U.S. Forest Service
Field Services and Innovation Center – Water Resources
National Stream and Aquatic Ecology Center

July 16, 2025

Virginia Creeper Trail Flooding from Hurricane Helene: Hydrology Analyses for Reconstruction

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Bridge 19 on Whitetop Laurel Creek

Bridge 41 on Green Cove Creek

Summary

Powerful remnants of Hurricane Helene impacted the Southern Appalachians from September 25 to 28, 2024, with up to 24 inches of rain causing large-scale flooding. On the Mt Rogers National Recreation Area District of the Jefferson National Forest, the popular rails-to-trails Virginia Creeper Trail was heavily impacted by flooding from Whitetop Laurel Creek, with 18 bridges (trestles) severely damaged or destroyed, and portions of the embankment eroded and nonfunctional. At the request of the George Washington and Jefferson National Forests, the National Stream and Aquatic Ecology Center (a part of the Forest Service Field Services and Innovation Center – Water Resources group) has performed hydrology analyses of Whitetop Laurel Creek and other streams along the trail alignment to quantify design flood discharges for use in the design of the trail reconstruction.

Hurricane Helene induced flooding in Whitetop Laurel Creek that was unexpectedly large. While there were no active streamgages present in the watershed, high water indicators were marked and surveyed by the U.S. Geological Survey and peak discharge estimates were developed. These analyses indicate that this event exceeded the size of floods that are expected and most infrastructure is designed to safely pass. In some places, the flooding was extreme. Using a preliminary version of the six-level Flood Severity Scale currently in testing, this event was at the Fl-4 and Fl-5 levels. Generally, a Fl-4 flood indicates that peak discharges exceeds design and base flood discharges, with infrastructure damage, extensive floodplain inundation, and some extreme magnitudes. A Fl-5 flood indicates that the event was major, with extreme magnitudes and catastrophic consequences. In contrast, streamgages in the area indicate that floods in this northern portion of the Helene-induced flooding extent were large and notable, but generally not unprecedented. It appears that Helene's rainfall and induced flooding was focused, in part, on the Whitetop Laurel Creek watershed, resulting in devastation to the Virginia Creeper Trail.

Generally, this portion of the Southern Appalachians is highly susceptible to flooding from hurricanes, with the most substantial recorded event being induced from a hurricane that came ashore at Beaufort, South Carolina on August 11, 1940. Previously, a powerful flood event was induced across the southern Blue Ridge Mountains from hurricane remnants in July of 1916. Whitetop Laurel Creek is located in flood potential zone 73 in the Blue Ridge Mountains (see Flood Potential Portal). Floods are inherently large in this area, at the 78th percentile compared to all of the United States. On average floods are twice as large in this portion of the Blue Ridge Mountains than in the neighboring portion of the Valley and Ridge physiographic province. However, portions of the Blue Ridge Mountains to the South (between Boone and Ashville, North Carolina) experience floods 3 times larger, on average. Trends in moderate- and bankfull-scale floods are increasing in zone 73 (+7.7% and +5.6%, respectively), but no increasing trends in large floods are currently being observed.

Recommendations on design flood discharges at the 100-year (1% chance of occurrence) scale are quantified for the Virginia Creeper Trail reconstruction. Effectively passing the 100-year flood balances the need for reasonable levels of both safety and expense, and is the generally accepted flood magnitude for use in planning and design. These values are based on results provided by the Flood Potential Portal Watershed Analysis module, which yields three sets of results from which to make recommendations. These design flood discharges are reported in a tabular format and as a GIS shapefile. Note that these design flood discharges are expected to be eventually experienced as indicated by what has been measured at local streamgages; they are not conceptual and can occur in any year. Design flood discharges are the size of large floods we can expect, and should plan and design for.

Introduction

In late September of 2024, powerful remnants of Hurricane Helene caused large-scale flooding in the Southern Appalachians, impacting numerous National Forests. On the Mt. Rogers National Recreation Area District of the Jefferson National Forest, the Virginia Creeper Trail was heavily impacted by the flooding, with 18 bridges (trestles) severely damaged or destroyed, and needing replaced (Figure 1; Figure 2), and portions of the embankment eroded and nonfunctional. The Virginia Creeper Trail is a popular rails-to-trails segment, with reconstruction expected to be a high-profile project in the Helene flood recovery effort. A design-build project was initiated with an estimated cost of $200 to $300 million to reestablish the trail, to rebuild bridges, trail treads, embankments, and associated infrastructure.

At the request of the George Washington and Jefferson National Forests, to support and accelerate this flood recovery project the Forest Service National Stream and Aquatic Ecology Center, a part of the Field Services and Innovation Center – Water Resources group, has performed hydrologic analysis of Whitetop Laurel Creek and other streams to quantify design flood discharges for use in the trail redesign. These estimates are provided within this report along with the general characterization of flooding in the area, as well as streamgage flood-frequency analyses that include Helene peak discharge values, and discharge estimates and context at surveyed high water marks to provide understanding of flood severity along the Virginia Creeper Trail.

Figure 1: Failure of Virginia Creeper Trail Bridge 37 over Whitetop Laurel Creek from Hurricane Helene.

Figure 2: Failure of Virginia Creeper Trail Bridge 41 over Green Cove Creek from Hurricane Helene.

Hydrology: Flood Characteristics and Predictions

Powerful remnants of Hurricane Helene impacted the Southern Appalachians from September 25 to 28, 2024, inducing extensive flooding that had catastrophic impacts to communities and infrastructure from Southwest Virginia through the Western Carolinas. Many lives were lost, including 103 individuals in North Carolina (NCDHHS, 2024). Two-day rainfall estimates are illustrated in Figure 3, indicating the extent and severity of this storm system. Antecedent soil moisture may have also played a role in the flood severity.

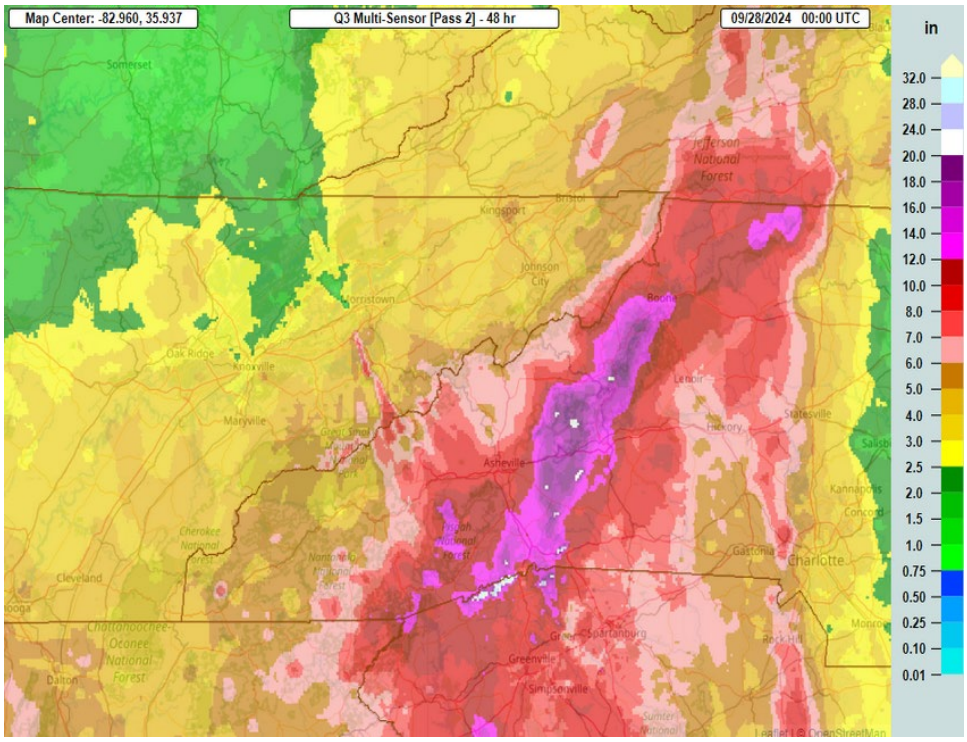


Figure 3: Two-day radar rainfall estimates ending in the evening of September 27, 2024. Up to 12 to 20 inches of rainfall were experienced across a band that extended across Western North Carolina and into adjacent areas of Southwest Virginia and South Carolina (NWS, 2025).

As indicated by National Weather Service radar (Figure 3), the Whitetop Laurel Creek watershed experienced between 12 and 4 inches of rain over a 2-day period. However, this may be an underestimate due to radar terrain shadow for portions of the watershed. More generally, locations with the highest rainfall depths and consequential floods occurred in areas that have previously experienced some of the most substantial floods in the contiguous United States (see the next section). Extensive flooding has previously and repeatedly occurred in this region from tropical cyclones (Amorim et al., 2025), including watersheds in the vicinity of the Virginia Creeper Trail.

To place context on this event, general flooding characteristics of the area are summarized, the results of flood-frequency analyses of streamgages are presented, and peak discharge estimates of streams within the Whitetop Laurel Creek watershed are provided. These analyses frame the severity of this event within the context of the streamgage record of floods within this region. Design flood discharges are then provided along the extent of the Virginia Creeper Trail impacted by Helene, for use in planning and design activities to reestablish the trail.

General Flooding Characteristics

The status and trends of floods in the vicinity of the Virginia Creeper Trail as measured by the U.S. Geological Survey (USGS) streamgaging network is provided in this section, for background on the inherent nature of flooding in this area. The status and trends of floods, specifically how floods vary from place to place and trends in flood magnitudes, frequency, and flashiness over time, respectively, have been quantified using the Flood Potential Method (Yochum et al., 2019), and available publicly through the Flood Potential Portal (https://floodpotential.erams.com; Yochum et al., 2024).

There are three flood potential zones in the vicinity of the Virginia Creeper Trail: 73 (P_f = 23.4), 72 (P_f = 11.2) and 73S (P_f = 69.5). The flood potential index (P_f) quantifies how large flood magnitudes vary from place to place. In this area, large floods in the Blue Ridge Mountains (73 and 73S) are substantially larger than in the adjacent Valley and Ridge physiographic province (zone 72). Specifically, floods in zone 73 (the zone where Whitetop Laurel Creek is located) are, on average, 2.1 times larger (23.4/11.2) than in in the Valley and Ridge. However, large floods further south in the Blue Ridge are 3.0 times larger (69.5/23.4) than floods in zone 73. Floods in zone 73S are some of the largest in the contiguous United States!

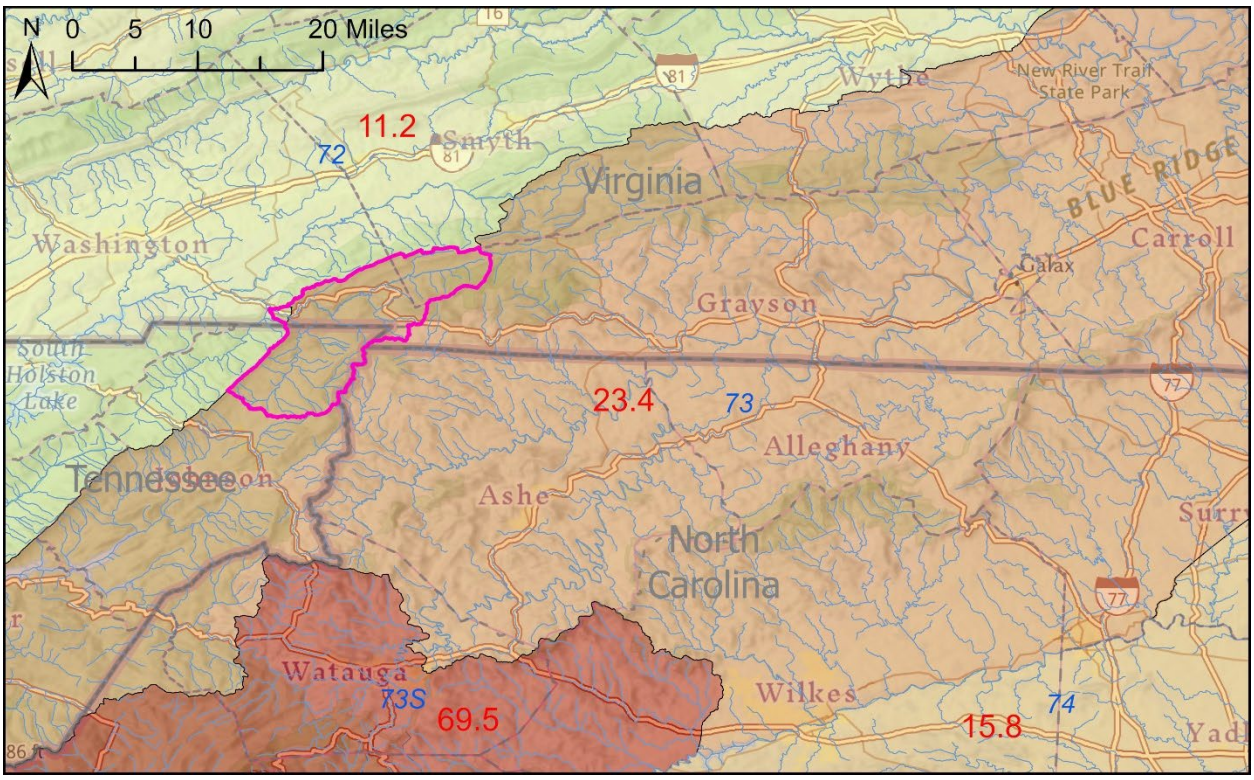


Figure 4: Flood Potential Method zones and the Flood Potential Index (P_f) in the vicinity of Whitetop Laurel Creek at Damascus, Virginia watershed (magenta polygon). Blue text: zone IDs; red text: P_f values. Zone72 and 73 boundaries, algorithms, and trends were updated during the Spring of 2025 using data collected through the end of the 2024 water year (including Helene peak discharges).

Being the zone most relevant for the reconstruction, zone 73 (Blue Ridge) characteristics are summarized below. Percentiles compare flooding characteristics to 212 zones throughout the United States. This information, and those of adjacent zones, are provided in the Flood Potential Portal Mapping module. For zone 73, this summary includes streamgage data collected from 1878 to 2024.

- Years when most notable large floods have occurred: 1940 (August); 1985 (November); 2024 (September); 1916 (July)
- Flood potential index: P_f = 23.4 (78th percentile)

- Watershed scale ratio: R_f = 1.41 (78th percentile)
- Beard flashiness index: F = 0.71 (48th percentile)
- Richards-Baker flashiness index: R-B = 0.31 (47th percentile)
- Bimodality index: B_i = 7.7 (61st percentile)
- Dominant and secondary flooding month: September, August
- Average flood potential watersheds elevation: 2169 feet
- Average flood potential watersheds slope: 13.7 degrees
- Average flood potential watersheds annual precipitation: 50.1 inches
- Number of streamgages in analyses: 43
- R^2 (flood potential regressions): 0.96
- R^2 (index equations): 0.98
- Trends in largest 5% annual peak discharges: possibly decreasing (-9.2%; Figure 5)
- Trends in largest quarter of annual peak discharges (>4-year return interval): none
- Trends in moderate quarter of annual peak discharges (4- to 2-year return interval): significantly increasing (+7.7%; Figure 6)
- Trends in ~bankfull quarter of annual peak discharges (2- to 1.33-year return interval): significantly increasing (+5.6%)
- Trends in <bankfull quarter of annual peak discharges (<1.33-year return interval): significantly decreasing (-5.0%)
- Trends in annual flood frequency, event flood frequency, flashiness: none

Observed trends in large and moderate-scale floods across zone 73 are provided (Figure 5; Figure 6). The largest 5% of annual peak discharges (the scale most relevant for infrastructure design and floodplain management) are not increasing in severity; instead, streamgage data indicate that this scale of flooding is currently becoming less severe. Though moderate-scale floods (nuisance floods) are becoming more severe (+7.7%).

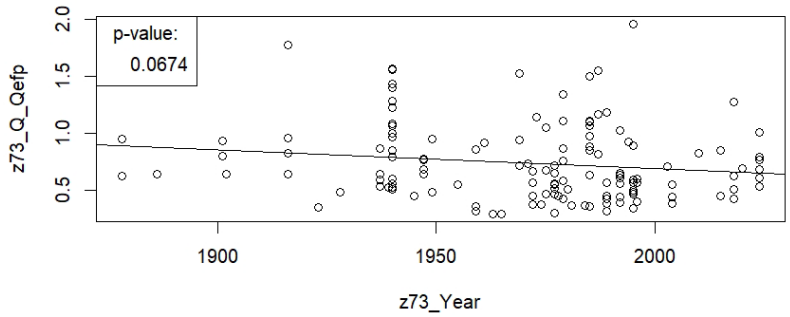


Figure 5: Possible decreasing (p-value = 0.0674) trend in the largest 5% of annual peak discharges in zone 73, for a period from 1878 to 2024. The y-axis is the flood extreme index, $E_f = Q/Q_{efp}$, where Q is measured peak discharge and Q_{efp} is the expected flood potential discharge for each streamgage.

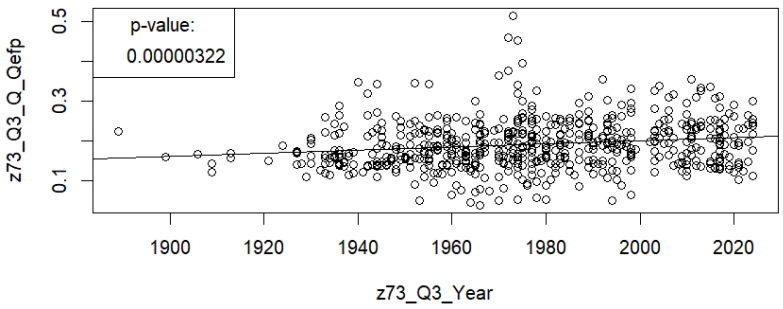


Figure 6: Significant increasing (p-value = 0.00000322 < 0.05 = α) trend in the moderate quarter (Q3; 4- to 2-year return interval) annual peak discharges in zone 73, for a period from 1889 to 2024. Percent increase of the most recent 30 years of data compared to the entire record: +7.7%. The y-axis is the flood extreme index, $E_f = Q/Q_{efp}$, where Q is the measured peak discharge and Q_{efp} is the expected flood potential discharge for each streamgage.

To summarize the nature of floods in the area of the Virginia Creeper Trail, Whitetop Laurel Creek is located in zone 73 which has a flood potential index = P_f = 23.4 indicating that floods, on average, are larger than 78% of the zones delineated through the United States. However, floods further south in the Blue Ridge Mountains (zone 73S; south of Boone, NC) are, on average, three times larger (P_f = 69.5, 97th percentile). Floods in the Blue Ridge Mountains are larger than most other parts of the United States. The 1940 event induced the most substantial flooding on record in zone 73, due to a hurricane that came ashore at Beaufort, South Carolina on August 11, 1940. This portion of the Southern Appalachians, in zones 73 and 73S, is highly susceptible to flooding from hurricanes. Floods in zone 73 are also moderately flashy, and have a relatively high bimodality (large floods are substantially larger than more common annual peak discharges). Large floods are not becoming larger at this time, though moderate- to bankfull-scale floods are becoming larger (+7.7% and +5.6%, respectively). The smallest annual peak discharges, during dry years, are becoming smaller (-5.0%); dry years may be becoming drier in zone 73. Large floods are not becoming more frequent, and flashiness is not increasing.

Helene Flooding and Streamgage Flood-Frequency Analyses

Streamgages within the vicinity of the Virginia-North Carolina-Tennessee borders and the Virginia Creeper Trail, including available peak discharges from the Helene event, were analyzed using standard streamgage flood-frequency analysis techniques. These gages, and their contributing watersheds, are shown in Figure 7. Whitetop Laurel Creek, which the Creeper Trail follows and repeatedly crosses, is not streamgaged. The streamgage analyses results were compared with the results of ungaged analysis techniques; since the bridge crossings and other points of interest for the Virginia Creeper Trail are all at ungaged locations, a comparison at sites with streamgages for a range in watershed sizes will provide guidance and quality assurance for peak discharge predictions at ungaged locations. Both the streamgage analyses and the ungaged analyses were performed in the Flood Potential Portal (https://floodpotential.erams.com/). Plots of the annual peak discharges and the streamgage analysis results are presented in Appendix A.

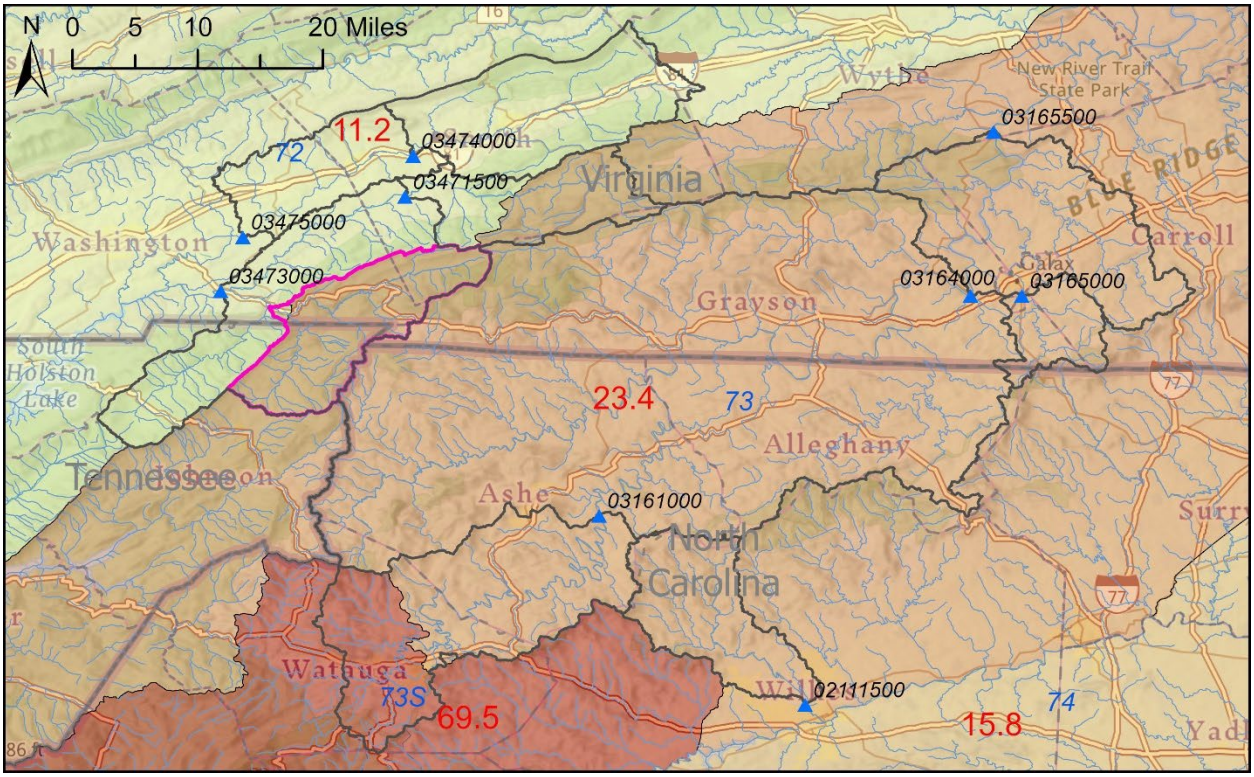


Figure 7: Streamgages (blue triangles) and contributing watersheds (dark-gray polygons) in vicinity of the Virginia Creeper Trail. The magenta polygon illustrates Whiterock Laurel Creek watershed at Damascus, Virginia. Flood potential zones are shown, indicating that floods are substantially larger in the Blue Ridge Mountains than in this portion of the Valley and Ridge. Zone IDs (blue text) and flood potential index (P_f) values (red text) are also shown.

Available streamgage data (Table 1; posted before 6/17/2025) indicate that this region experienced large and notable floods from the remnants of Hurricane Helene, but this event was generally not unprecedented across zone 73. The expansive record for the New River at Ivanhoe, VA (03165500; Figure 14) illustrates the large floods that have repeatedly impacted this portion of the Appalachians, from hurricane remnants. (See the Flood Potential Portal Streamgage Analysis module to dynamically interact with these streamgage data.) This streamgage has recorded both typical annual peak discharge events (median = 22,700 cfs) and five large mode floods (100,000 cfs: 9/1/1878; 132,000 cfs: 7/16/1916; 155,000 cfs : 8/14/1940; 91,600 cfs: 11/7/1977; 127,000 cfs: 9/27/2024). These two scales of floods indicate that bimodality is present within this dataset and across this zone, with normal- and high-mode events from different flood-producing mechanisms. Generally, floods induced by Helene were at or lower than the 100-year (1% chance of occurrence) scale design flood discharge (1.03 to 0.61 multiplier).

Table 1: Streamgages in the vicinity of the Virginia Creeper Trail, with watersheds dominated by zones 73 and 72 characteristics. Record peak discharge values are provided, alongside of Helene peak discharge values. Bold discharge values: selected design flood discharge estimate. $Q_{100\ GageL}$, $Q_{100\ GageH}$: Lowest and highest estimated 100 year (1% change of exceedance) streamgage analysis result. Q_{efp}: expected flood potential discharge; $Q_{100\ Index}$: 100-year peak discharge estimate from the Index method; $Q_{100\ Reg}$: 100-year peak discharge estimate from the Regional Regression Equations method.

USGS ID	Zone	Record Length	Area	Peak Q	Peak Q Date	Helene Peak Q	Possible Design Flood Discharges (cfs)				
			(mi^2)	(cfs)		(cfs)	$Q_{100\ GageL}$	$Q_{100\ GageH}$	Q_{efp}	$Q_{100\ Index}$	$Q_{100\ Reg}$
02111500	73	83	89.3	27,000	8/14/1940	10,400	14,100	**14,400**	19,300	20,600	12,900
03161000	73, 73S	98	204	52,800	8/14/1940	37,100	29,200	**40,000**	73,100	69,700	25,800
03164000	73, 73S	95	1140	141,000	8/14/1940	108,000	104,000	**105,000**	180,000	168,000	98,900
03165000	73	81	39.4	11,000	8/14/1940	6230	9600	9770	**10,200**	10,400	13,500
03165500	73, 73S	84	1350	155,000	5/14/1940	127,000	132,000	**141,000**	200,000	184,000	109,000
03451500	73, 72	96	76.5	11,700	9/27/2024	11,700	8230	8290	15,600	**14,700**	13,200
03473000	73, 72	94	303	26,500	3/1/1867	26,400	23,800	23,900	42,600	39,700	**32,700**
03474000	72	83	131	14,500	11/6/1977	11,800	14,600	**15,000**	12,500	12,100	17,400
03475000	72	73	206	12,500	11/7/1977	10,000	13,200	13,800	17,100	**15,700**	24,300

However, streamgage data on the S.F. Holston River at Riverside, Virginia (03471500; Figure 15) and the S.F. Holston River near Damascus, Virginia (03473000; Figure 16) indicate this portion of zone 73, on the leeward side of the Blue Ridge Mountains (from hurricane remnants that track along the axis of the Appalachians) and adjacent to and downstream of Whiterock Laurel Creek, may have experienced flooding that was more exceptional than further East. The gage at 03471500 experienced a flood-of-record from Helene (Table 1), with a peak discharge of 11,700 cfs (previous peak Q = 9600 cfs on 11/6/1977). Downstream, gage 03473000 experienced a peak discharge (26,400 cfs) essentially equal to the flood of record on 3/1/1867 (26,500 cfs). It is possible that flooding characteristics of this northwest edge of the Blue Ridge Mountains are shifting, with hurricane remnants causing enhanced flooding that have been more commonly experienced further east in zone 73. It was assumed this is the case when the boundary between zones 73 and 72 was shifted northwest to the base of the Blue Ridge Mountains in updated analyses made available in the Flood Potential Portal in the Spring of 2025.

To understand possible bias in peak discharge predictions to be used for the Virginia Creeper Trail reconstruction, streamgage flood-frequency analyses were performed for the nine sets of annual peak discharge data, using the Bulletins 17C (England et al., 2018) and 17B (IACWD, 1982) methods and both the station skew and weighted generalized skew (yielding four sets of results). These results were compared to the three sets of predictions for ungaged watersheds. The analyses were performed in the Flood Potential Portal Streamgage Analysis and Watershed Analysis modules. Ungaged analysis methods, all streamgage based, were the flood potential (Yochum et al., 2019), index flood frequency (Yochum et al., 2024), and USGS regional regression equations flood frequency (Austin et al., 2011) as computed in StreamStats (Ries et al., 2024). Five possible 100-year return interval (1% chance of exceedance) scale design flood discharges are provided in Table 1. Bold values indicate the selected design-flood discharge estimate at each streamgage; the median value (3rd largest) or the 2nd largest was selected, based upon engineering judgement. The highest streamgage analysis result was selected for five of the nine analyses, while for the other four the streamgage analysis result was low and a watershed analysis result was instead used.

To quantify how well each of the ungaged analysis methods perform for predicting peak discharges, it is assumed that the seven streamgaged watersheds predominantly in zone 73 are surrogates for the actual locations where design flood discharge values are needed for the reconstruction of the Virginia Creeper Trail. Though in this situation, the streamgaged watersheds typically have substantially larger watershed areas than the locations needing predictions. With relative bias (β) computed as each peak discharge estimate divided by the selected design flood discharge value, Figure 8 indicates how bias varies by watershed size and ungaged prediction method. Generally, both the expected flood potential (Q_{efp}) and index ($Q_{100\ Index}$) methods tend to overpredict design flood discharges for larger watershed sizes, while the USGS regional regressions ($Q_{100\ Regional\ Regression}$) method tends to underpredict for larger watershed sizes.

Overall, all three ungaged methods perform relatively well for watersheds smaller than 100 mi^2, though the regional regression method overpredicted the design flood discharge for the smallest streamgaged watershed (39.4 mi^2). With the Whitetop Laurel Creek at Damascus having a watershed area of 98.4 mi^2 and all of the locations where predictions are needed having smaller watersheds, it appears that any of the estimates could perform well for identifying the most appropriate design flood discharge estimate, but the regional regression result may overpredict in smaller watersheds.

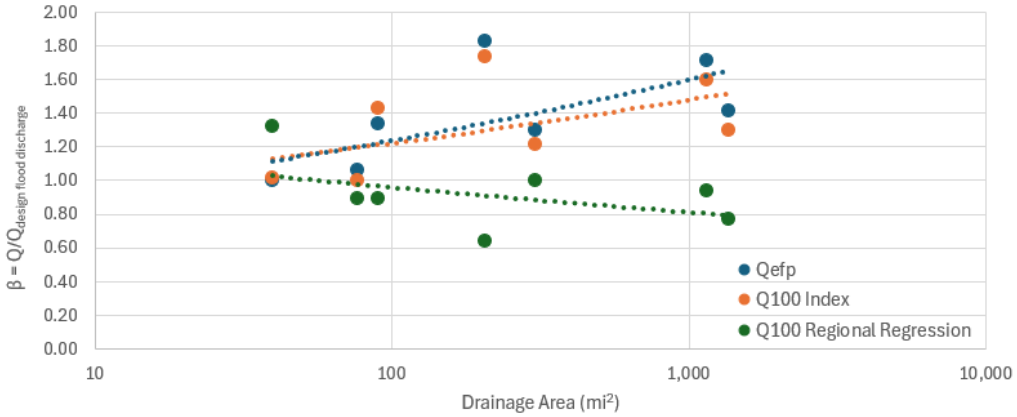


Figure 8: Relative prediction bias (β) of the expected flood potential discharge (Q_{efp}), 100-year (1% chance of exceedance) index flood frequency ($Q_{100\ Index}$), and 100-year USGS regional regression ($Q_{100\ Regional\ Regression}$) results, by watershed area for flood potential zone 73. $\beta = Q/Q_{design\ flood\ discharge}$ as shown in Table 1.

Discharges from High Water Marks

The U.S. Geological Survey (Marion, Virginia field station) marked and surveyed high water marks for numerous locations along the Virginia Creeper Trail and within the Whiterock Laurel Creek watershed (USGS, 2025). Using these provided peak stage indicators, peak discharge estimates were computed for six locations (Table 2), to develop understanding of the severity of the flooding experienced within the Whitetop Laurel watershed. (Appendix B provides the cross section locations and computations.) The peak discharges were compared to 100-year (1% chance of exceedance) scale peak discharge estimates generated from the Flood Potential Portal Watershed Analysis module. The maximum likely flood potential discharges (Q_{mlf}; upper 90% prediction limit of the flood potential regressions) were also tabulated. Floods greater than the Q_{mlf} are systematically defined as extreme using the Flood Potential Method (Yochum et al., 2019). The flood extreme index was also provided ($E_f = Q/Q_{efp}$), with an $E_f = 1$ being similar (or identical to) the 100-year scale design flood discharge event. Finally, the flood severity is provided for each location, based on a new Flood Severity Scale that is currently in testing for use in ranking the sizes of floods experienced across the United States.

Table 2: Preliminary and approximate peak discharge estimates on Whitetop Laurel Creek and Valley Creek at Taylors Valley, compared to the expected flood potential discharge (Q_{efp}), maximum likely flood potential discharge (Q_{mlf}), and the 100-year (1% chance of occurrence) discharges for the Index method ($Q_{100\ Index}$) and Regional Regression Equations method ($Q_{100\ Reg}$). E_f = flood extreme index = Q/Q_{efp} (Yochum et al., 2024).

Stream	Location	Peak Q (cfs)	Q_{efp} (cfs)	Q_{mlf} (cfs)	$Q_{100\ Index}$ (cfs)	$Q_{100\ Reg}$ (cfs)	E_f	Extreme?	Flood Severity
Whitetop Laurel Creek	Damascus	29,000	20,900	32,000	19,800	18,600	1.39	No	Fl-4
Whitetop Laurel Creek	Taylors Valley	19,000	11,100	17,100	11,700	13,200	1.71	Yes	Fl-4
Valley Creek	Taylors Valley	3,100	2,110	3,260	2,180	3,310	1.47	No	Fl-4
Sturgill Branch	creek mouth	1930	933	1,440	1,090	2,190	2.07	Yes	Fl-5
Whitetop Laurel Creek	above Sturgill	12,000	5,970	9,180	6,750	8,250	1.93	Yes	Fl-5
Whitetop Laurel Creek	above Big Branch	5,390	3,460	5,330	4,110	5,600	1.56	Yes	Fl-4

Generally, these analyses indicate that floods induced in the Whitetop-Laurel watershed from Hurricane Helene exceeded the size of floods that most infrastructure is designed to safely pass during floods (E_f ranged from 2.07 in the headwaters to 1.39 at Damascus). In some places, the flooding was extreme as systematically defined by the Flood Potential Method (Yochum et al., 2019). Using the preliminary version of the Flood Severity Scale that is currently being tested (see descriptions below), this event was at the Fl-4 and Fl-5 levels. Fl-4 indicates that peak discharges exceeded design and base flood discharge, with infrastructure damage, extensive floodplain inundation, and some extreme magnitudes expected, and Fl-5 indicates that the event was a major flood, with extreme magnitudes and catastrophic consequences. These descriptions appear to well describe flood experiences of infrastructure and communities during the Helene event in this area.

The critical depth method was used estimate the peak discharges; this method assumes these streams are generally alluvial and were steep enough and the discharge great enough so that critical flow was experienced during the flooding. Preliminary hydraulic modeling indicates that this assumption is reasonable in these streams for large floods. An additional assumption is that the USGS-Virginia-FEMA-sourced LiDAR data well matches the vertical control used by the USGS for surveying the high water marks.

The Flood Severity column of Table 2 refers to the Flood Severity Scale, a method currently being tested for systematically ranking the severity of riverine floods in the United States. Using more than 8200 streamgages across the contiguous United States where at least 10 years of annual peak discharges have been recorded over the full periods of record (through 2022), for a total of more than 367,000 data points, this scale uses the flood extreme index (E_f) to categorize discharges measured at streamgages into the 6 level Flood Severity Scale.

Descriptions of the Flood Severity Scale levels (using 367,712 annual peak discharge records):

- **Fl-1**: Small to moderate magnitude flooding, with consistent out-of-channel flow (> 2 year return interval / 50% probability of annual exceedance). $0.210 \leq E_f < 0.538$. 1 in 2 (183,856) annual peak discharge values have exceeded this magnitude of flooding.
- **Fl-2**: Moderate to large magnitude flooding. $0.538 \leq E_f < 0.883$. 1 in 8 (45,964) annual peak discharge values have exceeded this magnitude of flooding.
- **Fl-3**: Design flood / base flood discharge event (~100-year return interval / ~1% probability of annual exceedance). $0.883 \leq E_f < 1.27$. 1 in 32 (11,491) annual peak discharge values have exceeded this magnitude of flooding.
- **Fl-4**: Exceeds design and base flood discharge, with infrastructure damage, extensive floodplain inundation, and some extreme magnitudes. $1.27 \leq E_f < 1.73$. 1 in 128 (2872) annual peak discharge values have exceeded this magnitude of flooding.
- **Fl-5**: Major flood, with extreme magnitudes and catastrophic consequences. $1.73 \leq E_f < 2.67$. 1 in 512 (718) annual peak discharge values have exceeded this magnitude of flooding.
- **Fl-6**: Extreme flooding, with extensive catastrophic consequences. $2.67 \leq E_f$. 1 in 2048 (180) annual peak discharge values have exceeded this magnitude of flooding.

Design Flood Discharge Predictions

Recommendations are provided for design flood discharges at the 100-year (1% chance of occurrence) scale for the Virginia Creeper Trail reconstruction based on results provided by the Flood Potential Portal (https://floodpotential.erams.com/) Watershed Analysis module (Figure 9). At each site, three sets of results are furnished by this module and reported, and a most appropriate value designated (Table 3; GIS shapefile). Recommended design flood discharges at each bridge are also provided (Table 4).

Prediction methods currently available in the Watershed Analysis module are the Flood Potential method (Yochum et al., 2019), Index flood-frequency method (Yochum et al., 2024), and USGS regional regression equations flood-frequency method (Austin et al., 2011) as computed in StreamStats (Ries et al., 2024) and automatically imported into the Flood Potential Portal results. These design flood discharges are expected to be experienced, which could occur in any year. This what a design flood discharge is – the size of large flood we can expect and should design and plan for.

With the finding that the USGS regional regression results may overpredict in some smaller watersheds (< ~40 mi^2) and considering the documented extreme or near-extreme nature of this flooding in the Whitetop Laurel Creek watershed, the median result is recommended for use rather than the highest, which was generally the regional regression result in these relatively small watersheds. Typically the median result is recommended for use when utilizing the Flood Potential Portal for peak discharge estimation.

Additionally, reflecting observed flooding induced from Hurricane Helene and recorded and published by the USGS, the Flood Potential Portal was updated. Specifically: (1) the zone boundary between zones 73 and 72 was shifted northwest to the edge of the Blue Ridge physiographic province (Damascus); and (2), algorithms used in the Flood Potential and Index Flood analyses were updated to account for new data (including Helene peak discharges) and the shifted boundary. These updates are integrated into the peak discharge estimates recommended for use for the Virginia Creeper Trail reconstruction.

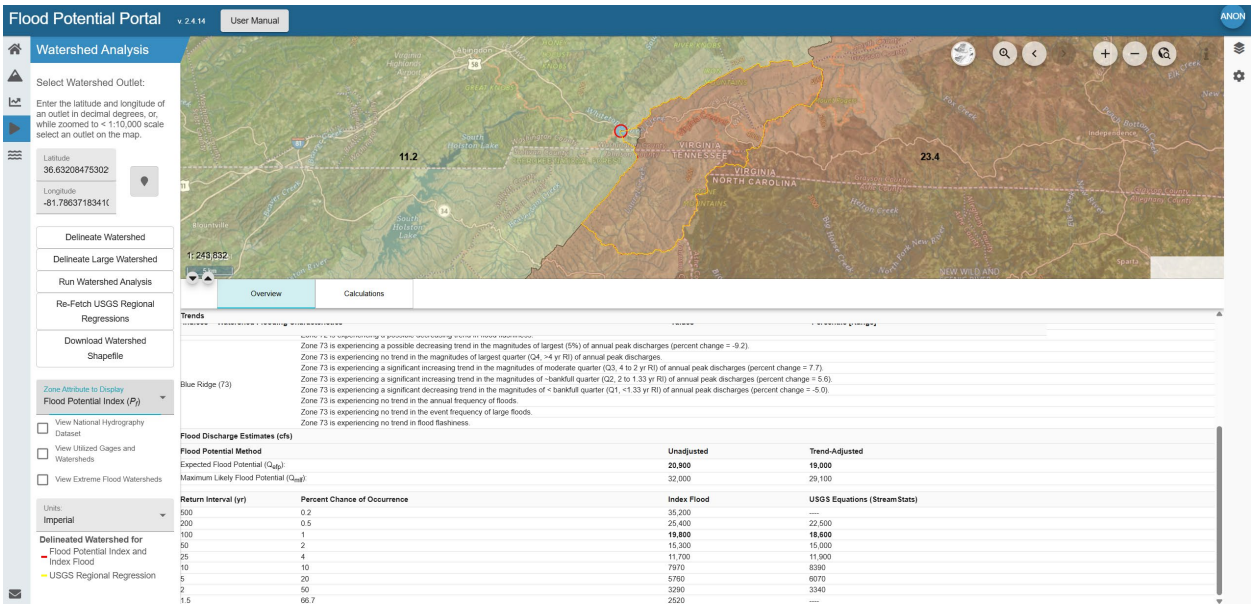


Figure 9: Flood Potential Portal Watershed Analysis module results for Whitetop Laurel Creek at Damascus.

Table 3: Recommended design flood discharge values (**in bold**) from downstream to upstream, with flood potential discharges, and flood-frequency discharges for the Virginia Creeper Trail reconstruction project. Shaded values are directly comparable at the 100-year (Q_{100}; 1% chance of occurrence) scale flood level, and are generally appropriate for selection as the design flood discharge. Q_{efp}: expected flood potential discharge; Q_{mlf}: maximum likely flood potential discharge. See GIS shapefile for mapped locations.

ID	Q_{efp} (cfs)	Q_{mlf} (cfs)	Q_{500} (cfs)	Q_{200} (cfs)	Q_{100} (cfs)	Q_{50} (cfs)	Q_{25} (cfs)	Q_{10} (cfs)	Q_{5} (cfs)	Q_{2} (cfs)	$Q_{1.5}$ (cfs)
WLC-1	20,900	32,000	Whitetop Laurel Creek (Laurel Creek) at Damascus, at Bridge 17; drainage area: 98.4 mi^2								
		Index:	35,200	25,400	**19,800**	15,300	11,700	7,970	5,760	3,290	2,520
		Regional Regressions:	----	22,500	18,600	15,000	11,900	8,390	6,070	3,340	----
LC-1	10,500	16,100	Laurel Creek upstream of Whitetop Laurel Creek confluence; drainage area: 41.0 mi^2								
		Index:	16,200	11,700	9,080	6,990	5,330	3,620	2,610	1,480	1,130
		Regional Regressions:	----	11,700	**9,630**	7,850	6,260	4,410	3,190	1,740	----
WLC-2	13,400	20,500	Whitetop Laurel Creek upstream of Laurel Creek; drainage area: 56.0 mi^2								
		Index:	24,600	17,800	**13,800**	10,600	8,080	5,490	3,950	2,250	1,720
		Regional Regressions:	----	17,700	14,400	11,400	8,860	6,080	4,290	2,260	----
WLC-3	13,100	20,100	Whitetop Laurel Creek upstream of Bridge 21; drainage area: 54.3 mi^2								
		Index:	24,200	17,400	**13,500**	10,400	7,930	5,390	3,880	2,210	1,690
		Regional Regressions:	----	17,500	14,300	11,200	8,750	6,000	4,210	2,220	----
SB-1	2,790	4,310	Straight Branch at mouth, upstream of Bridge 22; drainage area: 7.5 mi^2								
		Index:	5,270	3,800	**2,950**	2,270	1,730	1,170	850	480	370
		Regional Regression:	----	3,910	3,180	2,580	2,010	1,380	970	500	----
WLC-4	11,400	17,500	Whitetop Laurell Creek upstream of Straight Branch; drainage area: 45.6 mi^2								
		Index:	21,400	15,400	**12,000**	9,210	7,020	4,770	3,430	1,950	1,490
		Regional Regression:	----	16,600	13,500	10,500	8,100	5,490	3,810	1,970	----
WLC-5	11,300	17,300	Whitetop Laurel Creek upstream of Bridge 25; drainage area: 44.8 mi^2								
		Index:	21,100	15,200	**11,800**	9,110	6,940	4,720	3,390	1,930	1,480
		Regional Regression:	----	16,500	13,400	10,400	8,030	5,440	3,780	1,950	----
WLC-6	11,100	17,100	Whitetop Laurel Creek in Taylors Valley, downstream; drainage area: 44.1 mi^2								
		Index:	21,000	15,100	**11,700**	9,020	6,870	4,670	3,360	1,910	1,460
		Regional Regressions:	----	16,500	13,300	10,300	7,980	5,400	3,750	1,930	----
UN-1	460	710	unnamed creek in Taylors Valley, downstream of Valley Creek; drainage area: 0.74 mi^2								
		Index:	860	620	**480**	370	280	190	140	78	60
		Regional Regressions:	----	960	760	600	450	290	190	90	----
VC-1	2,110	3,250	Valley Creek at mouth, in Taylors Valley; drainage area: 5.23 mi^2								
		Index:	3,900	2,810	**2,180**	1,680	1,280	870	630	360	270
		Regional Regressions:	----	4,130	3,310	2,510	1,900	1,260	840	410	----
WLC-7	9,910	15,200	Whitetop Laurel Creek in Taylors Valley, upstream of Valley Creek; drainage area: 38.1 mi^2								
		Index:	19,000	13,700	**10,600**	8,170	6,230	4,230	3,050	1,730	1,320
		Regional Regressions:	----	15,400	12,500	9,620	7,390	4,970	3,430	1,750	----
WOB-1	380	580	White Oak Branch at mouth, at bridge 28; drainage area: 0.57 mi^2								
		Index:	730	530	**410**	320	240	160	120	67	51
		Regional Regressions:	----	1,120	880	640	470	300	190	83	----
WLC-8	9,730	14,900	Whitetop Laurel Creek upstream of White Oak Branch; drainage area: 37.2 mi^2								
		Index:	18,700	13,500	**10,400**	8,040	6,130	4,170	3,000	1,700	1,300
		Regional Regressions:	----	15,300	12,300	9,500	7,300	4,910	3,380	1,720	----
WLC-9	9,600	14,700	Whitetop Laurel Creek upstream of Bridge 30; drainage area: 36.5 mi^2								
		Index:	18,500	13,300	**10,300**	7,950	6,060	4,120	2,960	1,690	1,290
		Regional Regressions:	----	15,100	12,200	9,400	7,220	4,850	3,340	1,700	----
WLC-10	9,480	14,600	Whitetop Laurel Creek upstream of Steep Branch; drainage area: 36.0 mi^2								
		Index:	18,300	13,200	**10,200**	7,870	6,000	4,080	2,940	1,670	1,280
		Regional Regressions:	----	14,900	12,100	9,320	7,160	4,810	3,310	1,680	----
WLC-11	9,350	14,400	Whitetop Laurel Creek downstream of Bridge 36; drainage area: 35.3 mi^2								
		Index:	18,100	13,000	**10,100**	7,780	5,930	4,030	2,900	1,650	1,260
		Regional Regressions:	----	14,900	12,000	9,210	7,070	4,750	3,260	1,660	----
WLC-12	9,220	14,200	Whitetop Laurel Creek at Creek Junction; drainage area: 34.7 mi^2								
		Index:	17,800	12,900	**9,980**	7,680	5,850	3,980	2,860	1,630	1,250
		Regional Regressions:	----	14,700	11,900	9,120	7,010	4,700	3,230	1,640	----

ID	Q_{efp} (cfs)	Q_{mlf} (cfs)	Q_{500} (cfs)	Q_{200} (cfs)	Q_{100} (cfs)	Q_{50} (cfs)	Q_{25} (cfs)	Q_{10} (cfs)	Q_5 (cfs)	Q_2 (cfs)	$Q_{1.5}$ (cfs)
WLC-13	6,850	10,500	Whitetop Laurel Creek upstream of Bridge 38 & Green Cove Creek; drainage area: 23.7 mi^2								
		Index:	13,700	9,840	**7,640**	5,880	4,480	3,050	2,190	1,250	950
		Regional Regressions:	----	11,400	9,240	7,060	5,400	3,620	2,470	1,240	----
GCC-1	3,720	5,730	Green Cove Creek at mouth, downstream of Bridge 39; drainage area: 10.8 mi^2								
		Index:	7,160	5,160	**4,000**	3,080	2,350	1,600	1,150	650	500
		Regional Regressions:	----	7,830	6,260	4,640	3,490	2,280	1,510	720	----
CB-1	230	360	Chestnut Branch at mouth, upstream of Bridge 40; drainage area: 0.3 mi^2								
		Index:	470	340	**260**	200	150	100	75	43	33
		Regional Regression:	----	980	760	520	370	230	140	58	----
GCC-2	3,520	5,430	Green Cove Creek upstream of Chestnut Branch; drainage area: 10.1 mi^2								
		Index:	6,820	4,910	**3,810**	2,940	2,240	1,520	1,090	620	480
		Regional Regression:	----	7,530	6,020	4,450	3,350	2,180	1,450	690	----
GCC-3	3,440	5,300	Green Cove Creek downstream of Star Hill Branch; drainage area: 9.8 mi^2								
		Index:	6,670	4,810	**3,730**	2,870	2,190	1,490	1,070	610	470
		Regional Regression:	----	7,390	5,910	4,370	3,280	2,140	1,420	680	----
SHB-1	860	780	Star Hill Branch at mouth, upstream of Bridge 42; drainage area: 1.7 mi^2								
		Index:	1,730	1,240	**970**	740	570	390	280	160	120
		Regional Regressions:	----	2,590	2,050	1,450	1,070	670	430	190	----
UN-2	650	1000	unnamed creek upstream of Bridge 43; drainage area: 1.2 mi^2								
		Index:	1,320	950	**740**	570	430	300	210	120	90
		Regional Regressions:	----	2,120	1,670	1170	860	540	340	150	----
GGC-4	2,630	4,060	Green Cove Creek upstream of unnamed creek under Bridge 43; drainage area: 7.0 mi^2								
		Index:	5,190	3,740	**2,900**	2,230	1,700	1,160	830	470	360
		Regional Regression:	----	6,040	4,820	3,530	2,640	1,710	1,130	830	----
MQB-1	520	800	McQueen Branch at mouth; drainage area: 0.9 mi^2								
		Index:	1,020	740	**570**	440	340	230	160	93	71
		Regional Regression:	----	1,790	1,410	980	720	450	280	120	----
GCC-5	2,270	3,510	Green Cove Creek upstream of McQueen Branch; drainage area: 5.8 mi^2								
		Index:	4,550	3,280	**2,550**	1,960	1,490	1,020	730	420	320
		Regional Regression:	----	5,410	4,310	3,150	2,350	1,520	990	460	----
GCC-6	2,240	3,460	Green Cove Creek downstream of Bridge 44; drainage area: 5.7 mi^2								
		Index:	4,490	3,240	**2,510**	1,930	1,470	1,000	720	410	310
		Regional Regressions:	----	5,310	4,230	3,090	2,300	1,480	970	450	----
BB-1	1,180	1,820	Buckeye Branch at mouth; drainage area: 2.5 mi^2								
		Index:	2,290	1,650	**1,280**	990	750	510	370	210	160
		Regional Regressions:	----	3,300	2,610	1,870	1,380	880	570	250	----
GCC-7	1,350	2,080	Green Cove Creek upstream of Buckeye Branch; drainage area: 3.0 mi^2								
		Index:	2,860	2,060	**1,600**	1,230	940	640	460	260	200
		Regional Regressions:	----	3,670	2,910	2,090	1,550	990	640	290	----
GCC-8	1,020	1,570	headwaters Green Cove Creek upstream of Creeper Trail; drainage area: 2.1 mi^2								
		Index:	2,240	1,620	**1,250**	970	740	500	360	210	160
		Regional Regression:	----	2,970	2,350	1,680	1,240	780	500	220	----
HTB-1	120	190	High Trestle Branch at Bridge 46; drainage area: 0.1 mi^2								
		Index:	270	190	**150**	120	88	60	43	24	19
		Regional Regression:	----	590	460	310	220	130	79	32	----
BC-1	580	900	Burgess Creek at Bridge 47; drainage area: 1.0 mi^2								
		Index:	1,220	880	**680**	520	400	270	200	110	85
		Regional Regression:	----	1,950	1,540	1,080	790	490	310	140	----

Table 4: Recommended design flood discharges at Virginia Creeper Trail bridges (trestles) 17 through 47.

Bridge Number	Analysis ID	Design Flood Discharge (cfs)
17	WLC-1	19,800
18	WLC-2	13,800
19	WLC-2	13,800
20	WLC-2	13,800
21	WLC-3	13,500
22	SB-1	2,950
23	WLC-4	12,000
24	WLC-4	12,000
25	WLC-5	11,800
26	WLC-5	11,800
27	WLC-7	10,600
28	WOB-1	410
29	WLC-8	10,400
30	WLC-9	10,300
31	WLC-9	10,300
32	WLC-10	10,200
33	WLC-10	10,200
34	WLC-10	10,200
35	WLC-11	10,100
36	WLC-11	10,100
37	WLC-12	9,980
38	WLC-13	7,640
39	GCC-1	4,000
40	CB-1	260
41	GCC-2	3,810
42	SHB-1	970
43	UN-2	740
44	GCC-6	2,510
45	GCC-6	2,510
46	HTB-1	150
47	BC-1	680

Conclusions

Design flood discharge estimates have been computed for the Virginia Creeper Trail reconstruction effort. To support the development of these estimates, general flooding characteristics of the area have been documented using the Flood Potential Method, flooding from Hurricane Helene at U.S. Geological Survey streamgages have been reviewed, and estimated peak discharges at several locations within the Whitetop Laurel Creek watershed from high water marks surveyed by the U.S. Geological Survey have been computed. These peak discharge estimates are to be used for the hydraulic modeling needed to quantify peak stages, velocities, and shear stresses that the reconstructed trail will be designed to endure when the next large flood occurs.

Data Availability

Recommended design flood discharge values are provided in Table 3 and well as through a GIS Shapefile (https://y-water.com/wp-content/uploads/DesignQ_VACreeperTrail_2025-7.zip). Supporting streamgage, watershed, and peak discharge analyses are provided in the Appendices, with the exported Flood Potential Portal Watershed Analysis module results available for download (https://y-water.com/wp-content/uploads/VACreeperTrail_FPP_WatershedAnalyses.zip).

Acknowledgements

Review of this report by Zack Mondry and Tyler Wible has been greatly appreciated. Zack Mondry is also appreciated for his diligence in working with NSAEC on the hydrology and hydraulic analyses portions of the Virginia Creeper Trail reconstruction project, including providing insights, data, and surveying information, as well as for accompanying NSAEC staff in the field. Personnel at One Water Solutions Institute at Colorado State University are greatly appreciated for the development of the Flood Potential Portal. Additionally, appreciation is also expressed to the U.S. Geological Survey staff and contractors who marked and surveyed high water indicators from the Helene flooding, collected and analyzed streamgage stage and discharge data, and developed and maintained the StreamStats application.

References

Amorim, R., Villarini, G., Czajkowski, J., Smith, J. (2025). Flooding from Hurricane Helene and associated impacts: A historical perspective. Journal of Hydrology X, 27, 100204. doi:10.1016/j.hydroa.2025.100204.

Austin, S.H., Krstolic, J.L., Wiegand, U. (2011). Peak-Flow Characteristics of Virginia Streams. U.S. Geological Survey. Scientific Investigations Report 2011-5144.

England, J.F., Cohn, T.C., Faber, B.A., Stedinger, J.R., Thomas, W.O., Veilleux, A.G., Kiang, J.E., Mason, R.R. (2018). Guidelines for determining flood flow frequency—Bulletin 17C. U.S. Geological Survey Techniques and Methods, book 4, chap. B5, 148 p.

Interagency Advisory Committee on Water Data. (1982). Guidelines for Determining Flood Flow Frequency: Bulletin #17B for the Hydrology Subcommittee. U.S. Department of the Interior, Geological Survey, Office of Water Data Coordination, Reston, Virginia.

NCDHHS. (2024). Hurricane Helene Storm Related Fatalities. North Carolina Department of Health and Human Services, Raleigh, North Carolina. Accessed 12/5/2024. https://www.ncdhhs.gov/assistance/hurricane-helene-recovery-resources/hurricane-helene-storm-related-fatalities.

NWS. (2025). Hurricane Helene: Record-Breaking Rainfall and Historic Flooding. National Oceanic and Atmospheric Administration, National Weather Service. Accessed 6/30/2025. https://www.weather.gov/mrx/Hurricane_Helene.

Ries, K.G., III, Steeves, P.A., McCarthy, P. (2024). StreamStats—A quarter century of delivering web-based geospatial and hydrologic information to the public, and lessons learned: U.S. Geological Survey Circular 1514, 40 p., doi:10.3133/cir1514.

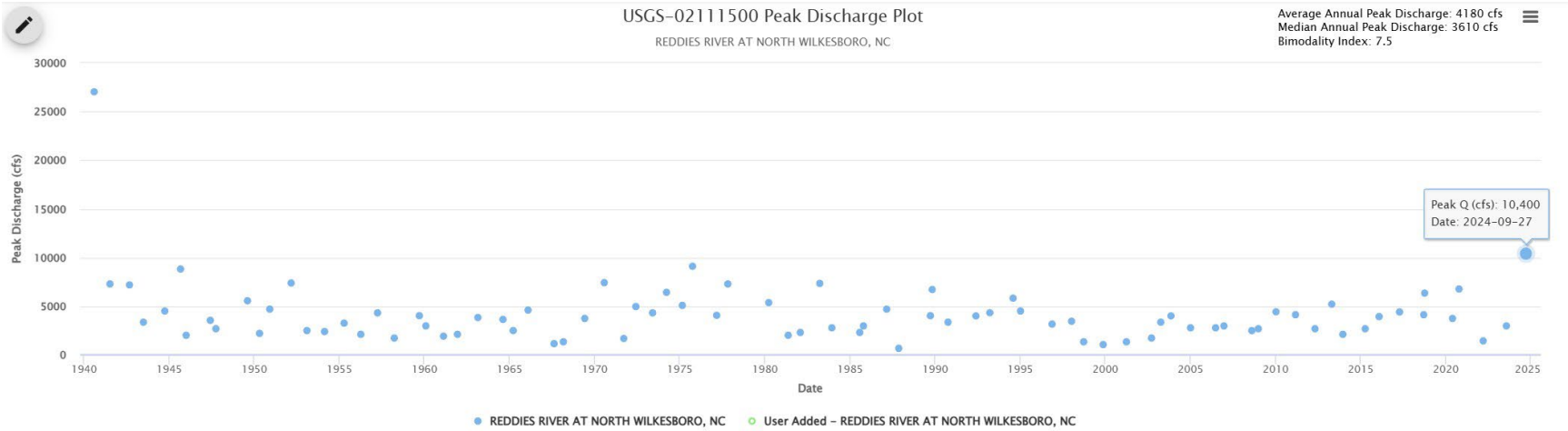
USGS (2025). Flood Event Viewer. U.S. Geological Survey. https://stn.wim.usgs.gov/FEV/#2024Helene Data accessed 6/20/2025.

Yochum, S.E., Scott, J.A., Levinson, D.H. (2019). Methods for Assessing Expected Flood Potential and Variability: Southern Rocky Mountains Region. Water Resources Research, 55, 6392-6416, doi:10.1029/2018WR024604.

Yochum, S.E., Wible, T., Korsa, M., Ghanbari, M., Arabi, M. (2024). Flood Potential Portal: A web tool for understanding flood variability and predicting peak discharges. River Research and Applications, 1-13. doi:10.1002/rra.4354.

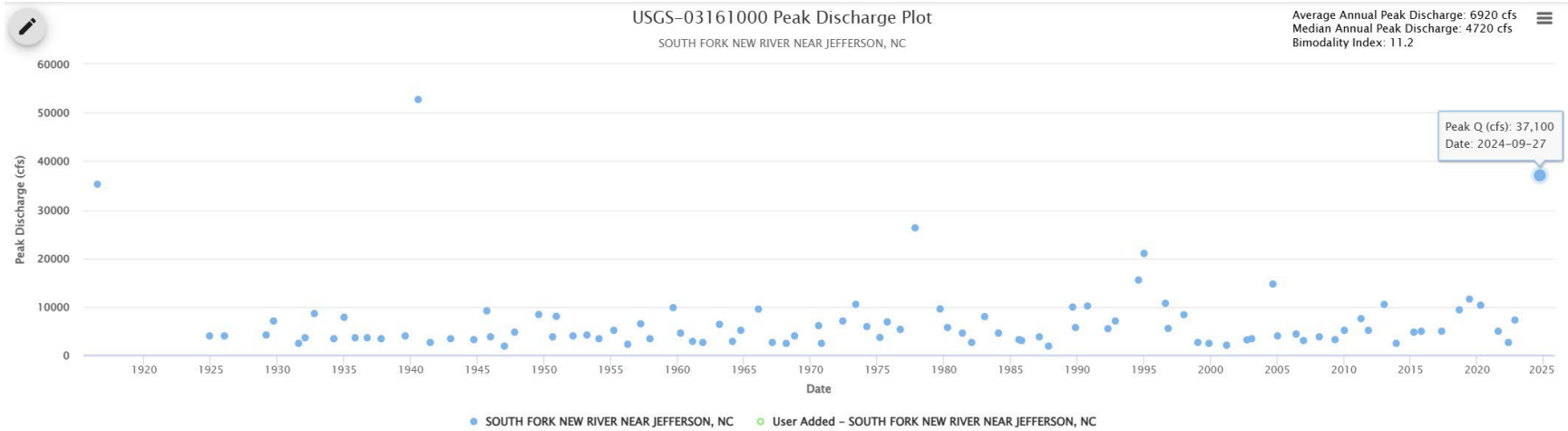
Appendix A: Streamgage Data and Flood-Frequency Analyses

In the vicinity of the Virginia Creeper Trail, nine streamgages have peak discharge values available for the 2024 water year, including the peak discharge values for Hurricane Helene-induced flooding on September 27, 2024. These streamgages have watersheds ranging from 39.4 to 1350 mi^2, and are predominantly in flood potential zones 73 and 72. Peak discharge plots for the available periods of record and the streamgage analysis results, from both Bulletins 17C (England et al., 2018) and 17B (IACWD, 1982) flood-frequency analysis methods, for both station and weighted generalized skews, are providing in Figure 10 through Figure 18.



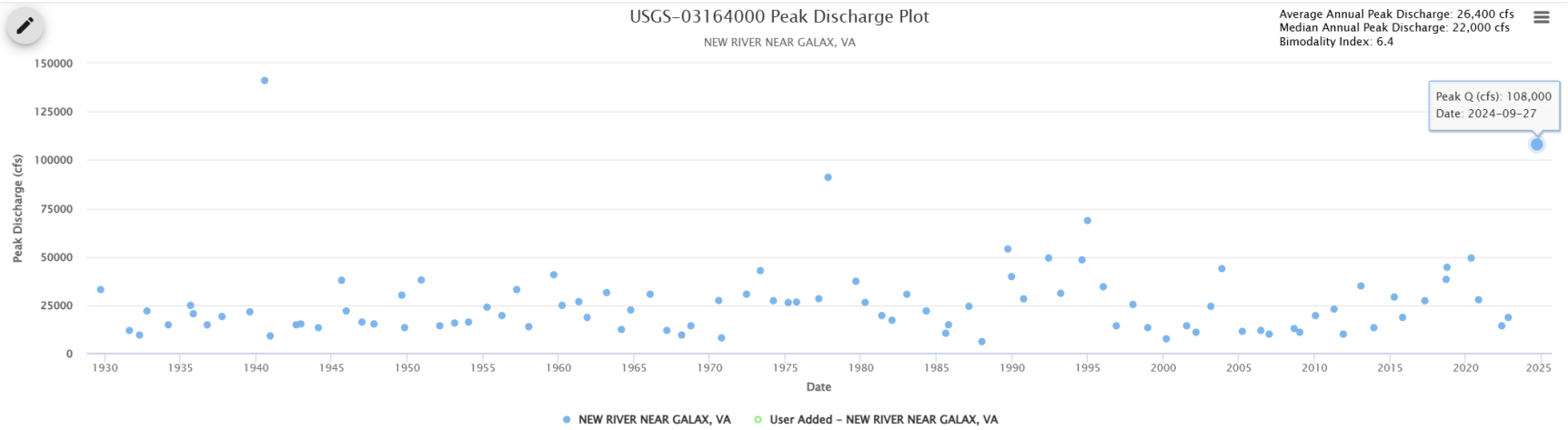
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval Lower	Confidence Interval Upper	Magnitude	Confidence Interval Lower	Confidence Interval Upper	Magnitude	Confidence Interval Lower	Confidence Interval Upper	Magnitude	Confidence Interval Lower	Confidence Interval Upper
500	0.2	20,700	*16,500*	*27,500*	20,000	*16,000*	*26,500*	20,700	*15,100*	*38,500*	20,000	*15,100*	*31,600*
200	0.5	16,900	*13,800*	*21,900*	16,500	*13,500*	*21,300*	16,900	*12,900*	*28,000*	16,500	*12,900*	*24,200*
100	**1**	**14,400**	***11,900***	***18,200***	**14,100**	***11,700***	***17,800***	**14,400**	***11,400***	***21,900***	**14,100**	***11,400***	***19,600***
50	2	12,100	*10,200*	*14,900*	11,900	*10,000*	*14,700*	12,100	*9,870*	*16,900*	11,900	*9,840*	*15,700*
25	4	9,940	*8,520*	*12,000*	9,850	*8,440*	*11,900*	9,940	*8,390*	*12,900*	9,850	*8,360*	*12,400*
10	10	7,410	*6,500*	*8,670*	7,390	*6,480*	*8,640*	7,410	*6,460*	*8,880*	7,390	*6,460*	*8,760*
5	20	5,670	*5,050*	*6,460*	5,670	*5,060*	*6,470*	5,670	*5,020*	*6,510*	5,670	*5,040*	*6,500*
2	50	3,440	*3,100*	*3,830*	3,460	*3,110*	*3,840*	3,440	*3,070*	*3,860*	3,460	*3,100*	*3,870*
1.5	66.7	2,690	*2,400*	*3,000*	2,700	*2,410*	*3,010*	2,690	*2,400*	*3,010*	2,700	*2,410*	*3,010*
1.25	80	2,140	*1,880*	*2,400*	2,140	*1,880*	*2,400*	2,140	*1,890*	*2,400*	2,140	*1,890*	*2,400*
1.05	95.2	1,370	*1,150*	*1,580*	1,360	*1,130*	*1,570*	1,390	*1,140*	*1,590*	1,370	*1,140*	*1,580*

Figure 10: Annual peak discharge data and flood-frequency analysis results for the Reddies River at North Wilkesboro, NC streamgage (USGS ID: 02111500). Helene peak Q: 10,400 cfs. Record peak Q: 27,000 cfs (8/14/1940). Drainage area: 89.3 mi^2.



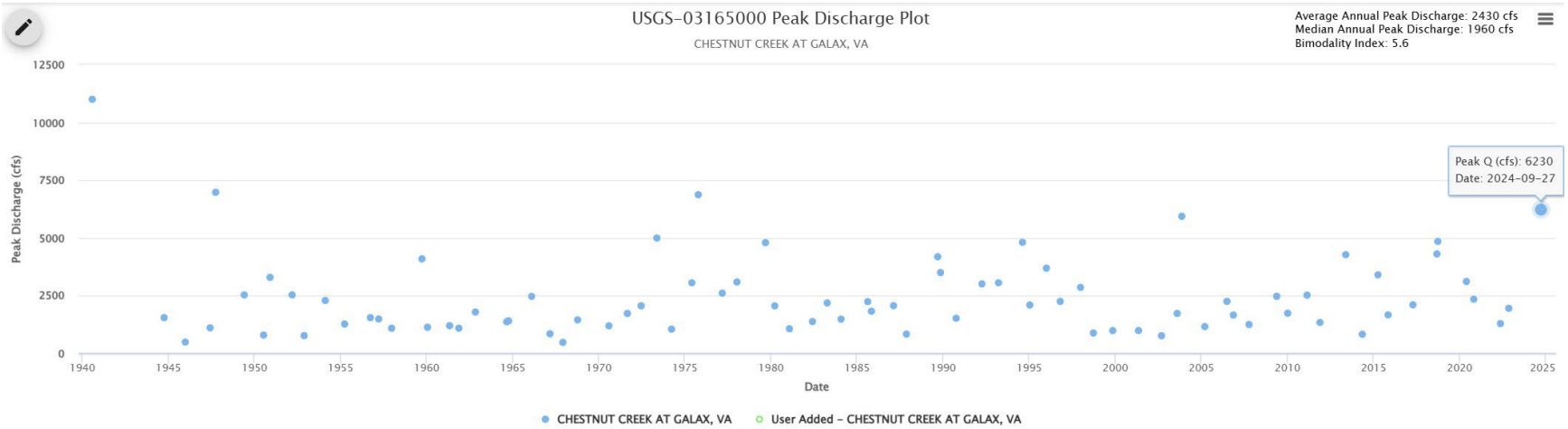
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	84,400	*61,900*	*124,000*	48,100	*37,300*	*66,100*	84,400	*44,200*	*347,000*	48,700	*33,800*	*89,400*
200	0.5	55,400	*42,400*	*77,300*	36,500	*29,100*	*48,400*	55,400	*32,800*	*164,000*	36,800	*26,900*	*60,800*
100	**1**	**40,000**	***31,600***	***53,600***	**29,200**	***23,800***	***37,700***	**40,000**	***25,800***	***93,900***	**29,400**	***22,400***	***45,000***
50	2	28,600	*23,300*	*36,900*	23,100	*19,200*	*29,000*	28,600	*20,100*	*54,400*	23,200	*18,400*	*33,000*
25	4	20,300	*17,000*	*25,100*	18,000	*15,300*	*21,900*	20,300	*15,400*	*32,100*	18,000	*14,800*	*23,900*
10	10	12,600	*11,000*	*14,800*	12,400	*10,800*	*14,600*	12,600	*10,400*	*16,500*	12,400	*10,600*	*15,200*
5	20	8,520	*7,590*	*9,690*	8,950	*7,960*	*10,200*	8,520	*7,280*	*10,300*	8,950	*7,840*	*10,500*
2	50	4,690	*4,200*	*5,220*	5,050	*4,530*	*5,630*	4,690	*4,110*	*5,330*	5,050	*4,520*	*5,670*
1.5	66.7	3,710	*3,290*	*4,150*	3,880	*3,450*	*4,330*	3,700	*3,350*	*4,140*	3,870	*3,470*	*4,310*
1.25	80	3,070	*2,690*	*3,460*	3,050	*2,670*	*3,440*	3,070	*2,830*	*3,360*	3,050	*2,730*	*3,400*
1.05	95.2	2,350	*2,010*	*2,690*	1,980	*1,660*	*2,290*	2,360	*2,070*	*2,760*	2,010	*1,720*	*2,280*

Figure 11: Annual peak discharge data and flood-frequency analysis results for the S.F. New River near Jefferson, NC streamgage (USGS ID: 03161000). Helene peak Q: 37,100 cfs. Record peak Q: 52,800 cfs (8/14/1940). Drainage area: 204 mi^2.



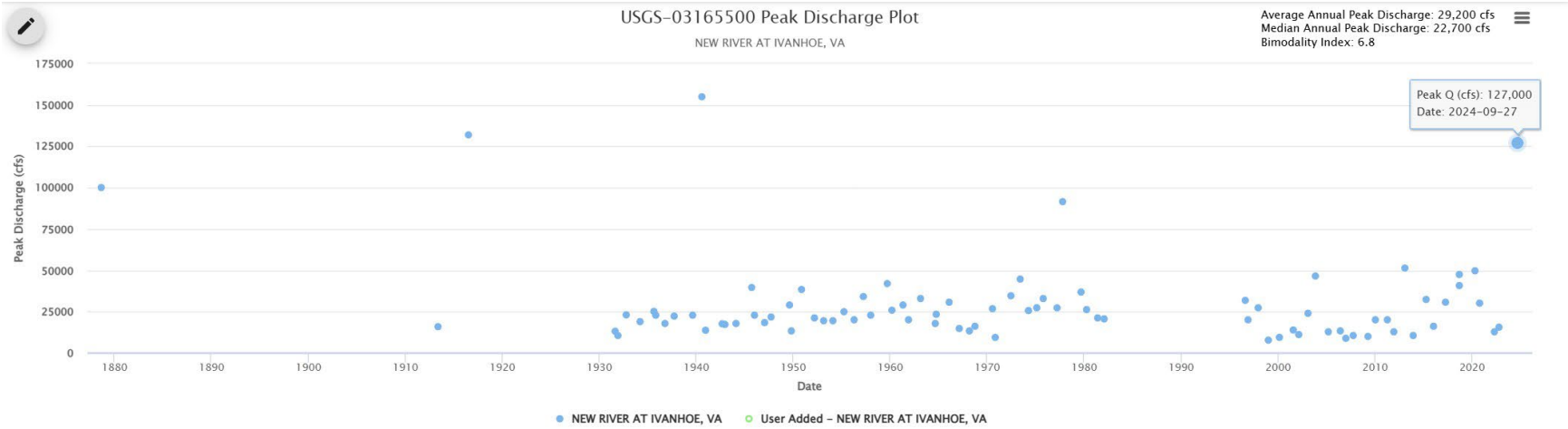
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	169,000	*133,000*	*227,000*	166,000	*131,000*	*223,000*	169,000	*116,000*	*397,000*	166,000	*116,000*	*335,000*
200	0.5	130,000	*105,000*	*169,000*	128,000	*104,000*	*167,000*	130,000	*94,800*	*255,000*	128,000	*94,700*	*225,000*
100	**1**	**105,000**	***86,800***	***133,000***	**104,000**	***86,100***	***132,000***	**105,000**	***80,300***	***181,000***	**104,000**	***80,200***	***166,000***
50	2	84,400	*71,000*	*104,000*	83,800	*70,600*	*103,000*	84,400	*67,100*	*129,000*	83,800	*67,100*	*122,000*
25	4	66,700	*57,300*	*80,100*	66,400	*57,100*	*79,800*	66,700	*55,100*	*91,400*	66,400	*55,100*	*88,700*
10	10	47,200	*41,700*	*54,700*	47,200	*41,700*	*54,700*	47,200	*40,800*	*57,700*	47,200	*40,800*	*57,400*
5	20	34,900	*31,400*	*39,400*	35,000	*31,400*	*39,500*	34,900	*30,900*	*40,400*	35,000	*31,000*	*40,400*
2	50	20,800	*18,800*	*22,900*	20,800	*18,900*	*23,000*	20,800	*18,600*	*23,200*	20,800	*18,800*	*23,200*
1.5	66.7	16,400	*14,700*	*18,200*	16,400	*14,800*	*18,200*	16,400	*14,800*	*18,200*	16,400	*14,900*	*18,200*
1.25	80	13,300	*11,800*	*14,800*	13,300	*11,800*	*14,800*	13,300	*12,000*	*14,700*	13,300	*12,000*	*14,700*
1.05	95.2	9,150	*7,820*	*10,400*	9,110	*7,780*	*10,400*	9,250	*8,000*	*10,400*	9,210	*7,970*	*10,300*

Figure 12: Annual peak discharge data and flood-frequency analysis results for the New River near Galax, VA streamgage (USGS ID: 03164000). Helene peak Q: 108,000 cfs. Record peak Q: 141,000 cfs (8/14/1940). Drainage area: 1140 mi^2.



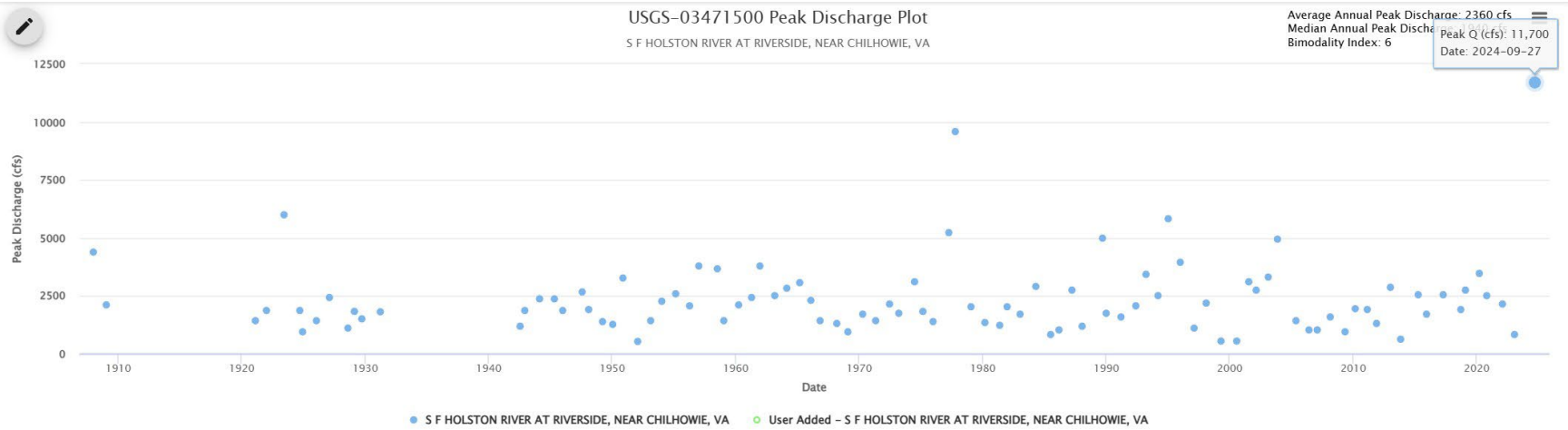
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	14,700	*11,400*	*20,300*	15,100	*11,700*	*21,000*	14,700	*10,200*	*31,700*	15,100	*10,500*	*29,500*
200	0.5	11,600	*9,220*	*15,600*	11,900	*9,410*	*15,900*	11,600	*8,530*	*21,600*	11,900	*8,680*	*20,500*
100	**1**	**9,600**	***7,770***	***12,500***	**9,770**	***7,890***	***12,800***	**9,600**	***7,350***	***16,000***	**9,770**	***7,440***	***15,400***
50	2	7,830	*6,460*	*9,950*	7,930	*6,540*	*10,100*	7,830	*6,230*	*11,800*	7,930	*6,270*	*11,500*
25	4	6,270	*5,280*	*7,750*	6,320	*5,320*	*7,820*	6,270	*5,170*	*8,600*	6,320	*5,180*	*8,490*
10	10	4,500	*3,890*	*5,350*	4,510	*3,900*	*5,360*	4,500	*3,850*	*5,550*	4,510	*3,840*	*5,540*
5	20	3,330	*2,930*	*3,840*	3,320	*2,930*	*3,840*	3,330	*2,910*	*3,900*	3,320	*2,900*	*3,900*
2	50	1,930	*1,710*	*2,160*	1,920	*1,710*	*2,150*	1,930	*1,700*	*2,180*	1,920	*1,700*	*2,170*
1.5	66.7	1,480	*1,300*	*1,660*	1,480	*1,300*	*1,660*	1,480	*1,300*	*1,670*	1,470	*1,300*	*1,660*
1.25	80	1,160	*1,000*	*1,310*	1,160	*1,000*	*1,310*	1,160	*1,020*	*1,310*	1,160	*1,020*	*1,310*
1.05	95.2	728	*601*	*854*	734	*606*	*860*	738	*603*	*854*	743	*613*	*858*

Figure 13: Annual peak discharge data and flood-frequency analysis results for Chestnut Creek at Galax, VA streamgage (USGS ID: 03165000). Helene peak Q: 6230 cfs. Record peak Q: 11,000 cfs (8/14/1940). Drainage area: 39.4 mi^2.



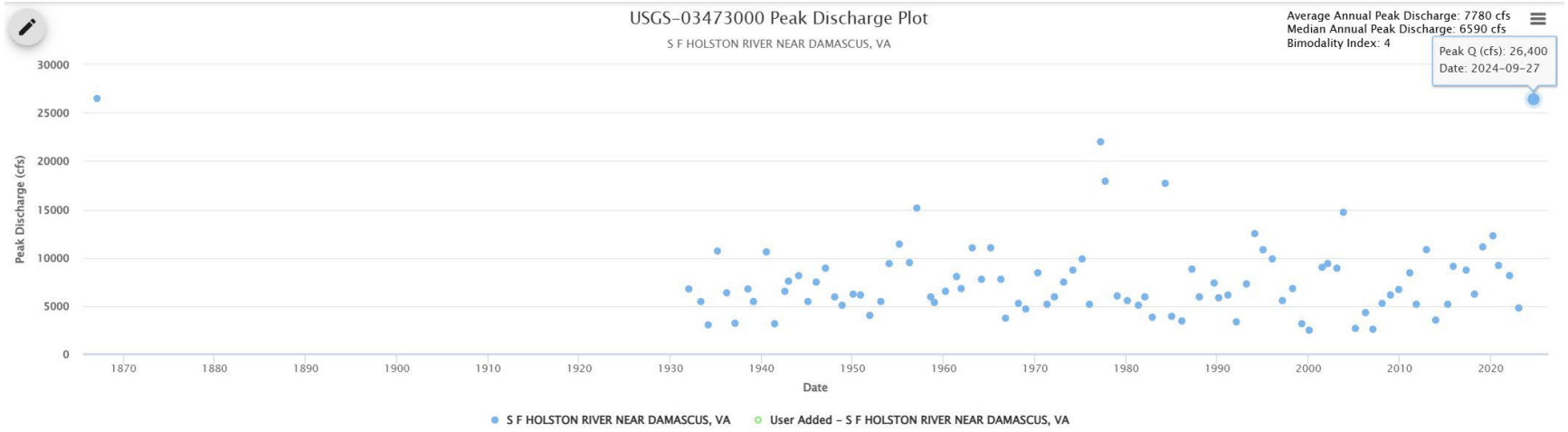
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	264,000	*197,000*	*382,000*	234,000	*177,000*	*334,000*	264,000	*155,000*	*1,070,000*	234,000	*149,000*	*614,000*
200	0.5	186,000	*144,000*	*257,000*	170,000	*133,000*	*232,000*	186,000	*120,000*	*540,000*	170,000	*116,000*	*367,000*
100	**1**	**141,000**	***113,000***	***188,000***	**132,000**	***106,000***	***175,000***	**141,000**	***97,700***	***326,000***	**132,000**	***95,600***	***248,000***
50	2	107,000	*87,300*	*137,000*	102,000	*83,900*	*130,000*	107,000	*78,600*	*199,000*	102,000	*77,500*	*168,000*
25	4	79,500	*66,900*	*98,200*	77,500	*65,400*	*95,500*	79,500	*62,200*	*124,000*	77,500	*61,800*	*113,000*
10	10	52,500	*45,800*	*61,800*	52,400	*45,700*	*61,700*	52,500	*43,900*	*68,400*	52,400	*44,100*	*66,900*
5	20	37,200	*33,100*	*42,400*	37,600	*33,400*	*42,900*	37,200	*32,000*	*44,600*	37,600	*32,600*	*44,700*
2	50	21,400	*19,200*	*23,800*	21,800	*19,500*	*24,200*	21,400	*18,800*	*24,300*	21,700	*19,400*	*24,500*
1.5	66.7	17,100	*15,100*	*19,100*	17,200	*15,200*	*19,200*	17,000	*15,300*	*19,000*	17,200	*15,500*	*19,200*
1.25	80	14,100	*12,300*	*15,900*	14,100	*12,300*	*15,800*	14,100	*12,900*	*15,600*	14,100	*12,700*	*15,600*
1.05	95.2	10,500	*8,900*	*12,000*	10,100	*8,540*	*11,600*	10,600	*9,290*	*12,100*	10,200	*8,870*	*11,500*

Figure 14: Annual peak discharge data and flood-frequency analysis results for New River at Ivanhoe, VA streamgage (USGS ID: 03165500). Helene peak Q: 127,000 cfs. Record peak Q: 155,000 cfs (8/14/1940). Drainage area: 1350 mi^2.



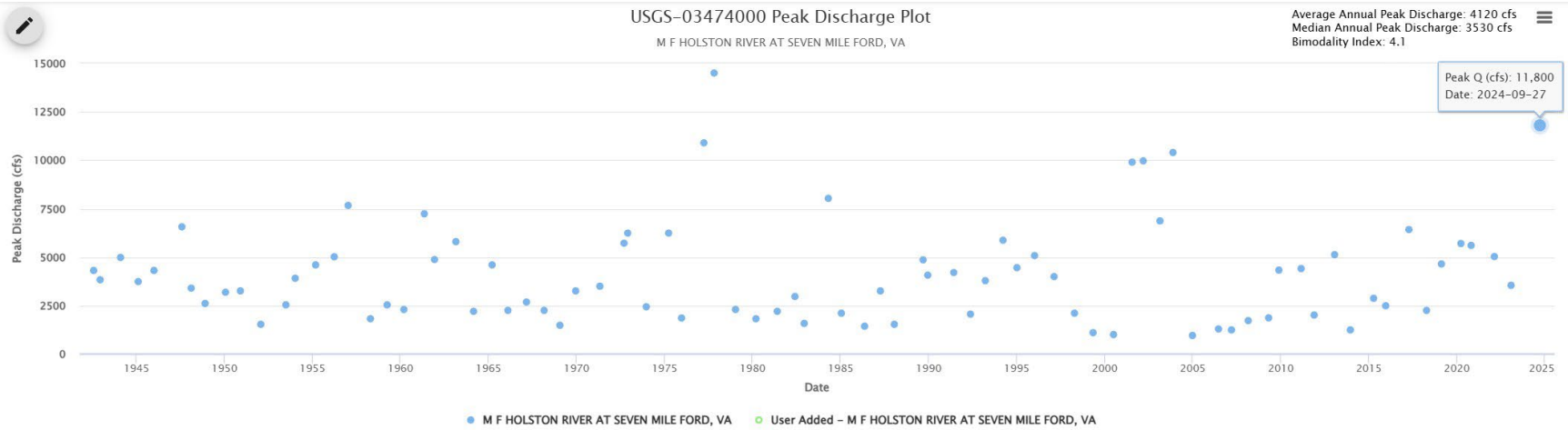
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	12,100	*9,760*	*15,700*	12,200	*9,870*	*15,900*	12,100	*8,870*	*22,500*	12,200	*8,960*	*20,900*
200	0.5	9,760	*8,060*	*12,400*	9,860	*8,130*	*12,500*	9,760	*7,540*	*16,200*	9,850	*7,580*	*15,300*
100	**1**	**8,230**	***6,900***	***10,200***	**8,290**	***6,950***	***10,300***	**8,230**	***6,580***	***12,500***	**8,280**	***6,600***	***12,000***
50	2	6,850	*5,840*	*8,320*	6,890	*5,870*	*8,370*	6,850	*5,660*	*9,570*	6,880	*5,670*	*9,300*
25	4	5,610	*4,870*	*6,670*	5,630	*4,880*	*6,690*	5,610	*4,780*	*7,260*	5,630	*4,780*	*7,140*
10	10	4,160	*3,690*	*4,790*	4,170	*3,700*	*4,800*	4,160	*3,660*	*4,940*	4,170	*3,650*	*4,920*
5	20	3,180	*2,860*	*3,570*	3,180	*2,860*	*3,570*	3,180	*2,840*	*3,620*	3,180	*2,840*	*3,610*
2	50	1,950	*1,770*	*2,140*	1,940	*1,770*	*2,140*	1,950	*1,760*	*2,160*	1,940	*1,760*	*2,150*
1.5	66.7	1,540	*1,390*	*1,690*	1,540	*1,380*	*1,690*	1,540	*1,390*	*1,700*	1,530	*1,390*	*1,690*
1.25	80	1,240	*1,100*	*1,370*	1,240	*1,100*	*1,370*	1,240	*1,110*	*1,370*	1,240	*1,110*	*1,370*
1.05	95.2	817	*698*	*931*	820	*701*	*934*	827	*702*	*933*	829	*708*	*934*

Figure 15: Annual peak discharge data and flood-frequency analysis results for the S.F. Holston River at Riverside, VA streamgage (USGS ID: 03471500). Helene peak Q: 11,700 cfs (new record peak discharge). Previous record peak Q: 9600 cfs (11/6/1977). Data is not available at this site for the expansive hurricane-related floods experienced in 1940 and 1916, though gage 03473000 (downstream) did not experience a large flood in 1940. Drainage area: 76.5 mi^2.



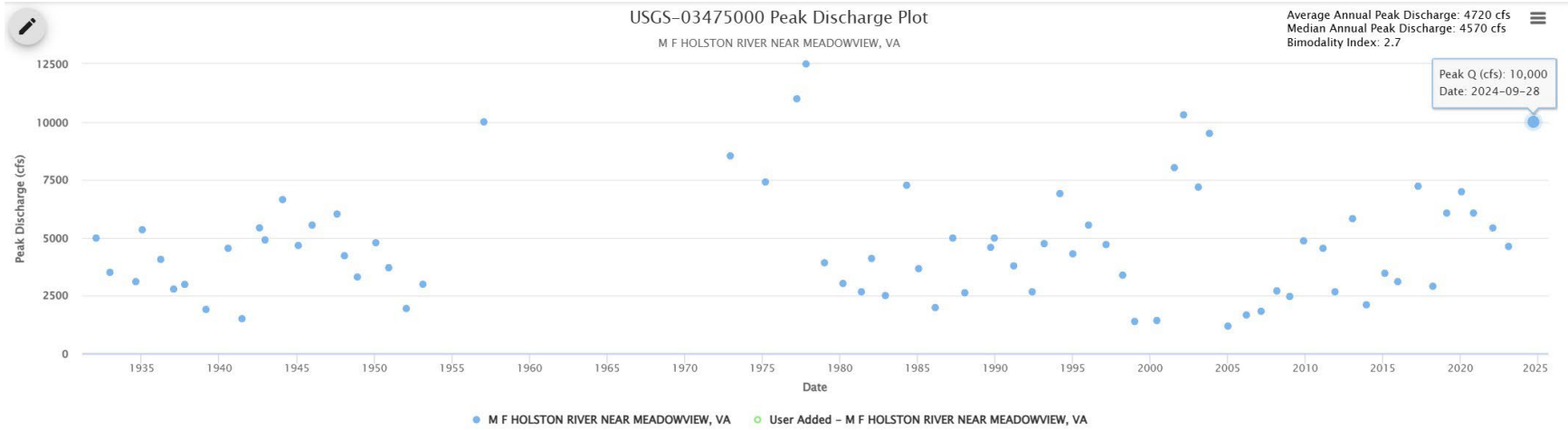
Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	33,900	*28,100*	*42,900*	33,800	*28,000*	*42,700*	33,900	*25,500*	*60,900*	33,800	*25,700*	*56,300*
200	0.5	27,900	*23,600*	*34,500*	27,800	*23,500*	*34,400*	27,900	*22,000*	*44,600*	27,800	*22,100*	*42,100*
100	**1**	**23,900**	***20,500***	***28,900***	**23,800**	***20,400***	***28,800***	**23,900**	***19,400***	***35,100***	**23,800**	***19,500***	***33,700***
50	2	20,200	*17,600*	*24,000*	20,200	*17,600*	*24,000*	20,200	*17,000*	*27,400*	20,200	*17,000*	*26,700*
25	4	16,900	*14,900*	*19,600*	16,900	*14,900*	*19,600*	16,900	*14,600*	*21,300*	16,900	*14,600*	*21,000*
10	10	13,000	*11,700*	*14,600*	12,900	*11,700*	*14,600*	13,000	*11,500*	*15,100*	13,000	*11,500*	*15,100*
5	20	10,200	*9,340*	*11,300*	10,200	*9,340*	*11,300*	10,200	*9,250*	*11,500*	10,200	*9,260*	*11,500*
2	50	6,690	*6,160*	*7,260*	6,700	*6,160*	*7,270*	6,690	*6,120*	*7,320*	6,700	*6,140*	*7,320*
1.5	66.7	5,480	*5,010*	*5,960*	5,480	*5,010*	*5,960*	5,480	*5,020*	*5,970*	5,480	*5,030*	*5,970*
1.25	80	4,570	*4,120*	*5,000*	4,570	*4,120*	*5,000*	4,570	*4,180*	*4,980*	4,570	*4,180*	*4,970*
1.05	95.2	3,260	*2,850*	*3,650*	3,260	*2,850*	*3,640*	3,290	*2,880*	*3,630*	3,290	*2,890*	*3,630*

Figure 16: Annual peak discharge data and flood-frequency analysis results for the S.F. Holston River near Damascus, VA streamgage (USGS ID: 03473000). Helene peak Q: 26,400 cfs. Record peak Q: 26,500 cfs (3/1/1867). Drainage area: 303 mi^2.



Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	20,800	*16,500*	*27,900*	21,700	*17,200*	*29,300*	20,800	*15,100*	*37,300*	21,700	*15,800*	*37,900*
200	0.5	17,200	*13,900*	*22,400*	17,700	*14,300*	*23,200*	17,200	*13,100*	*27,700*	17,700	*13,500*	*28,000*
100	**1**	**14,600**	***12,000***	***18,700***	**15,000**	***12,300***	***19,200***	**14,600**	***11,600***	***21,900***	**15,000**	***11,800***	***22,100***
50	2	12,300	*10,300*	*15,400*	12,500	*10,400*	*15,700*	12,300	*10,000*	*17,100*	12,500	*10,200*	*17,200*
25	4	10,100	*8,620*	*12,400*	10,300	*8,720*	*12,500*	10,100	*8,540*	*13,100*	10,300	*8,610*	*13,300*
10	10	7,550	*6,570*	*8,910*	7,570	*6,590*	*8,940*	7,550	*6,550*	*9,050*	7,570	*6,560*	*9,100*
5	20	5,730	*5,070*	*6,590*	5,720	*5,060*	*6,580*	5,730	*5,050*	*6,600*	5,720	*5,040*	*6,610*
2	50	3,400	*3,040*	*3,800*	3,380	*3,020*	*3,780*	3,400	*3,010*	*3,840*	3,380	*3,000*	*3,810*
1.5	66.7	2,610	*2,310*	*2,930*	2,600	*2,300*	*2,910*	2,610	*2,310*	*2,940*	2,600	*2,300*	*2,930*
1.25	80	2,030	*1,770*	*2,300*	2,030	*1,760*	*2,290*	2,030	*1,770*	*2,300*	2,030	*1,770*	*2,290*
1.05	95.2	1,230	*1,020*	*1,440*	1,250	*1,030*	*1,460*	1,250	*1,000*	*1,460*	1,260	*1,030*	*1,470*

Figure 17: Annual peak discharge data and flood-frequency analysis results for the M.F. Holston River at Seven Mile Fork, VA streamgage (USGS ID: 03474000). Helene peak Q: 11,800 cfs. Record peak Q: 14,500 cfs (11/6/1977). Drainage area: 131 mi^2.



Return Interval (yr)	Percent Chance of Occurence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew (0.3593)			Computed with Weighted Generalized Skew			Computed with Station Skew (0.3535)			Computed with Weighted Generalized Skew		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
			Lower	Upper		Lower	Upper		Lower	Upper		Lower	Upper
500	0.2	17,000	*13,900*	*21,800*	18,300	*14,900*	*23,700*	17,000	*12,900*	*26,100*	18,200	*13,900*	*28,200*
200	0.5	14,800	*12,400*	*18,700*	15,700	*13,000*	*19,900*	14,800	*11,800*	*21,300*	15,700	*12,500*	*22,600*
100	**1**	**13,200**	***11,200***	***16,400***	**13,800**	***11,600***	***17,300***	**13,200**	***10,900***	***18,000***	**13,800**	***11,400***	***18,900***
50	2	11,700	*9,960*	*14,200*	12,100	*10,300*	*14,800*	11,700	*9,910*	*15,100*	12,100	*10,200*	*15,600*
25	4	10,100	*8,750*	*12,100*	10,300	*8,930*	*12,400*	10,100	*8,800*	*12,500*	10,300	*8,920*	*12,800*
10	10	8,070	*7,110*	*9,400*	8,130	*7,160*	*9,470*	8,070	*7,170*	*9,370*	8,130	*7,180*	*9,500*
5	20	6,490	*5,800*	*7,390*	6,470	*5,780*	*7,370*	6,490	*5,810*	*7,320*	6,470	*5,780*	*7,340*
2	50	4,200	*3,790*	*4,660*	4,160	*3,750*	*4,610*	4,200	*3,760*	*4,690*	4,160	*3,720*	*4,640*
1.5	66.7	3,330	*2,980*	*3,700*	3,300	*2,950*	*3,670*	3,330	*2,960*	*3,730*	3,300	*2,940*	*3,690*
1.25	80	2,660	*2,340*	*2,970*	2,650	*2,330*	*2,960*	2,660	*2,310*	*2,990*	2,650	*2,320*	*2,970*
1.05	95.2	1,650	*1,380*	*1,920*	1,680	*1,410*	*1,950*	1,680	*1,320*	*1,970*	1,710	*1,380*	*1,980*

Figure 18: Annual peak discharge data and flood-frequency analysis results for the M.F. Holston River near Meadowview, VA streamgage (USGS ID: 03475000). Helene peak Q: 10,000 cfs. Record peak Q: 12,500 cfs (11/6/1977). Drainage area: 206 mi^2.

Appendix B: Peak Discharge Predictions

Cross sections at peak stage elevations surveyed by the U.S. Geological Survey are provided. Where possible, three sections were used for each peak discharge estimate (computed as the average of the three).

Whitetop Laurel Creek at Damascus

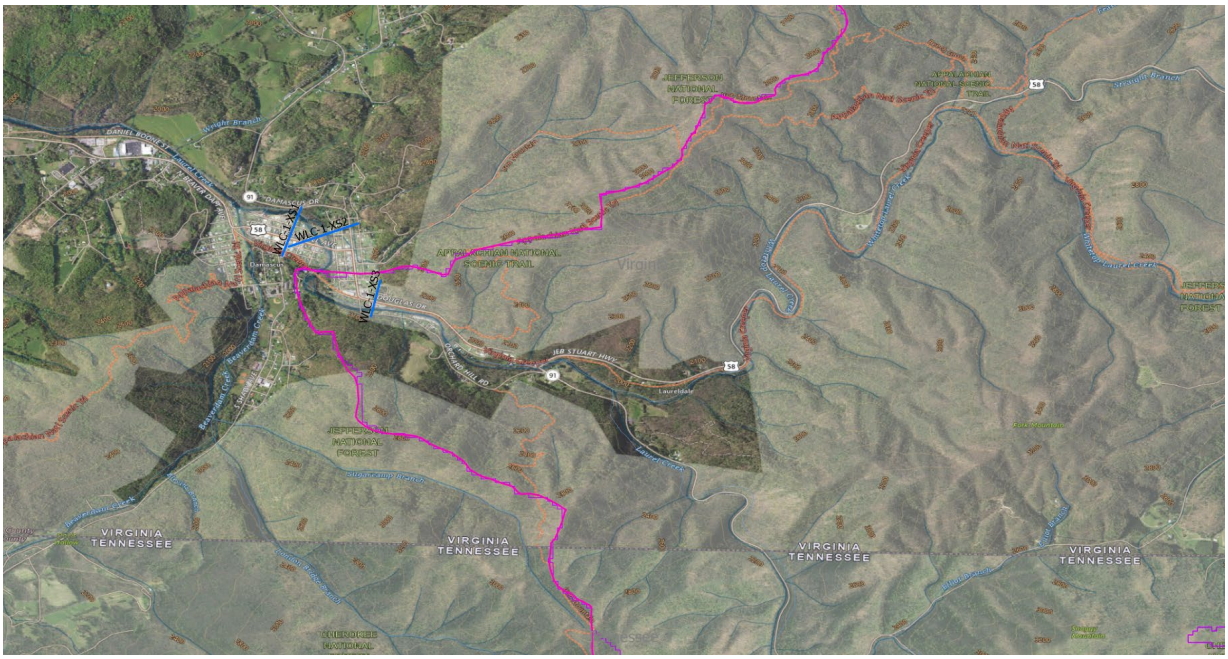


Figure 19: Whitetop Laurel Creek at Damascus watershed boundary and peak discharge estimates cross sections. Drainage area = 98.4 mi^2.

Top Width (ft):	445.2	Discharge (ft^3/s):	31255.8 (assuming critical flow)
Area (ft^2):	2381.4	Velocity (ft/s):	13.12
WP (ft):	449.3		
Maximum Depth (ft):	10.00		
Average WSEL: 1928.660	Average Depth (ft):	5.35	
	Hydraulic Radius (ft):	5.30	

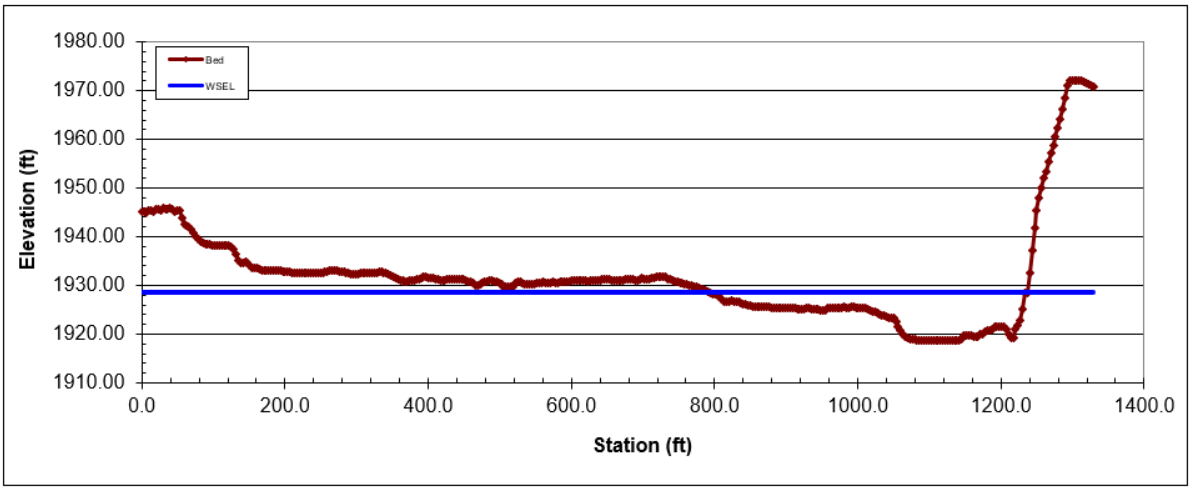


Figure 20: Whitetop Laurel Creek at Damascus cross-section 1 (WLC-1-XS1), at USGS high water mark STN Site No: VAWAS35762, HWM label: DAM TR1 009 MLF (1928.66 ft). Peak discharge = 31,300 cfs (assuming critical flow).

Top Width (ft):	845.4	Discharge (ft^3/s):	24546.0 (assuming critical flow)
Area (ft^2):	2510.3	Velocity (ft/s):	9.78
WP (ft):	849.7		
Maximum Depth (ft):	10.31		
Average WSEL: 1933.840	Average Depth (ft):	2.97	
	Hydraulic Radius (ft):	2.95	

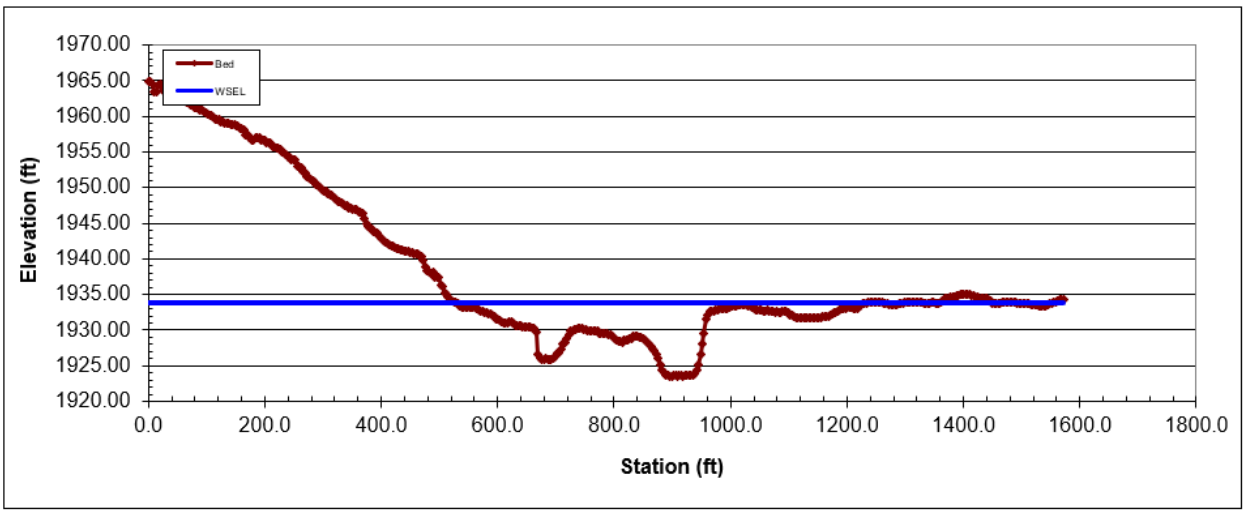


Figure 21: Whitetop Laurel Creek at Damascus cross-section 2 (WLC-1-XS2), at USGS high water mark STN Site No: VAWAS35752, HWM label: DAM TR1 002 ML-F (1933.84 ft). Peak discharge = 24,500 cfs (assuming critical flow).

Top Width (ft):	359.3	Discharge (ft^3/s):	30525 (assuming critical flow)
Area (ft^2):	2182.7	Velocity (ft/s):	13.99
WP (ft):	364.0		
Maximum Depth (ft):	11.56		
Average WSEL: 1956.44	Average Depth (ft):	6.07	
	Hydraulic Radius (ft):	6.00	

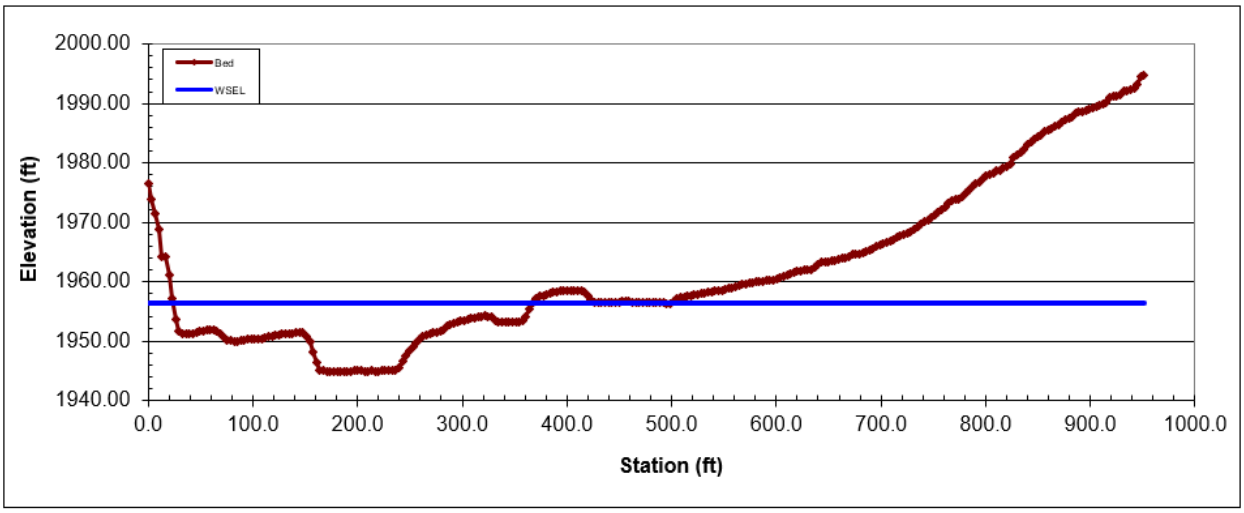


Figure 22: Whitetop Laurel Creek at Damascus cross-section 3 (WLC-1-XS3), at USGS high water mark STN Site No: VAWAS35760, HWM label: DAM-T2-101-DL-F (1956.44 ft). Peak discharge = 30,500 cfs (assuming critical flow).

Whitetop Laurel Creek at Taylors Valley

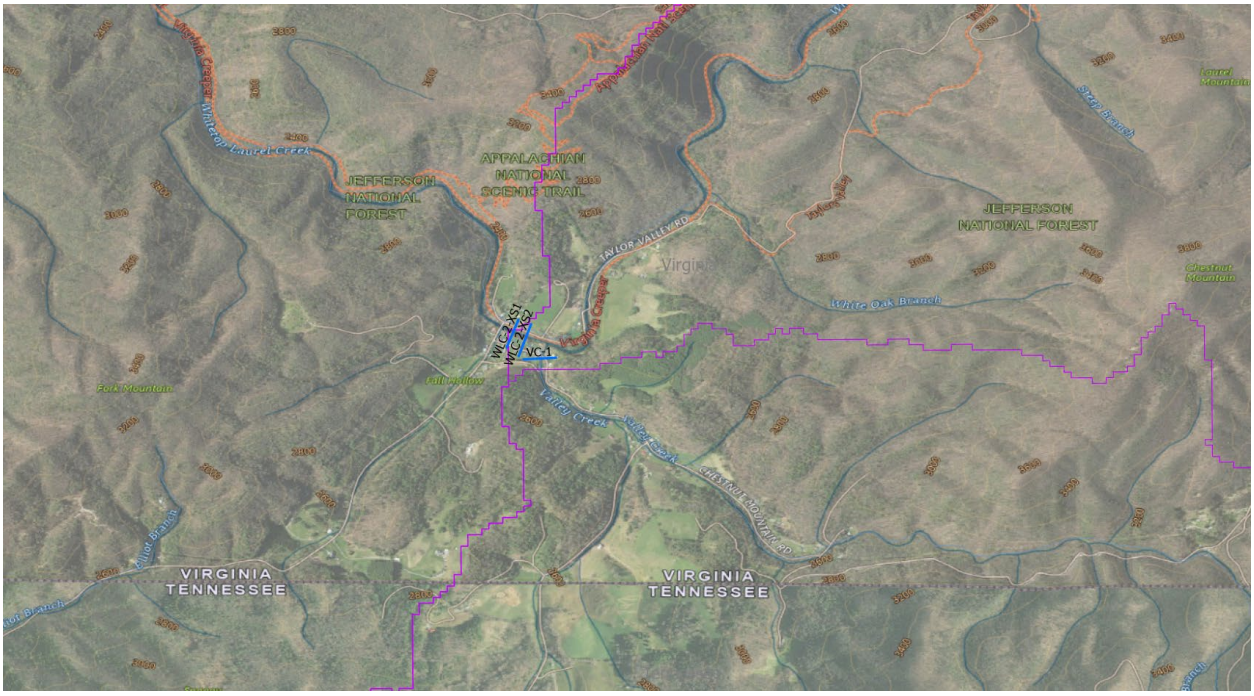


Figure 23: Whitetop Laurel Creek at Taylors Valley watershed boundary and peak discharge estimates cross sections. Drainage area = 44.1 mi^2.

Top Width (ft):	388.6	Discharge (ft^3/s):	21777 (assuming critical flow)
Area (ft^2):	1788.7	Velocity (ft/s):	12.17
WP (ft):	391.4		
Maximum Depth (ft):	11.64		
Average Depth (ft):	4.60		
Hydraulic Radius (ft):	4.57		

Average WSEL: 2383.61

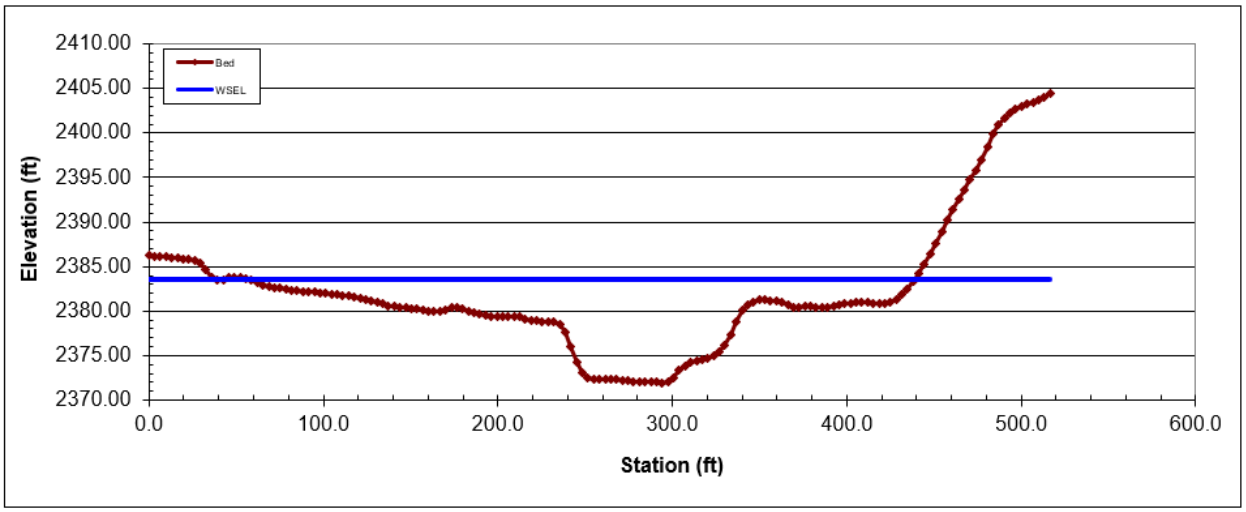


Figure 24: Whitetop Laurel Creek at Taylors Valley cross-section 1 (WLC-2-XS1), at USGS high water mark STN Site No: VAWAS35784, HWM label: TV-T2-100-SL-E (2383.61 ft). Peak discharge = 21,800 cfs (assuming critical flow).

		Top Width (ft):	321.6	Discharge (ft^3/s): 15605 (assuming critical flow)
		Area (ft^2):	1344.9	Velocity (ft/s): 11.60
		WP (ft):	324.3	
		Maximum Depth (ft):	11.14	
Average WSEL:	2384.57	Average Depth (ft):	4.18	
		Hydraulic Radius (ft):	4.15	

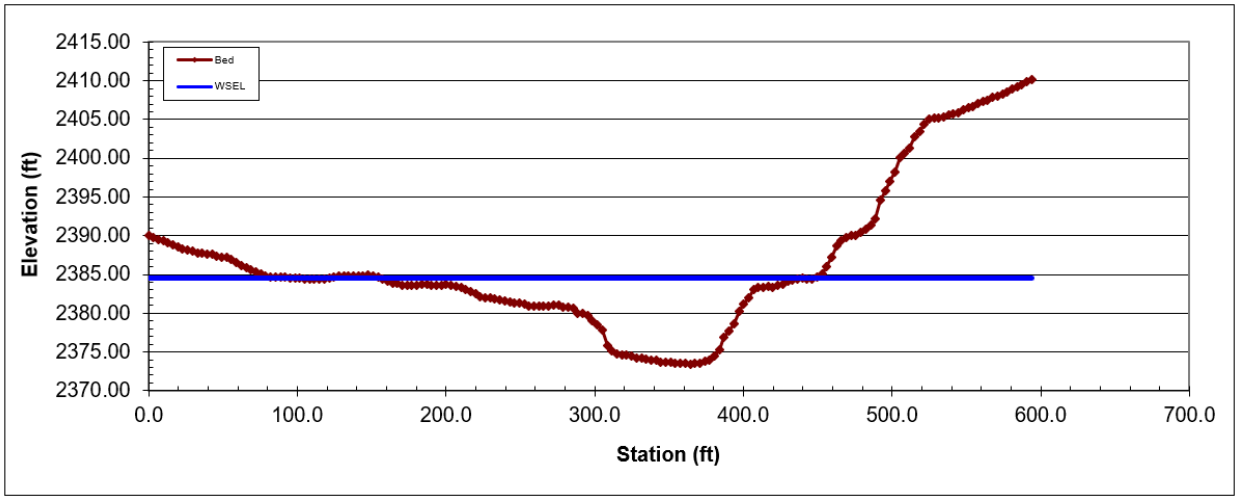


Figure 25: Whitetop Laurel Creek at Taylors Valley cross-section 2 (WLC-2-XS2), at USGS high water mark STN Site No: VAWAS35781, HWM label: TV-TR1-002-MLF (2384.57 ft). Peak discharge = 15,600 cfs (assuming critical flow).

Valley Creek at Taylors Valley

Figure 26: Valley Creek watershed boundary and peak discharge estimates cross sections. Drainage area = 5.2 mi^2.

	Top Width (ft):	133.9	Discharge (ft^3/s):	3150 (assuming critical flow)
	Area (ft^2):	345.5	Velocity (ft/s):	9.12
	WP (ft):	136.5		
	Maximum Depth (ft):	5.01		
Average WSEL: 2387.780	Average Depth (ft):	2.58		
	Hydraulic Radius (ft):	2.53		

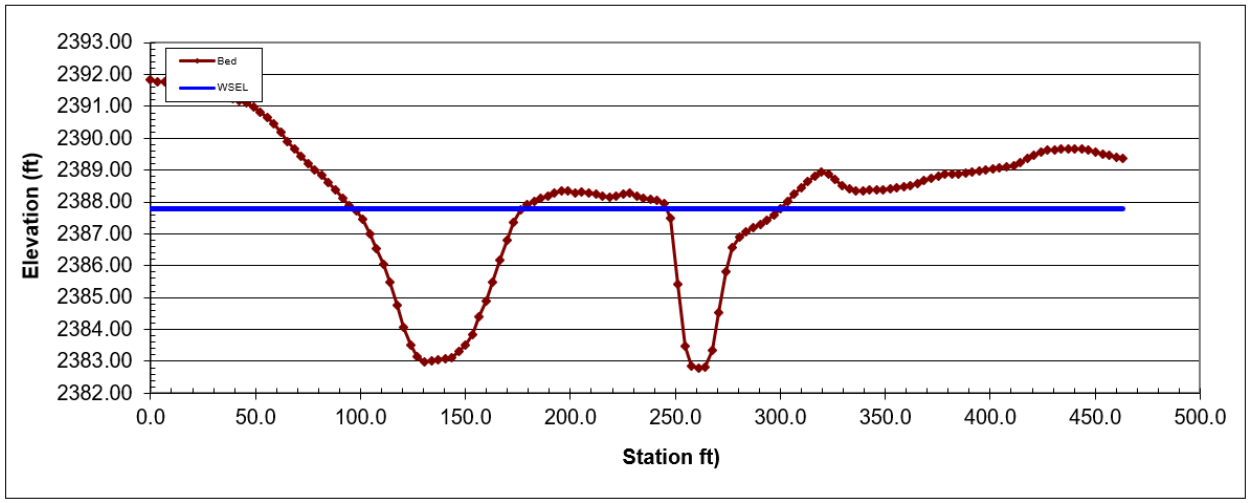


Figure 27: Valley Creek at Taylors Valley cross-section 1 (VC-1-XS1), at USGS high water mark STN Site No: VAWAS35783, HWM label: TV-TR1-004-MLF (2387.78 ft). Peak discharge = 3150 cfs (assuming critical flow).

Stargill Branch at Mouth

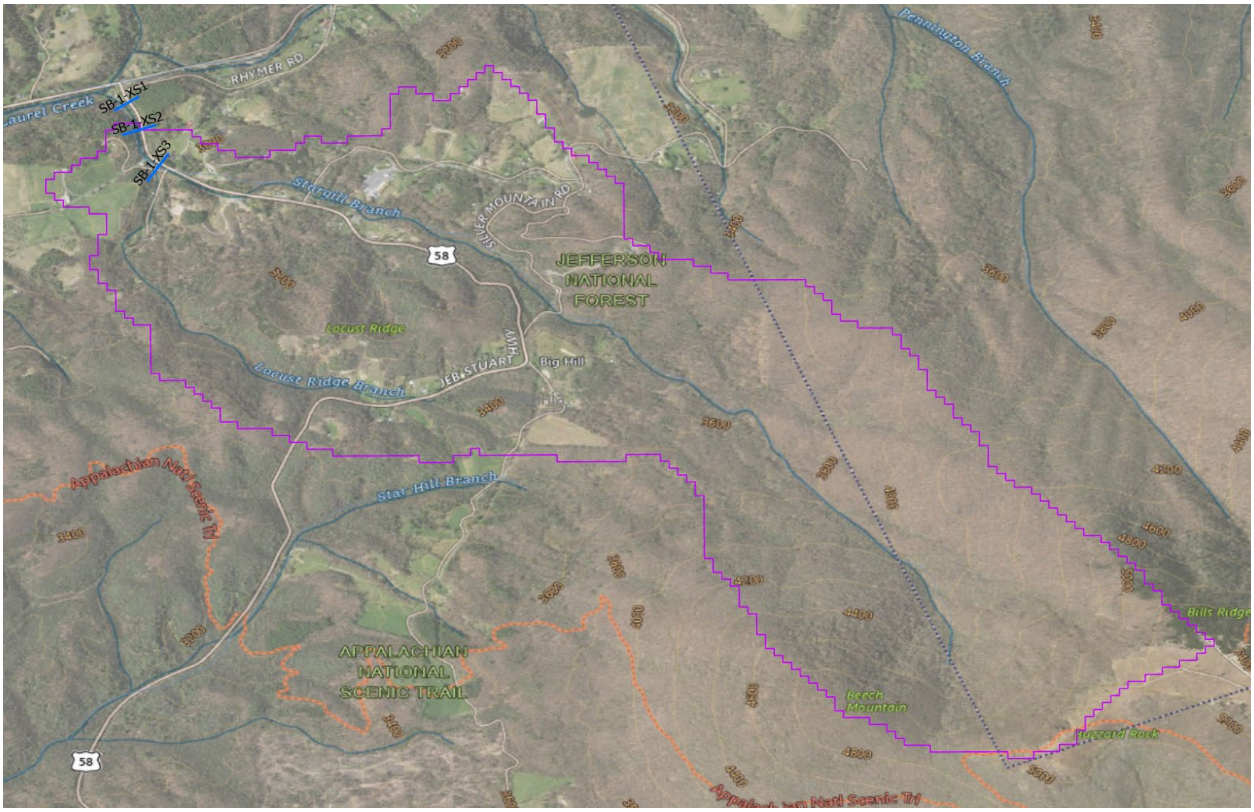


Figure 28: Stargill Branch watershed boundary, peak stage locations, and peak discharge estimates cross sections. Drainage area = 1.8 mi^2.

	Top Width (ft):	138.9	Discharge (ft^3/s):	2226.1 (assuming critical flow)
	Area (ft^2):	277.5	Velocity (ft/s):	8.02
	WP (ft):	139.8		
	Maximum Depth (ft):	4.86		
Average WSEL: 2887.180	Average Depth (ft):	2.00		
	Hydraulic Radius (ft):	1.99		

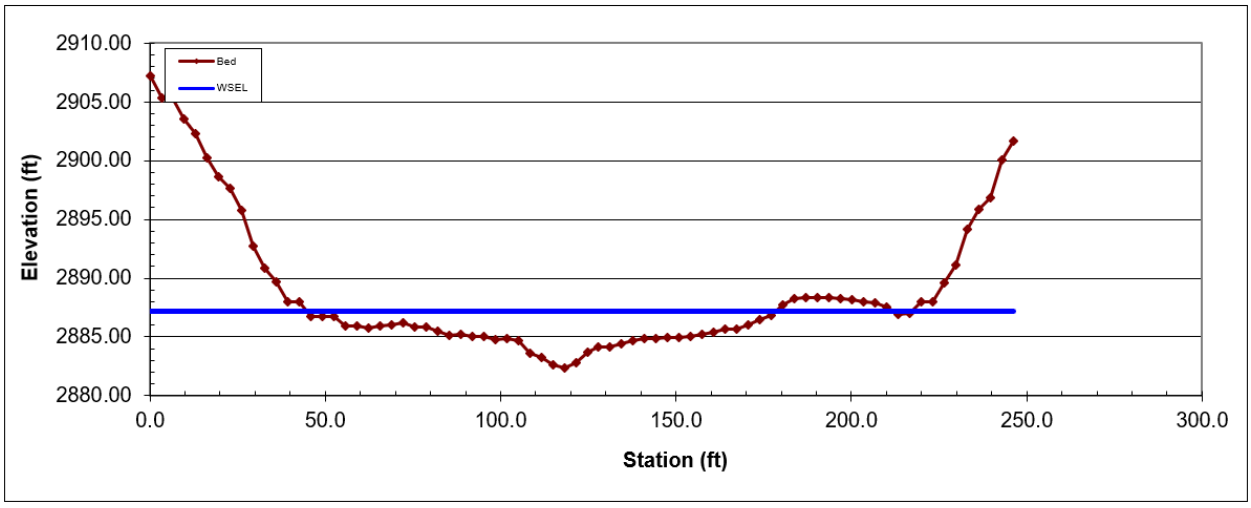


Figure 29: Stargill Branch cross-section 1 (SB-1-XS1), at USGS high water mark STN Site No: VAWAS35809, HWM label: WLC 001 DLF (2887.18 ft). Peak discharge = 2230 cfs (assuming critical flow).

		Top Width (ft):	188.3	Discharge (ft^3/s): 1921.0 (assuming critical flow)
		Area (ft^2):	278.4	Velocity (ft/s): 6.90
		WP (ft):	188.9	
		Maximum Depth (ft):	2.34	
Average WSEL:	2902.880	Average Depth (ft):	1.48	
		Hydraulic Radius (ft):	1.47	

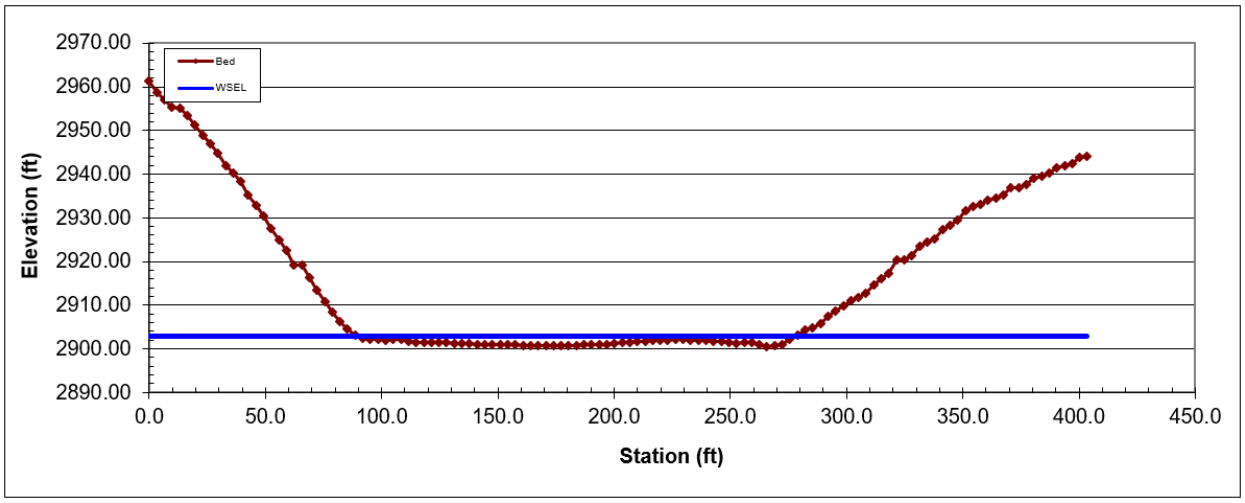


Figure 30: Stargill Branch cross-section 2 (SB-1-XS2), at USGS high water mark STN Site No: VAWAS35810, HWM label: WLC 002 DLG (2902.88 ft). Peak discharge = 1920 cfs (assuming critical flow).

		Top Width (ft):	92.6	Discharge (ft^3/s): 1656.2 (assuming critical flow)
		Area (ft^2):	199.1	Velocity (ft/s): 8.32
		WP (ft):	93.8	
		Maximum Depth (ft):	5.12	
Average WSEL:	2929.220	Average Depth (ft):	2.15	
		Hydraulic Radius (ft):	2.12	

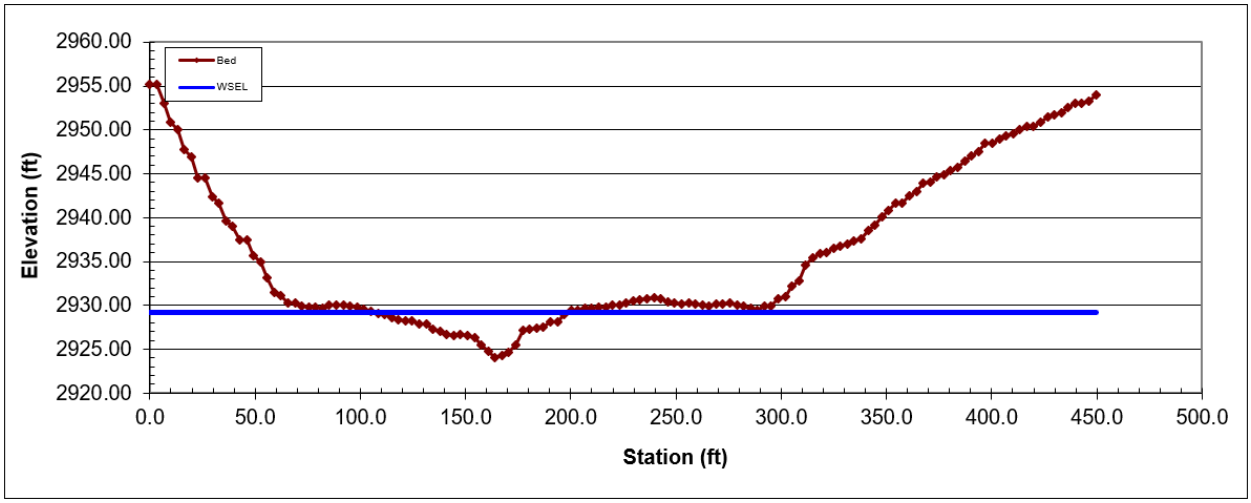


Figure 31: Stargill Branch cross-section 3 (SB-1-XS2), at USGS high water mark STN Site No: VAWAS35818, HWM label: WLC 003 SLG (2929.22 ft). Peak discharge = 1660 cfs (assuming critical flow).

Whitetop-Laurel Creek Upstream of Sturgill Branch

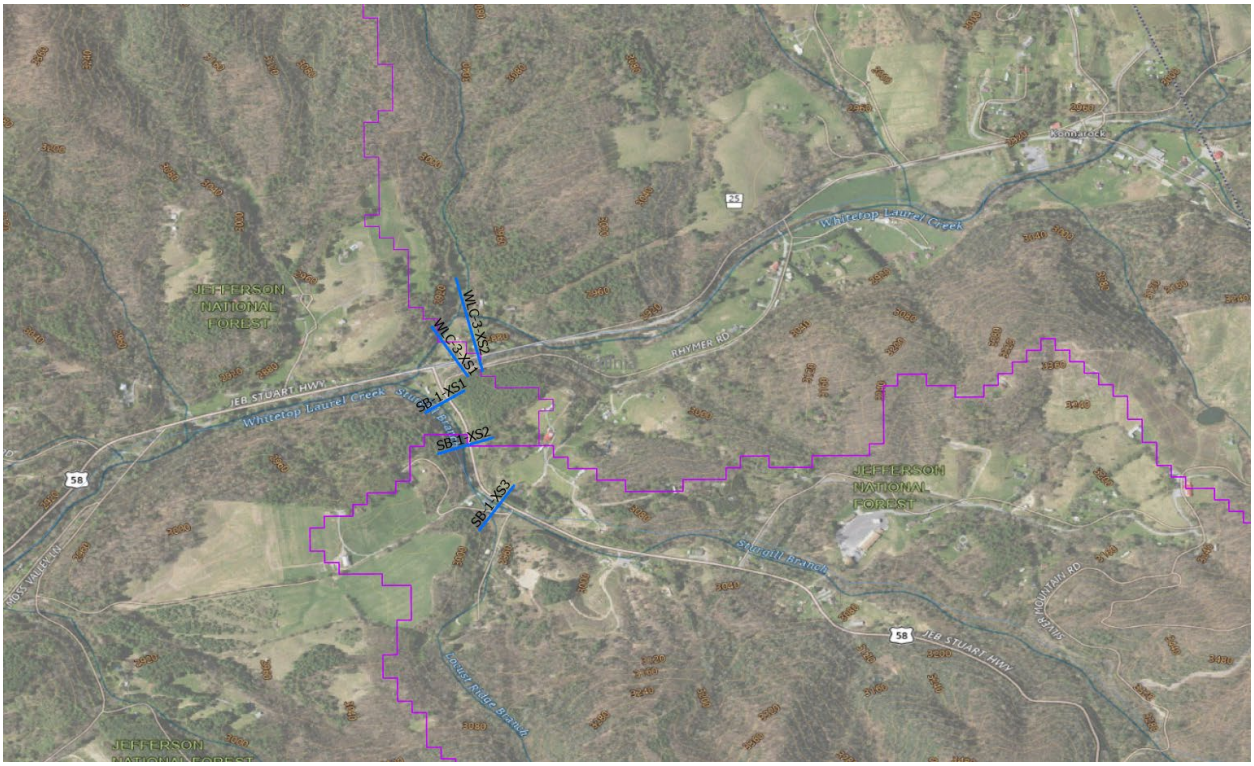


Figure 32: Whitetop Laurel Creek upstream of Sturgill Branch peak discharge estimates cross sections, with lower watershed boundaries. Drainage area = 19.8 mi2.

		Top Width (ft):	348.9	Discharge (ft^3/s): 14619.3 (assuming critical flow)
		Area (ft^2):	1323.0	Velocity (ft/s): 11.05
		WP (ft):	352.3	
		Maximum Depth (ft):	8.35	
Average WSEL:	2878.83	Average Depth (ft):	3.79	
		Hydraulic Radius (ft):	3.76	

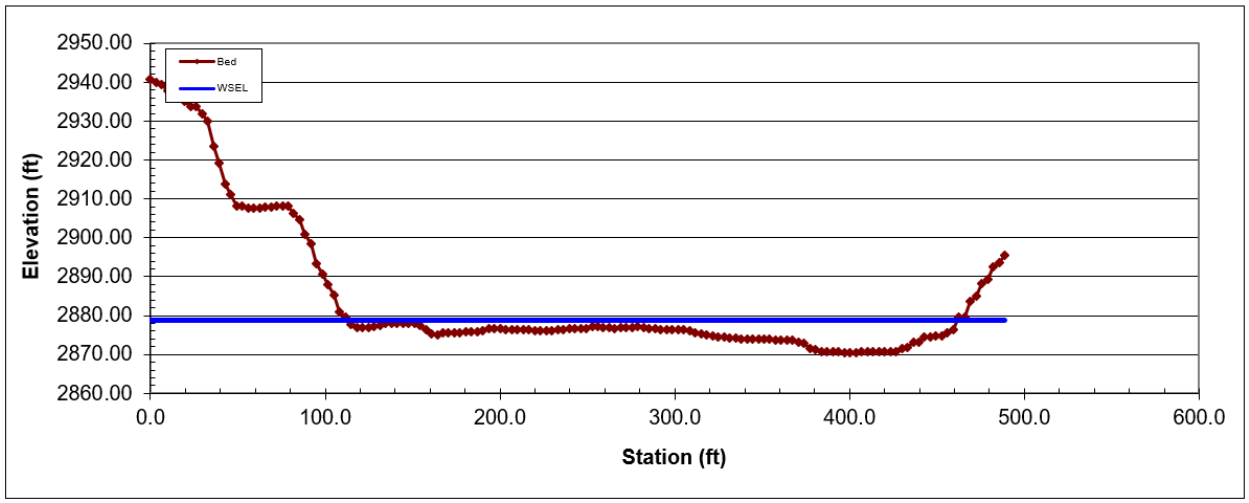


Figure 33: Whitetop Laurel Creek upstream of Sturgill Branch cross-section 1 (WLC-3-XS1), at USGS high water mark STN Site No: VAWAS35819, HWM label: WLC 004 DLF (2878.83 ft). Peak discharge = 14,600 cfs (assuming critical flow).

		Top Width (ft):	422.4	Discharge (ft^3/s): 8441.4 (assuming critical flow)
		Area (ft^2):	977.8	Velocity (ft/s): 8.63
		WP (ft):	424.9	
		Maximum Depth (ft):	6.00	
Average WSEL:	2879.58	Average Depth (ft):	2.31	
		Hydraulic Radius (ft):	2.30	

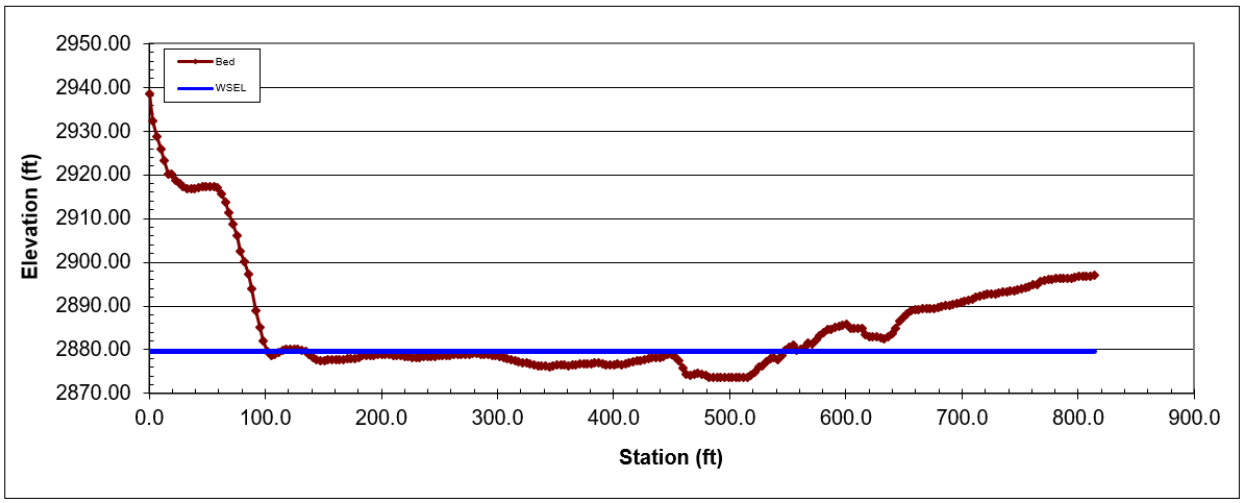


Figure 34: Whitetop Laurel Creek upstream of Sturgill Branch cross-section 2 (WLC-3-XS2), at USGS high water mark STN Site No: VAWAS35820, HWM label: WLC 005 DLP (2879.58 ft). Peak discharge = 8400 cfs (assuming critical flow).

Whitetop Laurel Creek Upstream of Big Branch

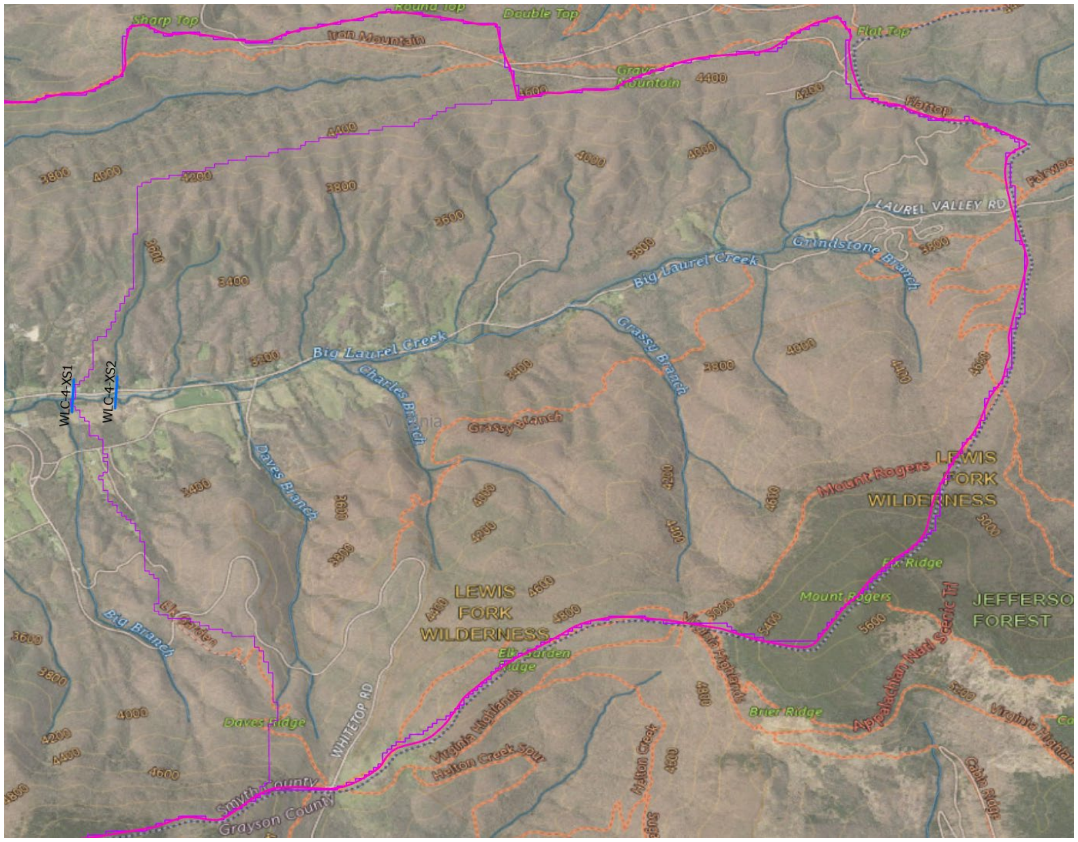


Figure 35: Big Laurel Creek upstream of Big Branch watershed boundary and peak discharge estimates cross sections. Drainage area = 9.9 mi2.

		Top Width (ft):	406.0	Discharge (ft^3/s): 3883.9 (assuming critical flow)
		Area (ft^2):	575.1	Velocity (ft/s): 6.75
		WP (ft):	407.5	
		Maximum Depth (ft):	5.43	
Average WSEL:	3070.45	Average Depth (ft):	1.42	
		Hydraulic Radius (ft):	1.41	

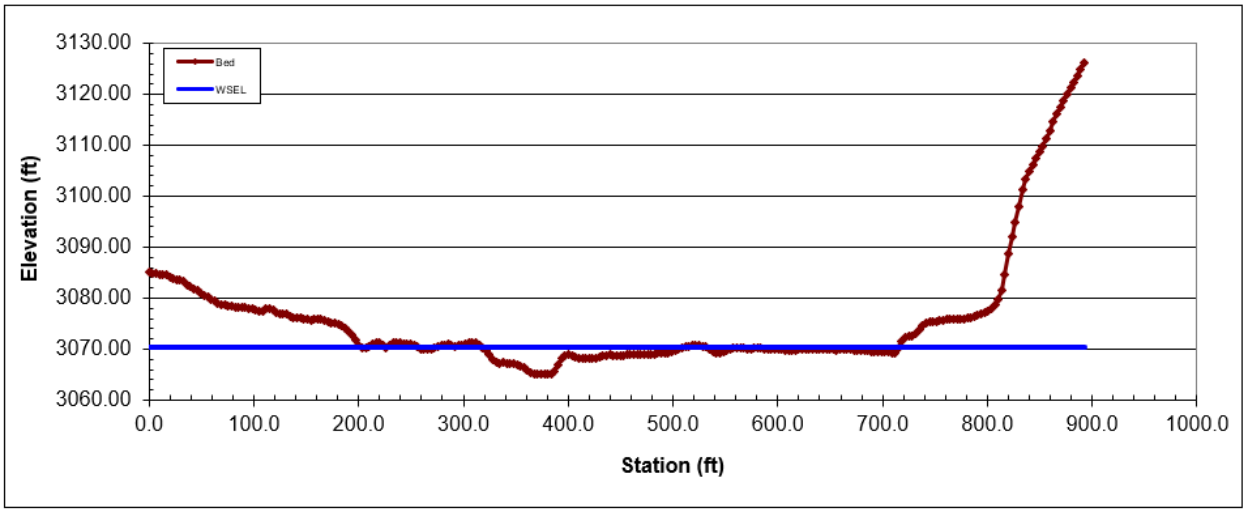


Figure 36: Whitetop Laurel Creek upstream of Big Branch cross-section 1 (WLC-4-XS1), at USGS high water mark STN Site No: VASMY35813, HWM label: BLC-003-DL-P (3070.45 ft). Peak discharge = 3900 cfs (assuming critical flow).

Top Width (ft):	402.4	Discharge (ft^3/s):	6895.9 (assuming critical flow)
Area (ft^2):	840.7	Velocity (ft/s):	8.20
WP (ft):	403.9		
Maximum Depth (ft):	5.18		
Average WSEL: 3087.90	Average Depth (ft):	2.09	
	Hydraulic Radius (ft):	2.08	

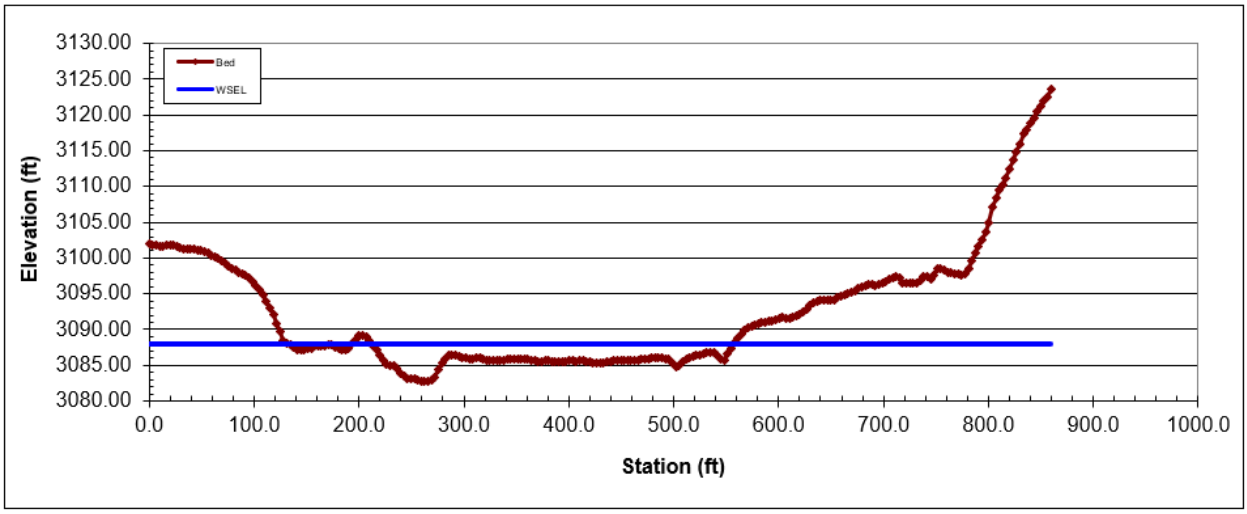


Figure 37: Whitetop Laurel Creek upstream of Big Branch cross-section 2 (WLC-4-XS2), at USGS high water mark STN Site No: VASMY35817, HWM label: BLC-002-DL-P (3087.90 ft). Peak discharge = 6900 cfs (assuming critical flow).