April 9, 2014

Ms. Brigitte Berger, P.E.
Director of Engineering
Village of Wilmette
1200 Wilmette Avenue
Wilmette, Illinois 60091-2721

SUBJECT: VILLAGE OF WILMETTE
2013-2015 CAPITAL IMPROVEMENT PROGRAM
2013 FLOW MONITORING REPORT

Dear Ms. Berger:

We are pleased to submit this report providing analysis of the flow monitoring data for the Village of Wilmette. This report summarizes the findings from a six-month flow monitoring program conducted by RJN Group between the spring and fall of 2013.

BACKGROUND AND PROJECT APPROACH

The 2013 flow monitoring program was conducted to collect flow data for the entire separate sanitary sewer system over multiple seasons of the year. Similar programs that monitored the entire system were conducted in 2003 and 2011 but were shorter in duration and did not include an adequate number of high-intensity rain events to observe the sanitary system's response to wet-weather events sufficiently.

Flow monitoring was conducted at four locations for a period of 200 days between March 15 and October 2, 2013. One meter was used to monitor the Harms Road Region – the western portion of the system roughly bordered on the east by Ramona Road – and three meters were used to monitor the Princeton Place Region, which includes the remainder of the separate sanitary system and is bordered to the west and east by Ramona Road and Ridge Road, respectively.

In addition to measuring the amount of inflow and infiltration (I/I) that enters the sanitary system during wet-weather events, the data was collected for the purpose of refining the calibration of the sanitary system hydraulic model originally developed in 2012. Findings and recommendations from additional modeling of the Harms Road Region were summarized in a

technical memorandum submitted to the Village in July 2013. A similar analysis of the Princeton Place Region is in progress as of the issuance of this report.

Meter Locations

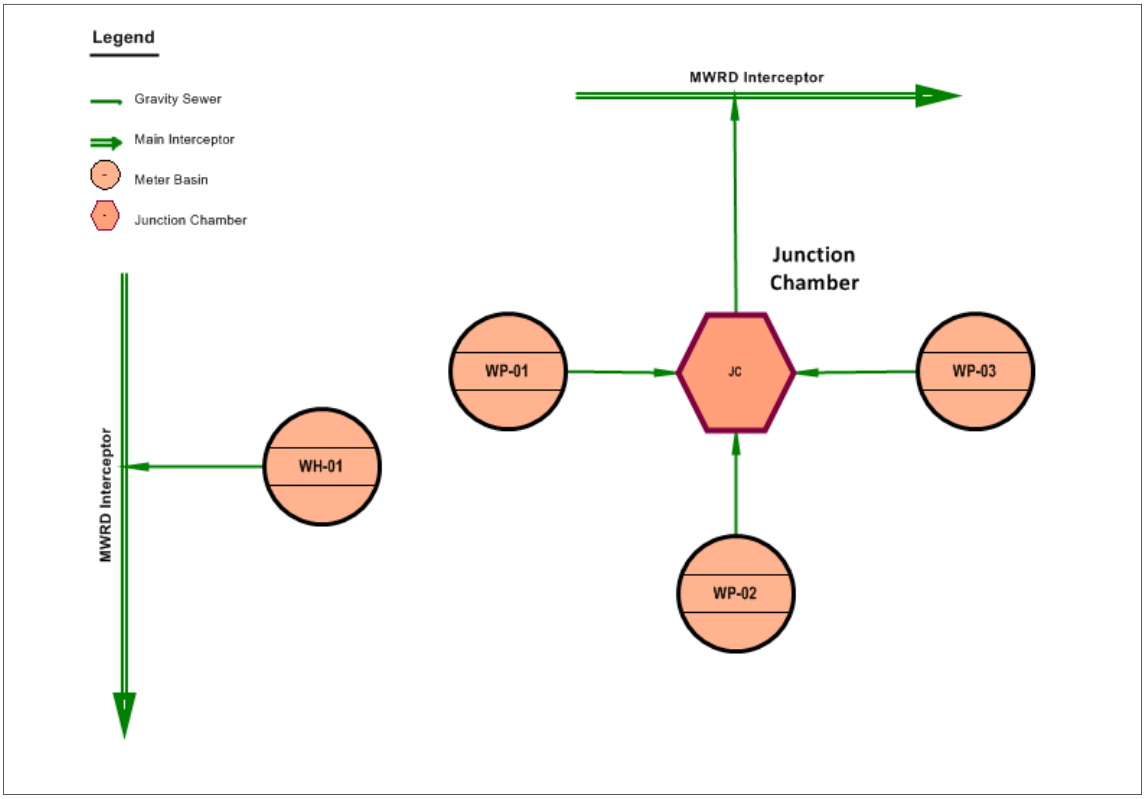
Prior to installing the flow meters, potential meter sites were investigated by RJN field crews and engineers, and the locations selected were those that would both maximize the tributary metered area and optimize data quality. The flow meter and rain gauge locations are summarized in Table 1 and shown on Exhibit 1 appended to the end of the report. Appendix A contains the site investigation and installation sheets for each of the meters and rain gauges, providing details regarding location, hydraulic conditions, and installation methods.

TABLE 1
METER SITE SUMMARY

Meter	Manhole	Parcel Count	Location	Pipe Material	Diameter (inches)
WH-01	1430	2024	E BOUND CURB ACROSS FROM BLDG AFTER BRIDGE	Concrete	36
WP-01	1091	1293	INTERSECTION OF CLEVLAND & KENILWORTH	Concrete	72
WP-02	2144	203	1235 PRINCETON PL.	Vitrified Clay	30
WP-03	1087	1853	I-SECTION OF DARTMOUGH & KENILWORTH	Concrete	120
WRG-01	(Rain Guage)	-	RIDGE & ELMWOOD WEST SIDE ON FLAT ROOF	-	-
WRG-02	(Rain Guage)	-	LAKE AVENUE LIFT STATION	-	-
WRG-03	(Rain Guage)	-	BELL SCHOOL ROOF	-	-

All three of the sites are immediately tributary to the Metropolitan Water Reclamation District of Greater Chicago (MWRD) system. Site WH-01 was located three pipe segments upstream of the primary connection to the Harms Road MWRD interceptor, and the other three sites were just upstream of the Princeton and Kenilworth outlet control junction chamber that regulates flow from the Princeton Place Region into the MWRD system. The flow meter sites are shown schematically in Figure 1.

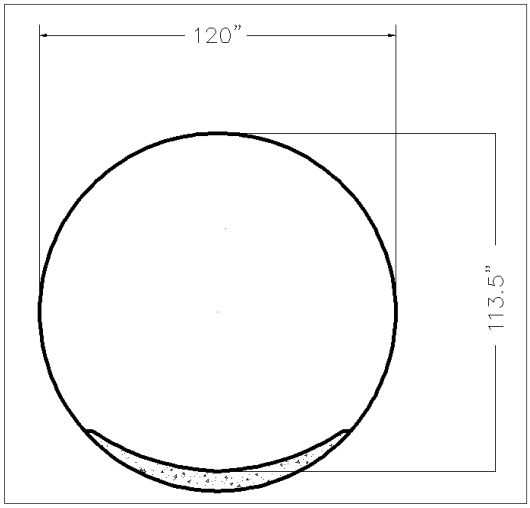
FIGURE 1
FLOW SCHEMATIC



Sites WP-01 and WP-03 are particularly unique in that the meters were located in the storage pipes, which are restricted at their downstream ends by flow regulator pipes in the Princeton and Kenilworth outlet control structure. The storage pipes extend upstream along Kenilworth Avenue to both the east and west, continuing along Hunter Road and Locust Road respectively. Because of the large diameter of these pipes, flows at these meter sites tended to be extremely slow and shallow during routine flow conditions, and both sites were subject to silt accumulation.

Meter site WP-03 was also unique in that the pipe where the meter was installed is not a standard circular cross section. The shape of this cross-section is shown in Figure 2.

FIGURE 2
PIPE CROSS-SECTION – SITE WP-03



Meter Equipment, Calibration, and Maintenance

Upon installation, the meters were regularly tended to and calibrated throughout the monitoring period. Data was continually processed and analyzed by RJN data analysts throughout the monitoring period to ensure quality and continuity of the data and to identify and remedy any potential maintenance concerns as they occurred.

The flow meters used for this project were ADS Environmental FlowShark 5000 area-velocity meters. The meters have three probes – a submerged pressure transducer at the invert of the pipe, a Doppler velocity sensor, and an ultrasonic depth sensor located at the crown of the pipe. The redundancy in depth measurements ensures that the meters collect accurate data during all flow conditions, including low flows and surcharged conditions.

The flow meters were installed with RU-33 telemetry units that allowed the data to be accessed and downloaded remotely. Therefore, meter data was downloaded daily and analyzed twice per week to assess whether they were functioning properly, and the probes were periodically assessed to ensure the accuracy of readings. In addition, the downloaded data was reviewed to check for missing data or a decline in data quality. When necessary, field crews would be sent to clean or replace a probe if the data indicated potential fouling.

Meters were calibrated a minimum of five times; once on install, once on removal, and three other times throughout the duration of the monitoring period. Calibrations serve as a basis for

fine adjustments to the level and velocity data, which are used to refine the final processed flow data. A calibration entails two separate measurements of water depth from the invert of the pipe, two peak velocity readings using a portable velocity meter (PVM), and a matrix of velocity measurements throughout the cross-section of the flow to obtain an average velocity. The number of cross-sectional velocity measurements depended on the size of the flow cross-section, which is determined by the size of the pipe and depth of the flow.

Additionally, silt depths were measured at each calibration. Measurements of silt – a general term for any kind of stationary deposit such as sand, gravel, silt, or sludge – are crucial for accurate flow calculation because the filled portion of the cross-sectional area covered with silt is not flowing and therefore must be subtracted out when calculating flow.

Data Analysis and Results

The flow and rainfall data was analyzed using RJN's proprietary RPM software to establish the average dry-weather flow (ADWF) baseline at each meter, observe seasonal variations in groundwater infiltration, and quantify the inflow and infiltration (I/I) response to wet-weather events.

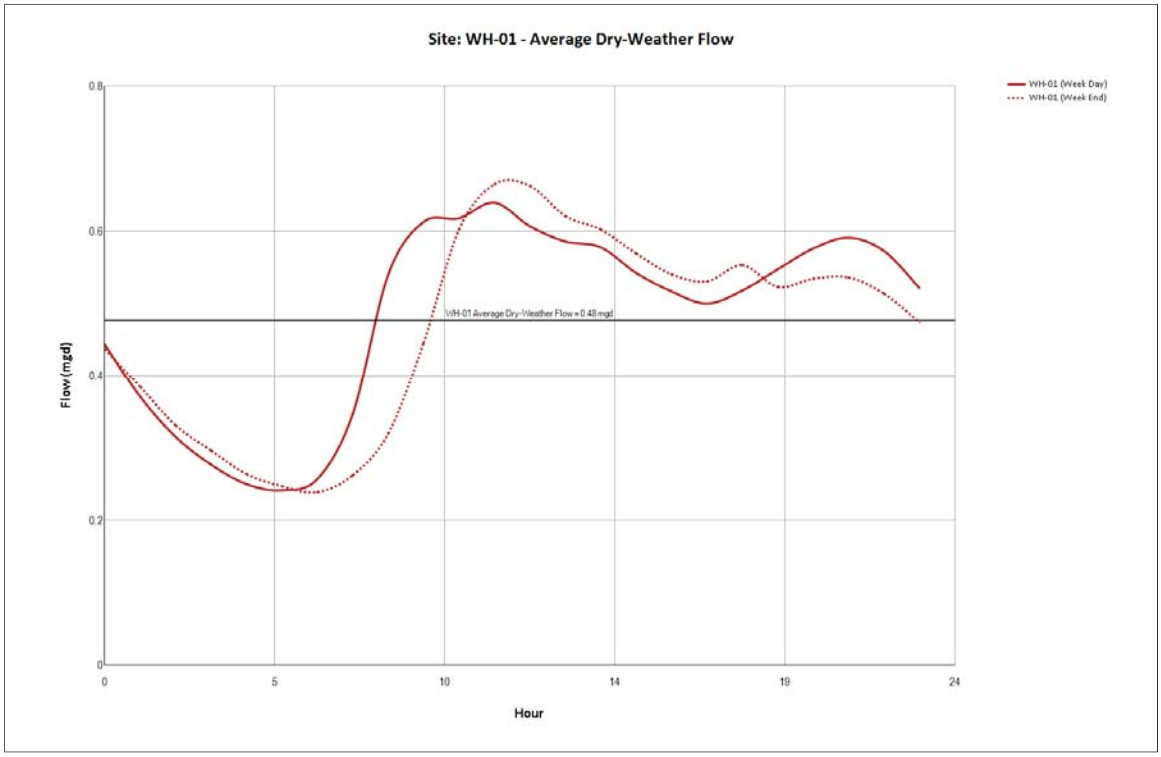
Hydrographs of the entire flow monitoring period are contained in Appendix B.

Dry-Weather Flow Analysis

Flow data collected during dry periods was analyzed to determine the average daily dry-weather flow (ADWF) for each meter. The dry-weather flow periods selected for computation of ADWF were September 1 through September 11 and September 23 through September 28. These periods provided the most continuous sample of rainless, low-groundwater conditions during the monitoring period.

Using the data from these periods, a composite diurnal dry-weather flow pattern was developed for each meter. Appendix C contains the diurnal flow curves for each meter, and an example is shown in Figure 3 below. The ADWF, diurnal low flow, and diurnal peak flow at each meter location are listed in Table 2. Also provided in Table 2 are the diurnal peaking factors – the ratio of the diurnal peak flow to the average flow – and the low flow as a percentage of ADWF.

FIGURE 3
AVERAGE DRY-WEATHER FLOW (ADWF) DIURNAL PATTERN



Diurnal peaking factors for a basin in a residential area are normally in the range of 1.3 to 1.8. All basins were within or very close to this range. Low flows, occurring during the late night and very early morning hours, are a good indicator of base infiltration in residential areas. All basins had relatively high low flow as a percentage of ADWF, indicating a high base infiltration. The typical range of low flow is around 15% to 30% of the ADWF.

TABLE 2
DRY-WEATHER FLOW SUMMARY

Meter/ Basin	Parcel Count	ADWF (mgd)	ADWF per Parcel (gpd)	Peak Hourly Flow (mgd)	Diurnal Peaking Factor	Daily Low Flow (mgd)	Percent of Daily Low Flow to ADWF
WH-01	2024	0.477	236	0.665	1.4	0.239	50.0%
WP-01	1293	0.503	389	0.659	1.3	0.330	65.7%
WP-02	203	0.046	227	0.068	1.8	0.025	55.6%
WP-03	1853	0.363	196	0.562	1.5	0.189	52.0%

The ADWF was also calculated for a sample of dry-weather days in March and April when the groundwater table is typically at or near its annual peak. The comparison of the two dry-weather samples is shown in Table 3. The period-to-period discrepancies indicate a substantial seasonal variation in dry-weather flow, which is typically a marker of high groundwater infiltration rates.

TABLE 3
SEASONAL DRY-WEATHER FLOW COMPARISON

Meter/ Basin	Parcel Count	September ADWF (mgd)	ADWF per Parcel (gpd)	March / April ADWF (mgd)	ADWF per Parcel (gpd)
WH-01	2024	0.48	237	0.73	361
WP-01	1293	0.50	387	0.75	580
WP-02	203	0.05	227	0.11	542
WP-03	1853	0.36	194	0.88	475

While detailed pipe dimension and silt measurements were conducted at each of the sites throughout the flow monitoring period to maximize data accuracy, it should be noted that low flows in oversized pipes are difficult to monitor due to shallow flow cross-sections, low velocities, and the tendency for silt to accumulate and vary in depth. All three meters in the Princeton Place Region were in pipes that are oversized relative to their tributary ADWF and were therefore subject to larger margins of error than standard flow meter installations.

Rain Data

Rain events that occurred during the flow metering period are listed in Table 4. The rainfall totals listed are composite averages of the totals from all three rain gauges. The totals from the individual rain gauges are detailed in Table A-1 appended to the end of this report. Table 4

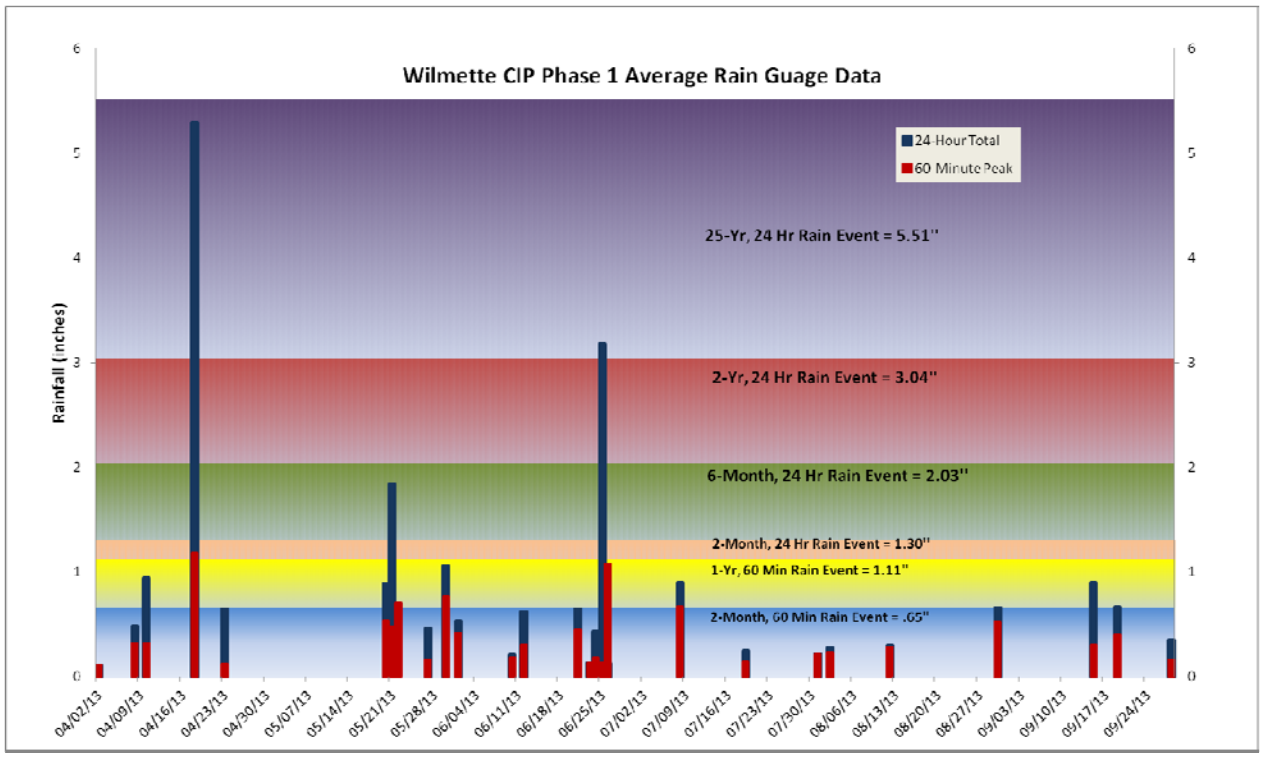
generally includes only rain events that were used in the flow analysis and excludes events with very small rainfall totals. The recurrence intervals of the storm events ranged from less than 2 months to 25 years, and these events are represented graphically in Figure 4.

TABLE 4
RAINFALL SUMMARY

Date	Average 60-Minute Peak (inches)	Recurrence Interval for 60-Minute Peak	Average 24-Hour Total (inches)	Recurrence Interval for 24-Hour Total
8-Apr	0.32	1-Month	0.49	1-Month
10-Apr	0.32	1-Month	0.94	1-Month
15-Apr	< 0.10	<1-Month	0.41	1-Month
18-Apr	1.18	1-Year	5.29	22-Year
23-Apr	0.12	<1-Month	0.65	1-Month
9-May	< 0.10	<1-Month	0.47	1-Month
20-May	0.53	2-Month	0.89	1-Month
21-May	0.48	1-Month	1.84	5-Month
22-May	0.70	2-Month	1.84	5-Month
27-May	0.16	<1-Month	0.46	1-Month
30-May	0.76	3-Month	1.06	2-Month
1-Jun	0.42	1-Month	0.53	1-Month
12-Jun	0.30	1-Month	0.62	1-Month
21-Jun	0.45	1-Month	0.65	1-Month
24-Jun	0.18	1-Month	0.43	1-Month
26-Jun	1.08	9-Month	3.18	2-Year
8-Jul	0.67	2-Month	0.9	1-Month
21-Jul	0.69	2-Month	0.91	1-Month
2-Aug	0.23	1-Month	0.28	<1-Month
12-Aug	0.28	1-Month	0.3	<1-Month
30-Aug	0.52	2-Month	0.66	1-Month
15-Sep	0.30	1-Month	0.9	1-Month
19-Sep	0.4	1-Month	0.67	1-Month

*** May 21 and May 22 rain events shared the same peak 24-hour rainfall period**

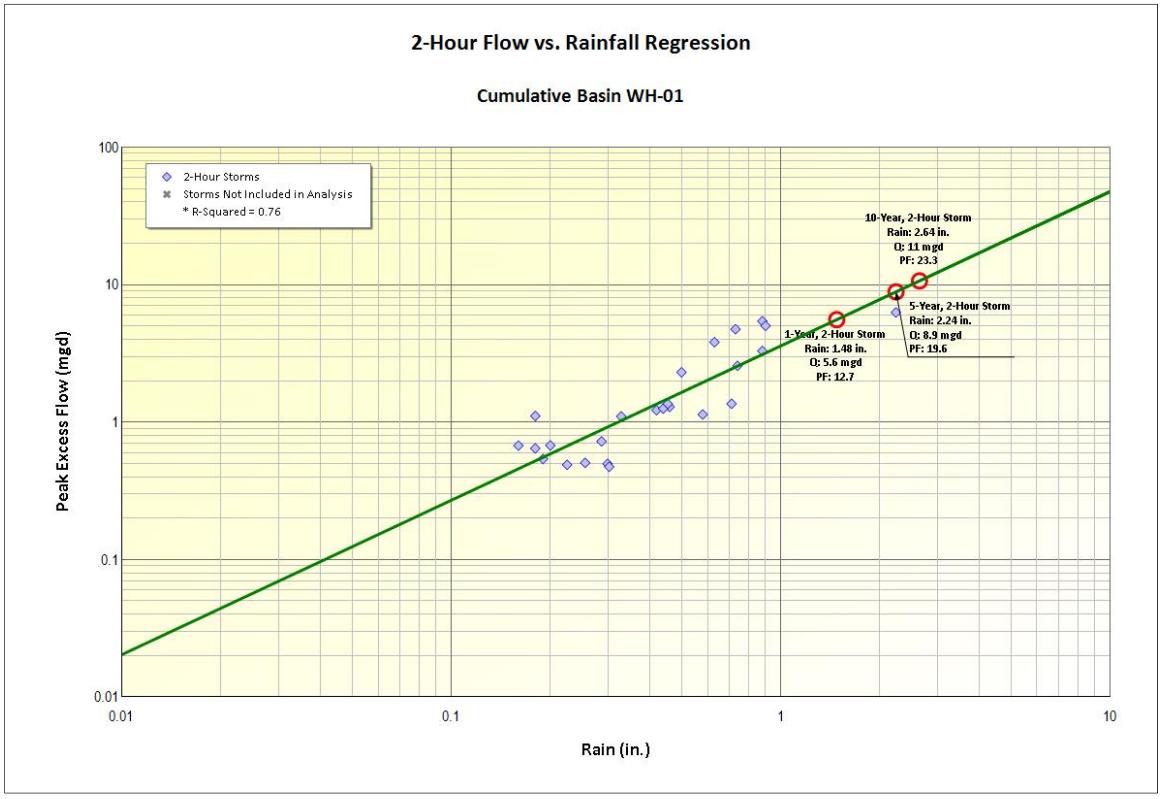
FIGURE 4
RAINFALL SUMMARY GRAPH



Wet-Weather Flow Analysis

All four of the flow meter basins exhibited large I/I responses during rain events. Peak flow data from storm events throughout the metering period was used to conduct a regression analysis to derive the logarithmic relationship between excess flow and rainfall. An example of the regression plot is shown in Figure 5, and results of the regression are presented in Table 5. The peaking factor (PF) is the ratio of the peak wet-weather flow to the ADWF. Appendix D contains graphs of the regression analyses for each meter.

FIGURE 5
REGRESSION ANALYSIS PLOT



Meter WP-02 – which had the smallest tributary area – and Meter WH-01 – which monitored the Harms Road Region, the largest meter basin in the study – exhibited the largest wet-weather peaking factors. It is typical for smaller basins to have higher peaking factors. Larger basins tend to have lower peaking factors do to attenuation of peak flows, as travel times from inflow sources to the meter are increased. However, the peaking factors for basin WP-02 are very large, even for a small basin, and the peaking factors for the Harms Road Region are extraordinarily high, particularly for a basin so large.

Appendix E contains hydrographs showing the three largest storm events, which occurred on April 18, May 21, and June 26. During both the April 18 and the June 26 storm events, meter WH-01 recorded several hours of reverse flow conditions which were discussed and analyzed in detail in the Harms Region technical memorandum issued in July 2013. During these two storm events, the flow at both meters on the Princeton Region storage pipes (sites WP-01 and WP-03) reached the hydraulic capacity of the restrictor pipes, causing the flow to plateau for several

hours. The causes and ramifications of this condition are being analyzed in further detail as part of a pending Princeton Place Region hydraulic modeling report.

TABLE 5
PROJECTED PEAK FLOWS

		Peak Flow (mgd)			Peaking Factor		
Meter Site	ADWF (mgd)	1-Year, 1-Hour Storm	5-Year, 1-Hour Storm	10-Year, 1-Hour Storm	1-Year, 1-Hour Storm	5-Year, 1-Hour Storm	10-Year, 1-Hour Storm
WH-01	0.477	6.28	9.37	10.52	13.2	19.6	22.8
WP-01	0.503	2.32	3.25	3.70	4.7	6.4	7.3
WP-02	0.046	0.53	0.82	0.98	11.5	18.1	21.5
WP-03	0.363	3.07	4.76	5.65	8.3	13.0	15.5

		Peak Flow (mgd)			Peaking Factor		
Meter Site	ADWF (mgd)	1-Year, 24-Hour Storm	5-Year, 24-Hour Storm	10-Year, 24-Hour Storm	1-Year, 24-Hour Storm	5-Year, 24-Hour Storm	10-Year, 24-Hour Storm
WH-01	0.477	2.12	3.32	4.00	4.4	7.0	8.4
WP-01	0.503	1.56	2.35	2.80	3.1	4.7	5.6
WP-02	0.046	0.30	0.50	0.61	6.5	10.9	13.5
WP-03	0.363	1.39	1.93	2.20	3.8	5.3	6.1

Figure 5 illustrates the typical components of a wet-weather response in a sanitary flow meter basin. The first 24 hours following the onset of a rain event are considered the inflow response period while the subsequent 24 hours are considered the peak infiltration period. Residual infiltration is the component of the wet-weather flow that follows the inflow and peak infiltration period and lasts until the flow returns to the normal dry-weather flow pattern.

FIGURE 6
WET-WEATHER FLOW COMPONENTS
(SAMPLE DATA FROM WP-03)

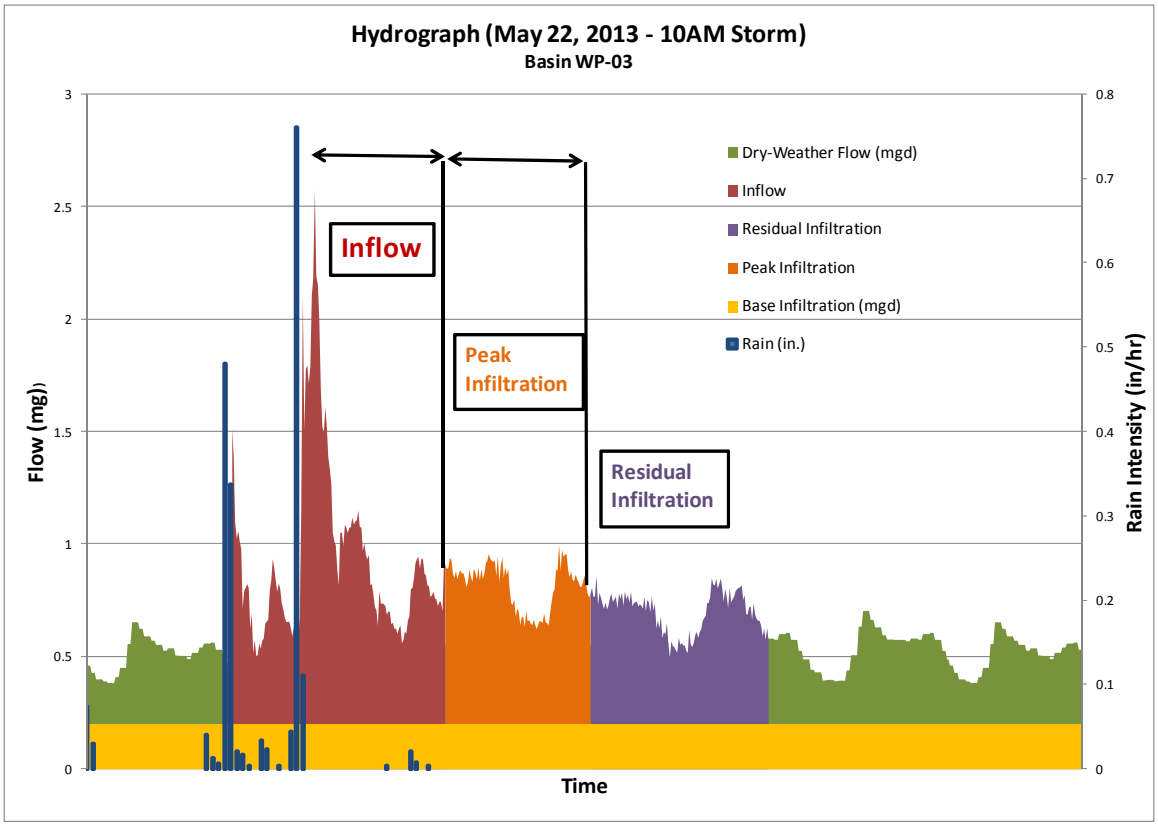


Table 6 details the percentage of rainfall capture within each of the four meter basins for multiple wet-weather periods. The percentage of rainfall capture is the percentage of the total volume of rainfall over a basin area that enters the sanitary sewer system and includes inflow, peak infiltration, and residual infiltration. Each of the periods encapsulates one of the three major rain events from the flow monitoring period, and based on this analysis, the percentage of rainfall capture was fairly consistent within each basin.

TABLE 6
RAINFALL CAPTURE PERCENTAGE

Meter Basin	Total R for April 6th to April 30th	Total R for May 20th to June 6th	Total R for June 21st to June 30th
WH-01	n/a	11.2%	n/a
WP-01	11.2%	6.6%	10.1%
WP-02	20.9%	14.9%	16.4%
WP-03	13.5%	10.0%	11.9%

All four of the basins have large rainfall capture percentages. Basins with rainfall capture in excess of 10% are especially out of the ordinary and indicate excessive amounts of I/I. The rainfall capture for the Harms Road Region (site WH-01) could not be calculated for the April and June periods due to the long periods of reverse flow during the April 18 and June 26 storm events.

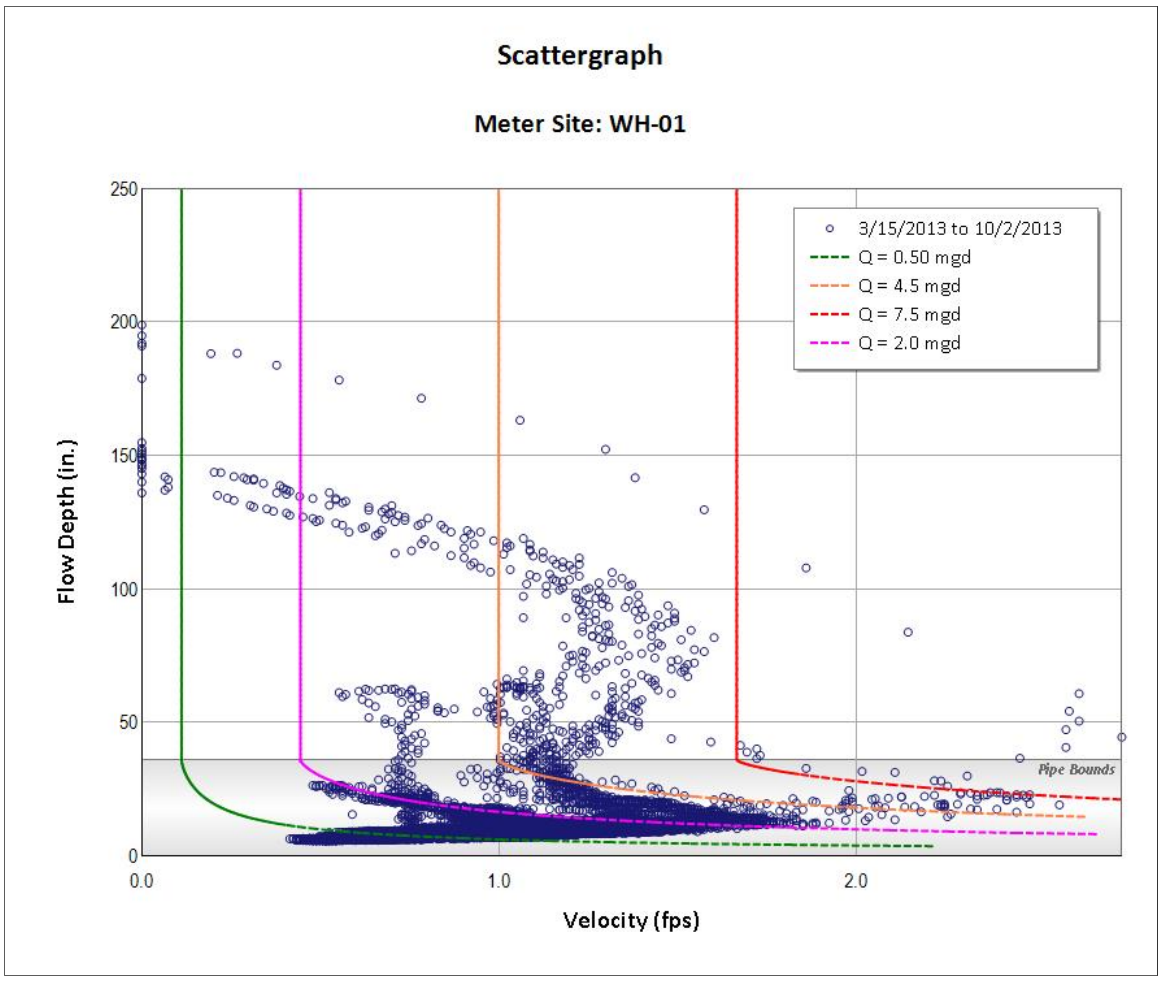
Capacity and Downstream Control

Downstream control is a restriction in flow originating downstream of the monitoring location that may limit the flow to a certain rate or may dampen the flow rate while allowing the flow rate to increase as pressure in the sewer increases. Downstream control can be caused by a wide variety of conditions such as a pipe with insufficient capacity downstream of the monitoring point, surcharging in receiving sewers, severe bends, offset joints, debris, pipe collapses, or a competing discharge of flow. Downstream control leads to surcharging since the system cannot relieve itself of excess flow, and as a result, the upstream pipes and structures act as storage for the pent up flow.

The primary tool for analyzing pipe capacity and downstream control is the depth-velocity scattergraph. The scattergraph is a plot of individual data points throughout the metering period that show the relationship between the depth and velocity at the meter site. The scattergraph provides visual evidence of downstream control, which occurs when the depth of flow increases, but the change in velocity decreases, deviating from the depth-velocity relationship expected in a free-flowing condition. In extreme cases of downstream control, the velocity will decrease or even become negative, creating a reverse flow condition. An example scattergraph is shown in Figure 7, and Appendix F contains the scattergraphs of each meter showing the data for the entire flow monitoring period as well as a period that did not include

any major surcharging events to show the depth-velocity relationship during more routine flow conditions.

FIGURE 7
DEPTH-VELOCITY SCATTERGRAPH



The scattergraphs were analyzed for estimated pipe capacity based on a best fit of Manning's Formula on the empirical meter data. Furthermore, "iso-Q" lines were plotted to show important flow "landmarks" on the graph, such as the pipe capacity, the beginning of downstream control, and the lower end dry-weather flows. Iso-Q lines track the data points along lines of constant flow representing periods when the depth increases and the velocity decreases, resulting in a constant flow value.

All four locations exhibit clear and significant effects of downstream control. Downstream control at meters WH-01 and WP-02 are the direct result of restrictions imposed by the MWRD interceptor systems downstream. Downstream control at sites WP-01 and WP-03 was caused in part by the MWRD system but also by the restrictor pipes at the Princeton and Kenilworth junction chamber. Ongoing modeling and analysis of the Princeton Place Region will further clarify the extent to which each of these factors contributes to the observed downstream control.

The downstream control at WH-01 near the connection to the Harms Road Interceptor was exceptionally severe, with more than 15 hours of continuous reverse flow occurring on April 18 and more than 7 hours of reverse flow on June 26.

CONCLUSIONS

Based on wet-weather flow analysis, it is evident that all four meter basins experience excessive I/I during storm events. The effects of I/I on peak flows is especially evident in the Harms Road Region (basin WH-01) and basin WP-02 in the Princeton Place Region. The other areas of the Princeton Place Region, monitored by meters WP-01 and WP-03, did not exhibit as large of peak flows in part due to attenuation caused by the outlet restrictors and in-pipe storage volume along Hunter Road, Locust Road, and Kenilworth Avenue. However, given these hydraulic constraints, the peaking factors in these basins were still very large, as are the total I/I volumes during storm events as indicated by the 24-hour peaking factors and rainfall capture values.

The magnitude and fast response of peak flows in all of the basins indicate that the I/I sources in the system include sources of direct runoff, which may include storm sewer-to-sanitary sewer cross connections, downspouts, area drains, foundation drains, and other private sector sources.

It is also evident that the Wilmette system is adversely impacted by significant downstream control from the MWRD interceptor systems at both the Harms Road connection point and at the outlet of the Princeton Place Region. Backflow prevention and a 5.5 million gallon (MG) detention storage basin near the Harms Road Interceptor connection – recommended by modeling of the Harms Region in summer 2013 – is already under preliminary design. Based on previous modeling of the Harms Road Region, the proposed storage project will result in approximately a 5-year level of protection for the Harms Region, and the Gregory and Kilpatrick local storage improvements currently under final design will provide an additional measure of protection for areas south of Glenview Road. However, flow reduction within the Harms Road

Region could increase the overall level of protection significantly in conjunction with these improvements. The effects of flow reduction on the level of protection are shown in Table 7.

TABLE 7
HARMS ROAD REGIONAL STORAGE LEVEL OF PROTECTION

Percentage I/I Reduction	Level of Protection
Current Flows	5-Year to 10-Year
10% Reduction	5-Year to 10-Year
25% Reduction	10-Year to 25-Year
40% Reduction	25-Year to 50-Year

Further modeling of the Princeton Place Region will be used to determine the extent to which downstream control observed at sites WP-01 and WP-03 is caused by the MWRD system, as some of the restriction is the intended effect of the junction chamber flow regulators. This analysis will be used to recommend any modifications to the system at or near the Princeton Place outlet control structure.

All four meters exhibited large seasonal variations in flow during dry-weather periods and large overnight flow components during the driest periods. Both of these observations indicate that the system is subject to large amounts of groundwater infiltration. Permanent groundwater infiltration is typically the product of cracks in sewer mains and laterals and deteriorated manholes and service connections.

RECOMMENDATIONS

It is recommended that further field investigations be conducted to quantify and identify the locations of I/I sources throughout the sanitary system. A manhole inspection and rehabilitation program has already been implemented in the Princeton Place Region, as has a smoke testing and dye inspection program in the Kenilworth Gardens area, which is part of basin WP-03. It is recommended that these efforts be replicated throughout additional areas of the Village.

It is also recommended that the Village continue to inspect and rehabilitate the public sewer system through its sewer cleaning, televising, and lining program. It is recommended that the Village extend the manhole inspection and rehabilitation program into the Harms Road Region within the next year.

Concurrent to this, it is recommended that additional SSES investigations be conducted throughout the entire Village. Based on preliminary findings of the Kenilworth Gardens SSES program – the detailed results of which will be summarized in a subsequent report – smoke testing of the remainder of the Princeton Place region is likely to identify large inflow sources both on public and private property. Smoke testing of the remainder of the Princeton Place Region is recommended as an immediate priority, in particular basins WP-02 and the remaining parts of WP-03 not already tested. Basin WP-01 projected to the lowest peak flows, and a portion of this area will also benefit from the Wilmette Avenue local storage improvements currently under design, and it is therefore recommended that the remaining areas tributary to WP-02 and WP-03 be given first priority.

Additionally, smoke testing of the Harms Road Region is recommended subsequent to the public sector manhole inspection and rehabilitation program. As in the Princeton Region, it is evident that there are large, direct runoff inflow sources within the Harms Region that could be easily identified by smoke testing. It is recommended that priority be given to the area tributary to the Central Road sewer west of Skokie Boulevard, which history and previous modeling indicates is most at risk of sewer backups and will not directly benefit from the Gregory and Kilpatrick local storage project scheduled for 2014 construction. Dye flood testing should follow the smoke testing program to confirm sources of inflow. The recommended investigations and improvements are listed in Table 8.

TABLE 8
COSTS OF RECOMMENDATIONS

Recommendation	Estimated Cost
Manhole inspection and rehabilitation design in Harms Region	$60,000
Rehabilitate manholes in Harms Region	$890,000
Smoke test the remainder of Princeton Region	$138,000
Smoke test the Harms Region	$96,000

Following the smoke testing and follow-up dye testing, building inspection and televising and lining of laterals may be considered in the future. However, these investigations and improvements are expensive, and it is recommended to first identify and implement a program to remove larger inflow sources such as downspouts and private area drains that are less costly to disconnect.

It is our pleasure to submit this summary of the 2013 flow monitoring completed for the Village. Should you have any questions or require further information regarding any part of this letter, please do not hesitate to contact us.

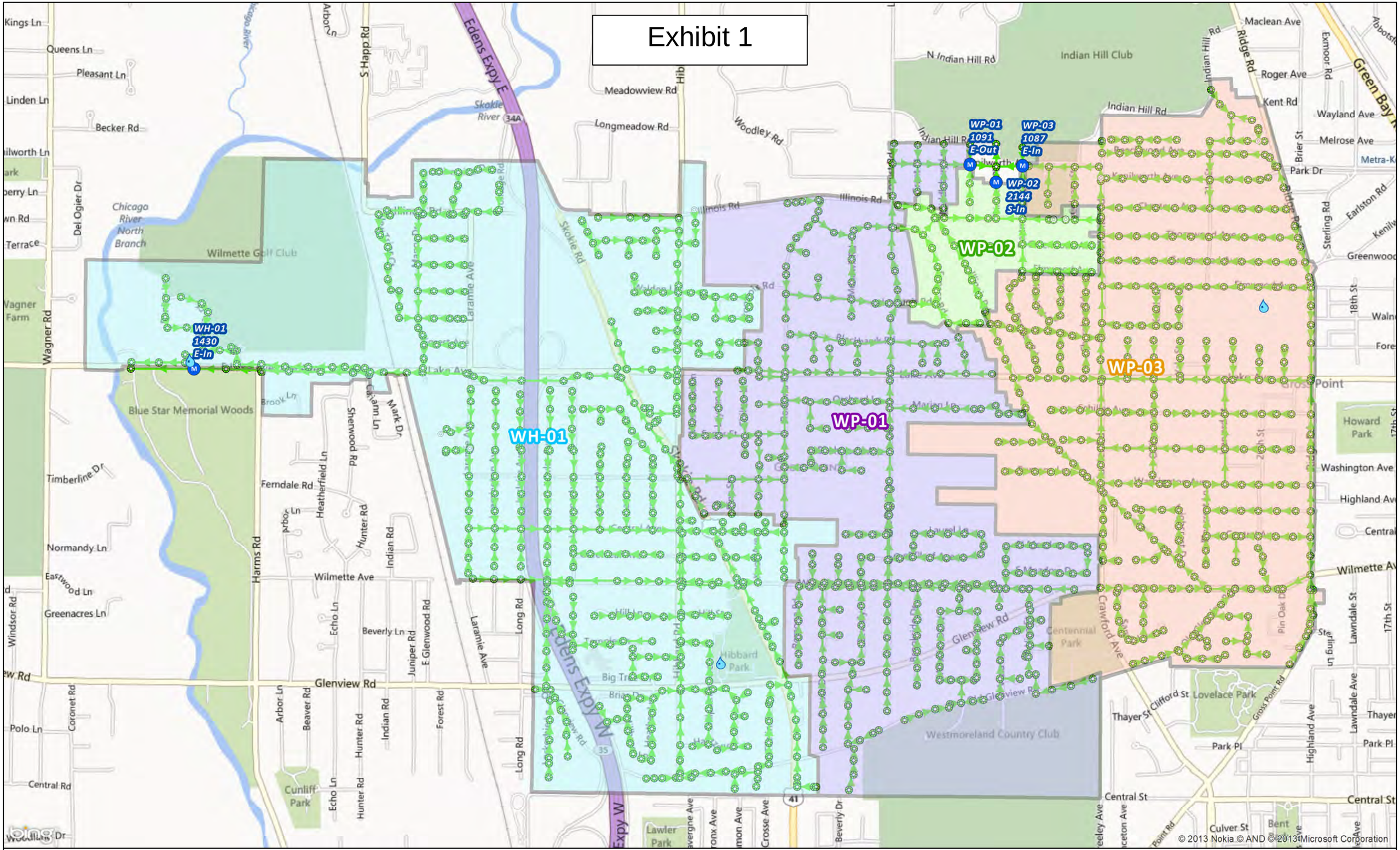
Sincerely,
RJN Group, Inc.

Vinnie Bergl, P.E.
Project Engineer

Attachments:

Exhibit 1
Table A-1
Appendices A to F

Exhibit 1



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The Choice for Collection System Solutions

Flow Meter Site | Rain Gauge Site | Sanitary Manhole | Sanitary Sewer

N W E S

Village of Wilmette
11-2659-00
Meter Locations and Basins
Exhibit 1

\\whe-cadd\WHE_OFFICE\PROJECTS\11265900 Wilmette 2013-2015 CIP Phase 1\5.0 GIS\Map Documents\Map Documents - Exhibits\Wilmette Meter Locations and Basins 2013 (11 x 17).mxd - Date Printed: 12/23/2013 2:25:35 PM

Table A-1
Rainfall Summary

Date	WRG-01 60-Minute Peak (inches)	WRG-01 24-Hour Total (inches)	WRG-02 60-Minute Peak (inches)	WRG-02 24-Hour Total (inches)	WRG-03 60-Minute Peak (inches)	WRG-03 24-Hour Total (inches)	Average 60-Minute Peak (inches)	Recurrence Interval for 60-Minute Peak	Average 24-Hour Total (inches)	Recurrence Interval for 24-Hour Total
8-Apr	.28	.42	.36	.55	.35	.51	0.32	1-Month	0.49	1-Month
10-Apr	.25	.94	.25	.97	.31	.92	0.32	1-Month	0.94	1-Month
15-Apr	< 0.10	.39	.12	.46	<.1	.39	< 0.10	<1-Month	0.41	1-Month
18-Apr	1.23	5.22	1.06	5.09	1.3	5.56	1.18	1-Year	5.29	22-Year
23-Apr	.12	.62	.11	.67	.12	.67	0.12	<1-Month	0.65	1-Month
9-May	< 0.10	.45	< 0.10	.53	< 0.10	.43	< 0.10	<1-Month	0.47	1-Month
20-May	.58	.94	.60	.91	.47	.83	0.53	2-Month	0.89	1-Month
21-May	.38	1.86	.49	1.50	.77	2.15	0.48	1-Month	1.84	5-Month
22-May	.93	1.86	.59	1.50	.90	2.15	0.70	2-Month	1.84	5-Month
27-May	.17	.58	.14	.45	.16	.36	0.16	<1-Month	0.46	1-Month
30-May	.94	1.24	.40	.69	.94	1.25	0.76	3-Month	1.06	2-Month
1-Jun	.59	.68	.19	.35	.47	.55	0.42	1-Month	0.53	1-Month
12-Jun	.34	.57	.34	.67	.29	.61	0.30	1-Month	0.62	1-Month
21-Jun	.39	.59	.51	.68	.52	.69	0.45	1-Month	0.65	1-Month
24-Jun	.24	.55	.12	.37	.17	.36	0.18	1-Month	0.43	1-Month
26-Jun	.88	2.89	1.04	3.49	1.24	3.16	1.08	9-Month	3.18	2-Year
8-Jul	.17	.40	.87	1.09	.96	1.21	0.67	2-Month	0.9	1-Month
21-Jul	1.01	1.29	.40	.70	.55	.75	0.69	2-Month	0.91	1-Month
2-Aug	.19	.25	.26	.29	.25	.30	0.23	1-Month	0.28	<1-Month
12-Aug	.19	.21	.43	.46	.22	.22	0.28	1-Month	0.3	<1-Month
30-Aug	.31	.44	.73	.87	.53	.66	0.52	2-Month	0.66	1-Month
15-Sep	.30	.89	.35	.91	.31	.90	0.30	1-Month	0.9	1-Month
19-Sep	.54	.73	.31	.51	.46	.76	0.4	1-Month	0.67	1-Month

APPENDIX A – SITE SHEETS

rjngroup
The Choice for Collection System Solutions

Flow Meter Site Investigation Report

Wilmette 2013-2015 CIP Phase 1

Site Name
WH-01

		Project No.	Site Code
Inspected By	TR/JS		
Inspected Date/Time	3/15/2013 8:15 AM	11-2659-00	T

System Information

Target Pipe Dia. (in)	36.0
Municipality	Villlage of Wilmette
District	MWRD
Assigned Rain Gauge	WRG-03
Client Manhole #	1430
U/S Connecting MH I.D	1431
System Characteristics:	
Residential - ☑	Commercial - ☐ Industrial - ☐
P/S Influence	No
WWTP Influence	No

Location Information

Site Address	E BOUND CURB ACROSS FROM BLDG AFTER BRIDGE
Site Access	Roadway, High Traffic
Longitude	-87.77423930
Latitude	42.07969768
MH Type	Lined
Manhole Depth (ft)	20.76
Manhole Width (ft)	4.0
Elevated MH	No
Height Elevated (ft)	
Structural Integrity	Safe

Site Information

Pipe Height (in)	36.00		
Pipe Width (in)	35.75		
Pipe Type	Concrete		
Pipe Shape	Circular		
O2	20.9	**LEL %**	0.0
H2S	0.0	**CO**	0.0

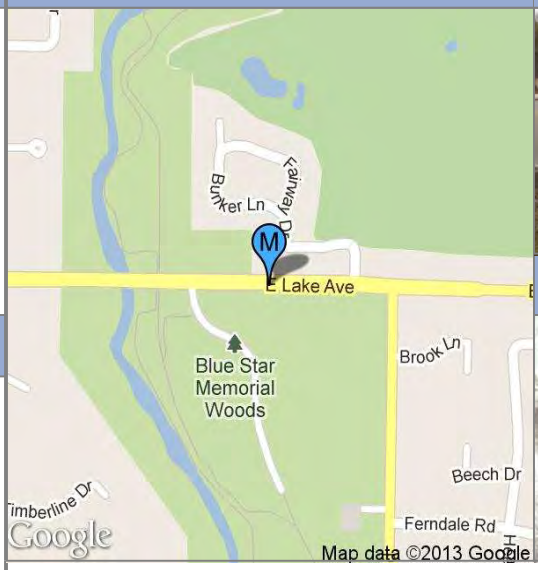
Hydraulic Information

Flow Depth (in)	10.50
Instant Velocity (fps)	1.35
Surcharge Evidence (ft)	2.00
Silt Type	None
Silt Depth (in)	N/A
Needs Cleaning	No
Backwater	No
Flow Path	Straight
Drop Inlet	No
Hydraulic Rating	Excellent

Installation Notes

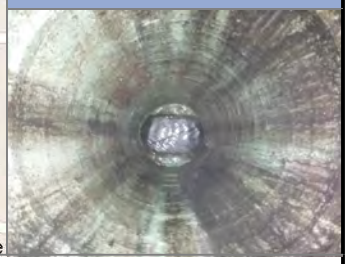
Location in Pipe (ft)	
Location from Manhole	Upstream
Sensors	V, P, Ultra
Antenna Surface	Concrete
Signal Strength	100

Area Location Map



Area View Picture

Top View Picture

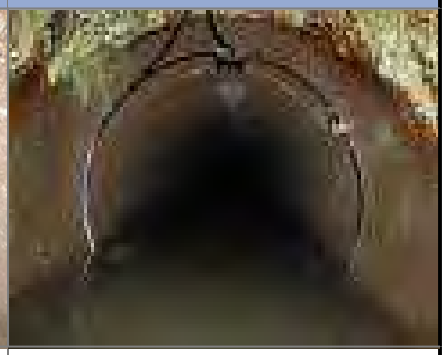


Access Notes CLOSE RIGHT LANE

Investigation Photo

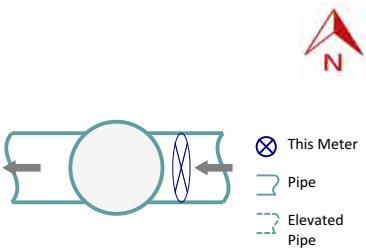
Hydraulic Characteristics

Installation Photo

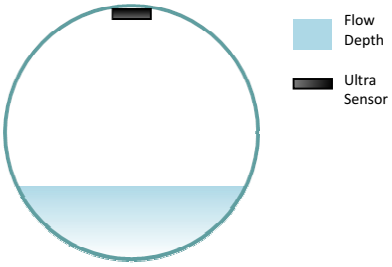


Installation Notes

Install Plan Sketch



Install Cross-Section Sketch



Post Installation Notes

Meter Type	
Telemetry Type	Bat-Wing
Installation Date	

Approvals

Recommended by FSP	Client Approval
Yes	Yes
3/25/2013	3/25/2013

rjngroup
The Choice for Collection System Solutions

Flow Meter Site Investigation Report

Wilmette 2013-2015 CIP Phase 1

Site Name
WP-01

		Project No.	Site Code
Inspected By	JSh/MH		
Inspected Date/Time	2/25/2013 4:09 PM	11-2659-00	T

System Information

Target Pipe Dia. (in)	72.0
Municipality	Villlage of Wilmette
District	MWRD
Assigned Rain Gauge	WRG-01
Client Manhole #	1091
U/S Connecting MH I.D	UNKNOWN
System Characteristics:	
Residential - ☑	Commercial - ☐ Industrial - ☐
P/S Influence	No
WWTP Influence	No

Location Information

Site Address	INTERSECTION OF CLEVELAND AND KENILWORTH
Site Access	Roadway, Low Traffic
Longitude	-87.73826926
Latitude	42.08655090
MH Type	Precast Concrete
Manhole Depth (ft)	22.48
Manhole Width (ft)	4.0
Elevated MH	No
Height Elevated (ft)	
Structural Integrity	Safe

Site Information

Pipe Height (in)	72.00		
Pipe Width (in)	72.75		
Pipe Type	Concrete		
Pipe Shape	Circular		
O2	20.9	LEL %	0.0
H2S	0.0	CO	0.0

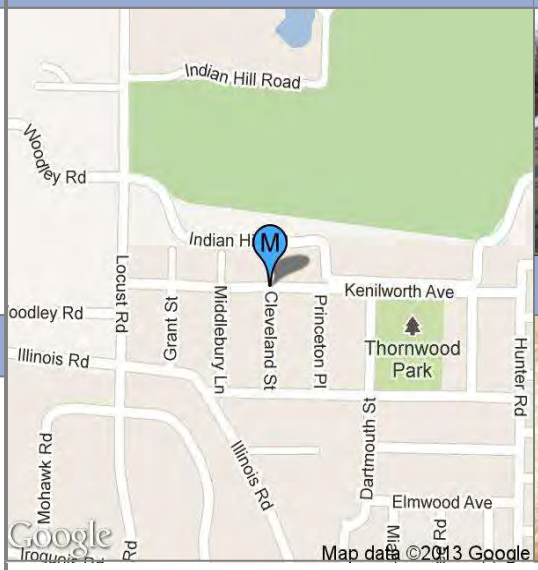
Hydraulic Information

Flow Depth (in)	9.25
Instant Velocity (fps)	1.01
Surcharge Evidence (ft)	N/A
Silt Type	Medium
Silt Depth (in)	6.00
Needs Cleaning	No
Backwater	Yes
Flow Path	Straight
Drop Inlet	No
Hydraulic Rating	Fair

Installation Notes

Location in Pipe (ft)	
Location from Manhole	Downstream
Sensors	A/V, Ultra
Antenna Surface	Asphalt
Signal Strength	75

Area Location Map



Area View Picture

Top View Picture

Access Notes

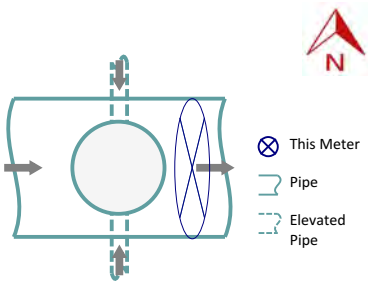
Investigation Photo

Hydraulic Characteristics

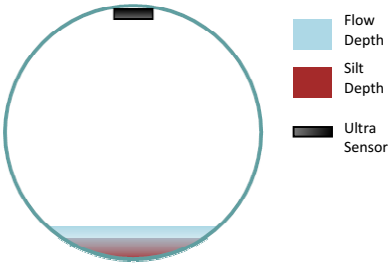
Installation Photo

Installation Notes

Install Plan Sketch



Install Cross-Section Sketch



Post Installation Notes

Meter Type	
Telemetry Type	Bat-Wing
Installation Date	

Approvals

Recommended by FSP	Client Approval
Yes	Yes
3/25/2013	3/25/2013

rjngroup
The Choice for Collection System Solutions

Flow Meter Site Investigation Report

Wilmette 2013-2015 CIP Phase 1

Site Name
WP-02

		Project No.	Site Code
Inspected By	JSh/MH		
Inspected Date/Time	2/25/2013 2:48 PM	11-2659-00	T

System Information

Target Pipe Dia. (in)	30.0
Municipality	Villlage of Wilmette
District	MWRD
Assigned Rain Gauge	WRG-01
Client Manhole #	2144
U/S Connecting MH I.D	UNKNOWN
System Characteristics:	
Residential - ☑	Commercial - ☐ Industrial - ☐
P/S Influence	No
WWTP Influence	No

Location Information

Site Address	1235 PRINCETON PL.
Site Access	Roadway, Low Traffic
Longitude	-87.73706597
Latitude	42.08592276
MH Type	Brick
Manhole Depth (ft)	23.42
Manhole Width (ft)	3.0
Elevated MH	No
Height Elevated (ft)	
Structural Integrity	Safe

Site Information

Pipe Height (in)	30.00		
Pipe Width (in)	30.00		
Pipe Type	Vitrified Clay		
Pipe Shape	0		
O2	20.9	LEL %	0.0
H2S	0.0	CO	0.0

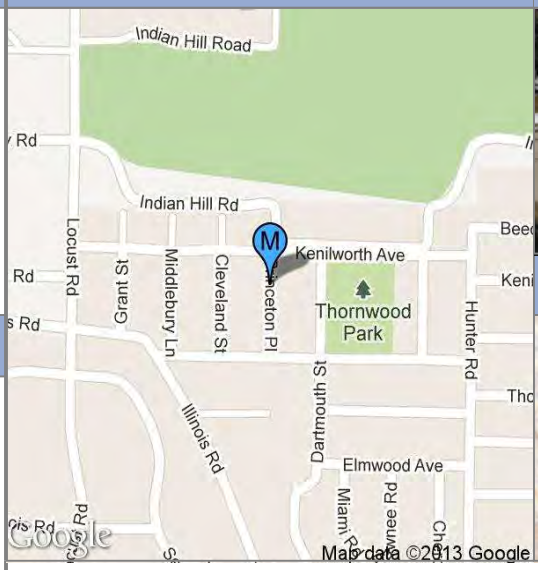
Hydraulic Information

Flow Depth (in)	9.25
Instant Velocity (fps)	0.42
Surcharge Evidence (ft)	10.00
Silt Type	Fine
Silt Depth (in)	4.00
Needs Cleaning	No
Backwater	No
Flow Path	Straight
Drop Inlet	No
Hydraulic Rating	Poor

Installation Notes

Location in Pipe (ft)	
Location from Manhole	Upstream
Sensors	V, P, Ultra
Antenna Surface	Concrete
Signal Strength	75

Area Location Map



Area View Picture

Top View Picture

Access Notes

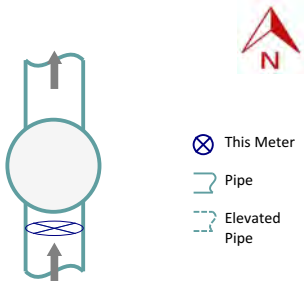
Investigation Photo

Hydraulic Characteristics	SLOW Q, NO TROUGH IN MH, ROUGH TRANS. FROM PIPE TO MH

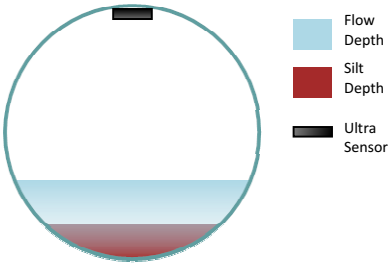
Installation Photo

Installation Notes

Install Plan Sketch



Install Cross-Section Sketch



Post Installation Notes

Meter Type	
Telemetry Type	Bat-Wing
Installation Date	

Approvals

Recommended by FSP	Client Approval
Yes	Yes
3/25/2013	3/25/2013

rjngroup
The Choice for Collection System Solutions

Flow Meter Site Investigation Report

Wilmette 2013-2015 CIP Phase 1

Site Name	Site Code
WP-03	T

Inspected By	JSh/MH	**Project No.**	
Inspected Date/Time	2/25/2013 2:03 PM	11-2659-00	

System Information

Target Pipe Dia. (in)	120.0
Municipality	Villlage of Wilmette
District	MWRD
Assigned Rain Gauge	WRG-01
Client Manhole #	1087
U/S Connecting MH I.D	UNKNOWN
System Characteristics:	
Residential - ☑	Commercial - ☐ Industrial - ☐
P/S Influence	No
WWTP Influence	No

Location Information

Site Address	I-SECTION OF DARTMOUTH & KENILWORTH
Site Access	Roadway, Low Traffic
Longitude	-87.73583929
Latitude	42.08649618
MH Type	Precast Concrete
Manhole Depth (ft)	23.65
Manhole Width (ft)	4.0
Elevated MH	No
Height Elevated (ft)	
Structural Integrity	Safe

Site Information

Pipe Height (in)	114.00		
Pipe Width (in)	120.00		
Pipe Type	Concrete		
Pipe Shape	Circular		
O2	20.9	**LEL %**	0.0
H2S	0.0	**CO**	0.0

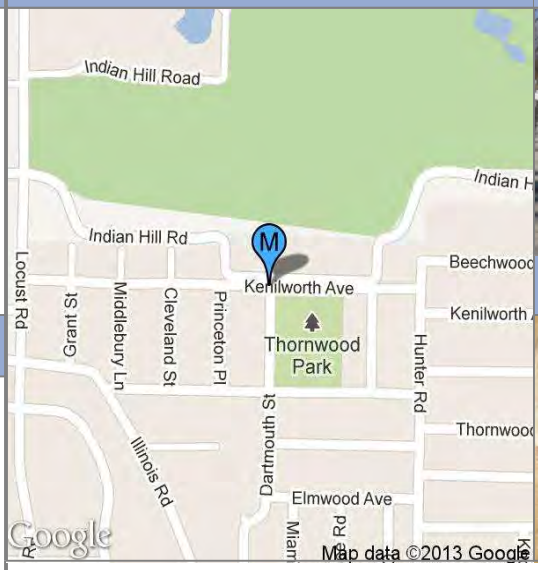
Hydraulic Information

Flow Depth (in)	7.50
Instant Velocity (fps)	1.06
Surcharge Evidence (ft)	N/A
Silt Type	Medium
Silt Depth (in)	4.00
Needs Cleaning	No
Backwater	Yes
Flow Path	Straight
Drop Inlet	No
Hydraulic Rating	Fair

Installation Notes

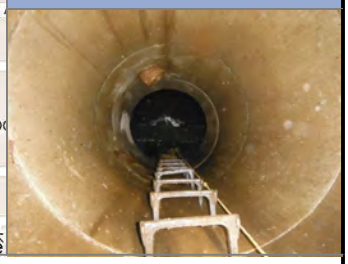
Location in Pipe (ft)	
Location from Manhole	Upstream
Sensors	A/V, Ultra
Antenna Surface	Asphalt
Signal Strength	75

Area Location Map



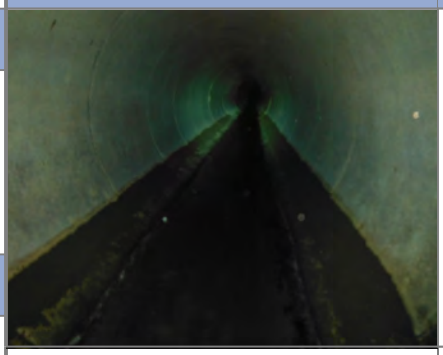
Area View Picture

Top View Picture



Access Notes

Investigation Photo

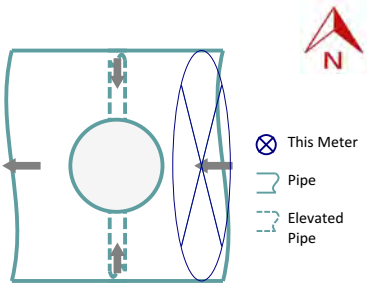


Hydraulic Characteristics

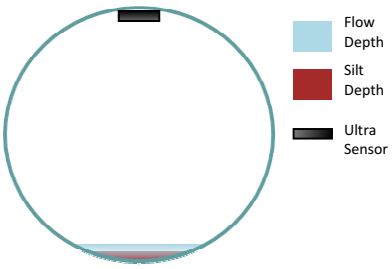
Installation Photo

Installation Notes

Install Plan Sketch



Install Cross-Section Sketch



Post Installation Notes

Meter Type	
Telemetry Type	Bat-Wing
Installation Date	

Approvals

Recommended by FSP	Client Approval
Yes	Yes
3/25/2013	3/25/2013

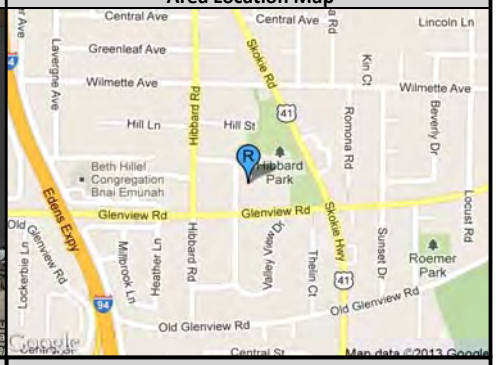
rjngroup The Choice for Collection System Solutions	Flow Meter Site Investigation Report Wilmette 2013-2015 CIP Phase 1	RG Site Name WRG-03

Project	Project No.	Inspection Date/Time	Facility Name
2013-2015 CIP Phase 1	11-2659-00	4/2/2013 1:27 PM	BELL SCHOOL
		Inspected By	**Access Instructions**
		JSh/TR	LADDER
Site Address:	BELL SCHOOL ROOF		

Installation Photo

Location Diagram of Rain Gauge

Area Location Map



Contact Info		Tipping Bucket Serial #	Rain Gauge Manufacturer	
Name	BILL	54476-213	Telog	
Title	CITY WORKER	**Logger Serial #**	**Recommended for Installation**	☐
Phone #	8472569639	371304		

Installation Instructions

Site Visits

Check By	Date	Time	Manual Depth (in)	Rain Depth (in)	Tip Test	Comments
OD/Jsh	10/1/2013	3:45 PM	0.00	0.00000000	☑	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
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					☐	
					☐	
					☐	
					☐	

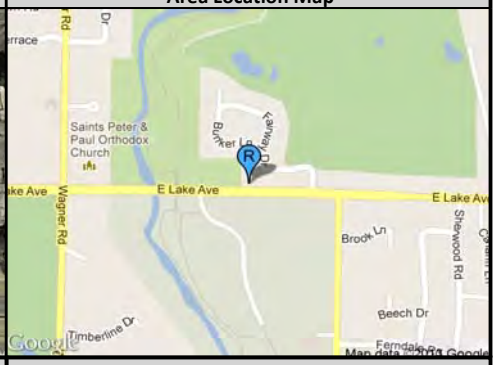
rjngroup The Choice for Collection System Solutions	Flow Meter Site Investigation Report Wilmette 2013-2015 CIP Phase 1	RG Site Name WRG-02

Project	Project No.	Inspection Date/Time	Facility Name
2013-2015 CIP Phase 1	11-2659-00	4/2/2013 11:07 AM	LAKE STREET LIFT STATION
		Inspected By	**Access Instructions**
		JSh/TR	CALL AHEAD GATE LOCKED
Site Address:	LAKE AVENUE LIFT STATION		

Installation Photo

Location Diagram of Rain Gauge

Area Location Map



Contact Info		Tipping Bucket Serial #	Rain Gauge Manufacturer	
Name	PETE	54480-213	Telog	
Title	CITY WORKER	**Logger Serial #**	**Recommended for Installation**	☐
Phone #	8478537538	371284		

Installation Instructions

Site Visits

Check By	Date	Time	Manual Depth (in)	Rain Depth (in)	Tip Test	Comments
OD/Jsh	10/1/2013	3:45 PM	0.00	0.00000000	☑	
					☐	
					☐	
					☐	
					☐	
					☐	
					☐	
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					☐	
					☐	
					☐	
					☐	

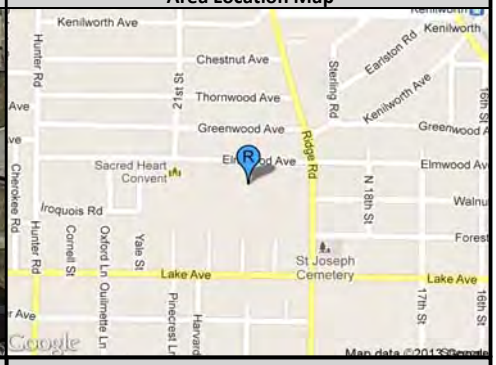
rjngroup The Choice for Collection System Solutions	Flow Meter Site Investigation Report Wilmette 2013-2015 CIP Phase 1	RG Site Name WRG-01

Project	Project No.	Inspection Date/Time	Facility Name
2013-2015 CIP Phase 1	11-2659-00	4/2/2013 10:21 AM	MESKILL CENTER
		Inspected By	**Access Instructions**
		JSh/TR	BRING A TALL LADDER
Site Address:	RIDGE AND ELMWOOD WEST SIDE ON FLAT ROOF		

Installation Photo

Location Diagram of Rain Gauge

Area Location Map



Contact Info		Tipping Bucket Serial #	Rain Gauge Manufacturer	
Name	BILL	54475-213	Telog	
Title	CITY WORKER	**Logger Serial #**	**Recommended for Installation**	☐
Phone #	8472569639	371414		

Installation Instructions

Site Visits

Check By	Date	Time	Manual Depth (in)	Rain Depth (in)	Tip Test	Comments
OD/Jsh	10/1/2013	3:44 PM	0.00	0.00000000	☑	
					☐	
					☐	
					☐	
					☐	
					☐	
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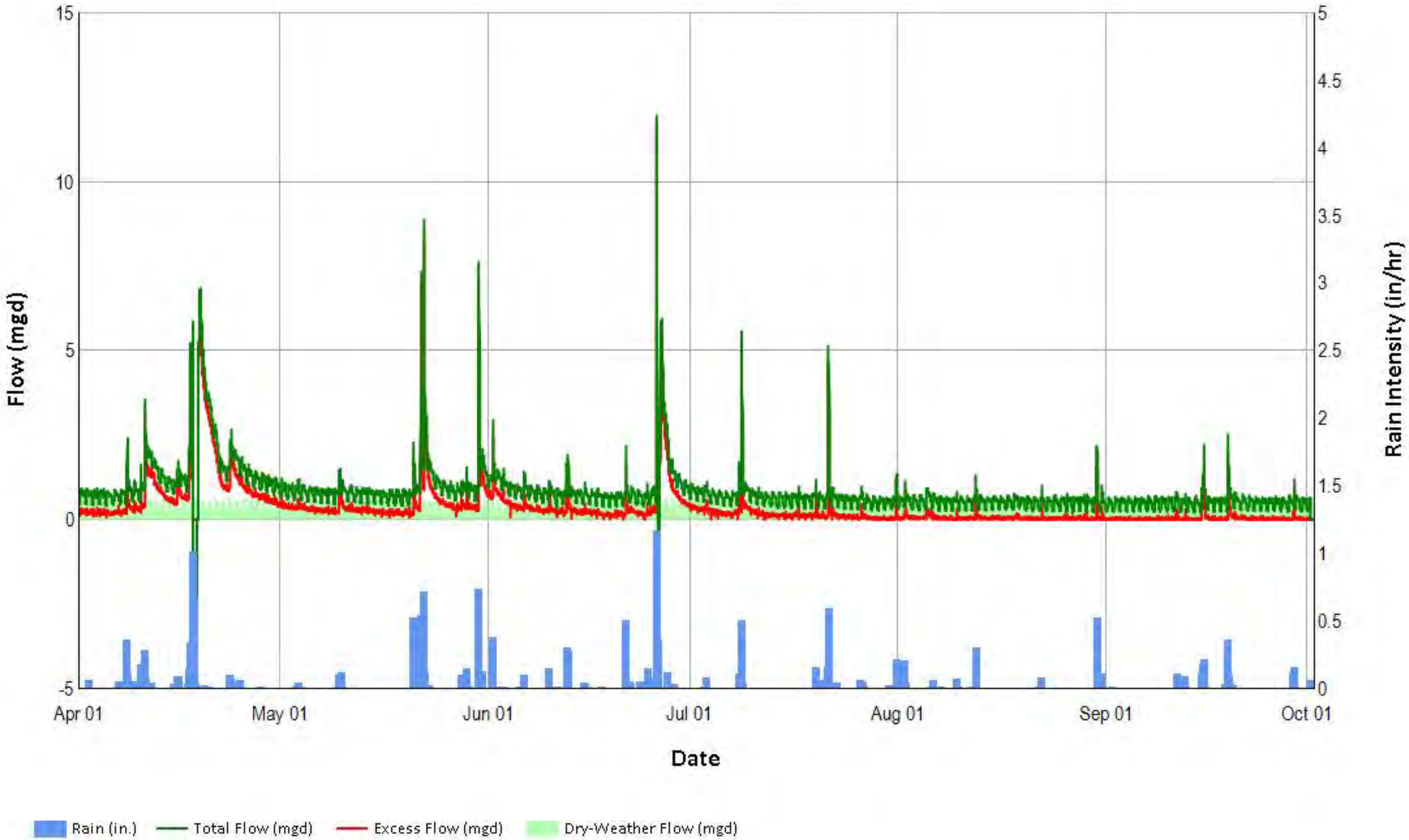
					☐	

APPENDIX B - HYDROGRAPHS

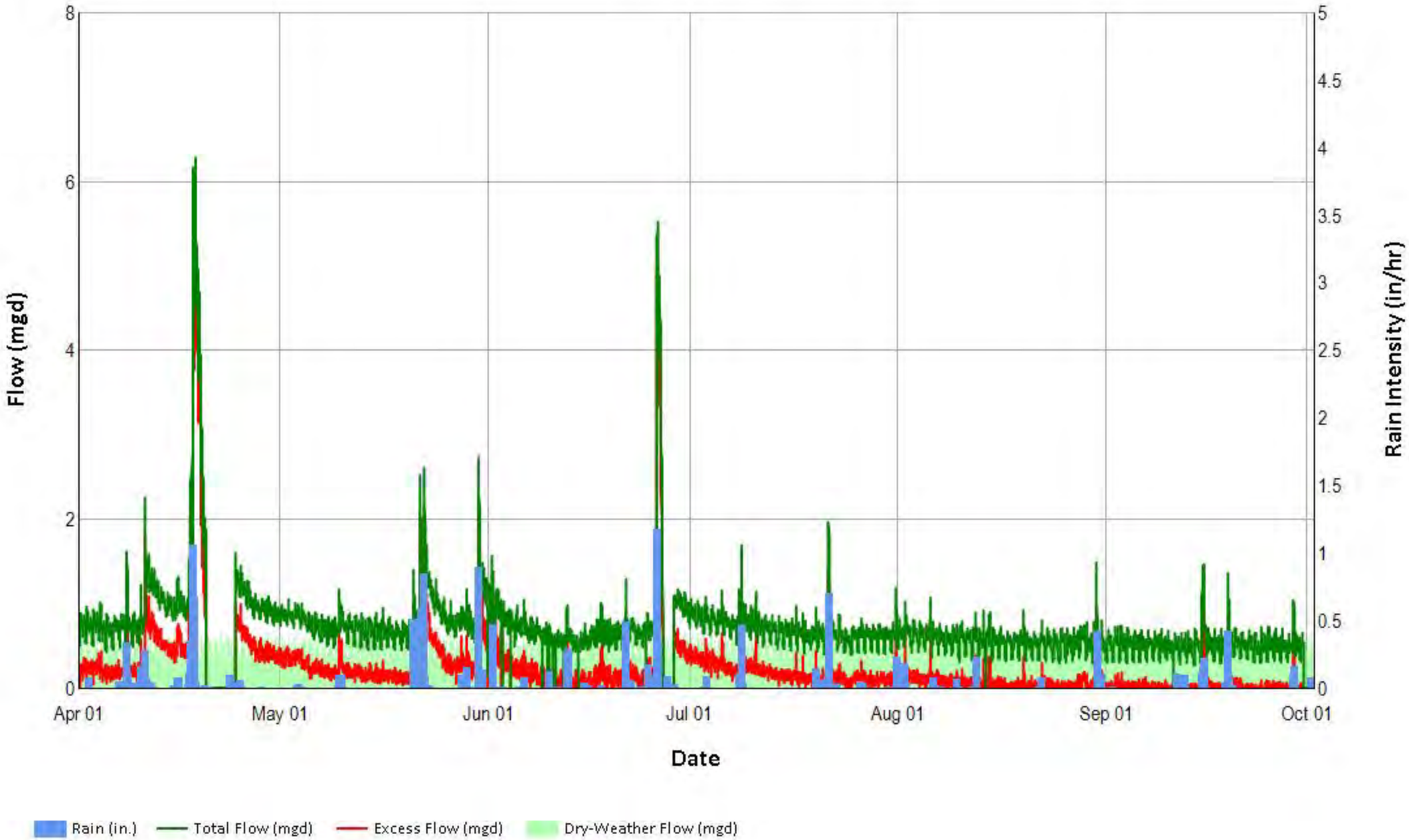
Metered Flow Hydrograph

Basin WH-01



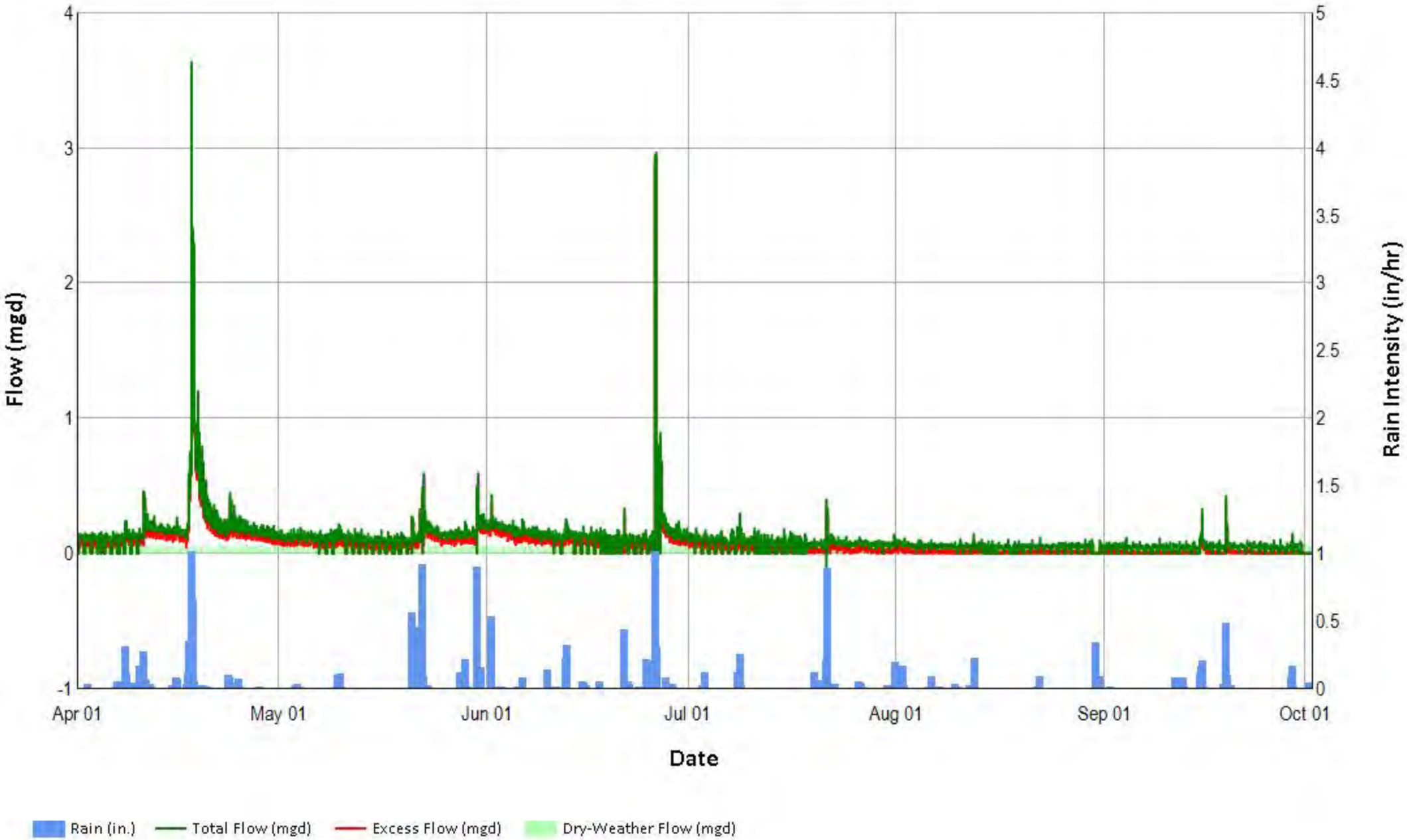
Metered Flow Hydrograph

Basin WP-01



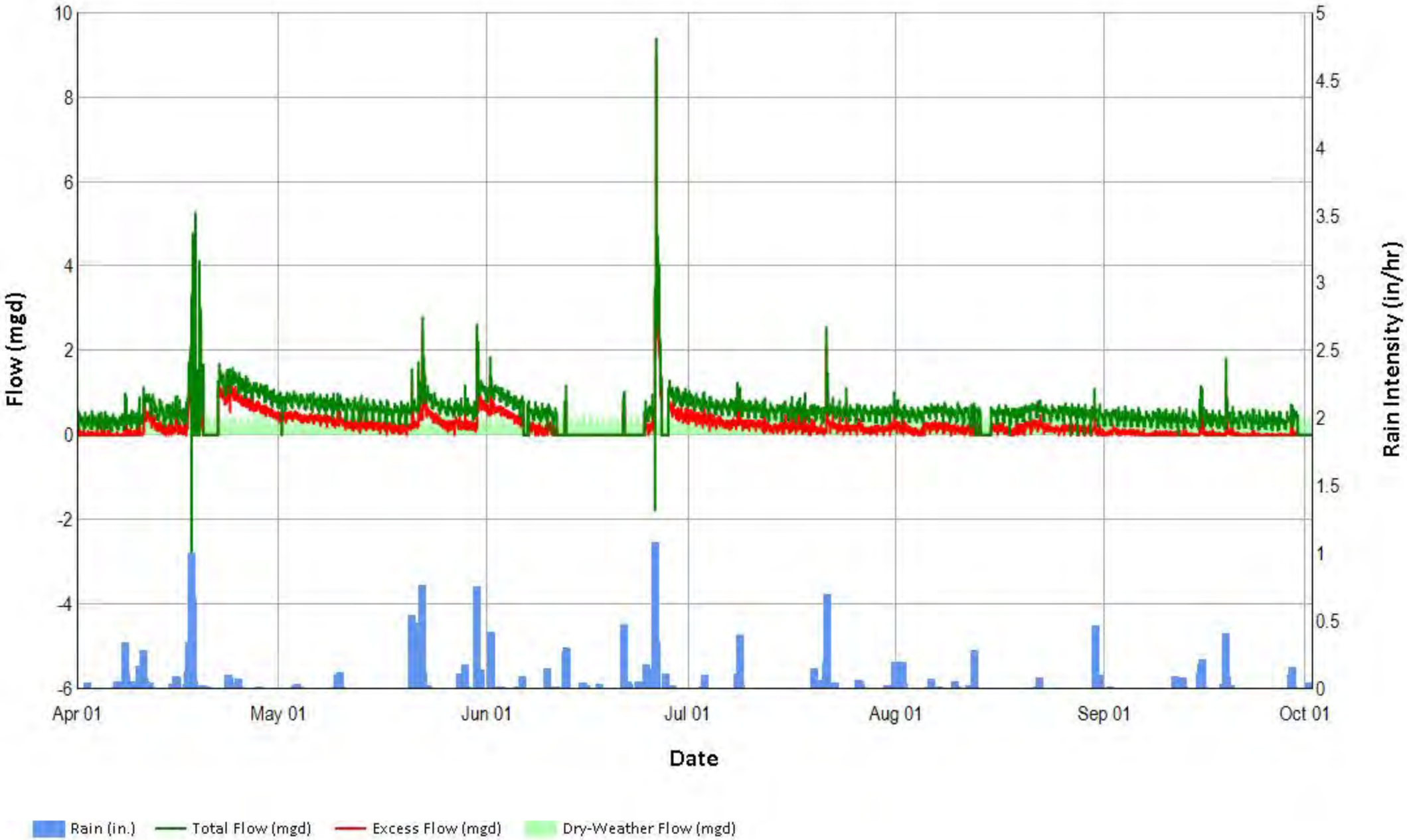
Metered Flow Hydrograph

Basin WP-02



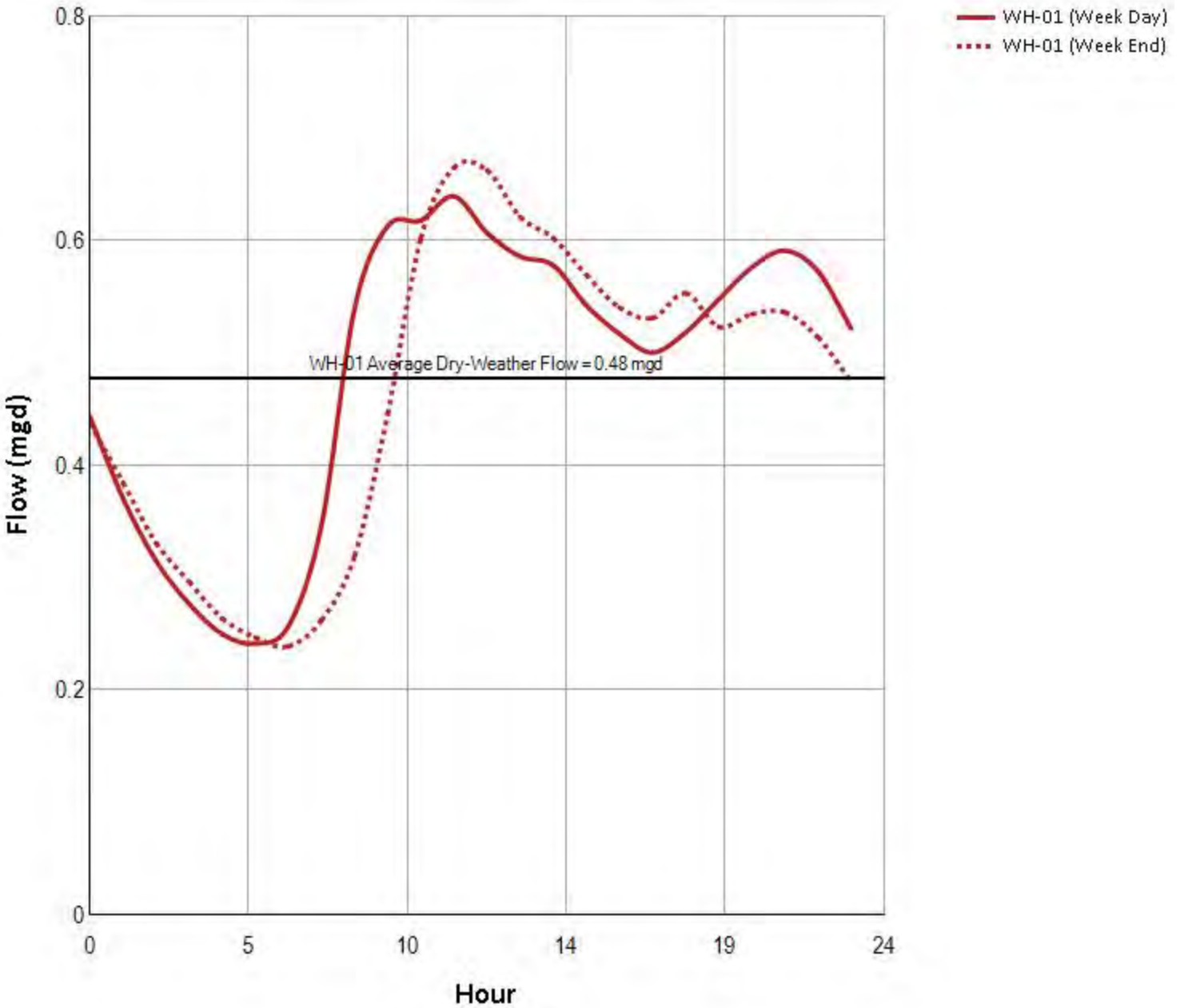
Metered Flow Hydrograph

Basin WP-03

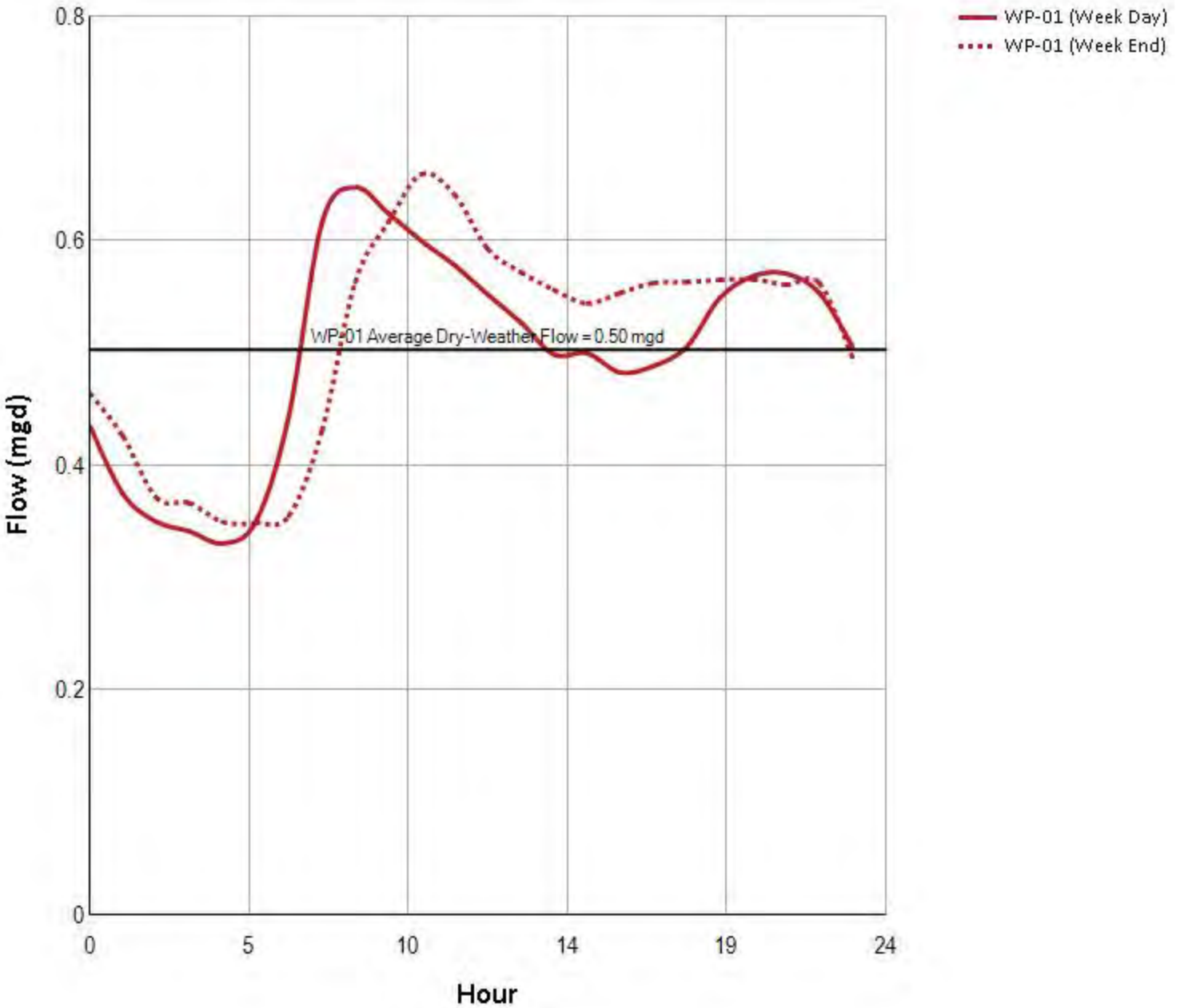


APPENDIX C – AVERAGE DRY-WEATHER FLOW

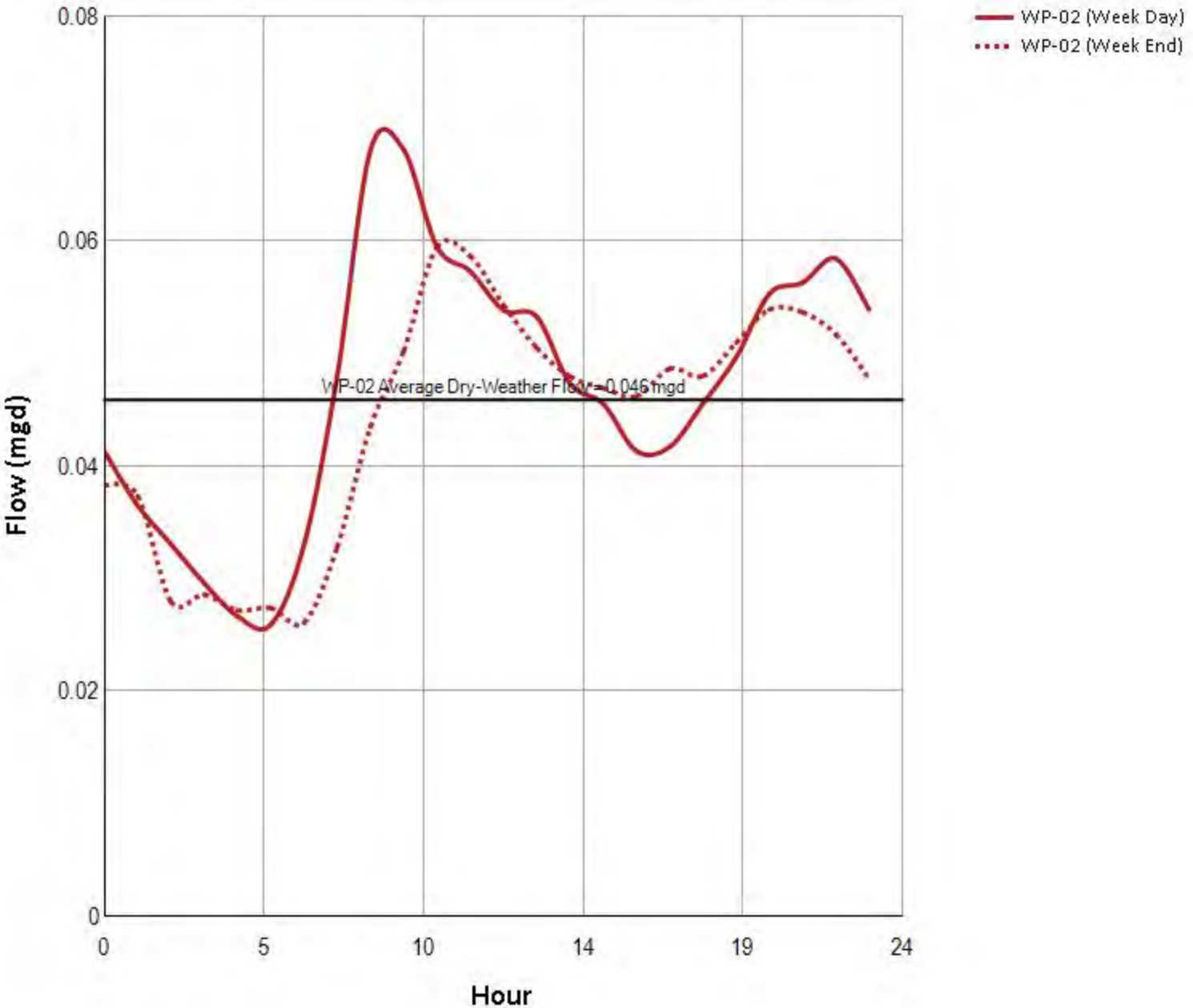
Site: WH-01 - Average Dry-Weather Flow



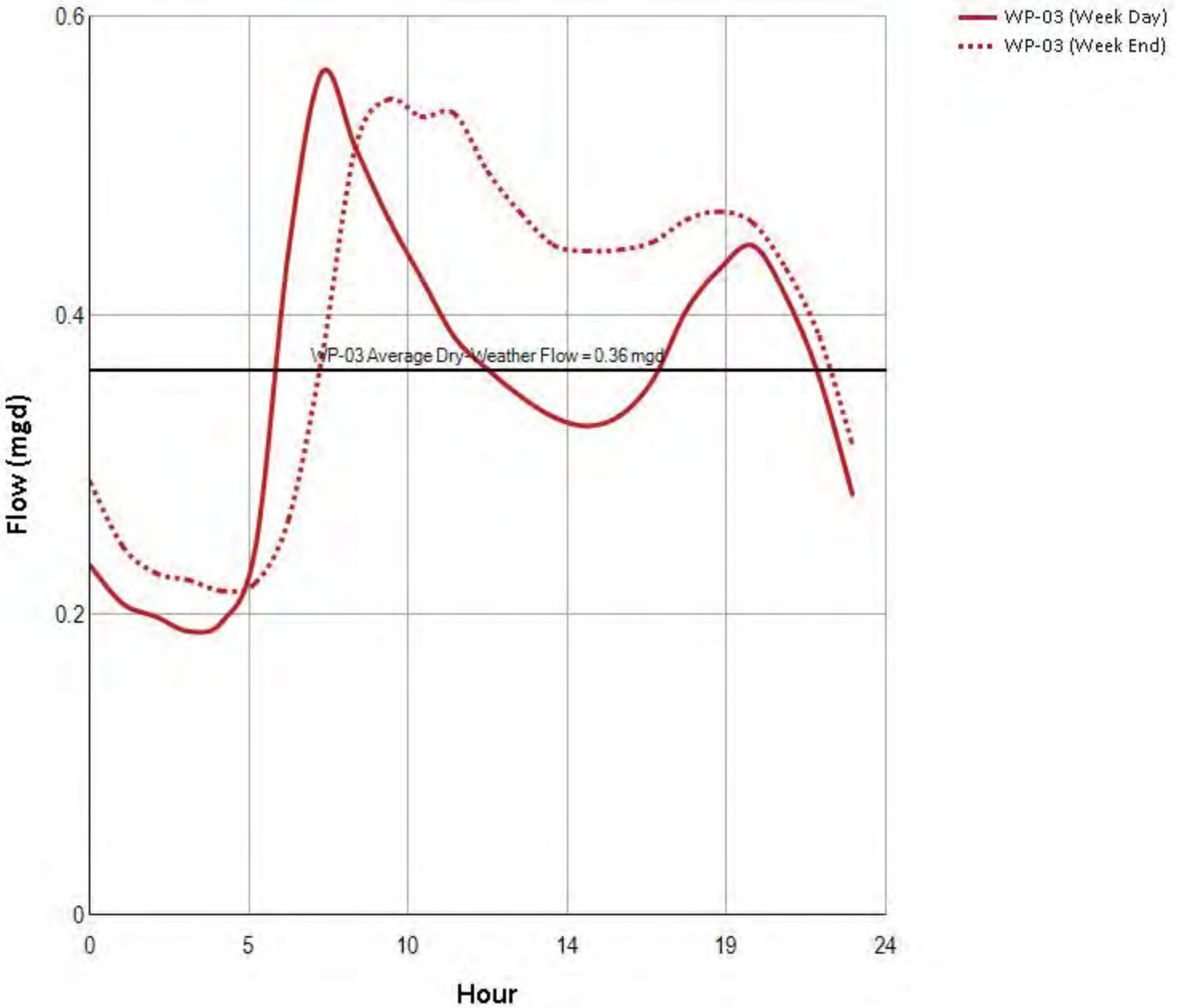
Site: WP-01 - Average Dry-Weather Flow



Site: WP-02 - Average Dry-Weather Flow



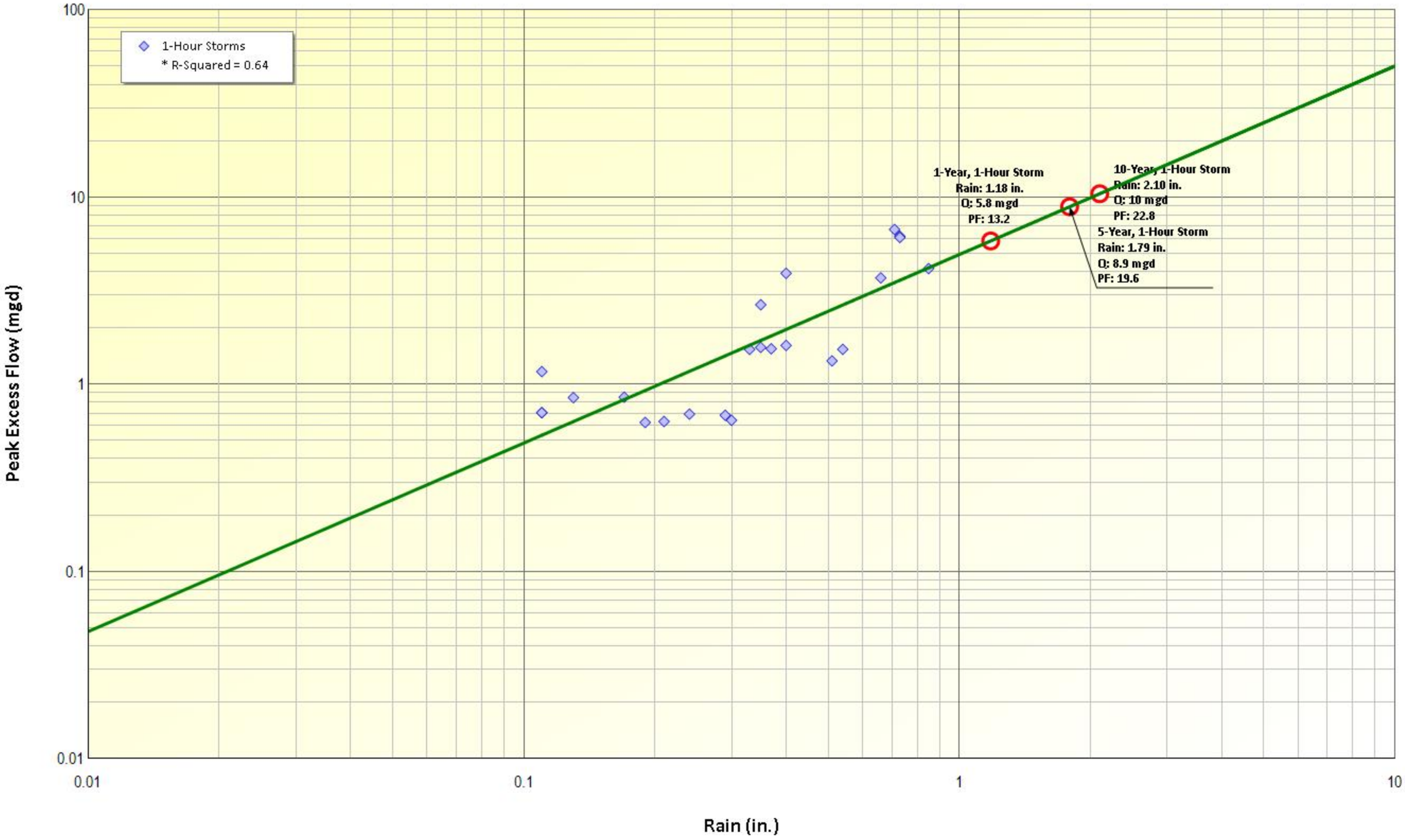
Site: WP-03 - Average Dry-Weather Flow



APPENDIX D – REGRESSION ANALYSIS

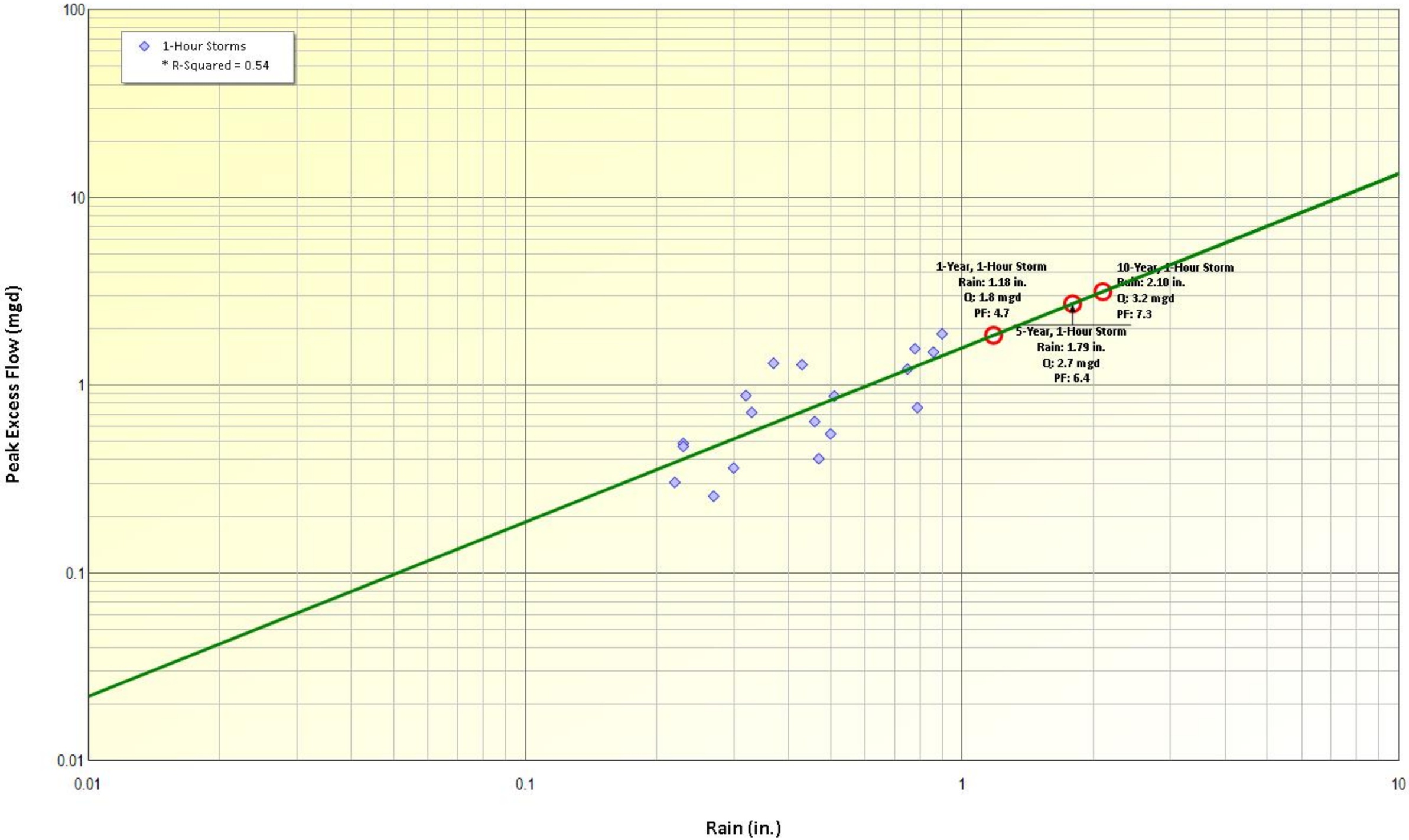
1-Hour Flow vs. Rainfall Regression

Cumulative Basin WH-01



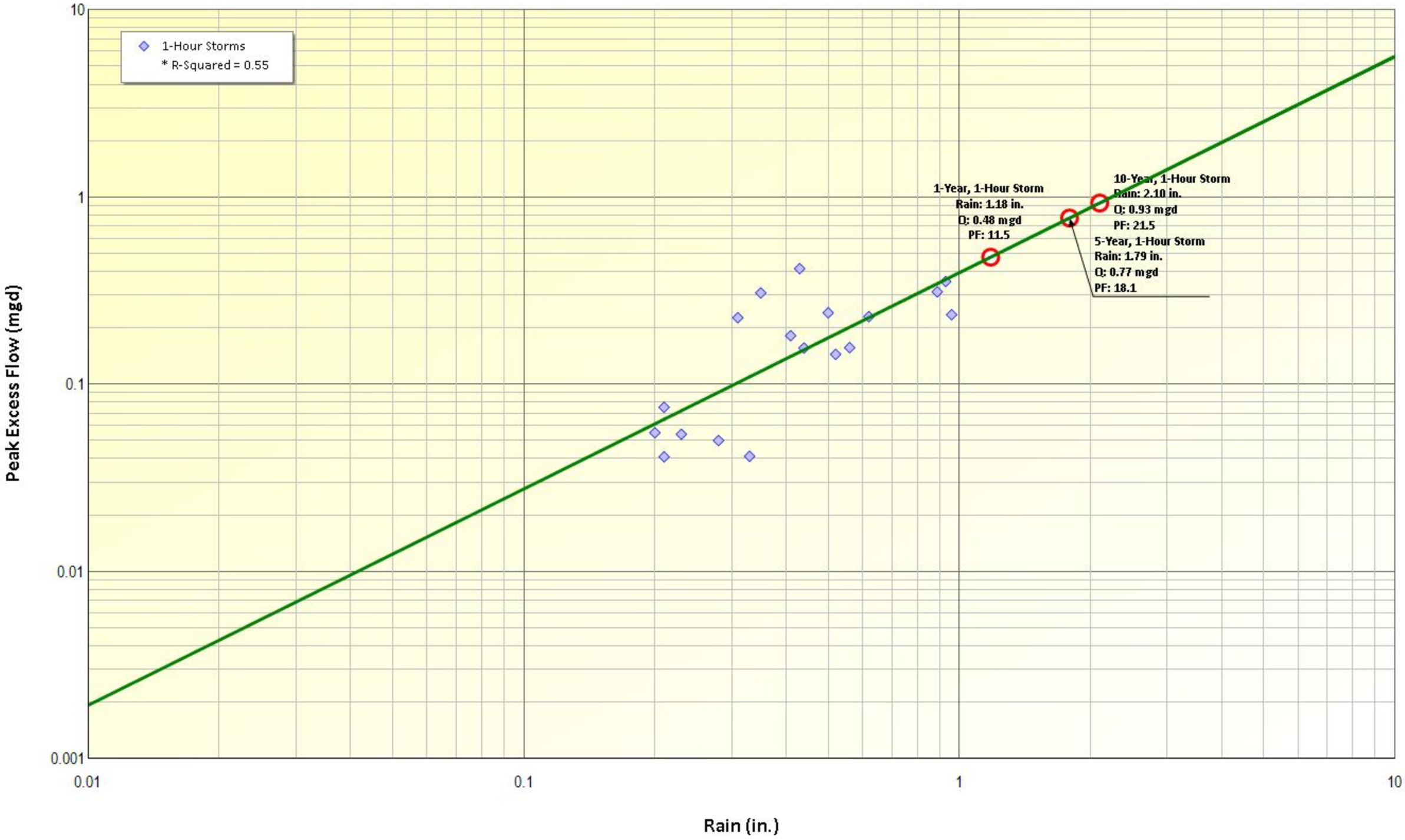
1-Hour Flow vs. Rainfall Regression

Cumulative Basin WP-01



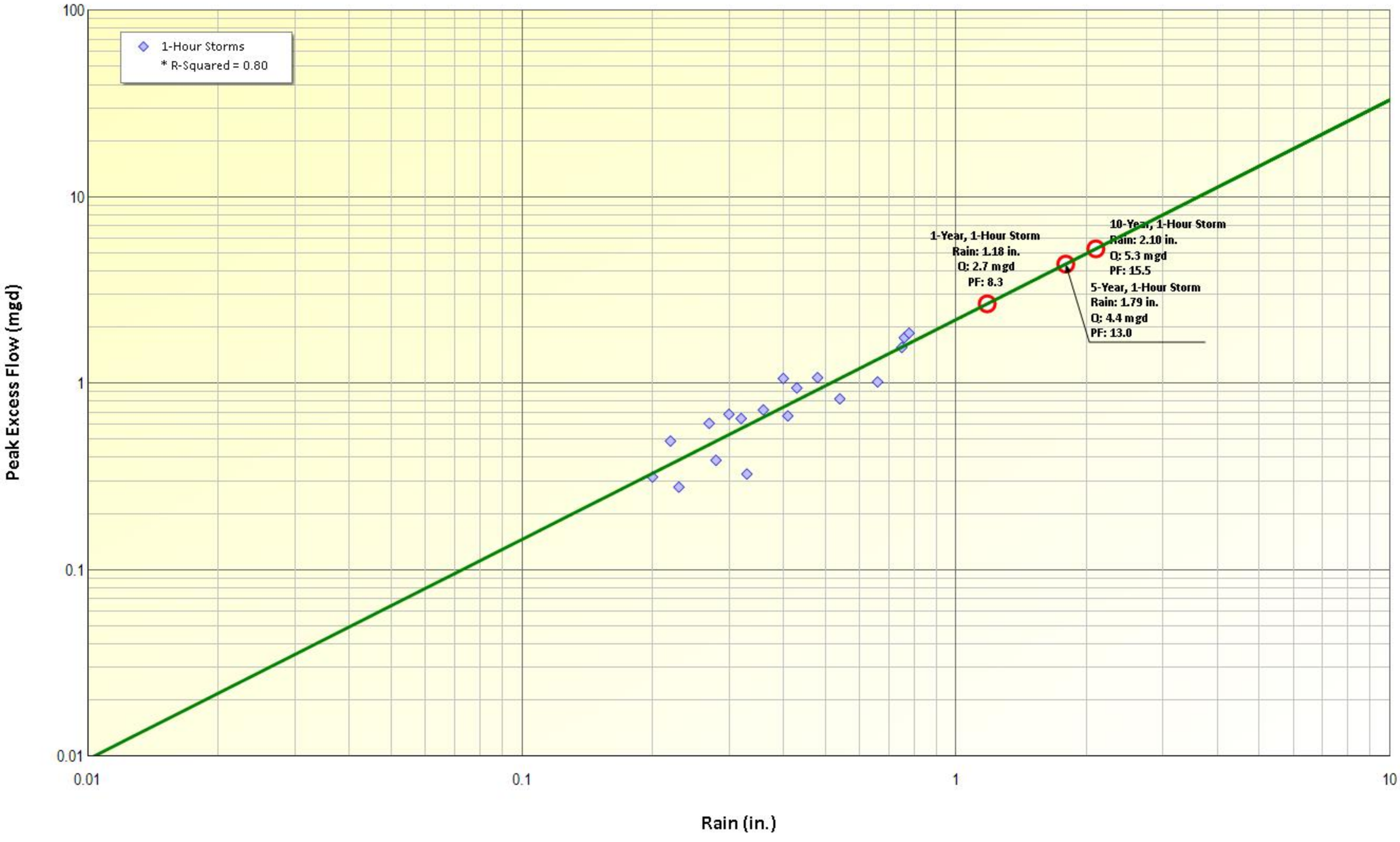
1-Hour Flow vs. Rainfall Regression

Cumulative Basin WP-02

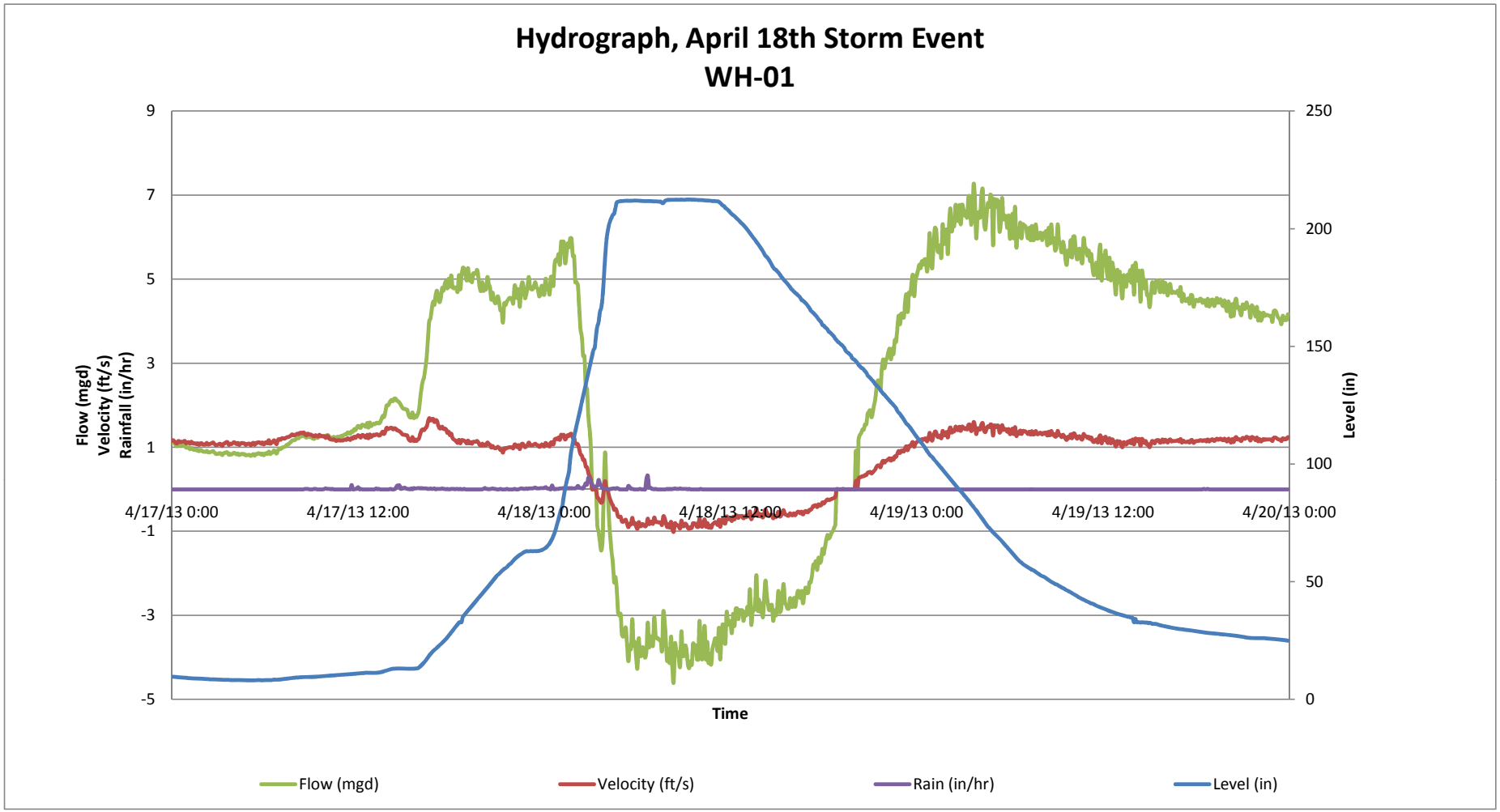


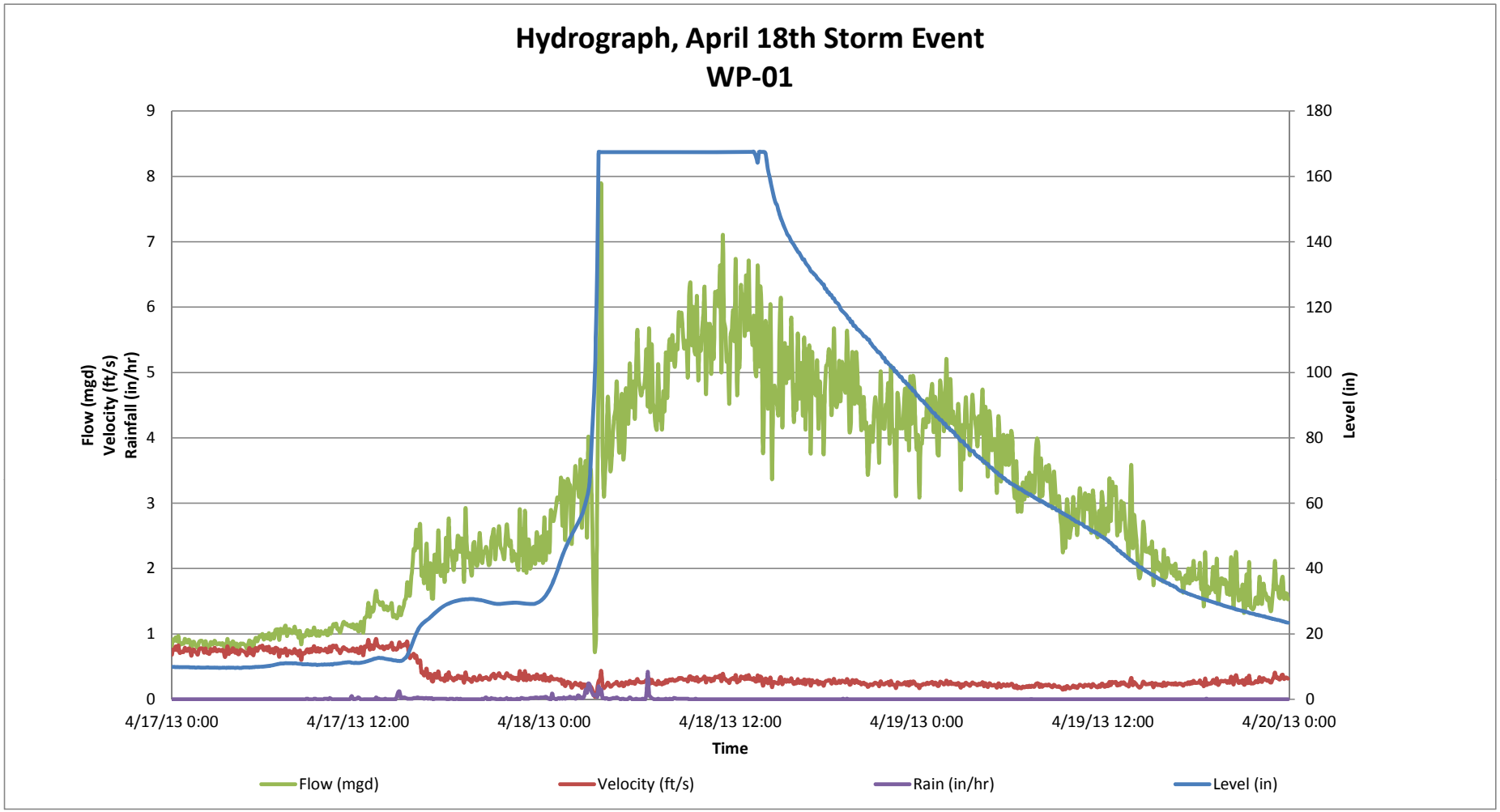
1-Hour Flow vs. Rainfall Regression

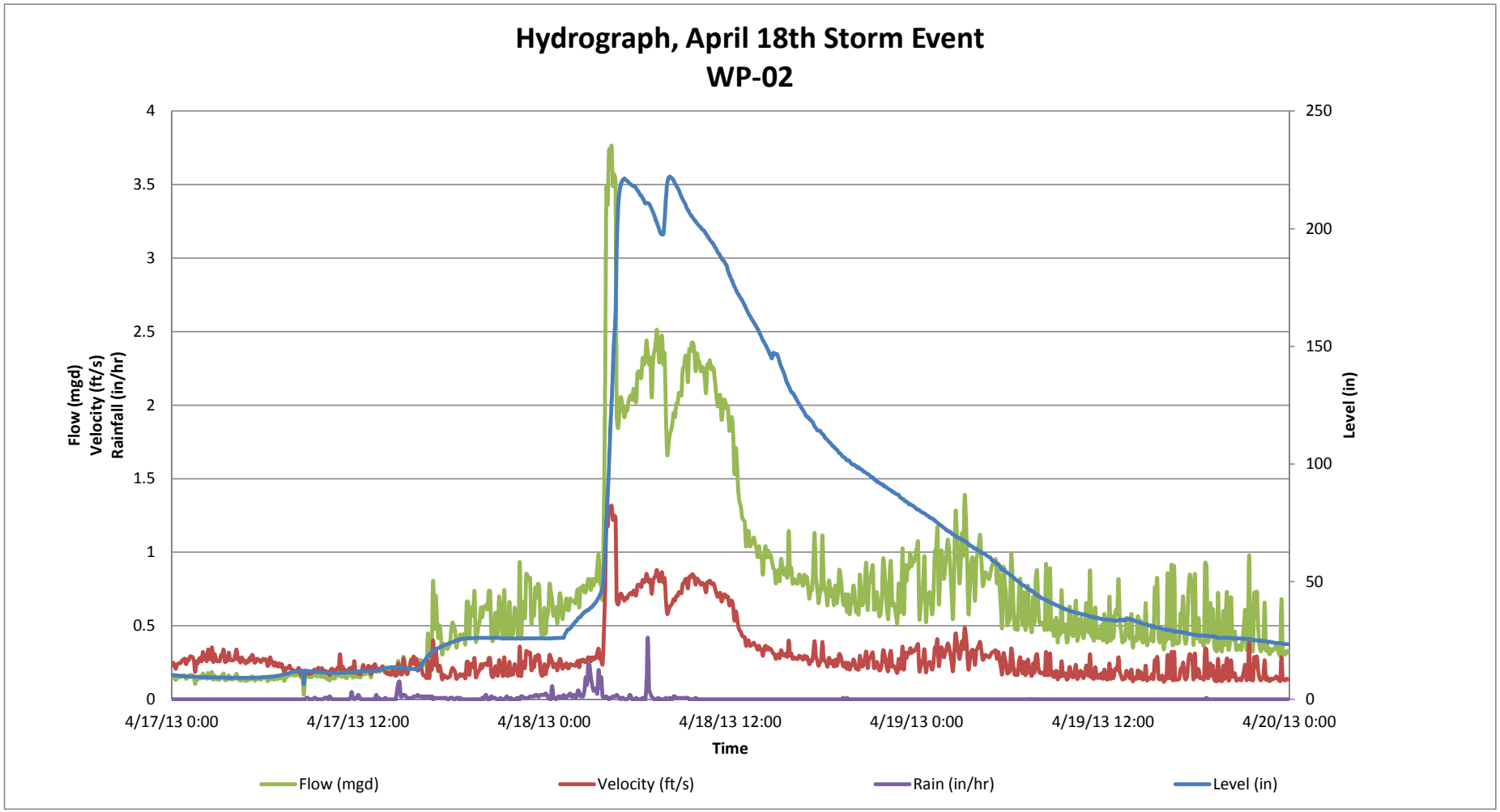
Cumulative Basin WP-03

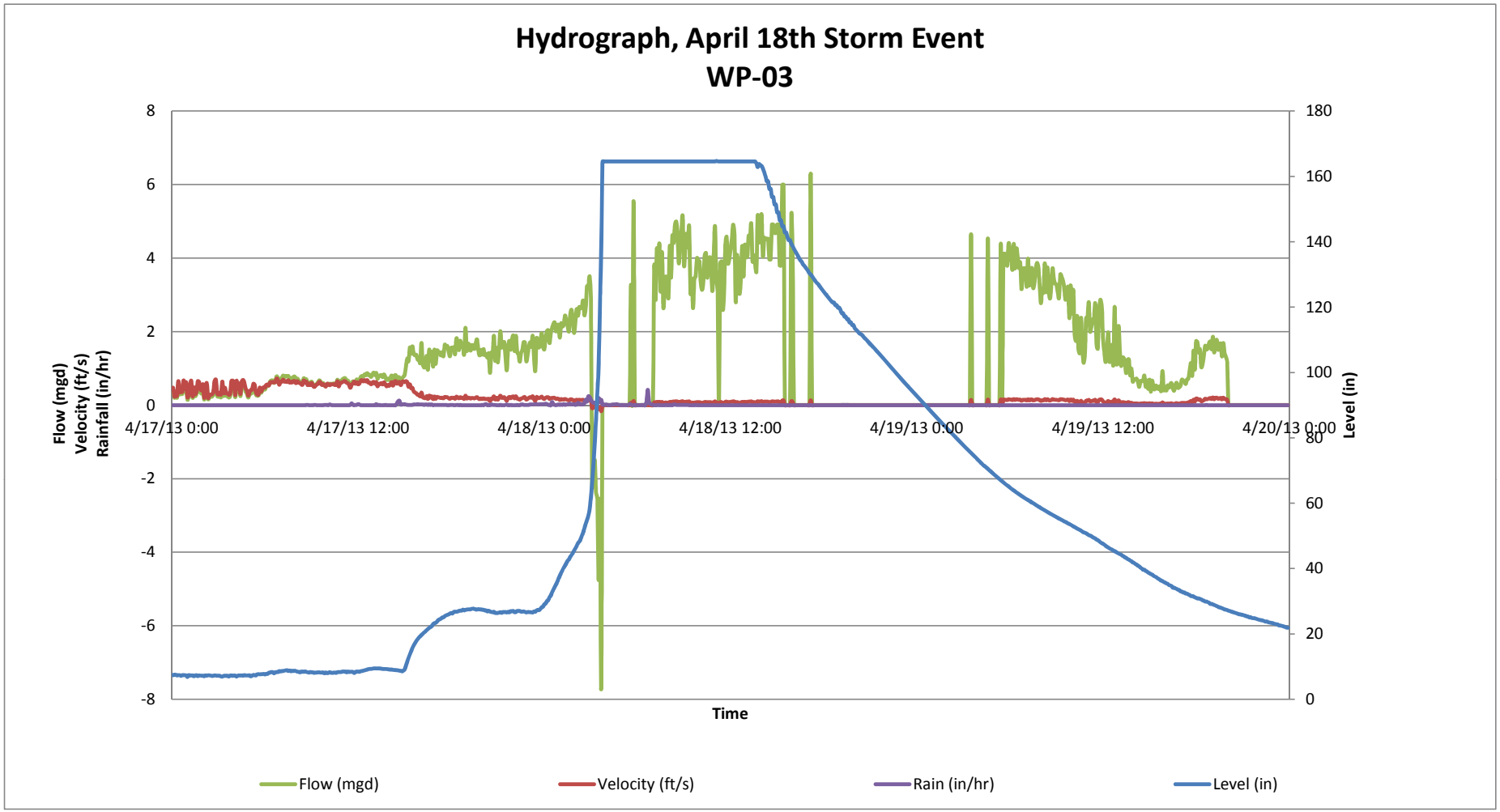


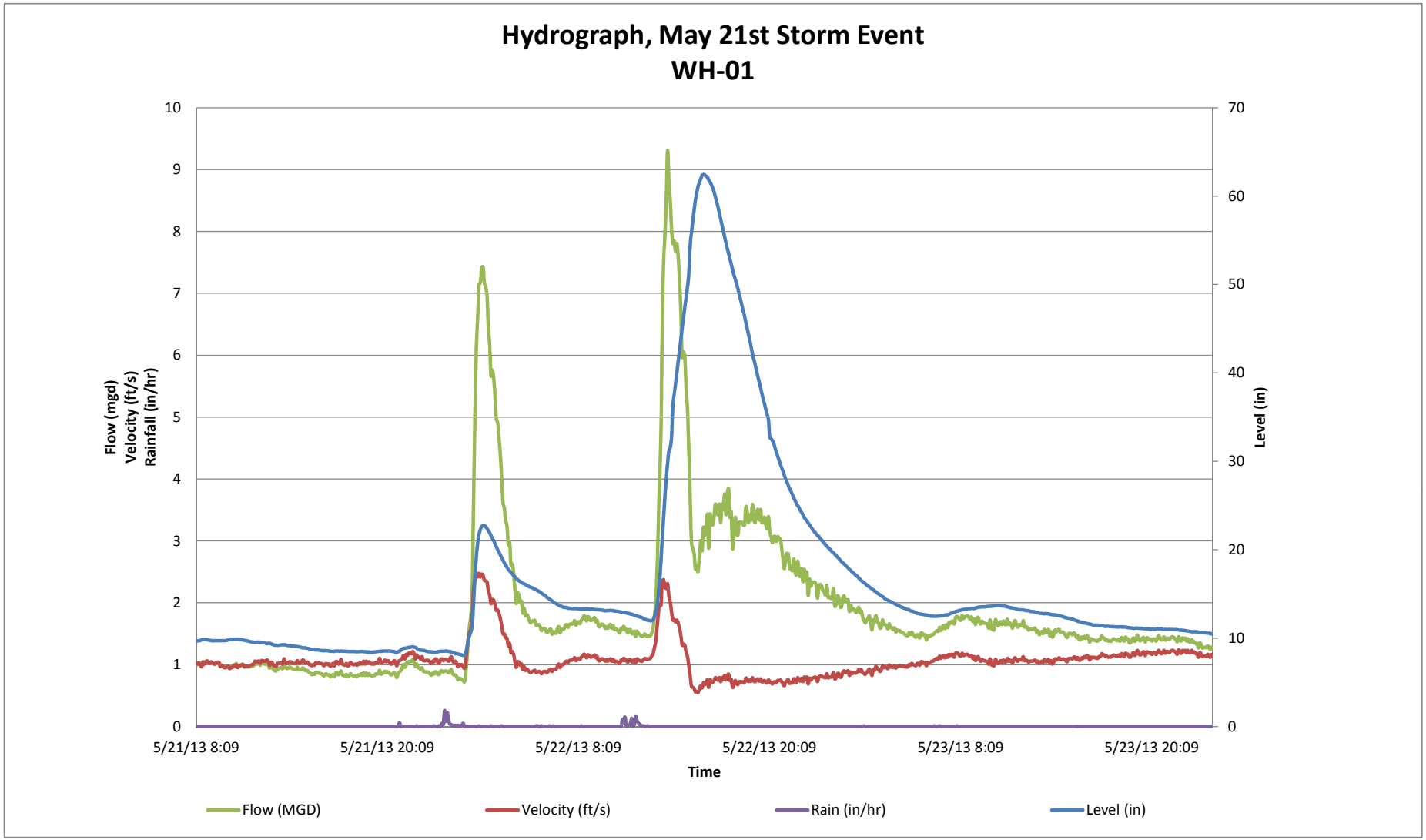
APPENDIX E – WET-WEATHER HYDROGRAPHS

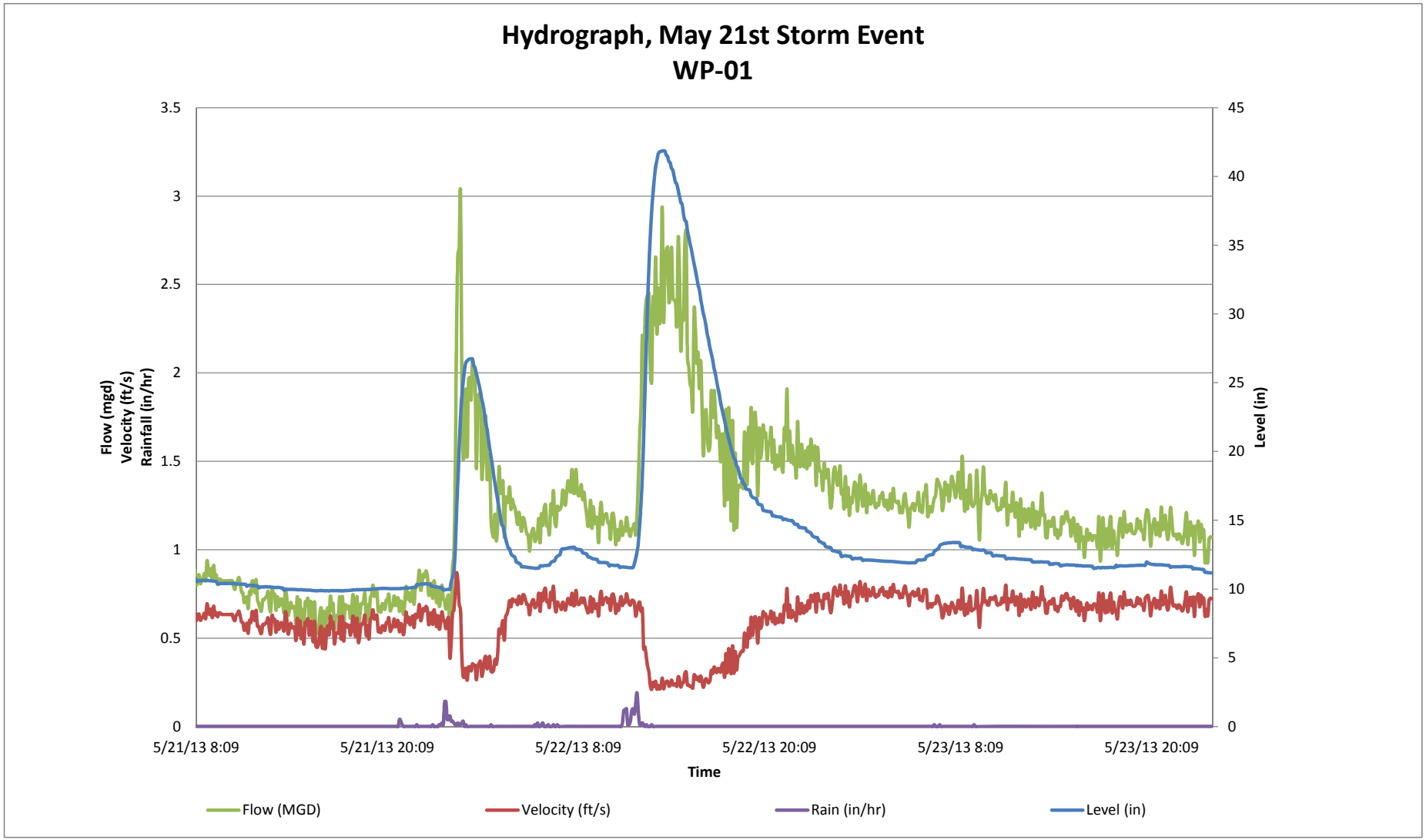

Hydrograph, April 18th Storm Event
WH-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
9
7
5
3
1
-1
-3
-5
250
200
150
100
50
0
4/17/13 0:00
4/17/13 12:00
4/18/13 0:00
4/18/13 12:00
4/19/13 0:00
4/19/13 12:00
4/20/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

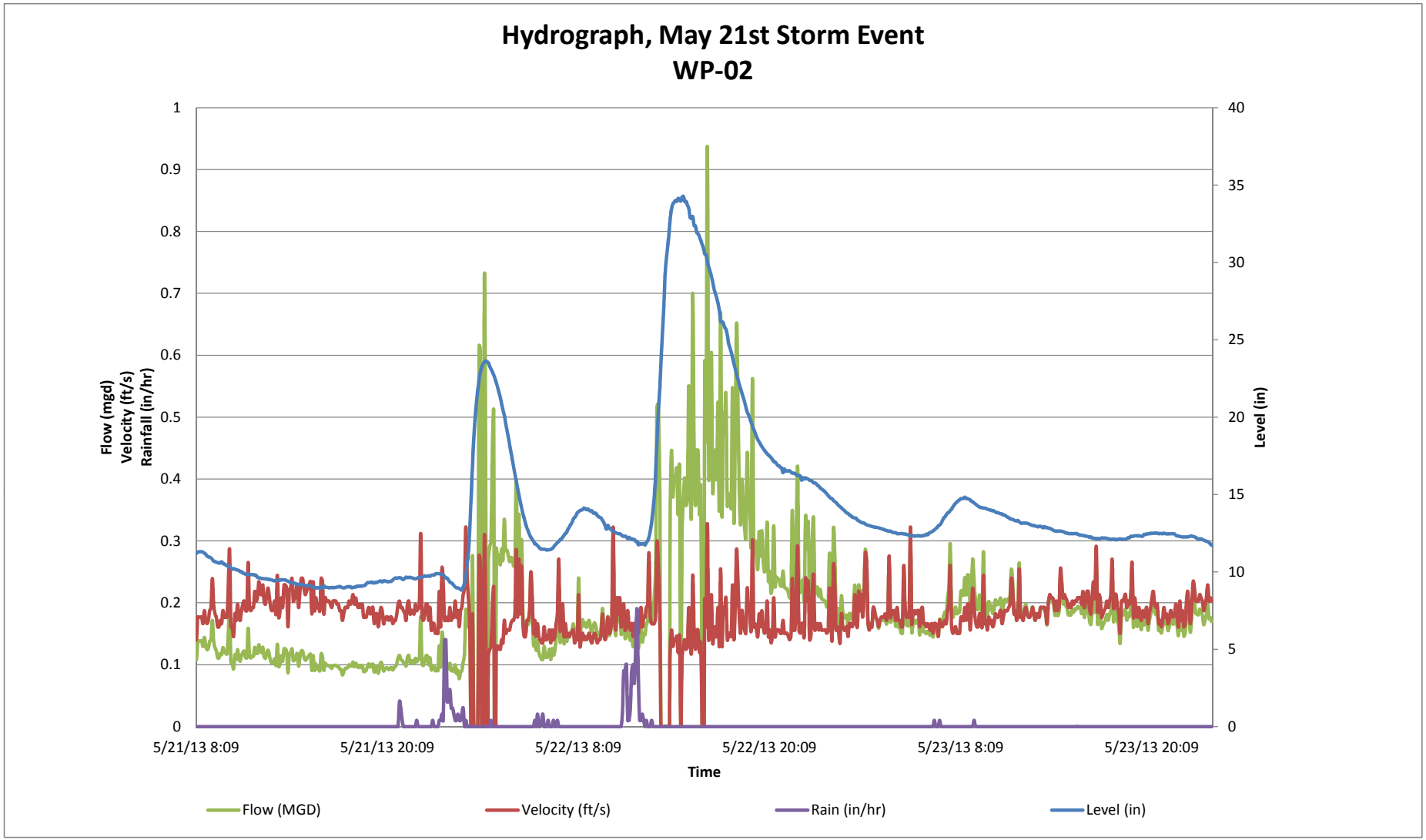

Hydrograph, April 18th Storm Event
WP-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
9
8
7
6
5
4
3
2
1
0
180
160
140
120
100
80
60
40
20
0
4/17/13 0:00
4/17/13 12:00
4/18/13 0:00
4/18/13 12:00
4/19/13 0:00
4/19/13 12:00
4/20/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

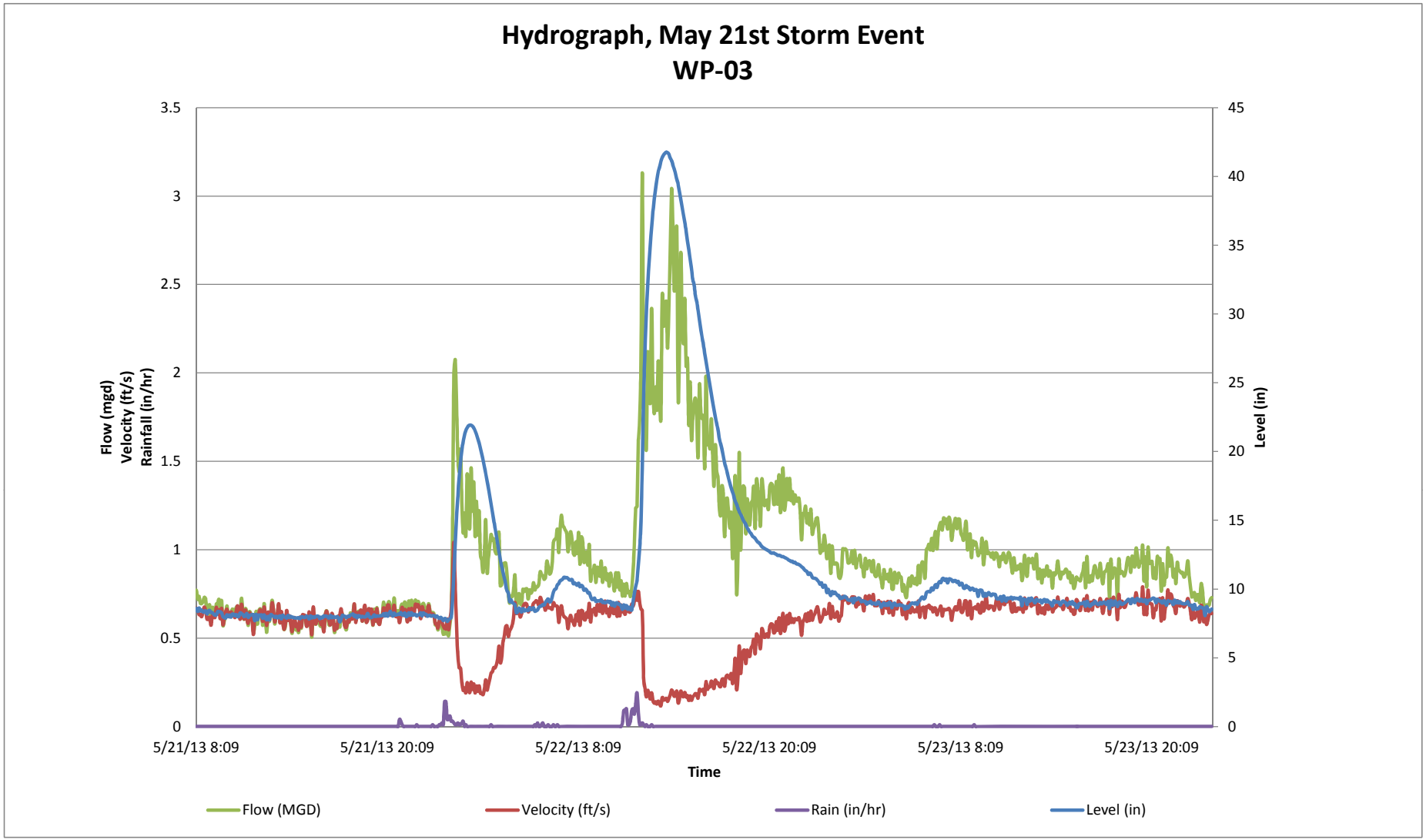

Hydrograph, April 18th Storm Event
WP-02
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
4
3.5
3
2.5
2
1.5
1
0.5
0
250
200
150
100
50
0
4/17/13 0:00
4/17/13 12:00
4/18/13 0:00
4/18/13 12:00
4/19/13 0:00
4/19/13 12:00
4/20/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

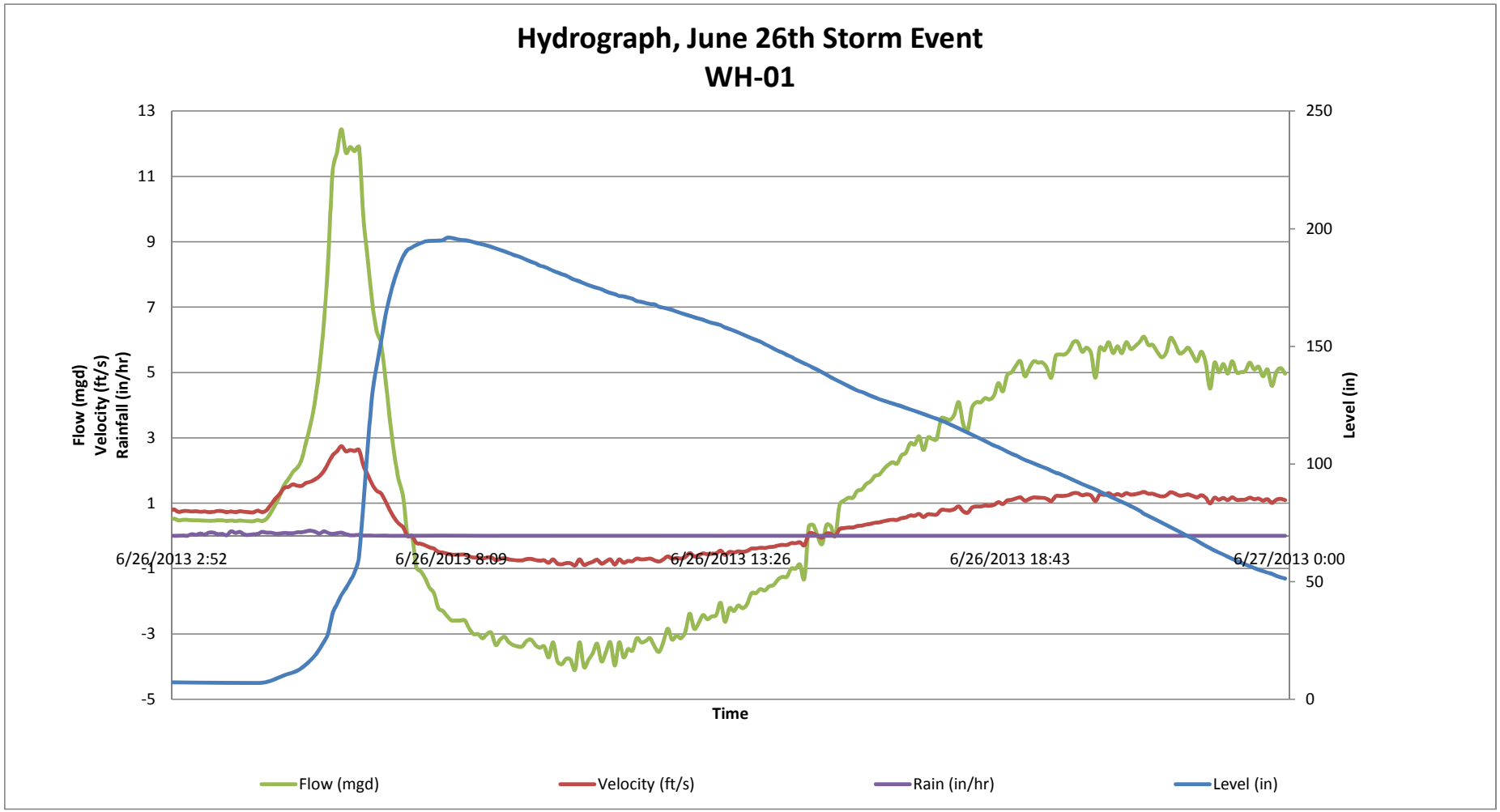

Hydrograph, April 18th Storm Event
WP-03
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
8
6
4
2
0
-2
-4
-6
-8
180
160
140
120
100
80
60
40
20
0
4/17/13 0:00
4/17/13 12:00
4/18/13 0:00
4/18/13 12:00
4/19/13 0:00
4/19/13 12:00
4/20/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

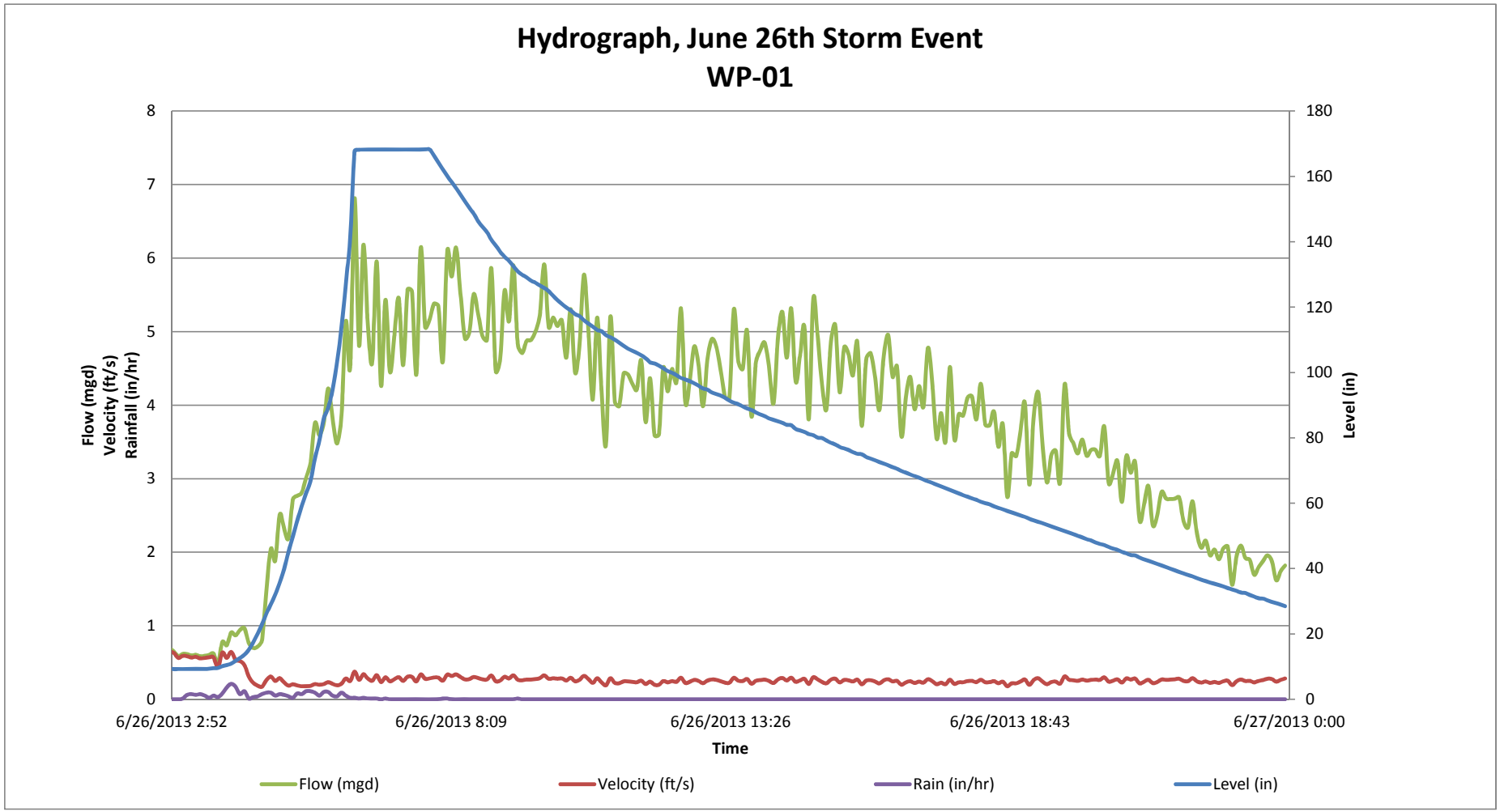

Hydrograph, May 21st Storm Event
WH-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
10
9
8
7
6
5
4
3
2
1
0
70
60
50
40
30
20
10
0
5/21/13 8:09
5/21/13 20:09
5/22/13 8:09
5/22/13 20:09
5/23/13 8:09
5/23/13 20:09
Time
Flow (MGD)
Velocity (ft/s)
Rain (in/hr)
Level (in)

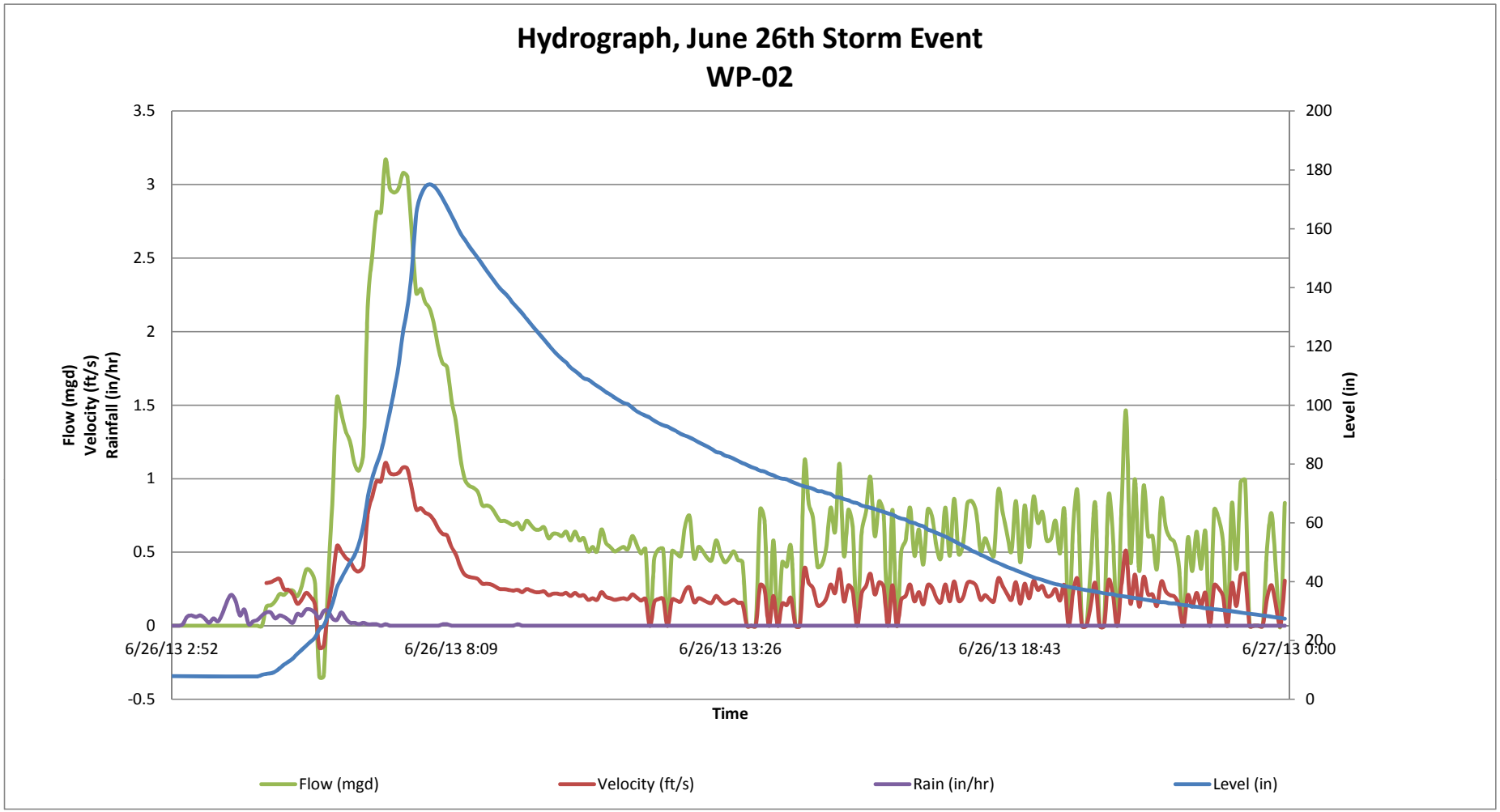

Hydrograph, May 21st Storm Event
WP-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
3.5
3
2.5
2
1.5
1
0.5
0
45
40
35
30
25
20
15
10
5
0
5/21/13 8:09
5/21/13 20:09
5/22/13 8:09
5/22/13 20:09
5/23/13 8:09
5/23/13 20:09
Time
Flow (MGD)
Velocity (ft/s)
Rain (in/hr)
Level (in)

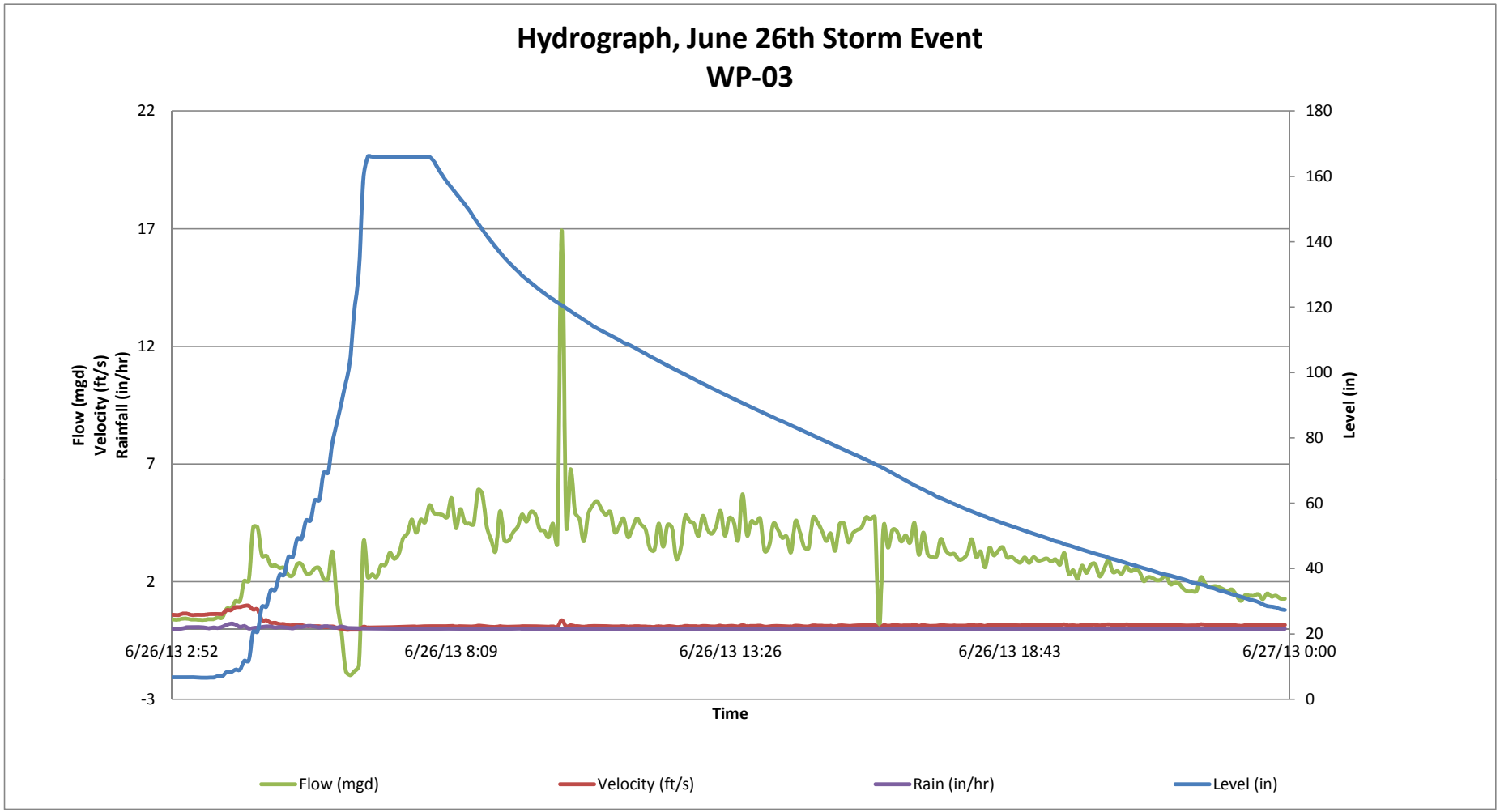

Hydrograph, May 21st Storm Event
WP-02
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
40
35
30
25
20
15
10
5
0
5/21/13 8:09
5/21/13 20:09
5/22/13 8:09
5/22/13 20:09
5/23/13 8:09
5/23/13 20:09
Time
Flow (MGD)
Velocity (ft/s)
Rain (in/hr)
Level (in)


Hydrograph, May 21st Storm Event
WP-03
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
3.5
3
2.5
2
1.5
1
0.5
0
45
40
35
30
25
20
15
10
5
0
5/21/13 8:09
5/21/13 20:09
5/22/13 8:09
5/22/13 20:09
5/23/13 8:09
5/23/13 20:09
Time
Flow (MGD)
Velocity (ft/s)
Rain (in/hr)
Level (in)


Hydrograph, June 26th Storm Event
WH-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
13
11
9
7
5
3
1
-1
-3
-5
250
200
150
100
50
0
6/26/2013 2:52
6/26/2013 8:09
6/26/2013 13:26
6/26/2013 18:43
6/27/2013 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)


Hydrograph, June 26th Storm Event
WP-01
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
8
7
6
5
4
3
2
1
0
180
160
140
120
100
80
60
40
20
0
6/26/2013 2:52
6/26/2013 8:09
6/26/2013 13:26
6/26/2013 18:43
6/27/2013 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

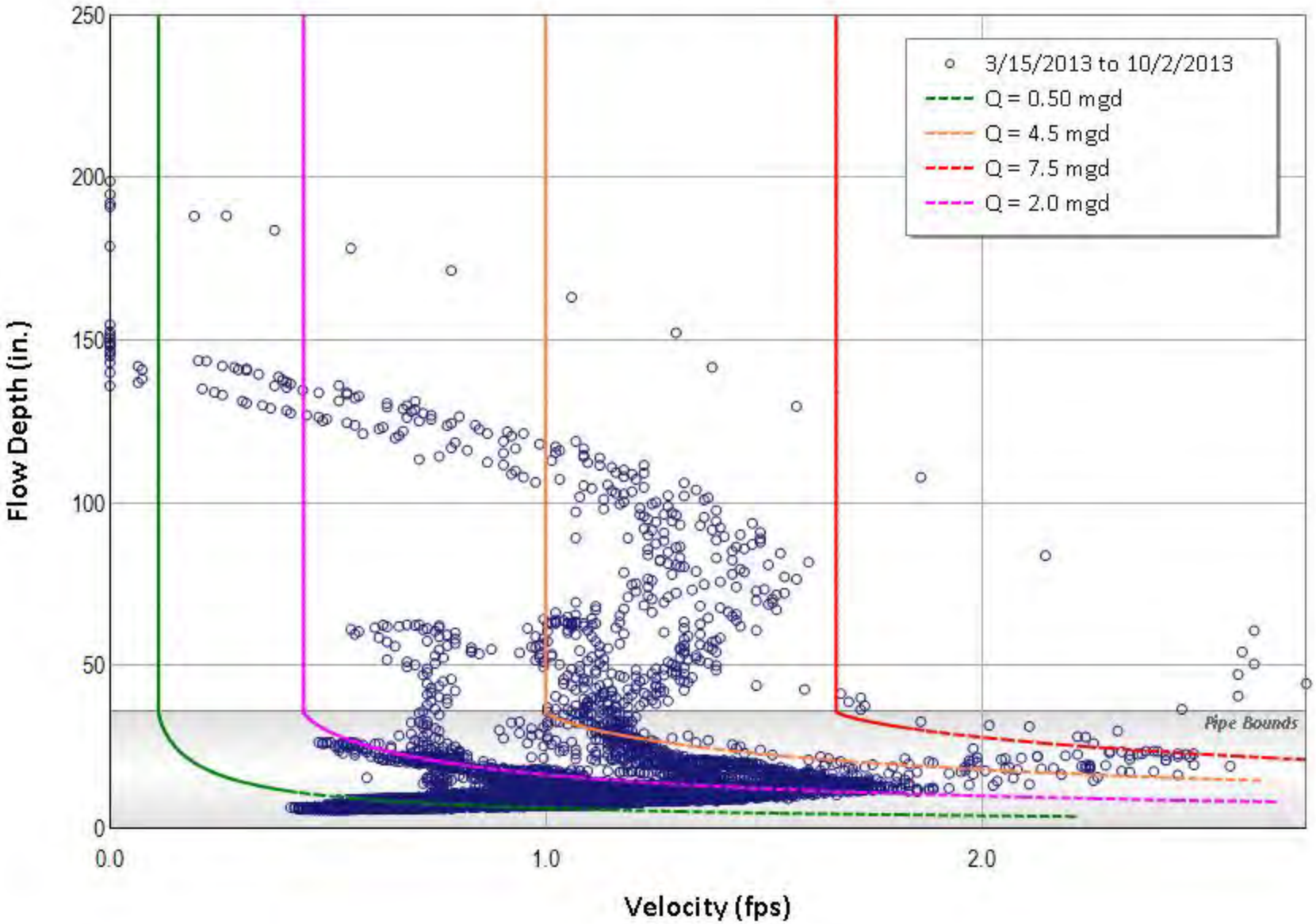

Hydrograph, June 26th Storm Event
WP-02
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
200
180
160
140
120
100
80
60
40
20
0
6/26/13 2:52
6/26/13 8:09
6/26/13 13:26
6/26/13 18:43
6/27/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)


Hydrograph, June 26th Storm Event
WP-03
Flow (mgd)
Velocity (ft/s)
Rainfall (in/hr)
Level (in)
22
17
12
7
2
-3
180
160
140
120
100
80
60
40
20
0
6/26/13 2:52
6/26/13 8:09
6/26/13 13:26
6/26/13 18:43
6/27/13 0:00
Time
Flow (mgd)
Velocity (ft/s)
Rain (in/hr)
Level (in)

APPENDIX F – SCATTERGRAPHS

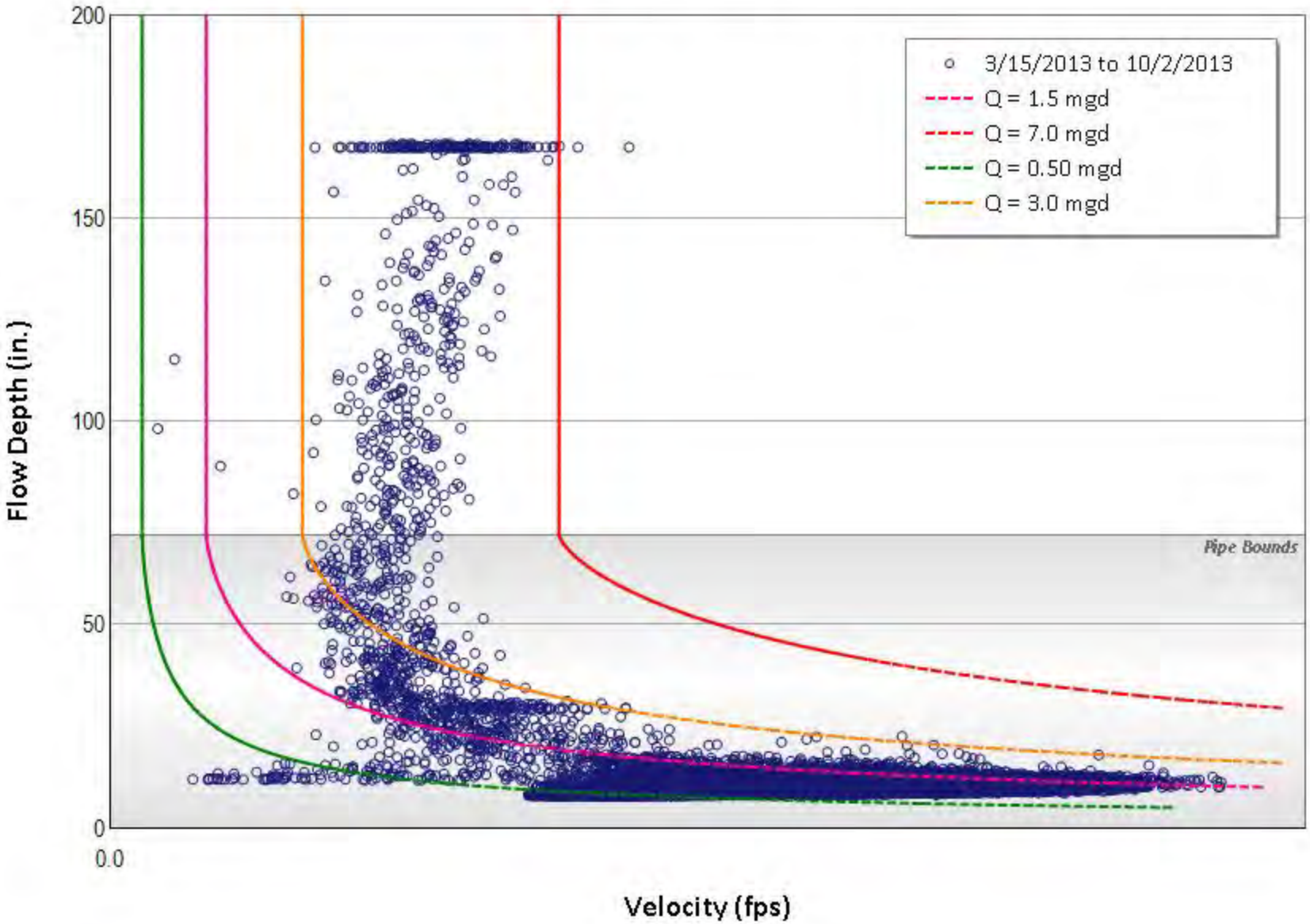
Scattergraph

Meter Site: WH-01



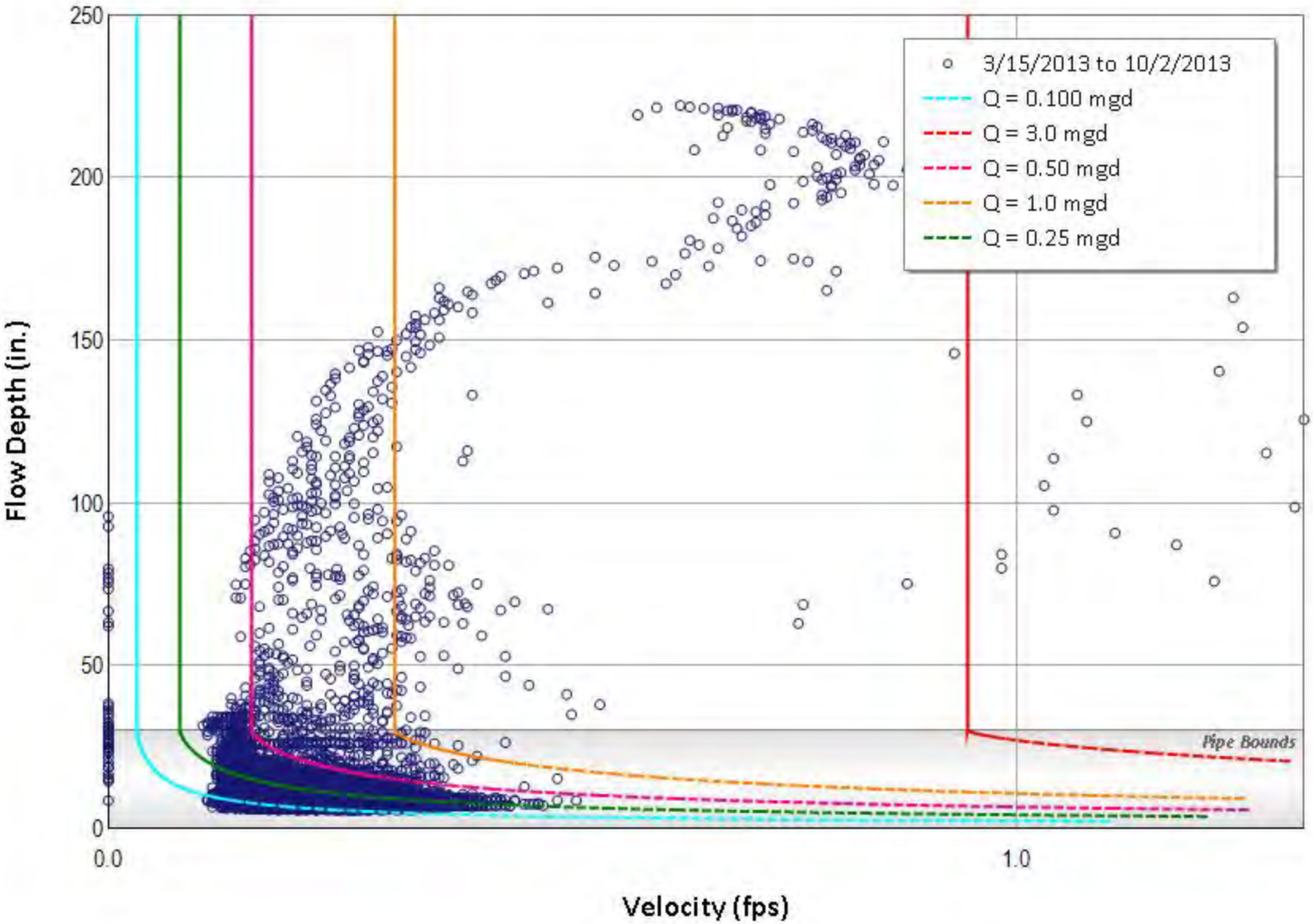
Scattergraph

Meter Site: WP-01



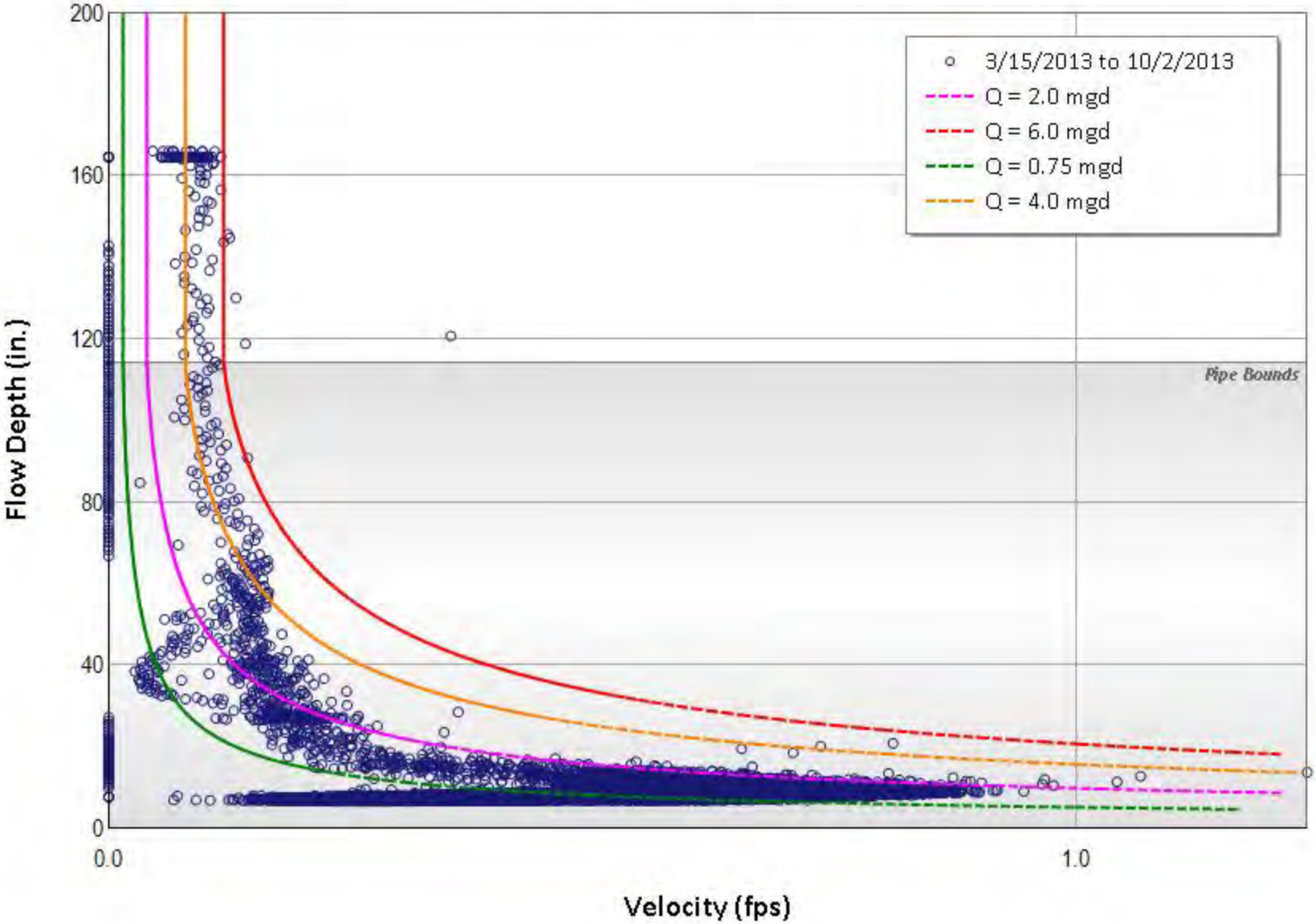
Scattergraph

Meter Site: WP-02



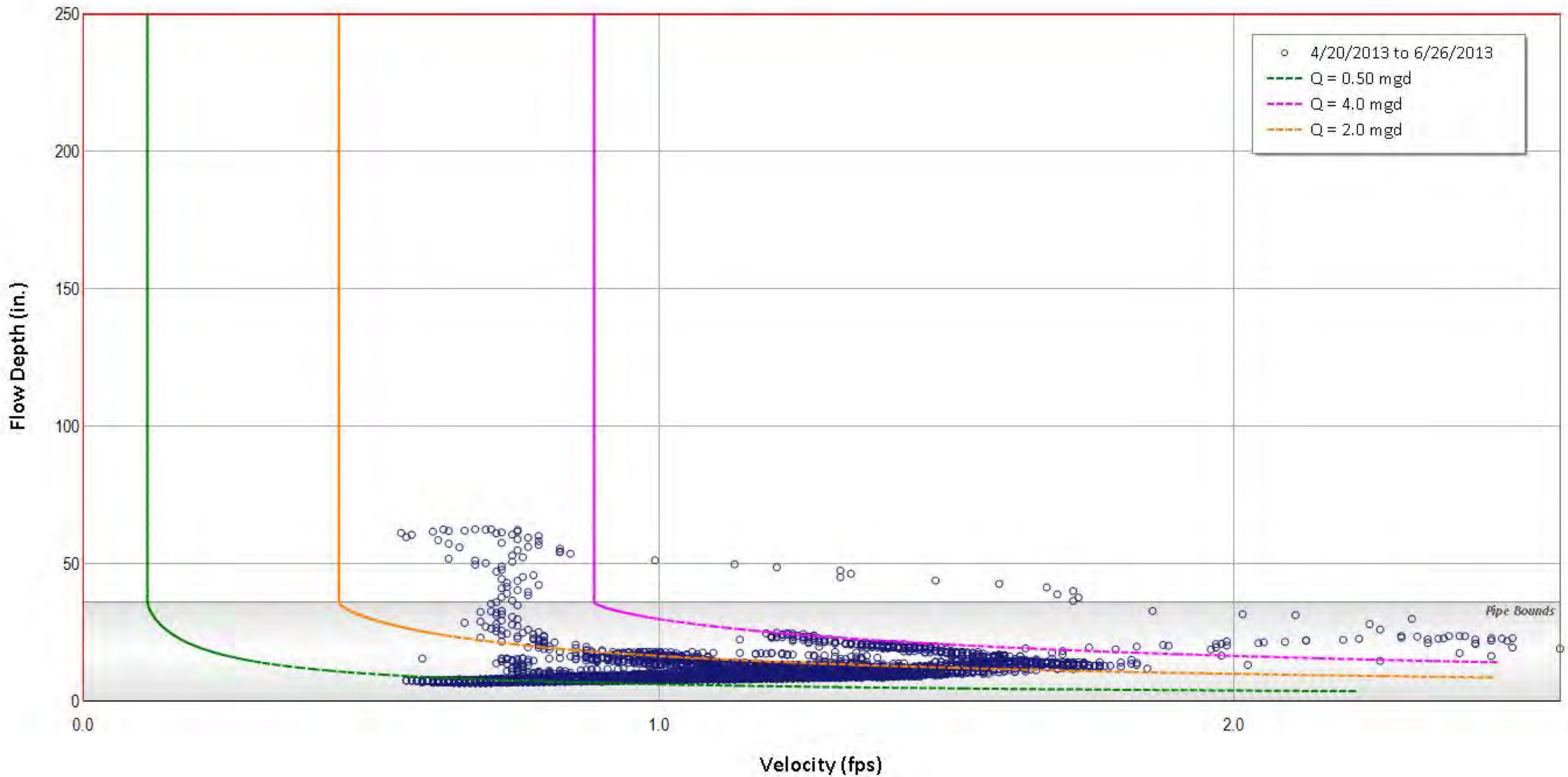
Scattergraph

Meter Site: WP-03



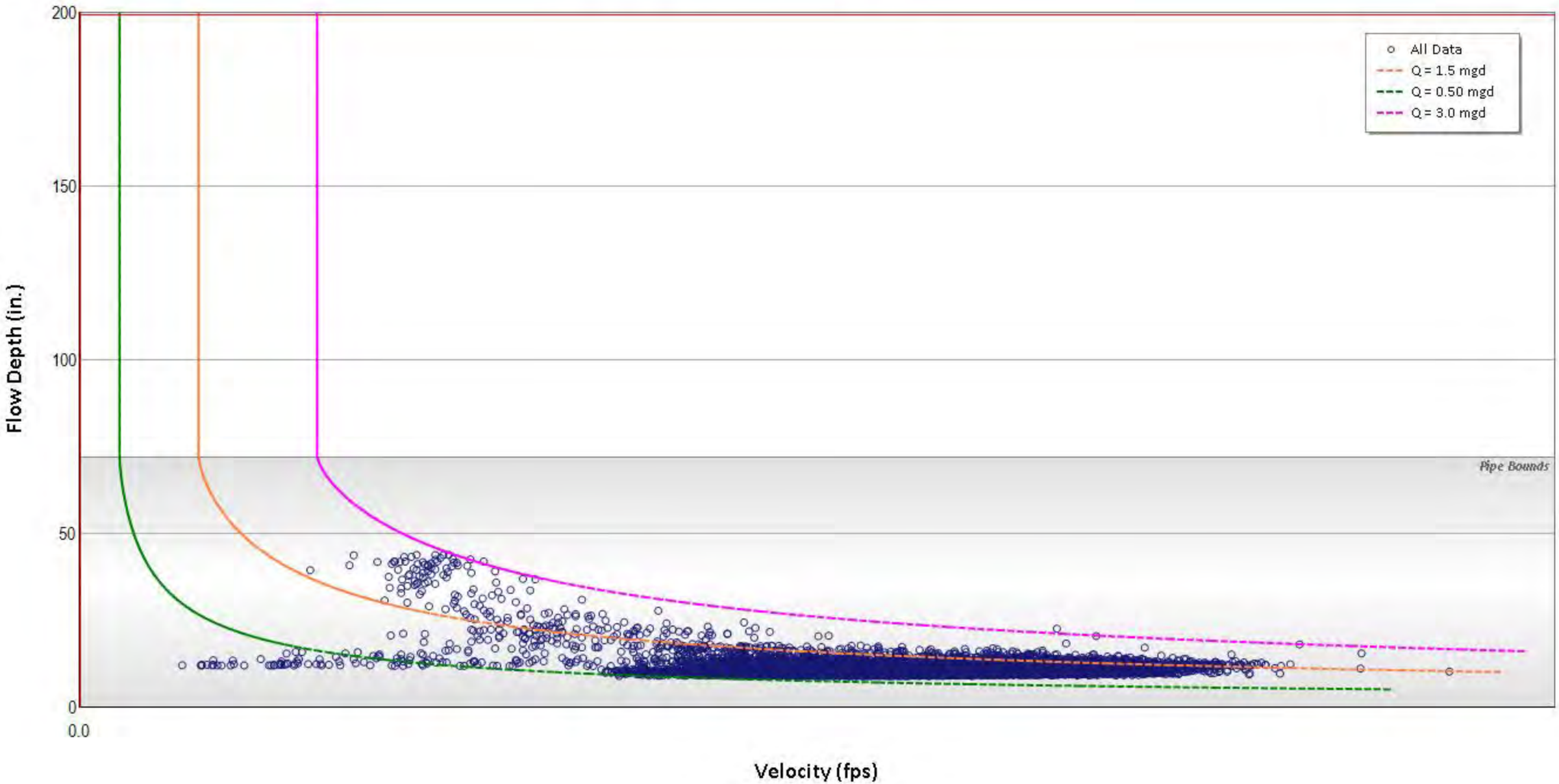
Scattergraph

Meter Site: WH-01



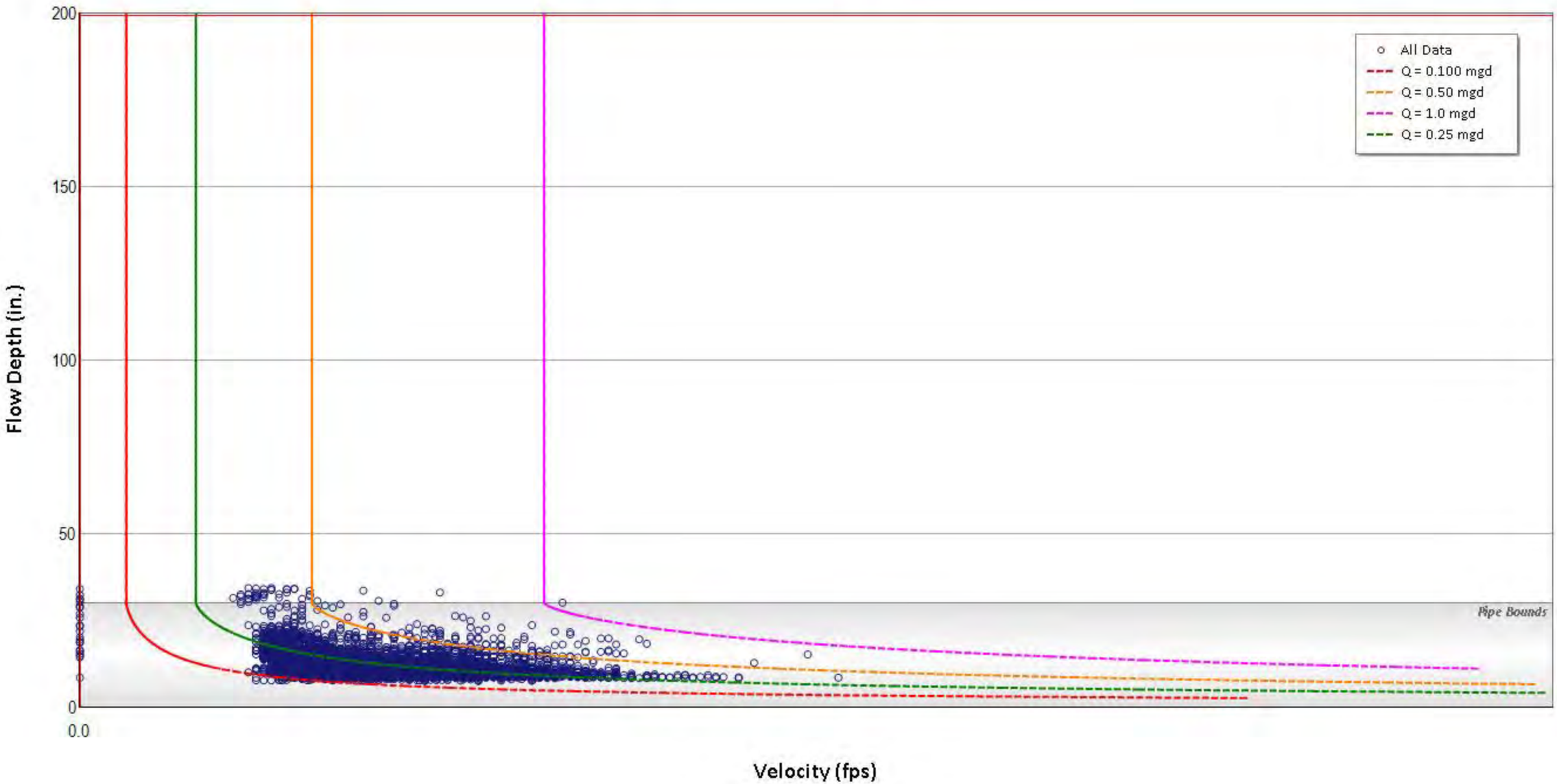
Scattergraph

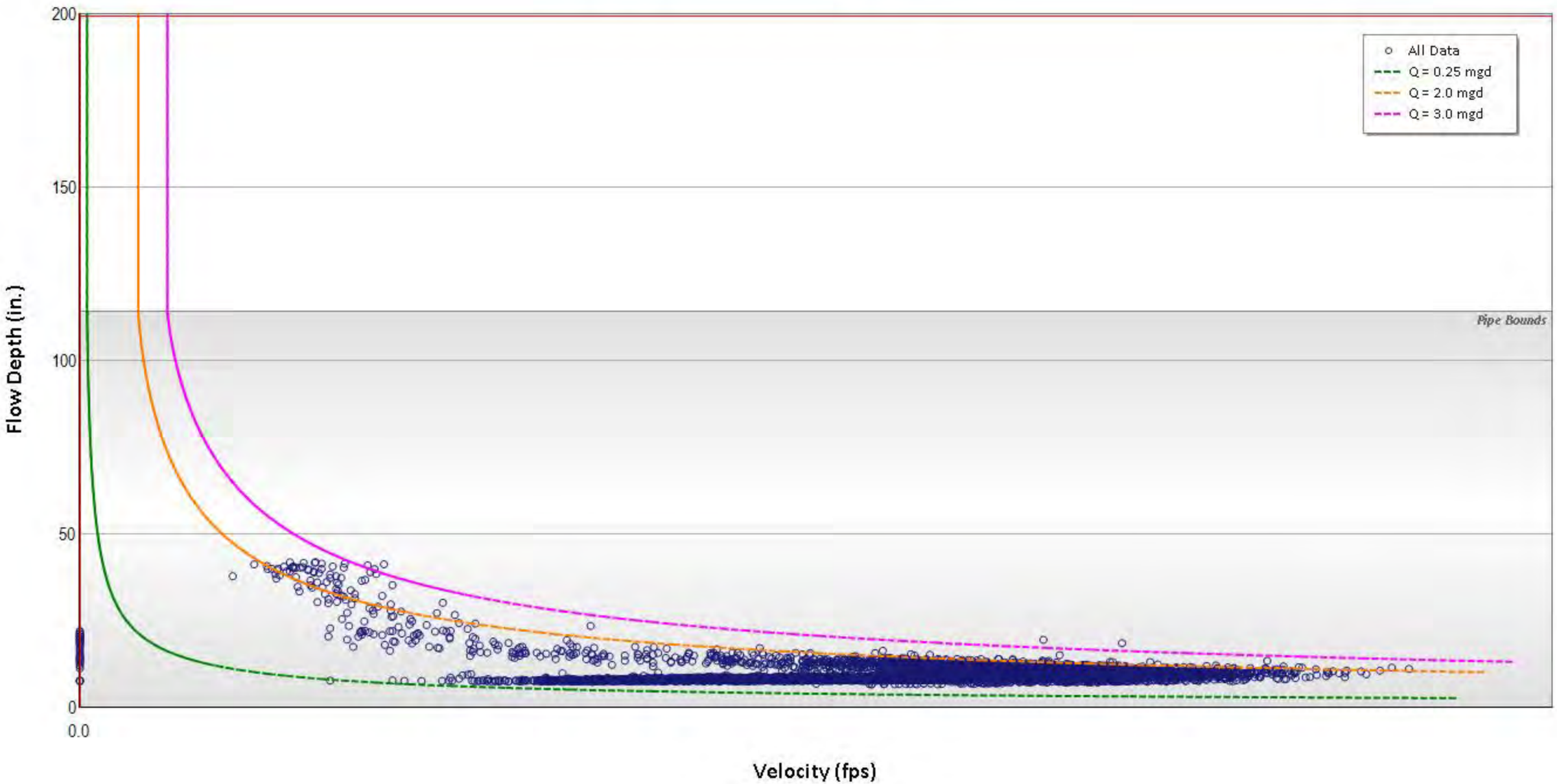
WP-01 (4/20/2013 to 6/26/2013)



Scattergraph

WP-02 (4/20/2013 to 6/26/2013)



Scattergraph

WP-03 (4/20/2013 to 6/26/2013)