SHARKS

Methods & User Manual©

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1. INTRODUCTION

Since 2014, the City of Roanoke has partnered with the Virginia Tech Via Department of Civil and Environmental Engineering to conduct research focused on effective management of stormwater runoff within the City to reduce the risk of downtown flooding and in developing tools, data, and methods for performing watershed master planning. The objective of the current phase of research is to provide the City with guidance on the effects of land development on hydrology in the Lick Run and Trout Run watersheds (Figure 1).

In order to accomplish this, Virginia Tech is developing a hydrology and hydraulics watershed model to evaluate the impacts of land development on stormwater runoff within the combined Lick Run and Trout Run watersheds. The U.S. Army Corps of Engineers' Gridded Surface/Subsurface Hydrologic Analysis (GSSHA) model will be used due to its fully distributed modelling capabilities. However, a library of storm event precipitation and runoff data must be compiled for use in model calibration and validation.

The Stream Hydrology And Rainfall Knowledge System (SHARKS) interactive web app (https://bigbadcrad.shinyapps.io/SHARKS/) has been developed, using the Shiny interface to R (https://shiny.rstudio.com/), to download data for the City of Roanoke to study the combined Lick Run and Trout Run watersheds. In addition to facilitating the creation of the library of storm events for model calibration/validation, the app also provides a tool for City employees to monitor the watersheds in real-time. Current applications of the web app include identifying the annual recurrence interval for precipitation events causing downtown flooding and studying the relationship between precipitation and stream specific conductance after road de-icer application during winter events.

2. DATA SOURCES

The SHARKS app synthesizes data from a variety of government, commercial, and local sources (Table 1).

Table 1: Summary of Data Sources

Parameter	Source	Availability
Meteorological, 5-minute interval	NOAA – Roanoke Regional Airport Station	Since 1/1/1948
	USGS – Roanoke Nine-Gauge Network	Since 2/21/2018
Discharge & Water Quality, 5-minute interval	USGS – Lick Run Station	Since 8/8/2016
	USGS – Roanoke River Station	Since 10/1/1990
Storm Sewer Flow Depth, 5-minute interval	City of Roanoke	Since 8/10/2017
10-Day Weather Forecast	Weather Underground	

2.1. Meteorological

NOAA meteorological data is acquired from the Roanoke Regional Airport Automated Surface Observing System (ASOS) station (Figure 1). The ASOS network is the flagship automated observing network that provides observations for the National Weather Service, Federal Aviation Administration (FAA), and Department of Defense. Precipitation data is also acquired from a network of nine USGS stations located across the City of Roanoke (Figure 1 & Table 2). Data for the Lick Run station is available since August of 2016. However, the other eight stations were installed later and data is only available since February of 2018.

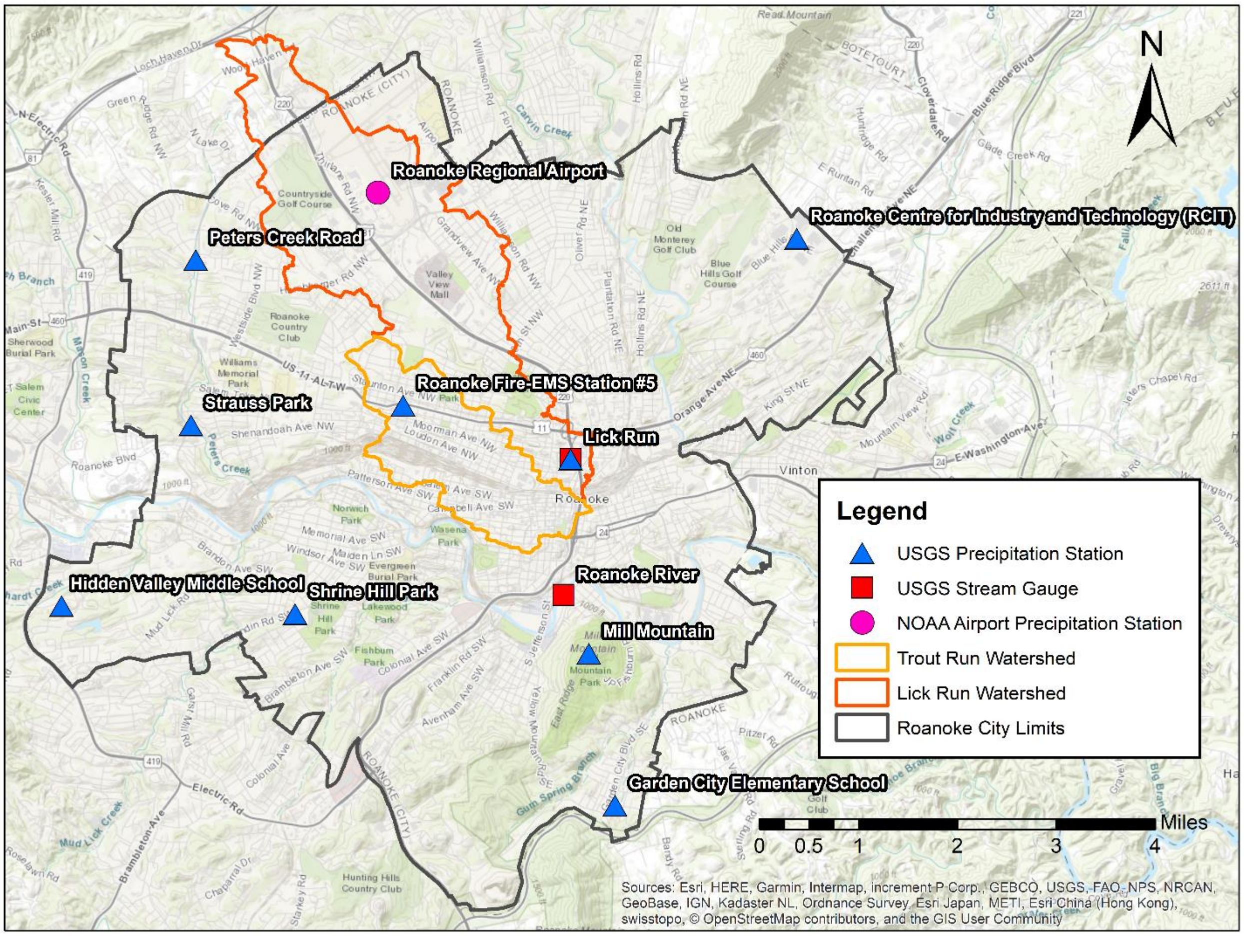


Figure 1: Lick Run & Trout Run watersheds and precipitation and flow stations

Table 2: USGS Meteorological Station Network

Site Number	Site Location Description	Watershed
0205551460	Lick Run	Lick Run
371840079534900	Roanoke Centre for Industry and Technology (RCIT)	Tinker Creek
371824080002600	Peters Creek Road	Peters Creek
371709079580800	Roanoke Fire-EMS Station #5	Trout Run
371657080002800	Strauss Park	Peters Creek
371518079591700	Shrine Hill Park	Murray Run
371339079554400	Garden City Elementary School	Garnard Creek
371520080015100	Hidden Valley Middle School	Barnhardt Creek
371459079560300	Mill Mountain	Roanoke River

2.2. Stream Flow & Water Quality

Stream flow and water quality is acquired from two USGS stations located within the City of Roanoke (Figure 1). Discharge data for the Roanoke River station (USGS Site 02055000) is available since October of 1990, but water quality is not monitored at the site. The Lick Run station (USGS Site 0205551460) was installed more recently and discharge, temperature, specific conductance, dissolved oxygen, pH, and turbidity data are available since August of 2016.

2.3. Storm Sewer Flow Depth

Storm sewer flow depth is monitored in eight critical pipe network locations in downtown Roanoke (Figure 2). At each location, a HOBO water level logger records the flow depth at 5-minute intervals. The sensors were installed in August of 2017. Data is manually retrieved from each sensor by a City of Roanoke employee and downloaded using HOBO software.

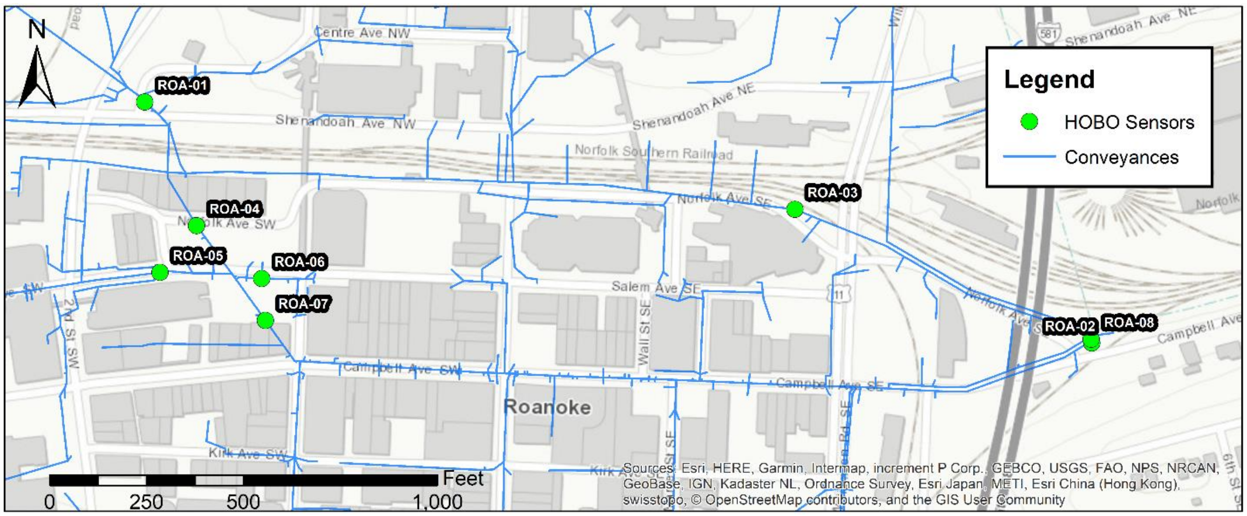


Figure 2: Storm Sewer sensor locations

2.4. Current Weather Conditions & 10-Day Weather Forecast

Current weather conditions and the 10-Day weather forecast for the City of Roanoke are obtained from Weather Underground.

3. METHODS

3.1. Download NOAA Meteorological Data

NOAA meteorological data for the user-specified Automated Surface Observing System (ASOS) station is obtained via the Iowa Environmental Mesonet maintained by Iowa State University (https://mesonet.agron.iastate.edu/request/download.phtml?network=VA_ASOS). Data is retrieved from the Mesonet via a URL based on user-inputted state, time zone, station/airport FAA ID, start date, and end date. Accessing the URL returns a comma delimited text file which is then converted to an R data frame. The ASOS network reports precipitation data as a cumulative precipitation depth that resets on the hour and sometimes other increments. To obtain an incremental precipitation time series, if the cumulative precipitation depth for a time point is greater than or equal to that of the previous time, then the incremental precipitation depth for the interval is set equal to the difference between the two cumulative precipitation depths. If, however, the cumulative precipitation depth for a time point is less than that of the previous time, then the cumulative precipitation depth has reset and the incremental precipitation depth for the interval is set to the cumulative precipitation depth for the time point. Precipitation intensity is calculated by dividing the incremental precipitation depth by the interval duration.

3.2. Download USGS Meteorological, Flow, & Water Quality Data

For each user-specified USGS precipitation station, incremental precipitation is downloaded from USGS using the readNWISuv() function in the dataRetrieval R package. Inputs to the function are the USGS station number and the user-specified start date, end date, and time zone. USGS precipitation data is reported as an incremental precipitation depth. To obtain a precipitation intensity time series, the precipitation intensity for each increment is calculated as the incremental precipitation depth divided by the increment duration. The same function is used to download flow and user-specified water quality parameter data for each stream station based on the USGS station number and the user-specified start date, end date, and time zone as well as the corresponding parameter code for each of the user-specified water quality parameters.

3.3. Perform Hydrograph Separation

Hydrograph separations are performed using the BaseflowSeparation() function in the EcoHydRology R package. This function uses the recursive digital filter from Nathan and McMahon (1990) to divide total stream flow into baseflow and stormflow components. Inputs to the function are the flow time series, the number of passes, and a filter parameter alpha. The number of passes controls the extent of smoothing applied to the hydrograph separation and three passes were selected as done in Nathan and McMahon (1990). Based on visual inspection of their data, Nathan and McMahon (1990) concluded that an alpha value in the range of 0.90-0.95 provided the most acceptable hydrograph separation.

To determine the optimal alpha values for the two Roanoke USGS stream flow stations, hydrograph separations performed using a conductivity mass-balance method were compared to hydrograph separations performed using the Nathan and McMahon (1990) digital filter method with alpha values ranging from 0.900-0.995.

3.3.1. Conductivity Mass-Balance Hydrograph Separation

The conductivity mass-balance hydrograph (CMB) separation method is detailed in Bhaskar and Welty (2015); Nathan and McMahon (1990); Pilgrim, Huff, and Steele (1979); Stewart, Cimino, and Ross (2007) and has been used to calibrate other hydrograph separation methods. During precipitation events, specific conductance decreases as flow is diluted due to the additional stormflow and this effect can be used to estimate the relative flow components to total discharge. The CMB hydrograph separation method is based on the steady state form of the mass-balance equation for dissolved solids (Eq. 1) and the continuity equation (Eq. 2):

$$Q_b C_b + Q_s C_s = Q_T C_T \tag{1}$$

$$Q_b + Q_s = Q_T \tag{2}$$

Where Q= flow and C= specific conductance and the subscripts b, s, and T refer to baseflow, stormflow, and total flow, respectively. Combining Eq. 1 and 2 yields baseflow as a function of total streamflow, total specific conductance, baseflow specific conductance, and stormflow specific conductance (Eq. 3):

$$Q_b = Q_T \left[\frac{C_s - C_T}{C_s - C_b}\right] \tag{3}$$

3.3.2. Calibration of Alpha

To calibrate the alpha parameter in the digital filter hydrograph separation method using the CMB hydrograph separation method, a set of precipitation events were chosen for analysis. For the Lick Run station, 11 precipitation events from 2017 and 2018 were chosen for analysis and for the Roanoke River station, 10 precipitation events from 2011 and 2018 were chosen for analysis. Events from 2011 were chosen for the Roanoke River station because specific conductivity data was unavailable from 2012-2017. Discharge and specific conductance time series were downloaded for each of the 21 events. The Lick Run station measures both discharge and specific conductance. However, the downtown Roanoke River station only measures discharge. Specific conductance is measured on the Roanoke River at a separate USGS station (02054750) located approximately 7 km upstream of the Roanoke River (02055000) station. The travel time lag of 7 km was estimated as one hour and the date/time of the specific conductance data was transposed to one hour later. Thus, discharge from the downtown Roanoke River station (02055000) and specific conductance from the upstream station (02054750) were joined by the transposed date/time. Upon visual inspection of the transposed data, the one-hour lag time successfully aligned peaks in the hydrograph with depressions in the specific conductance time series. Although total streamflow and total specific conductance are measured values, in the CMB hydrograph separation method, stormflow specific conductance and baseflow specific conductance must be estimated.

During precipitation events, stream conductance typically decreases until it reaches a minimum value corresponding in time with peak runoff. It can be assumed that this minimum specific conductance is the weighted average specific conductance of all surface runoff occurring upstream of the monitoring point (Stewart et al., 2007). Thus, for the CMB hydrograph separations, stormflow specific conductance was estimated as the minimum specific conductance value occurring during each event.

Baseflow specific conductance was estimated for the CMB method in two ways. First, baseflow specific conductance was estimated as the measured specific conductance immediately before the hydrograph started to rise for each event. With this method, a different baseflow specific conductance value was used for each hydrograph separation. Second, baseflow specific conductance was estimated by analyzing streamflow conductivity values for both the Lick Run (0205551460) and Roanoke River (02055000) USGS stations during periods of extreme low-flow when it was assumed that baseflow comprised 100% of the total streamflow (Stewart et al., 2007). Ten periods of low-flow were identified for both the Lick Run and Roanoke River stations. Then, the average specific conductivity for each low-flow period was calculated and the baseflow specific conductance for each station was estimated as the average of the ten-average low-flow specific conductivities for the respective station. With this method, the station's average baseflow specific conductance value was used for all hydrograph separations performed for the respective station.

Hydrograph separations were performed for each of the events using the CMB method with both baseflow specific conductance estimate methods. For these hydrograph separations, if the measured stream flow conductance was greater than or equal to the specified baseflow conductance, then baseflow was set as the total flow rate at the respective time (Stewart et al., 2007). Then, hydrograph separations were performed using the digital filter method with alpha values ranging from 0.900 to 0.995. The baseflow estimates from the digital filter method for each value of alpha were compared to the baseflow estimates from the CMB method for both baseflow specific conductance estimates and the Spearman's rho, Percent Bias (PBIAS), and Nash-Sutcliffe Efficiency (NSE) model-fit statistics were calculated with the CMB method baseflow estimates as the target values.

3.3.3. Model Fit Statistics

Spearman's rho is a rank-based correlation coefficient that does not require assumptions about normality. The Spearman's rho statistic was calculated between the baseflow estimated by the CMB method with both baseflow specific conductance estimates and the baseflow estimated by the digital filter method for each alpha value. Correlations were considered significant for p-values less than 0.05.

Percent Bias (PBIAS) measures the tendency for a model to over/underestimate the measured values and is calculated using Eq. 4 (Moriasi et al., 2007). The optimal PBIAS value is 0.0 and positive values indicate an underestimation bias while negative values indicate an overestimation bias (Gupta, Sorooshian, & Yapo, 1999). PBIAS was used to determine if the digital filter hydrograph separation method with the different alpha values over/underestimated the baseflow estimated using the CMB method with both estimates of baseflow specific conductance. PBIAS values between -25% and 25% were considered acceptable.

$$PBIAS = \frac{\sum_{i=1}^{n}\left(Y_i^{obs} - Y_i^{sim}\right) * (100)}{\sum_{i=1}^{n}(Y^{obs})} \tag{4}$$

The NSE statistic normalizes the residual variance by the measured data variance and is indicative of how well the simulated vs. measured data fits the 1:1 line (Moriasi et al., 2007). NSE is calculated using Eq. 5 and values range from −∞ to 1.0 with an optimal value of 1.0 (Moriasi et al., 2007). An NSE value of 1.0 indicates a perfect model fit whereas a value of 0.0 indicates that the model predictions are as accurate as the mean of the observed data. NSE values less than 0.0 indicate that the mean is a better predictor than the model. NSE was calculated for each combination of CMB and digital filter hydrograph separations and values between 0.0 and 1.0 were considered acceptable

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}{\sum_{i=1}^{n}\left(Y_i^{obs} - Y^{mean}\right)^2}\right] \tag{5}$$

3.3.4. Optimal Alpha Values

The optimal alpha values for the Lick Run and Roanoke River stations were selected after calculation of the model-fit statistics for the analyses between the baseflow estimates from the CMB and digital filter hydrograph separation methods for each of the analyzed precipitation events. The optimal alpha values for the Lick Run and Roanoke River stations were chosen as the alpha values that resulted in the greatest number of significant Spearman's Rho p-values, PBIAS values between -25% and 25%, and NSE values ≥ 0.0 (Table 3). Overall, the optimal alpha values for the Lick Run and Roanoke River stations were 0.9875 and 0.9250, respectively. For all other USGS stream flow stations, the Nathan and McMahon (1990) recommended alpha value of 0.925 will be used for hydrograph separations.

Table 3: Optimal alpha values with model-fit statistics

		Lick Run	**Roanoke River**
	Events Analyzed	11	10
	Optimal Alpha Value	0.9875	0.9250
Pre-Event Baseflow Conductance	Spearman's Rho p-value ≤ 0.05	10	10
	PBIAS between -25% & 25%	10	4
	NSE ≥ 0.0	4	2
Average Low-flow Baseflow Conductance	Spearman's Rho p-value ≤ 0.05	9	10
	PBIAS between -25% & 25%	10	3
	NSE ≥ 0.0	3	3

3.3.5. Calculate Direct Runoff

Direct runoff volume is calculated by trapezoidal integration of stormflow over time (Eq. 6).

$$DRO_{Volume} = 0.5 * (Stormflow_1 + Stormflow_2) * (Time_2 - Time_1) \tag{6}$$

Direct runoff depth is then calculated by dividing the direct runoff volume by the watershed area.

3.4. Download NOAA PFDS

NOAA Atlas 14 point precipitation frequency estimates are downloaded from NOAA (https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=va) for each of the user-specified ASOS and USGS precipitation stations. Data is retrieved from NOAA via a URL based on the station latitude and longitude. Accessing the URL returns a text file of mean precipitation depths for the corresponding event durations (5-min, 10-min, 15-min, 30-min, 60-min, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 2-day, 3-day, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day) and average recurrence intervals (1, 2, 5, 10, 25, 50, 100, 200, 500, 1000 year). This text file is then converted to an R data frame.

3.5. Interpolate Average Annual Recurrence Interval

The average annual recurrence interval (ARI) is interpolated for precipitation occurring during the user-specified date range for each precipitation station. First, a sliding window analysis is performed to determine the measured precipitation depth occurring during each possible interval for the specified date range. Then, the measured precipitation depth and duration for each interval are used to interpolate the ARI for the interval from the values in the NOAA PFDS table.

The sliding window analysis is performed using the rollapply() function in the zoo R package. The user-specified date range is divided into a set of intervals, or windows, with window lengths t, 2t, 3t, …, nt where t is the time increment between precipitation data points and n is the number of precipitation data points in the specified date range. Then, for each window length, a window is created starting at every precipitation data point (Figure 3) to obtain every possible interval of every possible length across the specified date range. Next, the total precipitation depth for each window is calculated as the sum of the incremental precipitation depths within the window. For example, for a window length of 2t, the precipitation depth for the first window is equal to the sum of the incremental precipitation depths of the first two data points, the precipitation depth for the second window is equal to the sum of the incremental precipitation depths of the second and third data points, and so forth. Finally, for each window, precipitation intensity is calculated as the total precipitation depth of the window divided by the window length.

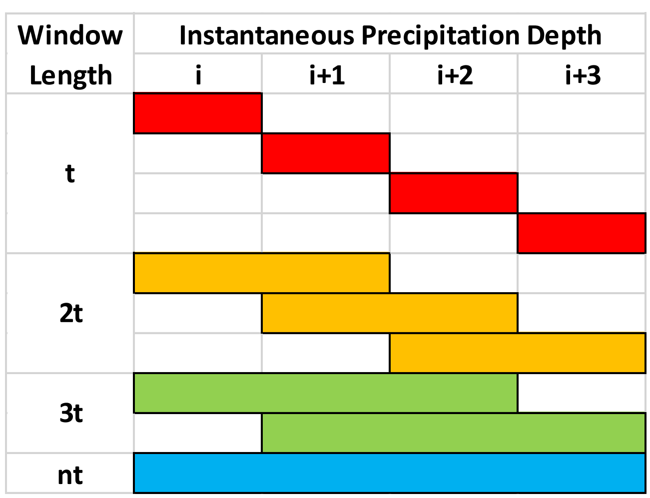


Figure 3: Sliding window example

Before calculating an ARI for each sliding window, the sliding window dataset is subset to only include sliding window durations equal to the event durations in the NOAA PFDS Table (5-min, 10-min, 15-min, 30-min, 60-min, 2-hr, 3-hr, 6-hr, 12-hr, 24-hr, 2-day, 3-day, 4-day, 7-day, 10-day, 20-day, 30-day, 45-day, 60-day). Instead of creating windows of all possible window lengths, sliding windows could have been created only for the event durations in the NOAA PFDS Table. However, creating windows of all possible lengths does not drastically increase program run time and it allows for the ability to also interpolate between event durations in addition to between ARIs. An ARI is then calculated for each sliding window by using the precipitation depth of the sliding window to interpolate ARI between the NOAA PFDS precipitation depths for event duration corresponding to the sliding window duration. If the sliding window precipitation depth is less than the depth of the 1-year storm, then the ARI for the window is set to ND. Finally, the sliding windows are sorted by ARI in descending order.

3.6. Calculate Summary Information

A set of summary information is calculated for each precipitation and stream station. For precipitation stations, total precipitation depth is calculated as the sum of all incremental precipitation depths for the date range and maximum intensity is set as the maximum incremental intensity for the date range. For streamflow stations, direct runoff volume and direct runoff depth are set to their respective values calculated during baseflow separation (Section 3.3.5) and maximum flow rate is set as the maximum recorded flow rate measured at the station over the given date range. In addition, runoff volume coefficients are calculated for each streamflow station and precipitation station combination. The runoff volume coefficient represents the proportion of precipitation leaving the watershed and is calculated as the direct runoff depth divided by the total precipitation depth.

3.7. Calculate Storm Sewer Relative Flow & Relative Depth

Because the storm sewer slope and roughness at each of the eight monitoring points are unknown, the Manning's equation flow rate and depth relative to full-flow conditions (Eq. 7 & 8), are calculated as a metric to identify choke points within the Trout Run storm sewer system.

$$Relative\ Flow = \frac{Q_m}{Q_f} = \frac{\frac{C}{n} A_m R_m^{2/3} S^{1/2}}{\frac{C}{n} A_f R_f^{2/3} S^{1/2}} = \frac{A_m}{A_f} \left(\frac{R_m}{R_f} \right)^{2/3} \quad (7)$$

$$Relative\ Depth = \frac{y_m}{y_f} \quad (8)$$

Where Q= flow rate, C= unit factor, n= Manning's roughness coefficient, A= flow area, R = hydraulic radius, S= channel slope, and y= flow depth and the subscripts m and f refer to the measured and full flow conditions, respectively.

Field measurements of the cross-sectional geometry at each monitoring point were used to create a rating curve of the hydraulic geometry (wetted perimeter and hydraulic radius) as a function of flow depth for each site.

3.8. Storm Sewer Data Processing

Storm sewer flow depth data from the HOBO Data loggers are manually downloaded by a City of Roanoke employee and exported to a CSV file for each sensor using the HOBO Software. Before processing of the data occurs, backups of the raw data are made on the City of Roanoke servers. Then, the relative flow and relative depth for each measured flow depth are calculated for each sensor using the rating curves developed from the sewer cross-sectional geometry. Since the HOBO sensors use pressure transducers to calculate flow depth, when the water level falls below the HOBO sensor the depth measurements can be inaccurate. Therefore, all negative flow depths are removed from the dataset. To prevent the censored data from "floating" when graphed, measurements immediately before and after removed data points are set to 0.001 feet below the position of the sensor. A value of -0.001 feet was chosen to indicate that, during events, the water level starts and ends below the HOBO sensor. The censored data is then uploaded to a Google Sheet specific to the HOBO sensor using the drive_update() function from the googledrive R package. Storing the censored HOBO data in a Google Sheet has several advantages. First, it allows the SHARKS app to access the data without the need for any local files. Second, it allows for controlled access to the data. A second, uncensored, version of the HOBO data is uploaded as a CSV to a Google Drive using the drive_update() function from the googledrive R package. This version of the data includes a censor code column that indicates which data points were censored and for what reason.

3.9. Retrieve Storm Sewer Data

In order for users to access the HOBO storm sewer data via the SHARKS app, they must first login with a Google Account that has access to the Google Sheets storing the data. The googleAuth R package was used to handle Google authentication and retrieve the Google access token. A function was then created from the Google Sheets API to download the data stored in the Google Sheets as a JSON dataset using the Google access token. Inputs to the function are the Google Sheet ID and the Cell Range containing the data of interest. The JSON data is then converted to an R data frame for use within the SHARKS app. Since it is complicated to query the Google Sheets to determine the cell range that matches the user-specified date range, when the user logs in with the Google authentication, the SHARKS app downloads the HOBO data for the entire period of record. Then, the SHARKS app subsets the HOBO data for the user-specified date range as required without the need to redownload the HOBO data.

3.10. Current Weather Conditions & 10-Day Weather Forecast

The Google Geocoding API is used to geocode the user-specified location. Then, current weather conditions for the user-specified location are retrieved from Weather Underground and displayed using a Weather Underground Weather Sticker (https://www.wunderground.com/stickers/).

The forecast10day() function in the rwunderground R package is used to download a 10-day weather forecast for the user-specified location. This R package requires an API key obtained by creating a Wunderground Developer Account.

4. USER MANUAL

4.1. App Layout

The web app consists of two panels: the main panel and the sidebar (Figure 4). At the top of the sidebar, a set of tabs allows the user to decide whether to display the Summary, Map, Forecast, Interactive Plots, Tables, Storm Sewer, Real-Time Flood Stages, or Help tab in the main panel. The sidebar also consists of sections that control data inputs and program options. Throughout the app, help buttons indicated with "?" symbols display help messages when clicked to provide information regarding the various inputs, outputs, and options.

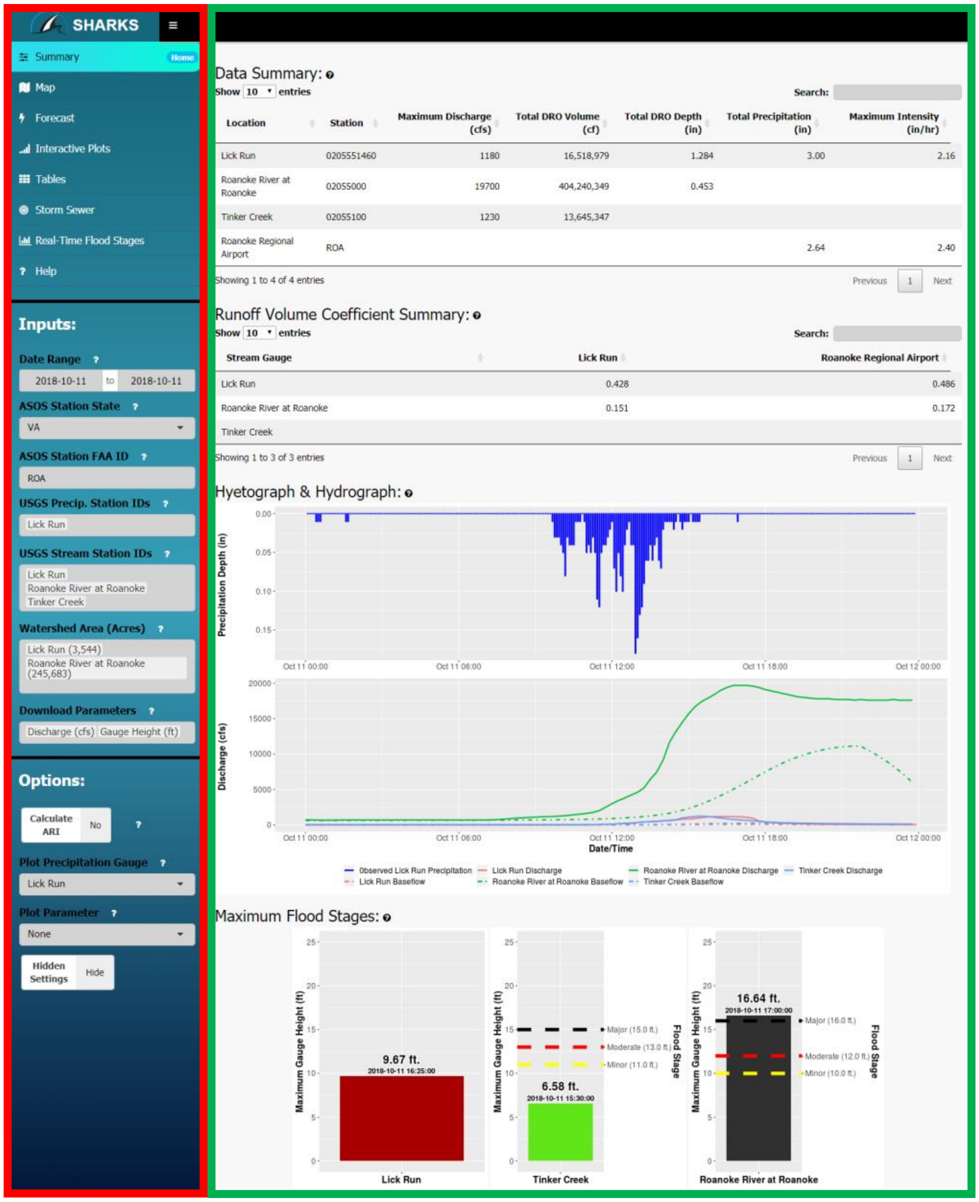


Figure 4: App layout with sidebar highlighted in red and main panel highlighted in green

4.2. *Sidebar Inputs*

4.2.1. Date Range

The *Date Range* input (Figure 5) allows users to specify the start and end dates of the date range for which they wish to download and display data. If the start and end of the date range are set to the same date, then the app will download and display data for 0:00-24:00 of the specified date. However, if the start and end of the date range are set to different dates, then the app will download and display data from 0:00 of the start date to 0:00 of the end date. The app is dynamically linked to the date range and will immediately retrieve data upon changes to the date range. Thus, if users wish to select a date range prior to the current date range, then users should first adjust the end date and then adjust the start date. Otherwise, the app will attempt to retrieve data from the new start date to the original end date. Likewise, if users wish to select a date range after the current date range, then users should first adjust the start date and then adjust the end date.

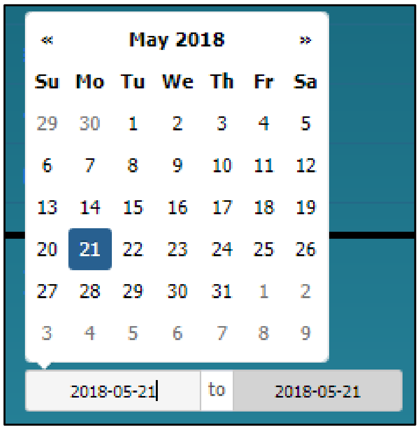


Figure 5: Date range input

4.2.2. ASOS Station State and FAA ID

The *ASOS Station State* and *ASOS Station FAA ID* inputs (Figure 6) control the NOAA meteorological station from which data is retrieved.

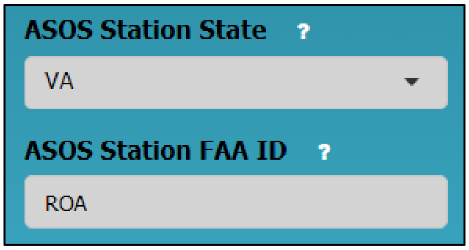


Figure 6: ASOS Station State and ASOS Station FAA ID inputs

The Automated Surface Observing System (ASOS) network is the flagship automated observing network that provides observations for the National Weather Service, Federal Aviation Administration (FAA), and Department of Defense. However, the FAA also operates the Automated Weather Observing Station (AWOS) network. NOAA data for the app is retrieved via the Iowa Environmental Mesonet maintained by Iowa State University (https://mesonet.agron.iastate.edu/request/download.phtml?network=VA_ASOS).

The *ASOS Station State* and *ASOS Station FAA ID* inputs allows users to specify the state and airport FAA ID for the ASOS station they wish to retrieve meteorological data from. Characters in the *ASOS Station FAA ID* input must be either capital letters or numbers. If a user wishes to search for an ASOS station in a specific state, leaving the *ASOS Station FAA ID* input empty will display a table on the Summary Tab with the location and FAA ID of every ASOS station within the state (Figure 7). The selected station is mapped on the interactive map in the app's Map Tab (Section 4.5).

FAA IDs for selected State:

Show 10 entries Search:

	Location	FAA ID
1	ABINGTON	VJI
2	Blackstone	BKT
3	Bridgewater	VBW
4	Brookneal	0V4
5	Bumpass	7W4
6	CHARLOTTESVILLE	CHO
7	Chase City	CXE
8	CHESAPEAKE	CPK
9	Chesterfield	FCI
10	Clarksville / Marks	W63

Showing 1 to 10 of 72 entries Previous 1 2 3 4 5 ... 8 Next

Figure 7: Location and FAA ID of ASOS stations in Virginia

4.2.3. USGS Precip. Station IDs

The *USGS Precip. Station IDs* input allows users to select the Roanoke USGS meteorological stations from which they wish to retrieve precipitation data (Figure 8). Stations are selected by clicking the station description in the drop-down list and are removed by clicking the name of a selected station and then pressing the backspace or delete keys. Selected stations are mapped on the interactive map on the app's Map Tab (Section 4.5). If users wish to retrieve precipitation data from a USGS station located outside of Roanoke, they can do so by manually entering the USGS ID number for the station in the input box.

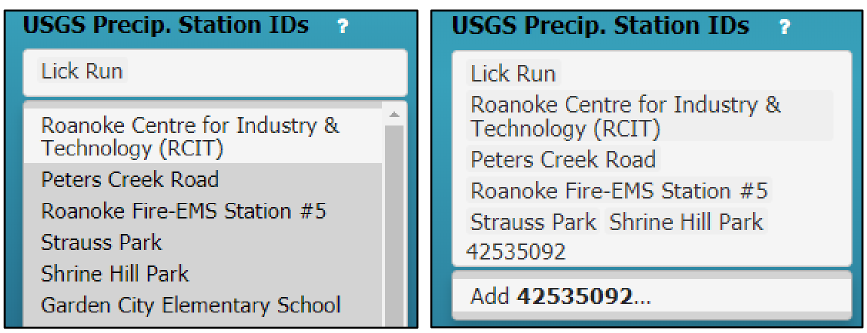


Figure 8: USGS Precip. Station IDs input; Users can choose sites by clicking stations in drop-down list (Left) or by manually typing the USGS ID number (Right)

4.2.4. USGS Stream Station IDs

The *USGS Stream Station IDs* input allows users to select the Roanoke USGS stream stations from which they wish to retrieve discharge and water quality data (Figure 9). Stations are selected by clicking the station description in the drop-down list and are removed by clicking the name of a selected station and then pressing the backspace or delete keys. If users wish to retrieve data from a USGS station located outside of Roanoke, they can do so by manually entering the USGS ID number for the station in the input box. Selected stations are mapped on the interactive map on the app's Map Tab (Section 4.5).

4.2.5. Watershed Area

The watershed area is used to calculate the depth of direct runoff for each USGS stream station. If the user selects one of the Roanoke stream stations, then the watershed area input automatically populates. However, if users have manually entered a station in the *USGS Stream Station IDs* input, then they must also manually enter the watershed area in acres for the station. The order of the stations in the *USGS Stream Station IDs* input must match the order of the areas in the *Watershed Area* input.

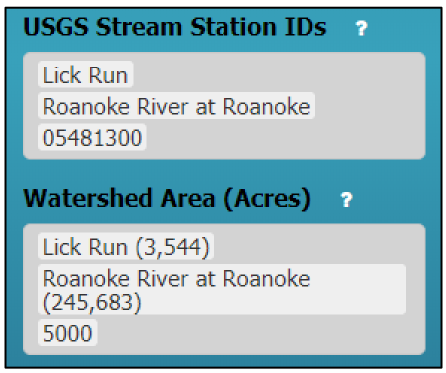


Figure 9: USGS Station IDs and Watershed Area inputs; Users can choose sites by clicking stations in drop-down list and watershed areas will automatically populate, or users can manually enter a stream station ID and watershed area

4.2.6. Download Parameters

The *Download Parameters* input (Figure 10) allows users to select which datasets to retrieve for the specified USGS stream stations. Available parameters are Discharge (cfs), Gauge Height (ft), Water Temperature (°C), Specific Conductance (µS/cm @ 25°C), Dissolved Oxygen (mg/L), pH, and Turbidity (FNU). Parameters are selected by clicking the parameter description in the drop-down list and are removed by clicking the name of a selected parameter and then pressing the backspace or delete keys.

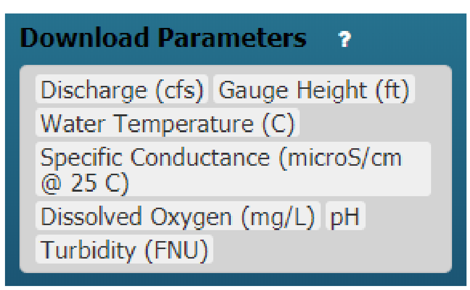


Figure 10: Download Parameters input

4.3. *Sidebar Options*

4.3.1. Calculate ARI

The *Calculate ARI* switch allows the user to determine whether the app will calculate the average annual recurrence interval (ARI) for precipitation events occurring during the user-specified date range. ARIs are interpolated from NOAA PFDS tables as detailed in Section 3.5. By default, the app will not calculate ARIs because the calculations can take several minutes for long date ranges. However, if the user sets the *Calculate ARI* switch to "Yes", then a table will appear above the hyetograph/hydrograph in the app's Summary Tab (Figure 11); the table summarizes the location, station ID, ARI, event duration, event start time, precipitation depth, and precipitation intensity of all events with an ARI >1 year occurring during the user-specified date range.

ARI Summary:

Download | Summary | Display

Show 10 entries

Search:

	Location	Station	ARI (years)	Duration (min)	Start Time	Precipitation Depth (in)	Precipitation Intensity (in/hr)
1	Hidden Valley Middle School	371520080015100	12.05	30	2018-05-16 16:30:00	1.49	2.98
2	Roanoke Fire-EMS Station #5	371709079580800	3.91	15	2018-05-16 16:55:00	0.85	3.40
3	Mill Mountain	371459079560300	3.75	5	2018-05-16 17:10:00	0.42	5.04
4	Strauss Park	371657080002800	2.81	30	2018-05-16 16:40:00	1.09	2.18
5	Roanoke Regional Airport	ROA	1.33	60	2018-05-16 16:40:00	1.14	1.14

Showing 1 to 5 of 5 entries

Previous 1 Next

Figure 11: ARI Summary Table

4.3.2. Plot Precipitation Gauge

The *Plot Precipitation Gauge* option allows the user to specify the source of data to be plotted in the hyetograph in the combined hyetograph/hydrograph on the Summary Tab and the interactive hyetograph on the Interactive Plots Tab. Clicking the drop-down menu displays a list of all of the selected NOAA and USGS precipitation stations and clicking the desired station name updates all of the aforementioned hyetographs. Hyetographs may be displayed for unlisted USGS and NOAA precipitation stations by adding the USGS station ID to the *USGS Precip. Station IDs* input or by changing the *ASOS Station FAA ID* as described in Sections 4.2.3 and 4.2.2, respectively.

4.3.3. Plot Parameter

The *Plot Parameter* option allows the user to specify which water quality parameter, if any, is displayed on a secondary axis on the hydrograph in the combined hyetograph/hydrograph on the Summary Tab and in the interactive hydrograph on the Interactive Plots Tab. Clicking the drop-down menu displays a list of all of the downloaded water quality parameters. Parameters that may be graphed on the secondary axis are Gauge Height (ft), Water Temperature (°C), Specific Conductance (µS/cm @ 25°C), Dissolved Oxygen (mg/L), pH, and Turbidity (FNU). If the desired parameter does not appear in the drop-down menu, then it is not set to download and must be added to the *Download Parameters* input as described in Section 4.2.6.

4.3.4. Hidden Setting – Time Zone

The *Time Zone* input (Figure 12) can be accessed by setting the *Hidden Settings* switch to "Show". The time zone setting controls how the NOAA and USGS precipitation, stream flow, and water quality data are downloaded and displayed. Time zone options are America/New York (EST/EDT), America/Chicago (CST/CDT), America/Denver (MST/MDT), America/Los Angeles (WST/WDT), America/Anchorage (AKST/AKDT), and Coordinated Universal Time (UTC).

The NOAA and USGS data sources used in the app handle time zones differently. While NOAA returns data for stations from 0:00-24:00 in the user-specified time zone, USGS returns data for stations from 0:00-24:00 in the local time zone of the station and the data must then be transposed to match the web app's user-specified time zone. Thus, if the app user specifies a time zone that is different than the local time of the USGS stations, the downloaded time periods for the NOAA and USGS data will be offset by the time difference between the user-specified time zone and the local time zone of the USGS station. This will cause the hyetograph and hydrograph on the Summary and Storm Sewer Tabs to appear offset despite being plotted correctly (Figure 13).

The NOAA and USGS data sources used in the app also handle Daylight Saving Time differently. During Daylight Savings Time, NOAA returns data from 0:00 on the user-specified start date to 24:00 on the user-specified end date. However, when Daylight Savings Time ends, NOAA returns data from 23:00 the day before the user-specified start date to 23:00 on the user-specified end date. In contrast, USGS returns data from 0:00 on the user-specified start date to 24:00 on the user-specified end date both during Daylight Savings Time and when Daylight Savings Time has ended. Thus, the hyetograph and hydrographs may also appear offset when Daylight Savings Time ends, despite being plotted correctly, because NOAA and USGS return data for slightly different time periods.

Figure 12: Time Zone of NOAA & USGS Stations Input

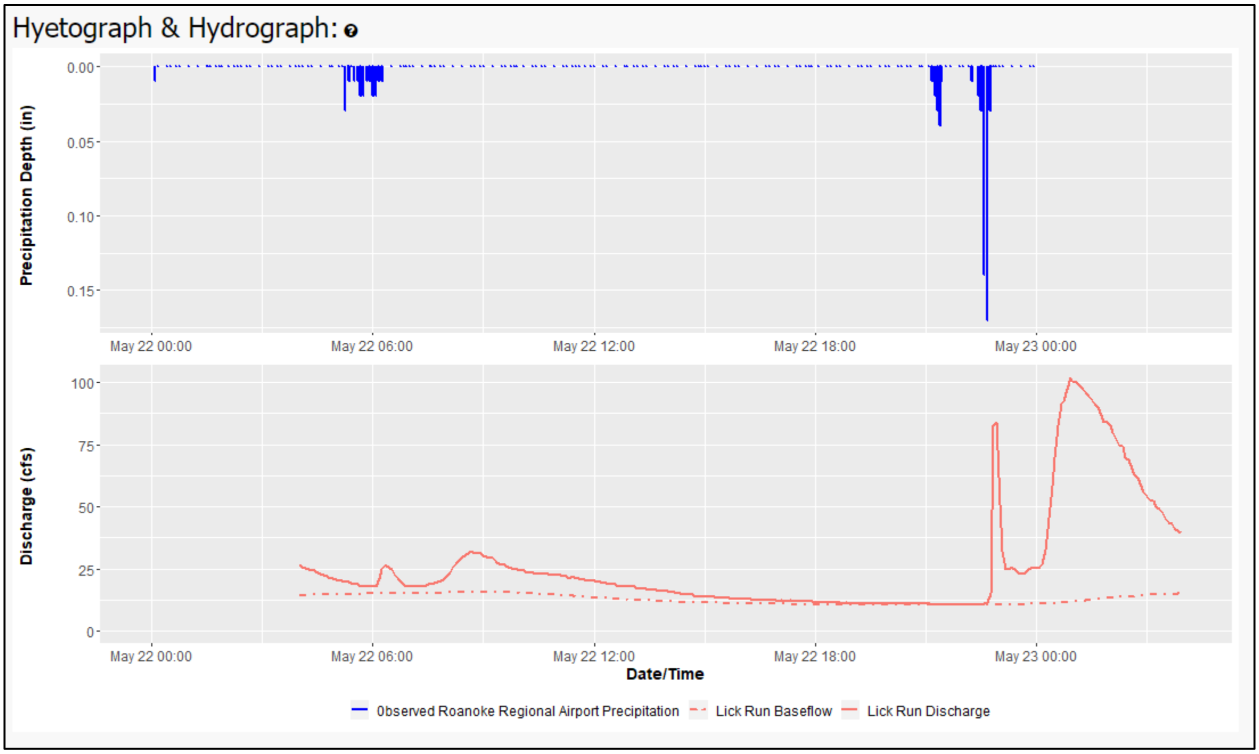


Figure 13: Roanoke NOAA Precipitation and USGS Stations (EST/EDT Time Zone) plotted as Coordinated Universal Time (UTC Time Zone) causes hyetograph and hydrograph to appear offset because NOAA returns data for 0:00-24:00 of the specified time zone while USGS returns data for 0:00-24:00 local time of the station

4.3.5. Hidden Setting – NOAA Network:

The Iowa Environmental Mesonet service (Section 4.2.2) does not currently support Virginia AWOS data. Thus, the only option listed under the *NOAA Network* input is ASOS, but this input is included in the app to allow for integration of AWOS data if it becomes available.

4.3.6. Hidden Setting – Plot Colors By:

The *Plot Colors By:* input can be accessed by setting the *Hidden Settings* switch to “Show”. This input allows users to set how the colors are displayed for the datasets in the combined hyetograph/hydrograph on the Summary Tab and the interactive hydrograph on the Interactive Plots Tab. If the input is set to plot colors by station, then the same color will be used for all datasets from the same station (Figure 14). However, if the input is set to plot colors by dataset, then a different color will be used for each dataset on the plot (Figure 15).

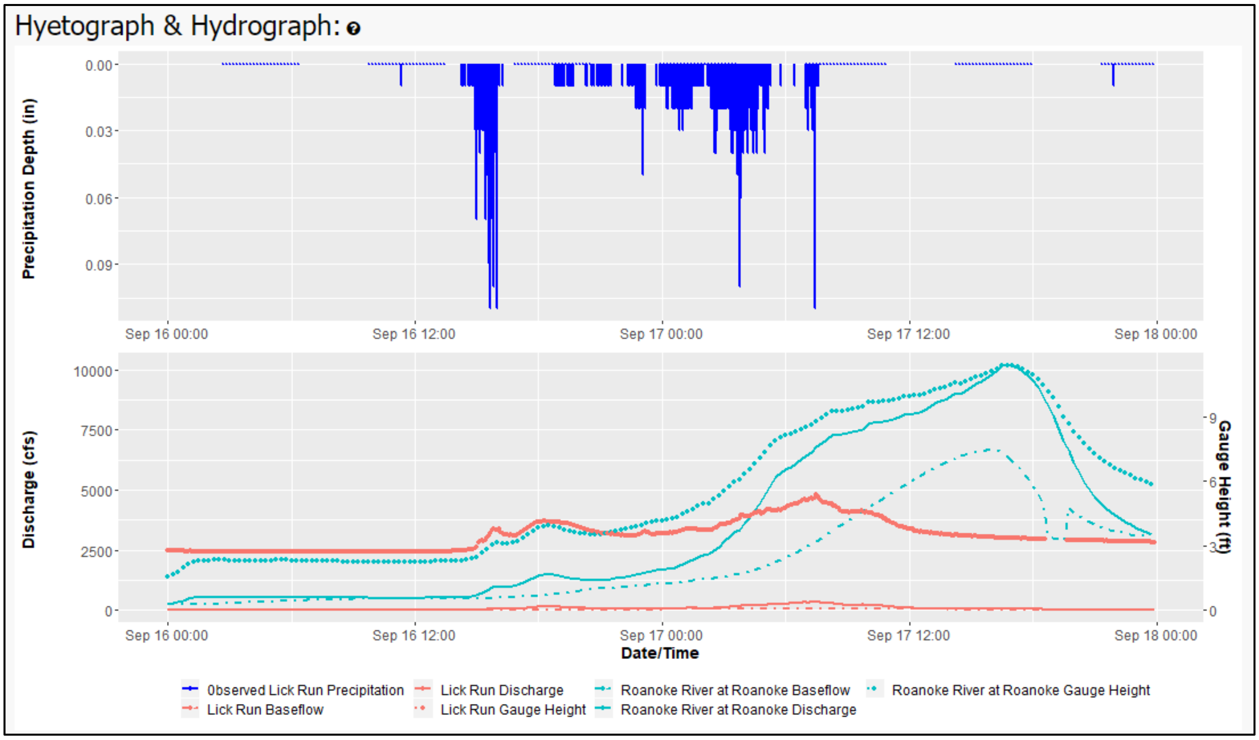


Figure 14: Colors plotted by Station

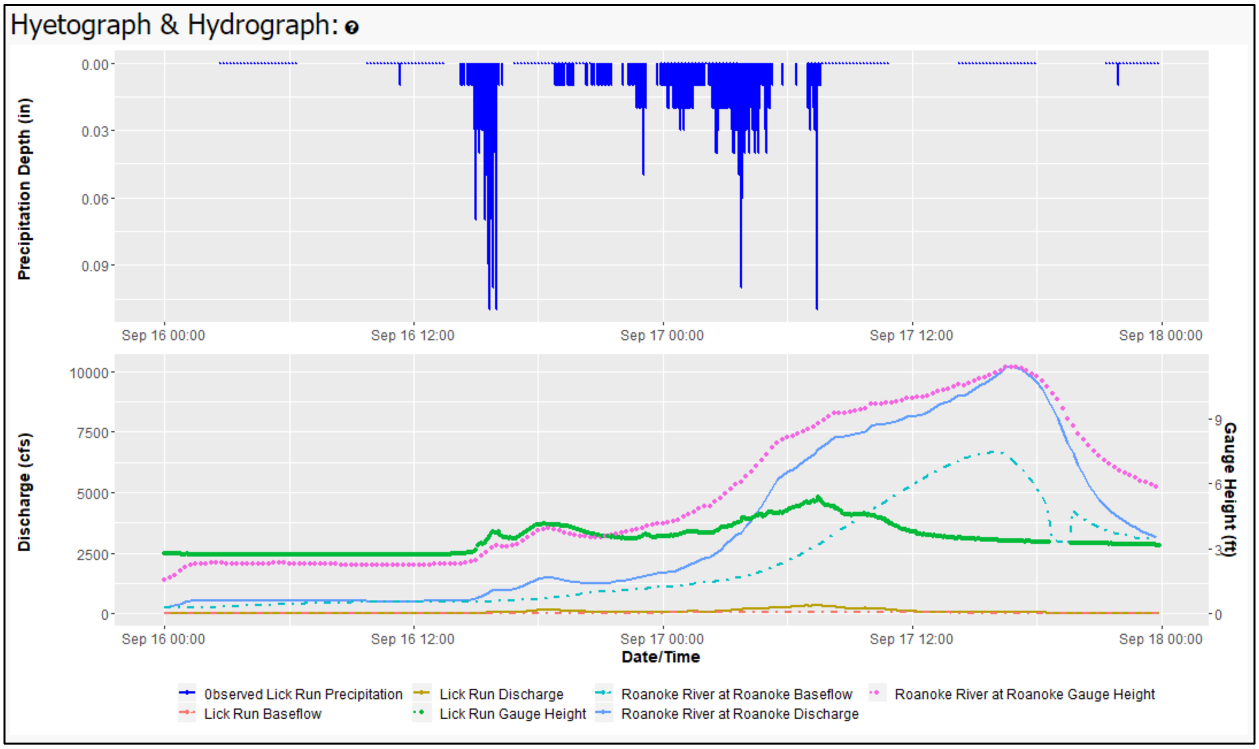


Figure 15: Colors plotted by Dataset

4.4. *Summary Tab*

The Summary Tab consists of a Data Summary table, a Runoff Volume Coefficient Summary table, an ARI table, a combined Hyetograph/Hydrograph, and a hidden table of NOAA ASOS stations.

4.4.1. Data Summary Table

The Data Summary table displays an overview of the selected NOAA meteorological station, USGS meteorological stations, and USGS stream stations (Figure 16). Parameters displayed in the table include the station location and the station ID. For meteorological stations, the total precipitation depth (inches) and the maximum incremental precipitation intensity (inches/hour) are displayed. For stream stations, the maximum flow rate (cubic feet/second), and total direct runoff volume (cubic feet) and total direct runoff depth (inches) are displayed. These summary values are calculated as described in Section 3.6. Data in the summary table can be sorted by clicking the column titles.

Data Summary:

Show 10 entries Search:

Location	Station	Maximum Discharge (cfs)	Total DRO Volume (cf)	Total DRO Depth (in)	Total Precipitation (in)	Maximum Intensity (in/hr)
Lick Run	0205551460	361	8,124,722	0.632	3.12	1.32
Roanoke River at Roanoke	02055000	10200	203,957,605	0.229		
Roanoke Centre for Industry & Technology (RCIT)	371840079534900				2.09	1.44
Roanoke Fire-EMS Station #5	371709079580800				3.11	1.56
Shrine Hill Park	371518079591700				2.93	1.44
Mill Mountain	371459079560300				3.16	1.44
Roanoke Regional Airport	ROA				3.53	16.50

Showing 1 to 7 of 7 entries Previous 1 Next

Figure 16: Data Summary Table

4.4.2. Runoff Volume Coefficient Summary Table

The Runoff Volume Coefficient Summary table displays the runoff volume coefficients calculated for each stream flow and meteorological station combination (Figure 17). Runoff volume coefficients represent the proportion of precipitation leaving the watershed and are calculated as the direct runoff depth calculated for the stream flow station divided by the total precipitation depth measured at the meteorological station. Data in the table can be sorted by clicking on the column titles.

Runoff Volume Coefficient Summary:

Show 10 entries Search:

Stream Gauge	Lick Run	Roanoke Centre for Industry & Technology (RCIT)	Roanoke Fire-EMS Station #5	Shrine Hill Park	Mill Mountain	Roanoke Regional Airport
Lick Run	0.202	0.302	0.203	0.216	0.200	0.179
Roanoke River at Roanoke	0.073	0.109	0.074	0.078	0.072	0.065

Showing 1 to 2 of 2 entries Previous 1 Next

Figure 17: Runoff Volume Coefficient Summary Table

4.4.3. ARI Table

A table of the average annual recurrence intervals (ARI) calculated for precipitation events occurring during the user-specified date range (Figure 11) will be displayed if the *Calculate ARI* switch is set to “Yes”. ARIs are interpolated from NOAA PFDS tables as detailed in Section 3.5. The data table summarizes the location, station ID, ARI, event duration, event start time, precipitation depth, and precipitation intensity of all events with an ARI >1 year occurring during the user-specified date range. Data can be sorted in the table by clicking the column titles and the “Display” toggle switch allows the user to either display only the maximum ARI recorded at each station or every calculated ARI for the specified date range. A button is also included to download the table as a CSV file.

4.4.4. Combined Hyetograph/Hydrograph

The combined hyetograph/hydrograph is controlled by the inputs and options located in the Sidebar menu (Sections 4.2 and 4.3) and displays the same information as the interactive hydrograph and interactive hyetograph on the Interactive Plots Tab.

While the hyetograph only displays data from the station specified in the *Plot Precipitation Gauge* option (Section 4.3.2) for the date range specified in the *Date Range* input (Section 4.2.1), the hydrograph displays all available data for the streamflow stations specified in the *USGS Stream Station IDs* input (Section 4.2.4). The *Plot Parameter* option (Section 4.3.3) can be used to graph Gauge Height (ft), Water Temperature (°C), Specific Conductance (µS/cm @ 25°C), Dissolved Oxygen (mg/L), pH, and Turbidity (FNU) on a secondary y-axis on the hydrograph. If data for the parameter selected using the *Plot Parameter* option is unavailable, a message is displayed in the secondary y-axis indicating that the data is unavailable (Figure 18).

The colors displayed for the datasets in the combined hyetograph/hydrograph can be set using the hidden setting, *Plot Colors By:* (Section 4.3.6). If the input is set to plot colors by station, then the same color will be used for all datasets from the same station (Figure 14). However, if the input is set to plot colors by dataset, then a different color will be used for each dataset on the plot (Figure 15).

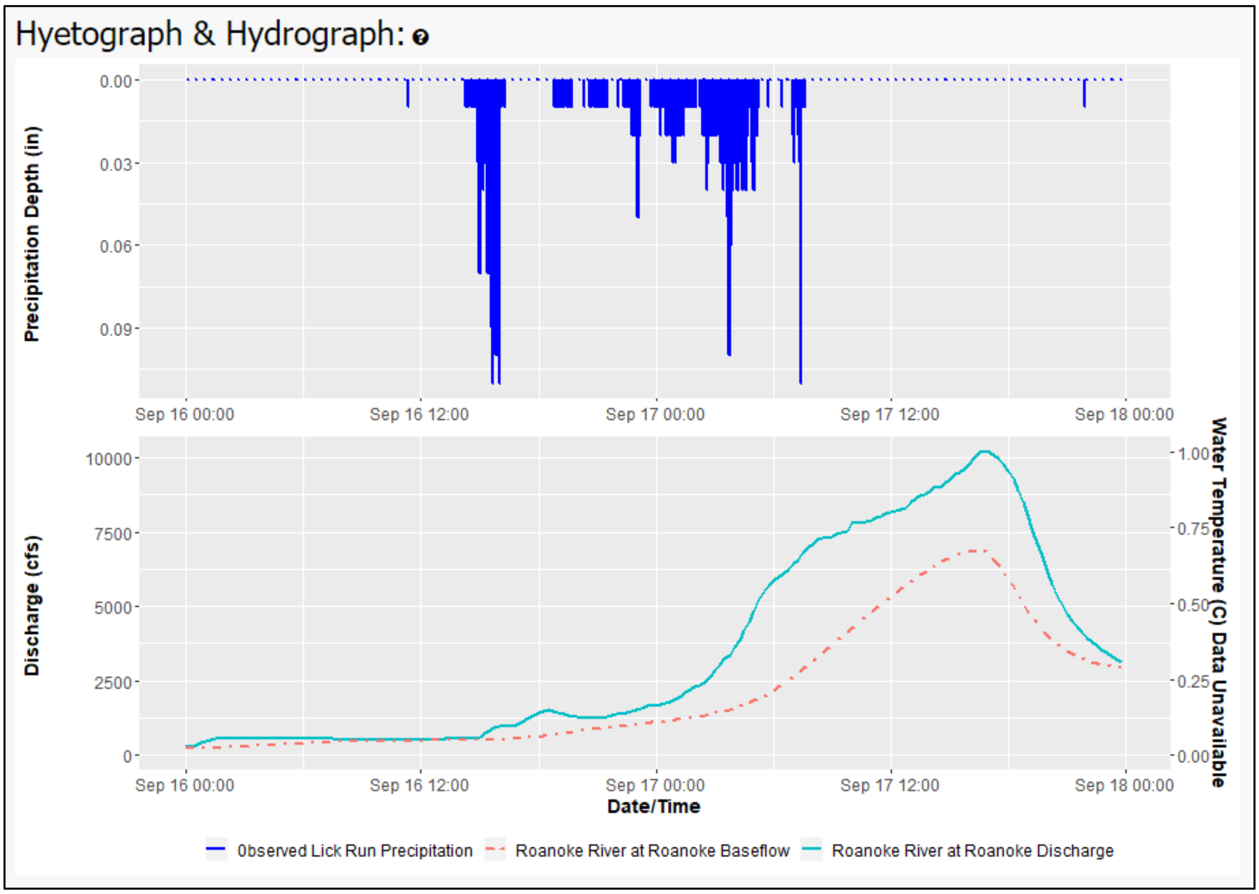


Figure 18: Combined Hyetograph/Hydrograph with message indicating data for secondary y-axis is unavailable for selected stream station and date range

4.4.1. NOAA ASOS Stations Table

If a user wishes to search for a NOAA ASOS station in a specific state, leaving the *ASOS Station FAA ID* input (Section 4.2.2) empty will display a table on the Summary Tab with the location and FAA ID of every ASOS station within the state (Figure 7).

4.4.2. Maximum Flood Stages

The maximum flood stage plots (Figure 19) appear if users download Gauge Height data for a Roanoke stream station using the *Download Parameters* (Section 4.2.6) and *USGS Stream Station IDs* (Section 4.2.4) inputs, respectively. These plots display the maximum gauge height measurements recorded during the selected date range relative to the National Weather Service (NWS) flood threshold values. Supported stations are Lick Run, Tinker Creek, Roanoke River at Roanoke, Roanoke River at Glenvar, and Roanoke River at Lafayette. The bar plot data labels indicate the most maximum gauge height measurement and the date/time it was recorded. In addition, the minor, moderate, and major flood stages are indicated by dashed yellow, red, and black lines, respectively. If an NWS flood threshold has been exceeded, then the color of the maximum gauge height bar will change from green to match the color of the exceeded flood stage (yellow, red, or black).

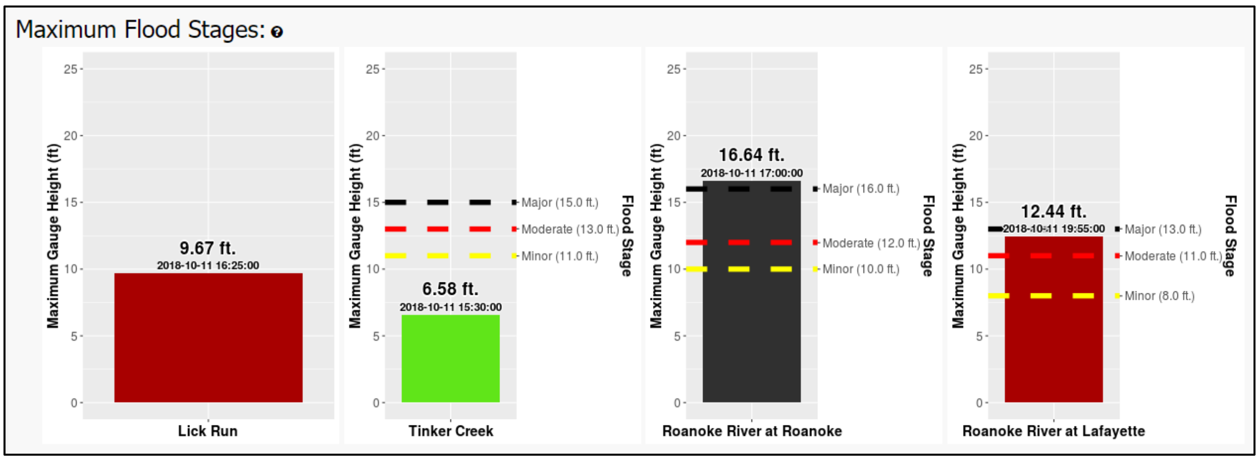


Figure 19: Maximum Flood Stages

4.5. Map Tab

The Map Tab displays an interactive map (Figure 20) with the spatial location of the NOAA ASOS meteorological station selected using the *ASOS Station State* and *ASOS Station FAA ID* inputs (Section 4.2.2), the USGS meteorological stations selected using the *USGS Precip. Station IDs* input (Section 4.2.3), and the USGS stream stations selected using the *USGS Stream Station IDs* input (section 4.2.4). In addition, clicking on the map marker for the NOAA ASOS station displays a label containing the station location, FAA ID, and the total precipitation depth and maximum precipitation intensity occurring over the date range specified using the *Date Range* input (Section 4.2.1). Similarly, click on the map markers for the USGS precipitation stations displays labels containing the station name/location, USGS station ID, and the total precipitation depth and maximum precipitation intensity occurring over the date range specified using the *Date Range* input (Section 4.2.1). Furthermore, clicking on the station name/location will open a browser tab to the USGS website for that station. Finally, clicking on the map markers for the USGS stream stations displays labels containing the station name/location, USGS station ID, and the maximum discharge occurring over the date range specified using the *Date Range* input (Section 4.2.1). Clicking on the station name/location will also open a browser tab to the USGS website for that station.

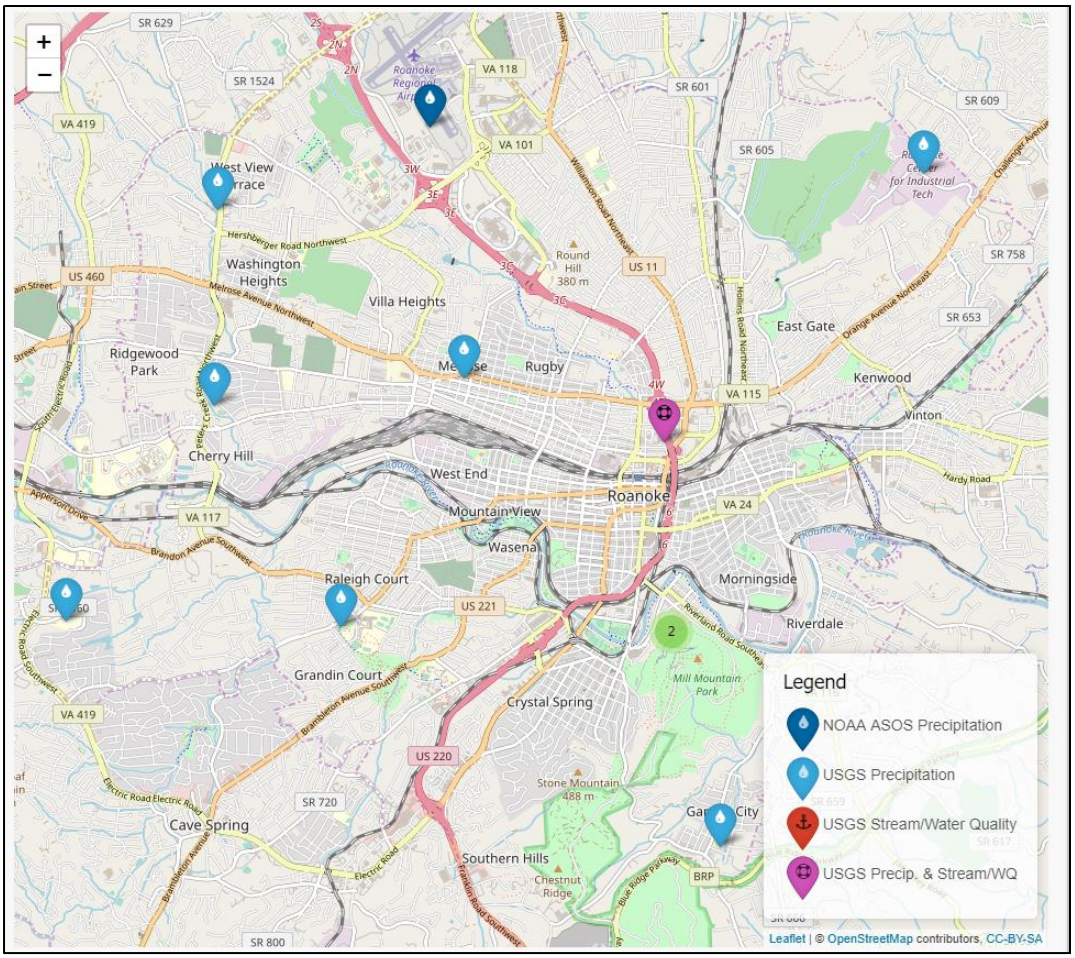


Figure 20: Map Tab interactive map

4.6. Forecast Tab

The Forecast Tab displays both the current weather conditions and the 10-Day weather forecast for the location specified in the input box titled "Forecast Location:" (Figure 21). The current weather conditions are displayed using a Weather Underground Weather Sticker (Figure 21) and clicking on the sticker will open a browser window to Weather Underground's website for the specified location (https://www.wunderground.com/). The 10-Day weather forecast for the specified location is displayed in a tabular format and includes the forecasted high and low temperatures, weather condition, precipitation probability, and precipitation depth (Figure 22). Data in the table can be sorted by clicking on the column titles.

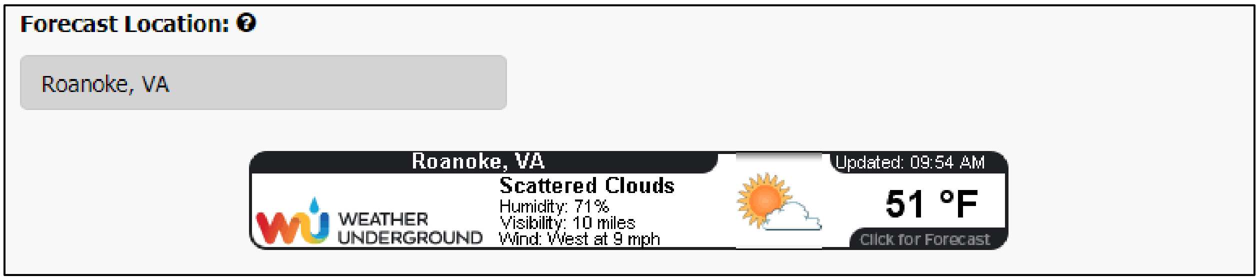


Figure 21: Location input and Weather Underground Weather Sticker with current weather conditions

	Day	Date	High Temp.	Low Temp.	Condition	Precip. Probability (%)	Precip. Depth (in)
1	Thursday	05/24	83	60	Partly Cloudy	0	0.00
2	Friday	05/25	83	66	Chance of a Thunderstorm	40	0.09
3	Saturday	05/26	82	67	Thunderstorm	90	0.71
4	Sunday	05/27	81	66	Thunderstorm	90	0.38
5	Monday	05/28	83	68	Chance of Rain	50	0.03
6	Tuesday	05/29	85	69	Chance of a Thunderstorm	40	0.09
7	Wednesday	05/30	80	69	Chance of Rain	40	0.32
8	Thursday	05/31	81	70	Chance of a Thunderstorm	60	0.58
9	Friday	06/01	87	70	Chance of a Thunderstorm	50	0.23
10	Saturday	06/02	83	68	Thunderstorm	80	0.38

Figure 22: 10-Day weather forecast table for user specified location

4.7. *Interactive Plots Tab*

The Interactive Plots tab lets users perform exploratory data analysis on the hydrograph and hyetograph displayed on the Summary Tab. At the top of the Interactive Plots tab, a switch allows users to either view an interactive hydrograph or an interactive hyetograph.

4.7.1. Interactive Hydrograph

The interactive hydrograph is controlled by the inputs and options located in the Sidebar menu (Sections 4.2 and 4.3) and displays the same information as the hydrograph on the Summary Tab. Users can interact with the interactive hydrograph in two ways. First, the user can click a spot on the hydrograph and data from the nearest point will be displayed in the section called "Clicked Data" (Figure 23). The Clicked Data section displays the date/time and Location of the data point as well as the baseflow, discharge, and any downloaded water quality parameters corresponding to that station and time.

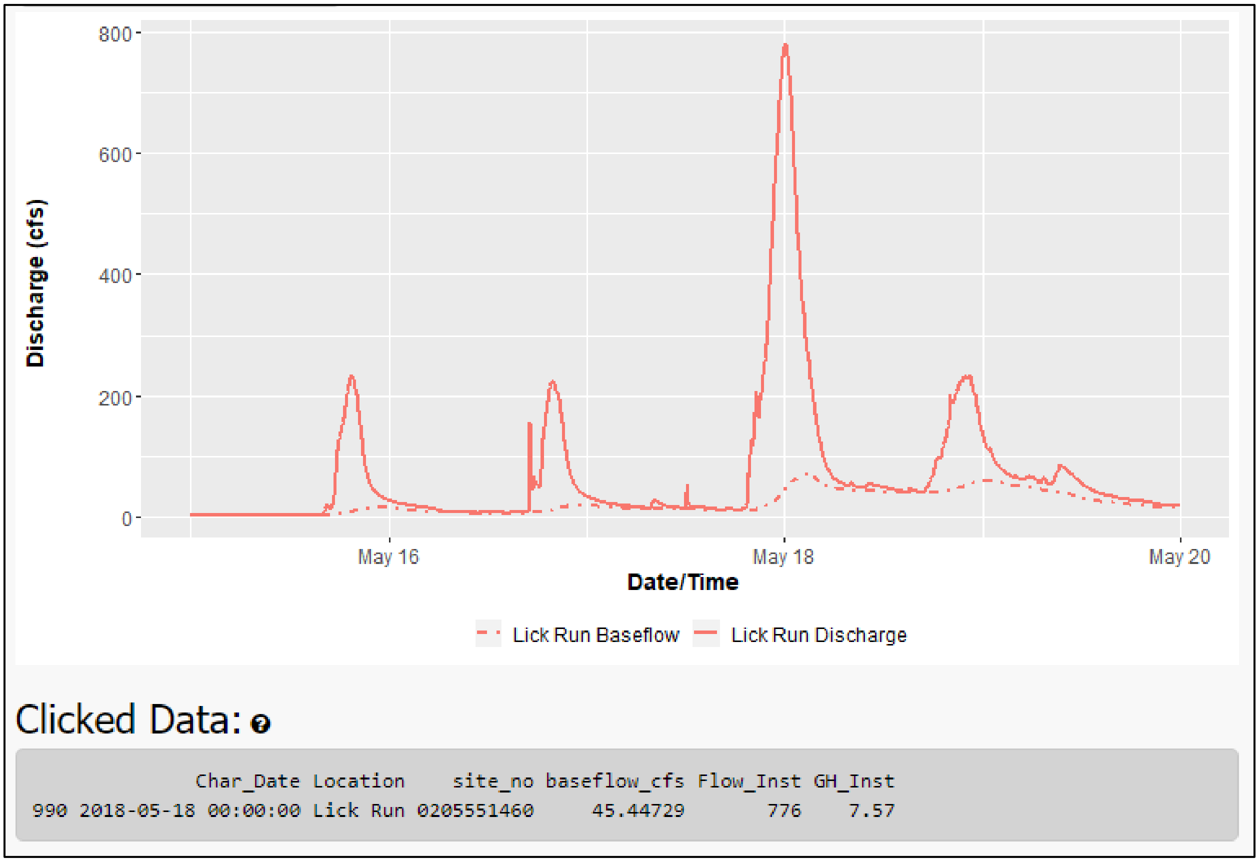
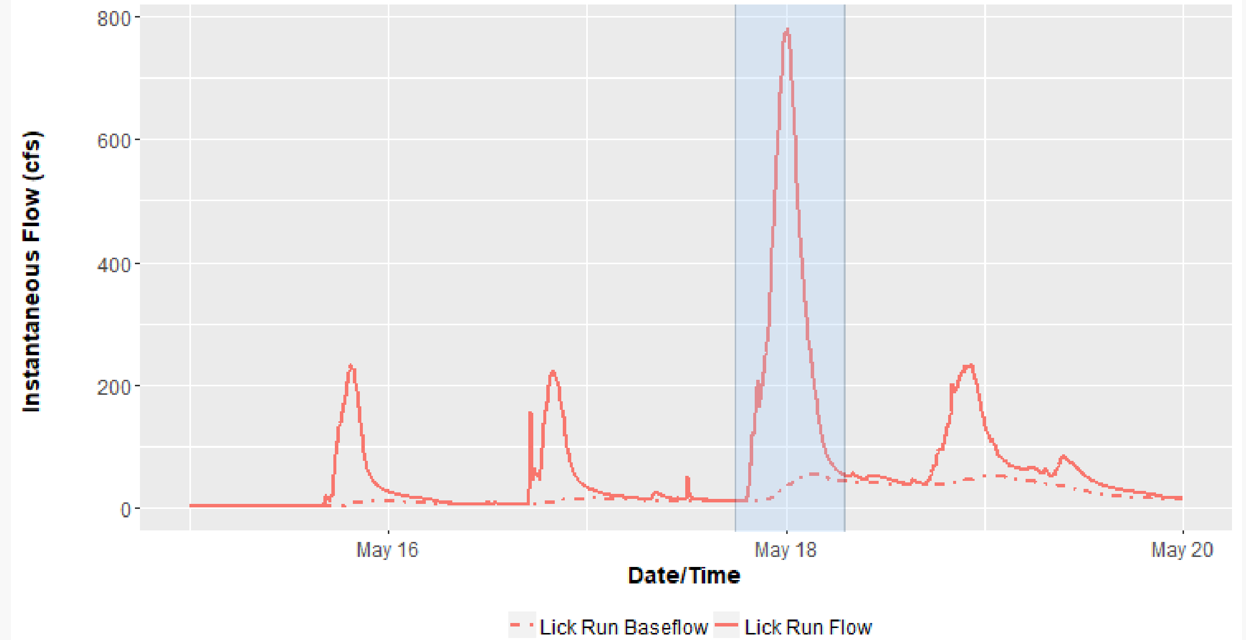


Figure 23: Interactive hydrograph and Clicked Data

Users can also click and drag a box around data on the hydrograph (Figure 24). Data from this "Brushed" time period is then displayed below the interactive hydrograph in a tabled titled "Brushed Data" (Figure 24). Data in the table can be sorted by clicking on the column titles and data can be downloaded to a CSV file by clicking the Download button. In addition, the total discharge volume, baseflow volume, and stormflow runoff volume for each stream flow station for the "Brushed" time period, calculated via trapezoidal integration, is displayed in a table titled "Volume Summary" (Figure 24). Data in this table can be sorted by clicking on the column titles. The "Brushed" time period and the data in the table can be refined by either drawing a new box or by resizing the box by hovering the cursor on the edges of the box until a double-sided arrow (←→) appears and then clicking and dragging the edges. The box can also be moved by clicking and dragging the middle of the box.



Volume Summary:

Show 10 entries

Search:

Location	Discharge Volume (cf)	Baseflow Volume (cf)	Runoff Volume (cf)
Lick Run	13,090,590	1,901,229	11,189,361

Showing 1 to 1 of 1 entries

Previous 1 Next

Brushed Data: Download

Show 10 entries

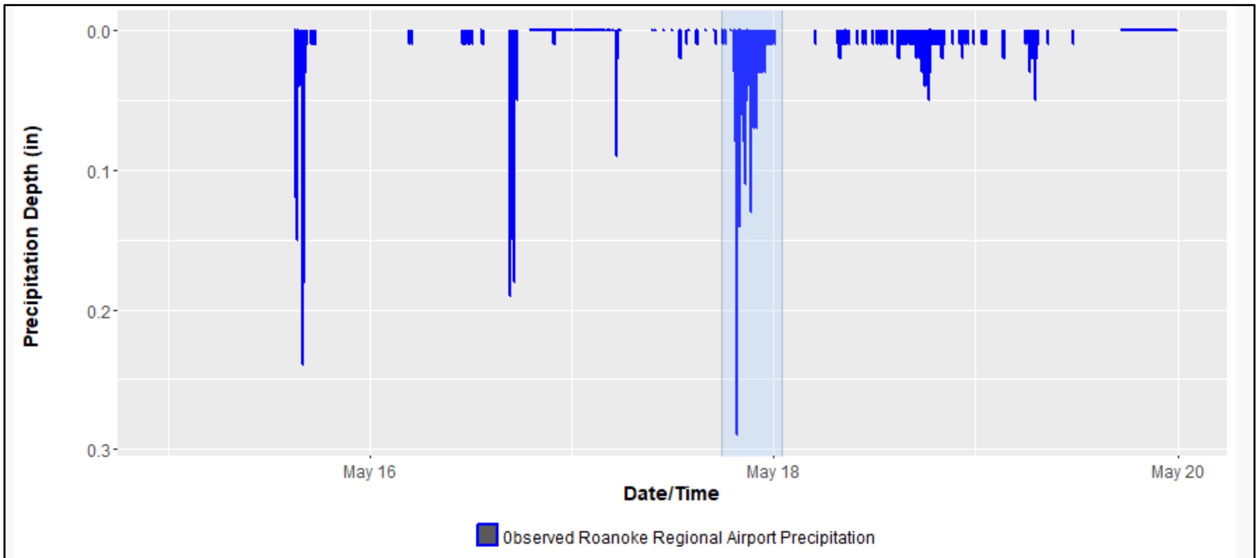
Search:

	Date	Location	Station	Baseflow (cfs)	Discharge (cfs)	Gauge Height (ft)
872	2018-05-17 15:45:00	Lick Run	0205551460	10.86	11.50	2.95
873	2018-05-17 15:50:00	Lick Run	0205551460	10.85	11.50	2.95
875	2018-05-17 15:55:00	Lick Run	0205551460	10.84	11.50	2.95

Figure 24: Interactive Hydrograph, Volume Summary, and Brushed Data

4.7.2. Interactive Hyetograph

The interactive hyetograph is controlled by the inputs and options located in the Sidebar menu (Sections 4.2 and 4.3) and displays the same information as the hyetograph on the Summary Tab. Users can interact with the interactive hyetograph by clicking and dragging a box around data on the hyetograph. This "Brushed" time period can be refined by either drawing a new box or by resizing the box by hovering the cursor on the edges of the box until a double-sided arrow (←→) appears and then clicking and dragging the edges. The box can also be moved by clicking and dragging the middle of the box. The duration of the "Brushed" time period is displayed below the interactive hyetograph as well as the total precipitation depth, average precipitation intensity, and maximum precipitation intensity occurring during the period (Figure 25). Furthermore, the date/time(s) in which the maximum precipitation intensity occurred are displayed after the maximum precipitation intensity value. The average precipitation intensity is calculated as the total precipitation depth occurring during the period divided by the duration of the period. A table of incremental precipitation and precipitation intensity occurring during the "Brushed" time period (Figure 26) is also displayed below the interactive hyetograph and data in the table can be sorted by clicking on the column titles. Data points with incremental precipitation depths equal to 0 are omitted from the table. The data table can also be downloaded as a CSV file by clicking the Download button.



Total Precipitation Depth of Brushed Data: 2.61"
Duration of Brushed Data: 7H 5M 0S
Average Intensity of Brushed Data: 0.37 (in/hr)
Maximum Intensity of Brushed Data: 3.48 in/hr at 2018-05-17 19:40:00

Figure 25: Interactive hyetograph with summary information

Brushed Data: Download

Show 10 entries Search:

	Date	Location	Station	Precip. Depth (in)	Precip. Intensity (in/hr)
2537	2018-05-17 17:05:00	Roanoke Regional Airport	ROA	0.01	0.12
2549	2018-05-17 18:00:00	Roanoke Regional Airport	ROA	0.01	0.12
2555	2018-05-17 18:20:00	Roanoke Regional Airport	ROA	0.01	0.12
2570	2018-05-17 19:20:00	Roanoke Regional Airport	ROA	0.03	0.36
2571	2018-05-17 19:21:00	Roanoke Regional Airport	ROA	0.01	0.60
2572	2018-05-17 19:24:00	Roanoke Regional Airport	ROA	0.02	0.40
2573	2018-05-17 19:25:00	Roanoke Regional Airport	ROA	0.01	0.60

Figure 26: Table of Brushed data from interactive hyetograph

4.8. *Tables Tab*

4.8.1. Combined Data Table

The combined data table presents all of the time series data for all NOAA and USGS stations in one table (Figure 27). The time series data are joined by date/time and each time series is displayed in its own column. Column names represent the station ID, dataset, and data units. Data in the table can be sorted by clicking on the column titles. The data table can also be downloaded as a CSV file by clicking the Download button.

Combined Data: Download

Show 10 entries Search:

	Date/Time	0205551460_Baseflow_cfs	0205551460_DRO_Depth_in	0205551460_DRO_Vol_cf	0205551460_Flow_cfs
1	2018-05-15 00:00:00	3.08			3.7
2	2018-05-15 00:05:00	3.09	0.00	155.70	3.51
3	2018-05-15 00:10:00	3.09	0.00	125.61	3.51
4	2018-05-15 00:15:00	3.10	0.00	124.04	3.51
5	2018-05-15 00:20:00	3.10	0.00	122.49	3.51
6	2018-05-15 00:25:00	3.11	0.00	120.96	3.51
7	2018-05-15 00:30:00	3.11	0.00	119.44	3.51
8	2018-05-15 00:35:00	3.12	0.00	117.95	3.51
9	2018-05-15 00:40:00	3.12	0.00	116.48	3.51
10	2018-05-15 00:45:00	3.13	0.00	143.52	3.7

Showing 1 to 10 of 1,647 entries Previous 1 2 3 4 5 ... 165 Next

Figure 27: Combined Data Table

4.8.2. NOAA and USGS PFDS Mean Values Tables

The NOAA and USGS PFDS Mean Values tables display the NOAA Atlas 14 point precipitation frequency estimates for user-specified ASOS and USGS precipitation stations (Figures 28 & 29). The PFDS tables are retrieved from NOAA as described in Section 3.4 and display the precipitation depth (inches) corresponding to different storm durations and average annual recurrence intervals (ARI). The app retrieves the latitude and longitude and automatically displays the PFDS table for any ASOS station specified using the *ASOS Station State* and *ASOS Station FAA ID* inputs (Section 4.2.2). The app also retrieves the latitude, longitude, and PFDS table for any USGS station specified using the *USGS Precip. Station IDs* input (Section 4.2.3). Users can then specify which USGS PFDS table to display by selecting the station name from the dropdown list above the table. PFDS tables can be downloaded by clicking the Download buttons.

NOAA PFDS Mean Values: Download

FAA ID Code: ROA

Show 10 **entries** **Search:**

Duration	ARI_1	ARI_2	ARI_5	ARI_10	ARI_25	ARI_50	ARI_100	ARI_200	ARI_500	ARI_1000	Duration_min
5-min:	0.311	0.372	0.451	0.507	0.576	0.625	0.674	0.719	0.775	0.818	5
10-min:	0.497	0.595	0.722	0.811	0.918	0.996	1.07	1.14	1.23	1.29	10
15-min:	0.621	0.748	0.914	1.03	1.16	1.26	1.35	1.44	1.54	1.62	15
30-min:	0.852	1.03	1.3	1.49	1.72	1.9	2.07	2.24	2.46	2.62	30
60-min:	1.06	1.3	1.66	1.94	2.3	2.57	2.85	3.14	3.52	3.82	60
2-hr:	1.25	1.53	1.98	2.31	2.77	3.13	3.5	3.88	4.39	4.79	120
3-hr:	1.35	1.65	2.12	2.48	2.97	3.36	3.77	4.18	4.76	5.21	180
6-hr:	1.69	2.05	2.6	3.05	3.67	4.19	4.73	5.31	6.14	6.82	360
12-hr:	2.07	2.51	3.18	3.73	4.55	5.24	6	6.82	8.04	9.07	720
24-hr:	2.6	3.14	4	4.7	5.72	6.57	7.5	8.5	9.96	11.2	1440

Showing 1 to 10 of 19 entries Previous 1 2 Next

Figure 28: PFDS Table for NOAA ASOS Station

USGS PFDS Mean Values: Download

Select USGS Precipitation Gauge

Lick Run

Show 10 **entries** **Search:**

Duration	ARI_1	ARI_2	ARI_5	ARI_10	ARI_25	ARI_50	ARI_100	ARI_200	ARI_500	ARI_1000	Duration_min
5-min:	0.312	0.373	0.45	0.506	0.573	0.621	0.667	0.71	0.763	0.802	5
10-min:	0.499	0.597	0.721	0.809	0.914	0.989	1.06	1.13	1.21	1.26	10
15-min:	0.624	0.75	0.912	1.02	1.16	1.25	1.34	1.42	1.52	1.59	15
30-min:	0.855	1.04	1.3	1.48	1.72	1.89	2.05	2.21	2.42	2.57	30
60-min:	1.07	1.3	1.66	1.93	2.28	2.56	2.83	3.1	3.47	3.75	60
2-hr:	1.25	1.53	1.97	2.31	2.75	3.11	3.47	3.84	4.33	4.72	120
3-hr:	1.36	1.65	2.12	2.47	2.95	3.33	3.73	4.14	4.69	5.12	180
6-hr:	1.7	2.06	2.6	3.04	3.66	4.17	4.7	5.27	6.08	6.73	360
12-hr:	2.08	2.51	3.17	3.73	4.54	5.22	5.97	6.78	7.97	8.97	720
24-hr:	2.6	3.15	4.01	4.71	5.74	6.6	7.53	8.54	10	11.2	1440

Showing 1 to 10 of 19 entries Previous 1 2 Next

Figure 29: PFDS Table for USGS Station

4.9. *Storm Sewer Tab*

The Storm Sewer Tab displays data from the HOBO level loggers placed in eight critical pipe network locations in downtown Roanoke. Users must have access to the Google Sheets that store the HOBO data in order to use the Storm Sewer Tab. For access to the Google Sheet, please contact the app developers.

To access the HOBO data using the web app, users must login by clicking the “Login via Google” button (Figure 30). Clicking the button will redirect users to a page in which they can enter their Google credentials with access to the Google Sheets containing the HOBO data. Logging in via Google allows the web app to access the user’s Google Drive and retrieve the HOBO data from the Google Sheets. After logging in, the user is redirected back to the web app and the Storm Sewer Tab will now display an interactive map of the location of the HOBO level loggers (Section 4.9.1), a hyetograph and hydrograph of relative flow/depth from the HOBO level loggers (Section 4.9.2), and a data table containing the HOBO level logger data for the specified date range and sensors (Section 4.9.3).

Figure 30: Storm Sewer Tab Login message

4.9.1. Storm Sewer Interactive Map

The interactive map on the Storm Sewer tab (Figure 31) displays the Roanoke storm sewer conveyances as well as the spatial location of each of the HOBO sensors selected using the *Select Sensors to Map/Plot* input below the map. Clicking on one of the sensor markers on the map will display a label with the sensor name and the maximum relative depth (Section 3.7) measured at the site for the date range specified using the *Date Range* input (Section 4.2.1).

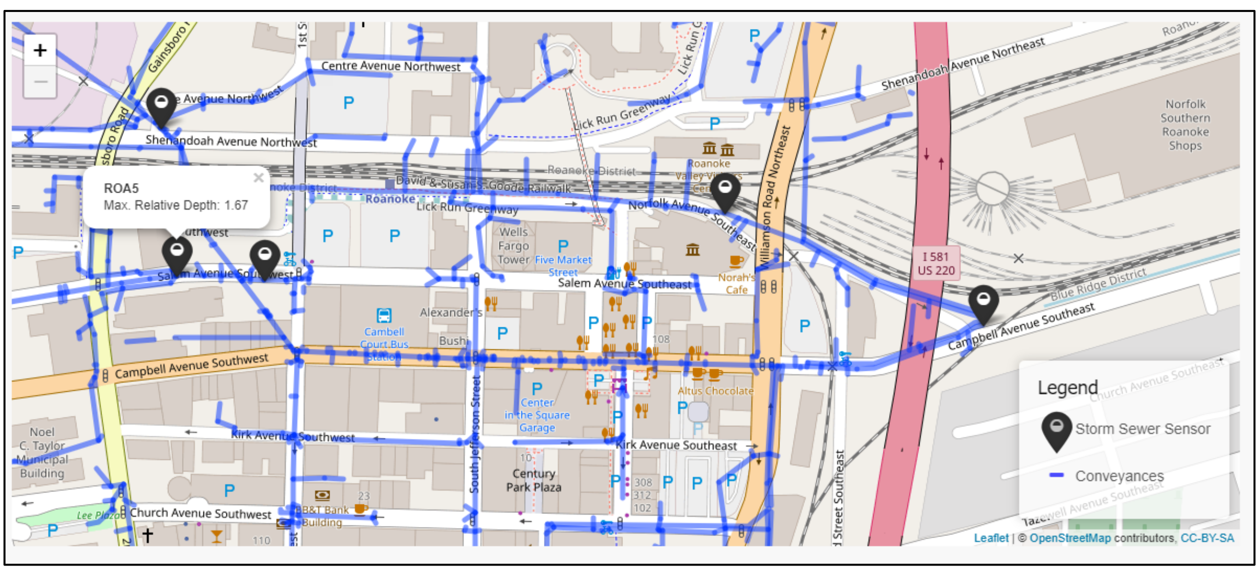


Figure 31: Storm Sewer Interactive Map

4.9.2. Storm Sewer Hyetograph/Hydrograph

The combined hyetograph/hydrograph on the Storm Sewer tab (Figure 32) displays data from the HOBO level loggers for the date range specified using the *Date Range* input (Section 4.2.1). Users can control the hyetograph/hydrograph using the three inputs located above the graph: *Select Sensors to Map/Plot*, *Storm Sewer Plot Precipitation Gauge*, and *Storm Sewer Plot Parameter*.

The *Select Sensors to Plot* input allows the user to specify which of the eight level loggers to display data for. Users can choose to display data for any combination of the eight sensors.

Users can display the hyetograph for any of the user-specified meteorological stations by selecting the station name from the dropdown list of the *Storm Sewer Plot Precipitation Gauge* input. Hyetographs may be displayed for unlisted USGS and NOAA precipitation stations by adding the USGS station ID to the *USGS Precip. Station IDs* input or by changing the *ASOS Station FAA ID* as described in Sections 4.2.3 and 4.2.2, respectively. Finally, the *Storm Sewer Plot Parameter* input allows users to either display the flow rate or flow depth relative to those of full-flow conditions as calculated in Section 3.7.

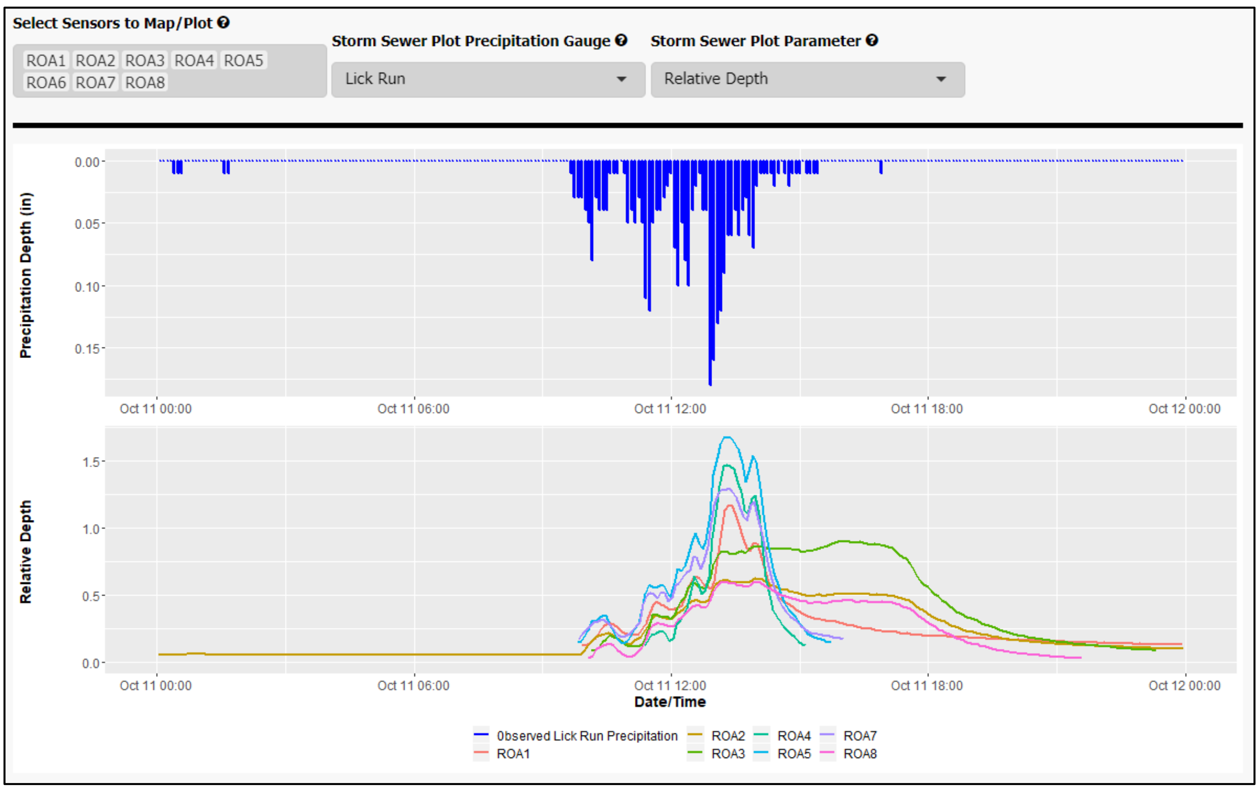
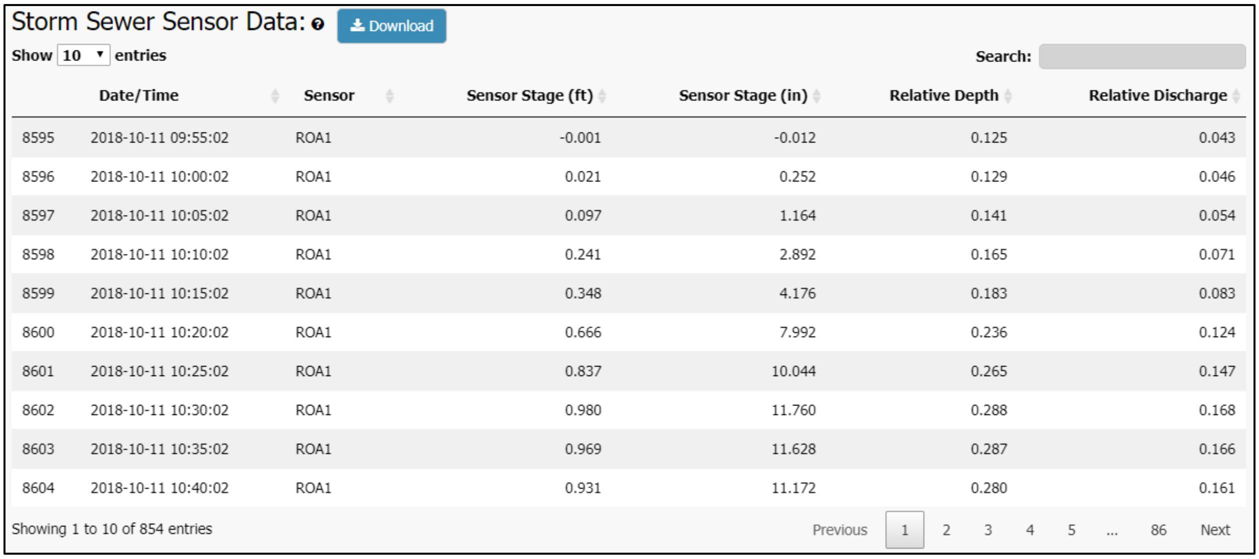


Figure 32: Storm Sewer combined hyetograph/hydrograph with input options

4.9.3. Storm Sewer Sensor Data Table

The Storm Sewer Sensor Data table (Figure 33) displays the sensor stage, relative depth (d_rel), and relative flow rate (Q_rel) for each of the sensors specified using the *Select Sensors to Plot* input for the date range specified using the *Date Range* input (Section 4.2.1). Data in the table can be sorted by clicking the column titles and the data table can be downloaded as a CSV file by clicking the Download button.



Storm Sewer Sensor Data: Download

Show 10 entries

Search:

	Date/Time	Sensor	Sensor Stage (ft)	Sensor Stage (in)	Relative Depth	Relative Discharge
8595	2018-10-11 09:55:02	ROA1	-0.001	-0.012	0.125	0.043
8596	2018-10-11 10:00:02	ROA1	0.021	0.252	0.129	0.046
8597	2018-10-11 10:05:02	ROA1	0.097	1.164	0.141	0.054
8598	2018-10-11 10:10:02	ROA1	0.241	2.892	0.165	0.071
8599	2018-10-11 10:15:02	ROA1	0.348	4.176	0.183	0.083
8600	2018-10-11 10:20:02	ROA1	0.666	7.992	0.236	0.124
8601	2018-10-11 10:25:02	ROA1	0.837	10.044	0.265	0.147
8602	2018-10-11 10:30:02	ROA1	0.980	11.760	0.288	0.168
8603	2018-10-11 10:35:02	ROA1	0.969	11.628	0.287	0.166
8604	2018-10-11 10:40:02	ROA1	0.931	11.172	0.280	0.161

Showing 1 to 10 of 854 entries

Previous 1 2 3 4 5 ... 86 Next

Figure 33: Storm Sewer Sensor Data table

4.10. *Real-Time Flood Stages Tab*

The Real-Time Flood Stages Tab displays the most recent gauge height measurements relative to the National Weather Service (NWS) flood threshold values for five Roanoke stream stations (Figure 34). Supported stations are Lick Run, Tinker Creek, Roanoke River at Roanoke, Roanoke River at Glenvar, and Roanoke River at Lafayette. The bar plot data labels indicate the most recent gauge height measurement and the date/time it was recorded. In addition, the minor, moderate, and major flood stages are indicated by dashed yellow, red, and black lines, respectively. If an NWS flood threshold has been exceeded, then the color of the current gauge height bar will change from green to match the color of the exceeded flood stage (yellow, red, or black).

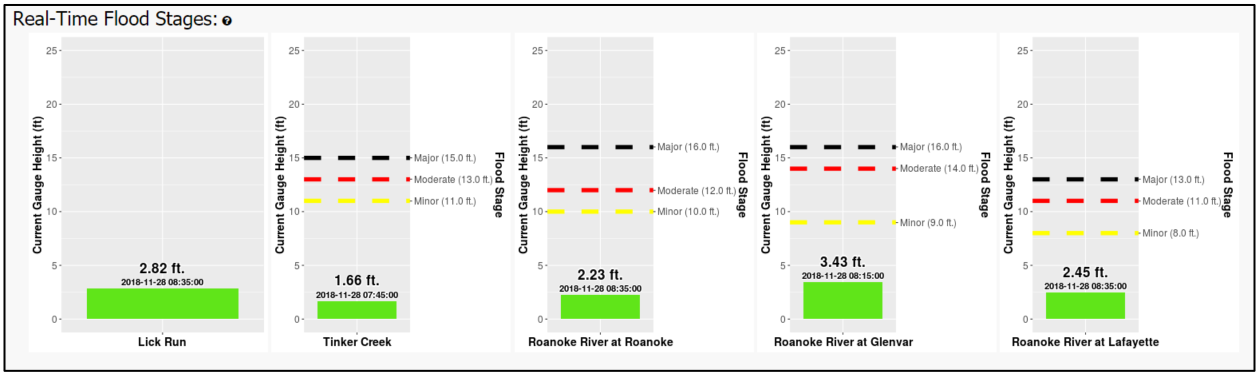


Figure 34: SHARKS Real-Time Flood Stages Tab

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