

# DOWNTOWN SOUTH

*RALEIGH, NORTH CAROLINA*

## ANALYSIS OF EXISTING CONDITIONS CALIBRATION

PROJECT NUMBER: KAN-19020  
DESIGNED BY: DANIEL WIEBKE, PE, CFM  
CAMERON JAMES, PE  
RICHARD WRIGHT, EI

DATE: May 2021



MCADAMS

2905 MERIDIAN PARKWAY  
DURHAM, NORTH CAROLINA 27713  
NC Lic. # C-0293

# DOWNTOWN SOUTH

## *Analysis of Existing Conditions Calibration*

### GENERAL DESCRIPTION

The Downtown South development will encompass several parcels located between Lake Wheeler Road and S. Wilmington Street along the I-40 corridor. Proposed development for Downtown South will be a mixed-use development combining lodging, retail, multi-family residential, recreation, and other uses. Downtown South is currently slated to have an overall impervious percentage less than 95%. Both proprietary and green stormwater infrastructure (GSI) techniques will be implemented to improve the water quality of stormwater runoff in the post-development condition. The purpose of this memo is to document the accuracy of the effective Walnut Creek Watershed HEC-HMS model in simulating peak flow rates for Walnut Creek, based on values reported for several USGS gage stations in vicinity of the proposed Downtown South project area.

### GENERAL METHODOLOGY

- Historic rainfall, discharge, and stage data was downloaded for the following USGS gage stations: **02087337** (Walnut Creek at Buck Jones Rd), **02087339** (Lake Johnson above dam), **0208734210** (Walnut Creek at Trailwood Drive), **0208735012** (Rocky Branch below Pullen Rd), **0208734795** (Walnut Creek at S. Wilmington St), **0208735460** (Walnut Creek at S. State St), and **02087359** (Walnut Creek at Sunnybrook Dr).
- The time increment with which rainfall data is reported was noted for each USGS gage station. For gages **02087337** (Walnut Creek at Buck Jones Rd), **028734210** (Walnut Creek at Trailwood Drive), and **0208735012** (Rocky Branch below Pullen Rd) the increment of rainfall data is 5 minutes. For all other USGS gages, the time increment of rainfall data is 15 minutes.
- **Table 1** below shows the beginning date of all downloaded rainfall and stage/flow data, which was obtained through the present date. It was noted that no stage or discharge data was available at the USGS gage **0208735460** (Walnut Creek at S. State St).

*Table 1. Begin Date of Downloaded USGS Gage Data*

Gage	Stage/Flow Data	Rainfall Data
02087337 (Walnut Creek at Buck Jones Rd)	8/1/2018	7/31/2018
02087339 (Lake Johnson above dam)	8/6/2018	8/6/2018
0208734210 (Walnut Creek at Trailwood Drive)	8/8/2018	8/8/2018
0208735012 (Rocky Branch below Pullen Rd)	9/30/2009	9/30/2009
0208734795 (Walnut Creek at S. Wilmington St)	8/8/2018	8/8/2018
0208735460 (Walnut Creek at S. State St)		8/14/2018
02087359 (Walnut Creek at Sunnybrook Dr)	9/30/1998	9/30/1998

- Downloaded rainfall data was processed for each USGS gage such that values were sorted and totaled for each day. Downloaded mean daily discharge values for each USGS gage were used in conjunction with daily total rainfall to identify rainfall events realized by all gages in the study area for use in model calibration. Two storm events (dated 8/20/2018 and 11/13/2018) were recognizable within the downloaded data for all gages in the study area and produced record peak flows at multiple USGS gages.

- Hydrologic “junctions” within the HEC-HMS model for Walnut Creek closest to each USGS gage location were identified. **Table 2** below shows the HEC-HMS “junctions” nearest to each USGS gage. Only rainfall and stage data is available for USGS gage **02087339** (Lake Johnson above dam), so no peak flow comparison was made at this location. A stage-discharge relationship (routing curve) for Lake Johnson was not provided with the downloaded data; therefore, discharge was not calculated for this gage. No peak discharge data was available for the **0208735460** (Walnut Creek at S. State St); therefore, no peak discharge comparison could be made at that location.

*Table 2. USGS Gage and Corresponding HEC-HMS Junction*

Gage	HMS Junction
02087337 (Walnut Creek at Buck Jones Rd)	J_WC_37
0208734210 (Walnut Creek at Trailwood Drive)	J_WC_29
0208735012 (Rocky Branch below Pullen Rd)	J_RB_11
0208734795 (Walnut Creek at S. Wilmington St)	J_WC_21
02087359 (Walnut Creek at Sunnybrook Dr)	J_WC_7

- For each USGS gage station, the time and magnitude of recorded peak discharges was noted from the downloaded incremental data. Time-series incremental rainfall data corresponding to the date and time of each peak discharge occurrence was identified for simulation of recorded storm events.

Three (3) analyses have been run so far, in effort to compare the timing and magnitude of peak flows generated in the HEC-HMS model to observed values at USGS gage stations. For the **first analysis**, at least two storm events were identified for each USGS gage listed above that yielded record peak streamflow. Each storm event was modeled individually within HEC-HMS, with rainfall data applied uniformly to all subbasins within the model. The HEC-HMS model outputs were then compared only at the specific HEC-HMS junction corresponding to the location at which the rainfall data was observed.

For the **second analysis**, two storm events (8/20/2018 and 11/13/2018) were identified that produced record peak streamflow at multiple USGS gages. The rainfall data observed at each USGS gage for these two storms was obtained and applied geospatially to basins across the Walnut Creek watershed via the Thiessen polygon rainfall distribution method. Best engineering judgment was used when assigning rainfall data to basins which reside on the border of two polygons. The attached GIS map, **Figure 1**, shows the geospatial distribution of USGS gage rainfall data to surrounding subbasins within the HEC-HMS model. The attached “Analysis 2 – USGS Rainfall Data” sheets document storm data applied within the HEC-HMS model. This second analysis was run in effort to ensure the model and recorded gage data show similar trends based on the progression of storms and the impacts to flow as it builds through the Walnut Creek Watershed as a whole.

The **third analysis** was a comparison of eight storm events of various timing and magnitude identified within data downloaded from the USGS gages listed above. Comparison of total rainfall depth, peak discharge, and timing of peak discharge was used to further understand general hydraulic and hydrologic reactions occurring within the Walnut Creek Watershed. Furthermore, the analysis was used to identify variability in how storms and flows of varying magnitude progress through the watershed.

## DISCUSSION OF RESULTS

### Analysis 1

After analyzing storm results within the HEC-HMS model, areas upstream of the site fluctuate both higher and lower than their measured values as observed at the USGS gages. When looking at USGS values compared to HEC-HMS outputs at the stations closest to the project and downstream, S. Wilmington and Sunnybrook Dr., the results are within 10% of the USGS observed values. In contrast, the upstream areas at Buck Jones, Trailwood, and Pullen do not replicate recorded peak streamflow as accurately. **Table 3** below shows results obtained for this first analysis:

Table 3. Analysis 1 Results

Time series	<b>Gage 02087337 Walnut At Buck Jones ; HMS J_WC_37 Upstream of project area above Lake Johnson</b>					
Date	Storm Depth / Duration	HMS Discharge [cfs]	USGS Discharge [cfs]	Difference [cfs]	%Difference	
8/20/2018	2.28" in 4.0 hrs	860.93	1530	-669.07	-43.73%	
8/2/2019	1.83" in 2.5 hrs	719.62	1570	-850.38	-54.16%	
SCS II 24	<b>Gage 0208735012 Rocky Branch Below Pullen Rd ; HMS J_RB_11 Upstream of project area near Pullen</b>					
Date	Storm Depth / Duration	HMS Discharge [cfs]	USGS Discharge [cfs]	Difference [cfs]	%Difference	
8/24/2015	1.47" in 24 hrs	144	731	-587	-80.30%	
8/12/2014	2.92" in 24 hrs	578	1740	-1162	-66.78%	
Time series	<b>Gage 0208734210 Walnut At Trailwood; HMS J_WC_29 Upstream of project area above Lake Raleigh</b>					
Date	Storm Depth / Duration	HMS Discharge [cfs]	USGS Discharge [cfs]	Difference [cfs]	%Difference	
8/20/2018	4.41" in 24 hrs	1350	803	547	68.12%	
11/13/2018	3.49" in 24 hrs	1005	662	343	51.81%	
Time series	<b>Gage 0208734795 Walnut At S Wilmington St ; HMS J_WC_21</b>				<b>*Directly within project area*</b>	
Date	Storm Depth / Duration	HMS Discharge [cfs]	USGS Discharge [cfs]	Difference [cfs]	% Difference	
8/20/2018	2.75" in 3 hrs	1648	1580	68	4.30%	
11/13/2018	3.34" in 3.5 hrs	1266	1170	96	8.21%	
SCS II 24	<b>Gage 02087359 Walnut At Sunny Brook Dr ; HMS J_WC_7 Downstream of project area past Rose Ln</b>					
Date	Storm Depth / Duration	HMS Discharge [cfs]	USGS Discharge [cfs]	Difference [cfs]	%Difference	
8/20/2018	3.49" in 1 day	2265	2160	105	4.86%	
11/13/2018	3.02" in 1 day	1760	1660	100	6.02%	
10/8/2016	7.42" in 1 day	7178	5960	1218	20.44%	

### Analysis 2

After analyzing results of the 8/20/2018 and 11/13/2018 storms within the HEC-HMS model, several observations were made regarding the magnitude and timing of the peak streamflow as it progresses through the Walnut Creek Watershed. For the 8/20/2018 storm, the USGS record peak discharges show a decrease from 1530 cfs at the Buck Jones Rd. gage to 803 cfs at the Trailwood Dr. gage. Conversely, the HEC-HMS model yielded an increase in flow from 883 cfs to 1,112 cfs between these two gages during the 8/20/2018 storm. As recorded by the USGS gages, the 11/13/2018 storm exhibits only a marginal increase in peak flow (from 600 cfs to 662 cfs) between these two USGS

gages, whereas the HEC-HMS model predicted an increase from 651 to 1091 cfs. Ongoing and effective management of Lake Johnson, which is situated between these two gages, is likely a major cause of peak flow attenuation between the Buck Jones Rd and Trailwood Dr gage stations. Divergence of peak flows generated in HEC-HMS from the recorded USGS gage values could be a result of the HEC-HMS model not incorporating the managed stage level into each individual simulation.

As shown in **Table 4** below, the HEC-HMS model generally overpredicts peak discharge calculated at each USGS gage, compared to the values observed. After looking at the “Time of Peak” results listed in **Table 4**, one interesting observation was the apparent slow-down of each storm’s peak flow rate between S. Wilmington St. and Sunnybrook Dr. For example, during the 8/20/2018 storm, the HEC-HMS model predicts the peak flow at the Sunnybrook Dr. gage occurs at 7:55pm whereas upstream at S. Wilmington St. it occurs at 1:50pm, about six hours earlier. For the same storm event, the USGS recorded peak flows as listed in the downloaded data occur at 2:15pm and 9:00pm, respectively – a difference of almost seven hours. This difference in time between the observed peaks at S. Wilmington St. and Sunnybrook Dr. are also apparent when looking at the 11/13/2018 storm results.

Additional basin-wide USGS storm events may be analyzed in subsequent analyses in order to further understand and validate HEC-HMS modeling results as it relates to the magnitude, timing, and progression of peak discharge through the Walnut Creek Watershed. Information from the City of Raleigh or other volunteer sources that could help enhance and/or further increase the validity and accuracy of the HEC-HMS model is continually being sought. If improvements in these areas can be made without sacrificing accuracy at the project and downstream area, then these efforts shall continue. If better calibration upstream in the watershed comes at a decrease in accuracy downstream in the watershed, then discussions with the City of Raleigh and stakeholders to determine the optimal model shall be pursued.

**Table 4. Analysis 2 Results**

<b>Peak Flow</b>	J_WC37_WCT25_1		J_WC_29		J_WC_21		J_WC_7	
	<b>Buck Jones Rd Gage</b>		<b>Trailwood Dr Gage</b>		<b>SWilmingtonSt Gage</b>		<b>Sunnybrook Dr Gage</b>	
<b>Storm</b>	HMS	USGS	HMS	USGS	HMS	USGS	HMS	USGS
<b>8/20/2018</b>	883	1530	1112	803	1917	1580	2314	2160
<b>11/13/2018</b>	651	600	1091	662	1360	1170	2161	1660

<b>Time of Peak</b>	J_WC37_WCT25_1		J_WC_29		J_WC_21		J_WC_7	
	<b>Buck Jones Rd Gage</b>		<b>Trailwood Dr Gage</b>		<b>SWilmingtonSt Gage</b>		<b>Sunnybrook Dr Gage</b>	
<b>Storm</b>	HMS	USGS	HMS	USGS	HMS	USGS	HMS	USGS
<b>8/20/2018</b>	2:00	1:20	1:20	1:35	1:50	2:15	7:55	9:00
<b>11/13/2018</b>	1:30	1:35	2:10	2:10	3:50	2:45	6:25	7:00

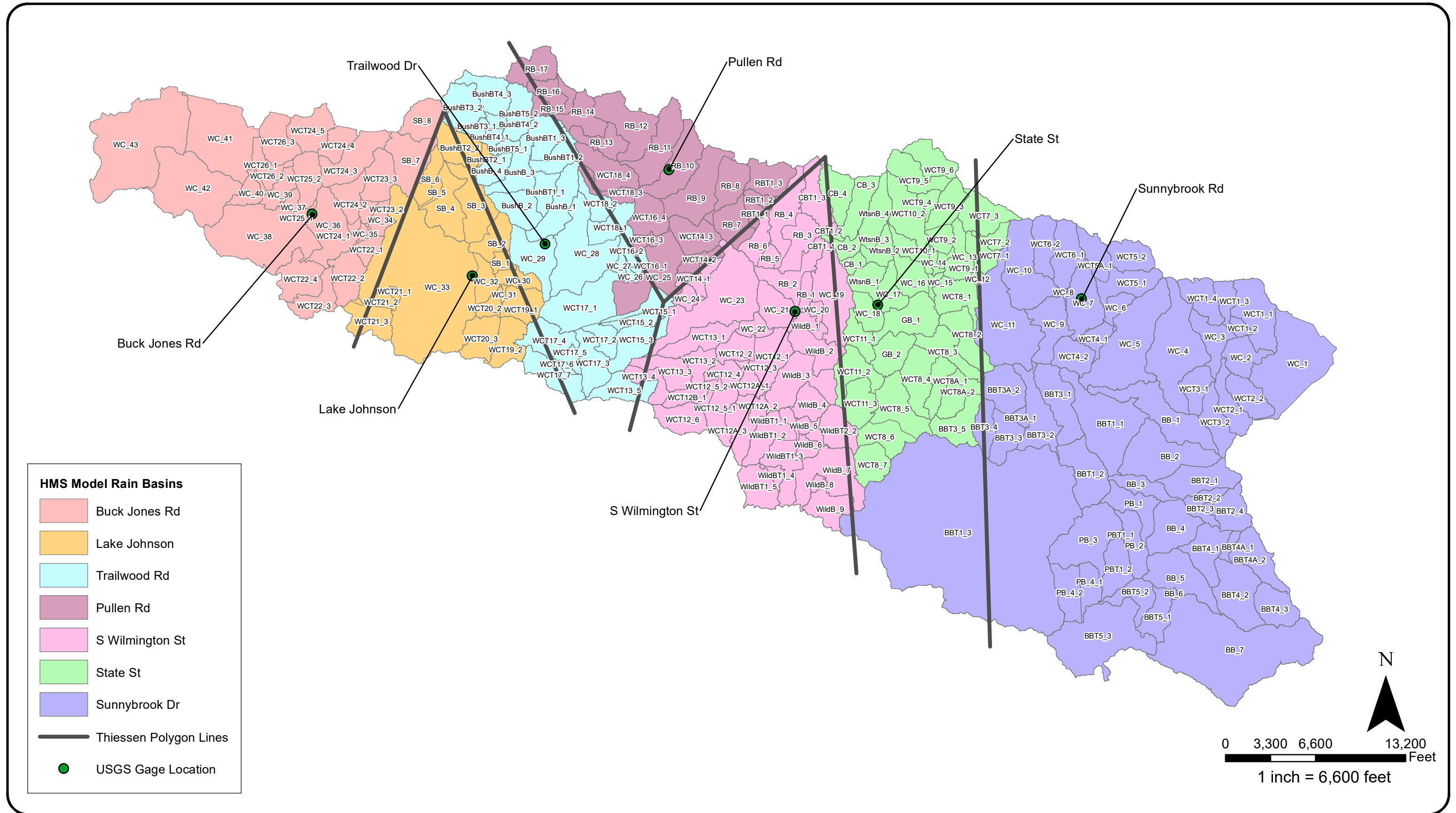
### Analysis 3

Visuals of the eight storms used in the analysis are included in the attached “Analysis 3 – Sample Storm Data”. Several trends between rainfall and the magnitude and timing of the recorded peak discharge at each gage station are evident though analysis of the sample storms. Note that instances where the time of peak discharge at Sunnybrook Dr. is less than the time of peak discharge at S. Wilmington St. indicating the peak discharge at Sunnybrook Dr. occurred on the day following the beginning of the storm event. Most notably, in seven of the eight storms, there is a significant decrease in peak discharge between the Buck Jones Rd. and Trailwood Dr. gage stations. Additionally, for the storm events on 8/2/2019 and 5/29/2019 where the greatest rainfall depth was recorded at the Buck Jones Rd. gage station, recorded peak flow rates at all downstream gage stations are significantly lower than the peak flow rate recorded at the Buck



Jones Rd. gage station despite the substantial increase in drainage area to the downstream gage stations. Only during storms where the downstream watershed receives similar or greater rainfall depth as the upstream watershed do we witness continual, significant increase in peak flow rate from the Trailwood Dr. gage station to the Sunnybrook Rd. gage station. As mentioned in the discussion of **Analysis 2**, active management of stage level and attenuation in Lake Johnson for flood mitigation is a likely cause of discontinuity between recorded discharge values at the Buck Jones Rd. gage station and the downstream gage stations. Accurate representation of the existing upper watershed is dependent on correct routing of Lake Johnson in the model.

Another notable finding from this analysis is the significant variability of timing and magnitude of peak discharges recorded at the Sunnybrook Dr. gage location relative to the values recorded at the S. Wilmington St. gage station. Wide variations in timing and magnitude indicate the likely presence of varying features providing stormwater attenuation along Walnut Creek between these two gage locations. Road crossings and other permanent structures provide consistent attenuation for most storms and wetlands and other temporary floodplain storage provide significant peak flow attenuation for storms when there has been little antecedent rainfall. Analysis of these storms will continue as the project progresses to better understand the function of the watershed. Where applicable, findings from this analysis may lead to changes being made to the effective model to more closely replicate the existing watershed.



Prepared For:

# DOWNTOWN SOUTH HMS MODEL BASINS

## EXISTING CONDITIONS

Raleigh, NC

Drawn By: RHW  
 Date: 3/19/2021  
 Scale: 1" = 6,600'  
 Project No.: KAN-19020

**FIGURE**  
**1**

# ANALYSIS 2 - USGS RAINFALL DATA

Buck Jones Rd. Gage

## 8/20/2018 Event

5 min increments

\_BuckJonesRd\_8-20-2018

Start Date = 19Aug2018

Start Time = 23:15

End Date = 20Aug2018

End Time = 3:30

Time	Rainfall Depth [in]
19Aug2018, 23:15	
19Aug2018, 23:20	0.01
19Aug2018, 23:25	0
19Aug2018, 23:30	0.01
19Aug2018, 23:35	0
19Aug2018, 23:40	0.01
19Aug2018, 23:45	0.04
19Aug2018, 23:50	0.02
19Aug2018, 23:55	0.12
20Aug2018, 00:00	0.12
20Aug2018, 00:05	0.3
20Aug2018, 00:10	0.16
20Aug2018, 00:15	0.12
20Aug2018, 00:20	0.15
20Aug2018, 00:25	0.05
20Aug2018, 00:30	0.09
20Aug2018, 00:35	0.08
20Aug2018, 00:40	0.22
20Aug2018, 00:45	0.04
20Aug2018, 00:50	0.09
20Aug2018, 00:55	0.09
20Aug2018, 01:00	0.14
20Aug2018, 01:05	0.1
20Aug2018, 01:10	0.01
20Aug2018, 01:15	0
20Aug2018, 01:20	0.02
20Aug2018, 01:25	0
20Aug2018, 01:30	0
20Aug2018, 01:35	0
20Aug2018, 01:40	0.01
20Aug2018, 01:45	0.07
20Aug2018, 01:50	0.07
20Aug2018, 01:55	0.01
20Aug2018, 02:00	0.01
20Aug2018, 02:05	0.02
20Aug2018, 02:10	0.01

## 11/13/2018 Event

5 min increments

\_BuckJonesRd\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:55

End Date = 13Nov2018

End Time = 3:00

Time	Rainfall Depth [in]
12Nov2018, 11:55	
12Nov2018, 12:00	0.01
12Nov2018, 12:05	0.01
12Nov2018, 12:10	0
12Nov2018, 12:15	0.01
12Nov2018, 12:20	0.01
12Nov2018, 12:25	0.01
12Nov2018, 12:30	0.01
12Nov2018, 12:35	0.01
12Nov2018, 12:40	0.01
12Nov2018, 12:45	0.02
12Nov2018, 12:50	0.01
12Nov2018, 12:55	0
12Nov2018, 13:00	0.01
12Nov2018, 13:05	0.02
12Nov2018, 13:10	0.01
12Nov2018, 13:15	0.02
12Nov2018, 13:20	0.02
12Nov2018, 13:25	0.01
12Nov2018, 13:30	0.01
12Nov2018, 13:35	0.02
12Nov2018, 13:40	0.02
12Nov2018, 13:45	0.02
12Nov2018, 13:50	0.01
12Nov2018, 13:55	0.01
12Nov2018, 14:00	0.01
12Nov2018, 14:05	0.02
12Nov2018, 14:10	0.02
12Nov2018, 14:15	0.01
12Nov2018, 14:20	0.01
12Nov2018, 14:25	0.01
12Nov2018, 14:30	0.01
12Nov2018, 14:35	0
12Nov2018, 14:40	0.01
12Nov2018, 14:45	0.01
12Nov2018, 14:50	0



Buck Jones Rd. Gage

### 8/20/2018 Event

20Aug2018, 02:15	0
20Aug2018, 02:20	0
20Aug2018, 02:25	0.01
20Aug2018, 02:30	0.03
20Aug2018, 02:35	0
20Aug2018, 02:40	0.01
20Aug2018, 02:45	0.01
20Aug2018, 02:50	0
20Aug2018, 02:55	0
20Aug2018, 03:00	0.01
20Aug2018, 03:05	0.01
20Aug2018, 03:10	0
20Aug2018, 03:15	0
20Aug2018, 03:20	0.01
20Aug2018, 03:25	0
20Aug2018, 03:30	0

### 11/13/2018 Event

12Nov2018, 14:55	0.01
12Nov2018, 15:00	0
12Nov2018, 15:05	0.01
12Nov2018, 15:10	0.01
12Nov2018, 15:15	0
12Nov2018, 15:20	0
12Nov2018, 15:25	0.01
12Nov2018, 15:30	0
12Nov2018, 15:35	0.01
12Nov2018, 15:40	0.02
12Nov2018, 15:45	0.01
12Nov2018, 15:50	0.01
12Nov2018, 15:55	0.02
12Nov2018, 16:00	0.01
12Nov2018, 16:05	0.02
12Nov2018, 16:10	0.03
12Nov2018, 16:15	0.02
12Nov2018, 16:20	0.02
12Nov2018, 16:25	0.03
12Nov2018, 16:30	0.03
12Nov2018, 16:35	0.02
12Nov2018, 16:40	0.02
12Nov2018, 16:45	0.04
12Nov2018, 16:50	0.03
12Nov2018, 16:55	0.02
12Nov2018, 17:00	0.01
12Nov2018, 17:05	0.02
12Nov2018, 17:10	0.01
12Nov2018, 17:15	0.01
12Nov2018, 17:20	0.01
12Nov2018, 17:25	0.01
12Nov2018, 17:30	0.01
12Nov2018, 17:35	0.01
12Nov2018, 17:40	0.02
12Nov2018, 17:45	0.01
12Nov2018, 17:50	0.01
12Nov2018, 17:55	0.01
12Nov2018, 18:00	0.02
12Nov2018, 18:05	0.03
12Nov2018, 18:10	0.02
12Nov2018, 18:15	0.04
12Nov2018, 18:20	0.02
12Nov2018, 18:25	0.02
12Nov2018, 18:30	0.05
12Nov2018, 18:35	0.03

## 8/20/2018 Event

## 11/13/2018 Event

12Nov2018, 18:40	0.03
12Nov2018, 18:45	0.03
12Nov2018, 18:50	0.02
12Nov2018, 18:55	0.03
12Nov2018, 19:00	0.02
12Nov2018, 19:05	0.03
12Nov2018, 19:10	0.02
12Nov2018, 19:15	0.03
12Nov2018, 19:20	0.02
12Nov2018, 19:25	0.02
12Nov2018, 19:30	0.01
12Nov2018, 19:35	0.03
12Nov2018, 19:40	0.03
12Nov2018, 19:45	0.03
12Nov2018, 19:50	0.02
12Nov2018, 19:55	0.01
12Nov2018, 20:00	0.04
12Nov2018, 20:05	0.03
12Nov2018, 20:10	0.02
12Nov2018, 20:15	0.03
12Nov2018, 20:20	0.05
12Nov2018, 20:25	0.04
12Nov2018, 20:30	0.03
12Nov2018, 20:35	0.01
12Nov2018, 20:40	0.02
12Nov2018, 20:45	0.04
12Nov2018, 20:50	0.03
12Nov2018, 20:55	0.02
12Nov2018, 21:00	0.01
12Nov2018, 21:05	0.01
12Nov2018, 21:10	0.02
12Nov2018, 21:15	0.01
12Nov2018, 21:20	0.02
12Nov2018, 21:25	0.01
12Nov2018, 21:30	0.02
12Nov2018, 21:35	0.02
12Nov2018, 21:40	0.02
12Nov2018, 21:45	0.02
12Nov2018, 21:50	0.03
12Nov2018, 21:55	0.02
12Nov2018, 22:00	0.02
12Nov2018, 22:05	0.01
12Nov2018, 22:10	0.01
12Nov2018, 22:15	0.02
12Nov2018, 22:20	0.01

## 8/20/2018 Event

## 11/13/2018 Event

12Nov2018, 22:25	0.01
12Nov2018, 22:30	0.03
12Nov2018, 22:35	0.05
12Nov2018, 22:40	0.03
12Nov2018, 22:45	0.04
12Nov2018, 22:50	0.04
12Nov2018, 22:55	0.03
12Nov2018, 23:00	0.01
12Nov2018, 23:05	0.02
12Nov2018, 23:10	0.02
12Nov2018, 23:15	0.01
12Nov2018, 23:20	0.01
12Nov2018, 23:25	0.01
12Nov2018, 23:30	0.03
12Nov2018, 23:35	0.04
12Nov2018, 23:40	0.04
12Nov2018, 23:45	0.04
12Nov2018, 23:50	0.03
12Nov2018, 23:55	0.04
13Nov2018, 00:00	0.05
13Nov2018, 00:05	0.06
13Nov2018, 00:10	0.05
13Nov2018, 00:15	0.03
13Nov2018, 00:20	0.02
13Nov2018, 00:25	0.04
13Nov2018, 00:30	0.03
13Nov2018, 00:35	0.06
13Nov2018, 00:40	0.03
13Nov2018, 00:45	0.02
13Nov2018, 00:50	0.02
13Nov2018, 00:55	0.03
13Nov2018, 01:00	0.04
13Nov2018, 01:05	0
13Nov2018, 01:10	0.02
13Nov2018, 01:15	0.03
13Nov2018, 01:20	0.04
13Nov2018, 01:25	0.04
13Nov2018, 01:30	0.03
13Nov2018, 01:35	0.01
13Nov2018, 01:40	0.05
13Nov2018, 01:45	0.02
13Nov2018, 01:50	0.03
13Nov2018, 01:55	0
13Nov2018, 02:00	0.01
13Nov2018, 02:05	0

Buck Jones Rd. Gage

8/20/2018 Event

11/13/2018 Event

13Nov2018, 02:10	0
13Nov2018, 02:15	0
13Nov2018, 02:20	0
13Nov2018, 02:25	0
13Nov2018, 02:30	0.01
13Nov2018, 02:35	0.01
13Nov2018, 02:40	0
13Nov2018, 02:45	0
13Nov2018, 02:50	0.01
13Nov2018, 02:55	0.01
13Nov2018, 03:00	0

Lake Johnson Gage

8/20/2018 Event

15 min increments

\_LakeJohnson\_8-20-2018

Start Date = 19Aug2018

Start Time = 23:00

End Date = 20Aug2018

End Time = 3:45

Time	Rainfall Depth [in]
19Aug2018, 23:00	
19Aug2018, 23:15	0.01
19Aug2018, 23:30	0.01
19Aug2018, 23:45	0.25
20Aug2018, 00:00	0.23
20Aug2018, 00:15	1
20Aug2018, 00:30	0.72
20Aug2018, 00:45	0.38
20Aug2018, 01:00	0.29
20Aug2018, 01:15	0.33
20Aug2018, 01:30	0.07
20Aug2018, 01:45	0.25
20Aug2018, 02:00	0.09
20Aug2018, 02:15	0
20Aug2018, 02:30	0
20Aug2018, 02:45	0.03
20Aug2018, 03:00	0.02
20Aug2018, 03:15	0.04
20Aug2018, 03:30	0.02
20Aug2018, 03:45	0

11/13/2018 Event

15 min increments

\_LakeJohnson\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:45

End Date = 13Nov2018

End Time = 3:30

Time	Rainfall Depth [in]
12Nov2018, 11:45	
12Nov2018, 12:00	0.01
12Nov2018, 12:15	0.02
12Nov2018, 12:30	0.03
12Nov2018, 12:45	0.04
12Nov2018, 13:00	0.03
12Nov2018, 13:15	0.05
12Nov2018, 13:30	0.05
12Nov2018, 13:45	0.04
12Nov2018, 14:00	0.04
12Nov2018, 14:15	0.04
12Nov2018, 14:30	0.03
12Nov2018, 14:45	0.01
12Nov2018, 15:00	0.02
12Nov2018, 15:15	0.01
12Nov2018, 15:30	0.02
12Nov2018, 15:45	0.03
12Nov2018, 16:00	0.05
12Nov2018, 16:15	0.07
12Nov2018, 16:30	0.07
12Nov2018, 16:45	0.07
12Nov2018, 17:00	0.07
12Nov2018, 17:15	0.03
12Nov2018, 17:30	0.04
12Nov2018, 17:45	0.04
12Nov2018, 18:00	0.05
12Nov2018, 18:15	0.08
12Nov2018, 18:30	0.09
12Nov2018, 18:45	0.08
12Nov2018, 19:00	0.08
12Nov2018, 19:15	0.08
12Nov2018, 19:30	0.07
12Nov2018, 19:45	0.07
12Nov2018, 20:00	0.06
12Nov2018, 20:15	0.09
12Nov2018, 20:30	0.12



Lake Johnson Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 20:45	0.08
12Nov2018, 21:00	0.06
12Nov2018, 21:15	0.04
12Nov2018, 21:30	0.03
12Nov2018, 21:45	0.05
12Nov2018, 22:00	0.06
12Nov2018, 22:15	0.03
12Nov2018, 22:30	0.06
12Nov2018, 22:45	0.12
12Nov2018, 23:00	0.09
12Nov2018, 23:15	0.04
12Nov2018, 23:30	0.07
12Nov2018, 23:45	0.1
13Nov2018, 00:00	0.14
13Nov2018, 00:15	0.11
13Nov2018, 00:30	0.09
13Nov2018, 00:45	0.12
13Nov2018, 01:00	0.06
13Nov2018, 01:15	0.11
13Nov2018, 01:30	0.08
13Nov2018, 01:45	0.11
13Nov2018, 02:00	0.03
13Nov2018, 02:15	0.01
13Nov2018, 02:30	0.01
13Nov2018, 02:45	0.01
13Nov2018, 03:00	0.01
13Nov2018, 03:15	0.01
13Nov2018, 03:30	0

Trailwood Dr Gage

8/20/2018 Event

5 min increments

\_TrailwoodRd\_8-20-2018

Start Date = 19Aug2018

Start Time = 23:20

End Date = 20Aug2018

End Time = 3:30

Time	Rainfall Depth [in]
19Aug2018, 23:20	
19Aug2018, 23:25	0.02
19Aug2018, 23:30	0
19Aug2018, 23:35	0.01
19Aug2018, 23:40	0
19Aug2018, 23:45	0
19Aug2018, 23:50	0.1
19Aug2018, 23:55	0.02
20Aug2018, 00:00	0.13
20Aug2018, 00:05	0.42
20Aug2018, 00:10	0.27
20Aug2018, 00:15	0.33
20Aug2018, 00:20	0.27
20Aug2018, 00:25	0.24
20Aug2018, 00:30	0.11
20Aug2018, 00:35	0.13
20Aug2018, 00:40	0.16
20Aug2018, 00:45	0.23
20Aug2018, 00:50	0.1
20Aug2018, 00:55	0.12
20Aug2018, 01:00	0.13
20Aug2018, 01:05	0.14
20Aug2018, 01:10	0.05
20Aug2018, 01:15	0.01
20Aug2018, 01:20	0.01
20Aug2018, 01:25	0.01
20Aug2018, 01:30	0.1
20Aug2018, 01:35	0.07
20Aug2018, 01:40	0
20Aug2018, 01:45	0.04
20Aug2018, 01:50	0.18
20Aug2018, 01:55	0.15
20Aug2018, 02:00	0.09
20Aug2018, 02:05	0
20Aug2018, 02:10	0
20Aug2018, 02:15	0

11/13/2018 Event

5 min increments

\_TrailwoodRd\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:50

End Date = 13Nov2018

End Time = 3:10

Time	Rainfall Depth [in]
12Nov2018, 11:50	
12Nov2018, 11:55	0.01
12Nov2018, 12:00	0
12Nov2018, 12:05	0.01
12Nov2018, 12:10	0
12Nov2018, 12:15	0.01
12Nov2018, 12:20	0.01
12Nov2018, 12:25	0
12Nov2018, 12:30	0.01
12Nov2018, 12:35	0
12Nov2018, 12:40	0.02
12Nov2018, 12:45	0.01
12Nov2018, 12:50	0.01
12Nov2018, 12:55	0.01
12Nov2018, 13:00	0.01
12Nov2018, 13:05	0.01
12Nov2018, 13:10	0.02
12Nov2018, 13:15	0.01
12Nov2018, 13:20	0.01
12Nov2018, 13:25	0.02
12Nov2018, 13:30	0.01
12Nov2018, 13:35	0.01
12Nov2018, 13:40	0.01
12Nov2018, 13:45	0.02
12Nov2018, 13:50	0.02
12Nov2018, 13:55	0.01
12Nov2018, 14:00	0
12Nov2018, 14:05	0.02
12Nov2018, 14:10	0.01
12Nov2018, 14:15	0.01
12Nov2018, 14:20	0.01
12Nov2018, 14:25	0.01
12Nov2018, 14:30	0
12Nov2018, 14:35	0.01
12Nov2018, 14:40	0
12Nov2018, 14:45	0

Trailwood Dr Gage

8/20/2018 Event

20Aug2018, 02:20	0
20Aug2018, 02:25	0
20Aug2018, 02:30	0
20Aug2018, 02:35	0
20Aug2018, 02:40	0.01
20Aug2018, 02:45	0.01
20Aug2018, 02:50	0
20Aug2018, 02:55	0.01
20Aug2018, 03:00	0.01
20Aug2018, 03:05	0.01
20Aug2018, 03:10	0.01
20Aug2018, 03:15	0.02
20Aug2018, 03:20	0.01
20Aug2018, 03:25	0.01
20Aug2018, 03:30	0

11/13/2018 Event

12Nov2018, 14:50	0.01
12Nov2018, 14:55	0
12Nov2018, 15:00	0.01
12Nov2018, 15:05	0
12Nov2018, 15:10	0.01
12Nov2018, 15:15	0
12Nov2018, 15:20	0.01
12Nov2018, 15:25	0
12Nov2018, 15:30	0
12Nov2018, 15:35	0.01
12Nov2018, 15:40	0.01
12Nov2018, 15:45	0.01
12Nov2018, 15:50	0.01
12Nov2018, 15:55	0.02
12Nov2018, 16:00	0.01
12Nov2018, 16:05	0.02
12Nov2018, 16:10	0.02
12Nov2018, 16:15	0.02
12Nov2018, 16:20	0.02
12Nov2018, 16:25	0.03
12Nov2018, 16:30	0.02
12Nov2018, 16:35	0.02
12Nov2018, 16:40	0.02
12Nov2018, 16:45	0.02
12Nov2018, 16:50	0.04
12Nov2018, 16:55	0.02
12Nov2018, 17:00	0.02
12Nov2018, 17:05	0.02
12Nov2018, 17:10	0.01
12Nov2018, 17:15	0.01
12Nov2018, 17:20	0
12Nov2018, 17:25	0.02
12Nov2018, 17:30	0.01
12Nov2018, 17:35	0.01
12Nov2018, 17:40	0.01
12Nov2018, 17:45	0.02
12Nov2018, 17:50	0
12Nov2018, 17:55	0.02
12Nov2018, 18:00	0.01
12Nov2018, 18:05	0.03
12Nov2018, 18:10	0.02
12Nov2018, 18:15	0.04
12Nov2018, 18:20	0.03
12Nov2018, 18:25	0.03
12Nov2018, 18:30	0.03

Trailwood Dr Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 18:35	0.03
12Nov2018, 18:40	0.03
12Nov2018, 18:45	0.02
12Nov2018, 18:50	0.02
12Nov2018, 18:55	0.03
12Nov2018, 19:00	0.03
12Nov2018, 19:05	0.03
12Nov2018, 19:10	0.02
12Nov2018, 19:15	0.02
12Nov2018, 19:20	0.02
12Nov2018, 19:25	0.03
12Nov2018, 19:30	0.02
12Nov2018, 19:35	0.02
12Nov2018, 19:40	0.03
12Nov2018, 19:45	0.01
12Nov2018, 19:50	0.03
12Nov2018, 19:55	0.02
12Nov2018, 20:00	0.02
12Nov2018, 20:05	0.03
12Nov2018, 20:10	0.02
12Nov2018, 20:15	0.04
12Nov2018, 20:20	0.04
12Nov2018, 20:25	0.04
12Nov2018, 20:30	0.03
12Nov2018, 20:35	0.02
12Nov2018, 20:40	0.03
12Nov2018, 20:45	0.03
12Nov2018, 20:50	0.03
12Nov2018, 20:55	0.02
12Nov2018, 21:00	0.01
12Nov2018, 21:05	0.02
12Nov2018, 21:10	0.01
12Nov2018, 21:15	0.01
12Nov2018, 21:20	0.02
12Nov2018, 21:25	0.01
12Nov2018, 21:30	0.01
12Nov2018, 21:35	0.01
12Nov2018, 21:40	0.02
12Nov2018, 21:45	0.01
12Nov2018, 21:50	0.02
12Nov2018, 21:55	0.02
12Nov2018, 22:00	0.02
12Nov2018, 22:05	0
12Nov2018, 22:10	0.02
12Nov2018, 22:15	0

Trailwood Dr Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 22:20	0.02
12Nov2018, 22:25	0.02
12Nov2018, 22:30	0.02
12Nov2018, 22:35	0.05
12Nov2018, 22:40	0.04
12Nov2018, 22:45	0.03
12Nov2018, 22:50	0.04
12Nov2018, 22:55	0.03
12Nov2018, 23:00	0.02
12Nov2018, 23:05	0.01
12Nov2018, 23:10	0.01
12Nov2018, 23:15	0.01
12Nov2018, 23:20	0.02
12Nov2018, 23:25	0.03
12Nov2018, 23:30	0.02
12Nov2018, 23:35	0.03
12Nov2018, 23:40	0.03
12Nov2018, 23:45	0.03
12Nov2018, 23:50	0.04
12Nov2018, 23:55	0.05
13Nov2018, 00:00	0.05
13Nov2018, 00:05	0.05
13Nov2018, 00:10	0.03
13Nov2018, 00:15	0.05
13Nov2018, 00:20	0.02
13Nov2018, 00:25	0.03
13Nov2018, 00:30	0.05
13Nov2018, 00:35	0.04
13Nov2018, 00:40	0.06
13Nov2018, 00:45	0.03
13Nov2018, 00:50	0.01
13Nov2018, 00:55	0.01
13Nov2018, 01:00	0.03
13Nov2018, 01:05	0.02
13Nov2018, 01:10	0.02
13Nov2018, 01:15	0.04
13Nov2018, 01:20	0.05
13Nov2018, 01:25	0
13Nov2018, 01:30	0.04
13Nov2018, 01:35	0.01
13Nov2018, 01:40	0.05
13Nov2018, 01:45	0.04
13Nov2018, 01:50	0.01
13Nov2018, 01:55	0.01
13Nov2018, 02:00	0.01



Trailwood Dr Gage

8/20/2018 Event

11/13/2018 Event

13Nov2018, 02:05	0
13Nov2018, 02:10	0
13Nov2018, 02:15	0.01
13Nov2018, 02:20	0
13Nov2018, 02:25	0
13Nov2018, 02:30	0.01
13Nov2018, 02:35	0.01
13Nov2018, 02:40	0
13Nov2018, 02:45	0
13Nov2018, 02:50	0.01
13Nov2018, 02:55	0
13Nov2018, 03:00	0.01
13Nov2018, 03:05	0.01
13Nov2018, 03:10	0

Pullen Rd Gage

## 8/20/2018 Event

5 min increments

\_PullenRd\_8-20-2018

Start Date = 19Aug2018

Start Time = 23:25

End Date = 20Aug2018

End Time = 3:35

Time	Rainfall Depth [in]
19Aug2018, 23:25	
19Aug2018, 23:30	0.02
19Aug2018, 23:35	0.01
19Aug2018, 23:40	0
19Aug2018, 23:45	0
19Aug2018, 23:50	0
19Aug2018, 23:55	0.1
20Aug2018, 00:00	0.06
20Aug2018, 00:05	0.14
20Aug2018, 00:10	0.36
20Aug2018, 00:15	0.36
20Aug2018, 00:20	0.23
20Aug2018, 00:25	0.29
20Aug2018, 00:30	0.15
20Aug2018, 00:35	0.17
20Aug2018, 00:40	0.14
20Aug2018, 00:45	0.28
20Aug2018, 00:50	0.22
20Aug2018, 00:55	0.08
20Aug2018, 01:00	0.18
20Aug2018, 01:05	0.12
20Aug2018, 01:10	0.1
20Aug2018, 01:15	0.01
20Aug2018, 01:20	0
20Aug2018, 01:25	0
20Aug2018, 01:30	0.05
20Aug2018, 01:35	0.09
20Aug2018, 01:40	0.04
20Aug2018, 01:45	0
20Aug2018, 01:50	0.07
20Aug2018, 01:55	0.2
20Aug2018, 02:00	0.17
20Aug2018, 02:05	0.01
20Aug2018, 02:10	0
20Aug2018, 02:15	0
20Aug2018, 02:20	0

## 11/13/2018 Event

5 min increments

\_PullenRd\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:55

End Date = 13Nov2018

End Time = 3:15

Time	Rainfall Depth [in]
12Nov2018, 11:55	
12Nov2018, 12:00	0.01
12Nov2018, 12:05	0.01
12Nov2018, 12:10	0.01
12Nov2018, 12:15	0.01
12Nov2018, 12:20	0
12Nov2018, 12:25	0.01
12Nov2018, 12:30	0
12Nov2018, 12:35	0.01
12Nov2018, 12:40	0.02
12Nov2018, 12:45	0.01
12Nov2018, 12:50	0.02
12Nov2018, 12:55	0.01
12Nov2018, 13:00	0.01
12Nov2018, 13:05	0
12Nov2018, 13:10	0.02
12Nov2018, 13:15	0.01
12Nov2018, 13:20	0.02
12Nov2018, 13:25	0.01
12Nov2018, 13:30	0.02
12Nov2018, 13:35	0.01
12Nov2018, 13:40	0.02
12Nov2018, 13:45	0.02
12Nov2018, 13:50	0.02
12Nov2018, 13:55	0.01
12Nov2018, 14:00	0.01
12Nov2018, 14:05	0.01
12Nov2018, 14:10	0.02
12Nov2018, 14:15	0.01
12Nov2018, 14:20	0.02
12Nov2018, 14:25	0.01
12Nov2018, 14:30	0.01
12Nov2018, 14:35	0
12Nov2018, 14:40	0.01
12Nov2018, 14:45	0
12Nov2018, 14:50	0.01

Pullen Rd Gage

8/20/2018 Event

20Aug2018, 02:25	0
20Aug2018, 02:30	0
20Aug2018, 02:35	0
20Aug2018, 02:40	0
20Aug2018, 02:45	0
20Aug2018, 02:50	0.01
20Aug2018, 02:55	0.01
20Aug2018, 03:00	0
20Aug2018, 03:05	0.01
20Aug2018, 03:10	0.01
20Aug2018, 03:15	0
20Aug2018, 03:20	0
20Aug2018, 03:25	0.01
20Aug2018, 03:30	0.01
20Aug2018, 03:35	0

11/13/2018 Event

12Nov2018, 14:55	0.01
12Nov2018, 15:00	0.01
12Nov2018, 15:05	0
12Nov2018, 15:10	0.01
12Nov2018, 15:15	0.01
12Nov2018, 15:20	0
12Nov2018, 15:25	0.01
12Nov2018, 15:30	0
12Nov2018, 15:35	0.01
12Nov2018, 15:40	0.01
12Nov2018, 15:45	0.02
12Nov2018, 15:50	0.02
12Nov2018, 15:55	0.02
12Nov2018, 16:00	0.01
12Nov2018, 16:05	0.02
12Nov2018, 16:10	0.03
12Nov2018, 16:15	0.03
12Nov2018, 16:20	0.03
12Nov2018, 16:25	0.03
12Nov2018, 16:30	0.04
12Nov2018, 16:35	0.03
12Nov2018, 16:40	0.02
12Nov2018, 16:45	0.02
12Nov2018, 16:50	0.04
12Nov2018, 16:55	0.05
12Nov2018, 17:00	0.03
12Nov2018, 17:05	0.01
12Nov2018, 17:10	0.01
12Nov2018, 17:15	0.02
12Nov2018, 17:20	0.01
12Nov2018, 17:25	0.02
12Nov2018, 17:30	0.02
12Nov2018, 17:35	0.01
12Nov2018, 17:40	0.02
12Nov2018, 17:45	0.01
12Nov2018, 17:50	0.02
12Nov2018, 17:55	0.01
12Nov2018, 18:00	0.02
12Nov2018, 18:05	0.02
12Nov2018, 18:10	0.03
12Nov2018, 18:15	0.04
12Nov2018, 18:20	0.05
12Nov2018, 18:25	0.03
12Nov2018, 18:30	0.05
12Nov2018, 18:35	0.04

Pullen Rd Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 18:40	0.05
12Nov2018, 18:45	0.03
12Nov2018, 18:50	0.03
12Nov2018, 18:55	0.02
12Nov2018, 19:00	0.04
12Nov2018, 19:05	0.03
12Nov2018, 19:10	0.03
12Nov2018, 19:15	0.02
12Nov2018, 19:20	0.03
12Nov2018, 19:25	0.04
12Nov2018, 19:30	0.03
12Nov2018, 19:35	0.02
12Nov2018, 19:40	0.03
12Nov2018, 19:45	0.02
12Nov2018, 19:50	0.03
12Nov2018, 19:55	0.02
12Nov2018, 20:00	0.03
12Nov2018, 20:05	0.03
12Nov2018, 20:10	0.02
12Nov2018, 20:15	0.03
12Nov2018, 20:20	0.05
12Nov2018, 20:25	0.05
12Nov2018, 20:30	0.03
12Nov2018, 20:35	0.03
12Nov2018, 20:40	0.04
12Nov2018, 20:45	0.04
12Nov2018, 20:50	0.03
12Nov2018, 20:55	0.02
12Nov2018, 21:00	0.02
12Nov2018, 21:05	0.02
12Nov2018, 21:10	0.02
12Nov2018, 21:15	0.01
12Nov2018, 21:20	0.01
12Nov2018, 21:25	0.02
12Nov2018, 21:30	0.01
12Nov2018, 21:35	0.02
12Nov2018, 21:40	0.02
12Nov2018, 21:45	0.04
12Nov2018, 21:50	0.02
12Nov2018, 21:55	0.02
12Nov2018, 22:00	0.03
12Nov2018, 22:05	0.01
12Nov2018, 22:10	0.01
12Nov2018, 22:15	0.01
12Nov2018, 22:20	0.03

Pullen Rd Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 22:25	0.01
12Nov2018, 22:30	0.02
12Nov2018, 22:35	0.07
12Nov2018, 22:40	0.04
12Nov2018, 22:45	0.03
12Nov2018, 22:50	0.03
12Nov2018, 22:55	0.05
12Nov2018, 23:00	0.02
12Nov2018, 23:05	0.02
12Nov2018, 23:10	0.04
12Nov2018, 23:15	0
12Nov2018, 23:20	0.02
12Nov2018, 23:25	0.04
12Nov2018, 23:30	0.03
12Nov2018, 23:35	0.04
12Nov2018, 23:40	0.03
12Nov2018, 23:45	0.03
12Nov2018, 23:50	0.03
12Nov2018, 23:55	0.04
13Nov2018, 00:00	0.05
13Nov2018, 00:05	0.06
13Nov2018, 00:10	0.02
13Nov2018, 00:15	0.05
13Nov2018, 00:20	0.03
13Nov2018, 00:25	0.02
13Nov2018, 00:30	0.04
13Nov2018, 00:35	0.05
13Nov2018, 00:40	0.08
13Nov2018, 00:45	0.04
13Nov2018, 00:50	0.03
13Nov2018, 00:55	0.01
13Nov2018, 01:00	0.03
13Nov2018, 01:05	0.02
13Nov2018, 01:10	0.02
13Nov2018, 01:15	0.03
13Nov2018, 01:20	0.05
13Nov2018, 01:25	0.03
13Nov2018, 01:30	0.03
13Nov2018, 01:35	0.03
13Nov2018, 01:40	0.04
13Nov2018, 01:45	0.06
13Nov2018, 01:50	0.01
13Nov2018, 01:55	0.01
13Nov2018, 02:00	0.01
13Nov2018, 02:05	0.01



Pullen Rd Gage

8/20/2018 Event

11/13/2018 Event

13Nov2018, 02:10	0
13Nov2018, 02:15	0.01
13Nov2018, 02:20	0
13Nov2018, 02:25	0.01
13Nov2018, 02:30	0
13Nov2018, 02:35	0.01
13Nov2018, 02:40	0
13Nov2018, 02:45	0
13Nov2018, 02:50	0.01
13Nov2018, 02:55	0
13Nov2018, 03:00	0.01
13Nov2018, 03:05	0.01
13Nov2018, 03:10	0.01
13Nov2018, 03:15	0

S. Wilmington St. Gage

8/20/2018 Event

15 min increments

\_SWilmingtonSt\_8-20-2018

Start Date = 20Aug2018

Start Time = 0:00

End Date = 20Aug2018

End Time = 3:30

Time	Rainfall Depth [in]
20Aug2018, 00:00	
20Aug2018, 00:15	0.25
20Aug2018, 00:30	0.97
20Aug2018, 00:45	0.71
20Aug2018, 01:00	0.35
20Aug2018, 01:15	0.27
20Aug2018, 01:30	0.1
20Aug2018, 01:45	0.01
20Aug2018, 02:00	0.01
20Aug2018, 02:15	0.01
20Aug2018, 02:30	0.05
20Aug2018, 02:45	0
20Aug2018, 03:00	0.01
20Aug2018, 03:15	0.01
20Aug2018, 03:30	0

11/13/2018 Event

15 min increments

\_SWilmingtonSt\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:45

End Date = 13Nov2018

End Time = 3:30

Time	Rainfall Depth [in]
12Nov2018, 11:45	
12Nov2018, 12:00	0.01
12Nov2018, 12:15	0.02
12Nov2018, 12:30	0.02
12Nov2018, 12:45	0.03
12Nov2018, 13:00	0.03
12Nov2018, 13:15	0.04
12Nov2018, 13:30	0.04
12Nov2018, 13:45	0.04
12Nov2018, 14:00	0.04
12Nov2018, 14:15	0.03
12Nov2018, 14:30	0.04
12Nov2018, 14:45	0.01
12Nov2018, 15:00	0.03
12Nov2018, 15:15	0.02
12Nov2018, 15:30	0.01
12Nov2018, 15:45	0.03
12Nov2018, 16:00	0.04
12Nov2018, 16:15	0.06
12Nov2018, 16:30	0.07
12Nov2018, 16:45	0.06
12Nov2018, 17:00	0.07
12Nov2018, 17:15	0.03
12Nov2018, 17:30	0.04
12Nov2018, 17:45	0.03
12Nov2018, 18:00	0.03
12Nov2018, 18:15	0.06
12Nov2018, 18:30	0.1
12Nov2018, 18:45	0.08
12Nov2018, 19:00	0.09
12Nov2018, 19:15	0.07
12Nov2018, 19:30	0.09
12Nov2018, 19:45	0.05
12Nov2018, 20:00	0.09
12Nov2018, 20:15	0.06
12Nov2018, 20:30	0.11

S. Wilmington St. Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 20:45	0.08
12Nov2018, 21:00	0.06
12Nov2018, 21:15	0.03
12Nov2018, 21:30	0.04
12Nov2018, 21:45	0.06
12Nov2018, 22:00	0.07
12Nov2018, 22:15	0.02
12Nov2018, 22:30	0.05
12Nov2018, 22:45	0.13
12Nov2018, 23:00	0.07
12Nov2018, 23:15	0.05
12Nov2018, 23:30	0.08
12Nov2018, 23:45	0.08
13Nov2018, 00:00	0.09
13Nov2018, 00:15	0.11
13Nov2018, 00:30	0.14
13Nov2018, 00:45	0.12
13Nov2018, 01:00	0.05
13Nov2018, 01:15	0.1
13Nov2018, 01:30	0.04
13Nov2018, 01:45	0.06
13Nov2018, 02:00	0.03
13Nov2018, 02:15	0.02
13Nov2018, 02:30	0.01
13Nov2018, 02:45	0.02
13Nov2018, 03:00	0.03
13Nov2018, 03:15	0.03
13Nov2018, 03:30	0

S. State St. Gage

## 8/20/2018 Event

15 min increments

\_StateSt\_8-20-2018

Start Date = 20Aug2018

Start Time = 0:00

End Date = 20Aug2018

End Time = 3:30

Time	Rainfall Depth [in]
20Aug2018, 00:00	
20Aug2018, 00:15	0.39
20Aug2018, 00:30	0.52
20Aug2018, 00:45	0.52
20Aug2018, 01:00	0.2
20Aug2018, 01:15	0.36
20Aug2018, 01:30	0.2
20Aug2018, 01:45	0.01
20Aug2018, 02:00	0.01
20Aug2018, 02:15	0
20Aug2018, 02:30	0.03
20Aug2018, 02:45	0.01
20Aug2018, 03:00	0
20Aug2018, 03:15	0.01
20Aug2018, 03:30	0

## 11/13/2018 Event

15 min increments

\_StateSt\_11-13-2018

Start Date = 12Nov2018

Start Time = 11:45

End Date = 13Nov2018

End Time = 3:30

Time	Rainfall Depth [in]
12Nov2018, 11:45	
12Nov2018, 12:00	0.01
12Nov2018, 12:15	0.01
12Nov2018, 12:30	0.03
12Nov2018, 12:45	0.03
12Nov2018, 13:00	0.02
12Nov2018, 13:15	0.03
12Nov2018, 13:30	0.03
12Nov2018, 13:45	0.04
12Nov2018, 14:00	0.03
12Nov2018, 14:15	0.03
12Nov2018, 14:30	0.03
12Nov2018, 14:45	0.01
12Nov2018, 15:00	0.02
12Nov2018, 15:15	0.02
12Nov2018, 15:30	0.01
12Nov2018, 15:45	0.03
12Nov2018, 16:00	0.03
12Nov2018, 16:15	0.04
12Nov2018, 16:30	0.07
12Nov2018, 16:45	0.05
12Nov2018, 17:00	0.07
12Nov2018, 17:15	0.02
12Nov2018, 17:30	0.04
12Nov2018, 17:45	0.03
12Nov2018, 18:00	0.03
12Nov2018, 18:15	0.06
12Nov2018, 18:30	0.09
12Nov2018, 18:45	0.08
12Nov2018, 19:00	0.08
12Nov2018, 19:15	0.07
12Nov2018, 19:30	0.08
12Nov2018, 19:45	0.05
12Nov2018, 20:00	0.07
12Nov2018, 20:15	0.06
12Nov2018, 20:30	0.1

S. State St. Gage

8/20/2018 Event

11/13/2018 Event

12Nov2018, 20:45	0.06
12Nov2018, 21:00	0.06
12Nov2018, 21:15	0.04
12Nov2018, 21:30	0.03
12Nov2018, 21:45	0.06
12Nov2018, 22:00	0.06
12Nov2018, 22:15	0.03
12Nov2018, 22:30	0.05
12Nov2018, 22:45	0.11
12Nov2018, 23:00	0.08
12Nov2018, 23:15	0.05
12Nov2018, 23:30	0.07
12Nov2018, 23:45	0.07
13Nov2018, 00:00	0.08
13Nov2018, 00:15	0.11
13Nov2018, 00:30	0.14
13Nov2018, 00:45	0.12
13Nov2018, 01:00	0.05
13Nov2018, 01:15	0.11
13Nov2018, 01:30	0.05
13Nov2018, 01:45	0.04
13Nov2018, 02:00	0.03
13Nov2018, 02:15	0.01
13Nov2018, 02:30	0.02
13Nov2018, 02:45	0.02
13Nov2018, 03:00	0.02
13Nov2018, 03:15	0.04
13Nov2018, 03:30	0

Sunnybrook Dr. Gage

## 8/20/2018 Event

15 min increments

\_SunnybrookRd\_8-20-2018

Start Date = 20Aug2018

Start Time = 0:00

End Date = 20Aug2018

End Time = 3:30

Time	Rainfall Depth [in]
20Aug2018, 00:00	
20Aug2018, 00:15	0.07
20Aug2018, 00:30	0.5
20Aug2018, 00:45	0.61
20Aug2018, 01:00	0.41
20Aug2018, 01:15	0.27
20Aug2018, 01:30	0.13
20Aug2018, 01:45	0.06
20Aug2018, 02:00	0
20Aug2018, 02:15	0
20Aug2018, 02:30	0.01
20Aug2018, 02:45	0
20Aug2018, 03:00	0
20Aug2018, 03:15	0.01
20Aug2018, 03:30	0

## 11/13/2018 Event

15 min increments

\_SunnybrookRd\_11-13-2018

Start Date = 12Nov2018

Start Time = 13:00

End Date = 13Nov2018

End Time = 4:30

Time	Rainfall Depth [in]
12Nov2018, 13:00	
12Nov2018, 13:15	0.03
12Nov2018, 13:30	0.04
12Nov2018, 13:45	0.03
12Nov2018, 14:00	0.04
12Nov2018, 14:15	0.03
12Nov2018, 14:30	0.03
12Nov2018, 14:45	0.01
12Nov2018, 15:00	0.02
12Nov2018, 15:15	0.01
12Nov2018, 15:30	0.02
12Nov2018, 15:45	0.02
12Nov2018, 16:00	0.03
12Nov2018, 16:15	0.03
12Nov2018, 16:30	0.07
12Nov2018, 16:45	0.06
12Nov2018, 17:00	0.05
12Nov2018, 17:15	0.04
12Nov2018, 17:30	0.04
12Nov2018, 17:45	0.03
12Nov2018, 18:00	0.03
12Nov2018, 18:15	0.04
12Nov2018, 18:30	0.07
12Nov2018, 18:45	0.09
12Nov2018, 19:00	0.09
12Nov2018, 19:15	0.06
12Nov2018, 19:30	0.07
12Nov2018, 19:45	0.04
12Nov2018, 20:00	0.05
12Nov2018, 20:15	0.05
12Nov2018, 20:30	0.08
12Nov2018, 20:45	0.06
12Nov2018, 21:00	0.08
12Nov2018, 21:15	0.05
12Nov2018, 21:30	0.04
12Nov2018, 21:45	0.05

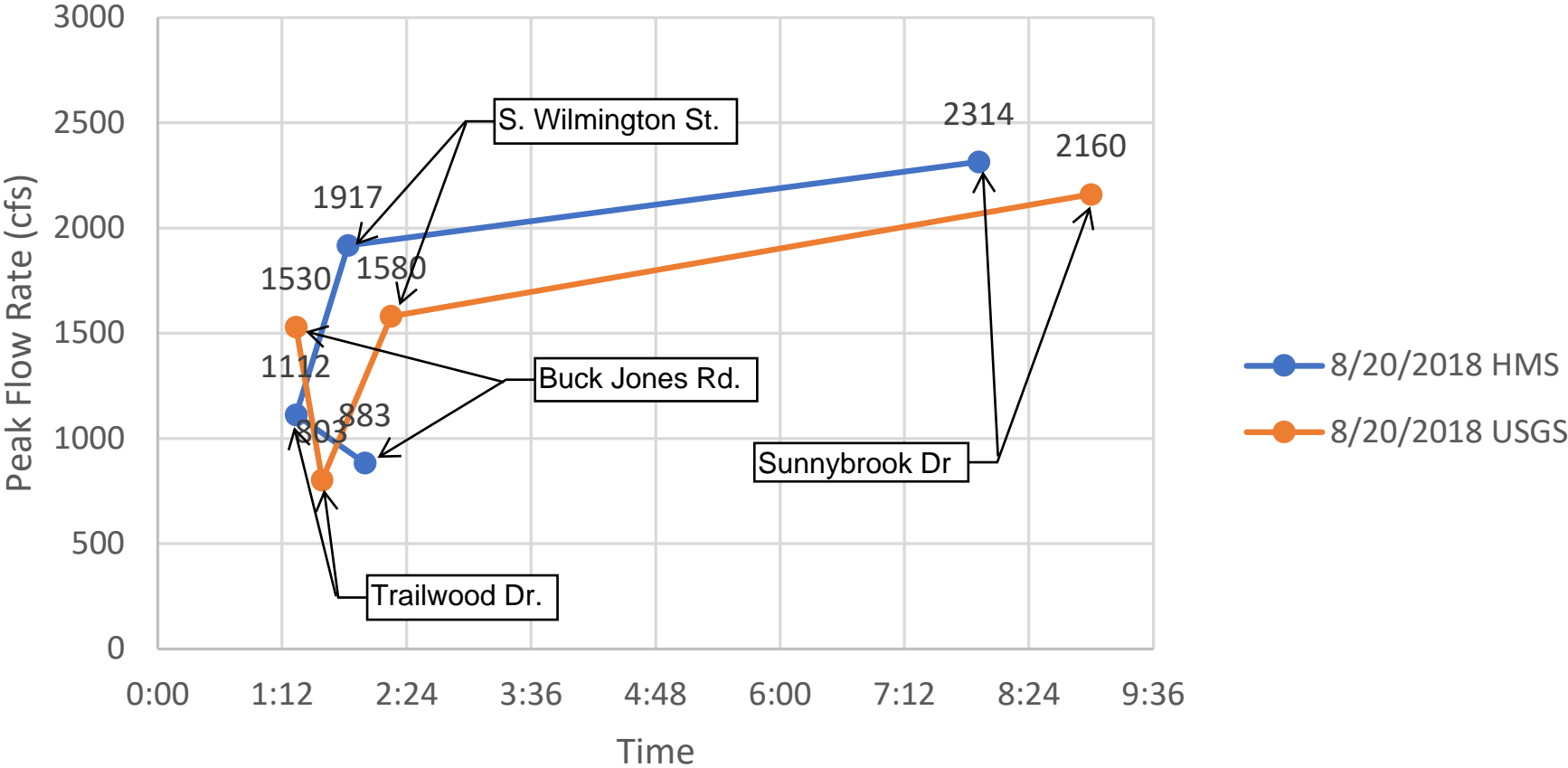
Sunnybrook Dr. Gage

8/20/2018 Event

11/13/2018 Event

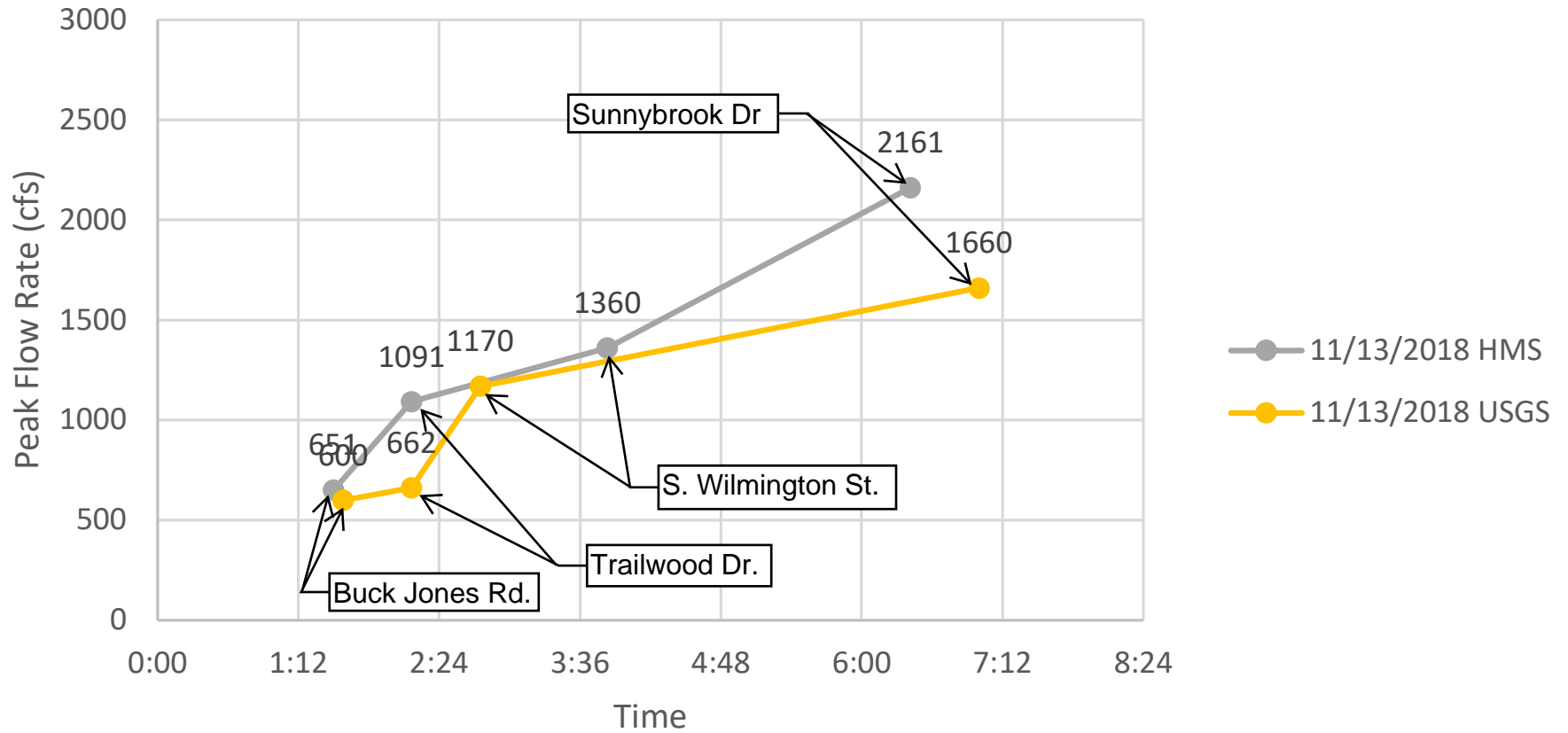
12Nov2018, 22:00	0.07
12Nov2018, 22:15	0.04
12Nov2018, 22:30	0.06
12Nov2018, 22:45	0.09
12Nov2018, 23:00	0.07
12Nov2018, 23:15	0.05
12Nov2018, 23:30	0.08
12Nov2018, 23:45	0.06
13Nov2018, 00:00	0.07
13Nov2018, 00:15	0.11
13Nov2018, 00:30	0.1
13Nov2018, 00:45	0.1
13Nov2018, 01:00	0.06
13Nov2018, 01:15	0.09
13Nov2018, 01:30	0.04
13Nov2018, 01:45	0.05
13Nov2018, 02:00	0.04
13Nov2018, 02:15	0.01
13Nov2018, 02:30	0.02
13Nov2018, 02:45	0.03
13Nov2018, 03:00	0.02
13Nov2018, 03:15	0.06
13Nov2018, 03:30	0
13Nov2018, 03:45	0
13Nov2018, 04:00	0
13Nov2018, 04:15	0.01
13Nov2018, 04:30	0

# HMS vs. USGS Storm Results

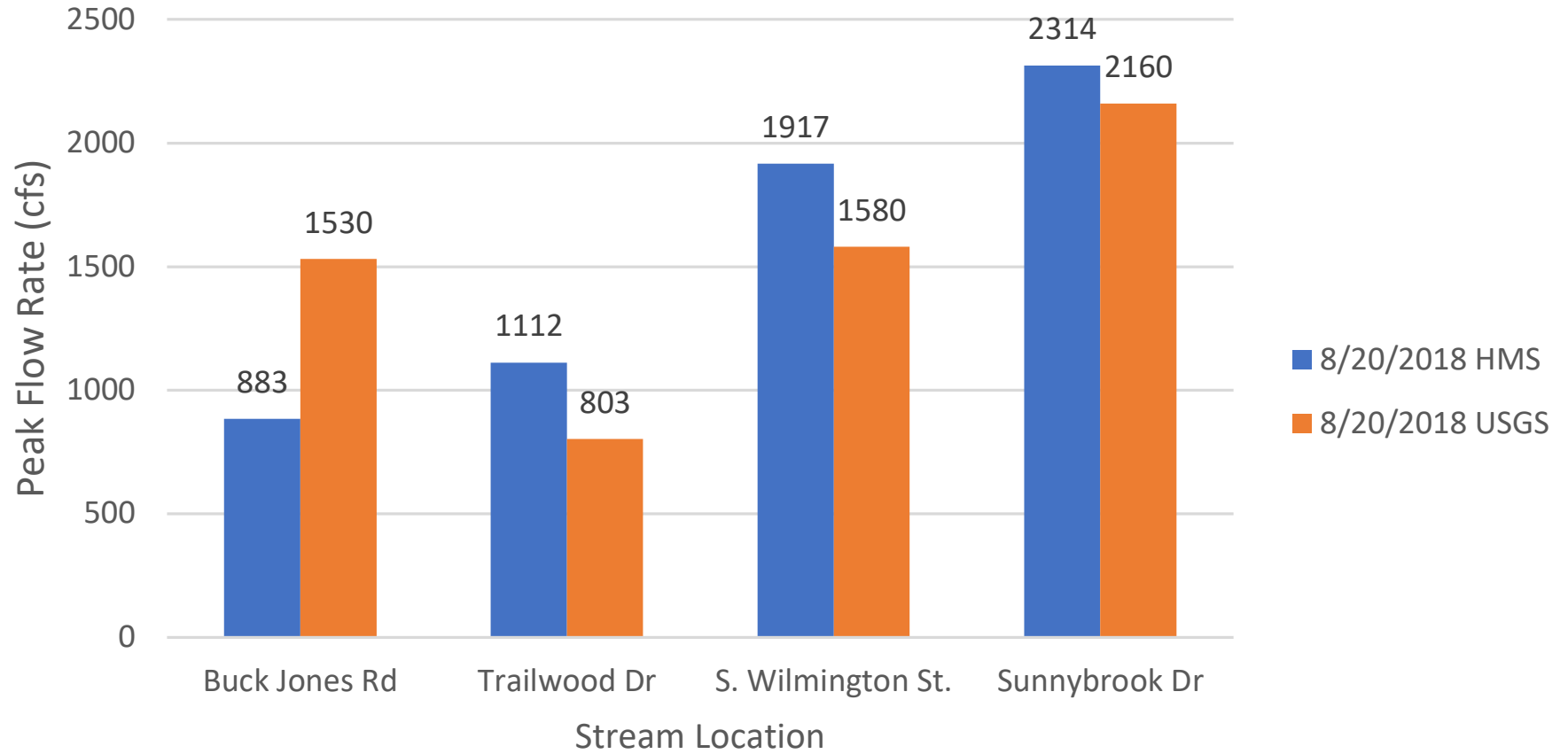




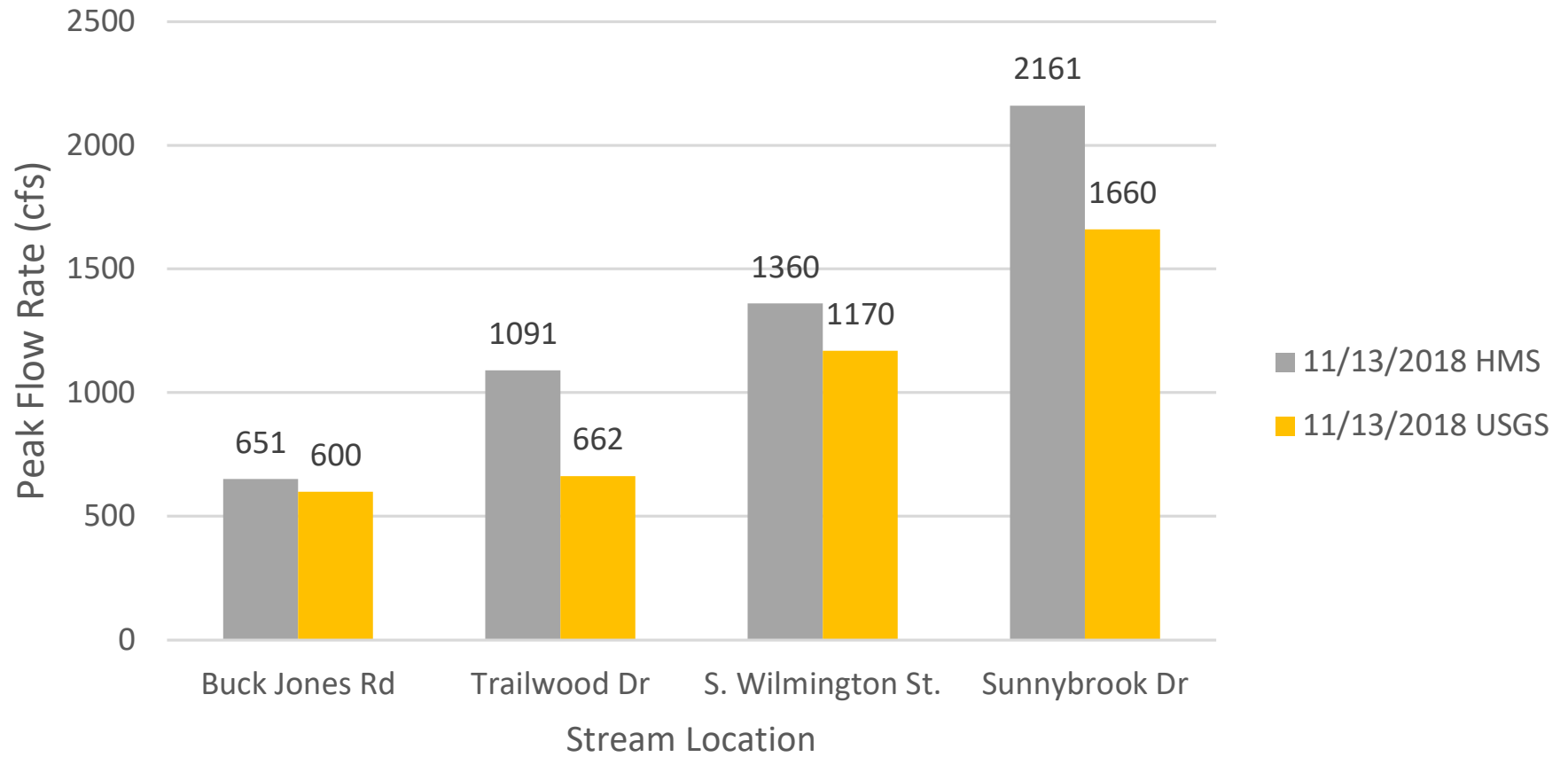
# HMS vs. USGS Storm Results



## HMS vs. USGS Peak Flow Progression



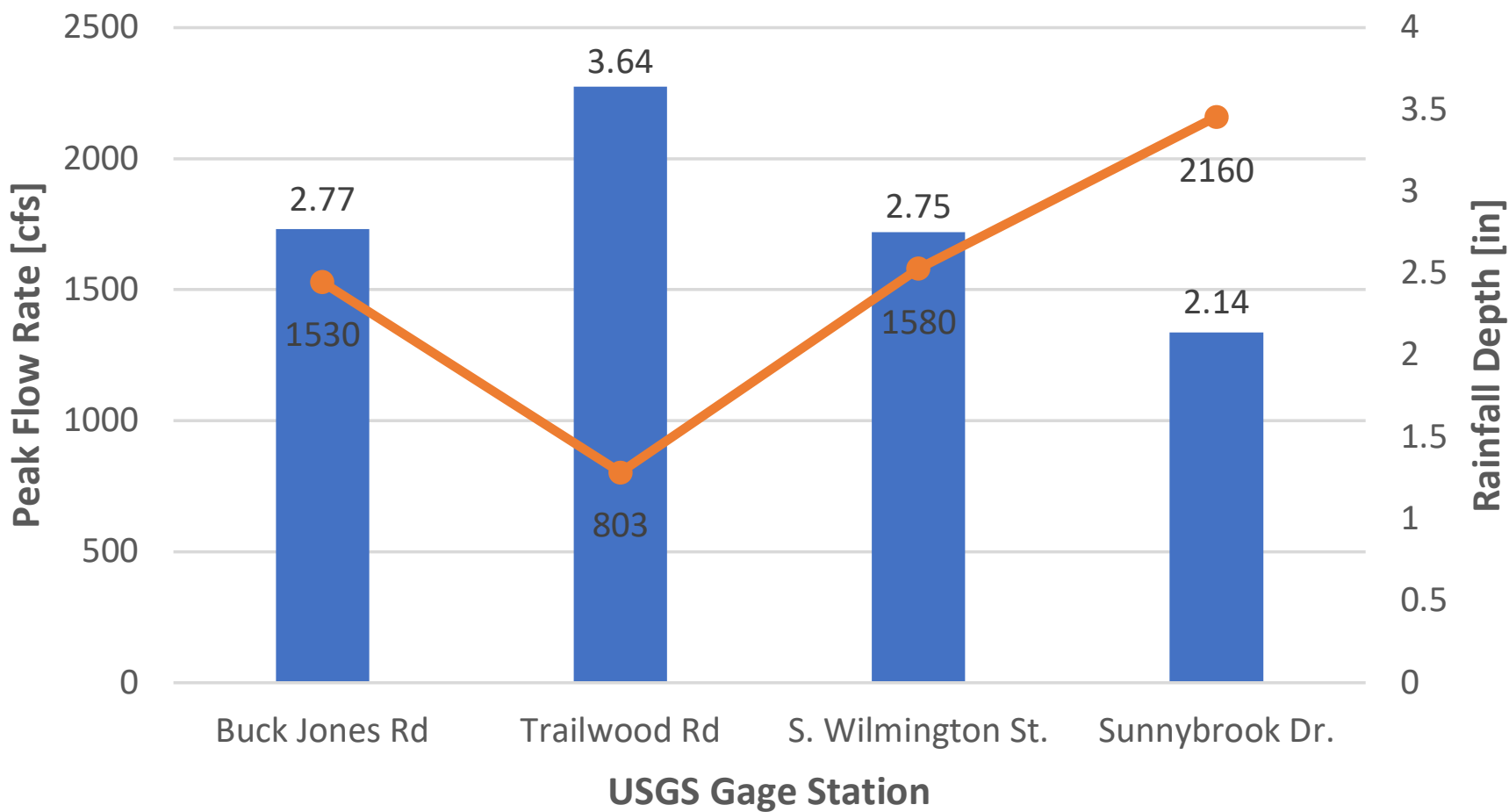
## HMS vs. USGS Peak Flow Progression



## ANALYSIS 3 - SAMPLE STORM DATA

<b>8/20/2018 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	2.77	1530	1:20	
Trailwood Rd	3.64	803	1:35	
S. Wilmington St.	2.75	1580	2:15	
Sunnybrook Dr.	2.14	2160	9:00	
<b>11/13/2018 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	3.63	600	1:35	
Trailwood Rd	3.37	662	2:10	
S. Wilmington St.	3.34	1170	2:45	
Sunnybrook Dr.	3.02	1660	7:00	
<b>4/8/2019 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	1.92	705	20:30	
Trailwood Rd	2.13	544	21:10	
S. Wilmington St.	1.77	1090	21:37	
Sunnybrook Dr.	1.26	1250	5:15	4/9/2019
<b>8/2/2019 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	1.84	1570	21:12	
Trailwood Rd	1.37	306	21:05	
S. Wilmington St.	1.4	540	21:15	
Sunnybrook Dr.	0.08	400	4:45	8/3/2019
<b>5/29/2020 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	1.96	1210	7:20	
Trailwood Rd	1.12	365	8:05	
S. Wilmington St.	0.66	346	13:30	
Sunnybrook Dr.	0.67	485	1:00	5/30/2020
<b>9/1/2020 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	2.05	1050	0:45	
Trailwood Rd	2.78	584	1:05	
S. Wilmington St.	4.15	1450	0:45	
Sunnybrook Dr.	4.19	2460	5:50	
<b>11/12/2020 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	3.6	1640	9:25	
Trailwood Rd	4.13	608	10:10	
S. Wilmington St.	3.48	1240	16:30	
Sunnybrook Dr.	3.46	1970	18:00	
<b>3/28/2021 Storm</b>	<b>Rainfall Depth [in]</b>	<b>Peak Flow Rate [cfs]</b>	<b>Time of Peak</b>	
Buck Jones Rd	0.43	340	6:25	
Trailwood Rd	0.87	311	6:55	
S. Wilmington St.	0.69	552	7:15	
Sunnybrook Dr.	0.43	524	14:10	

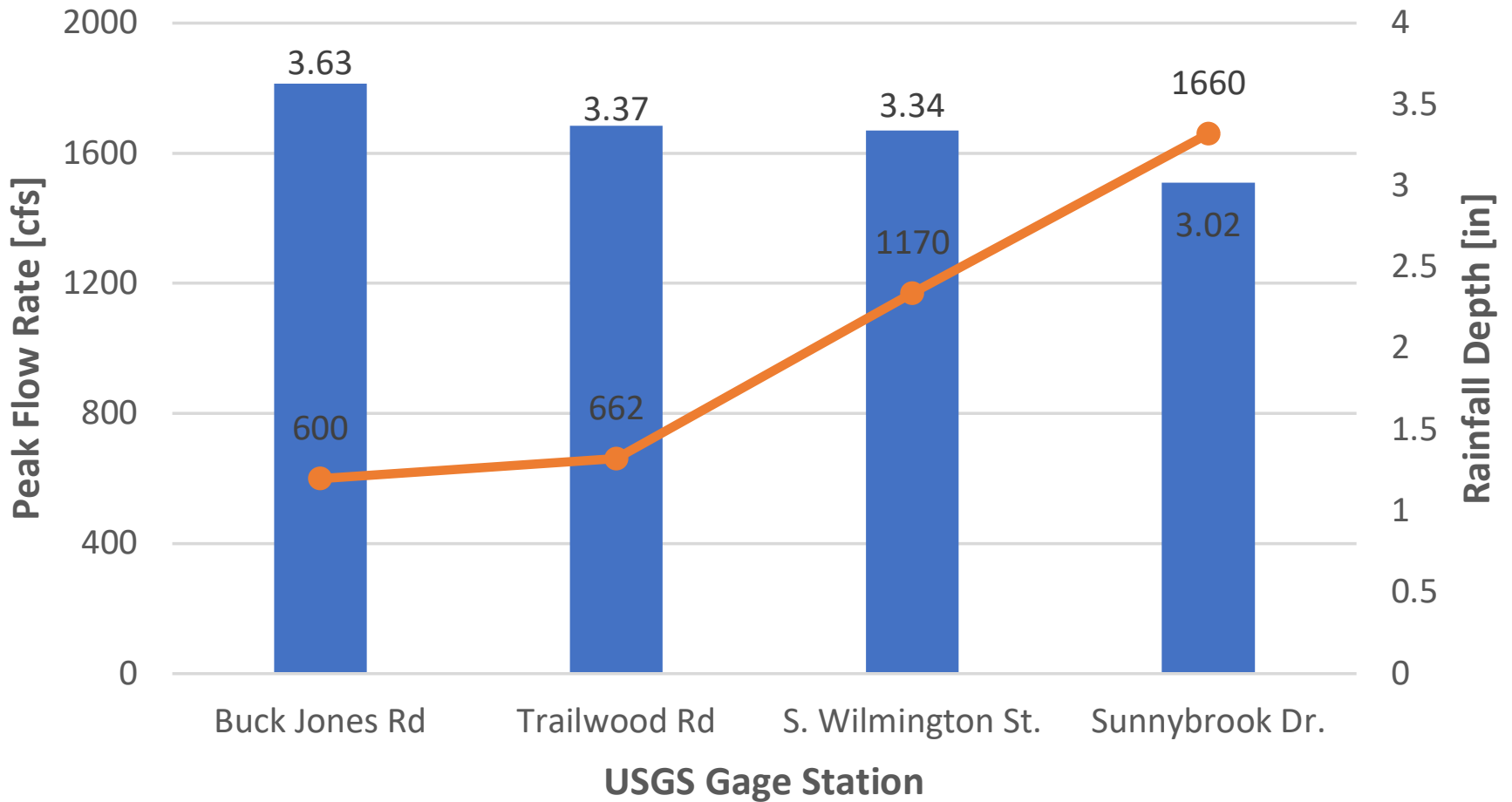
## USGS Gage Data: 8/20/2018 Storm



■ Rainfall Depth [in]

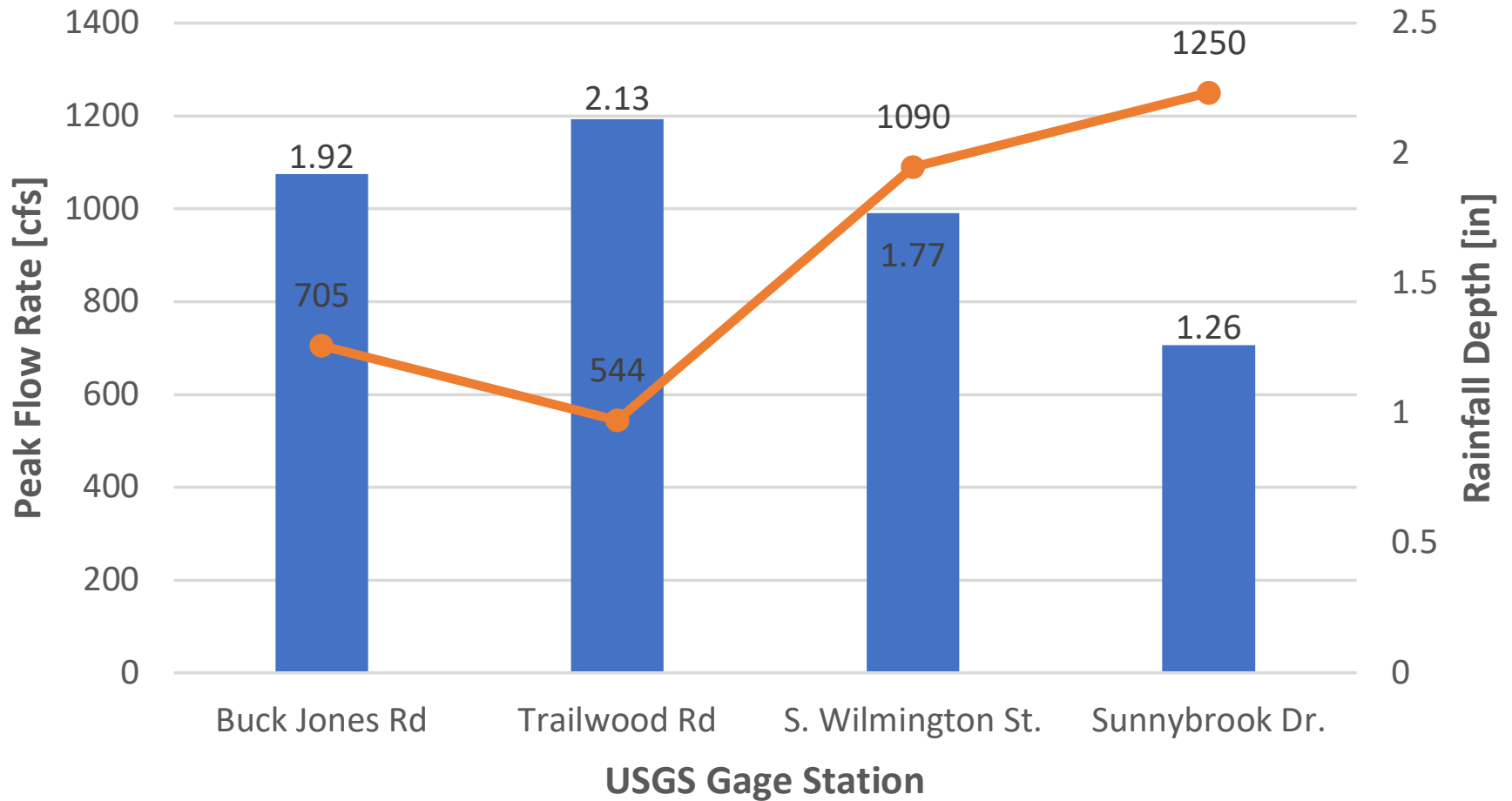
—●— Peak Flow Rate [cfs]

# USGS Gage Data: 11/13/2018 Storm



■ Rainfall Depth [in]    ● Peak Flow Rate [cfs]

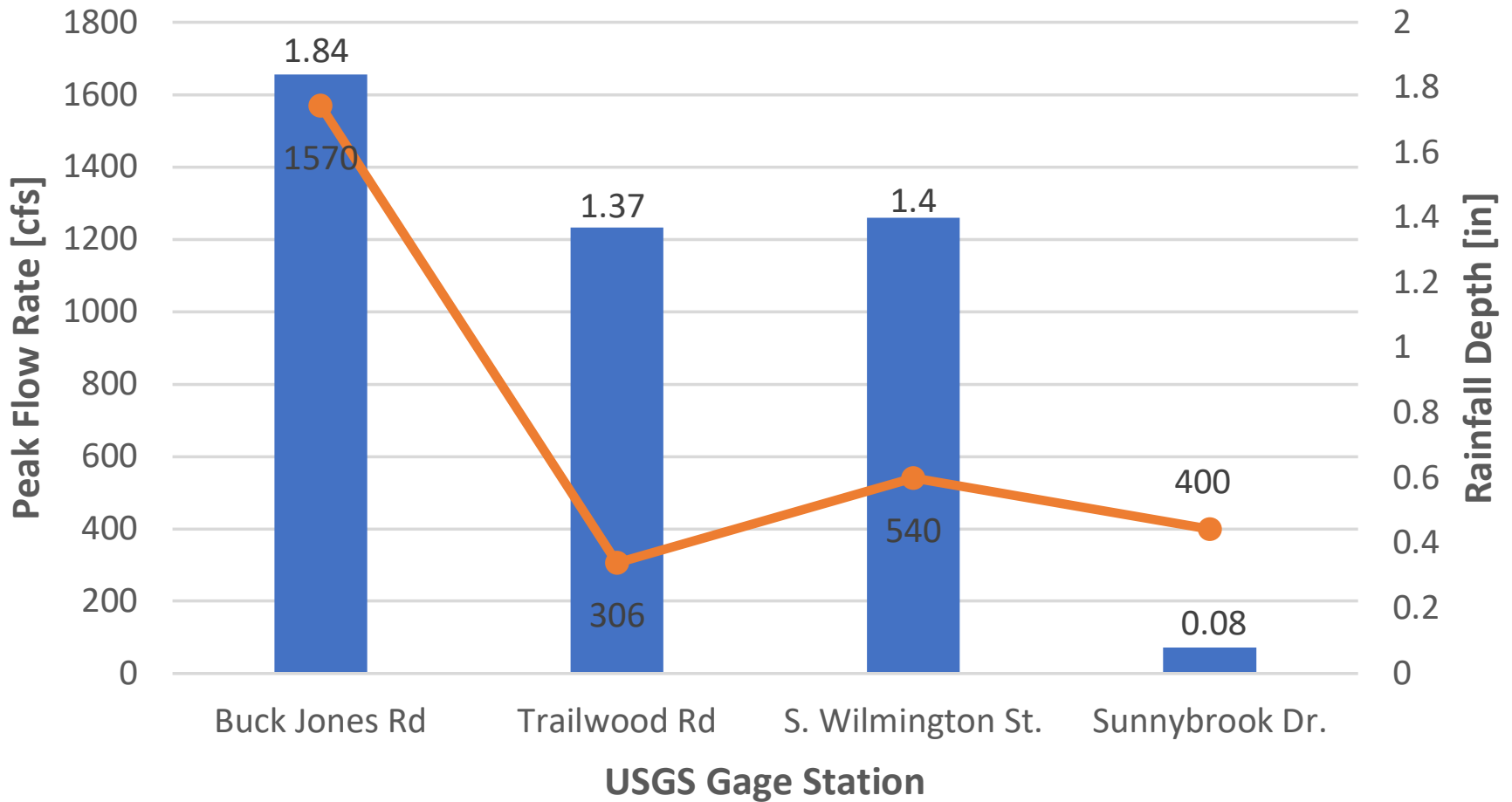
## USGS Gage Data: 4/8/2019 Storm



■ Rainfall Depth [in]

● Peak Flow Rate [cfs]

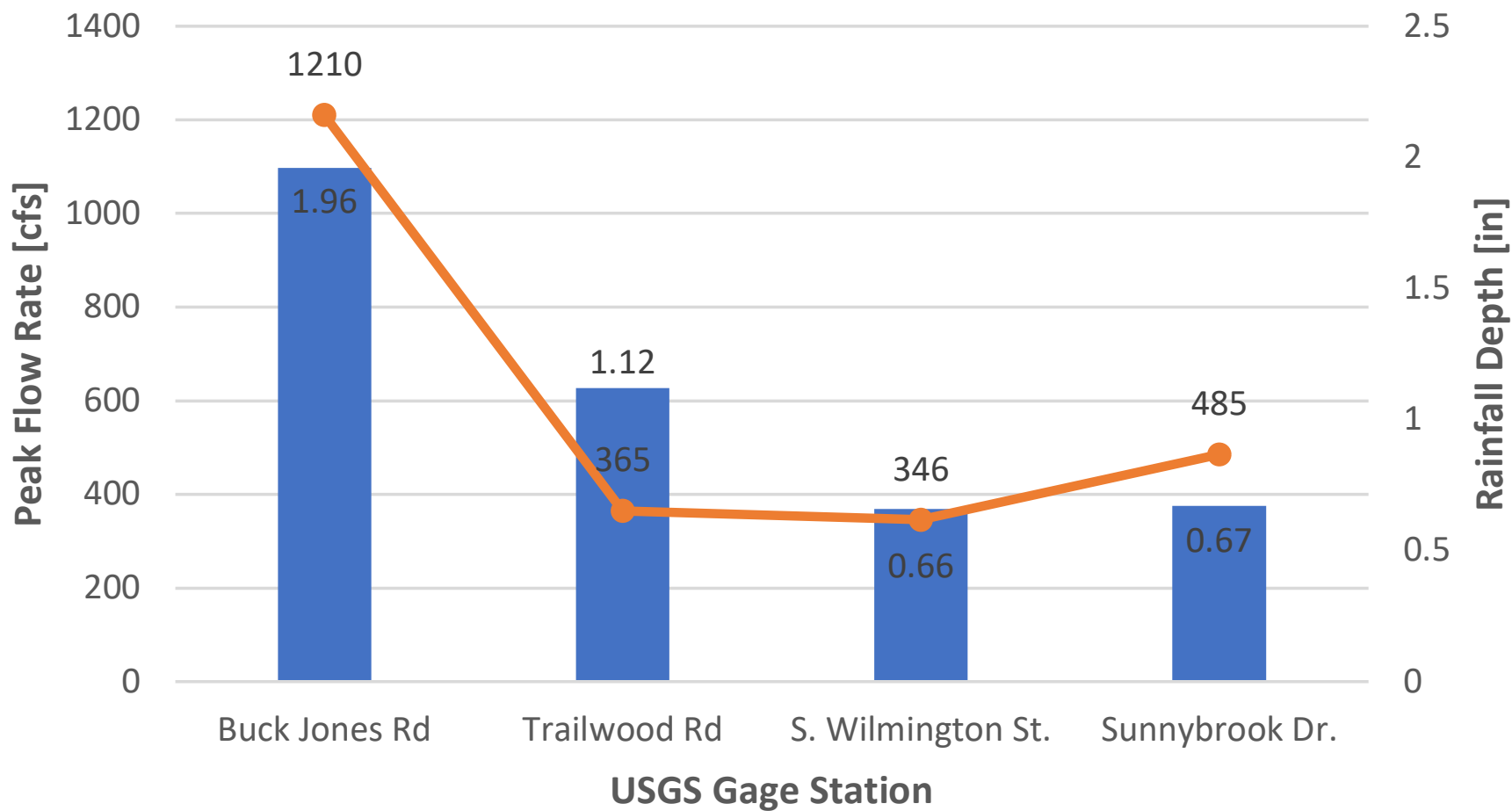
# USGS Gage Data 8/2/2019 Storm



■ Rainfall Depth [in]    ● Peak Flow Rate [cfs]



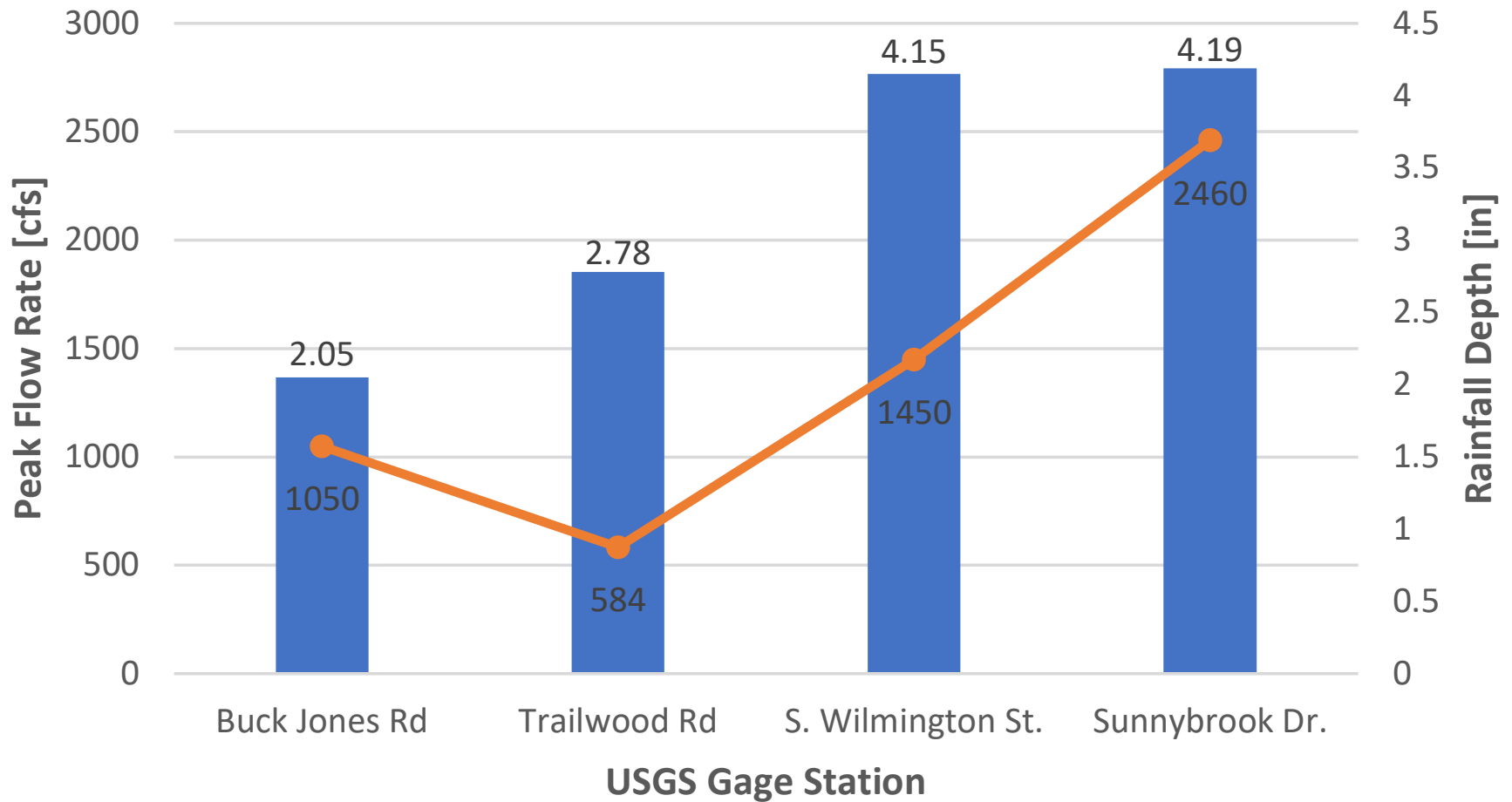
## USGS Gage Data: 5/29/2020 Storm



■ Rainfall Depth [in]

—●— Peak Flow Rate [cfs]

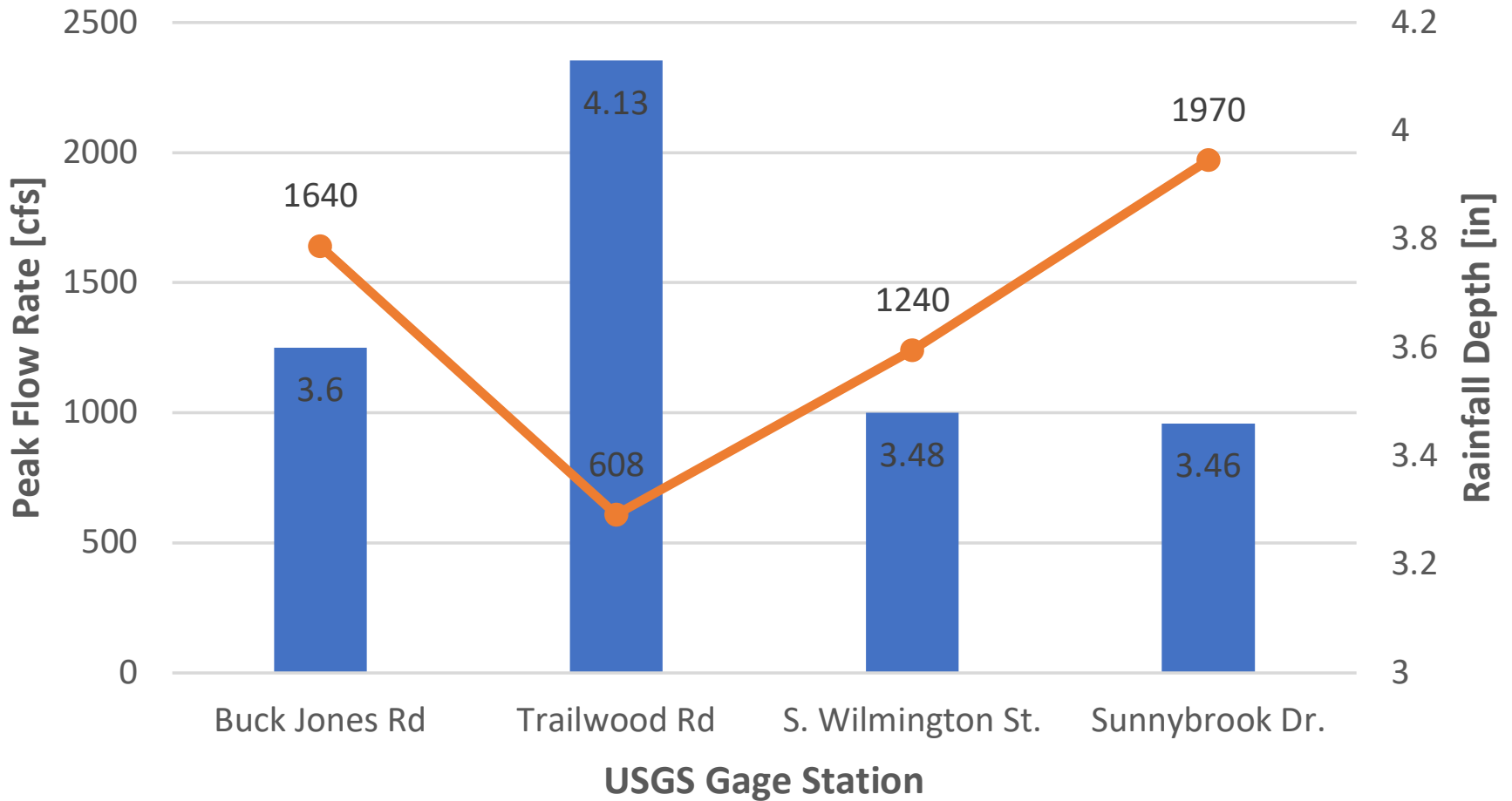
## USGS Gage Data: 9/1/2020 Storm



■ Rainfall Depth [in]

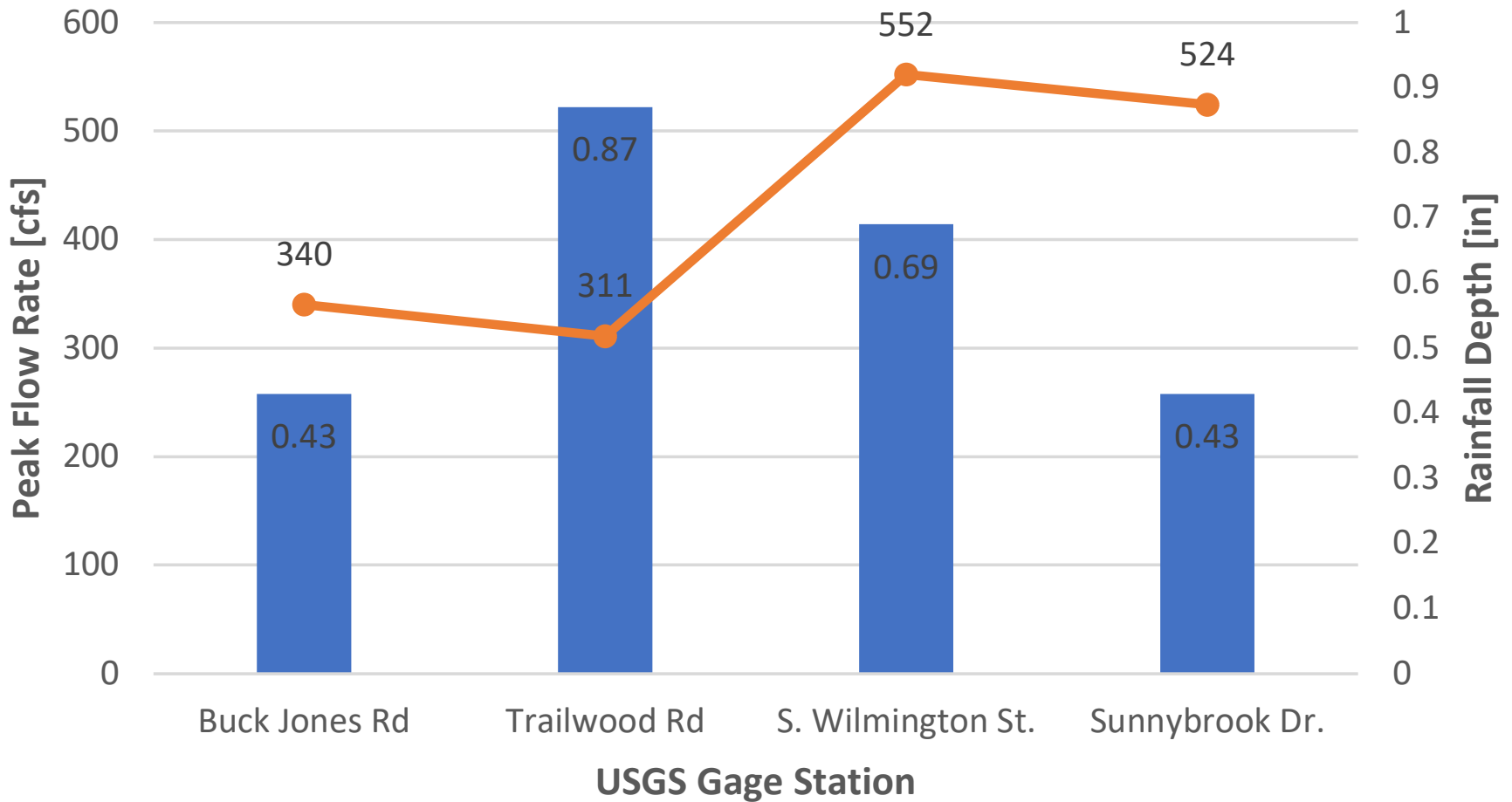
—●— Peak Flow Rate [cfs]

# USGS Gage Data: 11/12/2020 Storm



■ Rainfall Depth [in]    ● Peak Flow Rate [cfs]

# USGS Gage Data: 3/28/2021 Storm



■ Rainfall Depth [in]    ● Peak Flow Rate [cfs]