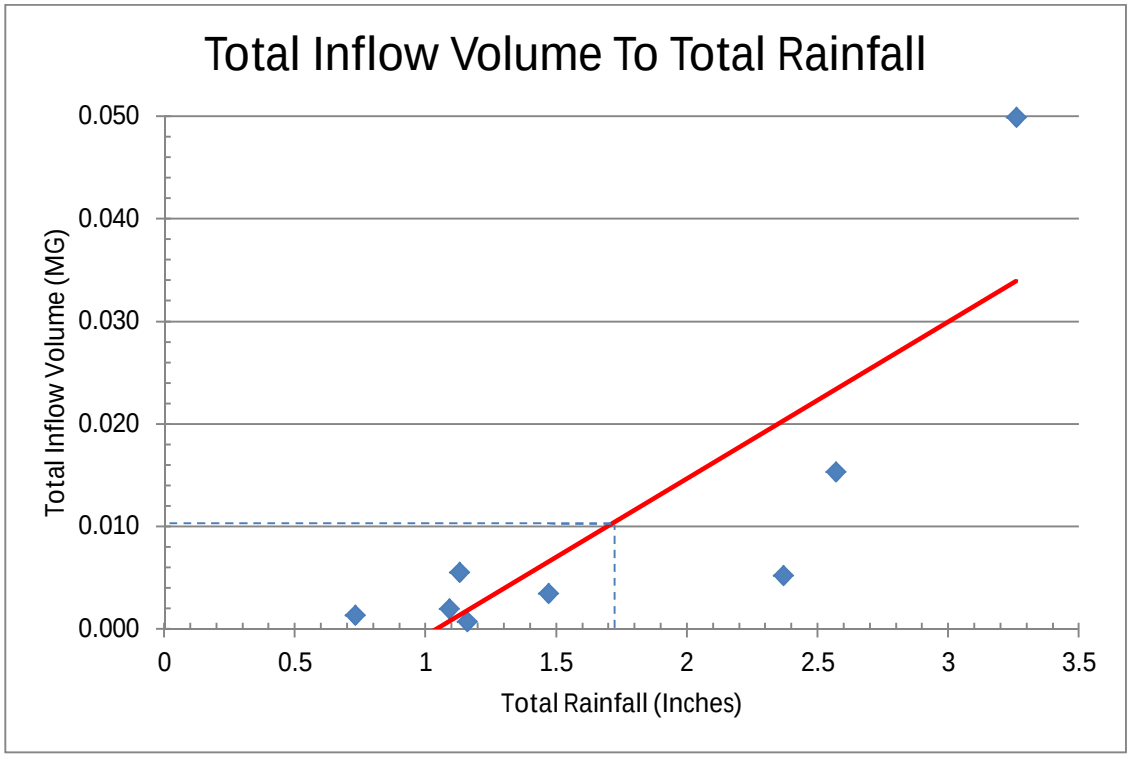
Arnold Street:



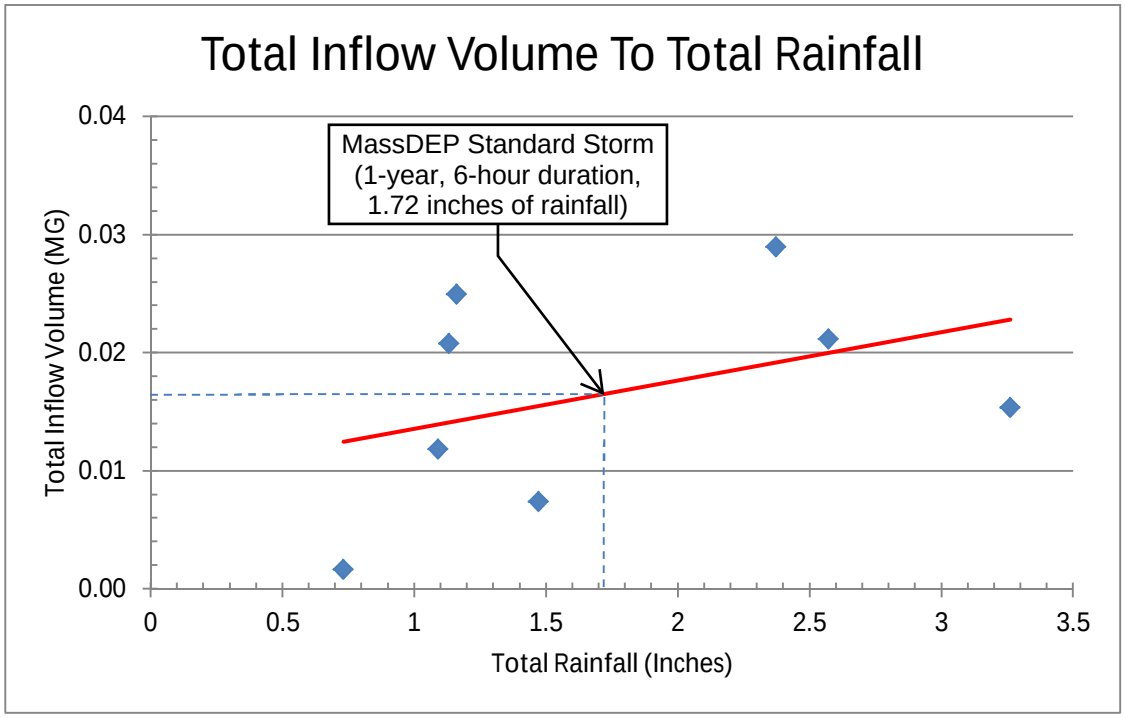
Briarwood Drive:



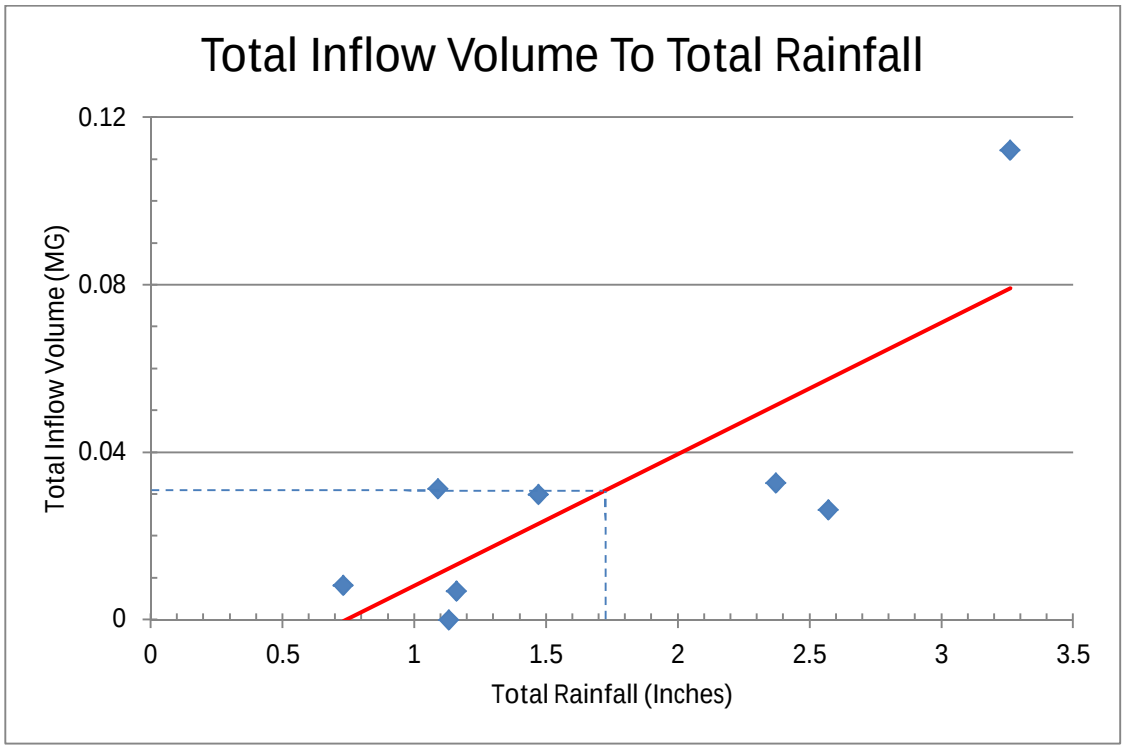
Cromesett Road:



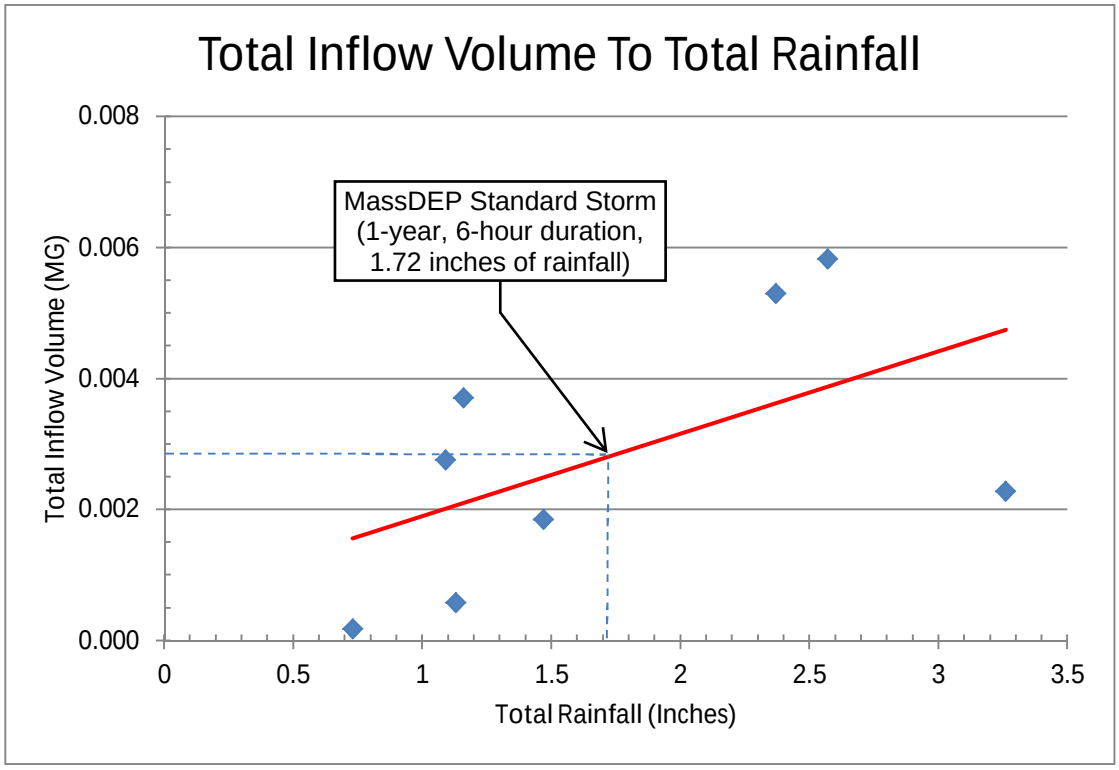
French-Canedy:



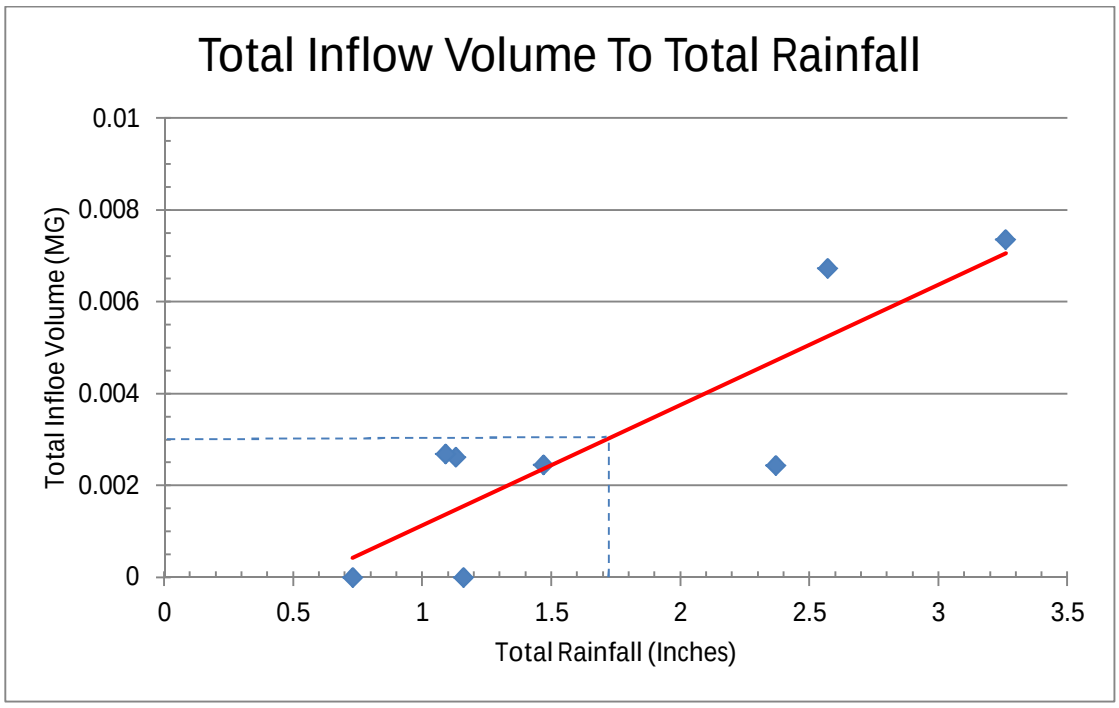
Hathaway:



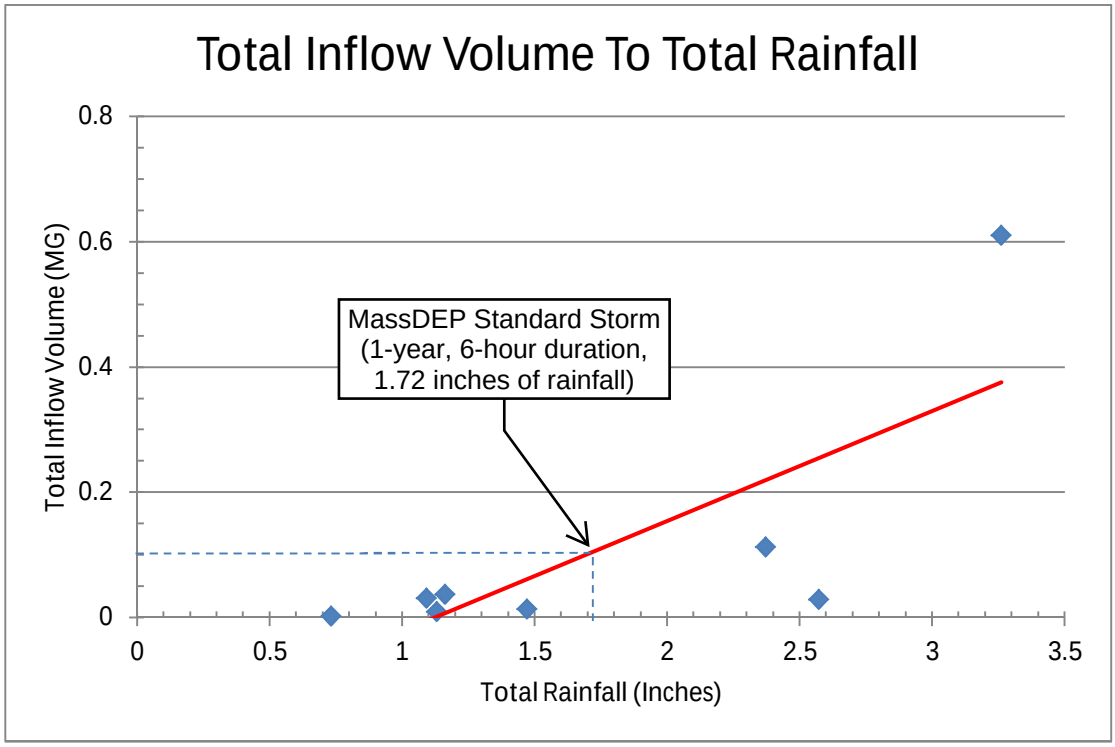
Leonard Street:



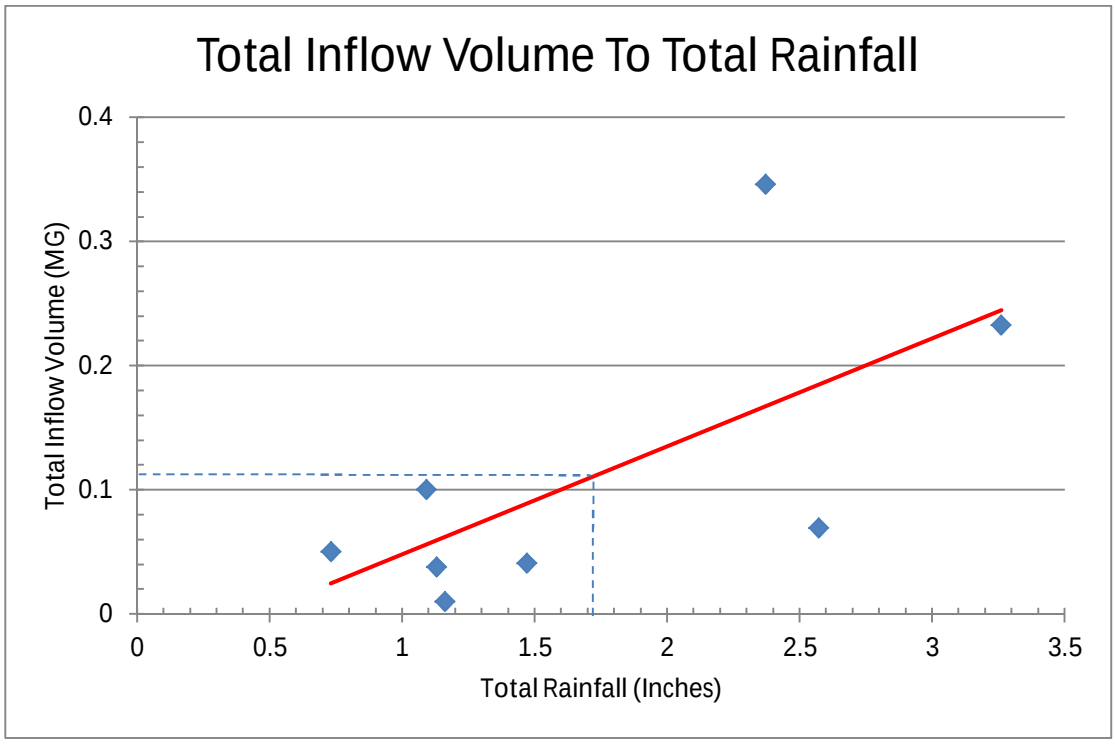
Mattapoisett Road:



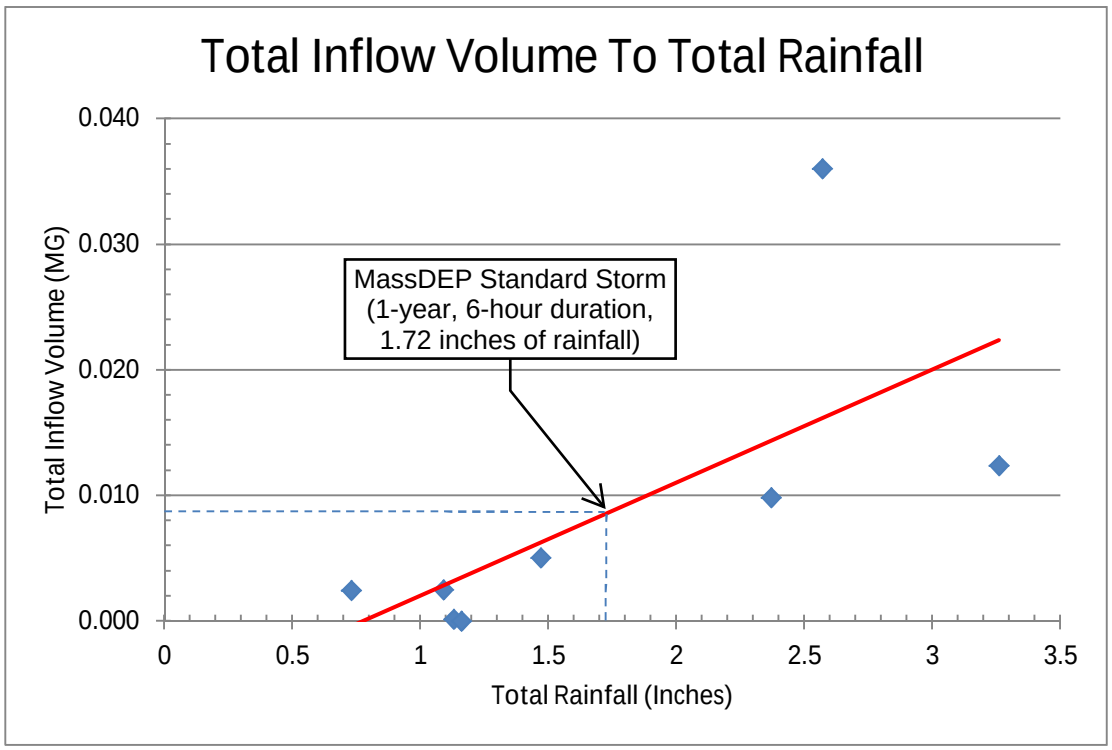
North Boulevard:



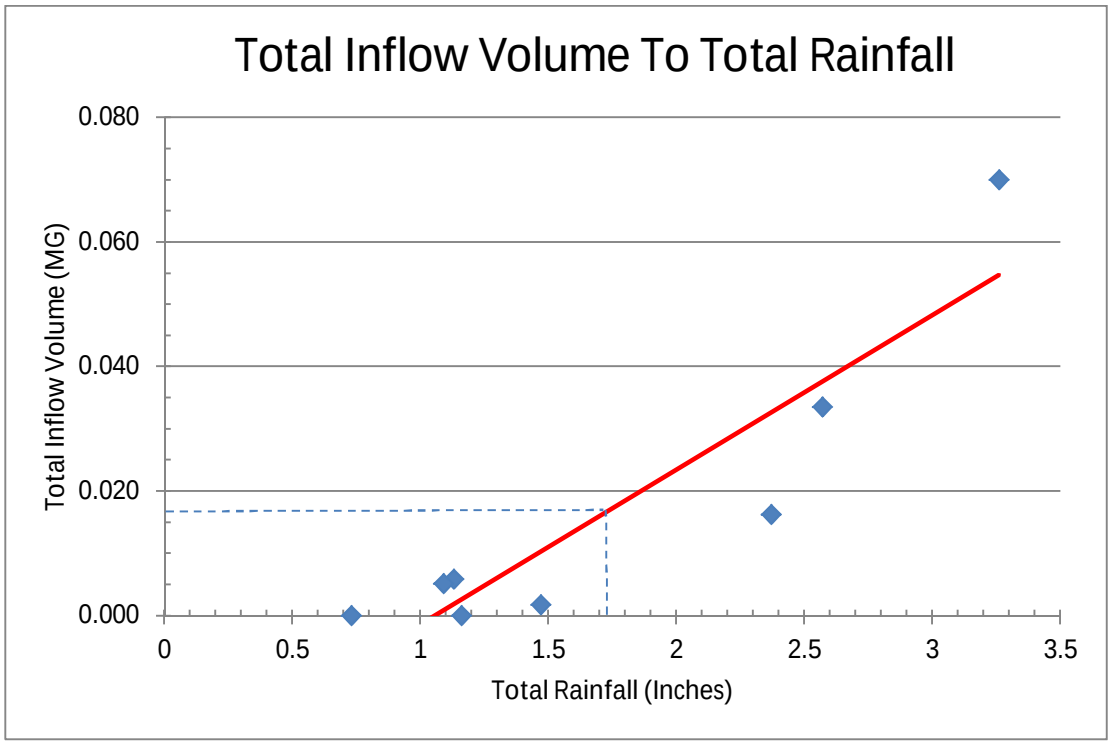
Onset Pier:



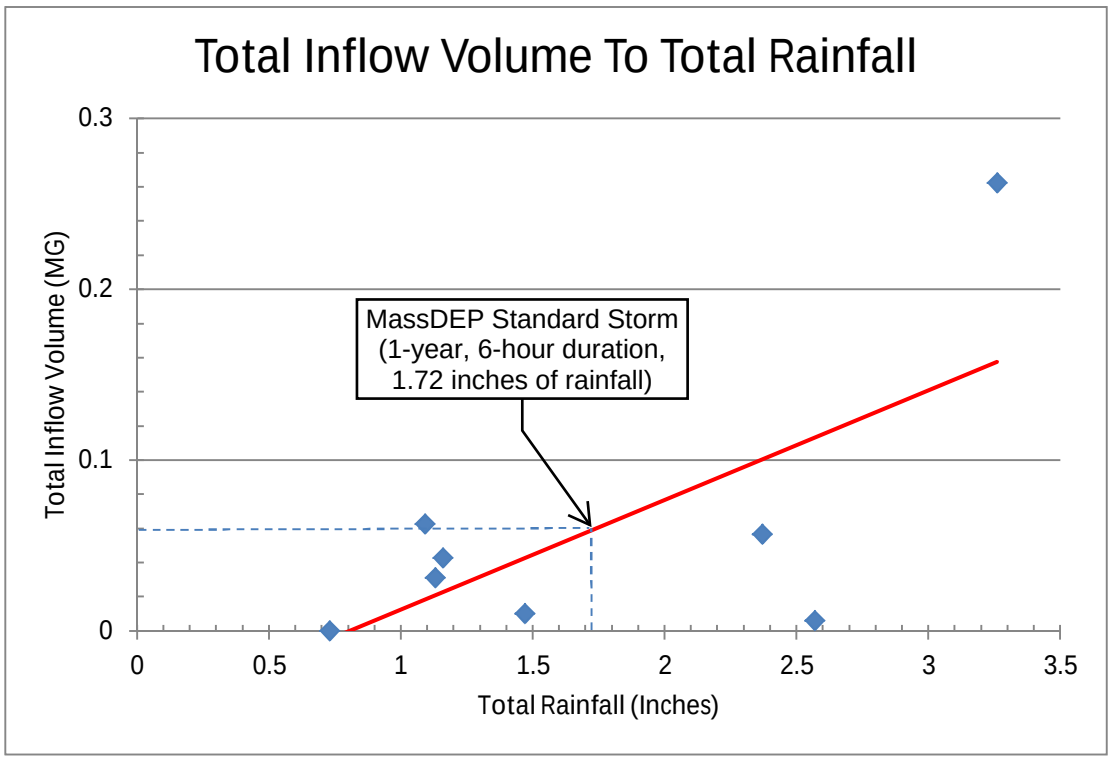
Peter Cooper Drive:



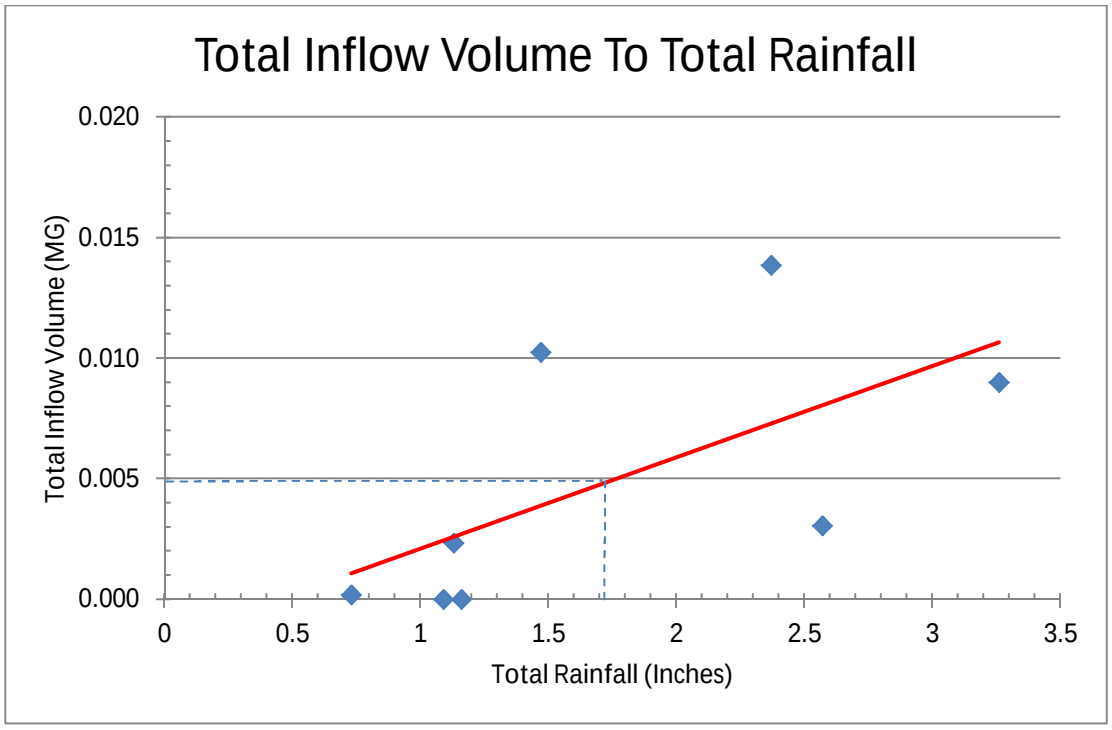
Pinehurst:



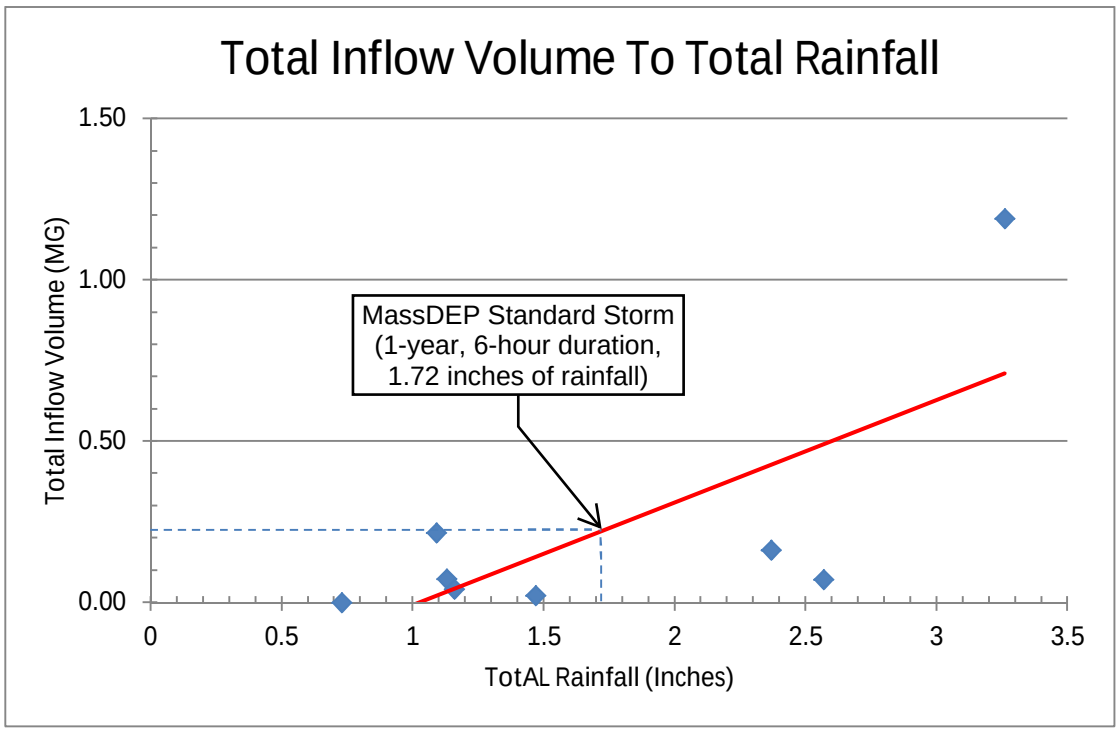
Ruggles:



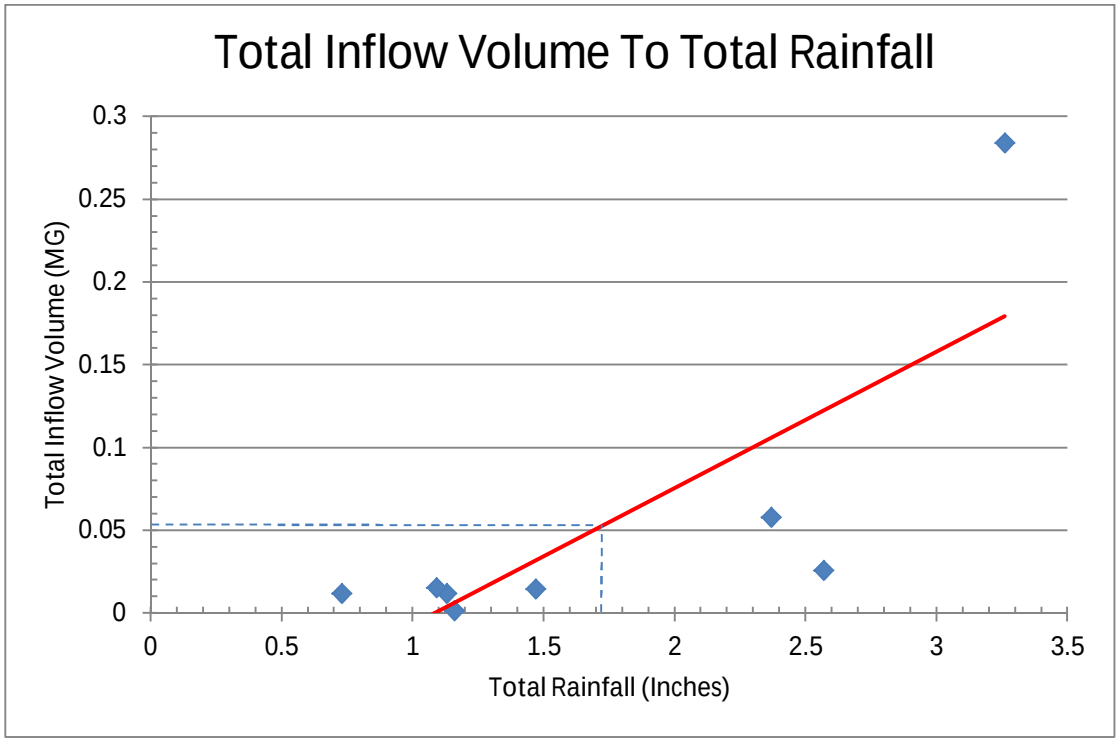
Salt Works Road:



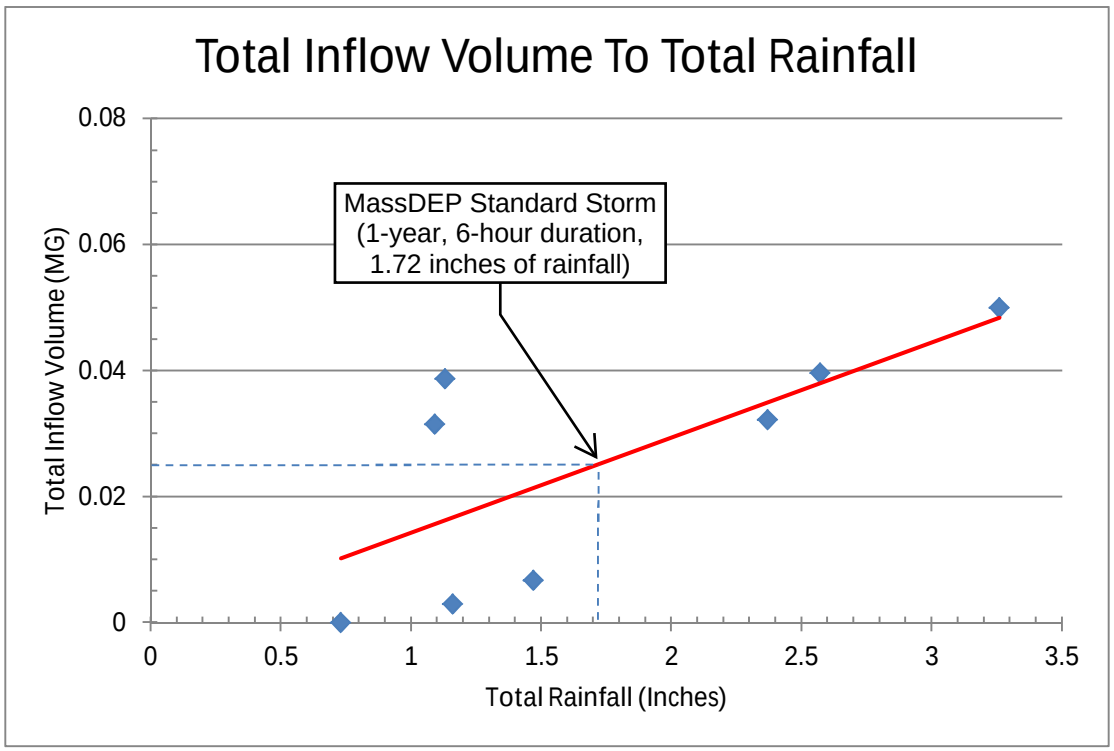
Smith Avenue:



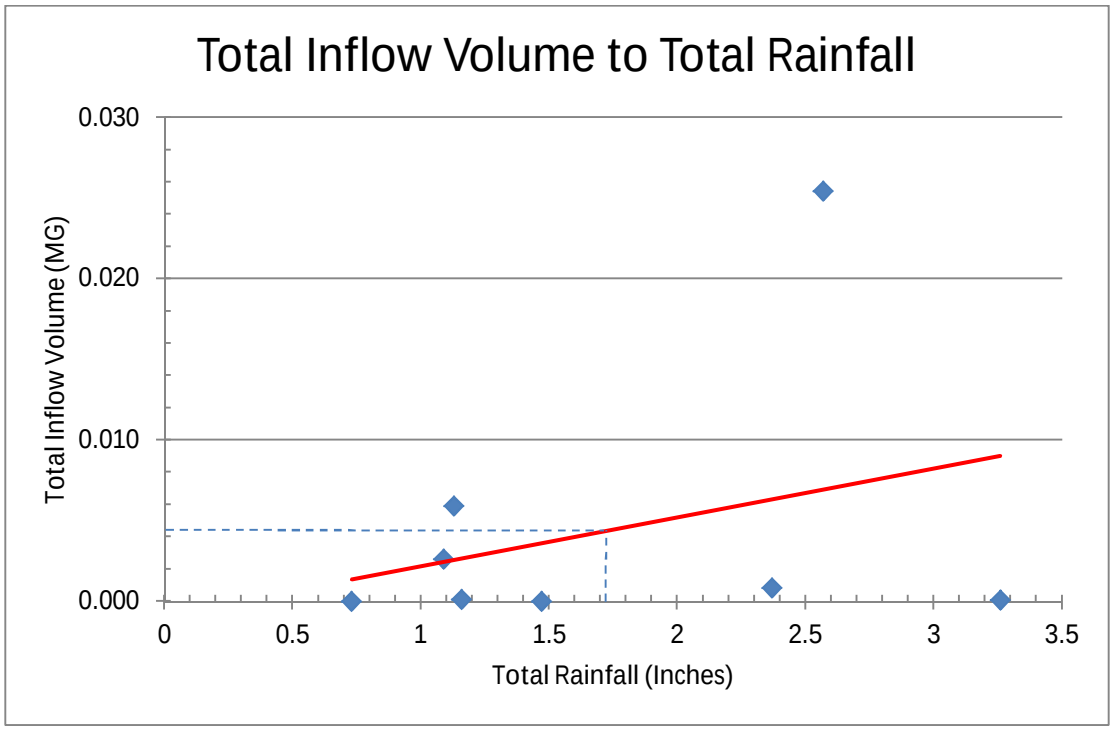
South Water:



Terry Lane:



13th Avenue:



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APPENDIX D

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TOWN OF WAREHAM, MA
SUMMARY OF SEWER PIPELINE CCTV INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
Briarwood Drive	1526	001606	001595	D.S.	8	PVC	Harding Avenue	Joint separation (258.5'). Sand deposits. Clear flow throughout pipe.	9/30/2016	yes
East Boulevard	413	000599	000537	D.S.	8	VCP	12th Street	Fine Roots (57.46', 83.59', 84.53'). Root ball at 10-o'clock (63.73', 66.90') (PAPER REPORT)	3/17/2016	yes
Hynes Field	459	000567	000564	U.S.	8	VCP	12th Street	Roots (no distance given) (PAPER REPORT)	3/17/2016	yes
Kennedy Lane	1379	001195	001473	D.S.	18	RCP	Swifts Beach Road	Aggregate visible at joint (52.9'). Infiltration dripping from lateral (201.2'). Sag in pipe (343.1').	11/1/2017	yes
Kennedy Lane	921	001204	001203	D.S.	18	RCP	Swifts Beach Road	Aggregate exposed at joints and along waterline. Infiltration dripping from lateral (231.5').	10/27/2017	yes
Kennedy Lane	922	001203	001202	D.S.	18	RCP	Swifts Beach Road	Aggregate exposed (0.5', 75.8'). Sag in pipe (59.8', 131.8'). Constant clear from lateral (98.7').	10/27/2017	yes
Kennedy Lane	923	001202	001201	D.S.	18	RCP	Swifts Beach Road	Infiltration dripping from lateral (34.9'). Sag in pipe (179.6').	10/27/2017	yes
Kennedy Lane	925	001200	001199	D.S.	18	RCP		Sag in pipe (93'). Reinforcement exposed (115.7').	10/27/2017	no
Kennedy Lane	918	001205	001204	D.S.	18	RCP	Swifts Beach Road	Aggregate visible (0.0'). Reinforcement visible (3.5').	10/27/2017	no
Kennedy Lane	924	001201	001200	D.S.	18	RCP	Swifts Beach Road	Aggregate exposed at joint (83.5', 115.9', 123', 284.9'). Sag in pipe (196.7', 260').	10/27/2017	no
Kennedy Lane	926	001199	001198	D.S.	18	RCP	Swifts Beach Road	none	10/27/2017	no
Kennedy Lane	927	00198	00197	D.S.	18	RCP	Swifts Beach Road	Aggregate exposed (9.1'). Aggregate exposed at joint	11/1/2017	no
Kennedy Lane	928	001196	001195	D.S.	18	RCP	Swifts Beach Road	Aggregate visible (12.7', 297.3').	10/27/2017	no
Kennedy Lane	775	001168	001902	D.S.	21	RCP	Behind High School off Viking Street	Infiltration running at joint (92'). Infiltration gushing	6/13/2016	yes
Kennedy Lane	1797	001901	001900	D.S.	21	RCP	Between Viking Drive and Glenda Aveunue	Possible infiltration at MH 001900	6/13/2016	yes
Kennedy Lane	1798	001901	001168	D.S.	21	RCP	Easement off Viking Drive	Infiltration dripping at joint (275.9'). Inspection abandoned (321.2').	6/13/2016	yes
Kennedy Lane	776	001902	001169	U.S.	21	RCP	Kennedy Lane / Viking Drive	Infiltration weepeing at joint (100').	6/13/2016	yes
Kennedy Lane	771	001190	001191	D.S.	21	RCP	Ripleys Trailer Park	Light roots at joint (227.3')	6/8/2016	yes
Kennedy Lane	763	001179	001190	U.S.	21	RCP	Ripleys Trailer Park	Light roots at joint (68.8', 168')	6/13/2016	yes
Kennedy Lane	1384	001191	001477	D.S.	21	RCP	Ripleys Trailer Park	none	6/8/2016	no
Kennedy Lane	761	001174	001179	D.S.	21	RCP	Ripleys Trailer Park	none	6/13/2016	no
Kennedy Lane	1797	001900	001901	D.S.	21	RCP	Easement Off Glenda Street	none	6/13/2016	no
Kennedy Lane	762	001173	001174	D.S.	21	RCP	Glenda Avenue to Longmeadow Drive	none	6/13/2016	no
Kennedy Lane	772	001170	001015	D.S.	21	RCP	Kennedy Lane	Aggregate exposed multiple areas. Joint separation (235').	10/31/2017	no
Kennedy Lane	774	001170	001169	D.S.	21	RCP	Kennedy Lane / Viking Drive	none	6/13/2016	no
Kennedy Lane	1796	001900	001173	D.S.	21	RCP	Off of Glenda Avenue	none	6/13/2016	no
Kennedy Lane	1380	001474	001473	U.S.	21	RCP	Swifts Beach Housing	Aggregate exposed at waterline. Aggregate exposed at joint (67.9', 131.6'). Severe exposed aggregate starting at 155'. Exposed reinforcement (291').	10/30/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER PIPELINE CCTV INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
Kennedy Lane	1380	001476	001477	D.S.	21	RCP	Swifts Beach Housing	none	10/30/2017	no
Kennedy Lane	1381	001474	001475	D.S.	21	RCP	Swifts Beach Housing	Aggregate exposed at joint (11.9').	10/30/2017	no
Kennedy Lane	1382	001475	001476	D.S.	21	RCP	Swifts Beach Housing	none	10/30/2017	no
Kennedy Lane	1384	001477	001191	D.S.	21	RCP	Swifts Beach Housing / Burr Parkway	Deposits (90').	6/8/2016	no
Kennedy Lane	750	001028	001027	D.S.	8	VCP	Behind Town Hall to Viking Drive	Fine roots at joint (2.66'). Root ball at joint, 40% (19.29'). Linear crack at joint (28.66' to 29.2'). Joint separation (42.97). Linear crack at joint (119.12 to 120.64').	7/13/2017	yes
Narrows	790	001024	001023	D.S.	21	RCP	Merchants Way	Exposed aggregate along pipe walls. obstacle in pipe prohibiting camera to move forward (154.2'). Infiltration running from chimney lateral (172', 244').	9/26/2017	yes
Narrows	791	001023	001022	D.S.	21	RCP	Merchants Way	Exposed aggregate along pipe walls. Infiltration running from lateral (67.6', 226.9').	9/26/2017	yes
Narrows	809	001022	001021	D.S.	21	RCP	Merchants Way	Exposed aggregate along pipe walls. Constant clear flow from lateral (238.7'). Deposits (260', 300').	9/26/2017	yes
Narrows	810	001021	001020	D.S.	21	RCP	Merchants Way	Infiltration dripper (6'). Aggregate exposed along pipe wall. Deposit accumulation in lateral with infiltration dripping (36'). Constant clear flow from lateral (117.3', 277.5').	9/27/2017	yes
Narrows	817	001020	001018	D.S.	21	RCP	Merchants Way	Infiltration running from lateral (21.8').	9/27/2017	yes
Narrows	818	001018	001017	D.S.	21	RCP	Merchants Way	Exposed aggregate (entire pipe). Infiltration gushing (59.1'). Obstuction in pipe (143', 149'). Infiltration dripping (154'). Pipe abandoned due to pipe blockages. Grease deposits seen further downstream.	9/27/2017	yes
Narrows	787	001026	000957	D.S.	21	RCP	Sawyer Street	Exposed aggregate along pipe walls. Constant clear flow from lateral (46').	9/27/2017	yes
Narrows	789	001025	001024	U.S.	21	RCP	From Main Street to Water side off Main	Exposed aggregate along pipe walls.	9/26/2017	no
Narrows	802	001012	001013	D.S.	21	RCP	High Street	Reinforcement exposed (61.1' to end). Exposed aggregate (entire pipe).	9/27/2017	no
Narrows	788	001025	000957	D.S.	21	RCP	Main Street	Exposed aggregate along pipe walls.	11/1/2017	no
Narrows	819	001017	001016	D.S.	21	RCP	Merchants Way	none	10/29/2017	no
Narrows	820	001016	Pump Station	D.S.	21	RCP	Merchants Way	none	10/29/2017	no
Narrows	786	001013	001026	D.S.	21	RCP	Sawyer Street	Exposed aggregate (entire pipe).	9/27/2017	no
North Boulevard	416	000600	000592	U.S.	8	VCP	12th Street	Roots (51' and no distance given). Broken pipe at joint (no distance given) (PAPER REPORT)	3/17/2016	yes
North Boulevard	439	000575	000574	D.S.	8	VCP	12th Street	Medium roots (132')(PAPER REPORT)	3/17/2016	yes

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
North Boulevard	440	000574	000573	D.S.	8	VCP	12th Street	Lateral roots blocking 75% of pipe (9') (PAPER REPORT)	3/17/2016	yes
North Boulevard	458	000566	000567	D.S.	8	VCP	12th Street	Fine roots (69.64', 75'). Medium Roots 80% blocked (85.43'). Intruding seal ring (119') (PAPER REPORT)	3/17/2016	yes
North Boulevard	437	000576	000573	D.S.	8	VCP	Twelfth Street	Crack with roots (0.45') (PAPER REPORT)	3/17/2016	yes
North Boulevard	442	000558	000560	D.S.	8	VCP	Crescent Place	none	5/31/2017	no
Pinehurst	859	001163	001165	D.S.	10	DI	Beach between Ross Avenue and Sea Street	Grease deposits (242', 264') (PAPER REPORT)	3/31/20116	no
Pinehurst	907	001146	001145	D.S.	8	AC	Blue Jay Terrace	Joint separation (0.61', 7.39').	4/22/2016	yes
Pinehurst	873	001122	001123	D.S.	8	AC	Circuit Avenue	Weeping from lateral (118.24'). Steady dripping from lateral (159.56').	4/9/2016	yes
Pinehurst	874	001123	001108	U.S.	8	AC	Circuit Avenue	Weeping from lateral (105.86', 142.30')	4/9/2016	yes
Pinehurst	865	001110	001111	D.S.	8	AC	Circuit Avenue	Broken lateral with roots (36.91'). From other direction: Slow constant clear flow from lateral (25.35'). (PAPER REPORT)	4/8/2016	yes
Pinehurst	870	001114	001113	D.S.	8	AC	Circuit Avenue	Longitudinal crack (68.26'). Medium roots, 50% (94.75') - Inspection abandoned. From other direction: Roots in lateral, 60% (49.75') - Inspection abandoned. (PAPER REPORT)	4/8/2016	yes
Pinehurst	863	001119	001120	UNK	8	AC	Seabreeze Drive	Constant clear flow from lateral (262.19'). (PAPER REPORT)	4/8/2016	yes
Pinehurst	909	001144	001143	D.S.	8	AC	Woodland Circle	Joint separation (3.69'). Deposits at joint (multiple joints).	4/21/2016	yes
Pinehurst	908	001145	001144	D.S.	8	AC	Woodland Circle	Deposits at joint (multiple locations). separation at joint (42.50').	4/21/2016	yes
Pinehurst	906	001148	001146	D.S.	8	AC	Woodland Circle	Joint separation (2.13', 23.67', 100'). Deposits at joint (multiple locations). Deposits (166.88').	4/22/2016	yes
Pinehurst	861	001117	001118	D.S.	8	AC	Circuit Avenue	none	4/8/2016	no
Pinehurst	864	001109	001110	D.S.	8	AC	Circuit Avenue	Cannot get past protruding lateral (196') (PAPER REPORT)	4/8/2016	no
Pinehurst	866	001111	001112	D.S.	8	AC	Circuit Avenue	none (PAPER REPORT)	4/8/2016	no
Pinehurst	869	001115	001114	D.S.	8	AC	Circuit Avenue	separation at lateral (3.42'). (PAPER REPORT)	4/8/2016	no
Pinehurst	871	001112	001113	U.S.	8	AC	Circuit Avenue	none (PAPER REPORT)	4/8/2016	no
Pinehurst	860	001116	001117	D.S.	8	DI	Circuit Avenue	none (PAPER REPORT)	4/8/2016	no
Pinehurst	890	001126	001125	D.S.	8	AC	Pinehurst Drive	none (PAPER REPORT)	4/16/2016	no
Pinehurst	891	001125	001124	D.S.	8	AC	Pinehurst Drive	Grease buildup (62.62'). Grease buildup and camera stopped (74.76') (PAPER REPORT)	4/16/2016	no
Pinehurst	898	001133	001132	D.S.	8	AC	Pinehurst Drive	none (PAPER REPORT)	4/16/2016	no
Pinehurst	878	001157	001163	D.S.	8	AC	Ross Avenue	none (PAPER REPORT)	3/31/2016	no
Pinehurst	854	001165	001091	D.S.	8	AC	Sea Street	Camera underwater (185' to 200') (PAPER REPORT)	3/30/2015	no
Pinehurst	862	001118	001119	D.S.	8	AC	Seabreeze Drive	none (PAPER REPORT)	4/8/2016	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER PIPELINE CCTV INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
Pinehurst	868	001121	001122	D.S.	8	VCP	Seabreeze Drive	none	4/8/2016	no
Pinehurst	880	001152	001153	D.S.	8	AC	Pinehurst Drive	none	5/2/2016	no
Pinehurst	902	001140	001152	D.S.	8	AC	Pinehurst Drive	None - Inspection ends (137.54').	5/2/2016	no
Pinehurst	868	001120	001121	D.S.	8	AC	Seabreeze Drive	Deposits at joints (multiple locations).	4/9/2016	no
Ruggles	1138	001430	001429	D.S.	8	AC (lined)	Bay View Street	Liner separation at lateral (55.17', 217.16'). Not a flush cut for lateral (106.7', 155.47', 217.18', 258.28', 266.49'). Infiltration gushing at lateral (209.23').	12/10/2016	yes
Ruggles	1139	001429	001410	D.S.	8	AC (lined)	Bay View Street	Not a flush cut for lateral (8.47'). Clear water through lateral (39.9'). Liner separation at lateral (118.70', 191.74'). Sag in pipe (215', 235.33'). Flow exits lateral at 6-o'clock (238.65').	12/10/2016	yes
Ruggles	1137	001433	001430	D.S.	8	AC (lined)	Bay View Street	separation of liner (46.05'). Sag in pipe (73.39', 119.44'). Ripped/broken liner (132.3').	2/16/2015	yes
Ruggles	1114	001366	001365		8	AC	Beach Street	Infiltration runner from factory tap (108.11')	3/19/2016	yes
Ruggles	1143	001415	001413	D.S.	8	AC	Murphy Street	Infiltration runner from lateral (51.34')	9/25/2015	yes
Ruggles	1152	001427	001428	D.S.	8	AC	Pleasant Street	Drip at 12-o'clock (no distance given) (PAPER REPORT)	9/24/2015	yes
Ruggles	1115	001367	001365	D.S.	8	AC	Pond Street	Constant flow from lateral (1.05'). Rocks in lateral (40.31'). (PAPER REPORT)	3/19/2016	yes
Ruggles	1116	001360	001361	D.S.	8	AC	Roby Street	Constant flow from lateral (47.25'). Camera underwater (182.87').	3/18/2016	yes
Ruggles	1118	001362	001363	U.S.	8	AC	Roby Street	Collapsed sewer 50% blocked (34.32')	3/29/2016	yes
Ruggles	1128	001413	001412	D.S.	8	AC	Wankinquoah Avenue	Clear water throughout pipe. Roots (70%) with drip infiltration from chimney lateral (129').	10/6/2016	yes
Ruggles	1131	001409	001402	U.S.	8	AC	Wankinquoah Avenue	Clear water throughout pipe. Chimney tap with running infiltration (34.83'). Deteriorating joint (71.81'). PVC Repair with sand accumulation (238'). Large grease deposits.	11/9/2016	yes
Ruggles	1131	001409	001402	D.S.	8	AC	Wankinquoah Avenue	Reverse video. Collapsed pipe (8.7')	11/9/2016	yes
Ruggles	1128	001413	001412	D.S.	8	AC	Wankinquoah Avenue	Roots hanging from lateral (131')	9/25/2015	yes
Ruggles	1112	001357	001356	D.S.	8	AC	Beach Street	none (PAPER REPORT)	3/19/2016	no
Ruggles	1119	001365	001364	D.S.	8	AC	Beach Street	none (PAPER REPORT)	3/19/2016	no
Ruggles	1120	001364	001363	D.S.	8	AC	Beach Street	Rocks in pipe (1') (PAPER REPORT)	3/19/2016	no
Ruggles	1127	001414	001413	D.S.	8	AC	Murphy Street	Intruding tap break in (32.32') (PAPER REPORT)	9/25/2015	no
Ruggles	1141	001418	001417	D.S.	8	AC	Murphy Street	none (PAPER REPORT)	9/25/2015	no
Ruggles	1142	001417	001415	D.S.	8	AC	Murphy Street	none (PAPER REPORT)	9/25/2015	no
Ruggles	1121	001406	001405	U.S.	8	AC	Oceanside Drive	Sag in pipe (9.34') (PAPER REPORT)	3/18/2016	no
Ruggles	1122	001405	001404	D.S.	8	AC	Oceanside Drive	Sand and rock deposits (101.49') (PAPER REPORT)	3/18/2016	no
Ruggles	1132	001402	001403	D.S.	8	AC	Oceanside Drive	Sag in pipe (53.81', 64') (PAPER REPORT)	1/15/2015	no
Ruggles	1151	001426	001427	D.S.	8	AC	Pleasant Street	none (PAPER REPORT)	9/24/2015	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER PIPELINE CCTV INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
Ruggles	1153	001428	001412	D.S.	8	AC	Pleasant Street	none (PAPER REPORT)	9/24/2015	no
Ruggles	1112	001357	001356	D.S.	8	AC	Ruggles	none (PAPER REPORT)	3/19/2016	no
Ruggles	1136	001402	001401	D.S.	8	AC	Swifts Beach Road	Grease buildup (84'). Camera underwater (141') (PAPER REPORT)	3/16/2016	no
Ruggles	1129	001412	001410	D.S.	8	AC	Wankinquoah Avenue	none	9/25/2016	no
Smith Avenue	1032	001349	001347	D.S.	12	AC	Almeida Street	none (PAPER REPORT)	9/29/2017	no
Smith Avenue	1085	001266	001265	D.S.	8	AC	Algelo Street (Hamilton Beach)	Material missing from lateral, 1-inch diameter (4.91'). Encrustation on joint (5.60', 8.43').	3/22/2016	yes
Smith Avenue	1086	001265	001264	D.S.	8	AC	Algelo Street (Hamilton Beach)	Joint separation / encrustation at joint (0.8'). Joint deterioration (72.26', 107.43'). Deposits at joint (144.63', 173.26'). Rocks and sand in lateral, 30% (163.91'). Unknown blockage from lateral, 75% (178.34') - inspection abandoned.	3/22/2016	yes
Smith Avenue	1073	001272	001270	U.S.	8	AC	Algelo Street (Hamilton Beach)	Deteriorating at joint (43'). Constant clear flow from lateral (224.14', 226.69'). Debris before manhole 5% blocked (227.15') - Inspection abandoned.	3/22/2016	yes
Smith Avenue	1098	001263	001262	U.S.	8	AC	Pilgrim Avenue	Encrustation at joint (5.1', 9.4', 45.5').	11/29/2017	yes
Smith Avenue	1099	001262	001261	U.S.	8	AC	Pilgrim Avenue	Encrustation at joint (42.9').	11/29/2017	yes
Smith Avenue	1101	001260	001259	D.S.	8	AC	Pilgrim Avenue	Encrustation at joint (64.2').	11/29/2017	yes
Smith Avenue	1103	001259	001257	D.S.	8	AC	Pilgrim Avenue	Encrustation at joint (65.4'). Sag in pipe (220.5' - 247')	11/29/2017	yes
Smith Avenue	1095	001288	001285	U.S.	8	AC	Pilgrim Avenue (Hamilton Avenue)	Infiltration running from lateral (50'). Infiltration dripper from lateral (94.67'). Infiltration runner from lateral (155.25').	12/3/2016	yes
Smith Avenue	1096	001285	001263	U.S.	8	AC	Pilgrim Avenue (Hamilton Avenue)	Infiltration dripper from lateral (111.87', 162.48').	12/3/2016	yes
Smith Avenue	1105	001337	001338	D.S.	8	AC	Pine Street	Roots (no distance given) (PAPER REPORT)	5/5/2016	yes
Smith Avenue	974	001309	001308	D.S.	8	AC	Shore Avenue	Infiltration dripper at seam (50', 155'). Infiltration dripper at seam (94.67')	12/14/2015	yes
Smith Avenue	1081	001280	001281	D.S.	8	AC	Turner Avenue	Constant clear flow from lateral (45.65'). (PAPER REPORT)	3/25/2016	yes
Smith Avenue	1076	001275	001276	U.S.	8	AC	Worral Avenue	Deposits at joint (multiple locations throughout pipe length). Constant clear flow from lateral (116.09').	3/22/2016	yes
Smith Avenue	1089	001281	001282	U.S.	8	AC	Worral Avenue	Deposits at joint (multiple locations). separation at joint (48.52').	3/12/2016	yes
Smith Avenue	1090	001282	001288	D.S.	8	AC	Worral Avenue	Deposits at joint (multiple locations). Sand and rock deposit in lateral (95.13', 142.30'). Sag in pipe (142.30'). Section missing from pipe 12-o'clock, 2 inch diameter (158.58').	3/12/2016	yes
Smith Avenue	1074	001273	001274	U.S.	8	AC	Reynolds Avenue	Pipe is dry. Debris accumulation (66.55').	3/22/2016	no
Smith Avenue	1075	001274	001275	D.S.	8	AC	Reynolds Avenue	none	3/22/2016	no
Smith Avenue	1072	001270	001269	D.S.	8	AC	Algelo Street (Hamilton Beach)	Spiderwebs on screen halfway through. Difficult to see. Blockage at MH 001269	3/22/2016	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER PIPELINE CCTV INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

PS Basin	PIPE I.D.	U.S. SMH I.D.	D.S. SMH I.D.	Inspection Direction	Pipe Size	Pipe Material	Location	Pipe Issues	CCTV Date	Signs of Infiltration
Smith Avenue	1082	001269	001268	D.S.	8	AC	Algelo Street (Hamilton Beach)	Deterioration at joint (41.33').	3/22/2016	no
Smith Avenue	1083	001268	001267	U.S.	8	AC	Algelo Street (Hamilton Beach)	none	3/22/2016	no
Smith Avenue	1084	001267	001266	U.S.	8	AC	Algelo Street (Hamilton Beach)	none	3/22/2016	no
Smith Avenue	1077	001278	001277	D.S.	8	AC	Glen Avenue	Debris accumulation in pipe (0.5'). separation at joint (70.14')	3/23/2016	no
Smith Avenue	1078	001277	001276	D.S.	8	AC	Glen Avenue	none	3/23/2016	no
Smith Avenue	1100	001261	001260	D.S.	8	AC	none	none	12/3/2015	no
Smith Avenue	1100	001261	001260	D.S.	8	AC	Pilgrim Avenue	none	11/29/2017	no
Smith Avenue	1098	001263	001262	U.S.	8	AC	Pilgrim Avenue (Hamilton Avenue)	none	12/3/2015	no
Smith Avenue	1099	001262	001261	D.S.	8	AC	Pilgrim Avenue (Hamilton Avenue)	none	12/3/2015	no
Smith Avenue	1080	001279	001280	D.S.	8	AC	Turner Avenue	Deposit accumulation at end of pipe (190.90').	3/25/2016	no
Smith Avenue	1079	001276	001281	D.S.	8	AC	Worral Avenue	separation at lateral (11.99'). Deposits at joints (multiple locations).	3/22/2016	no
South Water	267	000377	000378	D.S.	8	VCP	Captain Collis Drive	Multiple deposits in pipe (0'). Deposits in lateral (1.52'). separation at joint (19.86'). Roots at joint (24.54', 29'). Large deposit in pipe (55.08') - Inspection abandoned.	5/11/2016	yes
South Water	332	000257	000248	D.S.	8	VCP	Dogwood Avenue	Clear flow throughout pipe.	4/29/2017	yes
South Water	330	000256	000257		8	VCP	Fern Street	Clear water in pipe until 32'. Roots at joint, 40% (32'). Roots at joint,10% (41.5'). Roots fine at joint (47.32'). Roots heavy, 90% (51.74') - Inspection abandoned.	4/29/2017	yes
Terry Lane	1400	001557	001555	D.S.	8	PVC	Terry Lane West	Constant clear flow from lateral (105.6').	10/31/2017	yes
Terry Lane	1399	001556	001557	D.S.	8	PVC	Terry Lane West	Roots at end of pipe in manhole (168.6').	10/31/2017	no
Terry Lane	1401	001555	001554	D.S.	8	PVC	Terry Lane West	none	10/31/2017	no
Terry Lane	1402	001554	001553	D.S.	8	PVC	Terry Lane West	Deformed pipe (187.4').	10/31/2017	no

APPENDIX E

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TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

= Unsure MH ID

PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
13th Avenue	001702	Hathaway Street	none	10/7/2016	no
Arnold	001756	Rose Point Avenue	Large buildup of sand in invert	12/21/2017	no
Arnold	001785	Osbourne Avenue	Large buildup of rags in invert and dirt on bench	12/22/2017	no
Arnold	001787	Osbourne Avenue	none	12/22/2017	no
Arnold	001828	Osbourne Avenue	Rocks and debris on bench	12/22/2017	no
Arnold	001830	Marine Avenue	6" piece of frame missing	12/22/2017	no
Bay Street	000351	Sycamore Street	Infiltration through pick holes	10/6/2016	yes
Briarwood Shores	001630	Easement - Adjacent to Marsh	none	9/14/2017	no
Briarwood Shores	001746	Easement - Adjacent to Marsh	none	9/14/2017	no
Briarwood Shores	001747	Easement - Adjacent to Marsh	none	9/14/2017	no
Cohasset Narrows	000049	Choctaw Drive	Infiltration through pick holes	10/6/2016	yes
Cohasset Narrows	000056	Cohasset Road	Missing mortar, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000057	Cohasset Road	Missing mortar and seal, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000057	Cohasset Road	Infiltration through pick holes	10/6/2016	yes
Cohasset Narrows	000078	Cohasset Road	Missing mortar and seal, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000079	Cohasset Road	Missing mortar and seal, crushed bricks, evidence of infiltration. Asphalt sinking	12/12/2017	yes
Cohasset Narrows	000095	Cohasset Road	Missing mortar and seal, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000103	Cohasset Road	Missing mortar and seal, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000130	Cohasset Road	Missing mortar, crushed bricks, evidence of infiltration	12/12/2017	yes
Cohasset Narrows	000056	Cohasset Road	Cone, wall, chimney, and bench deteriorating	1/20/2018	no
Cohasset Narrows	000057	Cohasset Road	none	1/20/2018	no
Cohasset Narrows	000072	Cohasset Road	Missing mortar and seal	12/12/2017	no
Cohasset Narrows	000072	Cohasset Road	Concrete deteriorating above invert. Sand on invert	1/20/2018	no
Cohasset Narrows	000078	Cohasset Road	Concrete deteriorating above invert - rebar showing	1/20/2018	no
Cohasset Narrows	000079	Cohasset Road	Bricks accumulating on bench	1/20/2018	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Cohasset Narrows	000095	Cohasset Road	none	1/20/2018	no
Cohasset Narrows	000096	Cohasset Road	Missing mortar and crushed bricks	12/12/2017	no
Cohasset Narrows	000096	Cohasset Road	Grease buildup in invert	1/20/2018	no
Cohasset Narrows	000097	Cohasset Road	none	12/12/2017	no
Cohasset Narrows	000097	Cohasset Road	none	1/20/2018	no
Cohasset Narrows	000103	Cohasset Road	Bricks between channel and rim are missing and loose.	1/20/2018	no
Cohasset Narrows	000104	Cohasset Road	none	12/12/2017	no
Cohasset Narrows	000104	Cohasset Road	Invert full of brick pieces	1/20/2018	no
Cohasset Narrows	000109	Cohasset Road	Missing mortar and buildup of sand	12/12/2017	no
Cohasset Narrows	000109	Cohasset Road	Paper buildup in invert	1/20/2018	no
Cohasset Narrows	000110	Cohasset Road	none	12/12/2017	no
Cohasset Narrows	000110	Cohasset Road	Paper buildup in invert	1/20/2018	no
Cohasset Narrows	000129	Cohasset Road	Sand infiltration and missing mortar	12/12/2017	no
Cohasset Narrows	000131	Cohasset Road	Missing mortar	12/12/2017	no
Cohasset Narrows	000132	Cohasset Road	Missing mortar	12/12/2017	no
Cohasset Narrows	001835	Cranberry Highway	none	6/12/2017	no
Cohasset Narrows	001835	Cranberry Highway	none	11/6/2017	no
Cohasset Narrows	001836	Cranberry Highway	none	6/12/2017	no
Cohasset Narrows	001837	Cranberry Highway	none	6/17/2017	no
Cohasset Narrows	001838	Cranberry Highway	MH not designed for secondary cover	6/7/2017	no
Cohasset Narrows	001840	Cranberry Highway	none	6/13/2017	no
Cohasset Narrows	001841	Cranberry Highway	MH not designed for secondary cover	6/17/2017	no
Cohasset Narrows	001842	Cranberry Highway	MH not designed for secondary cover	6/13/2017	no
Cohasset Narrows	001843	Cranberry Highway	MH not designed for secondary cover	6/13/2017	no
Cohasset Narrows	001844	Cranberry Highway	MH not designed for secondary cover	8/12/2017	no
Cohasset Narrows	001845	Cranberry Highway	MH not designed for secondary cover	6/13/2017	no
Cohasset Narrows	001846	Cranberry Highway	none	6/12/2017	no
Cohasset Narrows	001847	Cranberry Highway	none	6/13/2017	no
Cohasset Narrows	001848	Cranberry Highway	MH not designed for secondary cover	6/13/2017	no
Cohasset Narrows	001849	Cranberry Highway	none	6/14/2017	no
Cohasset Narrows	001850	Cranberry Highway	none	6/17/2017	no
Cohasset Narrows	001851	Cranberry Highway	Worn cover	6/17/2017	no
Cohasset Narrows	001853	Cranberry Highway	none	6/14/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Cohasset Narrows	001854	Cranberry Highway	none	6/14/2017	no
Cohasset Narrows	001857	Cranberry Highway	none	6/15/2017	no
Cohasset Narrows	001858	Cranberry Highway	none	6/14/2017	no
Cohasset Narrows	001899	Cranberry Highway	none	6/17/2017	no
Cromesett Road	001562	Mattapoisett Road	Unknown debris in invert	10/3/2016	no
Cromesett Road	001576	Cromeset Road	none	9/27/2017	no
Cromesett Road	001576	Cromesset Road	Rim and cover not to grade	12/19/2017	no
Cromesett Road	001578	Cromesset Road	Sand buildup in invert	12/7/2017	no
Cromesett Road	001580	Cromesset Road	Debris in invert and lateral	12/19/2017	no
Dick's Pond	000672	Main Avenue	none	10/6/2016	no
East Boulevard	000532	East Boulevard	rusted frame	12/5/2017	no
East Boulevard	000533	East Boulevard	none	12/5/2017	no
East Boulevard	000535	East Boulevard	none	12/5/2017	no
East Boulevard	000536	East Boulevard	dislodged cover insert seal, missing bar	12/5/2017	no
East Boulevard	000541	Old East Boulevard	none	12/5/2017	no
East Boulevard	000595	Whittemore Avenue	Heavy deposits of sand on bench. Rim not designed for secondary cover.	12/5/2017	no
East Boulevard	000597	Whittemore Avenue	Secondary cover does not fit in rim. Sand on bench.	12/5/2017	no
Hathaway	001636	Hathaway Street	Anvil for secondary cover is broken	1/23/2018	no
Hathaway	001639	First Avenue	none	11/24/2017	no
Hathaway	001639	First Avenue	Rust and sand deposits on bench	10/3/2016	no
Hathaway	001647	Hathaway Street	none	1/23/2018	no
Hathaway	001710	Hathaway Street	none	11/3/2017	no
Hynes Field	000466	West Boulevard	none	7/17/2017	no
Hynes Field	000416	Onset Avenue	Grease in pipes. Debris on bench	1/23/2018	no
Hynes Field	000416	Onset Avenue	Sand located on shelf - needs mortar	10/7/2016	no
Hynes Field	000418	Onset Avenue	Sand on the bench	1/23/2018	no
Hynes Field	000422	Wareham Avenue	Grit and rags in channel. Anvil for secondary cover needs new bolt.	12/14/2017	no
Hynes Field	000449	West Boulevard	none	7/17/2017	no
Hynes Field	000452	West Boulevard	none	7/17/2017	no
Hynes Field	000453	West Boulevard	none	7/18/2017	no
Hynes Field	000454	West Boulevard	none	7/17/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Hynes Field	000455	West Boulevard	none	7/17/2017	no
Hynes Field	000468	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000469	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000470	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000471	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000471	West Boulevard - Adjacent to Beach	none	7/19/2017	no
Hynes Field	000472	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000473	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000474	West Boulevard - Adjacent to Beach	none	7/18/2017	no
Hynes Field	000475	South Boulevard - Adjacent to Beach	none	7/19/2017	no
Hynes Field	000476	South Boulevard - Adjacent to Beach	none	7/19/2017	no
Hynes Field	000477	South Boulevard - Adjacent to Beach	none	7/19/2017	no
Hynes Field	000497	West Central Avenue	Chimney needs repair	10/6/2016	no
Hynes Field	000500	Ninth Street	none	7/21/2017	no
Hynes Field	000502	Longwood Avenue	none	7/21/2017	no
Hynes Field	000504	Longwood Avenue	none	7/21/2017	no
Hynes Field	000506	Longwood Avenue	none	7/26/2017	no
Hynes Field	000508	Longwood Avenue	none	7/26/2017	no
Hynes Field	000511	Longwood Avenue	none	7/27/2017	no
Hynes Field	000512	Longwood Avenue	none	7/27/2017	no
Hynes Field	000513	Longwood Avenue	none	7/27/2017	no
Hynes Field	000519	Fourth Street	none	7/26/2017	no
Hynes Field	000519	Fourth Street	none	7/27/2017	no
Hynes Field	000522	Third Street	none	7/26/2017	no
Hynes Field	000565	Wareham Avenue	none	1/23/2018	no
Hynes Field	000565	Wareham Avenue	Chimney needs mortar	10/7/2016	no
Hynes Field	000566	West Boulevard - Adjacent to Marsh	none	7/26/2017	no
Hynes Field	000570	Wareham Avenue	Grit in invert. No anvil on secondary cover.	12/5/2017	no
Hynes Field	000570	Wareham Avenue	No anvil and hooks for secondary cover	1/23/2018	no
Hynes Field	000734	Easement - Marsh	none	8/8/2017	no
Hynes Field	000735	Easement - Marsh	none	9/17/2017	no
Hynes Field	000736	Easement - Marsh	none	8/8/2017	no
Hynes Field?	N/A	18 Commonwealth Ave	none	12/5/2017	no
Hynes Field?	N/A	21 Commonweath Ave.	dislodged cover insert seal	12/5/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Hynes Field?	N/A	Commonwealth Ave. & Sariah Lane	none	12/5/2017	no
Indian Neck	000847	Oak Street	Sand deposited on bench	10/7/2016	no
Kennedy Lane	001015	Kennedy Lane	Signs of infiltrations (stains)	10/7/2016	yes
Kennedy Lane	001170	Viking Drive	possible leak on bottom wall joint	10/31/2017	yes
Kennedy Lane	001202	Swifts Beach Road	frame corroded, lowest wall joint leaking	11/1/2017	yes
Kennedy Lane	001473	Swifts Beach Road	defective lower wall w/ aggregate visible, possible leak in lowest joint, frame corroded, FM discharge MH	11/1/2017	yes
Kennedy Lane	001195	Swifts Beach Road	frame corroded	11/1/2017	no
Kennedy Lane	001197	Swifts Beach Road	rusted frame	11/1/2017	no
Kennedy Lane	001198	Swifts Beach Road	rusted frame	11/1/2017	no
Kennedy Lane	001199	Swifts Beach Road	frame corroded	11/1/2017	no
Kennedy Lane	001200	Swifts Beach Road	frame corroded	11/1/2017	no
Kennedy Lane	001201	Swifts Beach Road	frame corroded, cover loose (undersized)	11/1/2017	no
Kennedy Lane	001203	Swifts Beach Road	none	10/27/2017	no
Kennedy Lane	001204	Swifts Beach Road	none	10/27/2017	no
Kennedy Lane	001204	Swifts Beach Road	none	1/23/2018	no
Kennedy Lane	001205	Swifts Beach Road	bench missing mortar	10/27/2017	no
Kennedy Lane	001205	Swifts Beach Road	none	1/23/2018	no
Kennedy Lane	001833	Littleton Drive	Possible blockages in pipes	10/3/2017	no
Leonard Street	001774	Leonard Street	Signs of infiltration (stains)	12/21/2017	yes
Leonard Street	001770	Leonard Street	none	12/21/2017	no
Leonard Street	001771	Leonard Street	none	12/21/2017	no
Leonard Street	001772	Leonard Street	none	12/21/2017	no
Leonard Street	001773	Leonard Street	none	12/21/2017	no
Narrows	001012	Sawyer Street	none	9/26/2017	no
Narrows	001013	Sawyer Street	none	9/26/2017	no
Narrows	001016	Merchants Way	Bench and invert not visible due to high water	9/26/2017	no
Narrows	001017	Merchants Way	Bench and invert not visible due to high water	9/26/2017	no
Narrows	001018	Merchants Way	No secondary cover	9/26/2017	no
Narrows	001020	Merchants Way	none	9/26/2017	no
Narrows	001021	Merchants Way	No secondary cover	9/26/2017	no
Narrows	001022	Merchants Way	none	9/26/2017	no
Narrows	001023	Merchants Way	Anvil for secondary cover needs repair	9/26/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Narrows	001024	Merchants Way	Anvil for secondary cover is broken	9/26/2017	no
Narrows	001025	Main Street	none	11/1/2017	no
Narrows	001026	Sawyer Street	none	9/26/2017	no
Narrows	001051	Warr Avenue	Rusted steps	7/28/2017	no
Narrows	001052	Warr Avenue	Cover adjustment ring has pieces missing, Rusted steps	7/28/2017	no
Narrows	001053	Warr Avenue	Cover adjustment ring has pieces missing, Rusted steps	7/28/2017	no
Narrows	001054	Warr Avenue	none	7/28/2017	no
Narrows	001054	Warr Avenue	none	1/23/2018	no
Narrows	001055	Warr Avenue	none	7/28/2017	no
Narrows	001084	Warr Avenue	Pitted walls, Cover adjustment ring corroded in rough shape, Rusted steps	7/28/2017	no
Narrows	001084	Warr Avenue	none	1/23/2018	no
North Boulevard	000546	North Boulevard	Infiltration from wall. Grease in pipe. Missing secondary cover and anvil. Missing brick from cone.	12/4/2017	yes
North Boulevard	000550	North Boulevard	5 locations of minor weeping infiltration	12/4/2017	yes
North Boulevard	000721	North Boulevard	Infiltration drip in wall. Excesive grease buildup	12/4/2017	yes
North Boulevard	000544	East Central Avenue	Cover adjustment ring has piece missing	10/18/2017	no
North Boulevard	000544	North Boulevard	Missing section of frame	10/18/2017	no
North Boulevard	000545	North Boulevard	Secondary anvil missing	12/4/2017	no
North Boulevard	000546	North Boulevard	Cover needs new eye bolts	10/18/2017	no
North Boulevard	000546	North Boulevard	Secondary cover has broken eye bolts	10/18/2017	no
North Boulevard	000547	North Boulevard	Grease in pipes	12/4/2017	no
North Boulevard	000548	North Boulevard	Grease and debris in invert	12/4/2017	no
North Boulevard	000549	North Boulevard	none	12/4/2017	no
North Boulevard	000550	North Boulevard	none	10/18/2017	no
North Boulevard	000552	North Boulevard	Anvil for secondary cover is missing	12/4/2017	no
North Boulevard	000559	Wareham Avenue	Rags, grease, and grit in pipes. Anvil of secondary cover is missing.	12/5/2017	no
North Boulevard	000564	Wareham Avenue	Anvil bolt needs to be replaced. Rags and grit in invert.	12/5/2017	no
North Boulevard	000594	Whittemore Avenue	3" construction ring is cracked	12/5/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Onset Pier	000530	East Boulevard	none	12/5/2017	no
Parkwood Beach	000931	Larch Street	none	10/18/2017	no
Parkwood Beach	000932	Larch Street	none	10/17/2017	no
Parkwood Beach	000933	Larch Street	none	10/17/2017	no
Parkwood Beach	000934	Larch Street	none	10/17/2017	no
Parkwood Beach	000935	Larch Street	none	10/17/2017	no
Parkwood Beach	000936	Larch Street	none	10/17/2017	no
Parkwood Beach	001470	Larch Street	none	10/17/2017	no
Parkwood Beach	001471	Hemlock Street	none	10/19/2017	no
Pinehurst	001085	Warr Avenue	Rusted steps	7/28/2017	no
Ruggles	001360	Roby Street	Sand and rock deposits on bench and in channel. Signs of infiltration (weeping and stains)	8/8/2015	yes
Ruggles	001361	Roby Street	Signs of infiltration (weeping and stain). Clogged pipe	8/8/2015	yes
Ruggles	001362	Roby Street	Multiple signs of infiltration (weeping and stain). Broken cover bolts	8/8/2015	yes
Ruggles	001366	Beach Street	Secondary cover needs anvil. Signs of infiltration (weeping and stains).	8/7/2015	yes
Ruggles	001367	Pond Street	Infiltration from stub in manhole.	8/7/2015	yes
Ruggles	001367	Pond Street	Signs of infiltration (weeping and stains). Infiltration from lateral. Anvil missing from secondary cover.	8/7/2015	yes
Ruggles	001403	Wankinquoah Avenue	Signs of infiltration (weeping and stains).	8/7/2015	yes
Ruggles	001405	Oceanside Drive	Signs of infiltration (weeping and stains).	8/7/2015	yes
Ruggles	001406	Oceanside Drive	Signs of infiltration (weeping and stains). Needs new anvil - bolt broken.	8/7/2015	yes
Ruggles	001407	Ruggles Street	Signs of infiltration (weeping and stains)	8/7/2015	yes
Ruggles	001408	Ruggles Street	Signs of infiltration (weeping and stains)	8/7/2015	yes
Ruggles	001363	Beach Street	Asphalt missing around cover	10/16/2017	no
Ruggles	001399	Swifts Beach Road	none	10/3/2016	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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Ruggles	001404	Ruggles Street	none	8/7/2015	no
Ruggles	001408	Ruggles Street	none	10/16/2017	no
Salt Works	000647	Beach	Manhole not dug up. Inspection done from camera. Leaking from secondary cover (inspection done during high tide)	10/21/2017	yes
Salt Works	000648	Beach	Manhole not dug up. Inspection done from camera. Leaking from secondary cover (inspection done during high tide)	10/21/2017	yes
Salt Works	000002	Gitchee Gumee Road	Loose bricks under frame. Anvil bolt needs to be replaced	12/19/2017	no
Salt Works	000003	Gitchee Gumee Road	Build up of rags in invert	12/19/2017	no
Salt Works	000005	Gitchee Gumee Road	Loose bricks under frame. Sand and grease on bench. Anvil bolt needs to be replaced. Hooks on secondary cover are broken.	12/19/2017	no
Salt Works	000006	Gitchee Gumee Road	Loose bricks under frame. Loose bricks on bench. Anvil bolt needs to be replaced. Hooks on secondary cover are broken.	12/19/2017	no
Salt Works	000009	Wychunas	none	12/14/2017	no
Salt Works	000010	Wychunas	Bricks loose underneath frame and cover.	12/14/2017	no
Salt Works	000018	Wychunas	none	12/14/2017	no
Salt Works	000019	Wychunas	none	12/14/2017	no
Salt Works	000028	Wychunas	Bricks below frame and cover fell onto bench.	12/14/2017	no
Salt Works	000031	Wychunas	Grit and rags in channel. Loose bricks under frame	12/14/2017	no
Salt Works	000032	Wychunas	none	12/14/2017	no
Salt Works	000033	Wychunas	Hooks on secondary cover are broken	12/14/2017	no
Salt Works	000034	Wychunas	none	12/14/2017	no
Salt Works	00004	Gitchee Gumee Road	none	12/19/2017	no
Salt Works	00007	Gitchee Gumee Road	none	12/14/2017	no
Salt Works	00008	Gitchee Gumee Road	Loose bricks under frame. Loose bricks on bench	12/14/2017	no
Salt Works	000646	Easement - Beach	none	8/9/2017	no
Salt Works	000647	Easement - Beach	none	8/9/2017	no
Salt Works	000648	Easement - Beach	none	8/9/2017	no
Salt Works	000649	Easement - Beach	none	8/9/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Salt Works	000655	Beach	none	10/19/2017	no
Smith Avenue	001245	Pilgrim Avenue	evidence of minor surcharge	12/2/2017	yes
Smith Avenue	001264	Angelo Street	lowest wall joint leaking, clogged inside drop	11/29/2017	yes
Smith Avenue	001347	Easement - Marsh	Cover buried in yard waste. Ran camera from MH-00149 and observed water stained walls. Cover appeared to be leaching	7/29/2017	yes
Smith Avenue	001349	Easement - Marsh	Walls water stained. Possible leak where 2 wall pieces meet. Concrete cracked/missing around raised rim/frame	7/28/2017	yes
Smith Avenue	001364	Beach Street	Sand infiltration from house lateral	8/8/2015	yes
Smith Avenue	001209	Swifts Beach Road	Loose mortar and brick on shelf	10/3/2016	no
Smith Avenue	001225	Broadmarsh Avenue	none	10/16/2017	no
Smith Avenue	001227	Broadmarsh Avenue	Sand/grit in invert, Leaking between frame and chimney	10/16/2017	no
Smith Avenue	001228	Pilgrim Avenue	missing cover insert seal & bar	12/2/2017	no
Smith Avenue	001229	Pilgrim Avenue	none	12/2/2017	no
Smith Avenue	001238	Pilgrim Avenue	Sand/grit in invert	10/16/2017	no
Smith Avenue	001238	Pilgrim Avenue	none	12/2/2017	no
Smith Avenue	001239	Pilgrim Avenue	none	12/2/2017	no
Smith Avenue	001244	Pilgrim Avenue	dislodged cover insert seal	12/2/2017	no
Smith Avenue	001246	Pilgrim Avenue	missing cover insert seal	12/2/2017	no
Smith Avenue	001247	Pilgrim Avenue	none	12/2/2017	no
Smith Avenue	001248	Pilgrim Avenue	none	12/2/2017	no
Smith Avenue	001249	Pilgrim Avenue	dislodged cover insert seal, grease deposits	12/2/2017	no
Smith Avenue	001253	Smith Avenue - Adjacent to Marsh	none	7/29/2017	no
Smith Avenue	001257	Pilgrim Avenue	none	11/29/2017	no
Smith Avenue	001259	Pilgrim Avenue	dislodged cover insert seal	11/29/2017	no
Smith Avenue	001260	Pilgrim Avenue	dislodged cover insert seal	11/29/2017	no
Smith Avenue	001261	Pilgrim Avenue	dislodged cover insert seal	11/29/2017	no
Smith Avenue	001262	Pilgrim Avenue	none	11/29/2017	no
Smith Avenue	001263	Pilgrim Avenue	none	11/25/2017	no
Smith Avenue	001264	Algelo Avenue	Roots and dirt in inverts and on bench	3/23/2016	no
Smith Avenue	001265	Angelo Street	dislodged cover insert seal	11/29/2017	no
Smith Avenue	001266	Angelo Street	dislodged cover insert seal, broken bar	11/28/2018	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
Smith Avenue	001267	Angelo Street	none	11/28/2017	no
Smith Avenue	001269	Angelo Street	MH is slightly back pitched	11/29/2017	no
Smith Avenue	001270	Angelo Street	none	11/28/2017	no
Smith Avenue	001271	Angelo Street	dislodged cover insert seal, debris in invert	11/28/2017	no
Smith Avenue	001272	Reynolds Avenue	debris in invert	11/25/2017	no
Smith Avenue	001273	Reynolds Avenue	none	11/25/2017	no
Smith Avenue	001274	Reynolds Avenue	none	11/25/2017	no
Smith Avenue	001275	Worrall Avenue	none	11/25/2017	no
Smith Avenue	001276	Worrall Avenue	none	11/25/2017	no
Smith Avenue	001281	Worrall Avenue	none	11/28/2017	no
Smith Avenue	001282	Worrall Avenue	broken handle on cover insert	11/28/2017	no
Smith Avenue	001285	Pilgrim Avenue	missing cover insert seal	11/25/2017	no
Smith Avenue	001286	Worrall Avenue	dislodged cover insert seal	11/28/2017	no
Smith Avenue	001288	Pilgrim Avenue	missing cover insert seal	11/28/2017	no
Smith Avenue	001290	Worrall Avenue	dislodged cover insert seal, debris in pipes & invert	11/28/2017	no
Smith Avenue	001302	Cliff Ave	none	12/5/2017	no
Smith Avenue	001346	Easement - Marsh	none	7/28/2017	no
Smith Avenue	001356	Beach Street	none	8/7/2015	no
Smith Avenue	001357	Beach Street	none	8/7/2015	no
Smith Avenue	001365	Beach Street	Bolt for anvil of secondary cover is broken	8/7/2015	no
Smith Avenue	001372	Shore Avenue	none	10/17/2017	no
Smith Avenue	001383	Circle Drive	Frame separation from cone 1ft and 6" offset from being hit. Sand/rocks on bench & in invert. Repair Immediately	10/6/2017	no
Smith Avenue	001384	Circle Drive	none	10/17/2017	no
Smith Avenue	001385	Circle Drive	none	10/12/2017	no
Smith Avenue	001386	Circle Drive	none	10/13/2017	no
Smith Avenue	001452	Easement - Marsh	Invert half full with grit/rocks	10/6/2017	no
South Boulevard	000478	South Boulevard - Adjacent to Beach	none	7/19/2017	no
South Boulevard	000482	South Boulevard - Adjacent to Beach	none	7/19/2017	no
South Boulevard	000483	South Boulevard - Adjacent to Beach	none	7/19/2017	no
South Boulevard	000484	South Boulevard - Adjacent to Beach	none	7/19/2017	no
South Boulevard	000485	South Boulevard - Adjacent to Beach	none	7/19/2017	no

TOWN OF WAREHAM, MA
SUMMARY OF SEWER MANHOLE INSPECTIONS COMPLETED W/ FINDINGS (2015 - 2017)

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PS Basin	GIS SMH I.D.	Location	SMH Issues	Inspection Date	Signs of Infiltration
South Boulevard	000487	Prospect Avenue	none	7/20/2017	no
South Boulevard	000489	Pleasant Avenue	none	7/20/2017	no
South Boulevard	000490	Pleasant Avenue	none	7/21/2017	no
South Water	000233/000234	Locust Street	Infiltration through pick holes	10/6/2016	yes
South Water	000305/000306	Gray Street	Concrete deterioration	10/6/2016	no
South Water	000316	Prospect Street	Invert not visible	10/6/2016	no
South Water	000367	Independence Lane - Adjacent to Beach	Missing chimney brick, Sand on bench	8/8/2017	no
South Water	000716	Easement - Adjacent to Beach	none	8/8/2017	no
South Water	000727	Onset Avenue	Missing anvil for secondary cover	10/6/2016	no
Terry Lane	001484	Parker Drive	dislodged & poor cover insert seal	11/24/2017	no
Terry Lane	001485	Parker Drive	debris in pipes & invert	11/24/2017	no
Terry Lane	001487	Parker Drive	missing cover insert seal	11/24/2017	no
Terry Lane	001489	Parker Drive	dislodged & poor cover insert seal, debris in pipes & invert	11/24/2017	no
Terry Lane	001490	Parker Drive	dislodged & poor cover insert seal	11/24/2017	no
Terry Lane	001495	Camardo Drive	none	10/13/2017	no
Terry Lane	001496	Camardo Drive	none	10/13/2017	no
Terry Lane	001497	Camardo Drive	Rags on bench/step, grease in invert Anvil for secondary cover missing	10/13/2017	no
Terry Lane	001498	Camardo Drive	none	10/13/2017	no
Terry Lane	001499	Camardo Drive	Anvil for secondary cover is missing	10/13/2017	no
Terry Lane	001524	Terry Lane East	debris in invert	11/24/2017	no
Terry Lane	001529	Terry Lane East	dislodged & poor cover insert seal, debris in pipes & invert	11/24/2017	no
Terry Lane	001554	Terry Lane West	none	10/31/2017	no
Terry Lane	001555	Terry Lane West	none	10/31/2017	no
Terry Lane	001556	Terry Lane West	none	10/31/2017	no
Terry Lane	001557	Terry Lane West	debris in invert	10/31/2017	no
Terry Lane	001589	Cromesset Road	Cover reported loose by homeowner	10/3/2016	no
Thatcher	001891	Thatcher Lane	Full of grease	10/7/2016	no
Thatcher	001898	Kendrick Road	Rim has been hit and is offset from cone.	10/22/2017	no

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APPENDIX F

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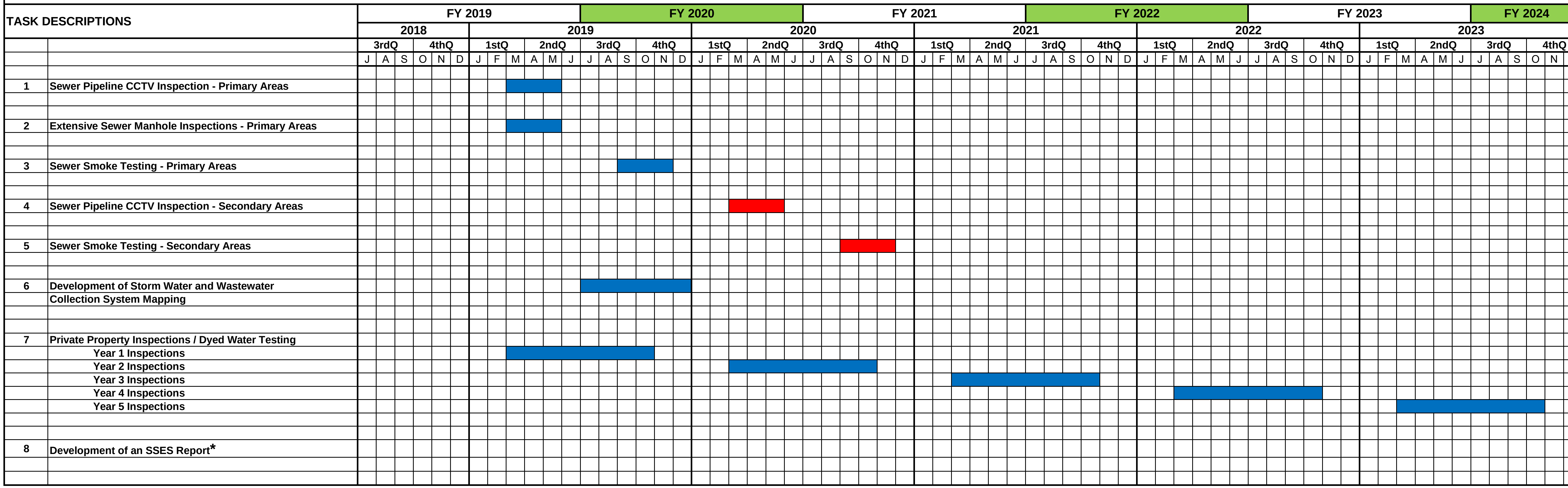
PROPOSED SSES IMPLEMENTATION SCHEDULE (DRAFT)

PHASE 2 INFILTRATION AND INFLOW (I/I) REPORT
TOWN OF WAREHAM, MA



*Development of an SSES Report will be contignent on the successful completion of and findings from identified recommended tasks. The scope of required collection system repairs will be developed based on the findings of the recommended investigation work.