

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

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Flooding on the Pisgah and Nantahala National Forests from Hurricane Helene: Hydrology Analyses for Reconstruction

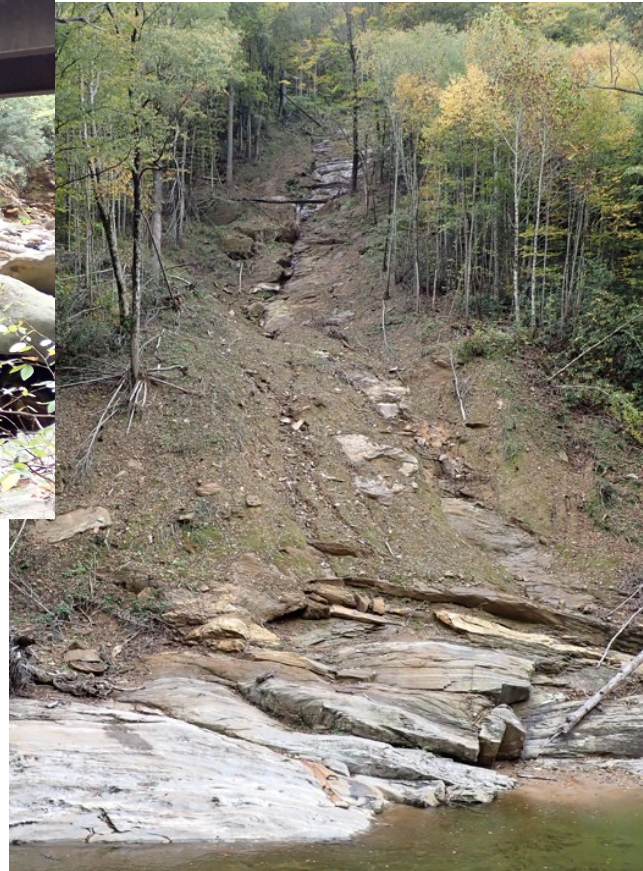
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Bridge abutment scour in the Curtis Creek watershed



Landslide in the South Toe River watershed



Executive Summary

In late September of 2024, powerful remnants of Hurricane Helene caused severe and widespread flooding in the Southern Appalachians, impacting several National Forests. Areas to the northeast and southwest of Asheville, NC, centered roughly on Mount Mitchell, received the highest rainfall depths, with 12 and 24 inches of rain over a 2-day period. Transportation infrastructure on the Pisgah and Nantahala National Forests was damaged in many locations by flooding and large woody debris, as well as from landslides and debris flows. Disaster supplemental funding has been provided to rebuild this infrastructure.

To support this work, at the request of the National Forests in North Carolina design flood discharge predictions are being generated for hundreds of road-stream crossings on the Pisgah and Nantahala National Forests by the U.S. Forest Service National Stream and Aquatic Ecology Center, a part of the Field Services and Innovation Center – Water Resources group. Initial analysis at 189 locations were performed for the Curtis Creek, Dillingham Creek, South Toe River, and Davidson River watersheds, for the National Forest System road networks as well as for primary crossings of neighboring non-USFS roads that provide access to these road networks. Peak discharge estimates for many additional watersheds on the Pisgah and Nantahala National Forests are planned to be provided.

There are three flood potential zones in the Blue Ridge Mountains that were most impacted by rainfall and flooding: 73S, 76, and 73. Streamgage data indicate that zone 73S, between Asheville and Boone, NC, has experienced larger-magnitude floods, on average, than 95% of the United States; floods are inherently very large in this area, with the most notable events induced from hurricanes. Floods are smaller in zones 76 (southwest of Asheville) and 73 (northeast of Boone), with half the flood magnitudes as zone 73S. Flood magnitudes are increasing by the largest percentage in the United States in zone 76 (+33.8% for the largest 5% of annual peak discharges).

Helene flooding was characterized using both traditional streamgage flood-frequency analyses and flood potential analyses. Watersheds that experienced the largest return intervals (lowest annual exceedance probability) are Cataloochee Creek, Mills River, French Broad River at Asheville, and the Middle Tyger River. These streams all experienced >500-year return interval floods. However, streamgage flood-frequency analyses appear to poorly fit some of the impacted streamgages, with the French Broad River at Asheville streamgage being especially problematic. An alternative interpretation is provided using a new flood severity scale, which expresses flood magnitudes from FI-1 to FI-6 (smallest to largest floods). FI-6 category flooding is extreme and catastrophic, and occurs very infrequently, while the smallest of FI-1 category floods are barely out of channel, occurring on average every other year. Floods of up to the FI-5 category were experienced during the Helene event, as illustrated in the [Flood Status Portal](#). A recorded video of the Hurricane Helene animation is [available at this link](#). Additionally, the flood potential method provides a systematic approach to quantify and rank extreme floods. Extreme floods (from most to least extreme) were experienced at the Pigeon River near Canton, South Toe River near Celo, Ivy River near Marshall, Beetree Creek near Swannanoa, and the West Fork Pigeon River near Retreat streamgages. These multiple extreme flood magnitudes quantifiably indicate that Hurricane Helene induced unexpectedly large floods in some watersheds, with magnitudes beyond the size that should reasonably be expected and planned for in the future.

Recommendations are provided for design flood discharges at the 100-year scale (1% annual exceedance probability, AEP) for the Helene recovery efforts on the Pisgah and Nantahala National Forests, based on results provided by the [Flood Potential Portal](#). These design flood discharges are expected to be experienced, and could occur in any year. Flood-frequency values are also provided, for the 1.5-year to 500-year return intervals (66.7% to 0.2% AEP). These recommended design flood discharges values are provided within a [GIS shapefile](#), which will be updated as additional analyzed watersheds are added. Results are also provided through ArcGIS Online.

Introduction

In late September of 2024, powerful remnants of Hurricane Helene caused severe and widespread flooding in the Southern Appalachians, impacting several National Forests. Transportation infrastructure on the Pisgah and Nantahala National Forests, in Western North Carolina, was damaged in many locations (Figure 1 to Figure 3), by flooding and large woody debris, as well as from landslides and debris flows (Figure 4). Disaster supplemental funding has been provided through the American Relief Act of 2025 to rebuild this infrastructure. The workload for planning, design, and construction will be considerable, with many organizations needed to contribute to this effort.

At the request of the National Forests in North Carolina, design flood discharge predictions are being generated for hundreds of road-stream crossings on the Pisgah and Nantahala National Forests. The U.S. Forest Service National Stream and Aquatic Ecology Center, a part of the Field Services and Innovation Center – Water Resources group, has performed hydrologic analysis in the Dillingham Creek, South Toe River, and Curtis Creek watersheds for the Big Ivy and Stony Fork, South Toe, and Curtis Creek road networks. Analyses were also performed for the Davidson River watershed. To inform these predictions, general flooding characteristics of the area are initially provided followed by a presentation of detailed analyses of the Helene-induced flooding event from the perspectives of streamgage flood-frequency analyses, flood severity scale results, documented extreme flooding, and an introduction to the Flood Status Portal for visualizing the event as it unfolded. A summary of the methods used to develop the design flood discharge estimates and flood-frequency results are then provided for these initial watersheds. Peak discharge estimates for additional watersheds on the Pisgah and Nantahala National Forests are planned to be provided after these initial deliverables.



Figure 1: Bridge failure due to wood debris and alluvium accumulation in the Dillingham Creek watershed.



Figure 2: Damaged bridge over the South Toe River.



Figure 3: Large wood and rock material accumulation on a blocked bridge opening in the Curtis Creek watershed.



Figure 4: Landslide that temporarily blocked the South Toe River.

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 northeast Georgia to southwest Virginia. Many lives were lost, including 103 individuals in North Carolina (NCDHHS, 2024). Two-day rainfall estimates are illustrated in Figure 5, indicating the extent and severity of this storm system. Elevated antecedent soil moisture likely played a role in the flood severity.

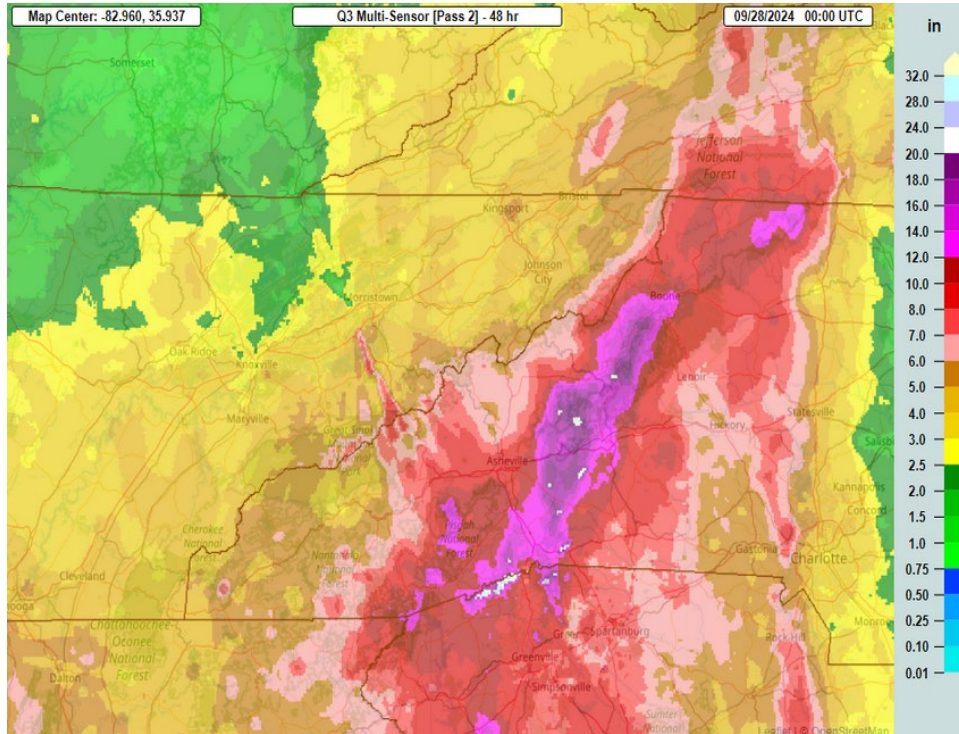


Figure 5: Two-day radar rainfall estimates ending in the evening of September 27, 2024. 12 to 24 inches of rainfall were experienced across a band that extended across Western North Carolina and into adjacent areas of southwest Virginia, northwest South Carolina, and northeast Georgia (NWS, 2025).

As indicated by National Weather Service radar (Figure 5), areas to the northeast and southwest of Asheville, NC, centered roughly on Mount Mitchell, received the highest rainfall depths. The most heavily impacted watersheds in this area experienced between 12 and 24 inches of rain over a 2-day period. 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. Extensive flooding has repeatedly occurred in this region from tropical cyclones (Amorim et al., 2025). For example, a pair of hurricane remnants induced large scale flooding in 1916, with an initial event in early July saturating soils and the second inducing 24 hour rainfall depths of 15 to 22 inches northeast Asheville (NCSCO, 2025). At Altapass, NC, 22.22 inches of rain fell from 2 PM on July 15 to 2 PM on July 16, 1916, setting a U.S. record at the time. The mountains within and adjacent to the Pisgah National Forest are susceptible to severe flooding from tropical cyclone remnants.

General Flooding Characteristics

The status and trends of floods across the primary extent of Helene’s impact area, as measured by the U.S. Geological Survey (USGS) streamgaging network, is provided 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, have been quantified using the Flood Potential Method (Yochum et al., 2019). There are three flood potential zones (Figure 6) in the Blue Ridge Mountains that were most impacted by rainfall (Figure 5) and flooding: 73S ($P_f = 46.1$), 76 ($P_f = 21.6$), and 73 ($P_f = 23.4$). The flood potential index (P_f) quantifies how large flood magnitudes vary from place to place, with warmer colors and higher values indicating that higher flood magnitudes have been experienced. Zone 73S has experienced larger-magnitude floods, on average, than 95% of the United States.

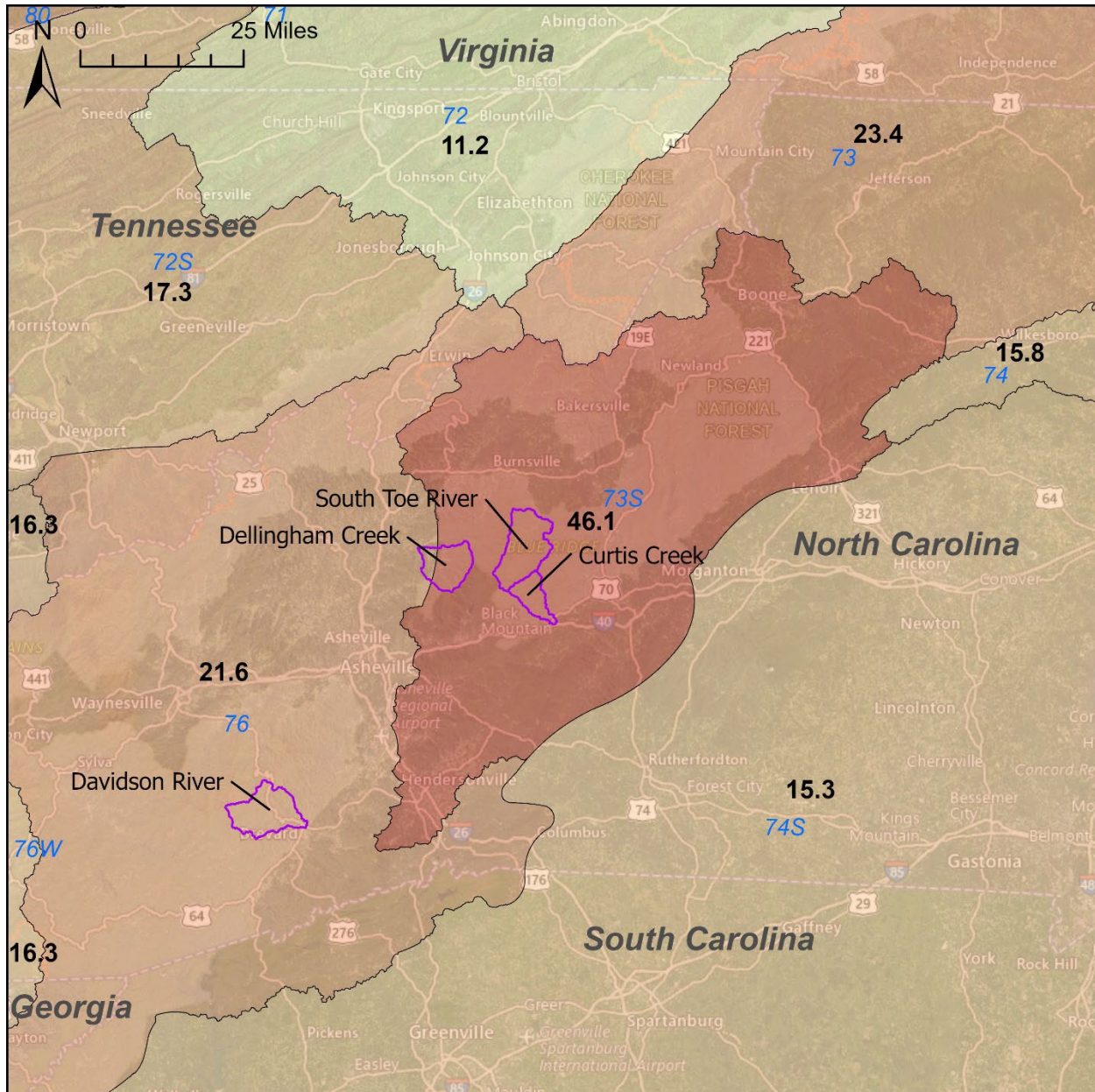


Figure 6: Flood Potential Method zones and the Flood Potential Index (P_f) across the primary Hurricane Helene-induced flooding extent within the Southern Appalachians. Blue text: zone IDs; larger bold black text: P_f values; magenta polygons: watersheds with initial computed peak discharge values.

Detailed map-based results across the Southern Appalachians (and the United States) based on the application of the Flood Potential Method are available through the Flood Potential Portal (<https://floodpotential.erams.com>) Mapping module, with detailed information on this approach available in Yochum et al. (2024) and the User Manual (Yochum et al., 2025). (Additional information on this approach is provided in the Design Flood Discharge Predictions section of this report.) In summary, flood potential is higher within the Blue Ridge Mountains in zones 73S, 76 and 73 than on the Piedmont to the southeast and the Valley and Ridge to the northwest. Zone 74S, on the Piedmont (Figure 6), experiences large flood magnitudes only 33% ($P_{f, 74S} / P_{f, 73S} = 15.3/46.1 = 0.33$) the magnitude, on average, than floods in the portion of the Blue Ridge Mountains between Asheville and Boone (zone 73S). Zone 73S also experiences floods 2.1 times larger ($P_{f, 73S} / P_{f, 76} = 46.1/21.6 = 2.1$) than floods that occur in zone 76 southwest of Asheville – the size of large floods vary substantially across this portion of the Blue Ridge Mountains, with streamgauge data indicating that flood magnitudes tend to vary dramatically in areas northeast compared to southwest of Asheville. Floods in the Blue Ridge Mountains are also substantially larger than in neighboring portions of the Valley and Ridge physiographic province, with large floods on average being up to 4.1 times larger ($P_{f, 73S} / P_{f, 72} = 46.1/11.2 = 4.1$). Flooding characteristics for zones 73S, 76, and 73 are provided in Table 1. These characteristics are based on data collected through the 2024 water year, including Helene-induced discharges.

Table 1: Flood characteristics of zones most impacted by Helene-induced flooding. Sig.: Significant trend (p-value ≤ 0.05); Pos.: Possible trend ($0.15 \leq p\text{-value} < 0.05$). Utilized data includes the 2024 water year.

Flooding Characteristic	Zone 73S	Percentile / % Trend	Zone 76	Percentile / % Trend	Zone 73	Percentile / % Trend
Flood Potential Index (P_f)	46.1	95 th	21.6	75 th	23.4	78 th
Watershed Scale ratio (R_f)	5.79	100 th	1.11	65 th	1.41	79 th
Beard Flashiness (F)	0.74	50 th	0.60	33 rd	0.71	47 th
Richards-Baker Flashiness (R-B)	0.51	73 rd	0.24	35 th	0.31	47 th
Bimodality (B_i)	11.4	75 th	5.7	48 th	7.7	61 st
Flood Variability (V_f)	2.06	93 rd	2.06	93 rd	1.55	44 th
Flood Hazard (H_f)	34.1	90 th	12.9	63 rd	16.6	72 nd
Flood Potential R^2	0.95	----	0.86	----	0.96	----
Number of Streamgages	21	----	35	----	43	----
Index R^2	0.98	----	0.94	----	0.98	----
Dominant Flooding Month	August	----	September	----	September	----
Secondary Flooding Month	September	----	March	----	August	----
Magnitude Trend, Largest 5% Floods	None	----	Sig. Increasing	+33.8	Pos. Decreasing	-9.2
Magnitude Trend, Largest Quarter	None	----	Sig. Increasing	+21.0	None	----
Magnitude Trend, Moderate Quarter	Sig. Increasing	+0%	Sig. Increasing	+12.1	Sig. Increasing	+7.7
Magnitude Trend, ~Bankfull Quarter	None	----	Sig. Increasing	+9.2	Sig. Increasing	+5.6
Magnitude Trend, <Bankfull Quarter	None	----	Sig. Increasing	+5.5	Sig. Decreasing	-5.0
Frequency Trend, Annual	Sig. Increasing	----	Pos. Increasing	----	None	----
Frequency Trend, Event	Pos. Increasing	----	Sig. Increasing	----	None	----
Flashiness Trend	Sig. Increasing	----	None	----	None	----

In zone 73S, of North Carolina (Figure 6), USGS streamgauge data indicate that this central portion of the Helene flood extent is an area that experiences some of the largest magnitude floods in the contiguous United States. The only areas experiencing larger floods are in the Balcones Escarpment of Texas Hill Country (zone 51; $P_f = 70.1$), where the Guadalupe River flood occurred in July 2025; along the Appalachian Front in Virginia (zone 73F; $P_f = 57.0$); in the Ouachitas in Arkansas (zone 57; $P_f = 54.3$), where the Albert Pike Recreation Area flood occurred in June 2010; and in South Texas (zone 53SW; $P_f = 48.1$). Floods have moderate to higher levels of flashiness, with relatively large amount of record peak discharge variability amongst the zone’s streamgages, and with relatively high bimodality (especially for the humid East). Bimodality is the situation where the largest floods are substantially larger than typical annual peak discharges; in this case the largest floods are 11.4 times larger than the median. This phenomena is also referred to as heavy tails of flood peak distributions (Merz et al., 2022) or mixed

populations of flood-producing mechanisms (England et al., 2018), and can complicate or bias statistical analyses of streamgauge data in some situations (Yochum and Wible, 2026). The watershed scale ratio indicates that larger watersheds experience the (relatively) largest floods, while smaller watersheds experience less dramatic floods. Large floods occur most frequently in August, followed by September, July and November; the largest floods occur during the hurricane season. These characteristics are quantified through a regression with high explained variance ($R^2 = 0.98$). Flood magnitudes are not increasing within this zone, though the frequency of flooding is increasing and floods are becoming more flashy.

Floods are inherently smaller (by half, on average) in zone 76, of North and South Carolina, Georgia, and Tennessee (Figure 6). Streamgauge data indicate that this southern portion of the Helene flood extent experiences moderate to lesser flashiness, moderate bimodality, and has the identical variability in record peak discharges as in zone 73S. Large floods occur most commonly in September and August, but a second late winter/early spring seasonality peak is also present (March and February) in this zone (contrasting with zone 73S). These characteristics are quantified through a regression with an $R^2 = 0.86$. All scales of flood magnitudes are experiencing significantly increasing trends, with the most substantial increases in the largest floods (+33.8% for the largest 5% of floods), and the smallest annual peak discharges experiencing lesser percent increases (+5.5% for < ~bankfull floods). This trend is illustrated (Figure 7), which indicates large flood events were experienced across this zone in 1876, 1902, 1916, 1940, 1966, 1976, 2004, 2021, and 2024. The frequency of floods is also increasing, though there is no trend in flashiness.

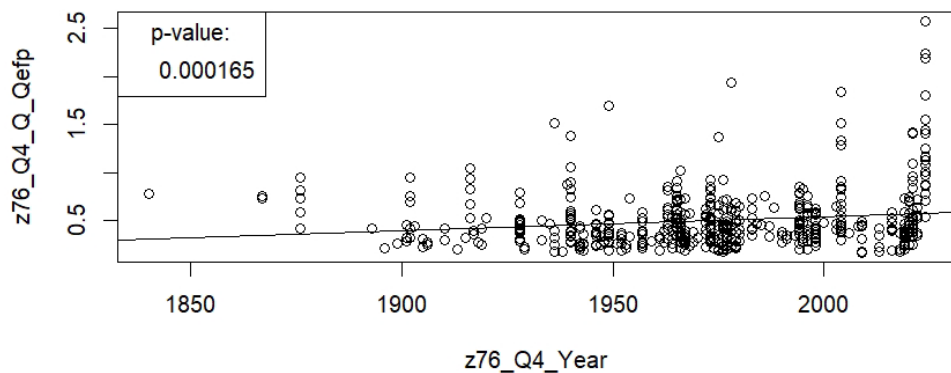


Figure 7: Significant increasing trend in the largest quarter of annual peak discharges in zone 76, for a period from 1840 to 2024. The y-axis is the flood extreme index, $E_f = Q/Q_{efp}$, where Q is measured peak discharge and Q_{efp} is the expected flood potential discharge for each streamgauge (see Design Flood Discharge Predictions section for detailed definitions of these terms). Note the peaks in 1916, 1940, and 2004, from previous hurricane remnants. The 1876 and 1902 flood events may have also been hurricane remnants.

Floods are also smaller in zone 73, of North Carolina, Tennessee, and Virginia (Figure 6). Streamgauge data indicate that flood magnitudes are experienced at the 78th percentile compared to all of the United States, with moderate flashiness, above moderate bimodality (7.7: 61st percentile), and lower flood variability than the other two zones. These characteristics are quantified through a regression with the highest of the explained variances ($R^2 = 0.96$). The largest floods occur most frequently in September and August, but the record indicates that large floods occur every month of the year. Trends in large flood magnitudes are mixed, with a possible decreasing trend in the largest 5% floods (-9.2%), significant increasing trends in moderate (2- to 4-year return interval floods; +7.7%) and ~bankfull scale floods (1.33- to 2-year floods; +5.6%), and significant decreasing trends in dry year (<bankfull) annual peak discharges (-5.0%). Such decreasing magnitude trends in dry year peak discharges are also occurring in zones to the east the west of zone 73. No trends in the frequency of large floods or flashiness are currently being observed.

Hurricane Helene-Induced Flooding

Hurricane Helene induced flooding across a large swath of the Southern Blue Ridge Mountains, as well as in the adjacent Piedmont physiographic province. Primary inland flooding extended from Georgia to southwest Virginia. The severity of this flooding was assessed using standard streamgage flood-frequency analysis techniques as well as novel approaches such as the Flood Potential Method and the Flood Severity Scale. Each technique has advantages and disadvantages, providing multiple perspectives on the extent, severity, and uniqueness of this event. In any case, the flooding was catastrophic in many locations, leading to extensive loss of life (NCDHHS, 2024), damaged or destroyed infrastructure, and property loss. The intent of this section is to describe what occurred, to provide context for rebuilding for resilience during recovery efforts. While the focus of this report is to provide analyses in support of recovery on the Pisgah and Nantahala National Forests, this assessment of what occurred in September 2024 is relevant for all flood-related Helene recovery efforts.

Streamgage Flood-Frequency Analyses

Annual peak discharges for 52 streamgages operated by the USGS were analyzed using standard flood-frequency analysis techniques, using the Bulletins 17C (England et al., 2018) and 17B (IACWD, 1982) methodologies. Each gage included the peak discharge estimate from Helene-induced flooding, with 34 of these sites experiencing a flood-of-record in 2024 (Table 2). Both station skews and weighted generalized skews were utilized in the analyses, with four sets of results provided for each streamgage ([Appendix A](#)). The analyses were performed within the Flood Potential Portal Streamgage Analysis module (Yochum et al., 2024; <https://floodpotential.erams.com/>). This module features map-based selection, automated data download, plotting of the annual peak discharges, data inspection/exclusion for outliers, and the quantification of generalized skew, peak discharge intervals, and perception thresholds. Generalized skew coefficients are automatically provided using state-based publications (where available).

For example, the South Toe River (USGS ID: 03463300) experienced high magnitude flooding, with a peak discharge magnitude more than twice what had been previously measured (from 1958 through 2024: 67 years). Substantial impacts were experienced (Figure 8). Annual peak discharge plots and flood-frequency analysis results are provided in Appendix A (Figure 66). The Helene peak discharge of 70,900 cfs corresponds with a range of return intervals as yielded by the streamgage flood frequency analyses, from 200-year to >500-year (Figure 9; Table 3). This range is due to substantially different results provided using station skew versus the weighted generalized skew, with the 100-year (1% annual exceedance probability; Q_{100}) discharge from a Bulletin 17C analysis ranging from 49,600 to 38,600 cfs (respectively). This is a common occurrence across the Helene-impacted area. The 100-year discharge is not a single value but is instead a range of values, which complicates interpretations.



Figure 8: Heavily-damaged bridge over the South Toe River, at the Black Mountain Campground on the Pisgah National Forest.

Table 2: Streamgages across the core portion of the Hurricane Helene-induced flooding extent, including key characteristics and streamgage analysis and watershed analysis results. Bold: Recommended watershed analysis result.

USGS ID	Zone(s)	Record Length	Area (mi ²)	Peak Q (cfs)	Peak Q Date	Helene Peak Q (cfs)	Streamgage Analysis Results (cfs)		Watershed Analysis Results (cfs)		
							Q ₁₀₀ GageL	Q ₁₀₀ GageH	Q _{efp}	Q ₁₀₀ Index	Q ₁₀₀ Reg
02111000	73S	84	29.0	16,200	8/13/1940	6050	9940	11,800	20,000	16,300	5770
02111180	73S	60	51.0	70,000	8/13/1940	13,000	29,900	36,600	35,100	24,900	8750
02111500	73	83	89.3	27,000	8/14/1940	10,400	14,100	14,400	19,300	20,500	12,900
02137727	73S	44	127	42,400	9/27/2024	42,400	32,800	34,100	84,600	55,800	17,800
02138500	73S	103	67.1	42,400	9/8/2004	28,300	33,200	38,300	36,700	35,900	10,900
02143040	74S	63	25.6	7220	10/17/1975	5970	7270	8420	6240	6750	5720
02152474	74S	17	190	16,400	2/6/2020	16,400	25,600	29,100	21,100	20,700	19,700
02154790	74S	36	56.0	11,400	9/27/2024	11,400	11,400	12,800	13,100	12,900	8420
02157000	74S	43	34.8	6250	2/6/2020	4400	5960	6110	6870	7070	6160
02157500	74S	77	68.6	12,800	9/27/2024	12,800	6050	7600	11,200	11,500	9400
02158408	74S	20	94.6	8430	9/27/2024	8430	9650	11,500	13,300	13,300	11,400
02160200	74S	24	49.5	5650	9/27/2024	5650	6400	8170	8920	9190	7640
02160325	74S	37	9.09	5910	9/27/2024	5910	4190	5820	2730	2880	2750
02160326	74S	32	84.7	14,200	9/27/2024	14,200	12,500	16,000	12,200	12,200	10,600
02162350	76	41	20.9	6750	9/27/2024	6750	7440	7490	6870	5970	4460
02162500	74S	80	295	13,400	9/28/2024	13,400	12,700	13,400	49,500	44,900	28,400
02164000	74S	73	48.3	6740	9/27/2024	6740	6580	6830	8550	8730	7520
02176930	76	14	46.7	12,500	9/27/2024	12,500	13,000	13,400	13,900	11,800	8290
02177000	76	99	203	34,300	9/27/2024	34,300	32,400	34,900	39,100	33,500	25,600
02186000	74S	45	104	11,700	2/26/2020	9150	11,200	11,700	14,600	14,700	12,100
03161000	73, 73S	95	204	52,800	8/14/1940	37,100	29,200	40,000	62,200	80,900	25,800
03164000	73, 73S	95	1140	141,000	8/14/1940	108,000	104,000	105,000	169,000	180,000	98,900
03439000	76	91	68.5	13,500	10/4/1964	12,800	13,700	13,700	18,100	15,500	11,100
03441000	76	101	40.5	11,200	8/17/2021	10,600	10,200	10,200	12,400	10,600	7420
03443000	76	104	296	30,000	10/5/1964	29,200	27,700	32,400	54,100	46,000	34,100
03446000	76	100	66.6	29,200	9/27/2024	29,200	13,700	15,600	16,200	14,000	10,900
03447687	76, 73S	24	640	67,300	9/27/2024	67,300	49,300	65,500	95,600	81,300	61,500
03450000	73S	91	5.45	7990	9/27/2024	7990	2540	3640	3590	3790	1600
03451000	73S	105	130	60,800	9/27/2024	60,800	26,400	31,400	69,600	44,000	18,200
03451500	76, 73S	129	945	113,000	9/27/2024	113,000	58,500	66,400	123,000	105,000	83,000
03453000	76, 73S	71	158	38,400	9/27/2024	38,400	24,400	28,700	37,500	26,900	21,100
03453500	76, 73S	84	1330	119,000	9/27/2024	119,000	89,100	95,500	153,000	132,000	108,000
03454500	76, 73S	30	1560	134,000	9/27/2024	134,000	160,000	179,000	171,000	147,000	122,000
03455500	76	70	27.4	14,800	9/27/2024	14,800	13,100	14,300	9370	7990	5510
03456100	76	44	57.7	21,200	9/27/2024	21,200	18,300	22,600	14,600	12,600	9750
03456500	76	70	51.5	19,800	8/17/2021	15,900	19,000	19,600	14,200	12,200	8940
03456991	76	41	130	67,300	9/27/2024	67,300	49,900	69,800	25,900	22,500	18,200
03459500	76	97	350	55,200	9/27/2024	55,200	43,600	44,900	44,400	39,700	38,800
03460000	76	80	49.1	12,800	9/27/2024	12,800	7260	7350	9110	8340	8620
03460795	76	28	537	67,900	9/27/2024	67,900	62,900	68,600	58,200	52,400	42,600
03463300	73S	67	43.3	70,900	9/27/2024	70,900	38,600	49,600	29,700	32,400	7830
03471500	73, 72	96	76.5	11,700	9/27/2024	11,700	8230	8280	15,600	14,700	13,200
03473000	73	94	303	26,500	3/1/1867	26,400	23,800	23,900	42,600	39,700	32,700
03479000	73S	86	90.9	50,800	8/13/1940	48,800	40,700	43,200	54,600	44,400	13,800
03485500	73	74	137	25,000	5/21/1901	23,700	18,600	20,700	27,000	23,500	14,600
03508050	76	21	145	12,200	9/27/2024	12,200	22,800	23,500	29,600	25,500	19,800
03510577	76	18	360	17,900	9/27/2024	17,900	23,800	24,000	50,700	44,600	39,600
03512000	76	73	184	15,900	12/30/1969	11,600	16,100	17,900	26,800	24,100	23,700
0344632850	73S	5	48.7	23,100	9/27/2024	23,100	----	----	12,700	31,600	8590
0344878100	76	6	104	34,200	9/27/2024	34,200	----	----	14,900	13,800	15,200
0344894205	73S	36	14.7	13,900	9/27/2024	13,900	12,000	18,600	11,100	12,200	3390
0345577330	76	36	33.2	22,600	9/27/2024	22,600	18,300	24,000	10,200	8810	6390

Table 3: Streamgages with Helene-induced peak discharges within and adjacent to the Southern Appalachian Mountains, with flood extreme index ($E_f = Q/Q_{efp}$), flood severity, and the range in streamgage return intervals associated with the Helene peak using both station and weighted generalized skews (Appendix A). Q_{efp} = expected flood potential discharge.

Stream	USGS ID	Helene Peak Discharge (cfs)	E_f	Extreme?	Flood Severity	Streamgage Return Interval (years)
Yadkin River	02111000	6050	0.30	No	FI-1	25-year to 50-year
Elk Creek	02111180	13,000	0.37	No	FI-1	10-year to 25-year
Reddies River	02111500	10,400	0.54	No	FI-2	25-year to 50-year
Catawba River	02137727	42,400	0.50	No	FI-1	200-year to 500-year
Unville River	02138500	28,300	0.77	No	FI-2	50-year to 100-year
Jacob Fork	02143040	5970	0.96	No	FI-3	25-year to 50-year
First Broad River	02152474	16,400	0.78	No	FI-2	10-year to 25-year
South Pacolet River	02154790	11,400	0.87	No	FI-2	5-year to 100-year
North Tyger River	02157000	4400	0.64	No	FI-2	25-year to 50-year
Middle Tyger River	02157500	12,800	1.14	No	FI-3	>500-year
South Tyger River	02158408	8430	0.63	No	FI-2	25-year to 100-year
Enoree River	02160200	5650	0.63	No	FI-2	25-year to 100-year
Brushy Creek	02160325	5910	2.16	Yes	FI-5	100-year to 500-year
Enoree River	02160326	14,200	1.16	No	FI-3	50-year to 200-year
Middle Saluda River	02162350	6750	0.98	No	FI-3	50-year to 100-year
Saluda River	02162500	13,400	0.27	No	FI-1	100-year to 200-year
Reedy River	02164000	6740	0.78	No	FI-2	~100-year
Chattooga River	02176930	12,500	0.92	No	FI-3	50-year to 100-year
Chattooga River	02177000	34,300	0.88	No	FI-2	100-year to 200-year
Twelvemile Creek	02186000	9150	0.63	No	FI-2	25-year to 50-year
South Fork New River	03161000	37,100	0.60	No	FI-2	50-year to ~200-year
New River	03164000	108,000	0.64	No	FI-2	100-year to 200-year
French Broad River	03439000	12,800	0.71	No	FI-2	50-year to 100-year
Davidson River	03441000	10,600	0.85	No	FI-2	~100-year
French Broad River	03443000	29,200	0.54	No	FI-2	50-year to 200-year
Mills River	03446000	29,200	1.80	No	FI-5	>500-year
French Broad River	03447687	67,300	0.70	No	FI-2	100-year to 500-year
Beetree Creek	03450000	7990	2.23	Yes	FI-5	200-year to >500-year
Swannanoa River	03451000	60,800	0.87	No	FI-2	200-year to >500-year
French Broad River	03451500	113,000	0.92	No	FI-3	>500-year
Ivy River	03453000	38,400	1.02	No	FI-3	200-year to 500-year
French Broad River	03453500	119,000	0.78	No	FI-2	200-year to 500-year
French Broad River	03454500	134,000	0.78	No	FI-2	~50-year
West Fork Pigeon River	03455500	14,800	1.58	No	FI-4	100-year to 200-year
West Fork Pigeon River	03456100	21,200	1.45	No	FI-4	~100-year to 200-year
East Fork Pigeon River	03456500	15,900	1.12	No	FI-3	25-year to 50-year
Pigeon River	03456991	67,300	2.59	Yes	FI-5	~100-year to 500-year
Pigeon River	03459500	55,200	1.24	No	FI-3	200-year to 500-year
Cataloochee River	03460000	12,800	1.41	No	FI-4	>500-year
Pigeon River	03460795	67,900	1.17	No	FI-3	~100-year
South Toe River	03463300	70,900	2.39	Yes	FI-5	200-year to >500-year
South Fork Holston River	03471500	11,700	0.75	No	FI-2	100-year to 500-year
South Fork Holston River	03473000	26,400	0.62	No	FI-2	100-year to 200-year
Watauga River	03479000	48,800	0.89	No	FI-3	100-year to 200-year
Doe River	03485500	23,700	0.88	No	FI-2	100-year to 200-year
Tuckasegee River	03508050	12,200	0.41	No	FI-1	10-year to 25-year
Tuckasegee River	03510577	17,900	0.35	No	FI-1	25-year
Oconaluftee River	03512000	11,600	0.43	No	FI-1	5-year to 10-year
Mud Creek	0344632850	23,100	1.82	No	FI-5	----
Hominy Creek	0344878100	34,200	2.30	Yes	FI-5	----
North Fork Swannanoa River	0344894205	13,900	1.25	No	FI-3	50-year to 200-year
West Fork Pigeon River	0345577330	22,600	2.22	Yes	FI-5	50-year to 200-year

For example, the New River at Galax streamgage (03164000) experienced a flood slightly larger than the 100-year return interval magnitude (Figure 47). This streamgage has a 95 year record and predicts the Q_{100} to be 105,000 cfs using the station skew and 104,000 cfs using the weighted generalized skew (Table 2). Three events have occurred in the last 95 years that are similar to or greater than the 100-year flood: 141,000 cfs (1940), 91,000 cfs (1977), and 108,000 cfs (2024). Is it reasonable to accept that this watershed has experienced three events of this ~100-year scale within one century? Or is logPearson not the most appropriate flood distribution for this streamgage?

Consider the French Broad River at Asheville streamgage (03451500). The streamgage flood-frequency analysis (Figure 55) predicts $Q_{100} = 66,400$ cfs (using station skew) and 58,700 cfs (using weighted generalized skew). This gage has 129 years of record, the longest of the 52 analyzed sites. The Helene peak discharge was 113,000 cfs, the largest magnitude on record, with the second largest being 110,000 cfs (July, 1916). The “Great Flood of 1916” induced catastrophic flooding reminiscent of Helene (Figure 10). All other annual peak discharges were $<45,000$ cfs. With a 500-year peak discharge (Q_{500}) estimate of 108,000 cfs (using the station skew), both the 2024 and 1916 events exceeded the 500-year flood. It is not uncommon for long term streamgages to have records that indicate the presence of multiple scales of floods. This phenomena is referred to as bimodal and multimodal data (Yochum et al., 2024), mixed population floods (England et al., 2018), and heavy tail behavior (Merz et al., 2022). Considering that this bimodality indicates this area is susceptible to at least two scales of flooding induced by hurricanes similar to Helene, is it reasonable to assume that the streamgage flood frequency analysis result ($Q_{100} = 66,400$ cfs) is best for infrastructure design and floodplain management along the French Broad River in and near Asheville? Is the use of the logPearson distribution appropriate at this site with mixed population floods? The use of analysis methods developed for ungaged locations provides additional information (Table 2). Using the results of the Flood Potential Portal Watershed Analysis module, the three streamgage transfer methods for predicting peak discharges at the 100-year scale event yield: expected flood potential discharge = 123,000 cfs; Q_{100} index = 105,000 cfs; and Q_{100} regional regression = 83,000 cfs. (These methods are described in the Design Flood Discharge Predictions section.) These results indicate that the Q_{100} from the streamgage flood frequency analysis may be underpredicting the actual flood risk in Asheville by 25% to 85%.



Figure 10: The “Great Flood of 1916” in Biltmore, NC.

Alternatively, analyses for the Ivy River near Marshall, NC streamgage (03453000; Figure 56) have relatively consistent results (Table 2). This streamgage has 71 years of record, with all the annual peak discharges being $<15,000$ cfs until 2024, when a peak discharge of 38,400 cfs was experienced. For this record, the high Helene-induced value leverages the logPearson type 3 distribution to providing a (station skew) Q_{100} value of 28,700 cfs. This peak is similar to the median result from the three streamgage transfer methods (expected flood potential discharge = 37,500 cfs; Q_{100} index = 26,900 cfs; and Q_{100} regional regression = 21,100 cfs), supporting the appropriateness of the streamgage flood-frequency analyses at this site. Using the station skew, this analysis indicates that the Ivy River experienced a ~200-year (0.5 percent annual exceedance probability) event from Helene.

Ultimately, the best practice is to utilize additional methods for flood magnitude prediction at streamgaged locations, to assess the appropriateness of results from use of the logPearson type 3 distribution in Bulletin 17C analyses and insure the reliability of results used for the selection of design flood discharges. Additionally, it may also be reasonable to account for trends in large flood magnitudes, as indicated from analyses of streamgage data or the results of climatological modeling.

Flood Severity Scale

An alternative method has been developed to express the magnitude of flooding across the United States using a consistent methodology that can be applied to both historic and realtime streamgauge data: the Flood Severity Scale. This method expresses flood magnitudes using a six-level scale, from FI-1 to FI-6 (smallest to largest floods). The smallest of the FI-1 category events are generally where a flood has barely emerged from a stream channel and occurs every other year, on average. FI-6 category flooding is extreme and catastrophic, and occurs very infrequently.

Flood severity scale results for Hurricane Helene-induced flooding are provide in Figure 11. The flood extreme index value, defined as $E_f = Q/Q_{eff}$ where Q_{eff} is the expected flood potential discharge, is also provided in this figure. FI-1 to FI-5 category events were experienced in streamgaged watersheds.

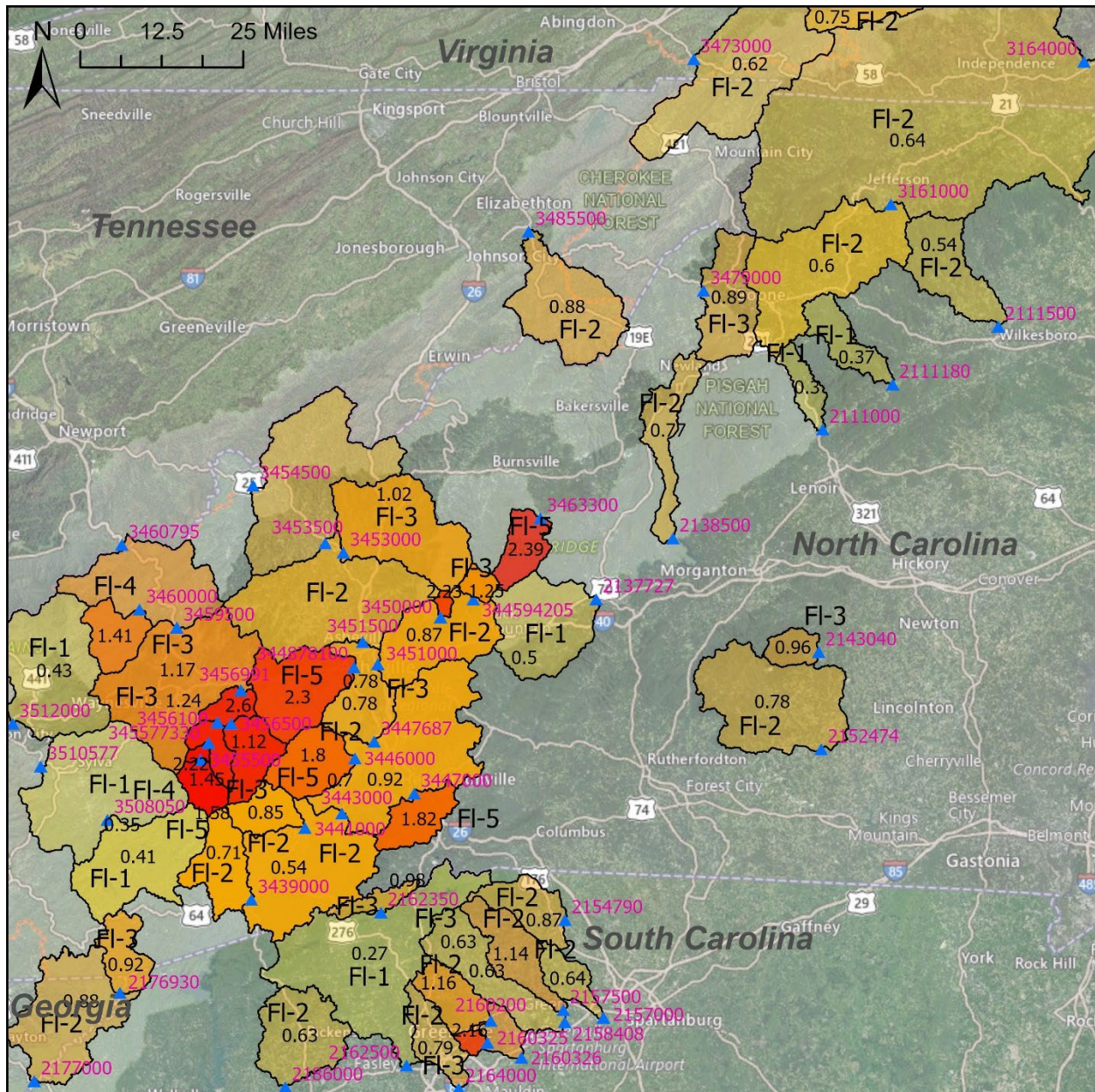


Figure 11: Flood severity scale results (FI-1 to FI-5) for Helene-induced flooding across the Blue Ridge Mountains and on the adjacent piedmont, with E_f values. USGS ID numbers are provided.

Descriptions of the Flood Severity Scale categories (using 367,712 annual peak discharge records) are as follows:

- **FI-1:** Small to moderate magnitude flooding, with out-of-channel flow (> 2 year return interval / 50% annual exceedance probability). $0.210 \leq E_f < 0.538$.
- **FI-2:** Moderate to large magnitude flooding. $0.538 \leq E_f < 0.883$.
- **FI-3:** Design flood / base flood discharge event (~100-year return interval / ~1% annual exceedance probability). $0.883 \leq E_f < 1.27$.
- **FI-4:** Exceeds design and base flood discharge, with infrastructure damage, extensive floodplain inundation, and some extreme magnitudes. $1.27 \leq E_f < 1.73$.
- **FI-5:** Major flood, with extreme magnitudes and catastrophic consequences. $1.73 \leq E_f < 2.67$.
- **FI-6:** Extreme flood, with extensive catastrophic consequences. $2.67 \leq E_f$.

Results indicate that Helene-induced flooding was most severe in Pigeon River (USGS ID 03456991; $E_f = 2.60$), South Toe River (03463300; $E_f = 2.39$); Hominy Creek (0344878100; $E_f = 2.30$), Beetree Creek (03450000, $E_f = 2.23$), West Fork Pigeon River (0345577330; $E_f = 2.22$), Brushy Creek (02160325; $E_f = 2.16$), Mud Creek (03447000; $E_f = 1.82$), and Mills River (03446000; $E_f = 1.80$). FI-5 category floods were experienced at each of these locations. No streamgaged watersheds experienced FI-6 category flooding from Hurricane Helene, though FI-4 category flooding was experienced in Cataloochee Creek. FI-3 category floods are similar in size to the 100-year scale event; this magnitude tests infrastructure and floodplain delineations, and may cause catastrophic consequences, but is generally of a magnitude that can be expected to eventually occur. The northern portion of the flood extent, near the Virginia border, experienced FI-2 floods at the streamgages (near the break between FI-2 and FI-3), but analyses using USGS-marked high water indicators and preliminary hydraulic analyses have indicated that FI-4 and FI-5 category floods occurred in Whitetop Laurel Creek along the Virginia Creeper Trail (Yochum, 2025). This rails-to-trails segment was inundated and washed out along much of its length, with 19 bridges severely damaged or destroyed.

This method is valuable since it can be applied uniformly across the United States, and can be automated for assessment of historic and current (realtime) flood events using a web-based decision support system. A weakness of this method is that it depends solely on expected flood potential discharge estimates, which have been shown to overpredict flood magnitudes for the selection of design flood discharges in some circumstances (Yochum and Wible, 2026). In such situations, flood severity can be understated.

Extreme Floods

The flood potential method (Yochum et al., 2019; Yochum et al., 2024) provides a systematic procedure for identifying and ranking extreme floods, with higher flood extreme index (E_f) values indicating greater extremity. Figure 12 illustrates watersheds that experienced extreme Helene-induced flooding, as well as extreme flooding from previous events. Extreme flood magnitudes were induced from Hurricane Helene in five streamgaged watersheds to both the northeast and southwest of Asheville along the axis of the Appalachians, specifically (from most to least extreme): Pigeon River near Canton ($E_f = 2.58$, USGS ID: 03456991); South Toe River near Celo ($E_f = 2.35$, 03463300); Ivy River near Marshall ($E_f = 2.24$, 03463300); Beetree Creek near Swannanoa ($E_f = 2.21$, 03450000); and the West Fork Pigeon River near Retreat ($E_f = 2.19$, 03463300). A streamgauge with an $E_f = 2.58$ indicates that the flood at this location was 2.58 times the size as what can be most reasonably expected using the streamgauge record of the area.

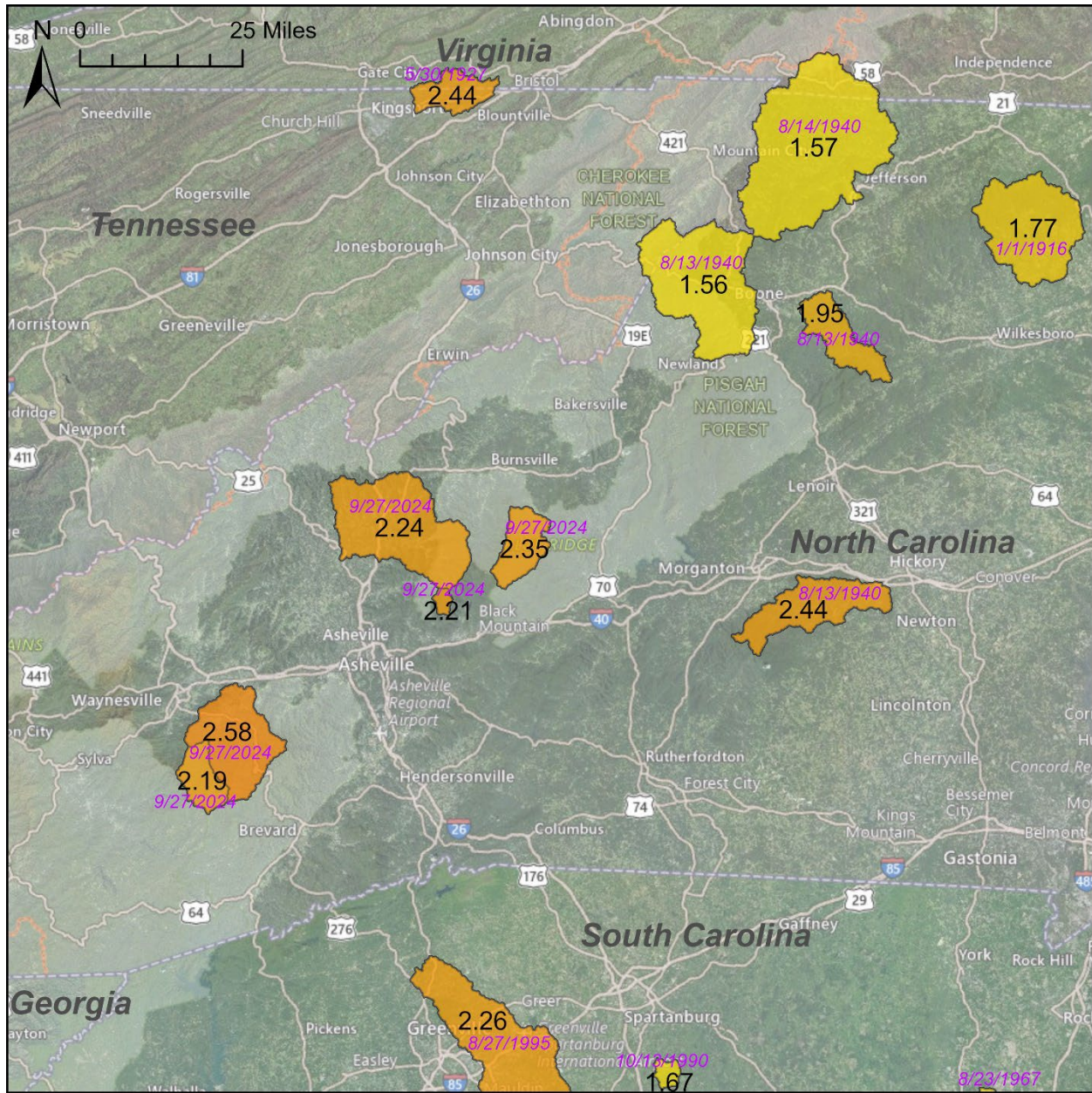


Figure 12: Extreme floods that have occurred across the region from Helene and prior flood events.

Other locations in the Blue Ridge Mountains and on the adjacent Piedmont have also experienced documented extreme floods from hurricane remnants, including the Roaring River in July, 1916 ($E_f = 1.77$; part of the “Great Flood of 1916”), and four watersheds in August, 1940, specifically Henry Fork ($E_f = 2.44$), Elk Creek ($E_f = 1.95$), North Fork New River ($E_f = 1.57$), and the Watauga River ($E_f = 1.56$). Extreme floods in this portion of the Blue Ridge Mountains are consistently induced from hurricane remnants.

Consider the Pigeon River streamgauge (Figure 13), which experienced the extreme peak discharge of 67,300 cfs on 9/27/2024. The record length is moderate (41 years), and does not include data from the earlier big flood years of 1916 and 1940. Data at this site indicates two scales of floods are experienced, with the median value (8580 cfs) quantifying the lower “normal” mode and three events in 2004, 2021, and 2024 representing high mode flooding. These floods were all induced from tropical cyclone remnants, including Hurricanes Ivan and Frances in 2004, and Tropical Storm Fred in 2021.

Streamgauge and meteorological records indicate that Hurricane remnants are the primary cause of extreme rainfall depths and floods in this area. This pattern can be expected to continue into the future, with more extreme floods induced from such events.

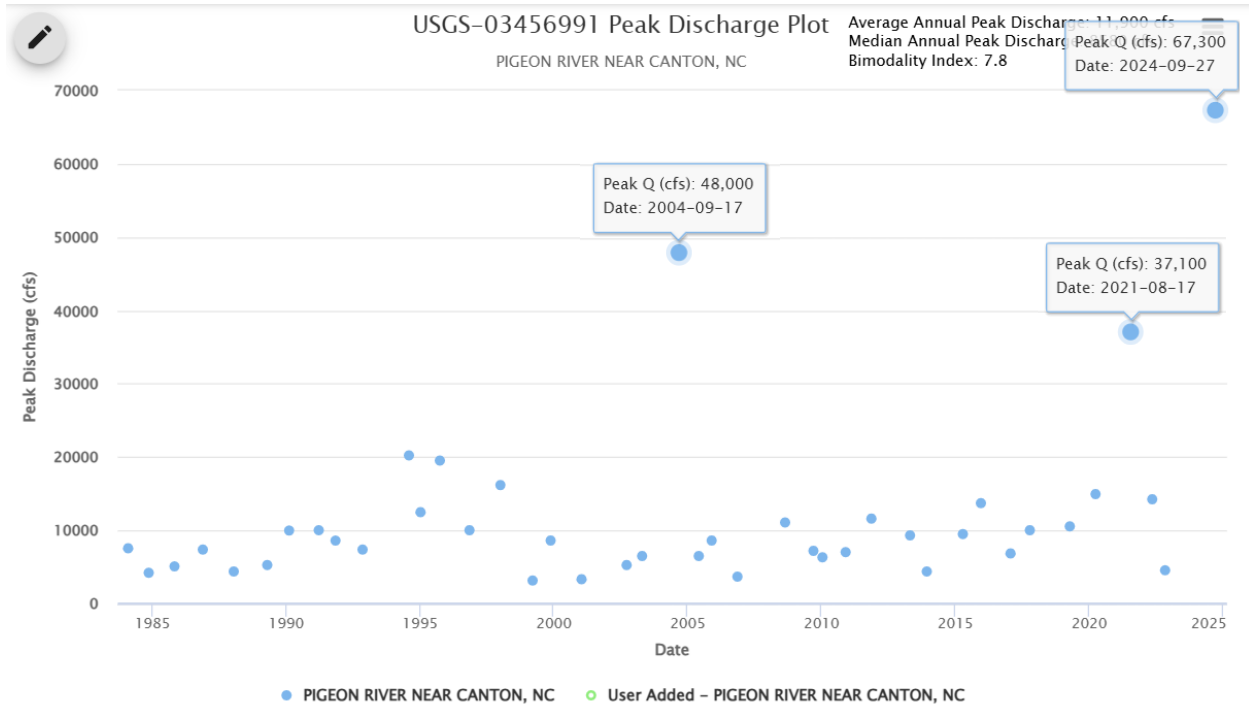


Figure 13: Flood Potential Portal Streamgauge Analysis module annual peak discharge plot for Pigeon River near Canton, NC.

Flood Status Portal

The Flood Status Portal (<https://floodstatus.erams.com>) has been developed to express the severity of current and selected historic floods using well-quantified metrics consistently applied across the contiguous United States. On a watershed basis, both E_f values and the Flood Severity Scale are used to illustrate floods currently being experienced, as well as presenting specific previous events including Hurricane Helene. Current, latest animated (prior 2 weeks), recent animated (2024 and later), and selected historic animated events can be viewed, with 15-minute time step increments. Radar data are also provided within both the current and animated views. Hydrographs can be viewed for specific watersheds of interest, and the data downloaded. Links are also provided to the source data. Screenshots from an animation illustrating the Helene just before landfall (Figure 14) and flooding in the Asheville area (Figure 15) are shown. A recorded video of the Helene animation is [available at this link](#).



Figure 14: Screenshot of a Flood Status Portal (<https://floodstatus.erams.com>) animation of Hurricane Helene shortly before landfall at 3:00 PM on 9/26/2024. Note the extensive rainfall across the South preceding the tropical cyclone.

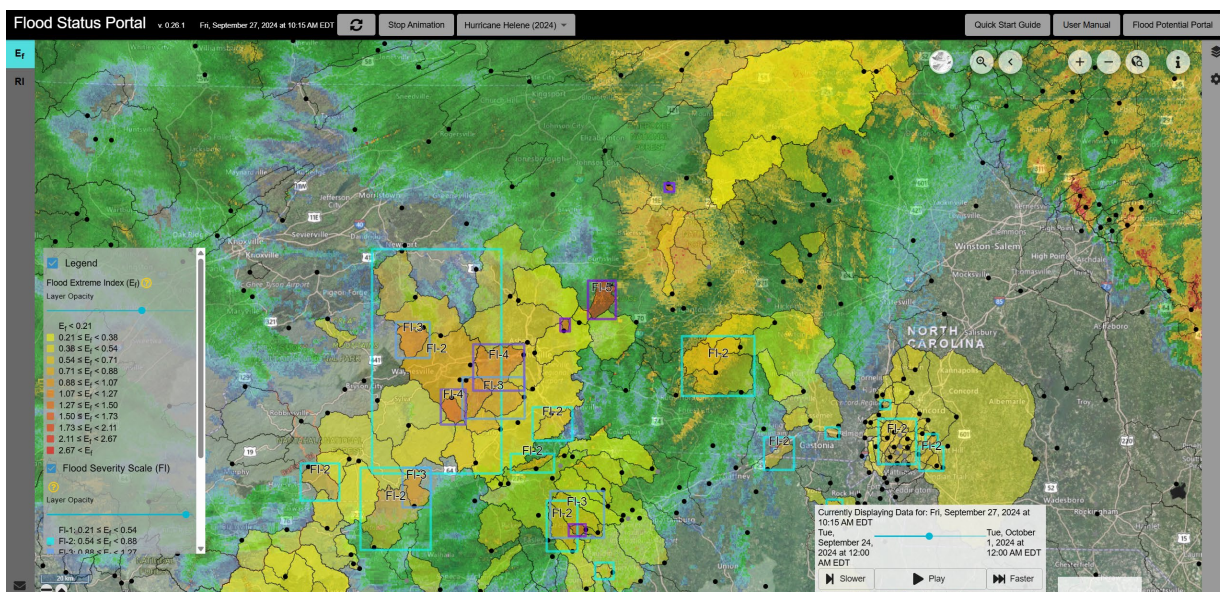


Figure 15: Watersheds experiencing various levels of flooding during the Helene event, at 10:15 AM on 9/27/2024.

Design Flood Discharge Predictions

Recommendations are provided for design flood discharges at the 100-year scale (1% annual exceedance probability, AEP) for the Helene recovery efforts on the Pisgah and Nantahala National Forests, based on results provided by the Flood Potential Portal (<https://floodpotential.erams.com/>). These design flood discharges are expected to be experienced, which could occur in any year. Additional flood-frequency values are also provided, for the 1.5-year to 500-year return intervals (66.7% to 0.2% AEP), as well as maximum likely flood potential values (see next section).

Recommended design flood discharges values are provided as a GIS shapefile at this link: https://y-water.com/wp-content/uploads/NFsNC_RoadStreamCrossings_DesignQ.zip. This file will be updated as additional analyzed watersheds are added.

Prediction Methods and the Flood Potential Portal

The Flood Potential Portal Watershed Analysis module was used to develop peak discharge estimates for road-stream crossings across the Pisgah and Nantahala National Forests, for both National Forest System roads as well as primary roads managed by other entities that connect the Forest Service transportation network to local communities. The Watershed Analysis module was developed as a tool to aid the design process by providing multiple sets of results that are used to avoid prediction bias (Yochum and Wible, 2026). Underestimation results in structures designed with undersized openings for flood passage, overtopped roads and structures, avoidable damage and failures, as well as underestimated base flood elevations and floodplains with insufficient extents, while overestimation leads to unnecessary additional infrastructure costs. Both forms of bias should be avoided, though underestimation poses the greatest risk.

The Watershed Analysis module (Figure 16) includes three approaches for prediction at user-selected points: (a) the flood potential method, including trend reporting of flood magnitudes (with percent change), flood frequency, and flashiness; (b) the index flood-frequency method, using flood potential zones; and (c) USGS regional regression flood-frequency equations, as presented in StreamStats. The expected flood potential, 100-year index, and the 100-year regional regression discharges are directly comparable for the selection of design flood discharges. Percent change from observed increasing trends in flood magnitudes can be used to adjust these values, at the discretion of the practitioner.

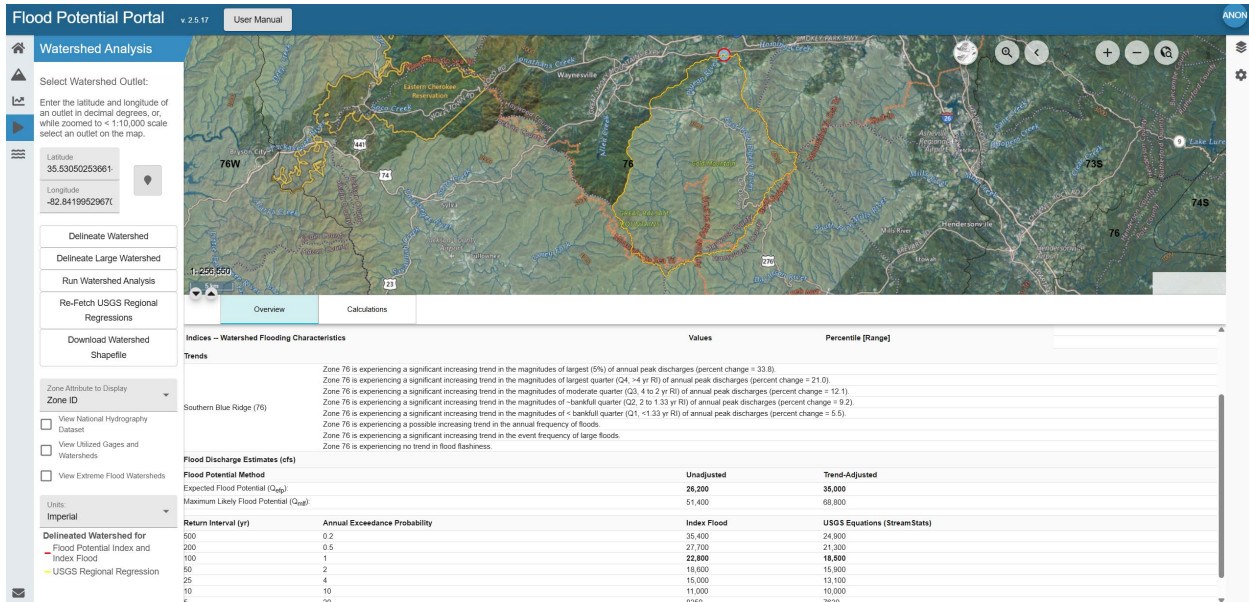


Figure 16: Flood Potential Portal (<https://floodpotential.erams.com/>) Watershed Analysis module results for the Pigeon River at Canton, NC.

Flood Potential

The flood potential method (Yochum et al., 2019) quantifies the central tendency of large flood magnitudes across zones of similar flood response. This central tendency is the expected flood potential, a regression of the maximum recorded (record) discharges for streamgages within each of 206 zones delineated across the contiguous United States, including in zone 73S between Asheville and Boone (Figure 17). Floods of this size can reasonably be expected to occur at a stream valley point of interest, which (in concert with flood-frequency methods) makes these estimates valuable for stream valley infrastructure design and floodplain management. The expected flood potential discharge (Q_{efp}) has been found to not be statistically different from the flood-frequency derived 100-year discharge (Q_{100} ; Yochum et al., 2019), though variability between Q_{efp} and Q_{100} may likely exist with respect to zone and watershed size, with systematic differences in some areas (Yochum and Wible, 2026). The flood potential method has an advantage over flood-frequency methods for addressing bimodal peak flow magnitudes (heavy tails in statistical distributions) due to mixed populations. The 90% prediction limit of the regressions is the maximum likely flood potential. Floods with discharges (Q) greater than the maximum likely flood potential discharge (Q_{mlf}) are quantitatively defined as extreme, with the departure above this limit indicating the degree of extremity. Hence, this method provides a systematic approach for identifying and ranking extreme floods. Each zone has flood potential plots that vary in scale (variability of flood magnitudes) and slope (variability of how watersheds of different sizes experience floods). Such characteristics are quantified and compared between zones through the use of indices ([Appendix B](#)). Finally, the flood potential method provides more statistical power in the assessment of trends in flood magnitudes and flood frequencies. Where trends in flood magnitudes have been detected, percent change is quantified. Algorithms used in the flood potential method were updated in 2025 using data through the 2024 water year, including Helene-induced peak discharges.

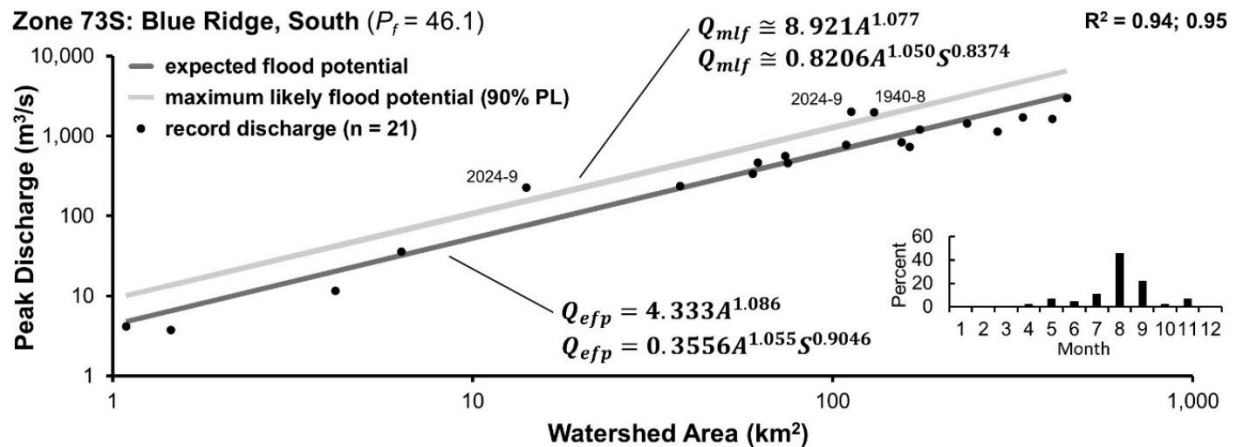


Figure 17: Flood potential plot for the Blue Ridge, South zone 73S. This high flood potential (high P_f) zone has experienced three extreme floods (floods >90% prediction limit, the Q_{mlf}), two during Hurricane Helene and one during the flood of 1940. The explained variance is high, with an $R^2 = 0.94$ for the area-only regression, and $R^2 = 0.95$ for the regression that uses average watershed slope (S) as a secondary predictor.

Index Flood-Frequency

The index flood frequency method, initially introduced by the USGS (Dalrymple, 1960), is a widely used flood frequency analysis method for prediction at ungaged locations as well as for refining at-a-station estimates through the utilization of available flood data for a given region. Based on Hosking and Wallis (1993), an index-flood analysis based on L-moments is utilized in the flood potential portal by assuming that all sites within a homogeneous region have the same distributions except for the scale or index-flood parameter. L-moments are estimated by linear combinations of order statistics (Hosking 1990). A dimensionless frequency curve is developed to represent the ratio between flooding of any given frequency and an index flood. The mean annual flood is used as the scale or index-flood parameter (Hosking and Wallis, 1997). Relationships between the geomorphologic characteristics of watersheds and the mean annual flood are then developed enabling estimation of the mean annual flood at any point. A regional frequency curve is formed by combining the mean annual flood with the dimensionless frequency curve.

Flood potential zones are used for the index flood-frequency method. Algorithms were updated in 2025 using data through the 2024 water year, including Helene-induced peak discharges.

USGS Regional Regression Flood-Frequency

The USGS provides a service of developing and publishing regional regression equations for predicting flood-frequency estimates at ungaged locations across the United States, typically on a state-by-state basis (Austin et al., 2011; Feaster et al., 2014; Feaster et al., 2023 – Figure 18). Generally, the development process has been for hydrologists to fit logPearson distributions (IACWD, 1982; England et al., 2018) to streamgage data, and develop regression equations for each standard recurrence interval (percent chance of exceedance) from these fitted distributions. These regression equations are then embedded within the USGS [StreamStats](#) application (Ries et al., 2017), for providing flood magnitude predictions alongside of predictions of a variety of other flow characteristics. The Flood Potential Portal has been integrated with web services that support the StreamStats website, including watershed delineation and watershed characteristics calculated by the [StreamStats Web Services](#) and the [National Stream Statistics Web Services](#) for regional regression locations, metrics, and results. Hence, these regional regression results from StreamStats are presented alongside the flood potential and index results in the Watershed Analysis module to provide three sets of values for decision making.

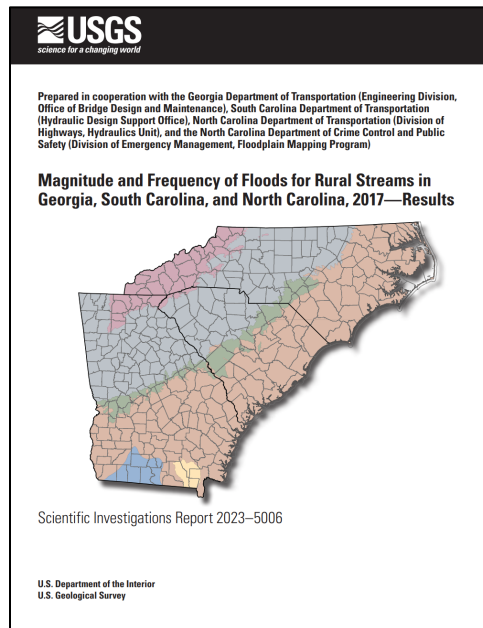


Figure 18: Source document (Feaster et al., 2023) for USGS regional regression equations in the Helene flood-impacted area.

Recommended Peak Discharge Values

With application of the Watershed Analysis module providing three possible (comparable) results, it is necessary to select the most appropriate result as the design flood discharge for each location of interest. Additionally, one of the two provided sets of flood-frequency relationships were selected for recommended use, or were computed by scaling the flood potential (Q_{efp}) result to the Index distribution if the Q_{efp} was deemed most appropriate for use.

For streamgages across the core portion of the Hurricane Helene-induced flooding extent within and adjacent to the Southern Appalachians (Table 2), results of the Watershed Analysis module were compared to each streamgage record and the range of each streamgage analysis Q_{100} results to judge which Watershed Analysis module result is most appropriate for use as the design flood discharge value. These recommendations are in bold, with 17 of the 50 recommendations based on the flood potential result (Q_{efp}), 23 based on Index flood-frequency result ($Q_{100\text{ Index}}$), and 9 based on the USGS regional regression equations result ($Q_{100\text{ Reg. Regr.}}$). These recommended values were then compared to each of the three results from the Watershed Analysis module, to identify systematic bias in predictions (Figure 19). Results indicate that USGS regression equations tend to underpredict flood magnitudes at these streamgages, and oftentimes dramatically so; regional regression equations predict flood magnitudes as little as only 24% of what is most appropriate. In such situations, flood magnitudes used for design and planning should be 4 times larger than this result. At these sites, underprediction increases with decreasing watershed areas. In contrast, the index method ($Q_{100\text{ Index}}$) predicts best for the full range in watershed sizes, but can overpredict in places. In some locations, the flood potential (Q_{efp}) result predicts best, but provides overestimated design flood discharge predictions at other locations.

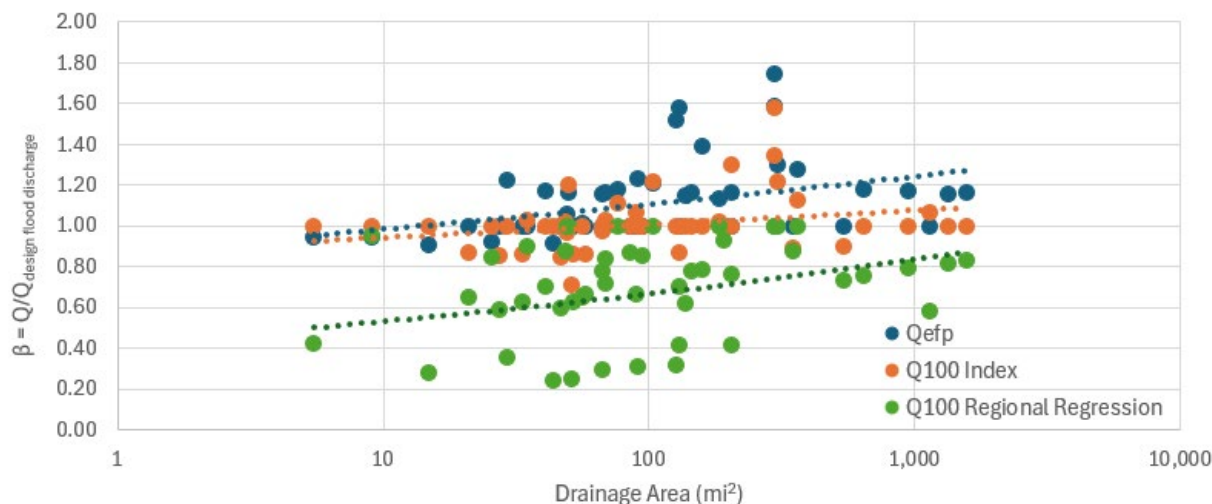


Figure 19: Ratio of FPP Watershed Analysis module result with the selected design flood discharge (Q/Q_{dfd}), by watershed area, for 50 streamgaged watersheds. Note that the index flood-frequency results ($Q_{100\text{ Index}}$) most commonly provides the best values for prediction, while the flood potential result (Q_{efp}) can overpredict flood magnitudes. USGS regional regression results ($Q_{100\text{ Reg. Regr.}}$) typically underpredict flood magnitudes for these drainage area sizes.

For the selection of each of the design flood discharges (at the 100-year scale), the median result from the Flood Potential Portal Watershed Analysis module has been most commonly utilized as the design flood discharge, though if nearby streamgage indicate that the high result may be most appropriate, this value was used. In no cases was the least value utilized. Flood-frequency results from the most appropriate distribution were also reported.

Headwater Catchments

Headwater catchments pose a considerable challenge for reliable design flood discharge predictions, with National Forest System roads frequently crossing channels draining such watersheds. With small contributing areas, methods based on streamgage data typically require extrapolations, which is the case for catchments with areas $<0.42 \text{ mi}^2$ in zone 73S and $<2.48 \text{ mi}^2$ in zone 76. While flood potential analyses in areas that monitor headwater catchments indicate that developed relationships are generally applicable in such situations (streamgages monitor watersheds as small as 0.022 mi^2 in the eastern United States), caution is still warranted. Additionally, for small contributing areas ($<0.46 \text{ mi}^2$), research performed by the USFS Southern Research Station indicates that the rational method can outperform USGS regional regression equations (Mukherjee et al., 2024).

Additionally, automated methods such as the Flood Potential Portal and StreamStats can have watershed delineation issues (due to the DEM size used in these computations) that substantially impact peak discharge predictions. While 30-meter and 10-meter DEMs are used (respectively) in watershed delineations (Figure 20), below a certain catchment size 1-meter DEMs from LiDAR data are required for accurate determination of contributing watersheds to points of interest (pour points). Confidence in the delineations and subsequent predictions is reduced for watershed areas less than $\sim 0.05 \text{ mi}^2$.

The following procedure can be used for sizing culverts that are contributed to by very small catchments, specifically for contributing areas $< \sim 0.05 \text{ mi}^2$:

- If a design flood discharge estimate is provided as a part of the analyses that this report is supporting, use these values as a check for a geomorphic-based design or as the basis of a hydraulics-based design.
- If a design flood discharge estimate is not provided, then:
 - Use a geomorphic approach (exclusively) for sizing the culvert, that is, size the culvert so that the barrel width is at least the width of the channel. Note that the minimum permitted culvert size is 24 inches in diameter.
 - Use the rational method for developing the design flood discharge, using a 1-meter LiDAR DEM to delineate the contributing watershed, and use this value as a check for a geomorphic-based design or as the basis of a hydraulics-based design.

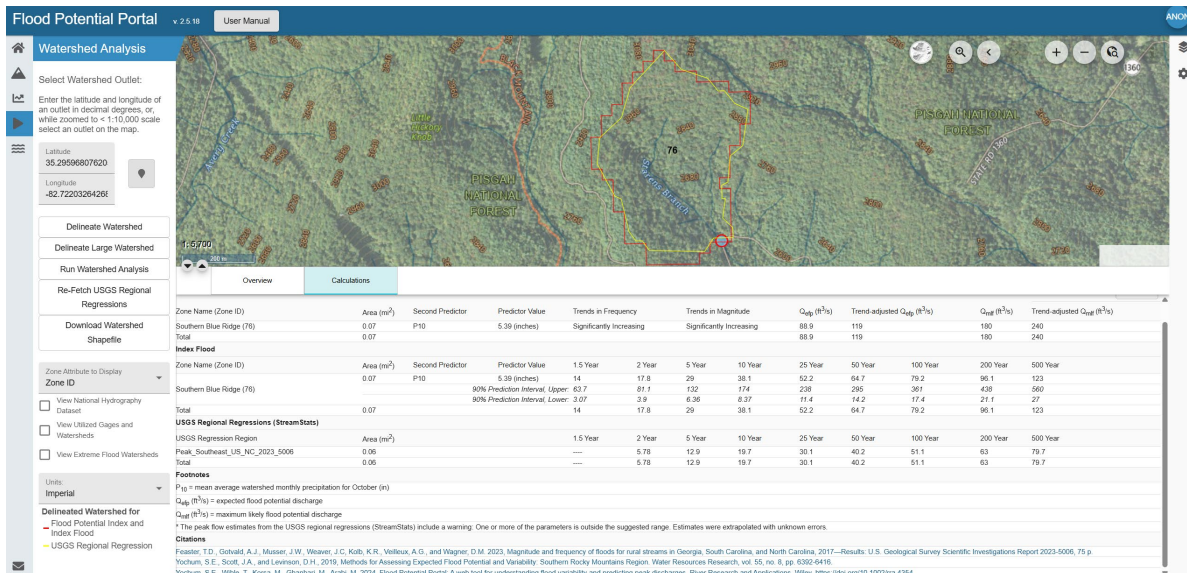


Figure 20: Flood Potential Portal Watershed Analysis module results (calculations tab) for site ID StB-2 in the Davidson River watershed (drainage area = 0.07 mi^2). The red watershed boundary is used in the Flood Potential and Index computations, while the yellow boundary is used USGS regional regressions computation.

Peak Discharge Predictions

Design flood discharges and flood-frequency relationships have been predicted for the Curtis Creek, Dillingham Creek, South Toe River, and Davidson River watersheds (Figure 6). Additional analyses are planned for many additional watersheds. Computations were performed at road-stream crossings for National Forest System roads, and primary road-stream crossings that provide access to these roads. Use of multiple prediction techniques and comparisons with streamgauge flood frequency results, where available, was used to strategically select preferred results that minimize bias (Yochum and Wible, 2026), especially underprediction bias.

Recommended design flood discharge values are provided as a GIS shapefile at this link: https://y-water.com/wp-content/uploads/NFsNC_RoadStreamCrossings_DesignQ.zip. This file will be updated as additional analyzed watersheds are added. Results are also provided through ArcGIS Online.

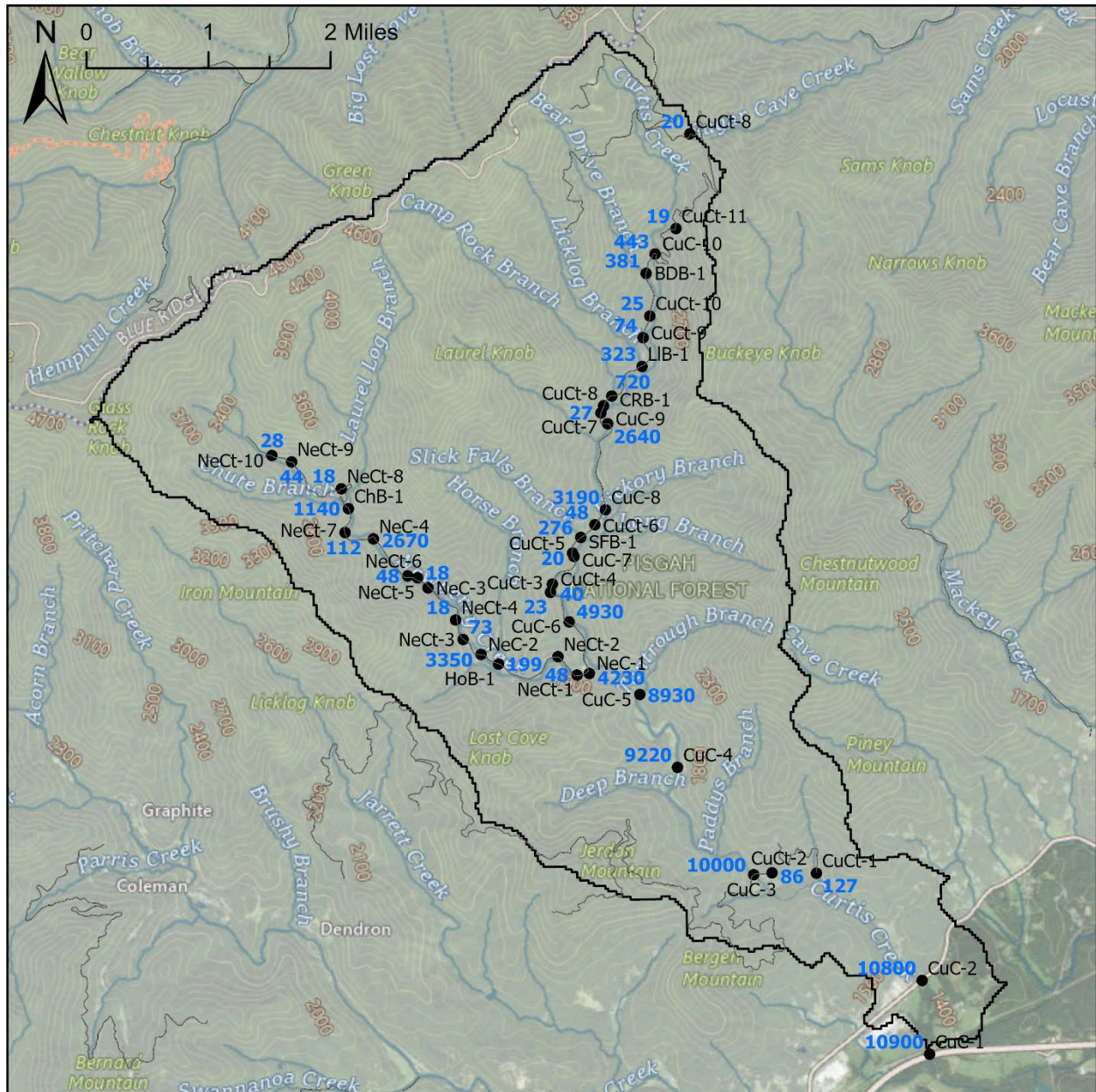
In regard to recommended flood-frequency relationships, if the median value for the selection of the design flood discharge is the expected flood potential discharge and this value is deemed most appropriate for use as the design flood discharge, the Index flood-frequency relationship was used as a basis for creating a new flood-frequency relationship, through scaling. To develop this new relationship, the Q_{efp} and $Q_{100\text{ Index}}$ values were compared to create a scaling factor that was applied to the Index flood-frequency results.



Figure 21: South Toe River Road (NFS-472) crossing of Big Lost Cove Creek (site ID: BLC-1), in the South Toe River watershed. Design flood discharge (Q_{dfd}) = 1360 cfs (flood potential method: Q_{efp}). $Q_{100\text{ Index}}$ = 2280 cfs; $Q_{100\text{ regional regressions}}$ = 751 cfs.

Curtis Creek

Recommended design flood discharges (Q_{dfd}) have been computed for the Curtis Creek watershed at 42 road-stream crossing supporting the local road network (Figure 22; Table 4). This watershed is entirely in zone 73S. These recommended peak discharges range from 10,900 cfs at I-40 to 18 cfs for a headwater catchment. These recommended predictions are the median value of the flood potential, index flood-frequency, and USGS regional regression flood-frequency. The flood-frequency values, for the 500-year to 1.5-year (or 2-year) return interval floods, were selected from the respective design flood discharge value, with the Q_{efp} result scaled from the Index flood-frequency relationship. Of special interest is if the I-40 crossing has been sized sufficiently to accommodate this flood magnitude, or if the interstate highway is at threat of inundation when the next large flood occurs.



Regional regression results (from StreamStats) underpredict peak discharges in watersheds $> \sim 0.25$ mi², with predictions as little as 35% of the recommended design flood discharge value – a standard method for predictions can result in bridges and culverts being only 1/3 the size of what is needed to accommodate the next large flood, when it occurs. Such a flood event could occur in any year, and should be expected and prepared for, to provide infrastructure resilience. This perceived bias is on a relative basis (compared to the other prediction techniques), though clearly show that regional regression equations are biased low in streams with relatively larger watersheds. Overall, the selected value was the flood potential result at 15 sites, index result at 5 sites, and the regional regression result at 22 sites (headwater streams, with areas < 0.25 mi²).

This pattern can be leveraged if additional predictions are needed for drainages from small catchments, a common need for sizing culverts in headwater streams on National Forests and neighboring properties. Specifically, if computations at additional sites are needed, and these watersheds have drainage areas < 0.25 mi², these analyses indicate that using USGS regional regression equation results from StreamStats would be appropriate for the selection of the design flood discharge. For larger catchments (> 0.25 mi²) in the Curtis Creek watershed, it is essential to perform analyses using multiple (at least three) methods, using the Flood Potential Portal or a combination of other tools.

Table 4: Recommended design flood discharge values (**in bold**) for a 9-location subset (of 42 total) for the Curtis Creek Watershed, with flood potential and flood-frequency discharges. Shaded values are directly comparable at the 100-year (Q₁₀₀; 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_{mif}: maximum likely flood potential discharge. See [GIS Shapefile](#) for locations and results.

ID	Q _{efp} (cfs)	Q _{mif} (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)	
CuC-1	13,100	23,900	Curtis Creek at I-25 (drainage area = 17.0 mi ²)									
			Index:	22,900	15,100	10,900	7900	5650	3550	2410	1270	951
			Regional Regressions:	5340	4460	3810	3200	2570	1880	1380	773	---
CuC-3	12,100	21,900	Curtis Creek upstream of roadside campsites (drainage area = 15.1 mi ²)									
			Index:	21,000	13,800	10,000	7240	5180	3250	2210	1170	872
			Regional Regressions:	4910	4100	3490	2930	2350	1720	1250	701	---
NeC-1	4230	7690	Newberry Creek at Curtis Creek Road crossing (drainage area = 5.46 mi ²)									
			Index:	9270	6100	4430	3190	2290	1430	974	515	385
			Regional Regressions:	2290	1900	1600	1330	1050	754	539	289	---
			Scaled Index:	8850	5830	4230	3050	2190	1370	930	492	368
CuC-6	4930	8990	Curtis Creek at Curtis Creek Road fill failure (drainage area = 6.51 mi ²)									
			Index:	10,600	7000	5080	3660	2620	1650	1120	591	441
			Regional Regression:	2610	2160	1830	1520	1210	868	623	337	---
			Scaled Index:	10,300	6790	4930	3550	2540	1600	1090	574	428
CuCt-5	32	59	Curtis Creek tributary at Curtis Creek Road crossing (drainage area = 0.05 mi ²)									
			Index:	173	114	83	60	43	27	18	10	7
			Regional Regression:	75	59	48	38	28	19	12	5	---
CuC-8	2640	4830	Curtis Creek at Curtis Creek Road bridge with abutment scour (drainage area: 3.65 mi ²)									
			Index:	7250	4770	3460	2500	1790	1120	762	403	301
			Regional Regressions:	1690	1400	1170	969	764	543	385	203	---
			Scaled index:	6690	4400	3190	2300	1650	1030	703	371	278
LiB-1	323	595	Licklog Branch at Curtis Creek Road crossing, with large debris flow (drainage area: 0.49 mi ²)									
			Index:	1490	981	712	514	368	231	157	83	62
			Regional Regressions:	385	311	257	207	159	109	74	36	---
			Scaled Index:	676	445	323	233	167	105	71	38	28
BDB-1	381	701	Bear Drive Branch at Curtis Creek Road crossing (drainage area: 0.55 mi ²)									
			Index:	1560	1020	744	537	384	241	164	87	65
			Regional Regressions:	413	334	276	223	172	117	80	39	---
			Scaled Index:	799	522	381	275	197	123	84	44	33
CuCt-1	----	----	Curtis Creek headwater tributary at Curtis Creek Road crossing (drainage area: 0.01 mi ²)									
			Index:	----	----	----	----	----	----	----	----	----
			Regional Regressions:	32	25	20	16	12	7	5	2	----

Dillingham Creek

Recommended design flood discharges (Q_{dfd}) have been computed for the Dillingham Creek watershed at 57 road-stream crossing supporting the local road network, including crossings for Big Ivy and Stony Fork (Figure 23; Table 5). Most of this watershed is in zone 73S, though lower portions are in zone 76. These recommended peak discharges range from 12,300 cfs for Dillingham Creek upstream of Paint Fork to 14 cfs for a headwater catchment. These recommended predictions are the median value of the flood potential, index flood-frequency, and USGS regional regression flood-frequency. The flood-frequency values were selected from the respective design flood discharge value, with the Q_{efp} result scaled from the Index flood-frequency relationship.

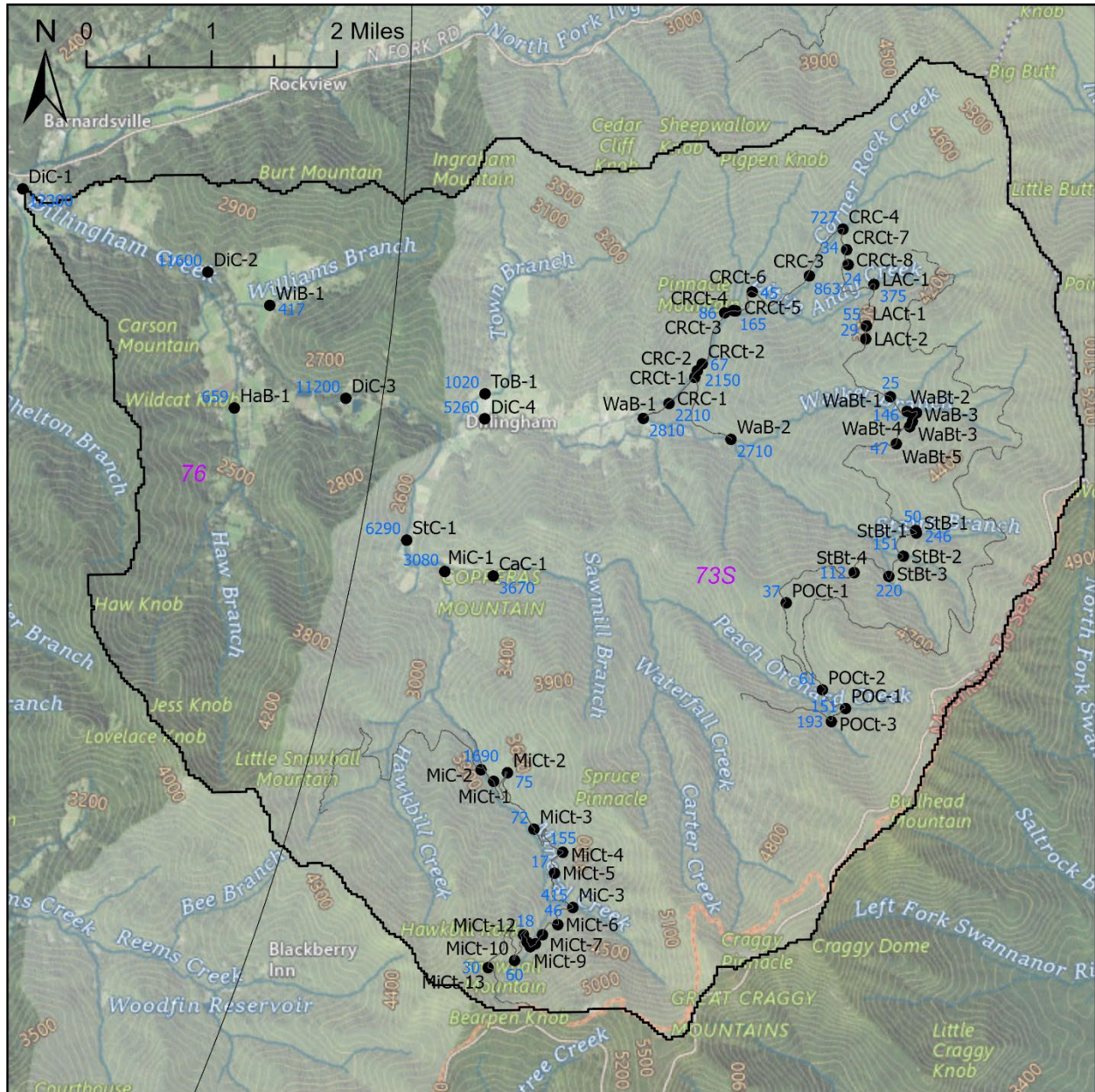


Figure 23: Design flood discharge (Q_{dfd}) predictions for 57 locations in the Dillingham Creek watershed, including road-stream crossings for Big Ivy and Stony Fork. Black text: point IDs; Blue text: design flood discharge predictions. Magenta text: zone ID for the illustrated zone boundary (narrow black curved line). See [GIS Shapefile](#) for locations and results.

Regional regression results (from StreamStats) underpredict peak discharges in watersheds $> \sim 0.25 \text{ mi}^2$, with predictions as little as 42% of the recommended value. On a relative basis (compared to the other prediction techniques), regional regression equations are biased low in streams with relatively larger watersheds (in zone 73S). Sizing structures using such a value would result in less than the half the needed flow capacity and poor resilience. However, for portions of this watershed in zone 76, regional regression results are not biased low (Figure 23, Table 5: HaB-1). Overall, the selected value was the flood potential result at 13 sites, index result at 11 sites, and the regional regression result at 33 sites (headwater streams, with areas $< 0.25 \text{ mi}^2$).

Table 5: Recommended design flood discharge values (**in bold**) for a 10-location subset (of 57 total) for the Dillingham Creek Watershed, with flood potential and flood-frequency discharges. 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_{mlr} : maximum likely flood potential discharge. See [GIS Shapefile](#) for locations and results.

ID	Q_{efp} (cfs)	Q_{mlr} (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)	
DiC-1	17,600	32,500	Dillingham Creek at Paint Fork Road (drainage area = 28.7 mi ²)									
			Index:	25,100	16,800	12,300	9040	6570	4220	2920	1590	1200
			Regional Regressions:	7930	6660	5710	4830	3910	2890	2140	1230	---
HaB-1	659	1350	Haw Branch at private bridge (drainage area = 2.01 mi ²)									
			Index:	980	767	632	516	416	304	231	142	112
			Regional Regressions:	1260	1030	867	712	559	394	277	144	---
			Scaled Index:	1020	800	659	538	434	317	241	148	117
StC-1	7,470	13,700	Stoney Creek at road crossing (drainage area = 10.3 mi ²)									
			Index:	13,100	8640	6290	4560	3280	2070	1410	753	565
			Regional Regressions:	3690	3070	2610	2180	1740	1260	913	503	---
CaC-1	3380	6190	Carter Creek at road crossing (drainage area = 4.69 mi ²)									
			Index:	7680	5050	3670	2650	1890	1190	807	427	319
			Regional Regressions:	2050	1690	1430	1180	934	666	475	253	---
POC-1	130	244	Peach Orchard Creek at Big Ivy Road (drainage area = 0.25 mi ²)									
			Index:	889	585	424	306	219	137	93	49	37
			Regional Regression:	229	184	151	121	92	62	42	20	---
MiC-2	1690	3090	Mineral Creek at road crossing (drainage area = 2.30 mi ²)									
			Index:	3980	2620	1900	1370	981	616	418	221	165
			Regional Regression:	1200	986	826	678	532	374	263	136	---
			Scaled Index:	3540	2330	1690	1220	873	548	372	197	147
DiC-4	6220	11,400	Dillingham Creek at Dillingham (drainage area: 9.13 mi ²)									
			Index:	11,000	7250	5260	3800	2720	1700	1160	612	457
			Regional Regressions:	3370	2800	2370	1980	1580	1140	826	452	---
WaB-1	2810	5170	Walker Branch at Big Ivy Road (drainage area: 4.24 mi ²)									
			Index:	6740	4440	3220	2320	1660	1040	709	374	280
			Regional Regressions:	1910	1570	1320	1100	865	616	439	233	---
			Scaled Index:	5880	3880	2810	2030	1450	908	619	326	244
WaBt-2	132	246	Walker Branch tributary at Big Ivy Road (drainage area: 0.24 mi ²)									
			Index:	544	358	259	187	134	84	57	30	23
			Regional Regressions:	222	178	146	117	89	60	40	19	---
WaB-3	447	831	Walker Branch at Big Ivy Road (drainage area: 0.76 mi ²)									
			Index:	1620	1060	771	556	398	250	170	90	67
			Regional Regressions:	531	431	357	290	224	154	106	53	---
			Scaled Index:	939	615	447	322	231	145	99	52	39

South Toe River

Recommended design flood discharges (Q_{dfd}) have been computed for the South Toe River watershed at 41 road-stream crossing supporting the local road network (Figure 24; Table 6). These recommended peak discharges range from 38,600 to 29 cfs. The downstream limit of this watershed is streamgaged, with a flood-frequency analysis of these peak discharge data used to inform the predictions. Generally these recommended predictions are the median value of the flood potential, index flood-frequency, and USGS regional regression flood-frequency. The flood-frequency values, for the 500-year to 1.5-year (or 2-year) return interval floods, were selected from the most appropriate of the index and regional regression sets of results, or were computed by scaling the flood potential (Q_{efp}) result to the Index distribution.

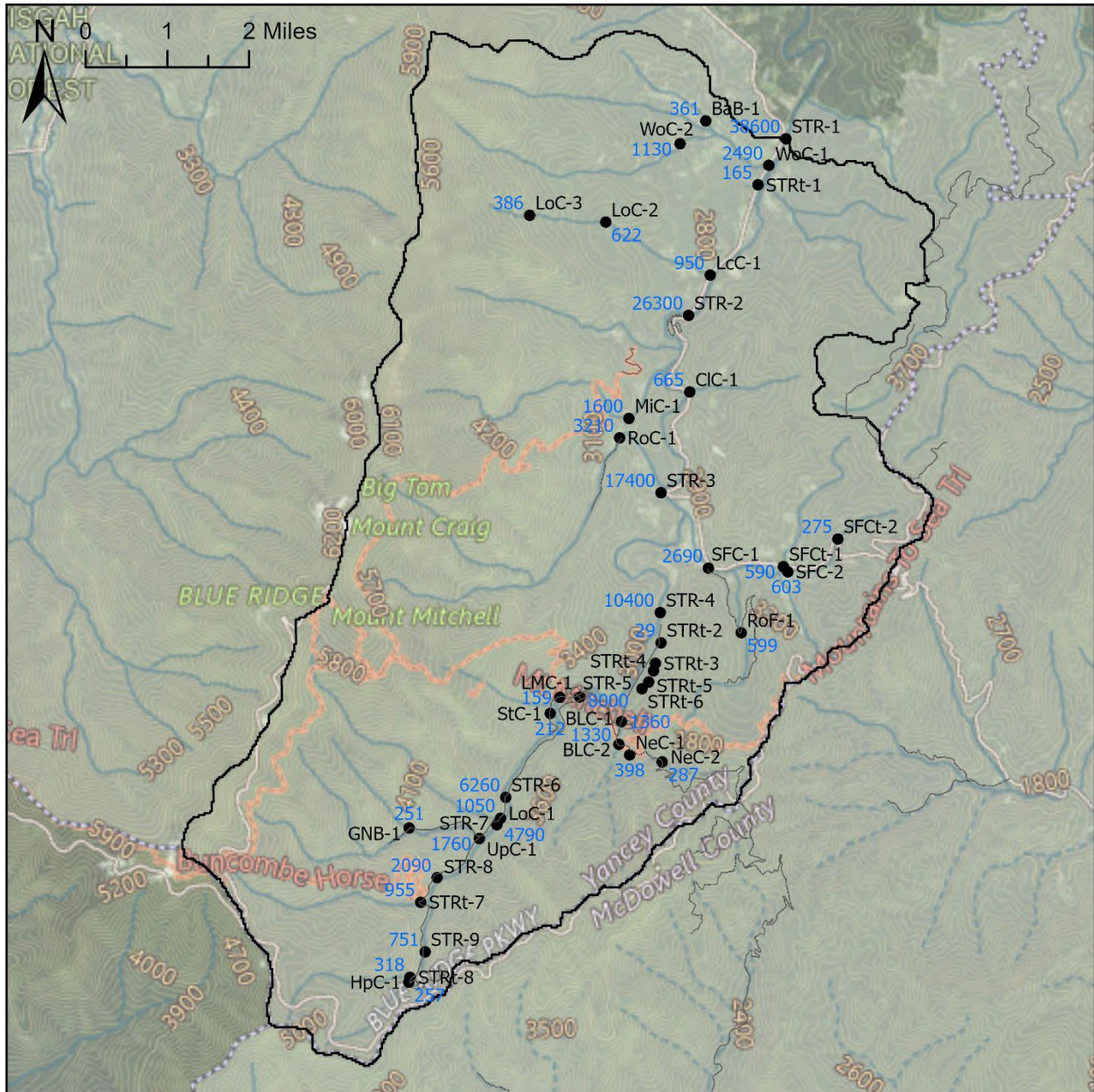


Figure 24: Design flood discharge (Q_{dfd}) predictions for 41 locations in the South Toe River watershed. Black text: point IDs; Blue text: design flood discharge predictions. See [GIS Shapefile](#) for locations and results.

The downstream limit of South Toe River analyses is at a USGS streamgage (ID: 03463300). Flood frequency analyses of these data are provided (Figure 66). This site has been monitored from WY1958 through present (68 years) – large floods that may have likely occurred in 1940 and 1916 in this watershed are not included in the dataset. The maximum recorded discharge is 70,900 cfs, on 9/27/2024 from Hurricane Helene, with this flood being extreme ($E_f = 2.35$), more than twice the magnitude as expected for a large flood and not expected to reoccur. The next largest flood had a peak of 32,900 cfs on 11/6/1977. The median annual peak discharge is 4880 cfs. Using the station skew, the 100-year (1% AEP) peak discharge is 49,600 cfs. Using the weighted generalized skew, the 100-year peak discharge is 38,600 cfs. The Flood Potential Portal Watershed Analysis module provides results of 32,400 cfs, 29,700 cfs, and 7830 cfs for the Index, flood potential, and USGS regional regression equations results, respectively. Clearly, USGS regional regressions (StreamStats) are underpredicting flood magnitudes at this location. These results indicate that predictions on the mainstem South Toe River may be best selected from the largest result (Index), with the median result most appropriate in smaller, upstream watersheds. For watersheds $<15 \text{ mi}^2$, the Index method is overpredicting flood magnitudes; using this highest of the three values is no longer appropriate in these situations. For such watersheds, the flood potential result is used and the flood-frequency results generated by scaling the Index flood-frequency relationship. In the smallest watersheds, USGS regional regression equations results are most appropriate for use.

Table 6: Recommended design flood discharge values (in bold) for a 8-location subset (of 29 total) for the South Toe River Watershed, with flood potential and flood-frequency discharges. Shaded values are directly comparable at the 100-year (Q_{100} ; 1% chance of occurrence) scale flood level. Q_{efp} : expected flood potential discharge; Q_{mlf} : maximum likely flood potential discharge. See GIS shapefile for locations and results. Notes: (1) Bulletin 17C analysis, computed using station skew; (2) Bulletin 17C analysis, computed using weighted generalized skew. See [GIS Shapefile](#) for locations and results.

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)	
STR-1	29,700	54,300	South Toe River at streamgage 03463300 (drainage area = 43.3 mi ²)									
			Index:	68,000	44,700	32,400	23,400	16,700	10,500	7140	3770	2820
			Regional Regressions:	10,800	9100	7830	6660	5410	4030	3010	1750	----
			Streamgage ⁽¹⁾ :	103,000	68,300	49,600	35,600	25,100	15,400	10,100	5180	3900
			Streamgage ⁽²⁾ :	66,200	49,100	38,600	29,900	22,700	15,100	10,500	5500	4050
STR-2	23,500	42,900	South Toe River at NC-80 and Carolina Hemlocks Campground (drainage area = 33.0 mi ²)									
			Index:	55,200	36,300	26,300	19,000	13,600	8540	5800	3060	2290
			Regional Regressions:	8800	7400	6360	5390	4360	3240	2400	1380	----
SFC-1	2690	5,000	Still Fork Creek at road crossing (drainage area = 4.77 mi ²)									
			Index:	9180	6040	4380	3160	2260	1420	964	510	381
			Regional Regressions:	2070	1710	1440	1200	946	675	482	257	----
			Scaled Index:	5640	3710	2690	1940	1390	872	592	313	234
STR-4	10,400	19,000	South Toe River at road crossing (drainage area = 14.6 mi ²)									
			Index:	28,200	18,600	13,500	9720	6850	4360	2960	1570	1170
			Regional Regressions:	4780	3990	3400	2860	2290	1670	1220	681	----
			Scaled Index:	21,700	14,300	10,400	7490	5350	3360	2280	1210	900
STR-5	8000	14,600	South Toe River at Black Mountain Campground (drainage area = 11.3 mi ²)									
			Index:	23,800	15,700	11,400	8210	5870	3690	2500	1320	989
			Regional Regressions:	3950	3290	2800	2340	1870	1360	986	545	----
			Scaled Index:	16,700	11,000	8000	5760	4120	2590	1750	926	694
LoC-1	1050	1930	Lower Creek at road crossing (drainage area = 1.58 mi ²)									
			Index:	6270	4130	2990	2160	1550	971	659	348	260
			Regional Regression:	909	742	620	506	395	276	193	98	----
			Scaled Index:	2200	1450	1050	759	544	341	231	122	91
STRt-2	955	1770	Right Prong South Toe River at road crossing (drainage area = 1.60 mi ²)									
			Index:	4470	2940	2130	1540	1100	692	470	248	186
			Regional Regression:	913	746	623	509	397	277	194	99	----
			Scaled Index:	2004	1318	955	690	493	310	211	111	83
HpC-1	242	456	Hemphill Creek at road crossing (drainage area: 0.50 mi ²)									
			Index:	1530	1010	732	528	378	237	161	85	64
			Regional Regressions:	385	311	257	207	159	109	74	36	----

The Davidson River watershed is in zone 76, which is experiencing significantly increasing trends in large flood magnitudes (see [General Flooding Characteristics](#) section). Specifically, the largest 5% of annual peak discharges are increasing by 33.8% and the largest quarter by 21.0%. Considering this, it could be considered prudent to increase design flood discharges by such a percentage. However, the flood potential and index algorithms are dominated by Hurricane Helene flooding, making the need for any trend adjustments (arguably) unnecessary. Using professional judgement and a concern for overprediction bias, it was decided that adding an additional 21.0% or 33.8% to the design flood discharge estimates too conservative and unnecessary.

Table 7: Recommended design flood discharge values (**in bold**) for a 6-location subset (of 49 total) for the Davidson River Watershed, with flood potential and flood-frequency discharges. Shaded values are directly comparable at the 100-year (Q_{100} ; 1% chance of occurrence) scale flood level. Q_{efp} : expected flood potential discharge; Q_{mlf} : maximum likely flood potential discharge. See GIS shapefile for locations and results. Notes: (1) Bulletin 17C analysis, computed using station skew; (2) Bulletin 17C analysis, computed using weighted generalized skew. See [GIS Shapefile](#) for locations and results.

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)	
DaR-1	12,400	24,200	Davidson River at US-64 road crossing, at streamgage 03441000 (drainage area = 40.5 mi ²)									
			Index:	16,400	12,800	10,600	8620	6950	5090	3860	2370	1860
			Regional Regressions:	10,200	8630	7420	6310	5120	3810	2840	1650	----
			Streamgage ⁽¹⁾ :	13,700	11,600	10,200	8740	7400	5720	4500	2840	2250
			Streamgage ⁽²⁾ :	13,900	11,700	10,200	8780	7420	5730	4500	2840	2250
DaR-2	11,900	23,400	Davidson River at National Forest System road crossing (drainage area = 38.5 mi ²)									
			Index:	15,800	12,400	10,200	8320	6710	4910	3730	2290	1800
			Regional Regressions:	9910	8350	7180	6100	4950	3680	2740	1590	----
AvC-1	2970	5860	Avery Creek at US-276 road crossing (drainage area = 6.44 mi ²)									
			Index:	3980	3120	2570	2100	1690	1240	940	577	453
			Regional Regressions:	2600	2150	1820	1510	1200	861	619	334	----
LGC-6	904	1790	Looking Glass Creek at National Forest System road crossing (drainage area = 1.15 mi ²)									
			Index:	1200	939	774	632	510	373	283	174	137
			Regional Regressions:	717	583	486	396	308	213	148	75	----
CoC-2	631	1250	Cove Creek at National Forest System road crossing (drainage area = 0.69 mi ²)									
			Index:	836	654	539	440	355	260	197	121	95
			Regional Regressions:	505	409	339	275	212	146	100	50	----
DaR-4	2980	5850	Davidson River at National Forest System road crossing (drainage area = 5.50 mi ²)									
			Index:	3920	3070	2530	2060	1660	1220	925	568	446
			Regional Regression:	2300	1900	1610	1330	1060	757	542	291	----

Conclusions

Design flood discharge estimates were computed for road-stream crossing replacement projects that are part of the Hurricane Helene flood recovery work being planned on the Pisgah and Nantahala National Forests. To support the development of these estimates, general flooding characteristics of the area have been documented using the Flood Potential Method, and flooding from Hurricane Helene at U.S. Geological Survey streamgages have been reviewed, using both standard and novel methodologies. Results at 189 locations are provided for four initial HUC-12 watersheds (Curtis Creek, Dillingham Creek, South Toe River, Davidson River), with plans to extend these analyses to many more HUC-12 watersheds with National Forest System lands.

Data Availability

Recommended design flood discharge values are provided through a GIS Shapefile (https://y-water.com/wp-content/uploads/NFsNC_RoadStreamCrossings_DesignQ.zip). Results are also provided through ArcGIS Online. Example results are presented in the tables and figures of this report, with supporting streamgage flood-frequency analyses provided in Appendix A. Computations are available upon request to this report's author.

Acknowledgements

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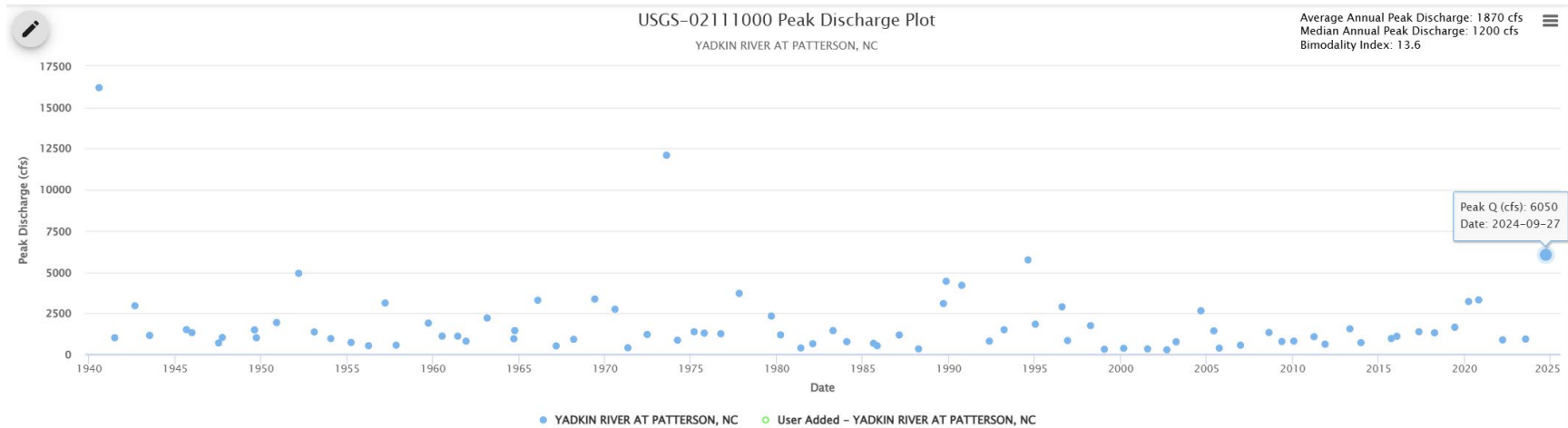
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Appendix A: Streamgage Data and Flood-Frequency Analyses

In the vicinity of the Pisgah and Nantahala National Forests, 52 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 5.45 to 1560 mi², and are predominantly in flood potential zones 73, 73S, and 76. 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 provided in Figure 26 to Figure 77.

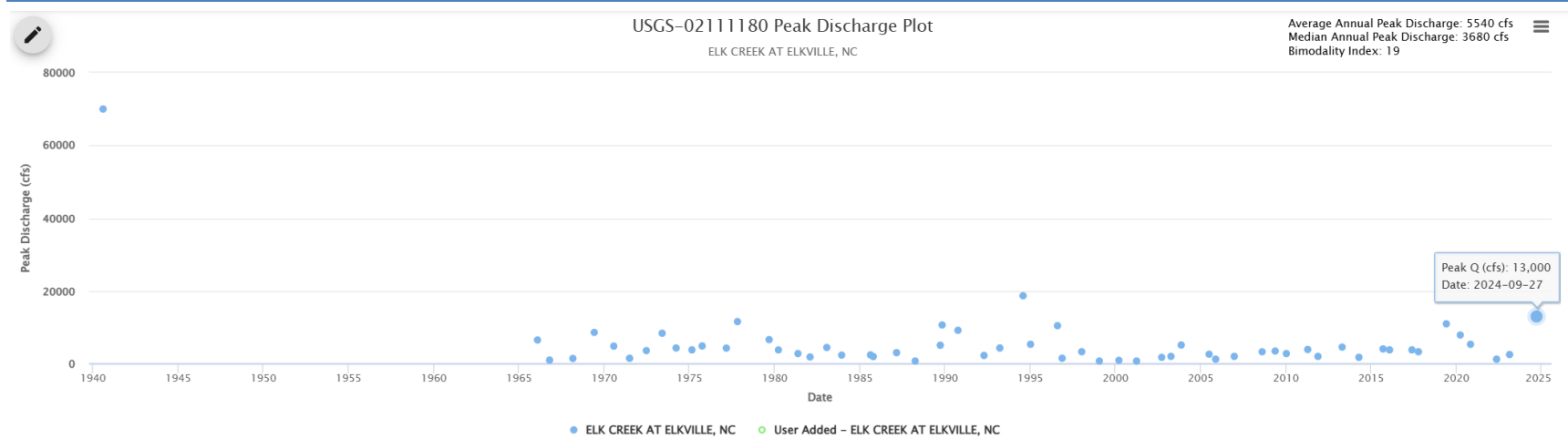
02111000: Yadkin River



Return Interval (yr)	Percent Chance of Occurrence	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	23,700	16,600	37,200	17,500	12,600	26,300	23,700	13,400	102,000	17,500	11,300	36,500
200	0.5	16,100	11,700	23,900	12,800	9,520	18,400	16,100	9,950	50,100	12,800	8,780	23,600
100	1	11,800	8,880	16,900	9,910	7,580	13,800	11,800	7,840	29,200	9,940	7,130	16,700
50	2	8,560	6,650	11,700	7,570	5,940	10,200	8,560	6,060	17,100	7,590	5,690	11,700
25	4	6,090	4,880	8,000	5,660	4,560	7,370	6,090	4,580	10,100	5,660	4,430	8,060
10	10	3,720	3,100	4,620	3,660	3,060	4,540	3,720	2,990	5,080	3,660	3,000	4,740
5	20	2,430	2,080	2,900	2,480	2,120	2,970	2,430	2,020	3,030	2,480	2,090	3,030
2	50	1,190	1,030	1,370	1,240	1,070	1,430	1,190	1,010	1,390	1,240	1,070	1,440
1.5	66.7	864	736	1,000	888	758	1,030	861	743	999	885	763	1,030
1.25	80	652	545	764	654	546	766	652	568	752	654	558	758
1.05	95.2	404	321	488	370	292	451	409	335	480	377	301	450

Figure 26: Annual peak discharge data and flood-frequency analysis results for the Yadkin River at Patterson, NC streamgage (USGS ID: 02111000). Helene peak Q: 6050 cfs. Record peak Q: 16,200 cfs (8/13/1940). Drainage area: 29.0 mi².

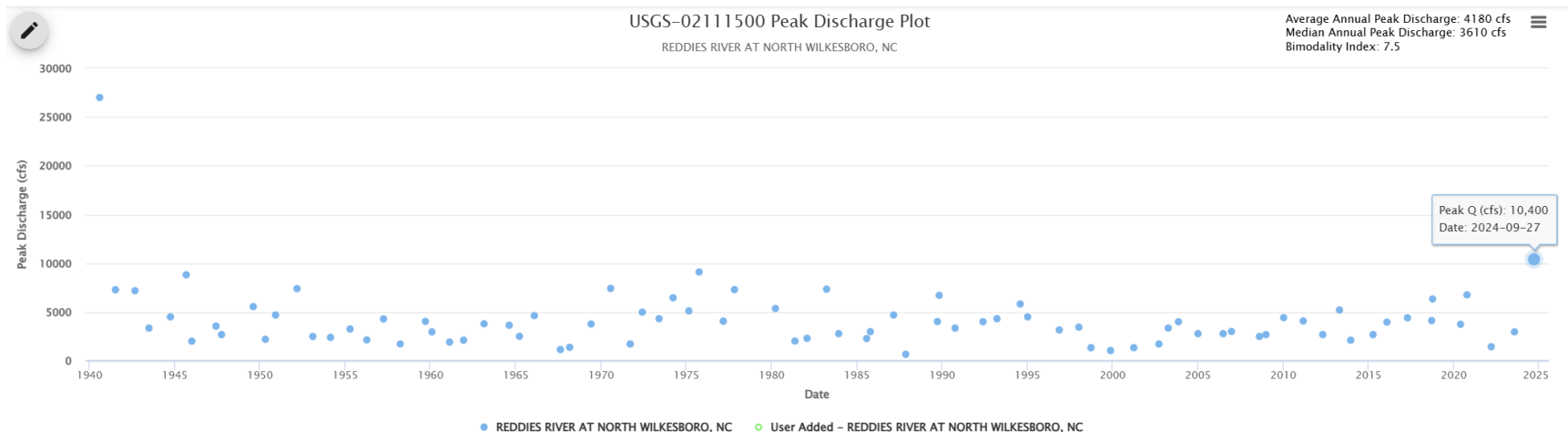
02111180: Elk Creek



Return Interval (yr)	Percent Chance of Occurrence	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	75,900	49,100	135,000	53,500	36,100	90,000	75,900	38,900	557,000	53,500	32,200	127,000
200	0.5	50,500	34,300	84,100	38,800	27,200	61,800	50,500	28,800	233,000	38,800	25,000	80,200
100	1	36,600	25,800	57,800	29,900	21,600	45,800	36,600	22,500	122,000	29,900	20,300	55,900
50	2	26,100	19,200	39,100	22,700	16,900	33,200	26,100	17,300	65,100	22,700	16,200	38,300
25	4	18,300	13,900	25,900	16,800	12,900	23,500	18,300	13,000	35,300	16,800	12,500	25,800
10	10	10,900	8,710	14,300	10,700	8,570	14,100	10,900	8,340	16,300	10,700	8,400	14,700
5	20	6,960	5,750	8,710	7,130	5,880	8,930	6,960	5,550	9,240	7,130	5,790	9,160
2	50	3,270	2,730	3,910	3,430	2,860	4,110	3,270	2,670	4,000	3,430	2,860	4,160
1.5	66.7	2,340	1,920	2,810	2,420	1,990	2,900	2,340	1,950	2,820	2,410	2,000	2,900
1.25	80	1,740	1,390	2,120	1,750	1,390	2,130	1,740	1,460	2,080	1,750	1,430	2,110
1.05	95.2	1,050	785	1,320	952	703	1,210	1,060	825	1,300	969	724	1,210

Figure 27: Annual peak discharge data and flood-frequency analysis results for the Elk Creek at Elkville, NC streamgauge (USGS ID: 02111180). Helene peak Q: 13,000 cfs. Record peak Q: 70,000 cfs (8/13/1940). Drainage area: 51.0 mi².

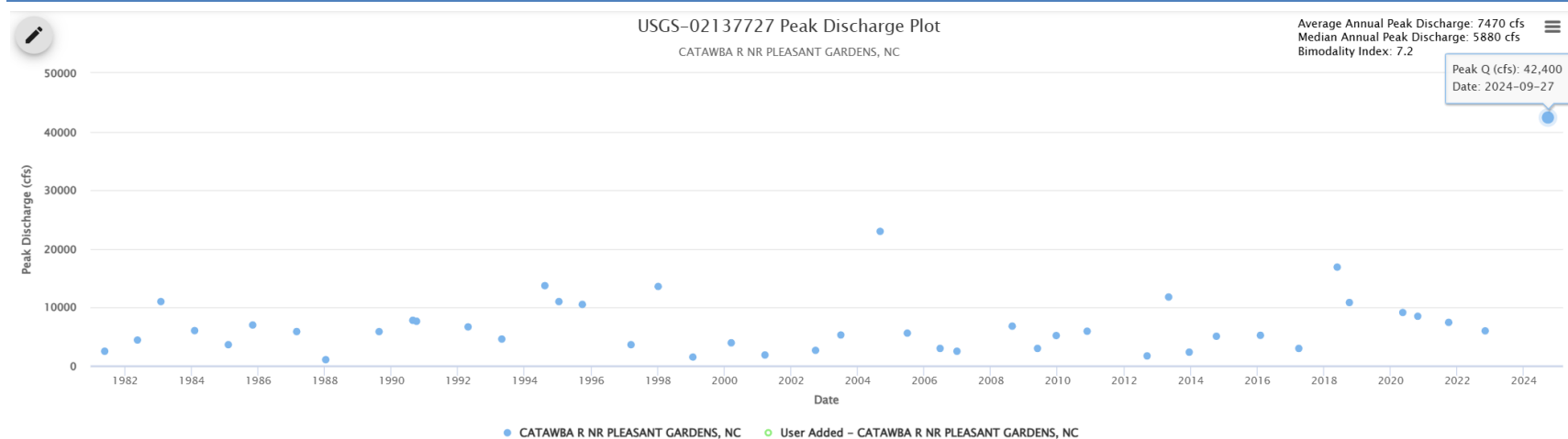
02111500: Reddies River



Return Interval (yr)	Percent Chance of Occurrence	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	20,700	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 28: 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 mi².

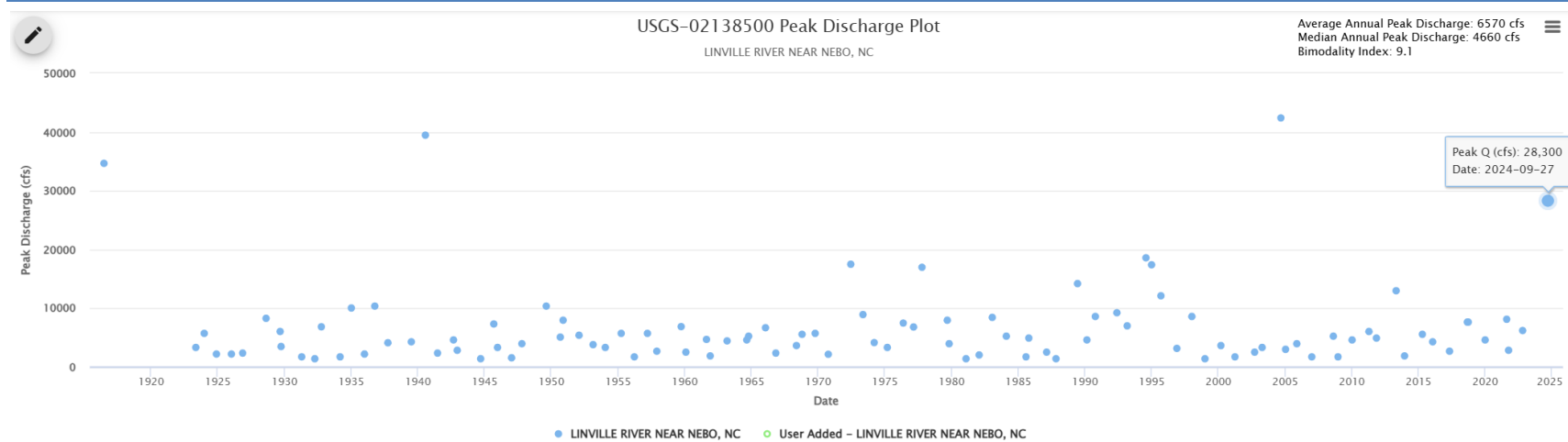
02137727: Catawba River



Return Interval (yr)	Percent Chance of Occurrence	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	54,100	37,000	91,600	50,800	35,100	84,900	54,100	32,700	183,000	50,900	32,800	109,000
200	0.5	41,900	29,700	67,500	39,900	28,500	63,600	41,900	27,300	112,000	40,000	27,300	76,400
100	1	34,100	24,800	52,600	32,800	24,000	50,300	34,100	23,400	76,700	32,800	23,300	57,600
50	2	27,200	20,300	40,300	26,500	19,900	39,000	27,200	19,600	52,100	26,500	19,500	42,800
25	4	21,300	16,400	30,100	20,900	16,100	29,500	21,300	16,100	35,100	20,900	16,000	31,200
10	10	14,700	11,700	19,500	14,600	11,700	19,400	14,700	11,600	20,500	14,600	11,600	19,800
5	20	10,400	8,570	13,200	10,500	8,590	13,200	10,400	8,450	13,400	10,500	8,530	13,300
2	50	5,550	4,610	6,670	5,600	4,650	6,730	5,550	4,550	6,780	5,600	4,630	6,790
1.5	66.7	4,070	3,320	4,900	4,100	3,340	4,930	4,060	3,320	4,940	4,090	3,350	4,940
1.25	80	3,040	2,400	3,700	3,050	2,400	3,710	3,040	2,440	3,710	3,050	2,430	3,710
1.05	95.2	1,730	1,250	2,210	1,700	1,230	2,180	1,760	1,220	2,220	1,730	1,240	2,200

Figure 29: Annual peak discharge data and flood-frequency analysis results for the Catawba River near Pleasant Gardens, NC streamgauge (USGS ID: 02137727). Helene peak Q: 42,400 cfs, the record peak Q (9/27/2024). Drainage area: 127 mi².

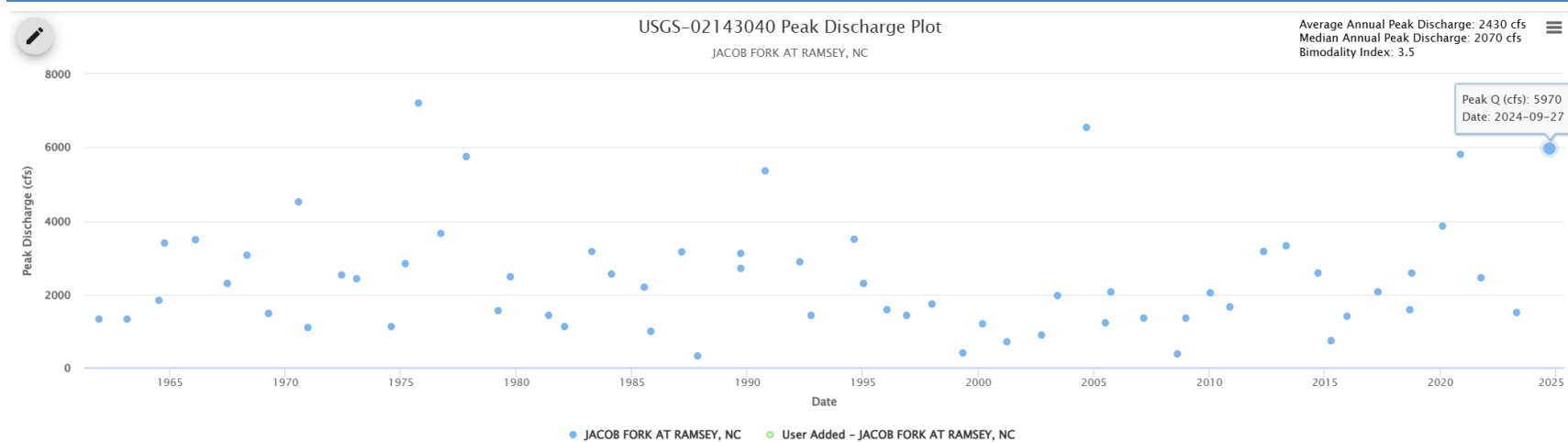
02138500: Linville River



Return Interval (yr)	Percent Chance of Occurrence	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	73,400	54,000	107,000	57,100	43,000	81,000	73,400	44,600	233,000	57,300	38,600	109,000
200	0.5	51,000	38,900	71,400	42,200	32,700	57,800	51,000	33,600	126,000	42,300	30,200	72,000
100	1	38,300	30,000	51,800	33,100	26,300	44,100	38,300	26,800	79,200	33,200	24,700	52,100
50	2	28,300	22,800	37,000	25,600	20,700	33,000	28,300	21,000	49,700	25,600	19,900	37,300
25	4	20,600	17,000	25,900	19,400	16,100	24,200	20,600	16,100	31,100	19,400	15,600	26,200
10	10	12,900	11,100	15,500	12,800	10,900	15,300	12,900	10,700	16,800	12,800	10,700	15,900
5	20	8,660	7,570	10,100	8,800	7,690	10,200	8,660	7,400	10,400	8,800	7,590	10,400
2	50	4,380	3,860	4,950	4,530	4,000	5,120	4,380	3,810	5,020	4,530	3,980	5,170
1.5	66.7	3,230	2,820	3,670	3,310	2,890	3,750	3,220	2,840	3,660	3,300	2,900	3,740
1.25	80	2,470	2,120	2,830	2,480	2,120	2,840	2,470	2,190	2,790	2,480	2,160	2,810
1.05	95.2	1,550	1,280	1,830	1,450	1,180	1,710	1,570	1,320	1,810	1,470	1,210	1,710

Figure 30: Annual peak discharge data and flood-frequency analysis results for the Linville River near Nebo, NC streamgage (USGS ID: 02138500). Helene peak Q: 28,300 cfs, Record peak Q: 42,400 cfs (9/8/2004). Drainage area: 67.1 mi².

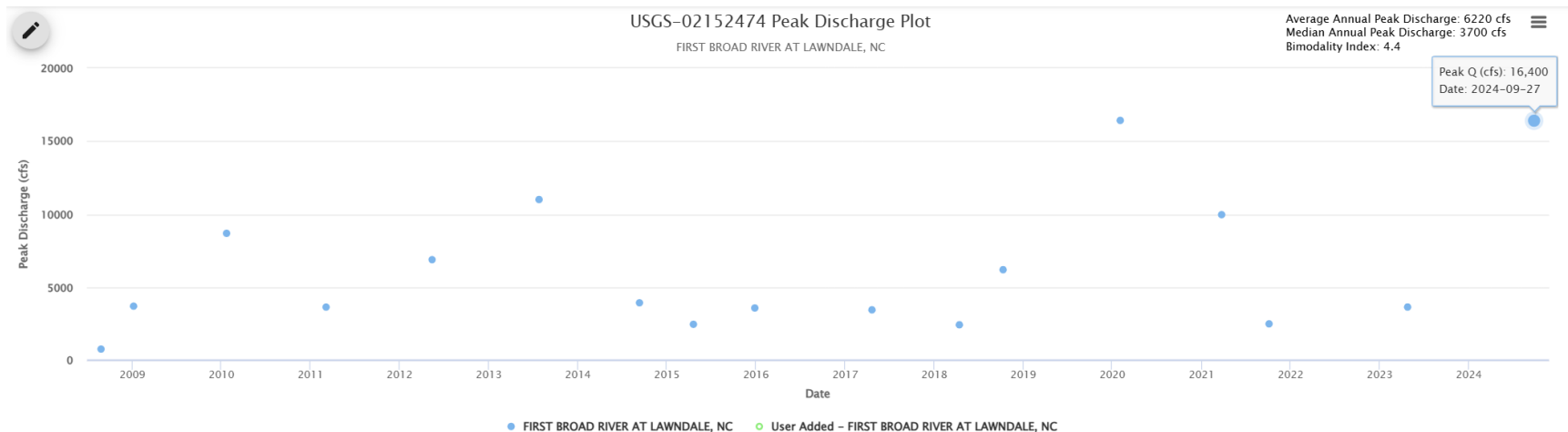
02143040: Jacob Fork



Return Interval (yr)	Percent Chance of Occurrence	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	9,060	7,180	12,200	11,400	8,830	16,000	10,500	7,640	19,900	11,500	8,490	18,800
200	0.5	8,060	6,470	10,700	9,680	7,620	13,200	8,990	6,880	15,100	9,630	7,410	14,600
100	1	7,270	5,900	9,500	8,420	6,730	11,200	7,880	6,260	12,200	8,320	6,580	11,900
50	2	6,460	5,300	8,300	7,210	5,860	9,410	6,810	5,580	9,690	7,080	5,760	9,590
25	4	5,620	4,680	7,080	6,050	5,000	7,700	5,770	4,860	7,600	5,910	4,930	7,610
10	10	4,460	3,780	5,450	4,580	3,880	5,620	4,440	3,820	5,360	4,460	3,820	5,420
5	20	3,520	3,030	4,180	3,500	3,020	4,160	3,440	2,990	4,010	3,420	2,980	4,020
2	50	2,110	1,850	2,430	2,050	1,790	2,350	2,080	1,810	2,390	2,050	1,790	2,350
1.5	66.7	1,590	1,370	1,820	1,540	1,330	1,770	1,590	1,370	1,830	1,580	1,360	1,800
1.25	80	1,180	995	1,370	1,160	980	1,350	1,220	1,010	1,420	1,220	1,030	1,410
1.05	95.2	616	479	752	649	509	788	719	485	875	740	548	887

Figure 31: Annual peak discharge data and flood-frequency analysis results for the Jacob Fork at Ramsey, NC streamgauge (USGS ID: 02143040). Helene peak Q: 5970 cfs. Record peak Q: 7220 cfs (10/17/1975). Drainage area: 25.6 mi².

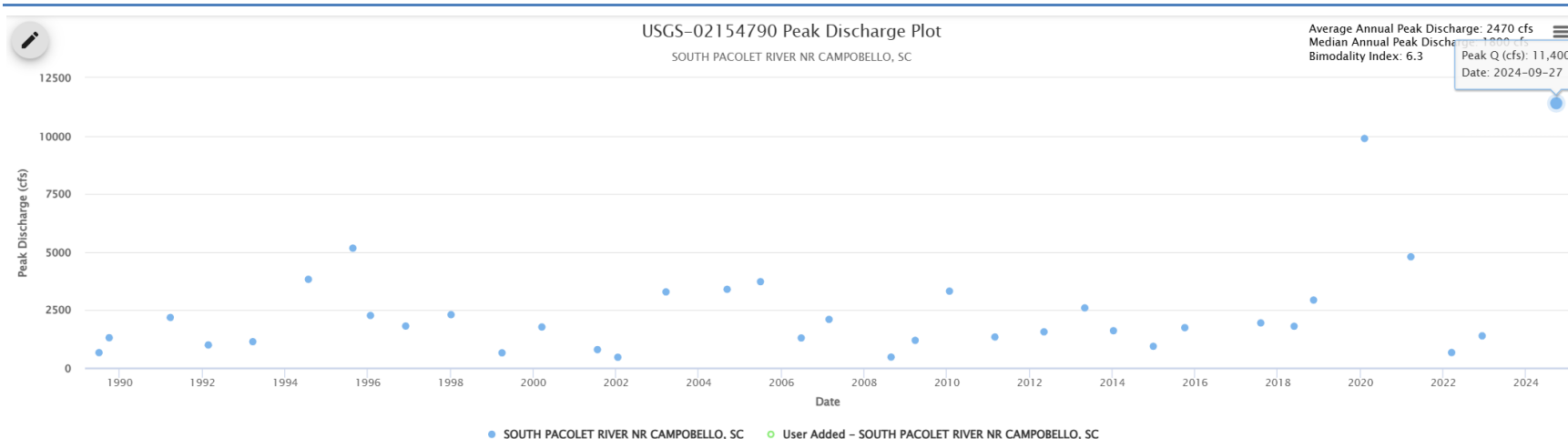
02152474: First Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	36,200	21,200	90,200	45,400	25,400	123,000	36,200	18,800	155,000	44,500	24,500	147,000
200	0.5	30,000	18,200	69,700	35,800	21,000	88,600	30,000	17,200	102,000	35,300	20,600	99,200
100	1	25,600	16,000	56,100	29,400	17,900	67,700	25,600	15,800	73,900	29,100	17,800	72,700
50	2	21,500	13,800	44,000	23,800	15,000	50,600	21,500	14,100	52,800	23,500	15,000	52,400
25	4	17,500	11,700	33,500	18,700	12,300	36,600	17,500	12,100	36,800	18,600	12,400	36,900
10	10	12,700	8,830	21,800	13,000	9,000	22,400	12,700	8,980	21,500	12,900	9,020	22,100
5	20	9,240	6,660	14,500	9,170	6,610	14,400	9,240	6,580	13,700	9,180	6,580	14,200
2	50	4,890	3,540	6,800	4,740	3,420	6,570	4,890	3,420	6,920	4,760	3,400	6,640
1.5	66.7	3,480	2,400	4,770	3,390	2,330	4,640	3,470	2,320	4,940	3,390	2,330	4,690
1.25	80	2,480	1,590	3,440	2,450	1,570	3,400	2,480	1,520	3,560	2,450	1,580	3,430
1.05	95.2	1,220	624	1,840	1,280	671	1,930	1,240	494	1,920	1,300	673	1,940

Figure 32: Annual peak discharge data and flood-frequency analysis results for the First Broad River, NC streamgauge (USGS ID: 02152474). Helene peak Q: 16,400 cfs, the same magnitude as a matching event (2/6/2020). Drainage area: 190 mi².

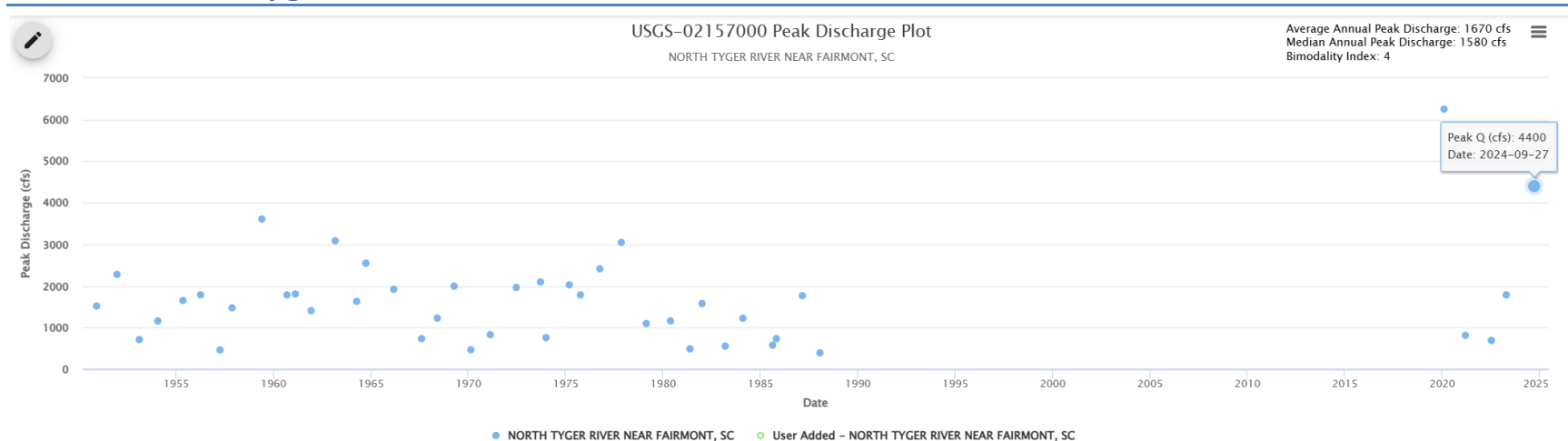
02154790: South Pacolet River



Return Interval (yr)	Percent Chance of Occurrence	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	22,300	14,200	42,700	18,200	12,000	33,400	22,300	12,100	140,000	18,400	11,200	45,100
200	0.5	16,400	10,900	29,400	14,100	9,590	24,400	16,400	9,780	72,400	14,200	9,200	30,400
100	1	12,800	8,870	21,800	11,400	8,010	18,800	12,800	8,160	42,300	11,500	7,780	22,300
50	2	9,900	7,080	15,800	9,100	6,580	14,300	9,900	6,690	24,900	9,140	6,460	16,100
25	4	7,480	5,550	11,300	7,100	5,300	10,600	7,480	5,340	14,800	7,120	5,230	11,400
10	10	4,930	3,840	6,860	4,860	3,790	6,750	4,930	3,740	7,610	4,870	3,750	6,970
5	20	3,400	2,730	4,450	3,440	2,760	4,510	3,400	2,660	4,650	3,440	2,730	4,580
2	50	1,760	1,420	2,170	1,810	1,470	2,230	1,760	1,400	2,220	1,810	1,460	2,250
1.5	66.7	1,290	1,020	1,590	1,320	1,040	1,620	1,290	1,030	1,600	1,310	1,050	1,620
1.25	80	972	740	1,210	976	744	1,220	972	771	1,210	976	758	1,210
1.05	95.2	576	400	755	546	376	720	584	403	740	557	384	721

Figure 33: Annual peak discharge data and flood-frequency analysis results for the South Pacolet River near Campobello, SC streamgage (USGS ID: 02154790). Helene peak Q: 11,400 cfs, the record peak Q (9/27/2024). Drainage area: 56.0 mi².

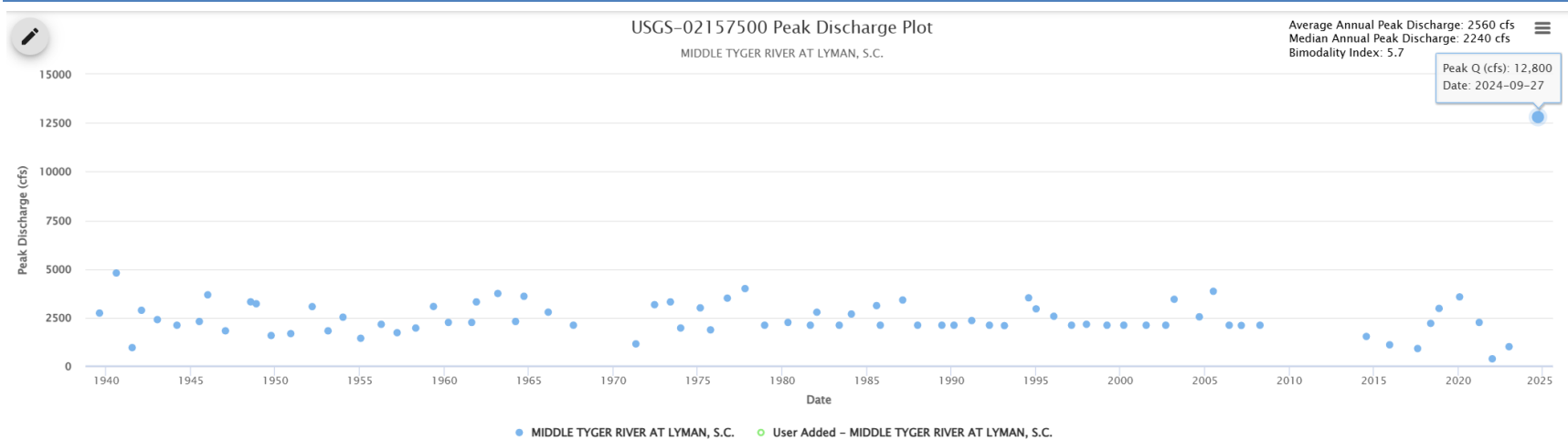
02157000: North Tyger River



Return Interval (yr)	Percent Chance of Occurrence	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	8,360	6,120	12,900	8,720	6,350	13,600	8,360	5,550	19,200	8,710	6,020	16,400
200	0.5	6,950	5,210	10,300	7,180	5,360	10,700	6,950	4,910	13,800	7,170	5,190	12,300
100	1	5,960	4,550	8,590	6,110	4,660	8,860	5,960	4,410	10,600	6,110	4,570	9,740
50	2	5,030	3,930	7,030	5,130	3,990	7,190	5,030	3,880	8,110	5,130	3,960	7,640
25	4	4,170	3,330	5,620	4,220	3,360	5,700	4,170	3,330	6,090	4,220	3,360	5,900
10	10	3,110	2,560	3,990	3,120	2,570	4,010	3,110	2,560	4,050	3,120	2,570	4,040
5	20	2,360	1,980	2,910	2,350	1,980	2,900	2,360	1,970	2,890	2,350	1,970	2,900
2	50	1,380	1,170	1,630	1,370	1,170	1,620	1,380	1,160	1,650	1,370	1,160	1,630
1.5	66.7	1,050	876	1,230	1,040	872	1,230	1,050	870	1,250	1,040	870	1,230
1.25	80	804	652	955	802	651	954	803	650	963	802	652	957
1.05	95.2	469	349	585	473	354	590	476	328	596	481	352	598

Figure 34: Annual peak discharge data and flood-frequency analysis results for the North Tyger River near Fairmont, SC streamgauge (USGS ID: 02157000). Helene peak Q: 4400 cfs. Record peak Q: 6250 cfs (2/6/2020). Drainage area: 34.8 mi².

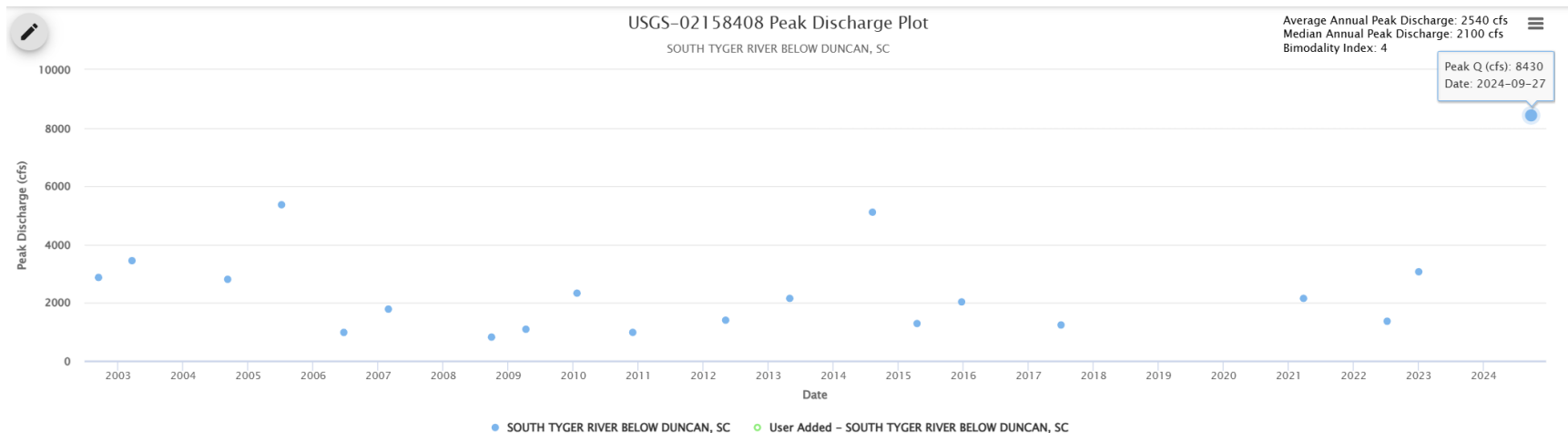
02157500: Middle Tyger River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	9,500	7,960	11,900	8,280	7,040	10,200	12,000	7,680	28,800	7,810	6,350	11,100
200	0.5	7,920	6,760	9,680	7,130	6,160	8,600	9,260	6,490	18,200	6,780	5,680	9,050
100	1	6,850	5,940	8,210	6,330	5,530	7,500	7,600	5,670	12,900	6,050	5,180	7,730
50	2	5,890	5,180	6,910	5,570	4,930	6,480	6,210	4,930	9,270	5,350	4,680	6,570
25	4	5,010	4,480	5,760	4,840	4,340	5,540	5,060	4,250	6,750	4,690	4,180	5,540
10	10	3,960	3,610	4,420	3,930	3,590	4,390	3,830	3,400	4,570	3,850	3,510	4,350
5	20	3,230	2,990	3,540	3,260	3,010	3,570	3,070	2,780	3,480	3,230	2,980	3,550
2	50	2,280	2,120	2,450	2,330	2,160	2,500	2,230	2,060	2,430	2,350	2,190	2,530
1.5	66.7	1,950	1,800	2,100	1,980	1,820	2,130	1,980	1,880	2,120	2,020	1,880	2,170
1.25	80	1,700	1,550	1,840	1,700	1,550	1,850	1,820	1,740	1,910	1,760	1,620	1,890
1.05	95.2	1,340	1,190	1,470	1,290	1,140	1,420	1,640	1,490	1,790	1,370	1,180	1,490

Figure 35: Annual peak discharge data and flood-frequency analysis results for the Middle Tyger River at Lyman, SC streamgauge (USGS ID: 02157500). Helene peak Q: 12,800 cfs, the record peak Q (9/27/2024). Drainage area: 68.6 mi².

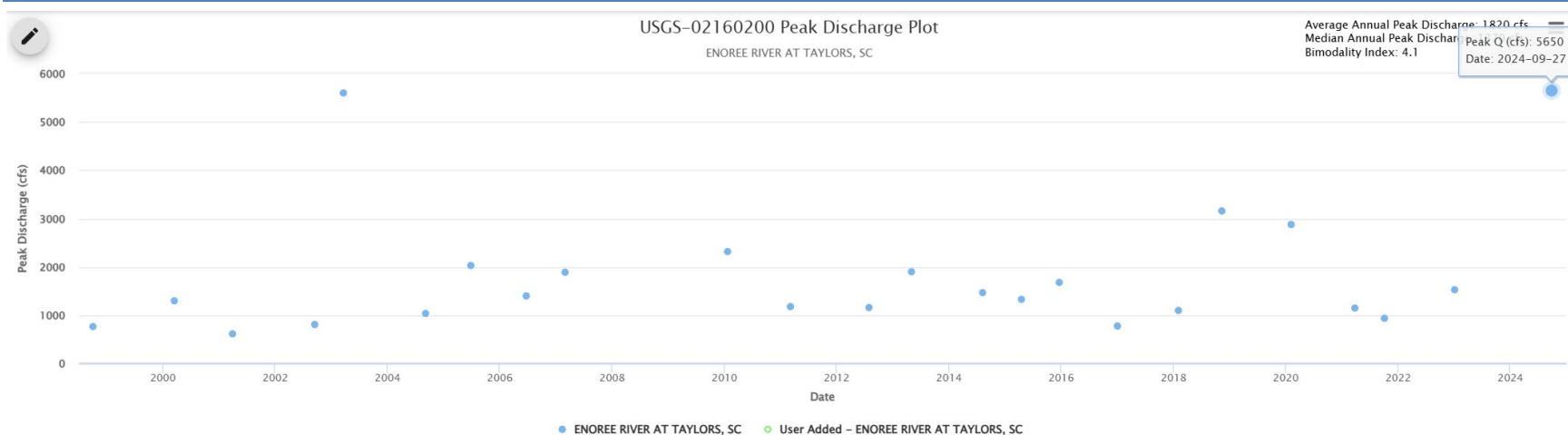
02158408: South Tyger River



Return Interval (yr)	Percent Chance of Occurrence	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	19,400	11,600	45,800	14,400	9,100	30,500	19,400	9,940	179,000	14,400	8,720	38,900
200	0.5	14,500	9,170	30,900	11,500	7,610	22,800	14,500	8,170	92,100	11,500	7,390	27,200
100	1	11,500	7,590	22,700	9,650	6,570	18,000	11,500	6,940	55,900	9,650	6,440	20,500
50	2	9,020	6,210	16,400	7,960	5,600	13,900	9,020	5,800	33,900	7,960	5,520	15,300
25	4	6,960	5,010	11,600	6,450	4,700	10,500	6,960	4,750	17,900	6,450	4,640	11,200
10	10	4,770	3,620	7,130	4,690	3,570	6,970	4,770	3,470	8,540	4,690	3,530	7,180
5	20	3,430	2,700	4,720	3,500	2,740	4,830	3,430	2,570	5,170	3,500	2,710	4,920
2	50	1,960	1,530	2,480	2,040	1,600	2,590	1,960	1,500	2,570	2,040	1,600	2,620
1.5	66.7	1,520	1,150	1,920	1,560	1,190	1,970	1,520	1,190	1,950	1,560	1,210	1,980
1.25	80	1,210	874	1,550	1,220	880	1,550	1,210	948	1,550	1,220	905	1,550
1.05	95.2	816	530	1,090	752	477	1,010	824	547	1,040	762	493	1,010

Figure 36: Annual peak discharge data and flood-frequency analysis results for the South Tyger River Below Duncan, SC streamgauge (USGS ID: 02158408). Helene peak Q: 8430 cfs, the record peak Q (9/27/2024). Drainage area: 94.6 mi².

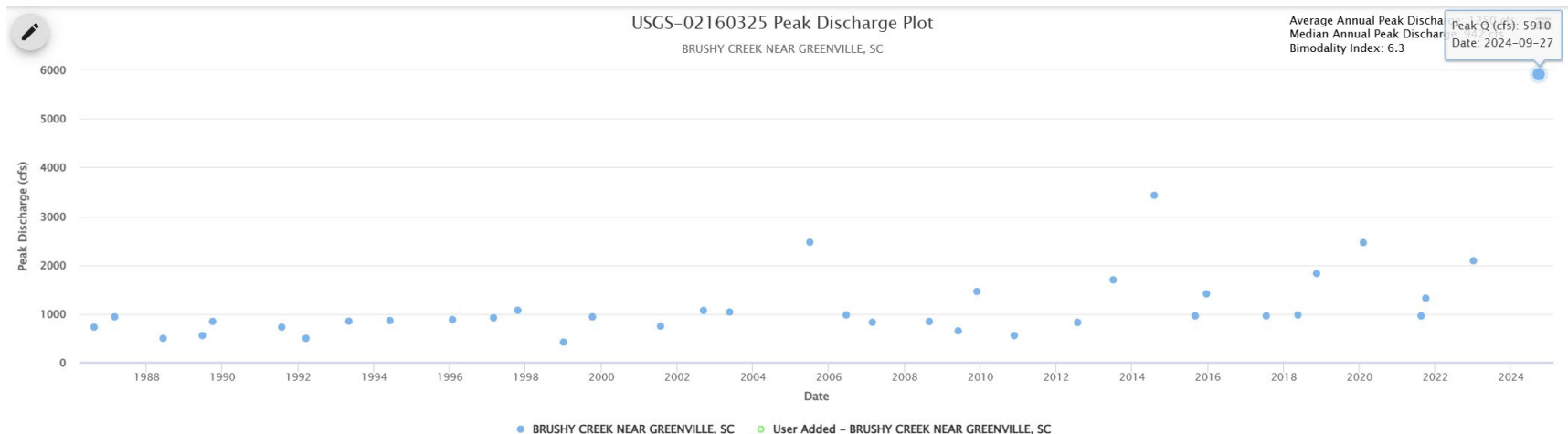
02160200: Enoree River



Return Interval (yr)	Percent Chance of Occurrence	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	14,400	8,980	30,600	9,290	6,260	17,300	14,400	7,100	140,000	9,410	6,030	23,100
200	0.5	10,500	6,920	20,200	7,530	5,260	13,200	10,500	5,780	67,500	7,600	5,130	16,400
100	1	8,170	5,630	14,600	6,350	4,570	10,600	8,170	4,890	39,100	6,400	4,490	12,500
50	2	6,310	4,540	10,500	5,290	3,920	8,350	6,310	4,080	21,600	5,320	3,870	9,480
25	4	4,810	3,620	7,400	4,340	3,310	6,480	4,810	3,340	11,500	4,350	3,270	7,070
10	10	3,280	2,600	4,550	3,210	2,550	4,440	3,280	2,450	5,580	3,220	2,520	4,650
5	20	2,370	1,940	3,070	2,450	1,990	3,180	2,370	1,830	3,420	2,440	1,970	3,270
2	50	1,400	1,140	1,700	1,490	1,220	1,810	1,400	1,120	1,780	1,480	1,220	1,830
1.5	66.7	1,120	888	1,360	1,170	929	1,420	1,120	929	1,390	1,160	944	1,420
1.25	80	928	711	1,140	931	713	1,140	928	776	1,130	930	735	1,140
1.05	95.2	685	490	867	604	419	778	690	520	837	614	438	774

Figure 37: Annual peak discharge data and flood-frequency analysis results for the Enoree River at Taylors, SC streamgauge (USGS ID: 02160200). Helene peak Q: 5650 cfs, the record peak Q (9/27/2024). Drainage area: 49.5 mi².

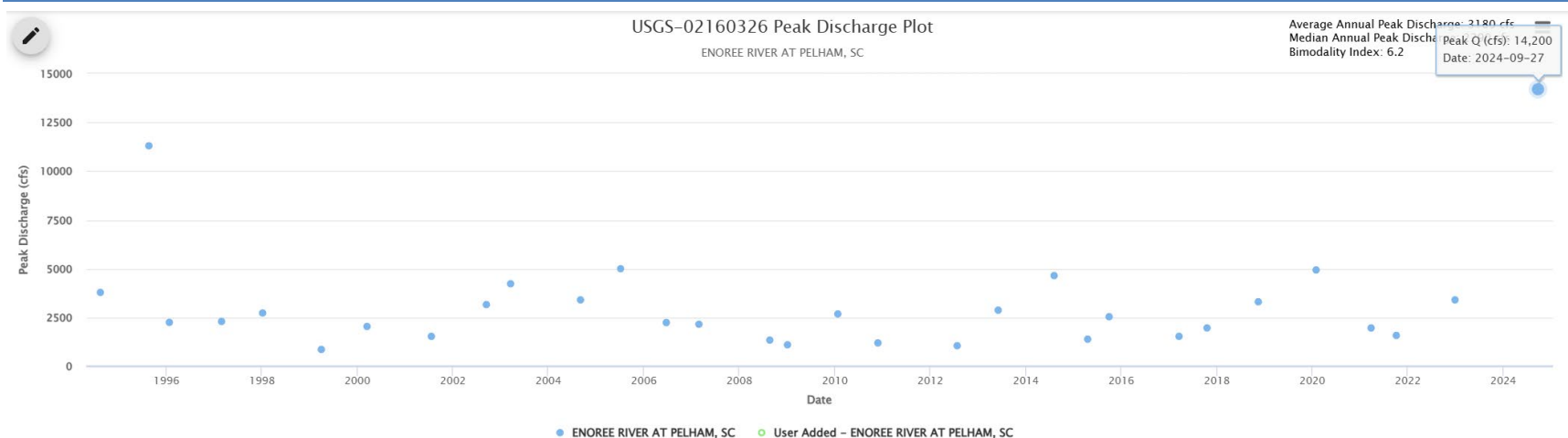
02160325: Brushy Creek



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	11,000	7,330	19,800	6,120	4,450	9,660	11,000	5,170	93,500	6,230	4,220	12,800
200	0.5	7,680	5,400	12,800	4,960	3,720	7,470	7,680	4,150	39,200	5,030	3,580	9,250
100	1	5,820	4,260	9,070	4,190	3,220	6,070	5,820	3,470	20,800	4,230	3,120	7,170
50	2	4,380	3,340	6,410	3,490	2,750	4,870	4,380	2,870	11,400	3,520	2,690	5,510
25	4	3,270	2,590	4,500	2,870	2,320	3,840	3,270	2,340	6,490	2,880	2,270	4,180
10	10	2,170	1,810	2,760	2,140	1,780	2,710	2,170	1,700	3,310	2,140	1,760	2,830
5	20	1,560	1,340	1,880	1,640	1,400	1,990	1,560	1,260	2,080	1,640	1,380	2,040
2	50	939	803	1,090	1,020	873	1,180	939	788	1,130	1,010	872	1,190
1.5	66.7	770	646	896	808	682	939	769	672	903	806	690	938
1.25	80	657	540	770	654	538	767	657	584	748	654	550	761
1.05	95.2	523	415	625	439	337	535	526	434	621	446	349	532

Figure 38: Annual peak discharge data and flood-frequency analysis results for the Brushy Creek near Greenville, SC streamgauge (USGS ID: 02160325). Helene peak Q: 5910 cfs, the record peak Q (9/27/2024). Drainage area: 9.09 mi².

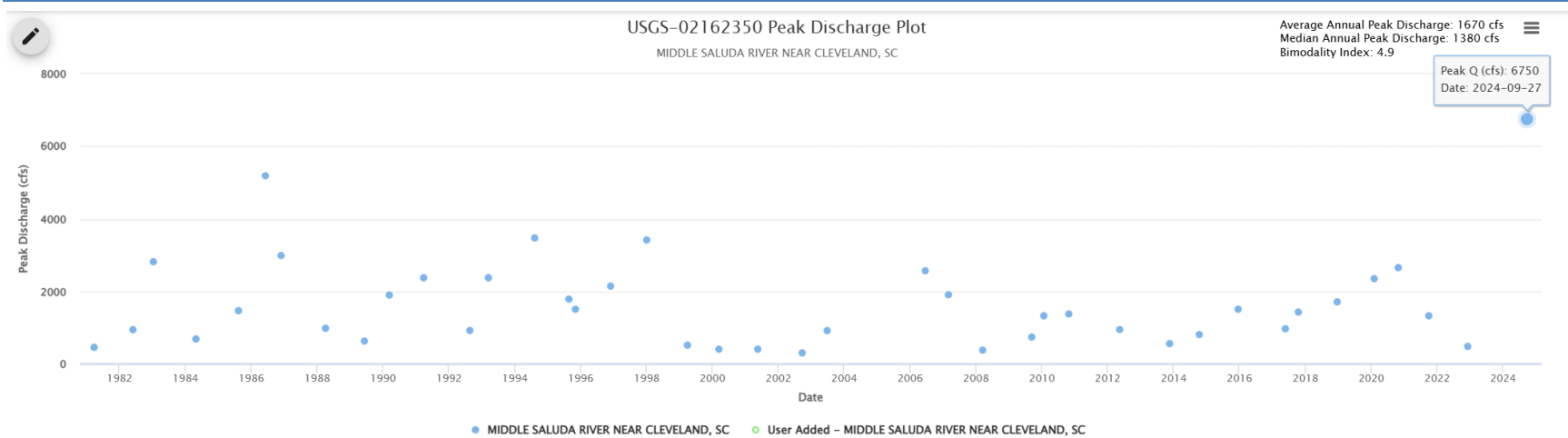
02160326: Enoree River



Return Interval (yr)	Percent Chance of Occurrence	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	29,600	18,600	59,500	19,200	13,000	34,500	29,700	14,500	283,000	19,300	12,100	46,300
200	0.5	21,000	14,000	38,600	15,100	10,600	25,600	21,000	11,500	133,000	15,200	10,100	32,000
100	1	16,000	11,100	27,500	12,500	9,000	20,200	16,000	9,570	75,200	12,500	8,670	23,900
50	2	12,100	8,750	19,400	10,200	7,540	15,600	12,100	7,820	38,300	10,200	7,330	17,700
25	4	9,000	6,790	13,400	8,120	6,210	11,800	9,000	6,260	20,300	8,130	6,080	12,900
10	10	5,910	4,700	8,060	5,800	4,620	7,870	5,910	4,450	9,680	5,800	4,540	8,220
5	20	4,140	3,400	5,290	4,280	3,500	5,490	4,140	3,230	5,830	4,270	3,450	5,630
2	50	2,320	1,910	2,800	2,460	2,030	2,980	2,320	1,860	2,900	2,460	2,030	3,020
1.5	66.7	1,810	1,450	2,190	1,890	1,520	2,280	1,810	1,510	2,220	1,880	1,540	2,280
1.25	80	1,470	1,140	1,800	1,470	1,140	1,800	1,470	1,230	1,770	1,470	1,180	1,790
1.05	95.2	1,040	760	1,320	922	654	1,180	1,050	811	1,280	935	679	1,170

Figure 39: Annual peak discharge data and flood-frequency analysis results for the Enoree River at Pelham, SC streamgauge (USGS ID: 02160326). Helene peak Q: 14,200 cfs, the record peak Q (9/27/2024). Drainage area: 84.7 mi².

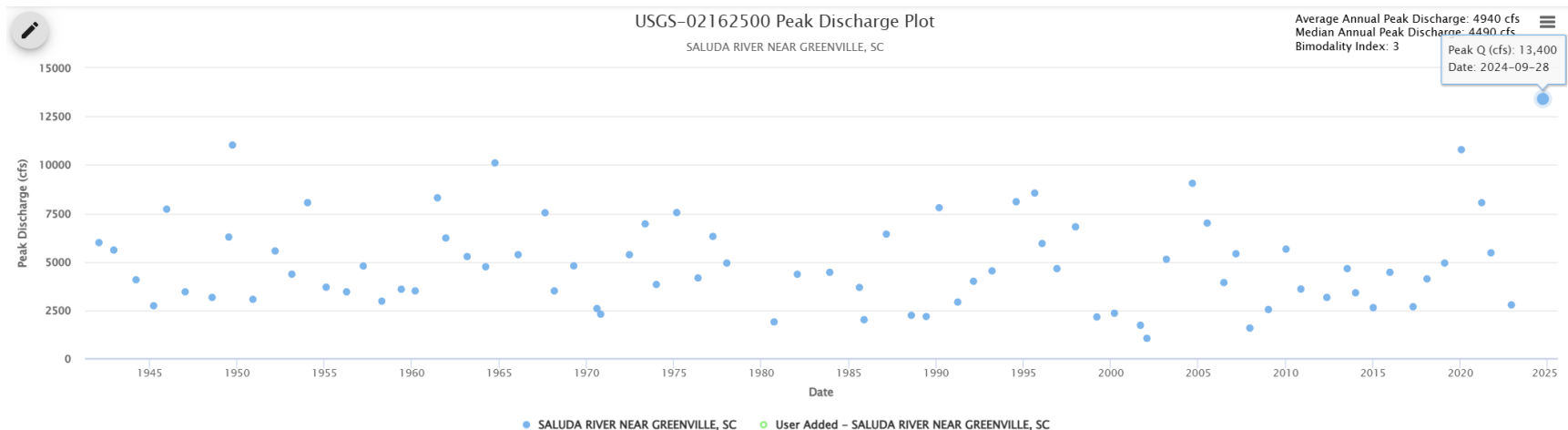
02162350: Middle Saluda River



Return Interval (yr)	Percent Chance of Occurrence	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	11,400	7,750	19,500	11,500	7,820	19,700	11,400	6,890	34,300	11,500	7,350	25,000
200	0.5	9,010	6,330	14,700	9,090	6,380	14,900	9,010	5,890	22,200	9,090	6,140	17,600
100	1	7,440	5,360	11,700	7,490	5,390	11,800	7,440	5,130	15,900	7,490	5,270	13,300
50	2	6,040	4,470	9,090	6,070	4,490	9,150	6,040	4,370	11,200	6,070	4,430	9,920
25	4	4,790	3,640	6,900	4,800	3,650	6,930	4,790	3,620	7,770	4,800	3,640	7,250
10	10	3,350	2,650	4,530	3,350	2,650	4,540	3,350	2,640	4,670	3,350	2,640	4,590
5	20	2,400	1,950	3,090	2,400	1,940	3,080	2,400	1,930	3,090	2,400	1,930	3,090
2	50	1,270	1,040	1,550	1,270	1,040	1,540	1,270	1,030	1,570	1,270	1,030	1,550
1.5	66.7	921	741	1,120	920	740	1,120	919	737	1,130	918	739	1,120
1.25	80	676	525	832	675	524	832	676	527	838	675	527	834
1.05	95.2	365	257	476	366	258	477	372	242	483	373	257	483

Figure 40: Annual peak discharge data and flood-frequency analysis results for Middle Saluda River near Cleveland, SC streamgage (USGS ID: 02162350). Helene peak Q: 6750 cfs, the record peak Q (9/27/2024). Drainage area: 20.9 mi².

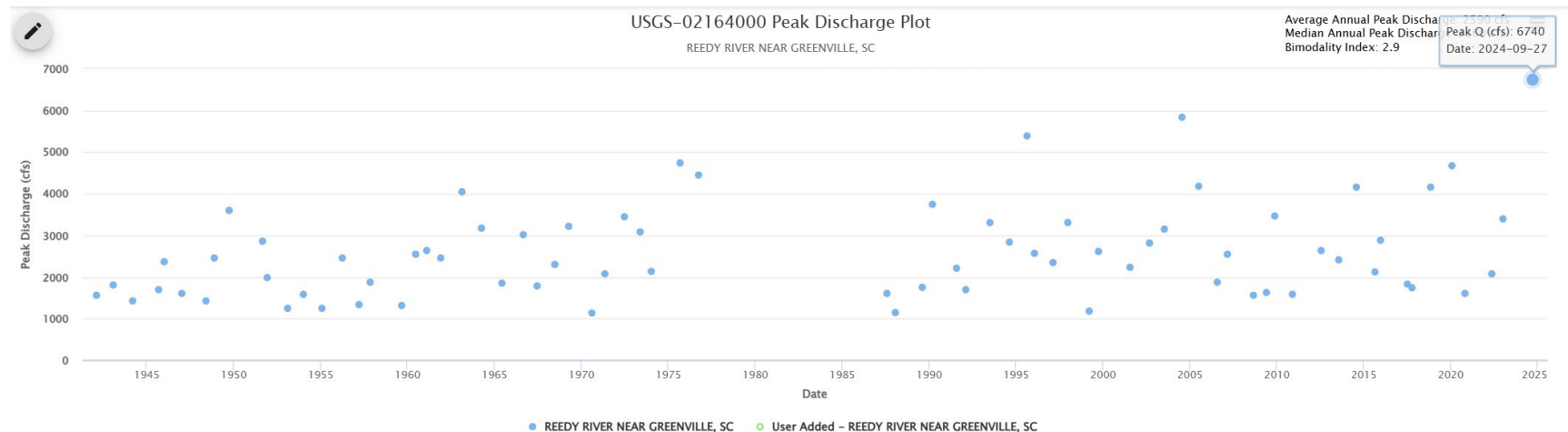
02162500: Saluda River



Return Interval (yr)	Percent Chance of Occurrence	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	15,900	13,400	19,700	17,100	14,300	21,500	15,900	12,400	22,600	17,100	13,700	23,900
200	0.5	14,100	12,000	17,200	15,000	12,700	18,400	14,100	11,500	18,900	15,000	12,400	19,900
100	1	12,700	11,000	15,400	13,400	11,400	16,200	12,700	10,700	16,400	13,400	11,300	17,100
50	2	11,400	9,910	13,500	11,800	10,200	14,100	11,400	9,830	14,100	11,800	10,200	14,500
25	4	10,000	8,820	11,700	10,300	9,000	12,000	10,000	8,850	11,900	10,300	9,020	12,200
10	10	8,170	7,300	9,340	8,230	7,350	9,420	8,170	7,360	9,270	8,230	7,380	9,400
5	20	6,690	6,060	7,510	6,680	6,040	7,490	6,690	6,070	7,430	6,680	6,050	7,450
2	50	4,480	4,090	4,910	4,430	4,050	4,860	4,480	4,060	4,950	4,430	4,030	4,880
1.5	66.7	3,610	3,270	3,960	3,580	3,240	3,930	3,610	3,250	4,000	3,580	3,230	3,940
1.25	80	2,920	2,610	3,230	2,910	2,600	3,210	2,920	2,580	3,250	2,910	2,590	3,230
1.05	95.2	1,870	1,590	2,130	1,900	1,620	2,160	1,890	1,510	2,180	1,920	1,600	2,200

Figure 41: Annual peak discharge data and flood-frequency analysis results for the Saluda River near Greenville, SC streamgage (USGS ID: 02162500). Helene peak Q: 13,400 cfs, the record peak Q (9/28/2024). Drainage area: 295 mi².

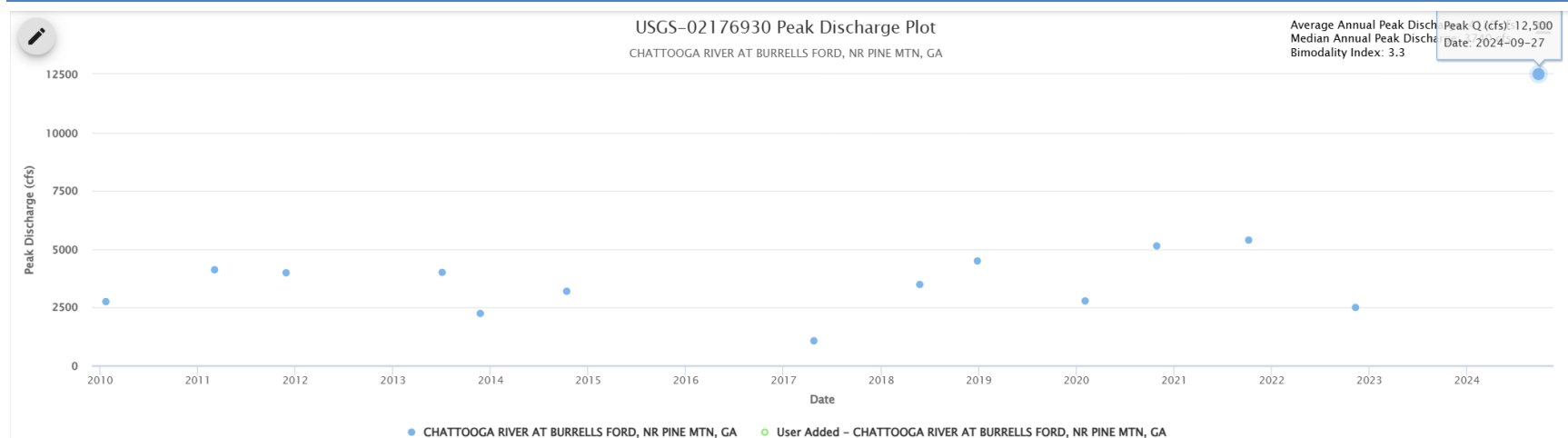
02164000: Reedy River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	9,120	7,620	11,500	8,570	7,210	10,700	9,120	7,060	16,200	8,580	6,880	12,400
200	0.5	7,770	6,610	9,550	7,410	6,330	9,050	7,770	6,260	12,300	7,410	6,130	10,100
100	1	6,830	5,890	8,240	6,580	5,690	7,900	6,830	5,660	9,980	6,580	5,560	8,560
50	2	5,940	5,200	7,040	5,790	5,080	6,830	5,940	5,060	8,040	5,790	5,000	7,220
25	4	5,120	4,540	5,940	5,030	4,470	5,830	5,120	4,470	6,440	5,040	4,430	6,040
10	10	4,090	3,700	4,620	4,070	3,680	4,600	4,090	3,670	4,760	4,070	3,660	4,660
5	20	3,340	3,060	3,700	3,360	3,070	3,710	3,340	3,040	3,740	3,360	3,060	3,730
2	50	2,330	2,140	2,520	2,350	2,160	2,540	2,330	2,130	2,540	2,350	2,160	2,550
1.5	66.7	1,950	1,790	2,120	1,970	1,800	2,130	1,950	1,790	2,130	1,970	1,800	2,140
1.25	80	1,670	1,500	1,820	1,670	1,510	1,820	1,670	1,520	1,810	1,670	1,520	1,820
1.05	95.2	1,230	1,080	1,370	1,210	1,060	1,350	1,240	1,080	1,370	1,220	1,060	1,360

Figure 42: Annual peak discharge data and flood-frequency analysis results for the Reedy River near Greenville, SC streamgauge (USGS ID: 02164000). Helene peak Q: 6740 cfs, the record peak Q (9/27/2024). Drainage area: 48.3 mi².

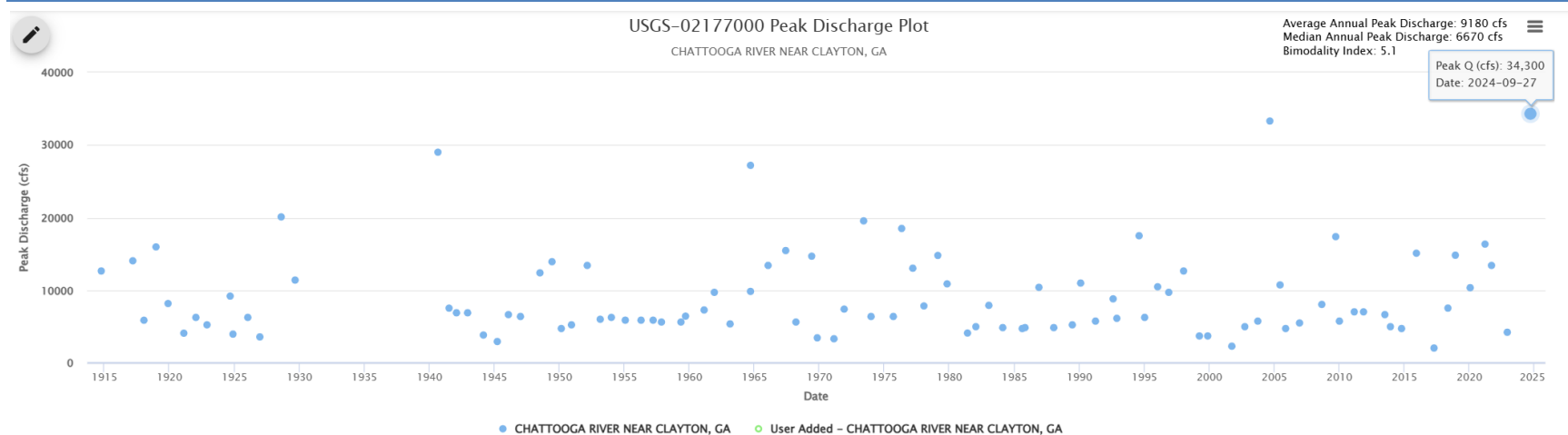
02176930: Chattooga River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	18,700	11,900	43,400	17,900	11,500	40,700	18,700	11,100	94,300	17,900	11,300	47,300
200	0.5	15,600	10,300	33,200	15,000	9,980	31,600	15,600	9,870	62,000	15,100	9,940	35,000
100	1	13,400	9,100	26,800	13,000	8,900	25,700	13,400	8,900	43,700	13,000	8,900	27,600
50	2	11,400	7,980	21,200	11,100	7,850	20,600	11,400	7,900	29,300	11,200	7,870	21,500
25	4	9,500	6,890	16,400	9,390	6,820	16,200	9,500	6,860	19,800	9,390	6,840	16,500
10	10	7,230	5,480	11,200	7,210	5,460	11,200	7,230	5,410	11,900	7,210	5,450	11,200
5	20	5,630	4,380	8,030	5,640	4,390	8,050	5,630	4,280	8,140	5,640	4,360	8,020
2	50	3,520	2,730	4,540	3,550	2,750	4,570	3,520	2,700	4,640	3,540	2,740	4,610
1.5	66.7	2,790	2,080	3,560	2,810	2,090	3,570	2,790	2,110	3,630	2,800	2,110	3,600
1.25	80	2,240	1,570	2,880	2,250	1,570	2,890	2,240	1,620	2,920	2,250	1,610	2,890
1.05	95.2	1,460	877	1,990	1,450	863	1,970	1,480	829	1,970	1,470	893	1,970

Figure 43: Annual peak discharge data and flood-frequency analysis results for the Chattooga River at Burrells ford, near Pine Mountain, GA streamgauge (USGS ID: 02176930). Helene peak Q: 12,500 cfs, the record peak Q (9/27/2024). Drainage area: 46.7 mi².

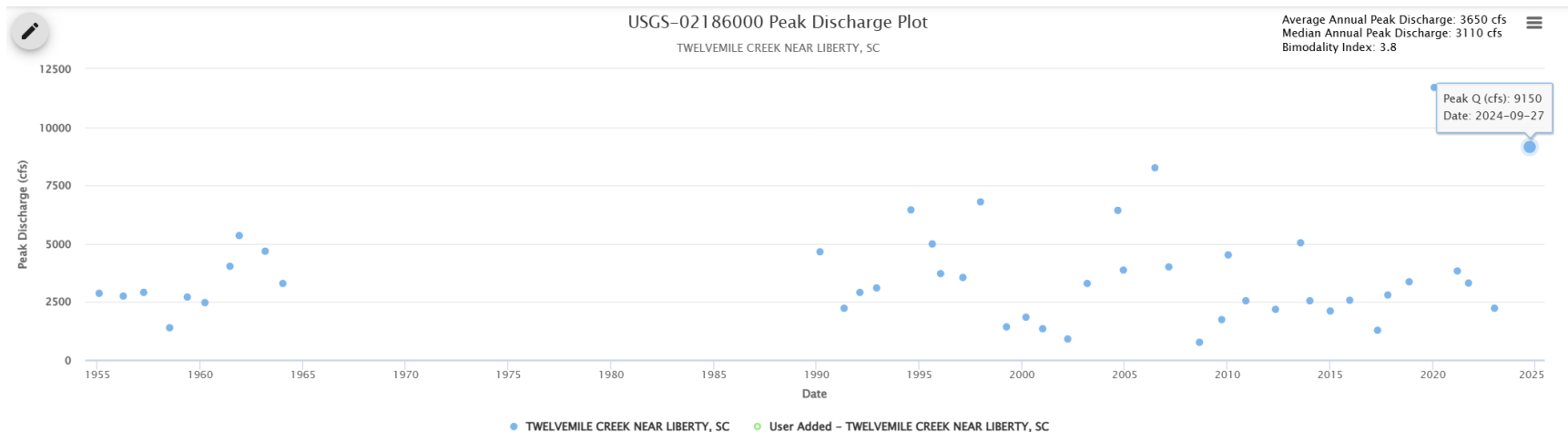
02177000: Chattooga River



Return Interval (yr)	Percent Chance of Occurrence	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	54,300	43,400	71,700	47,700	38,600	62,000	54,300	38,400	114,000	47,900	35,900	76,000
200	0.5	42,500	34,800	54,500	38,500	31,800	48,700	42,500	31,800	76,700	38,700	30,200	56,700
100	1	34,900	29,100	43,700	32,400	27,200	40,200	34,900	27,200	56,500	32,500	26,200	45,100
50	2	28,400	24,100	34,700	26,900	23,000	32,700	28,400	23,000	41,500	27,000	22,400	35,400
25	4	22,700	19,700	27,100	22,000	19,100	26,100	22,700	19,100	30,200	22,000	18,800	27,500
10	10	16,400	14,500	18,900	16,300	14,400	18,700	16,400	14,300	19,700	16,300	14,300	19,200
5	20	12,300	11,100	13,800	12,400	11,200	13,900	12,300	10,900	14,100	12,400	11,100	14,100
2	50	7,400	6,730	8,140	7,540	6,850	8,280	7,400	6,670	8,220	7,530	6,820	8,330
1.5	66.7	5,860	5,270	6,450	5,930	5,350	6,530	5,850	5,290	6,460	5,920	5,360	6,530
1.25	80	4,740	4,210	5,260	4,750	4,220	5,270	4,740	4,290	5,220	4,750	4,270	5,240
1.05	95.2	3,230	2,770	3,670	3,120	2,660	3,550	3,260	2,820	3,650	3,160	2,710	3,560

Figure 44: Annual peak discharge data and flood-frequency analysis results for the Chattooga River near Clayton, GA streamgauge (USGS ID: 02177000). Helene peak Q: 34,300 cfs, the record peak Q (9/27/2024). Drainage area: 203 mi².

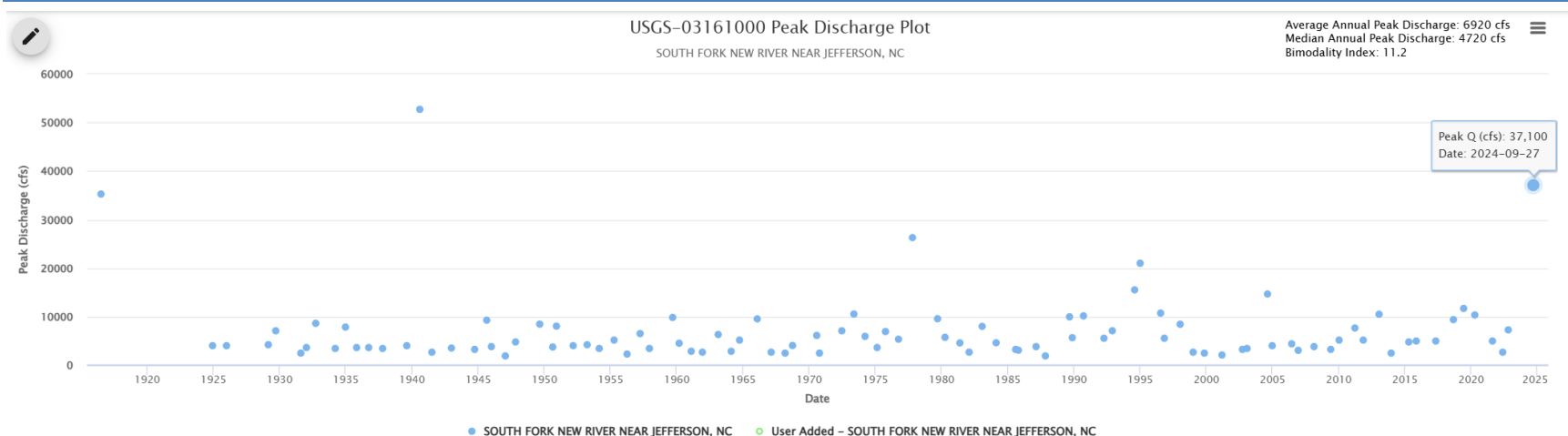
02186000: Twelvemile Creek



Return Interval (yr)	Percent Chance of Occurrence	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	14,900	11,400	21,500	16,000	12,200	23,500	14,900	10,500	28,900	16,000	11,600	27,400
200	0.5	12,800	9,980	17,900	13,500	10,500	19,200	12,800	9,490	22,100	13,500	10,200	21,400
100	1	11,200	8,920	15,400	11,700	9,260	16,200	11,200	8,680	17,900	11,700	9,120	17,500
50	2	9,750	7,860	13,000	10,100	8,090	13,500	9,750	7,810	14,400	10,100	8,040	14,200
25	4	8,310	6,820	10,800	8,480	6,950	11,000	8,310	6,850	11,400	8,470	6,950	11,300
10	10	6,450	5,440	8,020	6,500	5,470	8,080	6,450	5,470	8,050	6,490	5,480	8,100
5	20	5,070	4,350	6,090	5,050	4,340	6,070	5,070	4,340	6,030	5,060	4,330	6,050
2	50	3,150	2,730	3,640	3,120	2,710	3,600	3,150	2,700	3,680	3,120	2,690	3,620
1.5	66.7	2,460	2,100	2,830	2,440	2,080	2,810	2,460	2,080	2,870	2,440	2,080	2,830
1.25	80	1,930	1,610	2,250	1,920	1,600	2,240	1,930	1,590	2,270	1,920	1,600	2,250
1.05	95.2	1,170	903	1,420	1,190	921	1,450	1,190	843	1,460	1,210	912	1,470

Figure 45: Annual peak discharge data and flood-frequency analysis results for the Twelvemile Creek near Liberty, SC streamgauge (USGS ID: 02186000). Helene peak Q: 9150 cfs. Record peak Q: 11,700 cfs (2/6/2020). Drainage area: 104 mi².

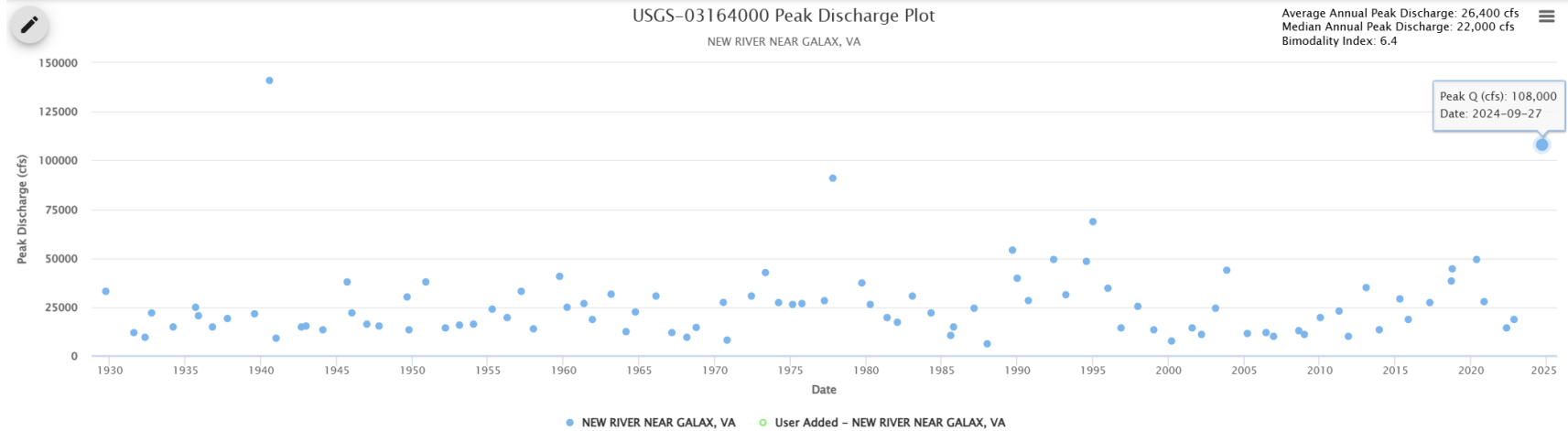
03161000: South Fork New River



Return Interval (yr)	Percent Chance of Occurrence	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 46: Annual peak discharge data and flood-frequency analysis results for the S.F. New River near Jefferson, NC streamgauge (USGS ID: 03161000). Helene peak Q: 37,100 cfs. Record peak Q: 52,800 cfs (8/14/1940). Drainage area: 204 mi².

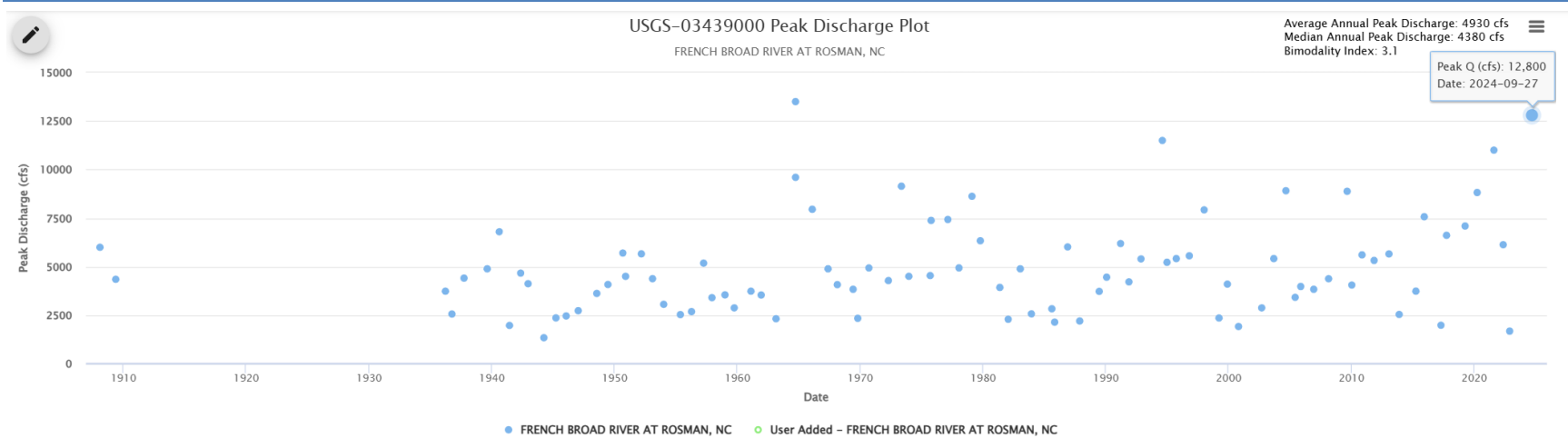
03164000: New River



Return Interval (yr)	Percent Chance of Occurrence	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 47: 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 mi².

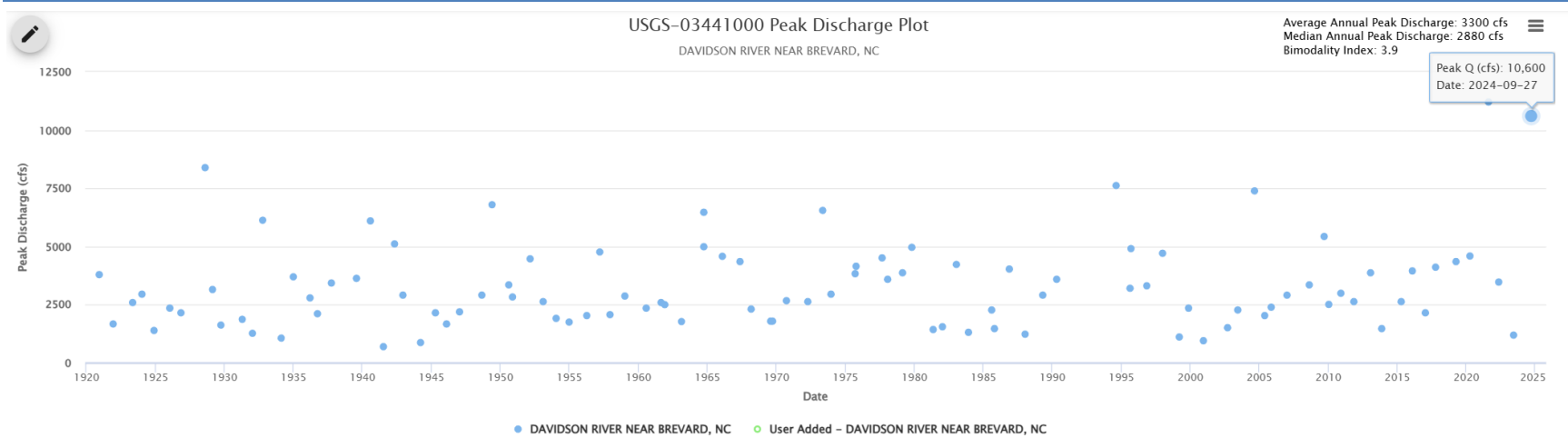
03439000: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	18,000	15,200	22,400	18,100	15,200	22,400	18,000	14,100	27,600	18,100	14,500	25,500
200	0.5	15,500	13,200	18,900	15,500	13,300	18,900	15,500	12,600	22,000	15,500	12,800	20,700
100	1	13,700	11,800	16,400	13,700	11,800	16,400	13,700	11,500	18,400	13,700	11,600	17,600
50	2	12,000	10,500	14,100	12,000	10,500	14,100	12,000	10,300	15,200	12,000	10,300	14,800
25	4	10,300	9,110	11,900	10,300	9,120	11,900	10,300	9,050	12,500	10,300	9,070	12,200
10	10	8,170	7,360	9,250	8,180	7,360	9,250	8,170	7,350	9,350	8,180	7,350	9,310
5	20	6,590	6,010	7,310	6,590	6,010	7,310	6,590	6,000	7,320	6,590	6,000	7,320
2	50	4,380	4,030	4,760	4,380	4,030	4,760	4,380	4,000	4,800	4,380	4,010	4,780
1.5	66.7	3,560	3,250	3,880	3,560	3,250	3,880	3,560	3,240	3,900	3,560	3,250	3,890
1.25	80	2,930	2,640	3,210	2,930	2,640	3,210	2,930	2,640	3,210	2,920	2,640	3,210
1.05	95.2	1,970	1,710	2,220	1,980	1,710	2,220	2,000	1,690	2,250	2,000	1,710	2,250

Figure 48: Annual peak discharge data and flood-frequency analysis results for the French Broad River at Rosman, NC streamgage (USGS ID: 03439000). Helene peak Q: 12,800 cfs. Record peak Q: 13,500 cfs (10/4/1964). Drainage area: 68.5 mi².

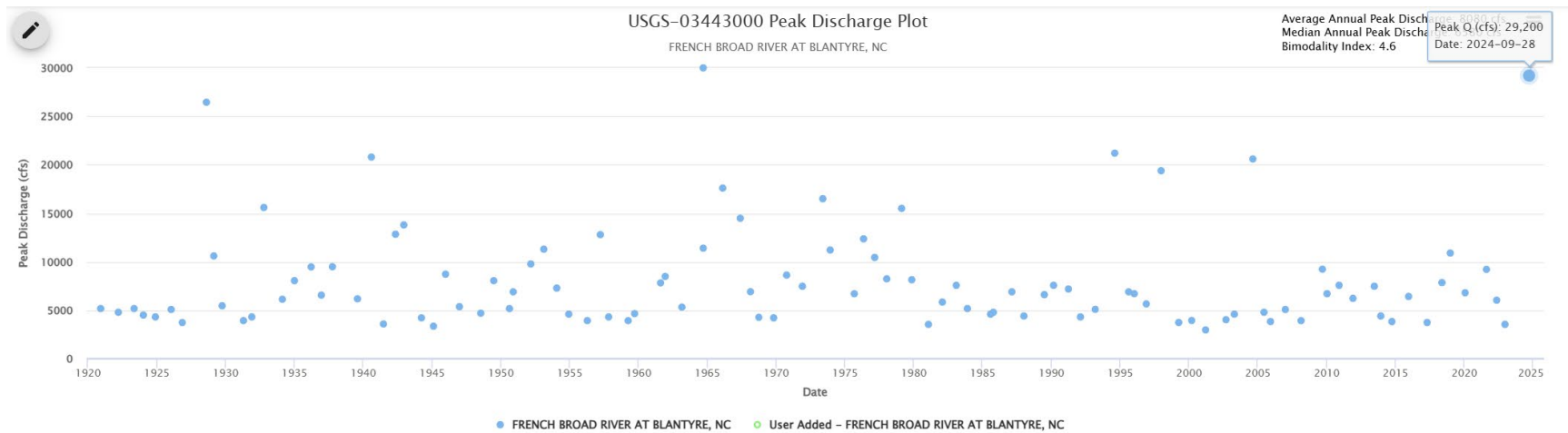
03441000: Davidson River



Return Interval (yr)	Percent Chance of Occurrence	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	13,800	11,400	17,300	13,900	11,500	17,500	13,700	10,600	21,300	13,900	10,900	20,000
200	0.5	11,600	9,830	14,300	11,700	9,890	14,500	11,600	9,350	16,700	11,700	9,550	15,900
100	1	10,200	8,670	12,300	10,200	8,720	12,400	10,200	8,400	13,800	10,200	8,520	13,300
50	2	8,740	7,560	10,400	8,780	7,590	10,500	8,740	7,430	11,200	8,780	7,500	11,000
25	4	7,400	6,490	8,660	7,420	6,510	8,690	7,400	6,450	9,030	7,420	6,470	8,910
10	10	5,720	5,120	6,530	5,730	5,120	6,530	5,720	5,110	6,590	5,730	5,120	6,570
5	20	4,500	4,080	5,030	4,500	4,080	5,030	4,500	4,070	5,030	4,500	4,070	5,030
2	50	2,840	2,600	3,110	2,840	2,590	3,110	2,840	2,580	3,130	2,840	2,580	3,120
1.5	66.7	2,250	2,040	2,460	2,250	2,040	2,460	2,250	2,030	2,480	2,250	2,030	2,470
1.25	80	1,800	1,610	1,980	1,800	1,610	1,980	1,800	1,610	1,990	1,800	1,610	1,980
1.05	95.2	1,150	985	1,300	1,150	987	1,310	1,160	970	1,320	1,160	986	1,320

Figure 49: Annual peak discharge data and flood-frequency analysis results for the Davidson River near Brevard, NC streamgauge (USGS ID: 03441000). Helene peak Q: 10,600 cfs. Record peak Q: 11,200 cfs (8/17/2021). Drainage area: 40.5 mi².

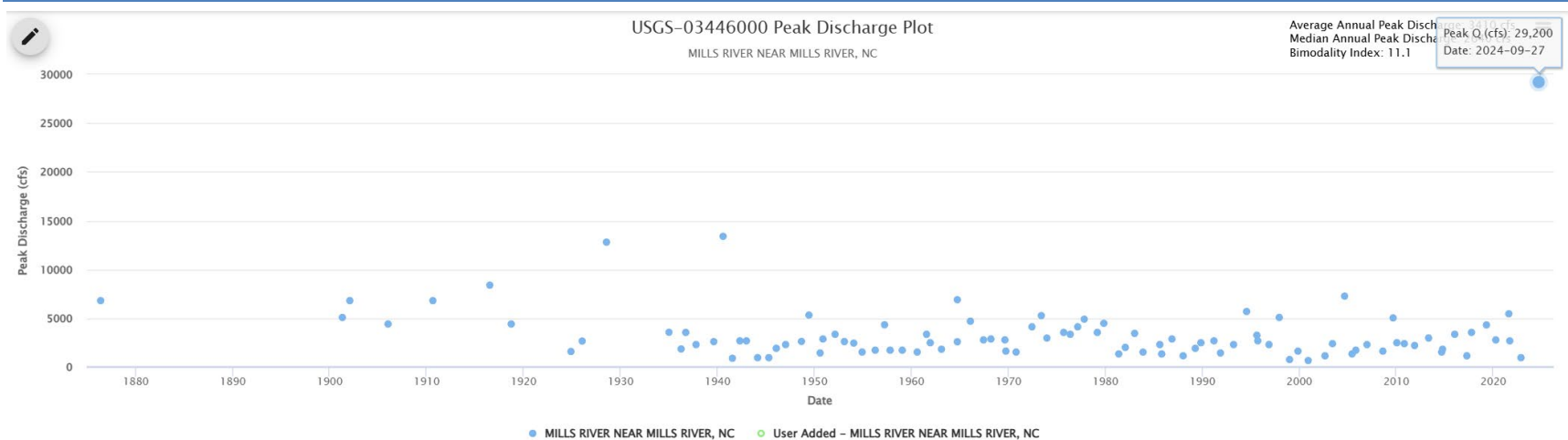
03443000: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	54,500	43,400	72,300	41,400	33,800	53,100	54,500	36,600	155,000	41,500	31,100	66,700
200	0.5	40,700	33,300	52,100	33,100	27,600	41,300	40,700	29,200	90,500	33,200	26,000	49,100
100	1	32,400	27,100	40,300	27,700	23,500	33,800	32,400	24,400	60,600	27,700	22,400	38,600
50	2	25,500	21,800	30,900	22,900	19,800	27,400	25,500	20,200	40,900	22,900	19,100	30,200
25	4	19,900	17,400	23,400	18,700	16,400	21,900	19,900	16,500	27,800	18,700	16,000	23,300
10	10	14,000	12,500	15,900	13,800	12,400	15,700	14,000	12,200	17,100	13,800	12,200	16,200
5	20	10,400	9,470	11,500	10,600	9,660	11,800	10,400	9,250	11,900	10,600	9,560	12,000
2	50	6,410	5,880	6,980	6,660	6,110	7,250	6,410	5,790	7,060	6,650	6,090	7,290
1.5	66.7	5,230	4,760	5,710	5,360	4,880	5,850	5,220	4,800	5,700	5,350	4,910	5,830
1.25	80	4,400	3,960	4,840	4,400	3,960	4,840	4,400	4,090	4,770	4,400	4,020	4,800
1.05	95.2	3,340	2,930	3,730	3,080	2,680	3,460	3,360	3,030	3,730	3,110	2,740	3,450

Figure 50: Annual peak discharge data and flood-frequency analysis results for the French Broad River at Blantyre, NC streamgauge (USGS ID: 03443000). Helene peak Q: 29,200 cfs. Record peak Q: 30,000 cfs (10/5/1964). Drainage area: 296 mi².

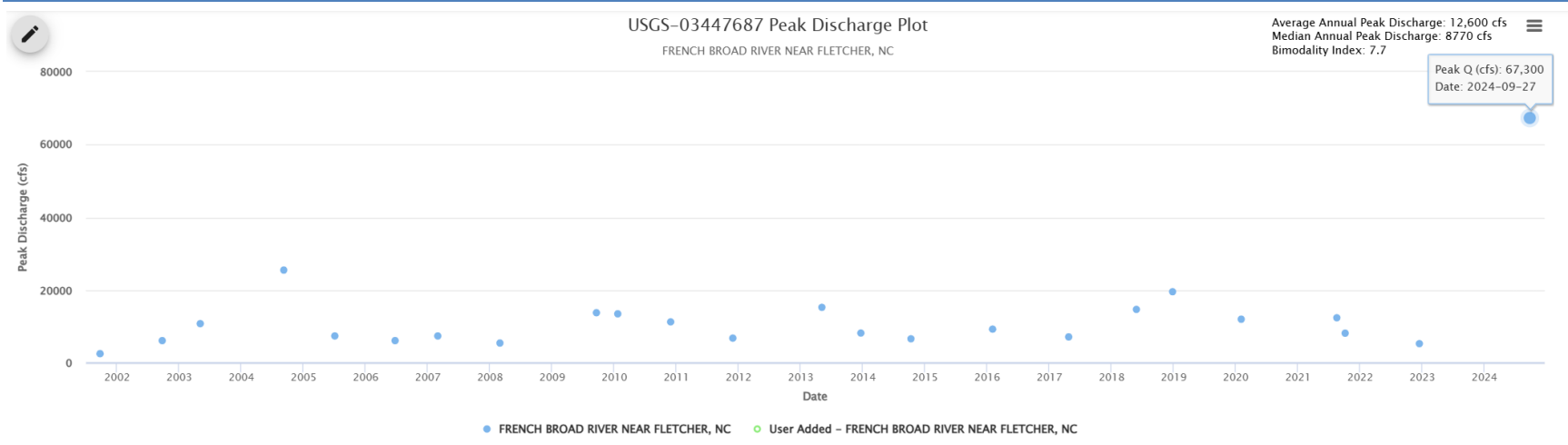
03446000: Mills River



Return Interval (yr)	Percent Chance of Occurrence	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	27,000	20,800	37,300	21,600	17,000	29,100	27,000	17,600	74,100	21,600	15,500	37,200
200	0.5	19,800	15,800	26,400	16,800	13,600	21,900	19,800	13,900	43,700	16,800	12,700	26,400
100	1	15,600	12,600	20,100	13,700	11,300	17,500	15,600	11,500	29,300	13,700	10,700	20,100
50	2	12,100	10,000	15,200	11,100	9,260	13,700	12,100	9,360	19,600	11,100	8,920	15,200
25	4	9,230	7,850	11,200	8,750	7,480	10,600	9,230	7,480	13,200	8,750	7,290	11,300
10	10	6,250	5,480	7,310	6,190	5,420	7,220	6,250	5,330	7,810	6,190	5,340	7,460
5	20	4,470	3,990	5,070	4,540	4,050	5,160	4,470	3,910	5,230	4,540	4,000	5,240
2	50	2,530	2,280	2,810	2,610	2,350	2,900	2,530	2,250	2,840	2,610	2,340	2,920
1.5	66.7	1,970	1,750	2,190	2,010	1,790	2,230	1,970	1,770	2,190	2,010	1,800	2,230
1.25	80	1,580	1,390	1,770	1,580	1,390	1,770	1,580	1,430	1,750	1,580	1,410	1,760
1.05	95.2	1,080	915	1,240	1,010	855	1,170	1,090	944	1,230	1,030	874	1,170

Figure 51: Annual peak discharge data and flood-frequency analysis results for the Mills River near Mill River, NC streamgauge (USGS ID: 03446000). Helene peak Q: 29,200 cfs, the record peak Q (9/27/2024). Drainage area: 66.6 mi².

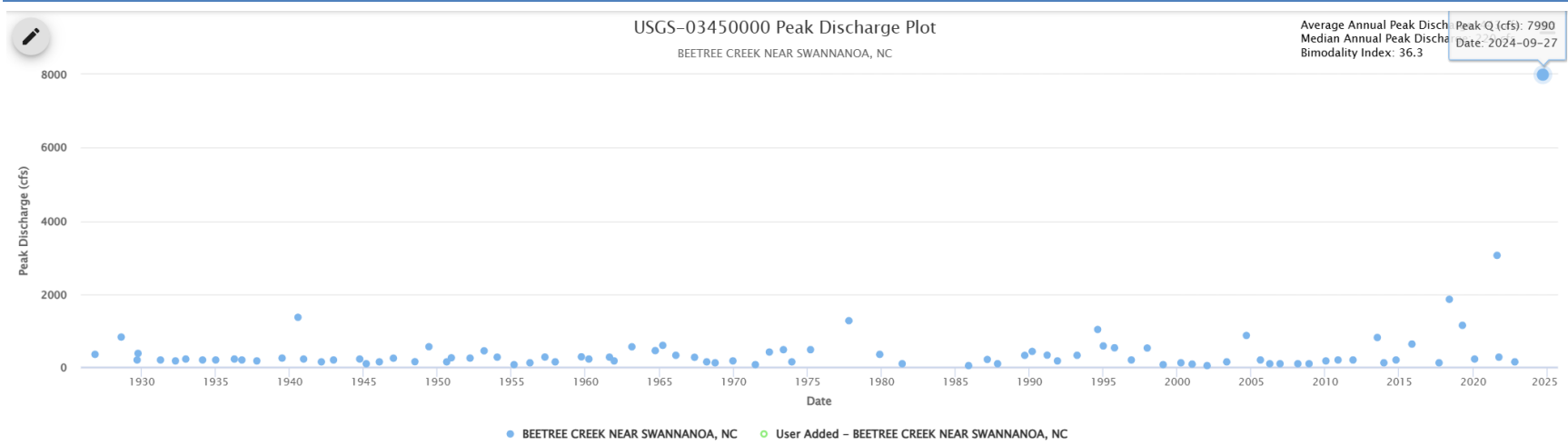
03447687: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	125,000	73,400	292,000	74,800	48,200	150,000	125,000	55,200	1,630,000	75,900	46,200	208,000
200	0.5	86,900	54,500	182,000	59,100	39,700	110,000	86,900	43,900	711,000	59,800	38,600	141,000
100	1	65,500	43,200	126,000	48,900	33,800	86,200	65,500	36,500	381,000	49,300	33,200	105,000
50	2	48,900	33,900	86,200	39,900	28,500	66,300	48,900	29,800	184,000	40,100	28,100	76,600
25	4	36,000	26,200	58,200	31,900	23,600	49,900	36,000	23,900	93,300	32,000	23,300	55,100
10	10	23,300	18,000	33,700	22,800	17,600	32,700	23,300	16,900	42,100	22,800	17,400	34,500
5	20	16,200	12,900	21,600	16,800	13,400	22,600	16,200	12,100	24,400	16,800	13,200	23,300
2	50	9,010	7,170	11,200	9,660	7,720	12,000	9,010	7,020	11,800	9,640	7,730	12,200
1.5	66.7	7,050	5,430	8,760	7,380	5,730	9,160	7,030	5,720	8,930	7,360	5,830	9,180
1.25	80	5,720	4,250	7,190	5,740	4,270	7,210	5,720	4,700	7,090	5,740	4,410	7,160
1.05	95.2	4,110	2,840	5,350	3,550	2,360	4,700	4,150	3,050	5,130	3,610	2,480	4,680

Figure 52: Annual peak discharge data and flood-frequency analysis results for the French Broad River near Fletcher, NC streamgauge (USGS ID: 03447687). Helene peak Q: 67,300 cfs, the record peak Q (9/27/2024). Drainage area: 640 mi².

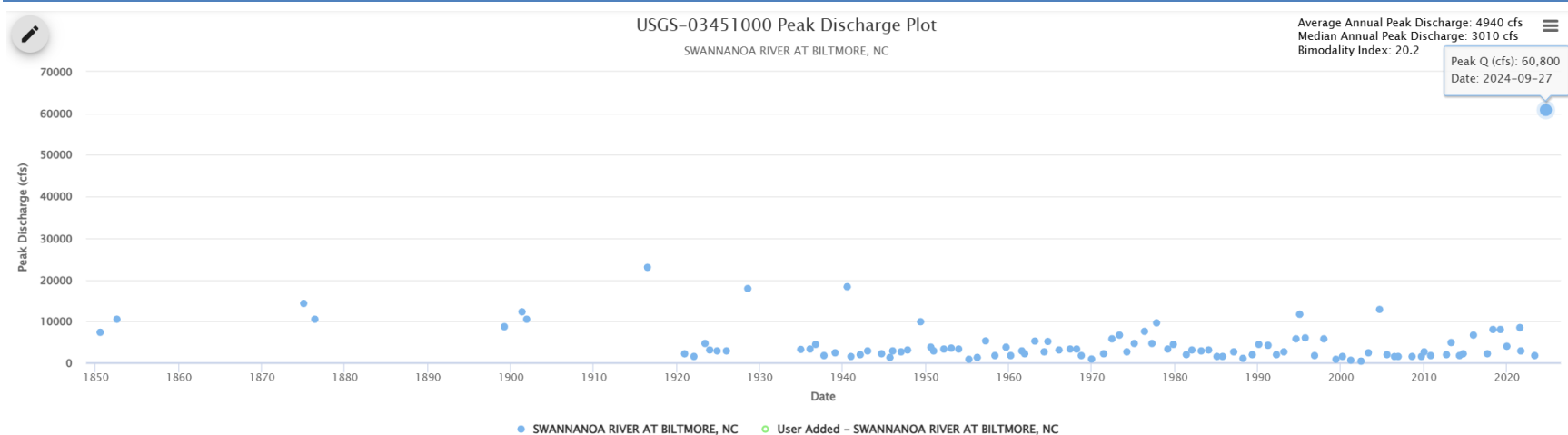
03450000: Beetree Creek



Return Interval (yr)	Percent Chance of Occurrence	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	9,380	6,190	15,900	4,920	3,470	7,630	9,380	4,150	65,500	4,930	3,000	11,300
200	0.5	5,500	3,830	8,670	3,400	2,490	5,030	5,510	2,830	24,300	3,410	2,230	6,760
100	1	3,640	2,640	5,430	2,530	1,900	3,610	3,640	2,080	11,700	2,540	1,750	4,540
50	2	2,380	1,800	3,370	1,860	1,440	2,550	2,380	1,510	5,700	1,860	1,350	3,010
25	4	1,530	1,210	2,050	1,330	1,060	1,750	1,530	1,070	2,850	1,330	1,010	1,960
10	10	826	684	1,030	811	672	1,010	826	640	1,200	811	654	1,070
5	20	497	424	595	525	446	631	497	402	641	525	438	651
2	50	224	193	260	245	211	284	224	187	267	245	210	287
1.5	66.7	163	138	190	172	146	201	163	141	190	172	148	200
1.25	80	126	104	148	125	104	147	126	111	143	125	107	145
1.05	95.2	85	68	102	70	55	86	86	72	105	71	57	85

Figure 53: Annual peak discharge data and flood-frequency analysis results for Beetree Creek near Swannanoa, NC streamgauge (USGS ID: 03450000). Helene peak Q: 7990 cfs, the record peak Q (9/27/2024). Drainage area: 5.45 mi².

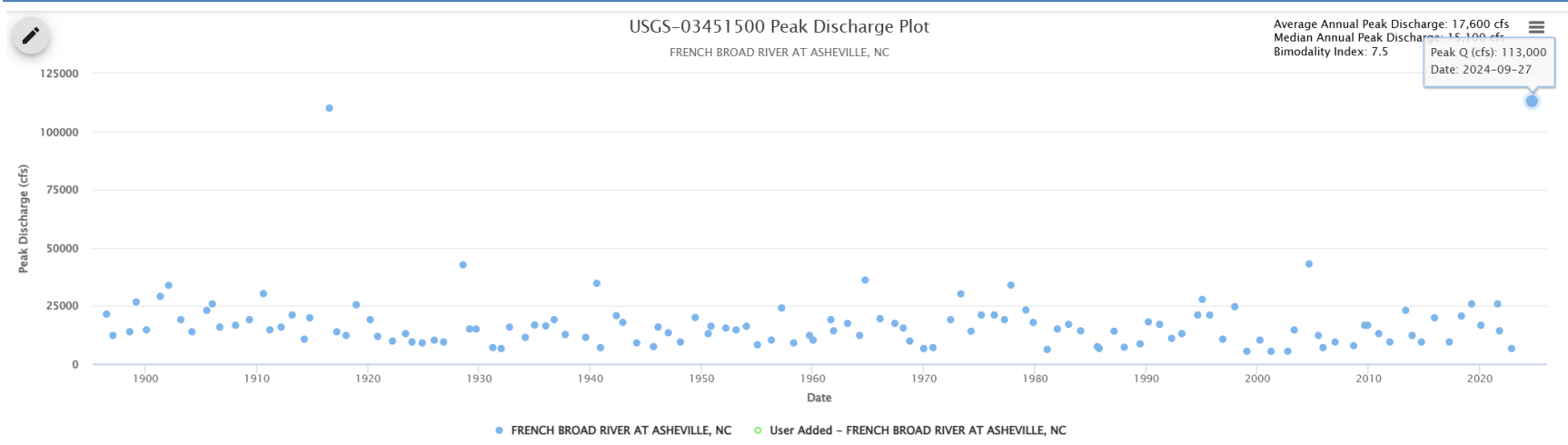
03451000: Swannanoa River



Return Interval (yr)	Percent Chance of Occurrence	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	64,000	46,200	95,700	47,300	35,200	68,200	64,000	37,300	232,000	47,600	31,300	93,900
200	0.5	43,000	32,300	61,300	34,300	26,200	47,500	43,000	27,400	117,000	34,400	24,100	60,400
100	1	31,400	24,300	43,200	26,400	20,700	35,600	31,400	21,400	70,000	26,500	19,400	42,800
50	2	22,700	18,000	30,000	20,100	16,100	26,200	22,700	16,400	41,900	20,100	15,400	29,900
25	4	16,000	13,100	20,400	14,900	12,300	18,800	16,000	12,300	25,100	14,900	11,900	20,600
10	10	9,730	8,260	11,800	9,590	8,150	11,600	9,730	7,970	12,800	9,590	7,990	12,100
5	20	6,330	5,510	7,400	6,470	5,620	7,570	6,330	5,370	7,710	6,470	5,540	7,740
2	50	3,090	2,710	3,510	3,210	2,820	3,650	3,090	2,660	3,560	3,210	2,810	3,680
1.5	66.7	2,250	1,950	2,570	2,310	2,010	2,640	2,240	1,970	2,560	2,310	2,020	2,630
1.25	80	1,710	1,450	1,970	1,710	1,460	1,970	1,710	1,510	1,930	1,710	1,490	1,950
1.05	95.2	1,070	874	1,260	980	795	1,170	1,080	910	1,250	996	819	1,170

Figure 54: Annual peak discharge data and flood-frequency analysis results for the Swannanoa River at Biltmore, NC streamgauge (USGS ID: 03451000). Helene peak Q: 60,800 cfs, the record peak Q (9/27/2024). Drainage area: 130 mi².

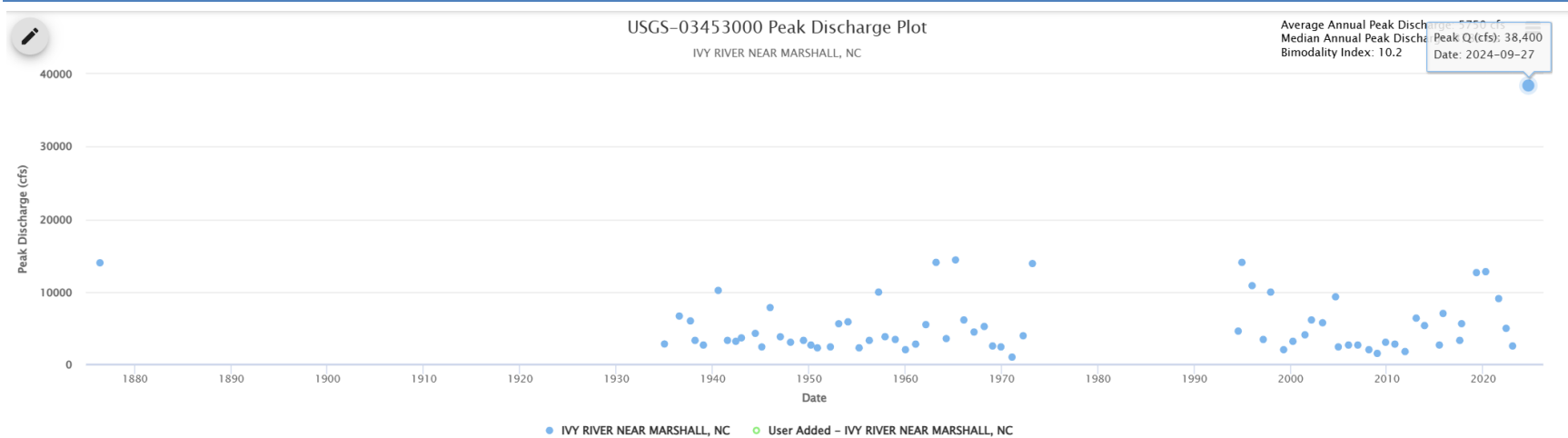
03451500: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	108,000	89,000	138,000	86,700	72,600	108,000	108,000	76,600	242,000	87,300	67,000	133,000
200	0.5	82,400	69,200	102,000	69,700	59,400	84,500	82,400	61,800	154,000	70,000	56,000	99,100
100	1	66,400	56,800	80,100	58,500	50,600	69,600	66,400	52,000	109,000	58,700	48,300	78,700
50	2	53,100	46,200	62,500	48,600	42,600	56,800	53,100	43,300	77,400	48,700	41,200	62,000
25	4	41,900	37,200	48,300	39,800	35,500	45,600	41,900	35,500	55,100	39,900	34,700	48,400
10	10	29,900	27,200	33,400	29,700	26,900	33,100	29,900	26,500	35,400	29,700	26,600	34,100
5	20	22,500	20,700	24,600	22,900	21,100	25,100	22,500	20,300	25,300	22,900	20,800	25,400
2	50	14,000	13,000	15,100	14,500	13,400	15,600	14,000	12,900	15,300	14,500	13,400	15,700
1.5	66.7	11,500	10,600	12,400	11,700	10,800	12,600	11,500	10,600	12,400	11,700	10,800	12,600
1.25	80	9,650	8,800	10,500	9,660	8,800	10,500	9,650	9,020	10,400	9,660	8,920	10,400
1.05	95.2	7,260	6,480	8,010	6,800	6,040	7,540	7,310	6,650	7,990	6,880	6,170	7,530

Figure 55: Annual peak discharge data and flood-frequency analysis results for the French Broad River at Asheville, NC streamgage (USGS ID: 03451500). Helene peak Q: 113,000 cfs, the record peak Q (9/27/2024). The second largest discharge (110,000 cfs) occurred on 7/16/1916. Drainage area: 945 mi².

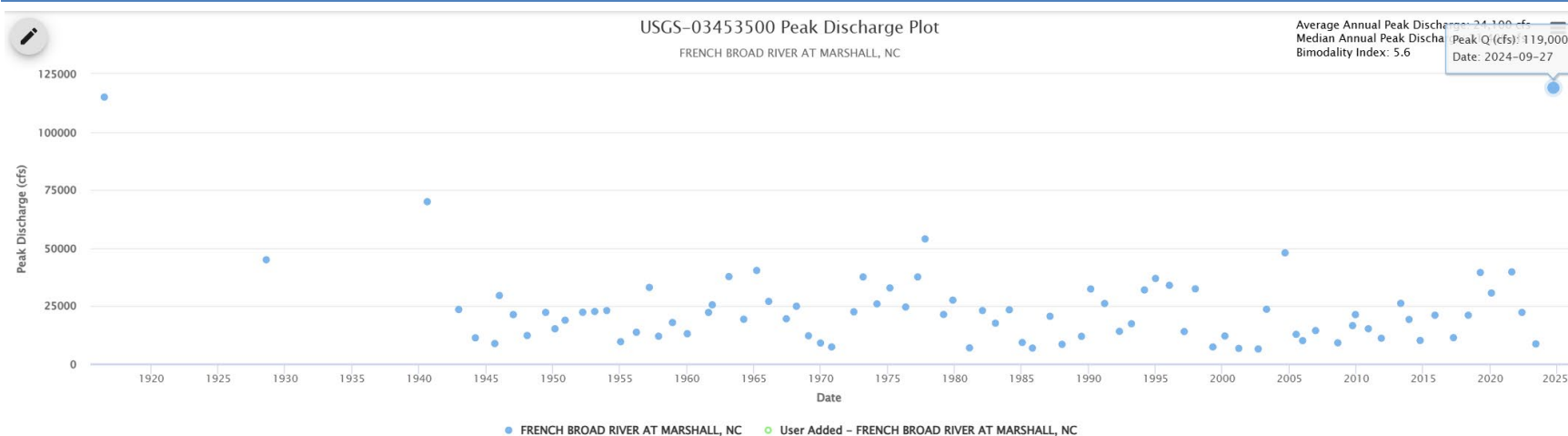
03453000: Ivy River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper			
500	0.2	51,600	37,400	78,400	39,000	29,200	56,800	51,600	31,000	217,000	39,000	26,600	75,000
200	0.5	37,200	27,900	53,700	30,100	23,100	42,100	37,200	24,200	112,000	30,100	21,600	51,900
100	1	28,700	22,200	39,900	24,400	19,200	33,100	28,700	19,800	68,700	24,400	18,200	38,900
50	2	21,800	17,400	29,200	19,500	15,700	25,700	21,800	16,000	42,400	19,500	15,100	28,800
25	4	16,400	13,400	21,100	15,300	12,600	19,500	16,400	12,700	26,400	15,300	12,300	21,100
10	10	10,800	9,200	13,200	10,700	9,080	13,000	10,800	8,890	14,500	10,700	8,940	13,500
5	20	7,580	6,590	8,900	7,730	6,710	9,090	7,580	6,420	9,300	7,730	6,630	9,280
2	50	4,170	3,650	4,740	4,330	3,800	4,930	4,170	3,590	4,820	4,330	3,790	4,970
1.5	66.7	3,200	2,770	3,660	3,290	2,840	3,750	3,190	2,800	3,660	3,280	2,870	3,750
1.25	80	2,540	2,160	2,930	2,550	2,160	2,940	2,540	2,240	2,890	2,550	2,200	2,910
1.05	95.2	1,720	1,390	2,030	1,580	1,280	1,890	1,730	1,450	2,000	1,610	1,310	1,880

Figure 56: Annual peak discharge data and flood-frequency analysis results for the Ivy River near Marshall, NC streamgauge (USGS ID: 03453000). Helene peak Q: 38,400 cfs, the record peak Q (9/27/2024). Drainage area: 158 mi².

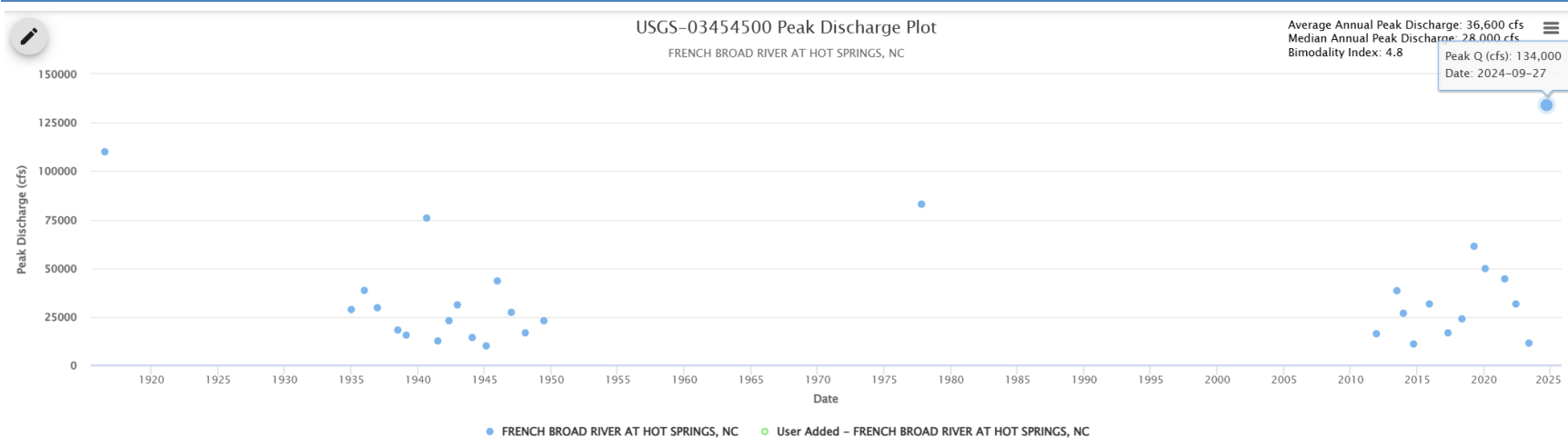
03453500: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	149,000	116,000	205,000	133,000	105,000	179,000	149,000	103,000	336,000	133,000	96,700	219,000
200	0.5	117,000	93,100	155,000	106,000	85,800	139,000	117,000	85,000	222,000	107,000	81,200	162,000
100	1	95,500	77,800	123,000	89,100	73,100	114,000	95,500	72,700	162,000	89,200	70,200	128,000
50	2	77,300	64,300	97,200	73,500	61,400	91,900	77,300	61,300	117,000	73,600	59,800	99,400
25	4	61,500	52,200	75,200	59,700	50,800	72,700	61,500	50,700	84,400	59,700	49,900	76,400
10	10	43,900	38,300	51,600	43,500	38,000	51,200	43,900	37,700	54,000	43,600	37,600	52,300
5	20	32,500	28,900	37,100	32,700	29,100	37,400	32,500	28,500	37,900	32,700	28,800	37,800
2	50	19,100	17,100	21,200	19,400	17,400	21,600	19,100	16,900	21,500	19,400	17,300	21,700
1.5	66.7	14,800	13,200	16,600	15,000	13,300	16,800	14,800	13,200	16,600	15,000	13,400	16,800
1.25	80	11,800	10,300	13,300	11,800	10,300	13,300	11,800	10,500	13,200	11,800	10,400	13,300
1.05	95.2	7,760	6,490	8,990	7,510	6,270	8,730	7,850	6,580	8,940	7,620	6,360	8,760

Figure 57: Annual peak discharge data and flood-frequency analysis results for the French Broad River at Marshall, NC streamgage (USGS ID: 03453500). Helene peak Q: 119,000 cfs, the record peak Q (9/27/2024). The second largest discharge (115,000 cfs) occurred on 7/16/1916. Drainage area: 1330 mi².

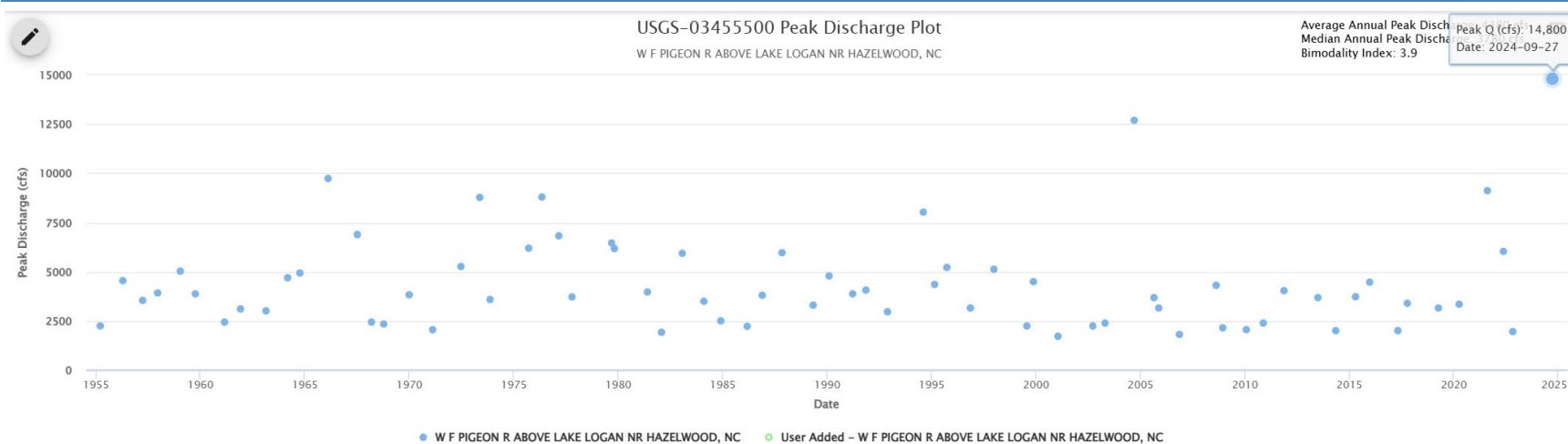
03454500: French Broad River



Return Interval (yr)	Percent Chance of Occurrence	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	310,000	196,000	622,000	256,000	167,000	489,000	310,000	165,000	2,290,000	256,000	151,000	860,000
200	0.5	229,000	151,000	423,000	198,000	134,000	353,000	229,000	134,000	1,200,000	198,000	125,000	538,000
100	1	179,000	123,000	312,000	160,000	112,000	271,000	179,000	112,000	738,000	160,000	107,000	374,000
50	2	139,000	99,100	226,000	128,000	92,700	205,000	139,000	92,300	404,000	128,000	89,600	258,000
25	4	105,000	78,300	161,000	101,000	75,200	152,000	105,000	74,400	227,000	101,000	73,400	177,000
10	10	70,600	55,100	98,700	69,800	54,600	97,400	70,600	53,200	113,000	69,900	53,700	104,000
5	20	49,700	40,100	65,100	50,300	40,500	66,000	49,700	38,600	69,500	50,300	39,800	68,300
2	50	27,200	22,000	33,400	27,900	22,600	34,300	27,200	21,600	34,300	27,900	22,500	34,900
1.5	66.7	20,600	16,300	25,300	21,000	16,600	25,800	20,600	16,600	25,600	21,000	16,800	25,900
1.25	80	16,100	12,200	20,000	16,200	12,300	20,100	16,100	13,000	19,900	16,200	12,700	20,000
1.05	95.2	10,400	7,250	13,500	9,870	6,800	12,900	10,500	7,480	13,100	10,000	6,970	12,700

Figure 58: Annual peak discharge data and flood-frequency analysis results for the French Broad River at Hot Springs, NC streamgage (USGS ID: 03454500). Helene peak Q: 134,000 cfs, the record peak Q (9/27/2024). The second largest discharge (110,000 cfs) occurred on 7/16/1916. Drainage area: 1560 mi².

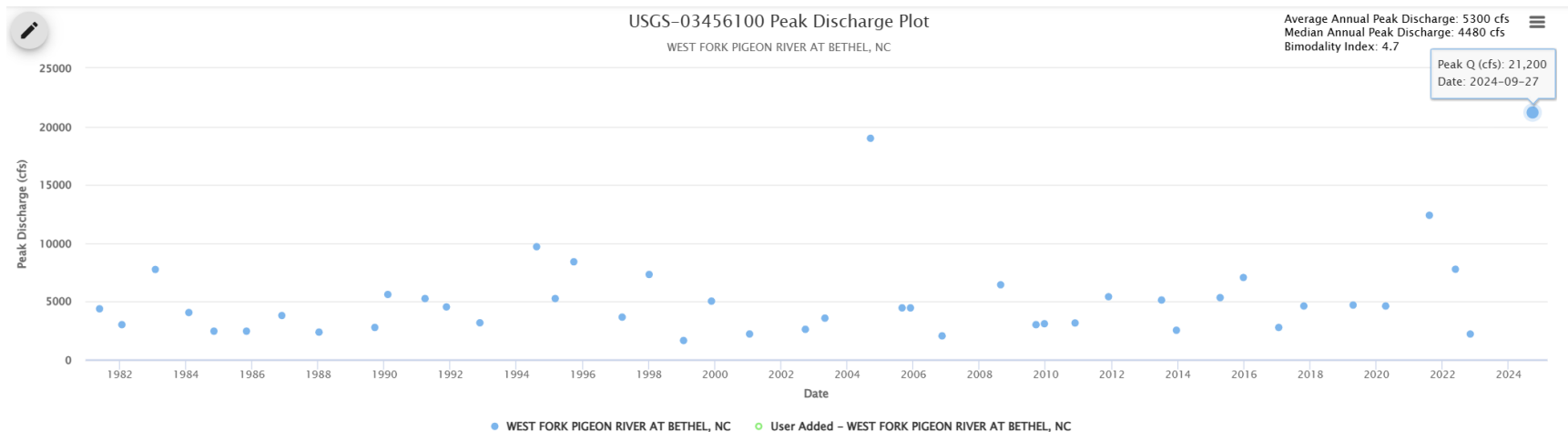
03455500: W.F. Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	21,200	16,900	28,500	18,300	14,800	24,000	21,200	15,000	51,800	18,300	13,800	28,800
200	0.5	17,000	13,900	22,200	15,200	12,600	19,400	17,000	12,700	34,300	15,200	12,000	22,300
100	1	14,300	11,900	18,100	13,100	11,000	16,400	14,300	11,100	25,100	13,100	10,600	18,200
50	2	11,900	10,100	14,700	11,200	9,550	13,700	11,900	9,620	18,400	11,200	9,320	14,700
25	4	9,790	8,460	11,700	9,430	8,180	11,300	9,790	8,190	13,500	9,430	8,050	11,800
10	10	7,350	6,520	8,500	7,280	6,460	8,420	7,350	6,390	8,980	7,280	6,400	8,610
5	20	5,720	5,150	6,440	5,770	5,200	6,510	5,720	5,080	6,600	5,770	5,160	6,590
2	50	3,710	3,360	4,080	3,780	3,440	4,160	3,710	3,330	4,120	3,780	3,430	4,190
1.5	66.7	3,040	2,730	3,360	3,090	2,780	3,400	3,040	2,750	3,360	3,090	2,790	3,400
1.25	80	2,550	2,260	2,830	2,560	2,270	2,840	2,550	2,310	2,810	2,560	2,290	2,830
1.05	95.2	1,870	1,600	2,120	1,790	1,520	2,040	1,880	1,630	2,100	1,810	1,550	2,040

Figure 59: Annual peak discharge data and flood-frequency analysis results for West Fork Pigeon River above Lake Logan near Hazelwood, NC streamgauge (USGS ID: 03455500). Helene peak Q: 14,800 cfs, the record peak Q (9/27/2024). Drainage area: 27.4 mi².

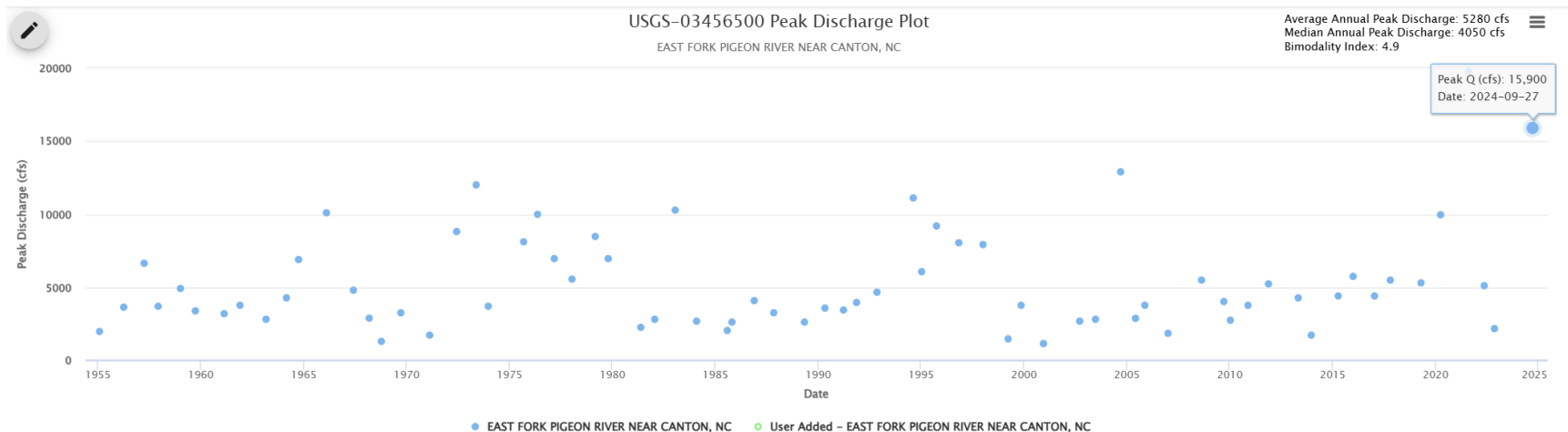
03456100: West Fork Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	39,100	27,500	63,900	27,100	20,000	41,100	39,100	22,200	224,000	27,300	18,800	53,600
200	0.5	28,700	21,100	44,200	21,800	16,600	31,800	28,700	17,900	119,000	22,000	15,900	38,800
100	1	22,600	17,200	33,100	18,300	14,300	25,800	22,600	15,100	69,200	18,400	13,800	30,100
50	2	17,600	13,800	24,600	15,200	12,200	20,700	17,600	12,600	40,400	15,300	11,800	23,200
25	4	13,600	11,000	18,100	12,500	10,200	16,300	13,600	10,300	24,400	12,500	9,990	17,600
10	10	9,380	7,900	11,700	9,230	7,780	11,500	9,380	7,570	13,300	9,230	7,670	11,900
5	20	6,850	5,920	8,170	7,040	6,070	8,420	6,850	5,690	8,730	7,040	5,990	8,600
2	50	4,120	3,570	4,730	4,330	3,760	4,980	4,120	3,500	4,840	4,320	3,750	5,020
1.5	66.7	3,320	2,830	3,820	3,430	2,930	3,940	3,310	2,890	3,840	3,420	2,960	3,940
1.25	80	2,760	2,300	3,210	2,770	2,310	3,210	2,760	2,440	3,160	2,760	2,360	3,190
1.05	95.2	2,050	1,640	2,440	1,850	1,450	2,220	2,070	1,720	2,410	1,870	1,490	2,210

Figure 60: Annual peak discharge data and flood-frequency analysis results for West Fork Pigeon River at Bethel, NC streamgauge (USGS ID: 03456100). Helene peak Q: 21,200 cfs, the record peak Q (9/27/2024). Drainage area: 57.7 mi².

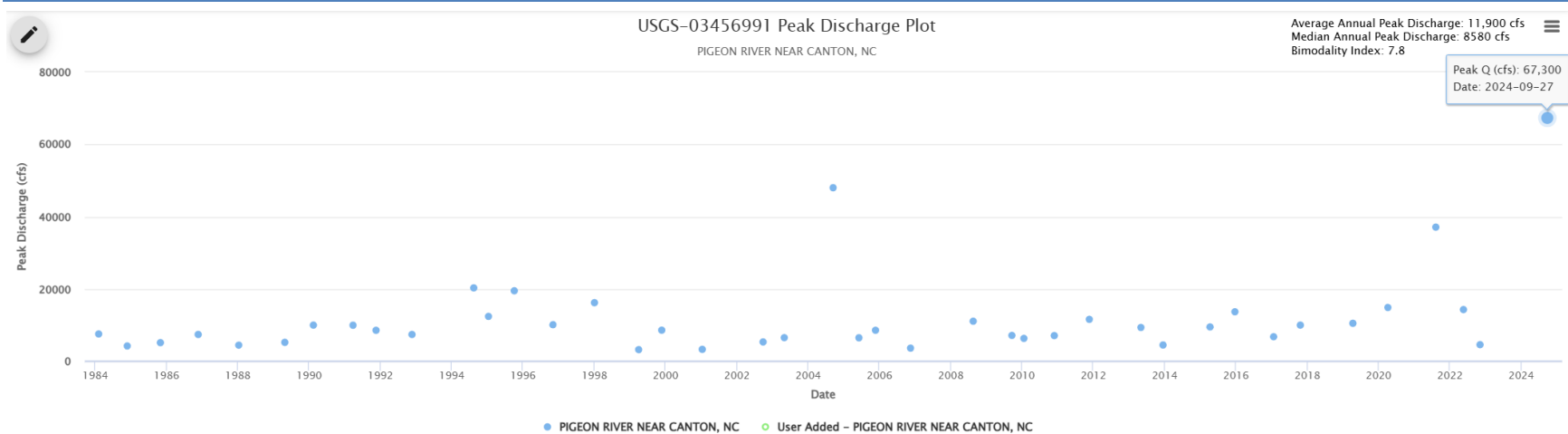
03456500: East Fork Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	28,900	22,300	40,300	27,500	21,400	38,100	28,900	20,100	61,300	27,500	20,000	46,300
200	0.5	23,300	18,400	31,500	22,400	17,800	30,100	23,300	17,200	42,800	22,400	17,100	34,700
100	1	19,600	15,800	25,800	19,000	15,400	24,900	19,600	15,000	32,400	19,000	14,900	27,700
50	2	16,200	13,300	20,800	15,900	13,100	20,300	16,200	12,900	24,300	15,900	12,800	21,800
25	4	13,200	11,100	16,400	13,000	10,900	16,200	13,200	10,900	18,000	13,000	10,800	16,900
10	10	9,650	8,310	11,600	9,620	8,280	11,500	9,650	8,240	11,900	9,620	8,240	11,700
5	20	7,260	6,370	8,440	7,280	6,390	8,460	7,260	6,320	8,530	7,280	6,350	8,520
2	50	4,300	3,810	4,850	4,330	3,840	4,880	4,300	3,770	4,900	4,330	3,820	4,910
1.5	66.7	3,330	2,910	3,760	3,340	2,930	3,780	3,320	2,910	3,770	3,340	2,930	3,780
1.25	80	2,610	2,250	2,980	2,620	2,250	2,980	2,610	2,270	2,980	2,620	2,270	2,980
1.05	95.2	1,640	1,340	1,940	1,620	1,320	1,920	1,670	1,330	1,950	1,650	1,330	1,930

Figure 61: Annual peak discharge data and flood-frequency analysis results for East Fork Pigeon River near Canton, NC streamgage (USGS ID: 03456500). Helene peak Q: 15,900 cfs. Record peak Q: 19,800 cfs (8/17/2021). Drainage area: 51.5 mi².

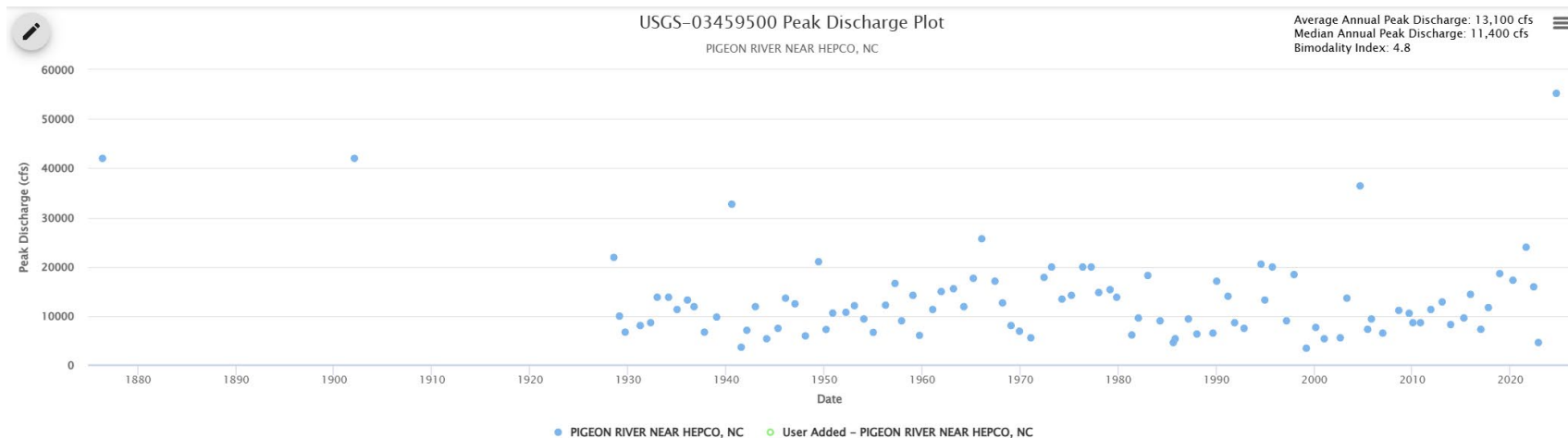
03456991: Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	145,000	91,700	279,000	80,100	55,100	136,000	145,000	63,900	1,600,000	80,300	50,600	187,000
200	0.5	96,100	64,500	169,000	61,600	44,000	98,700	96,100	48,900	597,000	61,700	41,300	126,000
100	1	69,800	49,000	115,000	49,900	36,600	76,600	69,800	39,500	291,000	50,000	34,900	92,400
50	2	50,200	36,800	77,100	39,800	30,100	58,400	50,200	31,400	146,000	39,900	29,100	67,100
25	4	35,700	27,400	51,300	31,200	24,300	43,700	35,700	24,500	76,700	31,300	23,700	48,100
10	10	22,200	17,900	29,200	21,700	17,600	28,500	22,200	16,800	35,300	21,700	17,300	30,000
5	20	14,900	12,500	18,600	15,700	13,100	19,600	14,900	11,700	20,600	15,700	12,800	20,200
2	50	8,080	6,750	9,590	8,750	7,340	10,400	8,080	6,590	9,970	8,750	7,340	10,500
1.5	66.7	6,310	5,160	7,510	6,630	5,460	7,890	6,290	5,360	7,570	6,620	5,530	7,890
1.25	80	5,150	4,110	6,190	5,130	4,100	6,180	5,150	4,470	6,010	5,130	4,220	6,120
1.05	95.2	3,800	2,900	4,690	3,190	2,360	4,000	3,830	3,080	4,650	3,230	2,440	3,960

Figure 62: Annual peak discharge data and flood-frequency analysis results for the Pigeon River near Canton, NC streamgauge (USGS ID: 03456991). Helene peak Q: 67,300 cfs, the record peak Q (9/27/2024). Drainage area: 130 mi².

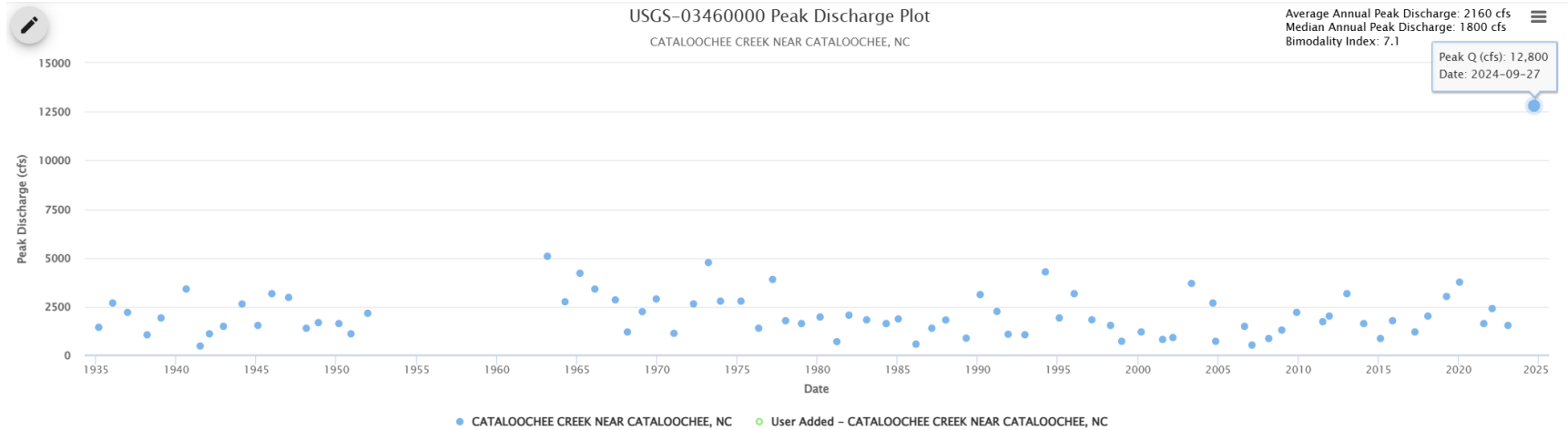
03459500: Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	66,400	54,100	85,500	63,100	51,700	80,800	66,400	48,700	126,000	63,300	47,400	105,000
200	0.5	53,400	44,500	67,000	51,400	42,900	64,200	53,400	41,200	89,000	51,500	40,300	78,100
100	1	44,900	38,000	55,100	43,600	37,000	53,300	44,900	35,800	68,200	43,600	35,300	61,800
50	2	37,300	32,100	44,800	36,500	31,500	43,800	37,300	30,800	51,900	36,500	30,500	48,600
25	4	30,500	26,700	35,900	30,100	26,400	35,400	30,500	26,000	39,300	30,200	25,900	37,800
10	10	22,700	20,300	25,900	22,600	20,300	25,800	22,700	20,000	26,800	22,600	20,000	26,500
5	20	17,500	15,900	19,400	17,500	15,900	19,500	17,500	15,700	19,700	17,500	15,800	19,700
2	50	10,900	10,000	11,900	11,000	10,100	12,000	10,900	9,940	12,100	11,000	10,000	12,100
1.5	66.7	8,790	7,980	9,610	8,830	8,020	9,660	8,780	8,000	9,630	8,820	8,040	9,670
1.25	80	7,200	6,450	7,930	7,200	6,450	7,940	7,200	6,540	7,890	7,200	6,530	7,900
1.05	95.2	4,980	4,310	5,610	4,910	4,250	5,540	5,030	4,370	5,600	4,970	4,300	5,550

Figure 63: Annual peak discharge data and flood-frequency analysis results for the Pigeon River near Hepco, NC streamgage (USGS ID: 03456500). Helene peak Q: 55,200 cfs, the record peak Q (9/27/2024). Drainage area: 350 mi².

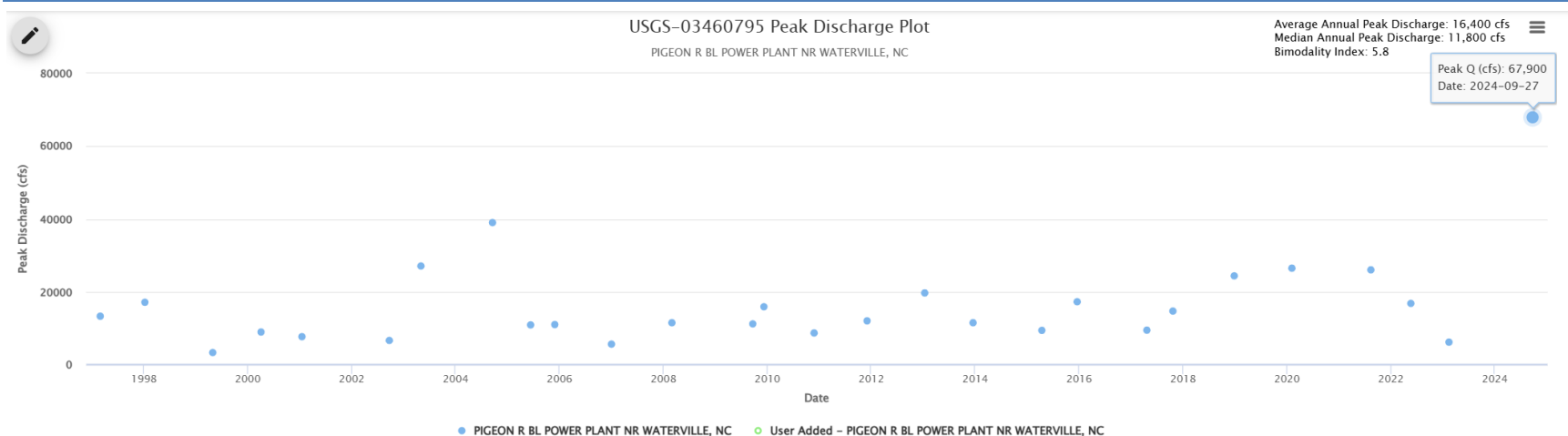
03460000: Cataloochee Creek



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	10,500	8,370	14,000	10,300	8,230	13,700	10,500	7,640	19,500	10,300	7,610	17,400
200	0.5	8,630	7,020	11,200	8,500	6,930	11,000	8,630	6,590	14,300	8,500	6,570	13,100
100	1	7,350	6,080	9,330	7,260	6,020	9,210	7,350	5,820	11,200	7,260	5,800	10,500
50	2	6,180	5,200	7,670	6,130	5,160	7,600	6,180	5,060	8,680	6,130	5,050	8,310
25	4	5,110	4,370	6,190	5,090	4,350	6,160	5,110	4,310	6,660	5,090	4,300	6,490
10	10	3,830	3,350	4,490	3,820	3,350	4,480	3,830	3,330	4,590	3,820	3,330	4,560
5	20	2,940	2,620	3,350	2,940	2,620	3,360	2,940	2,600	3,380	2,940	2,610	3,380
2	50	1,800	1,610	2,000	1,800	1,620	2,000	1,800	1,600	2,010	1,800	1,610	2,020
1.5	66.7	1,410	1,250	1,570	1,410	1,250	1,570	1,410	1,250	1,570	1,410	1,250	1,580
1.25	80	1,120	979	1,260	1,120	980	1,260	1,120	986	1,260	1,120	985	1,260
1.05	95.2	715	598	829	712	594	825	725	593	835	721	593	832

Figure 64: Annual peak discharge data and flood-frequency analysis results for the Cataloochee Creek near Cataloochee, NC streamgage (USGS ID: 03460000). Helene peak Q: 12,800 cfs, the record peak Q (9/27/2024). Drainage area: 49.1 mi².

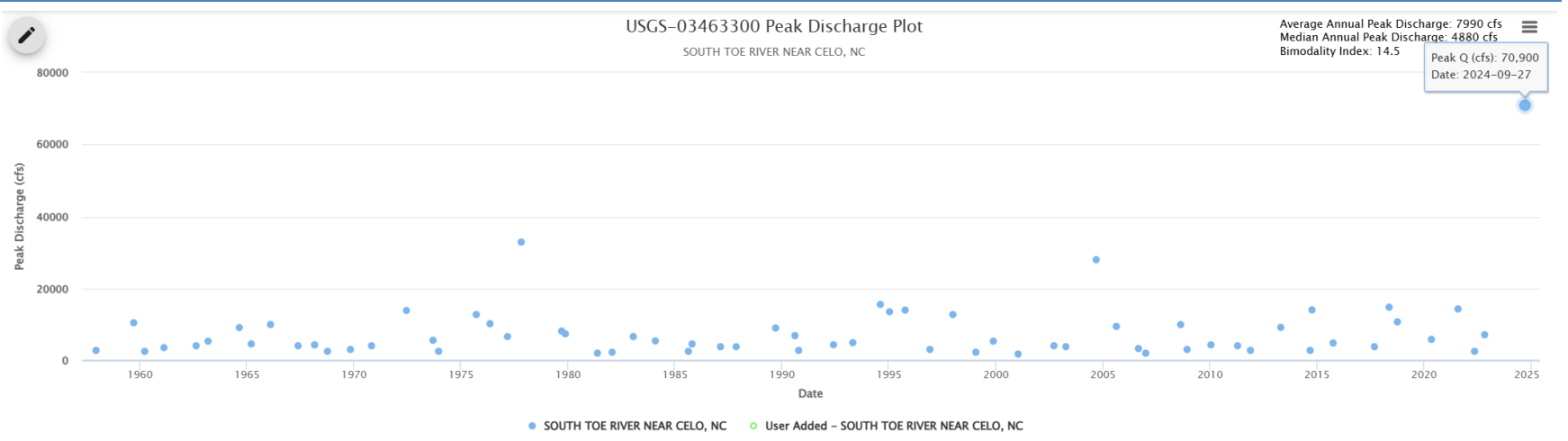
03460795: Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	109,000	71,500	208,000	94,200	63,200	173,000	109,000	62,900	611,000	96,100	59,000	281,000
200	0.5	84,400	57,600	150,000	75,400	52,400	130,000	84,400	52,600	356,000	76,600	50,100	187,000
100	1	68,600	48,400	116,000	62,900	45,000	104,000	68,600	45,300	226,000	63,700	43,700	136,000
50	2	55,100	40,200	87,700	51,800	38,100	81,100	55,100	38,300	138,000	52,200	37,400	98,200
25	4	43,500	32,800	65,200	41,800	31,700	62,100	43,500	31,800	85,300	42,100	31,300	70,100
10	10	30,600	24,100	42,300	30,300	23,900	41,800	30,600	23,600	47,000	30,300	23,600	43,900
5	20	22,400	18,200	29,100	22,600	18,300	29,300	22,400	17,700	30,400	22,500	18,000	30,000
2	50	12,800	10,500	15,700	13,100	10,700	16,000	12,800	10,300	16,000	13,100	10,600	16,200
1.5	66.7	9,890	7,870	12,100	10,000	8,000	12,200	9,880	8,000	12,200	10,000	8,070	12,300
1.25	80	7,790	5,970	9,610	7,820	6,000	9,640	7,790	6,240	9,590	7,810	6,140	9,620
1.05	95.2	5,020	3,520	6,480	4,830	3,350	6,260	5,090	3,540	6,350	4,920	3,390	6,250

Figure 65: Annual peak discharge data and flood-frequency analysis results for the Pigeon River Below PowerPlant near Waterville, NC streamgage (USGS ID: 03460795). Helene peak Q: 67,900 cfs, the record peak Q (9/27/2024). Drainage area: 537 mi².

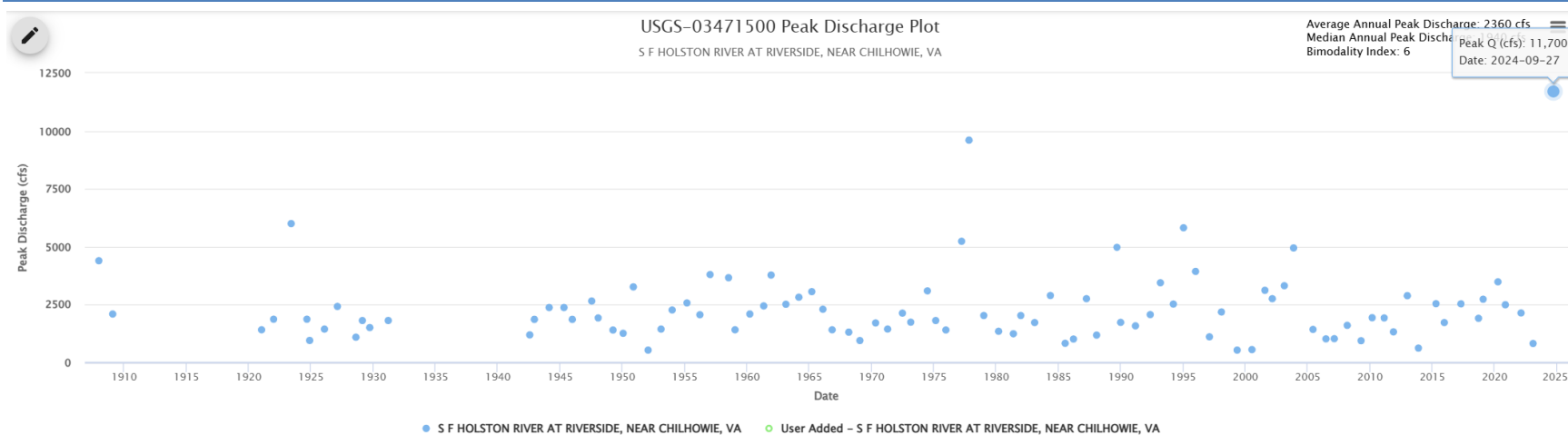
03463300: South Toe River



Return Interval (yr)	Percent Chance of Occurrence	Bulletin 17B Flood Method Estimates (cfs)						Bulletin 17C Flood Method Estimates (cfs)					
		Computed with Station Skew			Computed with Weighted Generalized			Computed with Station Skew			Computed with Weighted Generalized		
		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval		Magnitude	Confidence Interval	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	
500	0.2	103,000	69,900	171,000	65,300	46,800	101,000	103,000	53,200	704,000	66,200	42,300	143,000
200	0.5	68,300	48,700	106,000	48,600	36,000	71,700	68,300	39,500	295,000	49,100	33,400	93,400
100	1	49,600	36,600	73,500	38,300	29,100	54,600	49,600	31,100	155,000	38,600	27,500	66,900
50	2	35,600	27,200	50,100	29,700	23,200	40,800	35,600	24,100	83,500	29,900	22,300	47,400
25	4	25,100	20,000	33,700	22,600	18,100	29,900	25,100	18,300	46,100	22,700	17,600	33,000
10	10	15,400	12,700	19,300	15,100	12,500	18,900	15,400	12,100	22,000	15,100	12,300	19,900
5	20	10,100	8,650	12,200	10,500	8,940	12,600	10,100	8,300	13,000	10,500	8,790	13,000
2	50	5,180	4,450	6,010	5,510	4,740	6,390	5,180	4,350	6,140	5,500	4,730	6,450
1.5	66.7	3,910	3,310	4,550	4,070	3,450	4,730	3,900	3,370	4,550	4,050	3,480	4,710
1.25	80	3,080	2,550	3,620	3,080	2,550	3,620	3,080	2,700	3,540	3,080	2,610	3,580
1.05	95.2	2,100	1,670	2,530	1,840	1,440	2,240	2,120	1,760	2,520	1,870	1,490	2,230

Figure 66: Annual peak discharge data and flood-frequency analysis results for the South Toe River near Celo, NC streamgage (USGS ID: 03463300). Helene peak Q: 70,900 cfs, the record peak discharge (9/27/2024). Drainage area: 43.3 mi².

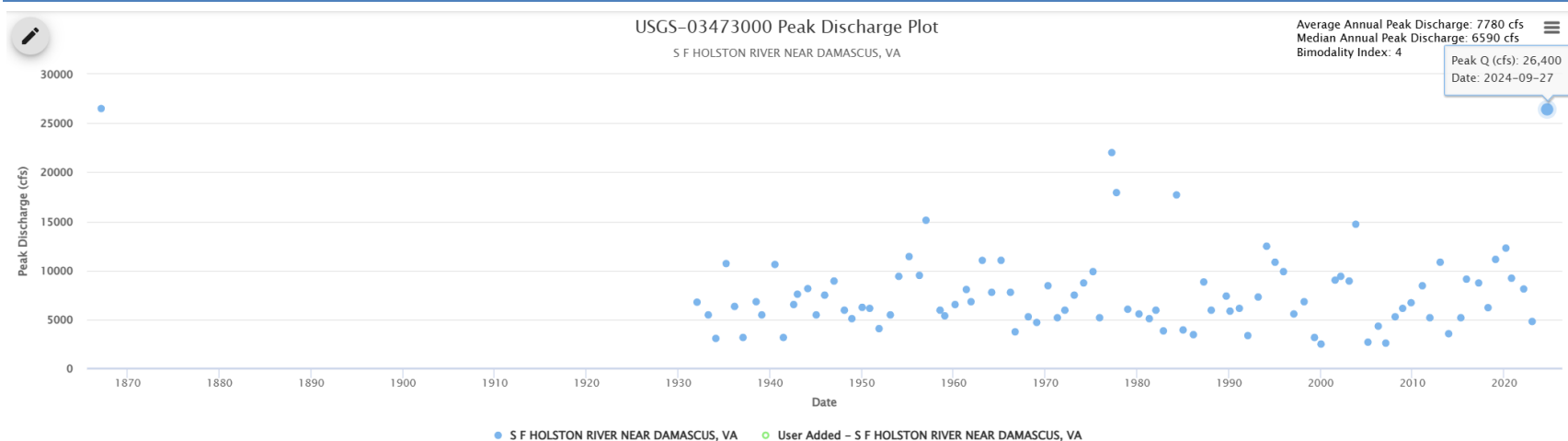
03471500: South Fork Holston River



Return Interval (yr)	Percent Chance of Occurrence	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 67: Annual peak discharge data and flood-frequency analysis results for the South Fork Holston River at Riverside, near Chilhowie, VA streamgage (USGS ID: 03471500). Helene peak Q: 11,700 cfs, the record peak discharge (9/27/2024). Drainage area: 76.5 mi².

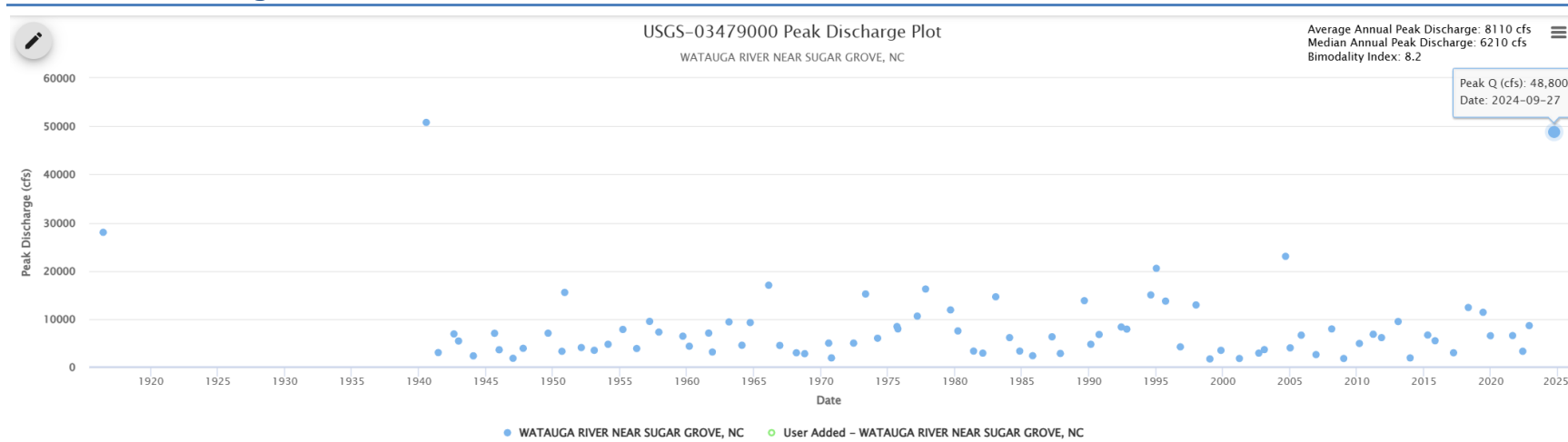
03473000: South Fork Holston River



Return Interval (yr)	Percent Chance of Occurrence	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 68: Annual peak discharge data and flood-frequency analysis results for the South Fork Holston River near Damascus, VA streamgauge (USGS ID: 03473000). Helene peak Q: 26,400 cfs. Record peak Q: 26,500 cfs (3/1/1867). Drainage area: 303 mi².

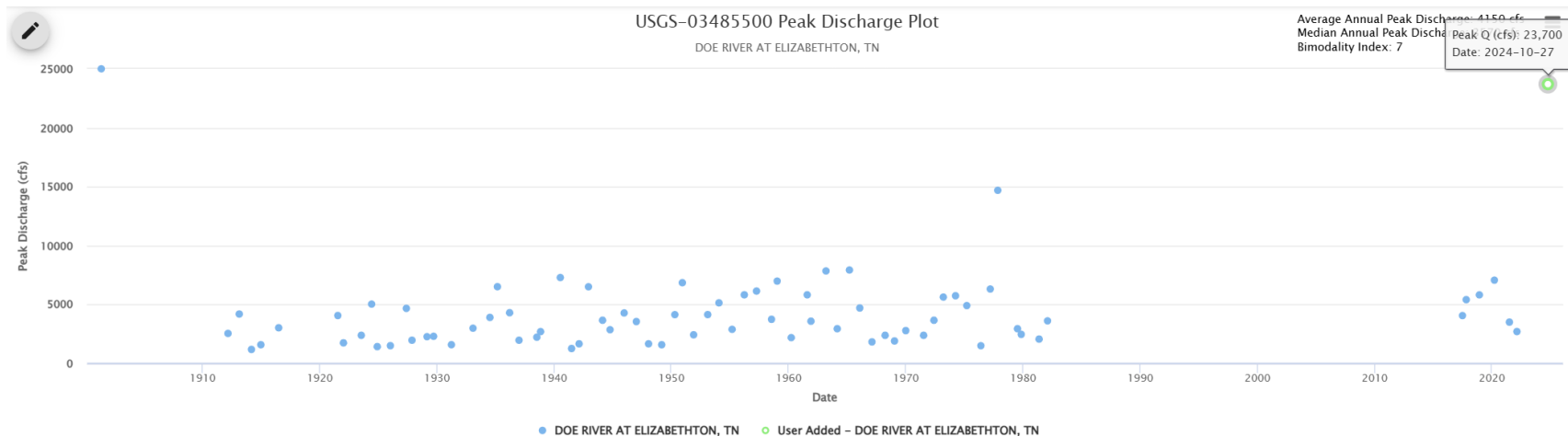
03479000: Watauga River



Return Interval (yr)	Percent Chance of Occurrence	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	78,600	57,600	117,000	70,500	52,200	103,000	78,600	48,200	256,000	70,800	45,400	168,000
200	0.5	56,300	42,700	79,900	51,900	39,600	72,800	56,300	37,400	142,000	52,100	35,700	105,000
100	1	43,200	33,600	59,200	40,600	31,800	55,200	43,200	30,400	91,000	40,700	29,400	72,700
50	2	32,700	26,100	43,200	31,300	25,100	41,100	32,700	24,300	58,200	31,400	23,700	50,100
25	4	24,300	19,900	31,000	23,700	19,500	30,100	24,300	19,000	37,200	23,700	18,700	34,100
10	10	15,800	13,400	19,100	15,700	13,300	19,000	15,800	13,000	20,600	15,700	13,000	20,100
5	20	10,800	9,400	12,700	10,900	9,470	12,800	10,800	9,200	13,100	10,900	9,310	13,100
2	50	5,660	4,970	6,440	5,750	5,040	6,530	5,660	4,900	6,530	5,740	5,010	6,610
1.5	66.7	4,230	3,670	4,820	4,270	3,700	4,870	4,220	3,690	4,820	4,260	3,730	4,870
1.25	80	3,260	2,770	3,750	3,260	2,770	3,760	3,260	2,860	3,710	3,260	2,840	3,720
1.05	95.2	2,060	1,680	2,450	2,000	1,620	2,380	2,090	1,730	2,410	2,030	1,660	2,360

Figure 69: Annual peak discharge data and flood-frequency analysis results for the Watauga River near Sugar Grove, NC streamgage (USGS ID: 03479000). Helene peak Q: 48,800 cfs. Record peak Q: 50,800 cfs (8/13/1940). Drainage area: 90.9 mi².

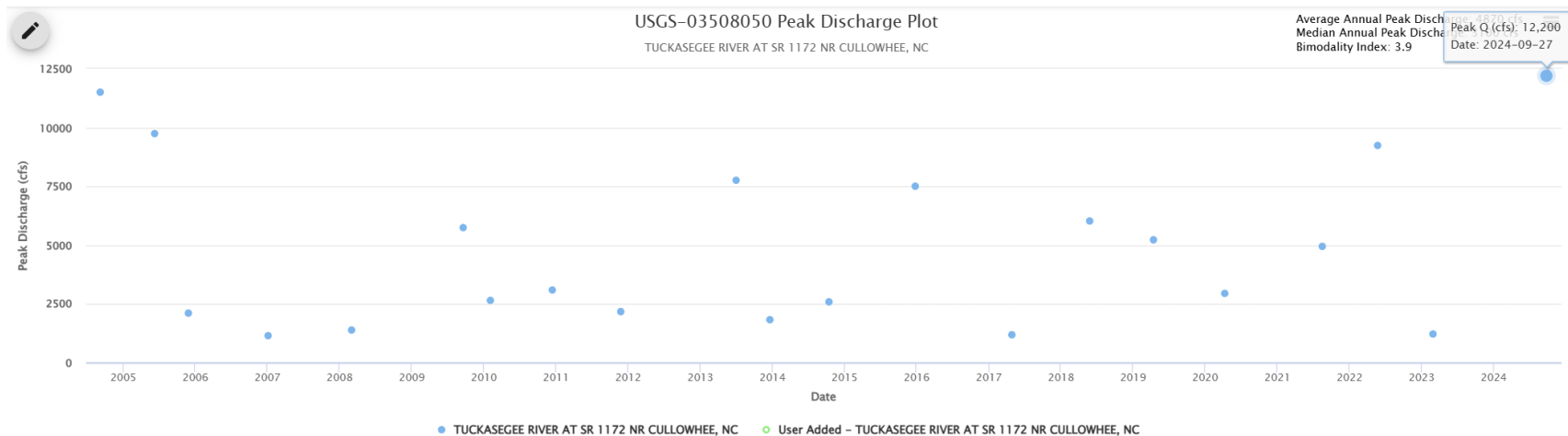
03485500: Doe River



Return Interval (yr)	Percent Chance of Occurrence	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	36,800	27,200	54,500	30,500	23,000	43,800	36,800	22,500	153,000	30,600	20,200	71,800
200	0.5	26,700	20,400	37,600	23,100	18,000	31,900	26,700	17,700	79,400	23,200	16,300	46,200
100	1	20,700	16,300	28,100	18,600	14,800	24,900	20,700	14,600	48,700	18,600	13,700	32,900
50	2	15,900	12,900	20,800	14,700	12,000	19,100	15,900	11,800	30,200	14,800	11,400	23,300
25	4	12,000	10,000	15,200	11,500	9,610	14,400	12,000	9,420	19,000	11,500	9,250	16,400
10	10	8,070	6,940	9,670	8,010	6,900	9,590	8,070	6,710	10,600	8,010	6,740	10,200
5	20	5,740	5,050	6,650	5,830	5,120	6,750	5,740	4,910	6,950	5,820	5,030	6,950
2	50	3,270	2,890	3,680	3,350	2,970	3,780	3,270	2,850	3,740	3,350	2,950	3,820
1.5	66.7	2,560	2,240	2,890	2,600	2,280	2,940	2,560	2,270	2,890	2,600	2,300	2,940
1.25	80	2,070	1,780	2,360	2,070	1,780	2,360	2,070	1,860	2,330	2,070	1,830	2,340
1.05	95.2	1,460	1,210	1,700	1,380	1,140	1,620	1,470	1,260	1,690	1,400	1,170	1,600

Figure 70: Annual peak discharge data and flood-frequency analysis results for the Doe River at Elizabethton, TN streamgage (USGS ID: 03485500). Helene peak Q: 23,700 cfs (preliminary). Record peak Q: 25,000 cfs (5/21/1901). Drainage area: 137 mi².

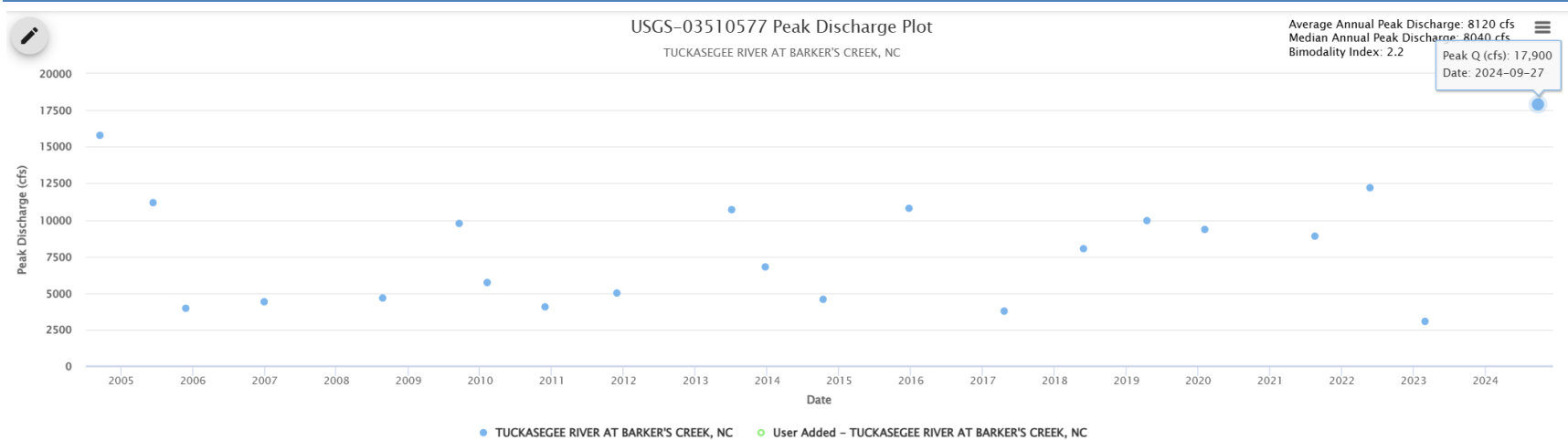
03508050: Tuckasegee River



Return Interval (yr)	Percent Chance of Occurrence	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	34,900	20,600	81,900	36,600	21,400	87,500	34,900	18,400	184,000	36,600	20,600	111,000
200	0.5	27,600	17,000	60,200	28,700	17,500	63,300	27,600	16,000	108,000	28,700	17,200	74,700
100	1	22,800	14,500	46,700	23,500	14,800	48,600	22,800	14,000	72,100	23,500	14,700	54,500
50	2	18,400	12,100	35,400	18,800	12,300	36,400	18,400	12,000	47,500	18,800	12,300	39,200
25	4	14,600	9,940	26,100	14,800	10,100	26,500	14,600	9,990	30,800	14,800	10,100	27,600
10	10	10,100	7,250	16,300	10,200	7,280	16,400	10,100	7,250	16,900	10,200	7,270	16,500
5	20	7,170	5,320	10,600	7,160	5,310	10,600	7,170	5,240	10,600	7,160	5,270	10,600
2	50	3,700	2,760	4,960	3,680	2,740	4,930	3,700	2,700	5,070	3,680	2,730	4,980
1.5	66.7	2,640	1,900	3,510	2,630	1,880	3,490	2,640	1,880	3,590	2,620	1,890	3,520
1.25	80	1,900	1,280	2,570	1,900	1,280	2,560	1,900	1,280	2,610	1,900	1,300	2,570
1.05	95.2	986	560	1,430	998	569	1,450	1,010	495	1,460	1,020	574	1,460

Figure 71: Annual peak discharge data and flood-frequency analysis results for the Tuckasegee River at SR1172 near Cullowhee, NC streamgage (USGS ID: 03508050). Helene peak Q: 12,200 cfs, the record peak Q (9/27/2024). Drainage area: 145 mi².

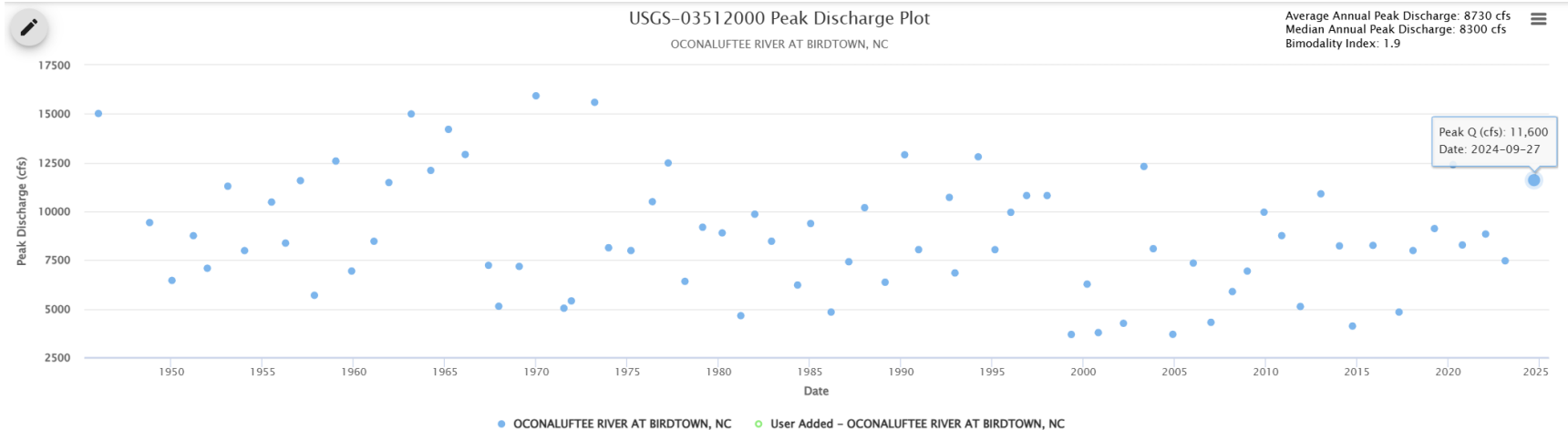
03510577: Tuckasegee River



Return Interval (yr)	Percent Chance of Occurrence	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	31,800	22,500	55,900	32,100	22,600	56,600	31,800	20,900	101,000	32,100	22,000	66,300
200	0.5	27,100	19,700	45,300	27,300	19,800	45,800	27,100	18,900	69,600	27,300	19,600	51,100
100	1	23,800	17,700	38,200	24,000	17,800	38,500	23,800	17,300	52,400	24,000	17,700	41,600
50	2	20,700	15,700	31,700	20,800	15,800	31,900	20,700	15,600	39,300	20,800	15,700	33,500
25	4	17,700	13,800	25,800	17,700	13,800	25,900	17,700	13,800	29,200	17,700	13,800	26,600
10	10	13,900	11,200	18,900	13,900	11,200	18,900	13,900	11,100	19,500	13,900	11,200	19,000
5	20	11,000	9,110	14,300	11,000	9,100	14,300	11,000	9,000	14,300	11,000	9,050	14,300
2	50	7,180	5,930	8,680	7,170	5,930	8,660	7,180	5,860	8,800	7,170	5,900	8,720
1.5	66.7	5,760	4,640	6,930	5,760	4,640	6,920	5,760	4,640	7,040	5,760	4,650	6,960
1.25	80	4,680	3,620	5,680	4,680	3,620	5,670	4,680	3,640	5,730	4,680	3,650	5,690
1.05	95.2	3,080	2,140	3,920	3,090	2,140	3,930	3,120	2,000	3,950	3,120	2,160	3,950

Figure 72: Annual peak discharge data and flood-frequency analysis results for the Tuckasegee River at Barkers Creek, NC streamgage (USGS ID: 03510577). Helene peak Q: 17,900 cfs, the record peak Q (9/27/2024). Drainage area: 360 mi².

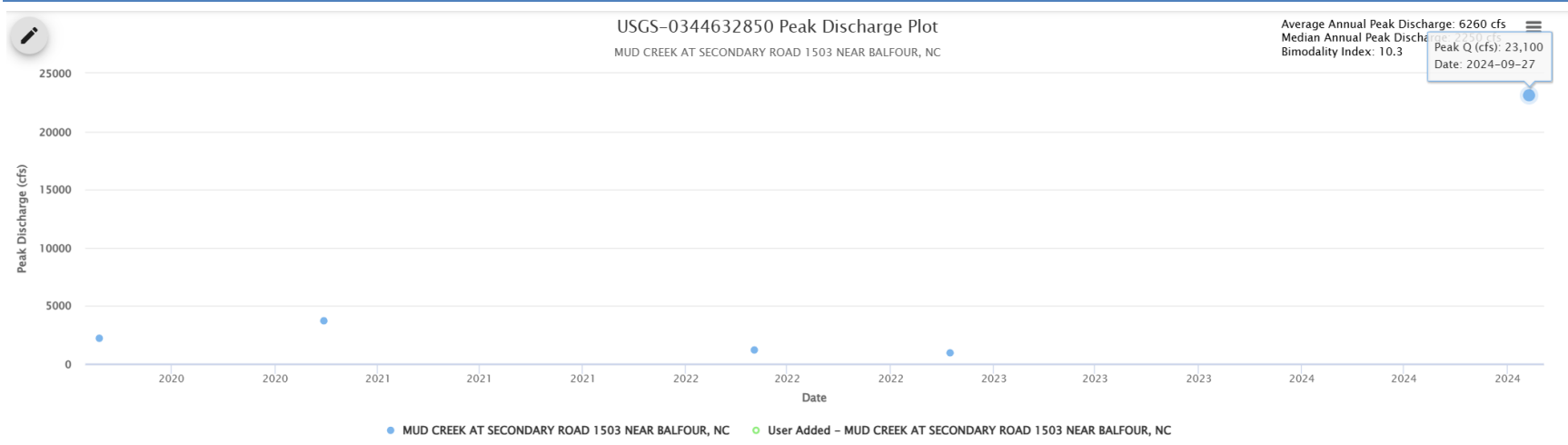
03512000: Oconaluftee River



Return Interval (yr)	Percent Chance of Occurrence	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	20,000	17,700	23,400	21,000	18,500	24,700	17,700	15,600	22,200	20,700	17,700	26,900
200	0.5	18,600	16,500	21,500	19,300	17,100	22,400	16,900	15,200	20,200	19,100	16,700	23,700
100	1	17,400	15,600	19,900	17,900	16,000	20,600	16,200	14,700	18,800	17,800	15,800	21,300
50	2	16,100	14,600	18,300	16,500	14,900	18,800	15,400	14,200	17,400	16,500	14,900	19,100
25	4	14,800	13,500	16,600	15,000	13,700	16,900	14,400	13,400	15,900	15,100	13,700	17,000
10	10	12,900	11,800	14,200	12,900	11,900	14,300	12,900	12,000	13,900	13,000	12,000	14,300
5	20	11,200	10,400	12,200	11,200	10,400	12,200	11,400	10,600	12,200	11,200	10,400	12,200
2	50	8,380	7,820	8,980	8,320	7,770	8,920	8,520	7,830	9,210	8,340	7,720	8,980
1.5	66.7	7,130	6,620	7,650	7,090	6,580	7,600	7,140	6,380	7,770	7,080	6,440	7,640
1.25	80	6,080	5,580	6,550	6,060	5,560	6,530	5,930	4,970	6,530	6,010	5,240	6,530
1.05	95.2	4,300	3,800	4,750	4,350	3,850	4,800	3,900	2,600	4,590	4,270	3,220	4,840

Figure 73: Annual peak discharge data and flood-frequency analysis results for the Oconaluftee River at Birdtown, NC streamgage (USGS ID: 03512000). Helene peak Q: 11,600 cfs. Record peak Q: 15,900 cfs (12/30/1969). Drainage area: 184 mi².

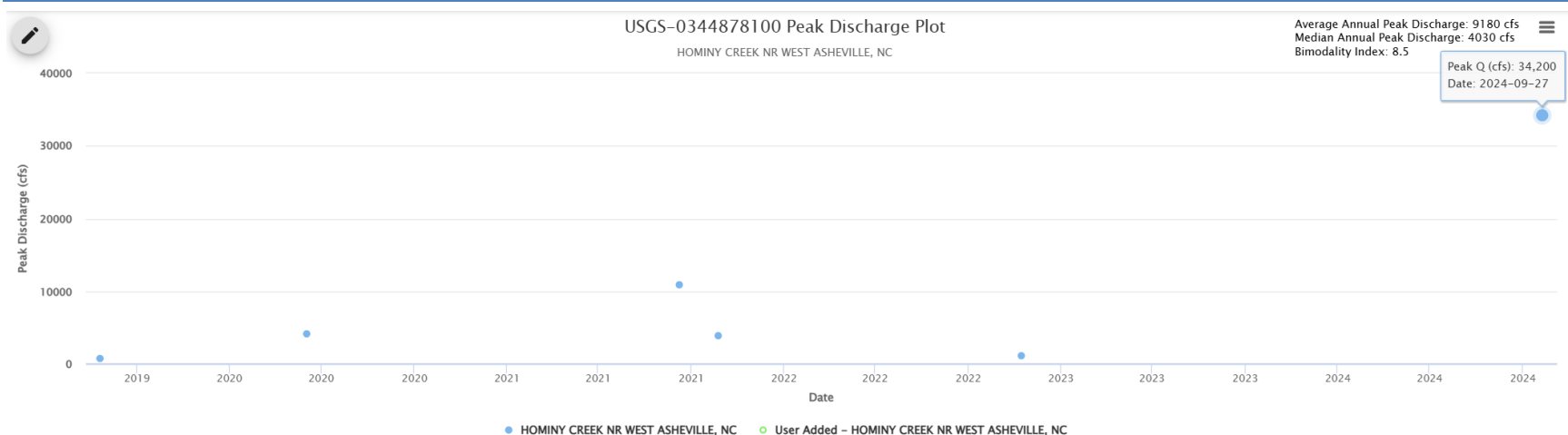
0344632850: Mud Creek



Return Interval (yr)	Percent Chance of Occurrence	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 Upper		Magnitude	Confidence Interval Lower Upper		Magnitude	Confidence Interval Lower Upper		Magnitude	Confidence Interval Lower Upper		
500	0.2	----	----	----	----	----	----	----	----	----	----	----	----	----
200	0.5	----	----	----	----	----	----	----	----	----	----	----	----	----
100	1	----	----	----	----	----	----	----	----	----	----	----	----	----
50	2	----	----	----	----	----	----	----	----	----	----	----	----	----
25	4	----	----	----	----	----	----	----	----	----	----	----	----	----
10	10	----	----	----	----	----	----	----	----	----	----	----	----	----
5	20	----	----	----	----	----	----	----	----	----	----	----	----	----
2	50	----	----	----	----	----	----	----	----	----	----	----	----	----
1.5	66.7	----	----	----	----	----	----	----	----	----	----	----	----	----
1.25	80	----	----	----	----	----	----	----	----	----	----	----	----	----
1.05	95.2	----	----	----	----	----	----	----	----	----	----	----	----	----

Figure 74: Annual peak discharge data and flood-frequency analysis results for the Mud Creek at Secondary Road 1503 near Balfour, NC streamgauge (USGS ID: 0344632850). Helene peak Q: 23,100 cfs, the record peak Q (9/27/2024). Drainage area: 48.7 mi².

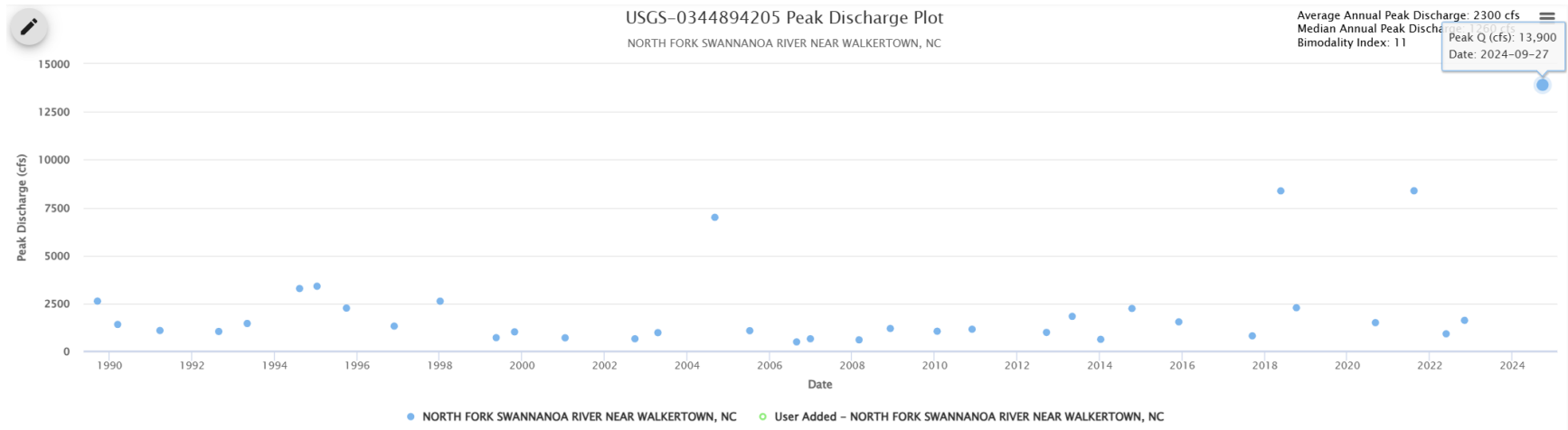
0344878100: Hominy Creek



Return Interval (yr)	Percent Chance of Occurrence	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 Upper		Magnitude	Confidence Interval Lower Upper		Magnitude	Confidence Interval Lower Upper		Magnitude	Confidence Interval Lower Upper		
500	0.2	----	----	----	----	----	----	----	----	----	----	----	----	----
200	0.5	----	----	----	----	----	----	----	----	----	----	----	----	----
100	1	----	----	----	----	----	----	----	----	----	----	----	----	----
50	2	----	----	----	----	----	----	----	----	----	----	----	----	----
25	4	----	----	----	----	----	----	----	----	----	----	----	----	----
10	10	----	----	----	----	----	----	----	----	----	----	----	----	----
5	20	----	----	----	----	----	----	----	----	----	----	----	----	----
2	50	----	----	----	----	----	----	----	----	----	----	----	----	----
1.5	66.7	----	----	----	----	----	----	----	----	----	----	----	----	----
1.25	80	----	----	----	----	----	----	----	----	----	----	----	----	----
1.05	95.2	----	----	----	----	----	----	----	----	----	----	----	----	----

Figure 75: Annual peak discharge data and flood-frequency analysis results for the Hominy Creek near West Ashville, NC streamgage (USGS ID: 0344878100). Helene peak Q: 34,200 cfs, the record peak Q (9/27/2024). Drainage area: 268 mi².

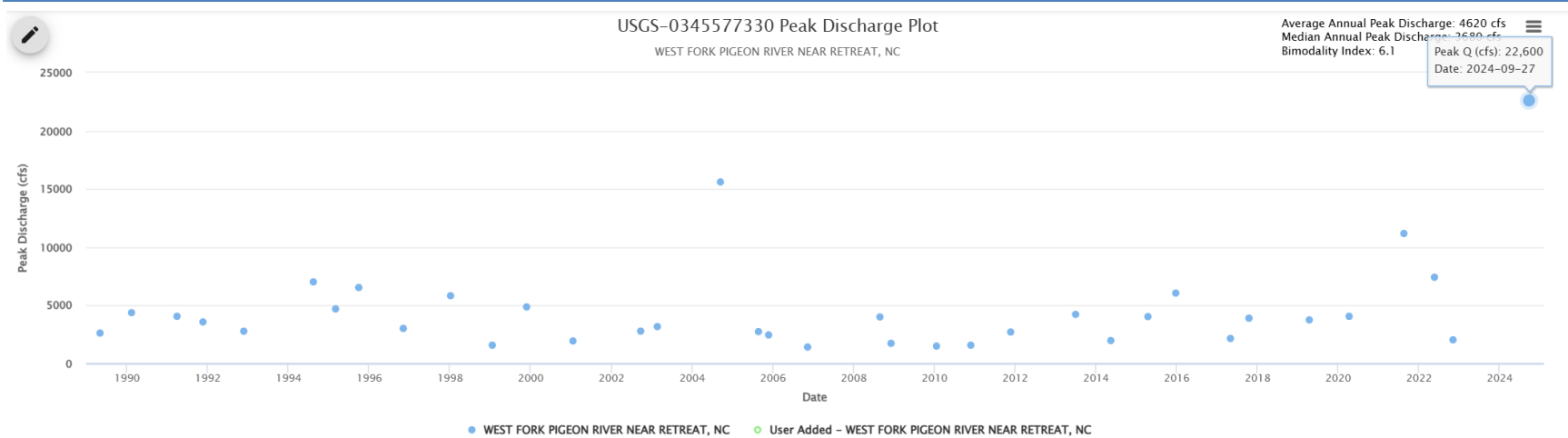
0344894205: North Fork Swannanoa River



Return Interval (yr)	Percent Chance of Occurrence	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	45,900	25,400	109,000	20,700	12,900	40,900	45,900	15,800	1,060,000	21,200	11,900	61,400
200	0.5	27,600	16,500	58,100	15,200	9,920	28,000	27,600	11,500	301,000	15,500	9,350	38,100
100	1	18,600	11,800	35,800	11,900	8,010	20,700	18,600	8,910	121,000	12,000	7,660	26,200
50	2	12,400	8,320	21,800	9,090	6,370	14,900	12,400	6,770	50,400	9,170	6,160	17,800
25	4	8,150	5,790	13,100	6,810	4,960	10,500	8,150	5,020	22,300	6,850	4,830	11,900
10	10	4,540	3,460	6,500	4,420	3,380	6,300	4,540	3,170	8,400	4,430	3,310	6,710
5	20	2,810	2,230	3,720	3,000	2,370	4,000	2,810	2,060	4,290	3,000	2,320	4,150
2	50	1,340	1,060	1,670	1,490	1,190	1,860	1,340	1,030	1,760	1,480	1,180	1,880
1.5	66.7	995	767	1,250	1,060	827	1,330	991	809	1,260	1,060	839	1,330
1.25	80	782	584	991	779	581	987	782	653	953	778	602	976
1.05	95.2	549	387	717	434	292	581	554	417	707	444	307	576

Figure 76: Annual peak discharge data and flood-frequency analysis results for the N.F. Swannanoa River near Walkertown, NC streamgauge (USGS ID: 0344894205). Helene peak Q: 13,900 cfs, the record peak Q (9/27/2024). Drainage area: 14.7 mi².

0345577330: W.F. Pigeon River



Return Interval (yr)	Percent Chance of Occurrence	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	Lower	Upper	Lower	Upper	
500	0.2	45,600	29,200	87,100	28,300	19,500	48,300	45,600	22,200	428,000	28,700	18,300	66,000
200	0.5	31,800	21,500	55,800	22,200	15,800	35,900	31,800	17,400	196,000	22,500	15,100	45,500
100	1	24,000	16,900	39,500	18,300	13,400	28,300	24,000	14,300	103,000	18,400	12,900	33,900
50	2	17,900	13,200	27,700	14,800	11,200	22,000	17,900	11,600	52,800	14,900	10,900	25,100
25	4	13,200	10,100	19,100	11,800	9,180	16,700	13,200	9,260	28,400	11,900	8,990	18,300
10	10	8,570	6,910	11,400	8,400	6,790	11,100	8,570	6,530	13,600	8,410	6,680	11,600
5	20	5,970	4,960	7,470	6,180	5,130	7,770	5,970	4,700	8,190	6,180	5,050	7,980
2	50	3,330	2,770	3,960	3,550	2,970	4,240	3,330	2,710	4,100	3,540	2,960	4,280
1.5	66.7	2,610	2,120	3,110	2,720	2,230	3,240	2,600	2,200	3,140	2,710	2,250	3,240
1.25	80	2,120	1,680	2,560	2,120	1,680	2,560	2,120	1,810	2,510	2,120	1,730	2,540
1.05	95.2	1,530	1,150	1,900	1,330	973	1,680	1,540	1,220	1,860	1,350	1,010	1,670

Figure 77: Annual peak discharge data and flood-frequency analysis results for the West Fork Pigeon River near Retreat, NC streamgage (USGS ID: 0345577330). Helene peak Q: 22,600 cfs, the record peak Q (9/27/2024). Drainage area: 33.2 mi².

Appendix B: Utilized Flood Potential Indices

Indices are used as key metrics that describe how floods vary between zones (Table 1). The flood potential index (P_f) ranks and compares experienced flood magnitudes between zones. Higher values indicate higher flood potential. This index is defined as:

$$P_f = \frac{\left(\frac{Q_a}{Q_{a,zone2}} + \frac{Q_b}{Q_{b,zone2}} + \frac{Q_c}{Q_{c,zone2}} \right)}{3}$$

where $a = 20 \text{ km}^2$, $b = 200 \text{ km}^2$, $c = 2000 \text{ km}^2$ and $Q_{20,zone2} = 4.15 \text{ m}^3/\text{s}$, $Q_{200,zone2} = 21.0 \text{ m}^3/\text{s}$, and $Q_{2000,zone2} = 106 \text{ m}^3/\text{s}$. Where the largest watershed size within a zone is $<1100 \text{ km}^2$, the Q_c term is assumed to be excessively extrapolated and dropped, with the utilized equation becoming:

$$P_f = \frac{\left(\frac{Q_a}{Q_{a,zone2}} + \frac{Q_b}{Q_{b,zone2}} \right)}{2}$$

The watershed scale ratio (R_f) quantifies the slope of the flood potential curve, with lesser values indicating that smaller watersheds experience relatively large flood magnitudes and greater values indicating that larger watersheds experience relatively large flood magnitudes. This index is defined as:

$$R_f = \frac{Q_c}{Q_{c,zone2}} / \frac{Q_a}{Q_{a,zone2}}$$

Flashiness is a measure of the frequency and rapidity of short-term changes in streamflow. A flashy stream responds to precipitation by rising and falling quickly. The two utilized indices are Beard F index (Beard, 1975) and the Richards-Baker index (Baker et al., 2004). The Beard F equation is:

$$F = \left[\frac{\sum (X_m - M)^2}{N - 1} \right]^{1/2}$$

where X_m is the natural logarithm of the annual maximum flood, M is the logarithm of the mean annual maximum flood, and N is the number of annual events. This index is the standard deviation of the natural logarithms of the annual peak flows at each streamgage; the Beard index quantifies flashiness using variability in annual peak discharges. The Richards-Baker Flashiness Index (*R-B Index*; Baker et al., 2004) is:

$$R - B \text{ Index} = \frac{\sum_{i=1}^n |q_i - q_{i-1}|}{\sum_{i=1}^n q_i}$$

where q is the mean daily discharge. The R-B Index quantifies flashiness using variability in daily average discharges. The R-B flashiness index is unitless and its value is independent of the units chosen to represent flow. Values can range from zero to two, with zero meaning the streamflow was constant. Streamgages must have at least 30 years of daily data.

The flood variability index (V_f) is computed as a ratio of the intercepts for the regressions for the maximum likely flood potential and the expected flood potential, specifically:

$$V_f = a_{mlf} / a_{efp}$$

where a is the intercept term in the single-predictor regression equation $Q = aA^b$, for each zone.

The flood extreme index (E_f) ranks flood magnitudes and extremity, with higher values indicating larger or more extreme events, and values less than 1 indicating a flood is less than the expected flood potential discharge. E_f is used for quantifying flood severity (Table 3) and extremity (Figure 12), and is used in the Flood Severity Scale. This index is:

$$E_f = Q / Q_{efp}$$

The bimodality index (B_i) is the ratio of the largest measured annual peak discharge to the typical (median) annual peak discharge. Averages of each of these streamgage index values are made for each zone. Higher zone average B_i indicate that the largest floods are much larger than more typical flood magnitudes, due to different flood-producing meteorologic and hydrologic mechanisms. The bimodality index is computed as:

$$B_i = Q_{max} / Q_{median}$$

where Q is the streamgage annual peak discharges.