



Memo

Project: SCDOT CLRB 2022-1

Subject: Preliminary Hydraulic Analysis

Route: S.C. Route 183 (Walhalla Hwy.) Bridge over Twelvemile Creek (Asset ID 00574)

Date: Tuesday, November 22, 2022

To: SCDOT

HDR is providing preliminary hydrologic and hydraulic assessment of the Twelvemile Creek Bridge Replacement along S.C. Route 183 (Walhalla Hwy.) in Pickens County, South Carolina. S.C. Route 183 in the vicinity of Twelvemile Creek is designated as a Primary Route and provides access to residential and commercial businesses. The Flood Insurance Study (FIS) for Pickens County and Flood Insurance Rate Map (FIRM) Panel No. 45077C0165E indicate the project is located within a Special Flood Hazard Area Zone AE.

Model Setup:

SCDOT requested the effective FEMA modeling and was provided a HEC-RAS model that included Twelvemile Creek from approximately 3.7 miles downstream to 9.5 miles upstream of the project area. The effective FEMA modeling was the basis for this study.

The study (effective model) included one geometry file including the existing S.C. Route 183 bridge. The effective model also included two (2) flow files including a multi-profile file consisting of the 10-, 25-, 50-, 100-, and 500-year events for various locations along the stream reach and a floodway flow profile. The FEMA effective multi-profile flows in the vicinity of the project (RS19930.32) are shown in Table 1.

Table 1: FEMA Effective Flows

River Station	10-Year (10% AEP)	25-Year (4% AEP)	50-Year (2% AEP)	100-Year (1% AEP)	500-Year (0.2% AEP)
32969.85	3578	4659	5589	6459	8587
31245.50	3645	4744	5690	6574	8736
29060.25	3711	4828	5791	6689	8886
24419.09	3764	4895	5872	6780	9005
22405.28	4650	6019	7212	8300	10979
19421.91	4705	6088	7294	8394	11101
14125.66	5063	6541	7834	9006	11893
8301.730	5081	6564	7861	9036	11933
5628.286	5871	7562	9048	10379	13670
1695.569	5904	7604	9097	10436	13742

Based on the FIS the effective flows were initially developed using the 2006 South Carolina Rural Regression Equations for various locations along Twelvemile Creek with an approximate drainage area of 52.3 square miles at the project site. The USGS StreamStats web application was used to approximate the 10, 25-, 50, 100, and 500-year storm events at the project site and multiple locations throughout the reach. The drainage area and basin characteristics were also reviewed with current



publicly available LiDAR and aerial imaging. The USGS StreamStats method was used for comparison of the watershed flows. Table 2 shows the comparison of project flows.

Table 2: Comparison of Project Flows

Design Event (% AEP)	FEMA Effective Model RS 19421.91 (cfs)	USGS StreamStats (cfs)
10 YR (10% AEP)	4705	4650
25 YR (4% AEP)	6088	6020
50 YR (2% AEP)	7294	7220
100 YR (1% AEP)	8394	8310
500 YR (0.2% AEP)	11101	11000

The USGS flows are generally consistent (+/- 2%) with the effective flows. The effective FEMA flows were used for this analysis.

Corrected Effective Model:

The Corrected Effective model was built using HEC-RAS v6.1 to update the effective model. A summary of the revisions is listed below.

- RS 19771 was added to the model to accommodate the downstream realignment.
- RS 19880.48 was removed to accommodate the downstream realignment.
- Existing channel geometry at RS 19986.16 and RS 20101.98 was updated based on project surveys
- The S.C. Route 183 bridge was updated based on the project surveys to reflect the current bridge geometry.
- Existing bridge at RS 19930.32 was updated based on project surveys. The existing bridge consists of 10 spans @ 25-ft for a total length of 250-ft. The existing bridge low chord was estimated as elevation 900.28 based on the project surveys and estimated bridge deck depth of 2-ft 3-inches.
- Contraction and expansion coefficients in the vicinity of the bridge were revised to 0.3 and 0.5 respectively.

The effective model extends approximately 3.75 miles downstream and approximately 9.5 miles upstream of S.C. Route 183. Due to the downstream length of the model a sensitivity analysis was not completed on the natural conditions model to verify the extents of the model. Any fluctuations in the downstream boundary condition will have no effect on the water surface elevations at the project site. There are no other hydraulic structures that would impact flow conditions at the project site. No additional hydraulic structures were added to the model.

The Manning's roughness values from the effective model were reviewed and are consistent with conditions along the project.

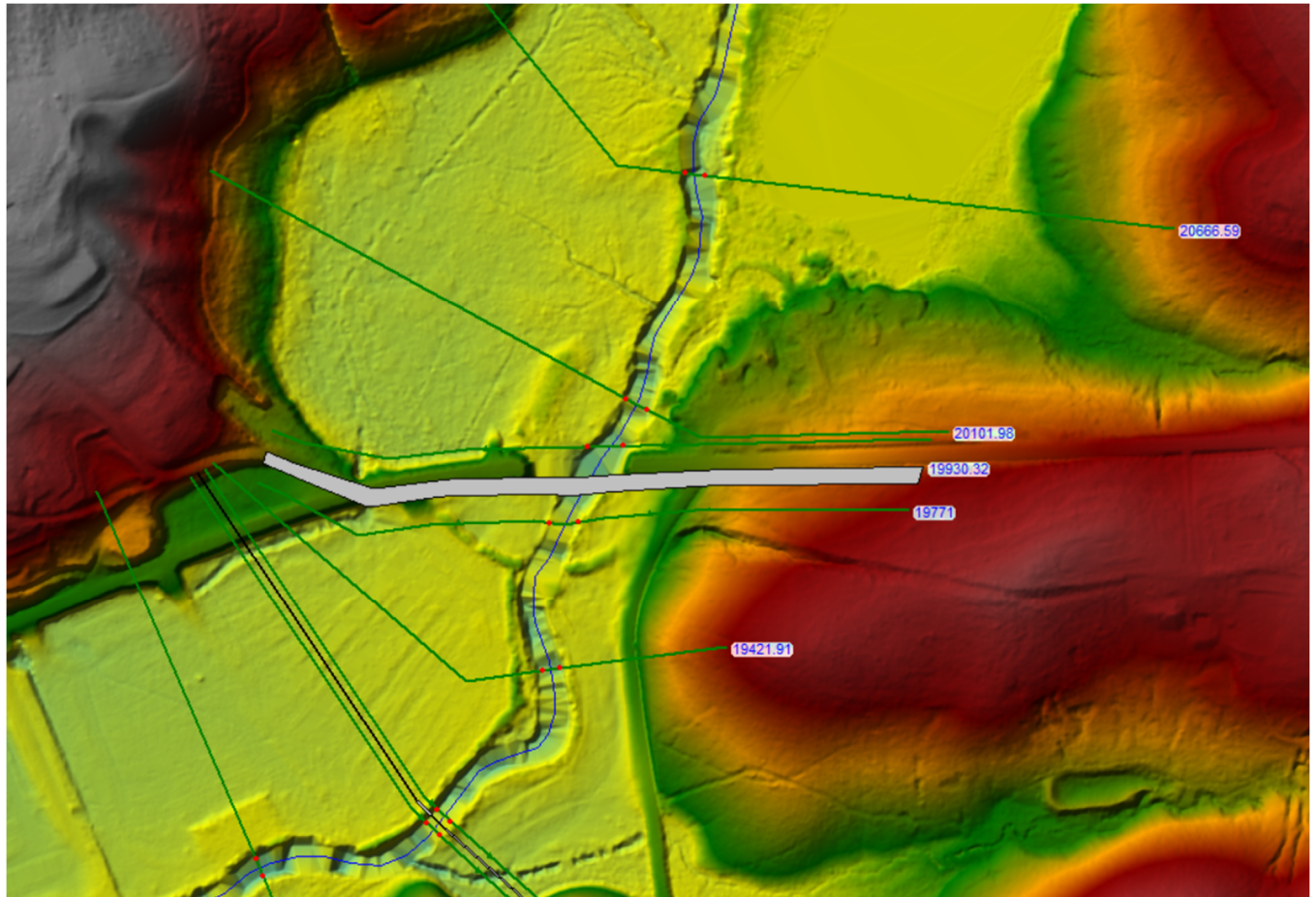


Figure 1: Twelvemile Creek Model Layout (S.C. Route 183)

Design Criteria:

S.C. Route 183. is classified as a primary route. Primary route crossings should be designed based on the 50-year design event as indicated in the *SCDOT Requirements for Hydraulic Design Studies*. Based on the Flood Insurance Study (FIS) for Chester County and Flood Insurance Rate Map (FIRM) Panel No. 45077C0165E the project is located within a Special Flood Hazard Area Zone AE with an established floodway. As such the bridge will be designed based on the following criteria:

1. The minimum low chord elevation shall be the 50-year (2% AEP) water surface elevation plus 2-ft of freeboard.
2. The 100-year (1% AEP) should not overtop, while maintaining free-surface flow.
3. The backwater for the 100-year (1% AEP) design event is one (1) foot or less when compared to the unrestricted or natural conditions.
4. The proposed bridge should not create more backwater than the existing bridge.

Additionally, for a finding of “No-Impact” there must be no increase in the 1% AEP flood and floodway profiles and there is no increase in floodway width in published and unpublished sections.



Existing Bridge Analysis:

The existing bridge consists of 10 spans @ 25-ft for a total length of 250-ft supported on 12-inch timber piles. The existing channel in the vicinity of the bridge is uniform, approximately 50 feet in width, and stable outside of the bridge. Ineffective flows upstream and downstream of the proposed bridge were set based on assumed 1:1 expansion and 1:1 contraction ratio. Sloping abutments were included in the existing bridge model based on project surveys.

The existing water surface elevations are presented in Tables 3 and 4.

Preliminary Bridge Analysis:

A three-span bridge with a 50-ft span, 140-ft main channel span, and 100-ft span for a total length of 290-ft with a width of 46.25-ft was assumed for the preliminary analysis. The existing low chord of 900.28 was maintained for the preliminary bridge. The bridge spans are supported on 4-ft diameter piers. The proposed bridge was relocated downstream of the existing bridge on a new roadway alignment.

Ineffective flows upstream and downstream of the proposed bridge were set based at 1:1 expansion and 1:1 contraction ratios and sloping abutments were added

The table below shows the resulting water surface elevations in the project area for the existing and preliminary bridge for the 50-year (2% AEP) event.

Table 3: 50-Year Design Event Water Surface Elevations

50-Year (2% AEP) Design Event			
RS	Existing 250' Bridge WSE (ft)	Preliminary 290' Bridge WSE (ft)	Difference (ft)
18956.20	892.05	892.05	0.00
19421.91	892.55	892.55	0.00
19771	892.94	892.94	0.00
19930.32	S.C. Route 183		
19986.16	893.39	893.19	-0.20
20101.98	894.16	893.95	-0.21
20666.59	894.39	894.20	-0.19
21211.30	894.84	894.70	-0.14
21759.82	895.18	895.07	-0.11
22405.28	895.69	895.61	-0.08
23164.62	896.46	896.41	-0.05
23733.89	896.88	896.84	-0.04
24419.09	898.78	898.78	0.00

The resulting water surface elevation upstream of the bridge was used to check the required minimum bridge low chord elevation for the preliminary bridge vs the existing low chord elevation.

$$\text{Min. Low Chord (proposed)} = 893.19 + 2.0\text{-ft freeboard} = 895.19 < \text{existing low chord of } 900.28$$

The resulting required bridge low chord is less than the existing bridge low chord therefore the preliminary bridge satisfies the low chord criteria. It is recommended that the existing bridge low chord be maintained.



In addition to the freeboard requirement, the *SCDOT Requirements for Hydraulic Design Studies*, states that the proposed bridge must not be subject to pressurized flow for the 100-year design event and produce less than 1' of backwater over natural conditions. The resulting water surface elevations along the stream are presented below.

Table 4: 100 Year (1% AEP) Design Event Water Surface Elevations

100-Year (1% AEP) Design Event					
RS	Natural WSE (ft)	Existing 250' Bridge WSE (ft)	Existing Backwater (ft)	Proposed 290' Bridge WSE (ft)	Proposed Backwater (ft)
18956.20	892.55	892.86	+0.31	892.86	+0.31
19421.91	892.95	893.26	+0.31	893.26	+0.31
19771	893.34	893.59	+0.25	893.59	+0.25
19930.32	S.C. Route 183				
19986.16	893.31	893.99	+0.58	893.77	+0.46
20101.98	893.72	894.91	+1.29	894.69	+0.97
20666.59	894.12	895.15	+1.13	894.95	+0.83
21211.30	894.67	895.54	+0.87	895.38	+0.71
21759.82	895.17	895.85	+0.68	895.72	+0.55
22405.28	895.84	896.32	+0.48	896.22	+0.38
23164.62	896.76	897.06	+0.30	897.00	+0.24
23733.89	897.20	897.46	+0.26	897.42	+0.22
24419.09	899.24	899.26	+0.02	899.25	+0.01

Table 5: Design Criteria Summary

Design Criteria Summary (WSEs at RS 19986.16)							
Prelim. Bridge (2% AEP) WSE (ft)	Minimum Required Freeboard (ft)	Prelim. Bridge Min. Low Chord (ft)	Existing Low Chord Elevation (ft)	Prelim. Bridge (1% AEP) WSE (ft)	Proposed (1% AEP) Backwater (ft)	Existing (1% AEP) Backwater (ft)	500-Year (0.2% AEP) WSE Check (ft)
893.19	2.0	895.19	900.28	893.77	+0.97 (RS 20101.98)	+1.26 (RS 20101.98)	895.44 < LC

The preliminary bridge configuration meets all SCDOT design criteria for freeboard and backwater.

A floodway analysis was completed to determine if the proposed design supports a finding of "No-Impact". Based on the *SCDOT's HDB 2019-4*, a project is considered to have no impact if there is no increase in the 1% AEP flood and floodway profiles and there is no increase in floodway width at published and unpublished cross sections. Existing floodway widths were maintained for the proposed conditions and encroachment stations were estimated at RS 19771 based on the effective floodplain mapping. The resulting water surface elevations are presented in Table 6.

The proposed design maintains the effective floodplain widths and results in reduced water surface profiles for both the 1% AEP and the floodway profiles when compared to the existing conditions. The information in Table 6 supports the finding of "No-Impact" for the project.

Table 6: FEMA Floodway Comparison

RS	Corrected Effective w/o Floodway WSE (ft)	Corrected Effective with Floodway WSE (ft)	Corrected Effective Increased	Proposed w/o Floodway WSE (ft)	Proposed With Floodway WSE (ft)	Proposed Increase	Pro-Cor Floodway Profile Difference (ft)
18956.20	892.9	893.8	0.9	892.9	893.8	0.9	0.0
19421.91 (P)	893.3	894.2	0.9	893.3	894.2	0.9	0.0
19771	893.6	894.5	0.9	893.6	894.5	0.9	0.0
19930.32							
19986.16	894.0	894.7	0.7	893.7	894.6	0.9	-0.1
20101.98 (Q)	894.9	895.2	0.3	894.7	895.1	0.4	-0.1
20666.59	895.2	895.8	0.6	895.0	895.7	0.7	-0.1
21211.30	895.5	896.3	0.8	895.4	896.2	0.8	-0.1
21759.82 (R)	895.9	896.7	0.8	895.7	896.6	0.9	-0.1
22405.28	896.3	897.2	0.9	896.2	897.2	1.0	0.0
23164.62 (S)	897.1	897.9	0.8	897.0	897.9	0.9	0.0
23733.89	897.5	898.4	0.9	897.4	898.3	0.9	-0.1
24419.09	899.3	900.1	0.8	899.3	900.0	0.7	-0.1

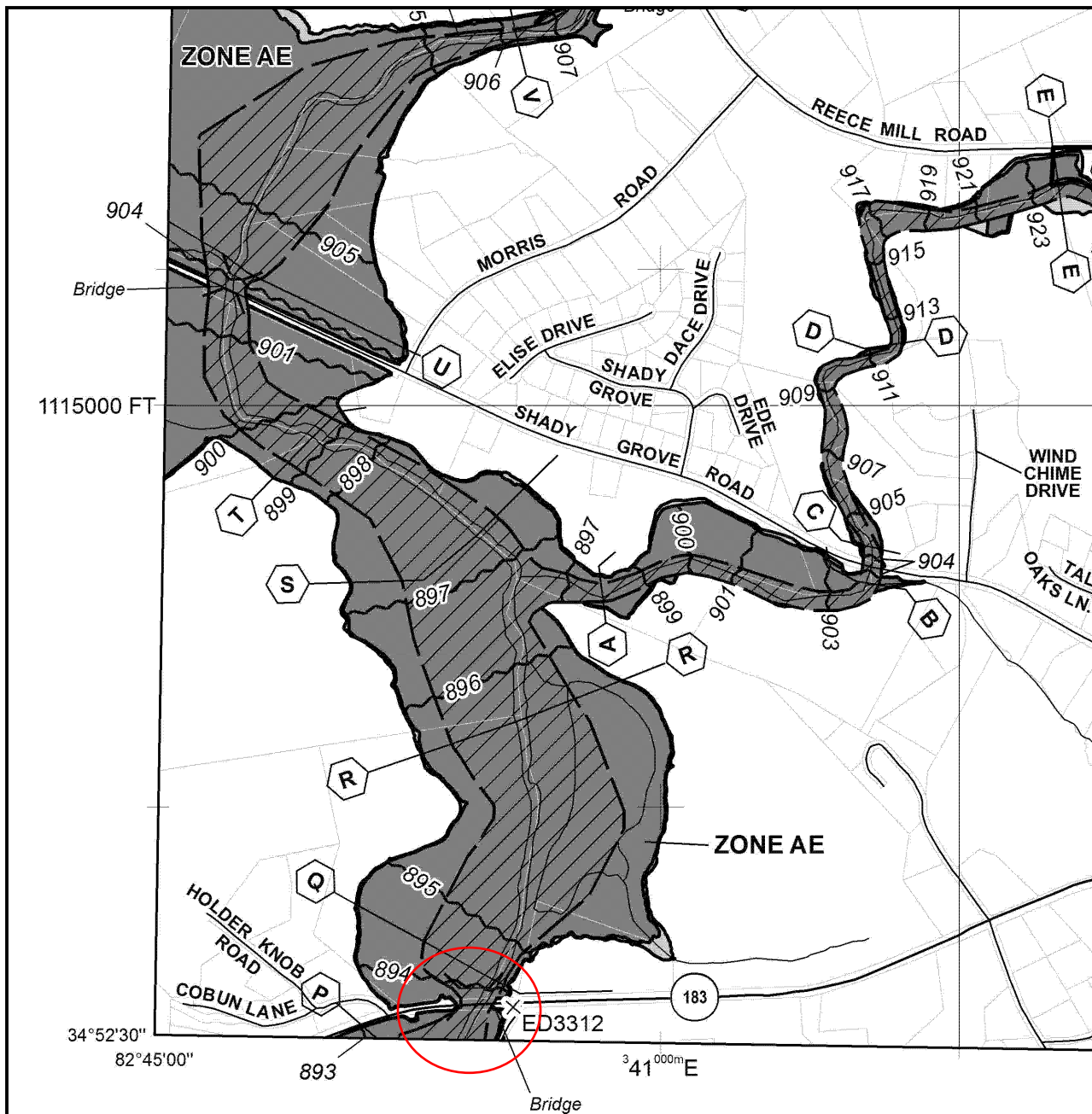
Design Considerations:

Field reviews of the existing bridge indicate very large trees and debris collecting on the existing bridge, proposed span lengths should allow for large debris to easily pass under the bridge.

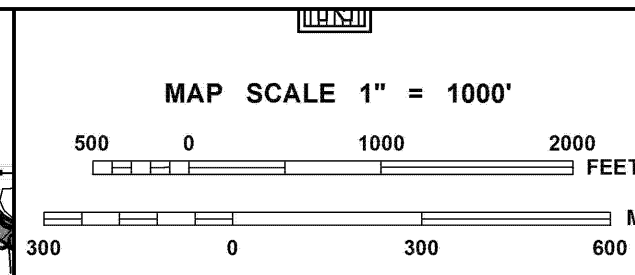




Existing velocities within the entire bridge section are approximately 5.8 fps. The proposed bridge reduces flow velocities slightly to approximately 5.4 fps within the bridge; rip rap abutment protection is recommended for the final design. Contraction scour was estimated to be in the range of 7-ft to 9-ft based on the *South Carolina Bridge Scour Envelope Curves Template, 2016* with total scour less than 15-ft.



Project Location (Asset ID: 00574)



NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0165E

FIRM

FLOOD INSURANCE RATE MAP

**PICKENS COUNTY,
SOUTH CAROLINA
AND INCORPORATED AREAS**

PANEL 165 OF 430

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
PICKENS, CITY OF	450169	0165	E
PICKENS COUNTY	450166	0165	E

Notice to User: The Map Number shown below should be used when placing map orders; the Community Number shown above should be used on insurance applications for the subject community.



**MAP NUMBER
45077C0165E**

**MAP REVISED
DECEMBER 21, 2017**

Federal Emergency Management Agency

This is an official FIRMette showing a portion of the above-referenced flood map created from the MSC FIRMette Web tool. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For additional information about how to make sure the map is current, please see the Flood Hazard Mapping Updates Overview Fact Sheet available on the FEMA Flood Map Service Center home page at <https://msc.fema.gov>.