



Memo

Project: SCDOT CLRB 2022-1

Subject: Preliminary Hydraulic Analysis

Route: S.C. Route 183 (Walhalla Hwy.) Bridge over Gregory Creek (Asset ID 00573)

Date: Tuesday, November 22, 2022

To: SCDOT

HDR is providing preliminary hydrologic and hydraulic assessment of the Gregory Creek Bridge Replacement along S.C. Route 183 (Walhalla Hwy.) in Pickens County, South Carolina. S.C. Route 183 in the vicinity of Gregory 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. 45077C026E indicate the project is located within a Special Flood Hazard Area Zone AE without an established floodway.

Model Setup:

SCDOT requested the effective FEMA modeling and was provided a HEC-RAS model that included Gregory Creek from approximately 2,000 feet downstream to 1,000 feet 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 one flow file including a single 100-year single profile. Based on the FIS the effective flows were initially developed using the 2006 South Carolina Rural Regression Equations. The USGS StreamStats application was used to estimate the 10-, 25-, 50-, 100- and 500-year events for the analysis with an approximate drainage area of 5.3 square miles. The drainage area and basin characteristics were also reviewed with current publicly available LiDAR and aerial imaging. The SCS Unit Hydrograph method was used for comparison of the watershed flows. Table 2 shows the comparison of project flows.

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Table 1: Comparison of Project Flows

Design Event (% AEP)	SCS Unit Hydrograph (cfs)	FEMA Effective (cfs)	USGS StreamStats (cfs)
10 YR (10% AEP)	430	-	1120
25 YR (4% AEP)	533	-	1480
50 YR (2% AEP)	620	-	1810
100 YR (1% AEP)	714	1552	2100
500 YR (0.2% AEP)	-	-	2850

The USGS flows were used for determining the minimum low chord elevation, water surface elevations and required bridge length for the proposed bridge. The FEMA flows were used for determining if a finding of “No-Impact” is feasible.



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.

- Cross section 0 and 593 were added based on an initial sensitivity analysis to mitigate differing water surface elevations at the project site by with differing downstream boundary conditions.
- Cross section data for RS 1415, 1522, 2000, 2573, 2953, and 3500 were updated based on project surveys.
- RS 3074 was removed to accommodate the proposed upstream realignment.
- RS 3100 was added based on project surveys to accommodate the proposed upstream realignment.
- Manning's roughness coefficients for the overbanks at RS 1000, RS 1415, RS 2953, & RS 4000 were revised from 10 to 0.10 for consistency with published roughness values. Channel and overbank areas adjacent to the channel were reviewed and are consistent with field conditions.
- Deck/Roadway information was updated to reflect the survey data.
- Flow data for the 10-, 25-, 50-, 100-, and 500-year events was added for comparison with the proposed bridge design.
- The minimum bridge low chord was revised to 895.50 to reflect the survey data and existing plans.

A sensitivity analysis was completed on the natural conditions model to verify the extents of the model. The analysis was performed by revising the downstream boundary conditions +/- 3-ft and comparing the resulting water surface elevations near the bridge location. The results of the sensitivity analysis are shown below.

Table 2: Sensitivity Analysis

100-Year (1% AEP) Water Surface Elevations – Sensitivity Analysis			
RS	Natural WSE (ft)	+3-ft WSE (ft)	-3-ft WSE (ft)
0	876.87	879.87	875.68*
593	879.59	880.68	879.75
1000	880.94	881.32	880.93
1415	883.56	883.33	883.49
1522	884.65	884.46	884.56
2000	886.41	886.31	886.34
2573	887.42	887.36	887.37
2953	888.44	888.39	888.39
3130	889.53	889.48	889.48
3500	891.03	890.99	890.99
4000	891.72	891.68	891.68

*WSE defaulted to Critical WS

The sensitivity analysis indicates that the model has sufficient downstream length to mitigate any effects of fluctuations in the downstream boundary condition.

The effective model includes the Winchester Mill Rd. bridge crossing approximately 1,500 feet downstream of the project. No other hydraulic structures were included in the model.

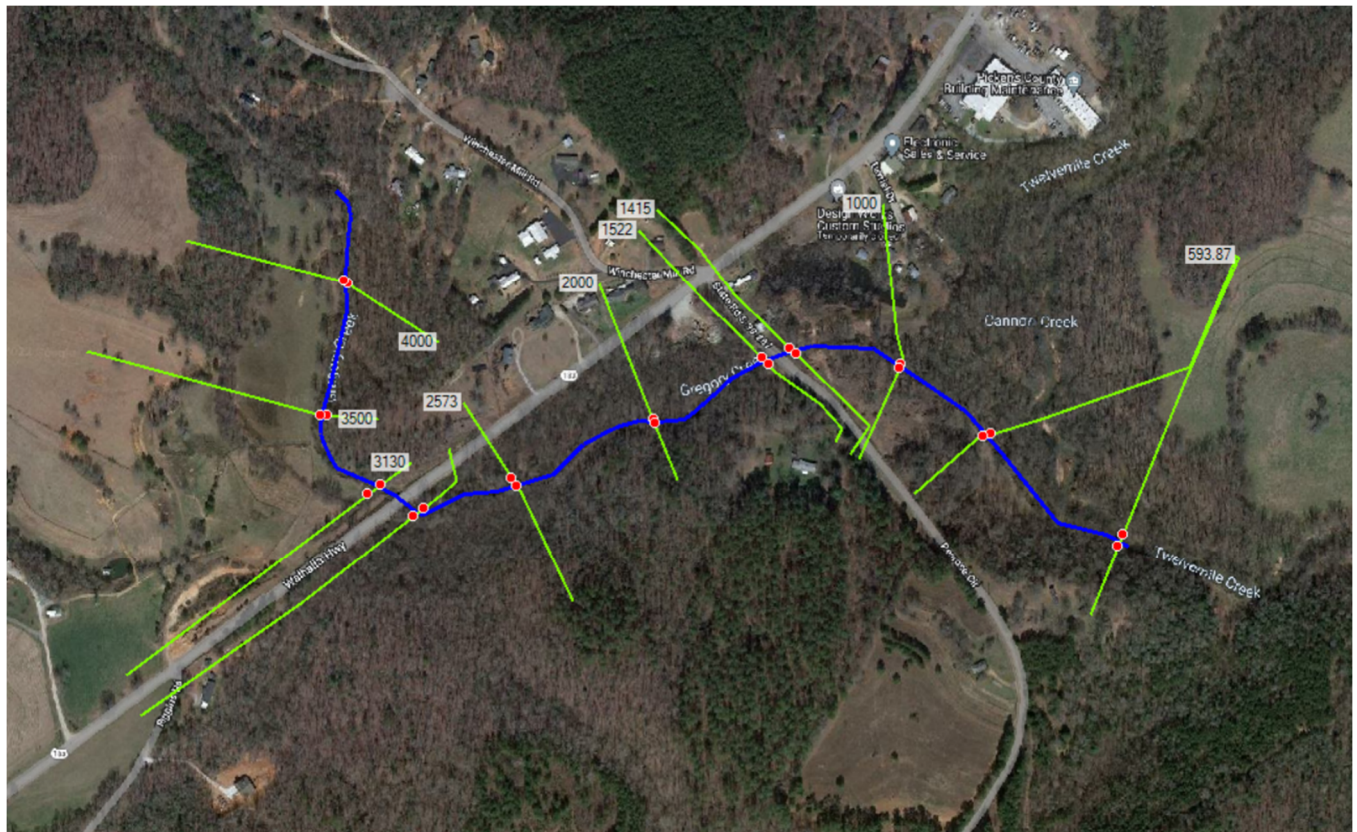


Figure 1: Gregory Creek Model Layout (SC-183, Walhalla Hwy)

Design Criteria:

Walhalla Hwy. is classified as a primary route. Primary route stream 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 Pickens County and Flood Insurance Rate Map (FIRM) Panel No. 45077C0260E the project is located within a Special Flood Hazard Area Zone AE. 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 or existing low chord, whichever is higher.
2. The 100-year (1% AEP) should not overtop, while maintaining free-surface flow.
3. The proposed bridge should not create more backwater than the existing bridge.

Existing Bridge Analysis:

The existing bridge consists of 3 spans (3 @ 25-ft 6-in) for a total length of 76-ft with a superstructure depth of approximately 28" resulting in a low chord elevation of 895.50. The existing channel in the vicinity of the bridge is uniform, 12 feet in width, with a gravel/cobble bottom. 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. One foot diameter timber piles were included based on project surveys.



Figure 2: Gregory Creek (Looking Upstream)

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

Preliminary Bridge Analysis:

A two-span bridge, 1 span @ 85-ft and 1 span @ 65-ft for a total length of 150-ft with a total width of 46.25-ft at a 25-degree skew was assumed for the preliminary analysis. The spans are supported on one pier having columns with a 4-ft diameter.

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: Preliminary Bridge Analysis – 150' Bridge (USGS Flows)**

RS	2% AEP Water Surface Elevations (ft)	1% AEP Water Surface Elevations (ft)
0	877.29	877.73
593	880.14	880.72
1000	881.64	882.08
1415	883.95	884.29
1485	Winchester Mill Rd	
1522	885.94	886.55
2000	887.53	888.21
2573	888.21	888.80
2953	888.99	889.47
3030	S.C. Route 183 (Walhalla Hwy)	
3130	890.95	891.43
3500	891.81	892.26
4000	892.31	892.73

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.

Min. Low Chord (proposed) = 890.95 + 2.0-ft freeboard = 892.95 < existing low chord of 895.50

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. The preliminary bridge geometry also satisfies the requirement that the proposed bridge must not be subject to pressurized flow for the 100-year design event.

Table 4: Backwater Comparison

100-Year (1% AEP) Backwater Comparison (USGS Flows)					
RS	Natural WSE (ft)	Existing 76' Bridge WSE (ft)	Existing Backwater (ft)	Proposed 150' Bridge WSE (ft)	Proposed Backwater (ft)
0	877.73	877.73	0.00	877.73	0.00
593	880.72	880.72	0.00	880.72	0.00
1000	881.85	882.08	0.00	882.08	0.00
1415	884.20	884.29	+0.09	884.29	+0.09
1485	Winchester Mill Rd				
1522	885.84	886.55	+0.71	886.55	+0.71
2000	887.48	888.21	+0.73	888.21	+0.73
2573	888.36	888.80	+0.44	888.80	+0.44
2953	889.21	889.46	+0.25	889.47	+0.25
3030	S.C. Route 183 (Walhalla Hwy)				
3130	890.34	891.66	+1.32	891.43	+1.09
3500	891.74	892.44	+0.70	892.26	+0.52
4000	892.41	892.85	+0.44	892.73	+0.32

Table 4 above shows that the proposed 150-ft bridge produces 1.09-ft of backwater over the natural unrestricted conditions and reduces backwater from the existing conditions.



Table 5: Comparison of 1% AEP Water Surface Elevations (FEMA Flows)

RS	Corrected Effective 76' Bridge WSE (ft)	Proposed 150' Bridge WSE (ft)	Difference (ft)
0	876.87	876.87	0.00
593	879.59	879.59	0.00
1000	881.19	881.19	0.00
1415	883.55	883.55	0.00
1485	Winchester Mill Rd		
1522	885.29	885.29	0.00
2000	886.86	886.86	0.00
2573	887.65	887.65	0.00
2953	888.57	888.57	0.00
3030	S.C. Route 183 (Walhalla Hwy)		
3130	890.66	890.50	-0.16
3500	891.50	891.39	-0.11
4000	891.97	891.91	-0.06

Table 6: Design Criteria Summary

Design Criteria Summary (WSEs at RS 3130)							
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)
890.95	2.0	892.95	895.50	891.44	+1.09	+1.32	892.57 < LC

The preliminary bridge configuration meets all SCDOT design criteria for FEMA streams and the results support a finding of “No-Impact” in accordance with the *SCDOT Requirements for Hydraulic Design Studies and HDB 2019-4*. The proposed design should maintain the existing bridge low chord elevation.

Design Considerations:

Field reviews of the existing bridge indicate little scour in the overbank areas of the bridge. Both abutments are protected with rip rap and are in good condition. Existing velocities within the entire bridge section are approximately 6.4 fps (1% AEP). The proposed bridge reduces flow velocities slightly to approximately 3.1 fps (1% AEP) within the bridge; however, rip rap abutment protection is recommended for the final design.