**PI NO. 0013997 MADISON COUNTY**

**SR 281 OVER BROAD RIVER**

**HYDRAULIC AND HYDROLOGICAL STUDY**

EXAMINED AND APPROVED:

Oct. 26, 2018
DATE

WILLIAM M. DUVALL, P.E.

STATE BRIDGE ENGINEER

____FEMA and Community Coordination Required
____Community Coordination Only Required
_X_No FEMA or Community Coordination Required

PI NO. 0013997 MADISON COUNTY

SR 281 OVER BROAD RIVER

HYDRAULIC AND HYDROLOGICAL STUDY

This project involves the replacement of the existing 390 ft long by 23.75 ft wide (gutter to gutter) reinforced concrete deck girder bridge at the crossing of SR 281 over Broad River. The proposed structure is to be a 430 ft long by 40 ft wide (gutter to gutter) PSC beam bridge with stub abutments and is to be located along the existing alignment. The bents of the proposed bridge are to be built at 90 degrees to the roadway centerline to align with the flood flow. The bents of the existing bridge are at 90 degrees to the roadway centerline. The drainage area of 651 sq mi was obtained from the USGS StreamStats website. The hydraulic slope of 5.96 ft/mi was obtained from the USGS Quad maps for this area.

The bridge width of 40 ft was obtained from Policy 4265-10 for a State Route with over 2000 vpd traffic. The proposed typical section has two 12 ft travel lanes with 8 ft shoulders which results in an out to out bridge width of 43.25 ft to accommodate barriers on both sides. The design year ADT is 2525 vpd and the design speed is 55 mph. The design storm is the 50 year storm as per the Drainage Design Manual for a State Route.

The proposed site is located in Madison County, Georgia. Madison County participates in the National Flood Insurance Program administered by the Federal Emergency Management Agency (FEMA). A detailed study with regulatory floodways has not been done for this reach of Broad River. Therefore, coordination with FEMA or Madison County will not be required.

The 2, 50, 100, and 500 year storm discharges for this site were obtained by transferring gage data from gage number 02191300 at Broad River above Carlton, Georgia using the method obtained from the USGS publication, "Magnitude and Frequency of Rural Floods in the Southeastern United States, 2006: Volume I, Georgia." The entire drainage basin is located in Region 1. The floodstage elevations, areas of opening, velocities and backwaters for the existing and proposed structures were calculated by using the

HEC-RAS computer program version 5.0.3. The existing and proposed bridges clear the 50 and 100 year floodstage elevations with no roadway overtopping occurring during either storm.

The existing 390 ft long bridge has channel velocities of 10.66 fps and 11.19 fps for the 50 and 100 year storms, respectively. The existing structure creates 0.16 ft of backwater during the 50 year storm and 0.18 ft of backwater during the 100 year storm. The natural channel velocities for the existing bridge are 10.54 fps and 11.11 fps for the 50 and 100 year storms, respectively.

The proposed 430 ft long bridge was chosen as the replacement bridge as the shortest bridge that has acceptable channel velocities and backwater depths while providing the required clearance from the top of river banks to the toes of the endrolls, and avoiding conflicts with existing bents. The proposed bridge has channel velocities of 10.81 fps and 11.33 fps during the 50 year and 100 year storms, respectively. Due to the significant obstruction of the caissons, the channel velocities have increased slightly on the proposed bridge. The proposed bridge creates 0.13 ft of backwater during the 50 year storm and 0.15 ft of backwater during the 100 year storm. The maximum calculated contraction scour depth for the 100 year storm is 1.90 ft in the river. (See the attached Predicted Scour Report).

A risk assessment was performed for the proposed bridge and no risk was found due to the fact that backwater is reduced for the proposed condition. Guide bank calculations which were performed as prescribed in the FHWA publication HEC No. 23, "Bridge Scour and Stream Instability Countermeasures," indicate that a guide bank is not required at the south end of the proposed bridge, but a 150 ft long guide bank is required at the north end of proposed bridge. However, due to the fact that the existing bridge has been in place since 1956, and there is no evidence of scour along the roadway embankments or bridge endrolls, no guide banks will be built at the proposed bridge. Calculations for riprap, using the method shown in the FHWA publication, HEC No. 23 "Bridge Scour and Stream Instability Countermeasures," indicate that Type I riprap is sufficient at south endroll of the proposed bridge, and Type III is sufficient at north endroll of the proposed bridge. However, Type I riprap will be used at both endrolls of the proposed bridge per the GDOT Drainage Manual. Deck drainage calculations

were performed using the method shown in the FHWA publication, HEC No. 21, "Design of Bridge Deck Drainage," indicate that the GDOT standard 4" scupper deck drains will be spaced at 10 ft interval through the deck.

SR 281 will be closed during the proposed construction. Traffic is to be maintained by using an off-site detour. The required maps, calculations, computer runs, roadway sheets, and preliminary layout are included in the following pages.

October 1, 2018

Prepared by: Hong Le

Checked by: Susan T. Beck

PI NO. 0013997 MADISON COUNTY

SR 281 OVER BROAD RIVER

HYDRAULIC SITE INSPECTION

A hydraulic site inspection was made at the crossing of State Route 281 over Broad River on September 5, 2018. The upstream and downstream floodplains are densely wooded with heavy undergrowth. A house is located approximately 70 ft north of the end of the bridge and approximately 400 ft upstream from the roadway. There are buried petroleum pipelines and fiber optic cables crossing the roadway south of the existing bridge. No other development was observed in the upstream or downstream floodplains in the vicinity of the existing bridge.

The river is approximately 210 ft wide at its crossing under the existing bridge and upstream and downstream from the existing bridge. The river banks are well defined, well vegetated, vertical, and approximately 12 ft high. At the time of the site inspection, the water in the river was approximately 1.5 ft deep on the south side and center of river, and was approximately 3 ft deep on the north side and was flowing slowly. A sand bar is located in front of the downstream face of the existing bridge. There are light debris on the upstream side of bent 5 and some rocks in the river downstream. The thalweg is located on the north side of the river. No scour was observed at the existing bridge.

The existing bridge is 390 ft long which consists of six simple steel beam spans with four 60 ft approach spans of W33 x 130 beams and two 75 ft main spans of W36 x 160 beams. The existing bridge has a concrete deck and five concrete intermediate bents. The existing intermediate bents were built at 90 degree to the roadway centerline. The existing abutments are sloping with no rip rap. The existing roadway is a paved State Route and is approximately 20 ft above the natural ground line near the bridge site.

September 5, 2018 Prepared by: Hong Le

PI NO. 0013997 MADISON COUNTY

SR 281 OVER BROAD RIVER

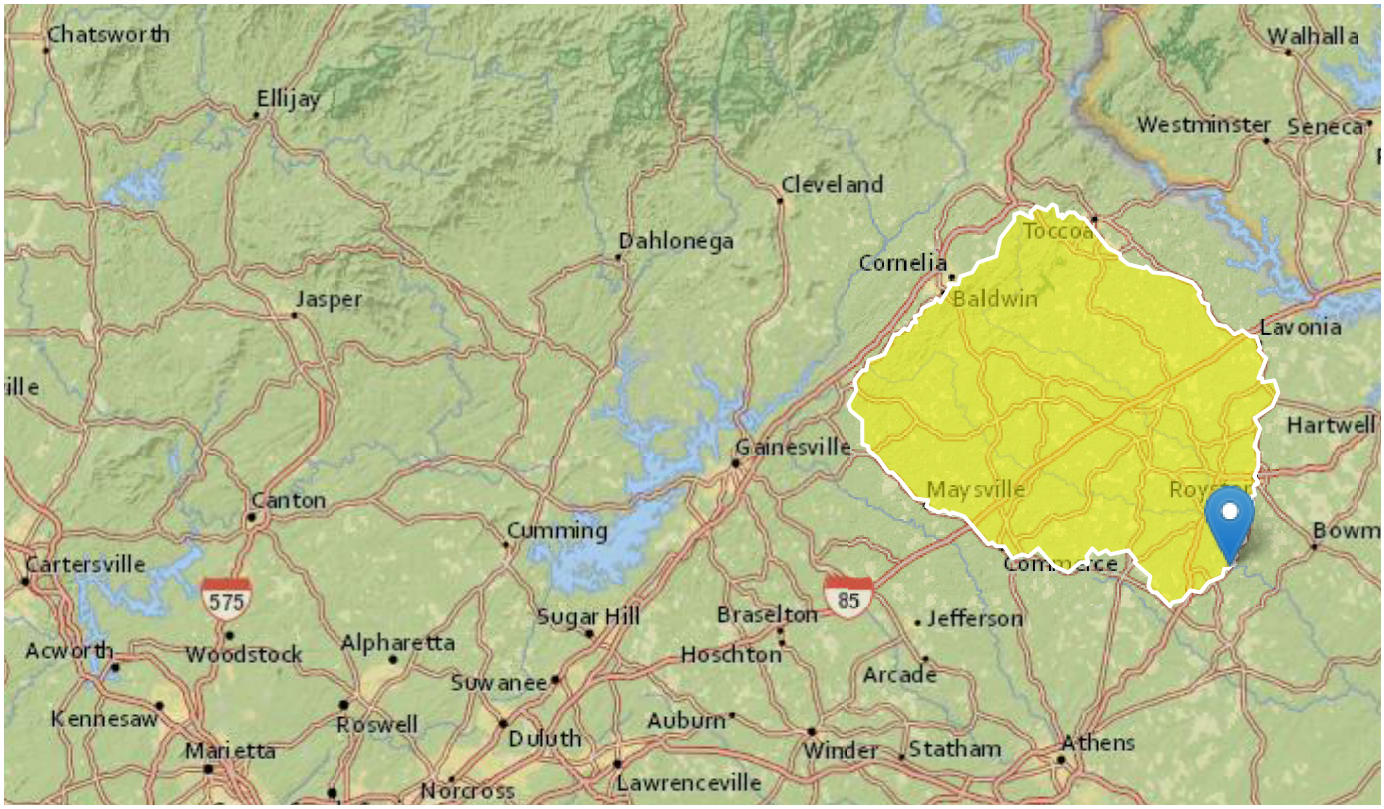
# PREDICTED SCOUR REPORT

Theoretical scour depths for the proposed bridge at this site were calculated by using the methods shown in the FHWA publication, HEC No. 18, "Evaluating Scour at Bridges". Contraction and local pier scour were calculated for the 100 and 500 year storms, as called for in this publication. The predicted scour depths at each intermediate bent of the proposed bridge will be provided to the Office of Materials Soils Lab and the Bridge Structural Designer for inclusion in the analysis and design of the bridge foundations. Tables and calculations showing these predicted scour depths are included in this study.

October 1, 2018 Prepared by: Hong Le

# StreamStats Report

**Region ID:** GA
**Workspace ID:** GA20180820140526470000
**Clicked Point (Latitude, Longitude):** 34.18199, -83.14674
**Time:** 2018-08-20 10:05:42 -0400




Basin Characteristics

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| DRNAREA | Area that drains to a point on a stream | 651 | square miles |
| PCTREG1 | Percentage of drainage area located in Region 1 | 100 | percent |
| PCTREG2 | Percentage of drainage area located in Region 2 | 0 | percent |
| PCTREG3 | Percentage of drainage area located in Region 3 | 0 | percent |
| PCTREG4 | Percentage of drainage area located in Region 4 | 0 | percent |
| PCTREG5 | Percentage of drainage area located in Region 5 | 0 | percent |

| Parameter Code | Parameter Description | Value | Unit |
|---|---|---|---|
| LC06IMP | Percentage of impervious area determined from NLCD 2006 impervious dataset | 1.63 | percent |

Peak-Flow Statistics Parameters [Peak Southeast US over 1 sqmi 2009 5043]

| Parameter Code | Parameter Name | Value | Units | Min Limit | Max Limit |
|---|---|---|---|---|---|
| DRNAREA | Drainage Area | 651 | square miles | 1 | 9000 |
| PCTREG1 | Percent Area in Region 1 | 100 | percent | 0 | 100 |
| PCTREG2 | Percent Area in Region 2 | 0 | percent | 0 | 100 |
| PCTREG3 | Percent Area in Region 3 | 0 | percent | 0 | 100 |
| PCTREG4 | Percent Area in Region 4 | 0 | percent | 0 | 100 |
| PCTREG5 | Percent Area in Region 5 | 0 | percent | 0 | 100 |

Peak-Flow Statistics Flow Report [Peak Southeast US over 1 sqmi 2009 5043]

PIl: Prediction Interval-Lower, PIu: Prediction Interval-Upper, SEp: Standard Error of Prediction, SE: Standard Error (other -- see report)

| Statistic | Value | Unit | PIl | PIu | SEp |
|---|---|---|---|---|---|
| 2 Year Peak Flood | 10600 | ft^3/s | 6130 | 18400 | 34.5 |
| 5 Year Peak Flood | 17100 | ft^3/s | 9970 | 29500 | 34 |
| 10 Year Peak Flood | 21700 | ft^3/s | 12400 | 37900 | 35.1 |
| 25 Year Peak Flood | 27200 | ft^3/s | 15000 | 49300 | 37.5 |
| 50 Year Peak Flood | 32200 | ft^3/s | 17300 | 60200 | 39.6 |
| 100 Year Peak Flood | 36400 | ft^3/s | 18900 | 70300 | 41.9 |
| 200 Year Peak Flood | 40500 | ft^3/s | 20300 | 80800 | 44.3 |
| 500 Year Peak Flood | 46800 | ft^3/s | 22300 | 98200 | 47.7 |

*Peak-Flow Statistics Citations*

**Gotvald, A.J., Feaster, T.D., and Weaver, J.C.,2009, Magnitude and Frequency of Rural Floods in the Southeastern United States, 2006: Volume 1, Georgia: U.S. Geological Survey Scientific Investigations Report 2009-5043, 120 p. (http://pubs.usgs.gov/sir/2009/5043/)**

National Water Information System: Web Interface

USGS Water Resources

Data Category: Site Information ▼ Geographic Area: Georgia ▼ GO

Click to hideNews Bulletins

- Please see news on new formats
- Full News

Click to hide state-specific text

*****PLEASE BOOKMARK THIS PAGE FOR EASE OF ACCESS*****

- USGS Water Resources of the South Atlantic Water Science Center: the place to start for all USGS water information in the SAWSC.
- Real-time data Streamflow || Water-Quality || Groundwater Levels || Precipitation
- Statewide Rainfall Map
- Live Streaming RiverCams
- Flood Inundation Maps
- StreamStats - online tool for basin and flow characteristics
- USGS Flood Event Viewer
- Sign up for custom Water Alerts by text or email

**Questions about data? Click here.**

**Real-time Data from Rapid Deployment Gages associated with Hurricane Florence can be found here.**

# USGS 02191300 BROAD RIVER ABOVE CARLTON, GA

Available data for this site SUMMARY OF ALL AVAILABLE DATA ▼ GO

## Stream Site

DESCRIPTION:

Latitude 34°04'24", Longitude 83°00'12" NAD83
Madison County, Georgia, Hydrologic Unit 03060104
Drainage area: 760 square miles
Datum of gage: 406.6 feet above NAVD88.

AVAILABLE DATA:

| Data Type | Begin Date | End Date | Count |
|---|---|---|---|
| **Current / Historical Observations** (availability statement) | 1997-10-01 | 2018-09-18 | |
| **Daily Data** | | | |
| Precipitation, total, inches | 1998-11-15 | 2017-10-15 | 6453 |
| Precipitation, total, inches | 2015-09-19 | 2018-09-17 | 1087 |
| Discharge, cubic feet per second | 1897-07-01 | 2018-09-17 | 13317 |
| Gage height, feet | 2001-10-01 | 2018-09-17 | 19315 |
| **Daily Statistics** | | | |
| Discharge, cubic feet per second | 1897-07-01 | 2018-06-05 | 13213 |
| Gage height, feet | 1997-10-01 | 2018-06-05 | 7275 |
| **Monthly Statistics** | | | |
| Discharge, cubic feet per second | 1897-07 | 2018-06 | |
| Gage height, feet | 1997-10 | 2018-06 | |
| **Annual Statistics** | | | |
| Discharge, cubic feet per second | 1897 | 2018 | |
| Gage height, feet | 1998 | 2018 | |
| **Peak streamflow** | 1898-09-02 | 2017-04-06 | 119 |
| **Field measurements** | 1942-10-29 | 2018-08-08 | 239 |
| **Field/Lab water-quality samples** | 2002-01-09 | 2007-12-12 | 50 |
| **Water-Year Summary** | 2005 | 2017 | 13 |
| **Revisions** | Available (site:1) (timeseries:0) | | |

OPERATION:

Record for this site is maintained by the USGS Georgia Water Science Center
**Email questions about this site to Georgia Water Science Center Water-Data Inquiries**

---

Questions about sites/data?
Feedback on this web site
Automated retrievals
Help
Data Tips
Explanation of terms

Subscribe for system changes
News

Accessibility Plug-Ins FOIA Privacy Policies and Notices

U.S. Department of the Interior | U.S. Geological Survey

**Title: NWIS Site Information for Georgia: Site Inventory**
**URL: https://waterdata.usgs.gov/ga/nwis/inventory/?site_no=02191300&agency_cd=USGS&**

Page Contact Information: Georgia Water Data Support Team
Page Last Modified: 2018-09-18 15:23:05 EDT
0.26 0.25 vaww01

**P-percent chance exceedance peak-flow discharge estimate weighted for ungaged location near gaged location**

To make use of this worksheet, enter the following within the yellow shaded cells:
(1) the drainage area and percentages of ungaged basin within each of the hydrologic regions, and
(2) station number of the nearby location.

Note:
(1) Ungaged and gaged locations should be on the same stream.
(2) The drainage area for the ungaged location should between 0.5 to 1.5 times the drainage area for the gaged location.
(3) Station number of gaged location must be listed in Table 1 of the appropriate flood-frequency report (be sure to include leading zero where applicable).
(4) The adjusted ungaged estimates in this spreadsheet use only the annual peak flows prior to the 2007 water year. If estimates need to be computed using any peak flow data after the 2006 water year then refer to the weighting equations in the appropriate flood-frequency report.

**UNGAGED LOCATION**

| | | |
|---|---|---|
| Drainage area (sqmi): | 651 | |

**Hydrologic region percentages (XX.X whole number to tenth)**

| | | |
|---|---|---|
| Hydrologic Region 1 (Ridge and Valley - Piedmont): | 100.0 | percent |
| Hydrologic Region 2 (Blue Ridge): | 0.0 | percent |
| Hydrologic Region 3 (Sand Hills): | 0.0 | percent |
| Hydrologic Region 4 (Coastal): | 0.0 | percent |
| Hydrologic Region 5 (Southwest Georgia): | 0.0 | percent |
| Check sum of regions (must equal 100.0): | 100.0 | |

WARNING MESSAGES

**Adjusted ungaged estimate based on nearby gaged location**

| | | | |
|---|---|---|---|
| 50% chance exceedance: | 11440 | 11,400 | cfs rounded |
| 20% chance exceedance: | 18584 | 18,600 | cfs rounded |
| 10% chance exceedance: | 23911 | 23,900 | cfs rounded |
| 4% chance exceedance: | 30768 | 30,800 | cfs rounded |
| 2% chance exceedance: | 36352 | 36,400 | cfs rounded |
| 1% chance exceedance: | 41930 | 41,900 | cfs rounded |
| 0.5% chance exceedance: | 47476 | 47,500 | cfs rounded |
| 0.2% chance exceedance: | 55340 | 55,300 | cfs rounded |

**NEARBY GAGED LOCATION**

Nearby gaged location…station number of gaged location must be listed in LPIII_RUN GLSNet initial worksheet (be sure to include leading zero where applicable):

02191300 **FOUND!!!**

| | | |
|---|---|---|
| Map identification number: | 407 | *(map identification number from Table 1 in flood-frequency reports)* |
| Station name: | Broad River above Carlton, GA | |
| Systematic period of record: | 1898-2006 | |
| Number of systematic peaks: | 108 | |

Note: For some sites, available period of record indicated above may include peaks affected by regulation that were not used in the flood-frequency analyses. Please check Table 1 in corresponding flood-frequency for additional information concern

| | | | | |
|---|---|---|---|---|
| Drainage area (DA): | 760 | sqmi | Ratio ungaged DA to gaged DA: | 0.86 |
| | | | Difference in DA (absolute value) | 109.00 |

**Hydrologic region percentages**

| | | |
|---|---|---|
| Hydrologic Region 1 (Ridge and Valley - Piedmont): | 100.0 | percent |
| Hydrologic Region 2 (Blue Ridge): | 0.0 | percent |
| Hydrologic Region 3 (Sand Hills): | 0.0 | percent |
| Hydrologic Region 4 (Coastal): | 0.0 | percent |
| Hydrologic Region 5 (Southwest Georgia): | 0.0 | percent |

**PI No. 0013997, MADISON COUNTY**

**SR 281 OVER BROAD RIVER**

**Slope Calculation (Quad Maps)**

| | | | |
|---|---|---|---|
| Upstream Elevation | = | 520.00 | |
| Downstream Elevation | = | 500.00 | |
| Horizontal Distance | = | 17,714.82 | |
| Slope | = | **0.001129** | **ft/ft** (used in study) |
| | = | 5.9611 | ft/mi |

**Slope Calculation (Survey WS Elevation)**

| | | | |
|---|---|---|---|
| 500' Upstream | = | 515.96 | |
| 500' Downstream | = | 515.71 | |
| Horizontal Distance | = | 1000 | |
| Slope | = | 0.00025 | ft/ft |
| | = | 1.3200 | ft/mi |

# Flow Transition Analysis

| | | | | |
|---|---|---|---|---|
| **Expansion** | A: | 1269.22 | ft | |
| | B: | 1293.14 | ft | |
| | C: | 1687.86 | ft | |
| | D: | 1610.44 | ft | |
| | AB | 23.92 | ft | |
| | CD | -77.42 | ft | |
| | AVG | 23.92 | ft | |
| | S | 5.96 | ft/mi | |
| | no_b/n_c | 3.71 | | |
| | b/B | 1.16 | | |
| | ER | 2 | or | |
| | Le | 47.84 | 60 ft (rounded) | |
| **Contraction** | A: | 1290.87 | ft | |
| | B: | 1293.14 | ft | |
| | C: | 1687.86 | ft | |
| | D: | 2067.81 | ft | |
| | AB | 2.27 | ft | |
| | CD | 379.95 | ft | |
| | AVG | 191.11 | ft | |
| | S | 5.96 | ft/mi | 0.001 ft/ft |
| | b/B | 0.51 | | |
| | nob/nc | 3.71 | | |
| | CR | 1.2 | or | |
| | Lc | 229.33 | 240 ft (rounded) | |

Note:
nob = manning of the overbank
nc = manning of the channel
b = bridge opening
B = floodplain width
S = hydrological slope
ER = Expansion Ratio
CR = Constraction Ratio
Le = Length of expansion
Lc = Length of contraction
Lobs = AVG = average of bridge obstruction

$$ER = \frac{L_e}{\overline{L}_{obs}}$$

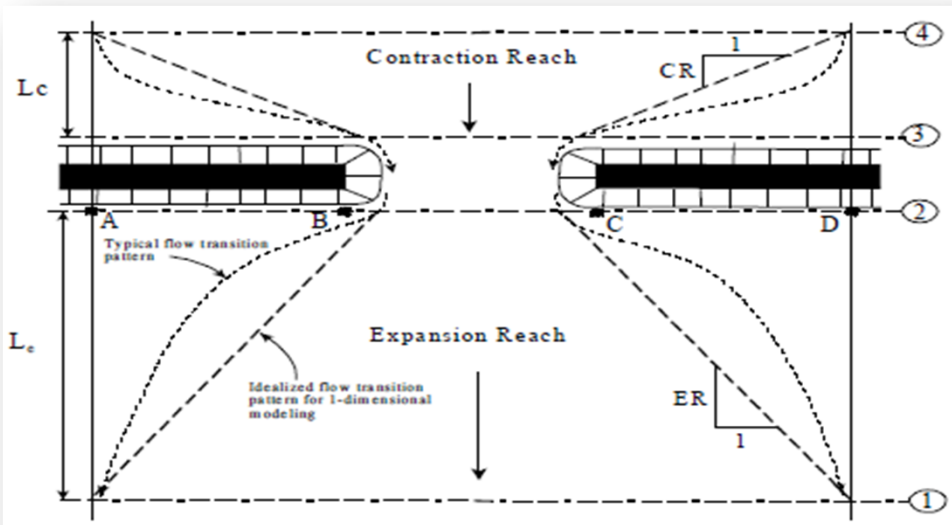



*Figure B- 1 Typical Cross Section Layout for Bridge Modeling*

*Table B-2 Ranges of Expansion Ratios*

| | | nob / nc = 1 | nob / nc = 2 | nob / nc = 4 |
|---|---|---|---|---|
| b/B = 0.10 | S = 1 ft/mile | 1.4 – 3.6 | 1.3 – 3.0 | 1.2 – 2.1 |
| | 5 ft/mile | 1.0 – 2.5 | 0.8 – 2.0 | 0.8 – 2.0 |
| | 10 ft/mile | 1.0 – 2.2 | 0.8 – 2.0 | 0.8 – 2.0 |
| b/B = 0.25 | S = 1 ft/mile | 1.6 – 3.0 | 1.4 – 2.5 | 1.2 – 2.0 |
| | 5 ft/mile | 1.5 – 2.5 | 1.3 – 2.0 | 1.3 – 2.0 |
| | 10 ft/mile | 1.5 – 2.0 | 1.3 – 2.0 | 1.3 – 2.0 |
| b/B = 0.50 | S = 1 ft/mile | 1.4 – 2.6 | 1.3 – 1.9 | 1.2 – 1.4 |
| | 5 ft/mile | 1.3 – 2.1 | 1.2 – 1.6 | 1.0 – 1.4 |
| | 10 ft/mile | 1.3 – 2.0 | 1.2 – 1.5 | 1.0 – 1.4 |

*Table B-3 Ranges of Contraction Ratios (CR)*

| | nob / nc = 1 | nob / nc = 2 | nob / nc = 4 |
|---|---|---|---|
| S = 1 ft/mile | 1.0 - 2.3 | 0.8 - 1.7 | 0.7 - 1.3 |
| 5 ft/mile | 1.0 - 1.9 | 0.8 - 1.5 | 0.7 - 1.2 |
| 10 ft/mile | 1.0 - 1.9 | 0.8 - 1.4 | 0.7 - 1.2 |

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**50 YEAR STORM**

| **ENGLISH UNIT** | EXISTING BRIDGE L = 396' (90°) | PROPOSED BRIDGE L = 430' (90°) |
|---|---|---|
| FLOODSTAGE | 534.82 | 534.82 |
| DISCHARGE THRU STRUCTURE ($ft^3/s$) | 36400 | 36400 |
| DISCHARGE OVER ROAD ($ft^3/s$) | 0 | 0 |
| AREA OF OPENING ($ft^2$) | 3798 | 3799 |
| VELOCITY THRU STRUCTURE (ft/s) | 9.58 | 9.58 |
| CHANNEL VELOCITY (ft/s) | 10.66 | 10.81 |
| BACKWATER(ft) | 0.16 | 0.13 |
| APPROACH W/O STRUCTURE | 535.17 | 535.17 |
| APPROACH W/ STRUCTURE | 535.33 | 535.30 |
| NATURAL CHANNEL VELOCITY = | 10.54 | 10.54 |

**100 YEAR STORM**

| | EXISTING BRIDGE L = 396' (90°) | PROPOSED BRIDGE L = 430' (90°) |
|---|---|---|
| FLOODSTAGE | 536.47 | 536.47 |
| DISCHARGE THRU STRUCTURE ($ft^3/s$) | 41900 | 41900 |
| DISCHARGE OVER ROAD ($ft^3/s$) | 0 | 0 |
| AREA OF OPENING ($ft^2$) | 4246 | 4288 |
| VELOCITY THRU STRUCTURE (ft/s) | 9.87 | 9.77 |
| CHANNEL VELOCITY (ft/s) | 11.19 | 11.33 |
| BACKWATER(ft) | 0.18 | 0.15 |
| APPROACH W/O STRUCTURE | 536.76 | 536.76 |
| APPROACH W/ STRUCTURE | 536.94 | 536.91 |
| NATURAL CHANNEL VELOCITY = | 11.11 | 11.11 |

2 YEAR FLOODSTAGE = 525.51

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**500 YEAR STORM**

| **ENGLISH UNIT** | EXISTING BRIDGE L = 396' (90°) | PROPOSED BRIDGE L = 430' (90°) |
|---|---|---|
| FLOODSTAGE | 540.09 | 540.09 |
| DISCHARGE THRU STRUCTURE ($ft^3/s$) | 55300 | 55300 |
| DISCHARGE OVER ROAD ($ft^3/s$) | 0 | 0 |
| AREA OF OPENING ($ft^2$) | 5258 | 5403 |
| VELOCITY THRU STRUCTURE (ft/s) | 10.52 | 10.24 |
| CHANNEL VELOCITY (ft/s) | 12.35 | 12.43 |
| BACKWATER(ft) | 0.22 | 0.17 |
| APPROACH W/O STRUCTURE | 540.29 | 540.29 |
| APPROACH W/ STRUCTURE | 540.51 | 540.46 |
| NATURAL CHANNEL VELOCITY = | 12.28 | 12.28 |

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**PROPOSED 430 FT LONG BRIDGE**

| | |
|---|---|
| PROFILE GRADE ELEVATION | 562.98 |
| DEPTH OF CROSS SLOPE | 0.40 |
| DEPTH OF SLAB AND BEAM | 7.17 |
| BOTTOM OF BEAM ELEVATION | 555.41 |

| | |
|---|---|
| BOTTOM OF BEAM ELEVATION | 555.41 |
| 50 YEAR FLOODSTAGE ELEVATION | 534.82 |
| CLEARANCE | 20.59 |

2 ft clearance required

| | |
|---|---|
| BOTTOM OF BEAM ELEVATION | 555.41 |
| 100 YEAR FLOODSTAGE ELEVATION | 536.47 |
| CLEARANCE | 18.94 |

1 ft clearance required

*CLEARANCE CALCULATED FOR PSC 74" BULB TEE

**PI No. 0013997, MADISON COUNTY**

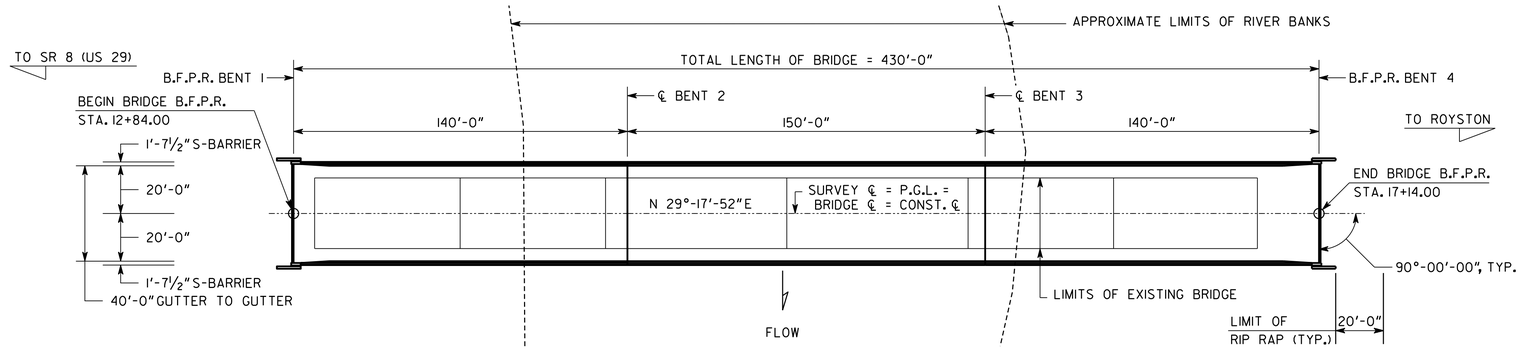
**SR 281 OVER BROAD RIVER**

**Slope Calculation (Quad Maps)**

| | | | |
|---|---|---|---|
| Upstream Elevation | = | 520.00 | |
| Downstream Elevation | = | 500.00 | |
| Horizontal Distance | = | 17,714.82 | |
| Slope | = | **0.001129** | **ft/ft** (used in study) |
| | = | 5.9611 | ft/mi |

**Slope Calculation (Survey WS Elevation)**

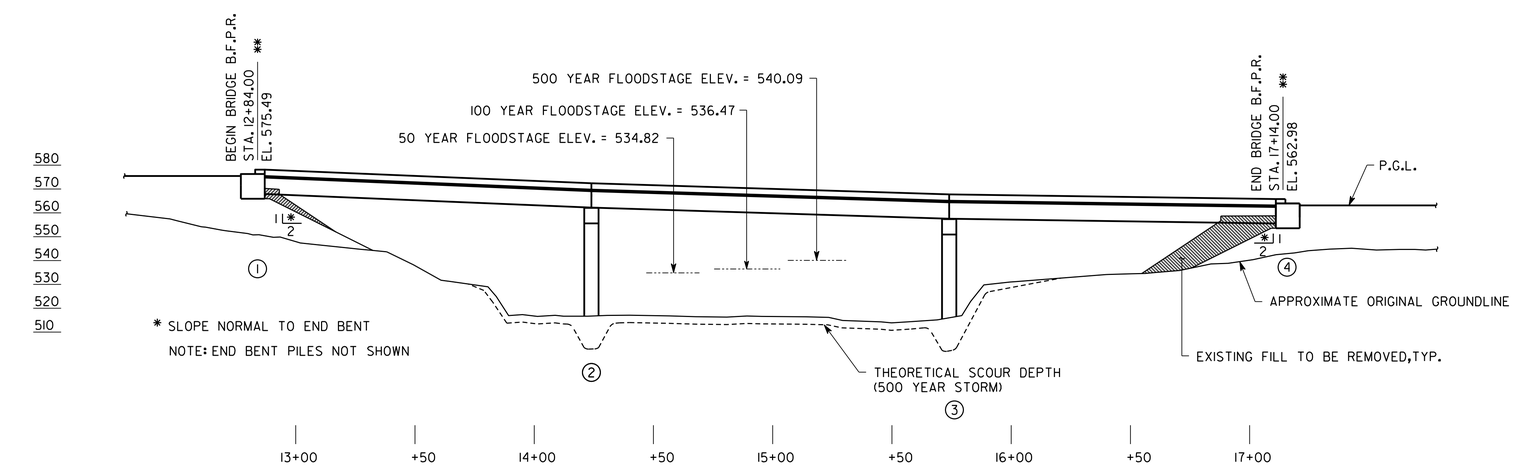
| | | | |
|---|---|---|---|
| 500' Upstream | = | 515.96 | |
| 500' Downstream | = | 515.71 | |
| Horizontal Distance | = | 1000 | |
| Slope | = | 0.00025 | ft/ft |
| | = | 1.3200 | ft/mi |



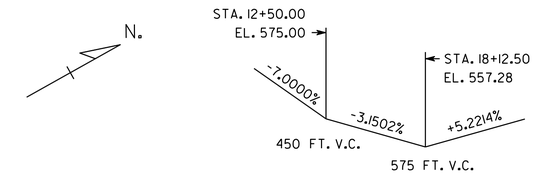

## PLAN

BM SLCD 11 - ⅝" REBAR SET AT THE NORTHWEST CORNER OF BRIDGE BEHIND THE GUARDRAIL, 16.67 FT. LT. OF STATION 17+00.72, ELEV. = 558.18 FT.

** STATIONS AND ELEVATIONS ARE ALONG PROFILE GRADE LINE AT THE INTERSECTION OF PROFILE GRADE LINE AND B.F.P.R.




## ELEVATION




## PROPOSED VERTICAL CURVE DATA

## PROPOSED BRIDGE CONSISTS OF

1 - 150'-0" BULB TEE, 74 IN, PSC BEAM SPAN ---------- SPECIAL DESIGN
2 - 140'-0" BULB TEE, 74 IN, PSC BEAM SPANS ---------- SPECIAL DESIGN
2 - PILE END BENTS ---------- SPECIAL DESIGN
2 - CONCRETE INTERMEDIATE BENTS ---------- SPECIAL DESIGN

24" TYPE I RIP RAP

## NOTES

CROSS-SLOPE - THE PROPOSED BRIDGE DECK IS TO BE BUILT ON A NORMAL CROWN OF 2.0%.

DECK DRAINS - DECK DRAINS TO BE PLACED AT 10 FT SPACING THROUGH DECK. ELIMINATE DECK DRAINS OVER ENDFILLS.

BENT LAYOUT - ALL BENTS ARE PARALLEL.

BEAM ELEVATION - MINIMUM BOTTOM OF BEAM ELEVATION FOR PROPOSED BRIDGE SHALL BE NO LOWER THAN ELEVATION 537.47.

BRIDGE REMOVAL - REMOVE EXISTING BRIDGE. REMOVE EXISTING SUBSTRUCTURE AS PER THE SPECIFICATIONS.

TRAFFIC CONTROLS - SR 281 WILL BE CLOSED TO TRAFFIC DURING THE PROPOSED CONSTRUCTION. TRAFFIC TO BE MAINTAINED BY UTILIZING AN OFF-SITE DETOUR.

## DESIGN DATA

SPECIFICATIONS ---------- AASHTO LRFD 7TH EDITION, 2014
DESIGN VEHICLE LIVE LOAD ---------- HL-93
FUTURE PAVING ALLOWANCE ---------- 30 LBS PER SQ FT

## EXISTING UTILITIES

BURIED PETROLEUM PIPELINE CROSSING SOUTH OF EXISTING BRIDGE.
BURIED FIBER OPTIC CABLE CROSSING SOUTH OF EXISTING BRIDGE.

## PROPOSED UTILITIES

12" DIA. WATER MAIN TO BE ATTACHED TO PROPOSED BRIDGE.

## TRAFFIC DATA

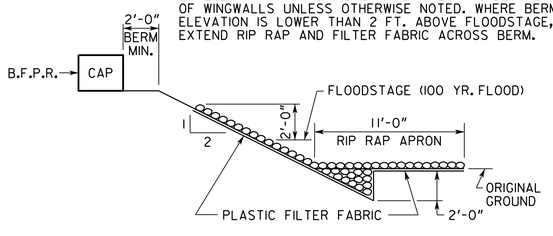
TRAFFIC ---------- ADT = 1,875 (2023)
ADT = 2,525 (2043)
DESIGN SPEED ---------- 55 MPH
TRUCKS ---------- 6.5 %
24 HR TRUCKS ---------- 8.5 %
DIRECTIONAL ---------- 51/49

## DRAINAGE DATA

DRAINAGE AREA ---------- 651 SQ MILES

| FLOOD FREQUENCY | TOTAL DISCHARGE | MEAN VELOCITY | AREA OF OPENING UNDER FLOODSTAGE | BACK WATER |
|---|---|---|---|---|
| 50 YEAR | 36,400 CFS | 9.58 FPS | 3,799 SQ FT | 0.13 FT |
| 100 YEAR | 41,900 CFS | 9.77 FPS | 4,288 SQ FT | 0.15 FT |
| 500 YEAR | 55,300 CFS | 10.24 FPS | 5,403 SQ FT | 0.17 FT |

PLACE RIP RAP AND FILTER FABRIC FROM 2 FT. BELOW ORIGINAL GROUND TO 2 FT. ABOVE FLOODSTAGE. EXTEND RIP RAP AND FILTER FABRIC 20 FT. BEYOND END OF WINGWALLS UNLESS OTHERWISE NOTED. WHERE BERM ELEVATION IS LOWER THAN 2 FT. ABOVE FLOODSTAGE, EXTEND RIP RAP AND FILTER FABRIC ACROSS BERM.




## RIP RAP DETAIL

| BERM ELEVATIONS ⊛ | |
|---|---|
| END BENT | ELEVATIONS |
| 1 LT & 1 RT | 565.76 |
| 4 LT & 4 RT | 553.25 |

⊛ NOTE: FOR BRIDGE ENDROLL STAKING PURPOSES ONLY.

| THEORETICAL SCOUR DEPTHS (FT) | | | | | | |
|---|---|---|---|---|---|---|
| | 100 YEAR STORM | | | 500 YEAR STORM | | |
| BENT LOCATION | GENERAL | LOCAL | TOTAL | GENERAL | LOCAL | TOTAL |
| BENT 2 | 1.9 | 9.5 | 11.4 | 3.1 | 10.2 | 13.3 |
| BENT 3 | 1.9 | 9.3 | 11.2 | 3.1 | 10.0 | 13.1 |

NOTE: THE 500 YEAR SCOUR IN THE RIVER IS 3.1 FT

BRIDGE SERIAL NO. 195-0021-0
BRIDGE I.D. NO. 195-0028ID-004.1IN
PROJECT P.I. NO. 0013997

BRIDGE NO. 1

GEORGIA
DEPARTMENT OF TRANSPORTATION
ENGINEERING DIVISION-OFFICE OF BRIDGES AND STRUCTURES

PRELIMINARY LAYOUT
SR 281 OVER BROAD RIVER
MADISON COUNTY 0013997

1" = 30'-0" (UNLESS OTHERWISE NOTED) OCTOBER 2018

DRAWING NO. 35-0001
BRIDGE SHEET 1 OF 1

REVISIONS | DATE | BY

DESIGNED HTL | CHECKED STB | REVIEWED DLC / SKG
DRAWN HTL | DESIGN GROUP STB | APPROVED WMD

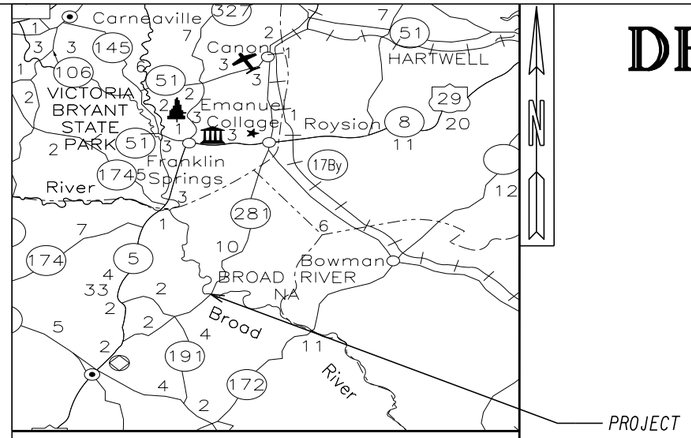
1 INCH WHEN PRINTED FULL SIZE

0013997 Pre. Layout.dgn

DATE: OCTOBER 1, 2018 TIME: 9:43 AM HTL

# DEPARTMENT OF TRANSPORTATION
# STATE OF GEORGIA

## PLAN AND PROFILE OF PROPOSED
# SR 281 @ BROAD RIVER
# BRIDGE REPLACEMENT




LOCATION SKETCH (N.T.S.)

STATE FUNDED

0013997

MADISON COUNTY

FEDERAL ROUTE * N/A

STATE ROUTE * 281

P.I. 0013997

NOTE :
ALL REFERENCES IN THIS DOCUMENT,WHICH INCLUDES ALL PAPERS,WRITINGS, DOCUMENTS,DRAWINGS,OR PHOTOGRAPHS USED,OR TO BE USED IN CONNECTION WITH THIS DOCUMENT,TO "STATE HIGHWAY DEPARTMENT OF GEORGIA ","STATE HIGHWAY DEPARTMENT ",GEORGIA STATE HIGHWAY DEPARTMENT ","HIGHWAY DEPARTMENT ",OR "DEPARTMENT "WHEN THE CONTEXT THEREOF MEANS THE STATE HIGHWAY DEPARTMENT OF GEORGIA,AND SHALL BE DEEMED TO MEAN THE DEPARTMENT OF TRANSPORTATION.

| DESIGN DATA: | |
|---|---|
| TRAFFIC 2023 A.D.T.: | 1875 |
| TRAFFIC 2043 A.D.T.: | 2525 |
| TRAFFIC D.H.V.: | 265 |
| DIRECTIONAL DIST: | 51/49 |
| % TRUCKS: | 6.5 |
| 24 HR.TRUCKS %: | 8.5 |
| SPEED DESIGN: | 55 MPH |

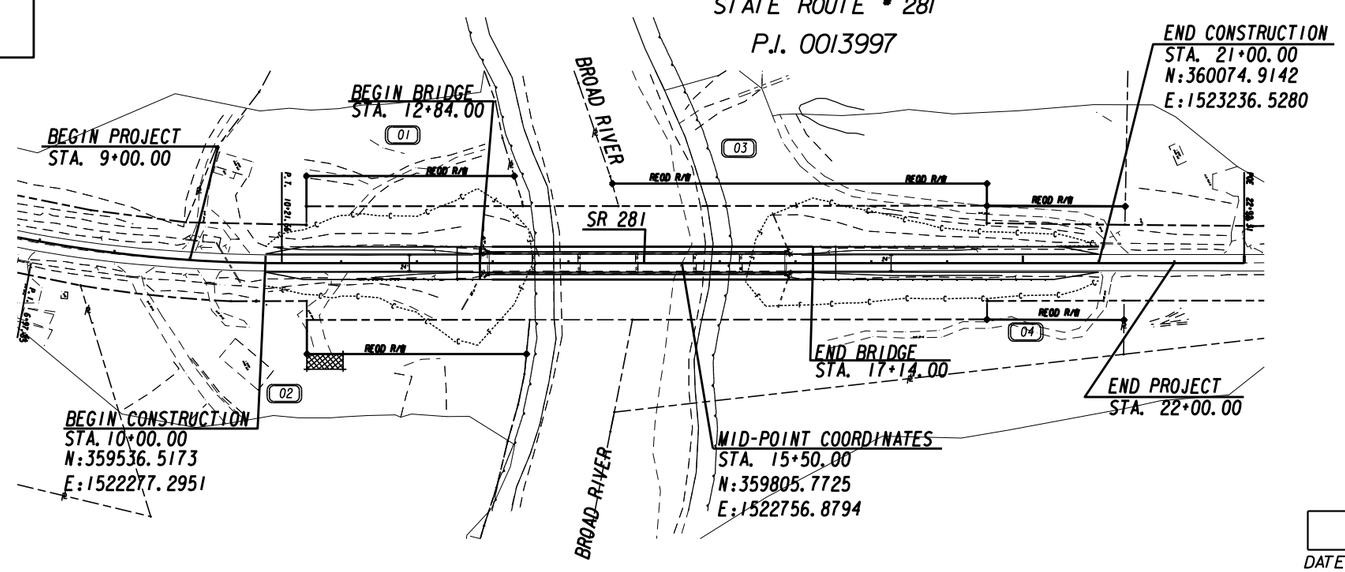
LOCATION & DESIGN APPROVAL DATE:

FUNCTIONAL CLASS:
RURAL MAJOR COLLECTOR

THIS PROJECT IS 100% IN MADISON COUNTY AND IS 100% IN CONG.DIST.NO.9

PROJECT DESIGNATION: EXEMPT

THIS PROJECT HAS BEEN PREPARED USING THE HORIZONTAL GEORGIA COORDINATE SYSTEM OF 1984 (NAD 1983)/94 EAST ZONE,AND THE NORTH AMERICAN VERTICAL DATUM (NAVD) OF 1988.




PREPARED BY: GARRETT K. STINSON
DESIGN ENGINEER

RECOMMENDED FOR SUBMISSION BY: MARVIN GAVINS,P.E.
DESIGN ENGINEER GROUP MANAGER

SUBMITTED BY:
STATE ROADWAY DESIGN ENGINEER

DATE CHIEF ENGINEER

| LENGTH OF PROJECT | COUNTY No.121 MADISON COUNTY Project No. 0013997 |
|---|---|
| | MILES |
| NET LENGTH OF ROADWAY | 0.126 |
| NET LENGTH OF BRIDGES | 0.081 |
| NET LENGTH OF PROJECT | 0.246 |
| NET LENGTH OF EXCEPTIONS | 0.000 |
| GROSS LENGTH OF PROJECT | 0.246 |

SCALE IN FEET
0 100 200 400

| | |
|---|---|
| PLANS COMPLETED ??-??-20?? | |
| REVISIONS | |

THE DATA,TOGETHER WITH ALL OTHER INFORMATION SHOWN ON THESE PLANS OR IN ANYWAY INDICATED THEREBY,WHETHER BY DRAWINGS OR NOTES,OR IN ANY OTHER MANNER,ARE BASED UPON FIELD INVESTIGATIONS AND ARE BELIEVED TO BE INDICATIVE OF ACTUAL CONDITIONS. HOWEVER,THE SAME ARE SHOWN AS INFORMATION ONLY,ARE NOT GUARANTEED,AND DO NOT BIND THE DEPARTMENT OF TRANSPORTATION IN ANY WAY.THE ATTENTION OF BIDDER IS SPECIFICALLY DIRECTED TO SUBSECTIONS 102.04,102.05,AND 104.03 OF THE SPECIFICATIONS.

DRAWING No.
01-001

## ALLOWABLE RANGES TABLE

FOR THIS PROJECT, CROSS SLOPES THAT ARE ADJUSTED TO "BEST FIT" EXISTING PAVEMENT SLOPES ARE SUBJECT TO THE FOLLOWING LIMITS:

A. NORMAL CROWN

| SECTION WITH GRADES 0.5% OR GREATER | SECTION WITH GRADES LESS THAN 0.5% |
|---|---|
| 0.0150 FT/FT - MINIMUM | 0.0156 FT/FT - MINIMUM |
| 0.0208 FT/FT - DESIRABLE | 0.0208 FT/FT - DESIRABLE |
| 0.0250 FT/FT - MAXIMUM | 0.0300 FT/FT - MAXIMUM |

B. SUPERELEVATION RATE

S.E. RATE SHOWN ON PLANS OR SE RATE EXISTING IN FIELD, WHICHEVER IS GREATER.

C. SUPERELEVATION TRANSITION LENGTH (LENGTH FROM FLAT POINT TO FULL SE)

| | RATE OF CHANGE | CORRESPONDING DIFFERENCE IN GRADE BETWEEN PIVOT POINT AND EDGE OF PAVEMENT |
|---|---|---|
| MINIMUM | 1:150 | 0.67% |
| DESIRABLE | 1:200 | 0.50% |
| MAXIMUM | 1:300 | 0.33% |

LENGTH SHALL BE SET TO AVOID CREATING A FLAT GUTTER GRADE ON LOW SIDE AND TO AVOID FLAT CROSS SLOPES AT OR NEAR THE LOW POINT OF VERTICAL CURVES.

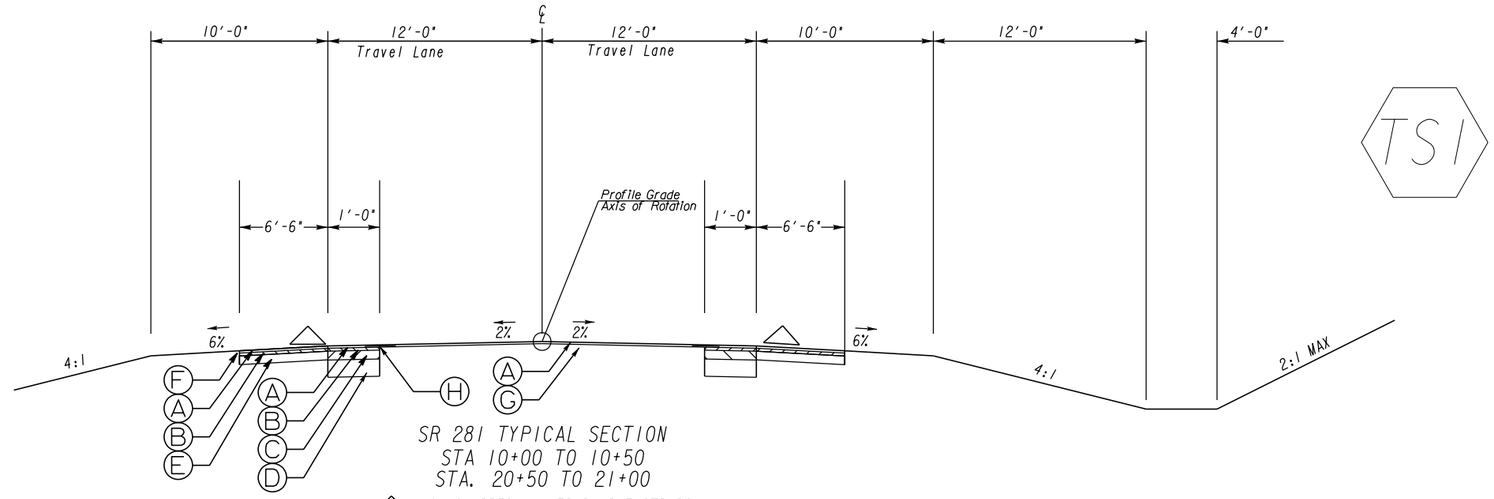
D. POSITIONING OF SUPERELEVATION TRANSITION LENGTH ON SIMPLE CURVES

50% OF TRANSITION INSIDE CURVE - MAXIMUM
33% OF TRANSITION INSIDE CURVE - DESIRABLE
20% OF TRANSITION INSIDE CURVE - MINIMUM

NOTE: CROWN WIPE-OUT SHALL BE AT THE SAME RATE AS THE SE TRANSITION.

E. SMOOTHING OF BREAKS IN EDGE PROFILE AT BEGIN AND END OF TRANSITION SHALL BE ACCOMPLISHED BY VERTICAL CURVE WITH A MINIMUM LENGTH (IN FEET) EQUAL TO THE SPEED DESIGN (IN MPH).

# TYPICAL SECTION APPLIES TO SR 281 OVER BROAD RIVER



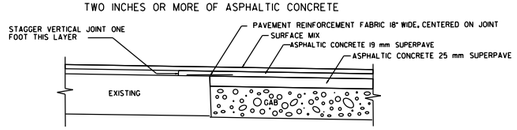

TS1

SR 281 TYPICAL SECTION
STA 10+00 TO 10+50
STA. 20+50 TO 21+00

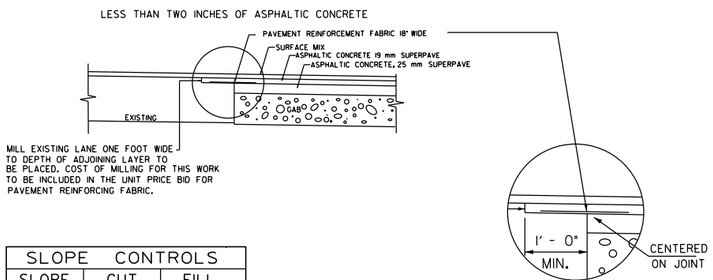
△ 16" SKIPPED MILLED RUMBLE STRIPS

(A) RECYCLED ASPH. CONC. 9.5 MM TYPE 11 SUPERPAVE, BLEND 1, INCL BITUM MATL & H LIME, 135 LBS/SY
(B) RECYCLED ASPH. CONC. 19 MM SUPERPAVE, GP 1 OR 2, INCL BITUM MATL & H LIME, 220 LBS/SY
(C) RECYCLED ASPH. CONC. 25 MM SUPERPAVE, GP 1 OR 2, INCL BITUM MATL & H LIME, 330 LBS/SY
(D) GRADED AGGREGATE BASE COURSE, 12" INCLUDING MATERIAL
(E) GRADED AGGREGATE BASE COURSE, 6" INCLUDING MATERIAL
(F) EDGE TREATMENT (SAFETY EDGE TREATMENT DETAIL P-7, SEE DETAIL.)
(G) MILL ASPHALTIC CONCRETE PAVEMENT: 1.25"
(H) PAVEMENT REINFORCEMENT FABRIC STRIPS, TYPE 2, 18 INCH WIDTH

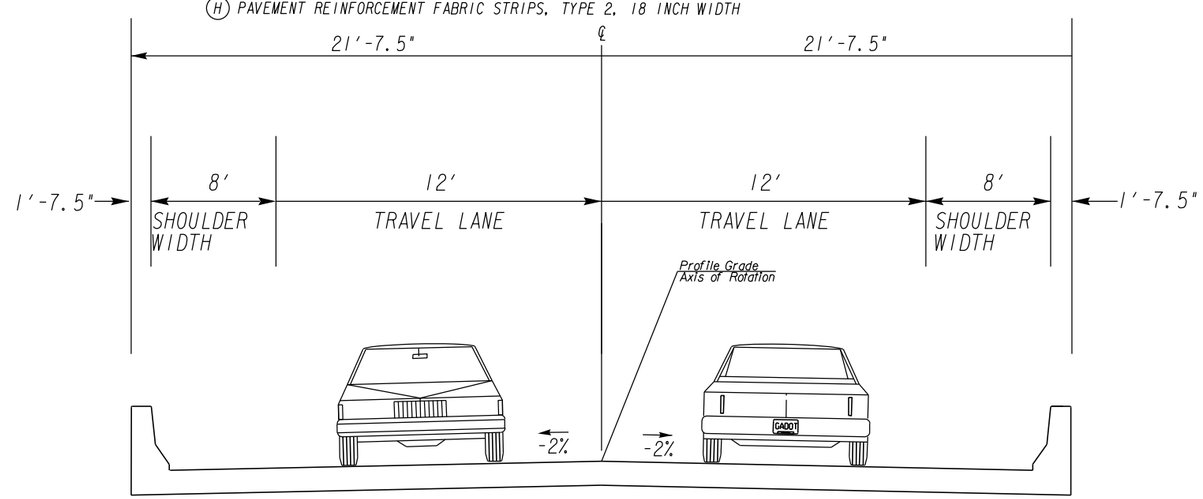
TYPICAL SECTION DETAIL TO BE USED WHEN EXISTING PAVEMENT IS TO BE RESURFACED WITH TWO INCHES OR MORE OF ASPHALTIC CONCRETE




TYPICAL SECTION DETAIL TO BE USED WHEN EXISTING PAVEMENT IS TO BE RESURFACED WITH LESS THAN TWO INCHES OF ASPHALTIC CONCRETE




| SLOPE CONTROLS | | |
|---|---|---|
| SLOPE | CUT | FILL |
| 4:1 | —— | 0-10' |
| 2:1 | ALL | OVER 10' |




TS2

# BROAD RIVER BRIDGE TYPICAL SECTION

STA. 12+84 TO 17+14

NOT TO SCALE

ROADWAY DESIGN

REVISION DATES

TYPICAL SECTIONS
0013997
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No. 05-0001

## ALLOWABLE RANGES TABLE

FOR THIS PROJECT, CROSS SLOPES THAT ARE ADJUSTED TO "BEST FIT" EXISTING PAVEMENT SLOPES ARE SUBJECT TO THE FOLLOWING LIMITS:

A. NORMAL CROWN

| SECTION WITH GRADES 0.5% OR GREATER | SECTION WITH GRADES LESS THAN 0.5% |
|---|---|
| 0.0150 FT/FT - MINIMUM | 0.0156 FT/FT - MINIMUM |
| 0.0208 FT/FT - DESIRABLE | 0.0208 FT/FT - DESIRABLE |
| 0.0250 FT/FT - MAXIMUM | 0.0300 FT/FT - MAXIMUM |

B. SUPERELEVATION RATE

S.E. RATE SHOWN ON PLANS OR SE RATE EXISTING IN FIELD, WHICHEVER IS GREATER.

C. SUPERELEVATION TRANSITION LENGTH (LENGTH FROM FLAT POINT TO FULL SE)

| | RATE OF CHANGE | CORRESPONDING DIFFERENCE IN GRADE BETWEEN PIVOT POINT AND EDGE OF PAVEMENT |
|---|---|---|
| MINIMUM | 1:150 | 0.67% |
| DESIRABLE | 1:200 | 0.50% |
| MAXIMUM | 1:300 | 0.33% |

LENGTH SHALL BE SET TO AVOID CREATING A FLAT GUTTER GRADE ON LOW SIDE AND TO AVOID FLAT CROSS SLOPES AT OR NEAR THE LOW POINT OF VERTICAL CURVES.

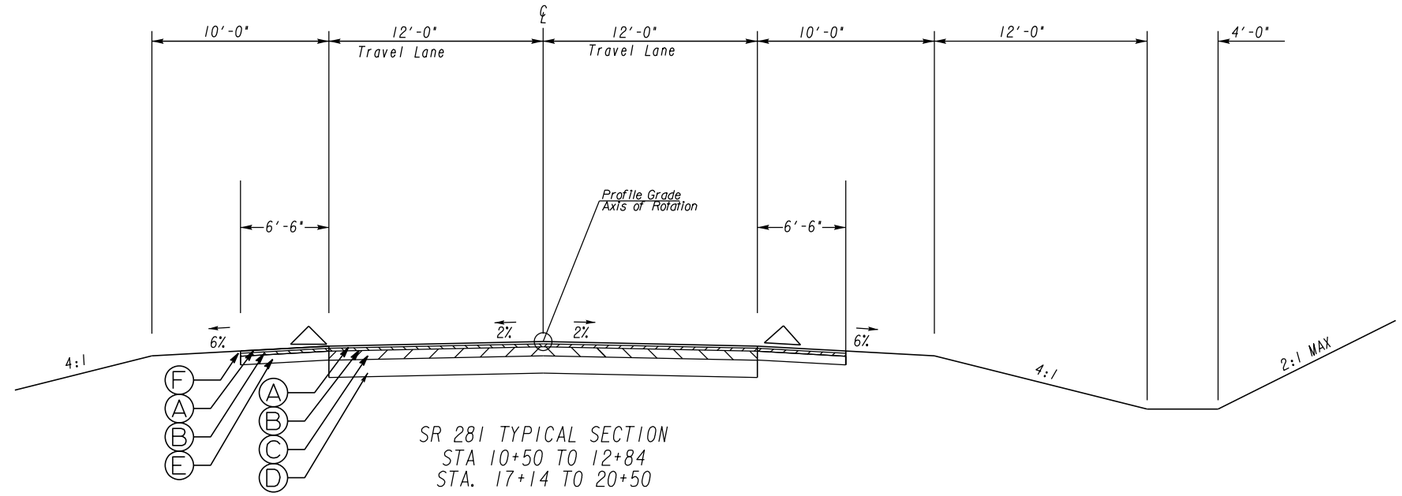
D. POSITIONING OF SUPERELEVATION TRANSITION LENGTH ON SIMPLE CURVES

50% OF TRANSITION INSIDE CURVE - MAXIMUM
33% OF TRANSITION INSIDE CURVE - DESIRABLE
20% OF TRANSITION INSIDE CURVE - MINIMUM

NOTE: CROWN WIPE-OUT SHALL BE AT THE SAME RATE AS THE SE TRANSITION.

E. SMOOTHING OF BREAKS IN EDGE PROFILE AT BEGIN AND END OF TRANSITION SHALL BE ACCOMPLISHED BY VERTICAL CURVE WITH A MINIMUM LENGTH (IN FEET) EQUAL TO THE SPEED DESIGN (IN MPH).

## TYPICAL SECTION APPLIES TO SR 281 OVER BROAD RIVER



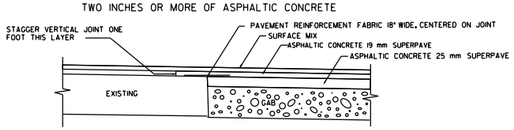

TS3

SR 281 TYPICAL SECTION
STA 10+50 TO 12+84
STA. 17+14 TO 20+50

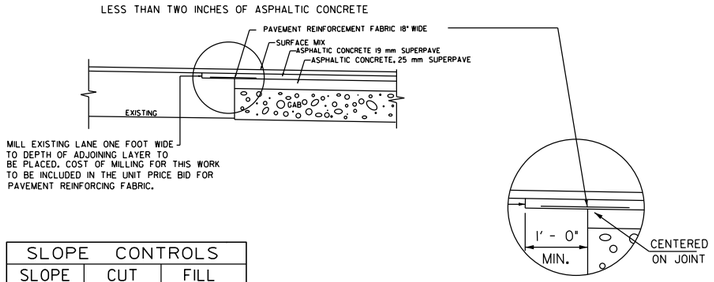
△ 16" SKIPPED MILLED RUMBLE STRIPS

(A) RECYCLED ASPH. CONC. 9.5 MM TYPE II SUPERPAVE, BLEND 1, INCL BITUM MATL & H LIME, 135 LBS/SY
(B) RECYCLED ASPH. CONC. 19 MM SUPERPAVE, GP 1 OR 2, INCL BITUM MATL & H LIME, 220 LBS/SY
(C) RECYCLED ASPH. CONC. 25 MM SUPERPAVE, GP 1 OR 2, INCL BITUM MATL & H LIME, 330 LBS/SY
(D) GRADED AGGREGATE BASE COURSE, 12" INCLUDING MATERIAL
(E) GRADED AGGREGATE BASE COURSE, 6" INCLUDING MATERIAL
(F) EDGE TREATMENT (SAFETY EDGE TREATMENT DETAIL P-7, SEE DETAIL.)

TYPICAL SECTION DETAIL TO BE USED WHEN EXISTING PAVEMENT IS TO BE RESURFACED WITH TWO INCHES OR MORE OF ASPHALTIC CONCRETE




TYPICAL SECTION DETAIL TO BE USED WHEN EXISTING PAVEMENT IS TO BE RESURFACED WITH LESS THAN TWO INCHES OF ASPHALTIC CONCRETE




| SLOPE CONTROLS | | |
|---|---|---|
| SLOPE | CUT | FILL |
| 4:1 | —— | 0-10' |
| 2:1 | ALL | OVER 10' |

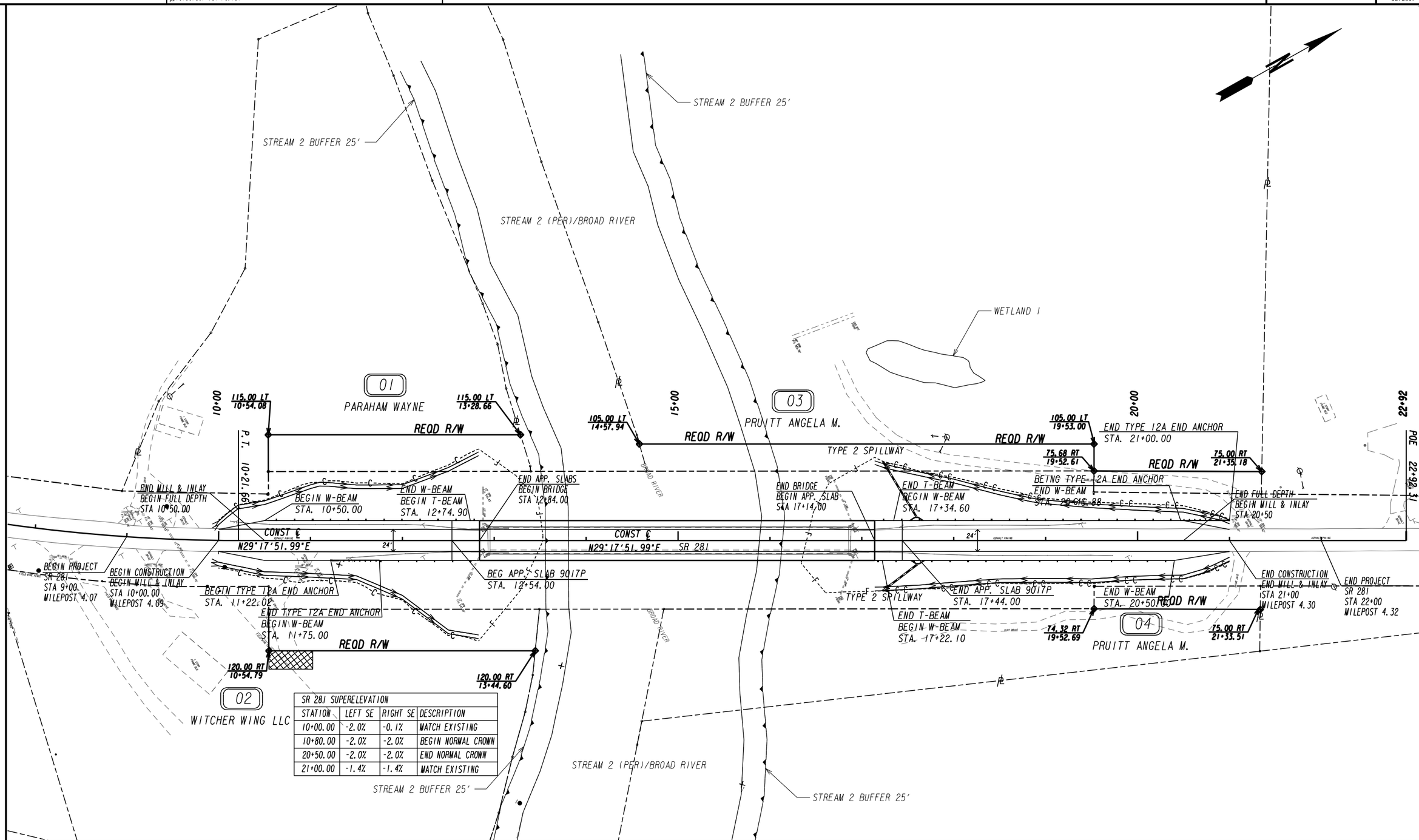
NOT TO SCALE

ROADWAY DESIGN

REVISION DATES

TYPICAL SECTIONS
0013997
MADISON COUNTY

| | | | | |
|---|---|---|---|---|
| CHECKED: | | DATE: | | DRAWING No. |
| BACKCHECKED: | | DATE: | | 05-0002 |
| CORRECTED: | | DATE: | | |
| VERIFIED: | | DATE: | | |




| SR 281 SUPERELEVATION | | | |
|---|---|---|---|
| STATION | LEFT SE | RIGHT SE | DESCRIPTION |
| 10+00.00 | -2.0% | -0.1% | MATCH EXISTING |
| 10+80.00 | -2.0% | -2.0% | BEGIN NORMAL CROWN |
| 20+50.00 | -2.0% | -2.0% | END NORMAL CROWN |
| 21+00.00 | -1.4% | -1.4% | MATCH EXISTING |

PROPERTY AND EXISTING R/W LINE
REQUIRED R/W LINE
CONSTRUCTION LIMITS
EASEMENT FOR CONSTR & MAINTENANCE OF SLOPES
EASEMENT FOR CONSTR OF SLOPES
EASEMENT FOR CONSTR OF DRIVES

BEGIN LIMIT OF ACCESS.....BLA
END LIMIT OF ACCESS.....ELA
LIMIT OF ACCESS
REQ'D R/W & LIMIT OF ACCESS
ORANGE BARRIER FENCE
ESA - ENV. SENSITIVE AREA (SEE ERIT TABLE)

**ROADWAY DESIGN**

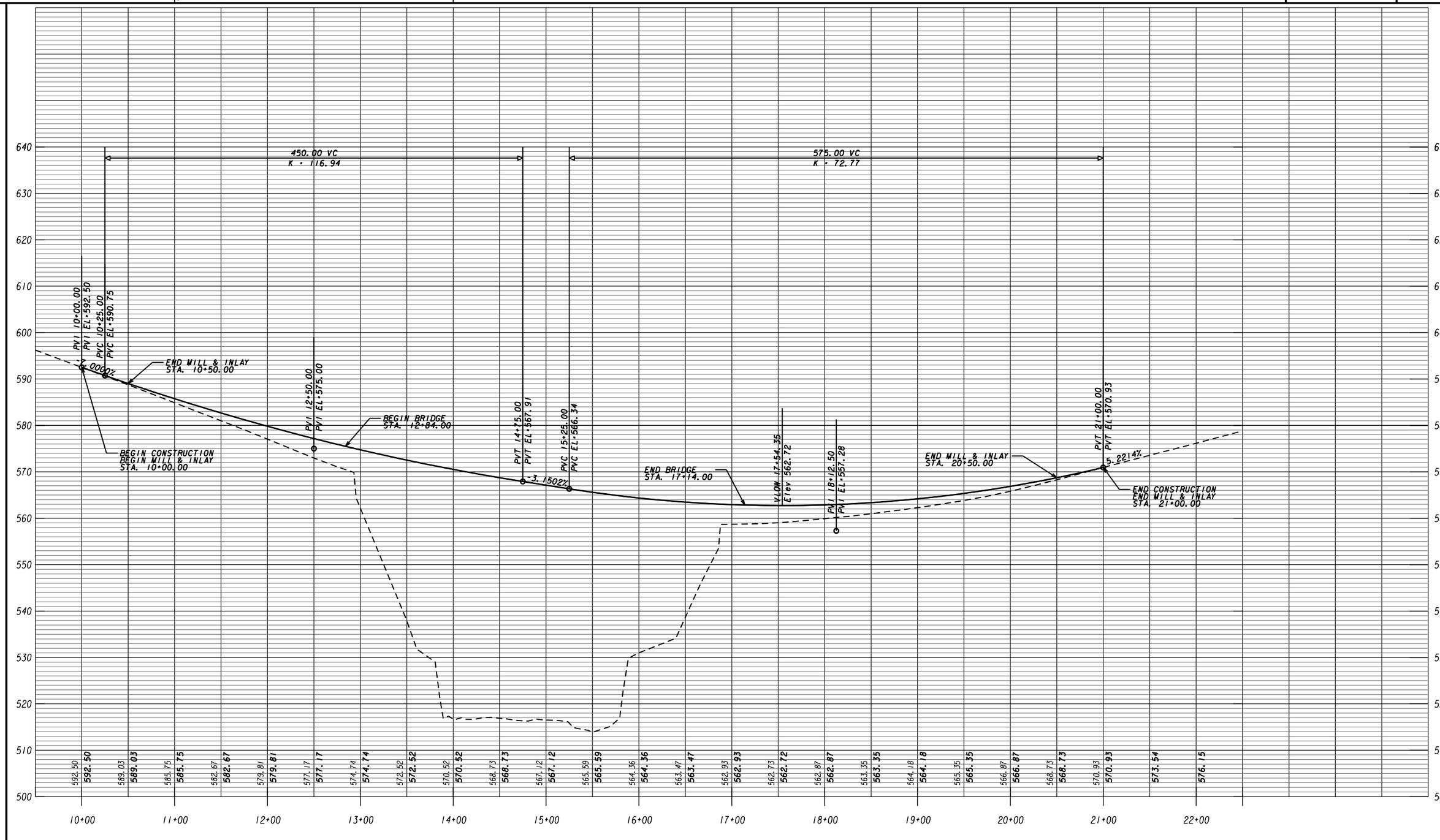
SCALE IN FEET
0 50 100 200

REVISION DATES

**CONSTRUCTION PLAN**
MADISON COUNTY

CHECKED: DATE:
BACKCHECKED: DATE:
CORRECTED: DATE:
VERIFIED: DATE:

DRAWING No. 13-0001




SR 281 DESIGN SPEED: 55 MPH

**ROADWAY DESIGN**

1"=10' VERTICAL
1"=100' HORIZONTAL

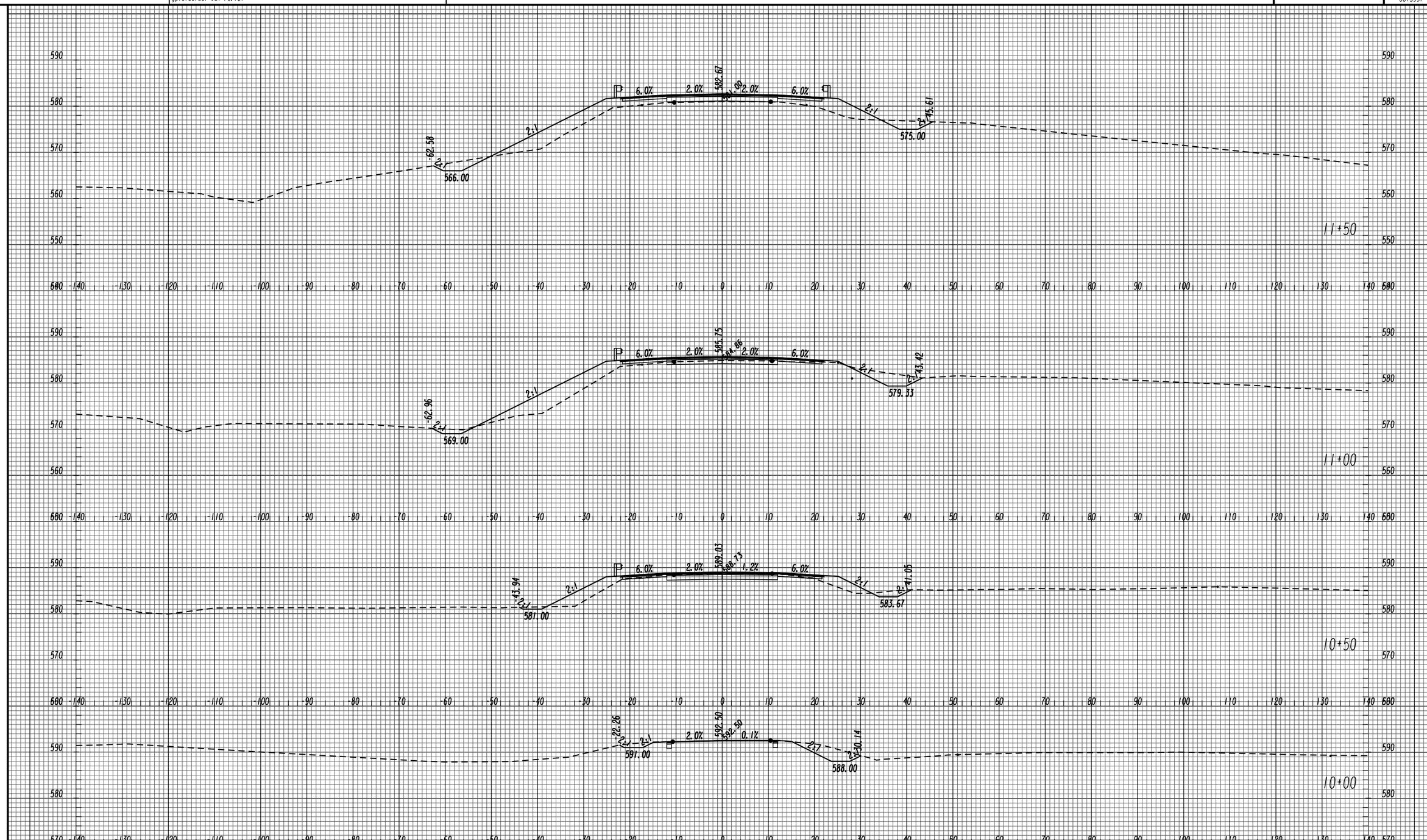
REVISION DATES

**MAINLINE PROFILE**

SR 281

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
15-0001




GDOT

ROADWAY DESIGN

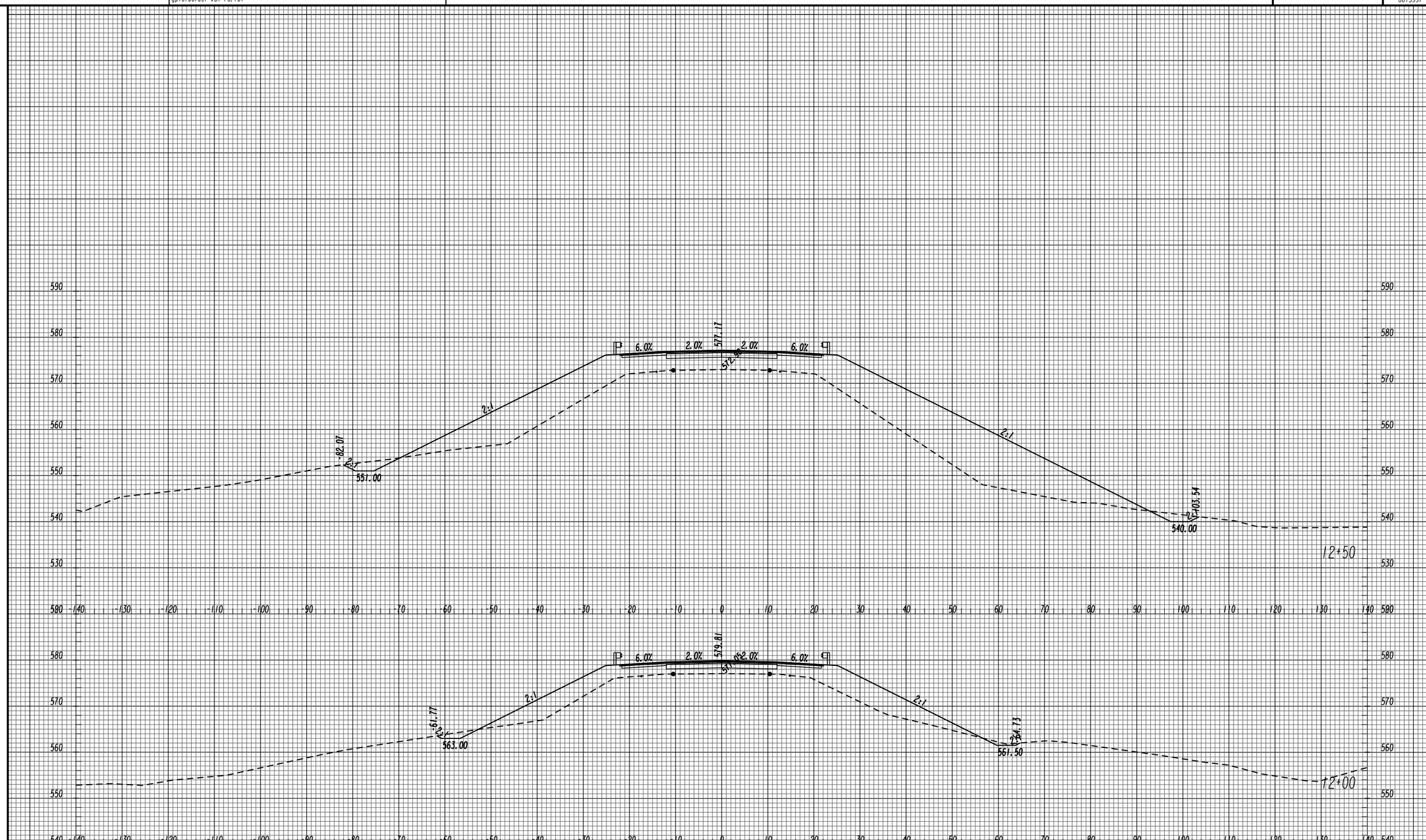
SCALE IN FEET
0 10 20 40

REVISION DATES

**CROSS SECTIONS**
SR 281
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
23-0001




ROADWAY DESIGN

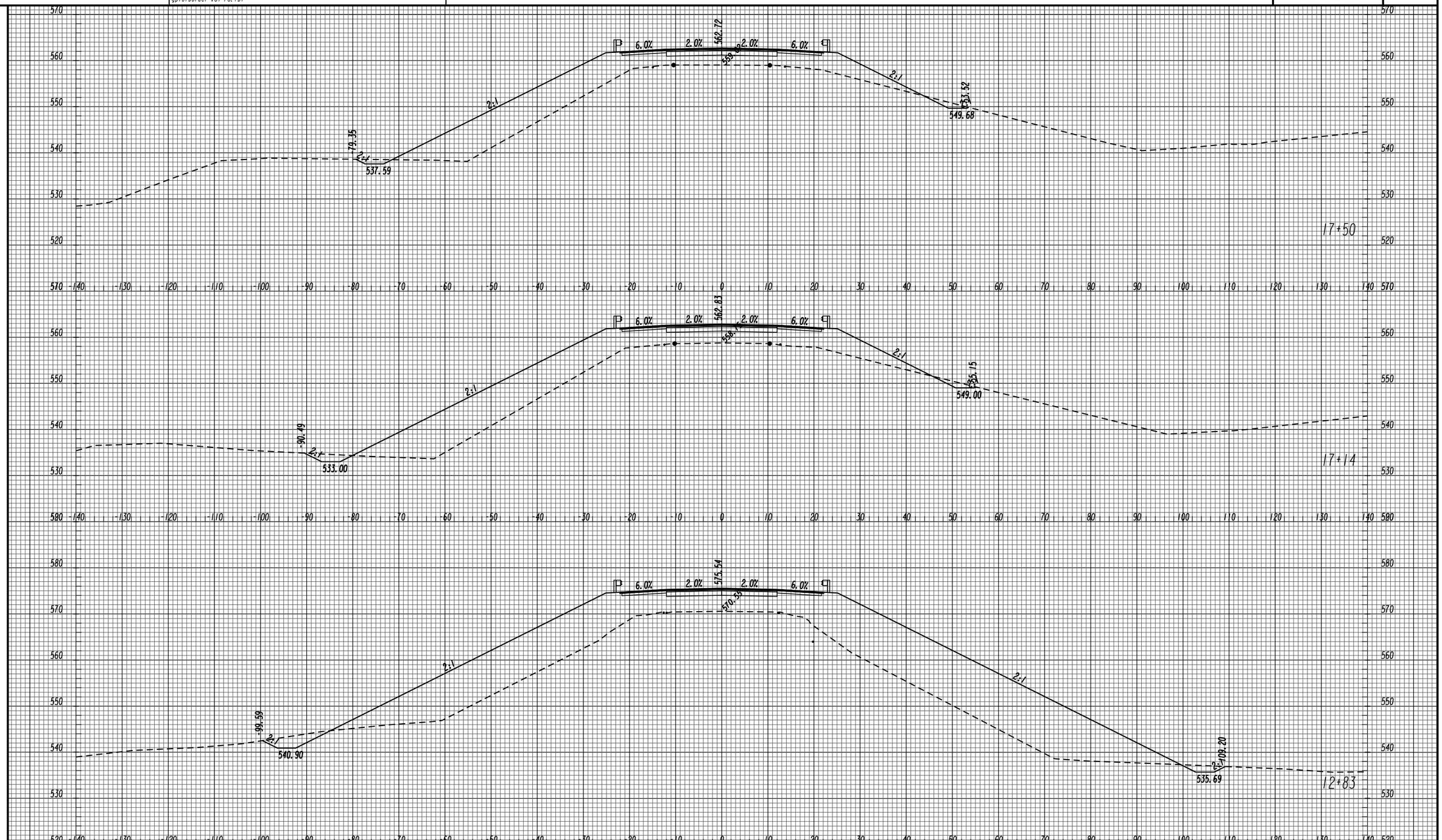
SCALE IN FEET
0 10 20 40

REVISION DATES

**CROSS SECTIONS**
SR 281
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
23-0002




ROADWAY DESIGN

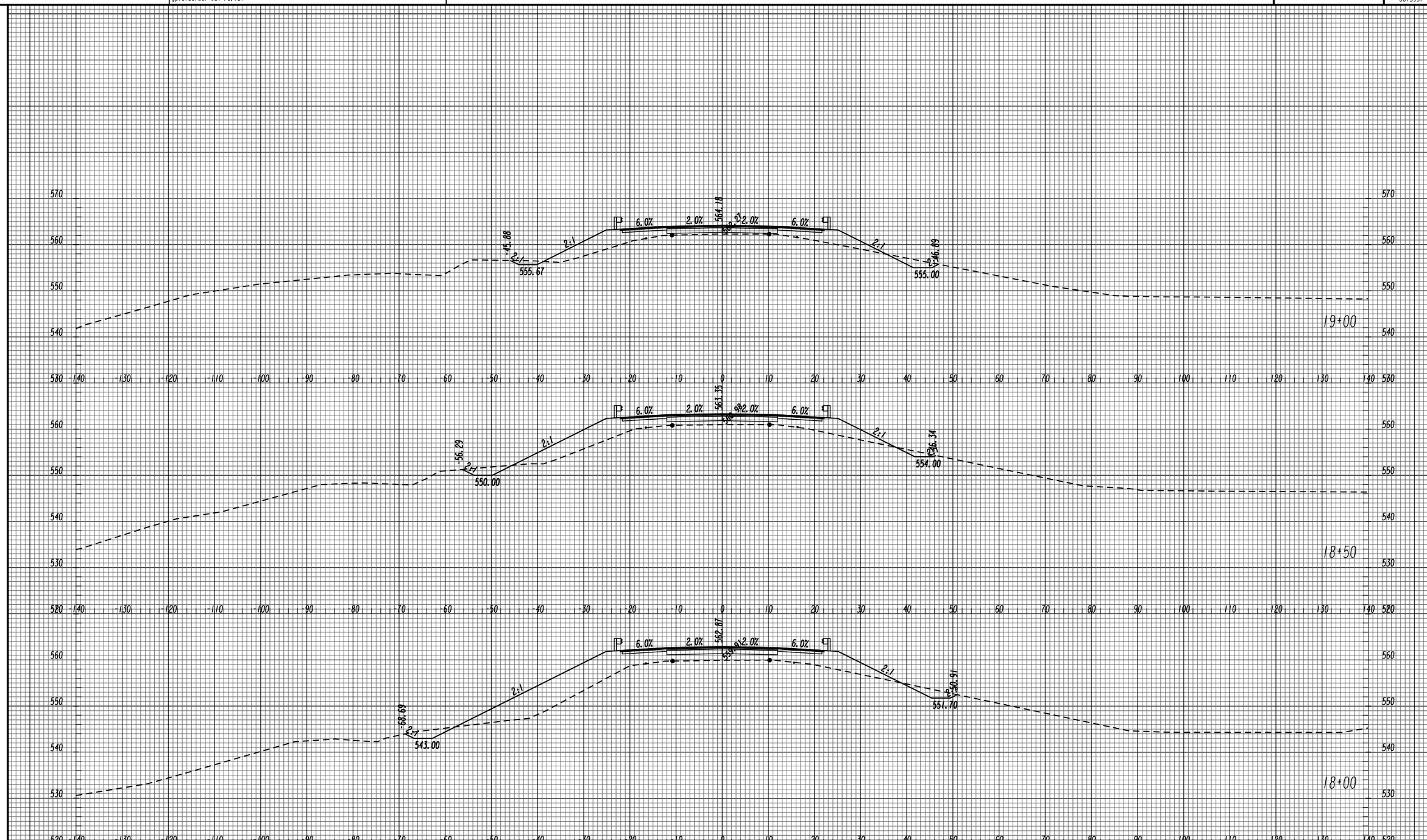
SCALE IN FEET
0 10 20 40

REVISION DATES

**CROSS SECTIONS**
SR 281
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
23-0003




GDOT

**ROADWAY DESIGN**

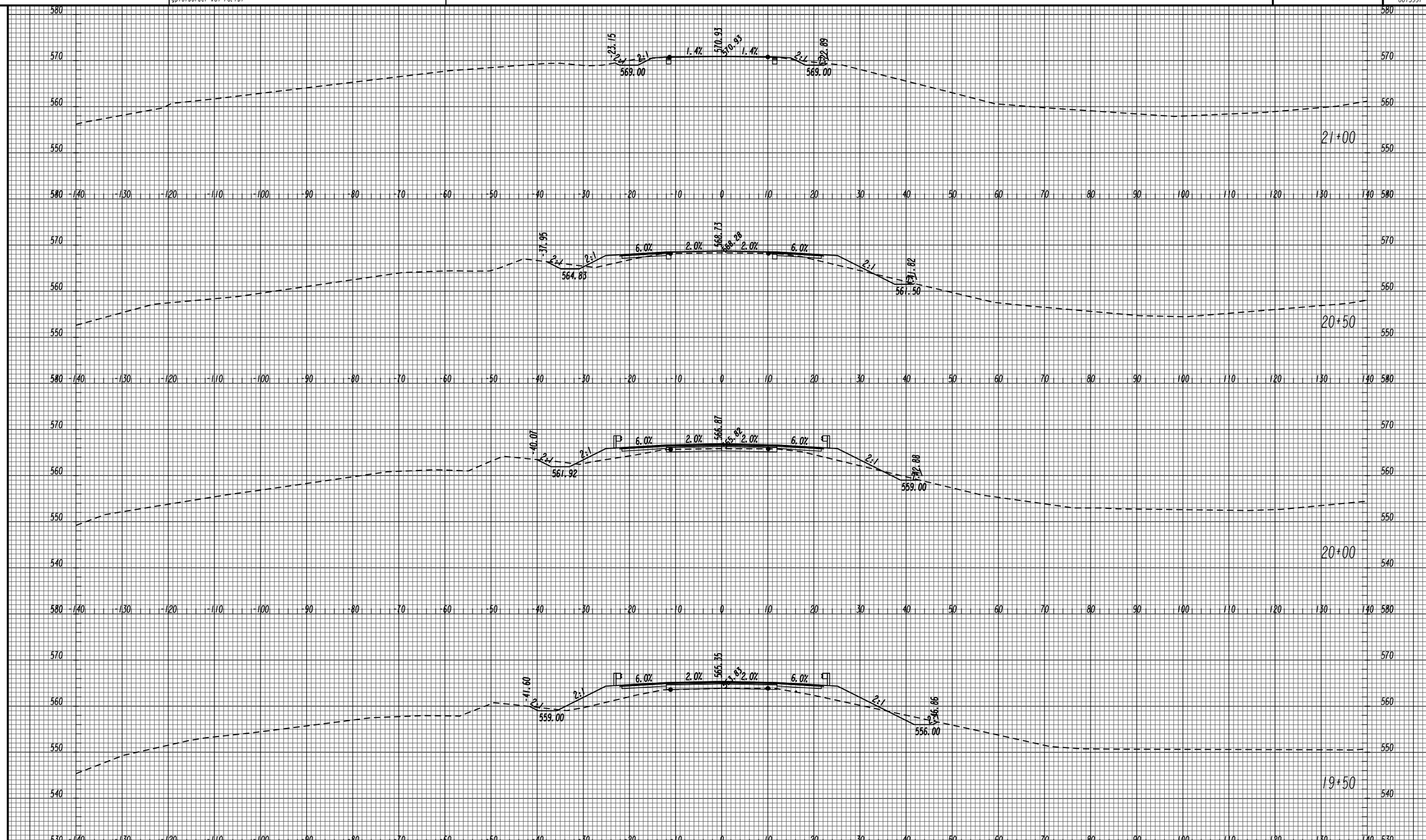
SCALE IN FEET
0 10 20 40

REVISION DATES

**CROSS SECTIONS**
SR 281
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
23-0004




ROADWAY DESIGN

SCALE IN FEET
0 10 20 40

REVISION DATES

**CROSS SECTIONS**
SR 281
MADISON COUNTY

| | | | |
|---|---|---|---|
| CHECKED: | | DATE: | |
| BACKCHECKED: | | DATE: | |
| CORRECTED: | | DATE: | |
| VERIFIED: | | DATE: | |

DRAWING No.
23-0005

SITE INSPECTION PHOTOS

SR 281 centerline looking north.

SR 281 centerline looking south.

Upstream floodplain north of river.

Upstream floodplain south of river.

Downstream floodplain north of river.

Downstream floodplain south of river.

River upstream from existing bridge.

River downstream from existing bridge.

Upstream face of existing bridge.

Downstream face of existing bridge.

Under existing bridge looking north.

Under existing bridge looking south.

Petroleum pipeline crossing the roadway south of existing bridge.

Petroleum pipeline warning sign located on the downstream north bank of the river

Fiber  optic cables crossing south of existing bridge.

House close to upstream north end of existing bridge.

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**100 Year Storm**
**Hydraulic Design Data**
**Contraction Scour**

| | Left | Channel | Right |
|---|---|---|---|
| **Input Data** | | | |
| Average Depth (ft): | 4.74 | 18.25 | 5.09 |
| Approach Velocity (ft/s): | 1.01 | 9.29 | 1.08 |
| Br Average Depth (ft): | 4.88 | 19.36 | 4.13 |
| BR Opening Flow (cfs): | 195.24 | 41216.48 | 488.29 |
| BR Top WD (ft): | 27.9 | 196.17 | 90.27 |
| Grain Size D50 (mm): | 0.38 | 0.38 | 0.38 |
| Approach Flow (cfs): | 204.67 | 40031.41 | 1663.92 |
| Approach Top WD (ft): | 42.52 | 236.09 | 303.14 |
| K1 Coefficient: | 0.69 | 0.69 | 0.69 |
| **Results** | | | |
| Scour Depth Ys (ft): | **0** | **1.90** | **0** |
| Critical Velocity (ft/s): | 1.56 | 1.96 | 1.58 |
| Equation: | Clear | Live | Clear |

**Pier Scour**
**Pier: #1 (CL = 1424)**
**Input Data**

| | |
|---|---|
| Pier Shape: | Square nose |
| Pier Width (ft): | 3 |
| Grain Size D50 (mm): | 0.38 |
| Depth Upstream (ft): | 19.76 |
| Velocity Upstream (ft/s): | 10.21 |
| K1 Nose Shape: | 1.1 |
| Pier Angle: | 0 |
| Pier Length (ft): | 40 |
| K2 Angle Coef: | 1 |
| K3 Bed Cond Coef: | 1.1 |
| Grain Size D90 (mm): | 0.57 |
| K4 Armouring Coef: | 1 |

**Results**

| | |
|---|---|
| Scour Depth Ys (ft): | **9.52** |
| Froude #: | 0.4 |
| Equation: | CSU equation |

**Pier: #2 (CL = 1574)**
**Input Data**

| | |
|---|---|
| Pier Shape: | Square nose |
| Pier Width (ft): | 3 |
| Grain Size D50 (mm): | 0.38 |
| Depth Upstream (ft): | 18.46 |
| Velocity Upstream (ft/s): | 9.97 |
| K1 Nose Shape: | 1.1 |
| Pier Angle: | 0 |
| Pier Length (ft): | 40 |
| K2 Angle Coef: | 1 |
| K3 Bed Cond Coef: | 1.1 |
| Grain Size D90 (mm): | 0.57 |
| K4 Armouring Coef: | 1 |

**Results**

| | |
|---|---|
| Scour Depth Ys (ft): | **9.34** |
| Froude #: | 0.41 |
| Equation: | CSU equation |

**Combined Scour Depths**

| | |
|---|---|
| **Pier : #1 (CL = 1424) (Contr + Pier) (ft):** | **11.42** |
| **Pier : #2 (CL = 1574) (Contr + Pier) (ft):** | **11.24** |

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**500 Year Storm**
**Hydraulic Design Data**
**Contraction Scour**

| | Left | Channel | Right |
|---|---|---|---|
| **Input Data** | | | |
| Average Depth (ft): | 6.18 | 21.81 | 8.12 |
| Approach Velocity (ft/s): | 1.14 | 9.94 | 1.4 |
| Br Average Depth (ft): | 6.92 | 22.65 | 7.02 |
| BR Opening Flow (cfs): | 442.17 | 53552.61 | 1305.22 |
| BR Top WD (ft): | 34.48 | 196.17 | 96.85 |
| Grain Size D50 (mm): | 0.38 | 0.38 | 0.38 |
| Approach Flow (cfs): | 420.59 | 51158.41 | 3721 |
| Approach Top WD (ft): | 59.48 | 236.09 | 327.88 |
| K1 Coefficient: | 0.69 | 0.69 | 0.69 |
| **Results** | | | |
| Scour Depth Ys (ft): | **0.11** | **3.12** | **0.32** |
| Critical Velocity (ft/s): | 1.63 | 2.02 | 1.71 |
| Equation: | Clear | Live | Clear |

**Pier Scour**
**Pier: #1 (CL = 1424)**
**Input Data**

| | |
|---|---|
| Pier Shape: | Square nose |
| Pier Width (ft): | 3 |
| Grain Size D50 (mm): | 0.38 |
| Depth Upstream (ft): | 23.14 |
| Velocity Upstream (ft/s): | 11.3 |
| K1 Nose Shape: | 1.1 |
| Pier Angle: | 0 |
| Pier Length (ft): | 40 |
| K2 Angle Coef: | 1 |
| K3 Bed Cond Coef: | 1.1 |
| Grain Size D90 (mm): | 0.57 |
| K4 Armouring Coef: | 1 |

**Results**

| | |
|---|---|
| Scour Depth Ys (ft): | **10.16** |
| Froude #: | 0.41 |
| Equation: | CSU equation |

**Pier: #2 (CL = 1574)**
**Input Data**

| | |
|---|---|
| Pier Shape: | Square nose |
| Pier Width (ft): | 3 |
| Grain Size D50 (mm): | 0.38 |
| Depth Upstream (ft): | 21.84 |
| Velocity Upstream (ft/s): | 11.06 |
| K1 Nose Shape: | 1.1 |
| Pier Angle: | 0 |
| Pier Length (ft): | 40 |
| K2 Angle Coef: | 1 |
| K3 Bed Cond Coef: | 1.1 |
| Grain Size D90 (mm): | 0.57 |
| K4 Armouring Coef: | 1 |

**Results**

| | |
|---|---|
| Scour Depth Ys (ft): | **9.98** |
| Froude #: | 0.42 |
| Equation: | CSU equation |

**Combined Scour Depths**

| | |
|---|---|
| **Pier : #1 (CL = 1424) (Contr + Pier) (ft):** | **13.28** |
| **Pier : #2 (CL = 1574) (Contr + Pier) (ft):** | **13.11** |

**FHWA GUIDE BANK CALCULATIONS**

Project: 0013997

County: Madison

Date: October, 2018

**STRUCTURE**: SR 281 Over Broad River

**LEFT SIDE**:

$Q_{Total}$ = 41,900 cfs

Station where 100 year floodstage reaches the left embankment = 13+52.56

$$\frac{Q_f}{Q_{100}} = \frac{K_f}{K_{100}} = \frac{3{,}247.74\ cfs}{20{,}796.03\ cfs} = 0.16$$

MEAN VELOCITY = 9.77 fps

LENGTH OF GUIDE BANK < 50 ft

**RIGHT SIDE**:

$Q_{Total}$ = 41,900 cfs

Station where 100 year floodstage reaches the right embankment = 16+73.66

$$\frac{Q_f}{Q_{100}} = \frac{K_f}{K_{100}} = \frac{973.87\ cfs}{606.95\ cfs} = 1.60$$

MEAN VELOCITY = 9.77 fps

LENGTH OF GUIDE BANK = 150 ft

**COMMENTS**: A guide bank is not required at the south end of the proposed bridge, but a 150 ft long guide bank is required at the north end of proposed bridge. However, due to the fact that the existing bridge has been in place since 1956, and there is no evidence of scour along the roadway embankments or bridge endrolls, no guide banks will be built at the proposed bridge.

The above equations are shown in the FHWA publication HEC No. 23. "Bridge Scour and Stream Instability Countermeasures."

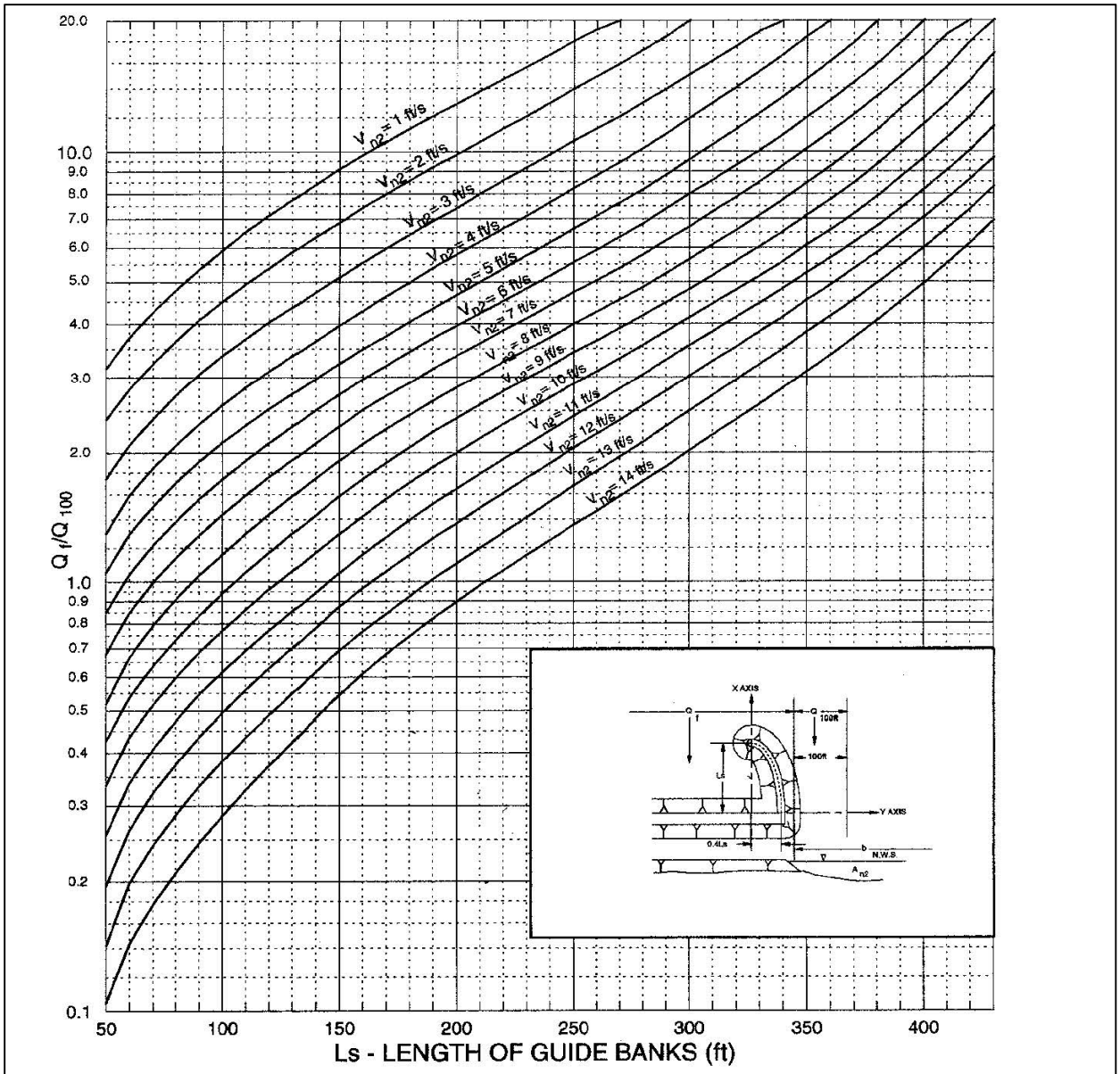



Figure 10.3. English version of nomograph to determine guidebank length (after Bradley).[1]

Plan: Pro  Broad River  SR 281  RS: 240  Profile: 100 yr

| | Pos | Left Sta | Right Sta | Flow | Area | W.P. | Percent | Hydr | Velocity | Shear | Power |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (ft) | (ft) | (cfs) | (sq ft) | (ft) | Conv | Depth(ft) | (ft/s) | (lb/sq ft) | (lb/ft s) |
| 1 | LOB | 1262.26 | 1294.55 | 11.98 | 21.96 | 11.01 | 0.03 | 2.15 | 0.55 | 0.13 | 0.07 |
| 2 | LOB | 1294.55 | 1326.84 | 192.69 | 179.70 | 32.68 | 0.46 | 5.57 | 1.07 | 0.35 | 0.38 |
| 3 | Chan | 1326.84 | 1338.65 | 864.64 | 141.16 | 14.08 | 2.06 | 11.96 | 6.13 | 0.64 | 3.93 |
| 4 | Chan | 1338.65 | 1350.45 | 1811.17 | 208.86 | 12.36 | 4.32 | 17.69 | 8.67 | 1.08 | 9.38 |
| 5 | Chan | 1350.45 | 1362.25 | 2053.86 | 221.41 | 11.85 | 4.90 | 18.76 | 9.28 | 1.20 | 11.10 |
| 6 | Chan | 1362.25 | 1374.06 | 2272.90 | 235.53 | 11.87 | 5.42 | 19.95 | 9.65 | 1.27 | 12.26 |
| 7 | Chan | 1374.06 | 1385.86 | 2518.50 | 250.36 | 11.86 | 6.01 | 21.21 | 10.06 | 1.35 | 13.60 |
| 8 | Chan | 1385.86 | 1397.67 | 2582.86 | 253.72 | 11.81 | 6.16 | 21.49 | 10.18 | 1.38 | 14.01 |
| 9 | Chan | 1397.67 | 1409.47 | 2618.42 | 255.82 | 11.81 | 6.25 | 21.67 | 10.24 | 1.39 | 14.20 |
| 10 | Chan | 1409.47 | 1421.28 | 2636.51 | 256.85 | 11.81 | 6.29 | 21.76 | 10.26 | 1.39 | 14.30 |
| 11 | Chan | 1421.28 | 1433.08 | 2555.33 | 252.29 | 11.83 | 6.10 | 21.37 | 10.13 | 1.37 | 13.83 |
| 12 | Chan | 1433.08 | 1444.89 | 2414.46 | 243.78 | 11.82 | 5.76 | 20.65 | 9.90 | 1.32 | 13.08 |
| 13 | Chan | 1444.89 | 1456.69 | 2323.76 | 238.16 | 11.81 | 5.55 | 20.18 | 9.76 | 1.29 | 12.60 |
| 14 | Chan | 1456.69 | 1468.49 | 2336.98 | 238.93 | 11.81 | 5.58 | 20.24 | 9.78 | 1.30 | 12.68 |
| 15 | Chan | 1468.49 | 1480.30 | 2399.07 | 243.00 | 11.84 | 5.73 | 20.59 | 9.87 | 1.31 | 12.98 |
| 16 | Chan | 1480.30 | 1492.10 | 2603.29 | 255.64 | 11.89 | 6.21 | 21.66 | 10.18 | 1.38 | 14.02 |
| 17 | Chan | 1492.10 | 1503.91 | 2399.30 | 244.22 | 11.99 | 5.73 | 20.69 | 9.82 | 1.30 | 12.82 |
| 18 | Chan | 1503.91 | 1515.71 | 1804.16 | 213.31 | 13.11 | 4.31 | 18.07 | 8.46 | 1.04 | 8.81 |
| 19 | Chan | 1515.71 | 1527.52 | 1359.92 | 173.57 | 11.96 | 3.25 | 14.70 | 7.83 | 0.93 | 7.28 |
| 20 | Chan | 1527.52 | 1539.32 | 1073.98 | 150.65 | 11.96 | 2.56 | 12.76 | 7.13 | 0.81 | 5.75 |
| 21 | Chan | 1539.32 | 1551.13 | 815.69 | 127.73 | 11.96 | 1.95 | 10.82 | 6.39 | 0.68 | 4.37 |
| 22 | Chan | 1551.13 | 1562.93 | 586.63 | 104.81 | 11.96 | 1.40 | 8.88 | 5.60 | 0.56 | 3.14 |
| 23 | ROB | 1562.93 | 1633.41 | 545.77 | 448.64 | 70.55 | 1.30 | 6.37 | 1.22 | 0.41 | 0.50 |
| 24 | ROB | 1633.41 | 1703.88 | 252.59 | 283.07 | 70.86 | 0.60 | 4.02 | 0.89 | 0.26 | 0.23 |
| 25 | ROB | 1703.88 | 1774.36 | 440.00 | 396.37 | 71.51 | 1.05 | 5.62 | 1.11 | 0.35 | 0.39 |
| 26 | ROB | 1774.36 | 1844.83 | 404.33 | 374.87 | 70.61 | 0.96 | 5.32 | 1.08 | 0.34 | 0.37 |
| 27 | ROB | 1844.83 | 1915.31 | 21.22 | 39.75 | 21.50 | 0.05 | 1.87 | 0.53 | 0.12 | 0.06 |

Plan: Pro  Broad River  SR 281  RS: 0  Profile: 100 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 537.97 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 536.42 | E.G. Elev (ft) | 537.89 | 537.81 |
| Q Total (cfs) | 41900.00 | W.S. Elev (ft) | 536.09 | 536.32 |
| Q Bridge (cfs) | 41900.00 | Crit W.S. (ft) | 527.95 | 528.55 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 21.75 | 22.03 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 9.73 | 9.77 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 4305.71 | 4287.86 |
| Weir Submerg | | Froude # Chl | 0.43 | 0.45 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 52396.53 | 50493.88 |
| Min El Weir Flow (ft) | 562.59 | Hydr Depth (ft) | 13.70 | 13.91 |
| Min El Prs (ft) | 567.92 | W.P. Total (ft) | 401.28 | 384.80 |
| Delta EG (ft) | 0.24 | Conv. Total (cfs) | 930837.4 | 908943.7 |
| Delta WS (ft) | -0.04 | Top Width (ft) | 314.34 | 308.18 |
| BR Open Area (sq ft) | 12909.35 | Frctn Loss (ft) | 0.08 | 0.08 |
| BR Open Vel (ft/s) | 9.77 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.36 | 1.48 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 13.21 | 14.45 |

**P.I. No. 0013997, MADISON COUNTY**
**SR 281 OVER BROAD RIVER**

**PROPOSED 430 FT LONG BRIDGE**

ENDROLL RIPRAP CALCULATIONS (100 YEAR STORM)
METHOD IN HEC-23,"BRIDGE SCOUR AND STREAM INSTABILITY COUNTERMEASURES"

| | | |
|---|---|---|
| BRIDGE ABUTMENT LOCATION | 13+57.85 | 16+94.04 |

| | | |
|---|---|---|
| SET BACK LENGTH (ft) | 23.21 | 116.95 |
| MAIN CHANNEL AREA @ BRIDGE ($ft^2$) | 3598.66 | 3598.66 |
| TOP WIDTH OF MAIN CHANNEL @ BRIDGE (ft) | 184.03 | 184.03 |
| AVERAGE DEPTH OF MAIN CHANNEL @ BR (ft) | 19.55 | 19.55 |
| SET BACK RATIO | 1.19 | 5.98 |

CHARACTERISTIC AVG VELOCITY CALCULATIONS

| | | |
|---|---|---|
| DISCHARGE @ ABUTMENT (cfs) | 41045.52 | 854.48 |
| AREA @ ABUTMENT ($ft^2$) | 3773.40 | 514.46 |
| AVERAGE VELOCITY, V (ft/s) | 10.88 | 1.66 |

| | | |
|---|---|---|
| AREA OF OVERBANK FLOW @ BRIDGE ($ft^2$) | 174.74 | 514.46 |
| LENGTH OF OVERBANK FLOW @ BRIDGE (ft) | 33.19 | 90.97 |
| AVERAGE DEPTH OF OVERBANK FLOW (ft) | 5.26 | 5.66 |

| | | |
|---|---|---|
| FROUDE NUMBER | 0.84 | 0.13 |

| | | |
|---|---|---|
| IF FROUDE NUMBER ≤ 0.80, THEN D50 = | 1.98 | 0.05 |
| IF FROUDE NUMBER > 0.80, THEN D50 = | 1.85 | 1.16 |

| | | |
|---|---|---|
| MEDIAN STONE DIAMETER REQUIRED, D50 = | 1.85 | 0.05 |

| | | |
|---|---|---|
| TYPE OF RIPRAP REQUIRED | TYPE 1 | TYPE 3 |

**Use Type I riprap at both endrolls per Drainage Manual.**

**Rip Rap Data**

| **Plan: Pro Broad River SR 281 RS: 0** | | **BR D Profile: 100 yr** | | | |
|---|---|---|---|---|---|
| **E.G. Elev (ft)** | 537.81 | **Element** | **Left OB** | **Channel** | **Right OB** |
| **Vel Head (ft)** | 1.48 | **Wt. n-Val.** | 0.13 | 0.035 | 0.13 |
| **W.S. Elev (ft)** | 536.32 | **Reach Len. (ft)** | 50 | 50 | 50 |
| **Crit W.S. (ft)** | 528.55 | **Flow Area (sq ft)** | 174.74 | 3598.66 | 514.46 |
| **E.G. Slope (ft/ft)** | 0.002125 | **Area (sq ft)** | 174.74 | 3598.66 | 514.46 |
| **Q Total (cfs)** | 41900 | **Flow (cfs)** | 271.31 | 40774.21 | 854.48 |
| **Top Width (ft)** | 308.18 | **Top Width (ft)** | 33.19 | 184.03 | 90.97 |
| **Vel Total (ft/s)** | 9.77 | **Avg. Vel. (ft/s)** | 1.55 | 11.33 | 1.66 |
| **Max Chl Dpth (ft)** | 22.03 | **Hydr. Depth (ft)** | 5.27 | 19.55 | 5.66 |
| **Conv. Total (cfs)** | 908943.7 | **Conv. (cfs)** | 5885.6 | 884521.7 | 18536.5 |
| **Length Wtd. (ft)** | 50 | **Wetted Per. (ft)** | 34.55 | 258.33 | 91.92 |
| **Min Ch El (ft)** | 514.29 | **Shear (lb/sq ft)** | 0.67 | 1.85 | 0.74 |
| **Alpha** | 1 | **Stream Power (lb/ft s)** | 1.04 | 20.94 | 1.23 |
| **Frctn Loss (ft)** | 0.08 | **Cum Volume (acre-ft)** | 1.37 | 19.42 | 1.91 |
| **C & E Loss (ft)** | 0 | **Cum SA (acres)** | 0.33 | 1.02 | 0.37 |

## Geometric Variables

| FLAT GRADE | CONSTANT GRADE | **VERTICAL CURVE** |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| g1 | = | **-7.0000** | % | Grade 1, vertical grade before PVI |
| g2 | = | **-3.1502** | % | Grade 2, vertical grade after PVI |
| LVC | = | **450.00** | ft | Length of vertical curve |
| PVI | = | **12+50.00** | - | Station at PVI |
| Beg | = | **12+84.00** | - | Station at beginning of bridge |
| L | = | **241.00** | ft | Length of bridge |

## Preliminary Data Analysis

| | | | | |
|---|---|---|---|---|
| Freq | = | **10** | year | Storm frequency -- 10 year per GDOT design manual |
| Speed | = | **55** | mph | Vehicle design speed |
| ID | = | **195-0021-0** | - | Existing Bridge Serial Number |

## Street Hydraulics

| | | | | |
|---|---|---|---|---|
| $W_p$ | = | **20.000** | ft | Width being drained -- typically half of pavement |
| T | = | **8.0000** | ft | Design spread |
| $S_x$ | = | **2.0** | % | Cross-slope of deck |
| n | = | **0.016** | - | Manning's coefficient -- typically, n = 0.016 |
| C | = | **0.90** | - | Runoff -- typically, C = 0.9 for pavements |

## Inlet Specifications

| CURB INLET | NEENAH | HEC-22 | **GDOT** |
|---|---|---|---|

| **4 in. Scupper** | | | | Grate Details |
|---|---|---|---|---|
| L | = | 0.33 | ft | Inlet opening length |
| W | = | 0.33 | ft | Inlet opening width |
| H | = | n/a | ft | Inlet opening height |
| a | = | n/a | ft | Local Inlet depression |

*Capacity determined by information found in GDOT drainage manual, capacity in-sump determined by weir/orifice hydraulics.*

## Design Notes

- Bridge analysis broken into two parts for each vertical curve
- Bridge length of 241 ft goes to PVC of second curve where second part of bridge analysis will begin

  Deck drain at station 15+14 has 0.128 cfs of bypass flow that will be included in next part of analysis

## Establishment of Rainfall Intensity

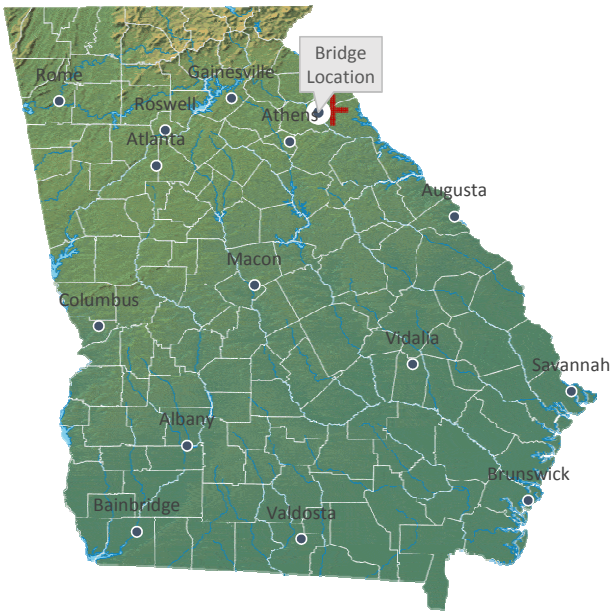
Closest station

| |
|---|
| Bowman |

Station Information

| |
|---|
| Bowman, GA |
| BOWMAN |
| 34.2000$^0$ LAT |
| -83.0333$^0$ LON |
| 785 ft |

Station Location




IDF Calculations

| | | | |
|---|---|---|---|
| $t_o$ | = | 0.70 | min |
| $t_g$ | = | 4.45 | min |
| $t_c$ | = | 5.15 | min |
| $t_t$ | = | 5.10 | min |
| i | = | 7.74 | in/hr |
| $L_o$ | = | - | ft |

Inlet requirement

SEE VERTICAL CURVE SECTION

*Rainfall intensity is calculated using intensity-duration-frequency (IDF) curves and methods consistent with GDOT drainage manual. Point precipitation frequency estimates are taken from NOAA Atlas 14 Volume 9 for partial duration time series.*

## Inlet Spacing on Flat Bridge

| | | | | |
|---|---|---|---|---|
| $P_{INLET}$ | = | 1.05 | ft | Inlet perimeter |
| $P_{REQ}$ | = | 3.58 | ft | Required inlet perimeter |
| $L_c$ | = | 220 | ft | Inlet spacing assuming 100% efficiency |
| Spacing | = | 64 | ft | Required inlet spacing |

## Inlet Spacing for Bridge on Grade

| | Spacing (ft) | Gutter Flow (cfs) | Efficiency (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|
| $L_0$ | | | | | |
| $L_1$ | | | | | |
| $L_2$ | | | | | |
| $L_3$ | | | | | |
| $L_4$ | | | | | |
| $L_n$ | | | | | |

*Flat bridge spacing should be considered for bridges with grades less than 0.03%.*

## Hydroplaining and Visibility

| | | | |
|---|---|---|---|
| Hydroplane Depth | = | 0.080 in | Depth at which hydroplaning can occur |
| Hydroplain | = | OK | Risk of hydroplaning at rain intensity |
| Visibility | = | Reduced | Risk of impaired vision due to rain |

*Hydroplaning and visibility design procedures taken from methods in HEC-22. Methods shown are for constant-slope and flat bridges.*

# Inlet Spacing on Vertical Curve

| | | |
|---|---|---|
| Curve = | **CREST** | Vertical Curve Type |
| $X_{HP}$ = | **10+25.00** | Vertical Curve High or Low Point |
| $B_{HP}$ = | **12+84.00** | Bridge High or Low point |

| | Inlet | Station | Spacing (ft) | Local S (ft/ft) | Flow (cfs) | Eff. (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|---|---|---|
| ↑ ↑ ↑ LEFT OF HIGH/LOW POINT ↑ ↑ ↑ | | | | | | | | |
| -- High Point at 12+84.00 with -4.784% Slope -- | | | | | | | | |
| ↓ ↓ ↓ RIGHT OF HIGH/LOW POINT ↓ ↓ ↓ | $L_1$ | 12+94.00 | 10 | -0.047 | 0.032 | 33.83 | 0.02 | 1.48 |
| | $L_2$ | 13+04.00 | 10 | -0.046 | 0.053 | 22.93 | 0.04 | 1.80 |
| | $L_3$ | 13+14.00 | 10 | -0.045 | 0.073 | 18.96 | 0.06 | 2.03 |
| | $L_4$ | 13+24.00 | 10 | -0.044 | 0.091 | 17.10 | 0.08 | 2.22 |
| | $L_5$ | 13+34.00 | 10 | -0.044 | 0.107 | 16.15 | 0.09 | 2.37 |
| | $L_6$ | 13+44.00 | 10 | -0.043 | 0.122 | 15.68 | 0.10 | 2.50 |
| | $L_7$ | 13+54.00 | 10 | -0.042 | 0.135 | 15.49 | 0.11 | 2.60 |
| | $L_8$ | 13+64.00 | 10 | -0.041 | 0.146 | 15.48 | 0.12 | 2.69 |
| | $L_9$ | 13+74.00 | 10 | -0.040 | 0.155 | 15.60 | 0.13 | 2.76 |
| | $L_{10}$ | 13+84.00 | 10 | -0.039 | 0.163 | 15.81 | 0.14 | 2.83 |
| | $L_{11}$ | 13+94.00 | 10 | -0.038 | 0.169 | 16.11 | 0.14 | 2.88 |
| | $L_{12}$ | 14+04.00 | 10 | -0.038 | 0.174 | 16.46 | 0.15 | 2.92 |
| | $L_{13}$ | 14+14.00 | 10 | -0.037 | 0.177 | 16.88 | 0.15 | 2.95 |
| | $L_{14}$ | 14+24.00 | 10 | -0.036 | 0.179 | 17.34 | 0.15 | 2.98 |
| | $L_{15}$ | 14+34.00 | 10 | -0.035 | 0.180 | 17.85 | 0.15 | 3.00 |
| | $L_{16}$ | 14+44.00 | 10 | -0.034 | 0.180 | 18.40 | 0.15 | 3.01 |
| | ... | ... | ... | ... | ... | ... | ... | ... |

*If the low point lies on the bridge, additional checks to the gutter spread and flanking inlets are required. Refer to the GDOT Drainage Manual for more info.*

## Inlet Spacing for Bridge on Vertical Curve (continued)

| | Inlet | Station | Spacing (ft) | Local S (ft/ft) | Flow (cfs) | Eff. (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|---|---|---|
| | -- High Point at 12+84.00 with -4.784% Slope -- | | | | | | | |
| ← ← ← ← ← ← RIGHT OF HIGH/LOW POINT ← ← ← | $L_1$ | 12+94 | 10 | -0.047 | 0.032 | 33.83 | 0.021 | 1.48 |
| | $L_2$ | 13+04 | 10 | -0.046 | 0.053 | 22.93 | 0.041 | 1.80 |
| | $L_3$ | 13+14 | 10 | -0.045 | 0.073 | 18.96 | 0.059 | 2.03 |
| | $L_4$ | 13+24 | 10 | -0.044 | 0.091 | 17.10 | 0.076 | 2.22 |
| | $L_5$ | 13+34 | 10 | -0.044 | 0.107 | 16.15 | 0.090 | 2.37 |
| | $L_6$ | 13+44 | 10 | -0.043 | 0.122 | 15.68 | 0.103 | 2.50 |
| | $L_7$ | 13+54 | 10 | -0.042 | 0.135 | 15.49 | 0.114 | 2.60 |
| | $L_8$ | 13+64 | 10 | -0.041 | 0.146 | 15.48 | 0.123 | 2.69 |
| | $L_9$ | 13+74 | 10 | -0.040 | 0.155 | 15.60 | 0.131 | 2.76 |
| | $L_{10}$ | 13+84 | 10 | -0.039 | 0.163 | 15.81 | 0.137 | 2.83 |
| | $L_{11}$ | 13+94 | 10 | -0.038 | 0.169 | 16.11 | 0.142 | 2.88 |
| | $L_{12}$ | 14+04 | 10 | -0.038 | 0.174 | 16.46 | 0.145 | 2.92 |
| | $L_{13}$ | 14+14 | 10 | -0.037 | 0.177 | 16.88 | 0.147 | 2.95 |
| | $L_{14}$ | 14+24 | 10 | -0.036 | 0.179 | 17.34 | 0.148 | 2.98 |
| | $L_{15}$ | 14+34 | 10 | -0.035 | 0.180 | 17.85 | 0.148 | 3.00 |
| | $L_{16}$ | 14+44 | 10 | -0.034 | 0.180 | 18.40 | 0.147 | 3.01 |
| | $L_{17}$ | 14+54 | 10 | -0.033 | 0.179 | 18.99 | 0.145 | 3.02 |
| | $L_{18}$ | 14+64 | 10 | -0.032 | 0.177 | 19.62 | 0.142 | 3.02 |
| | $L_{19}$ | 14+74 | 10 | -0.032 | 0.174 | 20.28 | 0.139 | 3.02 |
| | $L_{20}$ | 14+84 | 10 | -0.032 | 0.171 | 20.53 | 0.136 | 3.00 |
| | $L_{21}$ | 14+94 | 10 | -0.032 | 0.168 | 20.71 | 0.133 | 2.98 |
| | $L_{22}$ | 15+04 | 10 | -0.032 | 0.165 | 20.88 | 0.131 | 2.96 |
| | $L_{23}$ | 15+14 | 10 | -0.032 | 0.163 | 21.03 | 0.128 | 2.94 |
| | $L_{24}$ | | | | | | | |
| | $L_{25}$ | | | | | | | |
| | $L_{26}$ | | | | | | | |
| | $L_{27}$ | | | | | | | |
| | $L_{28}$ | | | | | | | |
| | $L_{29}$ | | | | | | | |
| | $L_{30}$ | | | | | | | |
| | $L_{31}$ | | | | | | | |
| | $L_{32}$ | | | | | | | |
| | $L_{33}$ | | | | | | | |
| | $L_{34}$ | | | | | | | |
| | $L_{35}$ | | | | | | | |
| | $L_{36}$ | | | | | | | |
| | $L_{37}$ | | | | | | | |
| | $L_{38}$ | | | | | | | |
| | $L_{39}$ | | | | | | | |

## Geometric Variables

| FLAT GRADE | CONSTANT GRADE | **VERTICAL CURVE** |
|---|---|---|

| | | | | |
|---|---|---|---|---|
| g1 | = | **-3.1502** | % | Grade 1, vertical grade before PVI |
| g2 | = | **5.2214** | % | Grade 2, vertical grade after PVI |
| LVC | = | **575.00** | ft | Length of vertical curve |
| PVI | = | **18+12.50** | - | Station at PVI |
| Beg | = | **15+14.00** | - | Station at beginning of bridge |
| L | = | **200.00** | ft | Length of bridge |

## Preliminary Data Analysis

| | | | | |
|---|---|---|---|---|
| Freq | = | **10** | year | Storm frequency -- 10 year per GDOT design manual |
| Speed | = | **55** | mph | Vehicle design speed |
| ID | = | **195-0021-0** | - | Existing Bridge Serial Number |

## Street Hydraulics

| | | | | |
|---|---|---|---|---|
| $W_p$ | = | **20.000** | ft | Width being drained -- typically half of pavement |
| T | = | **8.0000** | ft | Design spread |
| $S_x$ | = | **2.0** | % | Cross-slope of deck |
| n | = | **0.016** | - | Manning's coefficient -- typically, n = 0.016 |
| C | = | **0.90** | - | Runoff -- typically, C = 0.9 for pavements |

## Inlet Specifications

| CURB INLET | NEENAH | HEC-22 | **GDOT** |
|---|---|---|---|

| **4 in. Scupper** | | | | Grate Details |
|---|---|---|---|---|
| L | = | 0.33 | ft | Inlet opening length |
| W | = | 0.33 | ft | Inlet opening width |
| H | = | n/a | ft | Inlet opening height |
| a | = | n/a | ft | Local Inlet depression |

*Capacity determined by information found in GDOT drainage manual, capacity in-sump determined by weir/orifice hydraulics.*

## Design Notes

- Second part of bridge analysis begins at last deck drain of previous part
- Deck drain at station 15+14 has inlet flow of 0.128 cfs included in analysis

## Establishment of Rainfall Intensity

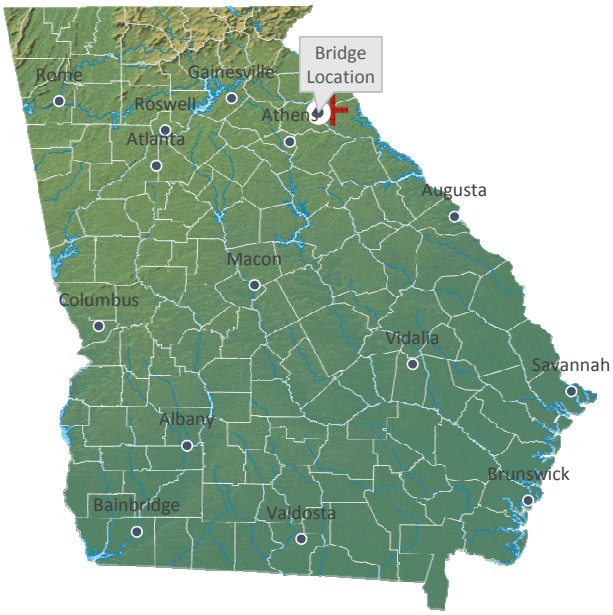
Closest station

| |
|---|
| Bowman |

Station Information

| |
|---|
| Bowman, GA |
| BOWMAN |
| 34.2000$^0$ LAT |
| -83.0333$^0$ LON |
| 785 ft |

Station Location




IDF Calculations

| | | | |
|---|---|---|---|
| $t_o$ | = | 0.70 | min |
| $t_g$ | = | 4.45 | min |
| $t_c$ | = | 5.15 | min |
| $t_t$ | = | 5.10 | min |
| i | = | 7.74 | in/hr |
| $L_o$ | = | - | ft |

Inlet requirement

SEE VERTICAL CURVE SECTION

*Rainfall intensity is calculated using intensity-duration-frequency (IDF) curves and methods consistent with GDOT drainage manual. Point precipitation frequency estimates are taken from NOAA Atlas 14 Volume 9 for partial duration time series.*

## Inlet Spacing on Flat Bridge

| | | | | |
|---|---|---|---|---|
| $P_{INLET}$ | = | 1.05 | ft | Inlet perimeter |
| $P_{REQ}$ | = | 3.58 | ft | Required inlet perimeter |
| $L_c$ | = | 220 | ft | Inlet spacing assuming 100% efficiency |
| Spacing | = | 64 | ft | Required inlet spacing |

## Inlet Spacing for Bridge on Grade

| | Spacing (ft) | Gutter Flow (cfs) | Efficiency (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|
| $L_0$ | | | | | |
| $L_1$ | | | | | |
| $L_2$ | | | | | |
| $L_3$ | | | | | |
| $L_4$ | | | | | |
| $L_n$ | | | | | |

*Flat bridge spacing should be considered for bridges with grades less than 0.03%.*

## Hydroplaining and Visibility

| | | | |
|---|---|---|---|
| Hydroplane Depth | = | 0.080 in | Depth at which hydroplaning can occur |
| Hydroplain | = | OK | Risk of hydroplaning at rain intensity |
| Visibility | = | Reduced | Risk of impaired vision due to rain |

*Hydroplaning and visibility design procedures taken from methods in HEC-22. Methods shown are for constant-slope and flat bridges.*

# Inlet Spacing on Vertical Curve

| | | |
|---|---|---|
| Curve = | **SAG** | Vertical Curve Type |
| $X_{HP}$ = | **17+41.37** | Vertical Curve High or Low Point |
| $B_{HP}$ = | **15+14.00** | Bridge High or Low point |

| | Inlet | Station | Spacing (ft) | Local S (ft/ft) | Flow (cfs) | Eff. (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|---|---|---|
| | ... | ... | ... | ... | ... | ... | ... | ... |
| ↑ | $L_{16}$ | 15+54.00 | 10 | -0.027 | 0.070 | 35.79 | 0.04 | 2.20 |
| ↑ | $L_{15}$ | 15+64.00 | 10 | -0.026 | 0.077 | 34.41 | 0.05 | 2.31 |
| ↑ | $L_{14}$ | 15+74.00 | 10 | -0.024 | 0.082 | 33.34 | 0.05 | 2.39 |
| LEFT OF HIGH/LOW POINT | $L_{13}$ | 15+84.00 | 10 | -0.023 | 0.087 | 32.46 | 0.06 | 2.47 |
| | $L_{12}$ | 15+94.00 | 10 | -0.021 | 0.091 | 31.68 | 0.06 | 2.54 |
| | $L_{11}$ | 16+04.00 | 10 | -0.020 | 0.094 | 30.97 | 0.06 | 2.61 |
| | $L_{10}$ | 16+14.00 | 10 | -0.019 | 0.097 | 30.31 | 0.07 | 2.67 |
| | $L_9$ | 16+24.00 | 10 | -0.017 | 0.099 | 29.66 | 0.07 | 2.74 |
| | $L_8$ | 16+34.00 | 10 | -0.016 | 0.102 | 29.02 | 0.07 | 2.82 |
| | $L_7$ | 16+44.00 | 10 | -0.014 | 0.104 | 28.37 | 0.07 | 2.89 |
| | $L_6$ | 16+54.00 | 10 | -0.013 | 0.107 | 27.69 | 0.08 | 2.98 |
| | $L_5$ | 16+64.00 | 10 | -0.011 | 0.109 | 26.98 | 0.08 | 3.07 |
| ↑ | $L_4$ | 16+74.00 | 10 | -0.010 | 0.112 | 26.23 | 0.08 | 3.18 |
| ↑ | $L_3$ | 16+84.00 | 10 | -0.008 | 0.114 | 25.41 | 0.09 | 3.31 |
| ↑ | $L_2$ | 16+94.00 | 10 | -0.007 | 0.117 | 24.51 | 0.09 | 3.46 |
| | $L_1$ | 17+04.00 | 10 | -0.005 | 0.121 | 23.49 | 0.09 | 3.65 |
| -- Sump at 17+41.37 (off bridge) -- | | | | | | | | |
| ↓ | | | | | | | | |
| ↓ | | | | | | | | |
| ↓ | | | | | | | | |
| RIGHT OF HIGH/LOW POINT | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| ↓ | | | | | | | | |
| ↓ | | | | | | | | |
| ↓ | | | | | | | | |
| | | | | | | | | |

*If the low point lies on the bridge, additional checks to the gutter spread and flanking inlets are required. Refer to the GDOT Drainage Manual for more info.*

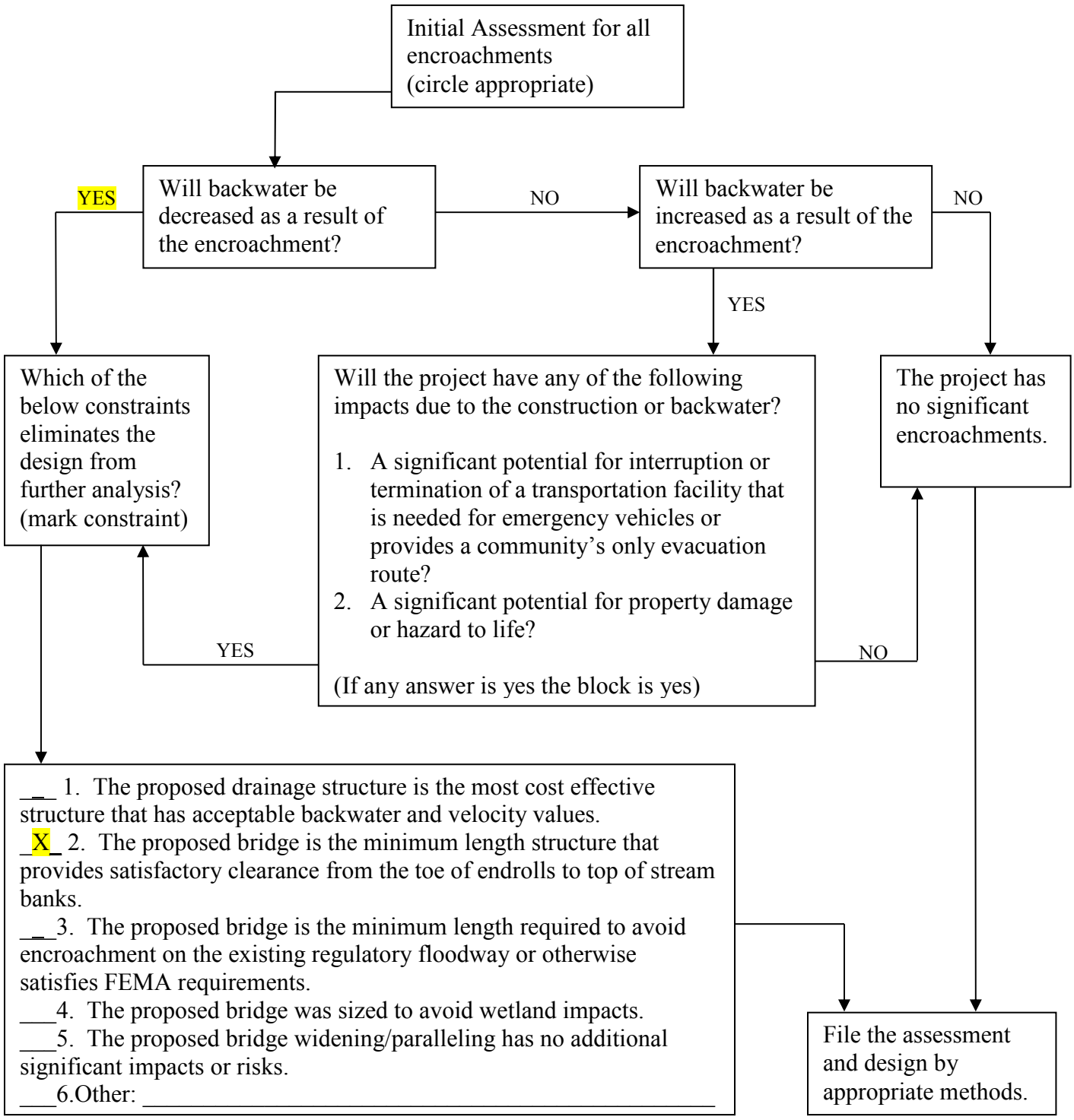
## Inlet Spacing for Bridge on Vertical Curve (continued)

| | Inlet | Station | Spacing (ft) | Local S (ft/ft) | Flow (cfs) | Eff. (%) | Bypass (cfs) | Spread (ft) |
|---|---|---|---|---|---|---|---|---|
| | -- Sump at 17+41.37 (off bridge) -- | | | | | | | |
| ← ← ← ← ← LEFT OF HIGH/LOW POINT | $L_1$ | 17+04 | 10 | -0.005 | 0.121 | 23.49 | 0.092 | 3.65 |
| | $L_2$ | 16+94 | 10 | -0.007 | 0.117 | 24.51 | 0.089 | 3.46 |
| | $L_3$ | 16+84 | 10 | -0.008 | 0.114 | 25.41 | 0.085 | 3.31 |
| | $L_4$ | 16+74 | 10 | -0.010 | 0.112 | 26.23 | 0.082 | 3.18 |
| | $L_5$ | 16+64 | 10 | -0.011 | 0.109 | 26.98 | 0.080 | 3.07 |
| | $L_6$ | 16+54 | 10 | -0.013 | 0.107 | 27.69 | 0.077 | 2.98 |
| | $L_7$ | 16+44 | 10 | -0.014 | 0.104 | 28.37 | 0.075 | 2.89 |
| | $L_8$ | 16+34 | 10 | -0.016 | 0.102 | 29.02 | 0.072 | 2.82 |
| | $L_9$ | 16+24 | 10 | -0.017 | 0.099 | 29.66 | 0.070 | 2.74 |
| | $L_{10}$ | 16+14 | 10 | -0.019 | 0.097 | 30.31 | 0.067 | 2.67 |
| | $L_{11}$ | 16+04 | 10 | -0.020 | 0.094 | 30.97 | 0.065 | 2.61 |
| | $L_{12}$ | 15+94 | 10 | -0.021 | 0.091 | 31.68 | 0.062 | 2.54 |
| | $L_{13}$ | 15+84 | 10 | -0.023 | 0.087 | 32.46 | 0.059 | 2.47 |
| | $L_{14}$ | 15+74 | 10 | -0.024 | 0.082 | 33.34 | 0.055 | 2.39 |
| | $L_{15}$ | 15+64 | 10 | -0.026 | 0.077 | 34.41 | 0.050 | 2.31 |
| | $L_{16}$ | 15+54 | 10 | -0.027 | 0.070 | 35.79 | 0.045 | 2.20 |
| | $L_{17}$ | 15+44 | 10 | -0.029 | 0.061 | 37.71 | 0.038 | 2.07 |
| | $L_{18}$ | 15+34 | 10 | -0.030 | 0.049 | 40.74 | 0.029 | 1.89 |
| | $L_{19}$ | 15+24 | 10 | -0.032 | 0.032 | 46.78 | 0.017 | 1.60 |
| | $L_{20}$ | | | | | | | |
| | $L_{21}$ | | | | | | | |
| | $L_{22}$ | | | | | | | |
| | $L_{23}$ | | | | | | | |
| | $L_{24}$ | | | | | | | |
| | $L_{25}$ | | | | | | | |
| | $L_{26}$ | | | | | | | |
| | $L_{27}$ | | | | | | | |
| | $L_{28}$ | | | | | | | |
| | $L_{29}$ | | | | | | | |
| | $L_{30}$ | | | | | | | |
| | $L_{31}$ | | | | | | | |
| | $L_{32}$ | | | | | | | |
| | $L_{33}$ | | | | | | | |
| | $L_{34}$ | | | | | | | |
| | $L_{35}$ | | | | | | | |
| | $L_{36}$ | | | | | | | |
| | $L_{37}$ | | | | | | | |
| | $L_{38}$ | | | | | | | |
| | $L_{39}$ | | | | | | | |

**PI No. 0013997 Madison County**

# APPENDIX B

## RISK ASSESSMENT



# National Flood Hazard Layer FIRMette

FEMA

34°11'10.01"N

83°9'6.88"W

83°8'29.43"W

34°10'40.25"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

## Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

**SPECIAL FLOOD HAZARD AREAS**
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

**OTHER AREAS OF FLOOD HAZARD**
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

**OTHER AREAS**
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

**GENERAL STRUCTURES**
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

**OTHER FEATURES**
- B 20.2 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

**MAP PANELS**
- Digital Data Available
- No Digital Data Available
- Unmapped

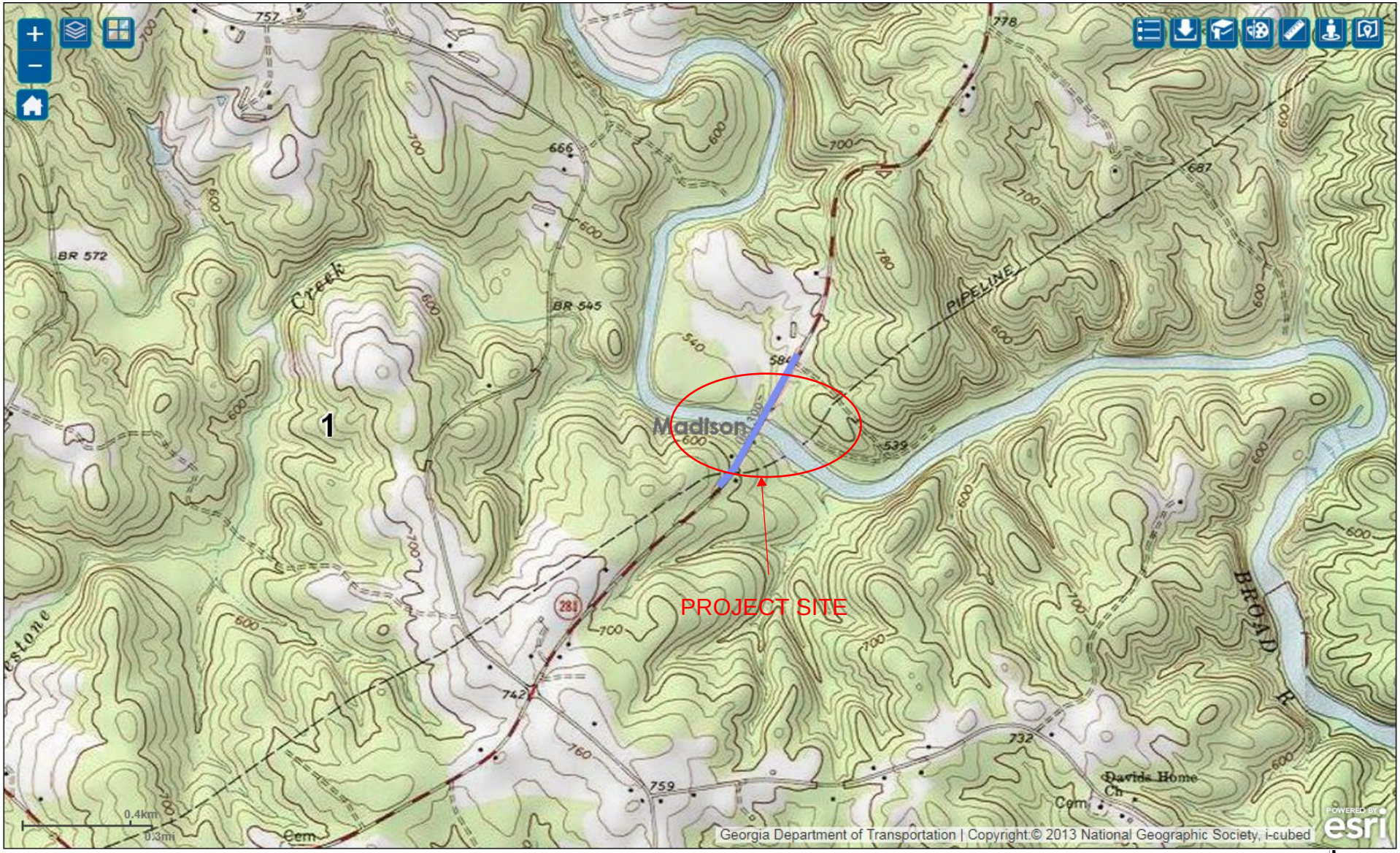
N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 8/20/2018 at 10:14:06 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.



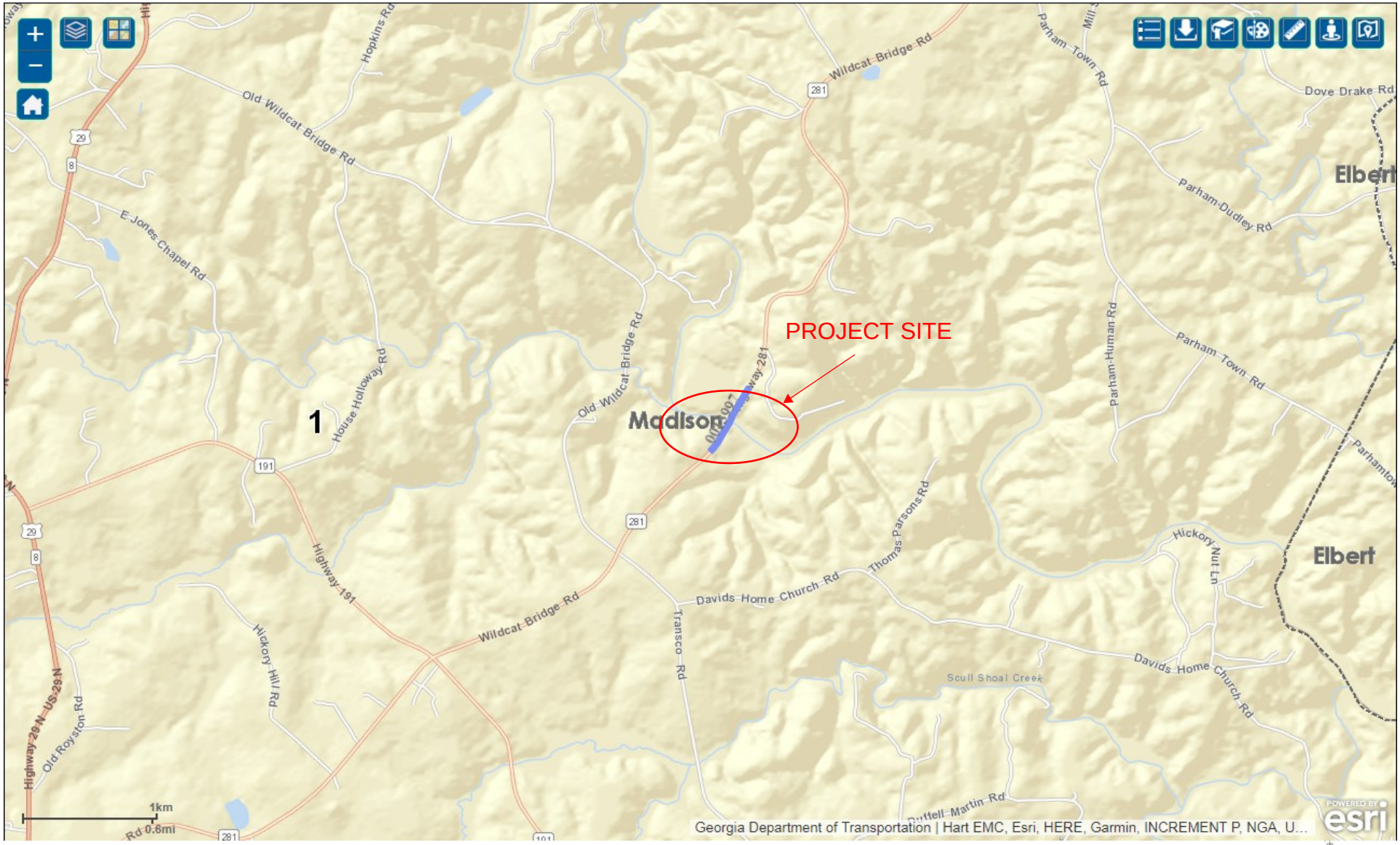
# USGS QUAD MAP

Structure No. 195-0021-0

SR 281 OVER BROAD RIVER

Madison County

PI# 0013997



# LOCATION MAP

Structure No. 195-0021-0

SR 281 OVER BROAD RIVER
Madison County
PI# 0013997

# HYDRAULIC ENGINEERING FIELD REPORT

*I. HYDRAULIC AND HYDROLOGICAL DATA REQUIRED FOR ALL EXISTING OR PROPOSED BRIDGE STREAM CROSSING PROJECTS*

**A. Project Location**

Project No.: _____ County: MADISON_____ District:

P.I. No.: 013997_ Stream Name: BROAD RIVER_____ Route:SR 281

Surveyed By: ARCADIS_____ Date: 10-3-2017_____

**B. Site Information**

**Floodplain and Stream Channel description:**

1. Flat, rolling, mountainous, etc.: ROLLING_____

2. Wooded, heavily vegetated, pasture, swampy, etc.: Wooded with heavy undergrowth_____

3. Stream channel description: well-defined banks, meandering, debris, etc.

Well defined banks with visible rock outcroppings

4. Is there any fill in the upstream or downstream floodplain, which will affect the natural drainage or limit the floodplain width at this site?

No

**C. Required Existing Bridge Information at Project Site** 195-00281D-004.11N (STB)

1. Bridge Identification No.: 0013997 195-0021-0 (STB)
2. Date Built: ??? 1956 (STB)
3. Skew angle of bridge bents: 90
4. Height of curb, parapet or barrier: NA

**Substructure Information:**

1. Column type (concrete, steel, etc): Concrete
2. Size of columns: 2' square 2'-6", 3'-4" (STB)
3. Number of columns per bent: 2
4. Guide Bank (Spur Dike) length, elevation and location (if applicable):

NA

5. Note any scour problems at intermediate bents or abutments:

NA

Note: The above information is required for all bridges within the floodplain (main and overflow bridges) along the roadway. In addition, the location, size and number of barrels are required for all box culverts located within the floodplain.

## D. Normal Water Surface Data

| | WS ELEV |
|---|---|
| 500 feet upstream of survey centerline: | 515.96 |
| At the survey centerline: | 515.73 |
| 500 feet downstream of survey centerline: | 515.71 |
| Normal high tide: | |
| Normal low tide: | |

## E. Historical Flood Data

1. Extreme high water elevation at site: 535.5' Date: ????
2. Highest observed tide elevation: _____ Date: _____
3. Location of extreme high water elevation (upstream/downstream face of bridge at the centerline or station and offset if not at bridge):
   175' upstream of bridge along old road bed
4. Source of high water information: Homeowner
5. Location and floor elevation of any houses/buildings/structures that have been flooded:
   NA
6. Information about flood (number oftimes structure has been flooded, water surface elevations and date(s) of flood):
   NA
7. Location and floor elevation of any houses/buildings/structures that have floor elevations within 2 feet of the extreme high water elevation:
   NA

## F. Benchmark Information

**Location 1:**

1. Benchmark Name: SLCD 11 Elevation: 558.18
2. Location *(project stations/offset):* _____
   Northing: 1522896.4760 Easting: 359864.9920
3. Physical description: 5/8" REBAR SET AT THE NORTHWEST CORNER OF BRIDGE BEHIND GARDRAIL

**Location 2:**

1. Benchmark Name: SLCD 12 Elevation: 570.88
2. Location *(project stations/offset):* _____
   Northing:1522505.7760 Easting: 359684.9810
3. Physical description: 5/8" REBAR SET AT THE SOUTHEAST CORNER OF BRIDGE

**Location 3:**

1. Benchmark Name: _____ Elevation: _____
2. Location *(project stations/offset):* _____
   Northing: _____ Easting: _____
3. Physical description: _____

## G. Upstream and Downstream Structures

**Structure 1**

1. Structure Type (railroad/highway bridge, culvert): NA
2. Route Number (if applicable): NA
3. Distance from proposed structure along stream centerline: NA
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**Structure 2**

1. Structure Type (railroad/highway bridge, culvert): _____
2. Route Number (if applicable): _____
3. Distance from proposed structure along stream centerline: _____
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**Structure 3**

1. Structure Type (railroad/highway bridge, culvert): _____
2. Route Number (if applicable): _____
3. Distance from proposed structure along stream centerline: _____
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**NOTE: The above information is required for all bridges or culverts, which lie within 2000 feet upstream or downstream of the project bridge, unless otherwise directed by the Office of Bridge Hydraulics.**

## H. Miscellaneous Information

1. Are there water surfaces affected by other factors (high water from other streams, reservoirs, etc.):

   NO

2. Give location (horizontal distance to dam or spill way along stream centerline), length, width and elevation of dam and spillway, if applicable:

   NA

## D. Normal Water Surface Data

| | WS ELEV |
|---|---|
| 500 feet upstream of survey centerline: | 515.96 |
| At the survey centerline: | 515.73 |
| 500 feet downstream of survey centerline: | 515.71 |
| Normal high tide: | |
| Normal low tide: | |

## E. Historical Flood Data

1. Extreme high water elevation at site: 535.5' Date: ????
2. Highest observed tide elevation: _____ Date: _____
3. Location of extreme high water elevation (upstream/downstream face of bridge at the centerline or station and offset if not at bridge):
   175' upstream of bridge along old road bed
4. Source of high water information: Homeowner
5. Location and floor elevation of any houses/buildings/structures that have been flooded:
   NA
6. Information about flood (number oftimes structure has been flooded, water surface elevations and date(s) of flood):
   NA
7. Location and floor elevation of any houses/buildings/structures that have floor elevations within 2 feet of the extreme high water elevation:
   NA

## F. Benchmark Information

**Location 1:**

1. Benchmark Name: SLCD 11 Elevation: 558.18
2. Location *(project stations/offset):* _____
   Northing: 1522896.4760 Easting: 359864.9920
3. Physical description: 5/8" REBAR SET AT THE NORTHWEST CORNER OF BRIDGE BEHIND GARDRAIL

**Location 2:**

1. Benchmark Name: SLCD 12 Elevation: 570.88
2. Location *(project stations/offset):* _____
   Northing:1522505.7760 Easting: 359684.9810
3. Physical description: 5/8" REBAR SET AT THE SOUTHEAST CORNER OF BRIDGE

**Location 3:**

1. Benchmark Name: _____ Elevation: _____
2. Location *(project stations/offset):* _____
   Northing: _____ Easting: _____
3. Physical description: _____

## G. Upstream and Downstream Structures

**Structure 1**

1. Structure Type (railroad/highway bridge, culvert): NA
2. Route Number (if applicable): NA
3. Distance from proposed structure along stream centerline: NA
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**Structure 2**

1. Structure Type (railroad/highway bridge, culvert): _____
2. Route Number (if applicable): _____
3. Distance from proposed structure along stream centerline: _____
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**Structure 3**

1. Structure Type (railroad/highway bridge, culvert): _____
2. Route Number (if applicable): _____
3. Distance from proposed structure along stream centerline: _____
4. Length of bridge or culvert size: _____
5. Superstructure (slab thickness, beam depth): _____
6. Substructure information: _____
7. Column Type (concrete, steel, etc.): _____
8. Size of Column: _____
9. Number of Columns per bent: _____

**NOTE: The above information is required for all bridges or culverts, which lie within 2000 feet upstream or downstream of the project bridge, unless otherwise directed by the Office of Bridge Hydraulics.**

## H. Miscellaneous Information

1. Are there water surfaces affected by other factors (high water from other streams, reservoirs, etc.):

   NO

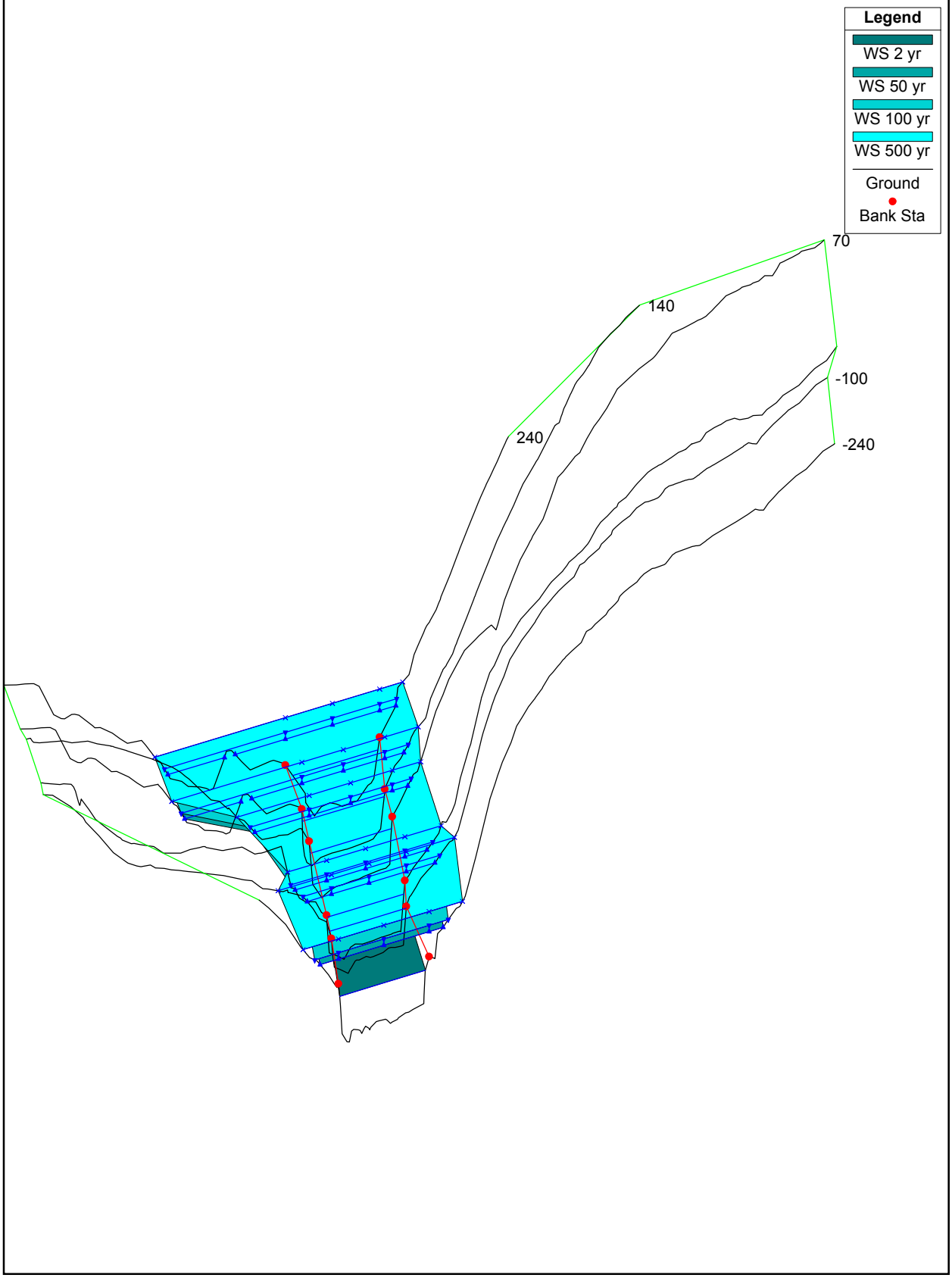
2. Give location (horizontal distance to dam or spill way along stream centerline), length, width and elevation of dam and spillway, if applicable:

   NA

# HEC–RAS OUTPUT

# NATURAL CONDITION

0013997 SR 281 over Broad River Plan: Natural 10/2/2018



0013997SR281over.rep

HEC-RAS HEC-RAS 5.0.3 September 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: 0013997 SR 281 over Broad River
Project File : 0013997SR281over.prj
Run Date and Time: 10/2/2018 1:45:15 PM

Project in English units

PLAN DATA

Plan Title: Natural
Plan File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.p01

Geometry Title: Natural
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g02

Flow Title : 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Plan Summary Information:

| | | | | | |
|---|---|---|---|---|---|
| Number of: | Cross Sections = | 6 | Multiple Openings = | 0 |
| | Culverts = | 0 | Inline Structures = | 0 |
| | Bridges = | 0 | Lateral Structures = | 0 |

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Flow Data (cfs)

| River | Reach | RS | 2 yr | 50 yr | 100 yr | 500 yr |
|---|---|---|---|---|---|---|
| Broad River | SR 281 | 240 | 11400 | 36400 | 41900 | 55300 |

Boundary Conditions

| River | Reach | Profile | Upstream | Downstream |
|---|---|---|---|---|
| Broad River | SR 281 | 2 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 50 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 100 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 500 yr | Normal S = 0.001129 | |

GEOMETRY DATA

Geometry Title: Natural
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g02

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 240

INPUT
Description: Approach
Station Elevation Data num= 117

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 1003.96 | 591.04 | 1008.97 | 590.39 | 1009.56 | 590.28 | 1012.81 | 589.68 | 1020.4 | 588.29 |
| 1021.66 | 588.05 | 1030.5 | 586.29 | 1031.92 | 586.01 | 1037.55 | 585.09 | 1040.5 | 584.58 |
| 1050.22 | 582.88 | 1050.5 | 582.84 | 1060.41 | 581.18 | 1060.5 | 581.16 | 1074.14 | 578.73 |
| 1080.5 | 577.42 | 1090.5 | 575.38 | 1095.78 | 574.29 | 1105.75 | 572.12 | 1125.97 | 567.92 |
| 1129.71 | 567.07 | 1130.5 | 566.9 | 1132.25 | 566.54 | 1150.5 | 562.49 | 1152.95 | 561.94 |
| 1173.22 | 557.84 | 1175.36 | 557.22 | 1178.4 | 556.63 | 1180.5 | 556.13 | 1185.19 | 555.03 |
| 1200.5 | 552.88 | 1202.02 | 552.67 | 1209.36 | 551.95 | 1210.5 | 551.74 | 1213.14 | 551.24 |
| 1216.31 | 550.58 | 1230.5 | 548 | 1240.5 | 546.01 | 1240.57 | 546 | 1249.91 | 542.69 |
| 1250.5 | 542.51 | 1252.93 | 541.78 | 1253.71 | 541.58 | 1258.11 | 541.2 | 1280.5 | 539.41 |
| 1281.42 | 539.33 | 1286.56 | 535.03 | 1314.88 | 530.71 | 1320.44 | 529.85 | 1323.52 | 529.34 |
| 1326.56 | 528.9 | 1326.79 | 528.86 | 1326.84 | 528.823 | 1327.81 | 528.1 | 1336.56 | 522.5 |
| 1341.31 | 519.45 | 1346.56 | 518.77 | 1347.69 | 518.62 | 1356.17 | 518.26 | 1356.56 | 518.22 |
| 1383.39 | 515.29 | 1395.11 | 515.48 | 1404.05 | 515.18 | 1421 | 515.13 | 1426.56 | 515.49 |

```
 1436.17  516.13 1436.56  516.14 1446.56  516.63 1450.38 516.811 1472.54 516.547
 1477.82 516.068 1490.09 514.797 1493.76 515.472  1511.6 518.606 1513.13 520.806
 1562.93528.9979 1567.17529.5379 1592.56530.9759 1600.35531.0159  1600.5531.0139
 1651.02530.3939 1671.79532.9369 1697.32536.3169 1702.22536.4629 1711.09536.5299
 1715.48534.9549 1742.69528.6459 1752.31528.5119  1760.5529.1229 1777.04529.9419
 1806.19530.9039 1822.44532.6159  1850.5534.0309 1850.77534.0449 1875.84538.7339
 1883.79539.3849 1912.89543.8469 1922.22545.0699 1922.64545.2179  1958.4545.5289
 1975.85547.0939 1995.81549.0189  2026.4551.2379 2039.47551.5489  2045.5552.2669
 2079.73555.7219 2090.26556.2619    2098556.3879 2115.44555.8699 2123.96556.1979
 2142.45557.6229 2178.83565.4359 2192.42566.4219 2199.09566.6629 2214.94567.0589
 2235.91567.3859 2267.69568.2769

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 1003.96     .13 1326.84    .035 1562.93     .13

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       1326.84 1562.93              100     100     100             .1       .3

CROSS SECTION


RIVER: Broad River
REACH: SR 281             RS: 140

INPUT
Description: 140 ft upstream of the existing bridge
Station Elevation Data    num=     158
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  716.79  624.31   747.3  622.59  749.32  622.48  753.05  622.26     765  621.18
  767.51  620.96  790.06  619.61  820.21  617.19  825.22  616.45  826.95   616.2
   835.8   614.9  836.06  614.86  844.65   613.6  844.86  613.57   853.5   612.6
  860.38  611.84  862.35  611.67   871.2  610.95  874.19   610.7  879.44  609.98
  880.05  609.89  880.51  609.83   888.9  608.34  890.28  608.09  897.76  606.77
  901.12  606.17  906.61   605.2  906.72  605.18  911.97  603.91   913.6  603.52
  915.46  603.03  918.63  602.21  922.81  602.04  923.46  602.01  924.31  601.98
  928.21  601.82     929  601.86  933.16  601.21  933.65  601.14  936.81  600.65
   971.7  595.08  977.03  594.46  977.41  594.42  979.24  594.21   990.2   592.7
  995.11  592.06 1008.97  590.28 1009.56  590.17  1020.4  588.17 1021.66  587.94
  1030.5  586.18 1031.92  585.89 1037.55  584.98  1040.5  584.47 1050.22  582.77
  1050.5  582.72 1060.41  581.06  1060.5  581.05 1074.14  578.61 1095.78  574.18
 1105.75  572.01 1125.97  567.81 1129.71  566.96  1130.5  566.79 1132.25  566.42
  1150.5  562.38 1152.95  561.83 1173.22  557.73 1175.36  557.11  1178.4  556.52
 1185.19  554.91  1200.5  552.77 1202.02  552.55 1209.36  551.84  1210.5  551.62
 1213.14  551.12 1216.31  550.47  1230.5  547.89  1240.5   545.9 1240.57  545.88
 1249.91  542.58 1252.93  541.66 1253.71  541.47 1258.11  541.09  1280.5   539.3
 1281.42  539.22 1289.04     538 1291.53  537.25 1316.04  533.73  1330.5  532.46
 1331.21  532.39  1350.5  528.65 1352.68  528.22 1355.44 527.656 1355.98  526.48
  1360.5  522.65 1365.41  518.48  1380.5     517 1383.82  516.67 1394.75  516.43
 1436.78  516.14  1450.5  516.11 1451.53  516.11  1480.5  516.22 1488.22  516.26
  1490.5  516.22 1490.83  516.22  1515.5  515.99 1522.79  515.58 1537.04  514.67
 1550.14   515.8  1550.5  515.91 1556.06  517.57 1560.44 520.686  1560.5 520.883
 1562.93 528.885 1562.94 528.886 1567.17 529.425 1592.56 530.863 1600.35 530.903
  1600.5 530.901 1651.02 530.281 1671.79 532.824 1697.32 536.204 1702.22  536.35
 1711.09 536.417 1715.48 534.842 1742.69 528.533 1752.31 528.399  1760.5  529.01
 1777.04 529.829 1806.19 530.791 1822.44 532.503  1850.5 533.918 1850.77 533.932
 1875.84 538.621 1883.79 539.272 1912.89 543.734 1922.22 544.957 1922.64 545.105
  1958.4 545.416 1975.85 546.981 1995.81 548.906  2026.4 551.125 2039.47 551.436
  2045.5 552.154 2079.73 555.609 2090.26 556.149    2098 556.275 2115.44 555.757
 2123.96 556.085 2142.45  557.51 2178.83 565.323 2192.42 566.309 2199.09  566.55
 2214.94 566.946 2235.91 567.273 2267.69 568.164

Manning's n Values        num=       3
```

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 716.79 | .13 | 1355.44 | .035 | 1562.94 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1355.44 | 1562.94 | 70 | 70 | 70 | .1 | .3 |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 70

INPUT
Description: 70 ft upstream of the existing bridge
Station Elevation Data num= 170

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 294.84 | 634.575 | 302.88 | 634.075 | 319.16 | 633.355 | 351.6 | 633.529 | 355.11 | 633.294 |
| 358.05 | 633.162 | 375.45 | 632.778 | 392.92 | 632.431 | 395.98 | 632.376 | 405.89 | 632.222 |
| 413.73 | 631.075 | 424.51 | 629.784 | 436.58 | 630.142 | 443.92 | 630.372 | 454.05 | 629.783 |
| 458.93 | 629.508 | 471.51 | 629.443 | 472.94 | 629.438 | 480.24 | 629.209 | 480.72 | 629.195 |
| 497.71 | 629.241 | 499.38 | 629.249 | 500.03 | 629.227 | 506.44 | 629 | 509.18 | 628.909 |
| 515.17 | 628.783 | 523.91 | 628.617 | 541.17 | 628.339 | 541.37 | 628.324 | 541.65 | 628.304 |
| 550.1 | 627.689 | 553.46 | 627.454 | 558.84 | 627.064 | 567.57 | 626.453 | 576.3 | 625.863 |
| 585.03 | 625.295 | 590.6 | 624.946 | 593.67 | 624.855 | 593.77 | 624.853 | 601.16 | 624.652 |
| 602.5 | 624.635 | 611.21 | 624.545 | 619.97 | 624.323 | 628.7 | 624.12 | 645.69 | 623.776 |
| 646.16 | 623.767 | 654.9 | 623.616 | 672.36 | 623.367 | 674.29 | 623.346 | 677.79 | 623.119 |
| 681.09 | 622.779 | 697.72 | 621.117 | 698.56 | 621.034 | 716.02 | 619.356 | 719.68 | 619.015 |
| 724.18 | 618.76 | 724.76 | 618.732 | 742.22 | 617.938 | 760.08 | 617.194 | 761.77 | 617.083 |
| 762.69 | 617.012 | 812.08 | 614.062 | 812.17 | 614.057 | 813.37 | 613.987 | 819.4 | 613.077 |
| 839.56 | 610.229 | 858.26 | 608.077 | 871.63 | 606.83 | 889.23 | 604.452 | 904.41 | 602.052 |
| 907.06 | 601.625 | 912.27 | 601.381 | 918.87 | 601.012 | 921.8 | 600.729 | 949.1 | 598.195 |
| 961.96 | 597.337 | 978 | 593.373 | 978.64 | 593.214 | 989.03 | 590.647 | 998.97 | 588.48 |
| 1021.66 | 585.625 | 1024.58 | 585.245 | 1028.92 | 584.435 | 1030.31 | 584.217 | 1037.17 | 583.152 |
| 1055.94 | 580.411 | 1070.31 | 577.387 | 1070.86 | 577.273 | 1095.55 | 572.025 | 1100.31 | 570.483 |
| 1112.36 | 566.615 | 1116.59 | 565.507 | 1126.02 | 566.743 | 1128.31 | 567.025 | 1139.19 | 566.523 |
| 1147.6 | 566.004 | 1159.19 | 565.374 | 1169.03 | 564.675 | 1195.81 | 562.879 | 1214.51 | 560.163 |
| 1235.07 | 557.113 | 1250.31 | 553.737 | 1251.25 | 553.53 | 1267.32 | 550.532 | 1284.53 | 545.657 |
| 1293.02 | 542.912 | 1313.46 | 537.569 | 1323.65 | 537.153 | 1348.46 | 532.931 | 1359.2 | 531.052 |
| 1376.24 | 528.583 | 1376.38 | 528.563 | 1380.31 | 522.821 | 1380.63 | 522.358 | 1382.47 | 517.467 |
| 1392.16 | 516.842 | 1404.52 | 516.851 | 1447.21 | 516.435 | 1458.98 | 516.231 | 1476.8 | 516.23 |
| 1486.33 | 516.114 | 1499.76 | 515.988 | 1515.85 | 516.079 | 1531.69 | 515.584 | 1546.93 | 514.829 |
| 1552.18 | 514.339 | 1574.22 | 517.997 | 1575.29 | 518.182 | 1580.31 | 523.973 | 1583.55 | 527.703 |
| 1584.39 | 528.747 | 1584.41 | 528.751 | 1604.33 | 532.341 | 1608.44 | 532.442 | 1637.84 | 531.846 |
| 1659.44 | 532.287 | 1667.23 | 532.167 | 1702.01 | 532.501 | 1710.31 | 533.443 | 1710.44 | 533.458 |
| 1747 | 538.289 | 1763.4 | 539.371 | 1785.75 | 542.404 | 1787.42 | 542.251 | 1809.62 | 544.729 |
| 1828.28 | 545.543 | 1829.57 | 545.608 | 1885.29 | 552.211 | 1894.07 | 553.07 | 1905.61 | 554.312 |
| 1926.42 | 556.148 | 1926.82 | 556.154 | 1980.31 | 559.747 | 1980.87 | 559.784 | 2031.71 | 562.81 |
| 2040.31 | 563.361 | 2041.28 | 563.422 | 2073.37 | 565.205 | 2075.4 | 565.379 | 2080.31 | 565.603 |
| 2080.63 | 565.618 | 2115.22 | 567.181 | 2138.37 | 568.472 | 2178.31 | 569.195 | 2201.36 | 570.314 |
| 2259.29 | 571.51 | 2274.11 | 572.049 | 2277.78 | 572.508 | 2282.1 | 573.253 | 2292.31 | 573.322 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 294.84 | .13 | 1376.24 | .035 | 1584.41 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1376.24 | 1584.41 | 140 | 140 | 140 | .1 | .3 |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -70

INPUT
Description: 70 ft downstream of the existing bridge
Station Elevation Data num= 198

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 300.01 | 624.452 | 325.57 | 621.842 | 350.8 | 620.924 | 356.04 | 620.761 | 366.72 | 620.017 |
| 394.79 | 617.975 | 407.94 | 617.534 | 434.91 | 616.71 | 450.69 | 615.453 | 450.9 | 615.436 |
| 474.85 | 614.508 | 475.77 | 614.43 | 475.88 | 614.42 | 486.83 | 613.491 | 509.08 | 614.056 |
| 522.32 | 613.775 | 542.88 | 614.01 | 543.05 | 614.021 | 543.15 | 614.026 | 555.91 | 614.776 |
| 576.64 | 614.683 | 578.5 | 614.677 | 591.27 | 614.236 | 592.08 | 614.209 | 593.43 | 614.19 |
| 604.74 | 614.047 | 610.22 | 613.865 | 610.53 | 613.856 | 627.24 | 613.321 | 637.26 | 612.131 |
| 642.29 | 611.781 | 662.22 | 611.726 | 662.94 | 611.773 | 677.4 | 610.941 | 677.91 | 610.913 |
| 678.14 | 610.899 | 685.56 | 610.78 | 696.28 | 610.681 | 713.27 | 610.023 | 737.99 | 609.146 |
| 739.54 | 609.076 | 747.23 | 609.023 | 748.23 | 608.944 | 761.37 | 608.553 | 761.45 | 608.55 |
| 772.68 | 608.147 | 773.95 | 608.07 | 799.38 | 606.254 | 803.04 | 605.935 | 803.35 | 605.907 |
| 828.54 | 603.716 | 828.82 | 603.692 | 846.13 | 603.005 | 847.48 | 602.711 | 849.92 | 602.16 |
| 857.46 | 601.887 | 865.16 | 601.26 | 873.84 | 600.655 | 890.93 | 599.646 | 901.53 | 598.494 |
| 918.89 | 595.983 | 923.24 | 595.45 | 937.15 | 594.309 | 937.7 | 594.279 | 937.8 | 594.274 |
| 945.69 | 593.833 | 946.09 | 593.807 | 954.01 | 593.281 | 970.1 | 592.443 | 975.05 | 591.854 |
| 985.36 | 590.833 | 985.93 | 590.783 | 986.03 | 590.773 | 986.53 | 590.73 | 1014.7 | 588.977 |
| 1014.8 | 588.968 | 1016.46 | 588.834 | 1021.66 | 588.259 | 1041.74 | 586.119 | 1043.44 | 585.907 |
| 1070.85 | 583.934 | 1071.27 | 583.892 | 1073.45 | 583.726 | 1091.32 | 582.414 | 1094.28 | 581.981 |
| 1094.54 | 581.948 | 1115.83 | 579.192 | 1136.3 | 577.152 | 1157.2 | 573.268 | 1168.59 | 571.893 |
| 1188.75 | 566.704 | 1188.82 | 566.689 | 1188.88 | 566.673 | 1189.06 | 566.611 | 1190.04 | 566.246 |
| 1214.54 | 556.884 | 1215.95 | 556.342 | 1219.28 | 555.643 | 1221.06 | 555.223 | 1241.84 | 548.982 |
| 1253.92 | 543.734 | 1254.54 | 543.514 | 1255.27 | 543.249 | 1263.05 | 541.565 | 1276.87 | 539.603 |
| 1278.51 | 539.47 | 1287.3 | 539.9 | 1295.8 | 537.375 | 1321.2 | 534.732 | 1346.16 | 532.317 |
| 1361.06 | 530.921 | 1371.44 | 529.515 | 1380.41 | 528.712 | 1381.06 | 528.62 | 1381.25 | 528.315 |
| 1384.54 | 524.472 | 1391.12 | 516.757 | 1394.13 | 516.969 | 1411.91 | 516.954 | 1412.37 | 516.886 |
| 1414.54 | 516.881 | 1414.64 | 516.881 | 1436.78 | 516.811 | 1438.51 | 516.826 | 1462.04 | 516.629 |
| 1462.67 | 516.61 | 1487.14 | 516.586 | 1487.22 | 516.59 | 1488.59 | 516.629 | 1505.54 | 517.09 |
| 1517 | 516.666 | 1518.72 | 516.432 | 1533.11 | 514.293 | 1548.13 | 515.437 | 1570.38 | 516.859 |
| 1574.54 | 522.071 | 1575.11 | 522.794 | 1577.08 | 526.019 | 1577.09 | 526.02 | 1589.45 | 527.018 |
| 1604.24 | 529.99 | 1630.04 | 530.74 | 1644.74 | 531.998 | 1657.68 | 534.717 | 1664.54 | 534.97 |
| 1664.83 | 534.981 | 1690.4 | 545.619 | 1734.23 | 545.467 | 1740.97 | 545.496 | 1748.06 | 545.624 |
| 1756.24 | 545.661 | 1788.71 | 548.262 | 1795.48 | 548.385 | 1829.83 | 548.758 | 1834.54 | 548.795 |
| 1839.53 | 548.923 | 1877.67 | 550.712 | 1881.74 | 551.077 | 1886.47 | 551.241 | 1894.54 | 551.215 |
| 1894.75 | 551.214 | 1918.44 | 551.43 | 1921.37 | 551.423 | 1942.29 | 551.264 | 1942.88 | 551.298 |
| 1943.45 | 551.32 | 1984.54 | 552.468 | 1985.32 | 552.484 | 2009.72 | 554.78 | 2043.21 | 556.157 |
| 2058.49 | 556.909 | 2065.88 | 557.042 | 2088.57 | 558.557 | 2092.31 | 559.122 | 2100.25 | 559.787 |
| 2139.95 | 563.803 | 2155.88 | 565.457 | 2171.61 | 568.143 | 2190.65 | 571.204 | 2190.99 | 571.271 |
| 2191.28 | 571.087 | 2194.41 | 569.879 | 2194.54 | 569.876 | 2195.14 | 569.864 | 2197.96 | 570.764 |
| 2204.54 | 573.235 | 2205.28 | 573.515 | 2210.43 | 574.706 | 2216.15 | 575.466 | 2235.39 | 576.16 |
| 2244.09 | 576.258 | 2244.54 | 576.273 | 2282.88 | 577.641 | 2288.26 | 577.912 | 2288.85 | 577.935 |
| 2289.69 | 577.917 | 2291.86 | 578.013 | 2292.31 | 578.032 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 300.01 | .13 | 1381.06 | .035 | 1577.09 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1381.06 | 1577.09 | 30 | 30 | 30 | .1 | .3 |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -100

INPUT
Description: 100 ft downstream from the exisiting bridge
Station Elevation Data num= 216

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.23 | 330.25 | 621.13 | 331.16 | 621.1 | 358.02 | 620.27 | 359.32 | 620.17 |
| 363.31 | 619.9 | 366.72 | 619.66 | 369.19 | 619.47 | 375.01 | 619.04 | 378.66 | 618.76 |
| 399.88 | 617.18 | 399.98 | 617.17 | 407.08 | 616.93 | 408.17 | 616.89 | 416.46 | 616.61 |
| 416.56 | 616.61 | 424.75 | 616.33 | 426.03 | 616.29 | 426.28 | 616.28 | 433.04 | 615.88 |
| 435.5 | 615.73 | 441.33 | 615.39 | 444.98 | 615.17 | 463.92 | 614.07 | 466.21 | 613.94 |
| 467.22 | 613.88 | 482.79 | 612.74 | 482.87 | 612.73 | 491.08 | 612.12 | 492.34 | 612.03 |
| 494.87 | 611.84 | 506.81 | 610.53 | 507.66 | 610.55 | 515.95 | 610.8 | 517.53 | 610.85 |
| 527.45 | 611.37 | 532.53 | 611.17 | 539.71 | 610.9 | 540.82 | 610.85 | 548.29 | 610.57 |
| 549.11 | 610.55 | 549.19 | 610.54 | 565.69 | 610.03 | 568.13 | 609.96 | 577.61 | 609.67 |
| 615.43 | 608.62 | 615.5 | 608.62 | 623.72 | 608.41 | 624.98 | 608.38 | 632.01 | 608.2 |
| 633.3 | 608.17 | 640.3 | 607.86 | 643.92 | 607.71 | 648.42 | 607.51 | 648.59 | 607.5 |
| 651.78 | 607.32 | 653.4 | 607.26 | 656.89 | 607.12 | 665.18 | 606.8 | 666.11 | 606.76 |
| 671.59 | 606.8 | 673.47 | 606.85 | 676.02 | 606.93 | 681.76 | 606.97 | 681.82 | 606.97 |
| 685.43 | 607 | 690.05 | 606.97 | 691.29 | 606.96 | 698.34 | 606.92 | 700.77 | 606.9 |
| 714.14 | 606.83 | 714.92 | 606.83 | 723.21 | 606.79 | 726.67 | 606.78 | 731.5 | 606.59 |
| 735.23 | 606.45 | 738.66 | 606.11 | 739.79 | 605.99 | 747.45 | 605.23 | 752.2 | 604.85 |
| 755.9 | 604.74 | 756.37 | 604.74 | 764.66 | 604.67 | 767.08 | 604.66 | 778.48 | 604.579 |
| 786.01 | 604.69 | 806.11 | 603.971 | 806.58 | 603.955 | 815.03 | 603.349 | 823.92 | 602.564 |
| 824.19 | 602.541 | 842.87 | 601.785 | 842.94 | 601.782 | 857.26 | 600.992 | 865.46 | 600.501 |
| 867.88 | 600.221 | 870.84 | 599.491 | 877.63 | 598.964 | 887.46 | 598.343 | 895.32 | 597.875 |
| 901.08 | 597.009 | 928.13 | 595.542 | 928.34 | 595.53 | 937.61 | 594.798 | 938.29 | 594.743 |
| 938.76 | 594.731 | 949.8 | 594.438 | 950.16 | 594.411 | 953.76 | 593.808 | 963.12 | 592.181 |
| 964.21 | 592.107 | 987.3 | 590.794 | 1001.69 | 589.89 | 1004.95 | 589.598 | 1005.08 | 589.589 |
| 1008.27 | 589.388 | 1016.74 | 588.693 | 1021.66 | 588.251 | 1034.92 | 587.123 | 1043.11 | 586.501 |
| 1059.76 | 584.38 | 1060.83 | 584.116 | 1077.67 | 582.41 | 1078.94 | 582.243 | 1079.65 | 582.192 |
| 1095.23 | 580.747 | 1111.75 | 578.604 | 1124.83 | 576.995 | 1139.25 | 573.487 | 1161.1 | 569.418 |
| 1169.95 | 567.211 | 1172.24 | 566.665 | 1179.06 | 564.82 | 1191.5 | 561.586 | 1194.91 | 560.411 |
| 1217.11 | 552.362 | 1227.31 | 548.694 | 1253.91 | 540.237 | 1266.99 | 538.18 | 1275.93 | 538.003 |
| 1300.47 | 535.493 | 1310.18 | 534.253 | 1331.18 | 532.739 | 1347.11 | 531.404 | 1360.09 | 529.599 |
| 1372.35 | 528.125 | 1376.09 | 527.799 | 1382.94 | 525.985 | 1383.68 | 525.788 | 1383.7 | 525.776 |
| 1390.89 | 516.798 | 1397.88 | 516.749 | 1411.74 | 516.884 | 1421.71 | 517.183 | 1428.79 | 517.163 |
| 1441.85 | 516.528 | 1466.62 | 516.281 | 1473.55 | 516.268 | 1484.04 | 516.841 | 1502.07 | 516.489 |
| 1508.22 | 516.656 | 1512.04 | 516.515 | 1522.94 | 515.032 | 1523.66 | 514.933 | 1529.5 | 514.065 |
| 1549.3 | 515.574 | 1564.2 | 516.546 | 1567.3 | 518.836 | 1571.13 | 523.578 | 1571.16 | 523.588 |
| 1572.94 | 524.184 | 1584.06 | 527.926 | 1602.67 | 529.258 | 1602.94 | 529.31 | 1617.02 | 531.972 |
| 1617.22 | 532.002 | 1642.94 | 535.664 | 1643.44 | 535.736 | 1649.85 | 536.117 | 1676.95 | 537.505 |
| 1679.73 | 537.607 | 1681.25 | 538.241 | 1692.49 | 538.202 | 1730.06 | 539.893 | 1743.11 | 540.354 |
| 1750.05 | 540.988 | 1770.25 | 543.011 | 1791.2 | 543.853 | 1842.94 | 546.365 | 1843.4 | 546.388 |
| 1844.53 | 546.421 | 1892.23 | 548.336 | 1896.3 | 548.521 | 1930.37 | 549.827 | 1953.97 | 550.777 |
| 1971.51 | 551.408 | 1990.06 | 552.266 | 2012.31 | 553.04 | 2012.94 | 553.093 | 2024.31 | 554.072 |
| 2047.81 | 554.346 | 2051.58 | 554.499 | 2058.09 | 554.788 | 2080.95 | 556.143 | 2117.36 | 559.648 |
| 2153.69 | 564.77 | 2186.17 | 568.904 | 2189.68 | 569.658 | 2192.38 | 570.117 | 2192.94 | 570.181 |
| 2224.19 | 573.718 | 2269.22 | 577.695 | 2271.8 | 577.785 | 2272.83 | 577.823 | 2272.94 | 577.826 |
| 2292.31 | 578.497 | | | | | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1383.7 | .035 | 1571.16 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1383.7 | 1571.16 | 140 | 140 | 140 | .1 | .3 |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -240

INPUT
Description: Exit
Station Elevation Data num= 148

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.07 | 330.25 | 620.976 | 331.16 | 620.943 | 358.02 | 620.107 | 366.72 | 619.497 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 399.88 | 617.021 | 399.98 | 617.014 | 416.46 | 616.453 | 416.56 | 616.45 | 426.03 | 616.129 |
| 426.28 | 616.12 | 466.21 | 613.78 | 467.22 | 613.722 | 482.79 | 612.577 | 482.87 | 612.571 |
| 494.87 | 611.684 | 506.81 | 610.367 | 517.53 | 610.692 | 527.45 | 611.212 | 548.29 | 610.414 |
| 549.11 | 610.388 | 549.19 | 610.385 | 573.98 | 609.623 | 598.85 | 608.91 | 615.43 | 608.464 |
| 615.5 | 608.462 | 632.01 | 608.041 | 633.3 | 608.01 | 648.42 | 607.352 | 648.59 | 607.342 |
| 651.78 | 607.162 | 665.18 | 606.64 | 666.11 | 606.605 | 671.59 | 606.638 | 676.02 | 606.77 |
| 681.76 | 606.81 | 681.82 | 606.81 | 685.43 | 606.838 | 726.67 | 606.618 | 735.23 | 606.289 |
| 747.45 | 605.073 | 748.08 | 605.022 | 752.2 | 604.694 | 755.9 | 604.581 | 778.48 | 604.421 |
| 786.01 | 604.532 | 806.11 | 603.813 | 806.58 | 603.797 | 815.03 | 603.191 | 823.92 | 602.406 |
| 824.19 | 602.383 | 842.87 | 601.627 | 842.94 | 601.624 | 857.26 | 600.834 | 865.46 | 600.343 |
| 867.88 | 600.063 | 870.84 | 599.333 | 877.63 | 598.806 | 887.46 | 598.185 | 895.32 | 597.717 |
| 901.08 | 596.851 | 928.13 | 595.384 | 928.34 | 595.372 | 937.61 | 594.64 | 938.29 | 594.585 |
| 949.8 | 594.28 | 950.16 | 594.253 | 953.76 | 593.65 | 963.12 | 592.023 | 964.21 | 591.949 |
| 987.3 | 590.636 | 1001.69 | 589.732 | 1004.95 | 589.44 | 1005.08 | 589.431 | 1008.27 | 589.23 |
| 1016.74 | 588.535 | 1021.66 | 588.093 | 1034.92 | 586.965 | 1043.11 | 586.343 | 1059.76 | 584.222 |
| 1060.83 | 583.958 | 1077.67 | 582.252 | 1078.94 | 582.085 | 1079.65 | 582.034 | 1095.23 | 580.589 |
| 1111.75 | 578.446 | 1124.83 | 576.837 | 1139.25 | 573.329 | 1161.1 | 569.26 | 1169.95 | 567.053 |
| 1172.24 | 566.507 | 1179.06 | 564.662 | 1191.5 | 561.428 | 1194.91 | 560.253 | 1217.11 | 552.204 |
| 1227.31 | 548.536 | 1253.91 | 540.079 | 1266.99 | 538.022 | 1275.93 | 537.845 | 1300.47 | 535.335 |
| 1310.18 | 534.095 | 1322.94 | 533.175 | 1329.24 | 527.442 | 1329.67 | 527.472 | 1342.17 | 528.314 |
| 1343.8 | 528.328 | 1345.2 | 527.776 | 1353.51 | 525.307 | 1356.76 | 519.497 | 1357.44 | 517.566 |
| 1384.63 | 516.916 | 1395.11 | 516.594 | 1402.71 | 516.649 | 1420.75 | 516.027 | 1423.31 | 515.68 |
| 1436.87 | 515.444 | 1440.49 | 515.264 | 1440.84 | 515.305 | 1449.2 | 516.276 | 1452.93 | 516.581 |
| 1470.38 | 516.723 | 1476.49 | 516.714 | 1490.5 | 515.745 | 1492.41 | 515.227 | 1494.89 | 515.691 |
| 1502.72 | 516.343 | 1506.62 | 515.979 | 1512.51 | 514.902 | 1516.05 | 515.723 | 1520.48 | 516.016 |
| 1532.75 | 516.501 | 1538.24 | 516.248 | 1543.86 | 513.813 | 1549.63 | 514.016 | 1561.51 | 516.288 |
| 1565.98 | 523.208 | 1569.24 | 526.853 | 1570.61 | 528.373 | 1574.47 | 527.642 | 1579.24 | 528.349 |
| 1579.3 | 528.357 | 1595.63 | 531.253 | 1624.44 | 535.335 | 1643 | 536.716 | 1665.48 | 539.855 |
| 1702.87 | 546.339 | 1745.35 | 551.46 | 1769.24 | 554.006 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1343.8 | .035 | 1570.61 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1343.8 | 1570.61 | 0 | 0 | 0 | .1 | .3 |

SUMMARY OF MANNING'S N VALUES

River:Broad River

| Reach | River Sta. | n1 | n2 | n3 |
|---|---|---|---|---|
| SR 281 | 240 | .13 | .035 | .13 |
| SR 281 | 140 | .13 | .035 | .13 |
| SR 281 | 70 | .13 | .035 | .13 |
| SR 281 | -70 | .13 | .035 | .13 |
| SR 281 | -100 | .13 | .035 | .13 |
| SR 281 | -240 | .13 | .035 | .13 |

SUMMARY OF REACH LENGTHS

River: Broad River

| Reach | River Sta. | Left | Channel | Right |
|---|---|---|---|---|
| SR 281 | 240 | 100 | 100 | 100 |
| SR 281 | 140 | 70 | 70 | 70 |

| | | | | |
|---|---|---|---|---|
| SR 281 | 70 | 140 | 140 | 140 |
| SR 281 | -70 | 30 | 30 | 30 |
| SR 281 | -100 | 140 | 140 | 140 |
| SR 281 | -240 | 0 | 0 | 0 |

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Broad River

| Reach | River Sta. | Contr. | Expan. |
|---|---|---|---|
| SR 281 | 240 | .1 | .3 |
| SR 281 | 140 | .1 | .3 |
| SR 281 | 70 | .1 | .3 |
| SR 281 | -70 | .1 | .3 |
| SR 281 | -100 | .1 | .3 |
| SR 281 | -240 | .1 | .3 |

HEC-RAS Plan: Nat Locations: User Defined

| River | Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Broad River | SR 281 | 240 | 2 yr | 11400.00 | 514.80 | 525.96 | | 526.61 | 0.001434 | 6.48 | 1759.47 | 213.30 | 0.40 |
| Broad River | SR 281 | 240 | 50 yr | 36400.00 | 514.80 | 535.17 | | 536.40 | 0.001114 | 9.05 | 5077.28 | 544.10 | 0.39 |
| Broad River | SR 281 | 240 | 100 yr | 41900.00 | 514.80 | 536.76 | | 538.07 | 0.001056 | 9.38 | 5970.87 | 580.81 | 0.39 |
| Broad River | SR 281 | 240 | 500 yr | 55300.00 | 514.80 | 540.29 | | 541.74 | 0.000953 | 10.03 | 8072.58 | 620.23 | 0.38 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 11400.00 | 514.67 | 525.91 | | 526.46 | 0.001051 | 5.95 | 1916.77 | 205.37 | 0.34 |
| Broad River | SR 281 | 140 | 50 yr | 36400.00 | 514.67 | 534.98 | | 536.29 | 0.001069 | 9.31 | 4979.66 | 521.99 | 0.38 |
| Broad River | SR 281 | 140 | 100 yr | 41900.00 | 514.67 | 536.54 | | 537.95 | 0.001049 | 9.74 | 5826.06 | 568.27 | 0.39 |
| Broad River | SR 281 | 140 | 500 yr | 55300.00 | 514.67 | 540.02 | | 541.63 | 0.000994 | 10.56 | 7878.57 | 617.27 | 0.39 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 11400.00 | 514.34 | 525.82 | | 526.38 | 0.001099 | 6.03 | 1889.18 | 203.65 | 0.35 |
| Broad River | SR 281 | 70 | 50 yr | 36400.00 | 514.34 | 534.77 | | 536.20 | 0.001171 | 9.62 | 4227.70 | 382.76 | 0.40 |
| Broad River | SR 281 | 70 | 100 yr | 41900.00 | 514.34 | 536.29 | | 537.86 | 0.001166 | 10.13 | 4825.57 | 403.21 | 0.40 |
| Broad River | SR 281 | 70 | 500 yr | 55300.00 | 514.34 | 539.64 | | 541.53 | 0.001157 | 11.21 | 6269.11 | 459.83 | 0.41 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 11400.00 | 514.29 | 525.47 | | 526.19 | 0.001509 | 6.78 | 1681.61 | 193.06 | 0.40 |
| Broad River | SR 281 | -70 | 50 yr | 36400.00 | 514.29 | 534.28 | | 535.98 | 0.001469 | 10.54 | 3893.96 | 329.77 | 0.45 |
| Broad River | SR 281 | -70 | 100 yr | 41900.00 | 514.29 | 535.77 | | 537.65 | 0.001462 | 11.11 | 4405.16 | 355.49 | 0.45 |
| Broad River | SR 281 | -70 | 500 yr | 55300.00 | 514.29 | 539.05 | | 541.31 | 0.001443 | 12.28 | 5626.99 | 384.44 | 0.46 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 11400.00 | 514.07 | 525.40 | | 526.14 | 0.001528 | 6.90 | 1656.07 | 192.55 | 0.41 |
| Broad River | SR 281 | -100 | 50 yr | 36400.00 | 514.07 | 534.10 | | 535.93 | 0.001533 | 10.91 | 3794.33 | 319.75 | 0.46 |
| Broad River | SR 281 | -100 | 100 yr | 41900.00 | 514.07 | 535.57 | | 537.59 | 0.001536 | 11.53 | 4278.54 | 342.49 | 0.47 |
| Broad River | SR 281 | -100 | 500 yr | 55300.00 | 514.07 | 538.75 | | 541.24 | 0.001555 | 12.86 | 5513.36 | 441.44 | 0.48 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 11400.00 | 513.81 | 525.35 | 520.74 | 525.90 | 0.001129 | 5.95 | 1917.15 | 214.53 | 0.35 |
| Broad River | SR 281 | -240 | 50 yr | 36400.00 | 513.81 | 534.28 | 526.07 | 535.59 | 0.001130 | 9.21 | 4210.80 | 308.27 | 0.39 |
| Broad River | SR 281 | -240 | 100 yr | 41900.00 | 513.81 | 535.78 | 527.07 | 537.23 | 0.001130 | 9.73 | 4689.24 | 334.21 | 0.40 |
| Broad River | SR 281 | -240 | 500 yr | 55300.00 | 513.81 | 539.05 | 529.27 | 540.85 | 0.001131 | 10.84 | 5898.81 | 399.32 | 0.41 |

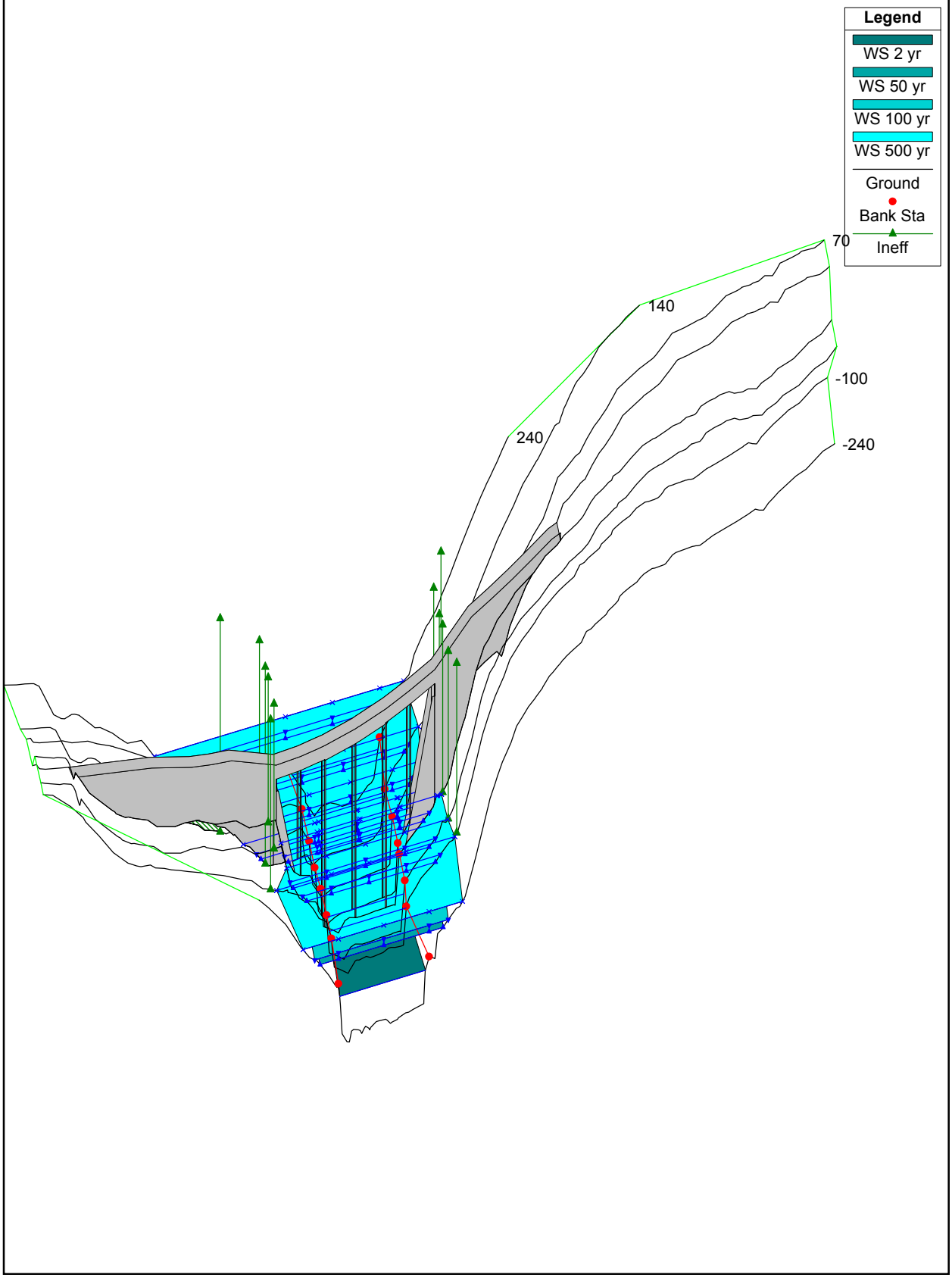
HEC-RAS Plan: Nat Locations: User Defined

| River | Reach | River Sta | Profile | E.G. Elev | W.S. Elev | Vel Head | Frctn Loss | C & E Loss | Q Left | Q Channel | Q Right | Top Width |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (cfs) | (ft) |
| Broad River | SR 281 | 240 | 2 yr | 526.61 | 525.96 | 0.65 | 0.12 | 0.03 | | 11400.00 | | 213.30 |
| Broad River | SR 281 | 240 | 50 yr | 536.40 | 535.17 | 1.24 | 0.11 | 0.01 | 106.38 | 35302.43 | 991.20 | 544.10 |
| Broad River | SR 281 | 240 | 100 yr | 538.07 | 536.76 | 1.31 | 0.11 | 0.01 | 198.02 | 40089.27 | 1612.71 | 580.81 |
| Broad River | SR 281 | 240 | 500 yr | 541.74 | 540.29 | 1.45 | 0.10 | 0.02 | 417.37 | 51229.50 | 3653.13 | 620.23 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 526.46 | 525.91 | 0.55 | 0.08 | 0.00 | | 11400.00 | | 205.37 |
| Broad River | SR 281 | 140 | 50 yr | 536.29 | 534.98 | 1.31 | 0.08 | 0.01 | 124.24 | 35332.37 | 943.39 | 521.99 |
| Broad River | SR 281 | 140 | 100 yr | 537.95 | 536.54 | 1.41 | 0.08 | 0.02 | 221.40 | 40126.62 | 1551.99 | 568.27 |
| Broad River | SR 281 | 140 | 500 yr | 541.63 | 540.02 | 1.60 | 0.07 | 0.03 | 547.50 | 51132.55 | 3619.95 | 617.27 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 526.38 | 525.82 | 0.57 | 0.18 | 0.01 | | 11400.00 | | 203.65 |
| Broad River | SR 281 | 70 | 50 yr | 536.20 | 534.77 | 1.42 | 0.18 | 0.03 | 105.10 | 36030.89 | 264.02 | 382.76 |
| Broad River | SR 281 | 70 | 100 yr | 537.86 | 536.29 | 1.57 | 0.18 | 0.03 | 184.87 | 41165.82 | 549.30 | 403.21 |
| Broad River | SR 281 | 70 | 500 yr | 541.53 | 539.64 | 1.89 | 0.18 | 0.04 | 479.11 | 53370.07 | 1450.82 | 459.83 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 526.19 | 525.47 | 0.71 | 0.05 | 0.00 | | 11400.00 | | 193.06 |
| Broad River | SR 281 | -70 | 50 yr | 535.98 | 534.28 | 1.70 | 0.05 | 0.01 | 130.12 | 35880.67 | 389.21 | 329.77 |
| Broad River | SR 281 | -70 | 100 yr | 537.65 | 535.77 | 1.88 | 0.04 | 0.01 | 246.32 | 41049.68 | 603.99 | 355.49 |
| Broad River | SR 281 | -70 | 500 yr | 541.31 | 539.05 | 2.26 | 0.04 | 0.02 | 711.41 | 53272.66 | 1315.93 | 384.44 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 526.14 | 525.40 | 0.74 | 0.18 | 0.06 | | 11398.03 | 1.97 | 192.55 |
| Broad River | SR 281 | -100 | 50 yr | 535.93 | 534.10 | 1.82 | 0.18 | 0.15 | 231.25 | 35833.87 | 334.88 | 319.75 |
| Broad River | SR 281 | -100 | 100 yr | 537.59 | 535.57 | 2.02 | 0.18 | 0.17 | 402.08 | 40999.98 | 497.94 | 342.49 |
| Broad River | SR 281 | -100 | 500 yr | 541.24 | 538.75 | 2.49 | 0.18 | 0.21 | 945.51 | 53436.81 | 917.68 | 441.44 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 525.90 | 525.35 | 0.55 | | | | 11400.00 | | 214.53 |
| Broad River | SR 281 | -240 | 50 yr | 535.59 | 534.28 | 1.31 | | | 108.71 | 36152.14 | 139.15 | 308.27 |
| Broad River | SR 281 | -240 | 100 yr | 537.23 | 535.78 | 1.46 | | | 173.47 | 41498.75 | 227.78 | 334.21 |
| Broad River | SR 281 | -240 | 500 yr | 540.85 | 539.05 | 1.79 | | | 432.73 | 54286.67 | 580.60 | 399.32 |

# HEC–RAS OUTPUT

# EXISTING CONDITION

0013997 SR 281 over Broad River Plan: Existing 10/2/2018



0013997SR281over.rep

HEC-RAS HEC-RAS 5.0.3 September 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: 0013997 SR 281 over Broad River
Project File : 0013997SR281over.prj
Run Date and Time: 10/2/2018 1:41:30 PM

Project in English units

PLAN DATA

Plan Title: Existing
Plan File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.p02

Geometry Title: Existing
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g01

Flow Title : 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Plan Summary Information:

| | | | | | |
|---|---|---|---|---|---|
| Number of: | Cross Sections = | 6 | Multiple Openings = | 0 |
| | Culverts = | 0 | Inline Structures = | 0 |
| | Bridges = | 1 | Lateral Structures = | 0 |

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Flow Data (cfs)

| River | Reach | RS | 2 yr | 50 yr | 100 yr | 500 yr |
|---|---|---|---|---|---|---|
| Broad River | SR 281 | 240 | 11400 | 36400 | 41900 | 55300 |

Boundary Conditions

| River | Reach | Profile | Upstream | Downstream |
|---|---|---|---|---|
| Broad River | SR 281 | 2 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 50 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 100 yr | Normal S = 0.001129 | |
| Broad River | SR 281 | 500 yr | Normal S = 0.001129 | |

GEOMETRY DATA

Geometry Title: Existing
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g01

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 240

INPUT
Description: Approach
Station Elevation Data num= 117

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 1003.96 | 591.04 | 1008.97 | 590.39 | 1009.56 | 590.28 | 1012.81 | 589.68 | 1020.4 | 588.29 |
| 1021.66 | 588.05 | 1030.5 | 586.29 | 1031.92 | 586.01 | 1037.55 | 585.09 | 1040.5 | 584.58 |
| 1050.22 | 582.88 | 1050.5 | 582.84 | 1060.41 | 581.18 | 1060.5 | 581.16 | 1074.14 | 578.73 |
| 1080.5 | 577.42 | 1090.5 | 575.38 | 1095.78 | 574.29 | 1105.75 | 572.12 | 1125.97 | 567.92 |
| 1129.71 | 567.07 | 1130.5 | 566.9 | 1132.25 | 566.54 | 1150.5 | 562.49 | 1152.95 | 561.94 |
| 1173.22 | 557.84 | 1175.36 | 557.22 | 1178.4 | 556.63 | 1180.5 | 556.13 | 1185.19 | 555.03 |
| 1200.5 | 552.88 | 1202.02 | 552.67 | 1209.36 | 551.95 | 1210.5 | 551.74 | 1213.14 | 551.24 |
| 1216.31 | 550.58 | 1230.5 | 548 | 1240.5 | 546.01 | 1240.57 | 546 | 1249.91 | 542.69 |
| 1250.5 | 542.51 | 1252.93 | 541.78 | 1253.71 | 541.58 | 1258.11 | 541.2 | 1280.5 | 539.41 |
| 1281.42 | 539.33 | 1286.56 | 535.03 | 1314.88 | 530.71 | 1320.44 | 529.85 | 1323.52 | 529.34 |
| 1326.56 | 528.9 | 1326.79 | 528.86 | 1326.84 | 528.823 | 1327.81 | 528.1 | 1336.56 | 522.5 |
| 1341.31 | 519.45 | 1346.56 | 518.77 | 1347.69 | 518.62 | 1356.17 | 518.26 | 1356.56 | 518.22 |
| 1383.39 | 515.29 | 1395.11 | 515.48 | 1404.05 | 515.18 | 1421 | 515.13 | 1426.56 | 515.49 |

```
 1436.17  516.13 1436.56  516.14 1446.56  516.63 1450.38 516.811 1472.54 516.547
 1477.82 516.068 1490.09 514.797 1493.76 515.472  1511.6 518.606 1513.13 520.806
 1562.93528.9979 1567.17529.5379 1592.56530.9759 1600.35531.0159  1600.5531.0139
 1651.02530.3939 1671.79532.9369 1697.32536.3169 1702.22536.4629 1711.09536.5299
 1715.48534.9549 1742.69528.6459 1752.31528.5119  1760.5529.1229 1777.04529.9419
 1806.19530.9039 1822.44532.6159  1850.5534.0309 1850.77534.0449 1875.84538.7339
 1883.79539.3849 1912.89543.8469 1922.22545.0699 1922.64545.2179  1958.4545.5289
 1975.85547.0939 1995.81549.0189  2026.4551.2379 2039.47551.5489  2045.5552.2669
 2079.73555.7219 2090.26556.2619    2098556.3879 2115.44555.8699 2123.96556.1979
 2142.45557.6229 2178.83565.4359 2192.42566.4219 2199.09566.6629 2214.94567.0589
 2235.91567.3859 2267.69568.2769

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 1003.96     .13 1326.84    .035 1562.93     .13

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       1326.84 1562.93              100     100     100             .3       .5

CROSS SECTION


RIVER: Broad River
REACH: SR 281             RS: 140

INPUT
Description: 140 ft upstream of the existing bridge
Station Elevation Data    num=     158
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  716.79  624.31   747.3  622.59  749.32  622.48  753.05  622.26     765  621.18
  767.51  620.96  790.06  619.61  820.21  617.19  825.22  616.45  826.95   616.2
   835.8   614.9  836.06  614.86  844.65   613.6  844.86  613.57   853.5   612.6
  860.38  611.84  862.35  611.67   871.2  610.95  874.19   610.7  879.44  609.98
  880.05  609.89  880.51  609.83   888.9  608.34  890.28  608.09  897.76  606.77
  901.12  606.17  906.61   605.2  906.72  605.18  911.97  603.91   913.6  603.52
  915.46  603.03  918.63  602.21  922.81  602.04  923.46  602.01  924.31  601.98
  928.21  601.82     929  601.86  933.16  601.21  933.65  601.14  936.81  600.65
   971.7  595.08  977.03  594.46  977.41  594.42  979.24  594.21   990.2   592.7
  995.11  592.06 1008.97  590.28 1009.56  590.17  1020.4  588.17 1021.66  587.94
  1030.5  586.18 1031.92  585.89 1037.55  584.98  1040.5  584.47 1050.22  582.77
  1050.5  582.72 1060.41  581.06  1060.5  581.05 1074.14  578.61 1095.78  574.18
 1105.75  572.01 1125.97  567.81 1129.71  566.96  1130.5  566.79 1132.25  566.42
  1150.5  562.38 1152.95  561.83 1173.22  557.73 1175.36  557.11  1178.4  556.52
 1185.19  554.91  1200.5  552.77 1202.02  552.55 1209.36  551.84  1210.5  551.62
 1213.14  551.12 1216.31  550.47  1230.5  547.89  1240.5   545.9 1240.57  545.88
 1249.91  542.58 1252.93  541.66 1253.71  541.47 1258.11  541.09  1280.5   539.3
 1281.42  539.22 1289.04     538 1291.53  537.25 1316.04  533.73  1330.5  532.46
 1331.21  532.39  1350.5  528.65 1352.68  528.22 1355.44 527.656 1355.98  526.48
  1360.5  522.65 1365.41  518.48  1380.5     517 1383.82  516.67 1394.75  516.43
 1436.78  516.14  1450.5  516.11 1451.53  516.11  1480.5  516.22 1488.22  516.26
  1490.5  516.22 1490.83  516.22  1515.5  515.99 1522.79  515.58 1537.04  514.67
 1550.14   515.8  1550.5  515.91 1556.06  517.57 1560.44 520.686  1560.5 520.883
 1562.93 528.885 1562.94 528.886 1567.17 529.425 1592.56 530.863 1600.35 530.903
  1600.5 530.901 1651.02 530.281 1671.79 532.824 1697.32 536.204 1702.22  536.35
 1711.09 536.417 1715.48 534.842 1742.69 528.533 1752.31 528.399  1760.5  529.01
 1777.04 529.829 1806.19 530.791 1822.44 532.503  1850.5 533.918 1850.77 533.932
 1875.84 538.621 1883.79 539.272 1912.89 543.734 1922.22 544.957 1922.64 545.105
  1958.4 545.416 1975.85 546.981 1995.81 548.906  2026.4 551.125 2039.47 551.436
  2045.5 552.154 2079.73 555.609 2090.26 556.149    2098 556.275 2115.44 555.757
 2123.96 556.085 2142.45  557.51 2178.83 565.323 2192.42 566.309 2199.09  566.55
 2214.94 566.946 2235.91 567.273 2267.69 568.164

Manning's n Values        num=       3
```

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 716.79 | .13 | 1355.44 | .035 | 1562.94 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1355.44 | 1562.94 | 70 | 70 | 70 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 716.79 | 1214.27 | 580 | F |
| 1766.933 | 2267.69 | 580 | F |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 70

INPUT
Description: 70 ft upstream of the existing bridge
Station Elevation Data num= 170

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 294.84 | 634.575 | 302.88 | 634.075 | 319.16 | 633.355 | 351.6 | 633.529 | 355.11 | 633.294 |
| 358.05 | 633.162 | 375.45 | 632.778 | 392.92 | 632.431 | 395.98 | 632.376 | 405.89 | 632.222 |
| 413.73 | 631.075 | 424.51 | 629.784 | 436.58 | 630.142 | 443.92 | 630.372 | 454.05 | 629.783 |
| 458.93 | 629.508 | 471.51 | 629.443 | 472.94 | 629.438 | 480.24 | 629.209 | 480.72 | 629.195 |
| 497.71 | 629.241 | 499.38 | 629.249 | 500.03 | 629.227 | 506.44 | 629 | 509.18 | 628.909 |
| 515.17 | 628.783 | 523.91 | 628.617 | 541.17 | 628.339 | 541.37 | 628.324 | 541.65 | 628.304 |
| 550.1 | 627.689 | 553.46 | 627.454 | 558.84 | 627.064 | 567.57 | 626.453 | 576.3 | 625.863 |
| 585.03 | 625.295 | 590.6 | 624.946 | 593.67 | 624.855 | 593.77 | 624.853 | 601.16 | 624.652 |
| 602.5 | 624.635 | 611.21 | 624.545 | 619.97 | 624.323 | 628.7 | 624.12 | 645.69 | 623.776 |
| 646.16 | 623.767 | 654.9 | 623.616 | 672.36 | 623.367 | 674.29 | 623.346 | 677.79 | 623.119 |
| 681.09 | 622.779 | 697.72 | 621.117 | 698.56 | 621.034 | 716.02 | 619.356 | 719.68 | 619.015 |
| 724.18 | 618.76 | 724.76 | 618.732 | 742.22 | 617.938 | 760.08 | 617.194 | 761.77 | 617.083 |
| 762.69 | 617.012 | 812.08 | 614.062 | 812.17 | 614.057 | 813.37 | 613.987 | 819.4 | 613.077 |
| 839.56 | 610.229 | 858.26 | 608.077 | 871.63 | 606.83 | 889.23 | 604.452 | 904.41 | 602.052 |
| 907.06 | 601.625 | 912.27 | 601.381 | 918.87 | 601.012 | 921.8 | 600.729 | 949.1 | 598.195 |
| 961.96 | 597.337 | 978 | 593.373 | 978.64 | 593.214 | 989.03 | 590.647 | 998.97 | 588.48 |
| 1021.66 | 585.625 | 1024.58 | 585.245 | 1028.92 | 584.435 | 1030.31 | 584.217 | 1037.17 | 583.152 |
| 1055.94 | 580.411 | 1070.31 | 577.387 | 1070.86 | 577.273 | 1095.55 | 572.025 | 1100.31 | 570.483 |
| 1112.36 | 566.615 | 1116.59 | 565.507 | 1126.02 | 566.743 | 1128.31 | 567.025 | 1139.19 | 566.523 |
| 1147.6 | 566.004 | 1159.19 | 565.374 | 1169.03 | 564.675 | 1195.81 | 562.879 | 1214.51 | 560.163 |
| 1235.07 | 557.113 | 1250.31 | 553.737 | 1251.25 | 553.53 | 1267.32 | 550.532 | 1284.53 | 545.657 |
| 1293.02 | 542.912 | 1313.46 | 537.569 | 1323.65 | 537.153 | 1348.46 | 532.931 | 1359.2 | 531.052 |
| 1376.24 | 528.583 | 1376.38 | 528.563 | 1380.31 | 522.821 | 1380.63 | 522.358 | 1382.47 | 517.467 |
| 1392.16 | 516.842 | 1404.52 | 516.851 | 1447.21 | 516.435 | 1458.98 | 516.231 | 1476.8 | 516.23 |
| 1486.33 | 516.114 | 1499.76 | 515.988 | 1515.85 | 516.079 | 1531.69 | 515.584 | 1546.93 | 514.829 |
| 1552.18 | 514.339 | 1574.22 | 517.997 | 1575.29 | 518.182 | 1580.31 | 523.973 | 1583.55 | 527.703 |
| 1584.39 | 528.747 | 1584.41 | 528.751 | 1604.33 | 532.341 | 1608.44 | 532.442 | 1637.84 | 531.846 |
| 1659.44 | 532.287 | 1667.23 | 532.167 | 1702.01 | 532.501 | 1710.31 | 533.443 | 1710.44 | 533.458 |
| 1747 | 538.289 | 1763.4 | 539.371 | 1785.75 | 542.404 | 1787.42 | 542.251 | 1809.62 | 544.729 |
| 1828.28 | 545.543 | 1829.57 | 545.608 | 1885.29 | 552.211 | 1894.07 | 553.07 | 1905.61 | 554.312 |
| 1926.42 | 556.148 | 1926.82 | 556.154 | 1980.31 | 559.747 | 1980.87 | 559.784 | 2031.71 | 562.81 |
| 2040.31 | 563.361 | 2041.28 | 563.422 | 2073.37 | 565.205 | 2075.4 | 565.379 | 2080.31 | 565.603 |
| 2080.63 | 565.618 | 2115.22 | 567.181 | 2138.37 | 568.472 | 2178.31 | 569.195 | 2201.36 | 570.314 |
| 2259.29 | 571.51 | 2274.11 | 572.049 | 2277.78 | 572.508 | 2282.1 | 573.253 | 2292.31 | 573.322 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 294.84 | .13 | 1376.24 | .035 | 1584.41 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1376.24 | 1584.41 | 140 | 140 | 140 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 294.84 | 1272.6 | 580 | F |
| 1708.6 | 2292.31 | 580 | F |

BRIDGE

RIVER: Broad River
REACH: SR 281 RS: 0

INPUT
Description:
Distance from Upstream XS = 58.15
Deck/Roadway Width = 23.7
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 22

| Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord |
|---|---|---|---|---|---|---|---|---|
| 978 | 593.37 | 0 | 1000 | 592.5 | 0 | 1050 | 589.03 | 0 |
| 1100 | 585.75 | 0 | 1150 | 582.67 | 0 | 1200 | 579.81 | 0 |
| 1292.6 | 569.9 | 0 | 1292.6 | 569.9 | 566.57 | 1353.6 | 566.83 | 563.5 |
| 1414.6 | 564.11 | 560.78 | 1414.6 | 564.11 | 560.53 | 1490.6 | 561.55 | 557.97 |
| 1566.6 | 559.75 | 556.17 | 1566.6 | 559.75 | 556.42 | 1627.6 | 558.92 | 555.59 |
| 1688.6 | 558.61 | 555.28 | 1688.6 | 558.61 | 0 | 1800 | 562.87 | 0 |
| 1850 | 563.36 | 0 | 1900 | 564.18 | 0 | 2000 | 566.87 | 0 |
| 2201.36 | 570.31 | 0 | | | | | | |

Upstream Bridge Cross Section Data
Station Elevation Data num= 170

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 294.84 | 634.575 | 302.88 | 634.075 | 319.16 | 633.355 | 351.6 | 633.529 | 355.11 | 633.294 |
| 358.05 | 633.162 | 375.45 | 632.778 | 392.92 | 632.431 | 395.98 | 632.376 | 405.89 | 632.222 |
| 413.73 | 631.075 | 424.51 | 629.784 | 436.58 | 630.142 | 443.92 | 630.372 | 454.05 | 629.783 |
| 458.93 | 629.508 | 471.51 | 629.443 | 472.94 | 629.438 | 480.24 | 629.209 | 480.72 | 629.195 |
| 497.71 | 629.241 | 499.38 | 629.249 | 500.03 | 629.227 | 506.44 | 629 | 509.18 | 628.909 |
| 515.17 | 628.783 | 523.91 | 628.617 | 541.17 | 628.339 | 541.37 | 628.324 | 541.65 | 628.304 |
| 550.1 | 627.689 | 553.46 | 627.454 | 558.84 | 627.064 | 567.57 | 626.453 | 576.3 | 625.863 |
| 585.03 | 625.295 | 590.6 | 624.946 | 593.67 | 624.855 | 593.77 | 624.853 | 601.16 | 624.652 |
| 602.5 | 624.635 | 611.21 | 624.545 | 619.97 | 624.323 | 628.7 | 624.12 | 645.69 | 623.776 |
| 646.16 | 623.767 | 654.9 | 623.616 | 672.36 | 623.367 | 674.29 | 623.346 | 677.79 | 623.119 |
| 681.09 | 622.779 | 697.72 | 621.117 | 698.56 | 621.034 | 716.02 | 619.356 | 719.68 | 619.015 |
| 724.18 | 618.76 | 724.76 | 618.732 | 742.22 | 617.938 | 760.08 | 617.194 | 761.77 | 617.083 |
| 762.69 | 617.012 | 812.08 | 614.062 | 812.17 | 614.057 | 813.37 | 613.987 | 819.4 | 613.077 |
| 839.56 | 610.229 | 858.26 | 608.077 | 871.63 | 606.83 | 889.23 | 604.452 | 904.41 | 602.052 |
| 907.06 | 601.625 | 912.27 | 601.381 | 918.87 | 601.012 | 921.8 | 600.729 | 949.1 | 598.195 |
| 961.96 | 597.337 | 978 | 593.373 | 978.64 | 593.214 | 989.03 | 590.647 | 998.97 | 588.48 |
| 1021.66 | 585.625 | 1024.58 | 585.245 | 1028.92 | 584.435 | 1030.31 | 584.217 | 1037.17 | 583.152 |
| 1055.94 | 580.411 | 1070.31 | 577.387 | 1070.86 | 577.273 | 1095.55 | 572.025 | 1100.31 | 570.483 |
| 1112.36 | 566.615 | 1116.59 | 565.507 | 1126.02 | 566.743 | 1128.31 | 567.025 | 1139.19 | 566.523 |
| 1147.6 | 566.004 | 1159.19 | 565.374 | 1169.03 | 564.675 | 1195.81 | 562.879 | 1214.51 | 560.163 |
| 1235.07 | 557.113 | 1250.31 | 553.737 | 1251.25 | 553.53 | 1267.32 | 550.532 | 1284.53 | 545.657 |
| 1293.02 | 542.912 | 1313.46 | 537.569 | 1323.65 | 537.153 | 1348.46 | 532.931 | 1359.2 | 531.052 |
| 1376.24 | 528.583 | 1376.38 | 528.563 | 1380.31 | 522.821 | 1380.63 | 522.358 | 1382.47 | 517.467 |
| 1392.16 | 516.842 | 1404.52 | 516.851 | 1447.21 | 516.435 | 1458.98 | 516.231 | 1476.8 | 516.23 |
| 1486.33 | 516.114 | 1499.76 | 515.988 | 1515.85 | 516.079 | 1531.69 | 515.584 | 1546.93 | 514.829 |
| 1552.18 | 514.339 | 1574.22 | 517.997 | 1575.29 | 518.182 | 1580.31 | 523.973 | 1583.55 | 527.703 |
| 1584.39 | 528.747 | 1584.41 | 528.751 | 1604.33 | 532.341 | 1608.44 | 532.442 | 1637.84 | 531.846 |
| 1659.44 | 532.287 | 1667.23 | 532.167 | 1702.01 | 532.501 | 1710.31 | 533.443 | 1710.44 | 533.458 |
| 1747 | 538.289 | 1763.4 | 539.371 | 1785.75 | 542.404 | 1787.42 | 542.251 | 1809.62 | 544.729 |
| 1828.28 | 545.543 | 1829.57 | 545.608 | 1885.29 | 552.211 | 1894.07 | 553.07 | 1905.61 | 554.312 |
| 1926.42 | 556.148 | 1926.82 | 556.154 | 1980.31 | 559.747 | 1980.87 | 559.784 | 2031.71 | 562.81 |
| 2040.31 | 563.361 | 2041.28 | 563.422 | 2073.37 | 565.205 | 2075.4 | 565.379 | 2080.31 | 565.603 |
| 2080.63 | 565.618 | 2115.22 | 567.181 | 2138.37 | 568.472 | 2178.31 | 569.195 | 2201.36 | 570.314 |
| 2259.29 | 571.51 | 2274.11 | 572.049 | 2277.78 | 572.508 | 2282.1 | 573.253 | 2292.31 | 573.322 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 294.84 | .13 | 1376.24 | .035 | 1584.41 | .13 |

| Bank Sta: Left | Right | Coeff Contr. | Expan. |
|---|---|---|---|
| 1376.24 | 1584.41 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 294.84 | 1272.6 | 580 | F |
| 1708.6 | 2292.31 | 580 | F |

Downstream Deck/Roadway Coordinates
num= 22

| Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord |
|---|---|---|---|---|---|---|---|---|
| 978 | 593.37 | 0 | 1000 | 592.5 | 0 | 1050 | 589.03 | 0 |
| 1100 | 585.75 | 0 | 1150 | 582.67 | 0 | 1200 | 579.81 | 0 |
| 1292.6 | 569.9 | 0 | 1292.6 | 569.9 | 566.57 | 1353.6 | 566.83 | 563.5 |
| 1414.6 | 564.11 | 560.78 | 1414.6 | 564.11 | 560.53 | 1490.6 | 561.55 | 557.97 |
| 1566.6 | 559.75 | 556.17 | 1566.6 | 559.75 | 556.42 | 1627.6 | 558.92 | 555.59 |
| 1688.6 | 558.61 | 555.28 | 1688.6 | 558.61 | 0 | 1800 | 562.87 | 0 |
| 1850 | 563.36 | 0 | 1900 | 564.18 | 0 | 2000 | 566.87 | 0 |
| 2201.36 | 570.31 | 0 | | | | | | |

Downstream Bridge Cross Section Data
Station Elevation Data num= 198

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 300.01 | 624.452 | 325.57 | 621.842 | 350.8 | 620.924 | 356.04 | 620.761 | 366.72 | 620.017 |
| 394.79 | 617.975 | 407.94 | 617.534 | 434.91 | 616.71 | 450.69 | 615.453 | 450.9 | 615.436 |
| 474.85 | 614.508 | 475.77 | 614.43 | 475.88 | 614.42 | 486.83 | 613.491 | 509.08 | 614.056 |
| 522.32 | 613.775 | 542.88 | 614.01 | 543.05 | 614.021 | 543.15 | 614.026 | 555.91 | 614.776 |
| 576.64 | 614.683 | 578.5 | 614.677 | 591.27 | 614.236 | 592.08 | 614.209 | 593.43 | 614.19 |
| 604.74 | 614.047 | 610.22 | 613.865 | 610.53 | 613.856 | 627.24 | 613.321 | 637.26 | 612.131 |
| 642.29 | 611.781 | 662.22 | 611.726 | 662.94 | 611.773 | 677.4 | 610.941 | 677.91 | 610.913 |
| 678.14 | 610.899 | 685.56 | 610.78 | 696.28 | 610.681 | 713.27 | 610.023 | 737.99 | 609.146 |
| 739.54 | 609.076 | 747.23 | 609.023 | 748.23 | 608.944 | 761.37 | 608.553 | 761.45 | 608.55 |
| 772.68 | 608.147 | 773.95 | 608.07 | 799.38 | 606.254 | 803.04 | 605.935 | 803.35 | 605.907 |
| 828.54 | 603.716 | 828.82 | 603.692 | 846.13 | 603.005 | 847.48 | 602.711 | 849.92 | 602.16 |
| 857.46 | 601.887 | 865.16 | 601.26 | 873.84 | 600.655 | 890.93 | 599.646 | 901.53 | 598.494 |
| 918.89 | 595.983 | 923.24 | 595.45 | 937.15 | 594.309 | 937.7 | 594.279 | 937.8 | 594.274 |
| 945.69 | 593.833 | 946.09 | 593.807 | 954.01 | 593.281 | 970.1 | 592.443 | 975.05 | 591.854 |
| 985.36 | 590.833 | 985.93 | 590.783 | 986.03 | 590.773 | 986.53 | 590.73 | 1014.7 | 588.977 |
| 1014.8 | 588.968 | 1016.46 | 588.834 | 1021.66 | 588.259 | 1041.74 | 586.119 | 1043.44 | 585.907 |
| 1070.85 | 583.934 | 1071.27 | 583.892 | 1073.45 | 583.726 | 1091.32 | 582.414 | 1094.28 | 581.981 |
| 1094.54 | 581.948 | 1115.83 | 579.192 | 1136.3 | 577.152 | 1157.2 | 573.268 | 1168.59 | 571.893 |
| 1188.75 | 566.704 | 1188.82 | 566.689 | 1188.88 | 566.673 | 1189.06 | 566.611 | 1190.04 | 566.246 |
| 1214.54 | 556.884 | 1215.95 | 556.342 | 1219.28 | 555.643 | 1221.06 | 555.223 | 1241.84 | 548.982 |
| 1253.92 | 543.734 | 1254.54 | 543.514 | 1255.27 | 543.249 | 1263.05 | 541.565 | 1276.87 | 539.603 |
| 1278.51 | 539.47 | 1287.3 | 539.9 | 1295.8 | 537.375 | 1321.2 | 534.732 | 1346.16 | 532.317 |
| 1361.06 | 530.921 | 1371.44 | 529.515 | 1380.41 | 528.712 | 1381.06 | 528.62 | 1381.25 | 528.315 |
| 1384.54 | 524.472 | 1391.12 | 516.757 | 1394.13 | 516.969 | 1411.91 | 516.954 | 1412.37 | 516.886 |
| 1414.54 | 516.881 | 1414.64 | 516.881 | 1436.78 | 516.811 | 1438.51 | 516.826 | 1462.04 | 516.629 |
| 1462.67 | 516.61 | 1487.14 | 516.586 | 1487.22 | 516.59 | 1488.59 | 516.629 | 1505.54 | 517.09 |
| 1517 | 516.666 | 1518.72 | 516.432 | 1533.11 | 514.293 | 1548.13 | 515.437 | 1570.38 | 516.859 |
| 1574.54 | 522.071 | 1575.11 | 522.794 | 1577.08 | 526.019 | 1577.09 | 526.02 | 1589.45 | 527.018 |
| 1604.24 | 529.99 | 1630.04 | 530.74 | 1644.74 | 531.998 | 1657.68 | 534.717 | 1664.54 | 534.97 |
| 1664.83 | 534.981 | 1690.4 | 545.619 | 1734.23 | 545.467 | 1740.97 | 545.496 | 1748.06 | 545.624 |
| 1756.24 | 545.661 | 1788.71 | 548.262 | 1795.48 | 548.385 | 1829.83 | 548.758 | 1834.54 | 548.795 |
| 1839.53 | 548.923 | 1877.67 | 550.712 | 1881.74 | 551.077 | 1886.47 | 551.241 | 1894.54 | 551.215 |
| 1894.75 | 551.214 | 1918.44 | 551.43 | 1921.37 | 551.423 | 1942.29 | 551.264 | 1942.88 | 551.298 |
| 1943.45 | 551.32 | 1984.54 | 552.468 | 1985.32 | 552.484 | 2009.72 | 554.78 | 2043.21 | 556.157 |
| 2058.49 | 556.909 | 2065.88 | 557.042 | 2088.57 | 558.557 | 2092.31 | 559.122 | 2100.25 | 559.787 |
| 2139.95 | 563.803 | 2155.88 | 565.457 | 2171.61 | 568.143 | 2190.65 | 571.204 | 2190.99 | 571.271 |

```
 2191.28 571.087 2194.41 569.879 2194.54 569.876 2195.14 569.864 2197.96 570.764
 2204.54 573.235 2205.28 573.515 2210.43 574.706 2216.15 575.466 2235.39  576.16
 2244.09 576.258 2244.54 576.273 2282.88 577.641 2288.26 577.912 2288.85 577.935
 2289.69 577.917 2291.86 578.013 2292.31 578.032

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  300.01     .13 1381.06    .035 1577.09     .13

Bank Sta: Left   Right    Coeff Contr.   Expan.
       1381.06 1577.09             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
  300.01  1272.6     580       F
  1708.6 2292.31     580       F

Upstream Embankment side slope              =       2 horiz. to 1.0 vertical
Downstream Embankment side slope            =       2 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =  558.61
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  1292.6  566.57  1292.6  563.65 1297.93  563.65 1377.93  523.65
Downstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  1292.6  566.57  1292.6  563.65 1297.93  563.65 1377.93  523.65

Abutment Data
Upstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 1583.27  502.36 1683.27  552.36  1688.6  552.36  1688.6  555.28
Downstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
 1583.27  502.36 1683.27  552.36  1688.6  552.36  1688.6  555.28

Number of Piers =  5

Pier Data
Pier Station     Upstream=  1353.6    Downstream=  1353.6
Upstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  564.87
Downstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  564.87

Pier Data
Pier Station     Upstream=  1414.6    Downstream=  1414.6
Upstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  562.15
Downstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  562.15

Pier Data
```

```
Pier Station     Upstream=  1490.6    Downstream=  1490.6
Upstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  559.59
Downstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  559.59

Pier Data
Pier Station     Upstream=  1566.6    Downstream=  1566.6
Upstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  557.79
Downstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  557.79

Pier Data
Pier Station     Upstream=  1627.6    Downstream=  1627.6
Upstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  556.96
Downstream     num=       2
    Width   Elev    Width   Elev
    2.75       0    2.75  556.96

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       W.S. Pro Method

  W.S.Pro Data
    Left Embankment
       El of the top of the embankment = 569.9
       El of the toe of the abutment   = 530.34
    Right Embankment
       El of the top of the embankment = 558.61
       El of the toe of the abutment   = 531.95
    Abtument Type                      = 3 Sloping abutments and sloping embankments
    Slope of abutments                 = 2
    Top with of embankment             = 23.7
    Centroid station of bridge opening =
    Wing Wall Type                     = No wing walls present
       Width                           =
       Angle                           =
       Radius                          =
    Guide Banks Type                   = No Guide Bank present
       Length                          =
       Offset                          =
       Angle                           =

Selected Low Flow Methods = W.S.Pro Method

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line
```

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -70

INPUT
Description: 70 ft downstream of the existing bridge
Station Elevation Data num= 198

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 300.01 | 624.452 | 325.57 | 621.842 | 350.8 | 620.924 | 356.04 | 620.761 | 366.72 | 620.017 |
| 394.79 | 617.975 | 407.94 | 617.534 | 434.91 | 616.71 | 450.69 | 615.453 | 450.9 | 615.436 |
| 474.85 | 614.508 | 475.77 | 614.43 | 475.88 | 614.42 | 486.83 | 613.491 | 509.08 | 614.056 |
| 522.32 | 613.775 | 542.88 | 614.01 | 543.05 | 614.021 | 543.15 | 614.026 | 555.91 | 614.776 |
| 576.64 | 614.683 | 578.5 | 614.677 | 591.27 | 614.236 | 592.08 | 614.209 | 593.43 | 614.19 |
| 604.74 | 614.047 | 610.22 | 613.865 | 610.53 | 613.856 | 627.24 | 613.321 | 637.26 | 612.131 |
| 642.29 | 611.781 | 662.22 | 611.726 | 662.94 | 611.773 | 677.4 | 610.941 | 677.91 | 610.913 |
| 678.14 | 610.899 | 685.56 | 610.78 | 696.28 | 610.681 | 713.27 | 610.023 | 737.99 | 609.146 |
| 739.54 | 609.076 | 747.23 | 609.023 | 748.23 | 608.944 | 761.37 | 608.553 | 761.45 | 608.55 |
| 772.68 | 608.147 | 773.95 | 608.07 | 799.38 | 606.254 | 803.04 | 605.935 | 803.35 | 605.907 |
| 828.54 | 603.716 | 828.82 | 603.692 | 846.13 | 603.005 | 847.48 | 602.711 | 849.92 | 602.16 |
| 857.46 | 601.887 | 865.16 | 601.26 | 873.84 | 600.655 | 890.93 | 599.646 | 901.53 | 598.494 |
| 918.89 | 595.983 | 923.24 | 595.45 | 937.15 | 594.309 | 937.7 | 594.279 | 937.8 | 594.274 |
| 945.69 | 593.833 | 946.09 | 593.807 | 954.01 | 593.281 | 970.1 | 592.443 | 975.05 | 591.854 |
| 985.36 | 590.833 | 985.93 | 590.783 | 986.03 | 590.773 | 986.53 | 590.73 | 1014.7 | 588.977 |
| 1014.8 | 588.968 | 1016.46 | 588.834 | 1021.66 | 588.259 | 1041.74 | 586.119 | 1043.44 | 585.907 |
| 1070.85 | 583.934 | 1071.27 | 583.892 | 1073.45 | 583.726 | 1091.32 | 582.414 | 1094.28 | 581.981 |
| 1094.54 | 581.948 | 1115.83 | 579.192 | 1136.3 | 577.152 | 1157.2 | 573.268 | 1168.59 | 571.893 |
| 1188.75 | 566.704 | 1188.82 | 566.689 | 1188.88 | 566.673 | 1189.06 | 566.611 | 1190.04 | 566.246 |
| 1214.54 | 556.884 | 1215.95 | 556.342 | 1219.28 | 555.643 | 1221.06 | 555.223 | 1241.84 | 548.982 |
| 1253.92 | 543.734 | 1254.54 | 543.514 | 1255.27 | 543.249 | 1263.05 | 541.565 | 1276.87 | 539.603 |
| 1278.51 | 539.47 | 1287.3 | 539.9 | 1295.8 | 537.375 | 1321.2 | 534.732 | 1346.16 | 532.317 |
| 1361.06 | 530.921 | 1371.44 | 529.515 | 1380.41 | 528.712 | 1381.06 | 528.62 | 1381.25 | 528.315 |
| 1384.54 | 524.472 | 1391.12 | 516.757 | 1394.13 | 516.969 | 1411.91 | 516.954 | 1412.37 | 516.886 |
| 1414.54 | 516.881 | 1414.64 | 516.881 | 1436.78 | 516.811 | 1438.51 | 516.826 | 1462.04 | 516.629 |
| 1462.67 | 516.61 | 1487.14 | 516.586 | 1487.22 | 516.59 | 1488.59 | 516.629 | 1505.54 | 517.09 |
| 1517 | 516.666 | 1518.72 | 516.432 | 1533.11 | 514.293 | 1548.13 | 515.437 | 1570.38 | 516.859 |
| 1574.54 | 522.071 | 1575.11 | 522.794 | 1577.08 | 526.019 | 1577.09 | 526.02 | 1589.45 | 527.018 |
| 1604.24 | 529.99 | 1630.04 | 530.74 | 1644.74 | 531.998 | 1657.68 | 534.717 | 1664.54 | 534.97 |
| 1664.83 | 534.981 | 1690.4 | 545.619 | 1734.23 | 545.467 | 1740.97 | 545.496 | 1748.06 | 545.624 |
| 1756.24 | 545.661 | 1788.71 | 548.262 | 1795.48 | 548.385 | 1829.83 | 548.758 | 1834.54 | 548.795 |
| 1839.53 | 548.923 | 1877.67 | 550.712 | 1881.74 | 551.077 | 1886.47 | 551.241 | 1894.54 | 551.215 |
| 1894.75 | 551.214 | 1918.44 | 551.43 | 1921.37 | 551.423 | 1942.29 | 551.264 | 1942.88 | 551.298 |
| 1943.45 | 551.32 | 1984.54 | 552.468 | 1985.32 | 552.484 | 2009.72 | 554.78 | 2043.21 | 556.157 |
| 2058.49 | 556.909 | 2065.88 | 557.042 | 2088.57 | 558.557 | 2092.31 | 559.122 | 2100.25 | 559.787 |
| 2139.95 | 563.803 | 2155.88 | 565.457 | 2171.61 | 568.143 | 2190.65 | 571.204 | 2190.99 | 571.271 |
| 2191.28 | 571.087 | 2194.41 | 569.879 | 2194.54 | 569.876 | 2195.14 | 569.864 | 2197.96 | 570.764 |
| 2204.54 | 573.235 | 2205.28 | 573.515 | 2210.43 | 574.706 | 2216.15 | 575.466 | 2235.39 | 576.16 |
| 2244.09 | 576.258 | 2244.54 | 576.273 | 2282.88 | 577.641 | 2288.26 | 577.912 | 2288.85 | 577.935 |
| 2289.69 | 577.917 | 2291.86 | 578.013 | 2292.31 | 578.032 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 300.01 | .13 | 1381.06 | .035 | 1577.09 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1381.06 | 1577.09 | 30 | 30 | 30 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 300.01 | 1272.6 | 580 | F |
| 1708.6 | 2292.31 | 580 | F |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -100

INPUT
Description: 100 ft downstream from existing bridge
Station Elevation Data num= 216

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.23 | 330.25 | 621.13 | 331.16 | 621.1 | 358.02 | 620.27 | 359.32 | 620.17 |
| 363.31 | 619.9 | 366.72 | 619.66 | 369.19 | 619.47 | 375.01 | 619.04 | 378.66 | 618.76 |
| 399.88 | 617.18 | 399.98 | 617.17 | 407.08 | 616.93 | 408.17 | 616.89 | 416.46 | 616.61 |
| 416.56 | 616.61 | 424.75 | 616.33 | 426.03 | 616.29 | 426.28 | 616.28 | 433.04 | 615.88 |
| 435.5 | 615.73 | 441.33 | 615.39 | 444.98 | 615.17 | 463.92 | 614.07 | 466.21 | 613.94 |
| 467.22 | 613.88 | 482.79 | 612.74 | 482.87 | 612.73 | 491.08 | 612.12 | 492.34 | 612.03 |
| 494.87 | 611.84 | 506.81 | 610.53 | 507.66 | 610.55 | 515.95 | 610.8 | 517.53 | 610.85 |
| 527.45 | 611.37 | 532.53 | 611.17 | 539.71 | 610.9 | 540.82 | 610.85 | 548.29 | 610.57 |
| 549.11 | 610.55 | 549.19 | 610.54 | 565.69 | 610.03 | 568.13 | 609.96 | 577.61 | 609.67 |
| 615.43 | 608.62 | 615.5 | 608.62 | 623.72 | 608.41 | 624.98 | 608.38 | 632.01 | 608.2 |
| 633.3 | 608.17 | 640.3 | 607.86 | 643.92 | 607.71 | 648.42 | 607.51 | 648.59 | 607.5 |
| 651.78 | 607.32 | 653.4 | 607.26 | 656.89 | 607.12 | 665.18 | 606.8 | 666.11 | 606.76 |
| 671.59 | 606.8 | 673.47 | 606.85 | 676.02 | 606.93 | 681.76 | 606.97 | 681.82 | 606.97 |
| 685.43 | 607 | 690.05 | 606.97 | 691.29 | 606.96 | 698.34 | 606.92 | 700.77 | 606.9 |
| 714.14 | 606.83 | 714.92 | 606.83 | 723.21 | 606.79 | 726.67 | 606.78 | 731.5 | 606.59 |
| 735.23 | 606.45 | 738.66 | 606.11 | 739.79 | 605.99 | 747.45 | 605.23 | 752.2 | 604.85 |
| 755.9 | 604.74 | 756.37 | 604.74 | 764.66 | 604.67 | 767.08 | 604.66 | 778.48 | 604.579 |
| 786.01 | 604.69 | 806.11 | 603.971 | 806.58 | 603.955 | 815.03 | 603.349 | 823.92 | 602.564 |
| 824.19 | 602.541 | 842.87 | 601.785 | 842.94 | 601.782 | 857.26 | 600.992 | 865.46 | 600.501 |
| 867.88 | 600.221 | 870.84 | 599.491 | 877.63 | 598.964 | 887.46 | 598.343 | 895.32 | 597.875 |
| 901.08 | 597.009 | 928.13 | 595.542 | 928.34 | 595.53 | 937.61 | 594.798 | 938.29 | 594.743 |
| 938.76 | 594.731 | 949.8 | 594.438 | 950.16 | 594.411 | 953.76 | 593.808 | 963.12 | 592.181 |
| 964.21 | 592.107 | 987.3 | 590.794 | 1001.69 | 589.89 | 1004.95 | 589.598 | 1005.08 | 589.589 |
| 1008.27 | 589.388 | 1016.74 | 588.693 | 1021.66 | 588.251 | 1034.92 | 587.123 | 1043.11 | 586.501 |
| 1059.76 | 584.38 | 1060.83 | 584.116 | 1077.67 | 582.41 | 1078.94 | 582.243 | 1079.65 | 582.192 |
| 1095.23 | 580.747 | 1111.75 | 578.604 | 1124.83 | 576.995 | 1139.25 | 573.487 | 1161.1 | 569.418 |
| 1169.95 | 567.211 | 1172.24 | 566.665 | 1179.06 | 564.82 | 1191.5 | 561.586 | 1194.91 | 560.411 |
| 1217.11 | 552.362 | 1227.31 | 548.694 | 1253.91 | 540.237 | 1266.99 | 538.18 | 1275.93 | 538.003 |
| 1300.47 | 535.493 | 1310.18 | 534.253 | 1331.18 | 532.739 | 1347.11 | 531.404 | 1360.09 | 529.599 |
| 1372.35 | 528.125 | 1376.09 | 527.799 | 1382.94 | 525.985 | 1383.68 | 525.788 | 1383.7 | 525.776 |
| 1390.89 | 516.798 | 1397.88 | 516.749 | 1411.74 | 516.884 | 1421.71 | 517.183 | 1428.79 | 517.163 |
| 1441.85 | 516.528 | 1466.62 | 516.281 | 1473.55 | 516.268 | 1484.04 | 516.841 | 1502.07 | 516.489 |
| 1508.22 | 516.656 | 1512.04 | 516.515 | 1522.94 | 515.032 | 1523.66 | 514.933 | 1529.5 | 514.065 |
| 1549.3 | 515.574 | 1564.2 | 516.546 | 1567.3 | 518.836 | 1571.13 | 523.578 | 1571.16 | 523.588 |
| 1572.94 | 524.184 | 1584.06 | 527.926 | 1602.67 | 529.258 | 1602.94 | 529.31 | 1617.02 | 531.972 |
| 1617.22 | 532.002 | 1642.94 | 535.664 | 1643.44 | 535.736 | 1649.85 | 536.117 | 1676.95 | 537.505 |
| 1679.73 | 537.607 | 1681.25 | 538.241 | 1692.49 | 538.202 | 1730.06 | 539.893 | 1743.11 | 540.354 |
| 1750.05 | 540.988 | 1770.25 | 543.011 | 1791.2 | 543.853 | 1842.94 | 546.365 | 1843.4 | 546.388 |
| 1844.53 | 546.421 | 1892.23 | 548.336 | 1896.3 | 548.521 | 1930.37 | 549.827 | 1953.97 | 550.777 |
| 1971.51 | 551.408 | 1990.06 | 552.266 | 2012.31 | 553.04 | 2012.94 | 553.093 | 2024.31 | 554.072 |
| 2047.81 | 554.346 | 2051.58 | 554.499 | 2058.09 | 554.788 | 2080.95 | 556.143 | 2117.36 | 559.648 |
| 2153.69 | 564.77 | 2186.17 | 568.904 | 2189.68 | 569.658 | 2192.38 | 570.117 | 2192.94 | 570.181 |
| 2224.19 | 573.718 | 2269.22 | 577.695 | 2271.8 | 577.785 | 2272.83 | 577.823 | 2272.94 | 577.826 |
| 2292.31 | 578.497 | | | | | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1383.7 | .035 | 1571.16 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1383.7 | 1571.16 | 140 | 140 | 140 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 329.32 | 1257.6 | 580 | F |

1723.6 2292.31 580 F

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -240

INPUT
Description: Exit
Station Elevation Data num= 148

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.07 | 330.25 | 620.976 | 331.16 | 620.943 | 358.02 | 620.107 | 366.72 | 619.497 |
| 399.88 | 617.021 | 399.98 | 617.014 | 416.46 | 616.453 | 416.56 | 616.45 | 426.03 | 616.129 |
| 426.28 | 616.12 | 466.21 | 613.78 | 467.22 | 613.722 | 482.79 | 612.577 | 482.87 | 612.571 |
| 494.87 | 611.684 | 506.81 | 610.367 | 517.53 | 610.692 | 527.45 | 611.212 | 548.29 | 610.414 |
| 549.11 | 610.388 | 549.19 | 610.385 | 573.98 | 609.623 | 598.85 | 608.91 | 615.43 | 608.464 |
| 615.5 | 608.462 | 632.01 | 608.041 | 633.3 | 608.01 | 648.42 | 607.352 | 648.59 | 607.342 |
| 651.78 | 607.162 | 665.18 | 606.64 | 666.11 | 606.605 | 671.59 | 606.638 | 676.02 | 606.77 |
| 681.76 | 606.81 | 681.82 | 606.81 | 685.43 | 606.838 | 726.67 | 606.618 | 735.23 | 606.289 |
| 747.45 | 605.073 | 748.08 | 605.022 | 752.2 | 604.694 | 755.9 | 604.581 | 778.48 | 604.421 |
| 786.01 | 604.532 | 806.11 | 603.813 | 806.58 | 603.797 | 815.03 | 603.191 | 823.92 | 602.406 |
| 824.19 | 602.383 | 842.87 | 601.627 | 842.94 | 601.624 | 857.26 | 600.834 | 865.46 | 600.343 |
| 867.88 | 600.063 | 870.84 | 599.333 | 877.63 | 598.806 | 887.46 | 598.185 | 895.32 | 597.717 |
| 901.08 | 596.851 | 928.13 | 595.384 | 928.34 | 595.372 | 937.61 | 594.64 | 938.29 | 594.585 |
| 949.8 | 594.28 | 950.16 | 594.253 | 953.76 | 593.65 | 963.12 | 592.023 | 964.21 | 591.949 |
| 987.3 | 590.636 | 1001.69 | 589.732 | 1004.95 | 589.44 | 1005.08 | 589.431 | 1008.27 | 589.23 |
| 1016.74 | 588.535 | 1021.66 | 588.093 | 1034.92 | 586.965 | 1043.11 | 586.343 | 1059.76 | 584.222 |
| 1060.83 | 583.958 | 1077.67 | 582.252 | 1078.94 | 582.085 | 1079.65 | 582.034 | 1095.23 | 580.589 |
| 1111.75 | 578.446 | 1124.83 | 576.837 | 1139.25 | 573.329 | 1161.1 | 569.26 | 1169.95 | 567.053 |
| 1172.24 | 566.507 | 1179.06 | 564.662 | 1191.5 | 561.428 | 1194.91 | 560.253 | 1217.11 | 552.204 |
| 1227.31 | 548.536 | 1253.91 | 540.079 | 1266.99 | 538.022 | 1275.93 | 537.845 | 1300.47 | 535.335 |
| 1310.18 | 534.095 | 1322.94 | 533.175 | 1329.24 | 527.442 | 1329.67 | 527.472 | 1342.17 | 528.314 |
| 1343.8 | 528.328 | 1345.2 | 527.776 | 1353.51 | 525.307 | 1356.76 | 519.497 | 1357.44 | 517.566 |
| 1384.63 | 516.916 | 1395.11 | 516.594 | 1402.71 | 516.649 | 1420.75 | 516.027 | 1423.31 | 515.68 |
| 1436.87 | 515.444 | 1440.49 | 515.264 | 1440.84 | 515.305 | 1449.2 | 516.276 | 1452.93 | 516.581 |
| 1470.38 | 516.723 | 1476.49 | 516.714 | 1490.5 | 515.745 | 1492.41 | 515.227 | 1494.89 | 515.691 |
| 1502.72 | 516.343 | 1506.62 | 515.979 | 1512.51 | 514.902 | 1516.05 | 515.723 | 1520.48 | 516.016 |
| 1532.75 | 516.501 | 1538.24 | 516.248 | 1543.86 | 513.813 | 1549.63 | 514.016 | 1561.51 | 516.288 |
| 1565.98 | 523.208 | 1569.24 | 526.853 | 1570.61 | 528.373 | 1574.47 | 527.642 | 1579.24 | 528.349 |
| 1579.3 | 528.357 | 1595.63 | 531.253 | 1624.44 | 535.335 | 1643 | 536.716 | 1665.48 | 539.855 |
| 1702.87 | 546.339 | 1745.35 | 551.46 | 1769.24 | 554.006 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1343.8 | .035 | 1570.61 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1343.8 | 1570.61 | 0 | 0 | 0 | .1 | .3 |

SUMMARY OF MANNING'S N VALUES

River:Broad River

| Reach | River Sta. | n1 | n2 | n3 |
|---|---|---|---|---|
| SR 281 | 240 | .13 | .035 | .13 |
| SR 281 | 140 | .13 | .035 | .13 |
| SR 281 | 70 | .13 | .035 | .13 |
| SR 281 | 0 | Bridge | | |
| SR 281 | -70 | .13 | .035 | .13 |

| | | | | |
|---|---|---|---|---|
| SR 281 | -100 | .13 | .035 | .13 |
| SR 281 | -240 | .13 | .035 | .13 |

SUMMARY OF REACH LENGTHS

River: Broad River

| Reach | River Sta. | Left | Channel | Right |
|---|---|---|---|---|
| SR 281 | 240 | 100 | 100 | 100 |
| SR 281 | 140 | 70 | 70 | 70 |
| SR 281 | 70 | 140 | 140 | 140 |
| SR 281 | 0 | Bridge | | |
| SR 281 | -70 | 30 | 30 | 30 |
| SR 281 | -100 | 140 | 140 | 140 |
| SR 281 | -240 | 0 | 0 | 0 |

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Broad River

| Reach | River Sta. | Contr. | Expan. |
|---|---|---|---|
| SR 281 | 240 | .3 | .5 |
| SR 281 | 140 | .3 | .5 |
| SR 281 | 70 | .3 | .5 |
| SR 281 | 0 | Bridge | |
| SR 281 | -70 | .3 | .5 |
| SR 281 | -100 | .3 | .5 |
| SR 281 | -240 | .1 | .3 |

HEC-RAS Plan: Exist Locations: User Defined

| River | Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Broad River | SR 281 | 240 | 2 yr | 11400.00 | 514.80 | 526.07 | | 526.70 | 0.001379 | 6.39 | 1783.03 | 214.14 | 0.39 |
| Broad River | SR 281 | 240 | 50 yr | 36400.00 | 514.80 | 535.33 | | 536.54 | 0.001074 | 8.95 | 5167.94 | 546.90 | 0.39 |
| Broad River | SR 281 | 240 | 100 yr | 41900.00 | 514.80 | 536.94 | | 538.22 | 0.001018 | 9.27 | 6075.84 | 581.99 | 0.38 |
| Broad River | SR 281 | 240 | 500 yr | 55300.00 | 514.80 | 540.51 | | 541.92 | 0.000918 | 9.91 | 8208.90 | 624.40 | 0.37 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 11400.00 | 514.67 | 526.00 | 521.01 | 526.54 | 0.001019 | 5.89 | 1935.35 | 205.51 | 0.34 |
| Broad River | SR 281 | 140 | 50 yr | 36400.00 | 514.67 | 535.10 | 526.53 | 536.40 | 0.001055 | 9.28 | 4732.96 | 524.65 | 0.38 |
| Broad River | SR 281 | 140 | 100 yr | 41900.00 | 514.67 | 536.65 | 527.50 | 538.07 | 0.001043 | 9.74 | 5431.66 | 569.57 | 0.38 |
| Broad River | SR 281 | 140 | 500 yr | 55300.00 | 514.67 | 540.08 | 529.77 | 541.75 | 0.001015 | 10.68 | 7086.07 | 618.41 | 0.39 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 11400.00 | 514.34 | 525.89 | 521.01 | 526.45 | 0.001071 | 5.99 | 1904.44 | 203.77 | 0.35 |
| Broad River | SR 281 | 70 | 50 yr | 36400.00 | 514.34 | 534.92 | 526.52 | 536.32 | 0.001137 | 9.53 | 4273.53 | 384.75 | 0.39 |
| Broad River | SR 281 | 70 | 100 yr | 41900.00 | 514.34 | 536.45 | 527.53 | 537.99 | 0.001134 | 10.04 | 4848.38 | 405.29 | 0.40 |
| Broad River | SR 281 | 70 | 500 yr | 55300.00 | 514.34 | 539.82 | 529.80 | 541.67 | 0.001126 | 11.12 | 6177.70 | 461.81 | 0.41 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 11400.00 | 514.29 | 525.51 | 521.40 | 526.22 | 0.001489 | 6.75 | 1688.64 | 193.12 | 0.40 |
| Broad River | SR 281 | -70 | 50 yr | 36400.00 | 514.29 | 534.82 | 527.13 | 536.06 | 0.001323 | 10.21 | 4072.15 | 339.98 | 0.43 |
| Broad River | SR 281 | -70 | 100 yr | 41900.00 | 514.29 | 536.47 | 528.17 | 537.72 | 0.001287 | 10.68 | 4655.65 | 363.86 | 0.43 |
| Broad River | SR 281 | -70 | 500 yr | 55300.00 | 514.29 | 540.09 | 530.51 | 541.40 | 0.001226 | 11.67 | 6036.78 | 403.70 | 0.43 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 11400.00 | 514.07 | 525.44 | 521.36 | 526.17 | 0.001505 | 6.87 | 1663.82 | 192.70 | 0.41 |
| Broad River | SR 281 | -100 | 50 yr | 36400.00 | 514.07 | 534.22 | 527.16 | 536.02 | 0.001499 | 10.84 | 3830.77 | 322.12 | 0.46 |
| Broad River | SR 281 | -100 | 100 yr | 41900.00 | 514.07 | 535.69 | 528.18 | 537.68 | 0.001501 | 11.45 | 4321.57 | 344.59 | 0.46 |
| Broad River | SR 281 | -100 | 500 yr | 55300.00 | 514.07 | 538.91 | 530.68 | 541.36 | 0.001516 | 12.76 | 5582.79 | 445.91 | 0.48 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 11400.00 | 513.81 | 525.35 | 520.74 | 525.90 | 0.001129 | 5.95 | 1917.15 | 214.53 | 0.35 |
| Broad River | SR 281 | -240 | 50 yr | 36400.00 | 513.81 | 534.28 | 526.08 | 535.59 | 0.001130 | 9.21 | 4210.80 | 308.27 | 0.39 |
| Broad River | SR 281 | -240 | 100 yr | 41900.00 | 513.81 | 535.78 | 527.07 | 537.23 | 0.001130 | 9.73 | 4689.24 | 334.21 | 0.40 |
| Broad River | SR 281 | -240 | 500 yr | 55300.00 | 513.81 | 539.05 | 529.28 | 540.85 | 0.001131 | 10.84 | 5898.78 | 399.32 | 0.41 |

HEC-RAS Plan: Exist Locations: User Defined

| River | Reach | River Sta | Profile | E.G. Elev | W.S. Elev | Vel Head | Frctn Loss | C & E Loss | Q Left | Q Channel | Q Right | Top Width |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (cfs) | (ft) |
| Broad River | SR 281 | 240 | 2 yr | 526.70 | 526.07 | 0.64 | 0.12 | 0.05 | | 11400.00 | | 214.14 |
| Broad River | SR 281 | 240 | 50 yr | 536.54 | 535.33 | 1.21 | 0.11 | 0.03 | 113.20 | 35250.19 | 1036.61 | 546.90 |
| Broad River | SR 281 | 240 | 100 yr | 538.22 | 536.94 | 1.28 | 0.10 | 0.04 | 206.40 | 40016.43 | 1677.18 | 581.99 |
| Broad River | SR 281 | 240 | 500 yr | 541.92 | 540.51 | 1.41 | 0.10 | 0.08 | 421.65 | 51137.40 | 3740.95 | 624.40 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 526.54 | 526.00 | 0.54 | 0.09 | 0.00 | | 11400.00 | | 205.51 |
| Broad River | SR 281 | 140 | 50 yr | 536.40 | 535.10 | 1.31 | 0.08 | 0.00 | 155.16 | 35471.75 | 773.10 | 524.65 |
| Broad River | SR 281 | 140 | 100 yr | 538.07 | 536.65 | 1.42 | 0.08 | 0.00 | 268.92 | 40370.26 | 1260.82 | 569.57 |
| Broad River | SR 281 | 140 | 500 yr | 541.75 | 540.08 | 1.67 | 0.08 | 0.00 | 674.18 | 51881.96 | 2743.85 | 618.41 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 526.45 | 525.89 | 0.56 | 0.08 | 0.00 | | 11400.00 | | 203.77 |
| Broad River | SR 281 | 70 | 50 yr | 536.32 | 534.92 | 1.40 | 0.09 | 0.00 | 110.09 | 36001.33 | 288.58 | 384.75 |
| Broad River | SR 281 | 70 | 100 yr | 537.99 | 536.45 | 1.54 | 0.10 | 0.00 | 191.87 | 41129.61 | 578.52 | 405.29 |
| Broad River | SR 281 | 70 | 500 yr | 541.67 | 539.82 | 1.85 | 0.10 | 0.00 | 494.80 | 53335.30 | 1469.90 | 461.81 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 0 | | Bridge | | | | | | | | |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 526.22 | 525.51 | 0.71 | 0.04 | 0.00 | | 11400.00 | | 193.12 |
| Broad River | SR 281 | -70 | 50 yr | 536.06 | 534.82 | 1.24 | 0.04 | 0.00 | 157.94 | 35809.06 | 433.00 | 339.98 |
| Broad River | SR 281 | -70 | 100 yr | 537.72 | 536.47 | 1.26 | 0.04 | 0.00 | 297.90 | 40910.84 | 691.26 | 363.86 |
| Broad River | SR 281 | -70 | 500 yr | 541.40 | 540.09 | 1.30 | 0.04 | 0.00 | 790.93 | 53040.29 | 1468.78 | 403.70 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 526.17 | 525.44 | 0.73 | 0.18 | 0.09 | | 11397.92 | 2.08 | 192.70 |
| Broad River | SR 281 | -100 | 50 yr | 536.02 | 534.22 | 1.80 | 0.18 | 0.24 | 238.66 | 35819.14 | 342.20 | 322.12 |
| Broad River | SR 281 | -100 | 100 yr | 537.68 | 535.69 | 1.99 | 0.18 | 0.27 | 413.79 | 40978.23 | 507.98 | 344.59 |
| Broad River | SR 281 | -100 | 500 yr | 541.36 | 538.91 | 2.44 | 0.18 | 0.33 | 972.59 | 53390.27 | 937.15 | 445.91 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 525.90 | 525.35 | 0.55 | | | | 11400.00 | | 214.53 |
| Broad River | SR 281 | -240 | 50 yr | 535.59 | 534.28 | 1.31 | | | 108.71 | 36152.14 | 139.15 | 308.27 |
| Broad River | SR 281 | -240 | 100 yr | 537.23 | 535.78 | 1.46 | | | 173.47 | 41498.75 | 227.78 | 334.21 |
| Broad River | SR 281 | -240 | 500 yr | 540.85 | 539.05 | 1.79 | | | 432.72 | 54286.68 | 580.60 | 399.32 |

HEC-RAS Plan: Exist Locations: User Defined

| River | Reach | River Sta | Profile | E.G. Elev | W.S. Elev | Crit W.S. | Frctn Loss | C & E Loss | Top Width | Q Left | Q Channel | Q Right | Vel Chnl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (cfs) | (ft/s) |
| Broad River | SR 281 | 240 | 2 yr | 526.70 | 526.07 | | 0.12 | 0.05 | 214.14 | | 11400.00 | | 6.39 |
| Broad River | SR 281 | 240 | 50 yr | 536.54 | 535.33 | | 0.11 | 0.03 | 546.90 | 113.20 | 35250.19 | 1036.61 | 8.95 |
| Broad River | SR 281 | 240 | 100 yr | 538.22 | 536.94 | | 0.10 | 0.04 | 581.99 | 206.40 | 40016.43 | 1677.18 | 9.27 |
| Broad River | SR 281 | 240 | 500 yr | 541.92 | 540.51 | | 0.10 | 0.08 | 624.40 | 421.65 | 51137.40 | 3740.95 | 9.91 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 526.54 | 526.00 | 521.01 | 0.09 | 0.00 | 205.51 | | 11400.00 | | 5.89 |
| Broad River | SR 281 | 140 | 50 yr | 536.40 | 535.10 | 526.53 | 0.08 | 0.00 | 524.65 | 155.16 | 35471.75 | 773.10 | 9.28 |
| Broad River | SR 281 | 140 | 100 yr | 538.07 | 536.65 | 527.50 | 0.08 | 0.00 | 569.57 | 268.92 | 40370.26 | 1260.82 | 9.74 |
| Broad River | SR 281 | 140 | 500 yr | 541.75 | 540.08 | 529.77 | 0.08 | 0.00 | 618.41 | 674.18 | 51881.96 | 2743.85 | 10.68 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 526.45 | 525.89 | 521.01 | 0.08 | 0.00 | 203.77 | | 11400.00 | | 5.99 |
| Broad River | SR 281 | 70 | 50 yr | 536.32 | 534.92 | 526.52 | 0.09 | 0.00 | 384.75 | 110.09 | 36001.33 | 288.58 | 9.53 |
| Broad River | SR 281 | 70 | 100 yr | 537.99 | 536.45 | 527.53 | 0.10 | 0.00 | 405.29 | 191.87 | 41129.61 | 578.52 | 10.04 |
| Broad River | SR 281 | 70 | 500 yr | 541.67 | 539.82 | 529.80 | 0.10 | 0.00 | 461.81 | 494.80 | 53335.30 | 1469.90 | 11.12 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 BR U | 2 yr | 526.37 | 525.75 | 521.13 | 0.05 | 0.00 | 195.29 | | 11400.00 | | 6.34 |
| Broad River | SR 281 | 0 BR U | 50 yr | 536.22 | 534.65 | 526.83 | 0.06 | 0.00 | 280.91 | 103.95 | 36107.18 | 188.87 | 10.11 |
| Broad River | SR 281 | 0 BR U | 100 yr | 537.89 | 536.14 | 527.86 | 0.06 | 0.00 | 284.85 | 173.88 | 41359.10 | 367.02 | 10.69 |
| Broad River | SR 281 | 0 BR U | 500 yr | 541.57 | 539.41 | 530.17 | 0.06 | 0.00 | 297.20 | 379.54 | 53994.66 | 925.80 | 11.94 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 BR D | 2 yr | 526.32 | 525.56 | 521.55 | 0.11 | 0.00 | 184.94 | | 11400.00 | | 7.01 |
| Broad River | SR 281 | 0 BR D | 50 yr | 536.17 | 534.74 | 527.47 | 0.11 | 0.00 | 281.27 | 157.31 | 35661.88 | 580.81 | 10.66 |
| Broad River | SR 281 | 0 BR D | 100 yr | 537.83 | 536.32 | 528.56 | 0.11 | 0.00 | 285.21 | 260.86 | 40758.22 | 880.91 | 11.19 |
| Broad River | SR 281 | 0 BR D | 500 yr | 541.51 | 539.79 | 531.12 | 0.11 | 0.00 | 298.72 | 559.64 | 53010.08 | 1730.28 | 12.35 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 526.22 | 525.51 | 521.40 | 0.04 | 0.00 | 193.12 | | 11400.00 | | 6.75 |
| Broad River | SR 281 | -70 | 50 yr | 536.06 | 534.82 | 527.13 | 0.04 | 0.00 | 339.98 | 157.94 | 35809.06 | 433.00 | 10.21 |
| Broad River | SR 281 | -70 | 100 yr | 537.72 | 536.47 | 528.17 | 0.04 | 0.00 | 363.86 | 297.90 | 40910.84 | 691.26 | 10.68 |
| Broad River | SR 281 | -70 | 500 yr | 541.40 | 540.09 | 530.51 | 0.04 | 0.00 | 403.70 | 790.93 | 53040.29 | 1468.78 | 11.67 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 526.17 | 525.44 | 521.36 | 0.18 | 0.09 | 192.70 | | 11397.92 | 2.08 | 6.87 |
| Broad River | SR 281 | -100 | 50 yr | 536.02 | 534.22 | 527.16 | 0.18 | 0.24 | 322.12 | 238.66 | 35819.14 | 342.20 | 10.84 |
| Broad River | SR 281 | -100 | 100 yr | 537.68 | 535.69 | 528.18 | 0.18 | 0.27 | 344.59 | 413.79 | 40978.23 | 507.98 | 11.45 |
| Broad River | SR 281 | -100 | 500 yr | 541.36 | 538.91 | 530.68 | 0.18 | 0.33 | 445.91 | 972.59 | 53390.27 | 937.15 | 12.76 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 525.90 | 525.35 | 520.74 | | | 214.53 | | 11400.00 | | 5.95 |
| Broad River | SR 281 | -240 | 50 yr | 535.59 | 534.28 | 526.08 | | | 308.27 | 108.71 | 36152.14 | 139.15 | 9.21 |
| Broad River | SR 281 | -240 | 100 yr | 537.23 | 535.78 | 527.07 | | | 334.21 | 173.47 | 41498.75 | 227.78 | 9.73 |
| Broad River | SR 281 | -240 | 500 yr | 540.85 | 539.05 | 529.28 | | | 399.32 | 432.72 | 54286.68 | 580.60 | 10.84 |

Plan: Exist  Broad River  SR 281  RS: 0  Profile: 2 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 526.45 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 525.89 | E.G. Elev (ft) | 526.37 | 526.32 |
| Q Total (cfs) | 11400.00 | W.S. Elev (ft) | 525.75 | 525.56 |
| Q Bridge (cfs) | 11400.00 | Crit W.S. (ft) | 521.13 | 521.55 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 11.41 | 11.27 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 6.34 | 7.01 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 1798.69 | 1625.27 |
| Weir Submerg | | Froude # Chl | 0.37 | 0.42 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 10771.32 | 9851.77 |
| Min El Weir Flow (ft) | 558.62 | Hydr Depth (ft) | 9.21 | 8.79 |
| Min El Prs (ft) | 566.57 | W.P. Total (ft) | 259.62 | 246.69 |
| Delta EG (ft) | 0.23 | Conv. Total (cfs) | 277520.1 | 242496.9 |
| Delta WS (ft) | 0.38 | Top Width (ft) | 195.29 | 184.94 |
| BR Open Area (sq ft) | 11714.86 | Frctn Loss (ft) | 0.05 | 0.11 |
| BR Open Vel (ft/s) | 7.01 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 0.73 | 0.91 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 4.63 | 6.38 |

Plan: Exist  Broad River  SR 281  RS: 0  Profile: 50 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 536.32 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 534.92 | E.G. Elev (ft) | 536.22 | 536.17 |
| Q Total (cfs) | 36400.00 | W.S. Elev (ft) | 534.65 | 534.74 |
| Q Bridge (cfs) | 36400.00 | Crit W.S. (ft) | 526.83 | 527.47 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 20.31 | 20.45 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 9.51 | 9.58 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 3828.59 | 3797.77 |
| Weir Submerg | | Froude # Chl | 0.42 | 0.45 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 44245.95 | 42285.99 |
| Min El Weir Flow (ft) | 558.62 | Hydr Depth (ft) | 13.63 | 13.50 |
| Min El Prs (ft) | 566.57 | W.P. Total (ft) | 408.85 | 410.13 |
| Delta EG (ft) | 0.26 | Conv. Total (cfs) | 762567.9 | 713511.3 |
| Delta WS (ft) | 0.11 | Top Width (ft) | 280.91 | 281.27 |
| BR Open Area (sq ft) | 11714.86 | Frctn Loss (ft) | 0.06 | 0.11 |
| BR Open Vel (ft/s) | 9.58 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.33 | 1.50 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 12.66 | 14.42 |

Plan: Exist  Broad River  SR 281  RS: 0  Profile: 100 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 537.99 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 536.45 | E.G. Elev (ft) | 537.89 | 537.83 |
| Q Total (cfs) | 41900.00 | W.S. Elev (ft) | 536.14 | 536.32 |
| Q Bridge (cfs) | 41900.00 | Crit W.S. (ft) | 527.86 | 528.56 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 21.80 | 22.03 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 9.86 | 9.87 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 4250.94 | 4245.91 |
| Weir Submerg | | Froude # Chl | 0.43 | 0.45 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 52676.98 | 50649.96 |
| Min El Weir Flow (ft) | 558.62 | Hydr Depth (ft) | 14.92 | 14.89 |
| Min El Prs (ft) | 566.57 | W.P. Total (ft) | 426.20 | 428.37 |
| Delta EG (ft) | 0.26 | Conv. Total (cfs) | 859954.1 | 811346.4 |
| Delta WS (ft) | -0.02 | Top Width (ft) | 284.85 | 285.21 |
| BR Open Area (sq ft) | 11714.86 | Frctn Loss (ft) | 0.06 | 0.11 |
| BR Open Vel (ft/s) | 9.87 | C & E Loss (ft) | 0.00 | 0.00 |

Plan: Exist  Broad River  SR 281  RS: 0  Profile: 100 yr (Continued)

| | | | | |
|---|---|---|---|---|
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.48 | 1.65 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 14.57 | 16.29 |

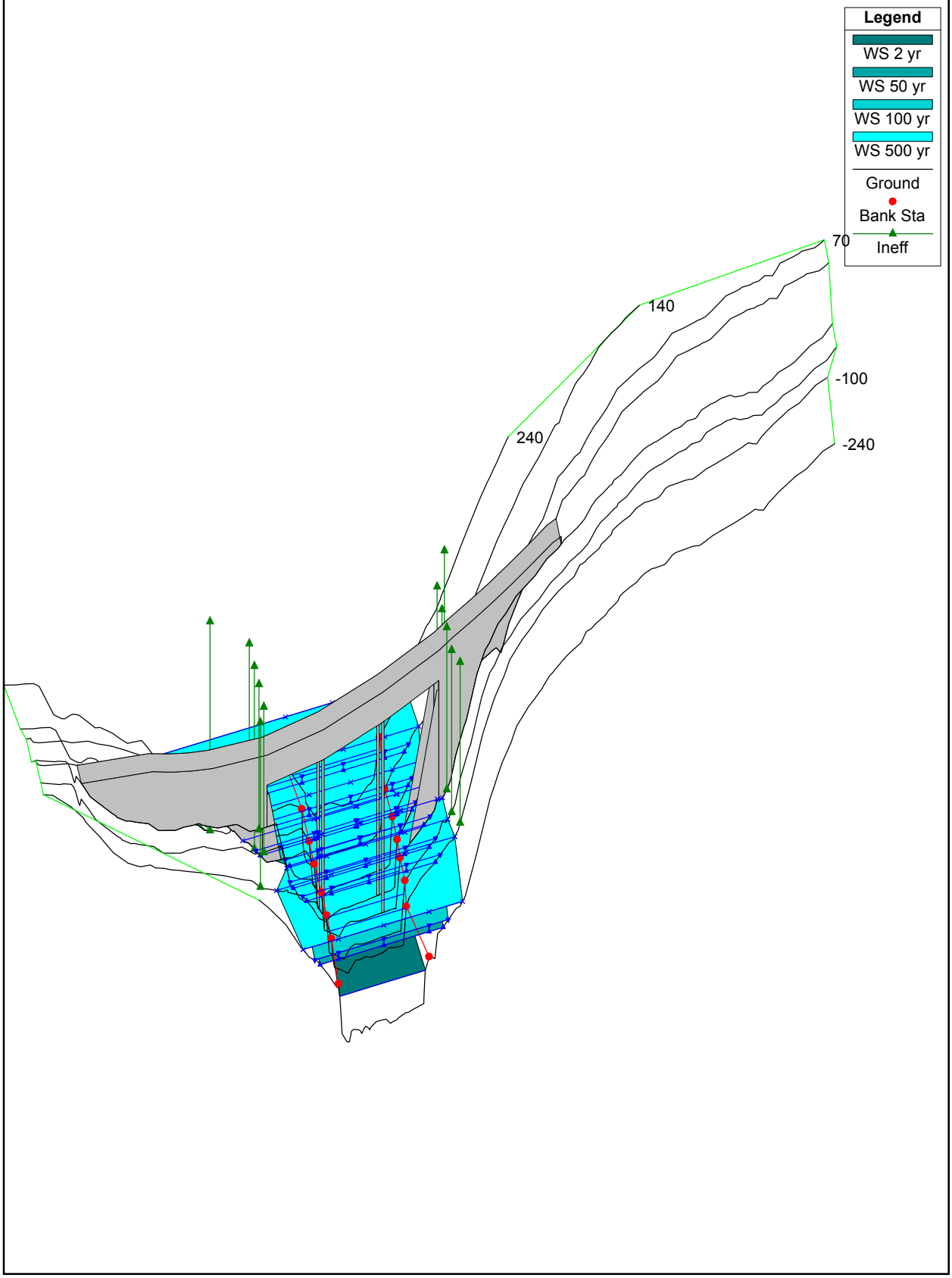
Plan: Exist  Broad River  SR 281  RS: 0  Profile: 500 yr

| E.G. US. (ft) | 541.67 | Element | Inside BR US | Inside BR DS |
|---|---|---|---|---|
| W.S. US. (ft) | 539.82 | E.G. Elev (ft) | 541.57 | 541.51 |
| Q Total (cfs) | 55300.00 | W.S. Elev (ft) | 539.41 | 539.79 |
| Q Bridge (cfs) | 55300.00 | Crit W.S. (ft) | 530.17 | 531.12 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 25.07 | 25.49 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 10.63 | 10.52 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 5200.76 | 5257.81 |
| Weir Submerg | | Froude # Chl | 0.44 | 0.46 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 74456.05 | 72341.20 |
| Min El Weir Flow (ft) | 558.62 | Hydr Depth (ft) | 17.50 | 17.60 |
| Min El Prs (ft) | 566.57 | W.P. Total (ft) | 472.31 | 477.96 |
| Delta EG (ft) | 0.27 | Conv. Total (cfs) | 1084857.0 | 1037940.0 |
| Delta WS (ft) | -0.28 | Top Width (ft) | 297.20 | 298.72 |
| BR Open Area (sq ft) | 11714.86 | Frctn Loss (ft) | 0.06 | 0.11 |
| BR Open Vel (ft/s) | 10.63 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.79 | 1.95 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 18.99 | 20.50 |

# HEC–RAS OUTPUT

# PROPOSED CONDITION

0013997 SR 281 over Broad River Plan: Proposed 10/2/2018



0013997SR281over.rep

HEC-RAS HEC-RAS 5.0.3 September 2016
U.S. Army Corps of Engineers
Hydrologic Engineering Center
609 Second Street
Davis, California

```
X     X  XXXXXX    XXXX        XXXX       XX      XXXX
X     X  X        X    X       X   X     X  X    X
X     X  X        X            X   X    X    X   X
XXXXXXX  XXXX     X       XXX  XXXX     XXXXXX    XXXX
X     X  X        X            X  X     X    X        X
X     X  X        X    X       X   X    X    X        X
X     X  XXXXXX    XXXX        X    X   X    X   XXXXX
```

PROJECT DATA
Project Title: 0013997 SR 281 over Broad River
Project File : 0013997SR281over.prj
Run Date and Time: 10/2/2018 1:27:53 PM

Project in English units

PLAN DATA

Plan Title: Proposed
Plan File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.p07

Geometry Title: Proposed
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g07

Flow Title : 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Plan Summary Information:

| | | | | | |
|---|---|---|---|---|---|
| Number of: | Cross Sections = | 6 | Multiple Openings = | 0 |
| | Culverts = | 0 | Inline Structures = | 0 |
| | Bridges = | 1 | Lateral Structures = | 0 |

Computational Information
Water surface calculation tolerance = 0.01
Critical depth calculation tolerance = 0.01
Maximum number of iterations = 20
Maximum difference tolerance = 0.3
Flow tolerance factor = 0.001

Computation Options
Critical depth computed only where necessary
Conveyance Calculation Method: At breaks in n values only
Friction Slope Method: Average Conveyance
Computational Flow Regime: Subcritical Flow

FLOW DATA

Flow Title: 0013997 Flow
Flow File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.f01

Flow Data (cfs)

| River | Reach | RS | 2 yr | 50 yr | 100 yr | 500 yr |
|---|---|---|---|---|---|---|
| Broad River | SR 281 | 240 | 11400 | 36400 | 41900 | 55300 |

Boundary Conditions

| River | Reach | Profile | Upstream | Downstream |
|---|---|---|---|---|
| Broad River | SR 281 | 2 yr | | Normal S = 0.001129 |
| Broad River | SR 281 | 50 yr | | Normal S = 0.001129 |
| Broad River | SR 281 | 100 yr | | Normal S = 0.001129 |
| Broad River | SR 281 | 500 yr | | Normal S = 0.001129 |

GEOMETRY DATA

Geometry Title: Proposed
Geometry File : y:\Hong\0013997 (195-0021-0) Madison County\HEC-RAS\0013997SR281over.g07

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 240

INPUT
Description: Approach
Station Elevation Data num= 117

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 1003.96 | 591.04 | 1008.97 | 590.39 | 1009.56 | 590.28 | 1012.81 | 589.68 | 1020.4 | 588.29 |
| 1021.66 | 588.05 | 1030.5 | 586.29 | 1031.92 | 586.01 | 1037.55 | 585.09 | 1040.5 | 584.58 |
| 1050.22 | 582.88 | 1050.5 | 582.84 | 1060.41 | 581.18 | 1060.5 | 581.16 | 1074.14 | 578.73 |
| 1080.5 | 577.42 | 1090.5 | 575.38 | 1095.78 | 574.29 | 1105.75 | 572.12 | 1125.97 | 567.92 |
| 1129.71 | 567.07 | 1130.5 | 566.9 | 1132.25 | 566.54 | 1150.5 | 562.49 | 1152.95 | 561.94 |
| 1173.22 | 557.84 | 1175.36 | 557.22 | 1178.4 | 556.63 | 1180.5 | 556.13 | 1185.19 | 555.03 |
| 1200.5 | 552.88 | 1202.02 | 552.67 | 1209.36 | 551.95 | 1210.5 | 551.74 | 1213.14 | 551.24 |
| 1216.31 | 550.58 | 1230.5 | 548 | 1240.5 | 546.01 | 1240.57 | 546 | 1249.91 | 542.69 |
| 1250.5 | 542.51 | 1252.93 | 541.78 | 1253.71 | 541.58 | 1258.11 | 541.2 | 1280.5 | 539.41 |
| 1281.42 | 539.33 | 1286.56 | 535.03 | 1314.88 | 530.71 | 1320.44 | 529.85 | 1323.52 | 529.34 |
| 1326.56 | 528.9 | 1326.79 | 528.86 | 1326.84 | 528.823 | 1327.81 | 528.1 | 1336.56 | 522.5 |
| 1341.31 | 519.45 | 1346.56 | 518.77 | 1347.69 | 518.62 | 1356.17 | 518.26 | 1356.56 | 518.22 |
| 1383.39 | 515.29 | 1395.11 | 515.48 | 1404.05 | 515.18 | 1421 | 515.13 | 1426.56 | 515.49 |

```
 1436.17  516.13 1436.56  516.14 1446.56  516.63 1450.38 516.811 1472.54 516.547
 1477.82 516.068 1490.09 514.797 1493.76 515.472  1511.6 518.606 1513.13 520.806
 1562.93528.9979 1567.17529.5379 1592.56530.9759 1600.35531.0159  1600.5531.0139
 1651.02530.3939 1671.79532.9369 1697.32536.3169 1702.22536.4629 1711.09536.5299
 1715.48534.9549 1742.69528.6459 1752.31528.5119  1760.5529.1229 1777.04529.9419
 1806.19530.9039 1822.44532.6159  1850.5534.0309 1850.77534.0449 1875.84538.7339
 1883.79539.3849 1912.89543.8469 1922.22545.0699 1922.64545.2179  1958.4545.5289
 1975.85547.0939 1995.81549.0189  2026.4551.2379 2039.47551.5489  2045.5552.2669
 2079.73555.7219 2090.26556.2619    2098556.3879 2115.44555.8699 2123.96556.1979
 2142.45557.6229 2178.83565.4359 2192.42566.4219 2199.09566.6629 2214.94567.0589
 2235.91567.3859 2267.69568.2769

Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
 1003.96     .13 1326.84    .035 1562.93     .13

Bank Sta: Left   Right    Lengths: Left Channel   Right     Coeff Contr.   Expan.
       1326.84 1562.93              100     100     100             .3       .5

CROSS SECTION


RIVER: Broad River
REACH: SR 281             RS: 140

INPUT
Description: 140 ft upstream of the existing bridge
Station Elevation Data    num=     158
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  716.79  624.31   747.3  622.59  749.32  622.48  753.05  622.26     765  621.18
  767.51  620.96  790.06  619.61  820.21  617.19  825.22  616.45  826.95   616.2
   835.8   614.9  836.06  614.86  844.65   613.6  844.86  613.57   853.5   612.6
  860.38  611.84  862.35  611.67   871.2  610.95  874.19   610.7  879.44  609.98
  880.05  609.89  880.51  609.83   888.9  608.34  890.28  608.09  897.76  606.77
  901.12  606.17  906.61   605.2  906.72  605.18  911.97  603.91   913.6  603.52
  915.46  603.03  918.63  602.21  922.81  602.04  923.46  602.01  924.31  601.98
  928.21  601.82     929  601.86  933.16  601.21  933.65  601.14  936.81  600.65
   971.7  595.08  977.03  594.46  977.41  594.42  979.24  594.21   990.2   592.7
  995.11  592.06 1008.97  590.28 1009.56  590.17  1020.4  588.17 1021.66  587.94
  1030.5  586.18 1031.92  585.89 1037.55  584.98  1040.5  584.47 1050.22  582.77
  1050.5  582.72 1060.41  581.06  1060.5  581.05 1074.14  578.61 1095.78  574.18
 1105.75  572.01 1125.97  567.81 1129.71  566.96  1130.5  566.79 1132.25  566.42
  1150.5  562.38 1152.95  561.83 1173.22  557.73 1175.36  557.11  1178.4  556.52
 1185.19  554.91  1200.5  552.77 1202.02  552.55 1209.36  551.84  1210.5  551.62
 1213.14  551.12 1216.31  550.47  1230.5  547.89  1240.5   545.9 1240.57  545.88
 1249.91  542.58 1252.93  541.66 1253.71  541.47 1258.11  541.09  1280.5   539.3
 1281.42  539.22 1289.04     538 1291.53  537.25 1316.04  533.73  1330.5  532.46
 1331.21  532.39  1350.5  528.65 1352.68  528.22 1355.44 527.656 1355.98  526.48
  1360.5  522.65 1365.41  518.48  1380.5     517 1383.82  516.67 1394.75  516.43
 1436.78  516.14  1450.5  516.11 1451.53  516.11  1480.5  516.22 1488.22  516.26
  1490.5  516.22 1490.83  516.22  1515.5  515.99 1522.79  515.58 1537.04  514.67
 1550.14   515.8  1550.5  515.91 1556.06  517.57 1560.44 520.686  1560.5 520.883
 1562.93 528.885 1562.94 528.886 1567.17 529.425 1592.56 530.863 1600.35 530.903
  1600.5 530.901 1651.02 530.281 1671.79 532.824 1697.32 536.204 1702.22  536.35
 1711.09 536.417 1715.48 534.842 1742.69 528.533 1752.31 528.399  1760.5  529.01
 1777.04 529.829 1806.19 530.791 1822.44 532.503  1850.5 533.918 1850.77 533.932
 1875.84 538.621 1883.79 539.272 1912.89 543.734 1922.22 544.957 1922.64 545.105
  1958.4 545.416 1975.85 546.981 1995.81 548.906  2026.4 551.125 2039.47 551.436
  2045.5 552.154 2079.73 555.609 2090.26 556.149    2098 556.275 2115.44 555.757
 2123.96 556.085 2142.45  557.51 2178.83 565.323 2192.42 566.309 2199.09  566.55
 2214.94 566.946 2235.91 567.273 2267.69 568.164

Manning's n Values        num=       3
```

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 716.79 | .13 | 1355.44 | .035 | 1562.94 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1355.44 | 1562.94 | 70 | 70 | 70 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 716.79 | 1205.667 | 580 | F |
| 1792.333 | 2267.69 | 580 | F |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: 70

INPUT
Description: 70 ft upstream of the existing bridge
Station Elevation Data num= 170

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 294.84 | 634.575 | 302.88 | 634.075 | 319.16 | 633.355 | 351.6 | 633.529 | 355.11 | 633.294 |
| 358.05 | 633.162 | 375.45 | 632.778 | 392.92 | 632.431 | 395.98 | 632.376 | 405.89 | 632.222 |
| 413.73 | 631.075 | 424.51 | 629.784 | 436.58 | 630.142 | 443.92 | 630.372 | 454.05 | 629.783 |
| 458.93 | 629.508 | 471.51 | 629.443 | 472.94 | 629.438 | 480.24 | 629.209 | 480.72 | 629.195 |
| 497.71 | 629.241 | 499.38 | 629.249 | 500.03 | 629.227 | 506.44 | 629 | 509.18 | 628.909 |
| 515.17 | 628.783 | 523.91 | 628.617 | 541.17 | 628.339 | 541.37 | 628.324 | 541.65 | 628.304 |
| 550.1 | 627.689 | 553.46 | 627.454 | 558.84 | 627.064 | 567.57 | 626.453 | 576.3 | 625.863 |
| 585.03 | 625.295 | 590.6 | 624.946 | 593.67 | 624.855 | 593.77 | 624.853 | 601.16 | 624.652 |
| 602.5 | 624.635 | 611.21 | 624.545 | 619.97 | 624.323 | 628.7 | 624.12 | 645.69 | 623.776 |
| 646.16 | 623.767 | 654.9 | 623.616 | 672.36 | 623.367 | 674.29 | 623.346 | 677.79 | 623.119 |
| 681.09 | 622.779 | 697.72 | 621.117 | 698.56 | 621.034 | 716.02 | 619.356 | 719.68 | 619.015 |
| 724.18 | 618.76 | 724.76 | 618.732 | 742.22 | 617.938 | 760.08 | 617.194 | 761.77 | 617.083 |
| 762.69 | 617.012 | 812.08 | 614.062 | 812.17 | 614.057 | 813.37 | 613.987 | 819.4 | 613.077 |
| 839.56 | 610.229 | 858.26 | 608.077 | 871.63 | 606.83 | 889.23 | 604.452 | 904.41 | 602.052 |
| 907.06 | 601.625 | 912.27 | 601.381 | 918.87 | 601.012 | 921.8 | 600.729 | 949.1 | 598.195 |
| 961.96 | 597.337 | 978 | 593.373 | 978.64 | 593.214 | 989.03 | 590.647 | 998.97 | 588.48 |
| 1021.66 | 585.625 | 1024.58 | 585.245 | 1028.92 | 584.435 | 1030.31 | 584.217 | 1037.17 | 583.152 |
| 1055.94 | 580.411 | 1070.31 | 577.387 | 1070.86 | 577.273 | 1095.55 | 572.025 | 1100.31 | 570.483 |
| 1112.36 | 566.615 | 1116.59 | 565.507 | 1126.02 | 566.743 | 1128.31 | 567.025 | 1139.19 | 566.523 |
| 1147.6 | 566.004 | 1159.19 | 565.374 | 1169.03 | 564.675 | 1195.81 | 562.879 | 1214.51 | 560.163 |
| 1235.07 | 557.113 | 1250.31 | 553.737 | 1251.25 | 553.53 | 1267.32 | 550.532 | 1284.53 | 545.657 |
| 1293.02 | 542.912 | 1313.46 | 537.569 | 1323.65 | 537.153 | 1348.46 | 532.931 | 1359.2 | 531.052 |
| 1376.24 | 528.583 | 1376.38 | 528.563 | 1380.31 | 522.821 | 1380.63 | 522.358 | 1382.47 | 517.467 |
| 1392.16 | 516.842 | 1404.52 | 516.851 | 1447.21 | 516.435 | 1458.98 | 516.231 | 1476.8 | 516.23 |
| 1486.33 | 516.114 | 1499.76 | 515.988 | 1515.85 | 516.079 | 1531.69 | 515.584 | 1546.93 | 514.829 |
| 1552.18 | 514.339 | 1574.22 | 517.997 | 1575.29 | 518.182 | 1580.31 | 523.973 | 1583.55 | 527.703 |
| 1584.39 | 528.747 | 1584.41 | 528.751 | 1604.33 | 532.341 | 1608.44 | 532.442 | 1637.84 | 531.846 |
| 1659.44 | 532.287 | 1667.23 | 532.167 | 1702.01 | 532.501 | 1710.31 | 533.443 | 1710.44 | 533.458 |
| 1747 | 538.289 | 1763.4 | 539.371 | 1785.75 | 542.404 | 1787.42 | 542.251 | 1809.62 | 544.729 |
| 1828.28 | 545.543 | 1829.57 | 545.608 | 1885.29 | 552.211 | 1894.07 | 553.07 | 1905.61 | 554.312 |
| 1926.42 | 556.148 | 1926.82 | 556.154 | 1980.31 | 559.747 | 1980.87 | 559.784 | 2031.71 | 562.81 |
| 2040.31 | 563.361 | 2041.28 | 563.422 | 2073.37 | 565.205 | 2075.4 | 565.379 | 2080.31 | 565.603 |
| 2080.63 | 565.618 | 2115.22 | 567.181 | 2138.37 | 568.472 | 2178.31 | 569.195 | 2201.36 | 570.314 |
| 2259.29 | 571.51 | 2274.11 | 572.049 | 2277.78 | 572.508 | 2282.1 | 573.253 | 2292.31 | 573.322 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 294.84 | .13 | 1376.24 | .035 | 1584.41 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1376.24 | 1584.41 | 140 | 140 | 140 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 294.84 | 1264 | 580 | F |
| 1734 | 2292.31 | 580 | F |

BRIDGE

RIVER: Broad River
REACH: SR 281 RS: 0

INPUT
Description:
Distance from Upstream XS = 50
Deck/Roadway Width = 40
Weir Coefficient = 2.6
Upstream Deck/Roadway Coordinates
num= 18

| Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord |
|---|---|---|---|---|---|---|---|---|
| 978 | 593.37 | 0 | 1000 | 592.5 | 0 | 1050 | 589.03 | 0 |
| 1100 | 585.75 | 0 | 1150 | 582.67 | 0 | 1200 | 579.81 | 0 |
| 1250 | 577.17 | 0 | 1284 | 575.09 | 0 | 1284 | 575.09 | 567.92 |
| 1424 | 569.23 | 562.06 | 1574 | 564.57 | 557.4 | 1714 | 562.58 | 555.41 |
| 1714 | 562.58 | 0 | 1850 | 563.35 | 0 | 1900 | 564.18 | 0 |
| 1950 | 565.35 | 0 | 2000 | 566.87 | 0 | 2178.31 | 569.2 | 0 |

Upstream Bridge Cross Section Data
Station Elevation Data num= 170

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 294.84 | 634.575 | 302.88 | 634.075 | 319.16 | 633.355 | 351.6 | 633.529 | 355.11 | 633.294 |
| 358.05 | 633.162 | 375.45 | 632.778 | 392.92 | 632.431 | 395.98 | 632.376 | 405.89 | 632.222 |
| 413.73 | 631.075 | 424.51 | 629.784 | 436.58 | 630.142 | 443.92 | 630.372 | 454.05 | 629.783 |
| 458.93 | 629.508 | 471.51 | 629.443 | 472.94 | 629.438 | 480.24 | 629.209 | 480.72 | 629.195 |
| 497.71 | 629.241 | 499.38 | 629.249 | 500.03 | 629.227 | 506.44 | 629 | 509.18 | 628.909 |
| 515.17 | 628.783 | 523.91 | 628.617 | 541.17 | 628.339 | 541.37 | 628.324 | 541.65 | 628.304 |
| 550.1 | 627.689 | 553.46 | 627.454 | 558.84 | 627.064 | 567.57 | 626.453 | 576.3 | 625.863 |
| 585.03 | 625.295 | 590.6 | 624.946 | 593.67 | 624.855 | 593.77 | 624.853 | 601.16 | 624.652 |
| 602.5 | 624.635 | 611.21 | 624.545 | 619.97 | 624.323 | 628.7 | 624.12 | 645.69 | 623.776 |
| 646.16 | 623.767 | 654.9 | 623.616 | 672.36 | 623.367 | 674.29 | 623.346 | 677.79 | 623.119 |
| 681.09 | 622.779 | 697.72 | 621.117 | 698.56 | 621.034 | 716.02 | 619.356 | 719.68 | 619.015 |
| 724.18 | 618.76 | 724.76 | 618.732 | 742.22 | 617.938 | 760.08 | 617.194 | 761.77 | 617.083 |
| 762.69 | 617.012 | 812.08 | 614.062 | 812.17 | 614.057 | 813.37 | 613.987 | 819.4 | 613.077 |
| 839.56 | 610.229 | 858.26 | 608.077 | 871.63 | 606.83 | 889.23 | 604.452 | 904.41 | 602.052 |
| 907.06 | 601.625 | 912.27 | 601.381 | 918.87 | 601.012 | 921.8 | 600.729 | 949.1 | 598.195 |
| 961.96 | 597.337 | 978 | 593.373 | 978.64 | 593.214 | 989.03 | 590.647 | 998.97 | 588.48 |
| 1021.66 | 585.625 | 1024.58 | 585.245 | 1028.92 | 584.435 | 1030.31 | 584.217 | 1037.17 | 583.152 |
| 1055.94 | 580.411 | 1070.31 | 577.387 | 1070.86 | 577.273 | 1095.55 | 572.025 | 1100.31 | 570.483 |
| 1112.36 | 566.615 | 1116.59 | 565.507 | 1126.02 | 566.743 | 1128.31 | 567.025 | 1139.19 | 566.523 |
| 1147.6 | 566.004 | 1159.19 | 565.374 | 1169.03 | 564.675 | 1195.81 | 562.879 | 1214.51 | 560.163 |
| 1235.07 | 557.113 | 1250.31 | 553.737 | 1251.25 | 553.53 | 1267.32 | 550.532 | 1284.53 | 545.657 |
| 1293.02 | 542.912 | 1313.46 | 537.569 | 1323.65 | 537.153 | 1348.46 | 532.931 | 1359.2 | 531.052 |
| 1376.24 | 528.583 | 1376.38 | 528.563 | 1380.31 | 522.821 | 1380.63 | 522.358 | 1382.47 | 517.467 |
| 1392.16 | 516.842 | 1404.52 | 516.851 | 1447.21 | 516.435 | 1458.98 | 516.231 | 1476.8 | 516.23 |
| 1486.33 | 516.114 | 1499.76 | 515.988 | 1515.85 | 516.079 | 1531.69 | 515.584 | 1546.93 | 514.829 |
| 1552.18 | 514.339 | 1574.22 | 517.997 | 1575.29 | 518.182 | 1580.31 | 523.973 | 1583.55 | 527.703 |
| 1584.39 | 528.747 | 1584.41 | 528.751 | 1604.33 | 532.341 | 1608.44 | 532.442 | 1637.84 | 531.846 |
| 1659.44 | 532.287 | 1667.23 | 532.167 | 1702.01 | 532.501 | 1710.31 | 533.443 | 1710.44 | 533.458 |
| 1747 | 538.289 | 1763.4 | 539.371 | 1785.75 | 542.404 | 1787.42 | 542.251 | 1809.62 | 544.729 |
| 1828.28 | 545.543 | 1829.57 | 545.608 | 1885.29 | 552.211 | 1894.07 | 553.07 | 1905.61 | 554.312 |
| 1926.42 | 556.148 | 1926.82 | 556.154 | 1980.31 | 559.747 | 1980.87 | 559.784 | 2031.71 | 562.81 |
| 2040.31 | 563.361 | 2041.28 | 563.422 | 2073.37 | 565.205 | 2075.4 | 565.379 | 2080.31 | 565.603 |
| 2080.63 | 565.618 | 2115.22 | 567.181 | 2138.37 | 568.472 | 2178.31 | 569.195 | 2201.36 | 570.314 |
| 2259.29 | 571.51 | 2274.11 | 572.049 | 2277.78 | 572.508 | 2282.1 | 573.253 | 2292.31 | 573.322 |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 294.84 | .13 | 1376.24 | .035 | 1584.41 | .13 |

| Bank Sta: Left | Right | Coeff Contr. | Expan. |
|---|---|---|---|
| 1376.24 | 1584.41 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 294.84 | 1264 | 580 | F |
| 1734 | 2292.31 | 580 | F |

Downstream Deck/Roadway Coordinates
num= 18

| Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord | Sta | Hi Cord | Lo Cord |
|---|---|---|---|---|---|---|---|---|
| 978 | 593.37 | 0 | 1000 | 592.5 | 0 | 1050 | 589.03 | 0 |
| 1100 | 585.75 | 0 | 1150 | 582.67 | 0 | 1200 | 579.81 | 0 |
| 1250 | 577.17 | 0 | 1284 | 575.09 | 0 | 1284 | 575.09 | 567.92 |
| 1424 | 569.23 | 562.06 | 1574 | 564.57 | 557.4 | 1714 | 562.58 | 555.41 |
| 1714 | 562.58 | 0 | 1850 | 563.35 | 0 | 1900 | 564.18 | 0 |
| 1950 | 565.35 | 0 | 2000 | 566.87 | 0 | 2178.31 | 569.2 | 0 |

Downstream Bridge Cross Section Data
Station Elevation Data num= 198

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 300.01 | 624.452 | 325.57 | 621.842 | 350.8 | 620.924 | 356.04 | 620.761 | 366.72 | 620.017 |
| 394.79 | 617.975 | 407.94 | 617.534 | 434.91 | 616.71 | 450.69 | 615.453 | 450.9 | 615.436 |
| 474.85 | 614.508 | 475.77 | 614.43 | 475.88 | 614.42 | 486.83 | 613.491 | 509.08 | 614.056 |
| 522.32 | 613.775 | 542.88 | 614.01 | 543.05 | 614.021 | 543.15 | 614.026 | 555.91 | 614.776 |
| 576.64 | 614.683 | 578.5 | 614.677 | 591.27 | 614.236 | 592.08 | 614.209 | 593.43 | 614.19 |
| 604.74 | 614.047 | 610.22 | 613.865 | 610.53 | 613.856 | 627.24 | 613.321 | 637.26 | 612.131 |
| 642.29 | 611.781 | 662.22 | 611.726 | 662.94 | 611.773 | 677.4 | 610.941 | 677.91 | 610.913 |
| 678.14 | 610.899 | 685.56 | 610.78 | 696.28 | 610.681 | 713.27 | 610.023 | 737.99 | 609.146 |
| 739.54 | 609.076 | 747.23 | 609.023 | 748.23 | 608.944 | 761.37 | 608.553 | 761.45 | 608.55 |
| 772.68 | 608.147 | 773.95 | 608.07 | 799.38 | 606.254 | 803.04 | 605.935 | 803.35 | 605.907 |
| 828.54 | 603.716 | 828.82 | 603.692 | 846.13 | 603.005 | 847.48 | 602.711 | 849.92 | 602.16 |
| 857.46 | 601.887 | 865.16 | 601.26 | 873.84 | 600.655 | 890.93 | 599.646 | 901.53 | 598.494 |
| 918.89 | 595.983 | 923.24 | 595.45 | 937.15 | 594.309 | 937.7 | 594.279 | 937.8 | 594.274 |
| 945.69 | 593.833 | 946.09 | 593.807 | 954.01 | 593.281 | 970.1 | 592.443 | 975.05 | 591.854 |
| 985.36 | 590.833 | 985.93 | 590.783 | 986.03 | 590.773 | 986.53 | 590.73 | 1014.7 | 588.977 |
| 1014.8 | 588.968 | 1016.46 | 588.834 | 1021.66 | 588.259 | 1041.74 | 586.119 | 1043.44 | 585.907 |
| 1070.85 | 583.934 | 1071.27 | 583.892 | 1073.45 | 583.726 | 1091.32 | 582.414 | 1094.28 | 581.981 |
| 1094.54 | 581.948 | 1115.83 | 579.192 | 1136.3 | 577.152 | 1157.2 | 573.268 | 1168.59 | 571.893 |
| 1188.75 | 566.704 | 1188.82 | 566.689 | 1188.88 | 566.673 | 1189.06 | 566.611 | 1190.04 | 566.246 |
| 1214.54 | 556.884 | 1215.95 | 556.342 | 1219.28 | 555.643 | 1221.06 | 555.223 | 1241.84 | 548.982 |
| 1253.92 | 543.734 | 1254.54 | 543.514 | 1255.27 | 543.249 | 1263.05 | 541.565 | 1276.87 | 539.603 |
| 1278.51 | 539.47 | 1287.3 | 539.9 | 1295.8 | 537.375 | 1321.2 | 534.732 | 1346.16 | 532.317 |
| 1361.06 | 530.921 | 1371.44 | 529.515 | 1380.41 | 528.712 | 1381.06 | 528.62 | 1381.25 | 528.315 |
| 1384.54 | 524.472 | 1391.12 | 516.757 | 1394.13 | 516.969 | 1411.91 | 516.954 | 1412.37 | 516.886 |
| 1414.54 | 516.881 | 1414.64 | 516.881 | 1436.78 | 516.811 | 1438.51 | 516.826 | 1462.04 | 516.629 |
| 1462.67 | 516.61 | 1487.14 | 516.586 | 1487.22 | 516.59 | 1488.59 | 516.629 | 1505.54 | 517.09 |
| 1517 | 516.666 | 1518.72 | 516.432 | 1533.11 | 514.293 | 1548.13 | 515.437 | 1570.38 | 516.859 |
| 1574.54 | 522.071 | 1575.11 | 522.794 | 1577.08 | 526.019 | 1577.09 | 526.02 | 1589.45 | 527.018 |
| 1604.24 | 529.99 | 1630.04 | 530.74 | 1644.74 | 531.998 | 1657.68 | 534.717 | 1664.54 | 534.97 |
| 1664.83 | 534.981 | 1690.4 | 545.619 | 1734.23 | 545.467 | 1740.97 | 545.496 | 1748.06 | 545.624 |
| 1756.24 | 545.661 | 1788.71 | 548.262 | 1795.48 | 548.385 | 1829.83 | 548.758 | 1834.54 | 548.795 |
| 1839.53 | 548.923 | 1877.67 | 550.712 | 1881.74 | 551.077 | 1886.47 | 551.241 | 1894.54 | 551.215 |
| 1894.75 | 551.214 | 1918.44 | 551.43 | 1921.37 | 551.423 | 1942.29 | 551.264 | 1942.88 | 551.298 |
| 1943.45 | 551.32 | 1984.54 | 552.468 | 1985.32 | 552.484 | 2009.72 | 554.78 | 2043.21 | 556.157 |
| 2058.49 | 556.909 | 2065.88 | 557.042 | 2088.57 | 558.557 | 2092.31 | 559.122 | 2100.25 | 559.787 |
| 2139.95 | 563.803 | 2155.88 | 565.457 | 2171.61 | 568.143 | 2190.65 | 571.204 | 2190.99 | 571.271 |
| 2191.28 | 571.087 | 2194.41 | 569.879 | 2194.54 | 569.876 | 2195.14 | 569.864 | 2197.96 | 570.764 |
| 2204.54 | 573.235 | 2205.28 | 573.515 | 2210.43 | 574.706 | 2216.15 | 575.466 | 2235.39 | 576.16 |
| 2244.09 | 576.258 | 2244.54 | 576.273 | 2282.88 | 577.641 | 2288.26 | 577.912 | 2288.85 | 577.935 |
| 2289.69 | 577.917 | 2291.86 | 578.013 | 2292.31 | 578.032 | | | | |

```
Manning's n Values        num=       3
     Sta   n Val     Sta   n Val     Sta   n Val
  300.01     .13 1381.06    .035 1577.09     .13

Bank Sta: Left   Right    Coeff Contr.   Expan.
       1381.06 1577.09             .3       .5
Ineffective Flow     num=       2
   Sta L   Sta R    Elev  Permanent
  300.01    1264     580       F
    1734 2292.31     580       F

Upstream Embankment side slope              =       2 horiz. to 1.0 vertical
Downstream Embankment side slope            =       2 horiz. to 1.0 vertical
Maximum allowable submergence for weir flow =     .98
Elevation at which weir flow begins         =  562.58
Energy head used in spillway design         =
Spillway height used in design              =
Weir crest shape                            = Broad Crested

Number of Abutments =  2

Abutment Data
Upstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1284  567.92    1284  565.76    1289  565.76    1379  520.76
Downstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1284  567.92    1284  565.76    1289  565.76    1379  520.76

Abutment Data
Upstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1619  508.25    1709  553.25    1714  553.25    1714  555.41
Downstream     num=       4
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
    1619  508.25    1709  553.25    1714  553.25    1714  555.41

Number of Piers =  2

Pier Data
Pier Station     Upstream=    1424    Downstream=    1424
Upstream     num=       2
    Width   Elev    Width   Elev
       6       0       6  565.15
Downstream     num=       2
    Width   Elev    Width   Elev
       6       0       6  565.15

Pier Data
Pier Station     Upstream=    1574    Downstream=    1574
Upstream     num=       2
    Width   Elev    Width   Elev
       6       0       6  560.49
Downstream     num=       2
    Width   Elev    Width   Elev
       6       0       6  560.49

Number of Bridge Coefficient Sets =  1

Low Flow Methods and Data
       W.S. Pro Method
```

```
  W.S.Pro Data
    Left Embankment
       El of the top of the embankment = 575.09
       El of the toe of the abutment   = 531.19
    Right Embankment
       El of the top of the embankment = 562.58
       El of the toe of the abutment   = 545.61
    Abtument Type                      = 3 Sloping abutments and sloping embankments
    Slope of abutments                 = 2
    Top with of embankment             = 40
    Centroid station of bridge opening =
    Wing Wall Type                     = No wing walls present
       Width                           =
       Angle                           =
       Radius                          =
    Guide Banks Type                   = No Guide Bank present
       Length                          =
       Offset                          =
       Angle                           =

Selected Low Flow Methods = W.S.Pro Method

High Flow Method
       Energy Only

Additional Bridge Parameters
       Add Friction component to Momentum
       Do not add Weight component to Momentum
       Class B flow critical depth computations use critical depth
           inside the bridge at the upstream end
       Criteria to check for pressure flow = Upstream energy grade line

CROSS SECTION


RIVER: Broad River
REACH: SR 281             RS: -70

INPUT
Description: 70 ft downstream of the existing bridge
Station Elevation Data    num=     198
     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev     Sta    Elev
  300.01 624.452  325.57 621.842   350.8 620.924  356.04 620.761  366.72 620.017
  394.79 617.975  407.94 617.534  434.91  616.71  450.69 615.453   450.9 615.436
  474.85 614.508  475.77  614.43  475.88  614.42  486.83 613.491  509.08 614.056
  522.32 613.775  542.88  614.01  543.05 614.021  543.15 614.026  555.91 614.776
  576.64 614.683   578.5 614.677  591.27 614.236  592.08 614.209  593.43  614.19
  604.74 614.047  610.22 613.865  610.53 613.856  627.24 613.321  637.26 612.131
  642.29 611.781  662.22 611.726  662.94 611.773   677.4 610.941  677.91 610.913
  678.14 610.899  685.56  610.78  696.28 610.681  713.27 610.023  737.99 609.146
  739.54 609.076  747.23 609.023  748.23 608.944  761.37 608.553  761.45  608.55
  772.68 608.147  773.95  608.07  799.38 606.254  803.04 605.935  803.35 605.907
  828.54 603.716  828.82 603.692  846.13 603.005  847.48 602.711  849.92  602.16
  857.46 601.887  865.16  601.26  873.84 600.655  890.93 599.646  901.53 598.494
  918.89 595.983  923.24  595.45  937.15 594.309   937.7 594.279   937.8 594.274
  945.69 593.833  946.09 593.807  954.01 593.281   970.1 592.443  975.05 591.854
  985.36 590.833  985.93 590.783  986.03 590.773  986.53  590.73  1014.7 588.977
  1014.8 588.968 1016.46 588.834 1021.66 588.259 1041.74 586.119 1043.44 585.907
 1070.85 583.934 1071.27 583.892 1073.45 583.726 1091.32 582.414 1094.28 581.981
 1094.54 581.948 1115.83 579.192  1136.3 577.152  1157.2 573.268 1168.59 571.893
 1188.75 566.704 1188.82 566.689 1188.88 566.673 1189.06 566.611 1190.04 566.246
 1214.54 556.884 1215.95 556.342 1219.28 555.643 1221.06 555.223 1241.84 548.982
 1253.92 543.734 1254.54 543.514 1255.27 543.249 1263.05 541.565 1276.87 539.603
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1278.51 | 539.47 | 1287.3 | 539.9 | 1295.8 | 537.375 | 1321.2 | 534.732 | 1346.16 | 532.317 |
| 1361.06 | 530.921 | 1371.44 | 529.515 | 1380.41 | 528.712 | 1381.06 | 528.62 | 1381.25 | 528.315 |
| 1384.54 | 524.472 | 1391.12 | 516.757 | 1394.13 | 516.969 | 1411.91 | 516.954 | 1412.37 | 516.886 |
| 1414.54 | 516.881 | 1414.64 | 516.881 | 1436.78 | 516.811 | 1438.51 | 516.826 | 1462.04 | 516.629 |
| 1462.67 | 516.61 | 1487.14 | 516.586 | 1487.22 | 516.59 | 1488.59 | 516.629 | 1505.54 | 517.09 |
| 1517 | 516.666 | 1518.72 | 516.432 | 1533.11 | 514.293 | 1548.13 | 515.437 | 1570.38 | 516.859 |
| 1574.54 | 522.071 | 1575.11 | 522.794 | 1577.08 | 526.019 | 1577.09 | 526.02 | 1589.45 | 527.018 |
| 1604.24 | 529.99 | 1630.04 | 530.74 | 1644.74 | 531.998 | 1657.68 | 534.717 | 1664.54 | 534.97 |
| 1664.83 | 534.981 | 1690.4 | 545.619 | 1734.23 | 545.467 | 1740.97 | 545.496 | 1748.06 | 545.624 |
| 1756.24 | 545.661 | 1788.71 | 548.262 | 1795.48 | 548.385 | 1829.83 | 548.758 | 1834.54 | 548.795 |
| 1839.53 | 548.923 | 1877.67 | 550.712 | 1881.74 | 551.077 | 1886.47 | 551.241 | 1894.54 | 551.215 |
| 1894.75 | 551.214 | 1918.44 | 551.43 | 1921.37 | 551.423 | 1942.29 | 551.264 | 1942.88 | 551.298 |
| 1943.45 | 551.32 | 1984.54 | 552.468 | 1985.32 | 552.484 | 2009.72 | 554.78 | 2043.21 | 556.157 |
| 2058.49 | 556.909 | 2065.88 | 557.042 | 2088.57 | 558.557 | 2092.31 | 559.122 | 2100.25 | 559.787 |
| 2139.95 | 563.803 | 2155.88 | 565.457 | 2171.61 | 568.143 | 2190.65 | 571.204 | 2190.99 | 571.271 |
| 2191.28 | 571.087 | 2194.41 | 569.879 | 2194.54 | 569.876 | 2195.14 | 569.864 | 2197.96 | 570.764 |
| 2204.54 | 573.235 | 2205.28 | 573.515 | 2210.43 | 574.706 | 2216.15 | 575.466 | 2235.39 | 576.16 |
| 2244.09 | 576.258 | 2244.54 | 576.273 | 2282.88 | 577.641 | 2288.26 | 577.912 | 2288.85 | 577.935 |
| 2289.69 | 577.917 | 2291.86 | 578.013 | 2292.31 | 578.032 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 300.01 | .13 | 1381.06 | .035 | 1577.09 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1381.06 | 1577.09 | 30 | 30 | 30 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 300.01 | 1264 | 580 | F |
| 1734 | 2292.31 | 580 | F |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -100

INPUT
Description: 100 ft downstream from existing bridge
Station Elevation Data num= 216

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.23 | 330.25 | 621.13 | 331.16 | 621.1 | 358.02 | 620.27 | 359.32 | 620.17 |
| 363.31 | 619.9 | 366.72 | 619.66 | 369.19 | 619.47 | 375.01 | 619.04 | 378.66 | 618.76 |
| 399.88 | 617.18 | 399.98 | 617.17 | 407.08 | 616.93 | 408.17 | 616.89 | 416.46 | 616.61 |
| 416.56 | 616.61 | 424.75 | 616.33 | 426.03 | 616.29 | 426.28 | 616.28 | 433.04 | 615.88 |
| 435.5 | 615.73 | 441.33 | 615.39 | 444.98 | 615.17 | 463.92 | 614.07 | 466.21 | 613.94 |
| 467.22 | 613.88 | 482.79 | 612.74 | 482.87 | 612.73 | 491.08 | 612.12 | 492.34 | 612.03 |
| 494.87 | 611.84 | 506.81 | 610.53 | 507.66 | 610.55 | 515.95 | 610.8 | 517.53 | 610.85 |
| 527.45 | 611.37 | 532.53 | 611.17 | 539.71 | 610.9 | 540.82 | 610.85 | 548.29 | 610.57 |
| 549.11 | 610.55 | 549.19 | 610.54 | 565.69 | 610.03 | 568.13 | 609.96 | 577.61 | 609.67 |
| 615.43 | 608.62 | 615.5 | 608.62 | 623.72 | 608.41 | 624.98 | 608.38 | 632.01 | 608.2 |
| 633.3 | 608.17 | 640.3 | 607.86 | 643.92 | 607.71 | 648.42 | 607.51 | 648.59 | 607.5 |
| 651.78 | 607.32 | 653.4 | 607.26 | 656.89 | 607.12 | 665.18 | 606.8 | 666.11 | 606.76 |
| 671.59 | 606.8 | 673.47 | 606.85 | 676.02 | 606.93 | 681.76 | 606.97 | 681.82 | 606.97 |
| 685.43 | 607 | 690.05 | 606.97 | 691.29 | 606.96 | 698.34 | 606.92 | 700.77 | 606.9 |
| 714.14 | 606.83 | 714.92 | 606.83 | 723.21 | 606.79 | 726.67 | 606.78 | 731.5 | 606.59 |
| 735.23 | 606.45 | 738.66 | 606.11 | 739.79 | 605.99 | 747.45 | 605.23 | 752.2 | 604.85 |
| 755.9 | 604.74 | 756.37 | 604.74 | 764.66 | 604.67 | 767.08 | 604.66 | 778.48 | 604.579 |
| 786.01 | 604.69 | 806.11 | 603.971 | 806.58 | 603.955 | 815.03 | 603.349 | 823.92 | 602.564 |
| 824.19 | 602.541 | 842.87 | 601.785 | 842.94 | 601.782 | 857.26 | 600.992 | 865.46 | 600.501 |
| 867.88 | 600.221 | 870.84 | 599.491 | 877.63 | 598.964 | 887.46 | 598.343 | 895.32 | 597.875 |
| 901.08 | 597.009 | 928.13 | 595.542 | 928.34 | 595.53 | 937.61 | 594.798 | 938.29 | 594.743 |
| 938.76 | 594.731 | 949.8 | 594.438 | 950.16 | 594.411 | 953.76 | 593.808 | 963.12 | 592.181 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 964.21 | 592.107 | 987.3 | 590.794 | 1001.69 | 589.89 | 1004.95 | 589.598 | 1005.08 | 589.589 |
| 1008.27 | 589.388 | 1016.74 | 588.693 | 1021.66 | 588.251 | 1034.92 | 587.123 | 1043.11 | 586.501 |
| 1059.76 | 584.38 | 1060.83 | 584.116 | 1077.67 | 582.41 | 1078.94 | 582.243 | 1079.65 | 582.192 |
| 1095.23 | 580.747 | 1111.75 | 578.604 | 1124.83 | 576.995 | 1139.25 | 573.487 | 1161.1 | 569.418 |
| 1169.95 | 567.211 | 1172.24 | 566.665 | 1179.06 | 564.82 | 1191.5 | 561.586 | 1194.91 | 560.411 |
| 1217.11 | 552.362 | 1227.31 | 548.694 | 1253.91 | 540.237 | 1266.99 | 538.18 | 1275.93 | 538.003 |
| 1300.47 | 535.493 | 1310.18 | 534.253 | 1331.18 | 532.739 | 1347.11 | 531.404 | 1360.09 | 529.599 |
| 1372.35 | 528.125 | 1376.09 | 527.799 | 1382.94 | 525.985 | 1383.68 | 525.788 | 1383.7 | 525.776 |
| 1390.89 | 516.798 | 1397.88 | 516.749 | 1411.74 | 516.884 | 1421.71 | 517.183 | 1428.79 | 517.163 |
| 1441.85 | 516.528 | 1466.62 | 516.281 | 1473.55 | 516.268 | 1484.04 | 516.841 | 1502.07 | 516.489 |
| 1508.22 | 516.656 | 1512.04 | 516.515 | 1522.94 | 515.032 | 1523.66 | 514.933 | 1529.5 | 514.065 |
| 1549.3 | 515.574 | 1564.2 | 516.546 | 1567.3 | 518.836 | 1571.13 | 523.578 | 1571.16 | 523.588 |
| 1572.94 | 524.184 | 1584.06 | 527.926 | 1602.67 | 529.258 | 1602.94 | 529.31 | 1617.02 | 531.972 |
| 1617.22 | 532.002 | 1642.94 | 535.664 | 1643.44 | 535.736 | 1649.85 | 536.117 | 1676.95 | 537.505 |
| 1679.73 | 537.607 | 1681.25 | 538.241 | 1692.49 | 538.202 | 1730.06 | 539.893 | 1743.11 | 540.354 |
| 1750.05 | 540.988 | 1770.25 | 543.011 | 1791.2 | 543.853 | 1842.94 | 546.365 | 1843.4 | 546.388 |
| 1844.53 | 546.421 | 1892.23 | 548.336 | 1896.3 | 548.521 | 1930.37 | 549.827 | 1953.97 | 550.777 |
| 1971.51 | 551.408 | 1990.06 | 552.266 | 2012.31 | 553.04 | 2012.94 | 553.093 | 2024.31 | 554.072 |
| 2047.81 | 554.346 | 2051.58 | 554.499 | 2058.09 | 554.788 | 2080.95 | 556.143 | 2117.36 | 559.648 |
| 2153.69 | 564.77 | 2186.17 | 568.904 | 2189.68 | 569.658 | 2192.38 | 570.117 | 2192.94 | 570.181 |
| 2224.19 | 573.718 | 2269.22 | 577.695 | 2271.8 | 577.785 | 2272.83 | 577.823 | 2272.94 | 577.826 |
| 2292.31 | 578.497 | | | | | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1383.7 | .035 | 1571.16 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1383.7 | 1571.16 | 140 | 140 | 140 | .3 | .5 |

Ineffective Flow num= 2

| Sta L | Sta R | Elev | Permanent |
|---|---|---|---|
| 329.32 | 1249 | 580 | F |
| 1749 | 2292.31 | 580 | F |

CROSS SECTION

RIVER: Broad River
REACH: SR 281 RS: -240

INPUT
Description: Exit
Station Elevation Data num= 148

| Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev | Sta | Elev |
|---|---|---|---|---|---|---|---|---|---|
| 329.32 | 621.07 | 330.25 | 620.976 | 331.16 | 620.943 | 358.02 | 620.107 | 366.72 | 619.497 |
| 399.88 | 617.021 | 399.98 | 617.014 | 416.46 | 616.453 | 416.56 | 616.45 | 426.03 | 616.129 |
| 426.28 | 616.12 | 466.21 | 613.78 | 467.22 | 613.722 | 482.79 | 612.577 | 482.87 | 612.571 |
| 494.87 | 611.684 | 506.81 | 610.367 | 517.53 | 610.692 | 527.45 | 611.212 | 548.29 | 610.414 |
| 549.11 | 610.388 | 549.19 | 610.385 | 573.98 | 609.623 | 598.85 | 608.91 | 615.43 | 608.464 |
| 615.5 | 608.462 | 632.01 | 608.041 | 633.3 | 608.01 | 648.42 | 607.352 | 648.59 | 607.342 |
| 651.78 | 607.162 | 665.18 | 606.64 | 666.11 | 606.605 | 671.59 | 606.638 | 676.02 | 606.77 |
| 681.76 | 606.81 | 681.82 | 606.81 | 685.43 | 606.838 | 726.67 | 606.618 | 735.23 | 606.289 |
| 747.45 | 605.073 | 748.08 | 605.022 | 752.2 | 604.694 | 755.9 | 604.581 | 778.48 | 604.421 |
| 786.01 | 604.532 | 806.11 | 603.813 | 806.58 | 603.797 | 815.03 | 603.191 | 823.92 | 602.406 |
| 824.19 | 602.383 | 842.87 | 601.627 | 842.94 | 601.624 | 857.26 | 600.834 | 865.46 | 600.343 |
| 867.88 | 600.063 | 870.84 | 599.333 | 877.63 | 598.806 | 887.46 | 598.185 | 895.32 | 597.717 |
| 901.08 | 596.851 | 928.13 | 595.384 | 928.34 | 595.372 | 937.61 | 594.64 | 938.29 | 594.585 |
| 949.8 | 594.28 | 950.16 | 594.253 | 953.76 | 593.65 | 963.12 | 592.023 | 964.21 | 591.949 |
| 987.3 | 590.636 | 1001.69 | 589.732 | 1004.95 | 589.44 | 1005.08 | 589.431 | 1008.27 | 589.23 |
| 1016.74 | 588.535 | 1021.66 | 588.093 | 1034.92 | 586.965 | 1043.11 | 586.343 | 1059.76 | 584.222 |
| 1060.83 | 583.958 | 1077.67 | 582.252 | 1078.94 | 582.085 | 1079.65 | 582.034 | 1095.23 | 580.589 |
| 1111.75 | 578.446 | 1124.83 | 576.837 | 1139.25 | 573.329 | 1161.1 | 569.26 | 1169.95 | 567.053 |
| 1172.24 | 566.507 | 1179.06 | 564.662 | 1191.5 | 561.428 | 1194.91 | 560.253 | 1217.11 | 552.204 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1227.31 | 548.536 | 1253.91 | 540.079 | 1266.99 | 538.022 | 1275.93 | 537.845 | 1300.47 | 535.335 |
| 1310.18 | 534.095 | 1322.94 | 533.175 | 1329.24 | 527.442 | 1329.67 | 527.472 | 1342.17 | 528.314 |
| 1343.8 | 528.328 | 1345.2 | 527.776 | 1353.51 | 525.307 | 1356.76 | 519.497 | 1357.44 | 517.566 |
| 1384.63 | 516.916 | 1395.11 | 516.594 | 1402.71 | 516.649 | 1420.75 | 516.027 | 1423.31 | 515.68 |
| 1436.87 | 515.444 | 1440.49 | 515.264 | 1440.84 | 515.305 | 1449.2 | 516.276 | 1452.93 | 516.581 |
| 1470.38 | 516.723 | 1476.49 | 516.714 | 1490.5 | 515.745 | 1492.41 | 515.227 | 1494.89 | 515.691 |
| 1502.72 | 516.343 | 1506.62 | 515.979 | 1512.51 | 514.902 | 1516.05 | 515.723 | 1520.48 | 516.016 |
| 1532.75 | 516.501 | 1538.24 | 516.248 | 1543.86 | 513.813 | 1549.63 | 514.016 | 1561.51 | 516.288 |
| 1565.98 | 523.208 | 1569.24 | 526.853 | 1570.61 | 528.373 | 1574.47 | 527.642 | 1579.24 | 528.349 |
| 1579.3 | 528.357 | 1595.63 | 531.253 | 1624.44 | 535.335 | 1643 | 536.716 | 1665.48 | 539.855 |
| 1702.87 | 546.339 | 1745.35 | 551.46 | 1769.24 | 554.006 | | | | |

Manning's n Values num= 3

| Sta | n Val | Sta | n Val | Sta | n Val |
|---|---|---|---|---|---|
| 329.32 | .13 | 1343.8 | .035 | 1570.61 | .13 |

| Bank Sta: Left | Right | Lengths: Left | Channel | Right | Coeff Contr. | Expan. |
|---|---|---|---|---|---|---|
| 1343.8 | 1570.61 | 0 | 0 | 0 | .1 | .3 |

SUMMARY OF MANNING'S N VALUES

River:Broad River

| Reach | River Sta. | n1 | n2 | n3 |
|---|---|---|---|---|
| SR 281 | 240 | .13 | .035 | .13 |
| SR 281 | 140 | .13 | .035 | .13 |
| SR 281 | 70 | .13 | .035 | .13 |
| SR 281 | 0 | Bridge | | |
| SR 281 | -70 | .13 | .035 | .13 |
| SR 281 | -100 | .13 | .035 | .13 |
| SR 281 | -240 | .13 | .035 | .13 |

SUMMARY OF REACH LENGTHS

River: Broad River

| Reach | River Sta. | Left | Channel | Right |
|---|---|---|---|---|
| SR 281 | 240 | 100 | 100 | 100 |
| SR 281 | 140 | 70 | 70 | 70 |
| SR 281 | 70 | 140 | 140 | 140 |
| SR 281 | 0 | Bridge | | |
| SR 281 | -70 | 30 | 30 | 30 |
| SR 281 | -100 | 140 | 140 | 140 |
| SR 281 | -240 | 0 | 0 | 0 |

SUMMARY OF CONTRACTION AND EXPANSION COEFFICIENTS
River: Broad River

| Reach | River Sta. | Contr. | Expan. |
|---|---|---|---|
| SR 281 | 240 | .3 | .5 |
| SR 281 | 140 | .3 | .5 |

```
SR 281                70              .3        .5
SR 281                0        Bridge
SR 281                -70             .3        .5
SR 281                -100            .3        .5
SR 281                -240            .1        .3
```

HEC-RAS Plan: Pro Locations: User Defined

| River | Reach | River Sta | Profile | Q Total | Min Ch El | W.S. Elev | Crit W.S. | E.G. Elev | E.G. Slope | Vel Chnl | Flow Area | Top Width | Froude # Chl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (cfs) | (ft) | (ft) | (ft) | (ft) | (ft/ft) | (ft/s) | (sq ft) | (ft) | |
| Broad River | SR 281 | 240 | 2 yr | 11400.00 | 514.80 | 526.05 | | 526.69 | 0.001387 | 6.41 | 1779.49 | 214.02 | 0.39 |
| Broad River | SR 281 | 240 | 50 yr | 36400.00 | 514.80 | 535.30 | | 536.51 | 0.001082 | 8.97 | 5150.59 | 546.37 | 0.39 |
| Broad River | SR 281 | 240 | 100 yr | 41900.00 | 514.80 | 536.91 | | 538.19 | 0.001026 | 9.29 | 6054.18 | 581.75 | 0.38 |
| Broad River | SR 281 | 240 | 500 yr | 55300.00 | 514.80 | 540.46 | | 541.88 | 0.000926 | 9.94 | 8177.71 | 623.45 | 0.38 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 11400.00 | 514.67 | 525.98 | 521.01 | 526.52 | 0.001025 | 5.90 | 1931.88 | 205.48 | 0.34 |
| Broad River | SR 281 | 140 | 50 yr | 36400.00 | 514.67 | 535.09 | 526.53 | 536.38 | 0.001047 | 9.25 | 4863.06 | 524.53 | 0.38 |
| Broad River | SR 281 | 140 | 100 yr | 41900.00 | 514.67 | 536.65 | 527.50 | 538.05 | 0.001032 | 9.69 | 5604.29 | 569.59 | 0.38 |
| Broad River | SR 281 | 140 | 500 yr | 55300.00 | 514.67 | 540.10 | 529.77 | 541.73 | 0.000996 | 10.59 | 7353.42 | 618.70 | 0.39 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 11400.00 | 514.34 | 525.87 | 521.01 | 526.43 | 0.001077 | 6.00 | 1900.85 | 203.74 | 0.35 |
| Broad River | SR 281 | 70 | 50 yr | 36400.00 | 514.34 | 534.90 | 526.52 | 536.30 | 0.001143 | 9.54 | 4275.11 | 384.42 | 0.40 |
| Broad River | SR 281 | 70 | 100 yr | 41900.00 | 514.34 | 536.42 | 527.53 | 537.97 | 0.001140 | 10.06 | 4877.39 | 404.94 | 0.40 |
| Broad River | SR 281 | 70 | 500 yr | 55300.00 | 514.34 | 539.80 | 529.80 | 541.64 | 0.001125 | 11.10 | 6295.64 | 461.63 | 0.41 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 | | Bridge | | | | | | | | | |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 11400.00 | 514.29 | 525.51 | 521.40 | 526.22 | 0.001489 | 6.75 | 1688.70 | 193.12 | 0.40 |
| Broad River | SR 281 | -70 | 50 yr | 36400.00 | 514.29 | 534.82 | 527.13 | 536.06 | 0.001323 | 10.21 | 4072.15 | 339.98 | 0.43 |
| Broad River | SR 281 | -70 | 100 yr | 41900.00 | 514.29 | 536.47 | 528.17 | 537.72 | 0.001287 | 10.68 | 4655.65 | 363.86 | 0.43 |
| Broad River | SR 281 | -70 | 500 yr | 55300.00 | 514.29 | 540.09 | 530.51 | 541.40 | 0.001226 | 11.67 | 6036.78 | 403.70 | 0.43 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 11400.00 | 514.07 | 525.44 | 521.36 | 526.17 | 0.001505 | 6.87 | 1663.82 | 192.70 | 0.41 |
| Broad River | SR 281 | -100 | 50 yr | 36400.00 | 514.07 | 534.22 | 527.16 | 536.02 | 0.001499 | 10.84 | 3830.77 | 322.12 | 0.46 |
| Broad River | SR 281 | -100 | 100 yr | 41900.00 | 514.07 | 535.69 | 528.18 | 537.68 | 0.001501 | 11.45 | 4321.57 | 344.59 | 0.46 |
| Broad River | SR 281 | -100 | 500 yr | 55300.00 | 514.07 | 538.91 | 530.68 | 541.36 | 0.001516 | 12.76 | 5582.79 | 445.91 | 0.48 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 11400.00 | 513.81 | 525.35 | 520.74 | 525.90 | 0.001129 | 5.95 | 1917.15 | 214.53 | 0.35 |
| Broad River | SR 281 | -240 | 50 yr | 36400.00 | 513.81 | 534.28 | 526.08 | 535.59 | 0.001130 | 9.21 | 4210.80 | 308.27 | 0.39 |
| Broad River | SR 281 | -240 | 100 yr | 41900.00 | 513.81 | 535.78 | 527.07 | 537.23 | 0.001130 | 9.73 | 4689.24 | 334.21 | 0.40 |
| Broad River | SR 281 | -240 | 500 yr | 55300.00 | 513.81 | 539.05 | 529.28 | 540.85 | 0.001131 | 10.84 | 5898.78 | 399.32 | 0.41 |

HEC-RAS Plan: Pro Locations: User Defined

| River | Reach | River Sta | Profile | E.G. Elev | W.S. Elev | Vel Head | Frctn Loss | C & E Loss | Q Left | Q Channel | Q Right | Top Width |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (cfs) | (ft) |
| Broad River | SR 281 | 240 | 2 yr | 526.69 | 526.05 | 0.64 | 0.12 | 0.05 | | 11400.00 | | 214.02 |
| Broad River | SR 281 | 240 | 50 yr | 536.51 | 535.30 | 1.21 | 0.11 | 0.02 | 111.90 | 35260.16 | 1027.94 | 546.37 |
| Broad River | SR 281 | 240 | 100 yr | 538.19 | 536.91 | 1.28 | 0.10 | 0.04 | 204.67 | 40031.41 | 1663.92 | 581.75 |
| Broad River | SR 281 | 240 | 500 yr | 541.88 | 540.46 | 1.42 | 0.10 | 0.06 | 420.59 | 51158.41 | 3721.00 | 623.45 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 526.52 | 525.98 | 0.54 | 0.09 | 0.00 | | 11400.00 | | 205.48 |
| Broad River | SR 281 | 140 | 50 yr | 536.38 | 535.09 | 1.29 | 0.08 | 0.00 | 154.29 | 35329.66 | 916.05 | 524.53 |
| Broad River | SR 281 | 140 | 100 yr | 538.05 | 536.65 | 1.40 | 0.08 | 0.00 | 267.56 | 40152.23 | 1480.21 | 569.59 |
| Broad River | SR 281 | 140 | 500 yr | 541.73 | 540.10 | 1.62 | 0.08 | 0.00 | 670.37 | 51462.25 | 3167.38 | 618.70 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 526.43 | 525.87 | 0.56 | 0.06 | 0.00 | | 11400.00 | | 203.74 |
| Broad River | SR 281 | 70 | 50 yr | 536.30 | 534.90 | 1.40 | 0.08 | 0.00 | 109.28 | 36010.23 | 280.49 | 384.42 |
| Broad River | SR 281 | 70 | 100 yr | 537.97 | 536.42 | 1.54 | 0.08 | 0.00 | 190.70 | 41138.47 | 570.84 | 404.94 |
| Broad River | SR 281 | 70 | 500 yr | 541.64 | 539.80 | 1.85 | 0.08 | 0.00 | 492.32 | 53227.79 | 1579.90 | 461.63 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | 0 | | Bridge | | | | | | | | |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 526.22 | 525.51 | 0.71 | 0.04 | 0.00 | | 11400.00 | | 193.12 |
| Broad River | SR 281 | -70 | 50 yr | 536.06 | 534.82 | 1.24 | 0.04 | 0.00 | 157.94 | 35809.05 | 433.00 | 339.98 |
| Broad River | SR 281 | -70 | 100 yr | 537.72 | 536.47 | 1.26 | 0.04 | 0.00 | 297.90 | 40910.84 | 691.26 | 363.86 |
| Broad River | SR 281 | -70 | 500 yr | 541.40 | 540.09 | 1.30 | 0.04 | 0.00 | 790.93 | 53040.30 | 1468.78 | 403.70 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 526.17 | 525.44 | 0.73 | 0.18 | 0.09 | | 11397.92 | 2.08 | 192.70 |
| Broad River | SR 281 | -100 | 50 yr | 536.02 | 534.22 | 1.80 | 0.18 | 0.24 | 238.66 | 35819.14 | 342.20 | 322.12 |
| Broad River | SR 281 | -100 | 100 yr | 537.68 | 535.69 | 1.99 | 0.18 | 0.27 | 413.79 | 40978.23 | 507.98 | 344.59 |
| Broad River | SR 281 | -100 | 500 yr | 541.36 | 538.91 | 2.44 | 0.18 | 0.33 | 972.59 | 53390.27 | 937.15 | 445.91 |
| | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 525.90 | 525.35 | 0.55 | | | | 11400.00 | | 214.53 |
| Broad River | SR 281 | -240 | 50 yr | 535.59 | 534.28 | 1.31 | | | 108.71 | 36152.14 | 139.15 | 308.27 |
| Broad River | SR 281 | -240 | 100 yr | 537.23 | 535.78 | 1.46 | | | 173.47 | 41498.75 | 227.78 | 334.21 |
| Broad River | SR 281 | -240 | 500 yr | 540.85 | 539.05 | 1.79 | | | 432.72 | 54286.68 | 580.60 | 399.32 |

HEC-RAS Plan: Pro Locations: User Defined

| River | Reach | River Sta | Profile | E.G. Elev | W.S. Elev | Crit W.S. | Frctn Loss | C & E Loss | Top Width | Q Left | Q Channel | Q Right | Vel Chnl |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (ft) | (ft) | (ft) | (ft) | (ft) | (ft) | (cfs) | (cfs) | (cfs) | (ft/s) |
| Broad River | SR 281 | 240 | 2 yr | 526.69 | 526.05 | | 0.12 | 0.05 | 214.02 | | 11400.00 | | 6.41 |
| Broad River | SR 281 | 240 | 50 yr | 536.51 | 535.30 | | 0.11 | 0.02 | 546.37 | 111.90 | 35260.16 | 1027.94 | 8.97 |
| Broad River | SR 281 | 240 | 100 yr | 538.19 | 536.91 | | 0.10 | 0.04 | 581.75 | 204.67 | 40031.41 | 1663.92 | 9.29 |
| Broad River | SR 281 | 240 | 500 yr | 541.88 | 540.46 | | 0.10 | 0.06 | 623.45 | 420.59 | 51158.41 | 3721.00 | 9.94 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 140 | 2 yr | 526.52 | 525.98 | 521.01 | 0.09 | 0.00 | 205.48 | | 11400.00 | | 5.90 |
| Broad River | SR 281 | 140 | 50 yr | 536.38 | 535.09 | 526.53 | 0.08 | 0.00 | 524.53 | 154.29 | 35329.66 | 916.05 | 9.25 |
| Broad River | SR 281 | 140 | 100 yr | 538.05 | 536.65 | 527.50 | 0.08 | 0.00 | 569.59 | 267.56 | 40152.23 | 1480.21 | 9.69 |
| Broad River | SR 281 | 140 | 500 yr | 541.73 | 540.10 | 529.77 | 0.08 | 0.00 | 618.70 | 670.37 | 51462.25 | 3167.38 | 10.59 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 70 | 2 yr | 526.43 | 525.87 | 521.01 | 0.06 | 0.00 | 203.74 | | 11400.00 | | 6.00 |
| Broad River | SR 281 | 70 | 50 yr | 536.30 | 534.90 | 526.52 | 0.08 | 0.00 | 384.42 | 109.28 | 36010.23 | 280.49 | 9.54 |
| Broad River | SR 281 | 70 | 100 yr | 537.97 | 536.42 | 527.53 | 0.08 | 0.00 | 404.94 | 190.70 | 41138.47 | 570.84 | 10.06 |
| Broad River | SR 281 | 70 | 500 yr | 541.64 | 539.80 | 529.80 | 0.08 | 0.00 | 461.63 | 492.32 | 53227.79 | 1579.90 | 11.10 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 BR U | 2 yr | 526.37 | 525.72 | 521.12 | 0.07 | 0.00 | 191.51 | | 11400.00 | | 6.44 |
| Broad River | SR 281 | 0 BR U | 50 yr | 536.22 | 534.59 | 526.91 | 0.08 | 0.00 | 308.36 | 117.90 | 36045.41 | 236.69 | 10.29 |
| Broad River | SR 281 | 0 BR U | 100 yr | 537.89 | 536.09 | 527.95 | 0.08 | 0.00 | 314.34 | 195.24 | 41216.48 | 488.29 | 10.85 |
| Broad River | SR 281 | 0 BR U | 500 yr | 541.57 | 539.38 | 530.29 | 0.09 | 0.00 | 327.49 | 442.17 | 53552.61 | 1305.22 | 12.05 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | 0 BR D | 2 yr | 526.30 | 525.53 | 521.51 | 0.08 | 0.00 | 181.36 | | 11400.00 | | 7.06 |
| Broad River | SR 281 | 0 BR D | 50 yr | 536.14 | 534.71 | 527.46 | 0.08 | 0.00 | 294.57 | 163.58 | 35699.40 | 537.02 | 10.81 |
| Broad River | SR 281 | 0 BR D | 100 yr | 537.81 | 536.32 | 528.55 | 0.08 | 0.00 | 308.18 | 271.31 | 40774.21 | 854.48 | 11.33 |
| Broad River | SR 281 | 0 BR D | 500 yr | 541.48 | 539.85 | 531.10 | 0.08 | 0.00 | 323.72 | 606.73 | 52807.37 | 1885.90 | 12.43 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -70 | 2 yr | 526.22 | 525.51 | 521.40 | 0.04 | 0.00 | 193.12 | | 11400.00 | | 6.75 |
| Broad River | SR 281 | -70 | 50 yr | 536.06 | 534.82 | 527.13 | 0.04 | 0.00 | 339.98 | 157.94 | 35809.05 | 433.00 | 10.21 |
| Broad River | SR 281 | -70 | 100 yr | 537.72 | 536.47 | 528.17 | 0.04 | 0.00 | 363.86 | 297.90 | 40910.84 | 691.26 | 10.68 |
| Broad River | SR 281 | -70 | 500 yr | 541.40 | 540.09 | 530.51 | 0.04 | 0.00 | 403.70 | 790.93 | 53040.30 | 1468.78 | 11.67 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -100 | 2 yr | 526.17 | 525.44 | 521.36 | 0.18 | 0.09 | 192.70 | | 11397.92 | 2.08 | 6.87 |
| Broad River | SR 281 | -100 | 50 yr | 536.02 | 534.22 | 527.16 | 0.18 | 0.24 | 322.12 | 238.66 | 35819.14 | 342.20 | 10.84 |
| Broad River | SR 281 | -100 | 100 yr | 537.68 | 535.69 | 528.18 | 0.18 | 0.27 | 344.59 | 413.79 | 40978.23 | 507.98 | 11.45 |
| Broad River | SR 281 | -100 | 500 yr | 541.36 | 538.91 | 530.68 | 0.18 | 0.33 | 445.91 | 972.59 | 53390.27 | 937.15 | 12.76 |
| | | | | | | | | | | | | | |
| Broad River | SR 281 | -240 | 2 yr | 525.90 | 525.35 | 520.74 | | | 214.53 | | 11400.00 | | 5.95 |
| Broad River | SR 281 | -240 | 50 yr | 535.59 | 534.28 | 526.08 | | | 308.27 | 108.71 | 36152.14 | 139.15 | 9.21 |
| Broad River | SR 281 | -240 | 100 yr | 537.23 | 535.78 | 527.07 | | | 334.21 | 173.47 | 41498.75 | 227.78 | 9.73 |
| Broad River | SR 281 | -240 | 500 yr | 540.85 | 539.05 | 529.28 | | | 399.32 | 432.72 | 54286.68 | 580.60 | 10.84 |

Plan: Pro Broad River SR 281 RS: 0 Profile: 2 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 526.43 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 525.87 | E.G. Elev (ft) | 526.37 | 526.30 |
| Q Total (cfs) | 11400.00 | W.S. Elev (ft) | 525.72 | 525.53 |
| Q Bridge (cfs) | 11400.00 | Crit W.S. (ft) | 521.12 | 521.51 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 11.39 | 11.23 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 6.44 | 7.06 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 1771.00 | 1615.86 |
| Weir Submerg | | Froude # Chl | 0.37 | 0.42 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 10700.83 | 9844.13 |
| Min El Weir Flow (ft) | 562.59 | Hydr Depth (ft) | 9.25 | 8.91 |
| Min El Prs (ft) | 567.92 | W.P. Total (ft) | 231.50 | 211.32 |
| Delta EG (ft) | 0.21 | Conv. Total (cfs) | 291918.2 | 266260.8 |
| Delta WS (ft) | 0.36 | Top Width (ft) | 191.51 | 181.36 |
| BR Open Area (sq ft) | 12909.35 | Frctn Loss (ft) | 0.07 | 0.08 |
| BR Open Vel (ft/s) | 7.06 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 0.73 | 0.88 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 4.69 | 6.17 |

Plan: Pro Broad River SR 281 RS: 0 Profile: 50 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 536.30 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 534.90 | E.G. Elev (ft) | 536.22 | 536.14 |
| Q Total (cfs) | 36400.00 | W.S. Elev (ft) | 534.59 | 534.71 |
| Q Bridge (cfs) | 36400.00 | Crit W.S. (ft) | 526.91 | 527.46 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 20.25 | 20.42 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 9.48 | 9.58 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 3840.24 | 3798.54 |
| Weir Submerg | | Froude # Chl | 0.43 | 0.45 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 43911.40 | 42105.59 |
| Min El Weir Flow (ft) | 562.59 | Hydr Depth (ft) | 12.45 | 12.90 |
| Min El Prs (ft) | 567.92 | W.P. Total (ft) | 388.61 | 364.10 |
| Delta EG (ft) | 0.24 | Conv. Total (cfs) | 820424.2 | 794873.1 |
| Delta WS (ft) | 0.08 | Top Width (ft) | 308.36 | 294.57 |
| BR Open Area (sq ft) | 12909.35 | Frctn Loss (ft) | 0.08 | 0.08 |
| BR Open Vel (ft/s) | 9.58 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.21 | 1.37 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 11.51 | 13.09 |

Plan: Pro Broad River SR 281 RS: 0 Profile: 100 yr

| | | | | |
|---|---|---|---|---|
| E.G. US. (ft) | 537.97 | Element | Inside BR US | Inside BR DS |
| W.S. US. (ft) | 536.42 | E.G. Elev (ft) | 537.89 | 537.81 |
| Q Total (cfs) | 41900.00 | W.S. Elev (ft) | 536.09 | 536.32 |
| Q Bridge (cfs) | 41900.00 | Crit W.S. (ft) | 527.95 | 528.55 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 21.75 | 22.03 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 9.73 | 9.77 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 4305.71 | 4287.86 |
| Weir Submerg | | Froude # Chl | 0.43 | 0.45 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 52396.53 | 50493.88 |
| Min El Weir Flow (ft) | 562.59 | Hydr Depth (ft) | 13.70 | 13.91 |
| Min El Prs (ft) | 567.92 | W.P. Total (ft) | 401.28 | 384.80 |
| Delta EG (ft) | 0.24 | Conv. Total (cfs) | 930837.4 | 908943.7 |
| Delta WS (ft) | -0.04 | Top Width (ft) | 314.34 | 308.18 |
| BR Open Area (sq ft) | 12909.35 | Frctn Loss (ft) | 0.08 | 0.08 |
| BR Open Vel (ft/s) | 9.77 | C & E Loss (ft) | 0.00 | 0.00 |

Plan: Pro  Broad River  SR 281  RS: 0  Profile: 100 yr (Continued)

| | | | | |
|---|---|---|---|---|
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.36 | 1.48 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 13.21 | 14.45 |

Plan: Pro  Broad River  SR 281  RS: 0  Profile: 500 yr

| E.G. US. (ft) | 541.64 | Element | Inside BR US | Inside BR DS |
|---|---|---|---|---|
| W.S. US. (ft) | 539.80 | E.G. Elev (ft) | 541.57 | 541.48 |
| Q Total (cfs) | 55300.00 | W.S. Elev (ft) | 539.38 | 539.85 |
| Q Bridge (cfs) | 55300.00 | Crit W.S. (ft) | 530.29 | 531.10 |
| Q Weir (cfs) | | Max Chl Dpth (ft) | 25.04 | 25.56 |
| Weir Sta Lft (ft) | | Vel Total (ft/s) | 10.31 | 10.24 |
| Weir Sta Rgt (ft) | | Flow Area (sq ft) | 5361.36 | 5402.52 |
| Weir Submerg | | Froude # Chl | 0.45 | 0.46 |
| Weir Max Depth (ft) | | Specif Force (cu ft) | 74518.66 | 72439.04 |
| Min El Weir Flow (ft) | 562.59 | Hydr Depth (ft) | 16.37 | 16.69 |
| Min El Prs (ft) | 567.92 | W.P. Total (ft) | 429.15 | 415.99 |
| Delta EG (ft) | 0.25 | Conv. Total (cfs) | 1191267.0 | 1178684.0 |
| Delta WS (ft) | -0.29 | Top Width (ft) | 327.49 | 323.72 |
| BR Open Area (sq ft) | 12909.35 | Frctn Loss (ft) | 0.09 | 0.08 |
| BR Open Vel (ft/s) | 10.31 | C & E Loss (ft) | 0.00 | 0.00 |
| BR Sluice Coef | | Shear Total (lb/sq ft) | 1.68 | 1.78 |
| BR Sel Method | WSPRO | Power Total (lb/ft s) | 17.34 | 18.27 |