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KANATA GOLF & COUNTRY CLUB 2019 MONITORING AND HYDROLOGIC MODEL CALIBRATION REPORT

September 2019

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1 PROJECT OVERVIEW

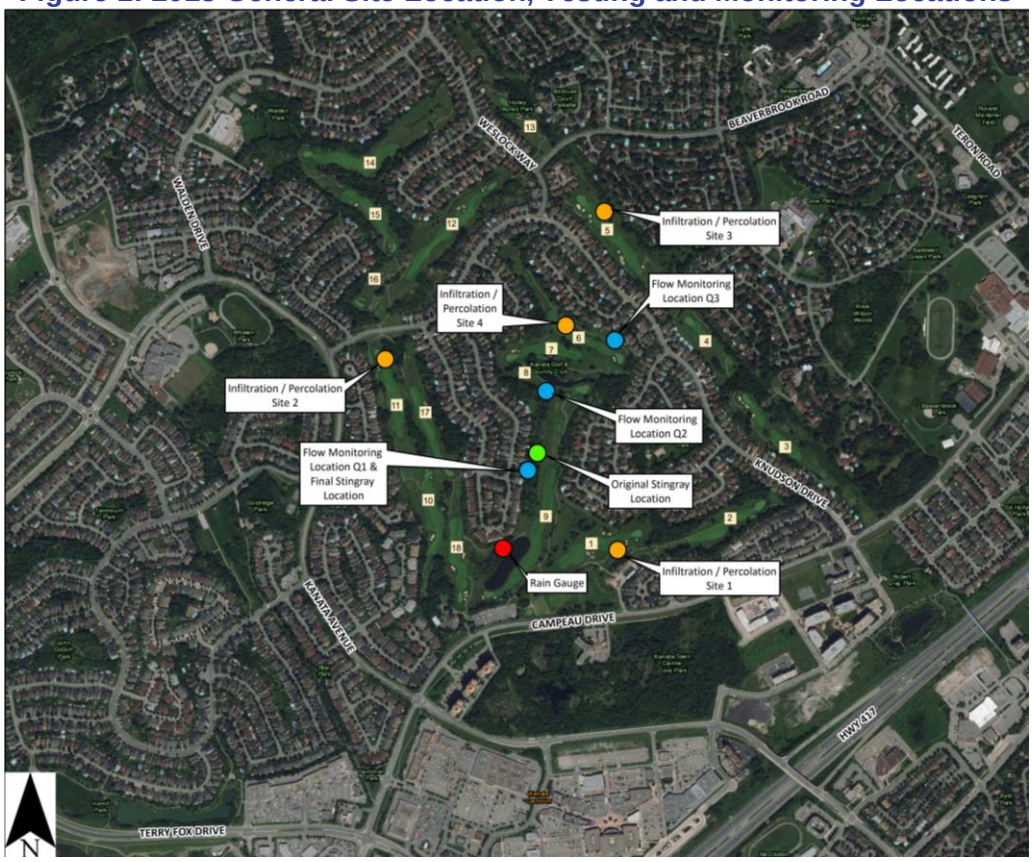
1.1 Introduction

The Kanata Golf and Country Club (the Site) is located at 7000 Campeau Drive in the City of Kanata, Ontario. The existing golf course is approximately located north of Campeau Drive, west of Teron Road, south of Walden Drive and east of Kanata Avenue. The area includes an 18-hole golf course surrounded by existing residential development. A water level and flow monitoring programs were implemented at the Site in 2018 and 2019 to better understand the hydrologic and hydraulic characteristics of this area. As part of this study, J.F. Sabourin and Associated (JFSA) collected surface water, storm sewer, and rainfall data around the Site.

1.1.1 Rainfall, Surface Runoff Monitoring and Infiltration Testing in 2018

The 2018 Monitoring Program consisted of three level loggers, one barometric logger, one Stingray Portable Level-Velocity Logger and one rain gauge all on the Kanata Golf and Country Club Property. Infiltration and percolation tests were undertaken at four sites. Refer to **Figure 1** for the general site location. All testing and monitoring locations from 2018 are also included on **Figure 1**. The results of the 2018 field program are presented in the *Kanata Golf & Country Club – 2018 Surface Water and Rainfall Monitoring* Program Memo dated February 6, 2019 for David Schaeffer Engineering.

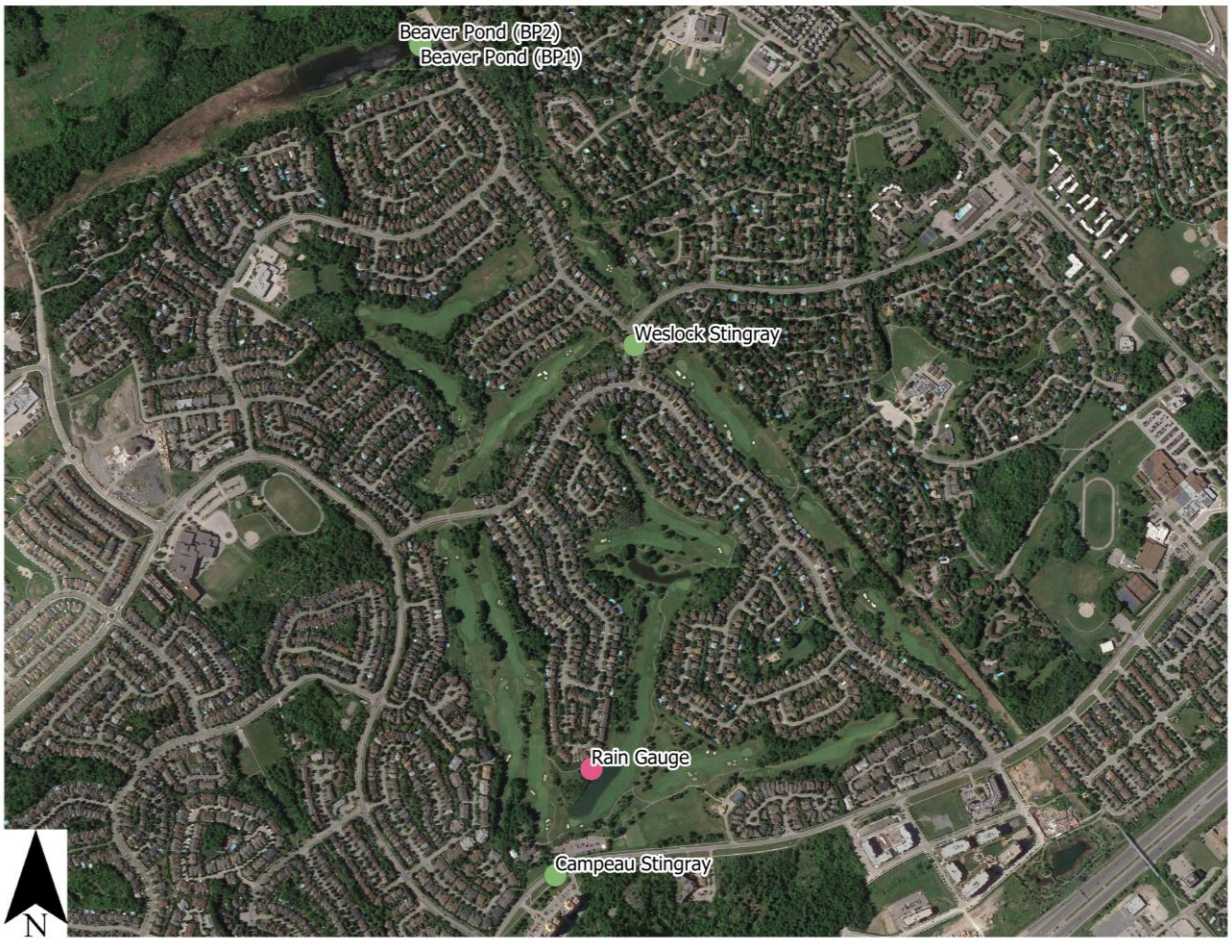
Figure 1: 2018 General Site Location, Testing and Monitoring Locations



1.1.2 Monitoring Program of 2019

The 2019 Monitoring Program consisted of two level-loggers (BP1 and BP2) and one barometric logger at the Beaver Pond, two Stingray Portable Level-Velocity Logger (Stingray) within storm sewer system and one rain gauge on the Kanata Golf and Country Club Site. The level-loggers installed at the Beaver Pond measured the pond water level and temperature from May to September. The two Stingray's were installed at two strategic locations in the storm sewer along the runoff flow path within the Beaver Pond subwatershed. The flow monitoring site located on Campeau Drive (a 1350 mm pipe) captured the runoff from a portion of the site that was entirely made up of a typical residential development while the monitoring site located on Weslock Way (a 2250 mm pipe) captured the largest possible area that could safely be monitored and not affected by the backwater from the Beaver Pond. The flows at the Weslock site were generated from both the golf course and developed areas. The rain gauge was re-installed at the same location as the 2018 rain gauge. Refer to **Figure 2** for all testing and monitoring locations from 2019.

Figure 2: 2019 General Site Location, Testing and Monitoring Locations



During the 2019 monitoring period, JFSA conducted 18 site visits to; install equipment, inspect the operation of the field equipment, download recorded data and measure instantaneous water levels and velocities. **Table 1** summarizes all dates JFSA staff were onsite and provides a brief description of the task(s) completed on that date. It should be noted, all instruments (BP1, BP2, Baro Logger, Campeau Stingray, Weslock Stingray) installed in the spring of 2019 are currently still collecting data and will be uninstalled in October 2019.

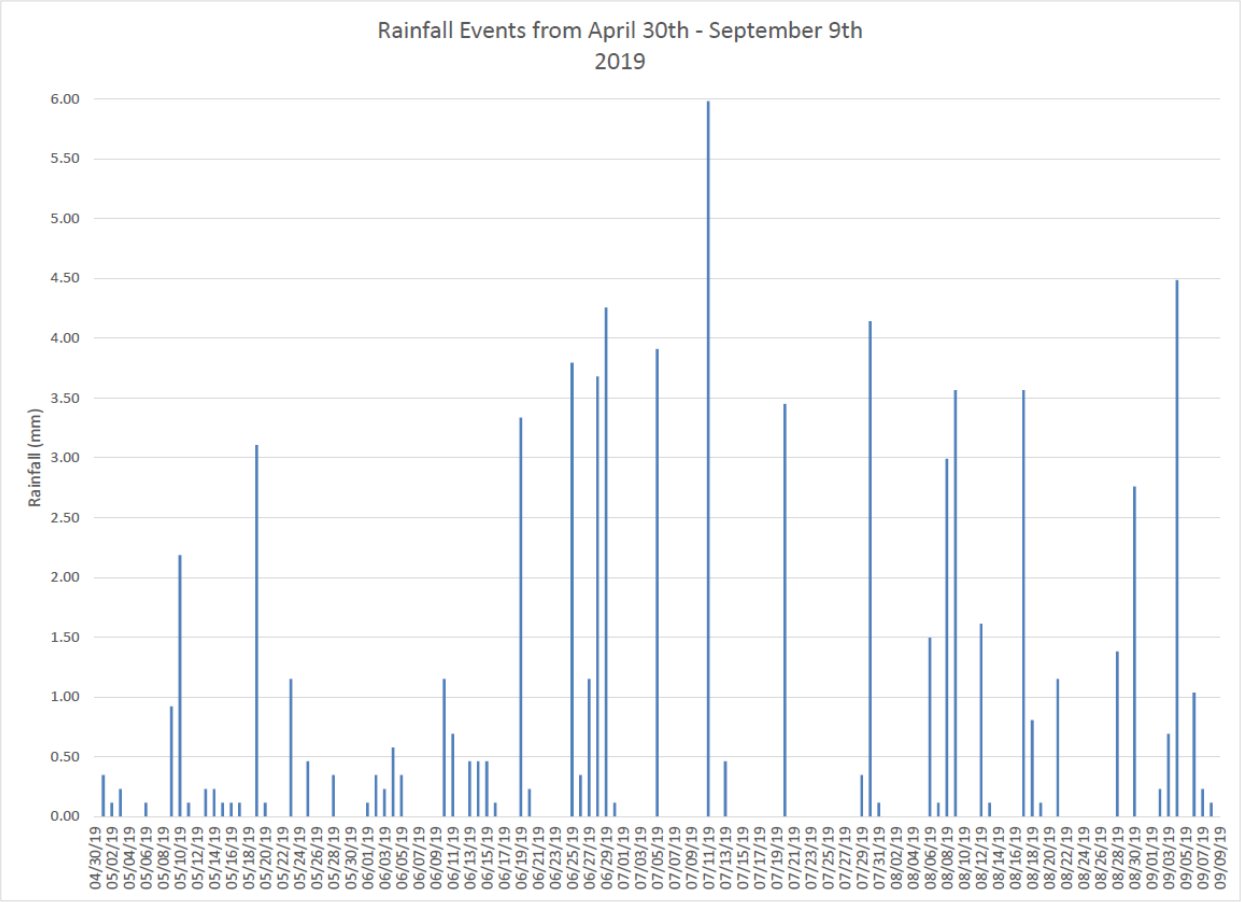
Table 1: 2019 Site Visit Summary

Date	Description
April 30, 2019	**Rain gauge installation**
May 15, 2019	Rain gauge download, **Beaver Pond levelogger and barometric logger Installation**
May 23, 2019	Download leveloggers
May 30, 2019	Download leveloggers
June 3, 2019	Manhole reconnaissance for Stingray levelogger location
June 5, 2019	**Campeau Drive Stingray installation**
June 6, 2019	**Weslock Way Stingray installation**
June 11, 2019	Stingray, levelogger, and rain gauge download
June 17, 2019	Stingray download
June 21, 2019	Stingray, levelogger, and rain gauge download
June 27, 2019	Move rain gauge logger to avoid working at heights during download
July 8, 2019	Stingray, levelogger, and rain gauge download
July 16, 2019	Stingray, levelogger, and rain gauge download
July 29, 2019	Stingray, levelogger, and rain gauge download
August 6, 2019	Levelogger download, GPS points, and velocity measurement downstream of the Beaver Pond
August 20, 2019	Stingray, levelogger rain gauge download and velocity measurement downstream of the Beaver Pond
August 29, 2019	Stingray, levelogger rain gauge download and velocity measurement downstream of the Beaver Pond
September 9, 2019	Stingray, levelogger rain gauge download and velocity measurement downstream of the Beaver Pond

2 RAINFALL

A tipping bucket rain gauge was installed on-site April 30th, 2019 and last downloaded September 9th, 2019. As such, the rain gauge has provided 132 days of operation. **Figure 3** shows the precipitation events captured within this period.

Figure 3: Rainfall Events from April 30th – September 9th, 2019



2.1 Significant Rainfall Events

In this instance, a 'Significant Rainfall Event' is defined by an amount of rainfall greater than 5 mm. It is also noted each rainfall event is required to have at least 12 hours of time without rain before the next event begins. A total of 27 significant rainfall events were observed and measured between April 30th to September 9th, 2019. See **Table 2** and **Table 3** for details.

Table 2: 2019 Rainfall Summary

Start Date	End Date	Duration (operational days)	Total Rain (mm)
4/30/2019	9/9/2019	132	386.98

Table 3: Total Significant Rainfall Events

(events with more than 5 mm and separated by at least 12 hours of no rain)

	Start (m/d/yyyy hh:mm)	Finish (m/d/yyyy hh:mm)	Duration (day:hr:min)	Total Rainfall (mm)
1	5/1/2019 11:15	5/2/2019 4:35	0:17:20	7.13
2	5/3/2019 4:00	5/3/2019 8:40	0:4:40	5.29
3	5/9/2019 16:35	5/10/2019 13:30	0:20:55	33.24
4	5/13/2019 16:55	5/14/2019 14:00	0:21:05	16.22
5	5/19/2019 3:55	5/20/2019 4:50	1:0:55	20.47
6	5/23/2019 14:40	5/23/2019 17:15	0:2:35	6.56
7	5/25/2019 11:30	5/25/2019 20:25	0:8:55	6.33
8	5/28/2019 5:55	5/28/2019 13:25	0:7:30	5.06
9	6/10/2019 16:25	6/11/2019 5:45	0:13:20	29.56
10	6/13/2019 15:05	6/16/2019 4:30	2:13:25	29.21
11	6/19/2019 15:10	6/19/2019 15:25	0:0:15	7.02
12	6/25/2019 4:20	6/25/2019 7:40	0:3:20	10.93
13	6/28/2019 13:30	6/28/2019 15:25	0:1:55	17.60
14	6/29/2019 16:25	6/30/2019 4:45	0:12:20	29.10
15	7/5/2019 16:40	7/5/2019 17:25	0:0:45	14.26
16	7/11/2019 15:15	7/11/2019 17:05	0:1:50	16.56
17	7/20/2019 15:45	7/20/2019 16:25	0:0:40	5.06
18	7/30/2019 10:50	7/31/2019 4:30	0:17:40	13.00
19	8/6/2019 12:35	8/6/2019 13:50	0:1:15	8.86
20	8/8/2019 14:30	8/8/2019 15:25	0:0:55	8.28
21	8/9/2019 12:20	8/9/2019 21:25	0:9:05	6.33
22	8/12/2019 18:35	8/13/2019 4:40	0:10:05	5.75
23	8/17/2019 3:15	8/17/2019 14:20	0:11:05	10.35
24	8/28/2019 3:00	8/28/2019 10:15	0:7:15	11.50
25	8/30/2019 2:55	8/30/2019 6:00	0:3:05	8.51
26	9/3/2019 22:40	9/4/2019 2:45	0:4:05	14.61
27	9/6/2019 14:10	9/8/2019 3:25	1:13:15	12.54

2.2 2019 Intensity-Duration-Frequency Analysis

The Rainfall-Duration Max Intensity summary for the 2018 collected rainfall is shown in **Table 4** for this analysis. The IDF curves from the Ottawa International Airport, based on data from 1967-2003 was used to evaluate the return period of the measured intensities. **Appendix A** contains the full hyetographs and their comparison against the Intensity-Duration-Frequency (IDF) curves.

Table 4: Kanata Golf and Country Club – 2019 Rainfall Duration/Max Intensity Summary

Duration	Maximum Measured Rainfall Intensity (mm/hr)	Return Periods Based on Ottawa Airport IDF (Years)
5 Minute	71.76	<2
10 Minute	51.06	<2
15 Minute	42.78	<2
30 Minute	28.98	<2
60 Minute	17.37	<2
2 Hour	13.57	<2
6 Hour	4.75	<2
12 Hour	2.43	<2
24 Hour	1.38	<2

As indicated in Table 4 above, all the significant events from April 30th to September 9th, 2019 were less than a 2-year return period.

3 BEAVER POND WATER LEVEL MONITORING

Two leveloggers and one barometric logger were installed at the Beaver Pond in May 2019. The purpose for these loggers was to identify the fluctuations water levels in the pond as well as observe the outflow of the pond. The barometric data obtained on site was used to account for the air pressure recorded by all leveloggers. With the atmospheric pressure accounted for in the recorded data, these values were then converted to depths, as both the temperature of the water and the total hydrostatic pressure were known. The depth measurements obtained in the field were used to correct water level records to reflect continuous water depths at the monitored locations in the Beaver Pond. GPS points were obtained on the August 6th field visit, therefore the benchmark used throughout site visits could now be converted to geodetic data, allowing for pond elevations to be reported. **Table 5** is a summary of the minimum, maximum, and average elevations obtained during this monitoring period at two locations (BP1 and BP2). **Table 6** is a summary of logger water elevations measured in the Beaver Pond. **Appendix B** contains plots of the continuous water levels.

To be noted that the invert of the Beaver Pond outlet (a 600 mm orifice) is at an elevation of 90.42 m. From the results presented in Table 6, with a maximum recorded pond level of 90.99 m, the 600 mm orifice was never completed submerged during the monitoring period. This is important because there are no exact or clear methods to calculate the flow through a circular orifice that is not flowing full.

Table 5: Summary of Manual Water Elevation Measurements of Beaver Pond

Date	Manual Measurements (m)
5/15/2019	90.85
5/23/2019	90.75
5/30/2019	90.64
6/11/2019	90.79
6/21/2019	90.58
7/8/2019	90.73
7/16/2019	90.52
7/29/2019	90.43
8/6/2019	90.42
8/20/2019	90.49
8/29/2019	90.47
9/9/2019	90.48

Table 6: Summary of Logger Water Elevations Measured in Beaver Pond

	BP1		BP2	
	Water Level Elevation (m)	Date and Time	Water Level Elevation (m)	Date and Time
Minimum	90.41	8/6/2019 12:30	90.42	8/25/2019 4:15
Maximum	90.99	6/30/2019 2:45	90.99	6/30/2019 2:50
Average	90.57	-	90.56	-

Below are photos taken from the field of the Beaver Pond throughout the monitoring period to validate the fluctuation of water levels.

Figure 4: April 30, 2019

Figure 5: June 11, 2019

Figure 6: July 16, 2019

Figure 7: August 29, 2019

4 FLOW MONITORING

Two Stingray water level, velocity, and temperature loggers were installed at two key locations within the Beaver Pond subwatershed. The first logger was installed June 5th in a storm sewer manhole at 7300 Campeau Drive (Campeau). This location was chosen as the flow path is upstream of the golf course therefore it captures flow only from a small developed neighborhood of approximately 22.6 ha. This site was also a convenient and safe location slightly off of Campeau Drive within a large swale on the south side of the road. The second logger was installed in a storm sewer manhole at 6 Weslock Way (Weslock). This location was chosen as it is the furthest downstream location to capture the largest drainage area (approximately 173.7 ha) of mixed urban and golf course draining to the Beaver Pond without approaching the backwater of the pond (for safety while installing logger).

The stingray units produce tables of flow using the observed water level and velocity to calculate discharge (m^3/s). **Table 7** summarizes the Minimum, Maximum, and Average flows observed from June to September 2019 from each stingray unit.

Table 7: Summary of Stingray Flows Measured at Campeau and Weslock

	Campeau Site (1350 mm pipe with approximate Qcap= 2.5 m^3/s)	**Weslock Site (2250 mm pipe with approximate Qcap= 8.5 m^3/s)**
	Flow (m3/s)	**Flow (m3/s)**
Minimum	0.00	0.00
Maximum	0.60	1.56
Average	0.003	0.02

Both stingray sites were compared against the simulated flows from the calibration in Section 5. See **Appendix C** for the Measured vs. Simulated hydrographs.

5 HYDROLOGIC MODEL REVIEW AND CALIBRATION

The SWMHYMO model used by the Mississippi Valley Conservation Authority in their "*Watts Creek / Kizell Drain Flood Plain Mapping Study* (Final November 2017)" was used in the current study. The source of the model was originally developed as part of another previous study "*Shirley's Brook and Watts Creek Phase 2 Stormwater Management Study*" (AECOM, 2015), undertaken for the City of Ottawa.

MVCA indicate in their report that the AECOM SWMHYMO model was thoroughly calibrated and verified. Therefore, as part of our analysis we did not revisit the model's catchment delineation, but we did undertake a review of model parameters. It is noted however that the AECOM model calibration was based on rainfall and Beaver Pond water level measurements. The measured Beaver Pond water levels were used to calculate flows and these flows were compared to the model's simulated results.

As part of our analysis, and as described in the previous sections of this report, we not only collected rainfall data and measured the Beaver Pond water levels, we also measured stormwater flows at two separate locations in the local storm sewers. The storm sewer flow data was helpful in advancing AECOM's previous model calibration.

5.1 Updated Model Parameters

The MVCA's existing conditions SWMHYMO model was used through the calibration process. There are two categories of model parameters that can be adjusted; i) those that affect the computed runoff volumes, and ii) those that affect the shape of the simulated hydrographs. In the first category we find the following parameters; depression storage or initial abstraction (Ia), total imperviousness (TIMP), directly connected imperviousness (XIMP), Curve Numbers (CN), Horton's infiltration parameters (Fo, Fc, DCAY), and groundwater / baseflow parameters (InitGWResVol, GSResk, VHydCond). In the second category of parameters, we have, surface slopes (SLPI and SLPP), surface lengths (LGP and LGI), surface Manning's values (MNI and MNP), Time to Peak (TP), and the number of linear reservoirs (N).

To undertake the calibration process using the 2019 collected rainfall and flow data, MVCA's single event model was transformed into a continuous model. A continuous model allows various parameters to change during the simulation based on conditions that may have been present just before a rainfall event. Furthermore, by using a continuous model, the need to undertake a baseflow separation exercise is eliminated from the analytical process.

Using the measured flow data at the Campeau Drive and Weslock Way sites, several SWMHYMO model parameters were further adjusted to improve the model's performance. **Table 8** provides a list of the parameters that were adjusted through a calibration process using the monitoring data of 2019.

Table 8: Updated Hydrologic Parameters

SWMHYMO parameters	As per MVCA model	Adjusted or Calibrated using 2019 data
NASHYD		
N	1.1	2
TP	Variable	Unchanged
CN for golf course	Variable	50
STANDHYD		
TIMP	Variable based on catchment	Unchanged
XIMP	Variable	Set to 0.25 for existing residential developments
Infiltration loss method	SCS Procedure	Horton's equation with Fo=125 mm/hr, Fc=25 mm/hr, DCAY=2.0 (see Note 1)
MNI	0.025	0.013 as per City default value
MNP	0.25	0.25, as per City default value
Depression storage, IAimp and IAper	1.57 mm for Impervious and 4.67 mm for Pervious	1.57 mm for Impervious and 4.67 mm for Pervious, as per City default values
Surface slopes, SLPI and SLPP	0.2% for Impervious and 2% for Pervious	1.0% for Impervious and 2% for Pervious
Length parameters, LGI and LGP	Variable value for impervious with some set to 225 m per ha, and 40 m for Pervious	SWMHYMO's default value for Impervious based on LGI=(A/1.5)^.5, and 40 m for Pervious
CONTINUOUS PARAMETERS		
APII and APIK	N/A	40 mm and 0.8
IaRECimp and IaRECper	N/A	1.5 hours and 6 hours
BASEFLOW PARAMETERS		
InitGWResVol	N/A	12 mm
GWResK	N/A	0.85 mm/day/mm
VHydCond	N/A	.001 mm/hr

Note 1: these infiltration rates are similar to the values obtain from the 2018 infiltration tests documented in "*Rainfall. Surface Runoff and Infiltration at Kanata Golf and Country Club, Summary Report – 2018 Monitoring Program",* by JFSA and Geofirma, February 2019.

5.2 Updated Model Parameters

With the updated set of hydrologic parameters provided in **Table 8**, it was found that simulated and measured Beaver Pond conditions were much improved over previous calibration efforts. As such, the two representative underground storage routing (one for the Kizell Wetland and another for the Beaver Pond) that were previously deemed necessary to better replicate the observed operation of the Beaver Pond, were removed from the model. A comparison of the measured versus simulated Beaver Pond flows is provided in **Appendix B**.

Table 9 provides a comparison of measured and simulated peak flows and runoff volumes for both the Campeau and Weslock sites. Refer to **Appendix C** for the complete comparison of measured and simulated hydrographs at both the Campeau and Weslock sites.

Table 9: Comparison of Observed and Simulated Peak Flows and Runoff Volumes
(based on 2019 monitoring data and updated calibrated model)

Event Date (2019)	Total Precipitation (mm)	Measured Peak Flows and Runoff Volumes				Simulated Peak Flows and Runoff Volumes			
		Campeau Site		Weslock Site		Campeau Site		Weslock Site	
		Qp (m3/s)	RV (mm)	Qp (m3/s)	RV (mm)	Qp (m3/s)	RV (mm)	Qp (m3/s)	RV (mm)
June 10	29.56	.186	6.87	.495	2.52	.189	6.28	.597	8.13
June 13	29.21	.080	7.76	.237	7.46	.081	4.62	.294	7.84
June 19	7.02	.342	1.26	.873	.44	.431	1.38	1.068	.61
June 25	10.93	.398	2.02	1.022	.60	.530	2.3	1.381	1.01
June 28	17.60	.490	3.27	1.271	2.18	.504	3.9	1.546	2.18
June 29	29.10	.489	5.54	1.509	4.25	.565	6.62	1.925	5.58
July 5	14.26	.376	2.31	1.238	1.77	.584	3.15	1.626	1.72
July 11	16.56	.602	2.96	1.290	1.53	.632	3.65	1.651	2.07
July 20	5.06	.194	1.45	.837	.520	.230	.860	.485	.52
July 30	13.00	.439	4.74	.966	1.23	.420	2.22	.934	1.06
August 6	8.86	.164	2.20	.325	.57	.170	1.84	.494	.82
August 8	8.25	.398	1.81	.763	.62	.386	1.67	.946	.76
August 9	6.33	.248	1.32	.597	.54	.299	1.09	.624	.57
August 12	5.75	.190	1.11	.222	.48	.167	.59	.353	.48
August 17	10.35	.280	1.09	.591	.41	.496	1.75	1.267	.93
August 28	11.50	.172	2.96	.439	.74	.202	1.65	.571	.80
August 20	8.51	.298	2.29	.597	.59	.287	1.47	.808	.66
September 3	14.61	.562	3.02	1.047	1.16	.607	2.83	1.553	1.16
September 6	12.54	.120	2.31	.255	1.09	.140	1.57	.387	1.37

From the results presented in Table 9, and for the 19 rainfall events that were used to update the model calibration, the following information and results can be obtained;

i) the total precipitation volume of the selected events is 259 mm,
ii) the measured runoff coefficients of the area draining through the Campeau site varies from 0.10 to 0.36 with an average of 0.22,
iii) the measured runoff coefficients of the area draining through the Weslock Site (which includes the drainage area from the Campeau site) varies from 0.04 to 0.25 with an average of 0.09 which can be explained by the presence of the golf course which lowers the amount of runoff generated by the area and possibly by the assumption that the entire area is subjected by the measured rainfall,
iv) for the 19 rainfall events summarized in Table 8, the total simulated runoff volume at the Campeau site is 49.44 m as compared to the measured value of 56.29 mm, an acceptable difference of approximately 12%,
v) for the 19 rainfall events summarized in Table 8, the total simulated runoff volume at the Weslock site is 38.67 mm as compared to the measured value of 28.70 mm, an over estimation of approximately 35% which is on the high side but still acceptable,

vi) in terms of peak flows, the ratio of simulated versus observed values vary from 0.88 to 1.77 with an average of 1.15 at the Campeau site and vary from 0.58 to 2.14 with an average of 1.31 at the Weslock site, again all acceptable results, noting that there is a higher variability of the results for the Weslock site which is not unusual for larger drainage areas (Weslock having close to 175 ha of drainage area is almost eight times larger than the area at the Campeau site).

6 CONCLUSIONS AND RECOMMENDATIONS

The results obtained from storm sewer flow monitoring allowed to confirm the higher than previously assumed infiltration losses over the study area.

The calibrated AECOM (2015) hydrologic model (SWMHYMO) used in MVCA's Watts Creek / Kizell Drain Flood Plain Mapping Study was successfully re-calibrated using monitored storm sewer flows within the existing Kanata Lakes subdivision as well as continuous measurements of the Beaver Pond water levels during a period of three months (June to September 2019). The updated model calibration allowed for the removal of the two underground storage reservoirs that were previously inserted in the model in order to attenuate flows out of the Beaver pond that were consistently overestimated.

The updated calibrated hydrologic model for the area draining to the Beaver Pond should by used to further analyze potential future developments in the area.

7 JFSA STATEMENT OF LIMITATIONS

This report, which specifically includes all tables, figures and appendices, is based on data and information assembled by JFSA and provided by others. JFSA has relied in good faith on all information provided and does not accept responsibility for any deficiencies, misstatements, or inaccuracies contained in the report as a result of omissions, misinterpretation, or fraudulent acts of the persons contacted or errors or omissions in the reviewed documentation and data. JFSA is not a guarantor of the accuracy, completeness or adequacy of this information provided by others. JFSA assumes no responsibility or liability for errors or omissions resulting from inaccuracies in the data received from others. JFSA assumes no responsibility for any negligence by others related to the data provided for this analysis. JFSA warrants only that its work was undertaken, and its report prepared in a manner consistent with the level of skill and diligence normally exercised by competent engineering professionals practicing in the Province of Ontario.

JFSA
WATER RESOURCES AND ENVIRONMENTAL CONSULTANTS

Project Ref #:P1581
Client: David Schaeffer Engineering

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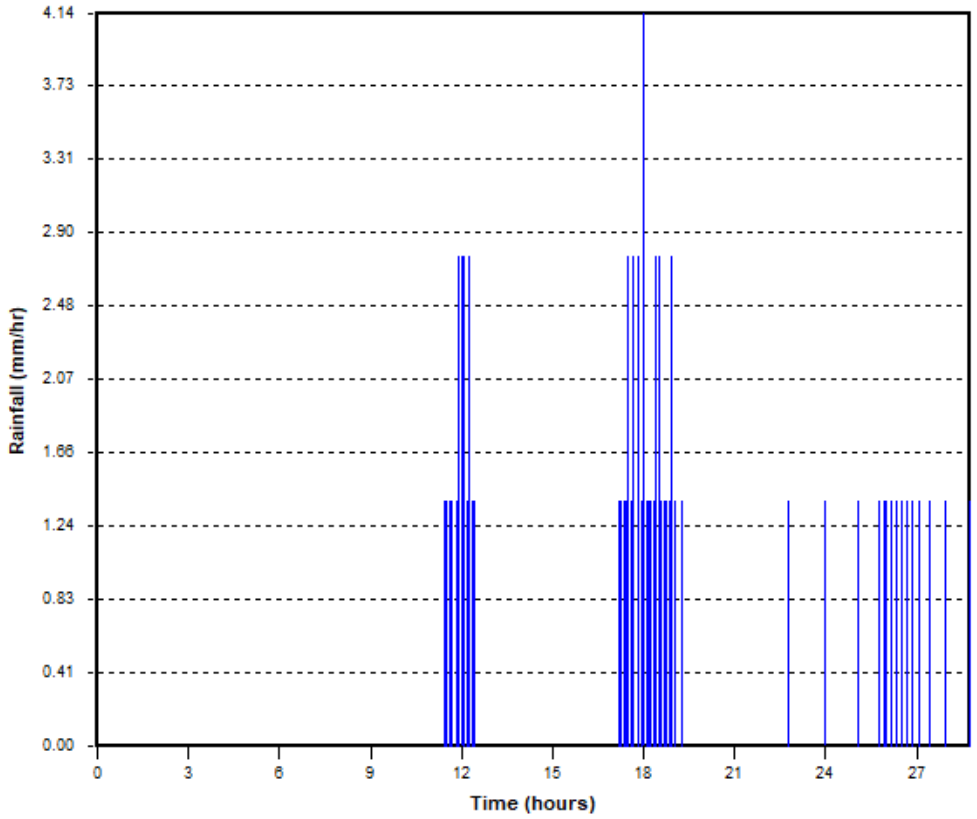
Appendix A

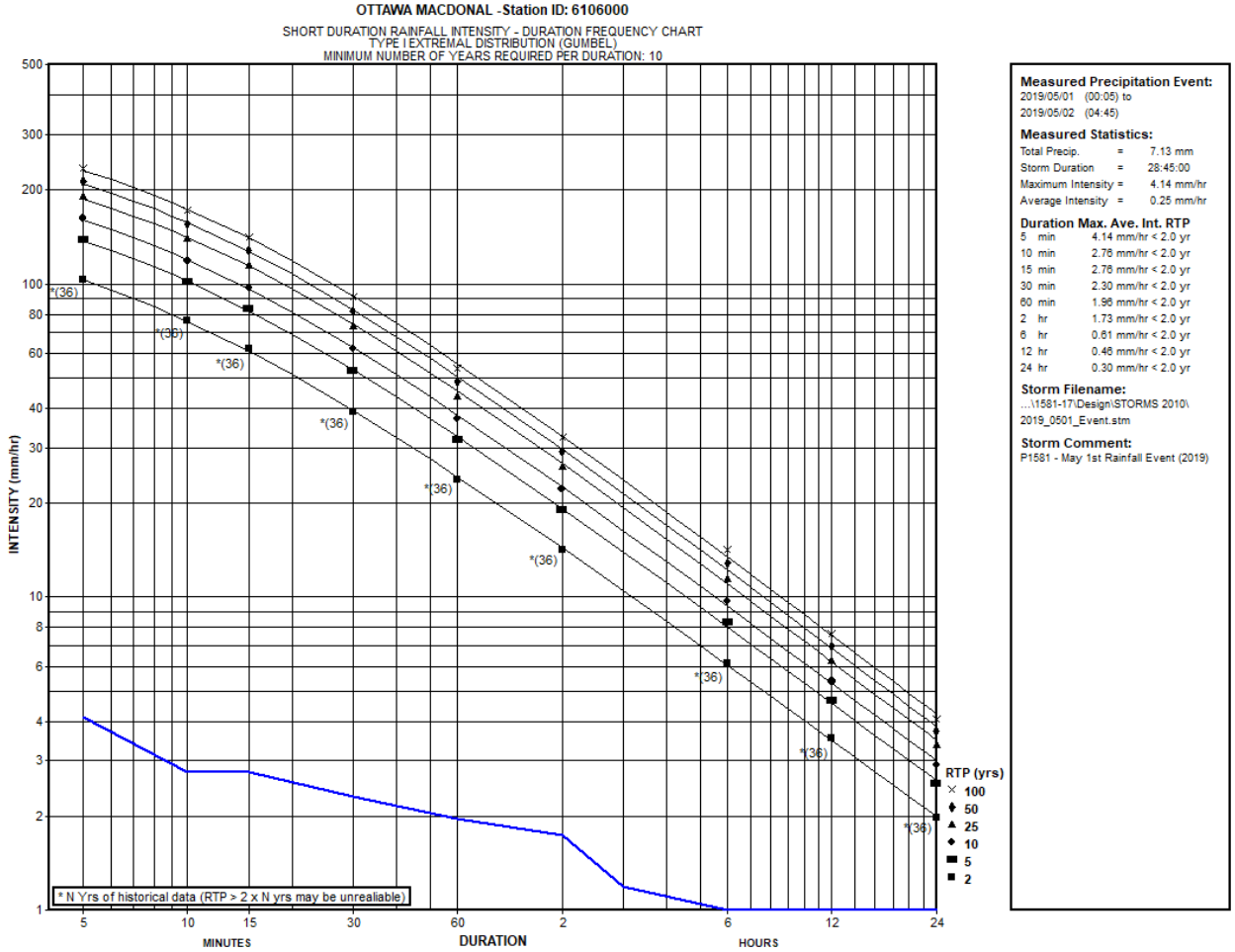
Rainfall Event Hyetographs and Comparison with IDF Curves

May 1st Rainfall Event (05/01/2019 00:00 – 05/01/2019 04:45)

Total Precipitation = 7.13 mm
Maximum Intensity 4.14 mm/hr
Average Intensity 0.25 mm/hr

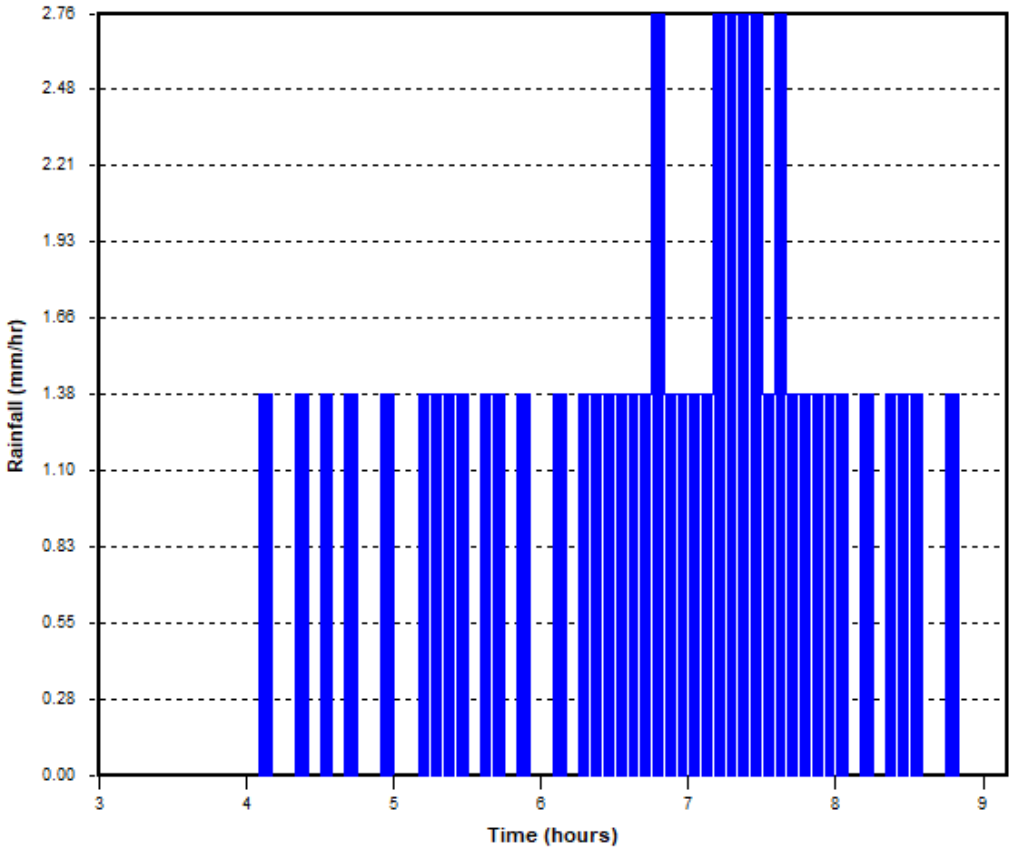


May 1st Duration Rainfall Intensity – Duration Frequency Chart (05/01/2019 00:00 – 05/01/2019 04:45)

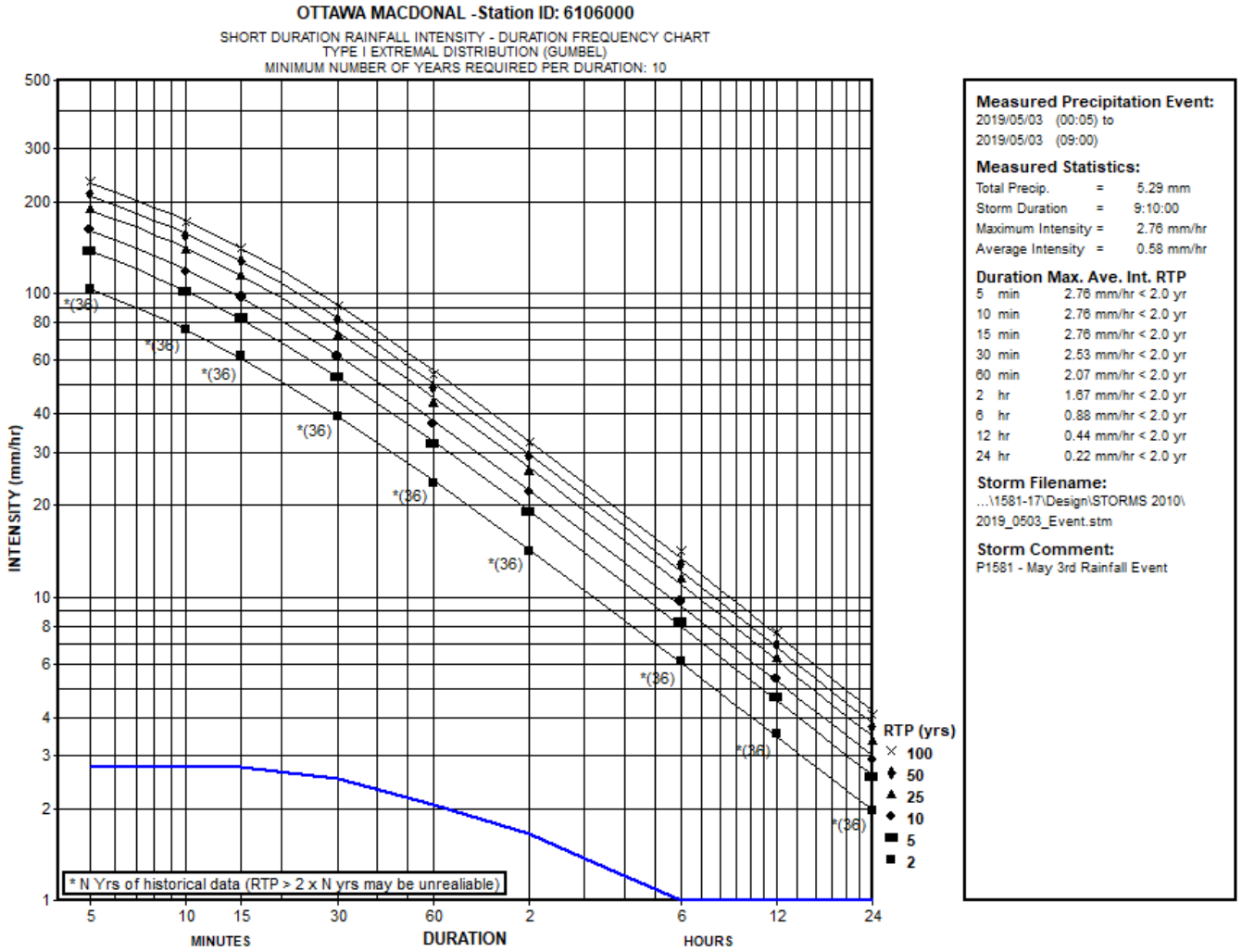


May 3rd Rainfall Event (05/03/2019 00:00 – 05/03/2019 09:00)

Total Precipitation = 5.29 mm
Maximum Intensity 2.76 mm/hr
Average Intensity 0.60 mm/hr

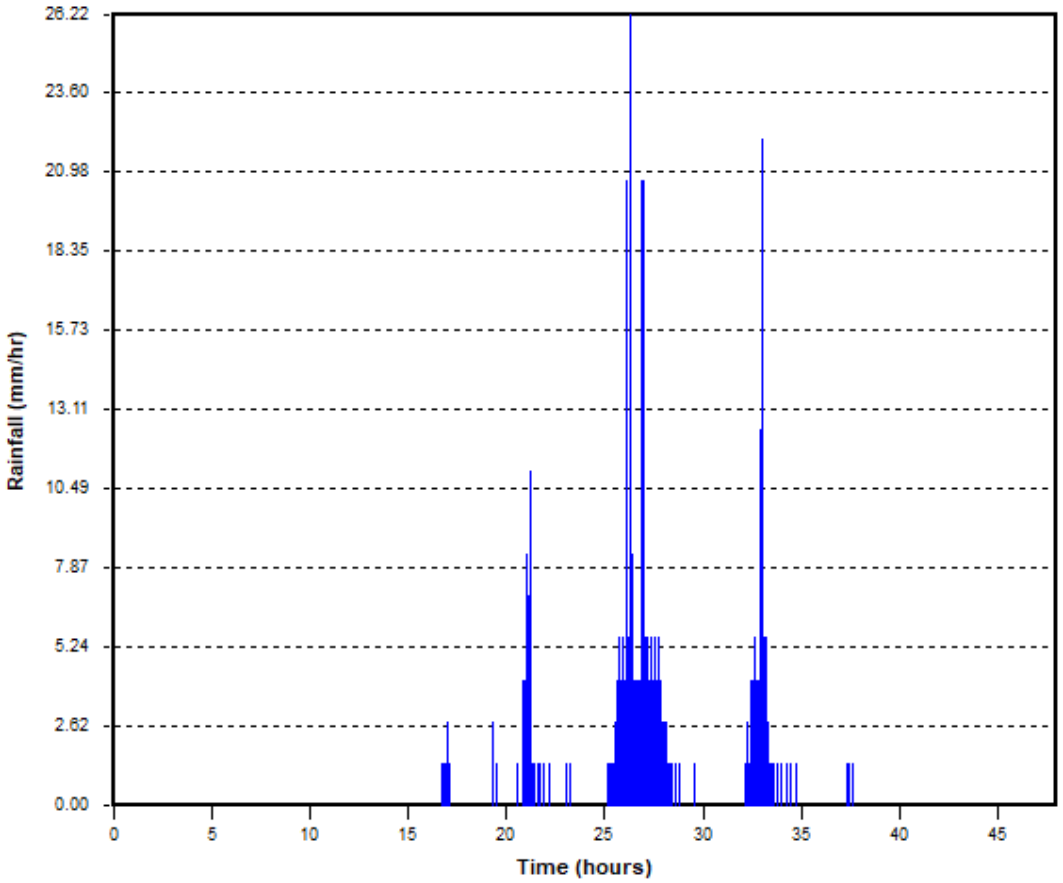


May 3rd Duration Rainfall Intensity – Duration Frequency Chart (05/03/2019 00:00 – 05/03/2019 09:00)

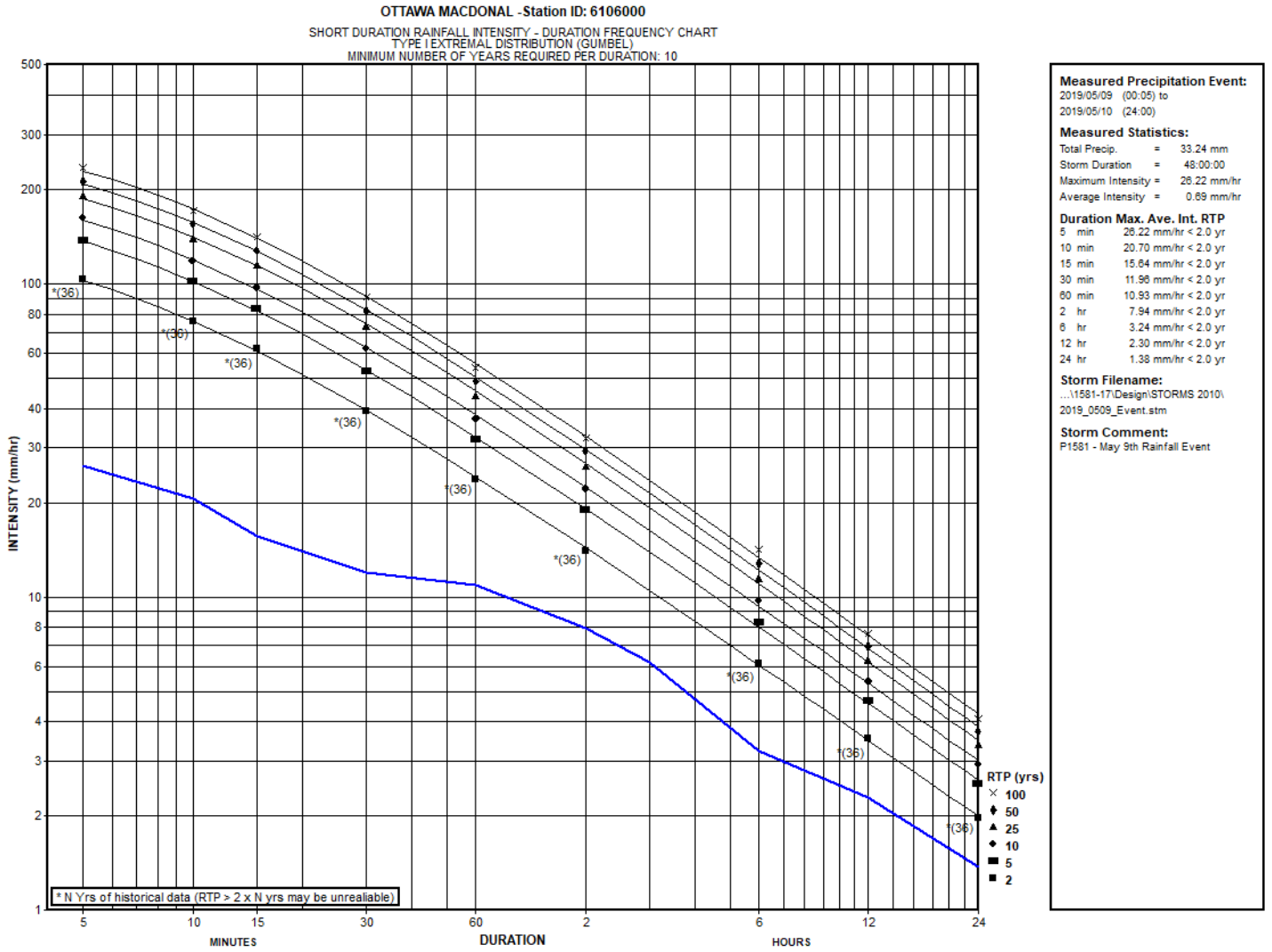


May 9th Rainfall Event (05/09/2019 00:00 – 05/10/2019 24:00)

Total Precipitation = 33.24 mm
Maximum Intensity = 26.22 mm/hr
Average Intensity = 0.69 mm/hr

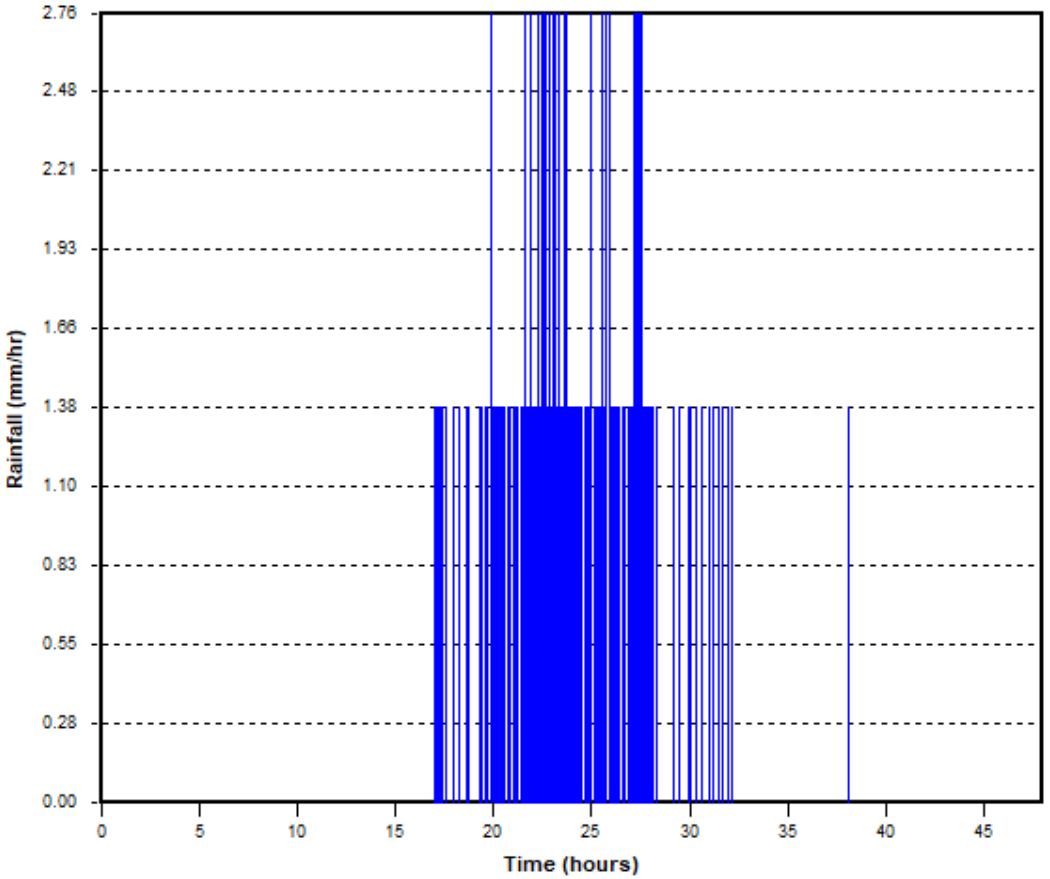


May 9th Duration Rainfall Intensity – Duration Frequency Chart (05/09/2019 00:00 – 05/10/2019 24:00)

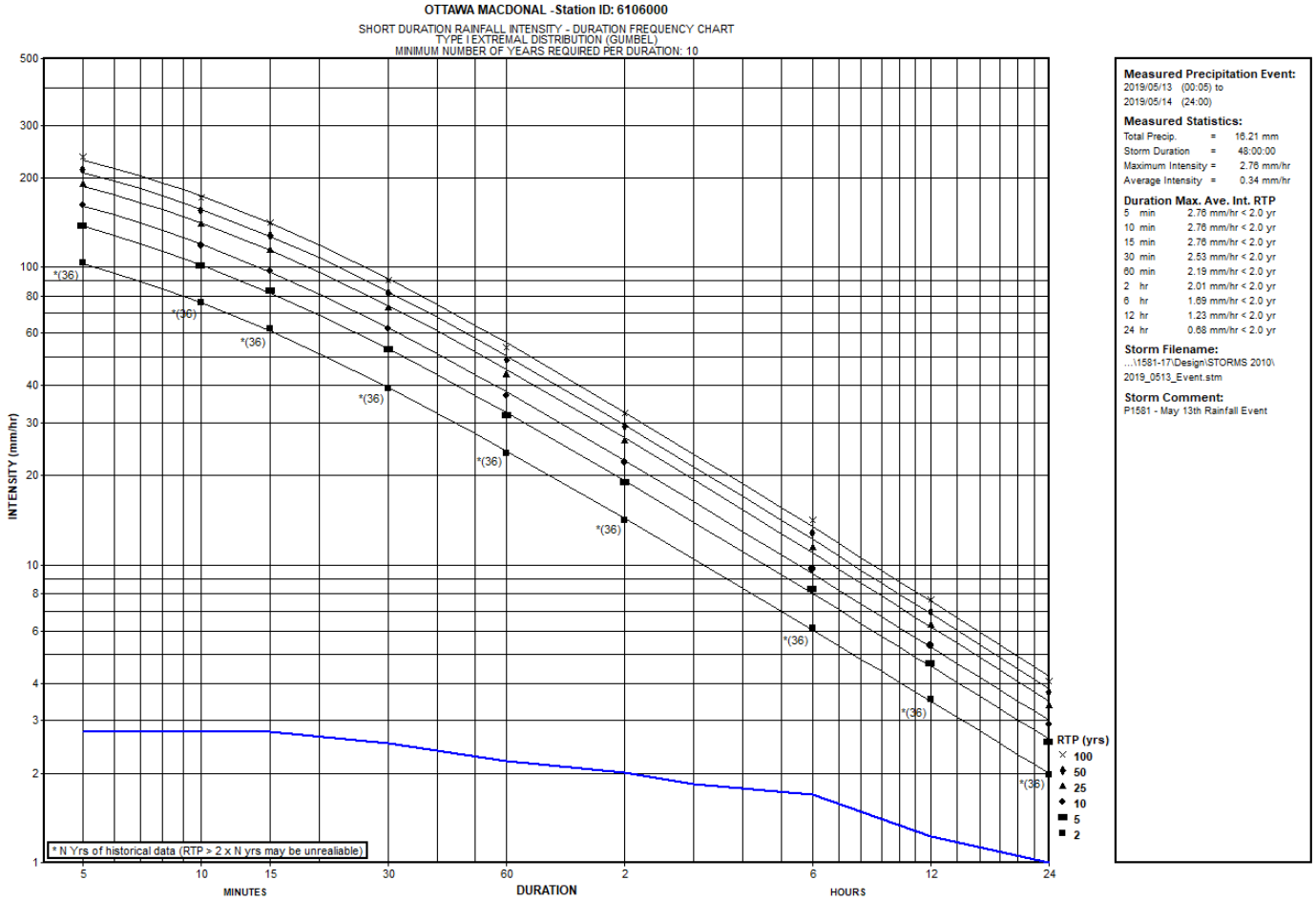


May 13th Rainfall Event (05/13/2019 00:00 – 05/14/2019 24:00)

Total Precipitation = 16.21 mm
Maximum Intensity = 2.76 mm/hr
Average Intensity = 0.34 mm/hr

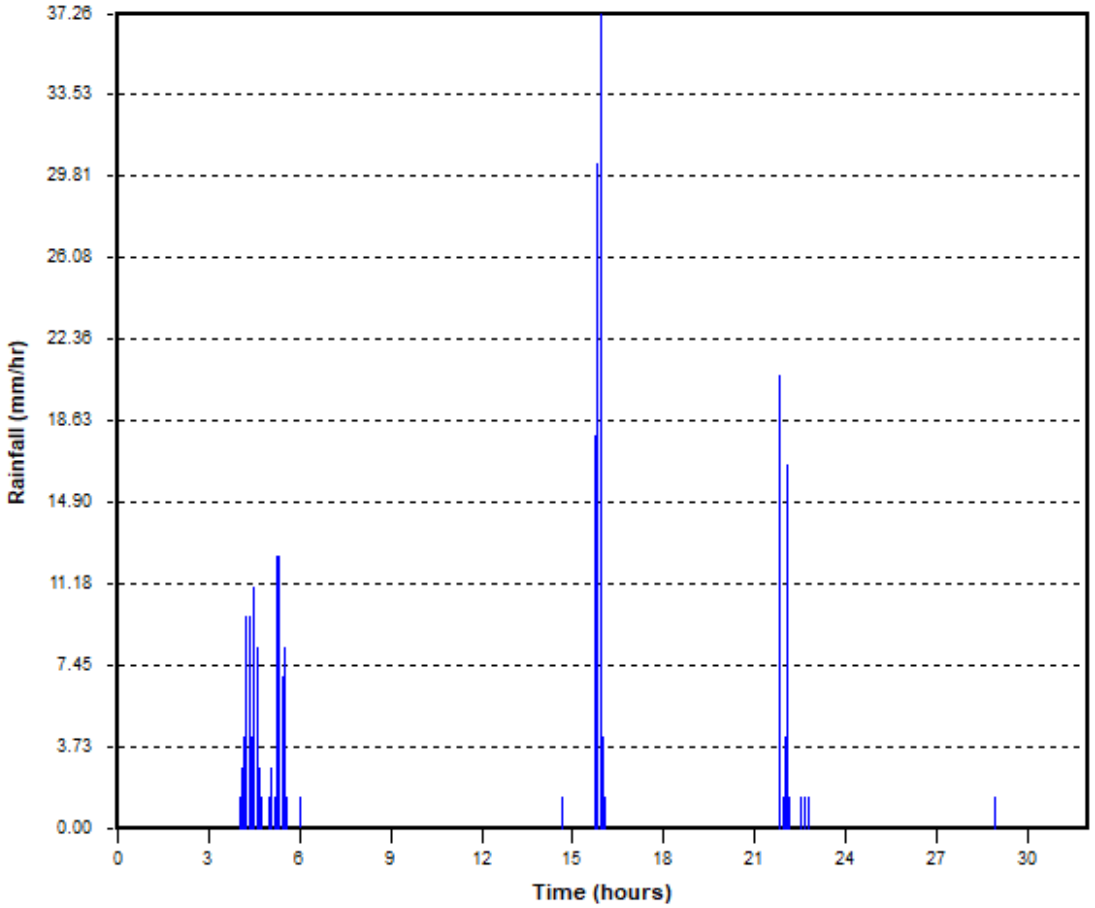


May 13th Duration Rainfall Intensity – Duration Frequency Chart (05/13/2019 00:00 – 05/14/2019 24:00)

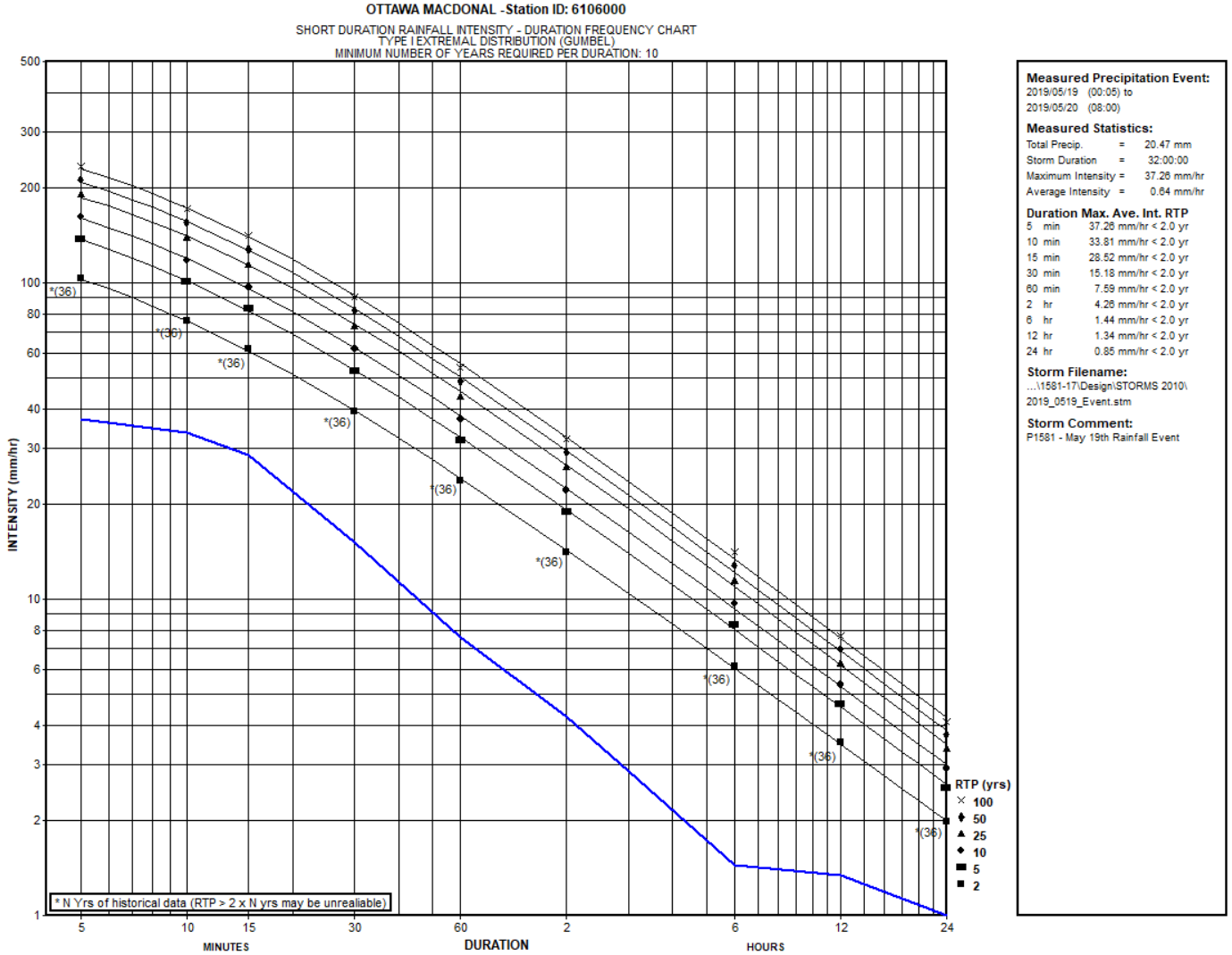


May 19th Rainfall Event (05/19/2019 00:00 – 05/20/2019 8:00)

Total Precipitation = 20.47 mm
Maximum Intensity = 37.26 mm/hr
Average Intensity = 0.64 mm/hr

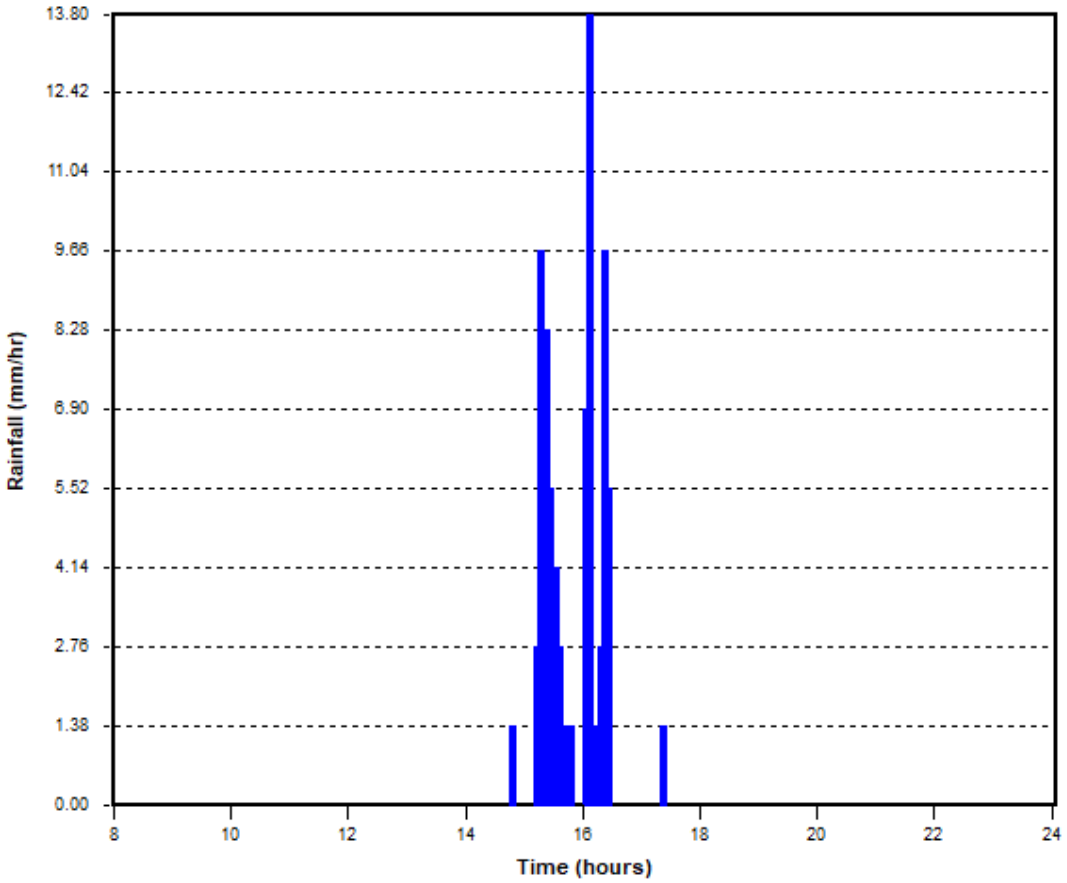


May 19th Duration Rainfall Intensity – Duration Frequency Chart (05/19/2019 00:00 – 05/20/2019 8:00)

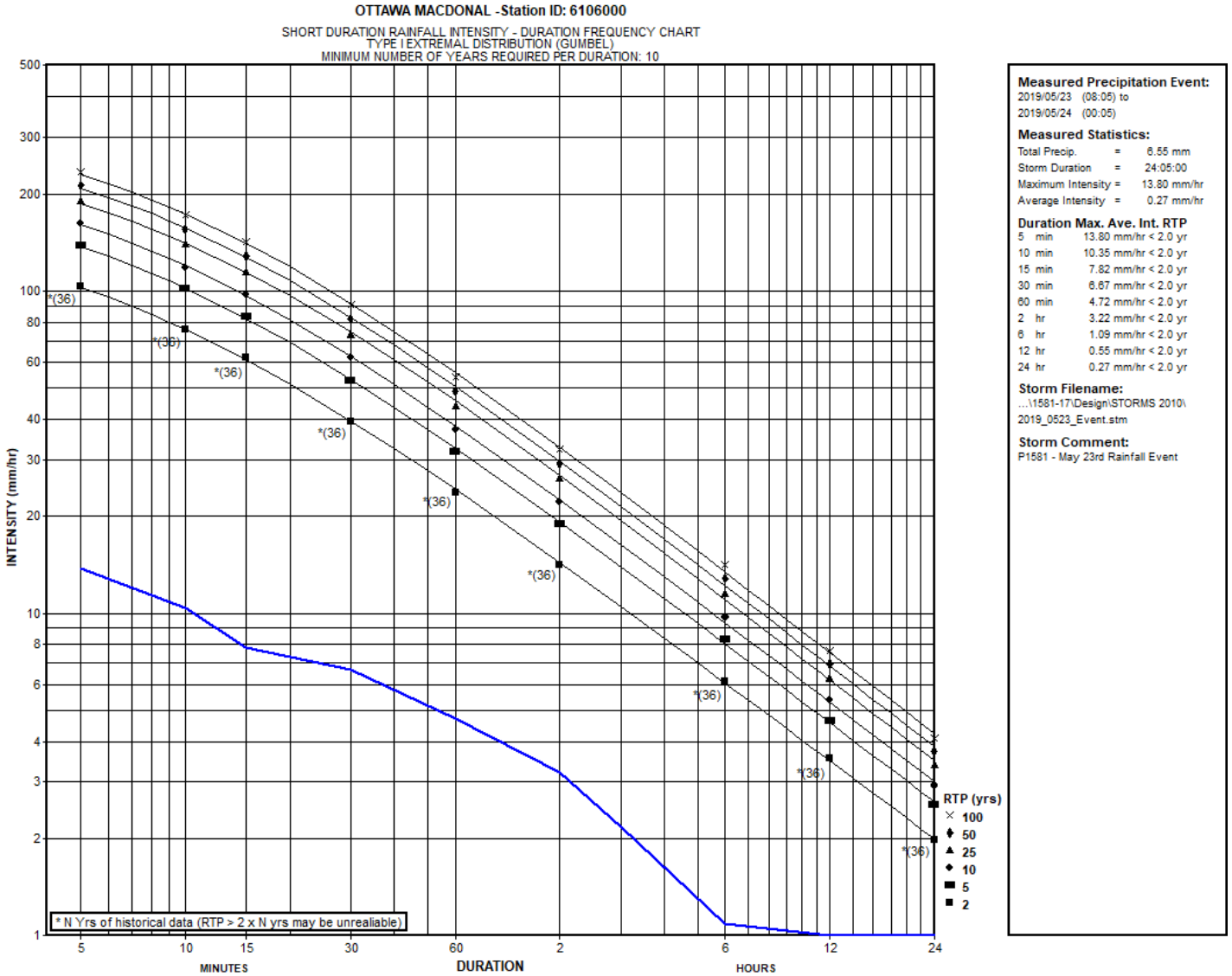


May 23rd Rainfall Event (05/23/2019 8:00 – 05/23/2019 24:00)

Total Precipitation = 6.55 mm
Maximum Intensity = 13.80 mm/hr
Average Intensity = 0.27 mm/hr

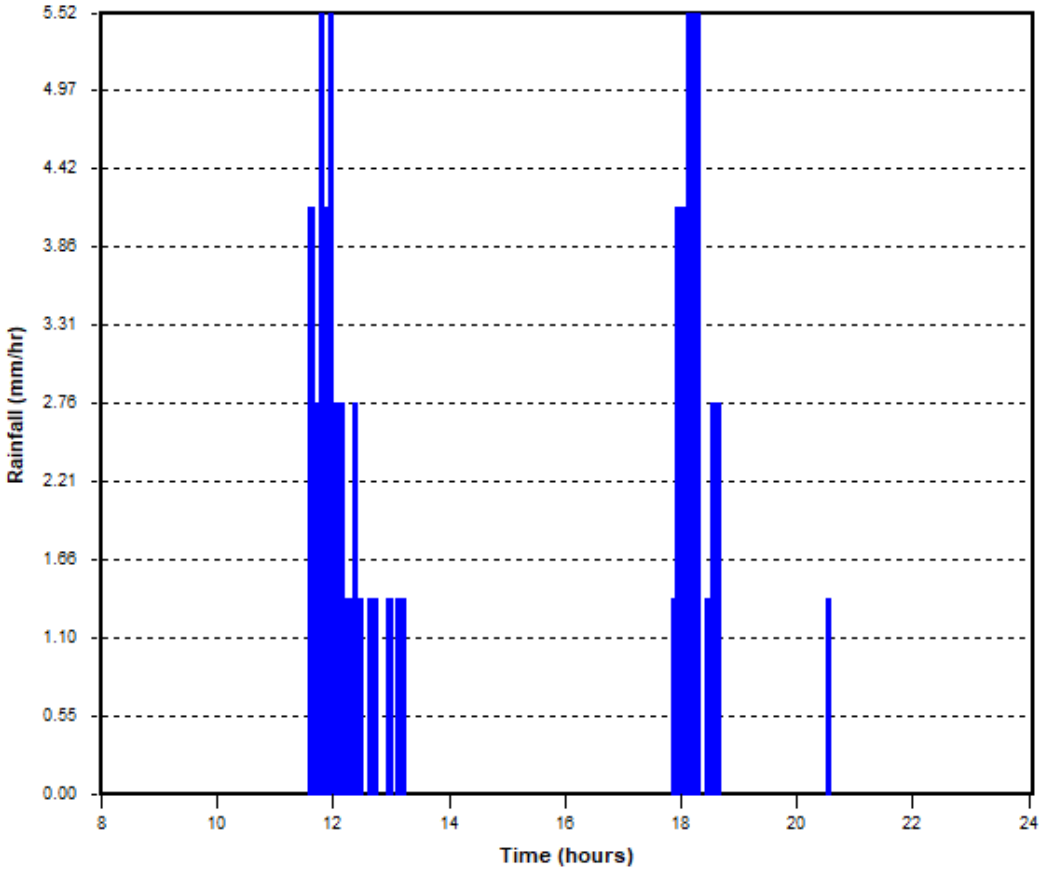


May 23rd Duration Rainfall Intensity – Duration Frequency Chart (05/23/2019 08:00 – 05/23/2019 24:00)

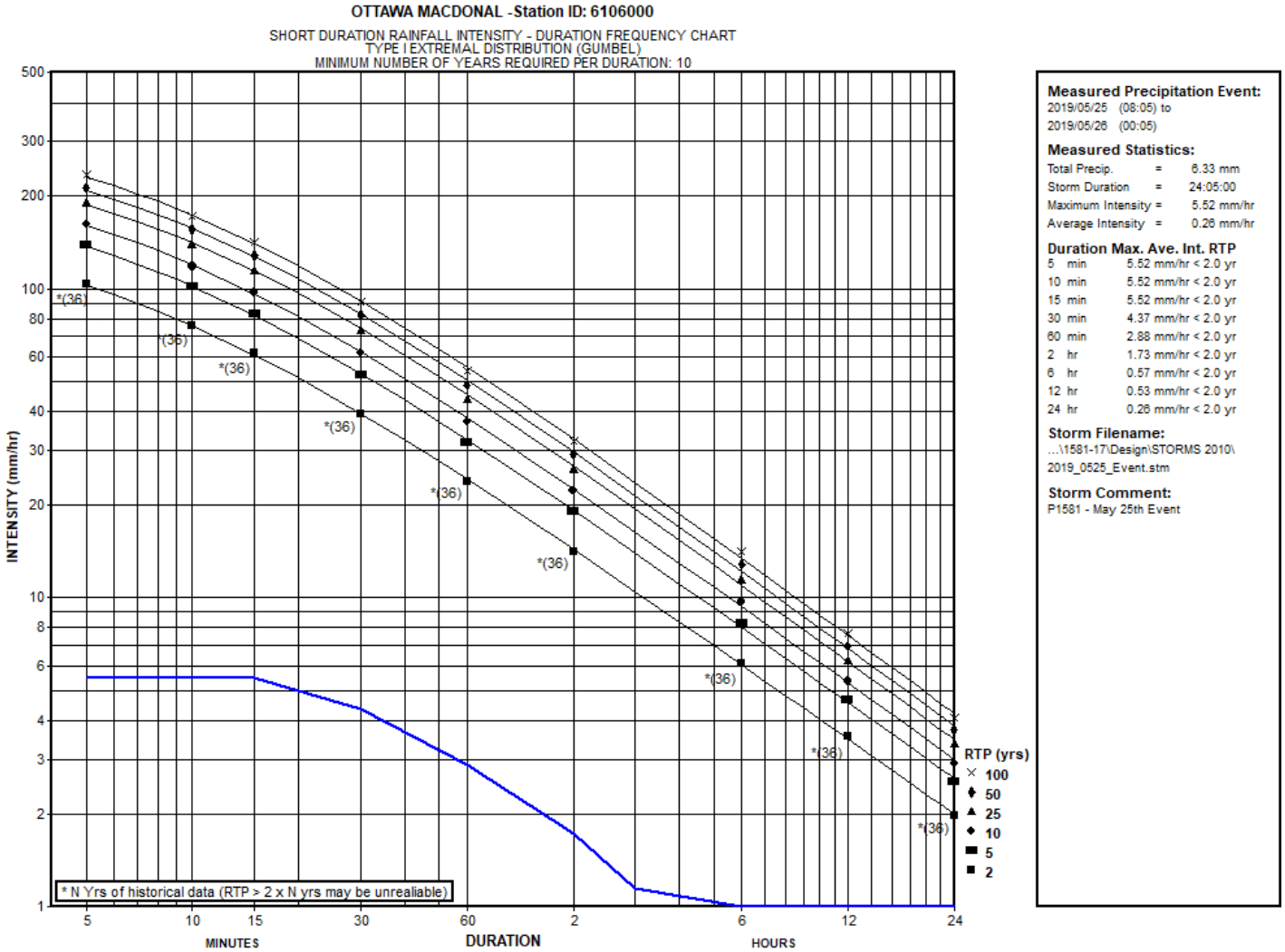


May 25th Rainfall Event (05/25/2019 8:00 – 05/26/2019 00:00)

Total Precipitation = 6.33 mm
Maximum Intensity = 5.52 mm/hr
Average Intensity = 0.26 mm/hr

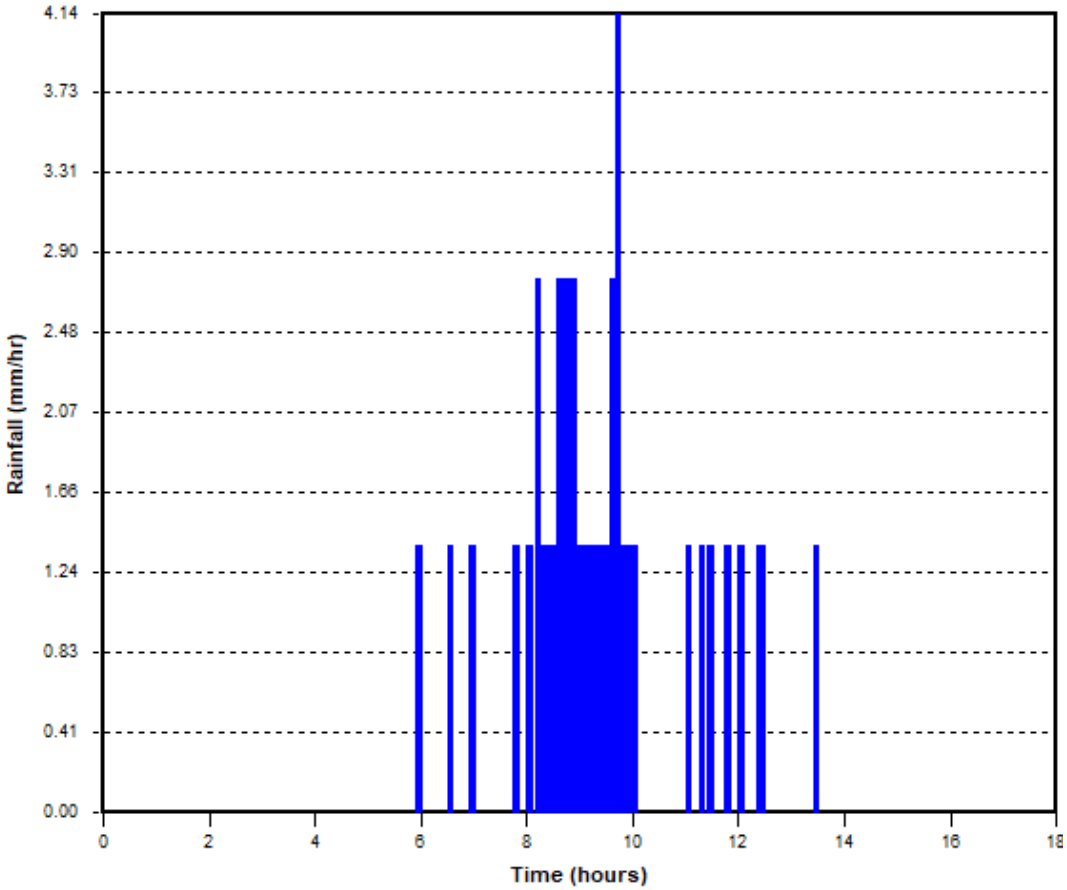


May 25th Duration Rainfall Intensity – Duration Frequency Chart (05/25/2019 08:00 – 05/26/2019 00:00)

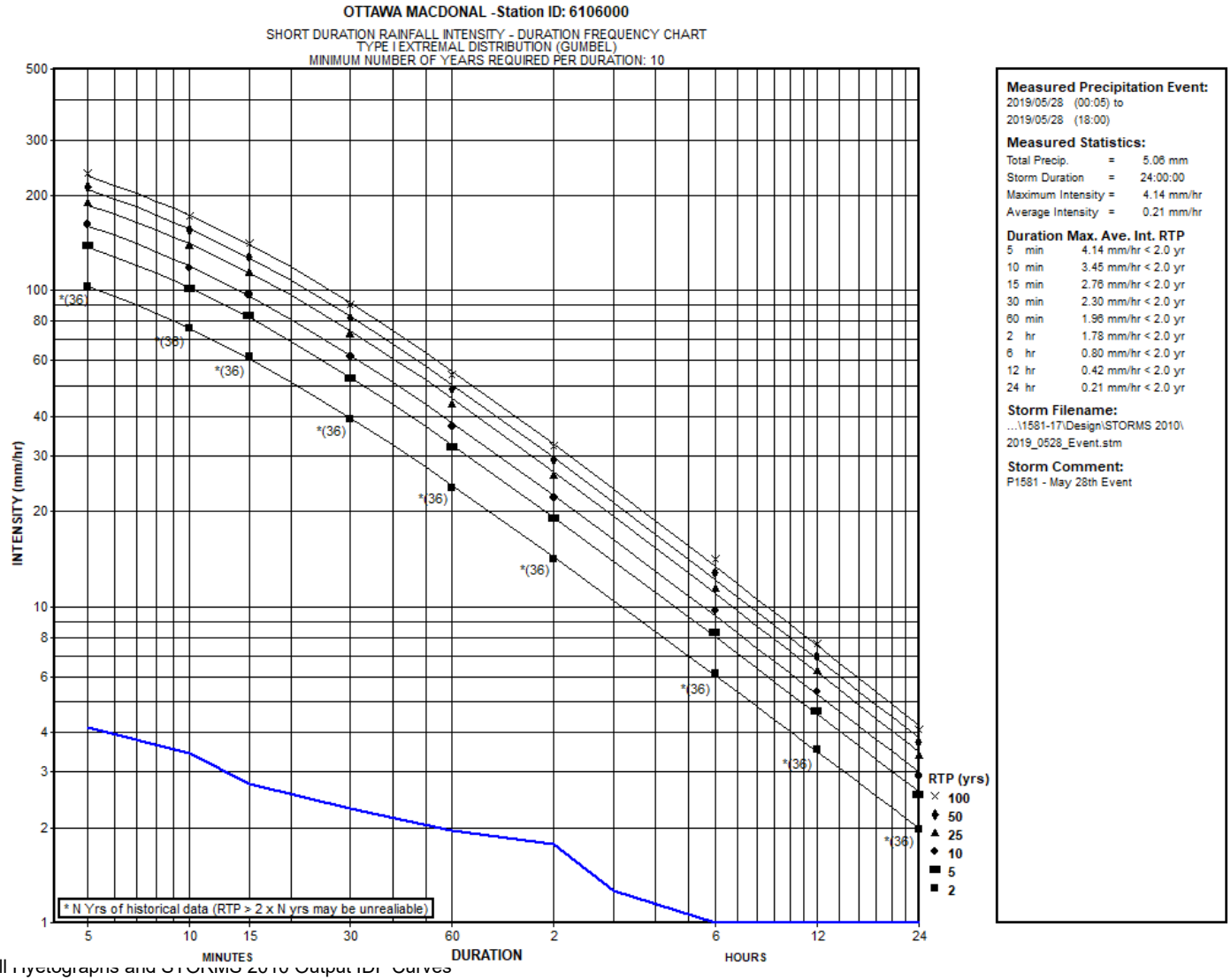


May 28th Rainfall Event (05/28/2019 00:00 – 05/28/2019 18:00)

Total Precipitation = 5.06 mm
Maximum Intensity = 4.14 mm/hr
Average Intensity = 0.21 mm/hr

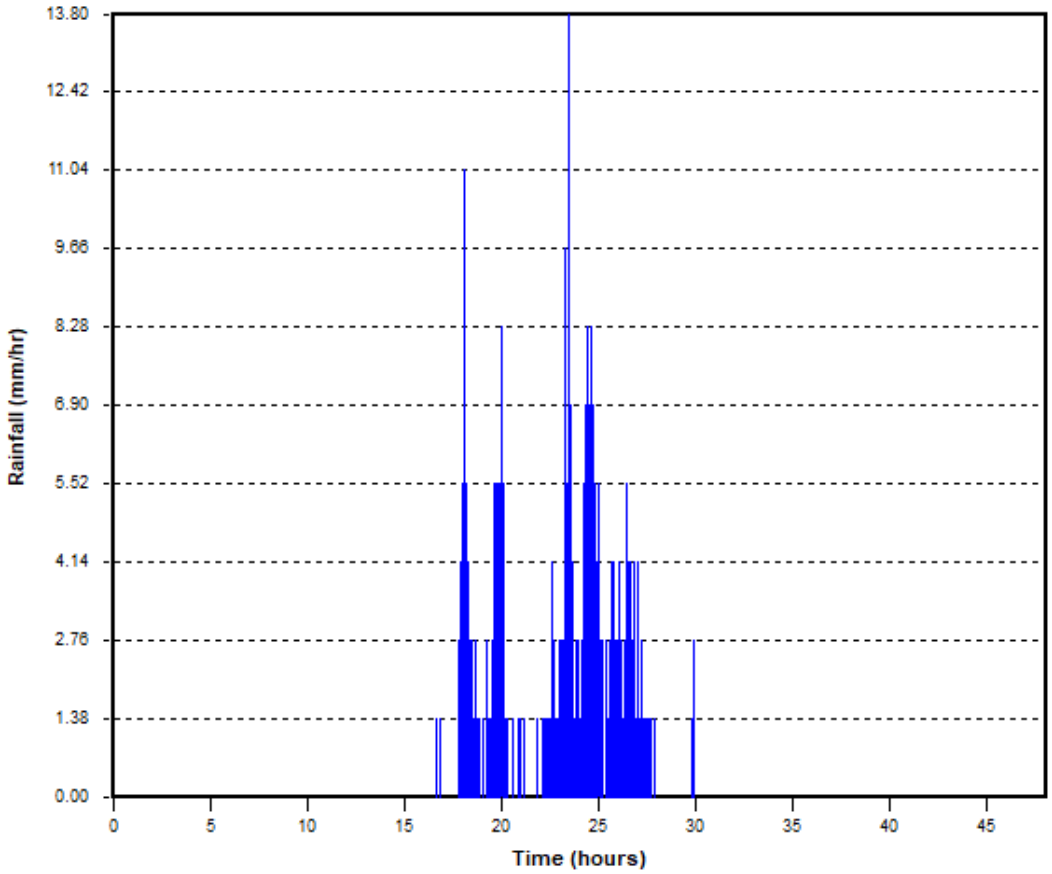


May 28th Duration Rainfall Intensity – Duration Frequency Chart (05/28/2019 00:00 – 05/28/2019 18:00)

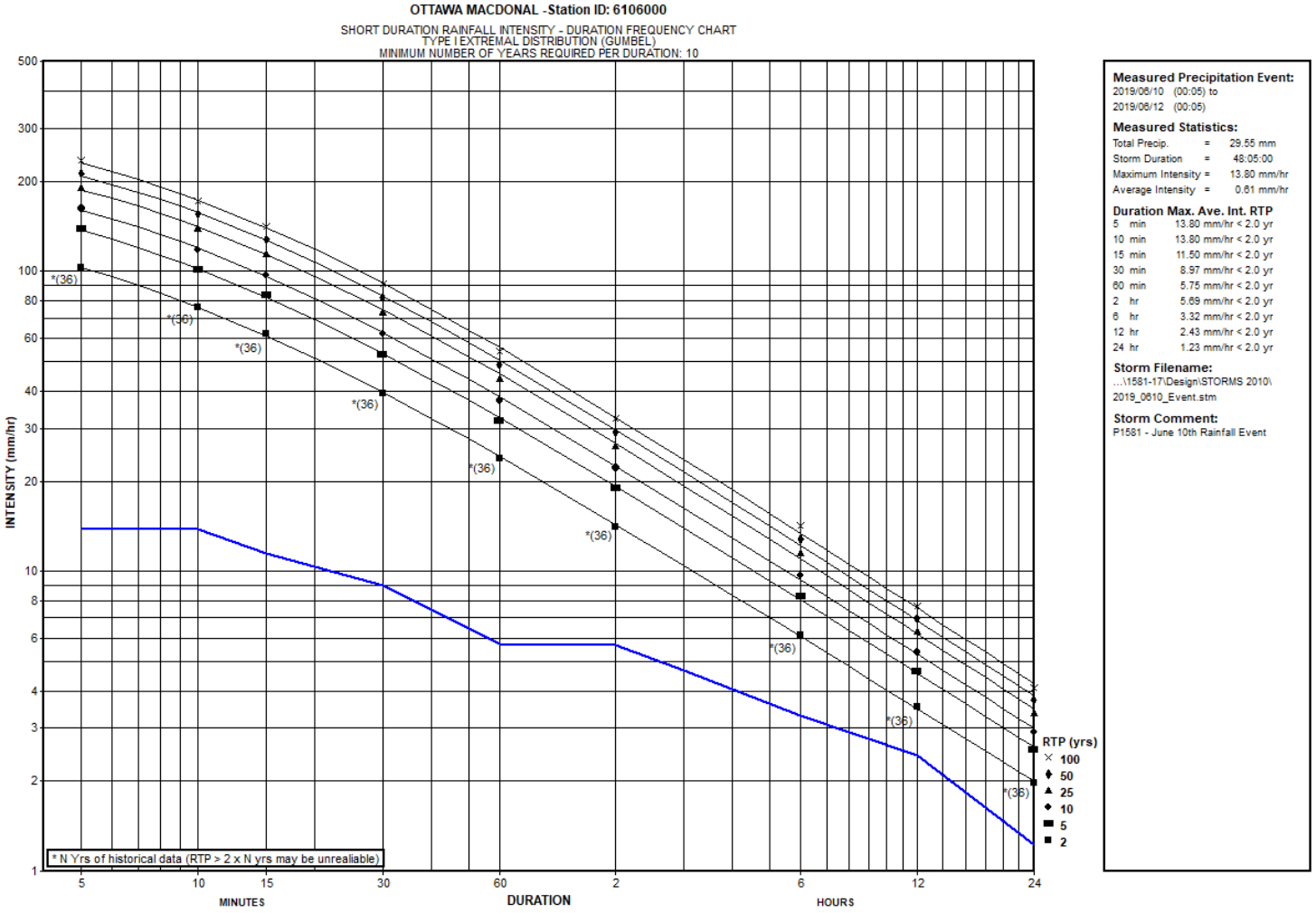


June 10th Rainfall Event (06/10/2019 00:00 – 06/12/2019 00:00)

Total Precipitation = 29.55 mm
Maximum Intensity = 13.80 mm/hr
Average Intensity = 0.61 mm/hr

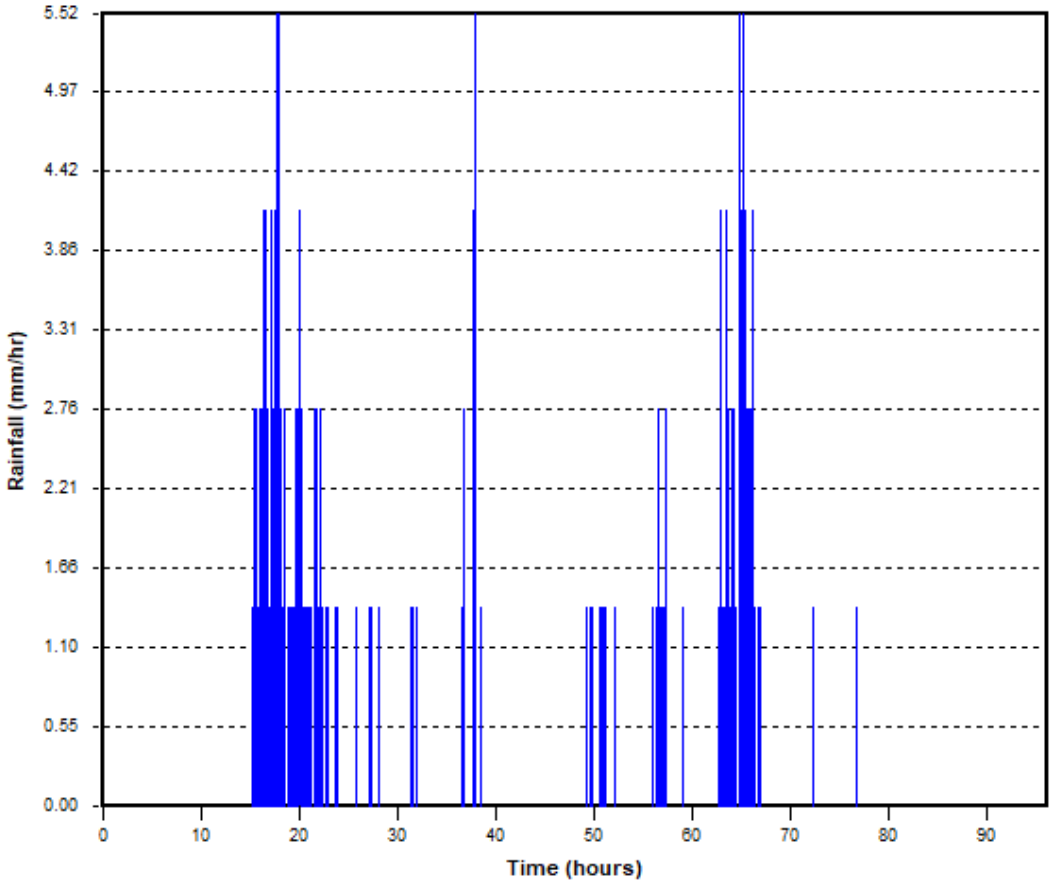


June 10th Duration Rainfall Intensity – Duration Frequency Chart (06/10/2019 00:00 – 06/12/2019 00:00)

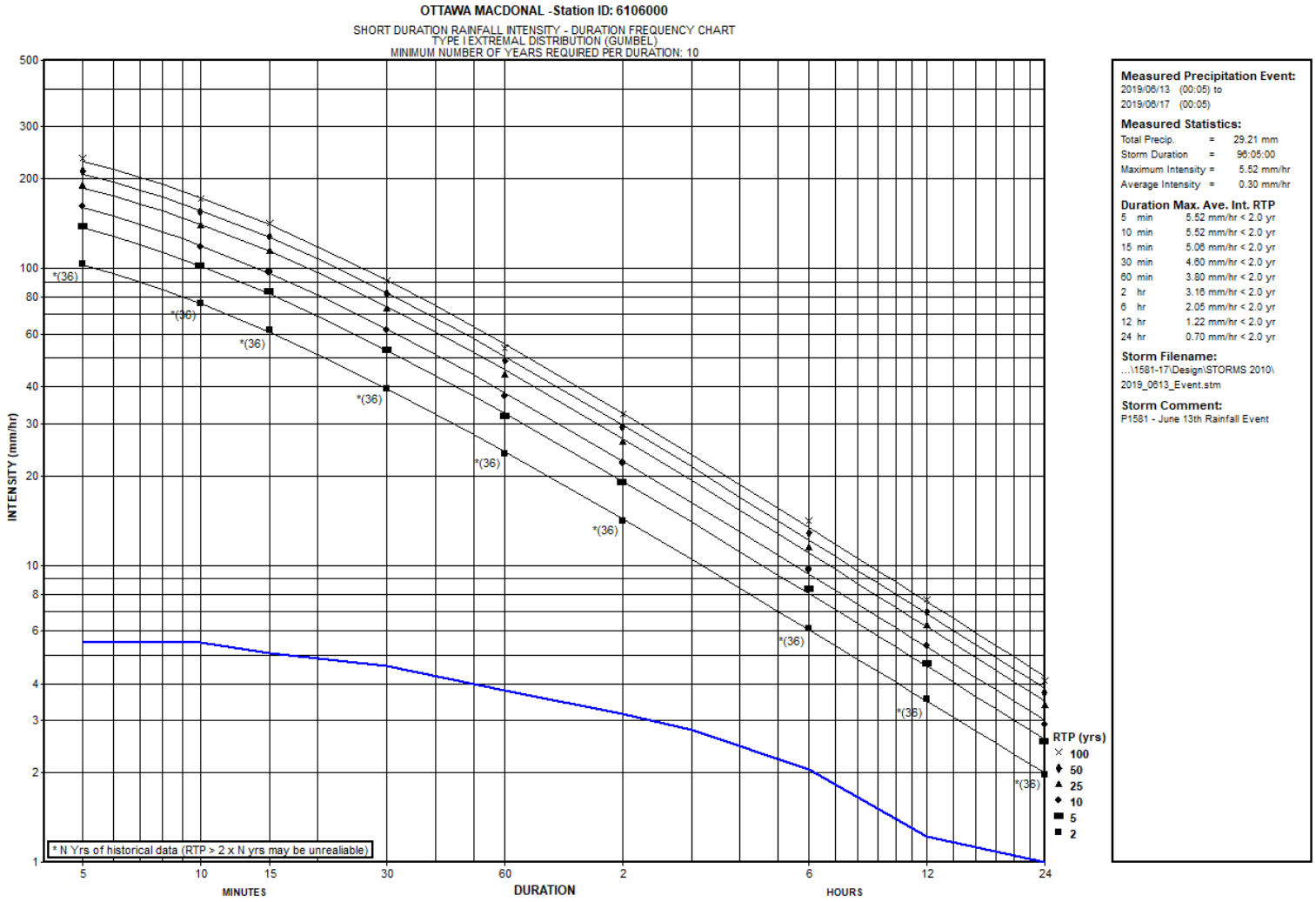


June 13th Rainfall Event (06/13/2019 00:00 – 06/17/2019 00:00)

Total Precipitation = 29.31 mm
Maximum Intensity = 5.52 mm/hr
Average Intensity = 0.30 mm/hr

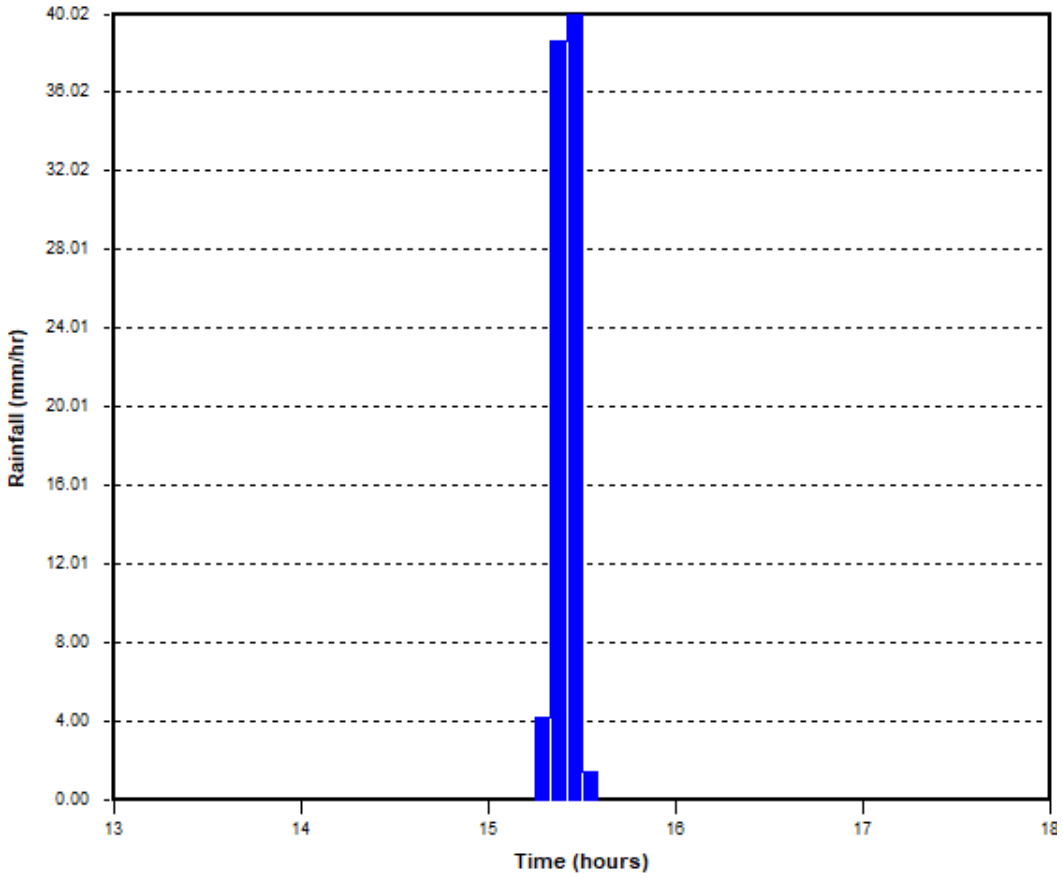


June 13th Duration Rainfall Intensity – Duration Frequency Chart (06/13/2019 00:00 – 06/17/2019 00:00)

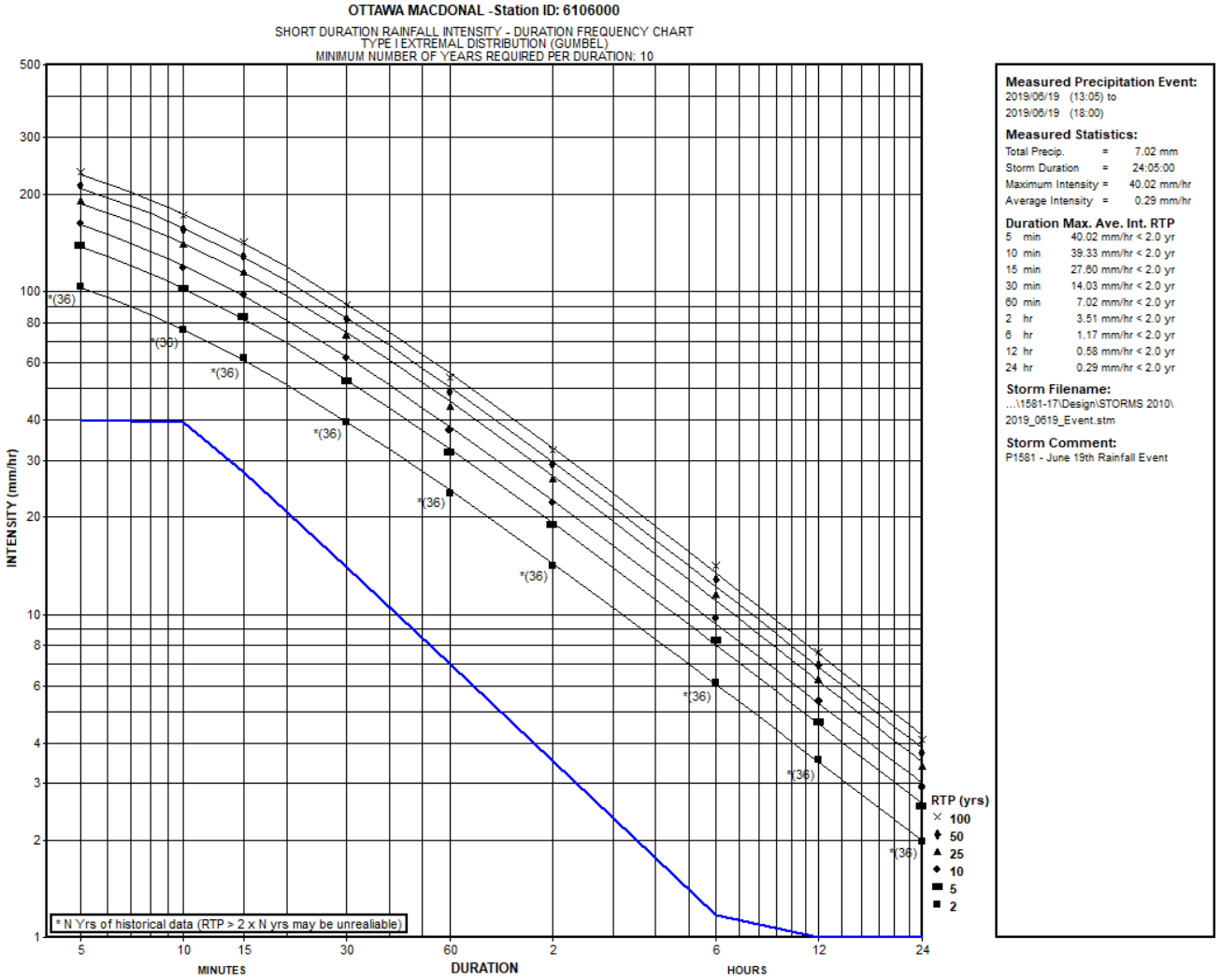


June 19th Rainfall Event (06/19/2019 13:00 – 06/19/2019 18:00)

Total Precipitation = 7.02 mm
Maximum Intensity = 40.02 mm/hr
Average Intensity = 0.29 mm/hr

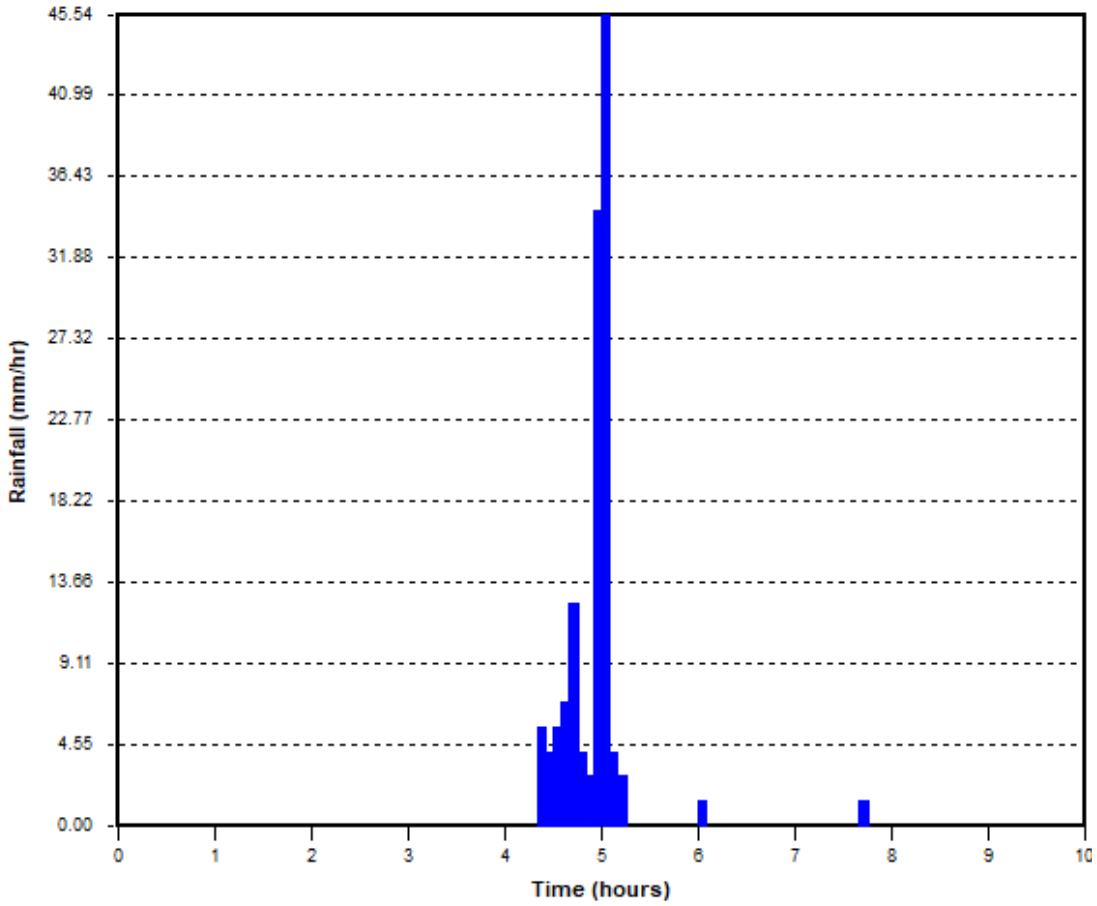


June 19th Duration Rainfall Intensity – Duration Frequency Chart (06/19/2019 13:00 – 06/19/2019 18:00)

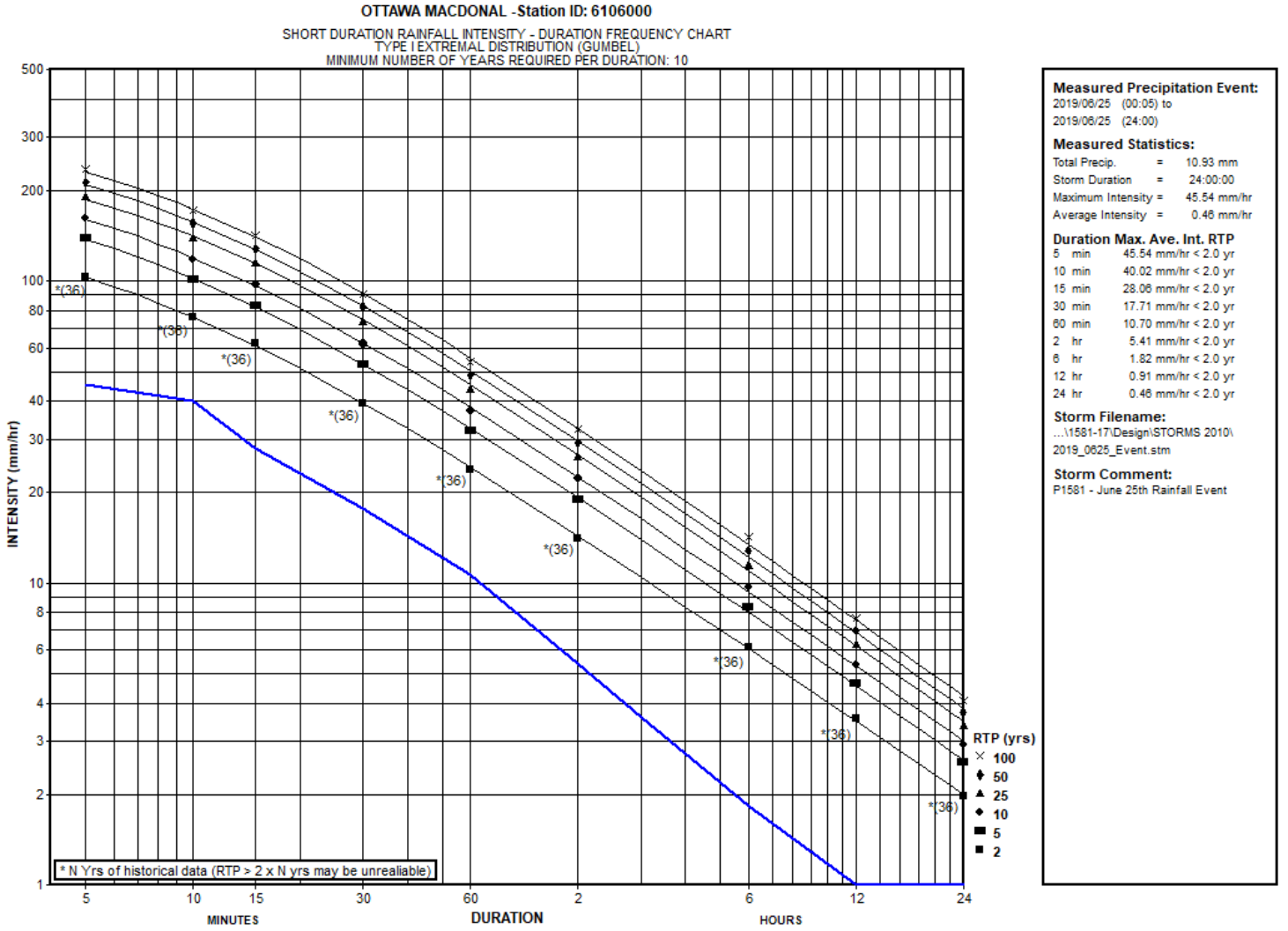


June 25th Rainfall Event (06/25/2019 00:00 – 06/25/2019 24:00)

Total Precipitation = 10.93mm
Maximum Intensity = 45.54 mm/hr
Average Intensity = 0.46 mm/hr

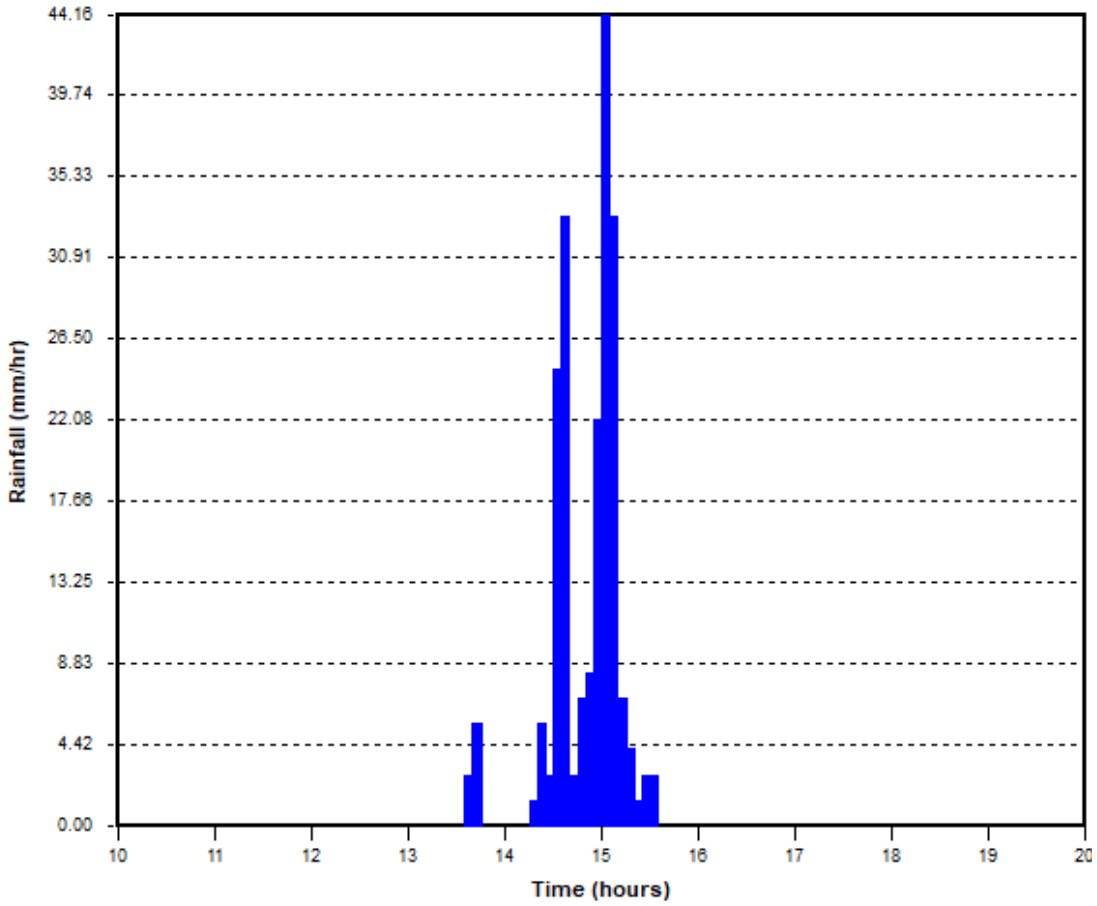


June 25th Duration Rainfall Intensity – Duration Frequency Chart (06/25/2019 00:00 – 06/25/2019 24:00)

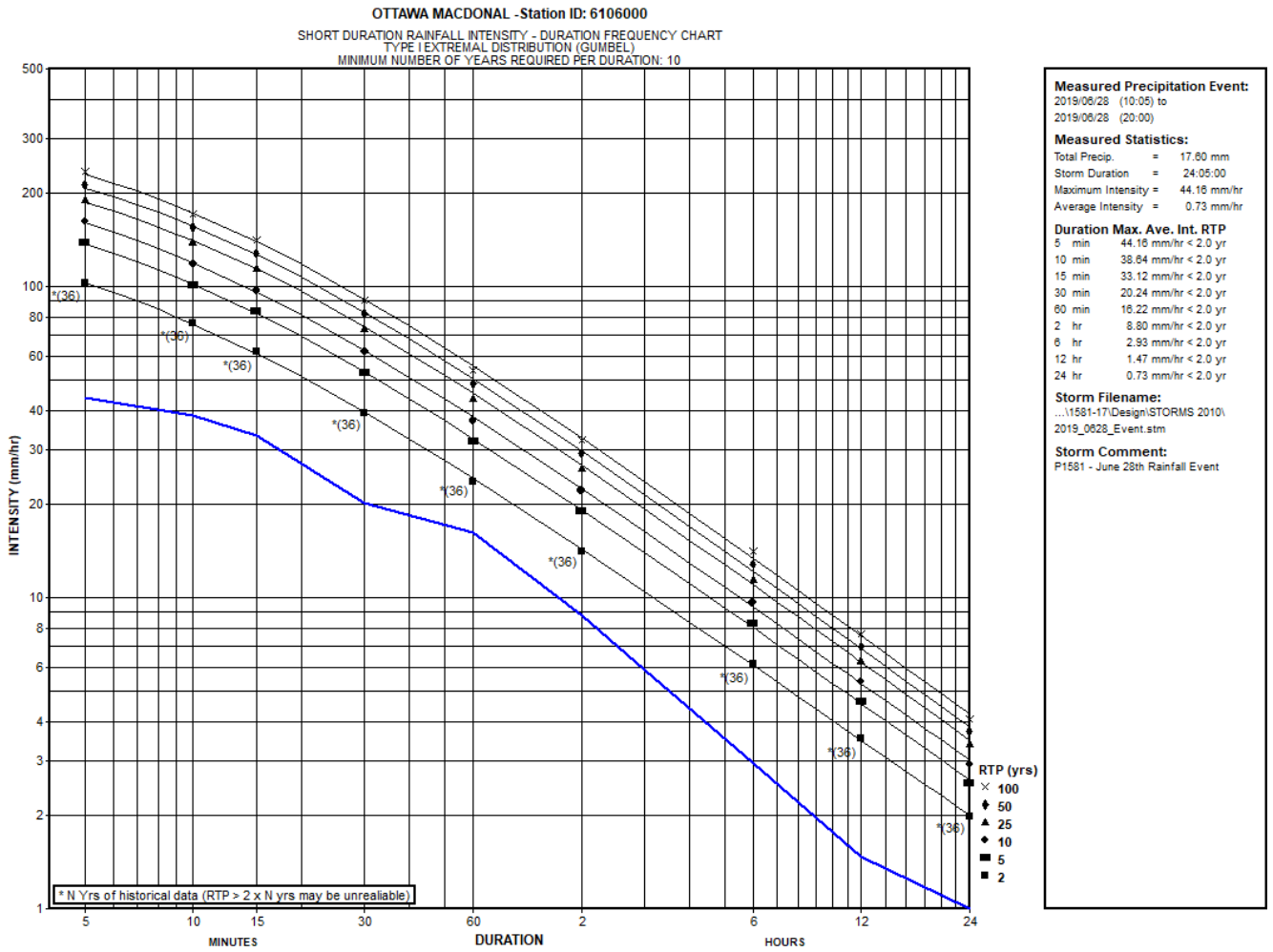


June 28th Rainfall Event (06/28/2019 10:00 – 06/28/2019 20:00)

Total Precipitation = 17.60 mm
Maximum Intensity = 44.16 mm/hr
Average Intensity = 0.73 mm/hr

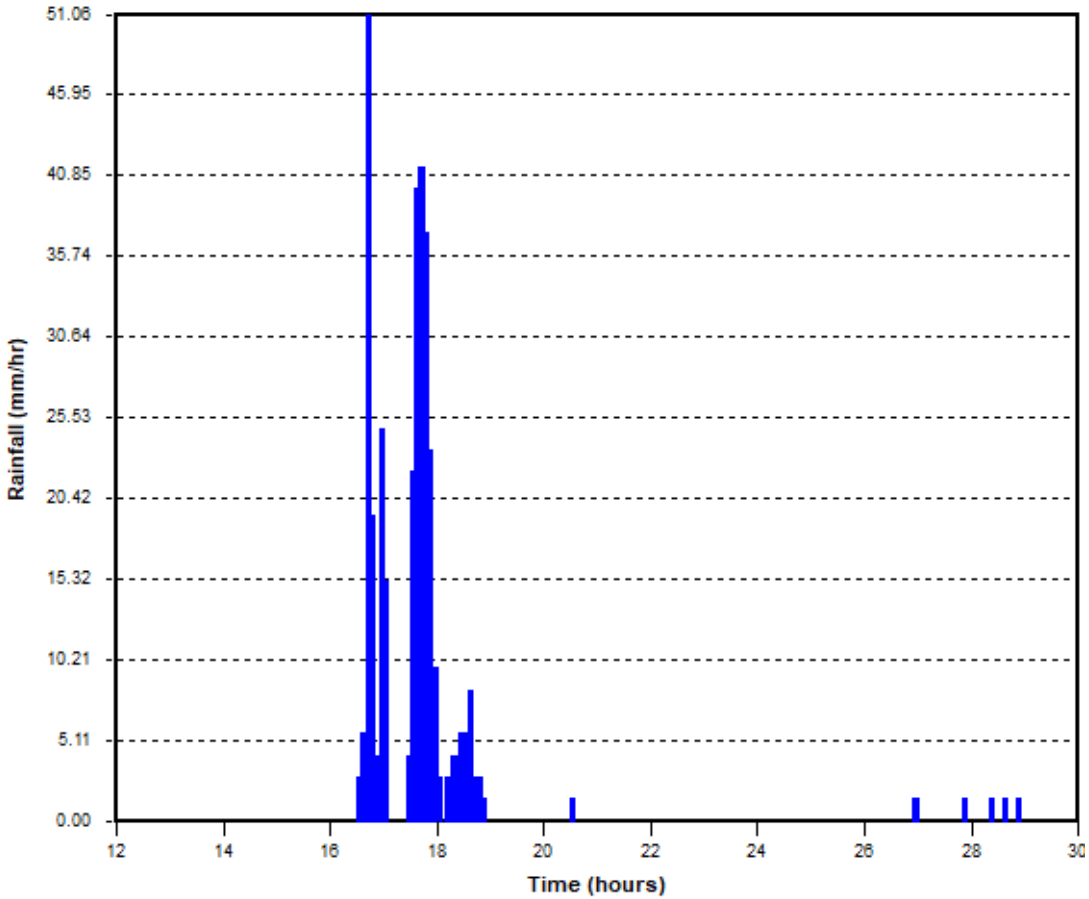


June 28th Duration Rainfall Intensity – Duration Frequency Chart (06/28/2019 00:00 – 06/28/2019 24:00)

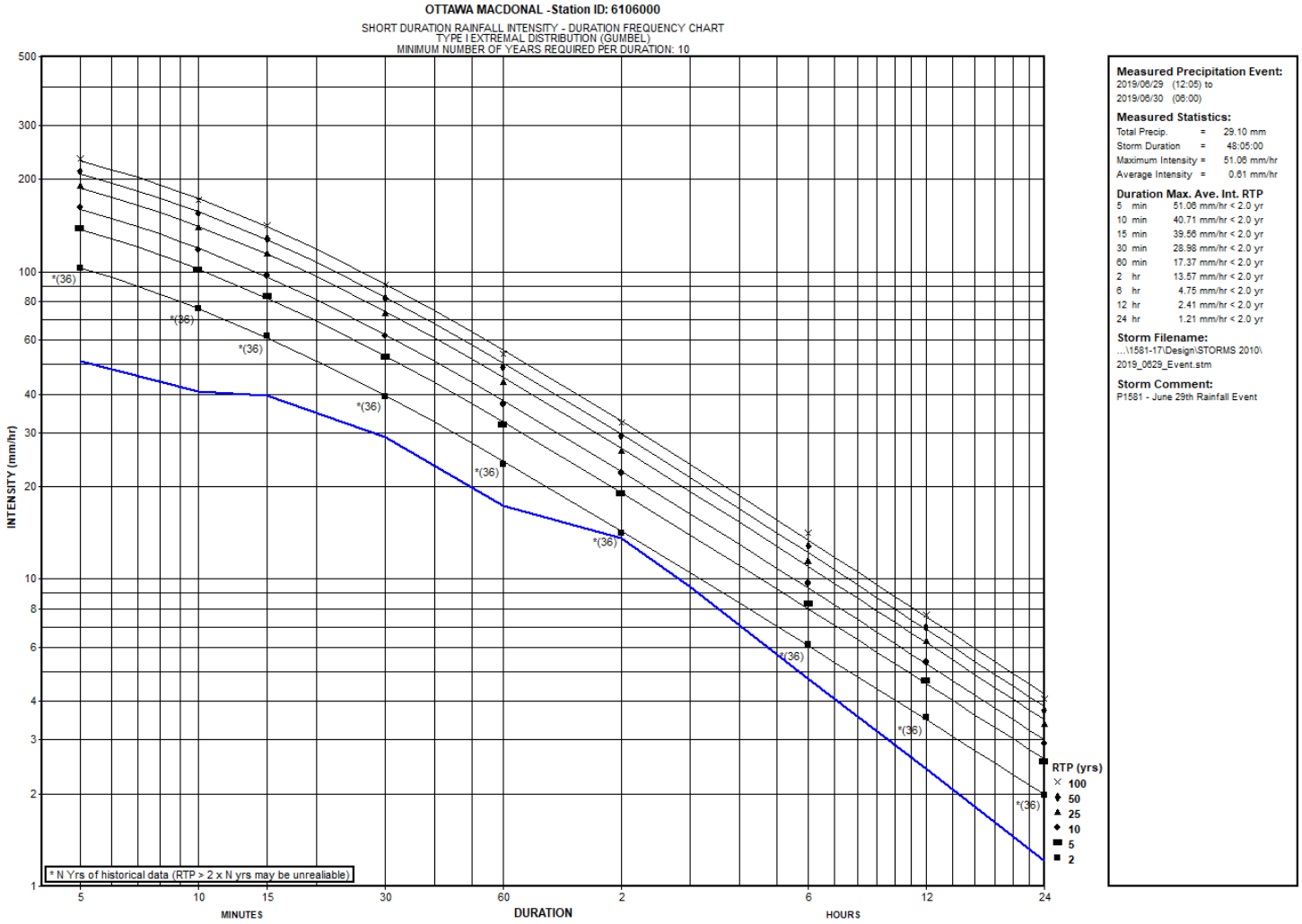


June 29th Rainfall Event (06/29/2019 12:00 – 06/30/2019 06:00)

Total Precipitation = 29.10 mm
Maximum Intensity = 51.06 mm/hr
Average Intensity = 0.61 mm/hr

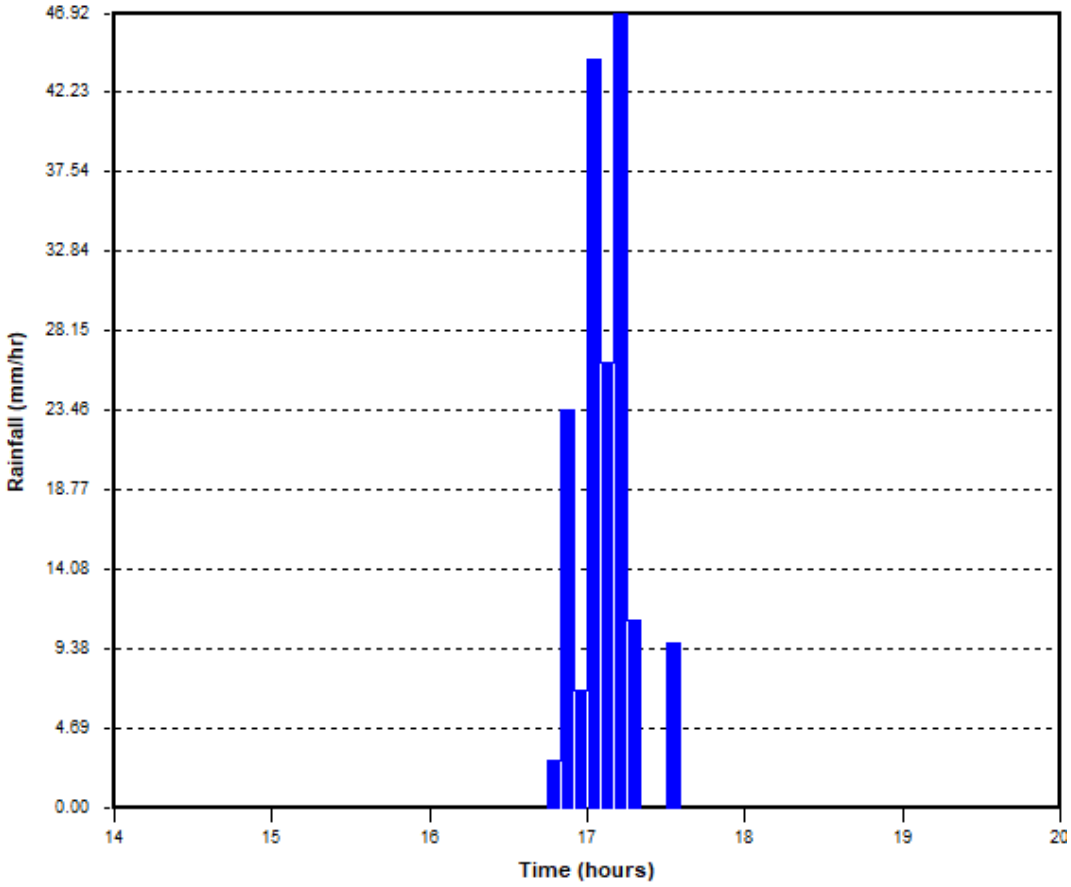


June 29th Duration Rainfall Intensity – Duration Frequency Chart (06/29/2019 12:00 – 06/30/2019 06:00)

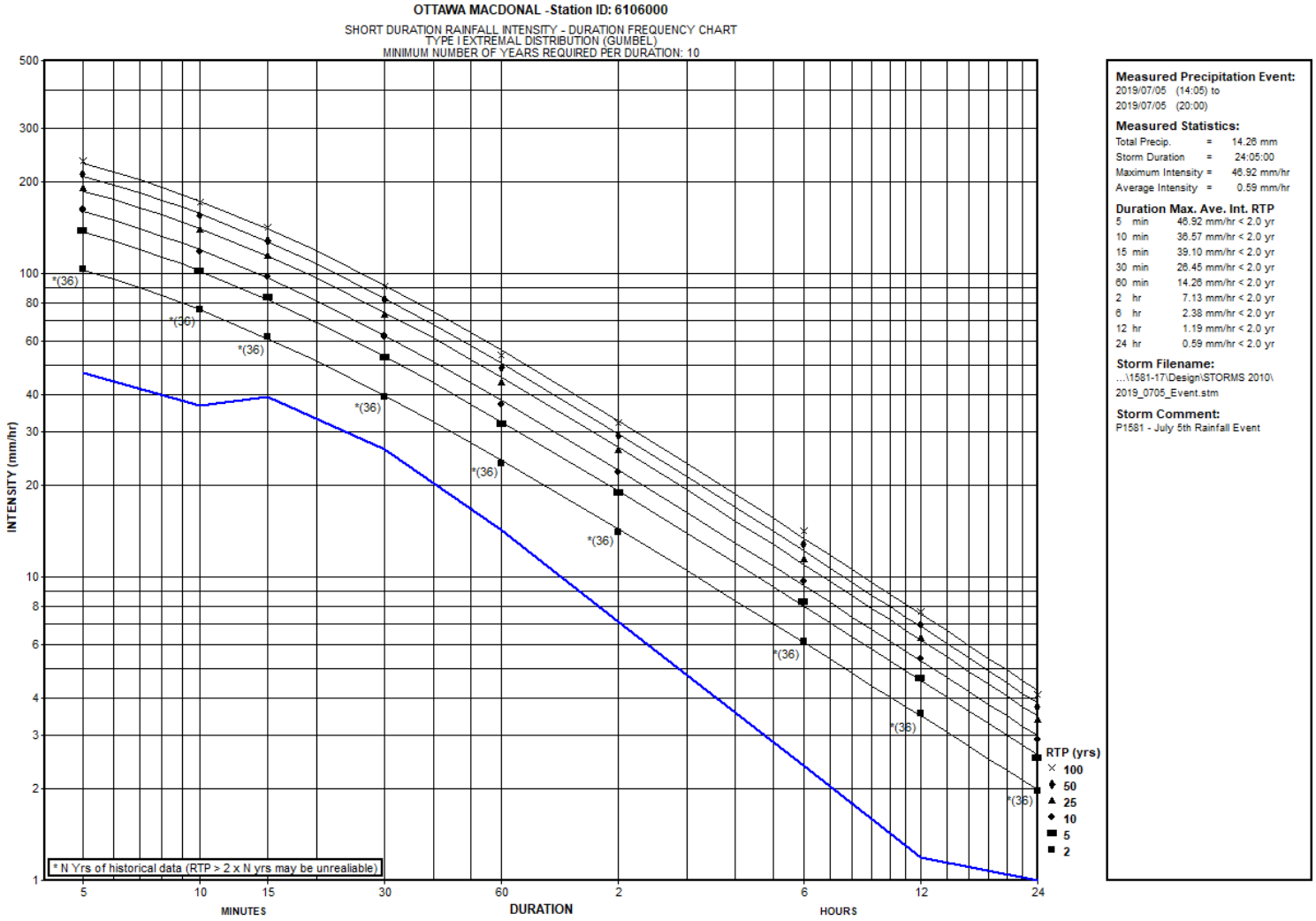


July 5th Rainfall Event (07/05/2019 14:00 – 07/05/2019 20:00)

Total Precipitation = 14.26 mm
Maximum Intensity = 46.92 mm/hr
Average Intensity = 0.59 mm/hr

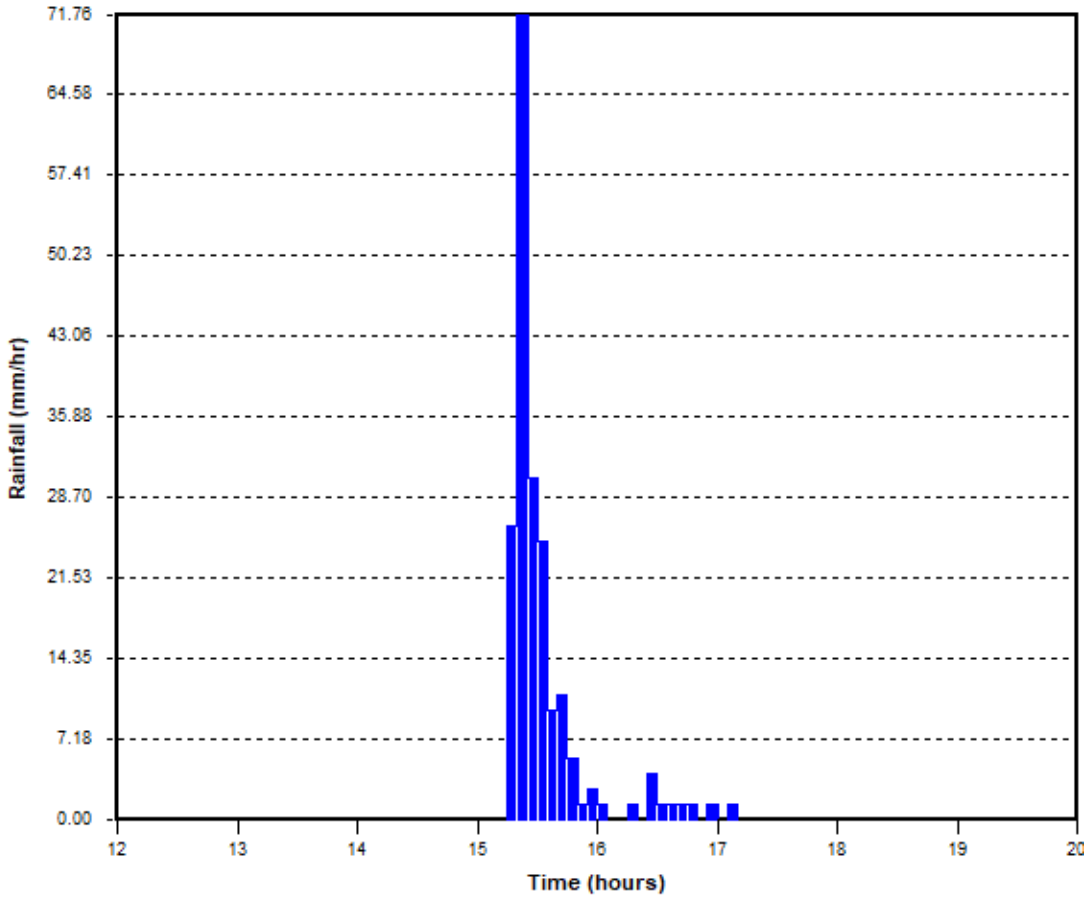


July 5th Duration Rainfall Intensity – Duration Frequency Chart (07/05/2019 14:00 – 07/05/2019 20:00)

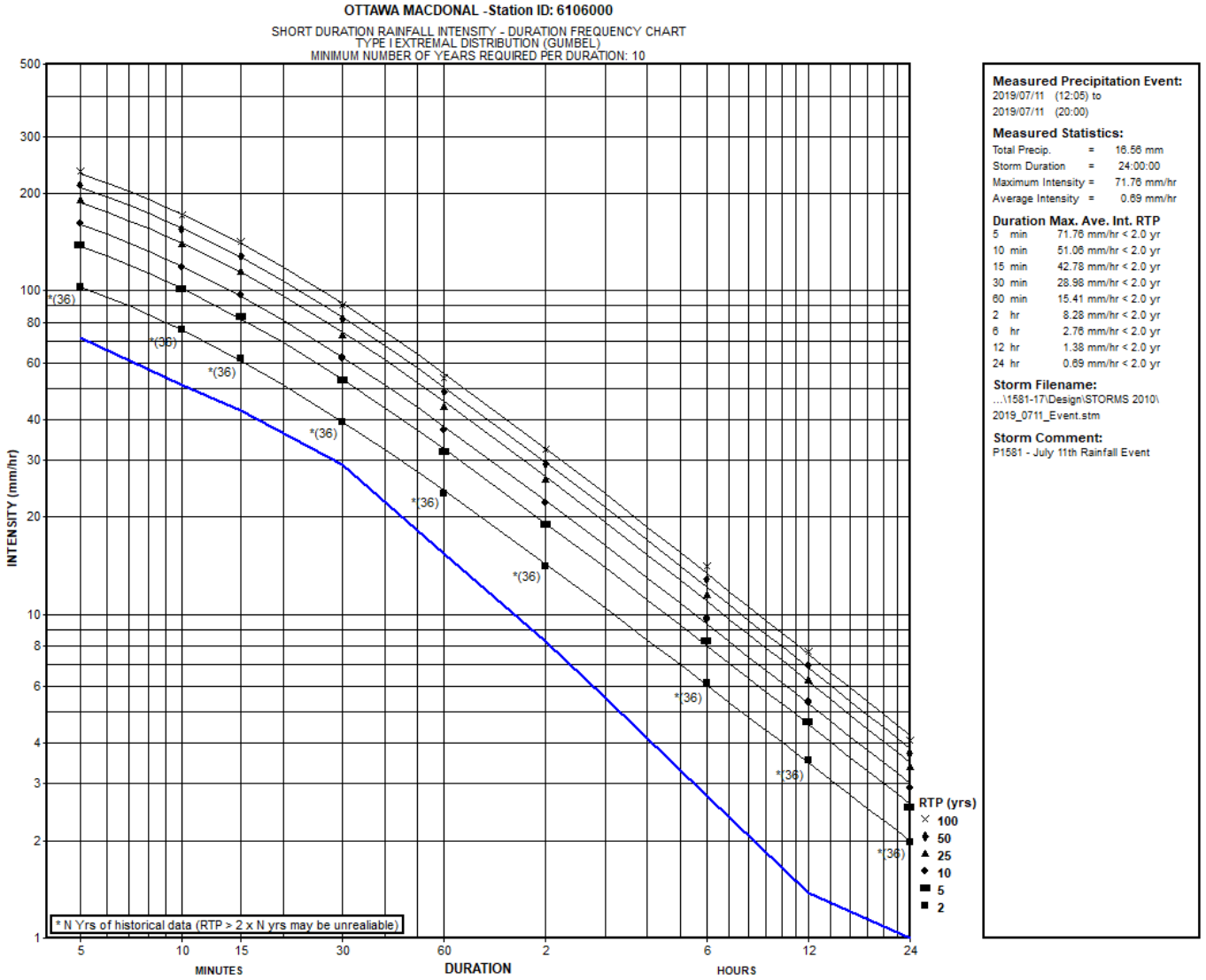


July 11th Rainfall Event (07/11/2019 12:00 – 07/11/2019 20:00)

Total Precipitation = 16.56 mm
Maximum Intensity = 71.76 mm/hr
Average Intensity = 0.69 mm/hr

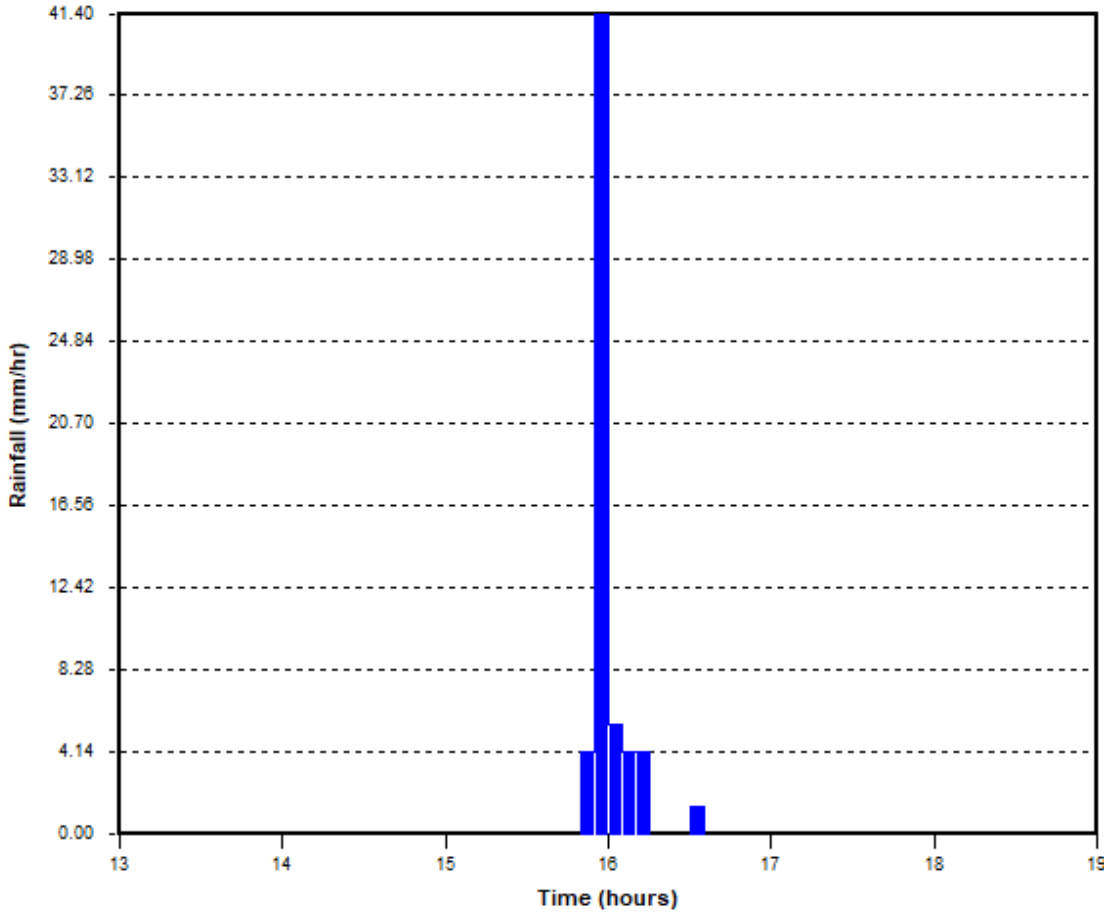


July 11th Duration Rainfall Intensity – Duration Frequency Chart (07/11/2019 12:00 – 07/11/2019 20:00)

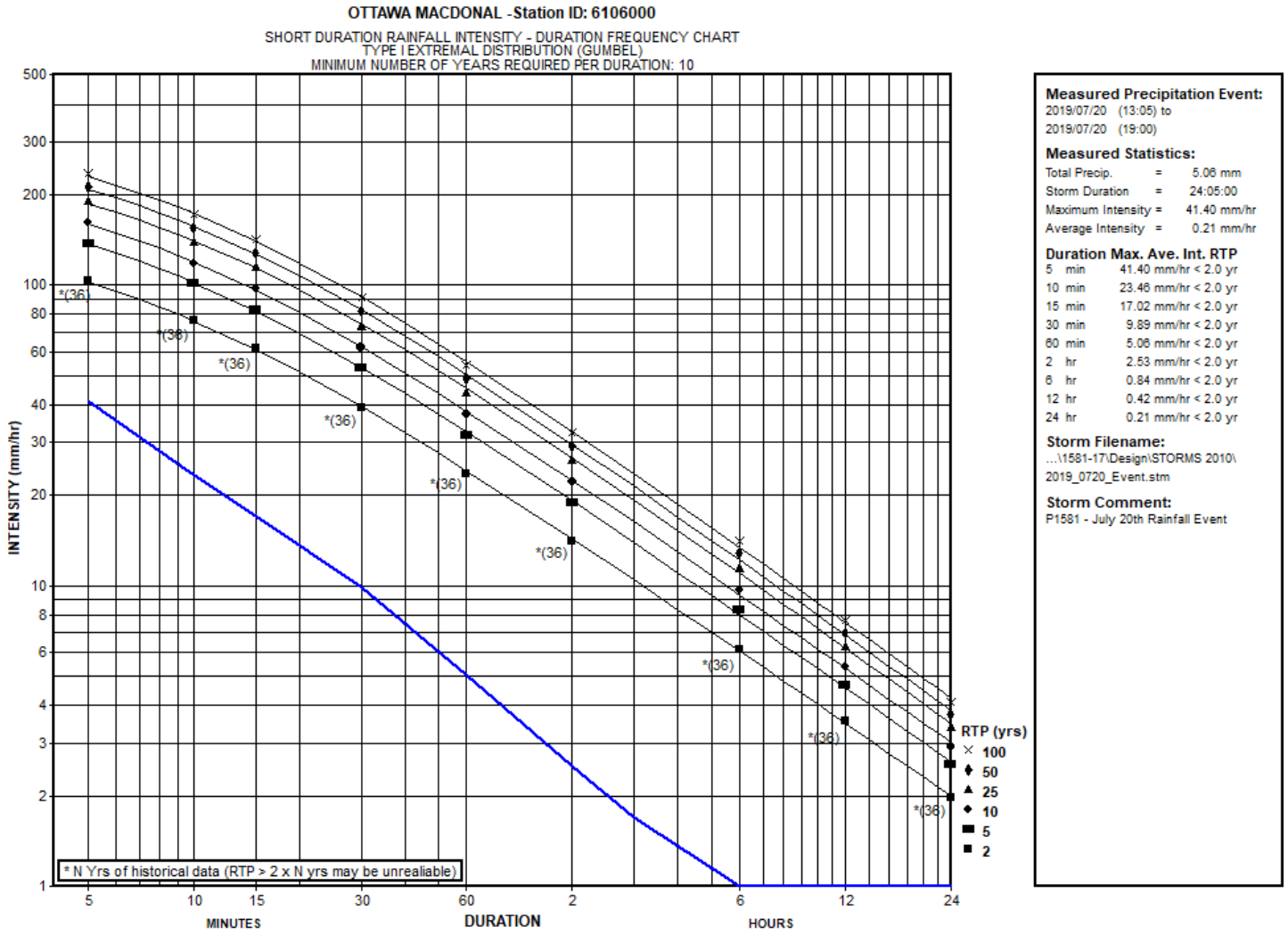


July 20th Rainfall Event (07/20/2019 13:00 – 07/20/2019 19:00)

Total Precipitation = 5.06 mm
Maximum Intensity = 41.40 mm/hr
Average Intensity = 0.21 mm/hr

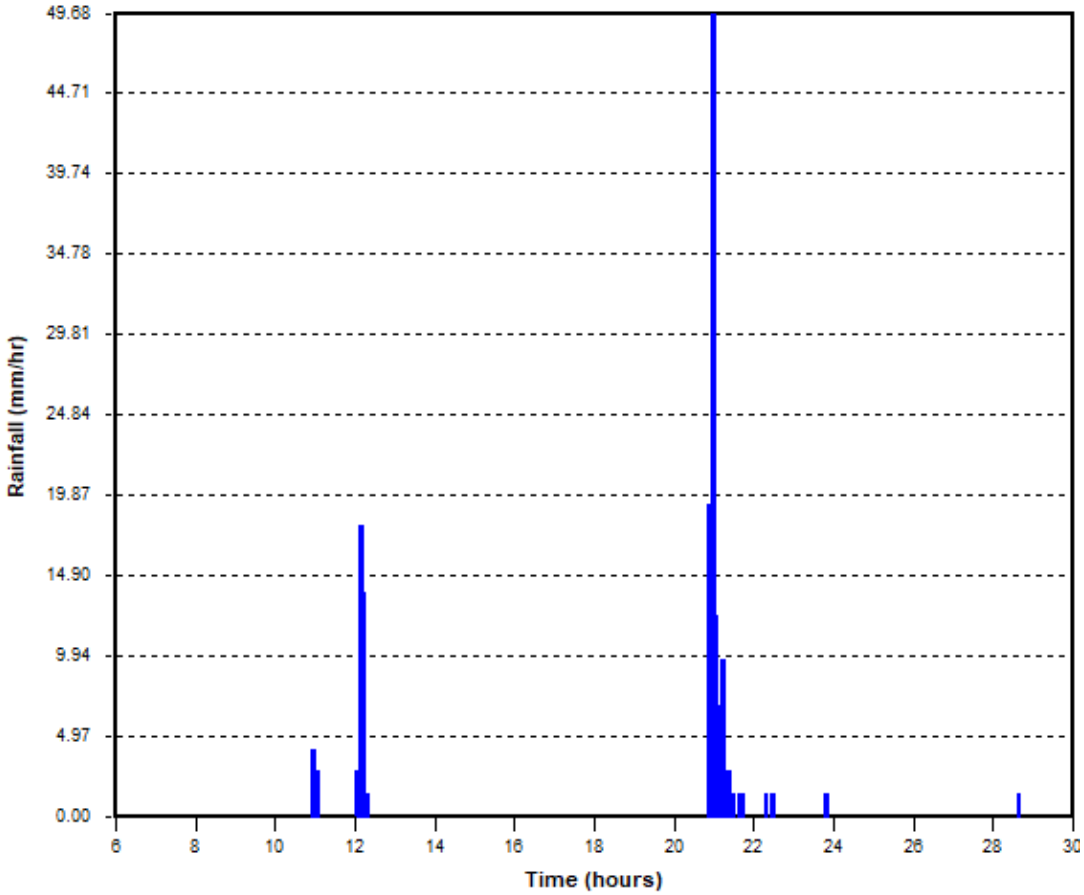


July 20th Duration Rainfall Intensity – Duration Frequency Chart (07/20/2019 13:00 – 07/20/2019 19:00)

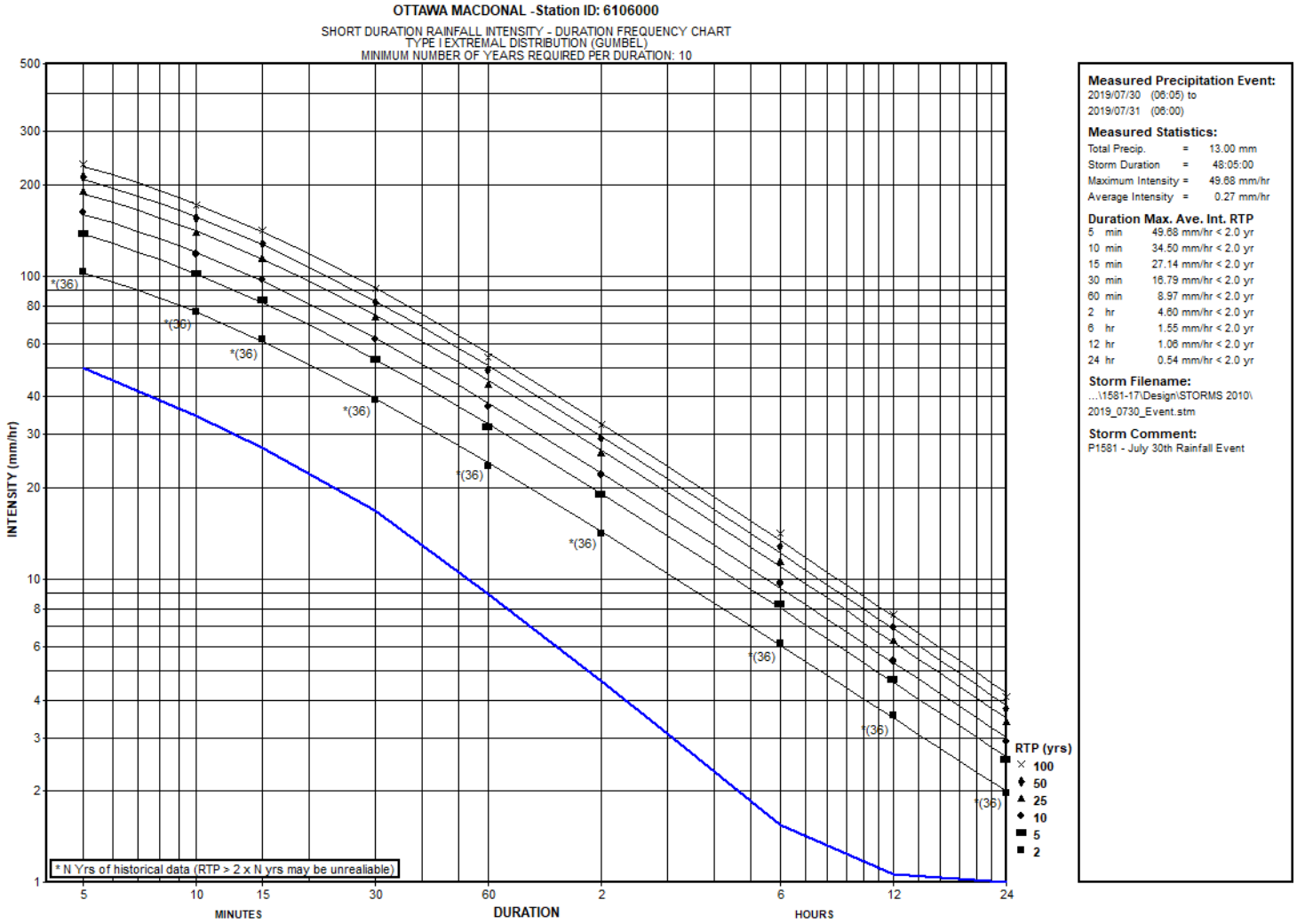


July 30th Rainfall Event (07/30/2019 06:00 – 07/31/2019 06:00)

Total Precipitation = 13.00 mm
Maximum Intensity = 49.68 mm/hr
Average Intensity = 0.27 mm/hr

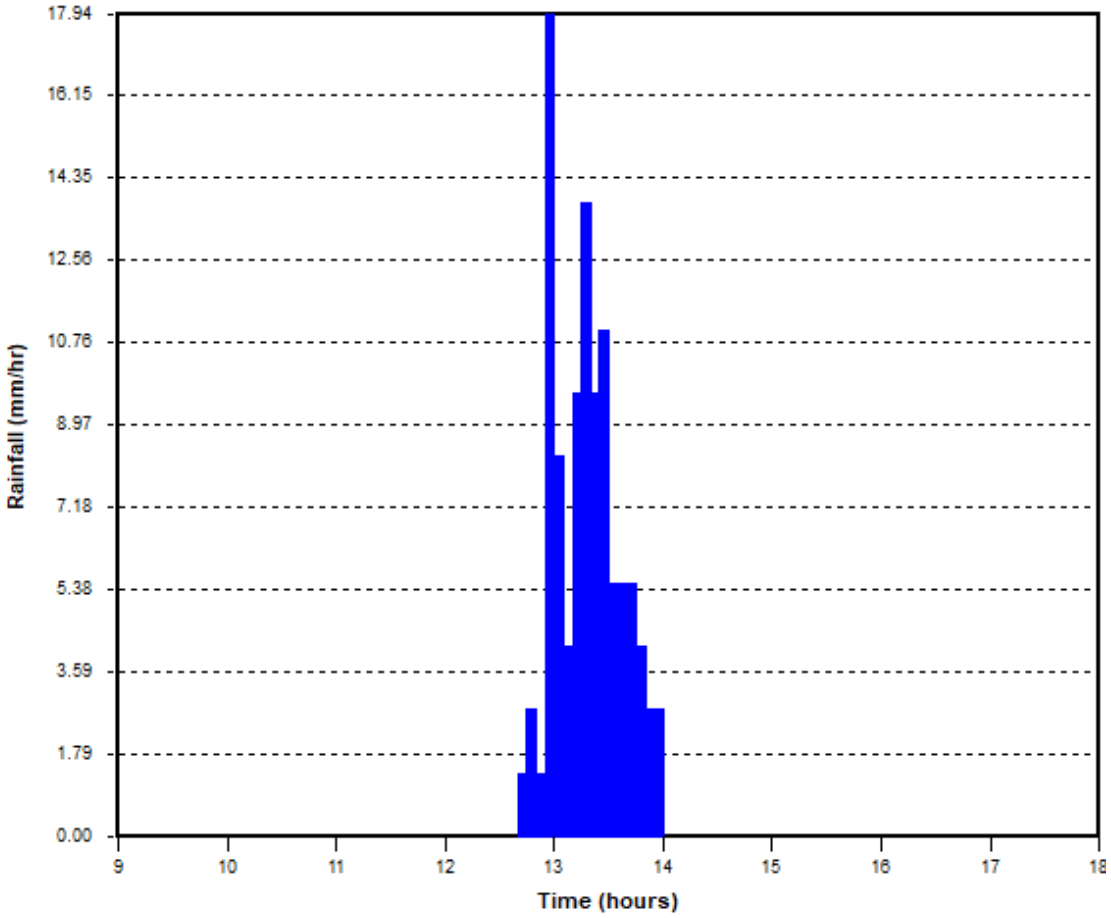


July 30th Duration Rainfall Intensity – Duration Frequency Chart (07/30/2019 06:00 – 07/31/2019 06:00)

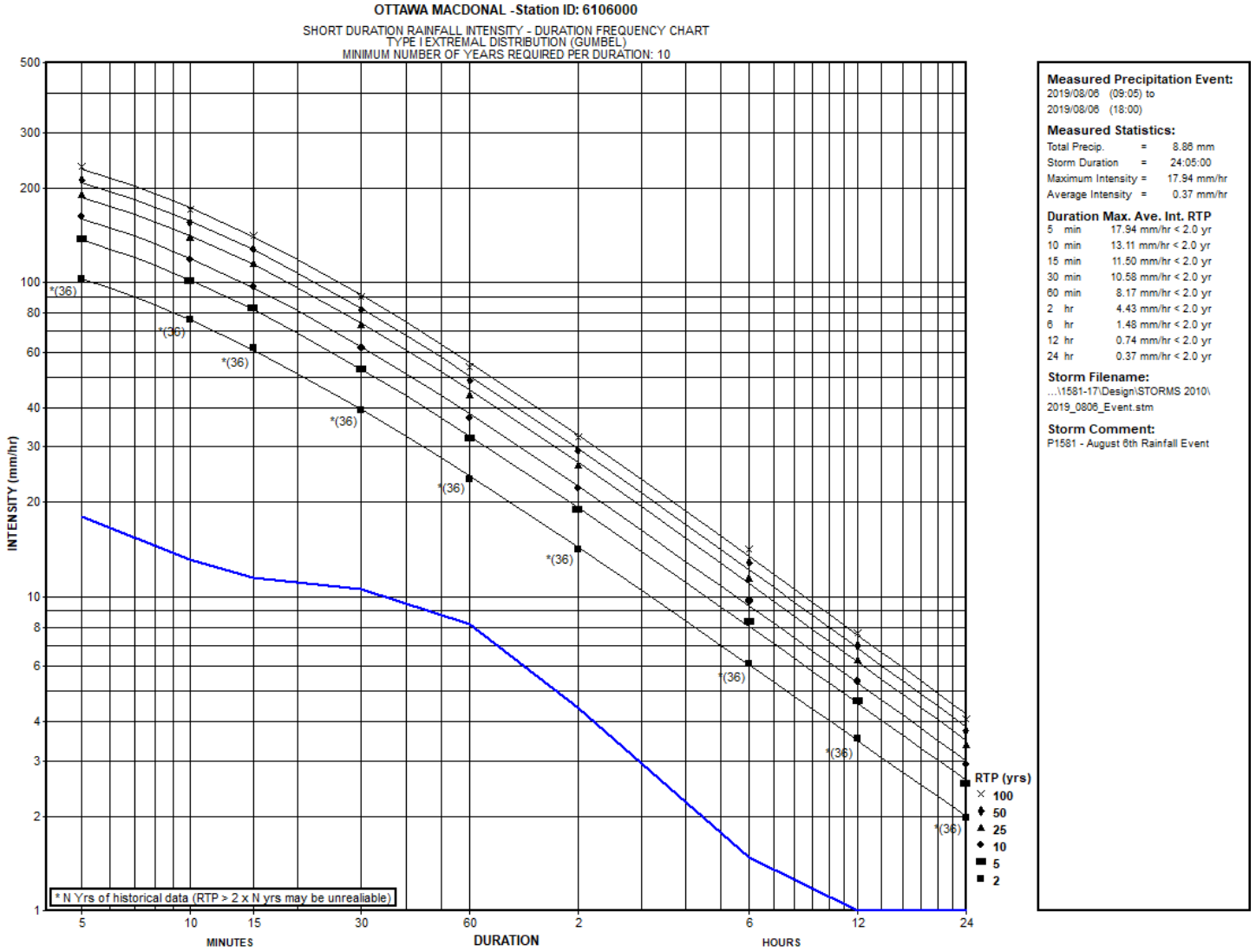


August 6th Rainfall Event (08/06/2019 09:00 – 08/06/2019 18:00)

Total Precipitation = 8.86 mm
Maximum Intensity = 17.94 mm/hr
Average Intensity = 0.37 mm/hr

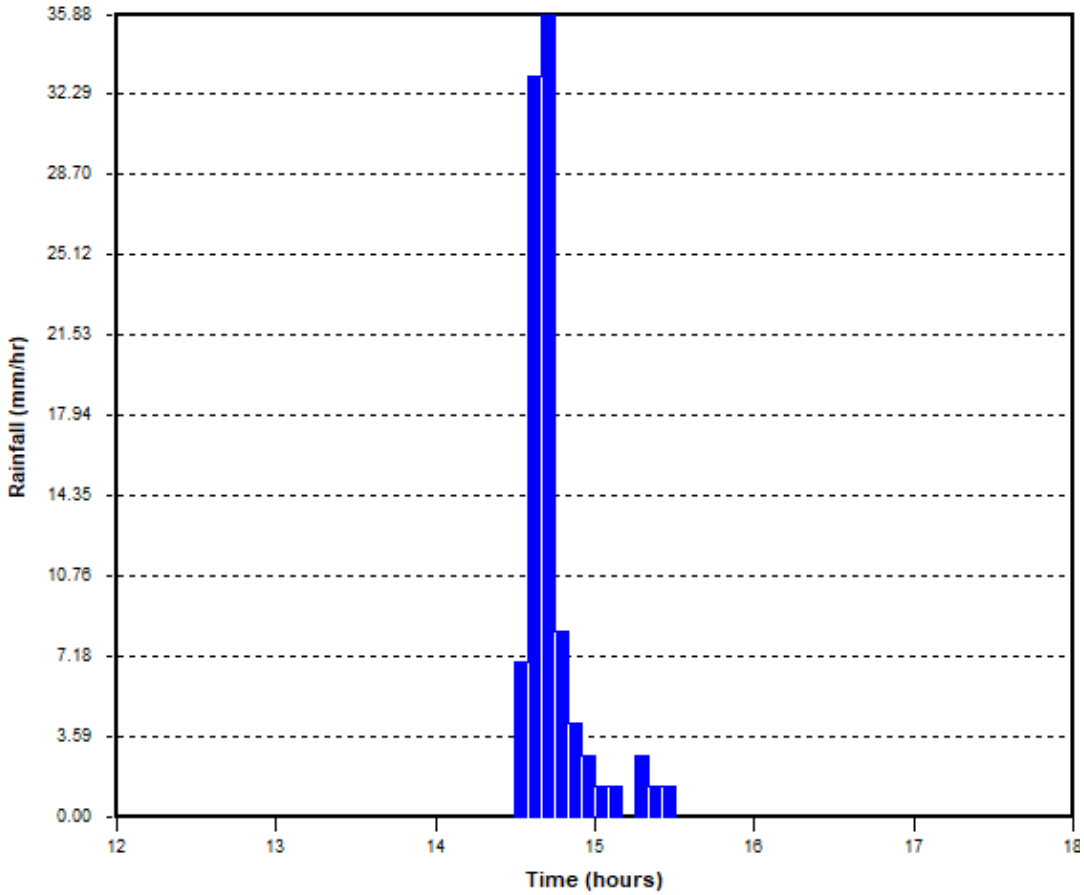


August 6th Duration Rainfall Intensity – Duration Frequency Chart (08/06/2019 09:00 – 08/06/2019 18:00)

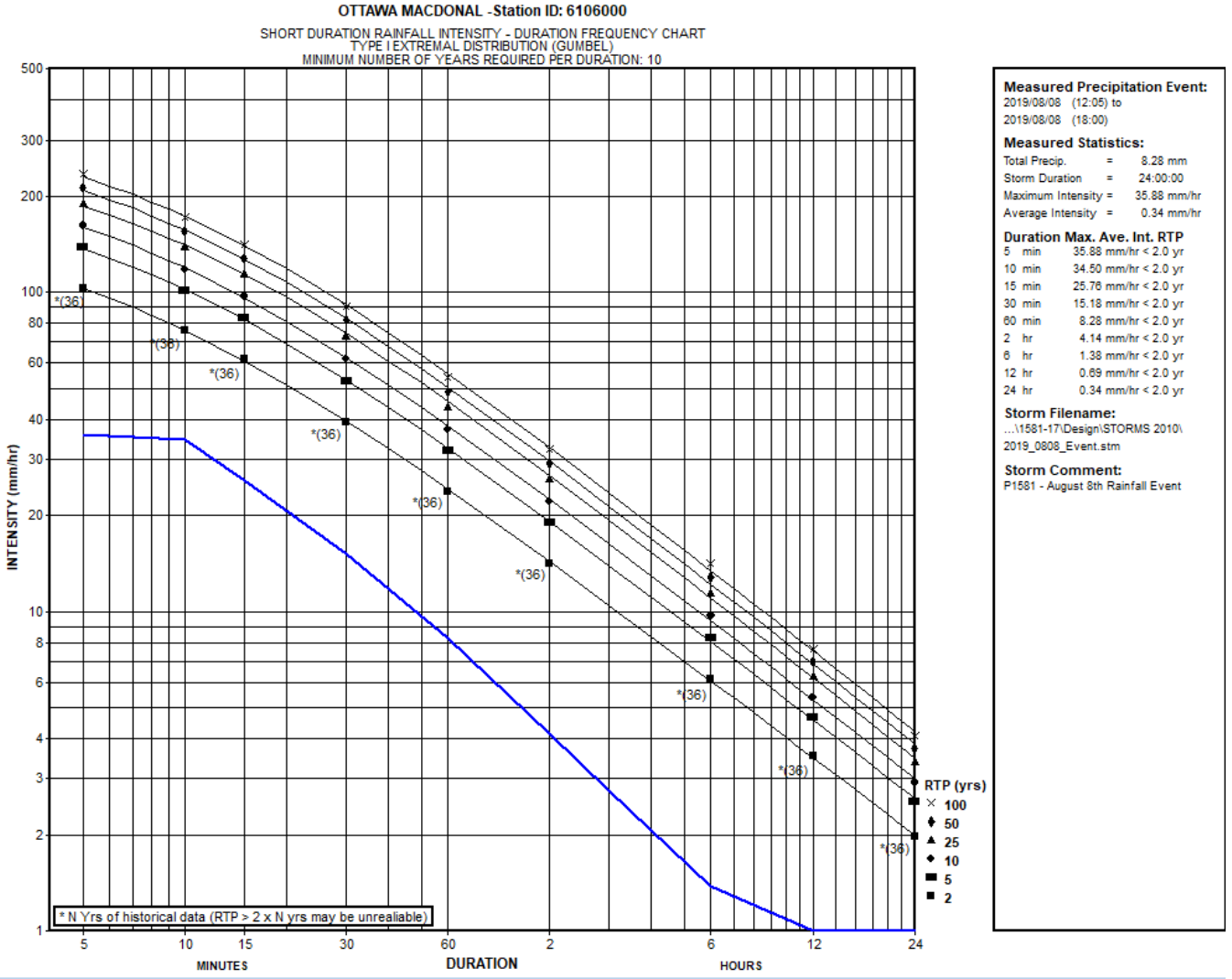


August 8th Rainfall Event (08/08/2019 12:00 – 08/08/2019 18:00)

Total Precipitation = 8.28 mm
Maximum Intensity = 35.88 mm/hr
Average Intensity = 0.34 mm/hr

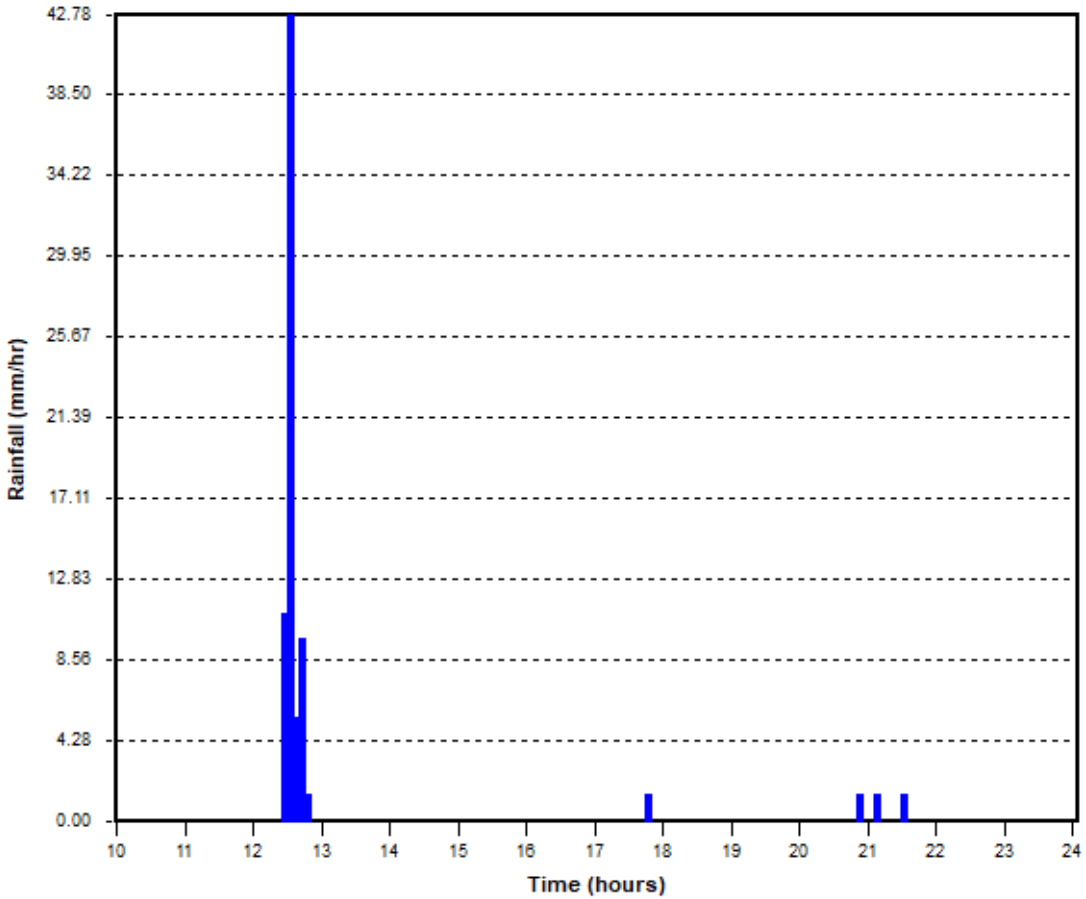


August 8th Duration Rainfall Intensity – Duration Frequency Chart (08/08/2019 12:00 – 08/08/2019 18:00)

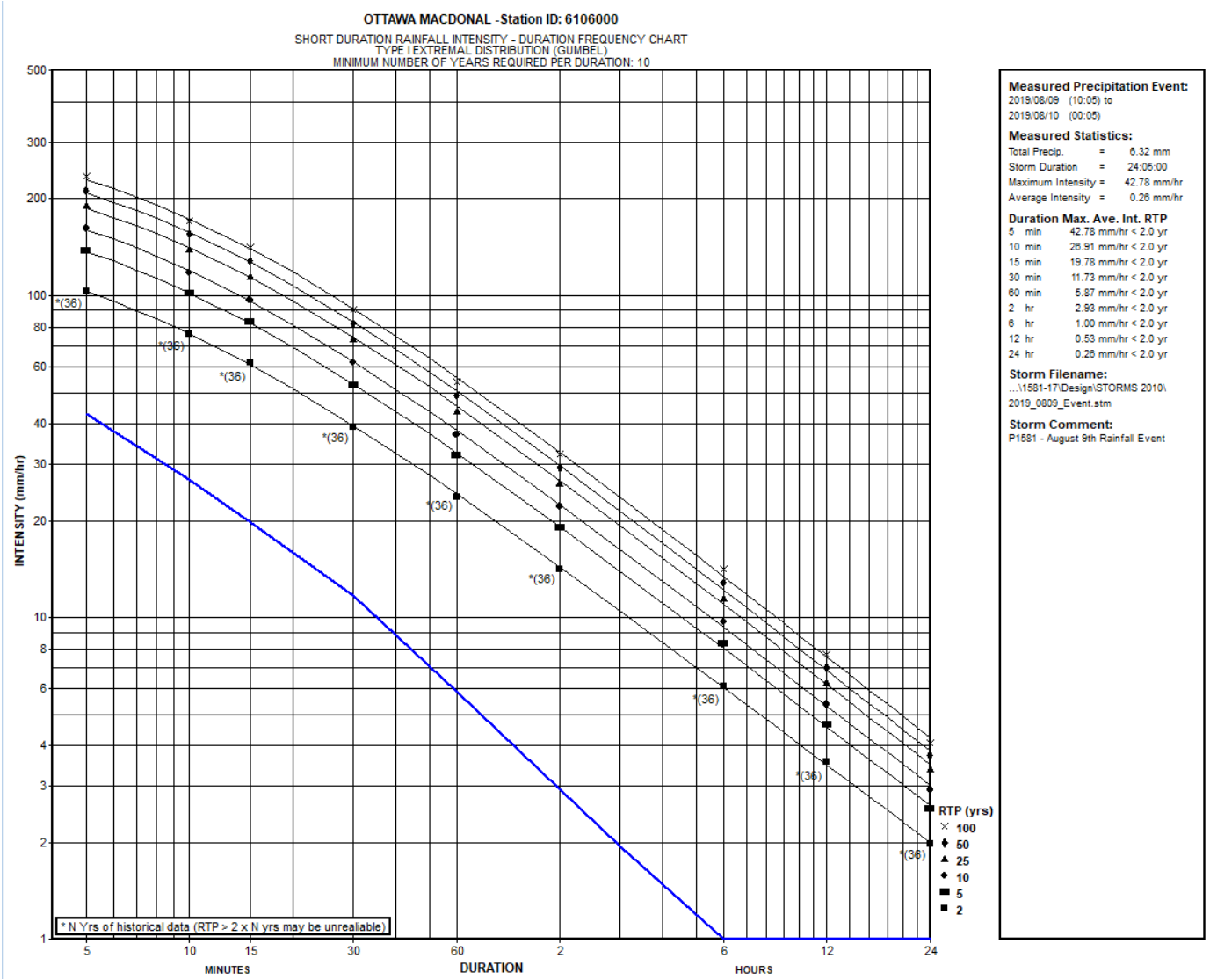


August 9th Rainfall Event (08/09/2019 10:00 – 08/10/2019 00:00)

Total Precipitation = 6.32 mm
Maximum Intensity = 42.78 mm/hr
Average Intensity = 0.26 mm/hr

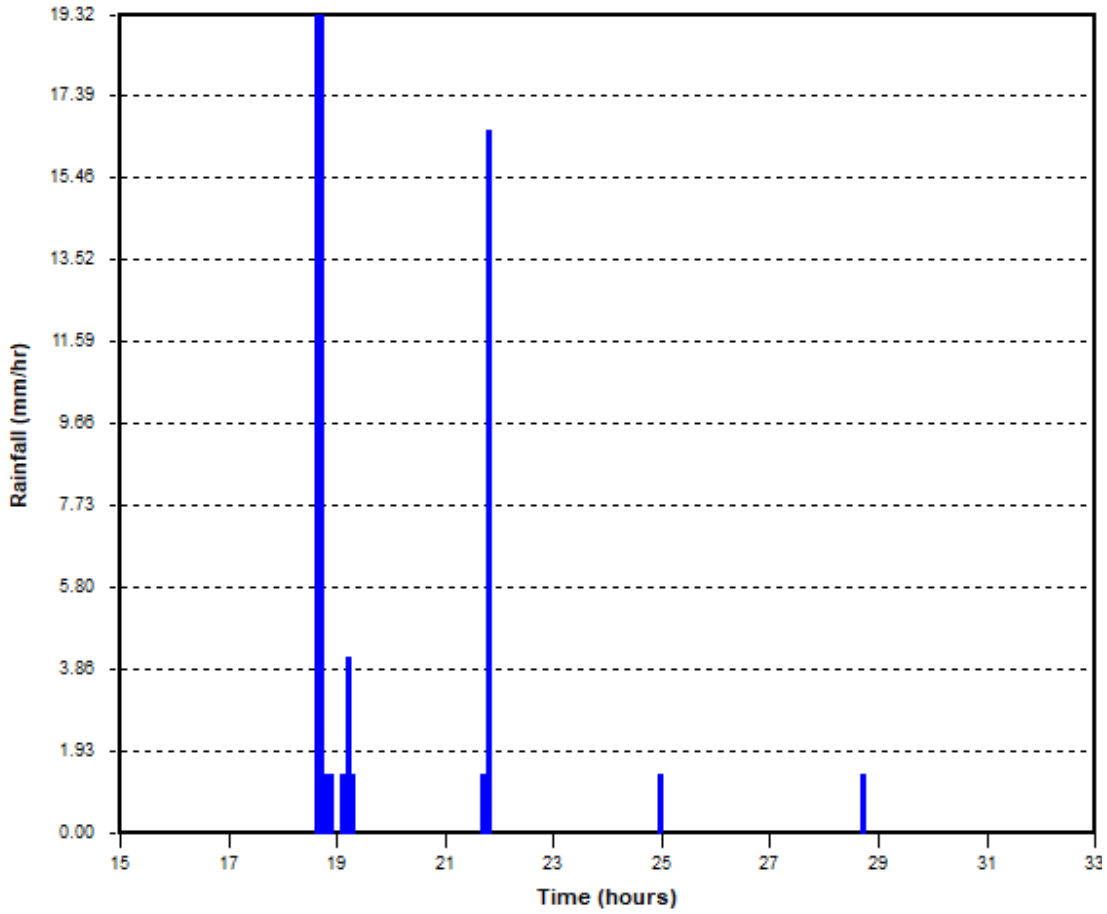


August 9th Duration Rainfall Intensity – Duration Frequency Chart (08/09/2019 12:00 – 08/09/2019 18:00)

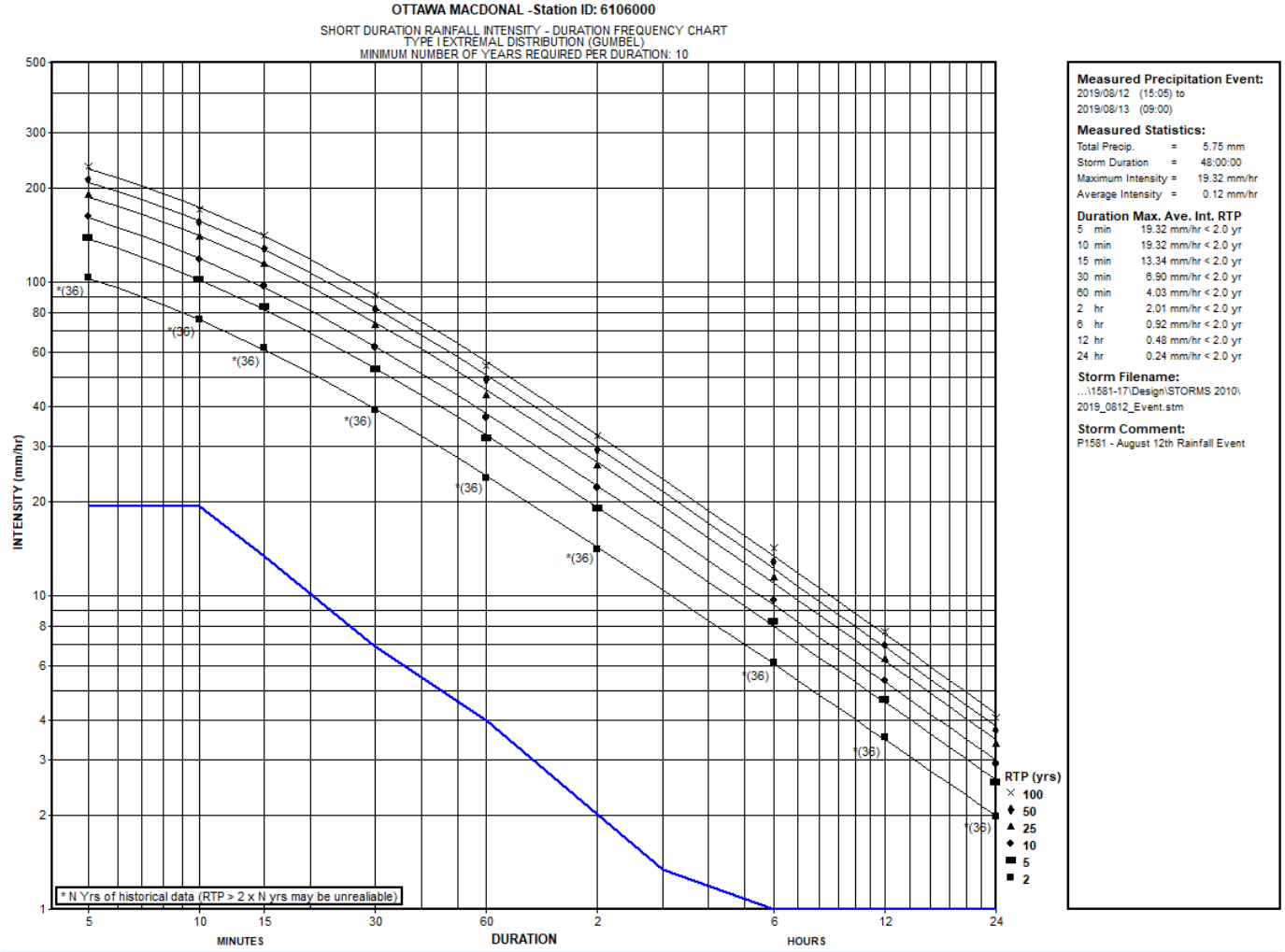


August 12th Rainfall Event (08/12/2019 15:00 – 08/13/2019 09:00)

Total Precipitation = 5.75 mm
Maximum Intensity = 19.32 mm/hr
Average Intensity = 0.12 mm/hr

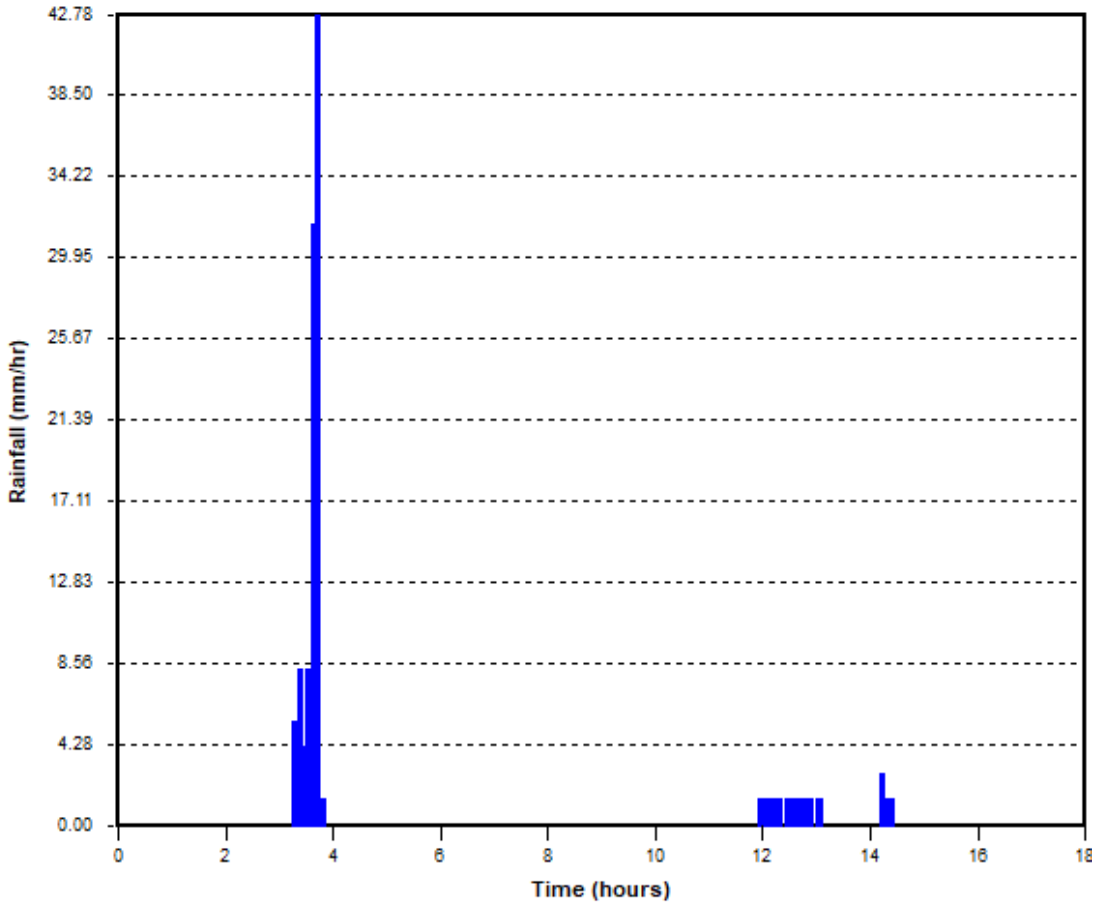


August 13th Duration Rainfall Intensity – Duration Frequency Chart (08/12/2019 15:00 – 08/13/2019 09:00)

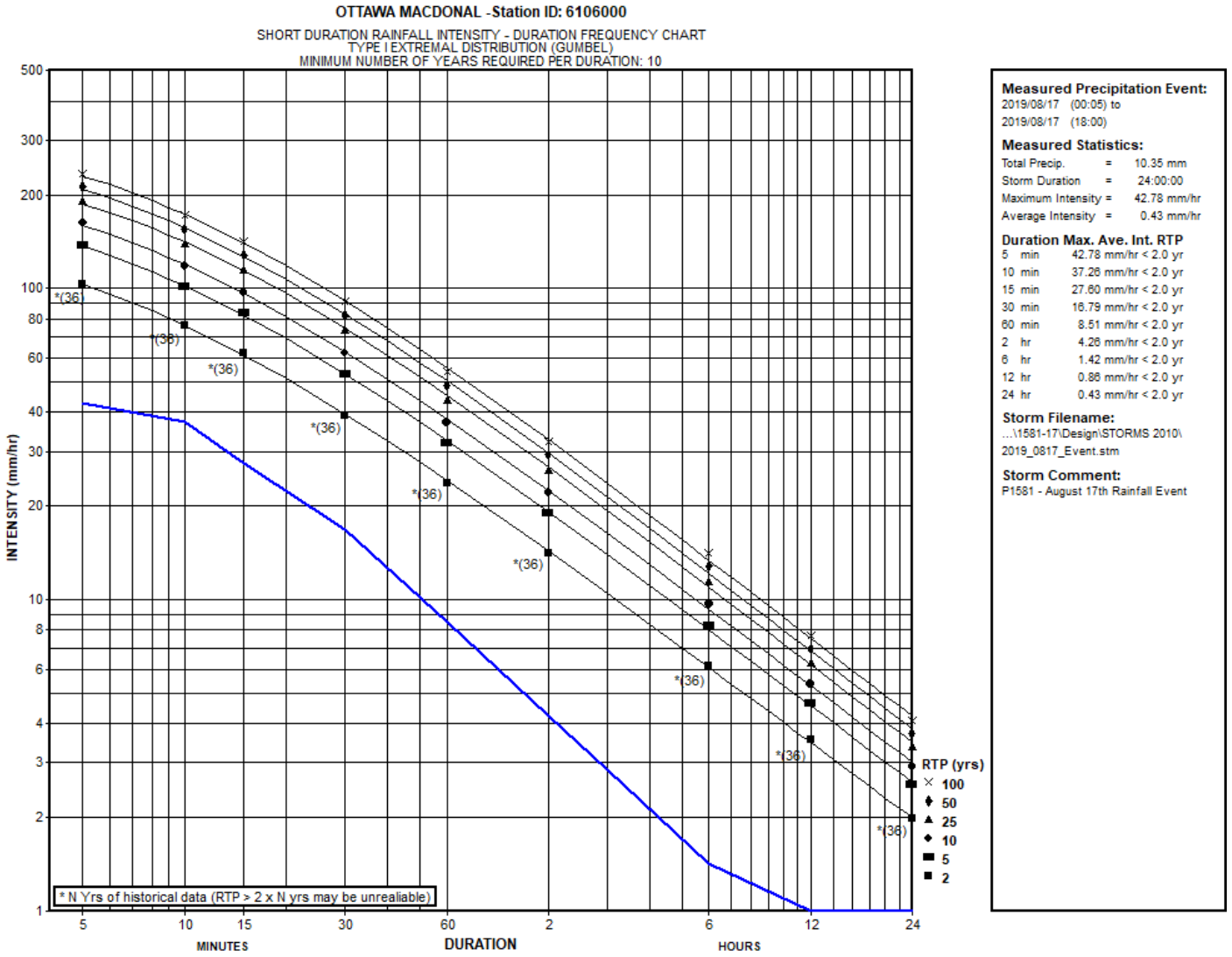


August 17th Rainfall Event (08/17/2019 00:00 – 08/17/2019 18:00)

Total Precipitation = 10.35 mm
Maximum Intensity = 42.78 mm/hr
Average Intensity = 0.43 mm/hr

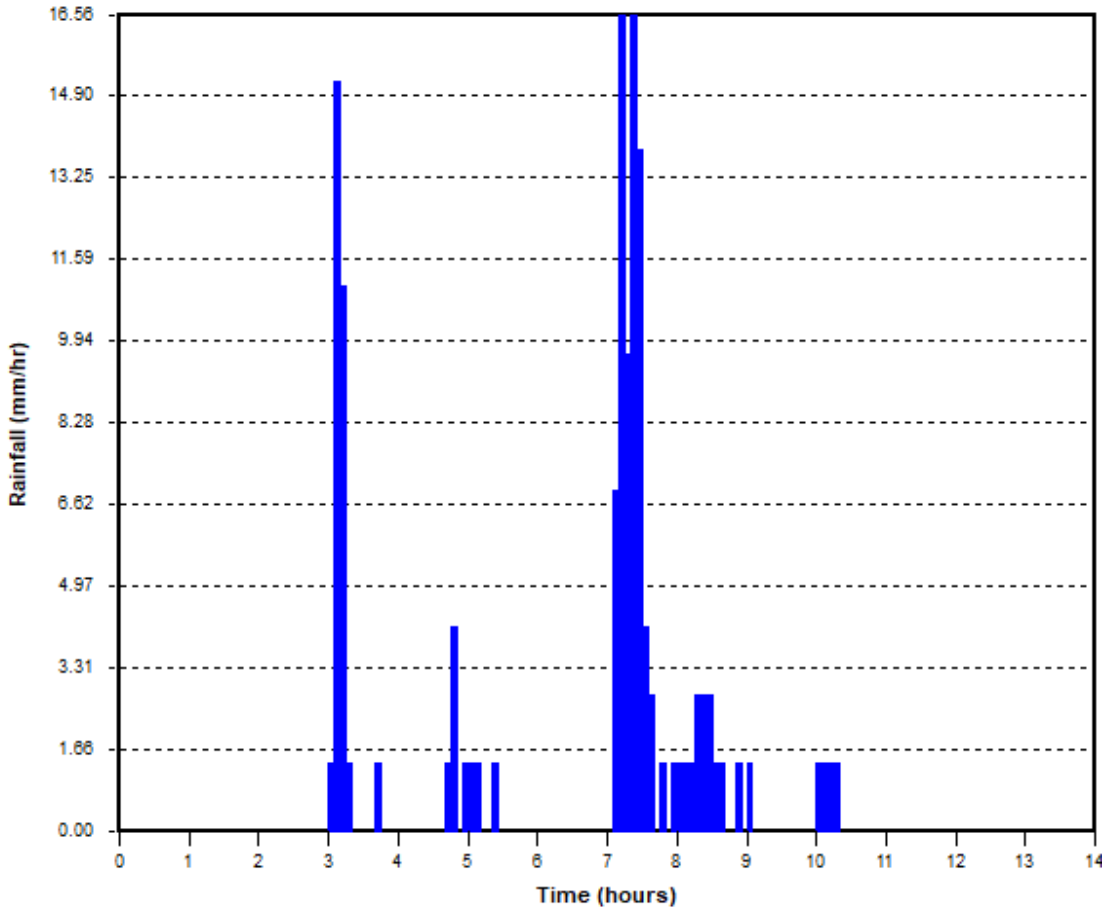


August 17th Duration Rainfall Intensity – Duration Frequency Chart (08/17/2019 00:00 – 08/17/2019 18:00)

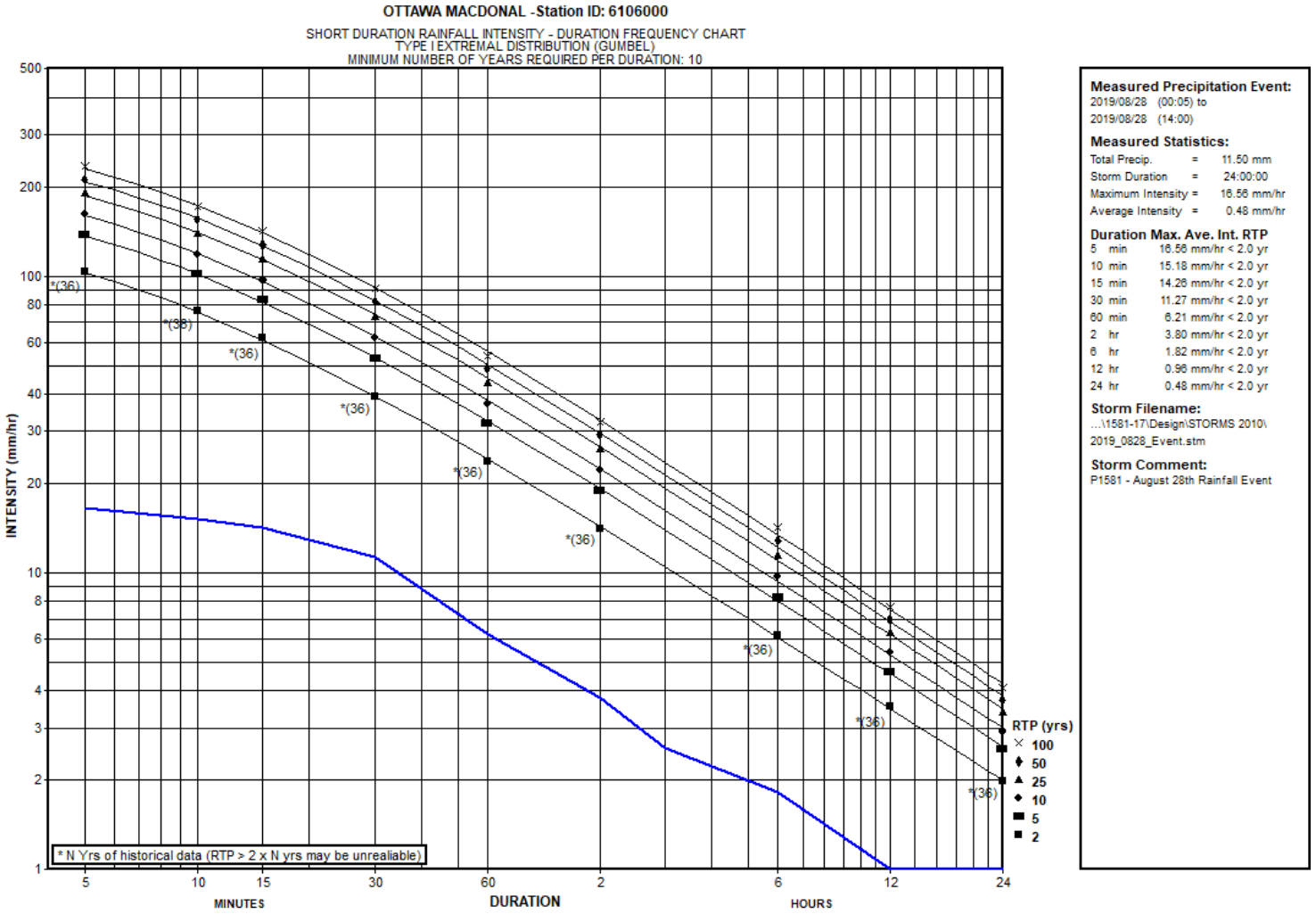


August 28th Rainfall Event (08/28/2019 00:00 – 08/28/2019 14:00)

Total Precipitation = 11.50 mm
Maximum Intensity = 16.56 mm/hr
Average Intensity = 0.48 mm/hr

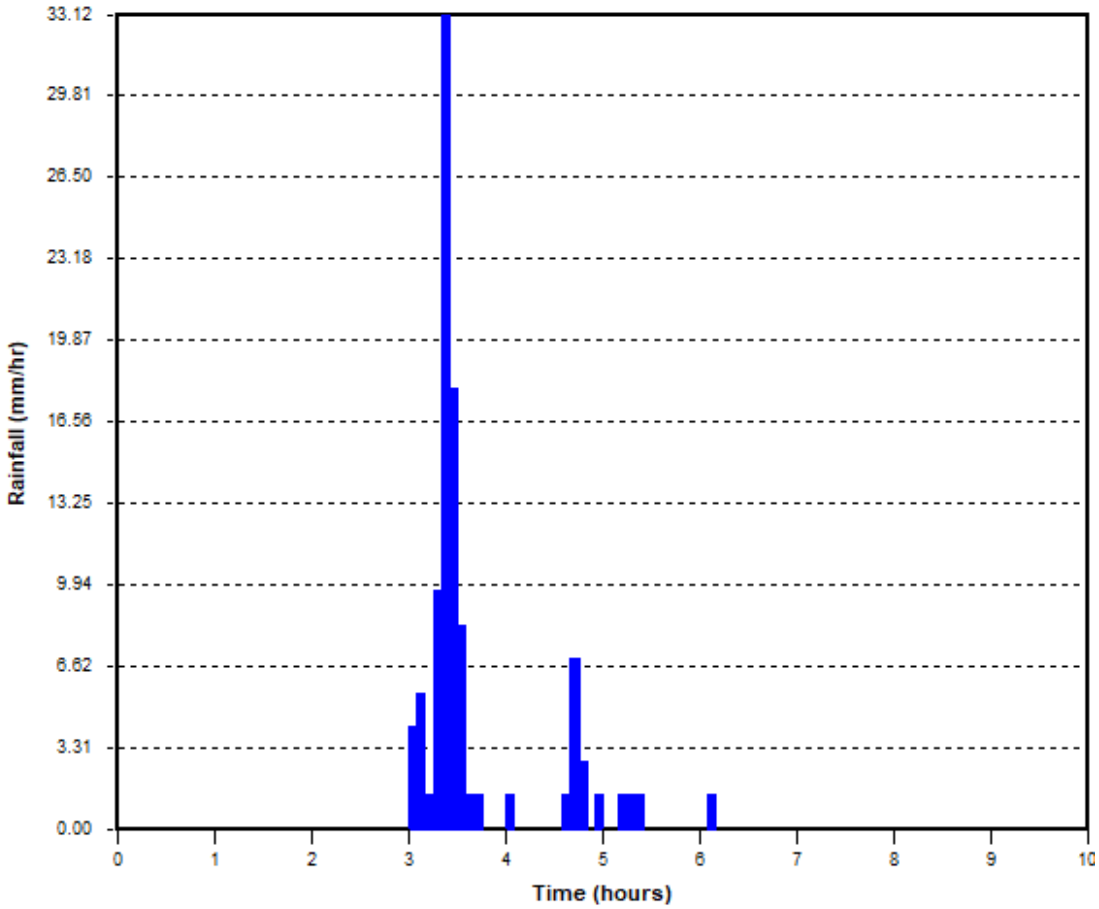


August 28th Duration Rainfall Intensity – Duration Frequency Chart (08/28/2019 00:00 – 08/28/2019 14:00)

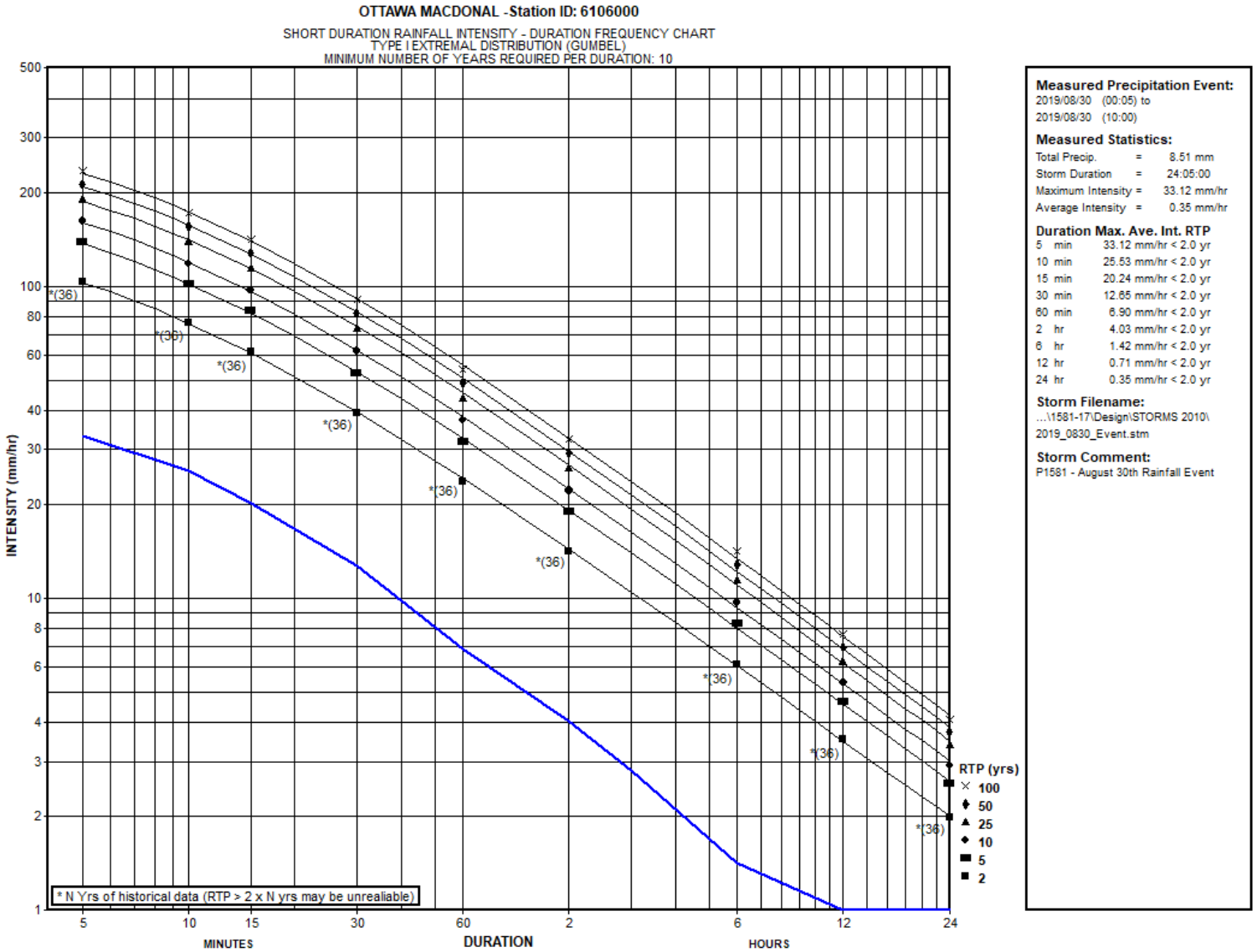


August 30th Rainfall Event (08/30/2019 00:00 – 08/30/2019 10:00)

Total Precipitation = 8.51 mm
Maximum Intensity = 33.12 mm/hr
Average Intensity = 0.35 mm/hr

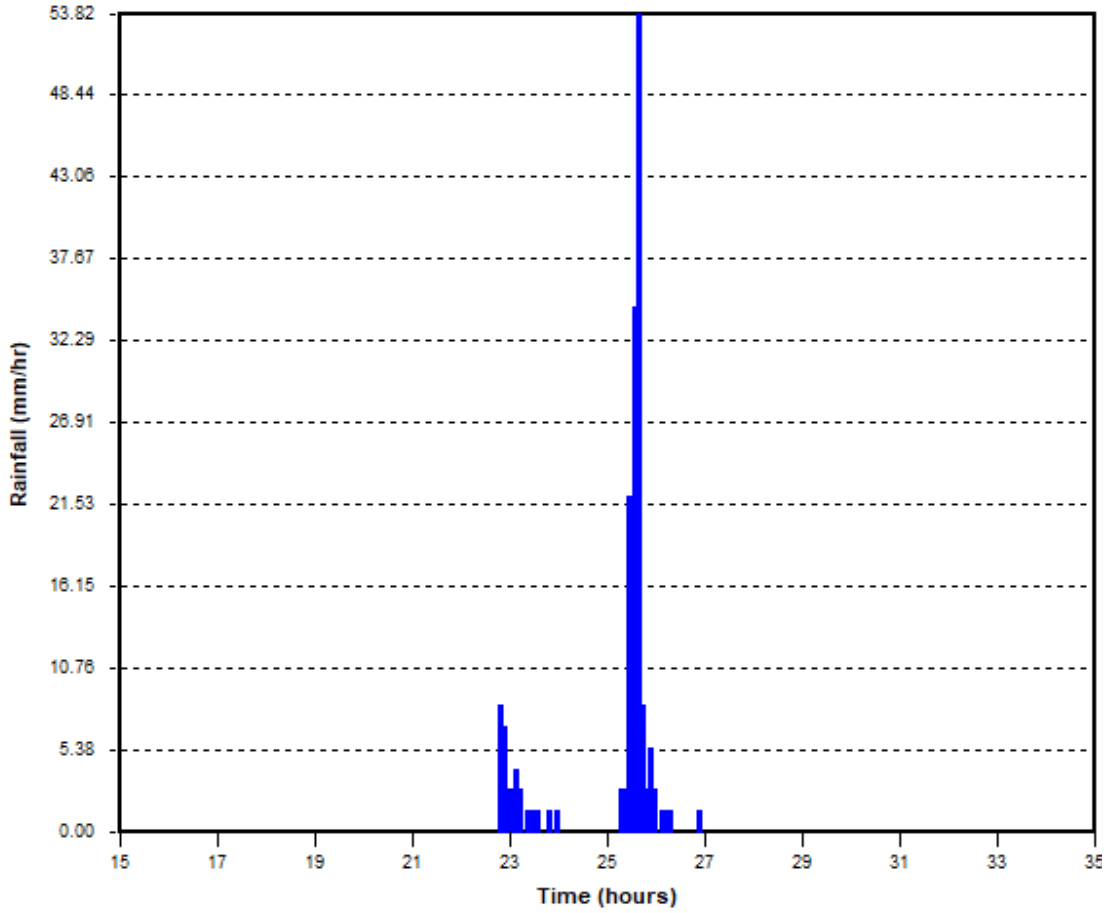


August 30th Duration Rainfall Intensity – Duration Frequency Chart (08/30/2019 00:00 – 08/30/2019 10:00)

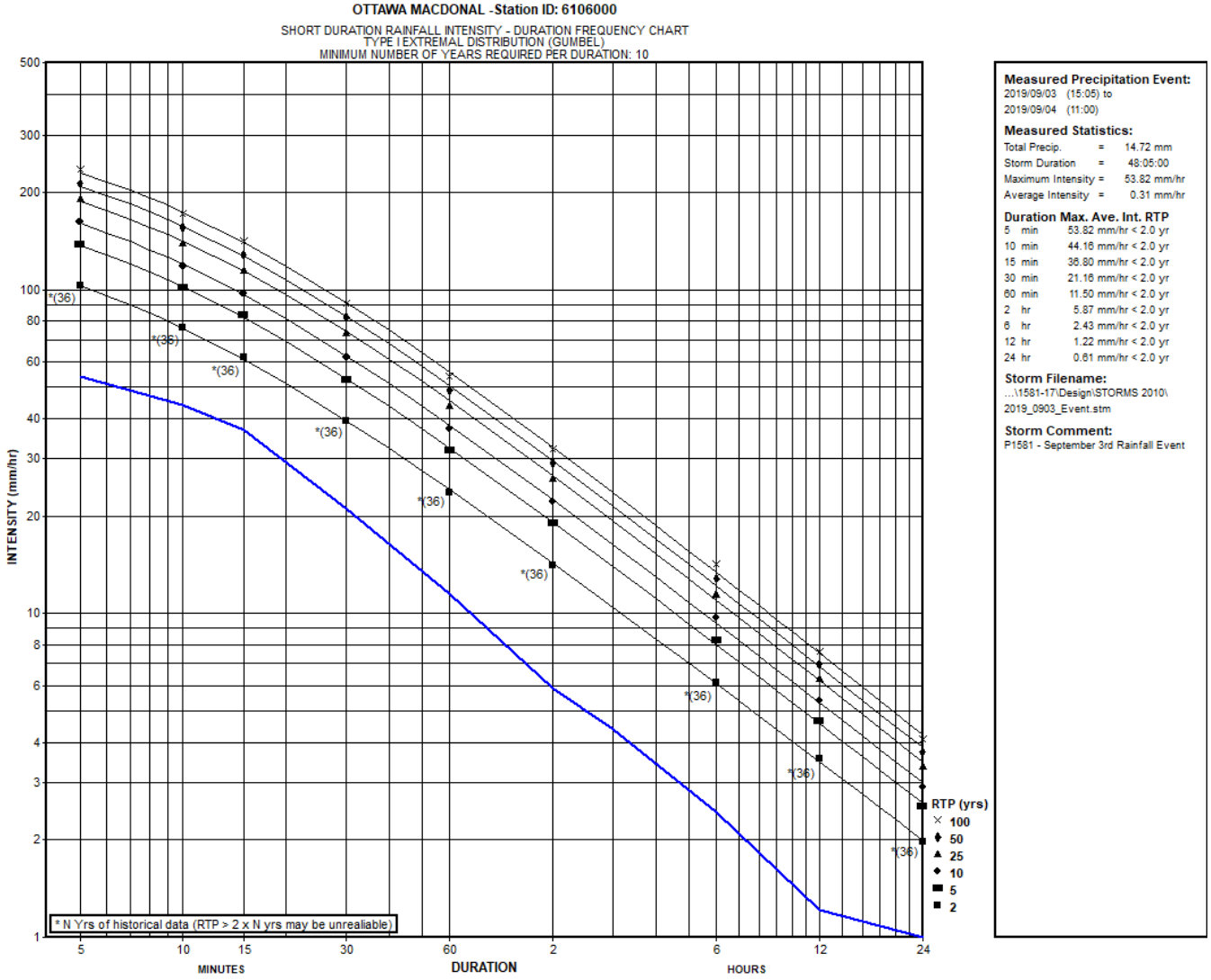


September 3rd Rainfall Event (09/03/2019 15:00 – 09/04/2019 11:00)

Total Precipitation = 14.72 mm
Maximum Intensity = 53.82 mm/hr
Average Intensity = 0.31 mm/hr

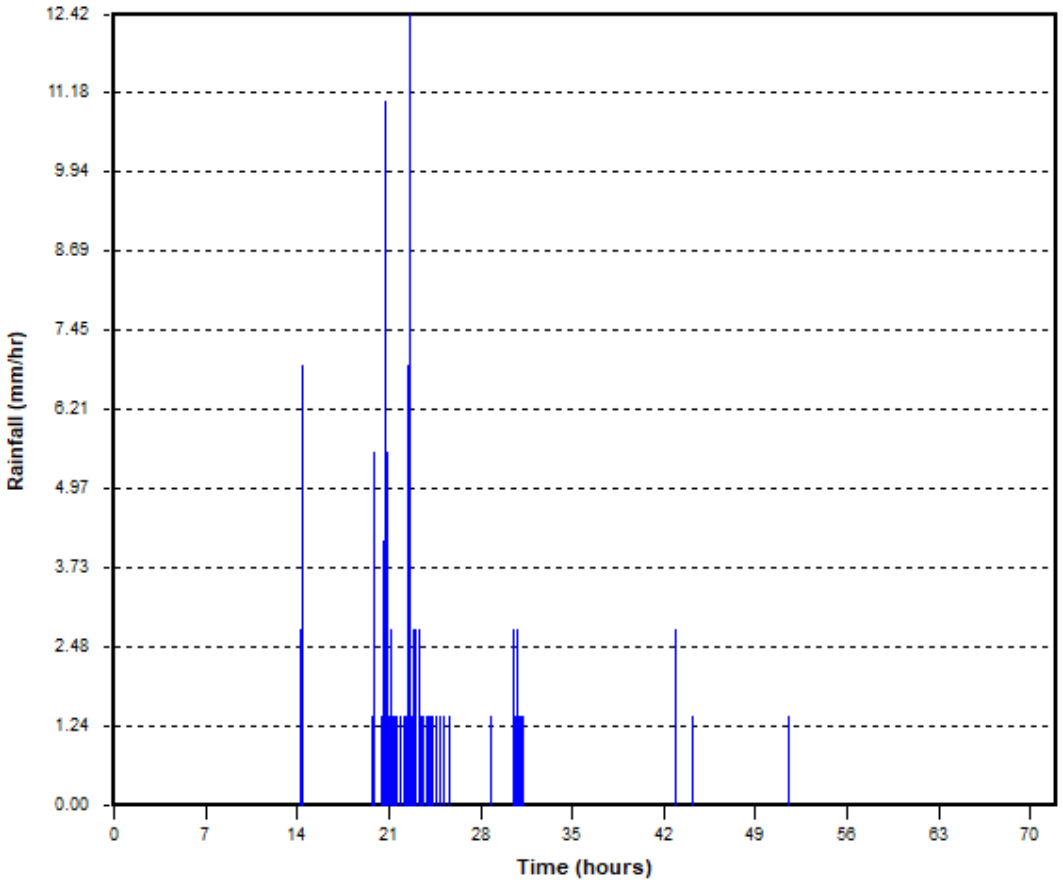


September 3rd Duration Rainfall Intensity – Duration Frequency Chart (09/03/2019 15:00 – 09/04/2019 11:00)

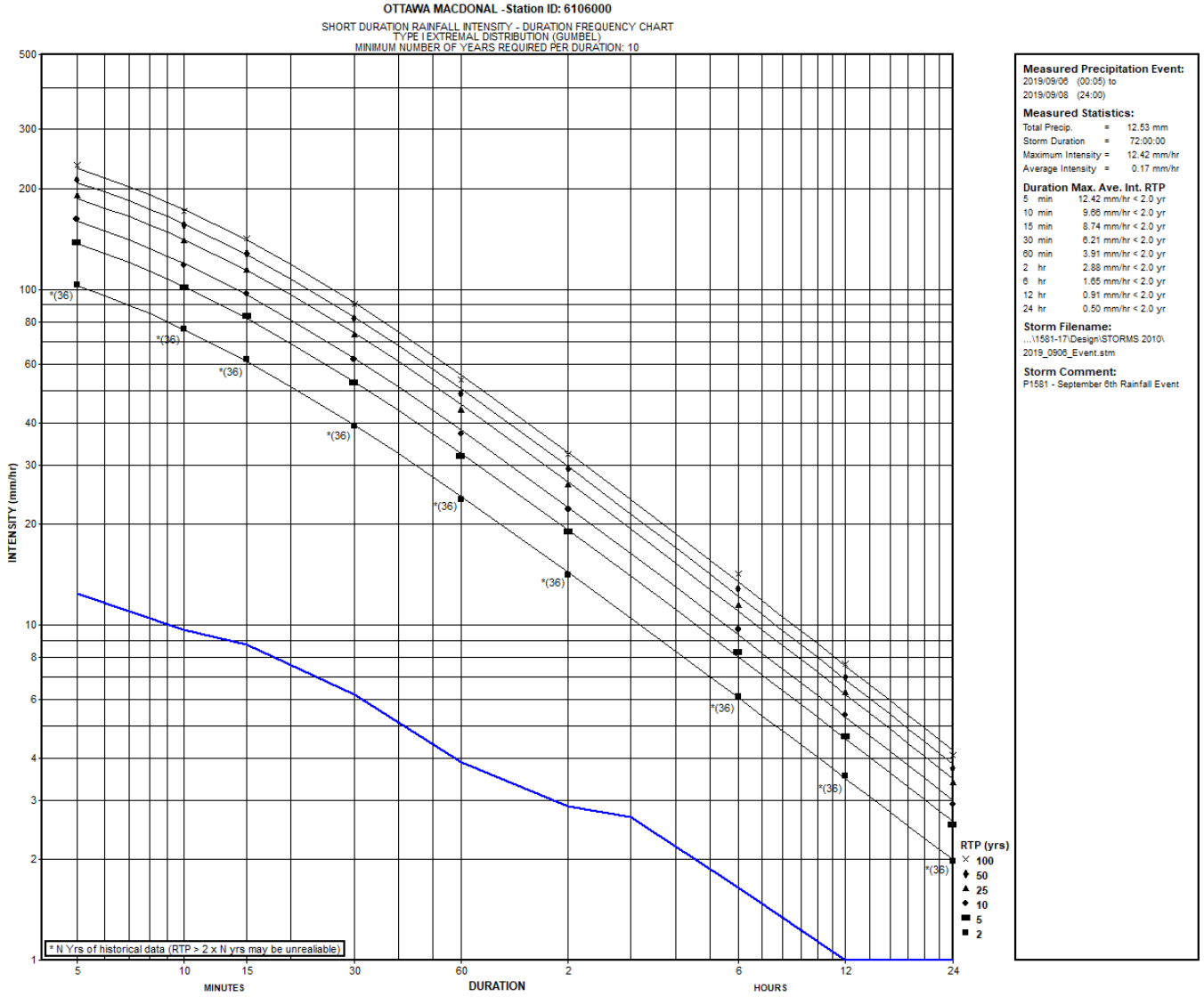


September 6th Rainfall Event (09/06/2019 00:00 – 09/08/2019 24:00)

Total Precipitation = 12.53 mm
Maximum Intensity = 12.42mm/hr
Average Intensity = 0.17 mm/hr



September 6th Duration Rainfall Intensity – Duration Frequency Chart (09/06/2019 00:00 – 09/06/2019 24:00)



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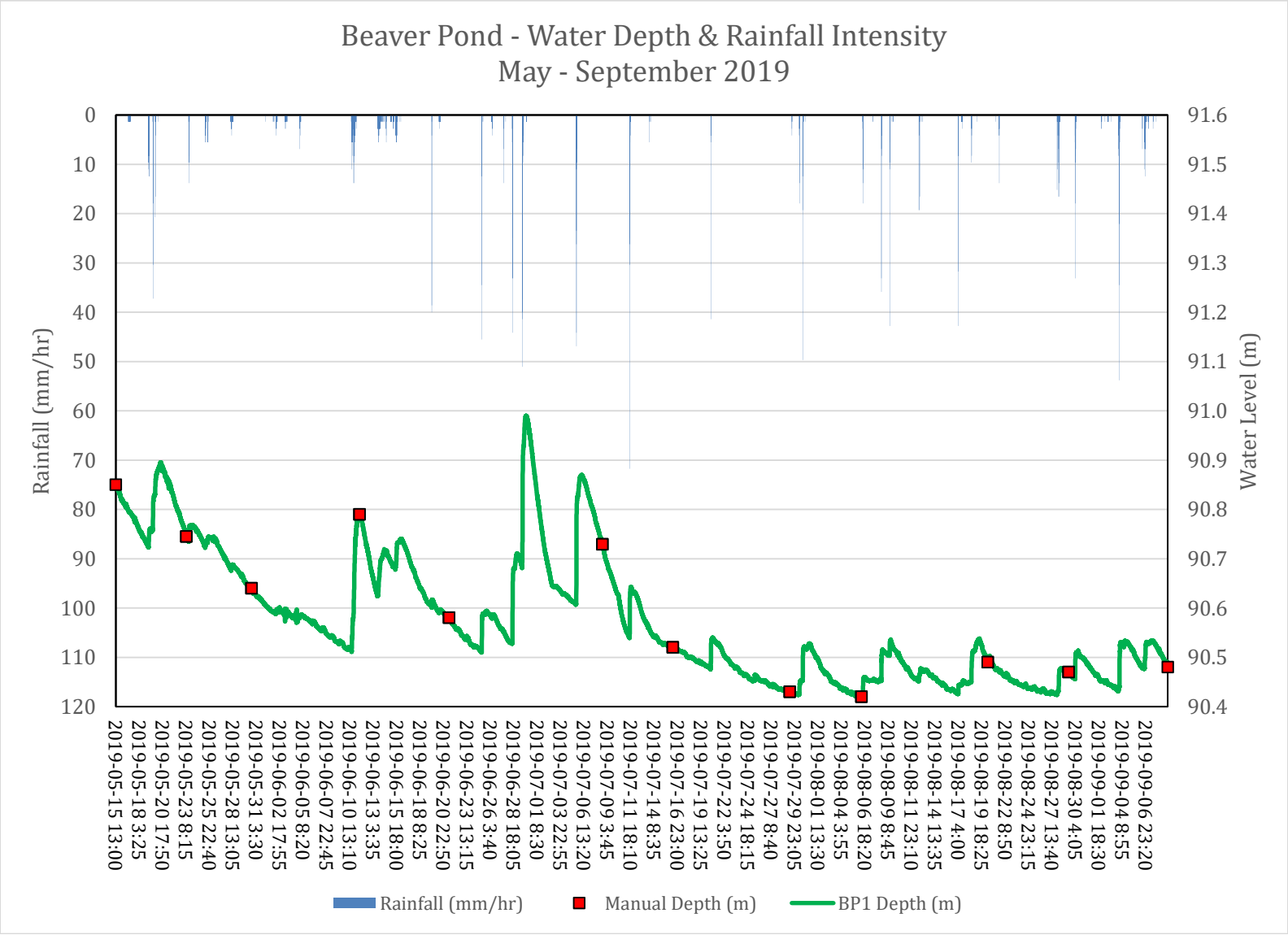
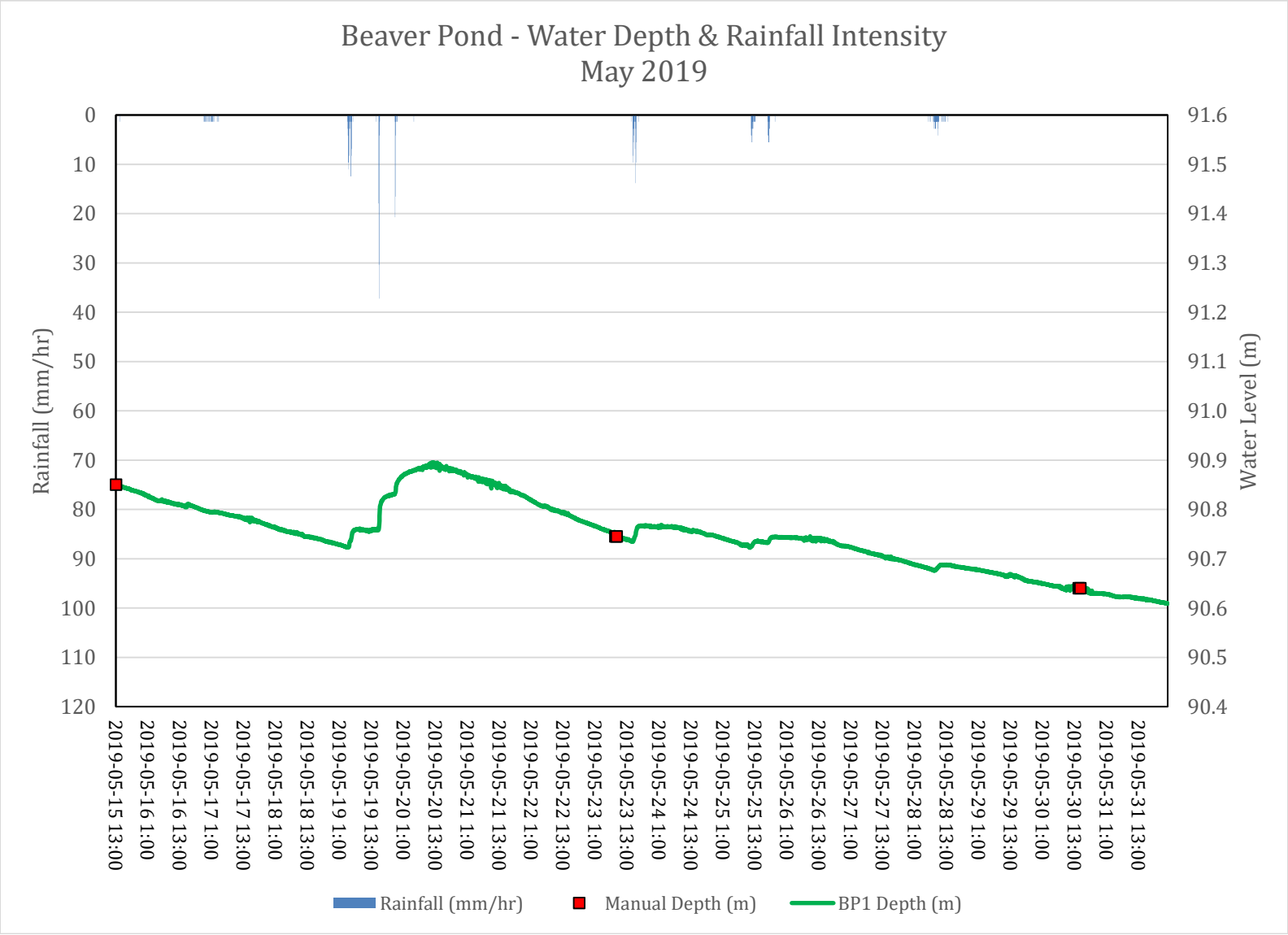
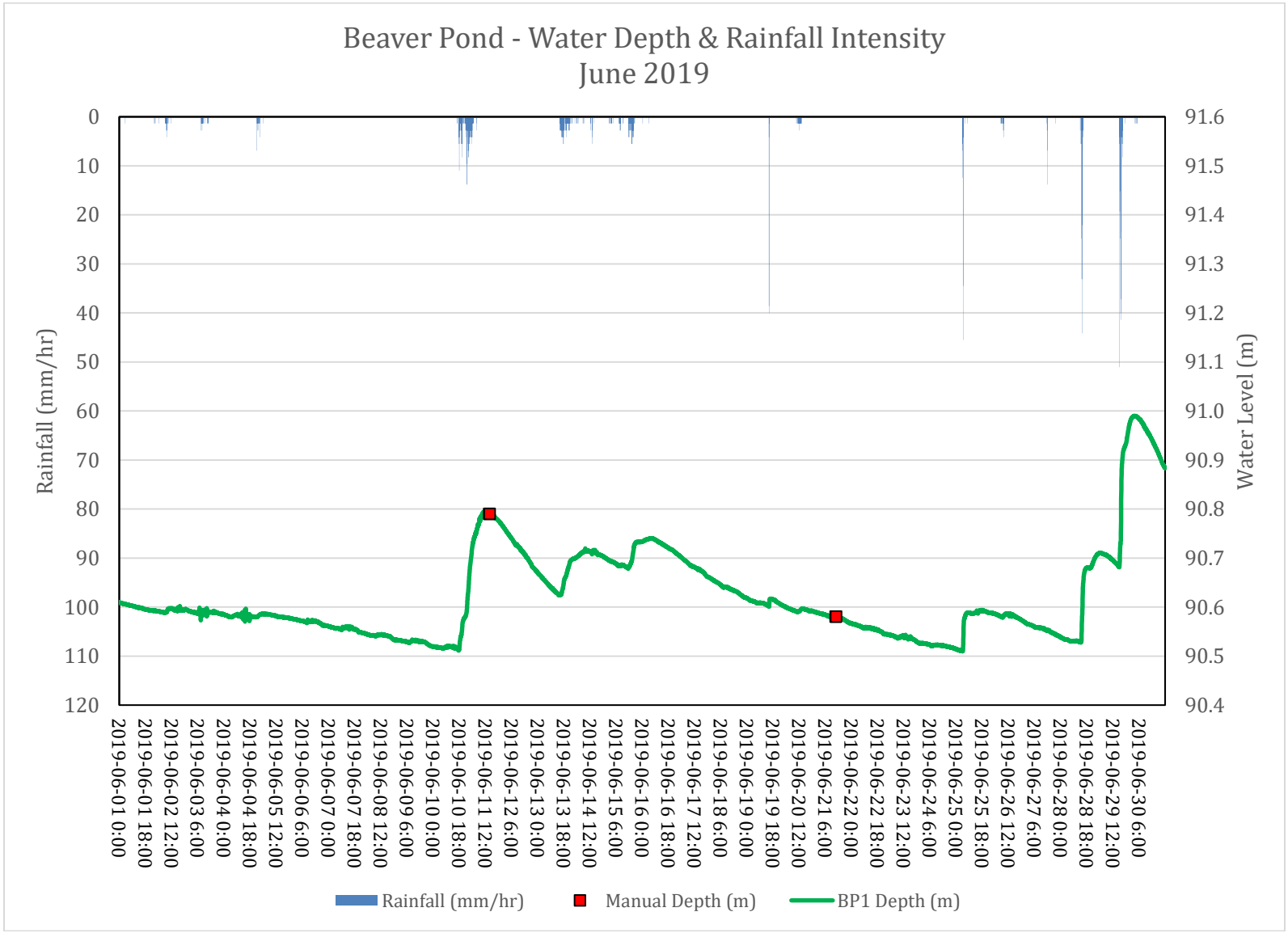
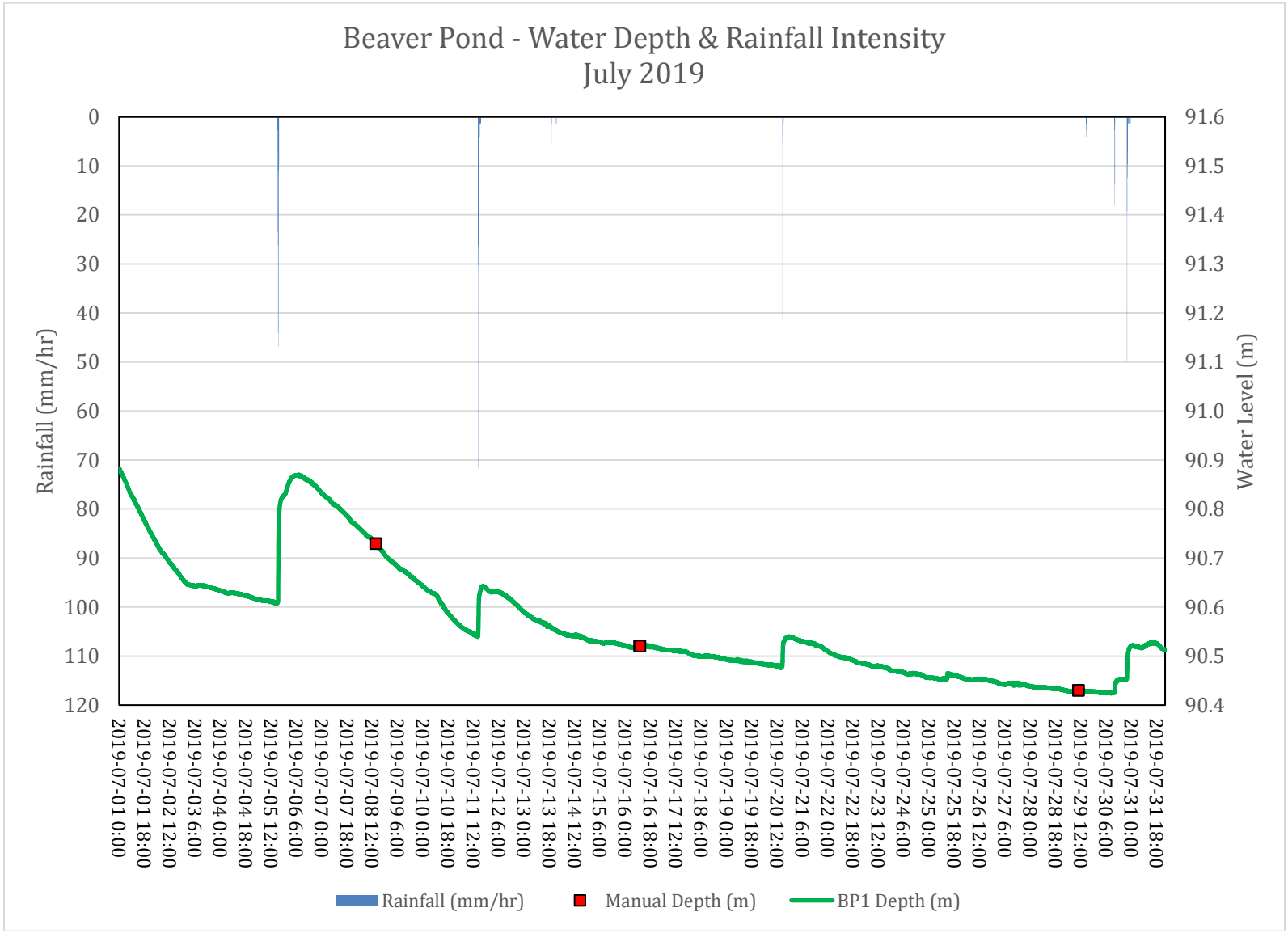
Appendix B

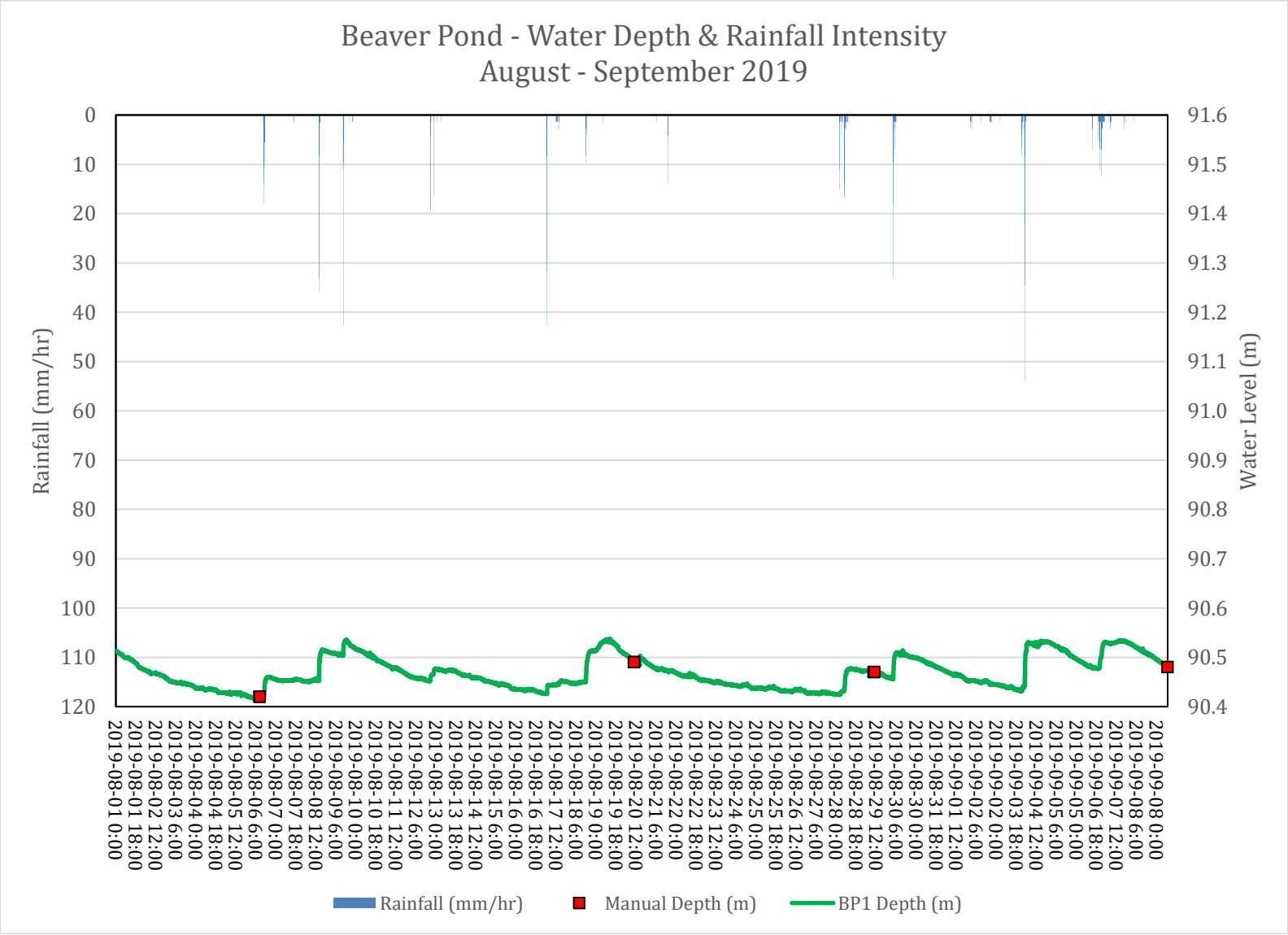
Beaver Pond Continuous Water Level Plots


Beaver Pond - Water Depth & Rainfall Intensity
May - September 2019
Rainfall (mm/hr)
Water Level (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
91.6
91.5
91.4
91.3
91.2
91.1
91.0
90.9
90.8
90.7
90.6
90.5
90.4
2019-05-15 13:00
2019-05-18 3:25
2019-05-20 17:50
2019-05-23 8:15
2019-05-25 22:40
2019-05-28 13:05
2019-05-31 3:30
2019-06-02 17:55
2019-06-05 8:20
2019-06-07 22:45
2019-06-10 13:10
2019-06-13 3:35
2019-06-15 18:00
2019-06-18 8:25
2019-06-20 22:50
2019-06-23 13:15
2019-06-26 3:40
2019-06-28 18:05
2019-07-01 8:30
2019-07-03 22:55
2019-07-06 13:20
2019-07-09 3:45
2019-07-11 18:10
2019-07-14 8:35
2019-07-16 23:00
2019-07-19 13:25
2019-07-22 3:50
2019-07-24 18:15
2019-07-27 8:40
2019-07-29 23:05
2019-08-01 13:30
2019-08-04 3:55
2019-08-06 18:20
2019-08-09 8:45
2019-08-11 23:10
2019-08-14 13:35
2019-08-17 4:00
2019-08-19 18:25
2019-08-22 8:50
2019-08-24 23:15
2019-08-27 13:40
2019-08-30 4:05
2019-09-01 18:30
2019-09-04 8:55
2019-09-06 23:20
Rainfall (mm/hr)
Manual Depth (m)
BP1 Depth (m)

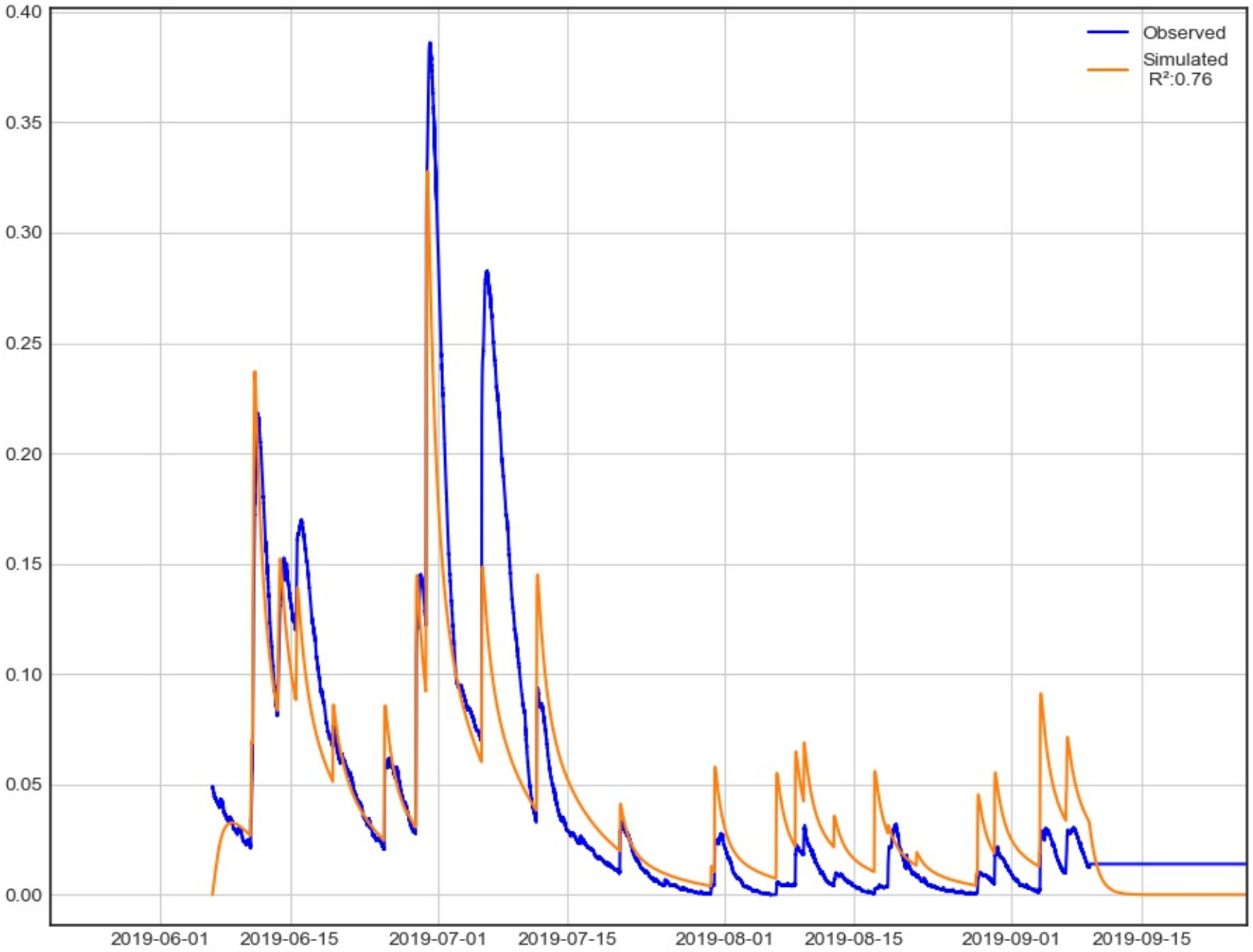

Beaver Pond - Water Depth & Rainfall Intensity
May 2019
Rainfall (mm/hr)
Water Level (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
91.6
91.5
91.4
91.3
91.2
91.1
91.0
90.9
90.8
90.7
90.6
90.5
90.4
2019-05-15 13:00
2019-05-16 1:00
2019-05-16 13:00
2019-05-17 1:00
2019-05-17 13:00
2019-05-18 1:00
2019-05-18 13:00
2019-05-19 1:00
2019-05-19 13:00
2019-05-20 1:00
2019-05-20 13:00
2019-05-21 1:00
2019-05-21 13:00
2019-05-22 1:00
2019-05-22 13:00
2019-05-23 1:00
2019-05-23 13:00
2019-05-24 1:00
2019-05-24 13:00
2019-05-25 1:00
2019-05-25 13:00
2019-05-26 1:00
2019-05-26 13:00
2019-05-27 1:00
2019-05-27 13:00
2019-05-28 1:00
2019-05-28 13:00
2019-05-29 1:00
2019-05-29 13:00
2019-05-30 1:00
2019-05-30 13:00
2019-05-31 1:00
2019-05-31 13:00
Rainfall (mm/hr)
Manual Depth (m)
BP1 Depth (m)


Beaver Pond - Water Depth & Rainfall Intensity
June 2019
Rainfall (mm/hr)
Water Level (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
91.6
91.5
91.4
91.3
91.2
91.1
91.0
90.9
90.8
90.7
90.6
90.5
90.4
2019-06-01 0:00
2019-06-01 18:00
2019-06-02 12:00
2019-06-03 6:00
2019-06-04 0:00
2019-06-04 18:00
2019-06-05 12:00
2019-06-06 6:00
2019-06-07 0:00
2019-06-07 18:00
2019-06-08 12:00
2019-06-09 6:00
2019-06-10 0:00
2019-06-10 18:00
2019-06-11 12:00
2019-06-12 6:00
2019-06-13 0:00
2019-06-13 18:00
2019-06-14 12:00
2019-06-15 6:00
2019-06-16 0:00
2019-06-16 18:00
2019-06-17 12:00
2019-06-18 6:00
2019-06-19 0:00
2019-06-19 18:00
2019-06-20 12:00
2019-06-21 6:00
2019-06-22 0:00
2019-06-22 18:00
2019-06-23 12:00
2019-06-24 6:00
2019-06-25 0:00
2019-06-25 18:00
2019-06-26 12:00
2019-06-27 6:00
2019-06-28 0:00
2019-06-28 18:00
2019-06-29 12:00
2019-06-30 6:00
Rainfall (mm/hr)
Manual Depth (m)
BP1 Depth (m)


Beaver Pond - Water Depth & Rainfall Intensity
July 2019
Rainfall (mm/hr)
Water Level (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
91.6
91.5
91.4
91.3
91.2
91.1
91.0
90.9
90.8
90.7
90.6
90.5
90.4
2019-07-01 0:00
2019-07-01 18:00
2019-07-02 12:00
2019-07-03 6:00
2019-07-04 0:00
2019-07-04 18:00
2019-07-05 12:00
2019-07-06 6:00
2019-07-07 0:00
2019-07-07 18:00
2019-07-08 12:00
2019-07-09 6:00
2019-07-10 0:00
2019-07-10 18:00
2019-07-11 12:00
2019-07-12 6:00
2019-07-13 0:00
2019-07-13 18:00
2019-07-14 12:00
2019-07-15 6:00
2019-07-16 0:00
2019-07-16 18:00
2019-07-17 12:00
2019-07-18 6:00
2019-07-19 0:00
2019-07-19 18:00
2019-07-20 12:00
2019-07-21 6:00
2019-07-22 0:00
2019-07-22 18:00
2019-07-23 12:00
2019-07-24 6:00
2019-07-25 0:00
2019-07-25 18:00
2019-07-26 12:00
2019-07-27 6:00
2019-07-28 0:00
2019-07-28 18:00
2019-07-29 12:00
2019-07-30 6:00
2019-07-31 0:00
2019-07-31 18:00
Rainfall (mm/hr)
Manual Depth (m)
BP1 Depth (m)


Beaver Pond - Water Depth & Rainfall Intensity
August - September 2019
Rainfall (mm/hr)
Water Level (m)
0
10
20
30
40
50
60
70
80
90
100
110
120
91.6
91.5
91.4
91.3
91.2
91.1
91.0
90.9
90.8
90.7
90.6
90.5
90.4
2019-08-01 0:00
2019-08-01 18:00
2019-08-02 12:00
2019-08-03 6:00
2019-08-04 0:00
2019-08-04 18:00
2019-08-05 12:00
2019-08-06 6:00
2019-08-07 0:00
2019-08-07 18:00
2019-08-08 12:00
2019-08-09 6:00
2019-08-10 0:00
2019-08-10 18:00
2019-08-11 12:00
2019-08-12 6:00
2019-08-13 0:00
2019-08-13 18:00
2019-08-14 12:00
2019-08-15 6:00
2019-08-16 0:00
2019-08-16 18:00
2019-08-17 12:00
2019-08-18 6:00
2019-08-19 0:00
2019-08-19 18:00
2019-08-20 12:00
2019-08-21 6:00
2019-08-22 0:00
2019-08-22 18:00
2019-08-23 12:00
2019-08-24 6:00
2019-08-25 0:00
2019-08-25 18:00
2019-08-26 12:00
2019-08-27 6:00
2019-08-28 0:00
2019-08-28 18:00
2019-08-29 12:00
2019-08-30 6:00
2019-08-31 0:00
2019-08-31 18:00
2019-09-01 12:00
2019-09-02 6:00
2019-09-03 0:00
2019-09-03 18:00
2019-09-04 12:00
2019-09-05 6:00
2019-09-06 0:00
2019-09-06 18:00
2019-09-07 12:00
2019-09-08 6:00
2019-09-09 0:00
Rainfall (mm/hr)
Manual Depth (m)
BP1 Depth (m)

Observed and Simulated Beaver Pond Outflows based on 2019 Monitoring Data and Updated Model Calibration
(measured runoff volume is 95.47 mm and simulated runoff volume is 94.31 mm)



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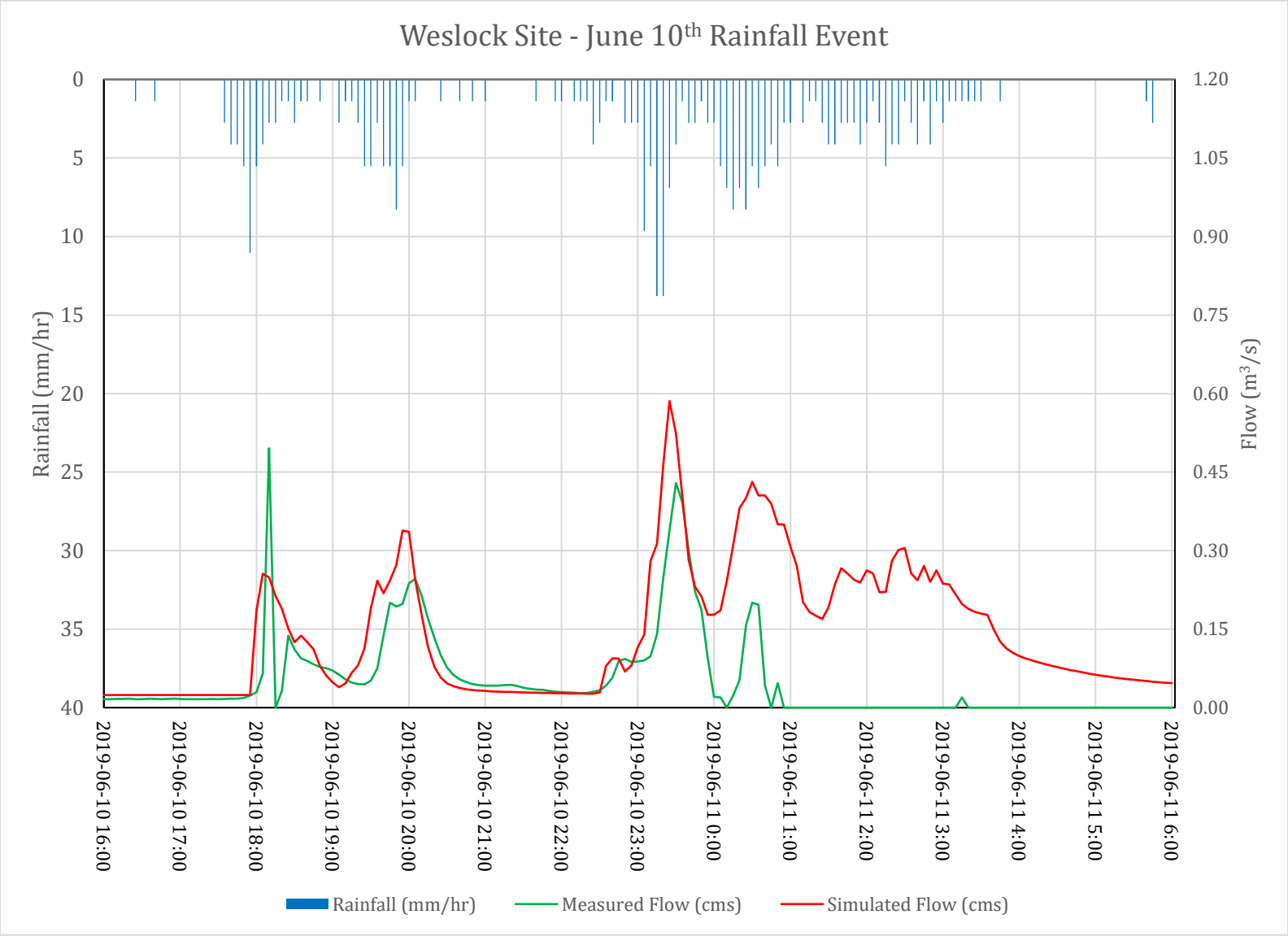
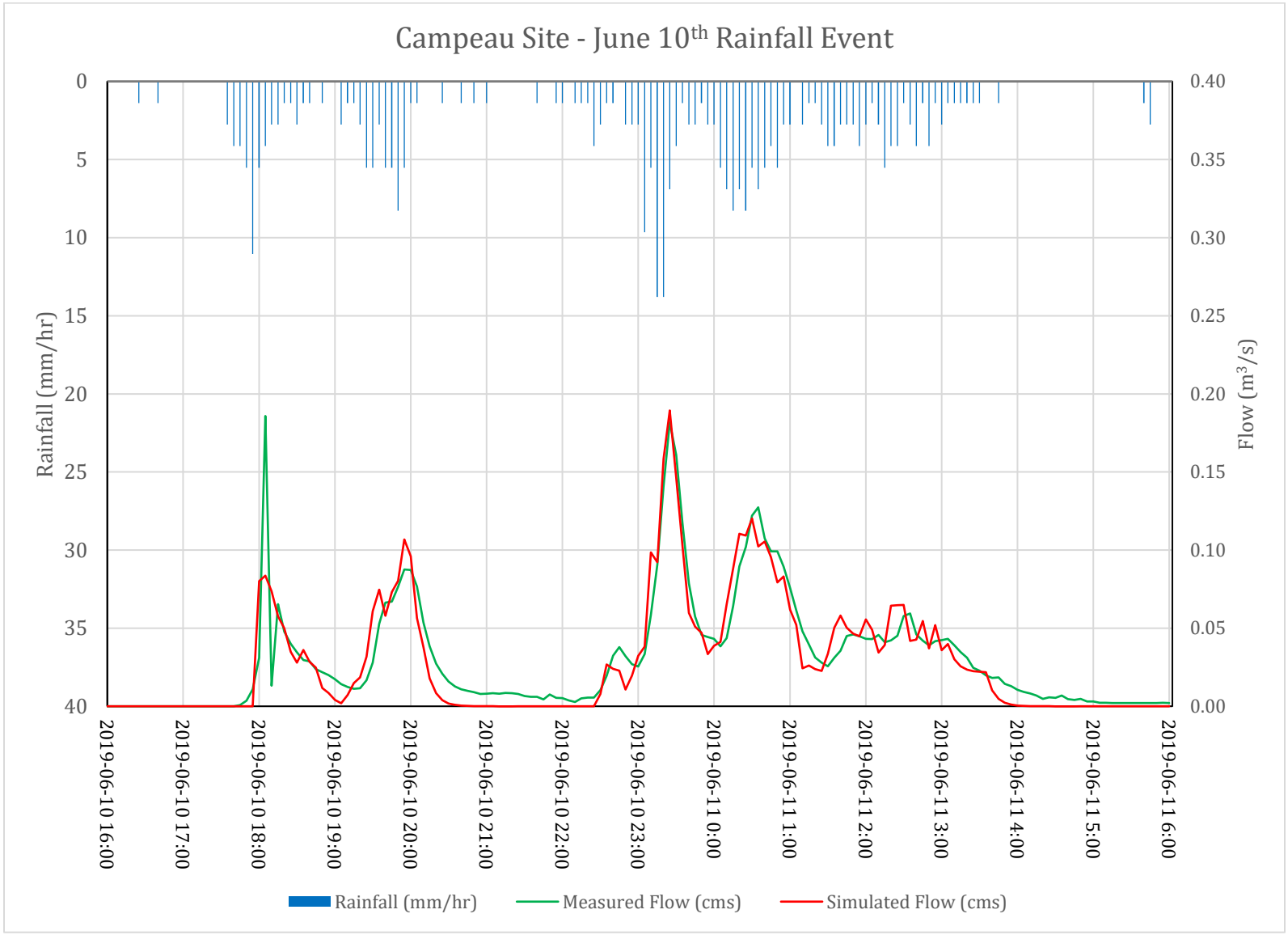
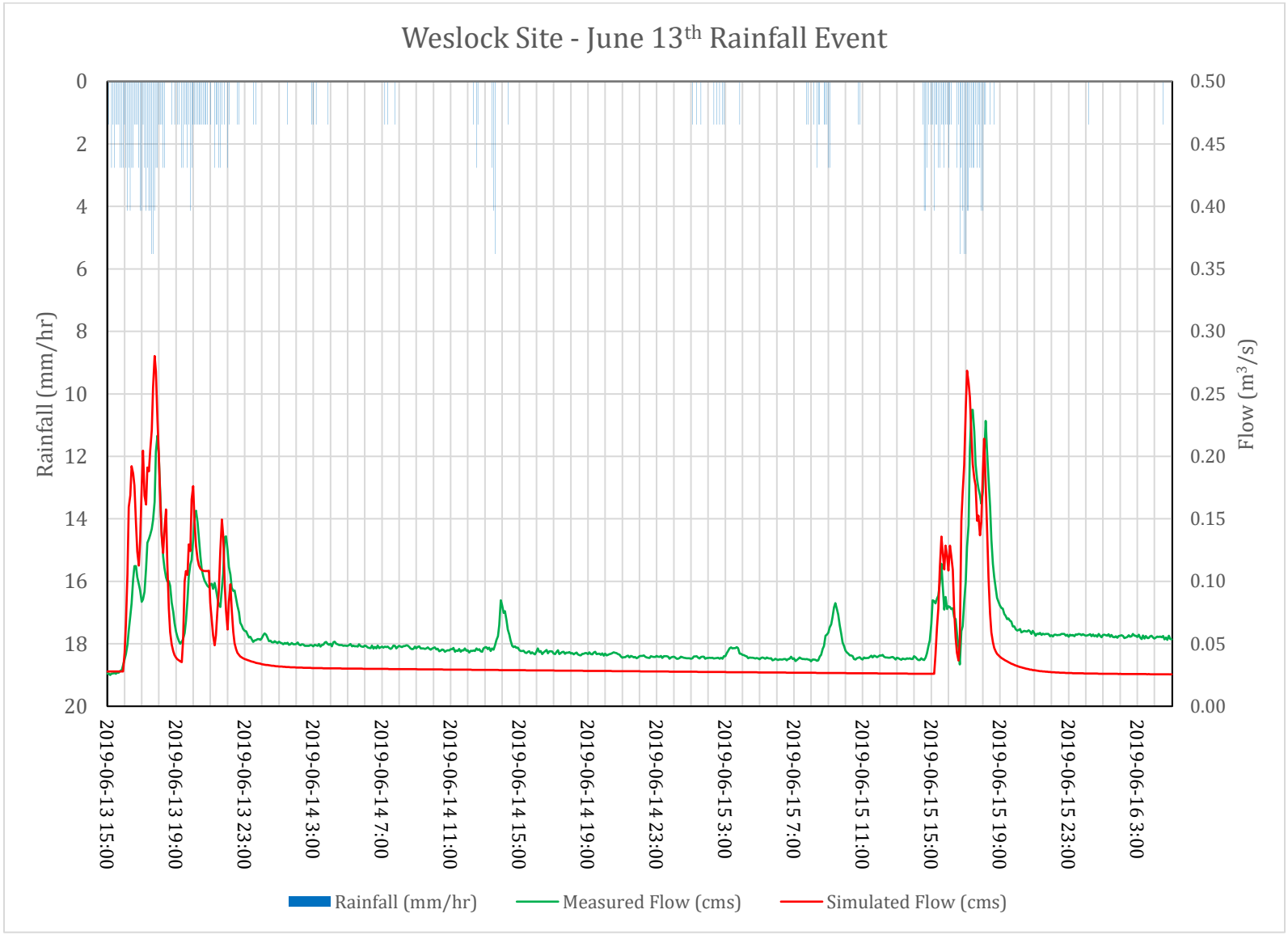
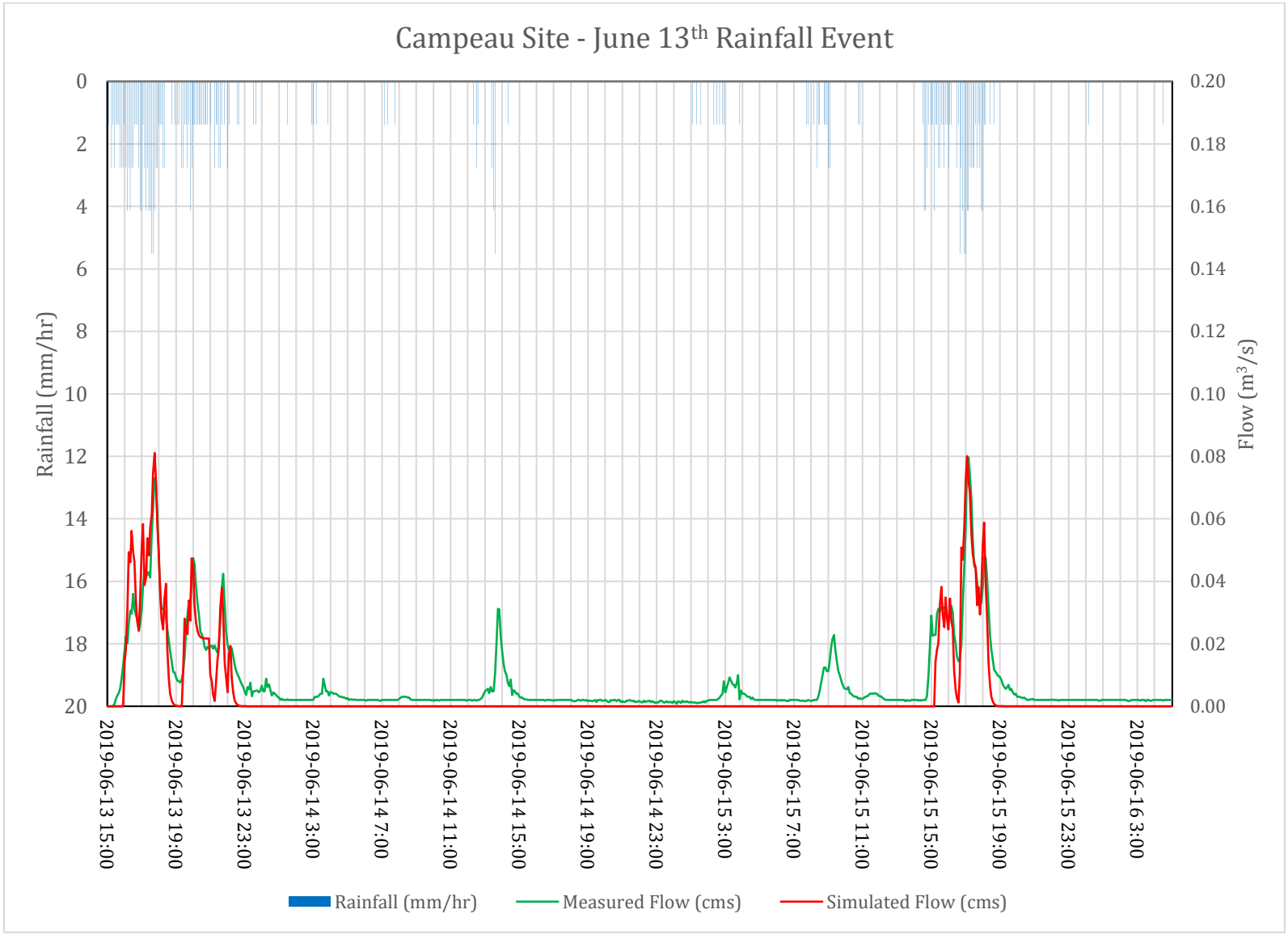
Appendix C

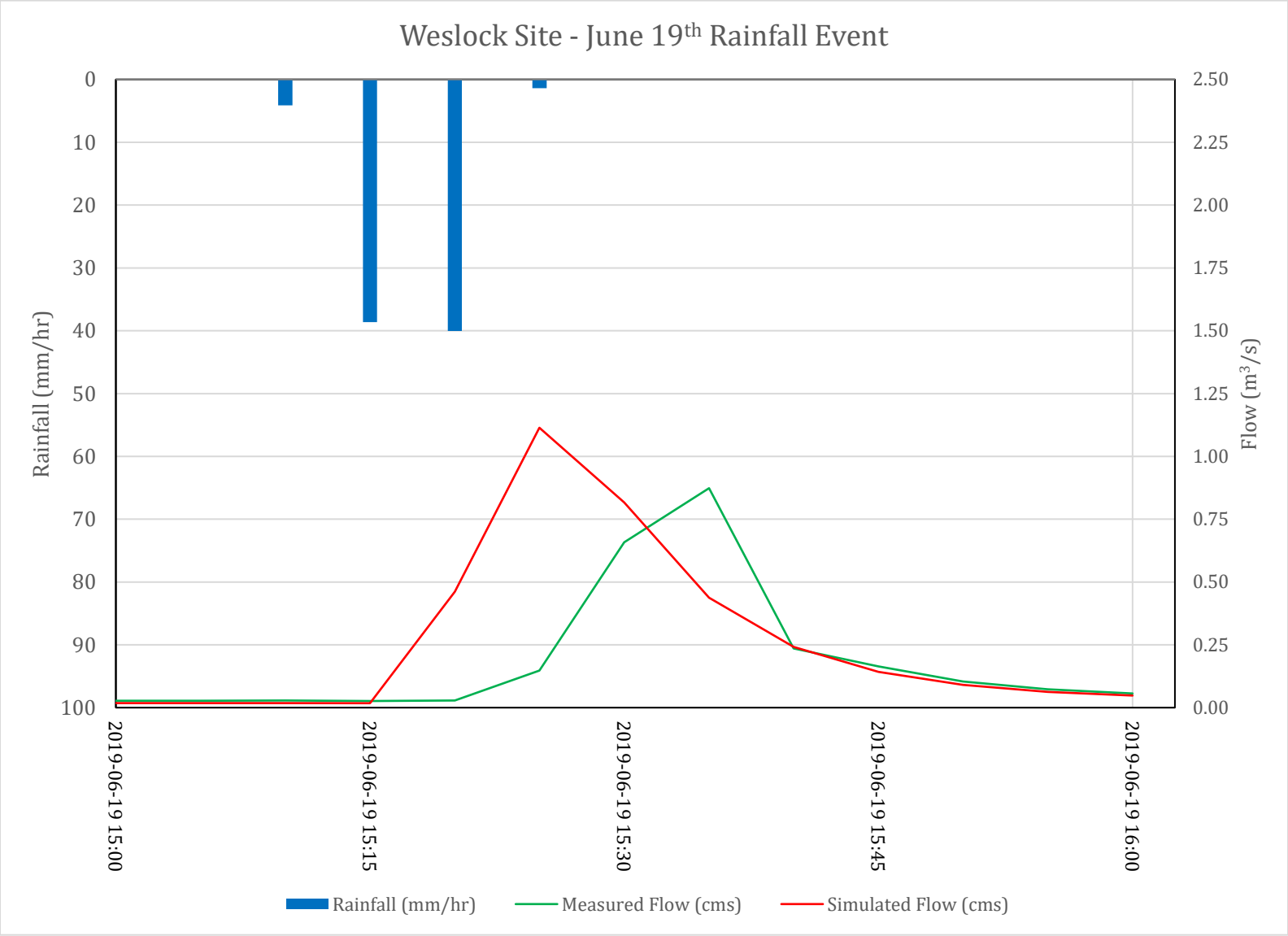
Measured vs. Simulated Flows at Campeau and Weslock Sites

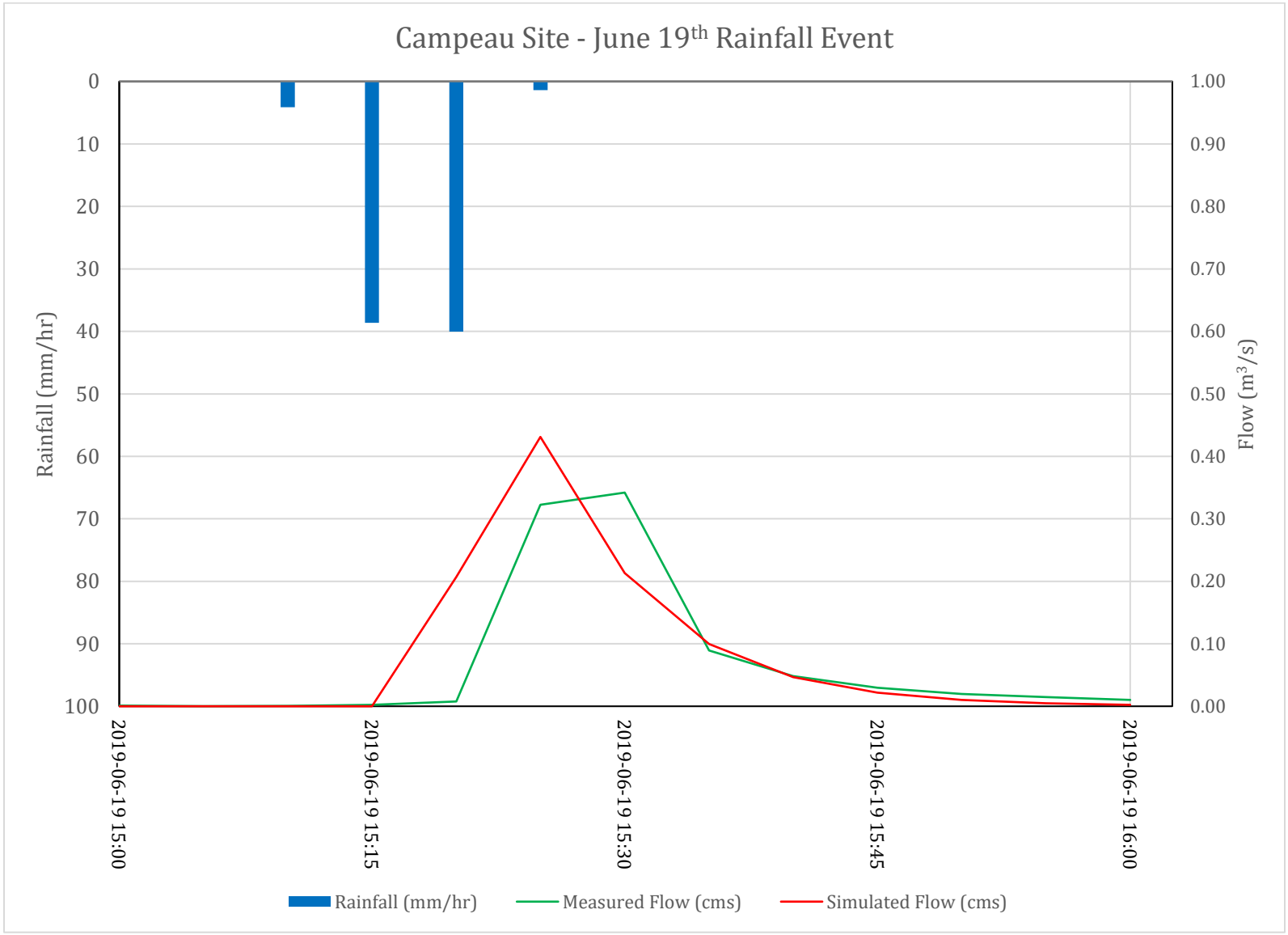

Weslock Site - June 10th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
2019-06-10 16:00
2019-06-10 17:00
2019-06-10 18:00
2019-06-10 19:00
2019-06-10 20:00
2019-06-10 21:00
2019-06-10 22:00
2019-06-10 23:00
2019-06-11 0:00
2019-06-11 1:00
2019-06-11 2:00
2019-06-11 3:00
2019-06-11 4:00
2019-06-11 5:00
2019-06-11 6:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

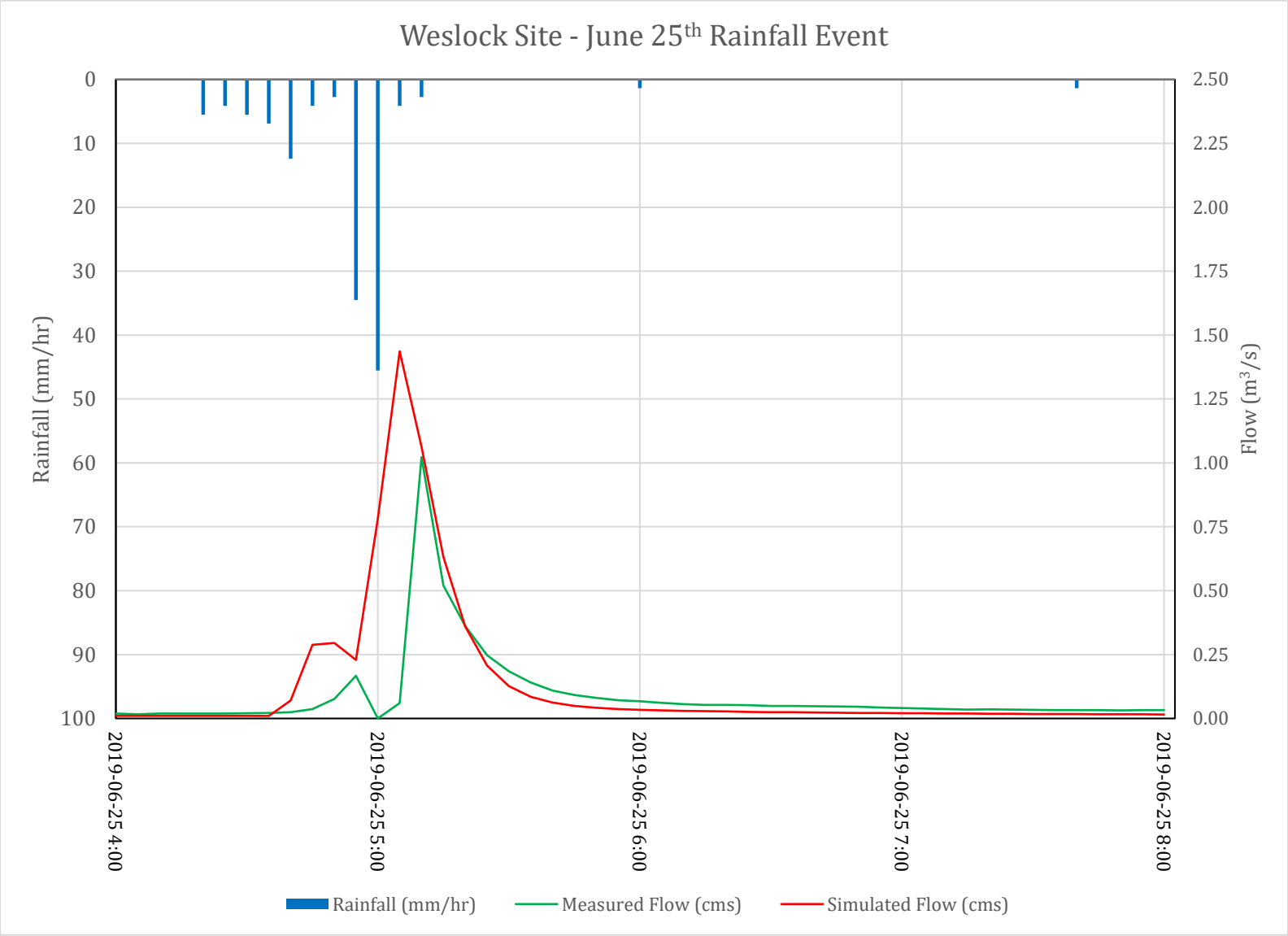

Campeau Site - June 10th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-06-10 16:00
2019-06-10 17:00
2019-06-10 18:00
2019-06-10 19:00
2019-06-10 20:00
2019-06-10 21:00
2019-06-10 22:00
2019-06-10 23:00
2019-06-11 0:00
2019-06-11 1:00
2019-06-11 2:00
2019-06-11 3:00
2019-06-11 4:00
2019-06-11 5:00
2019-06-11 6:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

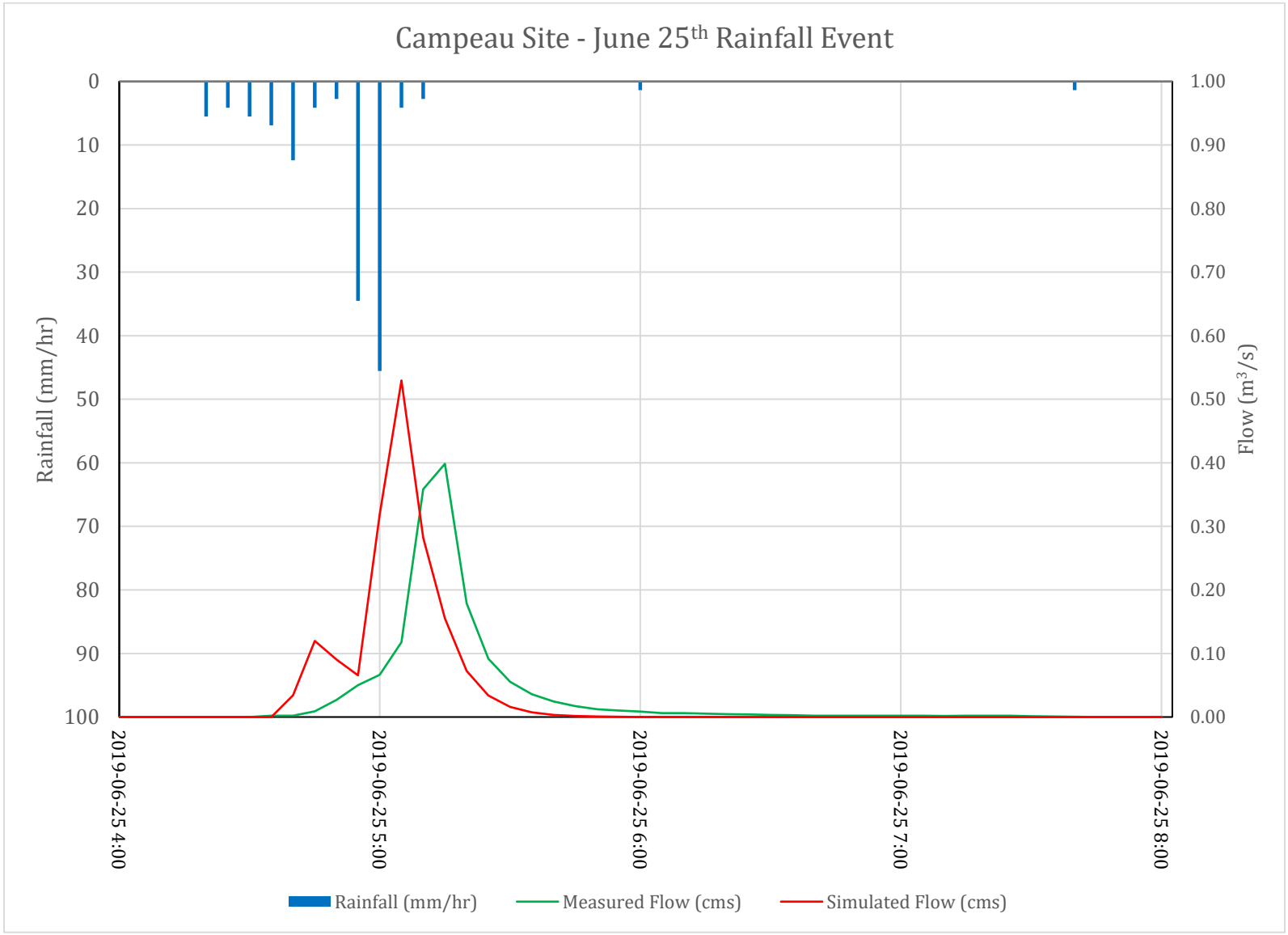

Weslock Site - June 13th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
2
4
6
8
10
12
14
16
18
20
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-06-13 15:00
2019-06-13 19:00
2019-06-13 23:00
2019-06-14 3:00
2019-06-14 7:00
2019-06-14 11:00
2019-06-14 15:00
2019-06-14 19:00
2019-06-14 23:00
2019-06-15 3:00
2019-06-15 7:00
2019-06-15 11:00
2019-06-15 15:00
2019-06-15 19:00
2019-06-15 23:00
2019-06-16 3:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

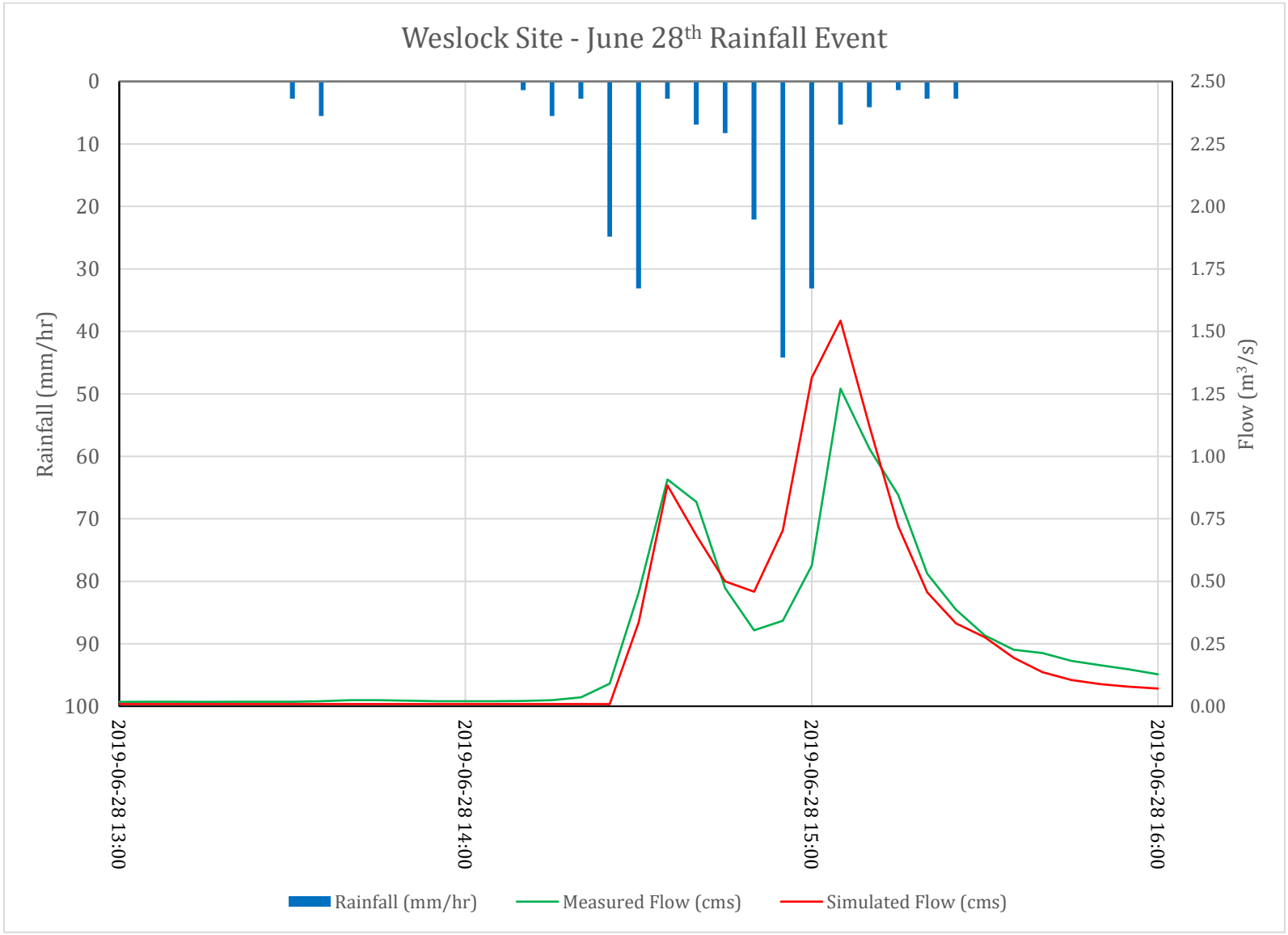

Campeau Site - June 13th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
2
4
6
8
10
12
14
16
18
20
0.20
0.18
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
2019-06-13 15:00
2019-06-13 19:00
2019-06-13 23:00
2019-06-14 3:00
2019-06-14 7:00
2019-06-14 11:00
2019-06-14 15:00
2019-06-14 19:00
2019-06-14 23:00
2019-06-15 3:00
2019-06-15 7:00
2019-06-15 11:00
2019-06-15 15:00
2019-06-15 19:00
2019-06-15 23:00
2019-06-16 3:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

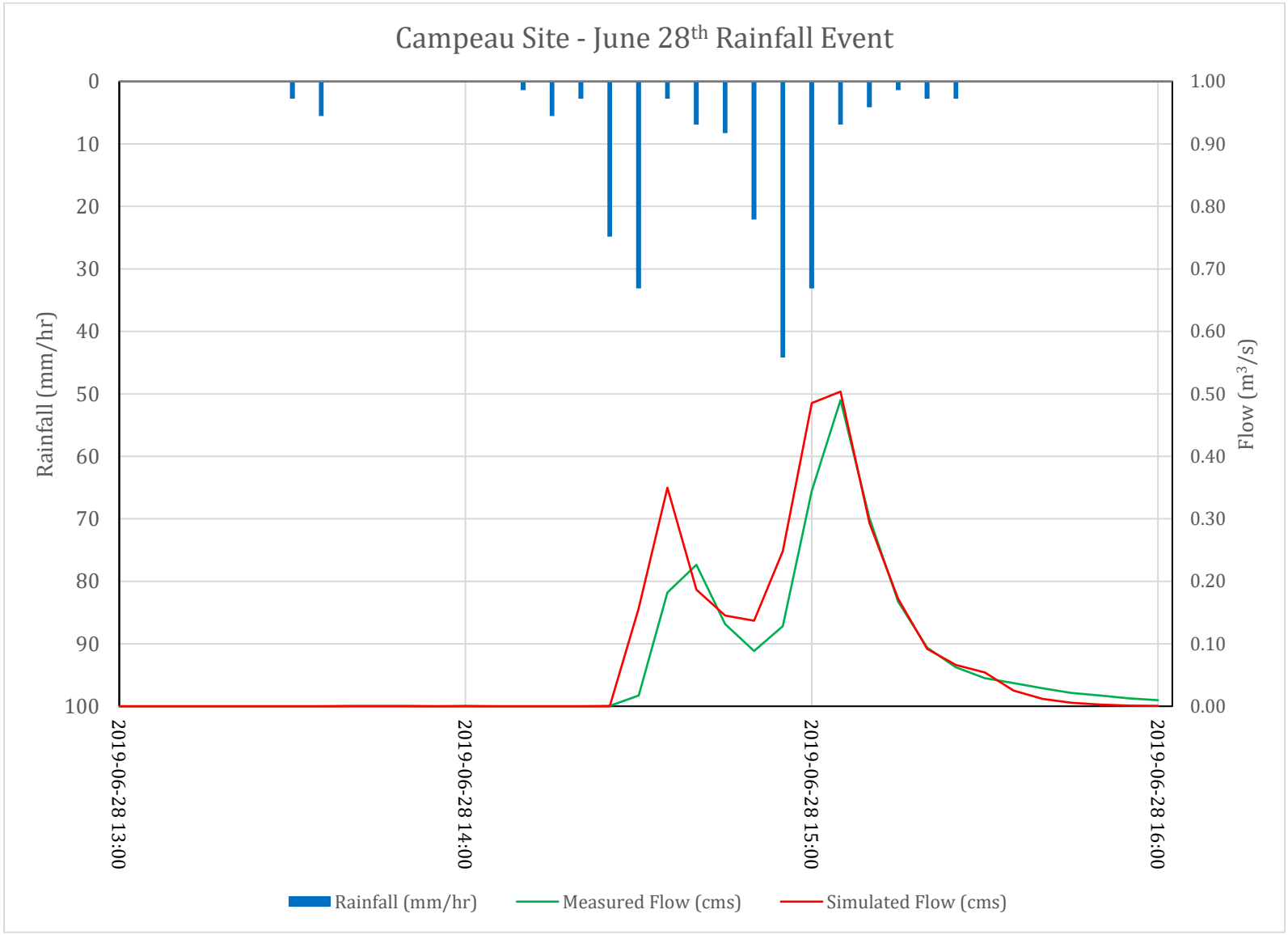

Weslock Site - June 19th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2019-06-19 15:00
2019-06-19 15:15
2019-06-19 15:30
2019-06-19 15:45
2019-06-19 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

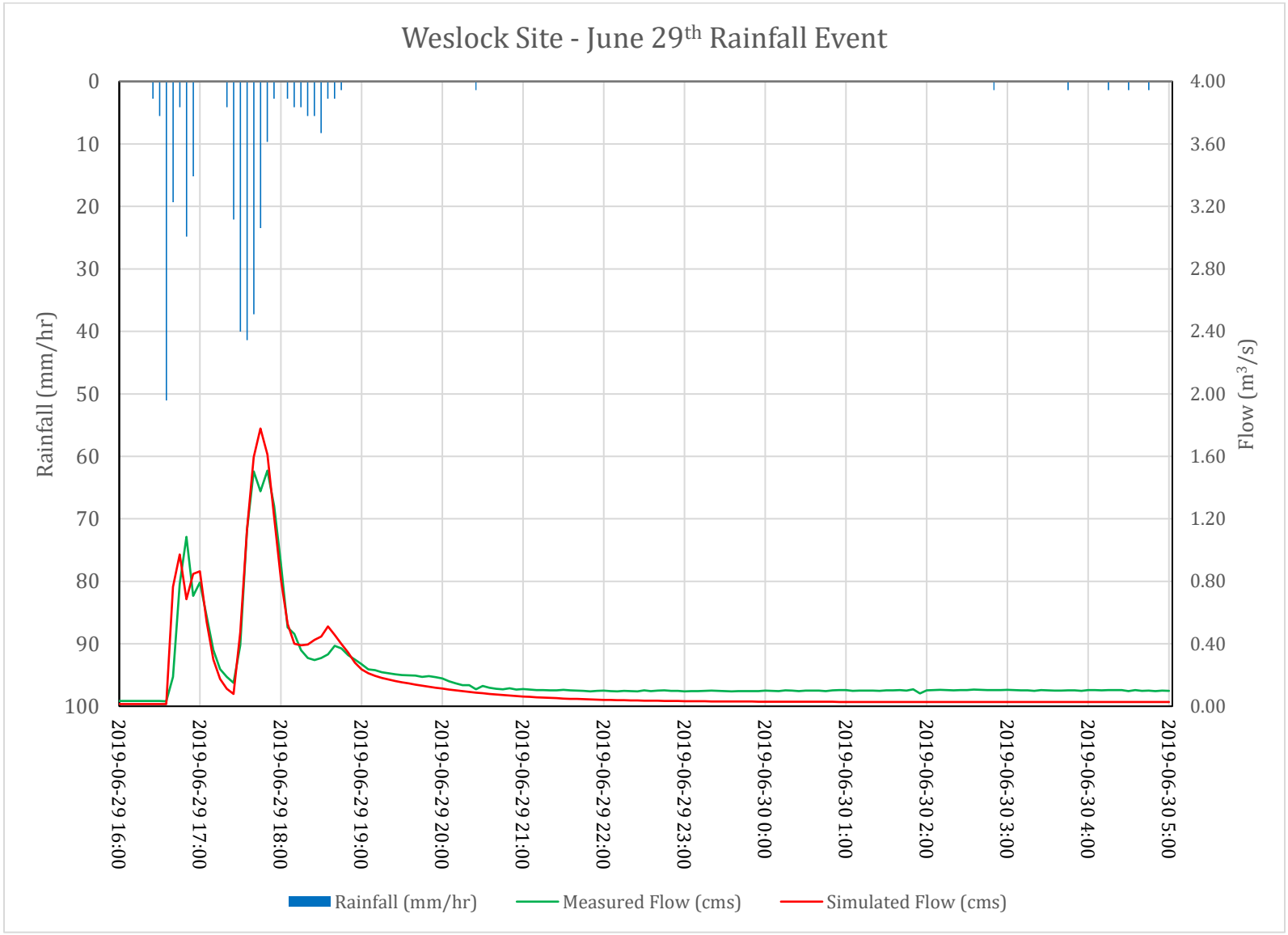

Campeau Site - June 19th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-06-19 15:00
2019-06-19 15:15
2019-06-19 15:30
2019-06-19 15:45
2019-06-19 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

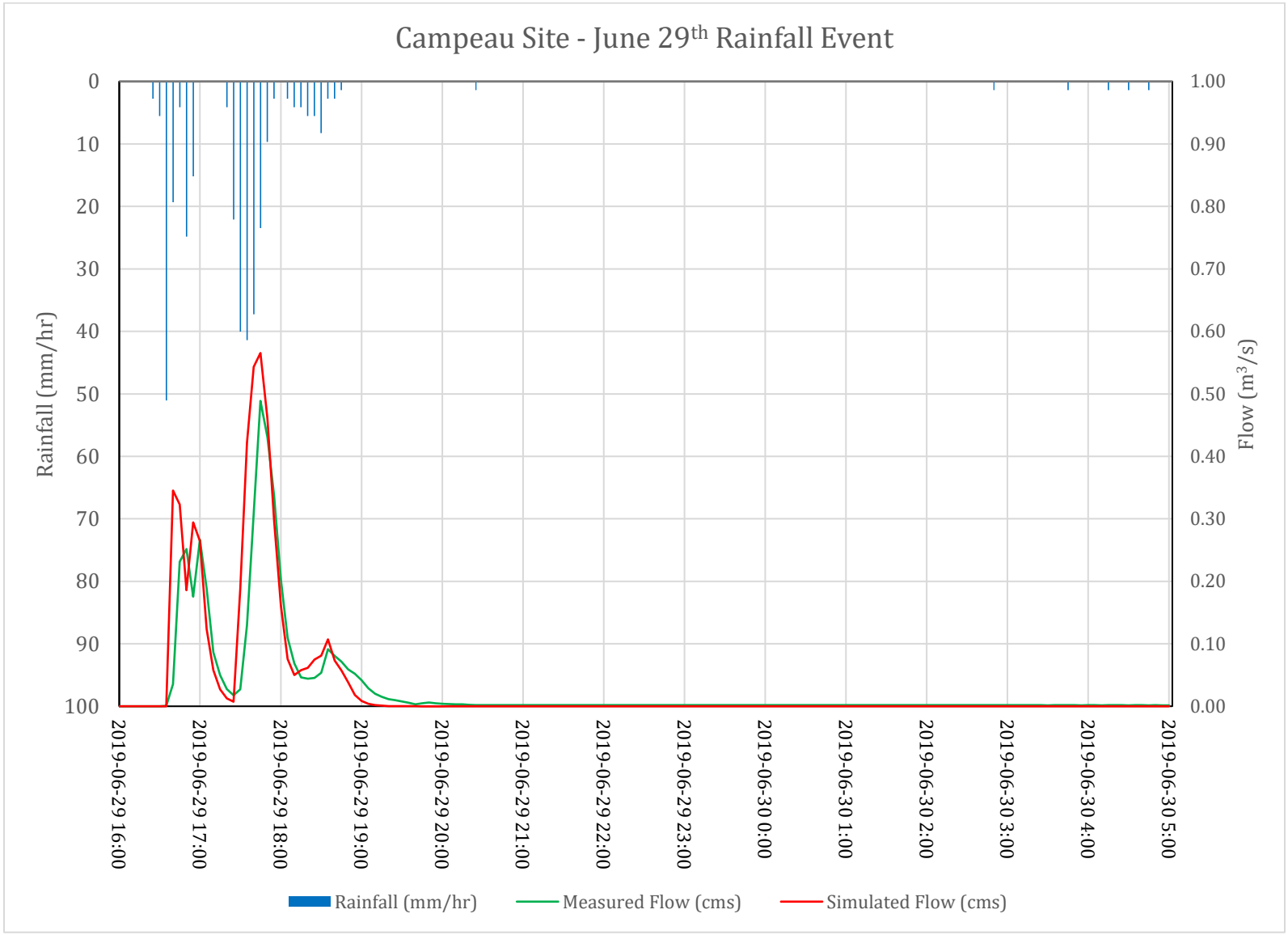

Weslock Site - June 25th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2019-06-25 4:00
2019-06-25 5:00
2019-06-25 6:00
2019-06-25 7:00
2019-06-25 8:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

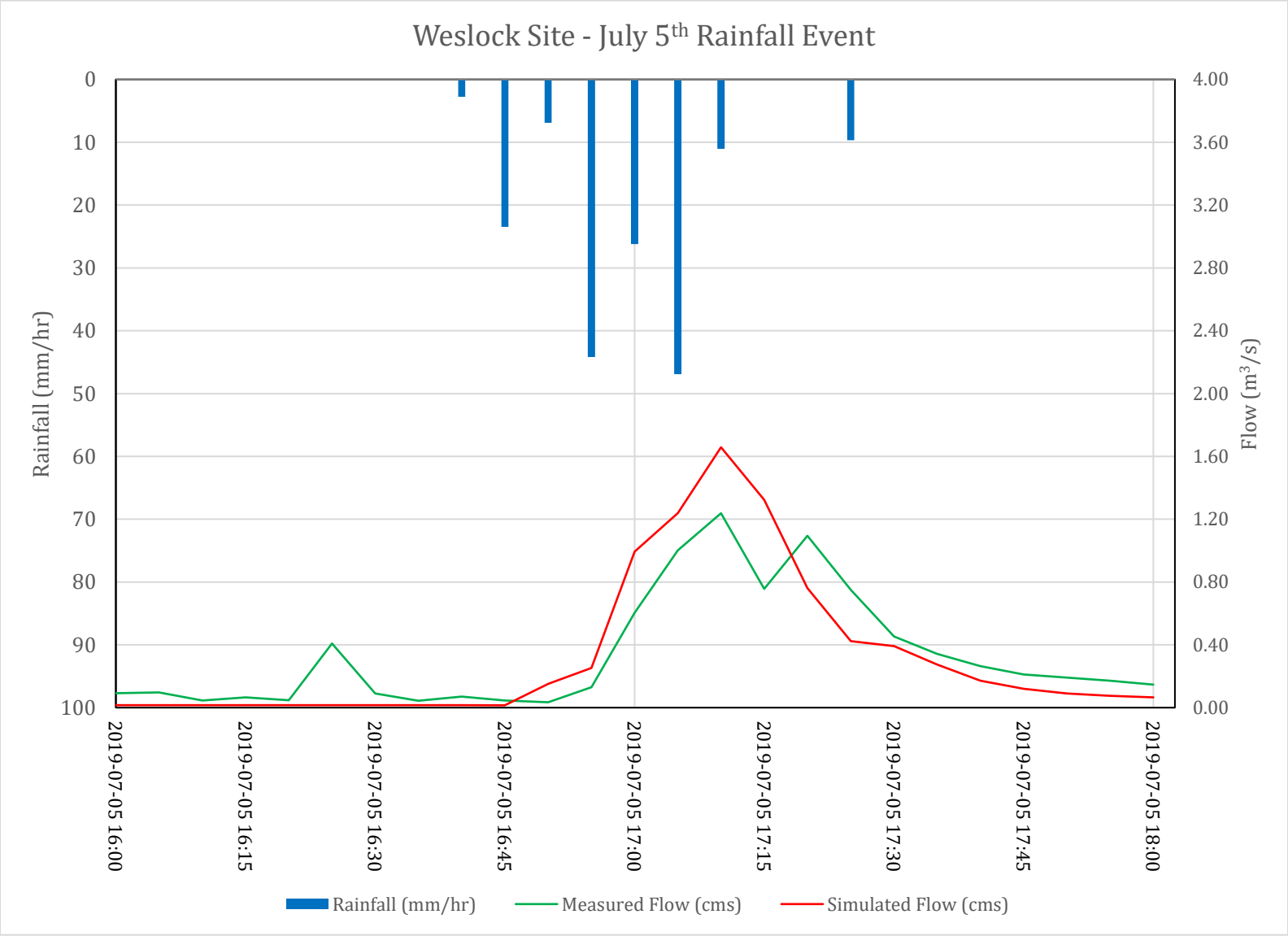

Campeau Site - June 25th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-06-25 4:00
2019-06-25 5:00
2019-06-25 6:00
2019-06-25 7:00
2019-06-25 8:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

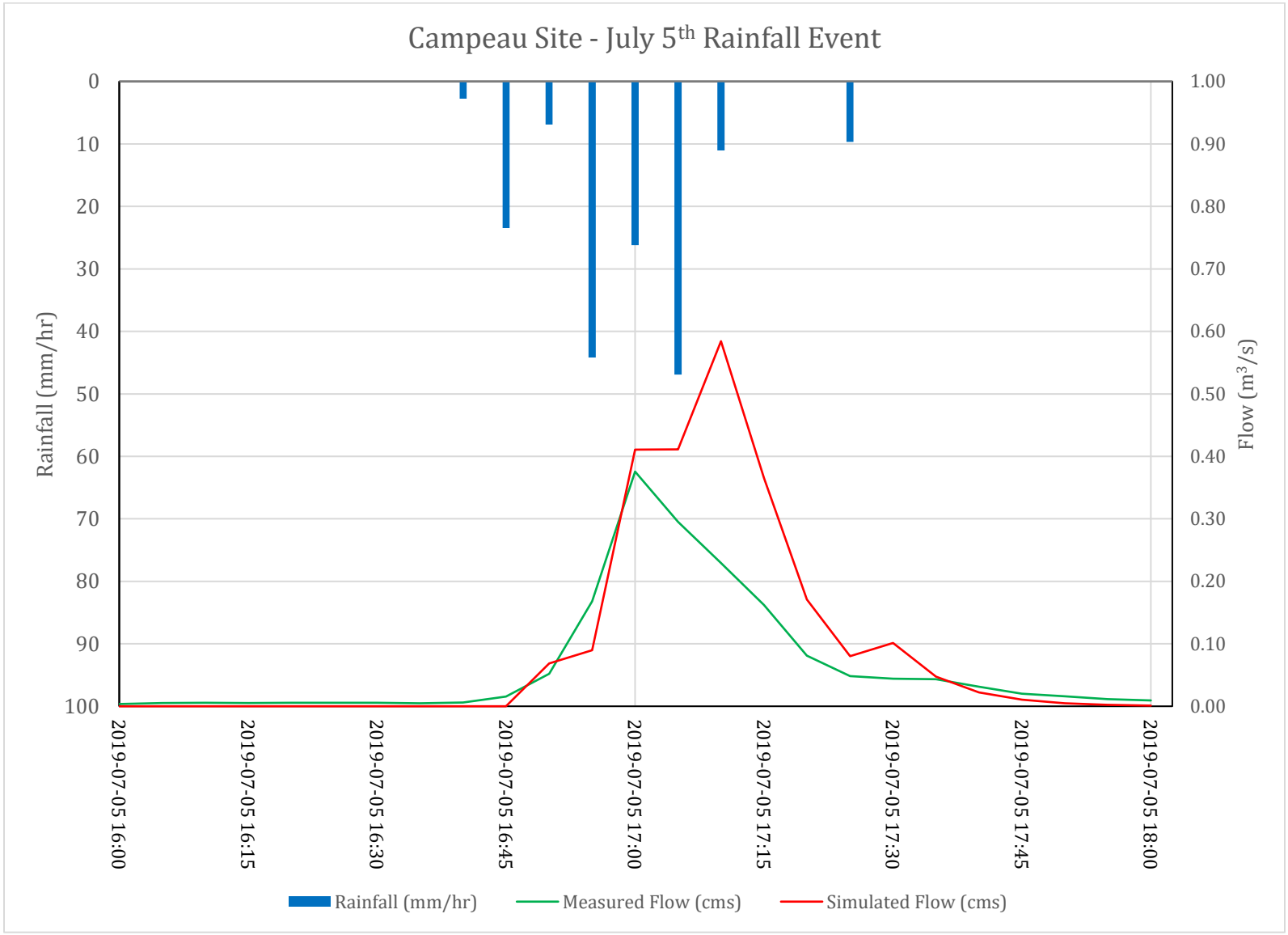

Weslock Site - June 28th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
2019-06-28 13:00
2019-06-28 14:00
2019-06-28 15:00
2019-06-28 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

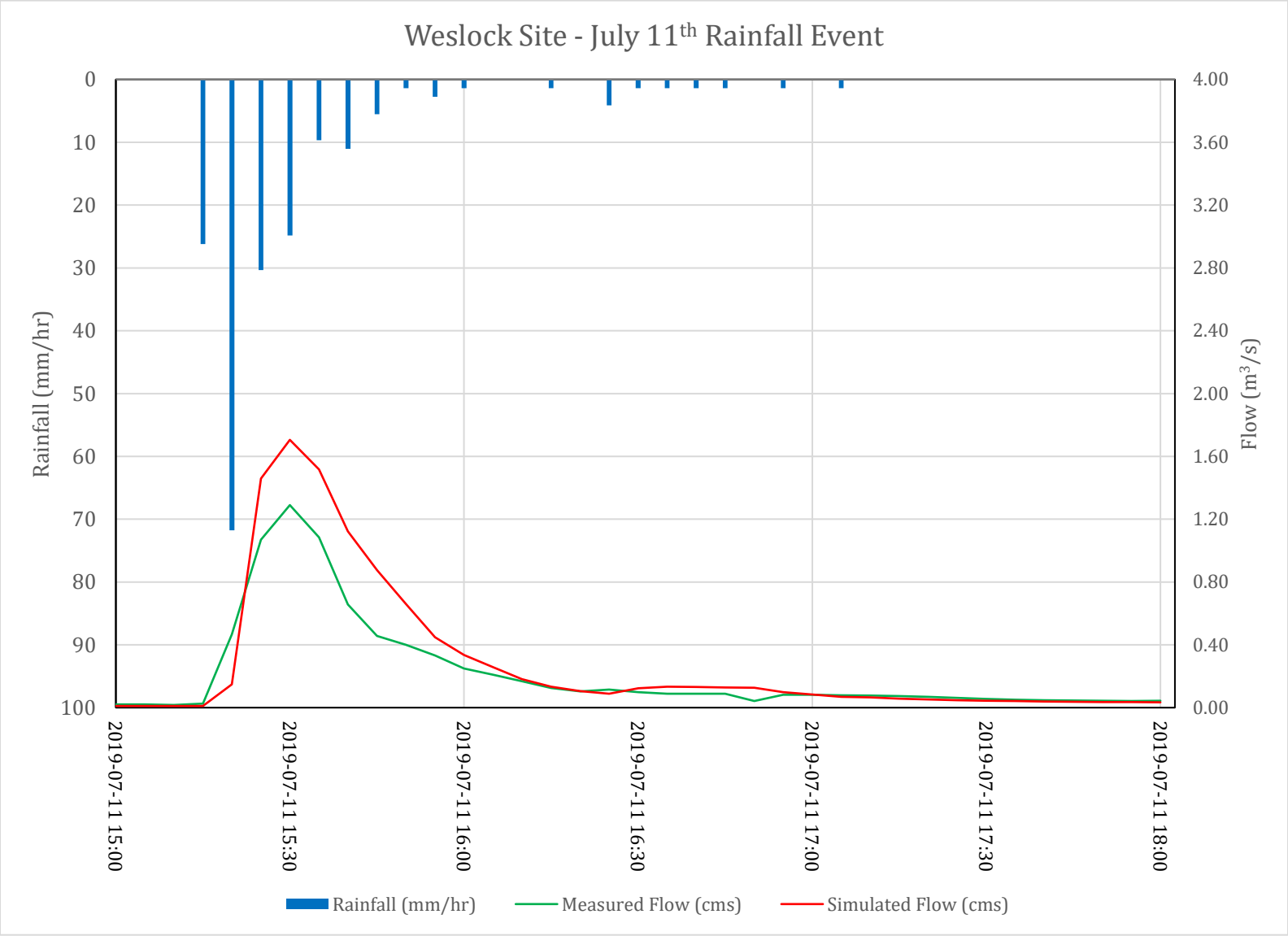

Campeau Site - June 28th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-06-28 13:00
2019-06-28 14:00
2019-06-28 15:00
2019-06-28 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

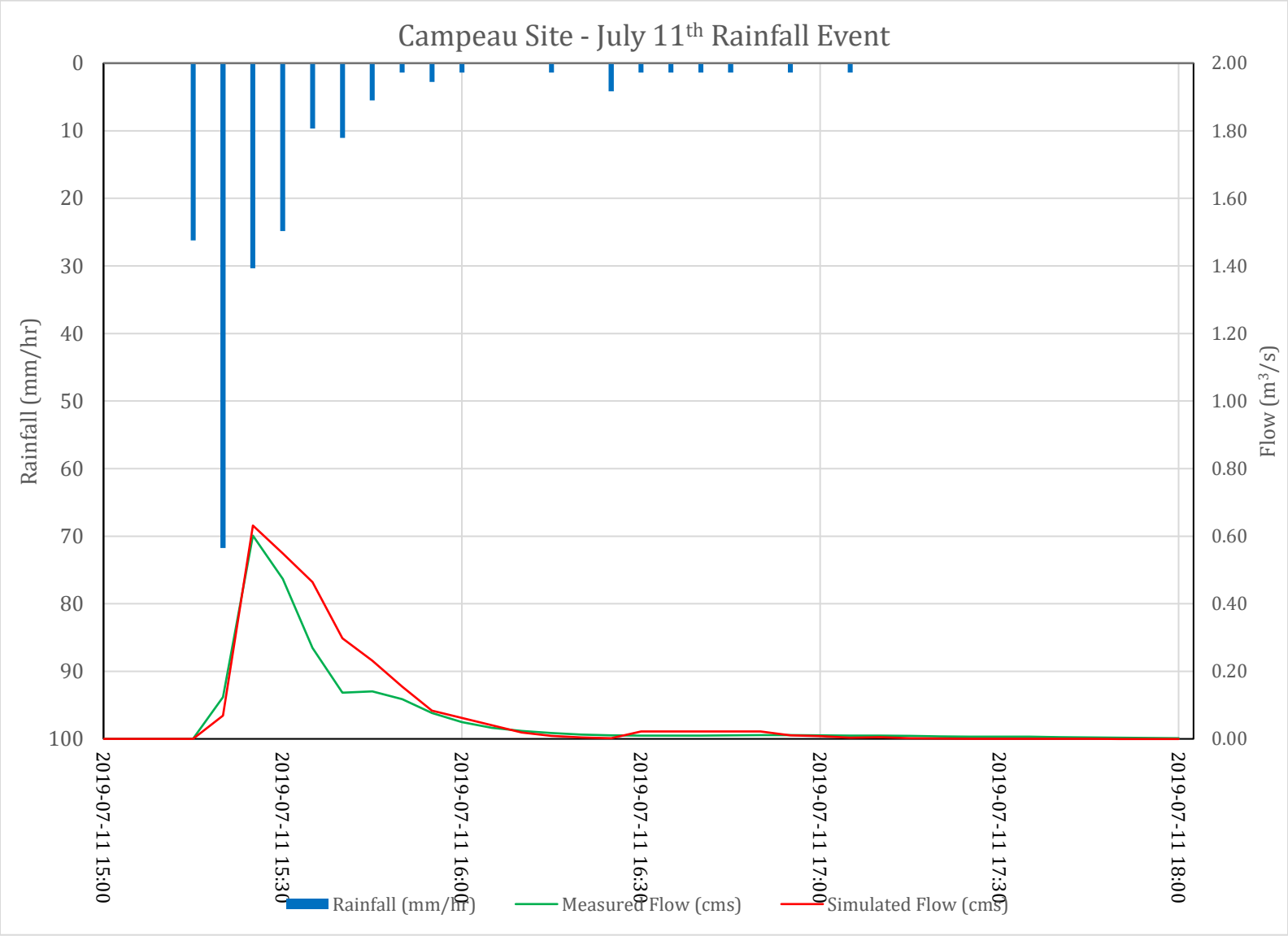

Weslock Site - June 29th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
2019-06-29 16:00
2019-06-29 17:00
2019-06-29 18:00
2019-06-29 19:00
2019-06-29 20:00
2019-06-29 21:00
2019-06-29 22:00
2019-06-29 23:00
2019-06-30 0:00
2019-06-30 1:00
2019-06-30 2:00
2019-06-30 3:00
2019-06-30 4:00
2019-06-30 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

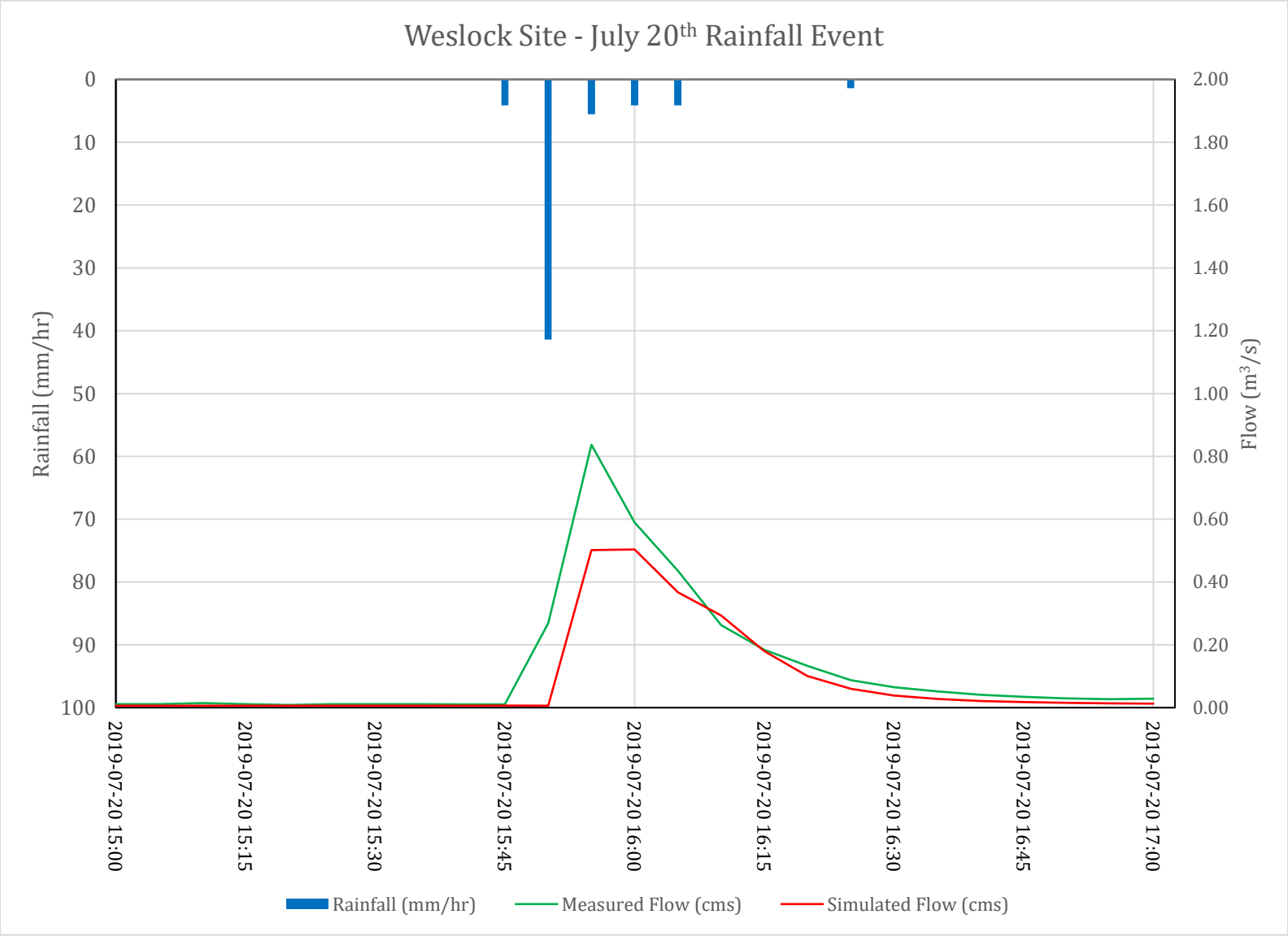

Campeau Site - June 29th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-06-29 16:00
2019-06-29 17:00
2019-06-29 18:00
2019-06-29 19:00
2019-06-29 20:00
2019-06-29 21:00
2019-06-29 22:00
2019-06-29 23:00
2019-06-30 0:00
2019-06-30 1:00
2019-06-30 2:00
2019-06-30 3:00
2019-06-30 4:00
2019-06-30 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

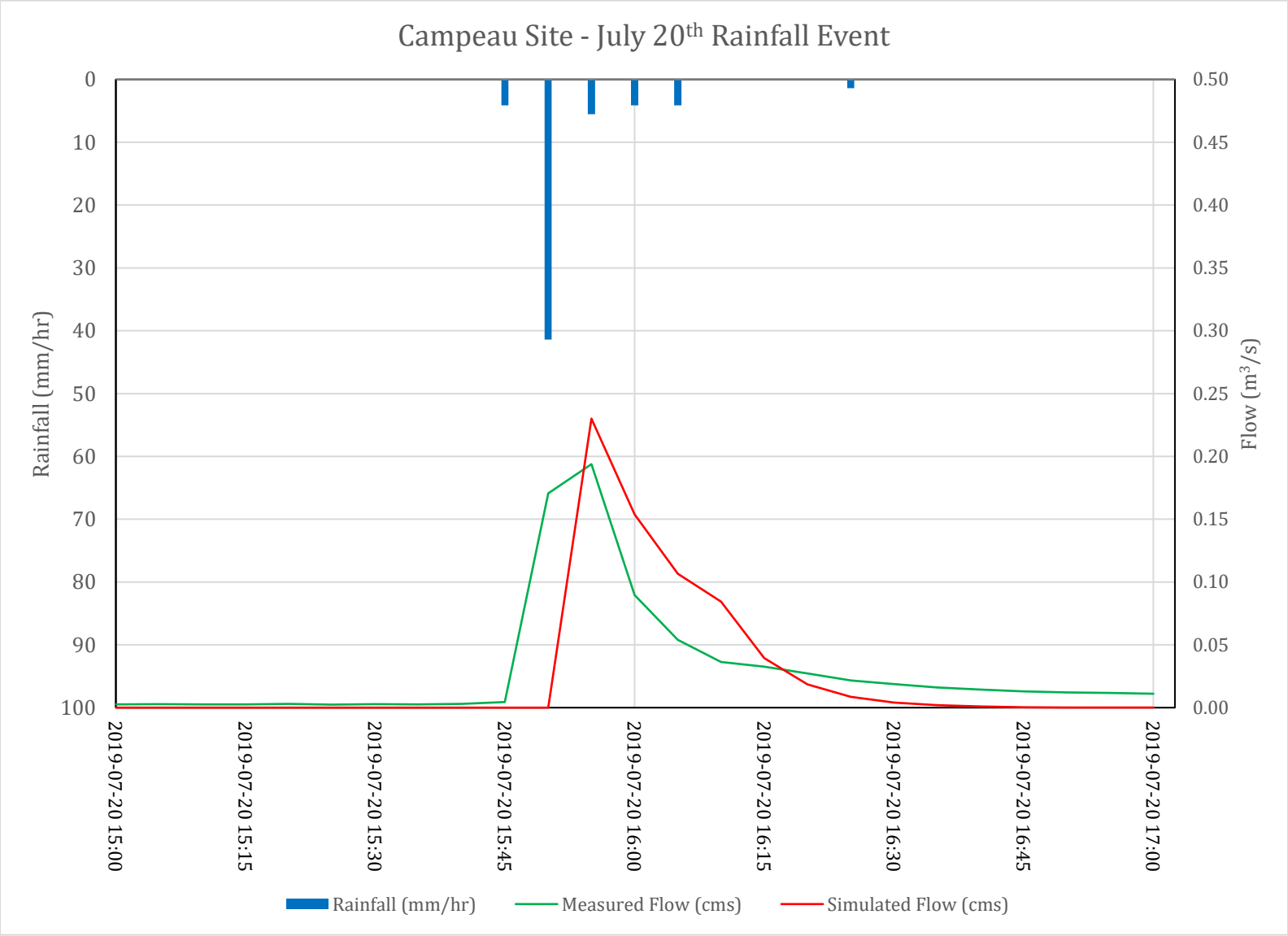

Weslock Site - July 5th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
2019-07-05 16:00
2019-07-05 16:15
2019-07-05 16:30
2019-07-05 16:45
2019-07-05 17:00
2019-07-05 17:15
2019-07-05 17:30
2019-07-05 17:45
2019-07-05 18:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

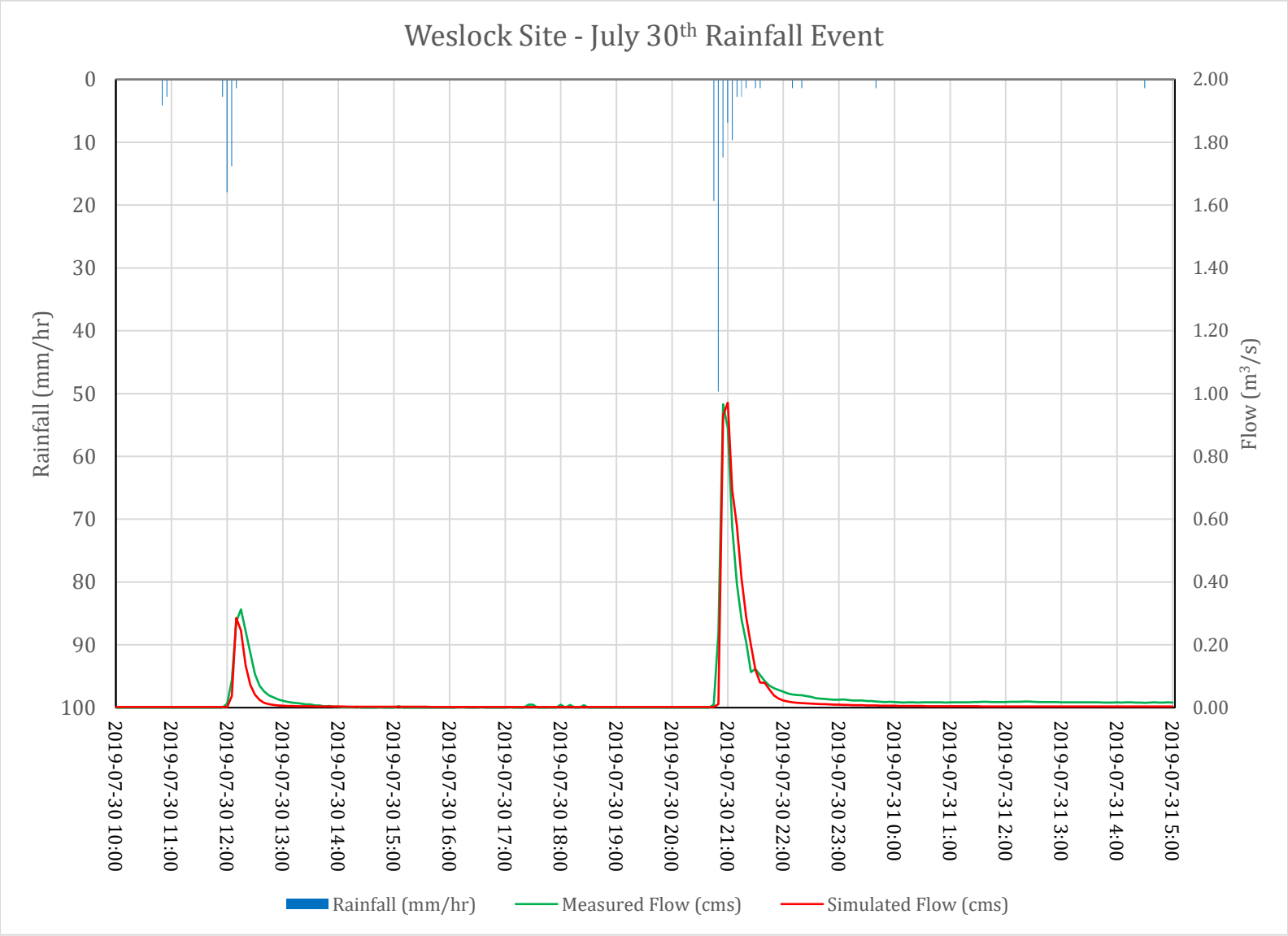

Campeau Site - July 5th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-07-05 16:00
2019-07-05 16:15
2019-07-05 16:30
2019-07-05 16:45
2019-07-05 17:00
2019-07-05 17:15
2019-07-05 17:30
2019-07-05 17:45
2019-07-05 18:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

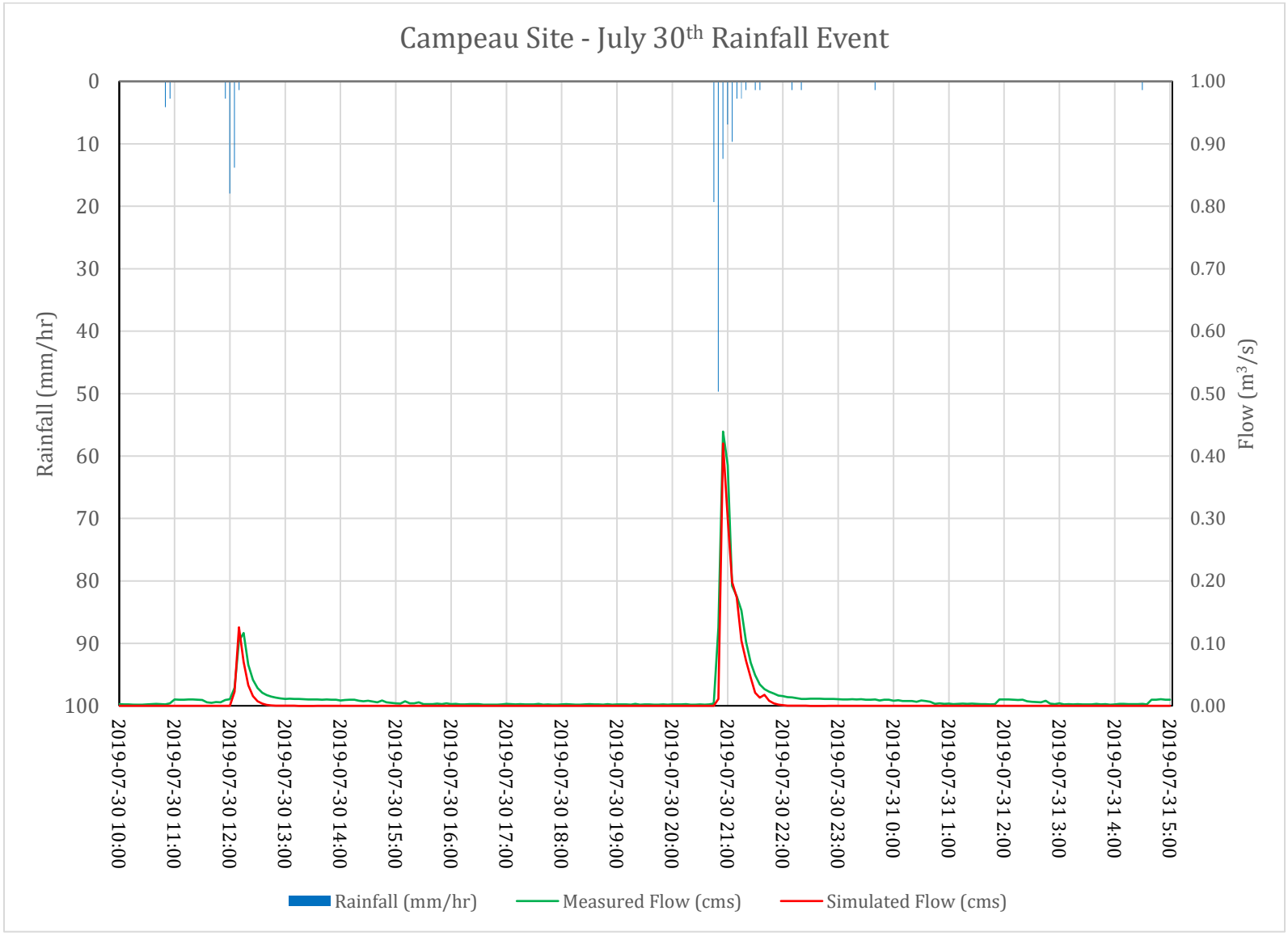

Weslock Site - July 11th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
2019-07-11 15:00
2019-07-11 15:30
2019-07-11 16:00
2019-07-11 16:30
2019-07-11 17:00
2019-07-11 17:30
2019-07-11 18:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

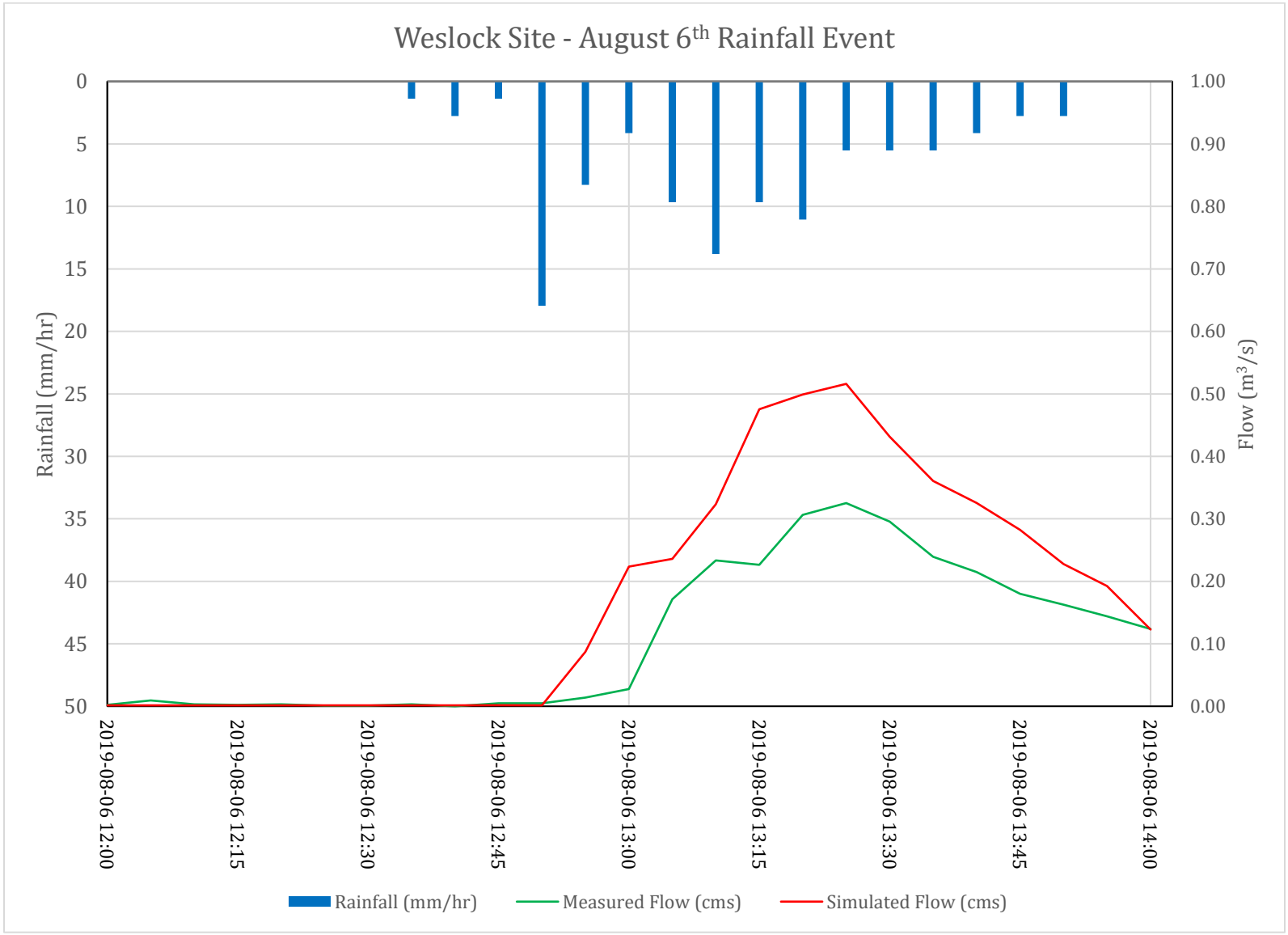

Campeau Site - July 11th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-07-11 15:00
2019-07-11 15:30
2019-07-11 16:00
2019-07-11 16:30
2019-07-11 17:00
2019-07-11 17:30
2019-07-11 18:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

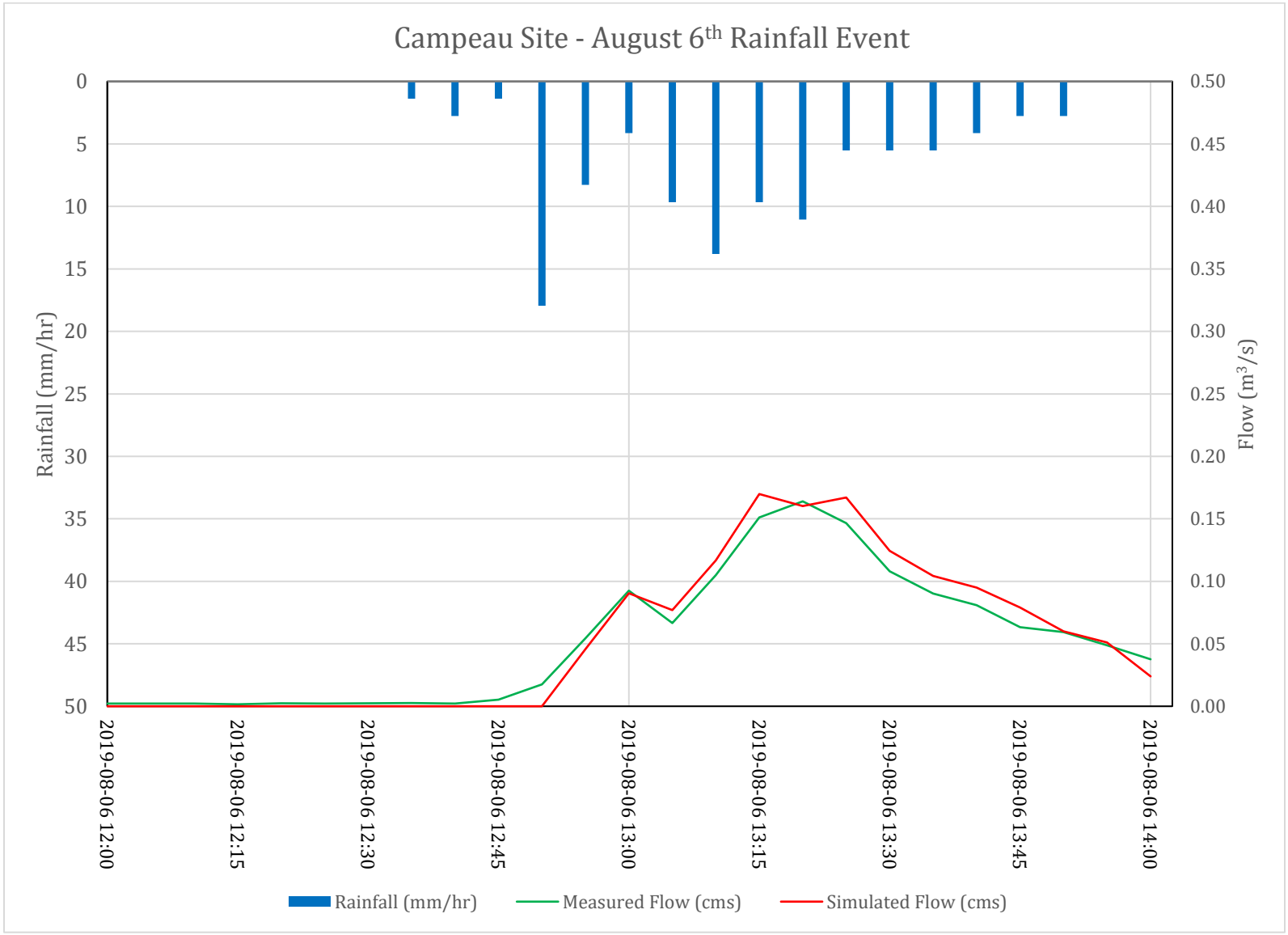

Weslock Site - July 20th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-07-20 15:00
2019-07-20 15:15
2019-07-20 15:30
2019-07-20 15:45
2019-07-20 16:00
2019-07-20 16:15
2019-07-20 16:30
2019-07-20 16:45
2019-07-20 17:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

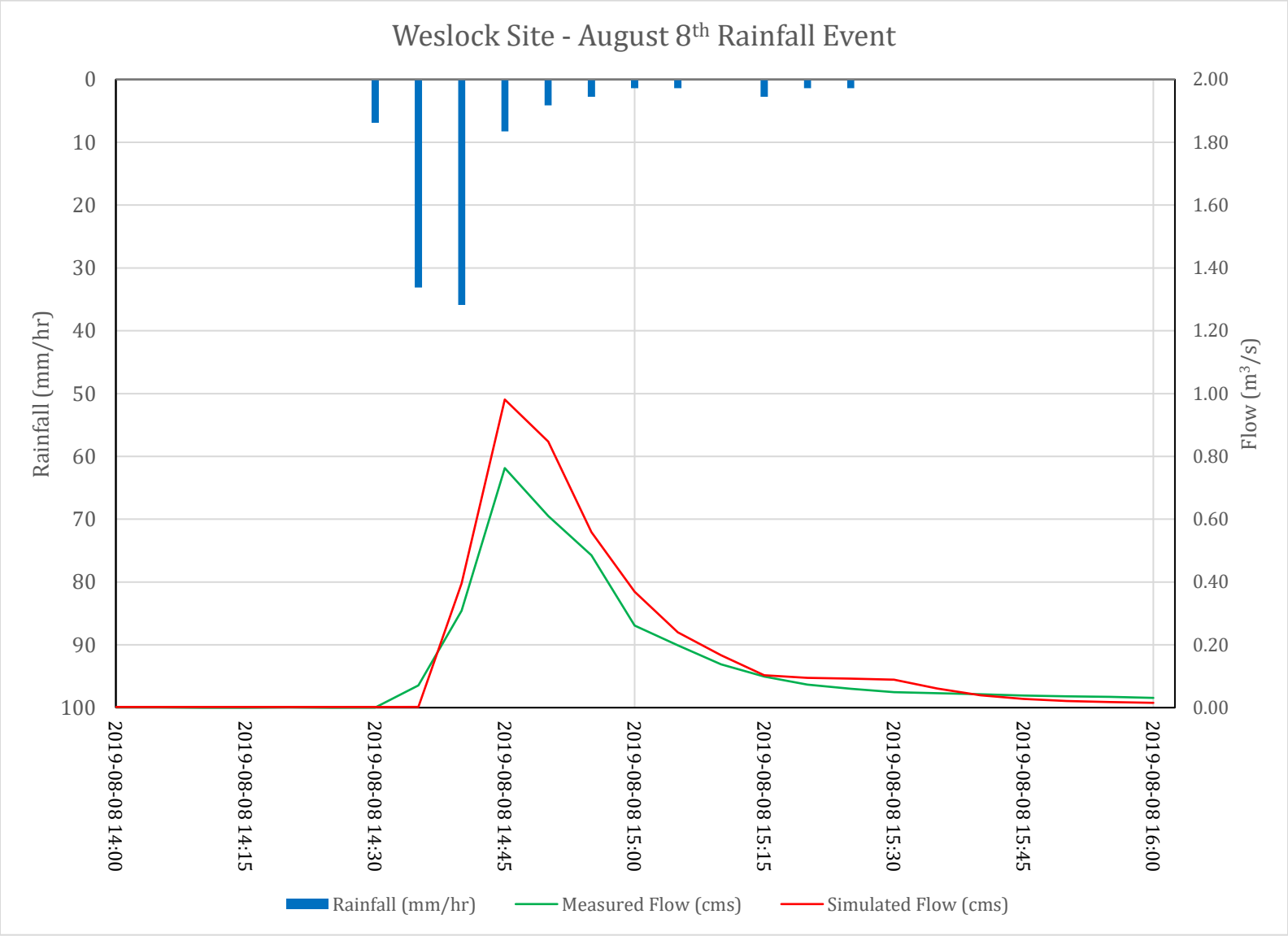

Campeau Site - July 20th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-07-20 15:00
2019-07-20 15:15
2019-07-20 15:30
2019-07-20 15:45
2019-07-20 16:00
2019-07-20 16:15
2019-07-20 16:30
2019-07-20 16:45
2019-07-20 17:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

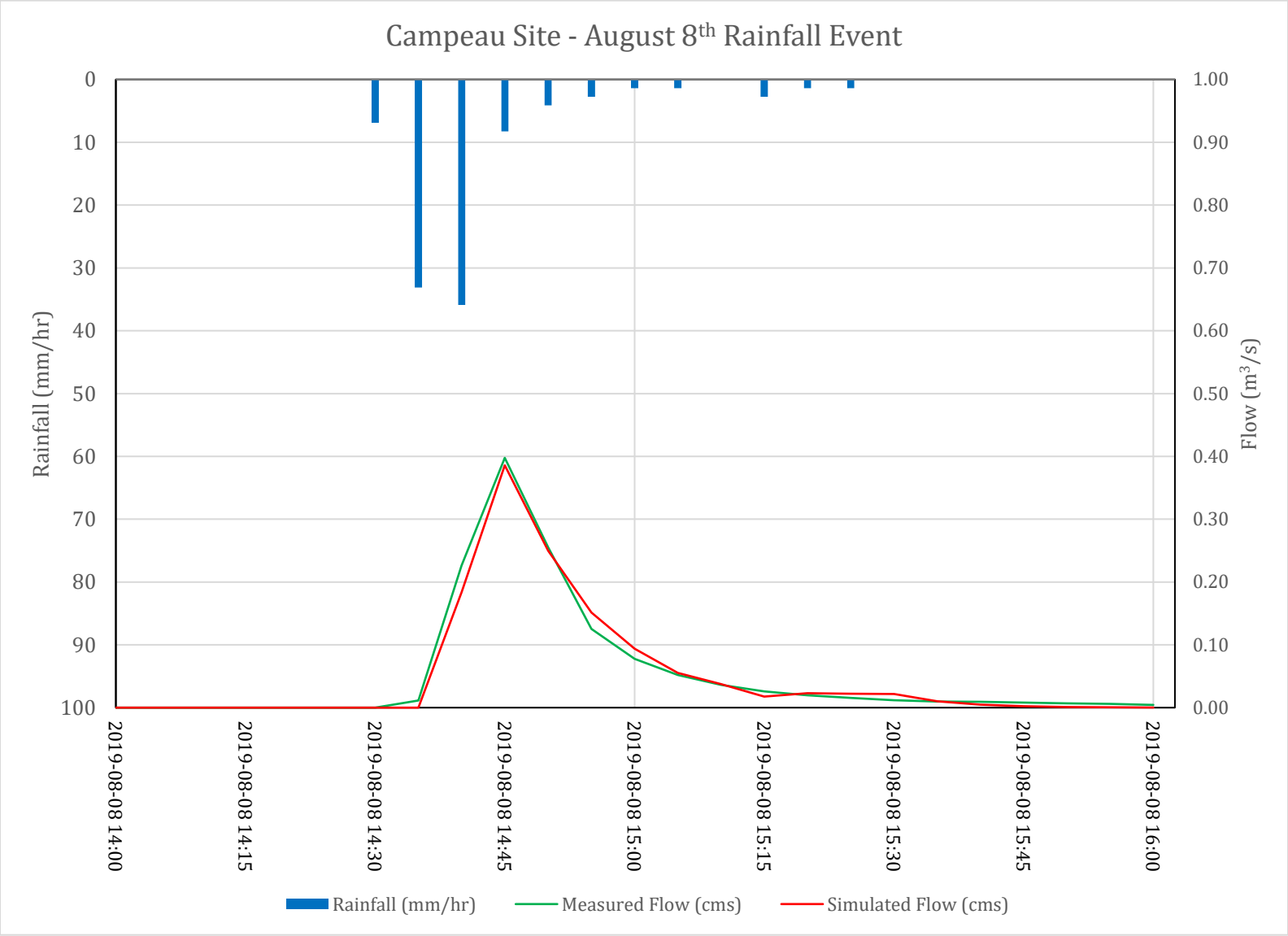

Weslock Site - July 30th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-07-30 10:00
2019-07-30 11:00
2019-07-30 12:00
2019-07-30 13:00
2019-07-30 14:00
2019-07-30 15:00
2019-07-30 16:00
2019-07-30 17:00
2019-07-30 18:00
2019-07-30 19:00
2019-07-30 20:00
2019-07-30 21:00
2019-07-30 22:00
2019-07-30 23:00
2019-07-31 0:00
2019-07-31 1:00
2019-07-31 2:00
2019-07-31 3:00
2019-07-31 4:00
2019-07-31 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

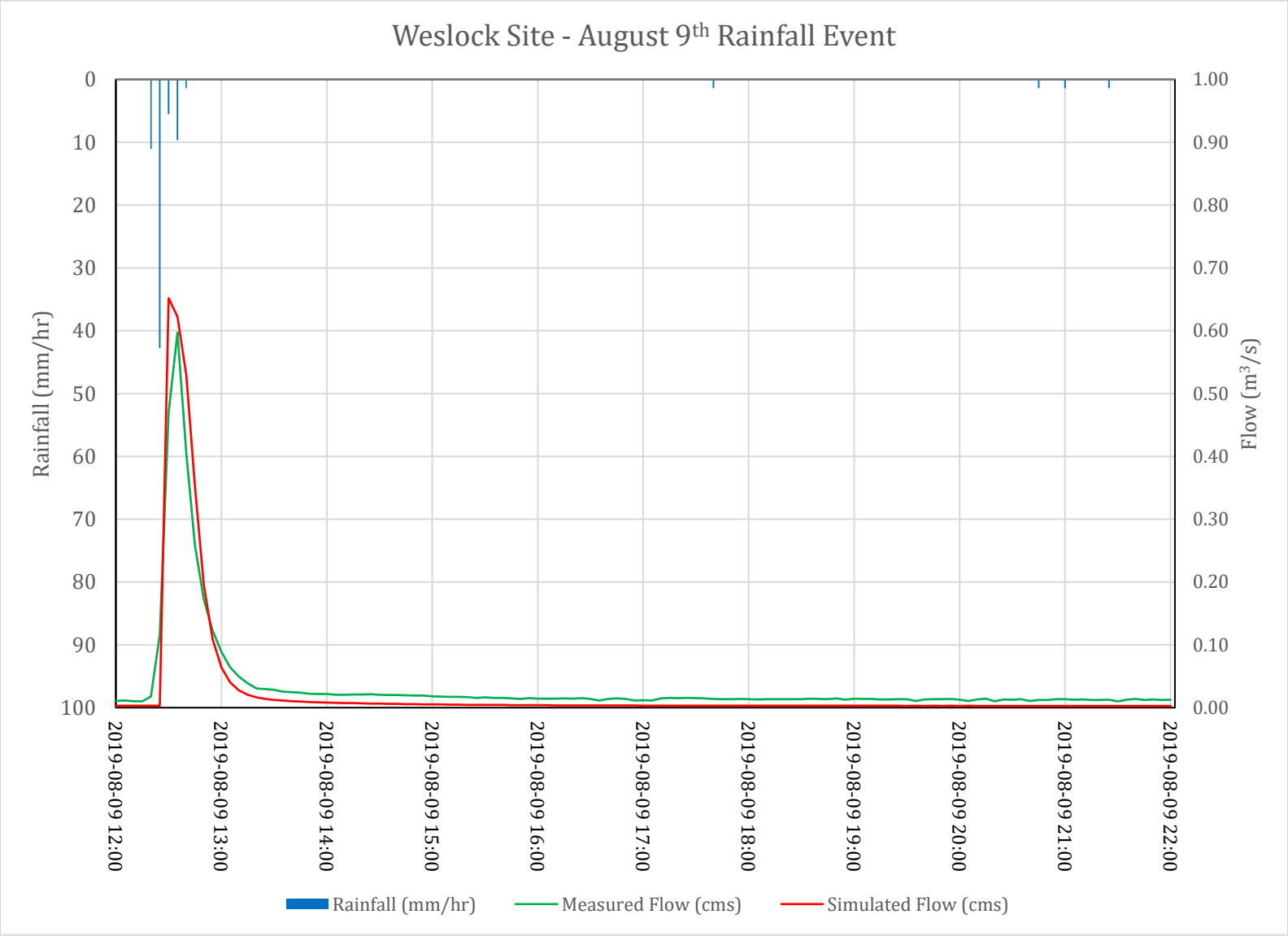

Campeau Site - July 30th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-07-30 10:00
2019-07-30 11:00
2019-07-30 12:00
2019-07-30 13:00
2019-07-30 14:00
2019-07-30 15:00
2019-07-30 16:00
2019-07-30 17:00
2019-07-30 18:00
2019-07-30 19:00
2019-07-30 20:00
2019-07-30 21:00
2019-07-30 22:00
2019-07-30 23:00
2019-07-31 0:00
2019-07-31 1:00
2019-07-31 2:00
2019-07-31 3:00
2019-07-31 4:00
2019-07-31 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

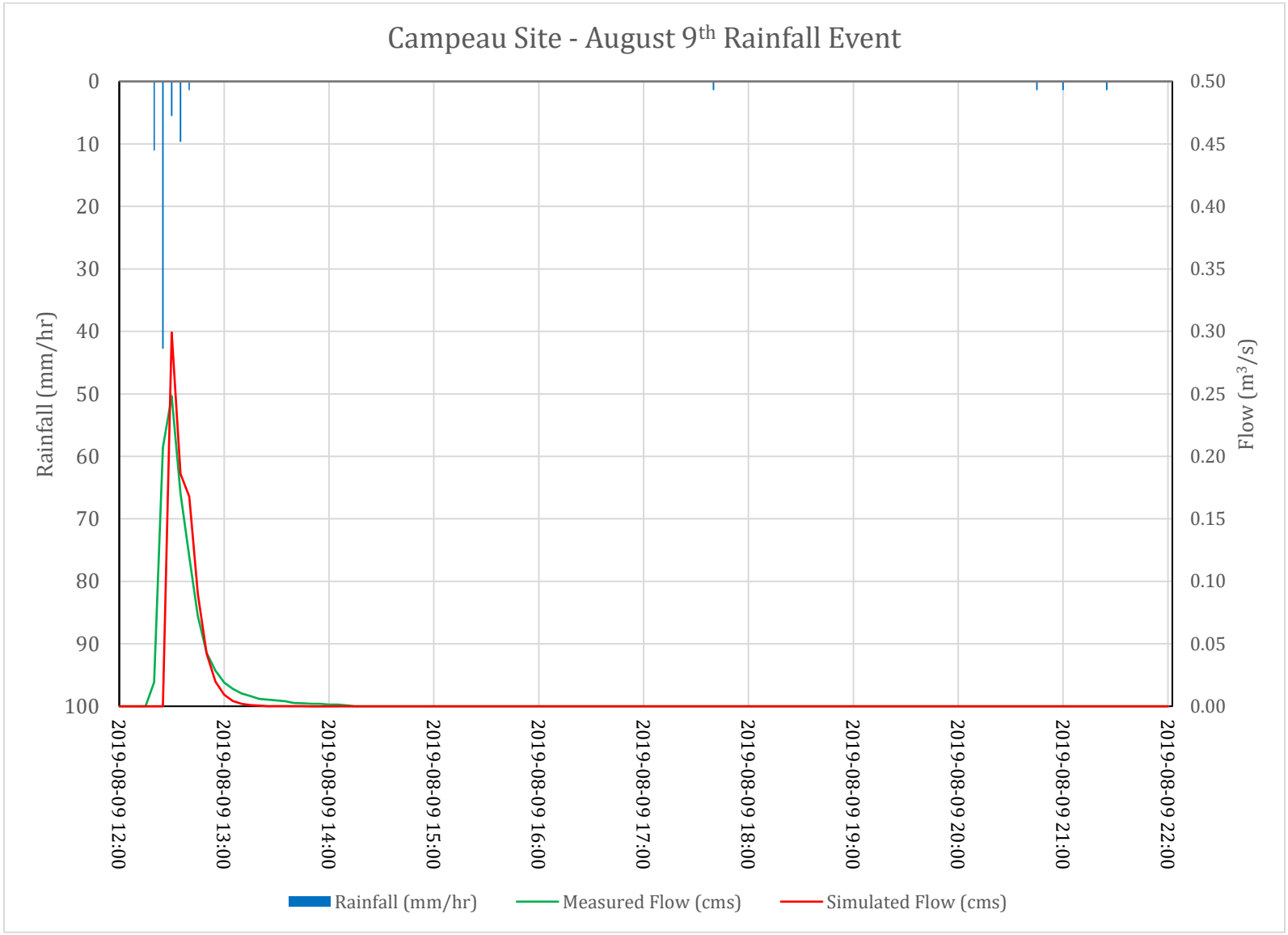

Weslock Site - August 6th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
5
10
15
20
25
30
35
40
45
50
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-06 12:00
2019-08-06 12:15
2019-08-06 12:30
2019-08-06 12:45
2019-08-06 13:00
2019-08-06 13:15
2019-08-06 13:30
2019-08-06 13:45
2019-08-06 14:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

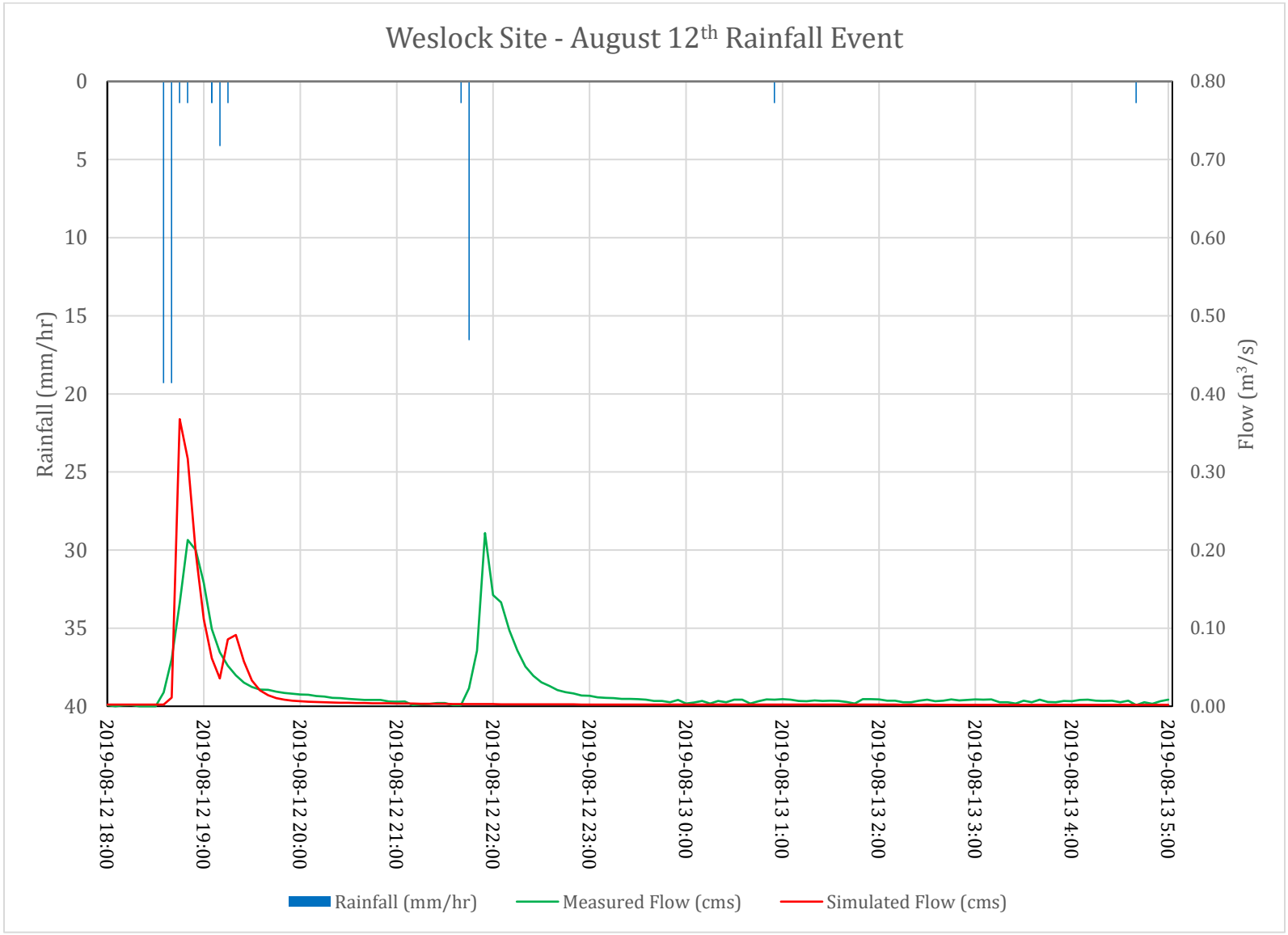

Campeau Site - August 6th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
5
10
15
20
25
30
35
40
45
50
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-08-06 12:00
2019-08-06 12:15
2019-08-06 12:30
2019-08-06 12:45
2019-08-06 13:00
2019-08-06 13:15
2019-08-06 13:30
2019-08-06 13:45
2019-08-06 14:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

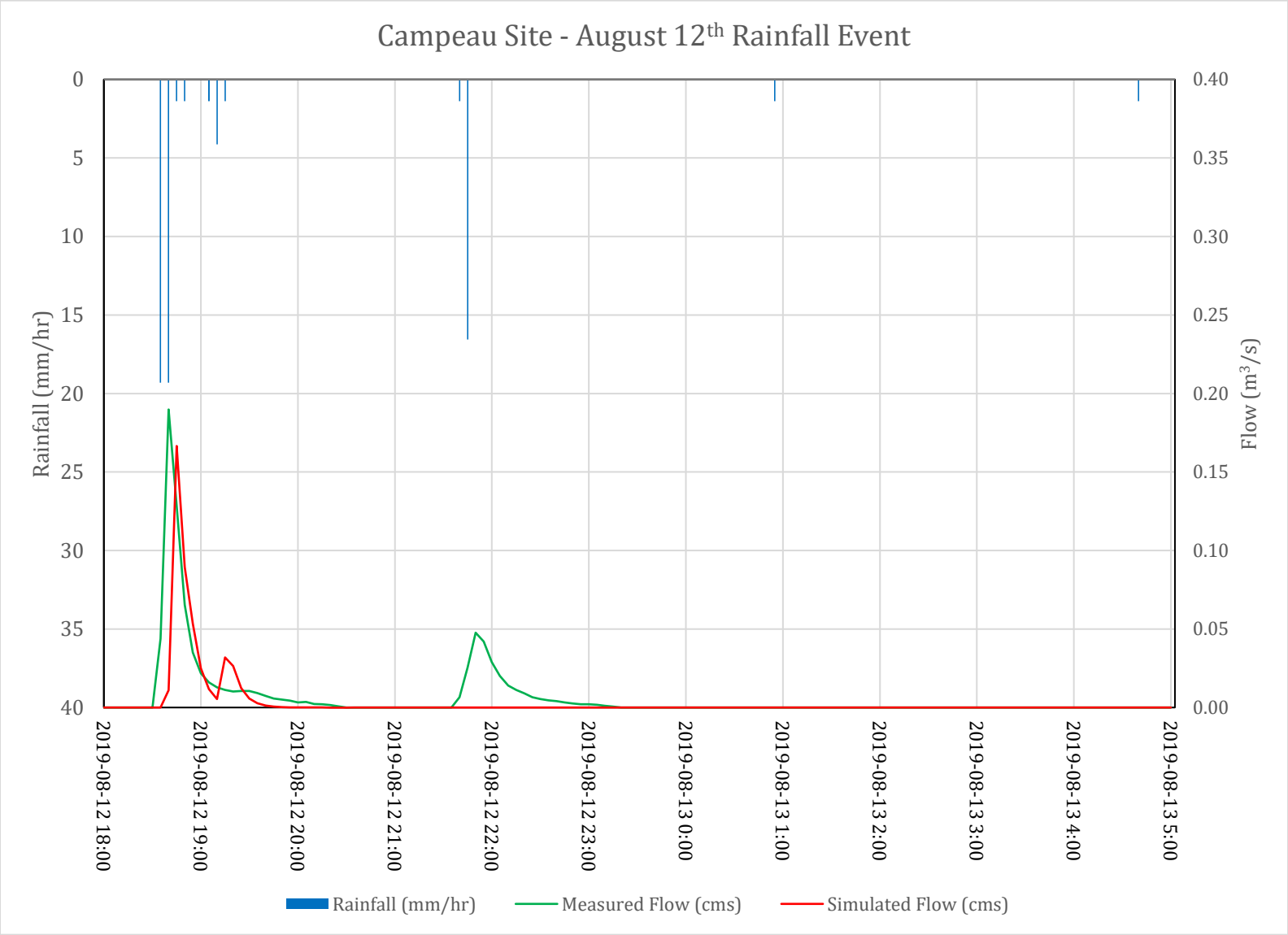

Weslock Site - August 8th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-08-08 14:00
2019-08-08 14:15
2019-08-08 14:30
2019-08-08 14:45
2019-08-08 15:00
2019-08-08 15:15
2019-08-08 15:30
2019-08-08 15:45
2019-08-08 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

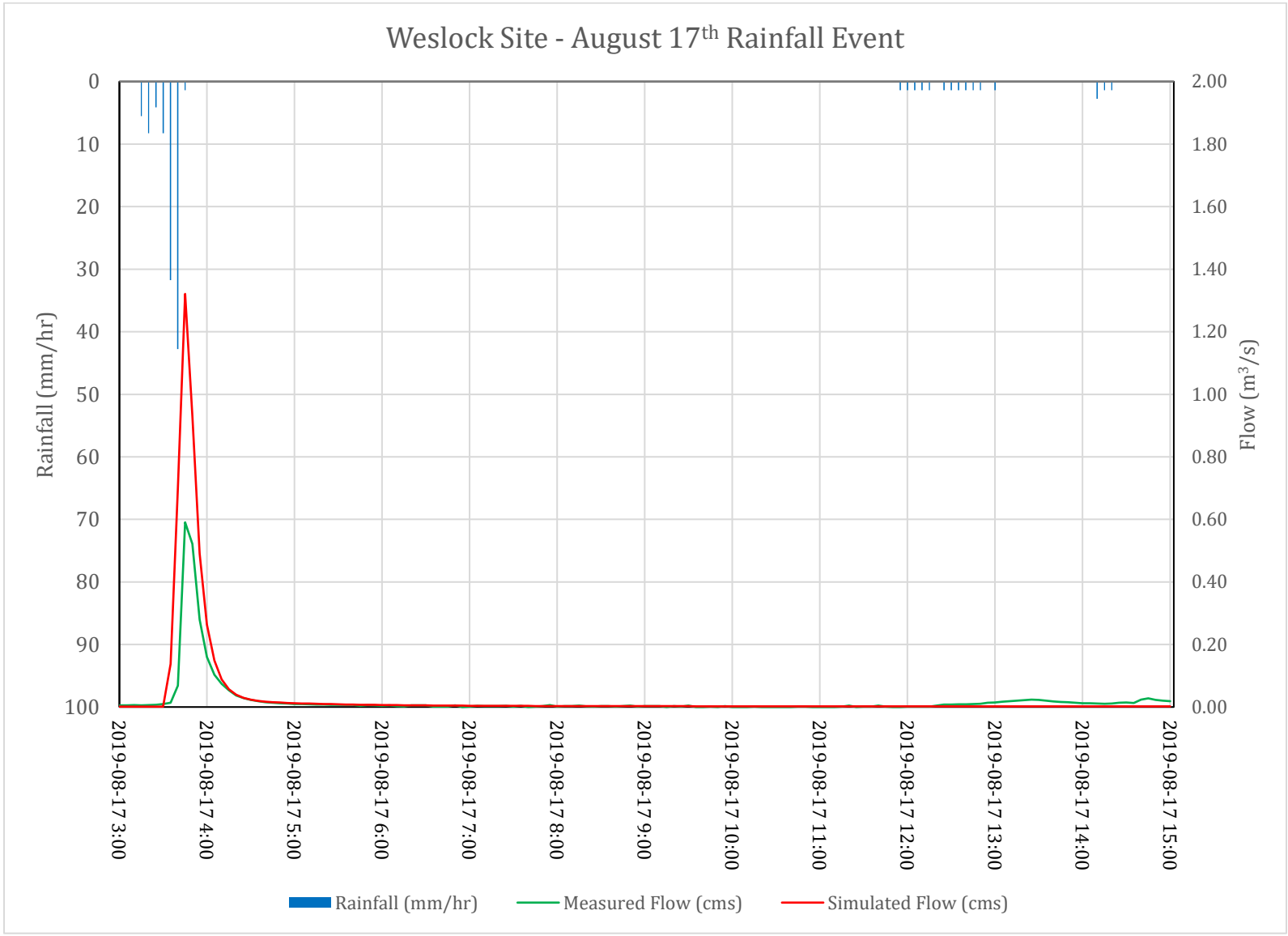

Campeau Site - August 8th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-08 14:00
2019-08-08 14:15
2019-08-08 14:30
2019-08-08 14:45
2019-08-08 15:00
2019-08-08 15:15
2019-08-08 15:30
2019-08-08 15:45
2019-08-08 16:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

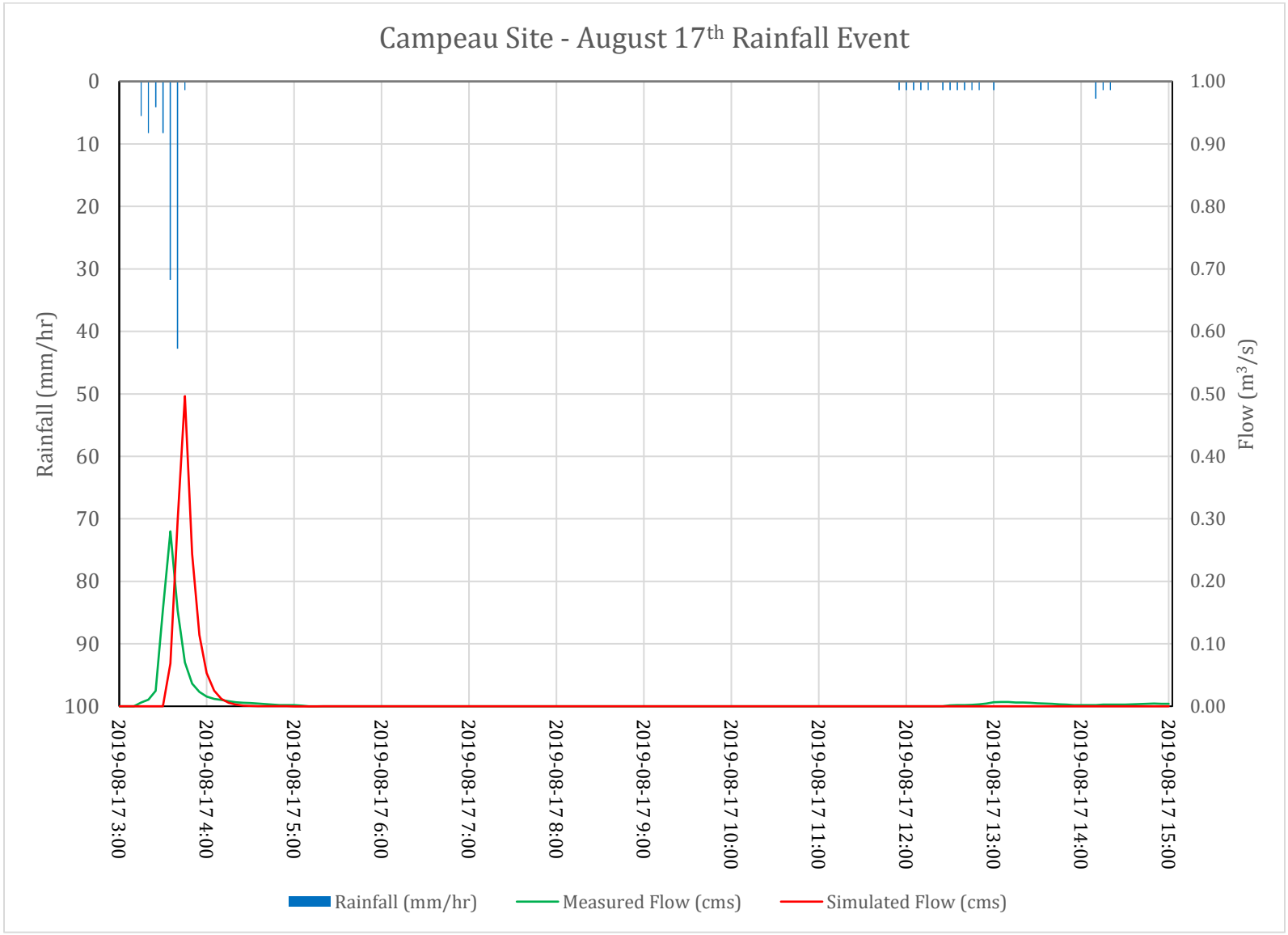

Weslock Site - August 9th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-09 12:00
2019-08-09 13:00
2019-08-09 14:00
2019-08-09 15:00
2019-08-09 16:00
2019-08-09 17:00
2019-08-09 18:00
2019-08-09 19:00
2019-08-09 20:00
2019-08-09 21:00
2019-08-09 22:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

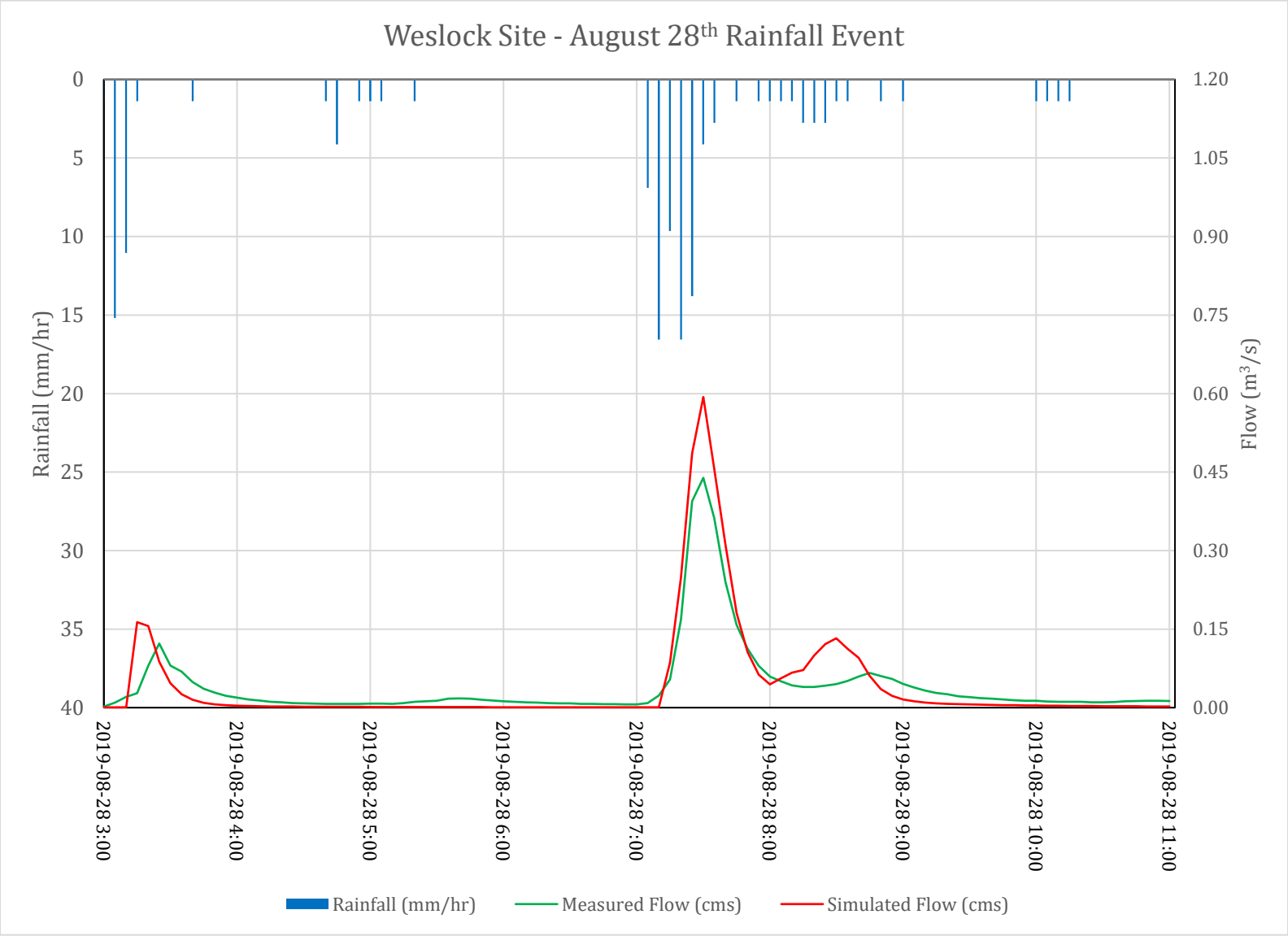

Campeau Site - August 9th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-08-09 12:00
2019-08-09 13:00
2019-08-09 14:00
2019-08-09 15:00
2019-08-09 16:00
2019-08-09 17:00
2019-08-09 18:00
2019-08-09 19:00
2019-08-09 20:00
2019-08-09 21:00
2019-08-09 22:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

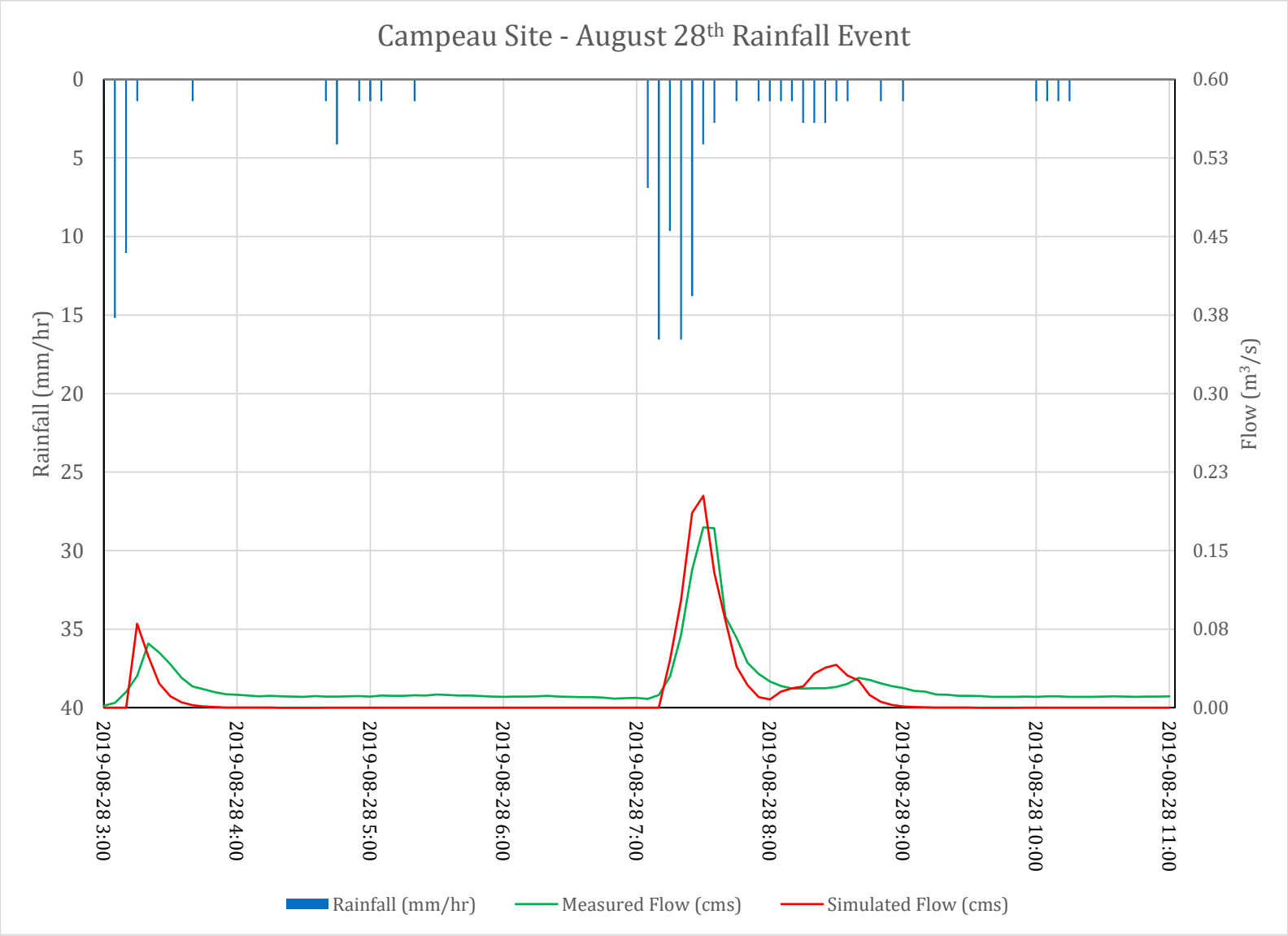

Weslock Site - August 12th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-12 18:00
2019-08-12 19:00
2019-08-12 20:00
2019-08-12 21:00
2019-08-12 22:00
2019-08-12 23:00
2019-08-13 0:00
2019-08-13 1:00
2019-08-13 2:00
2019-08-13 3:00
2019-08-13 4:00
2019-08-13 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

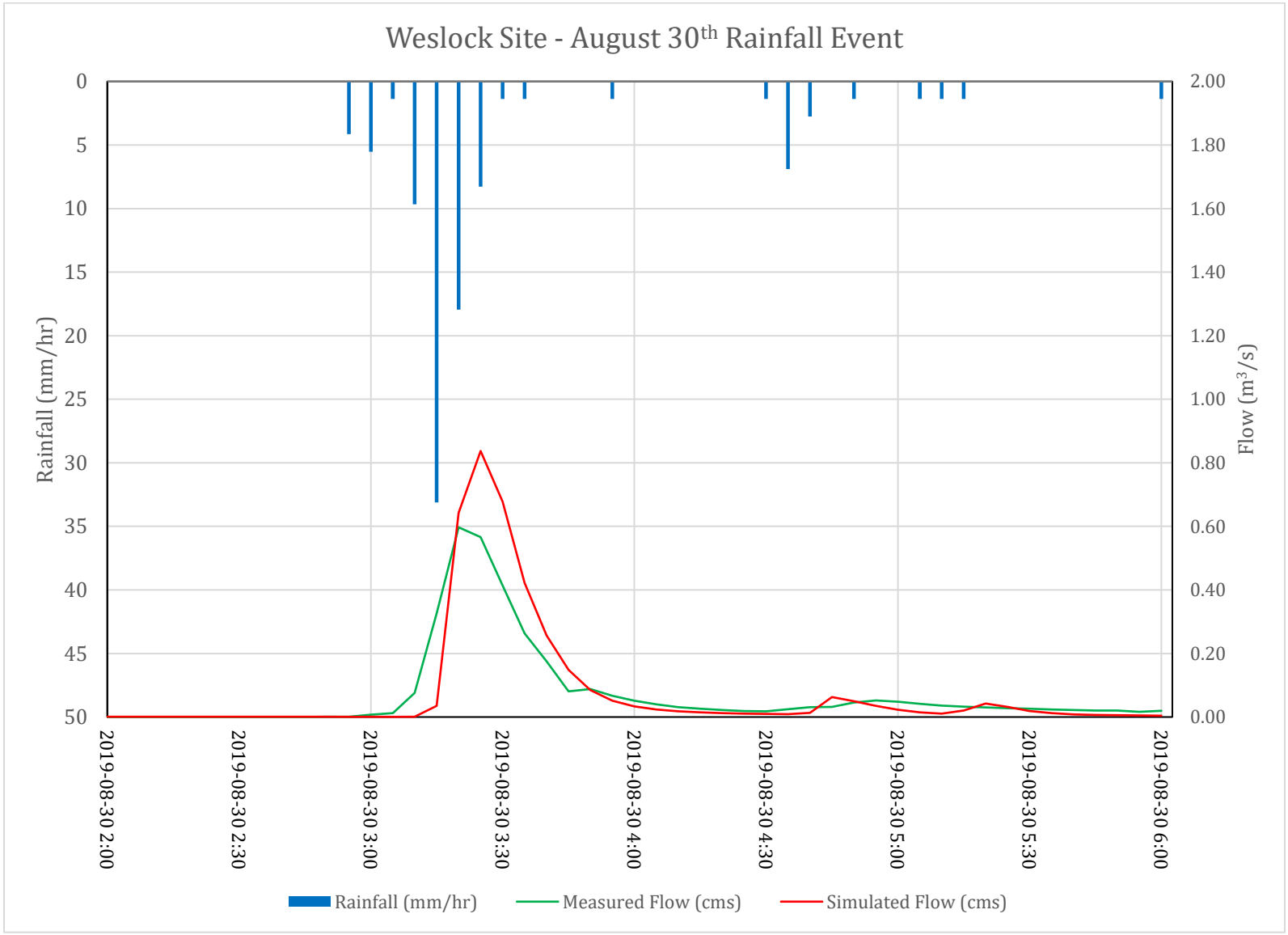

Campeau Site - August 12th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-08-12 18:00
2019-08-12 19:00
2019-08-12 20:00
2019-08-12 21:00
2019-08-12 22:00
2019-08-12 23:00
2019-08-13 0:00
2019-08-13 1:00
2019-08-13 2:00
2019-08-13 3:00
2019-08-13 4:00
2019-08-13 5:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

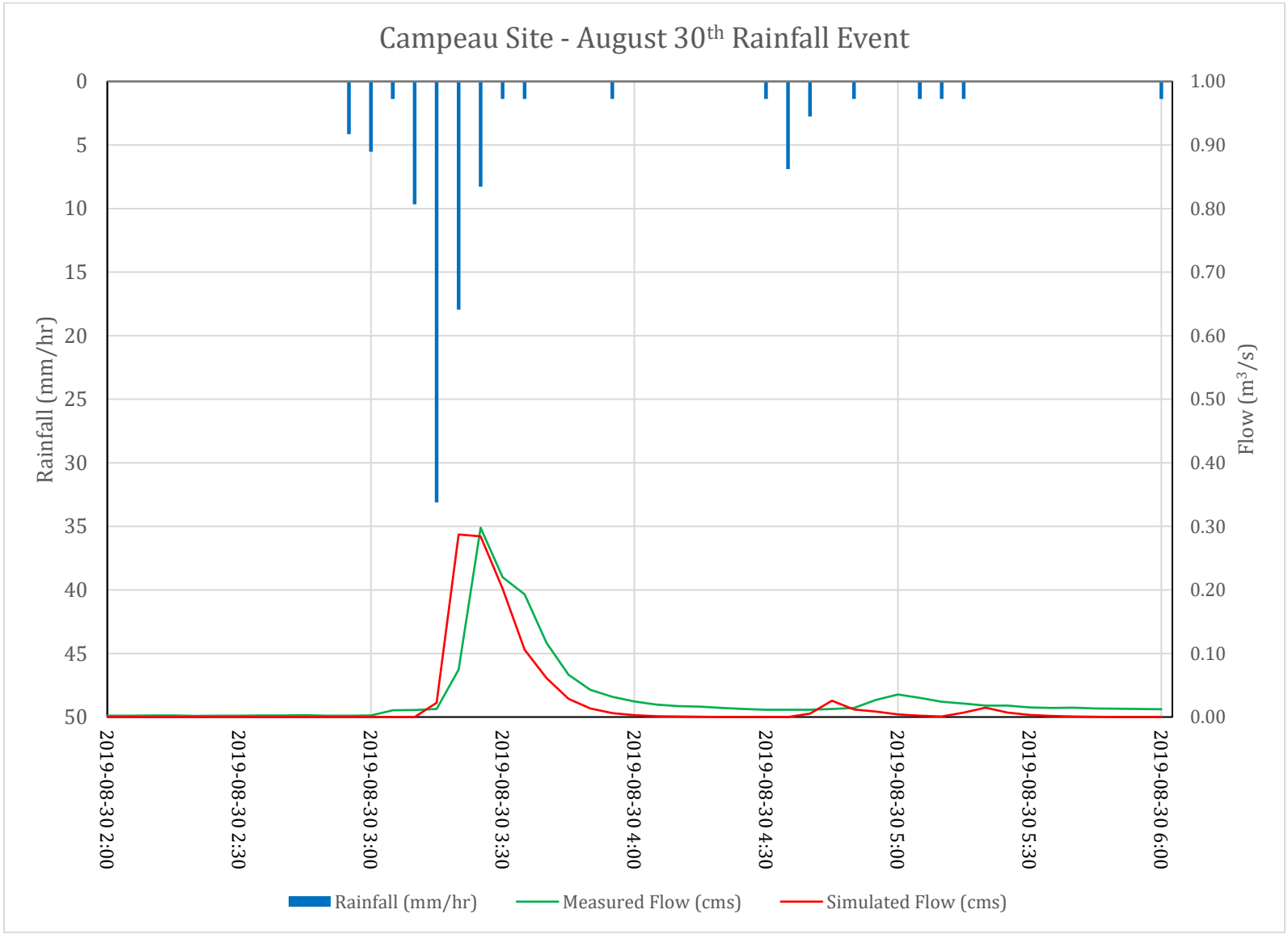

Weslock Site - August 17th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-08-17 3:00
2019-08-17 4:00
2019-08-17 5:00
2019-08-17 6:00
2019-08-17 7:00
2019-08-17 8:00
2019-08-17 9:00
2019-08-17 10:00
2019-08-17 11:00
2019-08-17 12:00
2019-08-17 13:00
2019-08-17 14:00
2019-08-17 15:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

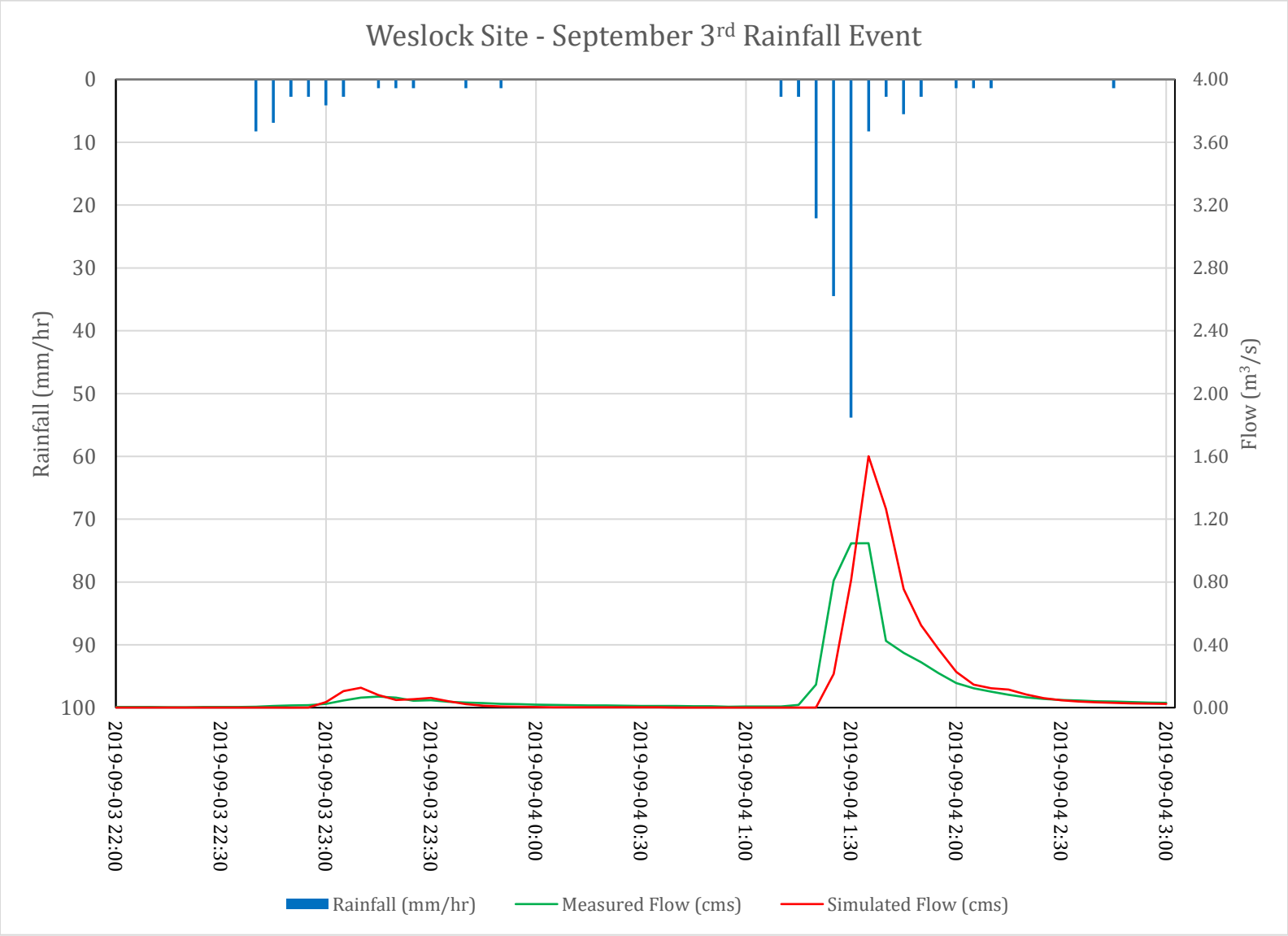

Campeau Site - August 17th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
10
20
30
40
50
60
70
80
90
100
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-17 3:00
2019-08-17 4:00
2019-08-17 5:00
2019-08-17 6:00
2019-08-17 7:00
2019-08-17 8:00
2019-08-17 9:00
2019-08-17 10:00
2019-08-17 11:00
2019-08-17 12:00
2019-08-17 13:00
2019-08-17 14:00
2019-08-17 15:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

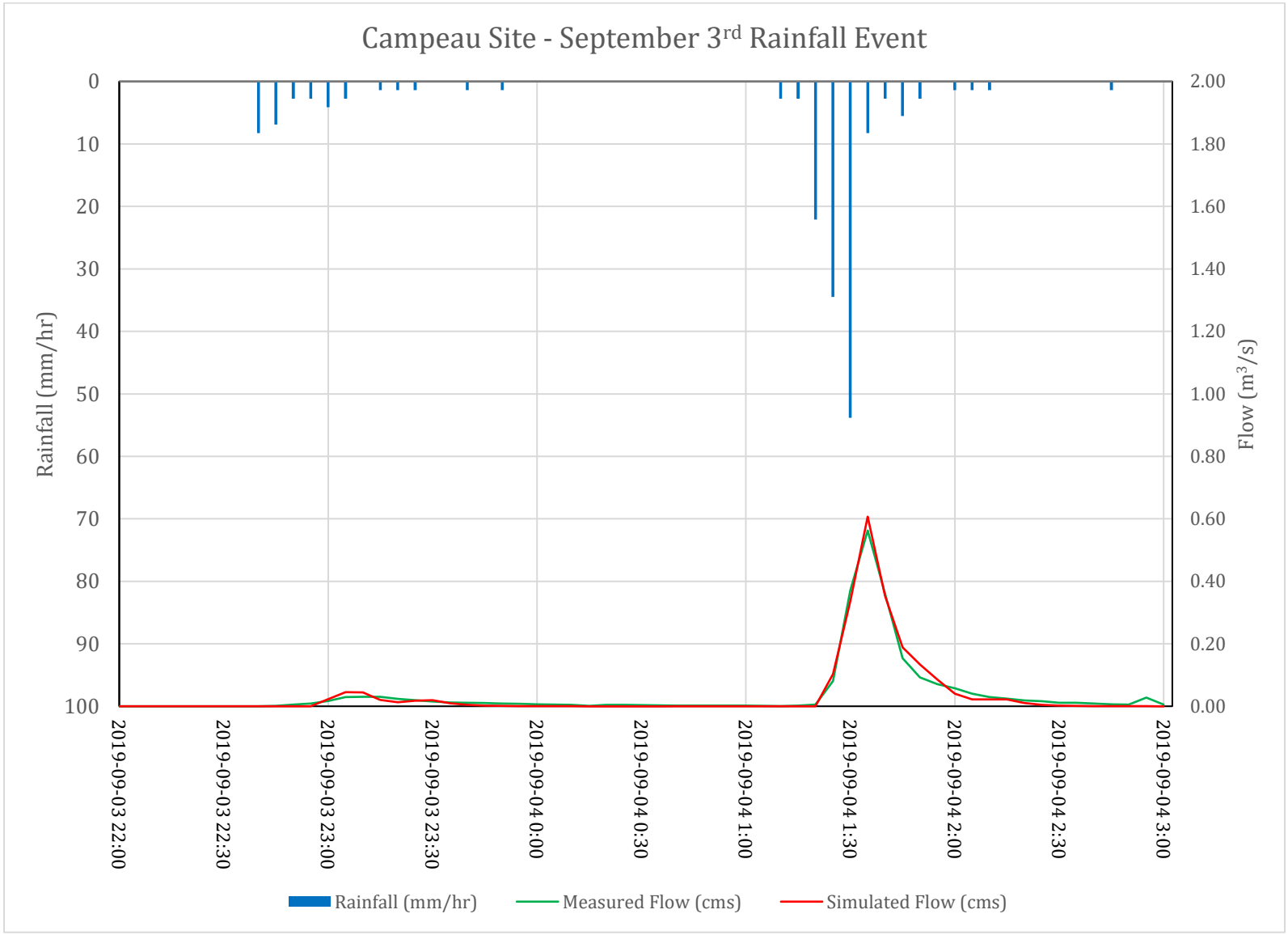

Weslock Site - August 28th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
1.20
1.05
0.90
0.75
0.60
0.45
0.30
0.15
0.00
2019-08-28 3:00
2019-08-28 4:00
2019-08-28 5:00
2019-08-28 6:00
2019-08-28 7:00
2019-08-28 8:00
2019-08-28 9:00
2019-08-28 10:00
2019-08-28 11:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

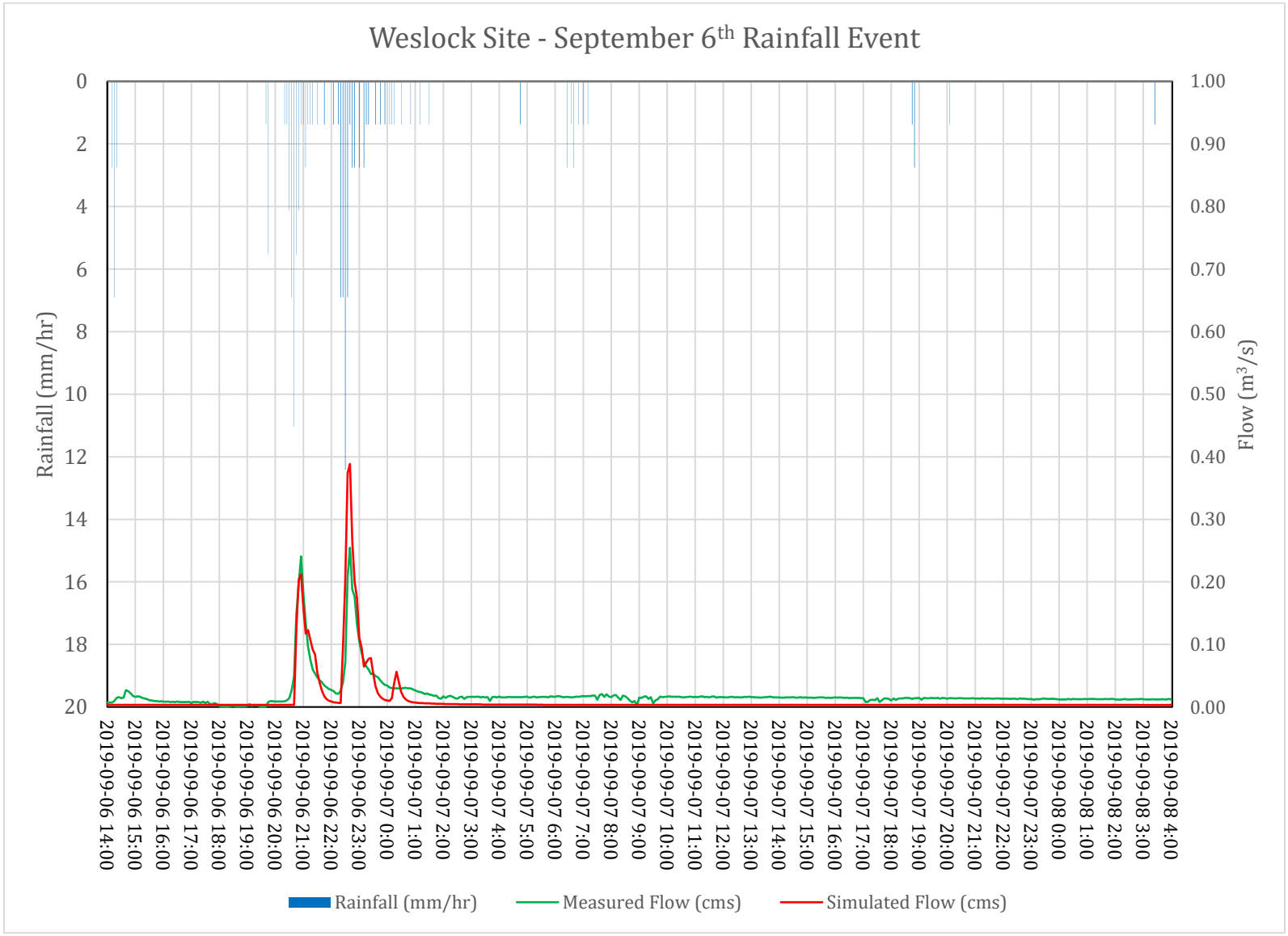

Campeau Site - August 28th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
0.60
0.53
0.45
0.38
0.30
0.23
0.15
0.08
0.00
2019-08-28 3:00
2019-08-28 4:00
2019-08-28 5:00
2019-08-28 6:00
2019-08-28 7:00
2019-08-28 8:00
2019-08-28 9:00
2019-08-28 10:00
2019-08-28 11:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)

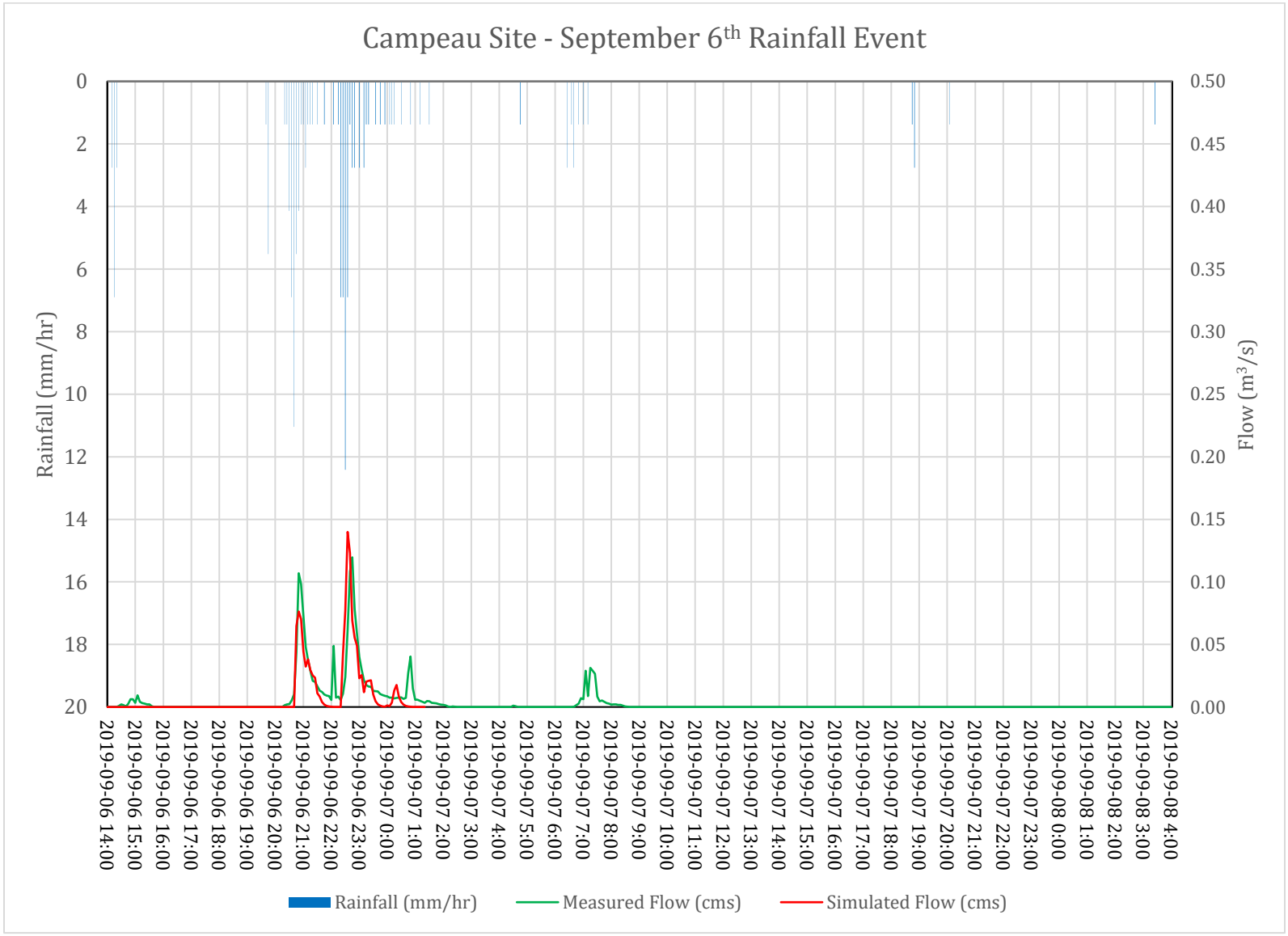

Weslock Site - August 30th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
5
10
15
20
25
30
35
40
45
50
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-08-30 2:00
2019-08-30 2:30
2019-08-30 3:00
2019-08-30 3:30
2019-08-30 4:00
2019-08-30 4:30
2019-08-30 5:00
2019-08-30 5:30
2019-08-30 6:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)


Campeau Site - August 30th Rainfall Event
Rainfall (mm/hr)
Flow (m³/s)
0
5
10
15
20
25
30
35
40
45
50
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-08-30 2:00
2019-08-30 2:30
2019-08-30 3:00
2019-08-30 3:30
2019-08-30 4:00
2019-08-30 4:30
2019-08-30 5:00
2019-08-30 5:30
2019-08-30 6:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)


Weslock Site - September 3rd Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
4.00
3.60
3.20
2.80
2.40
2.00
1.60
1.20
0.80
0.40
0.00
2019-09-03 22:00
2019-09-03 22:30
2019-09-03 23:00
2019-09-03 23:30
2019-09-04 0:00
2019-09-04 0:30
2019-09-04 1:00
2019-09-04 1:30
2019-09-04 2:00
2019-09-04 2:30
2019-09-04 3:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)


Campeau Site - September 3rd Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
10
20
30
40
50
60
70
80
90
100
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
2019-09-03 22:00
2019-09-03 22:30
2019-09-03 23:00
2019-09-03 23:30
2019-09-04 0:00
2019-09-04 0:30
2019-09-04 1:00
2019-09-04 1:30
2019-09-04 2:00
2019-09-04 2:30
2019-09-04 3:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)


Weslock Site - September 6th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
2
4
6
8
10
12
14
16
18
20
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
2019-09-06 14:00
2019-09-06 15:00
2019-09-06 16:00
2019-09-06 17:00
2019-09-06 18:00
2019-09-06 19:00
2019-09-06 20:00
2019-09-06 21:00
2019-09-06 22:00
2019-09-06 23:00
2019-09-07 0:00
2019-09-07 1:00
2019-09-07 2:00
2019-09-07 3:00
2019-09-07 4:00
2019-09-07 5:00
2019-09-07 6:00
2019-09-07 7:00
2019-09-07 8:00
2019-09-07 9:00
2019-09-07 10:00
2019-09-07 11:00
2019-09-07 12:00
2019-09-07 13:00
2019-09-07 14:00
2019-09-07 15:00
2019-09-07 16:00
2019-09-07 17:00
2019-09-07 18:00
2019-09-07 19:00
2019-09-07 20:00
2019-09-07 21:00
2019-09-07 22:00
2019-09-07 23:00
2019-09-08 0:00
2019-09-08 1:00
2019-09-08 2:00
2019-09-08 3:00
2019-09-08 4:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)


Campeau Site - September 6th Rainfall Event
Rainfall (mm/hr)
Flow (m3/s)
0
2
4
6
8
10
12
14
16
18
20
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
2019-09-06 14:00
2019-09-06 15:00
2019-09-06 16:00
2019-09-06 17:00
2019-09-06 18:00
2019-09-06 19:00
2019-09-06 20:00
2019-09-06 21:00
2019-09-06 22:00
2019-09-06 23:00
2019-09-07 0:00
2019-09-07 1:00
2019-09-07 2:00
2019-09-07 3:00
2019-09-07 4:00
2019-09-07 5:00
2019-09-07 6:00
2019-09-07 7:00
2019-09-07 8:00
2019-09-07 9:00
2019-09-07 10:00
2019-09-07 11:00
2019-09-07 12:00
2019-09-07 13:00
2019-09-07 14:00
2019-09-07 15:00
2019-09-07 16:00
2019-09-07 17:00
2019-09-07 18:00
2019-09-07 19:00
2019-09-07 20:00
2019-09-07 21:00
2019-09-07 22:00
2019-09-07 23:00
2019-09-08 0:00
2019-09-08 1:00
2019-09-08 2:00
2019-09-08 3:00
2019-09-08 4:00
Rainfall (mm/hr)
Measured Flow (cms)
Simulated Flow (cms)