Appendix B

2014 East Trunk Sanitary Sewer Flow Monitoring Analysis Tech Memo

AECOM
1555 N RiverCenter Drive, Suite 214
Milwaukee, WI 53212

414.944.6080 tel
414.944.6081 fax

Memorandum

To	Kristen Lundeen, PE	Page 1
CC	Chuck Boehm, Bryan Rogne	
Subject	**2014 East Trunk Sanitary Sewer Flow Monitoring Analysis**	
From	Thomas Nejedlo, PE	
Date	March 13, 2015	

Project Overview

The purpose of this memorandum is to evaluate sanitary sewer system flows under wet weather events in the East Trunk Sewer System from south of Sunnydale Lane to Zedler Lane East of North Port Washington Road by reviewing flow monitoring results from 2014. This information will be used to adjust the existing sanitary sewer system model developed and calibrated based on a 2009 rain event to better reflect observed conditions in this area. This will allow the City to move forward with further evaluation and recommendation of system improvements.

The City of Mequon in coordination with the Milwaukee Metropolitan Sewerage District (MMSD) conducted flow monitoring along the East Trunk Sewer in the area of Oriole Lane and Port Washington Road, south of Ranch Road (see attached Figure 1). The purpose of the flow monitoring was to build upon previous flow monitoring data collected in 2009 and provide additional information on system response to wet weather events. A total of 9 meters as shown in Table 1 and Figure 1 were utilized to document average daily flows as well as wet weather flows. They are listed in order from upstream to downstream in the sanitary sewer system.

Table 1
Flow Meter Locations

U/S to D/S Order	Flow Meter Site	Mequon Manhole Number	Location	Pipe Size (in)	Installation Date	Analysis End Date
1	ME3008	0430-108	Hidden Reserve Court, South of Hidden Reserve Circle	24	3/20/2014	12/31/2014
2	ME3013	0430-113	East of N. Stone Creek Drive, North of W. Donges Bay Road	24	3/31/2014	12/31/2014
3	ME3015	0430-115	N. Greenview Drive Extended, North of W. Donges Bay Road	24	3/18/2014	12/31/2014
4	ME3086	0430-086	W. Donges Bay Road, West of Westport Circle	27	3/18/2014	12/31/2014
5	ME3149	0431-149	Westport Circle, South of W. Donges Bay Road	27	3/19/2014	12/31/2014
6	ME3175	0431-175	N. Brookdale Drive, South of W. Clover Lane	27	3/17/2014	12/31/2014
7	ME3169	0431-169	W. Zedler Lane, West of N. Port Washington Drive	24	3/20/2014	12/31/2014
8	ME3205	0432-005	W. Zedler Lane extended, East of N. Port Washington Road	27	3/19/2014	12/31/2014
9	MS0409	0532-082	East side of Railroad Easement, at County Line Road Extended	30	6/10/2014	12/31/2014

Rainfall Evaluation

Rainfall data was obtained from MMSD for a total of six gage locations in the area (WS1207, WS1209, WS1214, WS1218, WS1224, and WS1228) as well as from the City rain gage at City Hall (over the City Clerks' office). Multiple rain events were recorded during the analysis period, with two being sufficient enough to cause the city to manually pump bypass water from the sanitary sewer system to avoid potential basement flooding. Pumped bypassing in 2014 was required during April 12-14 and June 17-18 rain events. The rain event of June 17-18 is discussed in more detail below as it produced the largest wet weather response in the sewer system.

The June 17-18, 2014 rain event produced a total of 4.19 inches of rain over 35 hours and 3.52 inches of rain over 12 hours. The rain event caused the City to bypass pump at a number of locations. Bypass pumping in the area of this analysis took place at Brookdale Drive and Clover Lane (manhole number 0431-176) and occurred for approximately 7 hours on June 18th. This bypass pumping location on the East Trunk Sewer is one manhole upstream of a meter located in manhole 0431-175.

Table 2 shows the peak intensity/duration/frequency for the June 17-18, 2014 rain event. Based on Huff and Angel's Rainfall Frequency Atlas of the Midwest, the 12-hour intensity/duration is equivalent to a 10-year storm event. Table 2 shows the peak intensity/duration/frequency for the June 18, 2014 rain event over different periods. Data for the rain events was taken at MMSD rain gauge WS1224, located at W. Green Tree Road and N. River Road.

Table 2
Intensity/Duration/Frequency Data

Intensity / Duration	Peak Rainfall Amount (in)	Recurrence Interval
1 hour	0.99	1-year event
2 hour	1.87	5-year event
6 hour	2.46	5-year event
12 hour	3.52	10-year event
24 hour	3.53	2 to 5 year event

Rainfall recurrence interval event characterization is not necessarily a direct correlation between system response and the 5-year wastewater recurrence interval which the MMSD uses to determine allowable flows into their interceptor system. A number of factors such as ground water level/saturation, snow melt, bypassing, and others will influence the amount of flow in the sanitary sewer system.

Flow Monitoring

Area-velocity flow meters were installed at locations in Mequon starting in mid-March 2014 for 8 sites. The MMSD also installed area-velocity flow meters at the east trunk sewer system connection point in mid-June, 2014 for MMSD meter MS0409. Therefore, the MMSD meter was not in place to capture the April rain event.

The City installed a number of surcharge indicators that were in place during the April rain event. The meters were placed at the crown of the pipe. Following the April 12-14 rain event, City crews measured the rise of the surcharge indicator above the crown of the pipe which is considered the surcharge depth. The results are shown in Table 3.

Table 3
April 2014 Surcharge Data

MH#	Surcharge (ft)
0430-011	0
0430-112	4.15
0431-152	4.5
0431-021	7.12

The data collected from the flow meters included velocity, depth, and internally calculated flow. The flow meters were kept in place throughout 2014 and this analysis covers the span from installation through December 31, 2014. Graphs for each flow monitor during the analysis period are attached to this memorandum. Flow data for the rain event of June17-18, 2014 for the 9 flow meters is presented in Table 4. This event is focused on because it was the largest rainfall in 2014 and caused the greatest flow response in the sanitary sewer system.

Table 4
Flow and Surcharge Data
June 17-18, 2014

Flow Meter Site	MH #	Pipe Size (in)	Base Flow (cfs)	1-hr Peak Flow (cfs)	1-hr Peaking Factor	24-hr Peak Flow (cfs)	24-hr Peaking Factor	24-hour RDII (cfs)	Time Surcharged (hh:mm)	Peak Level Above Invert (ft)
ME3008	0430-108	24	0.835	8.187	9.8	4.397	5.3	3.562	6:45	7.3
ME3013	0430-113	24	0.939	7.695	8.2	4.920	5.2	3.981	7:10	7.8
ME3015	0430-115	24	0.982	7.348	7.5	4.798	4.9	3.816	7:20	8.0
ME3086	0430-086	27	1.010	8.844	8.8	5.818	5.8	4.808	7:30	8.2
ME3149	0431-149	27	0.895	9.216	10.3	5.964	6.7	5.069	7:35	8.1
ME3175	0431-175	27	1.383	9.432	6.8	6.028	4.4	4.645	7:45	8.1
ME3169	0431-169	24	1.234	9.581	7.8	5.972	4.8	4.738	8:10	9.0
ME3205	0432-005	27	1.606	15.171	9.4	8.729	5.4	7.123	8:35	10.4
MS0409	0532-082	30	2.206	9.717	4.4	7.405	3.4	5.199	10:00	11.7

Bypassing

Bypass pumping to prevent basement backups was conducted by City employees in 2014 on April 14th and June 18th at manhole 0431-176. Manhole 0431-176 is located at Brookdale Drive and Clover Lane, which is one manhole and approximately 144 feet upstream of metering manhole ME3175.

Bypass pumping on April 14th totaled 72,000 gallons. Bypass pumping on June 18th started at 10:30 AM and continued until 5:30 PM with one 1,200 gpm pump. Due to the volume of flow, an additional pump rated at 325 gpm was utilized starting at 2:30 PM and that pump also continued until 5:30 PM. The total volume of flow that was bypassed on June 18th was 572,250 gallons. Table 5 shows bypass pumping data for the Brookdale Drive and Clover Lane manhole for June 18, 2014.

Table 5
Bypass Pumping Data
June 18, 2014

Pump	Start Bypass Pumping	End Bypass Pumping	Time Bypassing (hrs)	Time Bypassing (min)	Pumping Rate (gpm)	Amount Bypassed (gal)
Pump 1	6/18/2014 10:30	6/18/2014 17:30	7:00	420	1,200	504,000
Pump 2	6/18/2014 14:00	6/18/2014 17:30	3:30	210	325	68,250
					Total Amount Bypassed	**572,250**

Conclusions

Flow monitors installed in 2014 for this analysis in general appear to have produced a good data set. This data will assist in better understanding how the City's East Trunk Sewer System responds to rainfall events and how the existing sanitary sewer model might be adjusted to better reflect conditions noted in the field by City Staff during larger rainfall events. This is particularly important when events cause surcharging levels significant enough to mobilize Staff to manually bypass flows from the system.

Two rainfall events were captured in 2014 that were significant enough to cause pumped bypassing: April 12-14 and June 17-18. Initially, it was thought that the April 12-14 event would be a good storm to use to make model adjustments because it would represent similar spring characteristics to the April 2009 even used in the original model calibration; however, during this analysis several factors suggest that the June 17-18 event would be better. These factors include the fact that the June event was more significant and caused bypassing in several locations throughout the City similar to the 2009 modeled event, bypassing volume was greater, and the MMSD's master area-velocity flow meter for this system was not installed until June, 2014 and therefore did not meter the April 2014 event.

A comparison of peak flows and incremental percentage of flow increase between manhole locations as well as bypassed volume are shown on Table 6. The system responds differently to the two 2014 events, which is not unexpected but overall reflects similar changes. When comparing the 2014 events to the 2009 model data, some differences are noted in the reported incremental flow change including one key difference downstream of the bypass location at 431-175. The incremental increase for both 2014 events is positive at this location by about 7-9% where it is negative by 15% in the 2009 modeled event. Also, looking back at the original model calibration data for manhole location 430-086, the system was running slightly high in peak flow and volume, indicating that upstream segments of the system above the bypass location have too much flow and downstream segments appear to have too little flow. This information will be a focus in the model refinement process.

Based on the flow monitoring analysis, bypassing data, and information currently available, it is recommended that the June 17-18, 2014 event be utilized to modify the existing sanitary sewer system model to adjust flows into the system and better align with conditions observed in the field by City staff.

Table 6
2009 Model and 2014 Storm Event Comparison

Manhole ID	2009 Existing Conditions Model Peak Flow (cfs)	Incremental Percentage of Peak Flow Increase	April 12-14, 2014 Flow Meters Peak Flow (cfs)	Incremental Percentage of Peak Flow Increase	June 17-18, 2014 Flow Meters Peak Flow (cfs)	Incremental Percentage of Peak Flow Increase
430-108	10.7	-	7.8	-	8.5	-
430-113	10.4	-3%	8.4	8%	8.6	1%
430-115	10.4	0%	8.2	-2%	8.1	-5%
430-086 (2009 Calibration Point)	13.2	27%	9.1	11%	10.7	32%
431-149	13.2	0%	8.9	-2%	10.2	-5%
0431-176 Bypass Location - Volume (gal)	280,800		72,000		572,250	
431-175	11.1	-15%	9.7	9%	10.9	7%
431-169	12.2	10%	10.3	6%	11.4	4%
432-005	17.8	46%	14.6	41%	16.5	45%

Attachment 1

Figure 1

Legend

Meter Locations

- 2009 Flow Meter (ME-M2372)
- 2014 Flow Meter (ME3008/0430-108)
- 2009/2014 Flow Meter
- Modeled Force Mains
- Modeled Gravity Sewers

N

0 700 1,400 2,800 Feet

ME-M2372
ME-M2307
ME-M1642
ME-M1661
ME3008/0430-108
ME3013/0430-113
ME-M344
ME3015/0430-115
ME3086/0430-086
ME3149/0431-148
ME3175/0431-175
ME3205/0432-005
ME3169/0431-169
ME-M1714
ME-M2885
MS0409/0532-082

Highland Rd
Shoreland Dr W
Shoreland Dr
Yvonne Dr
Colony Dr
Oriole Ln
Joliet Ct
Chateau Ct
Woodland Ct
Lake Forest Ct
Vista Ct
Woodberry Dr
Shoreland Pkwy
Shoreland Dr E
River Forest Dr
Maple Crest Ln
Park Dr
River Forest Dr
New Castle Pl
Dorothy Pl
Circle Dr
Island Dr
Center Dr
Pilot Dr
Emily Ln
Portland Ave
Liebau Rd
Ville Du Parc Dr
Golf Cir
Golf Dr
Woodfield Ct
Fieldwood Rd
Lake Isle Dr
Shoreland Dr
River Oaks Ln
River Oaks Pl
Corporate Pkwy
Hidden River Dr
Freistadt Rd
Oak Shore Ln
Thrush Ln
Stillwater Cir
River Glen Ln
Edward Dr
Windpointe Cir
Port Washington Road
I-43
Willow Glen Ct
Glen Oaks Ln
Lake Shore Dr
Saddleworth Ct
Seacroft Ct
LaPorte Rd
Riverland Dr
Pheasant Ct
Schwenner Ln
Sholes Dr
Wilderness Ct
Forest Dr
Oriole Ln
Wildwood Dr
Woodside Ct
Sandhill Cir
Glen Oaks Ln
Grace Ave
St James Ct
Ranch Rd
Mulberry Dr
Bobolink Ln
St James Ln
Hickory Rd
Hickory Ln
Laguna Dr
Hillside Ln
Country Ln
W Aster Woods Ct
Eastbrook Ct
Eastbrook Dr
Homestead Trl
Pinehurst Cir
Shorecliff Ln
Chestnut Rd
Rosewood Dr
Glenbrook Ln
Arbor Ln
Lilac Ln
Oriole Ln
Valley Dr
Fairview Dr
Venture Ct
Prairie View Ln
Revere Rd
Lakeview Pl
Robin Ln
Mequon Rd
Sabra Ct
Crown Ct
Market St
Port Washington Road
San Jose Ln
Bonnie Lynn Dr
Lake Shore Ln
Monterey Ln
Wyngate Trl
Pebble Ln
Lakeside Rd
Barkwood Ct
Lake View Rd
San Marino Dr
Haddonstone Pl
Crimson Ct
Norway Dr
Sunnydale Ln
Baldwin Ct
North Point Rd
Ravine Ct
Ravine Dr
Briarwood Ct
Bradford Dr
De La Warr Cir
Winesap Ct
Hidden Reserve Cir
Winslow Dr
Winslow Ct
Ivy Ct
Lagoon Ct
Hollyhock Ct
Country Club Dr
Gateway Ct
Valleyview Ct
Ridgeline Ct
Range Line Cir
Plum Tree Ct
Marigold Ct
Stratford Pl
Pine Tree Cir
Stone Creek Dr
Hyacinth Ct
Larkspur Ct
Donges Bay Rd
Range Line Rd
Riverview Ct
Country Club Dr
Fairway Ln
Fairway Cir
Alsace Ct
Burgundy Ct
Range Line Ct
Riviera Ct
Le Mont Blvd
Hidden Lake Rd
Range Line Ter
Valley Hill Dr
Lamplighter Ln
Hilltop Ln
Columbia Dr
Columbia Ct
El Rancho Dr
Columbia Creek Ln
Greenview Ln
County Line Rd
Port Washington Ln
Port Washington Road
Linde Ct
Orchard Ct
Heritage Ct
Fox Hunt Trce
Haddonstone Pl
Wood Crest Dr
Pine Ridge Dr
Crest Ct
Wood Ct
Pine Ridge Cir
Chicory Ln
Beechwood Dr
Ironwood Cir
Lake Shore Dr
Circle Rd
Eastwyn Bay Dr
Birch Ct
Donges Bay Rd
Kenilworth Cir
Trillium Rd
Aster Ln
Ranchito Ln
Charter Mall
Adams Ct
Raleigh Ct
Quincy Ct
Norfolk Ct
Sunnycrest Dr
Greenview Dr
La Cresta Dr
Waterleaf Dr
Parkside Ct
Miller Ct
Anne Ct
Miller Dr
Vintage Dr
Maple Ln
Cedar Ln
Otto Rd
Glenview Ct
Corey Ln
Lake Shore Rd
Appletree Ct
Zedler Ln
Sierra Ln
Gettysburg Ct
Holmes Ct
Kirkland Ct
Grasslyn Rd
Katherine Dr
Shaker Cir
Auburn Ct
Thornapple Ln
Juniper Ln
Juniper Ct
Woodlyn Dr
Boundary Rd
McIntosh Ln
Russet Ln
White Oak Way
Juniper Trail
Juniper Cir

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Figure 1
2014 Meter Analysis
East Trunk Line
City of Mequon

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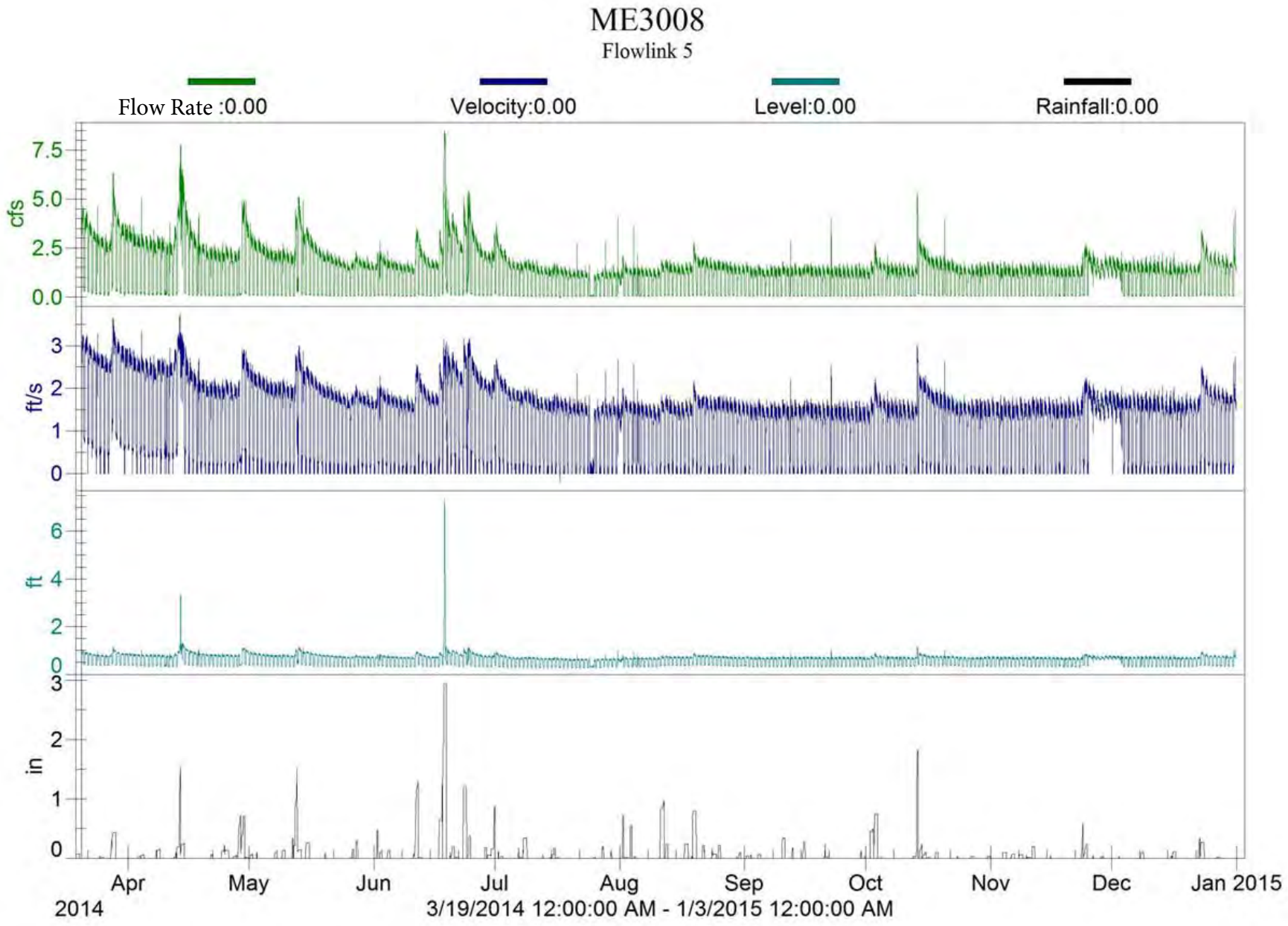
Attachment 2

Graphs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Rainfall:0.00
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5.0
2.5
0.0
ft/s
3
2
1
0
ft
6
4
2
0
in
3
2
1
0
Apr
May
Jun
Jul
Aug
Sep
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Jan 2015
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ME3013

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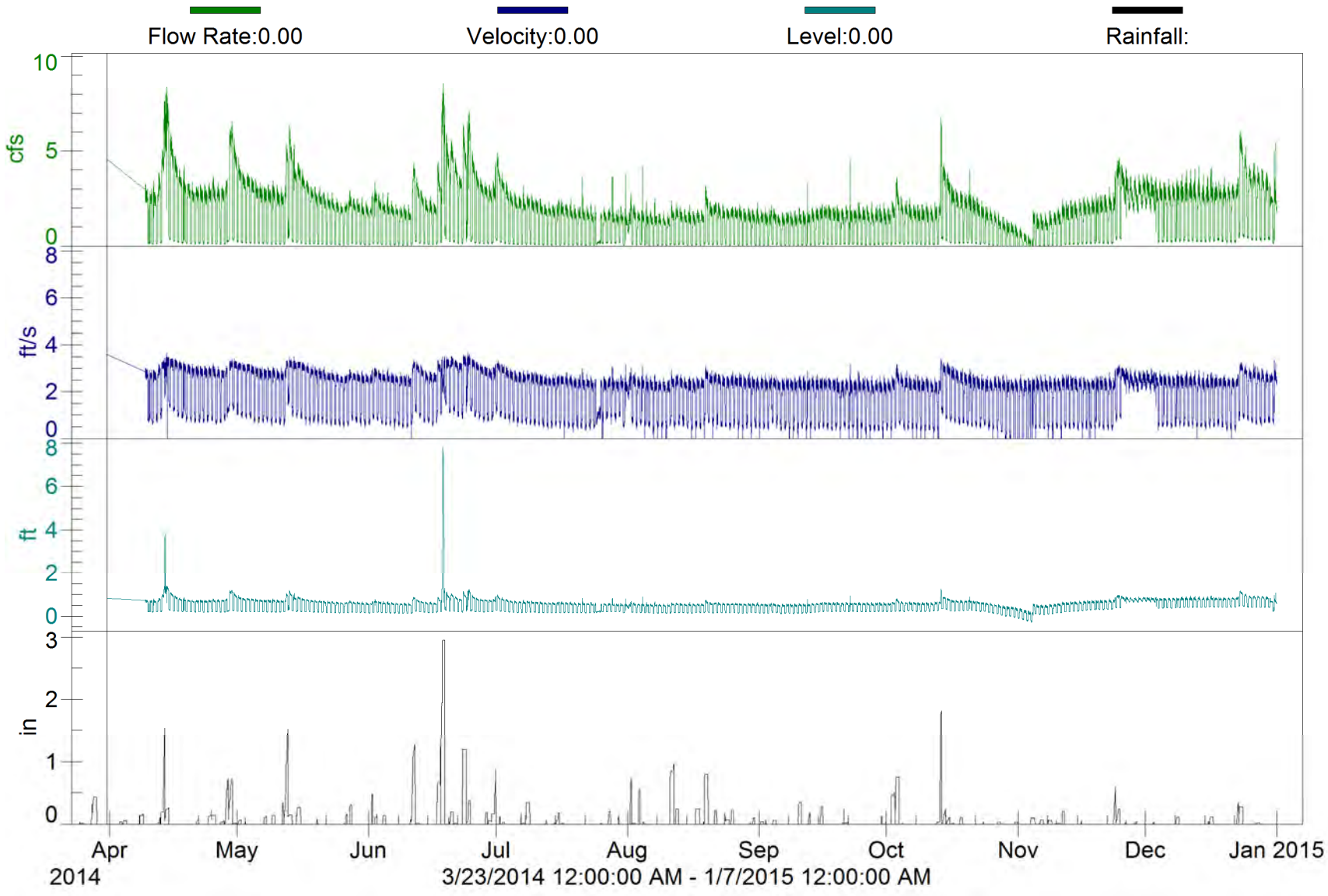

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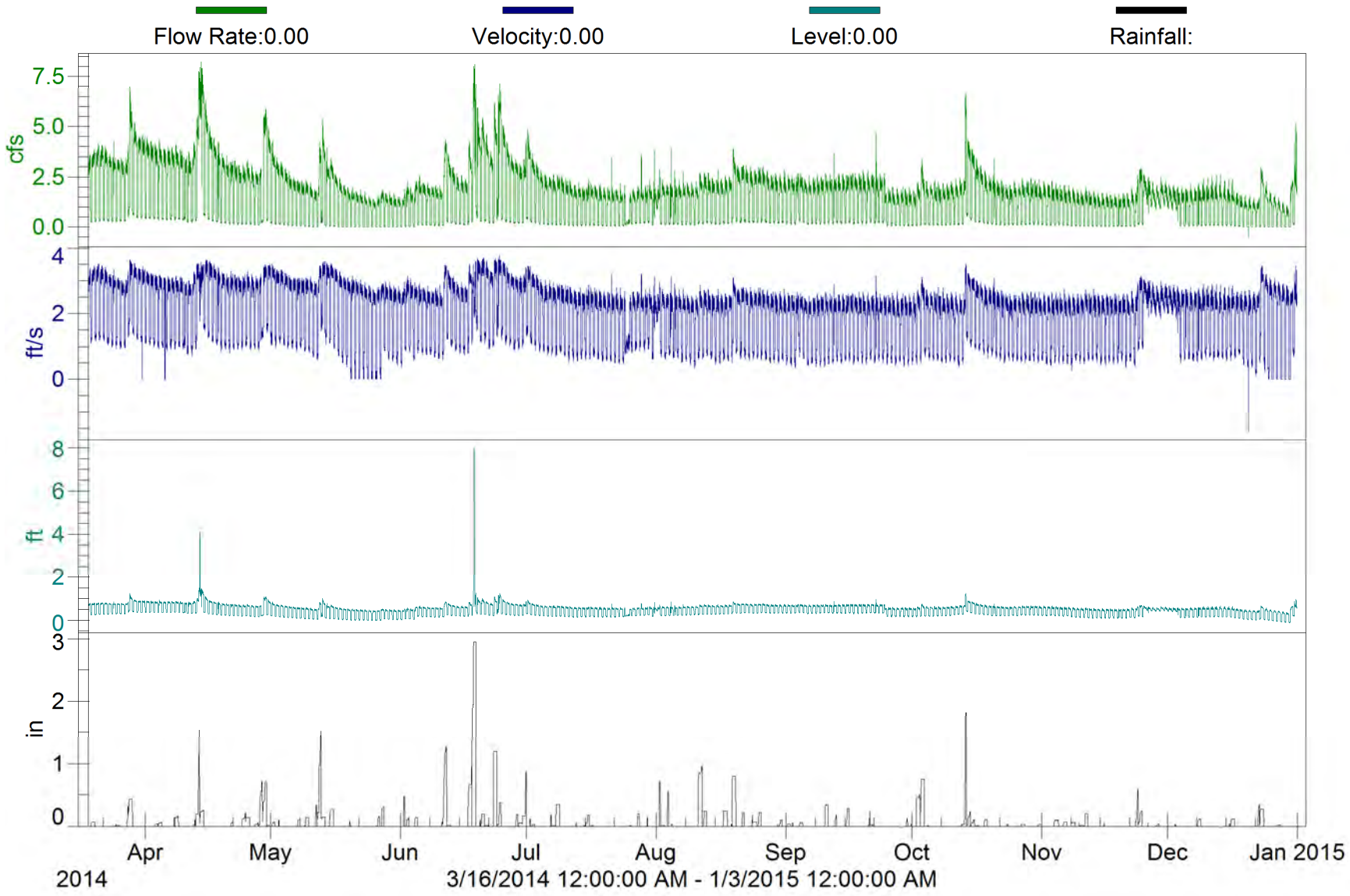

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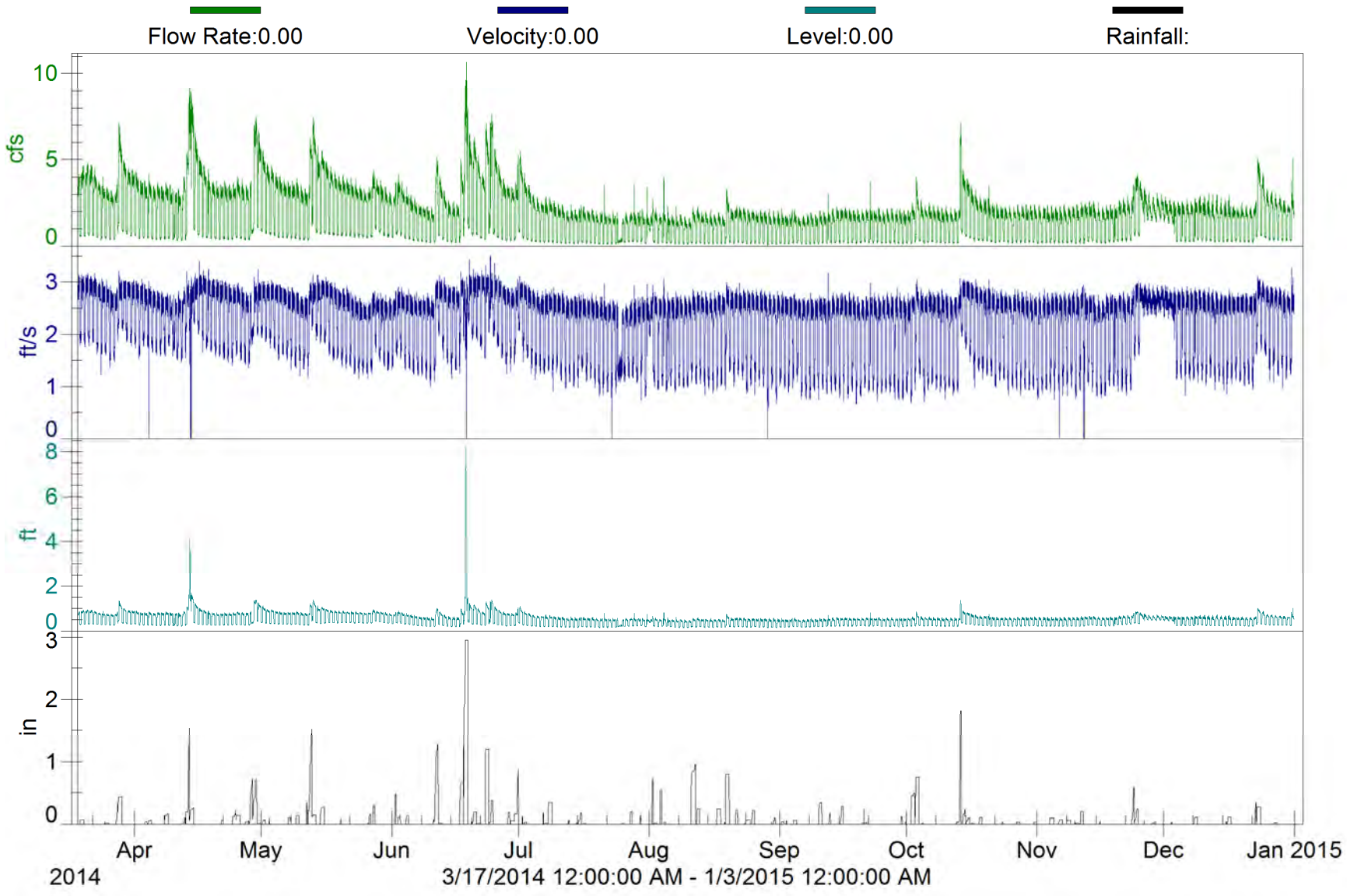

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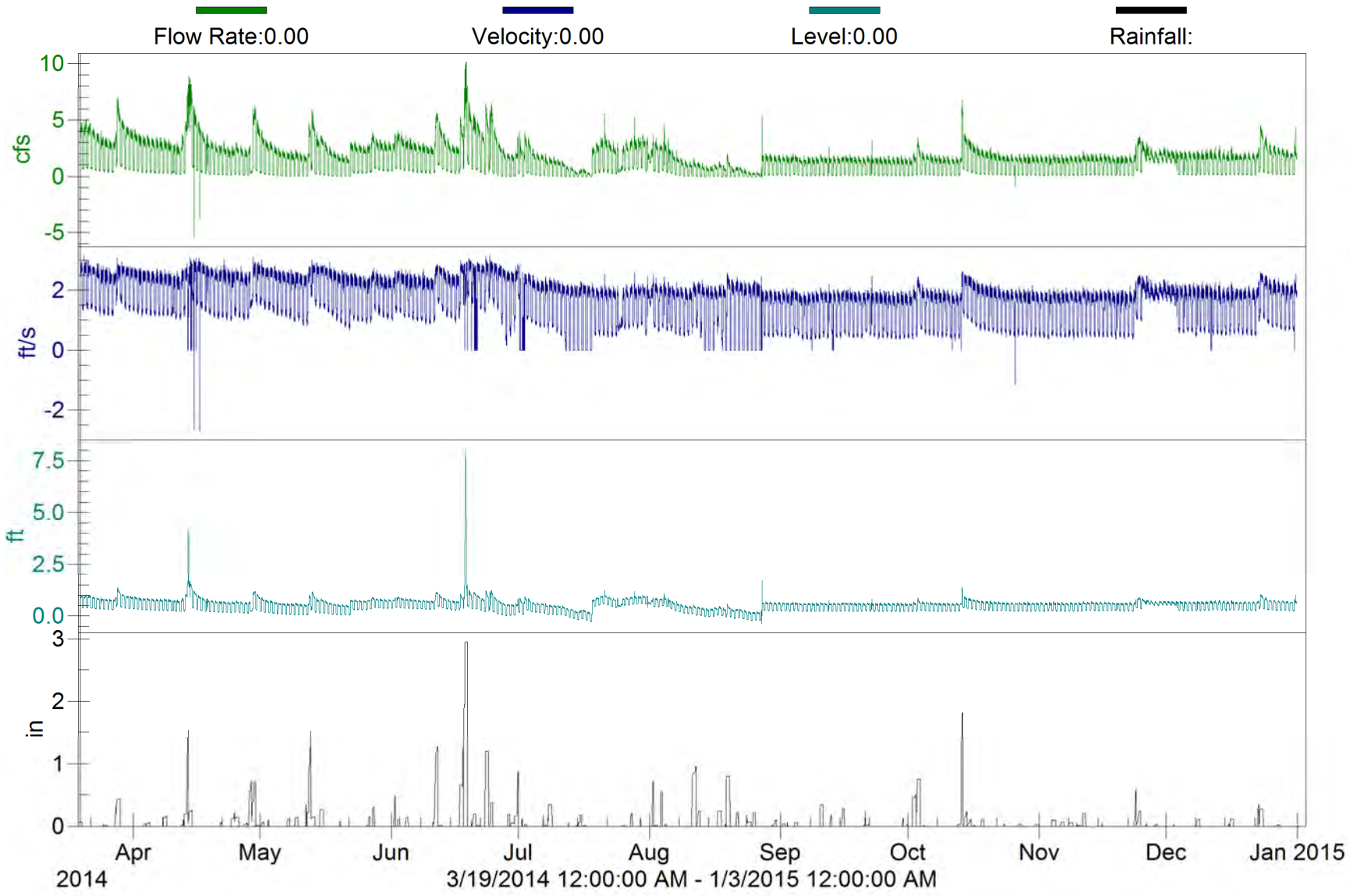

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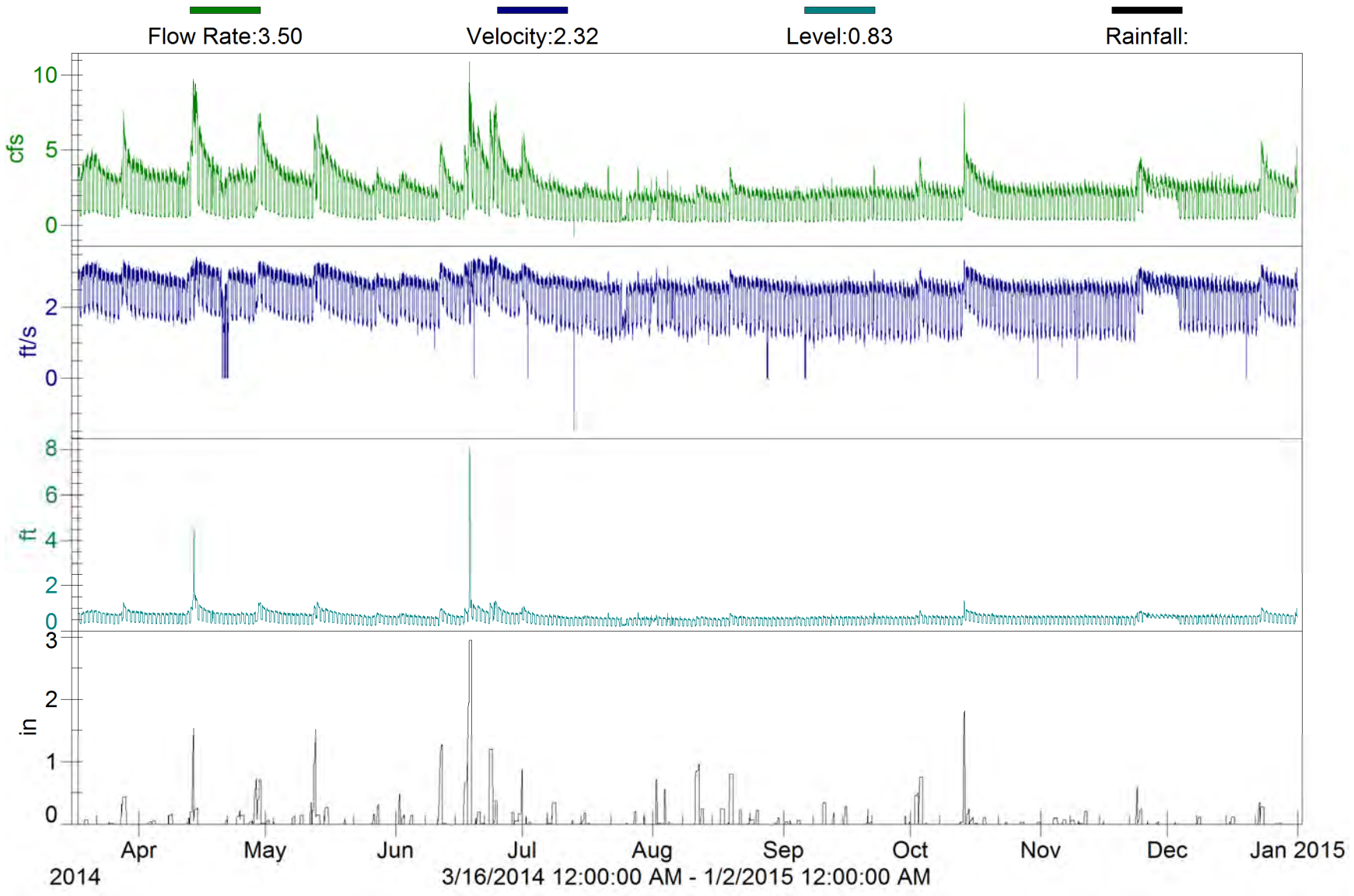

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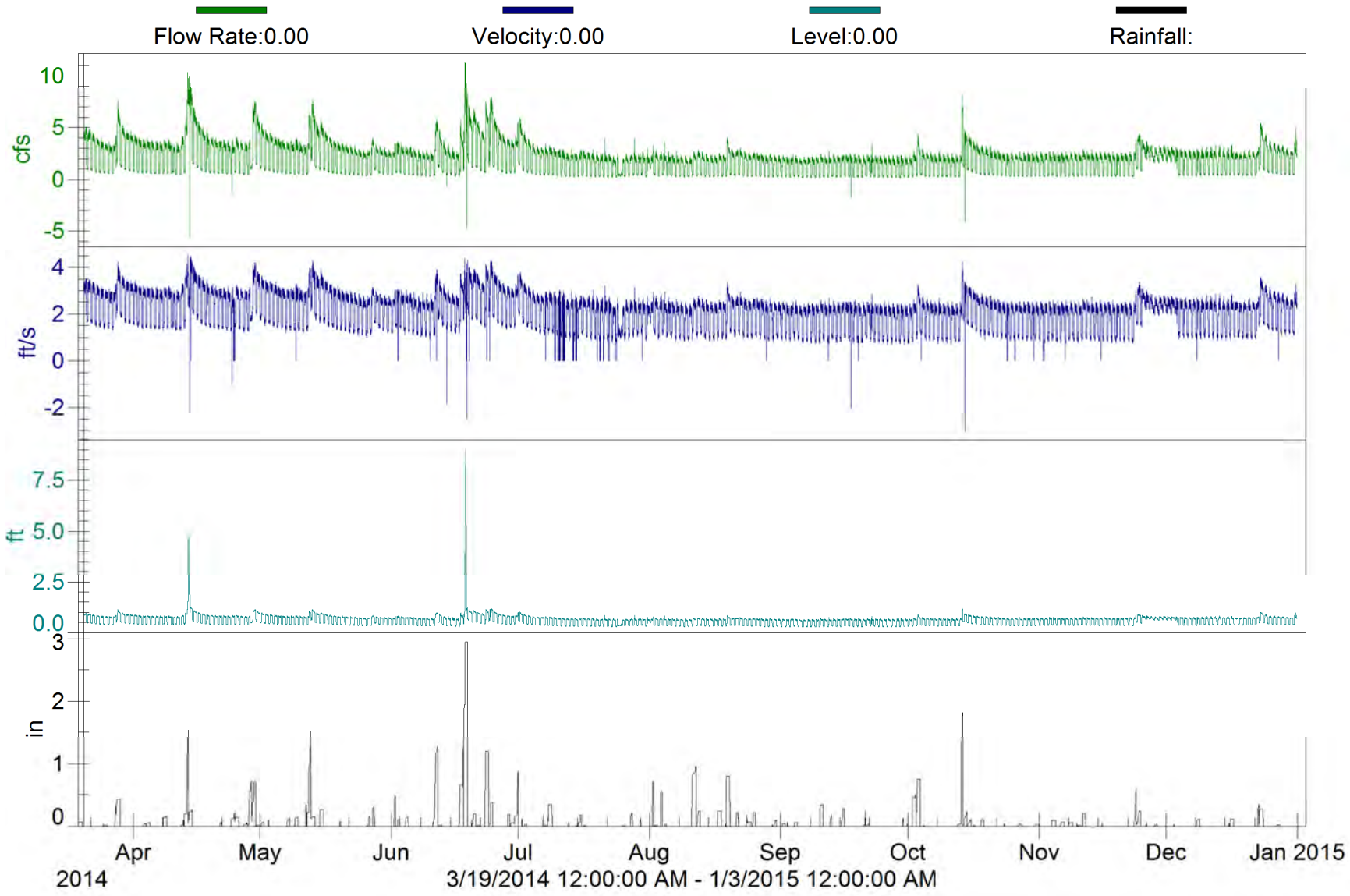

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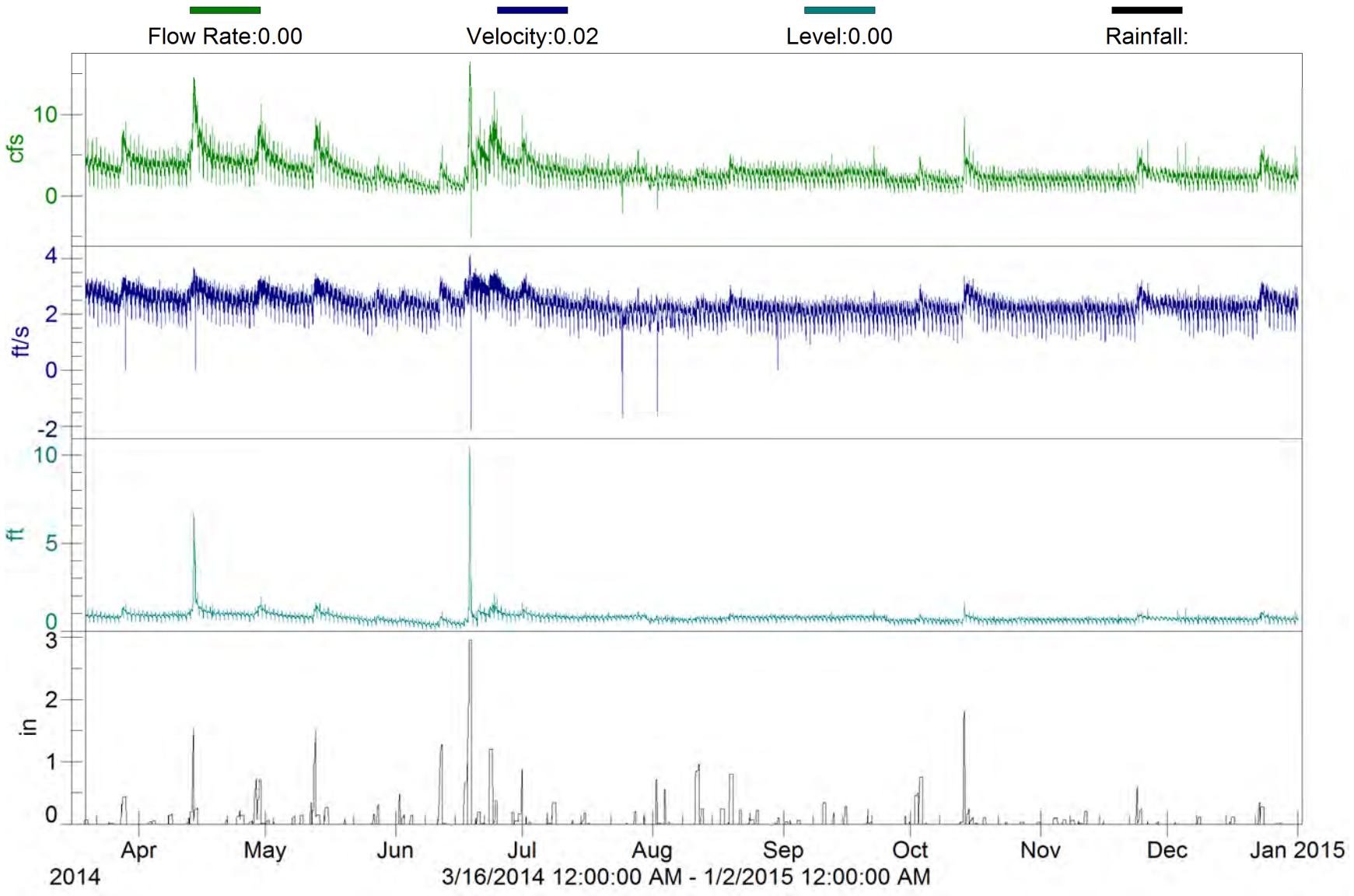

MS0409

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