Espey, Huston & Associates, Inc.

Level II Bridge Scour Analysis

for Structure 124000900100 on Route SC 9 Crossing the Broad River in Chester/Union County, South Carolina

EH&A Project No. 16139.01
EH&A File Number 16139.01 B-1

Prepared in cooperation with

South Carolina Department of Transportation

Columbia, South Carolina
January 1995

LEVEL II BRIDGE SCOUR ANALYSIS

FOR STRUCTURE 124000900100 ON ROUTE SC 9 CROSSING THE BROAD RIVER IN CHESTER/UNION COUNTY, SOUTH CAROLINA

This report provides the results of the detailed Level II analysis of scour potential at bridge 124000900100 on Route SC 9 crossing the Broad River in Chester/Union County, South Carolina. The site is located in the Piedmont physiographic province near Lockhart, South Carolina. The bridge lies at approximately 34° 47' 15" north, 081° 27' 24" west, at the town of Lockhart, South Carolina. The contributing watershed area for this bridge is 2557 mi^2. The watershed originates in the Blue Ridge province of North Carolina and flows east and south through the Piedmont to Columbia, South Carolina. In the vicinity of the bridge the floodplain consists of woodland, brush and some residential homes.

The 100- and 500-year discharges were calculated by transferring the gage data from the Carlisle gage upstream to the bridge. Difficulties arise in the calculations due to the large size of the watershed, 2557 mi^2. Regression equations used in the gage transfer were split between the Piedmont physiographic region of South Carolina and the Blue Ridge - Piedmont physiographic area of North Carolina. The South Carolina piedmont regression equation is only valid for 1430 mi^2.

The floodplain for the eastern bank of this river consists of dense trees and brush. The floodplain for the upstream, western bank consists of large boulders and trees (refer to photo 3). The downstream, west bank floodplain has two parts. One part extends for 130 feet away from the river bank to the roadway shown in photo 9. This part of the floodplain consists of tall grass and brush with a few widely spaced trees. Part two of the floodplain extends another 50 feet and includes the roadway and residence in photo 9.

This 729-foot bridge was build in 1948 and consists of nine bents, refer to the bridge drawing. Bents numbered 1 and 4 are at the abutments. Bents 2 and 3 consist of two 2.3-foot by 2.6-foot concrete piers. Bents A, C and E consist of a 10-foot wide continuous oval pier. Bents B and D consist of a continuous rectangular pier, with fillets. Bents B and D are 7.2 feet wide at the base and taper to 4 feet wide at the top (refer to photo 6). The footing for bent C is protected by a toroidal island constructed with coffer dams (refer to photos 7 and 8). Maximum span length is 140 feet, and occurs between bents B and C and C and D. The spill-through abutments are not protected by riprap. The east abutment is showing signs of surface erosion (refer to photo 10).

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 downstream face of the bridge ranged from 0 to 21.8 feet. The 500-year total scour depth at the downstream face of the bridge ranged from 0 to 26.7 feet. 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 downstream face of the bridge, 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 124000900100 Stream The Broad River
County Chester/Union Route SC 9 District 4

Description of Bridge

Bridge length 729 ft Bridge width 33.8 ft Max span length 140 ft

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

Abutment type Spill-through Embankment type Sloping

Riprap on abutment? No Date of inspection November 13, 1994

Description of riprap No riprap

Brief description of piers/pile bents Bents 2 and 3 consist of two 2.3-foot by 2.6-foot concrete piers. Bents A, C, and E consist of a 10-foot wide continuous oval pier (refer to photo 12). Bents B and D consist of a continuous rectangular pier that is 7.2 feet wide at the footing and tapers to 4 feet at the top (refer to photo 6).

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	November 13, 1994	0	0

Potential for debris Low

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

November 13, 1994. Weir operated by Lockhart Power and Water Company, one mile upstream, diverts the maximum of 4500 cfs from river.

Description of Floodplain

General topography Gently rolling

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

Date of inspection November 13, 1994

D/S left: Dense trees and brush

D/S right: Trees, brush, tall grass and residential lawns (refer to photo 9)

U/S left: Dense trees and brush

U/S right: Dense trees and brush

Description of Channel

Average top width 355 *ft* *Average depth* 35 *ft*

Predominant bed material Rock-sand *Bank material* Rock - sandy clay

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

Vegetative cover on channel banks near bridge: *Date of inspection* November 13, 1994

D/S left: Dense trees and brush

D/S right: Brush, tall grass and residential lawn

U/S left: Dense trees and brush

U/S right: Brush, tall grass

Do banks appear stable? Yes *If not, describe location and type of instability and date of observation.*

Describe any obstructions in channel and date of observation. None

Hydrology

Drainage area 2557 mi^2

Percentage of drainage area in physiographic provinces:

Physiographic province	Percent of drainage area
Piedmont, S.C.	50%
Blue Ridge - Piedmont, N.C.	50%

Is drainage area considered rural or urban? Rural Describe any significant urbanization and potential for development. The cities of Spartanburg, S.C., Gastonia, S.C., Shelby, S.C. and many other smaller towns lie on or near the river; however, the potential is low for urbanization to have a significant effect on such a vast watershed.

Is there a USGS gage on the stream of interest? Yes

USGS gage description Broad River near Carlisle, S.C.

USGS gage number 02156500

Gage drainage area 2790 mi^2

Is there a lake/pond that will significantly affect hydrology/hydraulics? No

If so, describe

Calculated Discharges

Q100 168500 ft^3/s Q500 234700 ft^3/s

Method used to determine discharges Stream gage data was transferred to the bridge using USGS procedures (Ref USGS WRIR 91-4157, "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988", Guimarares and Bowman).

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 from the SCDOT bridge plans match the USGS quad map.

Briefly describe the survey used to develop WSPRO model. No survey was available. The stream cross section at the downstream 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

Cross-section ID[1]	Section Reference Distance (SRD) in feet	How cross-section was developed[2]	Comments
EXIT	000	2,3	Exit Section
FULL	729	4	Full Valley Section
BRDG	729	1	Bridge Section
ROAD	Not Used	3	Road Section
APPR	1492	2,3	Approach Section

[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 "Lockhart, S.C." USGS quad map and from information collected during the field inspection on November 13, 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 (Ref USGS WRIR 91-4157, "Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988", Guimarares and Bowman). 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 397.2 ft

Average low steel elevation 391.6 ft

100-year discharge	168500	ft^3/s
Water-surface elevation at D/S bridge face	384.14	ft
Area of flow at D/S bridge face	20057	ft^2
Average velocity in bridge opening	8.40	ft/s
Maximum WSPRO tube velocity at bridge	12.54	ft/s

Water-surface elevation at Approach section with bridge	383.06	ft
Water-surface elevation at Approach section without bridge	383.58	ft
Amount of backwater caused by bridge	0	ft

500-year discharge	234700	ft^3/s
Water-surface elevation at D/S bridge face	390.44	ft
Area of flow at D/S bridge face	24402	ft^2
Average velocity in bridge opening	9.62	ft/s
Maximum WSPRO tube velocity at bridge	14.46	ft/s

Water-surface elevation at Approach section with bridge	389.30	ft
Water-surface elevation at Approach section without bridge	390.03	ft
Amount of backwater caused by bridge	0	ft

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 are summarized in Tables 1 and 2 on the following pages.

Table 1

Cumulative scour depths at piers/bents for the 100-year discharge at structure 124000900100 on SC 9 crossing the Broad River in Chester/Union 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 168500 cubic feet per second							
Abutment	0	9.6	0	9.6	373.8	390.1	16.3
3	58	9.6	4.7	14.3	351.0[5]	350.2	-0.8
E	115	9.6	12.2	21.8	339.5[5]	335.4	-4.1
D	225	0	19.6	19.6	337.0[5]	325.0	-12.0
C	365	0	21.7	21.7	336.0[5]	325.1	-10.9
B	505	0	18.8	18.8	336.0[5]	329.5	-6.5
A	616	0	9.8	9.8	341.5[5]	353.4	11.9
2	674	0	4.2	4.2	347.3	388.5	41.2
Abutment	729	0	0	0	334.6	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.

5 No data was available on piles. These are the bottom of footing elevations from SCDOT plans, Sheet 4. These piers appear to be anchored in bedrock.

Table 2

Cumulative scour depths at piers/bents for the 500-year discharge at structure 124000900100 on SC 9 crossing the Broad River in Chester/Union 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)
500-year discharge is 234700 cubic feet per second							
Abutment	0	13.7	0	13.7	373.8	386.0	12.2
3	58	13.7	5.0	18.7	351.0[5]	345.8	-5.2
E	115	13.7	13.0	26.7	339.5[5]	330.5	-9.0
D	225	0	21.4	21.4	337.0[5]	323.2	-13.8
C	365	0	23.7	23.7	336.0[5]	323.1	-12.9
B	505	0	19.8	19.8	336.0[5]	328.5	-7.5
A	616	0	10.5	10.5	341.5[5]	352.7	11.2
2	674	0	4.4	4.4	347.3	388.3	41.0
Abutment	729	0	0	0	334.6	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.

5 No data was available on piles. These are the bottom of footing elevations from SCDOT plans, Sheet 4. These piers appear to be anchored in bedrock.

Bridge 124000900100 Over the Broad River

Gage 02156500 at Carlisle (50 years of record)

Q_{100} = 178,000 cfs

Q_{500} = 248,000 cfs (From extrapolation on log probability paper)

Drainage Areas:

Gage at Carlisle = 2,790 mi^2 ≈ 20 miles downstream

Gage at Lockhart = 2720 mi^2 ≈ 5 miles downstream (1 year of record)
(Drainage area between gage at Lockhart and bridge = 163 mi^2
∴ Drainage area of Bridge = 2720 − 163 = 2557 mi^2.)

Bridge = 2557 mi^2

Adjusted Gage Data

$$Q_{bridge} = \left(\frac{A_{bridge}}{A_{gage}}\right)^{b} Q_{gage}$$

$$Q_{100\,bridge} = \left(\frac{2557}{2790}\right)^{.63} 178{,}000 = (0.9465)178{,}000 = 168{,}500 \text{ cfs}$$

$$Q_{500\,bridge} = \left(\frac{2557}{2790}\right)^{.63} 248{,}000 = (0.9465)248{,}000 = 234{,}700 \text{ cfs}$$

Note:
Regional Regression equations do not apply to this drainage area due to its size. See p.20 of SCDOT "Techniques for Estimating Magnitude and Frequency of Floods In South Carolina, 1988."

SANTEE RIVER BASIN

02156500 BROAD RIVER NEAR CARLISLE, SC

LOCATION.--Lat 34°35'46'', long 81°25'20'', Union County, Hydrologic Unit 03050106, on right bank at downstream side of bridge on State Highway 72, 1.3 mi upstream from Sandy River, 2.0 mi downstream from Seaboard Coast Line Railroad bridge, 2.5 mi east of Carlisle, 5.0 mi downstream from Neals Shoals Dam, and at mile 226.0.

DRAINAGE AREA.--2,790 mi^2, approximately.

PERIOD OF RECORD.--October 1938 to current year. Monthly discharge only for some periods, published in WSP 1303.

REVISED RECORDS.--WSP 892: 1939(M), drainage area.

GAGE.--Water-stage recorder. Datum of gage is 290.79 ft above National Geodetic Vertical Datum of 1929.

REMARKS.--Records good. Some regulation at low and medium flow by powerplants above station. Capacity of reservoirs insufficient to affect monthly figures of runoff.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 123,000 ft^3/s, Oct. 10, 1976, gage height, 31.51 ft.

STAGE-DISCHARGE RELATION.--Defined by current-meter measurements below 65,800 ft^3/s and extended on basis of computation of peak flow over Neal Shoals Dam.

FLOOD-FREQUENCY DATA (ft^3/s)
50 YEARS OF RECORD
LOG-PEARSON TYPE III

Q_2	= 41,200
Q_5	= 64,000
Q_{10}	= 84,000
Q_{25}	= 115,000
Q_{50}	= 144,000
Q_{100}	= 178,000

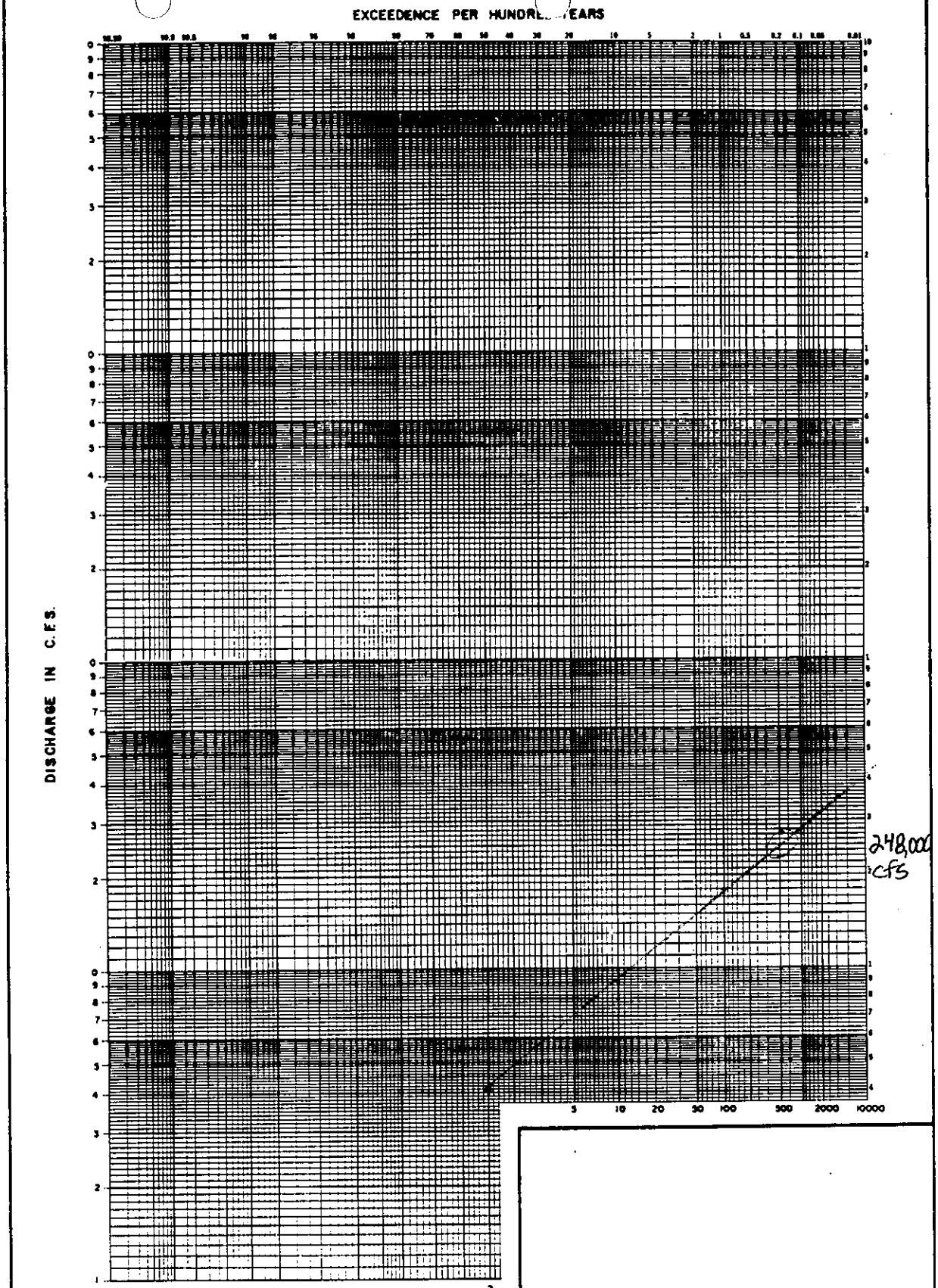
LOG-PEARSON TYPE III STATISTICS (LOG UNITS)

Mean	=	4.632
*Standard Deviation	=	0.184
Weighted Skew	=	0.050

Peak Stages and Discharges

Water year	Date	Gage height (ft)	Discharge (ft^3/s)	Water year	Date	Gage height (ft)	Discharge (ft^3/s)	Water year	Date	Gage height (ft)	Discharge (ft^3/s)
1939	Mar. 1	16.27	34,900	1959	Dec. 30	14.21	28,700	1979	Feb. 26	20.00	47,800
1940	Aug. 15	29.41	103,000	1960	Feb. 7	18.71	42,100	1980	Mar. 29	17.28	37,600
1941	July 18	17.06	37,600	1961	Feb. 22	15.82	33,200	1981	Oct. 2	10.09	15,600
1942	Feb. 18	18.42	42,200	1962	Apr. 12	17.25	37,400	1982	Jan. 5	17.89	39,700
1943	Jan. 29	18.96	44,500	1963	Mar. 14	21.78	57,200	1983	Mar. 18	14.21	27,600
1944	Mar. 20	19.58	46,900	1964	Apr. 8	23.90	69,500	1984	Feb. 15	18.40	41,500
1945	Sept. 19	25.72	78,500	1965	Oct. 13	25.82	79,900	1985	Aug. 19	16.72	35,100
1946	Jan. 8	20.11	49,200	1966	Mar. 5	18.89	45,600	1986	Aug. 20	17.33	37,300
1947	Jan. 21	17.21	37,900	1967	Aug. 24	20.23	51,200	1987	Mar. 2	25.77	72,100
1948	Feb. 14	16.20	34,600	1968	Mar. 14	14.57	29,700	1988	Jan. 21	9.15	13,400
1949	Nov. 29	22.81	62,200	1969	Aug. 15	29.41	103,000				
1950	Oct. 8	19.32	44,200	1970	Aug. 12	17.48	39,900				
1951	Dec. 9	13.65	27,000	1971	Mar. 3	15.05	31,200				
1952	Mar. 5	22.43	57,700	1972	Oct. 17	19.31	47,200				
1953	Feb. 22	15.77	33,200	1973	Feb. 3	21.54	57,700				
1954	Jan. 24	20.63	49,200	1974	Apr. 6	17.61	40,400				
1955	Apr. 15	13.79	27,500	1975	Mar. 15	23.75	63,100				
1956	Apr. 17	14.99	30,900	1976	Oct. 19	14.95	31,000				
1957	Apr. 7	13.24	25,900	1977	Oct. 10	31.51	123,000				
1958	Apr. 29	20.12	48,000	1978	Jan. 27	19.72	46,900				

*Standard deviation was adjusted according to Appendix 7 of Water Resources Council Bulletin 17-B to adjust the record at Broad River near Carlisle, S.C. (station no. 02156500) to the longer period of record at Broad River at Richtex, S.C. (station no. 02161500).



ALBUQUERQUE DISTRICT, CORPS OF ENGINEERS

4.f4

SANTEE RIVER BASIN

02156409 BROAD RIVER NEAR LOCKHART, SC

LOCATION.--Lat 34°43'56'', long 81°29'21'', Union County, Hydrologic Unit 03050106, on the right bank 10 ft upstream of the intake for the City of Union municipal supply, 0.9 mi upstream of Browns Creek, 4.0 mi southwest of Lockhart, 6.4 mi upstream of Neals Shoals Rowerplant, and at mile 239.2.

DRAINAGE AREA.--2,720 mi^2, approximately.

PERIOD OF RECORD.--October 1992 to September 1993.

GAGE.--Data Collection Platform. Elevation of gage is 338 ft above sea level.

REMARKS.--Estimated daily discharges: Nov. 3, 4, and July 22. Records fair.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1992 TO SEPTEMBER 1993
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2070	4160	5750	4910	5140	4950	11000	4450	3400	2370	1870	913
2	1870	4000	4940	4400	4940	4470	12000	4440	3490	2470	1560	1570
3	1800	5000	4460	4420	4690	4580	8840	4170	3150	1850	1790	1560
4	4490	6000	4380	4070	4590	16400	7470	4280	2980	2160	2440	1550
5	15100	10000	4200	8300	4510	25500	7420	11300	2880	2410	2300	1860
6	13500	8820	3940	12800	4380	12500	10400	12700	2950	1950	2500	1970
7	7520	5770	3720	8110	4320	7700	10000	9120	2820	1370	1800	1750
8	4860	4280	3750	9410	5250	6430	8520	6780	2550	1750	2570	1980
9	19000	3560	3630	18500	5360	5690	7770	6240	3030	1820	2720	1820
10	25900	3230	3760	18400	4630	5100	11700	5650	2650	1770	2340	1570
11	11100	3090	5460	10200	4480	5250	13000	5230	2560	1480	1980	1220
12	5880	5190	4770	17400	8030	4510	9270	4470	2570	1960	1680	1250
13	4340	15800	4430	16100	10800	12100	7930	4650	3010	1670	1680	1150
14	3670	11400	4110	10400	6780	17600	7350	4710	2630	1860	2040	1020
15	3170	6700	3460	7710	5450	8960	7010	4820	2920	1590	2350	1480
16	2930	4880	3520	6730	5750	6620	7270	4230	2830	2140	1630	1240
17	2570	4230	7210	6230	8130	6340	7760	4080	2750	1880	1700	1330
18	2730	3660	16300	5580	6380	8490	6430	4020	2880	1920	1770	1810
19	2440	3520	10700	5380	5380	8930	6060	3530	2660	2150	1550	1990
20	2330	3220	7920	5180	4890	8070	5680	4250	2690	1440	1950	1730
21	2990	3720	9280	9470	4690	6890	5740	4040	2260	1890	1540	1600
22	2670	6150	7600	25900	7870	6260	5480	3780	2890	1730	1850	1290
23	2660	14000	6480	17000	7970	6620	5350	3790	2390	1400	1560	1290
24	2510	15400	5870	9600	5690	27600	4860	3560	2600	1860	1770	1650
25	2520	9590	5380	10400	4910	40500	5020	3370	2100	2180	1650	1570
26	2550	19300	4900	8800	4800	18600	4890	3530	2400	1730	1350	1680
27	3020	27000	4540	7390	5300	18700	5250	3620	2160	1870	1620	1830
28	2180	14000	5120	6200	5180	27800	5090	3180	2680	2170	1710	2080
29	2390	8280	6900	5830	---	18300	4920	3110	2470	2020	1610	2280
30	2280	6580	6030	5570	---	11000	4880	3350	2240	1900	1450	1460
31	2450	---	5340	5260	---	8900	---	3410	---	1990	1180	---
TOTAL	165490	240530	177660	295650	160290	371360	224360	151860	81590	58750	57510	47493
MEAN	5338	8018	5731	9537	5725	11980	7479	4899	2720	1895	1855	1583
MAX	25900	27000	16300	25900	10800	40500	13000	12700	3490	2470	2720	2280
MIN	1800	3090	3460	4070	4320	4470	4860	3110	2100	1370	1180	913

STATISTICS OF MONTHLY MEAN DATA FOR WATER YEARS 1993 - 1993, BY WATER YEAR (WY)

MEAN	5338	8018	5731	9537	5725	11980	7479	4899	2720	1895	1855	1583
MAX	5338	8018	5731	9537	5725	11980	7479	4899	2720	1895	1855	1583
(WY)	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993
MIN	5338	8018	5731	9537	5725	11980	7479	4899	2720	1895	1855	1583
(WY)	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993	1993

SUMMARY STATISTICS FOR 1993 WATER YEAR

ANNUAL TOTAL	2032543	
ANNUAL MEAN	5569	
HIGHEST DAILY MEAN	40500	Mar 25
LOWEST DAILY MEAN	913	Sep 1
ANNUAL SEVEN-DAY MINIMUM	1240	Sep 11
INSTANTANEOUS PEAK FLOW	43200	Mar 25
INSTANTANEOUS PEAK STAGE	21.41	Mar 25
INSTANTANEOUS LOW FLOW	656	Sep 1
10 PERCENT EXCEEDS	11000	
50 PERCENT EXCEEDS	4320	
90 PERCENT EXCEEDS	1680	

WSPRO INPUT

```
T2        ROUTE 9 OVER THE BROAD RIVER
T3        EH&A FILE NO. 16139.01 B-1
*         UNION/CHESTER CO., SOUTH CAROLINA
*         FILE NAME: 16139W01.DAT
*         ************************************************************
J1         .5  .005  .005  .95
J3        5 3 13 15 23 430 446 448 * 5 17 29 30 6 16 555 * 7 14 3 11
*         ************************************************************
*          Q100    Q500
Q          168500  234700
SK        .0003  .0003
*         ************************************************************
*         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
*         SHEET "LOCKHART S.C." AND FROM INFORMATION
*         COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 13, 1994.
*         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNING COEFFICIENTS
*         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THE 100 AND
*         500-YEAR DISCHARGES WERE CALCULATED BY TRANSFERRING THE GAGE
*         02156500 UPSTREAM FROM CARLISLE.
*         BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
*         DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
*         THERE ARE NO HIGH WATER MARK DISCHARGES KNOWN TO CALIBRATE
*         THE MODEL.  THE CROSS SECTION DATA IS CODED LEFT TO RIGHT
*         FACING DOWNSTREAM.
*         ************************************************************
XS     EXIT  000 00
GR          1700,400 1800,380.0 1950,370.0
GR          2157,350.5
GR          2190,344.8 2225,344.6 2270,340.3 2300,340.2
GR          2462,345.2 2505,348.3
GR          2630,350.0 2700,360.0 2875,370.0 3100,380.0 3600,380.0
GR          3800,400.0
N           .10    .03    .10
SA             2157   2505
*         ************************************************************
XS     FULL  729 00
GR          2010,399.7 2058,364.5 2115,357.2
GR          2157,350.5
GR          2190,344.8 2225,344.6 2270,340.3 2300,340.2
GR          2462,345.2 2505,348.3 2512,350.0 2525,357.9
GR          2576,358.2 2616,363.2
GR          2635,372.2 2645,373.7 2649,373.6 2662,373.6
GR          2674,376.0 2703,380.8 2729,392.7 3000,392.7
GR          3500,400.0
N           .10  .03   .10
SA            2157  2512
*         ************************************************************
BR     BRDG  729 391.6 00
GR          2010,399.7 2058,364.5 2115,357.2
GR          2157,350.5
GR          2190,344.8 2225,344.6 2270,340.3 2300,340.2
GR          2316,347.1 2318,349.6 2331,355.0 2337,349.5
GR          2344,345.9 2365,346.8 2390,348.7 2395,349.6
GR          2410,349.5 2421,344.1
GR          2462,345.2 2505,348.3 2512,350.0 2525,357.9
GR          2576,358.2 2616,363.2
GR          2635,372.2 2645,373.7 2649,373.6 2662,373.6
GR          2674,376.0 2703,380.8 2729,392.7 2010,399.7
N           .10  .03   .10
SA            2157  2512
CD         3  33.8  2  397.2
PW 1       344.6,7.2 346.8,7.2 346.8,17.2 348.3,17.2
PW 1       348.3,24.4 357.2,24.4 357.2,34.4 363.2,34.4
PW 1       363.2,44.4 364.5,44.5 364.5,46.8 376.0,46.8
PW 1       376.0,49.1 391.6,49.1
*         ************************************************************
AS     APPR  1492 00
GR          2100,400.0 2200,380.0 2275,350.0
```

WSPRO INPUT (Cont.)

```
GR          2300,340.2 2462,345.2 2505,348.3 2512,350.0 2525,357.9
GR          2576,358.2 2700,360.0
GR          2800,370.0 3100,370.0 3700,400.0
N            .10  .03  .10
SA             2275  2512
*          ************************************************************
HP 1  APPR 383.06 * 383.06
HP 1  BRDG 384.14 * 384.14
HP 2  APPR 383.06 * 383.06 168500
HP 2  BRDG 384.14 * 384.14 168500
*
HP 1  APPR 389.30 * 389.30
HP 1  BRDG 390.44 * 390.44
HP 2  APPR 389.30 * 389.30 234700
HP 2  BRDG 390.44 * 390.44 234700
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: 12-29-94  12:42

   T2        ROUTE 9 OVER THE BROAD RIVER
   T3        EH&A FILE NO. 16139.01 B-1
   *         UNION/CHESTER CO., SOUTH CAROLINA
   *         FILE NAME: 16139W01.DAT
   *         ************************************************************
   J1         .5  .005  .005  .95

 J1 RECORD PARAMETERS:
 DELTAY =  .50   YTOL =  .00   QTOL =  .00   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          168500  234700
 *** Q-DATA FOR SEC-ID, ISEQ =           1
   SK        .0003  .0003
   *         ************************************************************
   *         CROSS SECTION INFORMATION WAS TAKEN FROM THE USGS QUAD
   *         SHEET "LOCKHART S.C." AND FROM INFORMATION
   *         COLLECTED DURING THE FIELD INSPECTION ON NOVEMBER 13, 1994.
   *         ELEVATIONS GIVEN ARE APPROXIMATE.  MANNING COEFFICIENTS
   *         WERE ESTIMATED FROM FIELD OBSERVATIONS.  THE 100 AND
   *         500-YEAR DISCHARGES WERE CALCULATED BY TRANSFERRING THE GAGE
   *         02156500 UPSTREAM FROM CARLISLE.
   *         BRIDGE STRUCTURAL ELEVATIONS WERE TAKEN FROM BRIDGE
   *         DRAWINGS PROVIDED BY SCDOT WHICH MATCHED THE QUAD SHEET.
   *         THERE ARE NO HIGH WATER MARK DISCHARGES KNOWN TO CALIBRATE
   *         THE MODEL.  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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42

 *** START PROCESSING CROSS SECTION - " EXIT"
   XS    EXIT  000 00
   GR          1700,400 1800,380.0 1950,370.0
   GR          2157,350.5
   GR          2190,344.8 2225,344.6 2270,340.3 2300,340.2
   GR          2462,345.2 2505,348.3
   GR          2630,350.0 2700,360.0 2875,370.0 3100,380.0 3600,380.0
   GR          3800,400.0
   N           .10    .03    .10
   SA             2157   2505
   *         ************************************************************

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

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

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

WSPRO OUTPUT (Cont.)

```
X-Y COORDINATE PAIRS  (NGP =  16):
      X      Y         X      Y         X      Y         X      Y
   1700.0  400.00    1800.0  380.00    1950.0  370.00    2157.0  350.50
   2190.0  344.80    2225.0  344.60    2270.0  340.30    2300.0  340.20
   2462.0  345.20    2505.0  348.30    2630.0  350.00    2700.0  360.00
   2875.0  370.00    3100.0  380.00    3600.0  380.00    3800.0  400.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   1700.0  400.00    2300.0  340.20    3800.0  400.00    1700.0  400.00

SUBAREA BREAKPOINTS (NSA =  3):
       2157.   2505.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .100    .030    .100
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42

*** START PROCESSING CROSS SECTION - " FULL"
  XS    FULL  729 00
  GR          2010,399.7 2058,364.5 2115,357.2
  GR          2157,350.5
  GR          2190,344.8 2225,344.6 2270,340.3 2300,340.2
  GR          2462,345.2 2505,348.3 2512,350.0 2525,357.9
  GR          2576,358.2 2616,363.2
  GR          2635,372.2 2645,373.7 2649,373.6 2662,373.6
  GR          2674,376.0 2703,380.8 2729,392.7 3000,392.7
  GR          3500,400.0
  N           .10  .03   .10
  SA            2157  2512
  *          ************************************************************

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

--- DATA SUMMARY FOR SECID " FULL" AT SRD =    729.  ERR-CODE =      0

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

X-Y COORDINATE PAIRS  (NGP =  23):
      X      Y         X      Y         X      Y         X      Y
   2010.0  399.70    2058.0  364.50    2115.0  357.20    2157.0  350.50
   2190.0  344.80    2225.0  344.60    2270.0  340.30    2300.0  340.20
   2462.0  345.20    2505.0  348.30    2512.0  350.00    2525.0  357.90
   2576.0  358.20    2616.0  363.20    2635.0  372.20    2645.0  373.70
   2649.0  373.60    2662.0  373.60    2674.0  376.00    2703.0  380.80
   2729.0  392.70    3000.0  392.70    3500.0  400.00

 X-Y MAX-MIN POINTS:
     XMIN       Y         X    YMIN      XMAX       Y         X    YMAX
   2010.0  399.70    2300.0  340.20    3500.0  400.00    3500.0  400.00

SUBAREA BREAKPOINTS (NSA =  3):
       2157.   2512.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .100    .030    .100
1
WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
```

WSPRO OUTPUT (Cont.)

```
P060188          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                  (Input modified to free format by GKY&A 01/92)


       ROUTE 9 OVER THE BROAD RIVER
       EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42

*** START PROCESSING CROSS SECTION - " BRDG"
  BR    BRDG  729 391.6 00
  GR         2010,399.7 2058,364.5 2115,357.2
  GR         2157,350.5
  GR         2190,344.8 2225,344.6 2270,340.3 2300,340.2
  GR         2316,347.1 2318,349.6 2331,355.0 2337,349.5
  GR         2344,345.9 2365,346.8 2390,348.7 2395,349.6
  GR         2410,349.5 2421,344.1
  GR         2462,345.2 2505,348.3 2512,350.0 2525,357.9
  GR         2576,358.2 2616,363.2
  GR         2635,372.2 2645,373.7 2649,373.6 2662,373.6
  GR         2674,376.0 2703,380.8 2729,392.7 2010,399.7
  N          .10  .03   .10
  SA           2157  2512
  CD        3  33.8  2  397.2
  PW 1      344.6,7.2 346.8,7.2 346.8,17.2 348.3,17.2
  PW 1      348.3,24.4 357.2,24.4 357.2,34.4 363.2,34.4
  PW 1      363.2,44.4 364.5,44.5 364.5,46.8 376.0,46.8
  PW 1      376.0,49.1 391.6,49.1
  *         ************************************************************

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

--- DATA SUMMARY FOR SECID " BRDG" AT SRD =    729.  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
   2010.0  399.70    2058.0  364.50    2115.0  357.20    2157.0  350.50
   2190.0  344.80    2225.0  344.60    2270.0  340.30    2300.0  340.20
   2316.0  347.10    2318.0  349.60    2331.0  355.00    2337.0  349.50
   2344.0  345.90    2365.0  346.80    2390.0  348.70    2395.0  349.60
   2410.0  349.50    2421.0  344.10    2462.0  345.20    2505.0  348.30
   2512.0  350.00    2525.0  357.90    2576.0  358.20    2616.0  363.20
   2635.0  372.20    2645.0  373.70    2649.0  373.60    2662.0  373.60
   2674.0  376.00    2703.0  380.80    2729.0  392.70    2010.0  399.70

 X-Y MAX-MIN POINTS:
     XMIN       Y         X     YMIN      XMAX       Y         X     YMAX
   2010.0  399.70    2300.0  340.20    2729.0  392.70    2010.0  399.70

SUBAREA BREAKPOINTS (NSA =  3):
       2157.   2512.

ROUGHNESS COEFFICIENTS (NSA =  3):
         .100    .030    .100

BRIDGE PARAMETERS:
 BRTYPE  BRWDTH     LSEL  USERCD  EMBSS   EMBELV  ABSLPL  ABSLPR
    3      33.8   391.60 *******   2.00   397.20 ******* *******

PIER DATA:  NPW = 14    PPCD = 1.
     PELV  PWDTH      PELV  PWDTH      PELV  PWDTH      PELV  PWDTH
    344.60   7.2     346.80   7.2     346.80  17.2     348.30  17.2
    348.30  24.4     357.20  24.4     357.20  34.4     363.20  34.4
    363.20  44.4     364.50  44.5     364.50  46.8     376.00  46.8
    376.00  49.1     391.60  49.1
```

WSPRO OUTPUT (Cont.)

```
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 9 OVER THE BROAD RIVER
         EH&A FILE NO. 16139.01 B-1
            *** RUN DATE & TIME: 12-29-94  12:42

 *** START PROCESSING CROSS SECTION - " APPR"
   AS    APPR  1492 00
   GR         2100,400.0 2200,380.0 2275,350.0
   GR         2300,340.2 2462,345.2 2505,348.3 2512,350.0 2525,357.9
   GR         2576,358.2 2700,360.0
   GR         2800,370.0 3100,370.0 3700,400.0
   N           .10  .03  .10
   SA            2275  2512
   *         ************************************************************
   HP 1  APPR 383.06 * 383.06

 *** FINISH PROCESSING CROSS SECTION - " APPR"
 *** CROSS SECTION " APPR" WRITTEN TO DISK, RECORD NO. =  4

 --- DATA SUMMARY FOR SECID " APPR" AT SRD =   1492.  ERR-CODE =      0

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

 X-Y COORDINATE PAIRS  (NGP =  13):
        X      Y          X      Y          X      Y          X      Y
    2100.0  400.00    2200.0  380.00    2275.0  350.00    2300.0  340.20
    2462.0  345.20    2505.0  348.30    2512.0  350.00    2525.0  357.90
    2576.0  358.20    2700.0  360.00    2800.0  370.00    3100.0  370.00
    3700.0  400.00

  X-Y MAX-MIN POINTS:
      XMIN       Y          X    YMIN      XMAX       Y          X    YMAX
    2100.0  400.00    2300.0  340.20    3700.0  400.00    2100.0  400.00

 SUBAREA BREAKPOINTS (NSA =  3):
        2275.   2512.

 ROUGHNESS COEFFICIENTS (NSA =  3):
          .100    .030    .100

 BRIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                         ******* ******* ******* *******
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 9 OVER THE BROAD RIVER
         EH&A FILE NO. 16139.01 B-1
            *** RUN DATE & TIME: 12-29-94  12:42
     CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =    1492.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    1378.   120938.    90.    96.                      30543.
             2    9286.  5287127.   237.   239.                     329836.
             3   12055.  1050502.   849.   852.                     257723.
    383.06       22719.  6458566.  1177.  1188.  3.30  2185.  3361. 311817.
1
   HP 1  BRDG 384.14 * 384.14
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
```

WSPRO OUTPUT (Cont.)

```
P060188          MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)


       ROUTE 9 OVER THE BROAD RIVER
       EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     729.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2863.  329707.   126.   133.                      77497.
             2   13637. 7580865.   355.   364.                     479601.
             3    3555.  355607.   198.   204.                      85401.
   384.14        20054. 8266179.   679.   702.  1.67  2031.  2710. 477997.
1
  HP 2  APPR 383.06 * 383.06 168500
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 9 OVER THE BROAD RIVER
       EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =    1492.

        WSEL     LEW     REW    AREA       K        Q    VEL
      383.06  2184.7  3361.2 22718.5 6458566.       0.    .00

X STA.      2184.7     2286.2     2300.8     2313.3     2326.1     2339.0
  A(I)          1774.3      589.0      529.8      540.7      541.7
  V(I)             .00        .00        .00        .00        .00

X STA.      2339.0     2352.3     2365.5     2379.1     2393.0     2406.9
  A(I)           549.4      542.8      551.7      558.9      553.0
  V(I)             .00        .00        .00        .00        .00

X STA.      2406.9     2421.0     2435.6     2450.6     2465.8     2481.6
  A(I)           555.9      567.1      578.1      576.8      583.2
  V(I)             .00        .00        .00        .00        .00

X STA.      2481.6     2498.4     2534.9     2640.9     2772.2     3361.2
  A(I)           602.1     1095.9     2610.8     2792.2     6025.3
  V(I)             .00        .00        .00        .00        .00
1
  HP 2  BRDG 384.14 * 384.14 168500
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 9 OVER THE BROAD RIVER
       EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     729.

        WSEL     LEW     REW    AREA       K        Q    VEL
      384.14  2031.2  2710.3 20054.1 8266179.       0.    .00

X STA.      2031.2     2161.8     2183.1     2201.6     2219.4     2237.5
```

WSPRO OUTPUT (Cont.)

```
  A(I)          3027.9      772.5      722.0      705.5      720.2
  V(I)             .00        .00        .00        .00        .00

X STA.       2237.5     2254.6     2270.4     2285.7     2301.6     2322.0
  A(I)           713.5      680.9      671.7      696.3      784.3
  V(I)             .00        .00        .00        .00        .00

X STA.       2322.0     2348.7     2368.2     2389.2     2412.1     2431.3
  A(I)           905.6      733.4      762.5      795.2      748.7
  V(I)             .00        .00        .00        .00        .00

X STA.       2431.3     2449.2     2468.1     2487.4     2508.6     2710.3
  A(I)           707.0      733.9      732.9      767.0     3673.0
  V(I)             .00        .00        .00        .00        .00
1
  *
  HP 1  APPR 389.30 * 389.30
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID =  APPR;  SRD =    1492.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2039.   192101.   121.   128.                      47389.
             2   10765. 6763739.   237.   239.                     411688.
             3   17743. 1826305.   974.   977.                     429723.
   389.30       30547. 8782144.  1332.  1345.  3.71  2154.  3486. 431023.
1
  HP 1  BRDG 390.44 * 390.44
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID =  BRDG;  SRD =     729.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    3682.   476506.   134.   144.                     109379.
             2   15873. 9764353.   355.   364.                     602300.
             3    4847.   568566.   212.   219.                     131505.
   390.44       24403.10809430.   701.   727.  1.75  2023.  2724. 617492.
1
  HP 2  APPR 389.30 * 389.30 234700
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID =  APPR;  SRD =    1492.

        WSEL     LEW     REW    AREA        K        Q    VEL
```

WSPRO OUTPUT (Cont.)

```
      389.30  2153.5  3486.0 30546.6 8782144.       0.    .00

 X STA.      2153.5     2285.6     2301.1     2314.5     2328.3     2342.3
   A(I)          2476.7      720.0      655.9      669.7      671.2
   V(I)            .00        .00        .00        .00        .00

 X STA.      2342.3     2356.6     2370.9     2385.6     2400.6     2415.6
   A(I)          681.2      673.4      684.9      694.3      687.3
   V(I)            .00        .00        .00        .00        .00

 X STA.      2415.6     2430.9     2446.7     2462.5     2479.1     2496.4
   A(I)          693.4      707.8      697.5      721.8      733.3
   V(I)            .00        .00        .00        .00        .00

 X STA.      2496.4     2525.7     2622.7     2727.5     2934.1     3486.0
   A(I)         1115.3     3010.9     3075.4     4249.6     6927.0
   V(I)            .00        .00        .00        .00        .00
1
   HP 2  BRDG 390.44 * 390.44 234700
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID =  BRDG;  SRD =     729.

         WSEL     LEW     REW    AREA        K        Q    VEL
       390.44  2022.6  2724.1 24402.710809430.       0.    .00

 X STA.      2022.6     2160.1     2181.4     2200.1     2218.7     2237.2
   A(I)          3804.9      904.7      843.9      854.7      851.3
   V(I)            .00        .00        .00        .00        .00

 X STA.      2237.2     2254.5     2271.2     2287.5     2303.7     2325.9
   A(I)          829.1      827.8      814.4      811.7      960.8
   V(I)            .00        .00        .00        .00        .00

 X STA.      2325.9     2350.9     2370.9     2392.1     2415.1     2433.7
   A(I)         1019.5      877.8      898.9      948.1      847.7
   V(I)            .00        .00        .00        .00        .00

 X STA.      2433.7     2452.5     2471.8     2491.9     2515.7     2724.1
   A(I)          859.3      874.5      880.7      989.4     4703.5
   V(I)            .00        .00        .00        .00        .00
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42

  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
```

WSPRO OUTPUT (Cont.)

```
 EXIT:XS   ******  1782.   33557.  1.31 *****  384.98  362.31 168500.  383.67
       0. ******  3637. 9722640.  3.35 ***** *******     .38    5.02

 FULL:FV     729.  2032.   20458.  1.74   .24  385.44 ******* 168500.  383.69
     729.   729. 2709. 8879824.  1.65   .21     .00     .34    8.24
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPR:AS     763.  2182.   23332.  2.71   .37  386.29 ******* 168500.  383.58
    1492.   763.  3372. 6636741.  3.34   .48     .00     .53    7.22
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

           <<<<<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     729.  2031.   20057.  1.18   .35  385.33  365.78 168500.  384.14
     729.   729. 2710. 8268037.  1.08   .00     .00     .28    8.40

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.   .963   .073  391.60 ****** ****** ******

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 APPR:AS     729.  2185.   22722.  2.82   .53  385.89  369.06 168500.  383.06
    1492.   745.  3361. 6459563.  3.30   .03     .00     .54    7.42

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      .430   .046 6161350.  2117.  2796.   382.57

                  <<<<<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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42
  FIRST USER DEFINED TABLE.

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    EXIT:XS   168500.  383.67    5.02  362.31  340.20
    FULL:FV   168500.  383.69    8.24********  340.20
    BRDG:BR   168500.  384.14    8.40  365.78  340.20
    APPR:AS   168500.  383.06    7.42  369.06  340.20
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42
  SECOND USER DEFINED TABLE.

    XSID:CODE       Q     AREA    LEW    REW    SRD        K
    EXIT:XS   168500.   33557.  1782.  3637.     0. 9722640.
    FULL:FV   168500.   20458.  2032.  2709.   729. 8879824.
    BRDG:BR   168500.   20057.  2031.  2710.   729. 8268037.
    APPR:AS   168500.   22722.  2185.  3361.  1492. 6459563.

    XSID:CODE    OTEL
    APPR:AS    382.57
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42
  THIRD USER DEFINED TABLE.

    XSID:CODE     EGL     FR#    WSEL    HF
    EXIT:XS    384.98     .38  383.67******
    FULL:FV    385.44     .34  383.69   .24
    BRDG:BR    385.33     .28  384.14   .35
    APPR:AS    385.89     .54  383.06   .53
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
          *** RUN DATE & TIME: 12-29-94  12:42

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXIT:XS   ******  1749.   46072.  1.49 *****  391.73  366.80 234700.  390.24
       0. ******  3702. ******** 3.70 ***** *******     .36    5.09

 FULL:FV     729.  2023.   24828.  2.41   .26  392.45 ******* 234700.  390.04
     729.    729.  2723. ******** 1.73   .46     .00     .37    9.45
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPR:AS     763.  2150.   31525.  3.23   .40  393.26 ******* 234700.  390.03
    1492.    763.  3501. 9079882.  3.75   .41     .00     .53    7.44
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

           <<<<<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     729.  2023.   24402.  1.66   .36  392.10  370.42 234700.  390.44
     729.    729.  2724. ******** 1.15   .00     .00     .31    9.62

    TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
      3.   1.   1.   .931   .073  391.60 ****** ****** ******

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 APPR:AS     729.  2154.   30546.  3.40   .58  392.70  375.97 234700.  389.30
    1492.    753.  3486. 8781922.  3.71   .02     .00     .54    7.68

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      .482   .075 8123151.  2114.  2815.   388.78

                 <<<<<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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
```

WSPRO OUTPUT (Cont.)

```
          *** RUN DATE & TIME: 12-29-94  12:42
  FIRST USER DEFINED TABLE.

    XSID:CODE       Q    WSEL     VEL    CRWS    YMIN
    EXIT:XS    234700.  390.24    5.09  366.80  340.20
    FULL:FV    234700.  390.04    9.45******** 340.20
    BRDG:BR    234700.  390.44    9.62  370.42  340.20
    APPR:AS    234700.  389.30    7.68  375.97  340.20
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42
  SECOND USER DEFINED TABLE.

    XSID:CODE       Q     AREA    LEW    REW    SRD        K
    EXIT:XS    234700.   46072.  1749.  3702.     0.13546850.
    FULL:FV    234700.   24828.  2023.  2723.   729.11525800.
    BRDG:BR    234700.   24402.  2023.  2724.   729.10809110.
    APPR:AS    234700.   30546.  2154.  3486.  1492. 8781922.

    XSID:CODE    OTEL
    APPR:AS    388.78
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 9 OVER THE BROAD RIVER
        EH&A FILE NO. 16139.01 B-1
           *** RUN DATE & TIME: 12-29-94  12:42
  THIRD USER DEFINED TABLE.

    XSID:CODE     EGL     FR#    WSEL     HF
    EXIT:XS    391.73     .36  390.24******
    FULL:FV    392.45     .37  390.04    .26
    BRDG:BR    392.10     .31  390.44    .36
    APPR:AS    392.70     .54  389.30    .58
  ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

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	9286
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	237
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	39.2
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.37
DIST	DISTANCE FROM BRIDGE TO APPR.	763
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.00048
Km	APPR. MAIN CHANNEL CONVEYANCE	5287127
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	12.5
	Vm = (Km*(Sf)^.5)/AREAm	
LEFT OVERBANK:		
Ssl	SPECIFIC GRAVITY OF LT. OVERBANK BED MATERIAL	2.65
D50l	MEAN DIAM. OF LT. OVERBANK BED MATL. (mm)	0.12
AREAl	LEFT OVERBANK AREA (ft)^2	1378
TOPW	LEFT OVERBANK TOP WIDTH (ft)	90
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	15.3
Kl	LEFT OVERBANK CONVEYANCE	120938
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	1.9
	Vl = (Kl*(Sf)^.5)/AREAl	
RIGHT OVERBANK:		
Ssr	SPECIFIC GRAVITY OF RT.OVERBANK BED MATERIAL	2.65
D50r	MEAN DIAM. OF RT. OVERBANK BED MATL. (mm)	0.12
AREAr	RIGHT OVERBANK AREA (ft)^2	12055
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	849
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	14.2
Kr	RIGHT OVERBANK CONVEYANCE	1050502
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	1.9

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

(1) MAIN CHANNEL CRITICAL VELOCITY (Vcm):
NEILL'S EQ;
Vcm=1.58*((Ssm-1)*g*D50m)^1/2*(Ym/D50m)^1/6
Vcm= 1.6 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.3 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.3 fps

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

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	168500
Q	TOTAL DISCHARGE(cfs) BRIDGE	168500
Ktot(APP)	APP. TOTAL CONVEYANCE	6458567
Ktot(BR)	BR. TOTAL CONVEYANCE	8266179
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.00048
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	5287127
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	237
Am(APP)	APP. MAIN CHANNEL AREA	9286
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	237
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	39.2
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	239
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	7580865
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	331
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	120938
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	90
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	1378
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	90
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	15.3
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	96
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	329707
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	113.5
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	1050502
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	849
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	12055
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	849
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	14.2
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	852
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	355607
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	186.0

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

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

Rm=Am(APP)/WETPm(APP)
Rm= 38.9 ft

(b) AVG. MAIN CHANNEL SHEAR STRESS (SHEARm):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARm=Ywater*Rm*Sf
SHEARm= 1.2 lb/sf

(c) SHEAR VELOCITY IN APP. MAIN CHANNEL (Vm*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vm*=(SHEARm/p)^.5
Vm*= 0.78 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= 0.030 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vm*/wm= 25.9
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 137937.9 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 154530.4 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 34.3 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= -4.9 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

(a) APP. LEFT OVERBANK HYD. RADIUS (Rl):

RI=AI(APP)/WETPI(APP)
RI= 14.4 ft

(b) AVG. LEFT OVERBANK SHEAR STRESS (SHEARl):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARI=Ywater*RI*Sf
SHEARI= 0.4 lb/sf

(c) SHEAR VELOCITY IN APP. LEFT OVERBANK (Vl*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vl*=(SHEARl/p)^.5
Vl*= 0.47 fps

(d) LEFT OVERBANK BED MATL.(D50l):

D50l= 0.12 mm
D50l= 0.00039 ft

(e) FALL VELOCITY (wl):
FROM FIG. 3, PAGE 34

wl= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vl*/wl= 15.77
K1= 0.69

(g) DISCHARGE IN LEFT OVERBANK OF APP (Q1l):

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 3155.2 cfs

(h) DISCHARGE IN LEFT OVERBANK OF BR (Q2l):

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 6720.8 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 24.9 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 9.6 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

(a) APP. RIGHT OVERBANK HYD. RADIUS(Rr):

Rr=Ar(APP)/WETPr(APP)
Rr= 14.1 ft

(b) AVG. RIGHT OVERBANK SHEAR STRESS (SHEARr):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARr=Ywater*Rr*Sf
SHEARr= 0.4 lb/sf

(c) SHEAR VELOCITY IN APP. RIGHT OVERBANK (Vr*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vr*=(SHEARr/p)^.5
Vr*= 0.47 fps

(d) RIGHT OVERBANK BED MATL. (D50r):

D50r= 0.12 mm
D50r= 0.00039 ft

(e) FALL VELOCITY (wr):
FROM FIG. 3, PAGE 34

wr= 0.03 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vr*/wr= 15.66
K1= 0.69

(g) DISCHARGE IN RIGHT OVERBANK OF APP (Q1r):

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 27406.9 cfs

(h) DISCHARGE IN RIGHT OVERBANK OF BR (Q2r):

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 7248.8 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 12.9 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= -1.3 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #3:	WSPRO STA	2058	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	3027.9
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	2.8
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	130.6
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	23.2
PIER #E:	WSPRO STA	2115	
AE		AREA OF CONVEYANCE TUBE AT PIER #E (sf)	3027.9
VE		VELOCITY IN CONVEYANCE TUBE AT PIER #E (fps)	2.8
TOPWE		TOPWIDTH OF CONVEYANCE TUBE AT PIER #E (ft)	130.6
YE		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #E (ft)	23.2
PIER #D:	WPSRO STA	2225	
AD		AREA OF CONVEYANCE TUBE AT PIER #D (sf)	720.2
VD		VELOCITY IN CONVEYANCE TUBE AT PIER #D (fps)	11.7
TOPWD		TOPWIDTH OF CONVEYANCE TUBE AT PIER #D (ft)	18.1
YD		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #D (ft)	39.8
PIER #C:	WSPRO STA	2365	
AC		AREA OF CONVEYANCE TUBE AT PIER #C (sf)	733.4
VC		VELOCITY IN CONVEYANCE TUBE AT PIER #C (fps)	11.5
TOPWC		TOPWIDTH OF CONVEYANCE TUBE AT PIER #C (ft)	19.5
YC		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #C (ft)	37.6
PIER #B:	WSPRO STA	2505	
AB		AREA OF CONVEYANCE TUBE AT PIER #B (sf)	767.0
VB		VELOCITY IN CONVEYANCE TUBE AT PIER #B (fps)	11.0
TOPWB		TOPWIDTH OF CONVEYANCE TUBE AT PIER #B (ft)	21.2
YB		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #B (ft)	36.2
PIER #A:	WSPRO STA	2616	
AA		AREA OF CONVEYANCE TUBE AT PIER #A (sf)	3673.0
VA		VELOCITY IN CONVEYANCE TUBE AT PIER #A (fps)	2.3
TOPWA		TOPWIDTH OF CONVEYANCE TUBE AT PIER #A (ft)	201.7
YA		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #A (ft)	18.2

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

PIER #2: WSPRO STA 2674

A2	AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	3673.0
V2	VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.3
TOPW2	TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	201.7
Y2	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	18.2

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

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

(a) a=PIER WIDTH (ft)=		2.3
(b) FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.1	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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= 4.7 ft

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

(a) a=PIER WIDTH (ft)=		10.0
(b) FROUDE NO.=FRE=VE/(g*YE)^.5=	0.1	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#E=YE*2*K1*K2*KE*(a/YE)^.65*FRE^.4E
Ys#E= 12.2 ft

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

(a) a=PIER WIDTH (ft)=		7.2
(b) FROUDE NO.=FRD=VD/(g*YD)^.5=	0.3	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#D=YD*2*K1*K2*K3*(a/YD)^.65*FRD^.D3
Ys#D= 19.6 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

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

(a) a=PIER WIDTH (ft)=		10.0
(b) FROUDE NO.=FRC=VC/(g*YC)^.5=	0.3	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.0
(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#C=YC*2*K1*K2*K3*(a/YC)^.65*FRC^.43
Ys#C= 21.7 ft

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

(a) a=PIER WIDTH (ft)=		7.2
(b) FROUDE NO.=FRB=VB/(g*YB)^.5=	0.3	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#B=YB*2*K1*K2*K3*(a/YB)^.65*FRB^.43
Ys#B= 18.8 ft

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

(a) a=PIER WIDTH (ft)=		10.0
(b) FROUDE NO.=FRA=VA/(g*YA)^.5=	0.1	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7,TBL2,PG40)=		1.0
(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#A=YA*2*K1*K2*K3*(a/YA)^.65*FRA^.43
Ys#A= 9.8 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

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

(a) a=PIER WIDTH (ft)= 2.3
(b) FROUDE NO.=FR2=V2/(g*Y2)^.5= 0.1
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)= 1.1
(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#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43
Ys#2= 4.2 ft

SCDOT BRIDGE SCOUR
Saved As: 16139A02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 100.0

IV. ABUTMENT SCOUR

THE ABUTMENTS DO NOT PROJECT OUTWARD, AND DO NOT BLOCK THE FLOW.
THE LIVE BED SCOUR WILL BE APPLIED UP TO THE ABUTMENTS.

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

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	10765
TOPW	APPR. MAIN CHANNEL TOP WIDTH (ft)	237
Ym	APPR. MAIN CHANNEL AVG. DEPTH = AREAm/TOPW	45.4
HFa	APPR. HEAD LOSS DUE TO FRICTION	0.4
DIST	DISTANCE FROM BRIDGE TO APPR.	763
Sf	AVG. UNCONSTRICTED ENERGY SLOPE = HFa/DIST	0.000524
Km	APPR. MAIN CHANNEL CONVEYANCE	6763739
Vm	APPR. MAIN CHANNEL AVG. VELOCITY (fps)	14.4
	Vm = (Km*(Sf)^.5)/AREAm	
LEFT OVERBANK:		
Ssl	SPECIFIC GRAVITY OF LT. OVERBANK BED MATERIAL	2.65
D50l	MEAN DIAM. OF LT. OVERBANK BED MATL. (mm)	0.12
AREAl	LEFT OVERBANK AREA (ft)^2	2039
TOPW	LEFT OVERBANK TOP WIDTH (ft)	121
Yl	APPR. LEFT OVERBANK AVG. DEPTH (ft)	16.9
Kl	LEFT OVERBANK CONVEYANCE	192101.0
Vl	APPR. LEFT OVERBANK AVG. VELOCITY (fps)	2.2
	Vl = (Kl*(Sf)^.5)/AREAl	
RIGHT OVERBANK:		
Ssr	SPECIFIC GRAVITY OF RT.OVERBANK BED MATERIAL	2.65
D50r	MEAN DIAM. OF RT. OVERBANK BED MATL. (mm)	0.12
AREAr	RIGHT OVERBANK AREA (ft)^2	17743.0
TOPW	RIGHT OVERBANK TOP WIDTH (ft)	974.0
Yr	APPR. RIGHT OVERBANK AVG. DEPTH (ft)	18.2
Kr	RIGHT OVERBANK CONVEYANCE	1826305.0
Vr	APPR. RIGHT OVERBANK AVG. VELOCITY (fps)	2.4

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

(1) MAIN CHANNEL CRITICAL VELOCITY (Vcm):
NEILL'S EQ;
Vcm=1.58*((Ssm-1)*g*D50m)^1/2*(Ym/D50m)^1/6
Vcm= 1.6 fps

(2) LEFT OVERBANK CRITICAL VELOCITY (Vcl):
NEILL'S EQ;
Vcl=1.58*((Ssl-1)*g*D50l)^1/2*(Yl/D50l)^1/6
Vcl= 1.4 fps

(3) RIGHT OVERBANK CRITICAL VELOCITY (Vcr):
NEILL'S EQ;
Vcr=1.58*((Ssr-1)*g*D50r)^1/2*(Yr/D50r)^1/6
Vcr= 1.4 fps

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

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

SCOUR CALCULATIONS

I. LIVE BED CONTRACTION SCOUR

(A) INPUT FROM WSPRO

VARIABLE	DESCRIPTION	VALUE
Q	TOTAL DISCHARGE(cfs) APPROACH	234700
Q	TOTAL DISCHARGE(cfs) BRIDGE	234700
Ktot(APP)	APP. TOTAL CONVEYANCE	8782145
Ktot(BR)	BR. TOTAL CONVEYANCE	10809430
Sf	AVG. UNCONSTRICTED ENERGY SLOPE	0.000524
MAIN CHANNEL:		
Km(APP)	APP. MAIN CHANNEL CONVEYANCE	6763739
W1m(APP)	APP. MAIN CHANNEL WIDTH(ft)	237
Am(APP)	APP. MAIN CHANNEL AREA	10765
TOPWm(APP)	APP. MAIN CHANNEL TOP WIDTH(ft)	237
Y1m(APP)	AVG. DEPTH IN UPSTR MAIN CHANNEL(ft)	45.4
WETPm(APP)	APP. MAIN CHANNEL WETTED PERIM.(ft)	239
Km(BR)	BR. MAIN CHANNEL CONVEYANCE	9764353
W2m(BR)	BR. MAIN CHANNEL WIDTH MINUS PIER WIDTHS(ft)	331
LEFT OVERBANK:		
Kl(APP)	APP. LEFT OVERBANK CONVEYANCE	192101
W1l(APP)	APP. LEFT OVERBANK WIDTH(ft)	121
Al(APP)	APP. LEFT OVERBANK AREA(ft^2)	2039
TOPWl(APP)	APP. LEFT OVERBANK TOP WIDTH(ft)	121
Y1l(APP)	AVG. DEPTH IN UPSTR LEFT OVERBANK (ft)	16.9
WETPl(APP)	APP. LEFT OVERBANK WETTED PERIM.(ft)	128
Kl(BR)	BR. LEFT OVERBANK CONVEYANCE	476506
W2l(BR)	BR. LEFT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	122.1
RIGHT OVERBANK:		
Kr(APP)	APP. RIGHT OVERBANK CONVEYANCE	1826305
W1r(APP)	APP. RIGHT OVERBANK WIDTH(ft)	974
Ar(APP)	APP. RIGHT OVERBANK AREA(ft^2)	17743
TOPWr(APP)	APP. RIGHT OVERBANK TOP WIDTH(ft)	974
Y1r(APP)	AVG. DEPTH IN UPSTR RIGHT OVERBANK ft)	18.2
WETPr(APP)	APP. RIGHT OVERBANK WETTED PERIM.(ft)	977
Kr(BR)	BR. RIGHT OVERBANK CONVEYANCE	568566
W2r(BR)	BR. RIGHT OVERBANK WIDTH MINUS PIER WIDTHS(ft)	200

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

(B) CALCULATIONS (CONTRACTION SCOUR)

1. MAIN CHANNEL CONTRACTION SCOUR (Ysm):

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

Rm=Am(APP)/WETPm(APP)
Rm= 45.0 ft

(b) AVG. MAIN CHANNEL SHEAR STRESS (SHEARm):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARm=Ywater*Rm*Sf
SHEARm= 1.5 lb/sf

(c) SHEAR VELOCITY IN APP. MAIN CHANNEL (Vm*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vm*=(SHEARm/p)^.5
Vm*= 0.87 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= 0.030 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vm*/wm= 29.0
K1= 0.69

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

Q1m=Q*(Km(APP)/Ktot(APP))
Q1m= 180758.7 cfs

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

Q2m=Q*(Km(BR)/Ktot(BR))
Q2m= 212008.7 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2m/Y1m=(Q2m/Q1m)^6/7*(W1m/W2m)^K1
Y2m= 41.4 ft

(j) MAIN CONTRACTION SCOUR DEPTH (Ysm):
Ysm=Y2m-Y1m
Ysm= -4.1 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

2. LEFT OVERBANK CONTRACTION SCOUR (Ysl):

(a) APP. LEFT OVERBANK HYD. RADIUS (Rl):

Rl=Al(APP)/WETPl(APP)
Rl= 15.9 ft

(b) AVG. LEFT OVERBANK SHEAR STRESS (SHEARl):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARl=Ywater*Rl*Sf
SHEARl= 0.5 lb/sf

(c) SHEAR VELOCITY IN APP. LEFT OVERBANK (Vl*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vl*=(SHEARl/p)^.5
Vl*= 0.52 fps

(d) LEFT OVERBANK BED MATL.(D50l):

D50l= 0.12 mm
D50l= 0.00039 ft

(e) FALL VELOCITY (wl):
FROM FIG. 3, PAGE 34

wl= 0.030 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vl*/wl= 17.3
K1= 0.69

(g) DISCHARGE IN LEFT OVERBANK OF APP (Q1l):

Q1l=Q*(Kl(APP)/Ktot(APP))
Q1l= 5133.8 cfs

(h) DISCHARGE IN LEFT OVERBANK OF BR (Q2l):

Q2l=Q*(Kl(BR)/Ktot(BR))
Q2l= 10346.1 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2l/Y1l=(Q2l/Q1l)^6/7*(W1l/W2l)^K1
Y2l= 30.5 ft

(j) LEFT OVERBANK CONTRACTION SCOUR DEPTH (Ysl):
Ysl=Y2l-Y1l
Ysl= 13.7 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

3. RIGHT OVERBANK CONTRACTION SCOUR (Ysr):

(a) APP. RIGHT OVERBANK HYD. RADIUS(Rr):

Rr=Ar(APP)/WETPr(APP)
Rr= 18.2 ft

(b) AVG. RIGHT OVERBANK SHEAR STRESS (SHEARr):
Ywater=UNIT WT. OF WATER(62.4 lb/cf)

SHEARr=Ywater*Rr*Sf
SHEARr= 0.6 lb/sf

(c) SHEAR VELOCITY IN APP. RIGHT OVERBANK (Vr*):
p=DENSITY OF WATER(1.94 slugs/cf)

Vr*=(SHEARr/p)^.5
Vr*= 0.55 fps

(d) RIGHT OVERBANK BED MATL. (D50r):

D50r= 0.12 mm
D50r= 0.00039 ft

(e) FALL VELOCITY (wr):
FROM FIG. 3, PAGE 34

wr= 0.030 fps

(f) EXPONENT (K1):
FROM TBL. ON PAGE 33

Vr*/wr= 18.4
K1= 0.69

(g) DISCHARGE IN RIGHT OVERBANK OF APP (Q1r):

Q1r=Q*(Kr(APP)/Ktot(APP))
Q1r= 48807.4 cfs

(h) DISCHARGE IN RIGHT OVERBANK OF BR (Q2r):

Q2r=Q*(Kr(BR)/Ktot(BR))
Q2r= 12345.0 cfs

(i) LAURSEN'S LIVE BED EQUATION:
Y2r/Y1r=(Q2r/Q1r)^6/7*(W1r/W2r)^K1
Y2r= 16.7 ft

(j) RIGHT OVERBANK CONTRACTION SCOUR DEPTH (Ysr):
Ysr=Y2r-Y1r
Ysr= -1.5 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

III. LOCAL SCOUR AT PIERS

(A) INPUT FROM WSPRO

VARIABLE		DESCRIPTION	VALUE
PIER #3:	WSPRO STA	2058	
A3		AREA OF CONVEYANCE TUBE AT PIER #3 (sf)	3804.9
V3		VELOCITY IN CONVEYANCE TUBE AT PIER #3 (fps)	3.08
TOPW3		TOPWIDTH OF CONVEYANCE TUBE AT PIER #3 (ft)	137.5
Y3		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #3 (ft)	27.7
PIER #E:	WSPRO STA	2115	
AE		AREA OF CONVEYANCE TUBE AT PIER #E (sf)	3804.9
VE		VELOCITY IN CONVEYANCE TUBE AT PIER #E (fps)	3.08
TOPWE		TOPWIDTH OF CONVEYANCE TUBE AT PIER #E (ft)	137.5
YE		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #E (ft)	27.7
PIER #D:	WPSRO STA	2225	
AD		AREA OF CONVEYANCE TUBE AT PIER #D (sf)	851.3
VD		VELOCITY IN CONVEYANCE TUBE AT PIER #D (fps)	13.78
TOPWD		TOPWIDTH OF CONVEYANCE TUBE AT PIER #D (ft)	18.5
YD		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #D (ft)	46.0
PIER #C:	WSPRO STA	2365	
AC		AREA OF CONVEYANCE TUBE AT PIER #C (sf)	877.8
VC		VELOCITY IN CONVEYANCE TUBE AT PIER #C (fps)	13.37
TOPWC		TOPWIDTH OF CONVEYANCE TUBE AT PIER #C (ft)	20.0
YC		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #C (ft)	43.9
PIER #B:	WSPRO STA	2505	
AB		AREA OF CONVEYANCE TUBE AT PIER #B (sf)	989.4
VB		VELOCITY IN CONVEYANCE TUBE AT PIER #B (fps)	11.86
TOPWB		TOPWIDTH OF CONVEYANCE TUBE AT PIER #B (ft)	23.8
YB		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #B (ft)	41.6
PIER #A:	WSPRO STA	2616	
AA		AREA OF CONVEYANCE TUBE AT PIER #A (sf)	4703.5
VA		VELOCITY IN CONVEYANCE TUBE AT PIER #A (fps)	2.49
TOPWA		TOPWIDTH OF CONVEYANCE TUBE AT PIER #A (ft)	208.4
YA		MEAN DEPTH OF CONVEYANCE TUBE AT PIER #A (ft)	22.6

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

PIER #2: WSPRO STA 2674

A2	AREA OF CONVEYANCE TUBE AT PIER #2 (sf)	4703.5
V2	VELOCITY IN CONVEYANCE TUBE AT PIER #2 (fps)	2.49
TOPW2	TOPWIDTH OF CONVEYANCE TUBE AT PIER #2 (ft)	208.4
Y2	MEAN DEPTH OF CONVEYANCE TUBE AT PIER #2 (ft)	22.6

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

(B) CALCULATIONS (LOCAL SCOUR AT PIERS)

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

(a)	a=PIER WIDTH (ft)=		2.3
(b)	FROUDE NO.=FR3=V3/(g*Y3)^.5=	0.1	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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= 5.0 ft		

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

(a)	a=PIER WIDTH (ft)=		10.0
(b)	FROUDE NO.=FRE=VE/(g*YE)^.5=	0.1	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#E=YE*2*K1*K2*KE*(a/YE)^.65*FRE^.4E		
	Ys#E= 13.0 ft		

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

(a)	a=PIER WIDTH (ft)=		7.2
(b)	FROUDE NO.=FRD=VD/(g*YD)^.5=	0.4	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#D=YD*2*K1*K2*K3*(a/YD)^.65*FRD^.D3		
	Ys#D= 21.4 ft		

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

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

(a) a=PIER WIDTH (ft)=		10.0
(b) FROUDE NO.=FRC=VC/(g*YC)^.5=	0.4	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.0
(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#C=YC*2*K1*K2*K3*(a/YC)^.65*FRC^.43
Ys#C= 23.7 ft

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

(a) a=PIER WIDTH (ft)=		7.2
(b) FROUDE NO.=FRB=VB/(g*YB)^.5=	0.3	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=		1.1
(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#B=YB*2*K1*K2*K3*(a/YB)^.65*FRB^.43
Ys#B= 19.8 ft

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

(a) a=PIER WIDTH (ft)=		10.0
(b) FROUDE NO.=FRA=VA/(g*YA)^.5=	0.1	
(c) K1=PIER NOSE SHAPE CORR. FACTOR (FIG7,TBL2,PG40)=		1.0
(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#A=YA*2*K1*K2*K3*(a/YA)^.65*FRA^.43
Ys#A= 10.5 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

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

(a)	a=PIER WIDTH (ft)=	2.3
(b)	FROUDE NO.=FR2=V2/(g*Y2)^.5= 0.1	
(c)	K1=PIER NOSE SHAPE CORR. FACTOR (FIG7, TBL2,PG40)=	1.1
(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#2=Y2*2*K1*K2*K3*(a/Y2)^.65*FR2^.43

Ys#2= 4.4 ft

SCDOT BRIDGE SCOUR
Saved As: 16139B02.WQ1
JOB NO. 16139.01 B-1
BRIDGE NO. 124000900100
BY/CHK: ABS/JNP

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

STORM EVENT (YR): 500.0

IV. ABUTMENT SCOUR

THE ABUTMENTS DO NOT PROJECT OUTWARD, AND DO NOT BLOCK THE FLOW.
THE LIVE BED SCOUR WILL BE APPLIED UP TO THE ABUTMENTS.

Photo 1: *View facing east along downstream face.*

Photo 2: *View facing west toward Lockhart.*

Photo 3: ***Upstream view, note weir (extreme center left).***

Photo 4: ***Downstream view.***

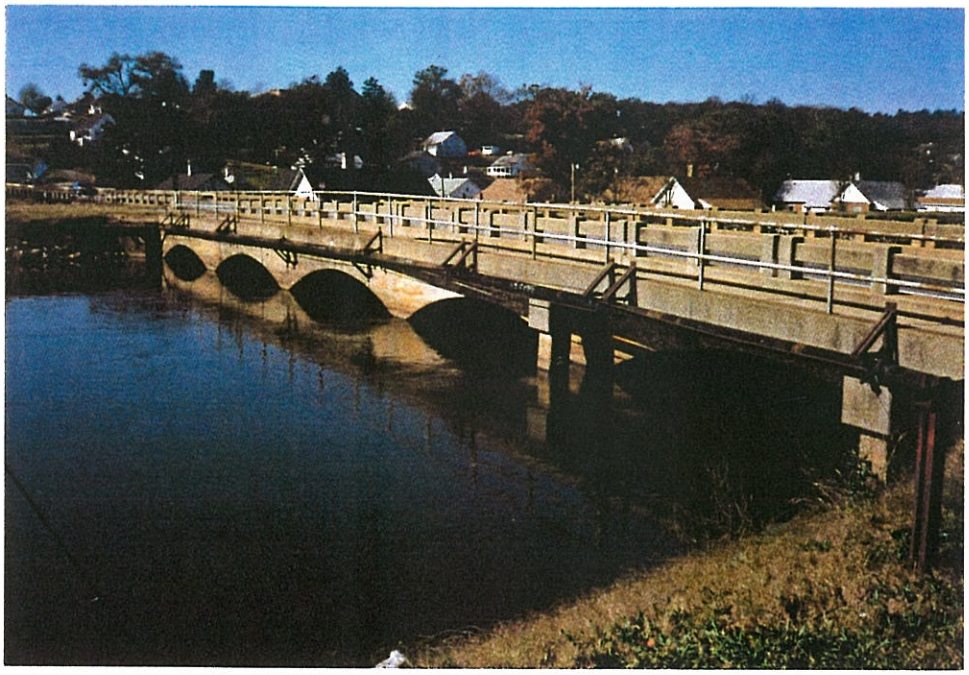


Photo 5: *Northwest view at Route 9 bridge over canal at Lockhart.*

Photo 6: *Eastern view along downstream face. Bent B is in the foreground.*

Photo 7: *Western view at coffer dam island around pier "C".*

Photo 8: *Downward view of coffer dam island around pier "C".*

Photo 9: ***Downstream view at west overbank from bridge.***

Photo 10: ***View of erosion at east abutment.***

Photo 11: ***Eastern view at weir 1 mile upstream from bridge.***

Photo 12: ***Eastern view of upstream face. Pier 2 is in right foreground followed by A, B, C, and D.***