

Espey, Huston & Associates, Inc.

LEVEL II BRIDGE SCOUR ANALYSIS

***FOR STRUCTURE 204021300200 ON ROUTE SC 213
CROSSING THE LITTLE RIVER
IN FAIRFIELD COUNTY, SOUTH CAROLINA***

**EH&A Project No. 16139.01
EH&A File Number 16139.01 B-10**

Prepared in cooperation with

**South Carolina Department
of Transportation**



**Columbia, South Carolina
January 1995**

LEVEL II BRIDGE SCOUR ANALYSIS
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IN FAIRFIELD COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 204021300200 on Route SC 213 crossing the Little River in Fairfield County, South Carolina. The site is located in the Piedmont physiographic province near Jenkinsville, South Carolina. The bridge lies at approximately 34° 16' 45" north, 081° 15' 30" west, 4 miles northeast of Jenkinsville, South Carolina. The contributing watershed area for this bridge is 163.9 mi². The watershed is rural, consisting of forest and farmland. In the vicinity of the bridge, the floodplain consists of woodland and brush.

The potential for debris accumulation at this bridge is moderate. This results from debris remaining because of clear-cutting in the watershed and trees falling into the river from the sloughing banks.

This 360-foot reinforced concrete bridge consists of eleven bents. Bents 1 and 11 are at the abutments, and bents 2 through 8 consist of six steel H-piles. Bents 9 and 10 border the main channel and consist of two rows of six steel H-piles canted toward the pile cap (refer to bridge drawing and photo 8). The spill-through abutments are protected by $D_{50} = 12$ in. riprap. Abutment scour calculations were not performed.

Scour calculations were performed using engineering judgement and according to the FHWA Hydraulic Engineering Circular No. 18, (Revised April 1993). The calculations were performed assuming a uniform fine-sand streambed particle with a D_{50} of 0.12 mm. The 100-year total scour depth at the upstream face of the bridge ranged from 0 to 24.13 feet. The 100-year discharge overtops the bridge. The 500-year discharge results in a submerged weir condition that cannot be modeled by WSPRO; therefore, the 500-year total scour depth calculations were not performed. It is assumed that scour activity will be arrested at the solid rock line.

This study was conducted using limited available data. Stream surveys and geotechnical assessments were not available. For hydraulic modeling purposes, stream cross sections were estimated using measurements taken at the upstream face of the bridge, due to superelevation, combined with contour data from the USGS quad map and field observations. Scour computations are dependent upon, and sensitive to, cross-sectional geometry. A sand grain size was assumed for scour calculations. For these reasons, the results of this study should be considered approximate.

SCOUR REPORT SUMMARY

Structure Number 204021300200 Stream The Little River
County Fairfield Route SC 213 District 4

Description of Bridge

Bridge length 360 ft Bridge width 43.5 ft Max span length 90 ft

Alignment of bridge to road (on curve or straight) Straight

Abutment type Spill-through Embankment type Sloping

Riprap on abutment? Yes Date of inspection October 26, 1994

Description of riprap D₅₀ = 12 inches in good condition.

Brief description of piers/pile bents Bents 2 through 8 consist of six steel H-piles; bents 9 and 10 consist of twelve steel H-piles.

Is bridge skewed to floodplain according to USGS quad map? No Angle _____

Is bridge located on a bend in channel? No If so, describe (mild, moderate, severe)

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	Percent of channel blocked horizontally	Percent of channel blocked vertically
Level I	_____	_____	_____
Level II	<u>October 26, 1994</u>	<u>0</u>	<u>0</u>

Potential for debris Moderate, due to clear-cutting upstream and sloughing channel banks.

Describe any features near or at the bridge that may affect flow (include observation date).

None.

Description of Floodplain

General topography Gently rolling

Floodplain conditions at bridge site; downstream (D/S), upstream (U/S)

Date of inspection October 26, 1994

D/S left: Dense woodland

D/S right: Dense woodland

U/S left: Dense woodland

U/S right: Dense woodland

Description of Channel

Average top width 51 ft

Average depth 1.2 ft

Predominant bed material Clayey sand

Bank material Clayey sand

Stream type (straight, meandering, braided, swampy, channelized) Meandering

Vegetative cover on channel banks near bridge: Date of inspection October 26, 1994

D/S left: Dense woodland

D/S right: Dense woodland

U/S left: Dense woodland

U/S right: Dense woodland

Do banks appear stable? No If not, describe location and type of instability and date of observation. October 26, 1994. Banks are sloughing and causing trees to fall into the channel.

Describe any obstructions in channel and date of observation. October 26, 1994. Numerous fallen trees.

Brief Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, SCDOT bridge plans) SCDOT bridge plans

Datum tie, if available Bridge elevations taken from the SCDOT bridge plans match the quad map.

Briefly describe the survey used to develop WSPRO model. No survey was available. Due to superelevation the stream cross section at the upstream face of the bridge was measured during the inspection. This cross section was then combined with data from the USGS quad map to produce other cross sections. Field observations were used to supplement and modify the sections.

Cross-Sections Used in WSPRO Analysis

<i>Cross-section ID¹</i>	<i>Section Reference Distance (SRD) in feet</i>	<i>How cross-section was developed²</i>	<i>Comments</i>
<u>EXIT</u>	<u>000</u>	<u>2,3</u>	<u>Exit Section</u>
<u>FULL</u>	<u>360</u>	<u>4</u>	<u>Full Valley Section</u>
<u>BRDG</u>	<u>360</u>	<u>1</u>	<u>Bridge Section</u>
<u>ROAD</u>	<u>382</u>	<u>3</u>	<u>Road Section</u>
<u>APPR</u>	<u>764</u>	<u>2,3</u>	<u>Approach Section</u>

¹ For more detail on how cross-sections were developed, see WSPRO input file.

² Cross-section development: 1) survey at SRD; 2) shift of survey data to SRD; 3) modification of survey data based on topographic map; 4) synthesized by combining channel survey data and topographic contours; and 5) other

Starting water-surface elevation for WSPRO analysis (place ✓ on the appropriate line):

used slope/conveyance and confirmed by testing for convergence when reasonably possible

used known water-surface elevations. Describe _____

Describe any special assumptions or considerations made in developing WSPRO model.

No survey was available. Cross section information was taken from the "Jenkinsville, S.C." USGS quad map and from information collected during the field inspection on October 26, 1994. Elevations given are approximate. Manning's roughness coefficients were estimated from field observations. The 100- and 500-year discharges were obtained using procedures described in USGS WRIR 87-4096, "Magnitude and Frequency of Floods in Rural and Urban Basins of North Carolina", Gunter, Mason, and Stamey. SCDOT recommends using the North Carolina regression equations for bridges located in this portion of the state where the South Carolina regression equations do not apply. The 500-year discharge for this site was obtained by plotting the 2- through 100-year North Carolina regression equation results on log-probability paper, and extrapolating to obtain the 500-year discharge. Bridge elevations were estimated from the USGS quad map and the SCDOT bridge plans using field measurements. There is no discharge data associated with high water marks available for model calibration. The cross section data is coded left to right facing downstream.

Bridge Hydraulics

Average embankment elevation 279.6 ft

Average low steel elevation 277.85 ft

100-year discharge 19085* ft³/s

Water-surface elevation at D/S bridge face 279.30 ft

Area of flow at D/S bridge face 5308 ft²

Average velocity in bridge opening 3.43 ft/s

Maximum WSPRO tube velocity at bridge 5.91 ft/s

Water-surface elevation at Approach section with bridge 281.15 ft

Water-surface elevation at Approach section without bridge 281.39 ft

Amount of backwater caused by bridge 0 ft

500-year discharge 26200 ft³/s

Water-surface elevation at D/S bridge face N/A ft

Area of flow at D/S bridge face N/A ft²

Average velocity in bridge opening N/A ft/s

Maximum WSPRO tube velocity at bridge N/A ft/s

Water-surface elevation at Approach section with bridge N/A ft

Water-surface elevation at Approach section without bridge N/A ft

Amount of backwater caused by bridge N/A ft

*Note: The 100-year discharge overtops the bridge. The 500-year discharge results in submerged weir conditions that cannot be modeled by WSPRO.

Scour

Describe any special assumptions or considerations made in bridge scour analysis.

Scour calculations were performed using engineering judgement according to FHWA Hydraulic Circular No. 18, "Evaluating Scour at Bridges" (Richardson et al., 1993). Because gradation information is unavailable for this site, the streambed was assumed to be comprised of fine sand having a D_{50} of 0.12 mm. It was further assumed that the streambed is composed of homogeneous, erosive fine sand down to the solid rock line, at which elevation all scour would be arrested. The results of the scour analysis is summarized in Table 1 on the following page.

Table 1

Cumulative scour depths at piers/bents for the 100-year discharge at structure 204021300200 on SC 213 crossing the Little River in Fairfield County, South Carolina.

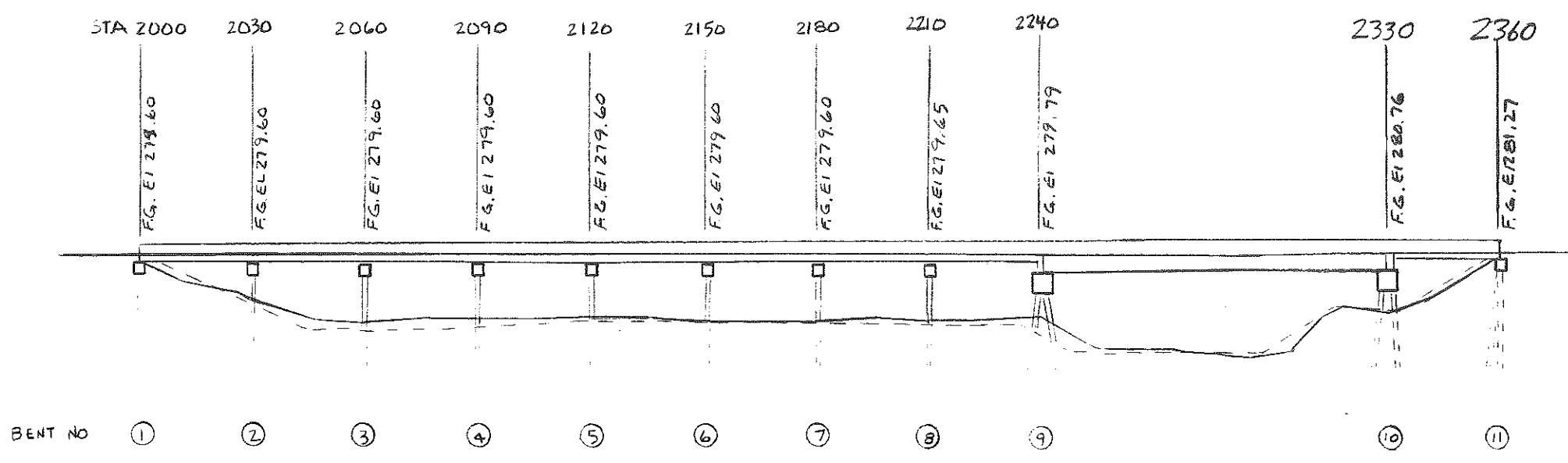
Pier/bent Number ¹	Distance ² from left end of bridge (feet)	Contraction scour depth (feet)	Local scour depth without debris (feet)	Total scour ³ depth without debris (feet)	Elevation of Highest Pile Tip (feet)	Elevation of Bottom of Scour Hole (feet)	Remaining ⁴ Embedment (feet)
100-year discharge is 7041 cubic feet per second							
Abutment	0	0	Abutment-Protected	0	258.30	N/A	N/A
2	30	0	Protected	0	250.0 ✓	266.60	16.60
3	60	21.57	1.49	23.06	243.15 ✓	238.84	-4.31
4	90	21.57	2.56	24.13	234.90 ✓	238.67	3.77
5	120	21.57	2.48	24.05	225.5 ✓	239.55	14.05
6	150	21.57	2.55	24.12	224.25 ✓	238.58	14.33
7	180	21.57	2.55	24.12	225.35 ✓	238.48	13.13
8	210	21.57	2.50	24.07	229.45 ✓	238.93	9.48
9	240	21.57	2.48	24.05	242.29 ✓	239.85	-2.44
10	330	0	1.95	1.95	244.96	264.15	19.19
Abutment	360	0	Abutment-Protected	0	250.58	N/A	N/A

¹ Piers/bent number corresponds to South Carolina Department of Transportation bridge plans.

² Distances are determined from left to right looking downstream.

³ Total scour depth is the sum of the contraction and local scour depths.

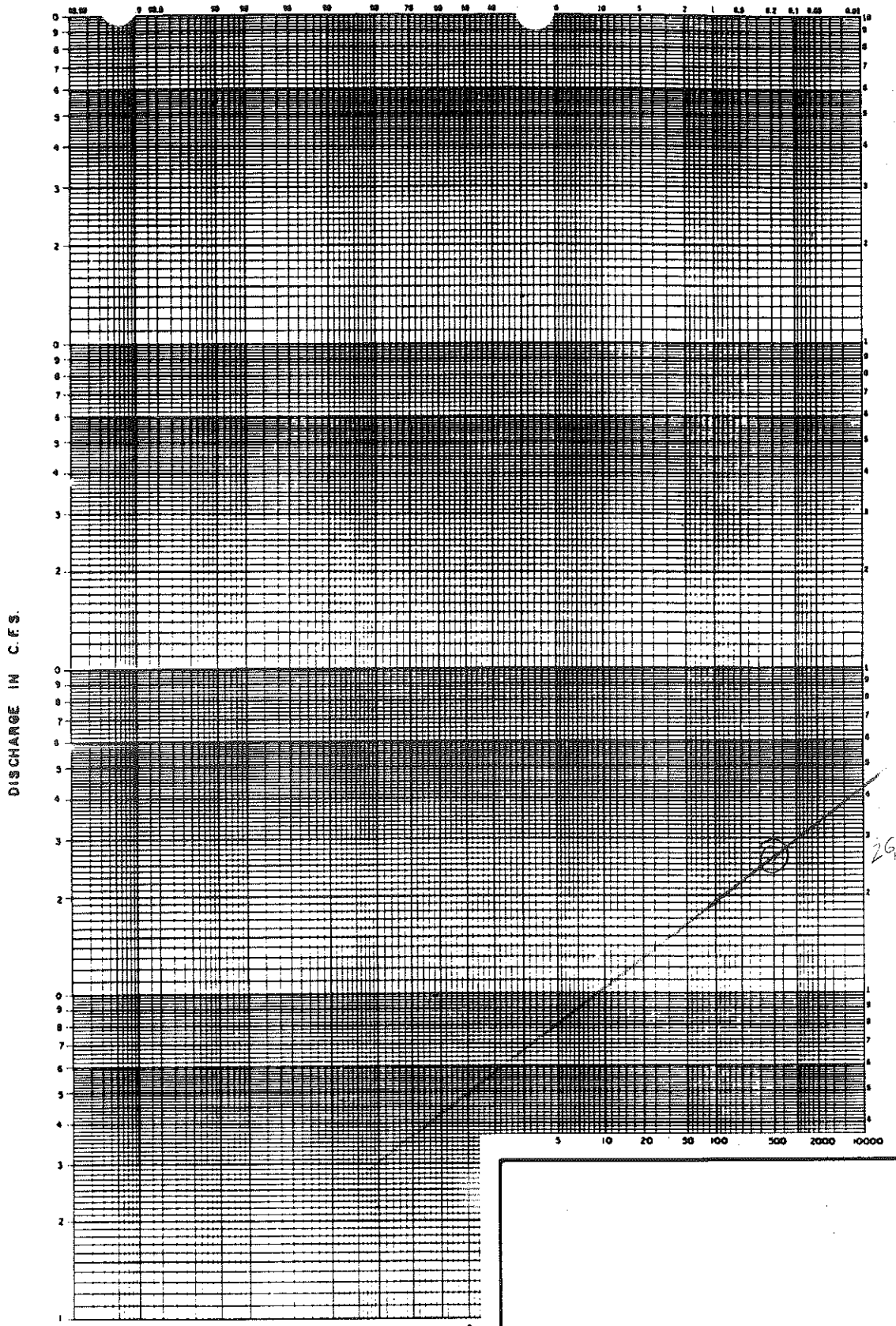
⁴ Elevation of bottom of scour hole minus elevation of highest pile tip. A negative number indicates computed scour is below the bottom of the pile tip.



----- SCDOT PLANS
 ————— MEASURED 10/26/94

VIEW - LOOKING DOWNSTREAM
 ROUTE SC 213 OVER THE LITTLE RIVER
 FAIRFIELD COUNTY
 EHA FILE NO. 16139.01 B-10

EXCEEDENCE PER HUNDRED YEARS



DISCHARGE IN C.F.S.

EXCEEDENCE INTERVAL IN YEARS

ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS

PROJECT 16139.01

DETERMINING THE FLOOD DISCHARGES FOR VARIOUS RECURRENCE INTERVALS IN THE BLUE RIDGE-PIEDMONT HYDROLOGIC AREA OF NORTH CAROLINA

BRIDGE NUMBER 10 LITTLE RIVER

AREA IN SQUARE FEET = 4569155965.0

AREA IN SQUARE MILES = 163.9

	DISCHARGE (CFS)	RECURRENCE INTERVAL (YEAR)
$Q_2 = 144 * (\text{AREA})^{0.691}$	$Q_2 = 4882$	2
$Q_5 = 248 * (\text{AREA})^{0.670}$	$Q_5 = 7555$	5
$Q_{10} = 334 * (\text{AREA})^{0.665}$	$Q_{10} = 9918$	10
$Q_{25} = 467 * (\text{AREA})^{0.655}$	$Q_{25} = 13868$	25
$Q_{50} = 581 * (\text{AREA})^{0.650}$	$Q_{50} = 15983$	50
$Q_{100} = 719 * (\text{AREA})^{0.643}$	$Q_{100} = 19085$	100
EXTRAPOLATION:	$Q_{500} = 26200$	500

WSPRO INPUT

```

T2 ROUTE 213 OVER THE LITTLE RIVER
T3 EH&A FILE NO. 16139.01 B-10
* FAIRFIELD CO., SOUTH CAROLINA
* FILE NAME: 16139W010.DAT
* *****
J1 .01 .01 .01 .95
J3 5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
* *****
* Q100 Q500
Q 19085 26200
SK .0011 .0011
* *****
* CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
* SHEET "JENKINSVILLE S.C." AND FROM INFORMATION
* COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 26, 1994.
* ELEVATIONS GIVEN ARE APPROXIMATE. MANNING COEFFICIENTS
* WERE ESTIMATED FROM FIELD OBSERVATIONS. THIS BRIDGE FALLS
* IN THE REGION WHERE THE S.C. REGIONAL REGRESSION EQUATIONS
* DO NOT APPLY. SCDOT SUGGESTED THE USE OF THE N.C. REGIONAL
* REGRESSION EQUATIONS FOR THIS AREA. THE 100-YEAR DISCHARGE
* WAS CALCULATED USING THE N.C. EQUATIONS. THE 500-YEAR
* DISCHARGE WAS OBTAINED BY PLOTTING THE 2- THROUGH 100-YEAR
* DISCHARGES ON LOG-PROBABILITY PAPER, AND EXTRAPOLATING TO
* OBTAIN THE 500-YEAR DISCHARGE. THE 100-YEAR FLOW JUST
* OVERTOPS THE BRIDGE. THE 500-YEAR FLOW IS CALCULATED AT
* ABOUT EIGHT FEET ABOVE THE BRIDGE. WSPRO IS UNABLE TO
* MODEL THIS SUBMERGED WEIR CONDITION.
* BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
* DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
* THE CROSS SECTION DATA IS CODED LEFT TO RIGHT FACING
* DOWNSTREAM.
* *****
XS EXIT 000 00
GR 2000,290.0 2100,280.0 2200,270.0
GR 2240,263.2 2251,254.9 2255,254.2 2267,254.2 2274,254.7
GR 2278,253.8 2288,253.5 2296,252.6 2306,254.0 2315,264.4
GR 2321,266.2 2345,270.0 2445,280.0 2545,290.0
N .15 .045 .15
SA 2240 2315
* *****
XS FULL 360 00
GR 1300,290.0 1800,280.0 2000,270.0 2046,262.7
GR 2240,263.9 2251,255.6 2255,255.0 2267,254.9 2274,255.4
GR 2278,254.5 2288,254.2 2296,253.3 2306,254.7 2315,265.1
GR 2321,266.9 2345,270.8 2445,280.0 2545,290.0
N .15 .035 .15
SA 2240 2315
* *****
BR BRDG 360 277.85 00
GR 2001,277.6 2011,274.2 2025,269.2 2030,266.6 2046,262.7
GR 2060,261.9 2075,262.6 2090,262.8 2105,262.5 2120,263.6
GR 2135,263.0 2150,262.7 2165,262.7 2180,262.6 2195,263.4
GR 2210,263.0 2225,263.6
GR 2240,263.9 2251,255.6 2255,255.0 2267,254.9 2274,255.4
GR 2278,254.5 2288,254.2 2296,253.3 2306,254.7 2315,265.1
GR 2321,266.9 2330,266.1 2345,270.8 2359,279.3 2001,277.6
N .045 .035 .045
SA 2240 2315
CD 3 43.3 2 279.6
PW 1 261.9,1 262.7,1 262.7,4 263.0,4 263.0,5 263.6,5 263.6,6
PW 1 263.9,6 263.9,8 266.1,8 266.1,10 266.6,10 266.6,11
PW 1 275.4,11
* *****
XR ROAD 382 45 1 * 00
GR 1000,290.0 1900,280.0 2000,279.6 2000,281.3 2210,281.3
GR 2240,281.5 2330,282.5 2360,283.0 2360,281.3 2600,290.0
N .015
* *****

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WSPRO INPUT (Cont.)

AS	APPR	763	00				
GR		1400,290.0	1500,280.0	2000,270.0	2046,263.5		
GR		2240,264.7	2251,256.4	2255,255.7	2267,255.7	2274,256.1	
GR		2278,255.3	2288,255.0	2296,254.1	2306,255.5	2315,265.9	
GR		2321,267.7	2445,280.0	2545,290.0			
N		.15	.035	.15			
SA		2240	2315				
*		*****					
HP 1	APPR	281.15	*	281.15			
HP 1	BRDG	277.85	*	277.85			
HP 2	APPR	281.15	*	281.15	19085		
HP 2	BRDG	277.85	*	277.85	18218		
*							
EX							
ER							

WSPRO OUTPUT

1
WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
(Input modified to free format by GKY&A 01/92)

*** RUN DATE & TIME: 01-04-95 16:04

T2 ROUTE 213 OVER THE LITTLE RIVER
T3 EH&A FILE NO. 16139.01 B-10
* FAIRFIELD CO., SOUTH CAROLINA
* FILE NAME: 16139W010.DAT
* *****
J1 .01 .01 .01 .95

J1 RECORD PARAMETERS:
DELTAY = .01 YTOL = .01 QTOL = .01 FNTEST = .95 IHFNOJ = -1

J3 5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
* *****
* Q100 Q500
Q 19085 26200
*** Q-DATA FOR SEC-ID, ISEQ = 1
SK .0011 .0011
* *****
* CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
* SHEET "JENKINSVILLE S.C." AND FROM INFORMATION
* COLLECTED DURING THE FIELD INSPECTION ON OCTOBER 26, 1994.
* ELEVATIONS GIVEN ARE APPROXIMATE. MANNING COEFFICIENTS
* WERE ESTIMATED FROM FIELD OBSERVATIONS. THIS BRIDGE FALLS
* IN THE REGION WHERE THE S.C. REGIONAL REGRESSION EQUATIONS
* DO NOT APPLY. SCDOT SUGGESTED THE USE OF THE N.C. REGIONAL
* REGRESSION EQUATIONS FOR THIS AREA. THE 100-YEAR DISCHARGE
* WAS CALCULATED USING THE N.C. EQUATIONS. THE 500-YEAR
* DISCHARGE WAS OBTAINED BY PLOTTING THE 2- THROUGH 100-YEAR
* DISCHARGES ON LOG-PROBABILITY PAPER, AND EXTRAPOLATING TO
* OBTAIN THE 500-YEAR DISCHARGE. THE 100-YEAR FLOW JUST
* OVERTOPS THE BRIDGE. THE 500-YEAR FLOW IS CALCULATED AT
* ABOUT EIGHT FEET ABOVE THE BRIDGE. WSPRO IS UNABLE TO
* MODEL THIS SUBMERGED WEIR CONDITION.
* BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
* DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
* THE CROSS SECTION DATA IS CODED LEFT TO RIGHT FACING
* DOWNSTREAM.
* *****

1
WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
(Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
EH&A FILE NO. 16139.01 B-10
*** RUN DATE & TIME: 01-04-95 16:04

*** START PROCESSING CROSS SECTION - "EXIT"
XS EXIT 000 00
GR 2000,290.0 2100,280.0 2200,270.0
GR 2240,263.2 2251,254.9 2255,254.2 2267,254.2 2274,254.7
GR 2278,253.8 2288,253.5 2296,252.6 2306,254.0 2315,264.4
GR 2321,266.2 2345,270.0 2445,280.0 2545,290.0
N .15 .045 .15
SA 2240 2315
* *****

*** FINISH PROCESSING CROSS SECTION - "EXIT"
*** CROSS SECTION "EXIT" WRITTEN TO DISK, RECORD NO. = 1

WSPRO OUTPUT (Cont.)

--- DATA SUMMARY FOR SECID " EXIT" AT SRD = 0. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
.0	0. *****		.50	.00

X-Y COORDINATE PAIRS (NGP = 17):

X	Y	X	Y	X	Y	X	Y
2000.0	290.00	2100.0	280.00	2200.0	270.00	2240.0	263.20
2251.0	254.90	2255.0	254.20	2267.0	254.20	2274.0	254.70
2278.0	253.80	2288.0	253.50	2296.0	252.60	2306.0	254.00
2315.0	264.40	2321.0	266.20	2345.0	270.00	2445.0	280.00
2545.0	290.00						

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
2000.0	290.00	2296.0	252.60	2545.0	290.00	2000.0	290.00

SUBAREA BREAKPOINTS (NSA = 3):

2240. 2315.

ROUGHNESS COEFFICIENTS (NSA = 3):

.150 .045 .150

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER

EH&A FILE NO. 16139.01 B-10

*** RUN DATE & TIME: 01-04-95 16:04

*** START PROCESSING CROSS SECTION - " FULL"

XS	FULL	360	00				
GR		1300,290.0	1800,280.0	2000,270.0	2046,262.7		
GR		2240,263.9	2251,255.6	2255,255.0	2267,254.9	2274,255.4	
GR		2278,254.5	2288,254.2	2296,253.3	2306,254.7	2315,265.1	
GR		2321,266.9	2345,270.8	2445,280.0	2545,290.0		
N		.15	.035	.15			
SA		2240	2315				
*		*****					

*** FINISH PROCESSING CROSS SECTION - " FULL"

*** CROSS SECTION " FULL" WRITTEN TO DISK, RECORD NO. = 2

--- DATA SUMMARY FOR SECID " FULL" AT SRD = 360. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
.0	0. *****		.50	.00

X-Y COORDINATE PAIRS (NGP = 18):

X	Y	X	Y	X	Y	X	Y
1300.0	290.00	1800.0	280.00	2000.0	270.00	2046.0	262.70
2240.0	263.90	2251.0	255.60	2255.0	255.00	2267.0	254.90
2274.0	255.40	2278.0	254.50	2288.0	254.20	2296.0	253.30
2306.0	254.70	2315.0	265.10	2321.0	266.90	2345.0	270.80
2445.0	280.00	2545.0	290.00				

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
1300.0	290.00	2296.0	253.30	2545.0	290.00	1300.0	290.00

SUBAREA BREAKPOINTS (NSA = 3):

2240. 2315.

ROUGHNESS COEFFICIENTS (NSA = 3):

.150 .035 .150

1

WSPRO OUTPUT (Cont.)

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04

*** START PROCESSING CROSS SECTION - " BRDG"
 BR BRDG 360 277.85 00
 GR 2001,277.6 2011,274.2 2025,269.2 2030,266.6 2046,262.7
 GR 2060,261.9 2075,262.6 2090,262.8 2105,262.5 2120,263.6
 GR 2135,263.0 2150,262.7 2165,262.7 2180,262.6 2195,263.4
 GR 2210,263.0 2225,263.6
 GR 2240,263.9 2251,255.6 2255,255.0 2267,254.9 2274,255.4
 GR 2278,254.5 2288,254.2 2296,253.3 2306,254.7 2315,265.1
 GR 2321,266.9 2330,266.1 2345,270.8 2359,279.3 2001,277.6
 N .045 .035 .045
 SA 2240 2315
 CD 3 43.3 2 279.6
 PW 1 261.9,1 262.7,1 262.7,4 263.0,4 263.0,5 263.6,5 263.6,6
 PW 1 263.9,6 263.9,8 266.1,8 266.1,10 266.6,10 266.6,11
 PW 1 275.4,11
 *

*** FINISH PROCESSING CROSS SECTION - " BRDG"
 *** CROSS SECTION " BRDG" WRITTEN TO DISK, RECORD NO. = 3

--- DATA SUMMARY FOR SECID " BRDG" AT SRD = 360. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
.0	0.	*****	.50	.00

X-Y COORDINATE PAIRS (NGP = 32):

X	Y	X	Y	X	Y	X	Y
2001.0	277.60	2011.0	274.20	2025.0	269.20	2030.0	266.60
2046.0	262.70	2060.0	261.90	2075.0	262.60	2090.0	262.80
2105.0	262.50	2120.0	263.60	2135.0	263.00	2150.0	262.70
2165.0	262.70	2180.0	262.60	2195.0	263.40	2210.0	263.00
2225.0	263.60	2240.0	263.90	2251.0	255.60	2255.0	255.00
2267.0	254.90	2274.0	255.40	2278.0	254.50	2288.0	254.20
2296.0	253.30	2306.0	254.70	2315.0	265.10	2321.0	266.90
2330.0	266.10	2345.0	270.80	2359.0	279.30	2001.0	277.60

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
2001.0	277.60	2296.0	253.30	2359.0	279.30	2359.0	279.30

SUBAREA BREAKPOINTS (NSA = 3):
 2240. 2315.

ROUGHNESS COEFFICIENTS (NSA = 3):
 .045 .035 .045

BRIDGE PARAMETERS:

BRTYPE	BRWDTH	LSEL	USERCD	EMBSS	EMBELV	ABSLPL	ABSLPR
3	43.3	277.85	*****	2.00	279.60	*****	*****

PIER DATA: NPW = 14 PPCD = 1.

PELV	PWDTH	PELV	PWDTH	PELV	PWDTH	PELV	PWDTH
261.90	1.0	262.70	1.0	262.70	4.0	263.00	4.0
263.00	5.0	263.60	5.0	263.60	6.0	263.90	6.0
263.90	8.0	266.10	8.0	266.10	10.0	266.60	10.0
266.60	11.0	275.40	11.0				

1
 WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS

WSPRO OUTPUT (Cont.)

(Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
EH&A FILE NO. 16139.01 B-10
*** RUN DATE & TIME: 01-04-95 16:04

*** START PROCESSING CROSS SECTION - "ROAD"

XR ROAD 382 45 1 * 00
GR 1000,290.0 1900,280.0 2000,279.6 2000,281.3 2210,281.3
GR 2240,281.5 2330,282.5 2360,283.0 2360,281.3 2600,290.0
N .015
* *****

*** FINISH PROCESSING CROSS SECTION - "ROAD"

*** CROSS SECTION "ROAD" WRITTEN TO DISK, RECORD NO. = 4

--- DATA SUMMARY FOR SECID "ROAD" AT SRD = 382. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
.0	0.	*****	.50	.00

X-Y COORDINATE PAIRS (NGP = 10):

X	Y	X	Y	X	Y	X	Y
1000.0	290.00	1900.0	280.00	2000.0	279.60	2000.0	281.30
2210.0	281.30	2240.0	281.50	2330.0	282.50	2360.0	283.00
2360.0	281.30	2600.0	290.00				

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
1000.0	290.00	2000.0	279.60	2600.0	290.00	1000.0	290.00

ROUGHNESS COEFFICIENTS (NSA = 1):

.015

ROAD GRADE DATA: IPAVE RDWID USERCF
1. 45.0 *****

BRIDGE PROJECTION DATA: XREFLT XREFRT FDSLTL FDSLRT

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
(Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
EH&A FILE NO. 16139.01 B-10
*** RUN DATE & TIME: 01-04-95 16:04

*** START PROCESSING CROSS SECTION - "APPR"

AS APPR 763 00
GR 1400,290.0 1500,280.0 2000,270.0 2046,263.5
GR 2240,264.7 2251,256.4 2255,255.7 2267,255.7 2274,256.1
GR 2278,255.3 2288,255.0 2296,254.1 2306,255.5 2315,265.9
GR 2321,267.7 2445,280.0 2545,290.0
N .15 .035 .15
SA 2240 2315
* *****

HP 1 APPR 281.15 * 281.15

*** FINISH PROCESSING CROSS SECTION - "APPR"

*** CROSS SECTION "APPR" WRITTEN TO DISK, RECORD NO. = 5

--- DATA SUMMARY FOR SECID "APPR" AT SRD = 763. ERR-CODE = 0

SKEW	IHFNO	VSLOPE	EK	CK
.0	0.	*****	.50	.00

WSPRO OUTPUT (Cont.)

X-Y COORDINATE PAIRS (NGP = 17):

X	Y	X	Y	X	Y	X	Y
1400.0	290.00	1500.0	280.00	2000.0	270.00	2046.0	263.50
2240.0	264.70	2251.0	256.40	2255.0	255.70	2267.0	255.70
2274.0	256.10	2278.0	255.30	2288.0	255.00	2296.0	254.10
2306.0	255.50	2315.0	265.90	2321.0	267.70	2445.0	280.00
2545.0	290.00						

X-Y MAX-MIN POINTS:

XMIN	Y	X	YMIN	XMAX	Y	X	YMAX
1400.0	290.00	2296.0	254.10	2545.0	290.00	1400.0	290.00

SUBAREA BREAKPOINTS (NSA = 3):

2240. 2315.

ROUGHNESS COEFFICIENTS (NSA = 3):

.150 .035 .150

BRIDGE PROJECTION DATA: XREFLT XREFRT FDSLTL FDLSTR

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER

EH&A FILE NO. 16139.01 B-10

*** RUN DATE & TIME: 01-04-95 16:04

CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPR; SRD = 763.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	7052.	311455.	751.	752.				122576.
	2	1831.	614091.	75.	83.				51350.
	3	998.	36295.	141.	142.				15038.
281.15		9881.	961840.	968.	977.	7.65	1489.	2457.	64774.

1

HP 1 BRDG 277.85 * 277.85

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER

EH&A FILE NO. 16139.01 B-10

*** RUN DATE & TIME: 01-04-95 16:04

CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRDG; SRD = 360.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	3260.	536269.	186.	294.				77361.
	2	1642.	512169.	75.	83.				43615.
	3	355.	46897.	42.	45.				5888.
277.85		5257.	1095336.	303.	422.	1.37	2001.	2357.	106176.

1

HP 2 APPR 281.15 * 281.15 19085

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER

EH&A FILE NO. 16139.01 B-10

*** RUN DATE & TIME: 01-04-95 16:04

WSPRO OUTPUT (Cont.)

VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPR; SRD = 763.

	WSEL	LEW	REW	AREA	K	Q	VEL
	281.15	1488.5	2456.5	9880.9	961840.	19085.	1.93
X STA.	1488.5	1984.7	2047.8	2089.0	2131.1	2174.4	
A(I)		2913.2	861.7	721.6	727.4	735.4	
V(I)		.33	1.11	1.32	1.31	1.30	
X STA.	2174.4	2218.7	2246.1	2252.7	2257.9	2263.0	
A(I)		740.9	465.2	155.1	133.1	129.5	
V(I)		1.29	2.05	6.15	7.17	7.37	
X STA.	2263.0	2268.3	2273.5	2278.7	2283.7	2288.7	
A(I)		133.7	132.6	130.8	129.7	130.8	
V(I)		7.14	7.20	7.30	7.36	7.30	
X STA.	2288.7	2293.6	2298.3	2303.1	2309.9	2456.5	
A(I)		129.7	125.9	128.1	165.5	1090.9	
V(I)		7.36	7.58	7.45	5.76	.87	

1

HP 2 BRDG 277.85 * 277.85 18218

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRDG; SRD = 360.

	WSEL	LEW	REW	AREA	K	Q	VEL
	277.85	2001.0	2356.6	5257.3	1095336.	18218.	3.47
X STA.	2001.0	2077.8	2095.3	2113.3	2132.6	2150.4	
A(I)		854.4	264.7	272.5	280.8	266.5	
V(I)		1.07	3.44	3.34	3.24	3.42	
X STA.	2150.4	2168.7	2186.3	2205.1	2224.1	2243.7	
A(I)		276.1	266.9	276.0	278.0	281.4	
V(I)		3.30	3.41	3.30	3.28	3.24	
X STA.	2243.7	2253.2	2260.5	2267.6	2274.9	2281.9	
A(I)		190.3	167.5	162.3	165.4	162.7	
V(I)		4.79	5.44	5.61	5.51	5.60	
X STA.	2281.9	2288.5	2294.9	2301.5	2310.3	2356.6	
A(I)		156.7	154.0	158.4	195.3	427.5	
V(I)		5.81	5.91	5.75	4.66	2.13	

1

*

EX

+++ BEGINNING PROFILE CALCULATIONS -- 2

1

WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04

WSPRO OUTPUT (Cont.)

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
EXIT:XS	*****	2096.	3895.	1.06	*****	281.42	268.11	19085.	280.37
0.	*****	2449.	575397.	2.83	*****	*****	.44	4.90	

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
 " FULL" KRATIO = 1.64

FULL:FV	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
360.	360.	1743.	8260.	.51	.24	281.66	*****	19085.	281.14
360.	360.	2456.	944356.	6.20	.00	-.01	.30	2.31	

<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

APPR:AS	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
403.	403.	1486.	10112.	.42	.16	281.81	*****	19085.	281.39
763.	403.	2459.	986185.	7.66	.00	.00	.29	1.89	

<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
 WS3N,LSEL = 281.14 277.85

<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
BRDG:BR	360.	2001.	5308.	.24	*****	279.54	267.24	18218.	279.30
360.	*****	2359.	801101.	1.28	*****	*****	.18	3.43	

TYPE	PPCD	FLOW	C	P/A	LSEL	BLEN	XLAB	XRAB
3.	1.	6.	.800	.031	277.85	*****	*****	*****

XSID:CODE	SRD	FLEN	HF	VHD	EGL	ERR	Q	WSEL
ROAD:RG	382.	358.	.14	.44	281.45	.00	904.	281.15

	Q	WLEN	LEW	REW	DMAX	DAVG	VMAX	VAVG	HAVG	CAVG
LT:	904.	203.	1797.	2000.	1.5	1.0	5.3	4.7	1.3	3.1
RT:	0.	16.	2239.	2368.	.3	.1	3.2	11.4	.5	3.0

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL	
APPR:AS	360.	1488.	9883.	.44	.17	281.60	269.27	19085.	281.15
763.	369.	2457.	962048.	7.65	.00	.00	.29	1.93	

M(G)	M(K)	KQ	XLKQ	XRKQ	OTEL
*****	*****	*****	*****	*****	*****

<<<<END OF BRIDGE COMPUTATIONS>>>>

1
 WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10

*** RUN DATE & TIME: 01-04-95 16:04

FIRST USER DEFINED TABLE.

XSID:CODE	Q	WSEL	VEL	CRWS	YMIN
EXIT:XS	19085.	280.37	4.90	268.11	252.60
FULL:FV	19085.	281.14	2.31	*****	253.30
BRDG:BR	18218.	279.30	3.43	267.24	253.30
ROAD:RG	904.	281.15	1.00	*****	279.60

XSID:CODE	Q	VMAX	VAVG
ROAD:RG	904.	5.3	4.7
ROAD:RG	0.	3.2	11.4

WSPRO OUTPUT (Cont.)

XSID:CODE Q WSEL VEL CRWS YMIN
 APPR:AS 19085. 281.15 1.93 269.27 254.10

1
 WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04
 SECOND USER DEFINED TABLE.

XSID:CODE	Q	AREA	LEW	REW	SRD	K
EXIT:XS	19085.	3895.	2096.	2449.	0.	575397.
FULL:FV	19085.	8260.	1743.	2456.	360.	944356.
BRDG:BR	18218.	5308.	2001.	2359.	360.	801101.
ROAD:RG	904.	0.*****	904.	382.*****		
APPR:AS	19085.	9883.	1488.	2457.	763.	962048.

XSID:CODE OTEL
 APPR:AS *****

1
 WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04
 THIRD USER DEFINED TABLE.

XSID:CODE	EGL	FR#	WSEL	HF
EXIT:XS	281.42	.44	280.37*****	
FULL:FV	281.66	.30	281.14	.24
BRDG:BR	279.54	.18	279.30*****	
ROAD:RG	281.45*****	281.15	.14	
APPR:AS	281.60	.29	281.15	.17

1
 WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 P060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
 (Input modified to free format by GKY&A 01/92)

ROUTE 213 OVER THE LITTLE RIVER
 EH&A FILE NO. 16139.01 B-10
 *** RUN DATE & TIME: 01-04-95 16:04

XSID:CODE	SRDL	LEW	AREA	VHD	HF	EGL	CRWS	Q	WSEL
	SRD	FLEN	REW	K	ALPH	HO	ERR	FR#	VEL
EXIT:XS	*****	2055.	5514.	1.22	*****	285.70	271.24	26200.	284.48
0.	*****	2490.	789563.	3.46	*****	*****	.44	4.75	

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
 " FULL" KRATIO = 1.65

FULL:FV	360.	1533.	11791.	.59	.24	285.94	*****	26200.	285.35
	360.	360.	2498.	1301964.	7.66	.00	.00	.31	2.22

<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

APPR:AS	403.	1443.	14486.	.39	.14	286.08	*****	26200.	285.69
	763.	403.	2502.	1480479.	7.58	.00	.00	.24	1.81

<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
 WS3N, LSEL = 285.35 277.85

WSPRO OUTPUT (Cont.)

===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.

WS,QBO,QRD = 285.35 19164. 19033.

===275 REJECTED FLOW CLASS 3 (6) SOLUTION.

===295 PROFILE COMPUTATIONS T _ E _ R _ M _ I _ N _ A _ T _ E _ D !!!!!

IPR = 2 BRIDGE FLOW COMPUTATIONS F _ A _ I _ L _ E _ D !!!!!

ER

1 NORMAL END OF WSPRO EXECUTION.

SCDOT BRIDGE SCOUR

Saved As: 16139A10.WQ1
 JOB NO. 16139.01 B-10
 BRIDGE NO. 204021300200
 BY/CHK: ABS/GG

ESPEY, HUSTON & ASSOC., INC
 460 McLAWS CIRCLE, SUITE 150
 WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

DETERMINATION OF CRITICAL SCOUR VELOCITY

(A) INPUT

VARIABLES	DESCRIPTION	VALUE
MAIN CHANNEL:		
Ssm	SPECIFIC GRAVITY OF MAIN CHANNEL BED MATERIAL	2.65
D50m	MEAN DIAM. OF MAIN CHANNEL BED MATERAIL (mm)	0.12
AREAm	APPR. MAIN CHANNEL AREA (ft)^2	1831
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	75
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	24.41
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.16
DIST	DISTANCE FROM BRIDGE TO APPR.	403
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00040
Km	APPR. MAIN CHANNEL CONVEYANCE	614091
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	6.68
	$Vm = (Km*(Sf)^.5)/AREAm$	
LEFT OVERBANK:		
Ssl	SPECIFIC GRAVITY OF LT. OVERBANK BED MATERIAL	2.65
D50I	MEAN DIAM. OF LT. OVERBANK BED MATL. (mm)	0.12
AREAI	LEFT OVERBANK AREA (ft)^2	7052
TOPW	LEFT OVERBANK TOP WIDTH (ft)	751
YI	APPR. LEFT OVERBANK AVG. DEPTH (ft)	9.39
KI	LEFT OVERBANK CONVEYANCE	311455
VI	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	0.88
	$VI = (KI*(Sf)^.5)/AREAI$	

RIGHT OVERBANK:

THERE IS NO RIGHT OVERBANK AT THE BRIDGE.

SCDOT BRIDGE SCOUR

Saved As: 16139A10.WQ1
JOB NO. 16139.01 B-10
BRIDGE NO. 204021300200
BY/CHK: ABS/GG

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

(1) MAIN CHANNEL CRITICAL VELOCITY (Vcm):

NEILL'S EQ;

$$V_{cm} = 1.58 * ((S_{sm} - 1) * g * D_{50m})^{1/2} * (Y_m / D_{50m})^{1/6}$$

$$V_{cm} = 1.44 \text{ fps}$$

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):

NEILL'S EQ;

$$V_{cl} = 1.58 * ((S_{sl} - 1) * g * D_{50l})^{1/2} * (Y_l / D_{50l})^{1/6}$$

$$V_{cl} = 1.23 \text{ fps}$$

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):

THERE IS NO RIGHT OVERBANK AT THE BRIDGE.

**NOTES: LIVE-BED SCOUR WILL BE COMPUTED FOR THE MAIN CHANNEL.
CLEAR-WATER SCOUR WILL BE COMPUTED FOR THE LEFT OVERBANK.**

SCDOT BRIDGE SCOUR

Saved As: 16139A10.WQ1
 JOB NO. 16139.01 B-10
 BRIDGE NO. 204021300200
 BY/CHK: ABS/GG

ESPEY, HUSTON & ASSOC., INC
 460 McLAWS CIRCLE, SUITE 150
 WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

SCOUR CALCULATIONS**I. LIVE BED CONTRACTION SCOUR****(A) INPUT FROM WSPRO**

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	19085
Q	TOTAL DISCHARGE(cfs) BRIDGE	18218
Ktot(APP)	APP. TOTAL CONVEYANCE	961840
Ktot(BR)	BR. TOTAL CONVEYANCE	1095336
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00040
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	614091
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	75
Am(APP)	APP. MAIN CHANNEL AREA	1831
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	75
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	24.41
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	83
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	512169
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	73

SCDOT BRIDGE SCOUR

Saved As: 16139A10.WQ1
JOB NO. 16139.01 B-10
BRIDGE NO. 204021300200
BY/CHK: ABS/GG

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

(a) APP. MAIN CHAN. HYD. RADIUS (Rm):

$$Rm = Am(APP) / WETPm(APP)$$

Rm = 22.06 ft

(b) AVG. MAIN CHANNEL SHEAR STRESS (SHEARm):

$$Y_{water} = \text{UNIT WT. OF WATER (62.4 lb/cf)}$$

$$SHEARm = Y_{water} * Rm * Sf$$

SHEARm = 0.55 lb/sf

(c) SHEAR VELOCITY IN APP. MAIN CHANNEL (Vm*):

$$p = \text{DENSITY OF WATER (1.94 slugs/cf)}$$

$$Vm^* = (SHEARm / p)^{.5}$$

Vm* = 0.53 fps

(d) MAIN CHANNEL BED MATL. D50m:

D50m = 0.12 mm

D50m = 0.00039 ft

(e) FALL VELOCITY (wm):

FROM FIG. 3, PAGE 34

wm = 0.03 fps

(f) EXPONENT (K1):

FROM TBL. ON PAGE 33

Vm*/wm = 17.69

K1 = 0.69

(g) DISCHARGE IN MAIN CHANNEL OF APP (Q1m):

$$Q1m = Q * (Km(APP) / Ktot(APP))$$

Q1m = 12185 cfs

(h) DISCHARGE IN MAIN CHANNEL OF BR (Q2m):

$$Q2m = Q * (Km(BR) / Ktot(BR))$$

Q2m = 8519 cfs

(i) LAURSEN'S LIVE BED EQUATION:

$$Y2m / Y1m = (Q2m / Q1m)^{.6 / 7} * (W1m / W2m)^{.K1}$$

Y2m = 18.30 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):

$$Ysm = Y2m - Y1m$$

Ysm = -6.11 ft

SCDOT BRIDGE SCOUR

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BRIDGE NO. 204021300200
BY/CHK: ABS/GG

ESPEY, HUSTON & ASSOC., INC
460 McLAWS CIRCLE, SUITE 150
WILLIAMSBURG, VA 23185

STORM EVENT (YR): 100

II. CLEAR-WATER CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE INPUT THRU BRIDGE (cfs)	18218
Ktot	TOTAL CONVEYANCE AT BRIDGE	1095336

LEFT OVERBANK:

KI	LEFT OVERBANK CONVEYANCE AT BRIDGE	536269
QI	FLOW IN LEFT OVERBANK THRU BRIDGE (cfs)	8919.4
D50I	MEDIAN GRAIN SIZE OF LEFT OVERBANK (ft)	0.00039
WI	DIST. FROM LEFT BANK TO TOE OF LEFT ABT. LESS PIER WIDTHS(ft)	188
AI	AREA OF LEFT OVERBANK AT APPR. (sf)	7052
TOPWI	TOPWIDTH OF LEFT OVERBANK AT APP. (ft)	751
YII	FLOW DEPTH IN LEFT OVERBANK AT APP. (ft)	9.39

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(B) CALCULATIONS (CLEAR WATER CONTRACTION SCOUR)

1. CLEAR WATER CONTRACTION SCOUR FOR LEFT OVERBANK (Ysl):

(a) EFFECTIVE MEAN DIAMETER OF LEFT OVERBANK BED MATL. (Dml):

Dml= 0.00049 ft

(b) $Y2I = ((QI^2) / (120 * Dml^{2/3} * WI^2))^{3/7}$

Y2I= 30.96 ft

(c) $Ysl = Y2I - Y1I$

Ysl= 21.57 ft

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III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
PIER #2:	WSPRO STA 2030	
PROTECTED BY RIPRAP		
PIER #3:	WSPRO STA 2060	
A3	AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	854.4
V3	VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	1.07
TOPW3	TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	76.8
Y3	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	11.13
PIER #4:	WSPRO STA 2090	
A4	AREA OF CONVEYANCE TUBE AT PIER #4 (sf)	264.7
V4	VELOCITY IN CONVEYANCE TUBE AT PIER #4 (fps)	3.44
TOPW4	TOPWIDTH OF CONVEYANCE TUBE AT PIER #4 (ft)	17.5
Y4	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #4 (ft)	15.13
PIER #5:	WSPRO STA 2120	
A5	AREA OF CONVEYANCE TUBE AT PIER #5 (sf)	280.8
V5	VELOCITY IN CONVEYANCE TUBE AT PIER #5 (fps)	3.24
TOPW5	TOPWIDTH OF CONVEYANCE TUBE AT PIER #5 (ft)	19.3
Y5	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #5 (ft)	14.55
PIER #6:	WSPRO STA 2150	
A6	AREA OF CONVEYANCE TUBE AT PIER #6 (sf)	266.5
V6	VELOCITY IN CONVEYANCE TUBE AT PIER #6 (fps)	3.42
TOPW6	TOPWIDTH OF CONVEYANCE TUBE AT PIER #6 (ft)	17.8
Y6	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #6 (ft)	14.97
PIER #7:	WSPRO STA 2180	
A7	AREA OF CONVEYANCE TUBE AT PIER #7 (sf)	266.9
V7	VELOCITY IN CONVEYANCE TUBE AT PIER #7 (fps)	3.41
TOPW7	TOPWIDTH OF CONVEYANCE TUBE AT PIER #7 (ft)	17.6
Y7	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #7 (ft)	15.16

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PIER #8:	WSPRO STA	2210	
A8		AREA OF CONVEYANCE TUBE AT PIER #8 (sf)	278
V8		VELOCITY IN CONVEYANCE TUBE AT PIER #8 (fps)	3.28
TOPW8		TOPWIDTH OF CONVEYANCE TUBE AT PIER #8 (ft)	19
Y8		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #8 (ft)	14.63
PIER #9:	WSPRO STA	2240	
A9		AREA OF CONVEYANCE TUBE AT PIER #9 (sf)	281.4
V9		VELOCITY IN CONVEYANCE TUBE AT PIER #9 (fps)	3.24
TOPW9		TOPWIDTH OF CONVEYANCE TUBE AT PIER #9 (ft)	19.6
Y9		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #9 (ft)	14.36
PIER #10:	WSPRO STA	2330	
A10		AREA OF CONVEYANCE TUBE AT PIER #10 (sf)	427.5
V10		VELOCITY IN CONVEYANCE TUBE AT PIER #10 (fps)	2.13
TOPW10		TOPWIDTH OF CONVEYANCE TUBE AT PIER #10 (ft)	46.3
Y10		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #10 (ft)	9.23

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(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

1. SCOUR DEPTH AT PIER #2 (Ys#2):

PROTECTED BY RIPRAP

PROTECTED

2. SCOUR DEPTH AT PIER #3 (Ys#3):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR3=V3/(g*Y3)^.5= 0.06
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#3=Y3^2*K1*K2*K3*(a/Y3)^.65*FR3^.43$
Ys#3= 1.49 ft

3. SCOUR DEPTH AT PIER #4 (Ys#4):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR4=V4/(g*Y4)^.5= 0.16
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#4=Y4^2*K1*K2*K3*(a/Y4)^.65*FR4^.43$
Ys#4= 2.56 ft

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4. SCOUR DEPTH AT PIER #5 (Ys#5):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR5=V5/(g*Y5)^.5= 0.15
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#5=Y5^2*K1*K2*K3*(a/Y5)^.65*FR5^.43$
 Ys#5= 2.48 ft

5. SCOUR DEPTH AT PIER #6 (Ys#6):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR6=V6/(g*Y6)^.5= 0.16
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#6=Y6^2*K1*K2*K3*(a/Y6)^.65*FR6^.43$
 Ys#6= 2.55 ft

6. SCOUR DEPTH AT PIER #7 (Ys#7):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR7=V7/(g*Y7)^.5= 0.15
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#7=Y7^2*K1*K2*K3*(a/Y7)^.65*FR7^.43$
 Ys#7= 2.55 ft

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7. SCOUR DEPTH AT PIER #8 (Ys#8):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR8=V8/(g*Y8)^.5= 0.15
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#8=Y8^2*K1*K2*K3*(a/Y8)^.65*FR8^.43$
Ys#8= 2.50 ft

8. SCOUR DEPTH AT PIER #9 (Ys#9):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR9=V9/(g*Y9)^.5= 0.15
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#9=Y9^2*K1*K2*K3*(a/Y9)^.65*FR9^.43$
Ys#9= 2.48 ft

9. SCOUR DEPTH AT PIER #10 (Ys#10):

- (a) a=PIER WIDTH (ft)= 1
- (b) FROUDE NO.=FR10=V10/(g*Y10)^.5= 0.12
- (c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1
- (d) K2=ANGLE OF ATTACK CORR. FACTOR (TBL3, PG40)= 1.0
- (e) K3=BED CONDITION CORR. FACTOR (TBL1, PG39)= 1.1
- (f) CSU EQ. FOR PIER SCOUR;
 $Ys\#10=Y10^2*K1*K2*K3*(a/Y10)^.65*FR10^.43$
Ys#10= 1.95 ft

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IV. ABUTMENT SCOUR:

PROTECTED BY RIPRAP
NO SCOUR CALCULATIONS PERFORMED



Photo 1: *View looking east.*



Photo 2: *View looking west.*



Photo 3: *View looking downstream from approach section.*



Photo 4: *View looking upstream from approach section.*



Photo 5: *View of rock outcropping about 150 feet upstream on west bank.*



Photo 6: *View looking toward east abutment from east bank of main channel.*



Photo 7: *View looking at east bank of main channel from west bank/abutment.*



Photo 8: *View looking at west bank/abutment from east bank of main channel.*



Photo 9: *View looking downstream at sloughing banks and numerous fallen trees from exit section.*



Photo 10: *View looking upstream at main channel from exit section.*



Photo 11: *View looking at downstream face, main channel is below this frame.*

Consultant Scour Study Check List

County Fairfield Crossing Little River
 Road/Route SC 213
 Consultant Esperon Hudson

Mark whether each item is completed correctly or incorrectly and make a comment as to what needs to be changed.

Check List	Correct	Incorrect	Comments
County	✓		
Structure #	✓		
Stream Name	✓		
Physiographic Province	✓		
Description of Location	✓		
Bridge Length and Width	✓		
Max Span Length	✓		
# of Spans	✓		
D50	✓		0.4 mm from soils manual
Skew	✓		
Q100	✓		
Q500	✓		
Discharge Method and applicability	✓		
WSPRO Cross section Locations	✓		
WSPRO Setup	✓		used values in R.R.O. HP lead cards used low steel for HP cards
Equations for Scour	✓		

* No 500yr Scour calculated. Submerged flow