SCOUR EVALUATION

FOR

SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION

ON

STRUCTURE #127020100100
S-201 OVER LITTLE SANDY RIVER
CHESTER COUNTY, SC

Prepared by:

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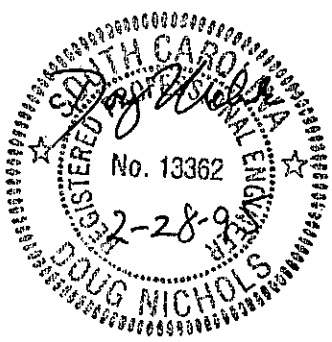
February 1995



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SCOUR EVALUATION FOR S-201 OVER LITTLE SANDY RIVER

1.0 STREAM STABILITY

1.1 Stream Characteristics

A field investigation recorded the stream characteristics on Figure 1 and on forms contained in Appendix 1. The investigation found that the overbank areas are well grassed or forested and the channel area is free from vegetation. The stream is described as a small perennial but flashy stream. A portion of the USGS Quad map is presented as Figure 2 for location purposes.

1.2 Land Use Changes

The bridge site is approximately 8.4 miles southwest of Chester, South Carolina. The land use in the drainage basin is rural. No future land use changes are expected for the life of the structure.

1.3 Overall Stream Stability

The overall stream stability appears to be stable. The 2-Year discharge and the stream slope have been plotted in the transitional zone on Figure 3 (Figure 8 in HEC-20[1]). This shows that a sand bed stream at this site would be in transition between a braided and a meandering stream. The actual stream conditions include moderate vegetation which will influence the behavior of the stream.

1.4 Lateral Stability

The stream alignment is perpendicular to the bridge opening. Photographs of the site (Appendix 2) show that the stream banks are vegetated and relatively stable during average flow conditions.

1.5 Vertical Stability

The stream bed profile is relatively stable. This is evidenced by similar channel depths for the 1978 construction plans and the channel depths measured for this report.

1.6 Channel Response to Change

The channel may still be responding to the change resulting from the construction of the bridge. No site changes are anticipated at this time which would further influence the stream behavior.

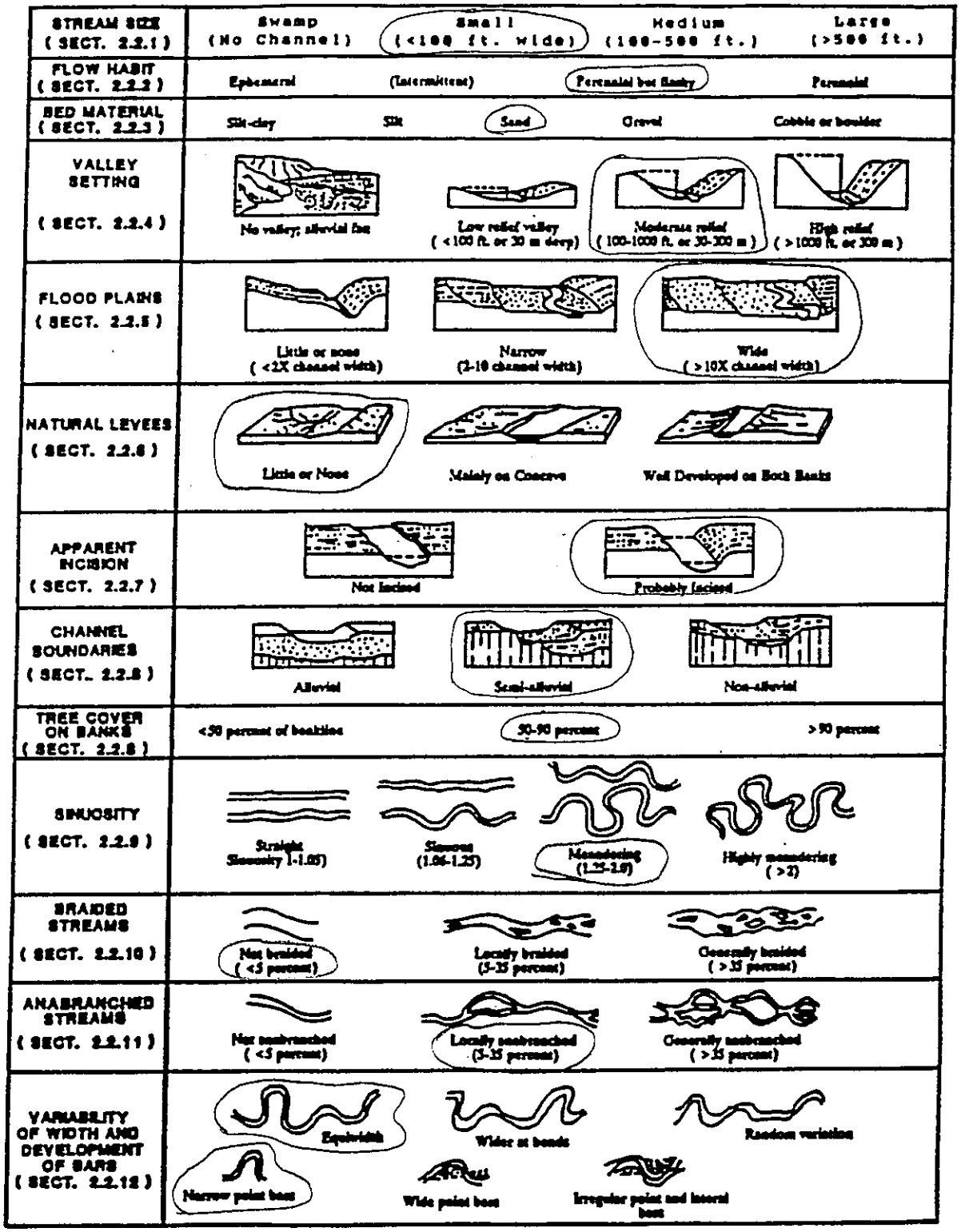
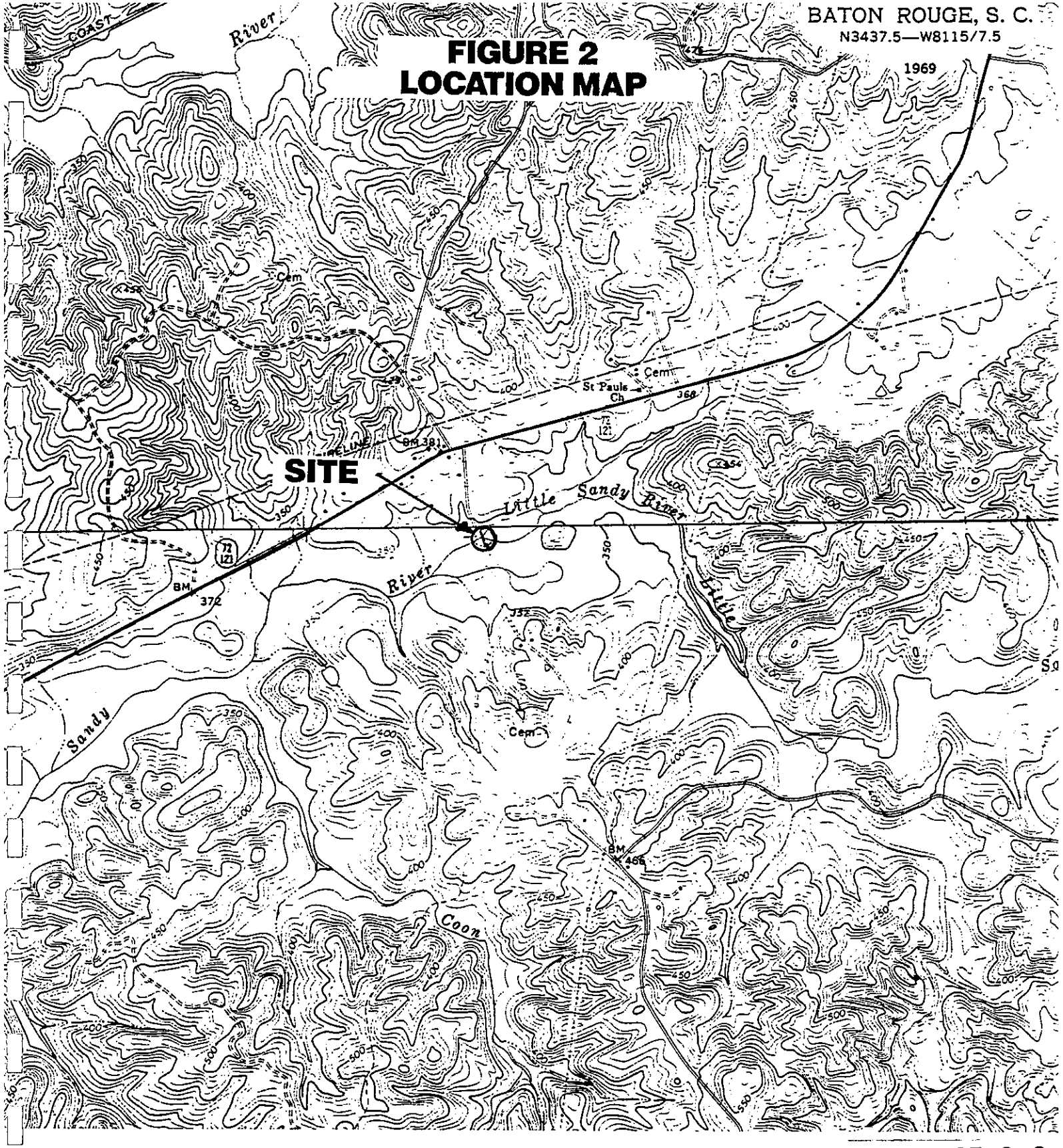


Figure 1. Geomorphic factors that affect stream stability (From HEC-20)

FIGURE 2
LOCATION MAP



CARLISLE SE, S. C.
N3430—W8115/7.5
1969

SCALE 1:24000

1 ½ 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL

MN
GN
2½° 44 MILS
0°11' 3 MILS

S.C.

QUADRANGLE LOCATION

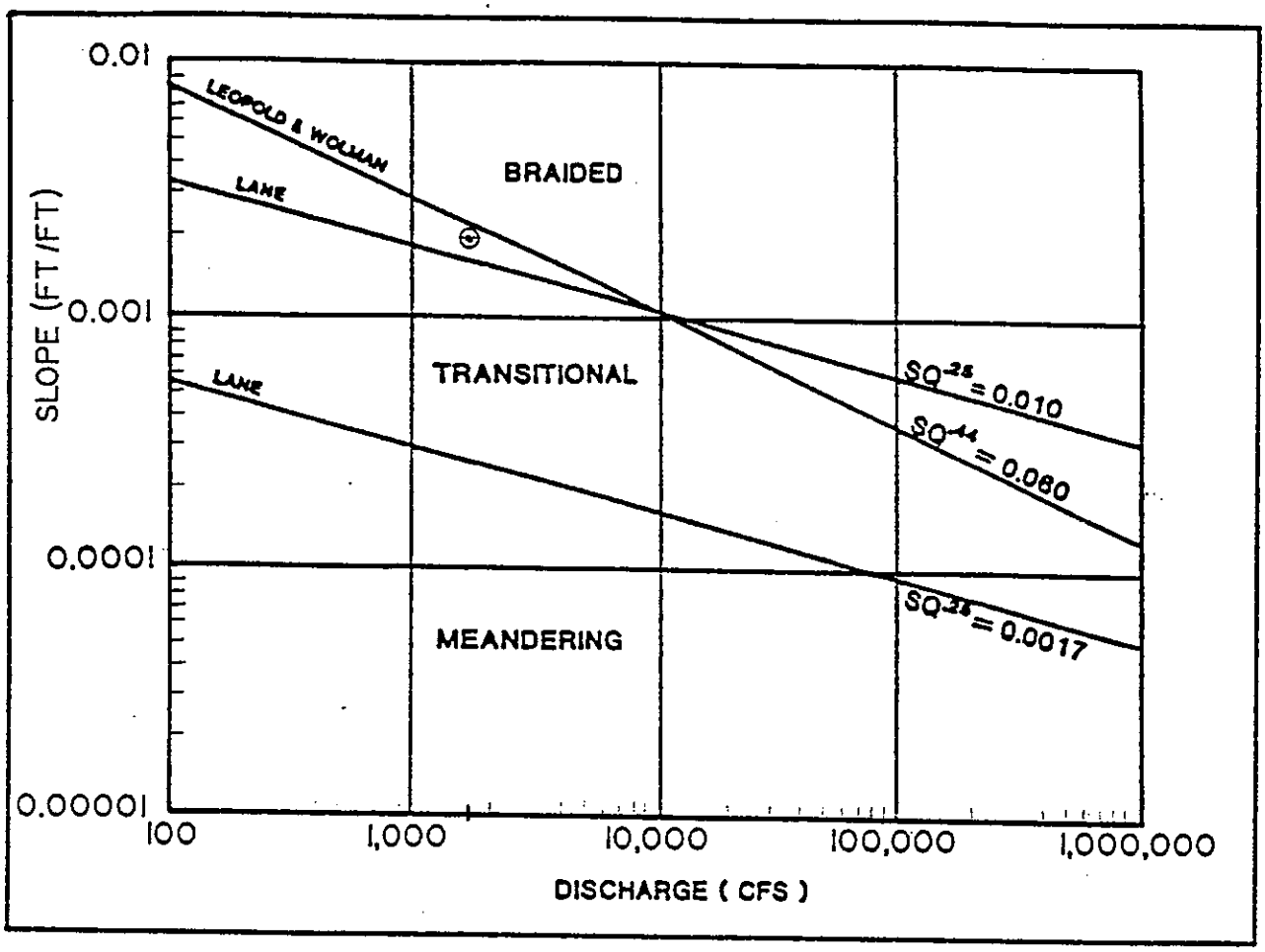


Figure 3. Slope-discharge relationship for braiding or meandering in sand bed streams (Figure 8 in HEC-20)

2.0 SCOUR ANALYSES

2.1 Flood History and Rainfall-Runoff Relations

The 1978 construction plans show a 1928 H.W. El. = 348.7 FT MSL. This water surface elevation is similar to the elevation that was calculated for the 500-year storm (348.2 FT MSL) by the WSPRO computer program.

The rainfall-runoff relations for the 34.1 sq. mi. drainage basin were obtained using the USGS Report 87-4096[5] titled "Magnitude and Frequency of Floods in Rural and Urban Basins of North Carolina. The North Carolina equations were used because Chester County is in an area where the South Carolina equations are not accurate. The results of the regression equations for the Piedmont are listed below:

Frequency (years)	Regression Equation Flowrate (cfs)
2	1649
10	3489
25	4709
50	5756
100	6950
500	10322

2.2 Hydraulic Conditions

The hydraulic conditions were investigated using the WSPRO[3] computer program and the bridge geometry measured in the field. The approach and exit cross sections were developed by combining the channel geometry from the bridge soundings and the flood plain geometry from a field survey along the upstream fill toe. The soundings were taken from the upstream face of the bridge along the entire bridge and along the downstream face of the bridge in the channel area.

The results of the computer analysis show that the bridge opening exceeds the limits that would be allowed for a new bridge at this site. The existing bridge creates 0.9 ft. of backwater and has a velocity of 5.7 fps in the bridge opening. Standard design practice for South Carolina is 1.0 ft. backwater and 5 fps maximum velocity for the 100-year event. In addition, the roadway is overtopped by storms greater than the 2-year event.

2.3 Bed and Bank Material Analysis

The field investigation visually identified the bed and bank materials as sand.

2.4 Watershed Sediment Yield Evaluation

The sediment yield for the watershed appears to be relatively stable as evidenced by the consistent stream bed elevation. A rural, well-vegetated drainage basin such as this one is generally characterized by relatively low sediment yields.

2.5 Rating Curve Shifts

Rating curve shifts have not been investigated at this time at the direction of SCDOT.

2.6 Scour Condition Evaluation

The bridge at this site was built in 1979. This current bridge replaced an old bridge at this site. The current bridge consists of a flat slab deck supported on 10" steel H piles with spill-thru abutments.

Scour conditions were evaluated using the WSPRO computer program and the scour equations presented in HEC-18[4]. The WSPRO computer output and the scour calculations are presented in Appendix 3. The results of the scour calculations have been summarized in Table 1.

The scour calculations resulted in depths of 1.6 and 3.0 feet for contraction and pier scour, respectively, during the overtopping storm.

The southern abutment scour for the overtopping storm was calculated to be 7.0 feet. Abutment scour depths for the 100- and 500-year storms were assumed to be half the overtopping depths.

The thalweg for this stream could easily shift to Bents 2,3 or 4 during the life of the structure. For this reason, the ground elevation at these bents was assumed to be the thalweg elevation.

The results of the scour calculations show that scour could expose a significant length of the piles. The pile tip elevations were from a SCDOT Pile Record Sheet and only the shortest piles were listed in Table 1. A geotechnical and structural review of the information will be needed to determine if the foundations are stable.

2.7 Recommendations

The scour calculations for the bridge show moderate scour depths. We recommend a structural engineer and a geotechnical engineer review the scour conditions at this site and decide if the stability of the bridge can be determined with the currently available information. The geotechnical engineer will need to determine if the calculated scour depths can be reduced due to erosion resistant material. The recommendations of the geotechnical engineer should then be given to a structural engineer for a structural stability analysis. The structural engineer should review the pile length data to determine the individual pile lengths.

The northern abutment is poorly protected with D_{50}=10" stone and the southern abutment is not protected with stone. The quantity of stone is inadequate to protect the bridge from the calculated abutment scour depths of 4.7 to 7.0 feet. We recommend that the abutments be repaired to meet the current SCDOT standards for new construction by adding D_{50}=12" stone to both abutments.

Table 1 - Remaining pile/footing penetration at piers/bents for Structure #127020100100 on Route S-201, crossing Little Sandy River in Chester County, South Carolina

Pier/bent[1] number	Station[1] (feet)	Pile tip[2] elevation (feet)	Ground[3] elevation at pier/bent (feet)	Total[4] scour depth (feet)	Elevation of scour (feet)	Remaining[5] pile penetration (feet)
Overtopping discharge (2-yr) is 1,750 cfs - 100-year discharge is 6,950 cfs - 500-year discharge is 10,322 cfs						
Scour Information for Overtopping Storm (2-Yr):						
1	492.5	318.8	NA	NA	NA	NA
2	522.5	320.2	338.3	11.6	326.7	6.5
3	552.5	323.5	338.3	4.6	333.7	10.2
4	582.5	320.3	338.3	9.3	329.0	8.8
5	612.5	324.9	NA	NA	NA	NA
Scour Information for 100-Year Storm:						
1	492.5	318.8	NA	NA	NA	NA
2	522.5	320.2	338.3	9.1	329.2	9.0
3	552.5	323.5	338.3	5.6	332.7	9.2
4	582.5	320.3	338.3	8.0	330.3	10.1
5	612.5	324.9	NA	NA	NA	NA
Scour Information for 500-Year Storm:						
1	492.5	318.8	NA	NA	NA	NA
2	522.5	320.2	338.3	8.1	330.2	10.0
3	552.5	323.5	338.3	4.6	333.7	10.1
4	582.5	320.3	338.3	7.0	331.3	11.0
5	612.5	324.9	NA	NA	NA	NA

[1]Pier/bent number and station corresponds to South Carolina Department of Transportation bridge plans.
[2]Pile tip elevations obtained from SCDOT bridge plans. Shortest pile length listed.
[3]Thalweg elevation used since thalweg may shift during life of structure.
[4]Total scour depth is the sum of the contraction, pier/bent and abutment scour depths.
[5]A negative number signifies undermining of pile tip/footing.

APPENDIX 1

FIELD INFORMATION

HYDRAULIC DESIGN
AND
RISK ASSESSMENT FOR
BRIDGE/BRIDGE REPLACEMENT OVER
~~stream name~~ LITTLE SANDY RIVER
ROUTE/ROAD NUMBER S-201
FILE NO._____ PROJECT NO._____
CHESTER COUNTY, SOUTH CAROLINA
STR # 127020100100

DATE

Prepared By TPW
Checked By MYN

Signed and Sealed

PROJECT DESCRIPTION

County CHESTER Rt./Rd. No. S-201
Stream LITTLE SANDY RIVER File No. 12.520 Project No. SBR-520
PIN _____ Charge Code _____
Project Engineer _____ Road Squad _____
STR. # 12702010010O

COMPARATIVE DATA

By JPW Date 2-2-95 Checked DVN Date 2-6-95

	# UPSTREAM	SITE		
ROUTE/ROAD NO.	S-160	S-201		
DIST. FROM NEW BR. (MI.)	4.7	0		
DRAINAGE AREA (SQ. MI.)	9.84	34.060		
ZONE	PIEDMONT	PIEDMONT		
Q_{10} (CFS) +	1528	3489		
Q_{25} +	2088	4709		
Q_{50} +	25108	5756		
Q_{100} +	3128	6950		
Q_{500} +	4768	10322		
BRIDGE LENGTH (FT.)	150	120		
AVG. F. G. (FT.)	-	348.328		
OPENING FURN.(SQ.FT.)	1457.19	1617.62		
VELOCITY (FT./SEC.) 100yr	2.15	11.25		
HIGH-WATER ELEV. (FT.)	-	348.7		
HIGH-WATER DATE	-	1928		
HIGH-WATER DEPTH	-	10.2		
NORMAL-WATER ELEV. (FT.)		340.10		
NORMAL-WATER DATE	1-3-95	1-3-95		
NORMAL-WATER DEPTH (FT)	0.5	1.6		
FILE/DOCKET/PROJ. NO.	-	12.520/SBR-520		
LOCATION OF PLANS	SCDOT	SCDOT		
DATUM/DATUM TIE	-			
FLOODWAY MAP	-			

NOT GOOD FOR COMPARISON : THE DRAINAGE AREA IS LESS THAN HALF THE DRAINAGE AREA OF THE BRIDGE SITE @ S-201.

+ The South Carolina Regression equations are not accurate in Chester County therefore the regression equations from Magnitude and Frequency of Floods in Rural and Urban North Carolina < U.S. Geological Survey Report 87-4096? were used at the request of SCDOT.

FIELD INSPECTION OF SCOUR BRIDGES (USGS)

COUNTY CHESTER Rt./Rd. No. S-201

STREAM NAME LITTLE SANDY RIVER STRUCTURE # 127020100100

CONSULTANT RWA INSPECTED BY DOUG K. / TONIA W.

Date 1-3-95

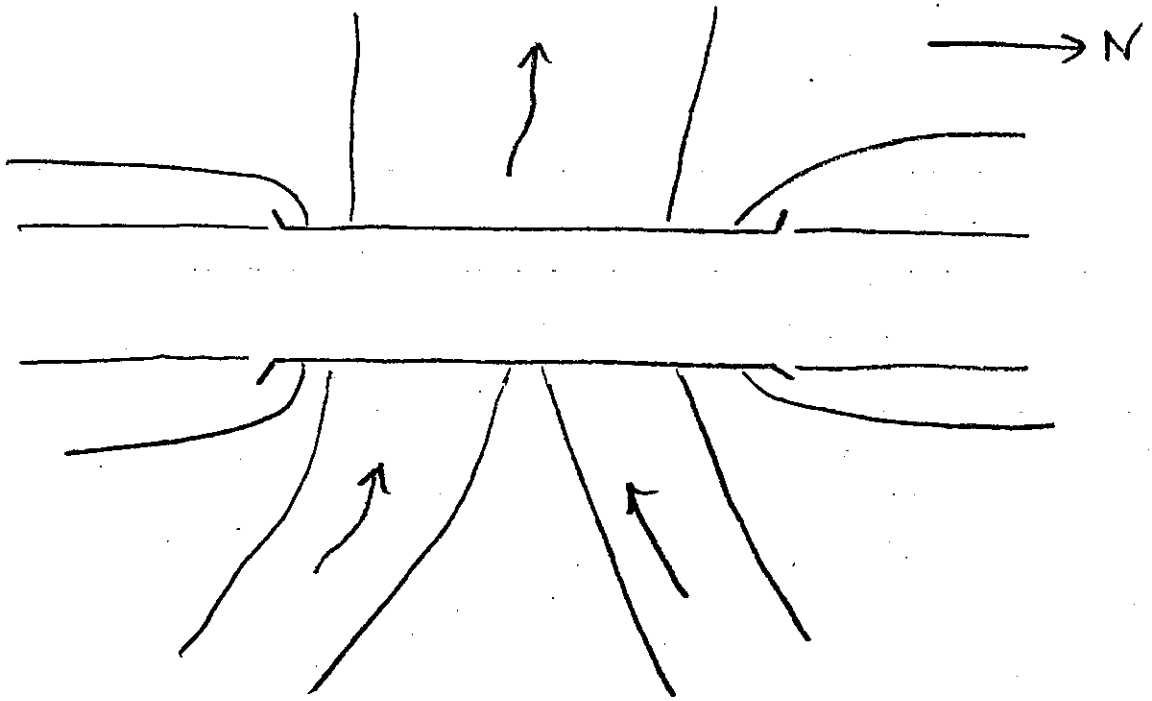
LENGTH 120 Ft. WIDTH 33.3 Ft. MAX.SPAN LENGTH 30 Ft.
Alignment (Tangent)/Curved Bridge Skewed Yes/(No) Angle ____
End Abutment Type SPILLTHROUGH
RipRap on fills ? Yes/No (NORTHERN SOUTHERN) Condition NORTHERN = POOR $D_{50} = 10"$ (NONE ON SOUTHERN)
Superstructure Type FLAT SLAB
Substructure Type 10" STEEL H PILES
Debris accumulations on bridge. (Yes)/No
Percent channel blocked horizontal 10
Percent channel blocked vertical 10
Guide Banks (Spur Dikes) Yes/(No)
Channel Spanned ? Yes/(No)
If No, number of bents in or near channel banks 2
Is the bridge crossing located in or near a channel bend ?
(Yes)/No
Is the bridge located on a tidal stream ? Yes/(No)

Are there any visible scour holes ? Yes/(No) ____
If Yes, locate scour holes on sketch.

Bank Condition: stable ✓, scalloped ____

Rock Present ? Yes/(No) Boulders, Bed Rock, Shoals, etc.
If Yes, what type ? ____

Draw Sketch of Bridge and Stream Below
(Show north arrow and direction of flow)



Site Characteristics

General Topography ROLLING HILLS
Stream Type (circle one) (Straight) Braided, or Meandering
Are Channel banks Stable? (Yes)/No If No, Describe vegetation - dense woods upstream on the North side and pasture-type grass on the remaining banks
Are there any Hydraulic Controls Upstream or Downstream? Yes/(No)
Describe _____

Soil type SAND Exposed Rock Yes/(No) If so, give description and location _____

Describe potential for drift MODERATE

Give description and location of any structures or other property that could be damaged by backwater NONE

Describe any other features that might affect or be affected by the hydraulic performance of the proposed bridge ROADWAY LIKELY OVERTOPPED BEFORE BRIDGE IS OVERTOPPED

Mannings "n" Values

Channel

$n = (n_b + n_1 + n_2 + n_3 \; n_4)\, m$

UPSTREAM: PASTURE
DOWNSTREAM SOUTH: PASTURE
DOWNSTREAM NORTH: WOODS (Moderate to dense)

n_b -- Base n for soil	(Earth)	.020	
	Rock Cut	.025	
	Fine Gravel	.024	
	Course Gravel	.028	
n_1 -- Degree of Irregularity	Smooth	.000	
	(Minor)	.001-.005	
	Moderate	.006-.010	
	Severe	.011-.020	
n_2 -- Variations of Channel Cross Sections	Gradual	.000	
	(Alternating occasionally)	.001-.005	
	Frequently	.010-.015	
n_3 -- Relative Effect of Obstructions	(Negligible)	.000-.004	
	Minor	.010-.015	
	Appreciable	.020-.030	
	Severe	.040-.060	

n_4 -- Vegetation	Low	.002-.010
	Medium	.010-.025
	High	.025-.050
	Very High	.050-.100
m -- Degree of Meandering	Minor	1.00
	Appreciable	1.15
	Severe	1.30

Field Observations for Channel

Channel Depth	n_b	n_1	n_2	n_3	n_4	m	Computed n
	.02	.001	.005	.002	.003	1.00	.031

Mannings "n" For Over Bank Areas

$$n = n_b + n_1 + n_3 + n_4$$

n_b -- Base n for soil	Earth	.020
	Rock Cut	.025
	Fine Gravel	.024
	Course Gravel	.028
n_1 -- Degree of Irregularity	Smooth	.000
	Minor	.001-.005 ←
	Moderate	.006-.010
	Severe	.011-.020
n_3 -- Effect of Obstructions	Negligible	.000-.004
	Minor	.005-.019
	Appreciable	.020-.030
n_4 -- Amount of Vegetation	Small	.001-.010
	Medium	.011-.025
	Large	.025-.Very Large

Field Observations
For Over Bank Areas

	Location	Depth	n_b	n_1	n_3	n_4	Computed n
	upstream		.020	.001	.002	.024	.047
South	downstream		.020	.001	.002	.024	.047
North	downstream	(wooded)	.020	.001	.002	.127	.150

STREAM BED SOUNDINGS

BRIDGE NO. 12702010010O COUNTY CHESTER DATE 1-3-95 BY DOUG K. / TONIA W.
S-201 L. Sandy River
RECORD SOUNDINGS FROM TOP OF RAIL. OTHER LOCATION IF NEEDED: _____

DISTANCE H. W. MARK TO TOP OF RAIL 4.8 LOCATION H. W. MARK NEAR BENT 3

~~DOWNSTREAM~~ P&L to Top of Rail = 2.4 UPSTREAM

STATION	SOUNDING	DESCRIPTION	STATION	SOUNDING	DESCRIPTION
117.6	5.6		—	4.1	NORTH Lower Chord
112.7		SOUTH FF	1.3	6.0	
			5.8	6.7	TOP OF BANK
			10.4	9.1	
—	DOWNSTREAM —		17.3	11.1	EDGE WATER
24.1	11.1	NORTH EDGE WATER	20.3	11.9	
32.4	11.1	EDGE WATER	25.0	12.0	
39.0	9.2		30.0	11.9	BENT 2
48.7	11.1	EDGE WATER	34.1	12.7	
56.8	12.0		37.1	11.1	EDGE WATER ←
64.5	12.2		43.9	8.0	TOP OF BANK
76.7	11.4		52.9	7.9	
82.2	10.9	EDGE WATER	59.8	7.8	BENT 3
			64.9	7.6	TOP OF BANK
			68.2	10.1	BOTTOM BANK
			75.8	10.8	EDGE WATER
			81.0	11.5	
			84.0	11.7	
			89.7	10.9	BENT 4
			94.7	10.7	EDGE WATER
			102.3	8.1	TOP BANK
			110.1	6.6	

SHEET ___ OF ___

UPSTREAM

COMPARATIVE BRIDGE SITE INSPECTION FORM

County Chester Rt/Rd No. S-116
Stream LITTLE SANDY RIVER Measured bridge length 150

Maximum span length 90 Superstructure type FLAT SLAB & STEEL GIRDER

Substructure type DRILLED SHAFT End Abutment type Spill through

Rip-rap present? (Yes)/No Condition EXCELLENT

Stream type (circle one) (Straight,) Braided, Meander, or Anabranched. Alluvial or (Rock) (circle)

Any visible signs of scour problems (describe) NO

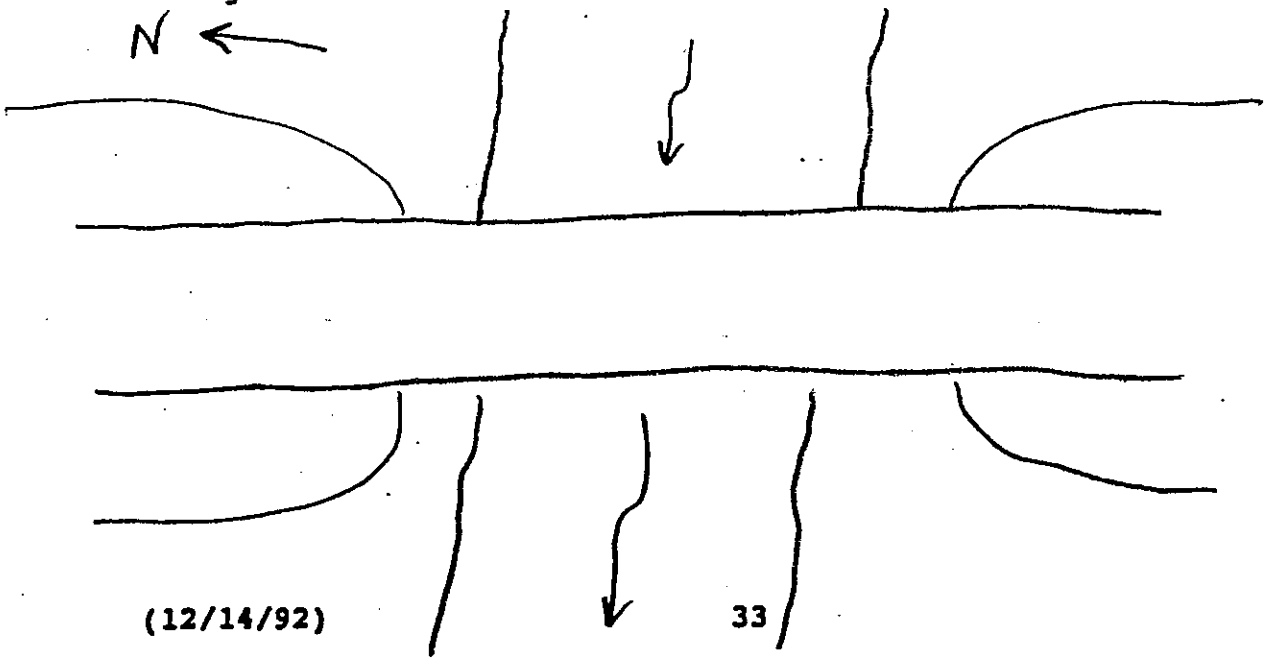
Are banks stable (describe) yes, vegetated

Debris blockage; Percent of channel blocked horizontally NONE

vertically _____. Describe other signs of debris _____

Any other problems NONE

Draw sketch and indicate problem areas. On sketch indicate location of woods, fields and other land uses in the vicinity of bridge. Show north arrow and direction of flow.



STREAM BED SOUNDINGS

BRIDGE NO. S-160 UPSTREAM COUNTY CHESTER DATE 1-3-95 BY DOUG N. / TONYA N.

RECORD SOUNDINGS FROM TOP OF RAIL. OTHER LOCATION IF NEEDED: _____

DISTANCE H. W. MARK TO TOP OF RAIL _____ LOCATION H. W. MARK _____

PGL to Top of Rail =

DOWNSTREAM STATION	DOWNSTREAM SOUNDING	DOWNSTREAM DESCRIPTION	UPSTREAM STATION	UPSTREAM SOUNDING	UPSTREAM DESCRIPTION
			—	4.3*	NORTH Lower Chord
			1.6	5.8	
			14.6	8.3	TOP RIP RAP
			30.0	14.9	BENT 2
			45.5	23.7	WATERS EDGE
			49.1	24.2	
			56.2	23.7	EDGE WATER
			69.0	23.2	
			76.1	22.7	
			85.0	20.9	TOE RIP RAP
			99.3	17.0	
			114.8	15.3	
			120.0	14.3	BENT 3
			136.4	8.0	
			146.1	6.0	
			150		SOUTH FF

7.2' Top rail to Lower Chord Span 2

SHEET ___ OF ___

Flood History

Local resident's name : Local Resident in passing pick-up truck
address :
Phone # :
Period of knowledge : 50 Yrs.
High water mark location : water gets to bottom of bridge 2
Date of occurrence : or 3 times a year. Water flows
Frequency of flooding : over road 3 or 4 times a year.

APPENDIX 2

PHOTOGRAPHS

S-201 OVER LITTLE SANDY RIVER
Chester County

(1) LOOKING NORTH ALONG ALIGNMENT.

(2) LOOKING UPSTREAM ALONG NORTHERN BRANCH.

S-201 OVER LITTLE SANDY RIVER
Chester County

(3) LOOKING UPSTREAM ALONG SOUTHERN BRANCH.

(4) LOOKING DOWNSTREAM.

S-201 OVER LITTLE SANDY RIVER
Chester County

(5) UPSTREAM FACE LOOKING NORTH.

(6) DOWNSTREAM FACE LOOKING NORTH.

S-201 OVER LITTLE SANDY RIVER
Chester County

(7) NORTHERN END BENT (#5).

(8) LOOKING SOUTH ALONG DOWNSTREAM SIDE OF BRIDGE.

S-201 OVER LITTLE SANDY RIVER
Chester County

(9) LOOKING UPSTREAM AT BENT 2.

(10) LOOKING UPSTREAM AT SOUTHERN END BENT (#1).

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T1         STR. NO. 127020100100 CHESTER CO.
T2         S-201 OVER LITTLE SANDY RIVER
*F
Q            1750          6950         10322
SK         0.0019        0.0019        0.0019
XT      1    1000
GR          252.5 370.0  302.5 360.0  352.5 350.0  982.5 344.2
GR         1012.5 343.9 1042.5 343.8 1072.5 343.7 1102.5 343.7
GR         1132.5 343.5 1162.5 343.4 1192.5 343.3 1222.5 343.5
GR         1252.5 343.3 1282.5 343.1 1312.5 343.4 1342.5 342.9
GR         1372.5 343.1 1402.5 343.5 1432.5 343.6 1462.5 344.0
GR         1492.5 344.5 1494.9 344.5 1502.4 343.5 1510.2 342.1
GR         1517.8 339.6 1522.8 339.5 1528.5 338.7 1531.5 339.0
GR         1536.7 339.7 1544.3 340.5 1547.6 343.0 1552.7 342.9
GR         1559.6 342.9 1568.6 342.9 1575.4 339.8 1578.4 338.3
GR         1582.5 339.1 1587.5 339.1 1592.2 339.2 1595.2 340.1
GR         1602.1 342.1 1606.7 344.6 1612.5 344.7 1642.5 344.2
GR         1672.5 344.9 1702.5 346.1 1732.5 348.5 1762.5 351.1
GR         1862.5 360.0
XS   EXIT     880     0      *     * 0.0019
GT
N           0.047 0.031   0.15 0.031   0.15
SA         1510.2        1547.6        1568.6        1606.7
XS   FULLV  1000     0      *     * 0.0019
GT
N           0.047 0.031   0.15 0.031   0.15
SA         1510.2        1547.6        1568.6        1606.7
BR   BRID   1000 346.5      0
GR         1492.5 345.9 1494.9 344.5 1502.4 343.5 1510.2 342.1
GR         1517.8 339.6 1522.8 339.5 1528.5 338.7 1531.5 339.0
GR         1536.7 339.7 1544.3 340.5 1547.6 343.0 1552.7 342.9
GR         1559.6 342.9 1568.6 342.9 1575.4 339.8 1578.4 338.3
GR         1582.5 339.1 1587.5 339.1 1592.2 339.2 1595.2 340.1
GR         1602.1 342.1 1606.7 344.6 1611.2 345.3 1612.5 347.3
GR         1492.5 345.9
N            0.04 0.031   0.04 0.031   0.04
SA         1510.2        1547.6        1568.6        1606.7
CD              3  33.3  2.000 348.3       0     0       0
PW 1        339.2 0.833  339.5 0.833  339.5 1.666  342.9 1.666 342.9   2.5
            346.3   2.5  346.3 1.666  346.6 1.666  346.6 0.833   347 0.833
              347     0
HP              1 BRID   343.9     *  343.9
HP              1 BRID  347.19     * 347.19
HP              1 BRID  347.07     * 347.07
HP              2 BRID   343.9     *  343.9  1750
HP              2 BRID  347.19     * 347.19  3455
HP              2 BRID  347.07     * 347.07  3705
XR   ROAD 1016.6  33.3       1
GR          252.5   370  302.5   360  352.5   350   1340 344.7
GR         1492.5 347.7 1612.5 349.0   1740 346.6 1867.5 348.9
AS   APPR 1153.3     0      *     * 0.0019
GT
N           0.047 0.031   0.15 0.031   0.15
SA         1510.2        1547.6        1568.6        1606.7
HP              1 APPR  344.69     * 344.69
HP              1 APPR  347.41     * 347.41
HP              1 APPR  348.16     * 348.16
HP              2 APPR  344.69     * 344.69  1750
HP              2 APPR  347.41     * 347.41  6950
HP              2 APPR  348.16     * 348.16 10322
EX
ER
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)

          *** RUN DATE & TIME: 02-15-95  09:28

T1         STR. NO. 127020100100 CHESTER CO.

T2         S-201 OVER LITTLE SANDY RIVER

*F

Q            1750          6950         10322

** Q-DATA FOR SEC-ID, ISEQ =              1
SK         0.0019        0.0019       0.0019
```

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SPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

** START PROCESSING CROSS SECTION - "1     "
 XT   1       1000

 GR         252.5 370.0  302.5 360.0  352.5 350.0  982.5 344.2

 GR        1012.5 343.9 1042.5 343.8 1072.5 343.7 1102.5 343.7

 GR        1132.5 343.5 1162.5 343.4 1192.5 343.3 1222.5 343.5

 GR        1252.5 343.3 1282.5 343.1 1312.5 343.4 1342.5 342.9

 GR        1372.5 343.1 1402.5 343.5 1432.5 343.6 1462.5 344.0

 GR        1492.5 344.5 1494.9 344.5 1502.4 343.5 1510.2 342.1

 GR        1517.8 339.6 1522.8 339.5 1528.5 338.7 1531.5 339.0

 GR        1536.7 339.7 1544.3 340.5 1547.6 343.0 1552.7 342.9

 GR        1559.6 342.9 1568.6 342.9 1575.4 339.8 1578.4 338.3

 GR        1582.5 339.1 1587.5 339.1 1592.2 339.2 1595.2 340.1

 GR        1602.1 342.1 1606.7 344.6 1612.5 344.7 1642.5 344.2

 GR        1672.5 344.9 1702.5 346.1 1732.5 348.5 1762.5 351.1

 GR        1862.5 360.0

** FINISH PROCESSING CROSS SECTION - "1     "
*** TEMPLATE CROSS SECTION "1     " SAVED INTERNALLY.
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SPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                   (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

*** START PROCESSING CROSS SECTION - "EXIT "
  XS   EXIT      880      0       *      * 0.0019

  GT

  N          0.047 0.031   0.15 0.031   0.15

  SA        1510.2        1547.6        1568.6        1606.7


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

-- DATA SUMMARY FOR SECID "EXIT " AT SRD =    880.  ERR-CODE =      0

    SKEW      IHFNO     VSLOPE         EK         CK
      .0         0.      .0019        .50        .00

X-Y COORDINATE PAIRS  (NGP =  49):
      X      Y           X      Y           X      Y           X      Y
   252.5  369.77      302.5  359.77      352.5  349.77      982.5  343.97
  1012.5  343.67     1042.5  343.57     1072.5  343.47     1102.5  343.47
  1132.5  343.27     1162.5  343.17     1192.5  343.07     1222.5  343.27
  1252.5  343.07     1282.5  342.87     1312.5  343.17     1342.5  342.67
  1372.5  342.87     1402.5  343.27     1432.5  343.37     1462.5  343.77
  1492.5  344.27     1494.9  344.27     1502.4  343.27     1510.2  341.87
  1517.8  339.37     1522.8  339.27     1528.5  338.47     1531.5  338.77
  1536.7  339.47     1544.3  340.27     1547.6  342.77     1552.7  342.67
  1559.6  342.67     1568.6  342.67     1575.4  339.57     1578.4  338.07
  1582.5  338.87     1587.5  338.87     1592.2  338.97     1595.2  339.87
  1602.1  341.87     1606.7  344.37     1612.5  344.47     1642.5  343.97
  1672.5  344.67     1702.5  345.87     1732.5  348.27     1762.5  350.87
  1862.5  359.77

 X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
   252.5  369.77     1578.4  338.07     1862.5  359.77      252.5  369.77

SUBAREA BREAKPOINTS (NSA =  5):
      1510.   1548.   1569.   1607.

ROUGHNESS COEFFICIENTS (NSA =  5):
        .047    .031    .150    .031    .150
```

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SPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

** START PROCESSING CROSS SECTION - "FULLV"
  XS   FULLV  1000     0      *      * 0.0019

 GT

 N          0.047 0.031   0.15 0.031   0.15

 SA        1510.2       1547.6       1568.6       1606.7


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

-- DATA SUMMARY FOR SECID "FULLV" AT SRD =   1000.  ERR-CODE =      0

    SKEW      IHFNO     VSLOPE         EK         CK
      .0         0.      .0019        .50        .00

X-Y COORDINATE PAIRS  (NGP =  49):
      X      Y           X      Y           X      Y           X      Y
   252.5  370.00      302.5  360.00      352.5  350.00      982.5  344.20
  1012.5  343.90     1042.5  343.80     1072.5  343.70     1102.5  343.70
  1132.5  343.50     1162.5  343.40     1192.5  343.30     1222.5  343.50
  1252.5  343.30     1282.5  343.10     1312.5  343.40     1342.5  342.90
  1372.5  343.10     1402.5  343.50     1432.5  343.60     1462.5  344.00
  1492.5  344.50     1494.9  344.50     1502.4  343.50     1510.2  342.10
  1517.8  339.60     1522.8  339.50     1528.5  338.70     1531.5  339.00
  1536.7  339.70     1544.3  340.50     1547.6  343.00     1552.7  342.90
  1559.6  342.90     1568.6  342.90     1575.4  339.80     1578.4  338.30
  1582.5  339.10     1587.5  339.10     1592.2  339.20     1595.2  340.10
  1602.1  342.10     1606.7  344.60     1612.5  344.70     1642.5  344.20
  1672.5  344.90     1702.5  346.10     1732.5  348.50     1762.5  351.10
  1862.5  360.00

 X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
   252.5  370.00     1578.4  338.30     1862.5  360.00      252.5  370.00

SUBAREA BREAKPOINTS (NSA =  5):
      1510.   1548.   1569.   1607.

ROUGHNESS COEFFICIENTS (NSA =  5):
        .047    .031    .150    .031    .150
```

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
.060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

*** START PROCESSING CROSS SECTION - "BRID "
  BR   BRID    1000 346.5      0

  GR         1492.5 345.9 1494.9 344.5 1502.4 343.5 1510.2 342.1

  GR         1517.8 339.6 1522.8 339.5 1528.5 338.7 1531.5 339.0

  GR         1536.7 339.7 1544.3 340.5 1547.6 343.0 1552.7 342.9

  GR         1559.6 342.9 1568.6 342.9 1575.4 339.8 1578.4 338.3

  GR         1582.5 339.1 1587.5 339.1 1592.2 339.2 1595.2 340.1

  GR         1602.1 342.1 1606.7 344.6 1611.2 345.3 1612.5 347.3

  GR         1492.5 345.9

  N            0.04 0.031   0.04 0.031   0.04

  SA         1510.2       1547.6       1568.6       1606.7

  CD             3  33.3  2.000 348.3      0     0       0

  PW 1        339.2 0.833  339.5 0.833  339.5 1.666  342.9 1.666 342.9   2.5

              346.3   2.5  346.3 1.666  346.6 1.666  346.6 0.833   347 0.833

                347     0

  HP             1 BRID   343.9     *  343.9


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

--- DATA SUMMARY FOR SECID "BRID " AT SRD =    1000.  ERR-CODE =       0

    SKEW      IHFNO     VSLOPE         EK         CK
      .0         0.      .0019        .50        .00

-Y COORDINATE PAIRS  (NGP =  25):
      X      Y          X      Y          X      Y          X      Y
  1492.5  345.90    1494.9  344.50    1502.4  343.50    1510.2  342.10
  1517.8  339.60    1522.8  339.50    1528.5  338.70    1531.5  339.00
  1536.7  339.70    1544.3  340.50    1547.6  343.00    1552.7  342.90
  1559.6  342.90    1568.6  342.90    1575.4  339.80    1578.4  338.30
  1582.5  339.10    1587.5  339.10    1592.2  339.20    1595.2  340.10
  1602.1  342.10    1606.7  344.60    1611.2  345.30    1612.5  347.30
  1492.5  345.90

X-Y MAX-MIN POINTS:
    XMIN       Y          X     YMIN       XMAX       Y          X     YMAX
  1492.5  345.90    1578.4  338.30    1612.5  347.30    1612.5  347.30

SUBAREA BREAKPOINTS (NSA =  5):
```

ROUGHNESS COEFFICIENTS (NSA = 5):

.040	.031	.040	.031	.040

BRIDGE PARAMETERS:

BRTYPE	BRWDTH	LSEL	USERCD	EMBSS	EMBELV	ABSLPL	ABSLPR
3	33.3	346.50	*******	2.00	348.30	*******	*******

PIER DATA: NPW = 11 PPCD = 1.

PELV	PWDTH	PELV	PWDTH	PELV	PWDTH	PELV	PWDTH
339.20	.8	339.50	.8	339.50	1.7	342.90	1.7
342.90	2.5	346.30	2.5	346.30	1.7	346.60	1.7
346.60	.8	347.00	.8	347.00	.0		

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	9.	304.	11.	11.				48.
	2	147.	17185.	37.	39.				1655.
	3	21.	766.	21.	21.				117.
	4	135.	14825.	37.	39.				1460.
343.90		312.	33081.	106.	110.	1.12	1499.	1605.	2870.

HP	1	BRID	347.19	* 347.19

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	42.	1730.	0.	36.				0.
	2	238.	24400.	0.	76.				0.
	3	79.	4467.	0.	42.				0.
	4	253.	27336.	4.	75.				11957.
	5	11.	585.	6.	7.				89.
347.19		622.	58519.	119.	236.	1.15	1493.	1612.	26831.

1612 - 1493 = 119 ft

HP 1 BRID 347.07 * 347.07

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28
CROSS-SECTION PROPERTIES: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	42.	1730.	0.	36.				0.
	2	238.	24400.	0.	76.				0.
	3	79.	4467.	0.	42.				0.
	4	251.	29964.	14.	64.				6068.
	5	11.	534.	6.	7.				82.
347.07		621.	61096.	20.	225.	1.18	1493.	1612.	18229.

HP	2	BRID	343.9	*	343.9	1750

SPRO
060188

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	LEW	REW	AREA	K	Q	VEL
343.90	1499.4	1605.4	311.6	33081.	1750.	5.62

STA.	1499.4	1516.2	1519.4	1522.4	1525.2	1527.7
A(I)		25.8	13.3	13.0	12.9	12.3
V(I)		3.39	6.57	6.71	6.79	7.10
STA.	1527.7	1530.1	1532.6	1535.5	1538.9	1542.5
A(I)		12.2	12.4	13.1	14.2	13.8
V(I)		7.18	7.04	6.69	6.16	6.36
STA.	1542.5	1567.4	1575.7	1578.5	1580.9	1583.5
A(I)		32.8	19.8	13.9	12.8	12.5
V(I)		2.67	4.42	6.29	6.83	6.99
STA.	1583.5	1586.0	1588.6	1591.3	1594.1	1605.4
A(I)		12.2	12.5	12.7	12.7	26.6
V(I)		7.16	6.99	6.91	6.88	3.29

HP 2 BRID 347.19 * 347.19 3455

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	LEW	REW	AREA	K	Q	VEL
347.19	1492.5	1612.4	622.3	58519.	3455.	5.55

STA.	1492.5	1513.6	1518.6	1522.8	1526.5	1529.9
A(I)		57.4	30.4	27.5	26.2	25.4
V(I)		3.01	5.68	6.28	6.59	6.81
X STA.	1529.9	1533.4	1537.4	1541.8	1548.6	1562.5
A(I)		26.2	27.4	28.5	34.5	51.8
V(I)		6.60	6.32	6.07	5.01	3.33
X STA.	1562.5	1572.6	1576.8	1579.8	1582.9	1586.0
A(I)		42.6	28.7	24.7	25.0	24.6
V(I)		4.06	6.02	6.99	6.90	7.03
STA.	1586.0	1589.1	1592.3	1595.8	1600.5	1612.4
A(I)		24.6	24.7	25.7	29.3	37.2
V(I)		7.01	6.99	6.72	5.89	4.65

HP 2 BRID 347.07 * 347.07 3705

WSPRO
060188

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28

VELOCITY DISTRIBUTION: ISEQ = 3; SECID = BRID ; SRD = 1000.

WSEL	LEW	REW	AREA	K	Q	VEL
347.07	1492.5	1612.4	620.6	61096.	3705.	5.97

STA.	1492.5	1513.8	1518.9	1523.2	1527.1	1530.6
A(I)		58.7	31.0	28.4	27.6	26.7
V(I)		3.15	5.97	6.51	6.72	6.94
STA.	1530.6	1534.4	1538.7	1543.5	1554.4	1568.3
A(I)		27.7	28.6	30.7	45.1	53.0
V(I)		6.69	6.48	6.04	4.11	3.49
STA.	1568.3	1574.8	1578.5	1581.6	1584.8	1588.1
A(I)		34.3	28.0	25.7	25.9	25.6
V(I)		5.41	6.61	7.20	7.15	7.24
STA.	1588.1	1591.3	1594.4	1597.3	1601.0	1612.4
A(I)		25.5	23.3	20.0	21.5	33.3
V(I)		7.27	7.95	9.28	8.60	5.57

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

** START PROCESSING CROSS SECTION - "ROAD "
 XR   ROAD  1016.6  33.3      1

 GR         252.5   370  302.5   360  352.5   350   1340 344.7

 GR        1492.5 347.7 1612.5 349.0   1740 346.6 1867.5 348.9


*** FINISH PROCESSING CROSS SECTION - "ROAD "
*** NO ROUGHNESS DATA INPUT, WILL PROPAGATE FROM PREVIOUS CROSS SECTION.
** CROSS SECTION "ROAD " WRITTEN TO DISK, RECORD NO. =  4

--- DATA SUMMARY FOR SECID "ROAD " AT SRD =   1017.  ERR-CODE =      0

    SKEW      IHFNO     VSLOPE         EK         CK
      .0         0.      .0019        .50        .00

X-Y COORDINATE PAIRS  (NGP =   8):
      X       Y           X       Y           X       Y           X       Y
  252.5  370.00      302.5  360.00      352.5  350.00     1340.0  344.70
 1492.5  347.70     1612.5  349.00     1740.0  346.60     1867.5  348.90

 X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
  252.5  370.00     1340.0  344.70     1867.5  348.90      252.5  370.00

SUBAREA BREAKPOINTS (NSA =  5):
      1510.   1548.   1569.   1607.

ROUGHNESS COEFFICIENTS (NSA =  5):
        .047    .031    .150    .031    .150

ROAD GRADE DATA:  IPAVE  RDWID  USERCF
                     1.   33.3 *******

BRIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                        ******* ******* ******* *******
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                    (Input modified to free format by GKY&A 01/92)

       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

** START PROCESSING CROSS SECTION - "APPR "
 AS   APPR  1153.3     0      *      * 0.0019

 GT

  N          0.047 0.031   0.15 0.031   0.15

 SA         1510.2       1547.6       1568.6       1606.7

  HP             1 APPR  344.69     * 344.69


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

--- DATA SUMMARY FOR SECID "APPR " AT SRD =   1153.  ERR-CODE =      0

    SKEW      IHFNO     VSLOPE         EK         CK
      .0         0.      .0019        .50        .00

-Y COORDINATE PAIRS  (NGP =  49):
      X      Y          X      Y          X      Y          X      Y
   252.5  370.29     302.5  360.29     352.5  350.29     982.5  344.49
  1012.5  344.19    1042.5  344.09    1072.5  343.99    1102.5  343.99
  1132.5  343.79    1162.5  343.69    1192.5  343.59    1222.5  343.79
  1252.5  343.59    1282.5  343.39    1312.5  343.69    1342.5  343.19
  1372.5  343.39    1402.5  343.79    1432.5  343.89    1462.5  344.29
  1492.5  344.79    1494.9  344.79    1502.4  343.79    1510.2  342.39
  1517.8  339.89    1522.8  339.79    1528.5  338.99    1531.5  339.29
  1536.7  339.99    1544.3  340.79    1547.6  343.29    1552.7  343.19
  1559.6  343.19    1568.6  343.19    1575.4  340.09    1578.4  338.59
  1582.5  339.39    1587.5  339.39    1592.2  339.49    1595.2  340.39
  1602.1  342.39    1606.7  344.89    1612.5  344.99    1642.5  344.49
  1672.5  345.19    1702.5  346.39    1732.5  348.79    1762.5  351.39
  1862.5  360.29

X-Y MAX-MIN POINTS:
    XMIN       Y          X    YMIN       XMAX       Y          X    YMAX
   252.5  370.29     1578.4  338.59     1862.5  360.29     252.5  370.29

UBAREA BREAKPOINTS (NSA =  5):
      1510.   1548.   1569.   1607.

OUGHNESS COEFFICIENTS (NSA =  5):
        .047    .031    .150    .031    .150

RIDGE PROJECTION DATA:  XREFLT  XREFRT  FDSTLT  FDSTRT
                       ******* ******* ******* *******
```

WSPRO
060188

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

STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28
CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPR ; SRD = 1153.

WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	460.	13091.	540.	540.				2408.
	2	166.	20969.	37.	39.				1980.
	3	31.	404.	21.	21.				216.
	4	153.	18070.	38.	40.				1751.
	5	2.	4.	20.	20.				4.
344.69		812.	52539.	657.	660.	2.72	961.	1651.	3108.

HP	1 APPR	347.41	*	347.41

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WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	2355.	147869.	845.	845.				22314.
	2	267.	46560.	37.	39.				4059.
	3	88.	2287.	21.	21.				1028.
	4	257.	42446.	38.	40.				3783.
	5	226.	3672.	109.	109.				1857.
347.41		3194.	242833.	1050.	1054.	2.25	665.	1715.	21083.

HP	1	APPR	348.16	* 348.16

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WSEL	SA#	AREA	K	TOPW	WETP	ALPH	LEW	REW	QCR
	1	3019.	210393.	926.	926.				30932.
	2	296.	54980.	37.	39.				4713.
	3	104.	3006.	21.	21.				1315.
	4	285.	50607.	38.	40.				4431.
	5	311.	5907.	118.	118.				2872.
348.16		4016.	324892.	1141.	1145.	2.13	584.	1725.	29323.

HP	2 APPR	344.69	*	344.69	1750

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FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
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STR. NO. 127020100100 CHESTER CO.
S-201 OVER LITTLE SANDY RIVER
*** RUN DATE & TIME: 02-15-95 09:28

VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPR ; SRD = 1153.

WSEL	LEW	REW	AREA	K	Q	VEL
344.69	960.9	1651.0	812.0	52539.	1750.	2.16

STA.	960.9	1170.6	1249.6	1315.8	1371.5	1510.6
A(I)		130.1	80.1	76.9	74.8	99.0
V(I)		.67	1.09	1.14	1.17	.88
X STA.	1510.6	1517.6	1521.6	1525.4	1528.7	1531.9
A(I)		25.1	19.2	19.1	18.0	18.1
V(I)		3.48	4.56	4.59	4.87	4.85
X STA.	1531.9	1535.6	1539.9	1554.0	1576.0	1579.6
A(I)		18.6	19.6	36.4	45.6	20.0
V(I)		4.71	4.46	2.40	1.92	4.37
STA.	1579.6	1582.8	1586.3	1589.9	1593.5	1651.0
A(I)		18.2	18.6	18.5	18.6	37.6
V(I)		4.80	4.71	4.72	4.71	2.33

HP	2 APPR	347.41	*	347.41	6950

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FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
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VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPR ; SRD = 1153.

WSEL	LEW	REW	AREA	K	Q	VEL
347.41	665.5	1715.2	3194.1	242833.	6950.	2.18

STA.	665.5	1006.7	1060.0	1109.9	1154.7	1196.2
A(I)		536.1	175.1	170.7	161.1	156.2
V(I)		.65	1.98	2.04	2.16	2.22
X STA.	1196.2	1240.0	1280.3	1321.1	1357.6	1396.4
A(I)		161.8	156.0	157.5	149.3	152.9
V(I)		2.15	2.23	2.21	2.33	2.27
X STA.	1396.4	1443.6	1504.3	1519.7	1527.9	1535.8
A(I)		167.6	184.2	88.5	64.4	63.5
V(I)		2.07	1.89	3.93	5.40	5.48
STA.	1535.8	1547.0	1578.2	1586.0	1594.1	1715.2
A(I)		75.1	153.0	64.1	64.0	293.1
V(I)		4.63	2.27	5.42	5.43	1.19

HP 2 APPR 348.16 * 348.16 10322

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FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
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VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPR ; SRD = 1153.

WSEL	LEW	REW	AREA	K	Q	VEL
348.16	584.0	1724.6	4015.5	324892.	10322.	2.57

STA.	584.0	977.8	1032.7	1079.9	1127.2	1170.6
A(I)	713.7	212.7	194.2	199.4	191.7	
V(I)	.72	2.43	2.66	2.59	2.69	
X STA.	1170.6	1212.3	1253.8	1293.2	1333.8	1368.4
A(I)	188.6	184.8	184.6	186.9	169.4	
V(I)	2.74	2.79	2.80	2.76	3.05	
X STA.	1368.4	1410.0	1458.7	1511.0	1522.8	1531.7
A(I)	189.3	203.9	205.1	90.0	79.1	
V(I)	2.73	2.53	2.52	5.74	6.53	
X STA.	1531.7	1541.9	1575.9	1585.0	1594.5	1724.6
A(I)	83.3	191.0	81.8	82.0	384.2	
V(I)	6.20	2.70	6.31	6.30	1.34	

EX

+++ BEGINNING PROFILE CALCULATIONS -- 3

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
                     (Input modified to free format by GKY&A 01/92)

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       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

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

 XIT :XS     ******     999.       590.    .34  *****   344.15   342.41    1750.  343.81
      880.   ******    1606.     40124.   2.48  *****  *******      .81     2.97

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =    .80      .80      344.04      342.63

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   343.31      370.00      .50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   343.31      370.00      342.63

FULLV:FV      120.     997.       601.    .33    .23   344.38   342.63    1750.  344.05
     1000.    120.    1606.     40696.   2.50    .00      .01      .79     2.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS      153.     998.       598.    .33    .28   344.67  *******   1750.  344.34
     1153.    153.    1606.     40570.   2.49    .00      .00      .80     2.92
         <<<<<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

BRID :BR      120.    1499.       312.    .64    .28   344.54   342.71    1750.  343.90
     1000.    120.    1605.     33107.   1.30    .11      .00      .66     5.61

    TYPE PPCD FLOW       C      P/A     LSEL    BLEN    XLAB    XRAB
      3.   1.   1.     .878     .027   346.50 ******  ******  ******

   XSID:CODE     SRD    FLEN     HF     VHD      EGL      ERR        Q     WSEL
  ROAD :RG      1017.          <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 PPR :AS      120.     961.       810.    .20    .24   344.88   342.93    1750.  344.69
     1153.    136.    1651.     52446.   2.72    .11      .02      .56     2.16

      M(G)    M(K)        KQ    XLKQ    XRKQ     OTEL
      .823    .238     39517.   1493.   1599.    344.55

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
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       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

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

XIT :XS     ******     766.     2274.    .36   *****   346.32    345.14     6950.   345.96
     880.   ******    1704.   159403.   2.45   *****  *******       .54      3.06

ULLV:FV      120.      765.     2287.    .35     .23   346.56   *******     6950.   346.21
    1000.    120.     1704.   160505.   2.45     .00      .01       .54      3.04
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

PPR :AS      153.      764.     2295.    .35     .29   346.85   *******     6950.   346.51
    1153.    153.     1704.   161206.   2.44     .00      .01       .53      3.03
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   350.93        .00     346.21     344.70

===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   346.74     347.19     347.64     346.50

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

          <<<<<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

BRID :BR     120.     1493.      607.    .58   *****   347.77    344.36     3455.   347.19
    1000.  ******    1612.    58457.   1.15   *****  *******       .48      5.69

     TYPE PPCD FLOW       C     P/A     LSEL    BLEN    XLAB    XRAB
       3.   1.    5.    .391    .025   346.50  ******  ******  ******

    XSID:CODE     SRD    FLEN     HF     VHD      EGL       ERR         Q     WSEL
   ROAD :RG      1017.    120.    .10     .17   347.47       .00    3501.   347.01

              Q    WLEN     LEW      REW   DMAX   DAVG   VMAX   VAVG   HAVG   CAVG
   LT:     3427.    548.     909.    1457.    2.3    1.2    5.8    5.4    1.6    3.0
   RT:       74.     45.    1718.    1763.     .4     .2    3.7    8.0     .7    3.0

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

APPR :AS     120.      666.     3190.    .17     .30   347.57    345.66     6950.   347.41
    1153.    160.     1715.   242441.   2.25     .05      .00       .33      2.18

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

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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SPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
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       STR. NO. 127020100100 CHESTER CO.
       S-201 OVER LITTLE SANDY RIVER
          *** RUN DATE & TIME: 02-15-95  09:28

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

XIT :XS    ******   672.     3129.    .38 *****  347.21  345.70  10322.  346.83
     880. ******  1714.   236626.   2.26 ***** *******     .50     3.30

ULLV:FV     120.    670.     3146.    .38    .23  347.45 *******  10322.  347.07
    1000.   120.   1715.   238266.   2.26    .00     .01     .50     3.28
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

PPR :AS     153.    669.     3158.    .37    .29  347.75 *******  10322.  347.38
    1153.   153.   1715.   239328.   2.26    .00     .01     .50     3.27
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   347.07     346.50

          <<<<<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

BRID :BR    120.   1493.      605.    .69 *****  347.76  344.56   3705.  347.07
    1000. ******  1612.    61023.   1.18 ***** *******     .52     6.12

     TYPE PPCD FLOW       C     P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.    6.    .800    .025  346.50 ****** ****** ******

    XSID:CODE    SRD    FLEN     HF    VHD      EGL      ERR        Q    WSEL
   ROAD :RG     1017.   120.    .12    .22   348.26      .02   6816.  347.67

              Q    WLEN     LEW     REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    6397.    703.    787.   1491.   3.0   1.5   6.6   6.1   2.1   3.0
   RT:     420.    116.   1683.   1799.   1.1    .5   4.8   6.8   1.1   3.0

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

APPR :AS    120.    584.     4017.    .22    .40  348.38  346.22  10322.  348.16
    1153.   165.   1725.   325069.   2.13    .05     .02     .35     2.57

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

                  <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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NORMAL END OF MSTRO EXECUTION.

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STRUCTURE NO. 127020100100 S-201 OVER LITTLE SANDY RIVER CHESTER CO.
100 YEAR CHANNEL CONTRACTION SCOUR

Y1=	8.8	ft
Wc1=	38	ft
Wc2=	38	ft
Qmc1=	1215	cfs
Qmc2=	1614	cfs
K1=	0.64	
Y2=	Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)	
Y2=	11.3	ft
Ys=Y2-Y1=	2.4	ft

500 YEAR CHANNEL CONTRACTION SCOUR

Y1=	9.6	ft
Wc1=	38	ft
Wc2=	38	ft
Qmc1=	1608	cfs
Qmc2=	1817	cfs
K1=	0.64	
Y2=	Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)	
Y2=	10.6	ft
Ys=Y2-Y1=	1.1	ft

100 YEAR CHANNEL PIER SCOUR

Y1=	8.89	
K1=	1.1	
K2=	1.0	
K3=	1.1	
a=	0.8	ft
V1=	7.0	
Fr1=	0.416	
Ys=	Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43	
Ys=	3.2	

500 YEAR CHANNEL PIER SCOUR

Y1=	8.8	
K1=	1.1	
K2=	1.0	
K3=	1.1	
a=	0.8	ft
V1=	9.28	
Fr1=	0.552	
Ys=	Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43	
Ys=	3.6	

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STRUCTURE NO. 127020100100 S-201 OVER LITTLE SANDY RIVER CHESTER CO.
OVERTOPPING CHANNEL CONTRACTION SCOUR

Y1=	6.1	ft
Wc1=	38	ft
Wc2=	38	ft
Qmc1=	602	cfs
Qmc2=	784	cfs
K1=	0.64	

Y2= Y1*(Qmc2/Qmc1)^(6/7)*(Wc1/Wc2)^K1)

Y2=	7.7	ft
Ys=Y2-Y1=	1.6	ft

OVERTOPPING CHANNEL PIER SCOUR

Y1=	5.6	
K1=	1.1	
K2=	1.0	
K3=	1.1	
a=	0.8	ft
V1=	7.2	
Fr1=	0.535	

Ys= Y1*2*K1*K2*K3*(a/Y1)^0.65*Fr1^0.43

Ys=	3.0	

STRUCTURE NO. 127020100100 S-201 OVER LITTLE SANDY RIVER CHESTER CO.
OVERTOPPING SOUTHERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	549.0	
OBSTRUCTED FLOW AREA=	460.9	
Ya=	0.8	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	90	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	1.000	
OBSTRUCTED FLOW (cfs)	436.8	
Ve=	0.95	
Fre=Ve/(gYa)^0.5=	0.1823	
Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1		
Ys=	7.0	

OVERTOPPING NORTHERN ABUTMENT SCOUR

a' LENGTH OF ABUT.		
PROJ. NORMAL TO FLOW=	58.0	
OBSTRUCTED FLOW AREA=	38	
Ya=	0.6	
VERT. WALL	1	
VERT. WALL W/ WINGS	0.82	
SPILL THROUGH	0.55	
K1=	0.55	
EMB. ANGLE (PERP.=90)	90	SIDE WITH FLOW REVERSAL HAS HIGHER ANGLE
K2=	1.000	
OBSTRUCTED FLOW (cfs)	88	
Ve=	2.33	
Fre=Ve/(gYa)^0.5=	0.5100	
Ys/Ya=2.27 K1 K2 (a'/Ya)^0.43 Fre^0.61 + 1		
Ys=	4.7	

APPENDIX 5

Selected References

1. HEC-20, Stream Stability at Highway Structures, Publication No. FHWA-IP-90-014. FHWA, U.S. Department of Transportation, February 1991

2. Techniques for Estimating Magnitude and Frequency of Floods in South Carolina, 1988, U.S. Geological Survey Water-Resources Investigations Report 91-4157.

3. The WSPRO computer program and manual, prepared by the U.S. Geological Survey for The Federal Highway Administration.

4. HEC-18, Evaluating Scour at Bridges (Second Edition), Publication No. FHWA-IP-90-017. FHWA, U.S. Department of Transportation, Revised April 1993.

5. Magnitude and Frequency of Floods in Rural and Urban Basins of North Carolina, 1987, U.S. Geological Survey, Water-Resources Investigations Report 87-4096.