U.S. DEPARTMENT OF THE INTERIOR U.S. GEOLOGICAL SURVEY

LEVEL II BRIDGE SCOUR ANALYSIS FOR STRUCTURE 124021500200 ON ROUTE SC 215, CROSSING THE SANDY RIVER IN CHESTER COUNTY, SOUTH CAROLINA

By J. Mike Sullivan and Michael G. Zalants

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Prepared in cooperation with the SOUTH CAROLINA DEPARTMENT OF TRANSPORTATION



Columbia, South Carolina 1994

UNIT ABBREVIATIONS

cubic foot per second ft³/s
feet per second ft/s
foot ft
mile mi
millimeter mm
square foot ft²
square mile mi²

OTHER ABBREVIATIONS

In this report, the words "right" and "left" refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, "sea level" refers to the National Geodetic Vertical

Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order
level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Level II bridge scour analysis for structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

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This report provides the results of the detailed Level II analysis of scour potential at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina (figure 1 in pocket; figures 4-8). The site is located in the Piedmont physiographic province near the town of Leeds in the southwestern part of Chester County. The drainage area for the site is 150 mi², and is a predominantly rural drainage basin with little development in recent years. In the vicinity of the study site, the land is covered by moderate to dense woods consisting of hardwoods.

In the study area, the Sandy River has a meandering channel with a slope of 0.00054 ft/ft (2.8 ft/mi), an average channel top width of 87 ft and an average channel depth of 15 ft. The predominant channel bed material is sand (D_{50} is 1.1 mm) and the channel banks consist of a silty sand (D_{50} is 0.30 mm). In general, the banks have moderate to heavy woody vegetative cover and were noted as having heavy fluvial erosion and some bank failure with exposed tree roots and trees leaning over the channel at the time of the Level I site visit, July 16, 1990, and the Level II site visit, April 20, 1993.

The Route SC 215 crossing of the Sandy River is a 450-ft-long, two-lane bridge consisting of fifteen 30-ft concrete spans, supported by steel and concrete bents with spillthrough abutments. The left abutment is protected by riprap but the right abutment has no riprap protection. In this report, the words "right" and "left" refer to directions that would be reported by an observer facing downstream. Additional details describing conditions at the site are included in the Scour Report Summary.

Scour depths were computed using engineering judgement and the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993) and the Transportation Research Board Draft Paper, "Evaluating scour at bridges using WSPRO" (Arneson and others, 1992). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 through 5 and a graph of the scour depths is shown on figure 2.

Pile penetration depths were obtained from SCDOT bridge plans. The minimum remaining pile penetration depth for the 100-year discharge is 5.0 ft and occurs at bent 12. The minimum remaining pile penetration depth for the 500-year discharge is 3.7 ft and occurs at bent 3.

It should be noted that the SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could affect the scour depths shown in this study. For more information, see the SCDOT bridge plans in the pocket at the back of the report.

Table 1. --Remaining pile/footing penetration at piers/bents for the 100-year discharge at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

Pier/bent ¹ number	Station from ² left end of bridge (feet)	Pile tip/3 footing elevation, SCDOT datum (feet)	Pile tip/ footing elevation, USGS datum (feet)	Ground elevation at pier/bent, USGS datum (feet)	Total 4 scour depth (feet)	Elevation of scour, USGS datum (feet)	Remaining pile/footing penetration (feet)
		100-year	discharge is 18,	100-year discharge is 18,000 cubic feet per second	r second		
2	30	293.0	293.1	319.5	6.2	313.3	20.2
င	09	294.9	295.0	308.5	6.4	302.1	7.1
4	90	292.2	292.3	313.9	6.3	307.6	15.3
S	120	292.7	292.8	315.4	6.3	309.1	16.3
9	150	295.3	295.4	315.1	6.3	308.8	13.4
7	180	296.0	296.1	314.6	6.3	308.3	12.2
œ	210	293.0	293.1	315.4	6.3	309.1	16.0
6	240	289.4	289.5	318.3	6.2	312.1	22.6
10	270	290.5	290.6	314.0	3.2	310.8	20.2
11	300	286.6	286.7	300.3	6.4	293.9	7.2
12	330	289.7	289.8	301.2	6.4	294.8	5.0
13	360	287.0	287.1	304.0	6.4	297.6	10.5
14	390	290.5	290.6	311.2	10.2	301.0	10.4
15	420	293.1	293.2	317.7	10.0	307.7	14.5

¹ Pier/bent number corresponds to the South Carolina Department of Transportation (SCDOT) bridge plans.

NOTE: The SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could reduce the scour depths shown in the above table. For more information, see the SCDOT plans in report pocket.

² Stations are determined from left to right looking downstream.

³ Pile tip/footing elevations obtained from the SCDOT bridge plans. The maximum elevation at each pier/bent is used.

⁴ Total scour depth is the sum of the contraction and pier/bent scour depths.

Table 2. --Remaining pile/footing penetration at piers/bents for the 500-year discharge at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

Pier/bent ¹ number	Station from ² left end of bridge (feet)	Pile tip/ ³ footing elevation, SCDOT datum (feet)	Pile tip/ footing elevation, USGS datum (feet)	Ground elevation at pier/bent, USGS datum (feet)	Total ⁴ scour depth (feet)	Elevation of scour, USGS datum (feet)	Remaining pile/footing penetration (feet)
		500-year	discharge is 26,4	500-year discharge is 26,400 cubic feet per second	r second		
2	30	293.0	293.1	319.5	9.6	309.9	16.8
က	09	294.9	295.0	308.5	8.6	298.7	3.7
4	06	292.2	292.3	313.9	9.7	304.2	11.9
۲,	120	292.7	292.8	315.4	<i>L</i> .6	305.7	12.9
9	150	295.3	295.4	315.1	6.7	305.4	10.0
7	180	296.0	296.1	314.6	6.7	304.9	8.8
&	210	293:0	293.1	315.4	9.6	305.8	12.7
6	240	289.4	289.5	318.3	7.6	308.6	19.1
10	270	290.5	290.6	314.0	3.6	310.4	19.8
11	300	286.6	286.7	300.3	7.3	293.0	6.3
12	330	289.7	289.8	301.2	7.3	293.9	4.1
13	360	287.0	287.1	304.0	7.3	296.7	9.6
14	390	290.5	290.6	311.2	16.8	294.4	3.8
15	420	293.1	293.2	317.7	16.7	301.0	7.8

¹ Pier/bent number corresponds to the South Carolina Department of Transportation (SCDOT) bridge plans.

NOTE: The SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could reduce the scour depths shown in the above table. For more information, see the SCDOT plans in report pocket.

² Stations are determined from left to right looking downstream.

³ Pile tip/footing elevations obtained from the SCDOT bridge plans. The maximum elevation at each pier/bent is used.

⁴ Total scour depth is the sum of the contraction and pler / bent scour depths.

Table 3. -- Cumulative scour depths at piers/bents for the 100-year discharge at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

Pier/bent ¹ number	Station from ² left end of bridge (feet)	Contraction scour depth (feet)	Pier/bent scour depth without debris (feet)	Total ³ scour depth without debris (feet)
	100-year dischar	ge is 18,000 cubi	ic feet per second	
2	30	3.4	2.8	6.2
3	60	3.4	3.0	6.4
4	90	3.4	2.9	6.3
5	120	3.4	2.9	6.3
6	150	3.4	2.9	6.3
7	180	3.4	2.9	6.3
8	210	3.4	2.9	6.3
9	240	3.4	2.8	6.2
10	270	0.04	3.2	3.2
11	300	0.0^{4}	6.4	6.4
12	330	0.04	6.4	6.4
13	360	0.0^{4}	6.4	6.4
14	390	7.2	3.0	10.2
15	420	7.2	2.8	10.0

¹ Pier/bent number corresponds to the South Carolina Department of Transportation (SCDOT) bridge plans.

NOTE: The SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could reduce the scour depths shown in the above table. For more information, see the SCDOT plans in report pocket.

NOTE: The pier and contraction scour equations used in this scour analysis were those recommended in Hydraulic Engineering Circular 18 (Richardson and others, 1993). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

² Stations are determined from left to right looking downstream.

³ Total scour depth is the sum of the contraction and pier/bent scour depths.

⁴ The calculated contraction scour is a negative value, but was set equal to zero to reflect a more reasonable estimate of scour during peak flood conditions.

Table 4. -- Cumulative scour depths at piers/bents for the 500-year discharge at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

Pier/bent ¹ number	Station from ² left end of bridge (feet)	Contraction scour depth (feet)	Pier/bent scour depth without debris (feet)	Total ³ scour depth without debris (feet)
	500-year discharg	ge is 26,400 cub	ic feet per second	
2	30	6.3	3.3	9.6
3	60	6.3	. 3.5	9.8
4	90	6.3	3.4	9.7
5	120	6.3	3.4	9.7
6	150	6.3	3.4	9.7
7	180	6.3	3.4	9.7
8	210	6.3	3.3	9.6
9	240	6.3	3.4	9.7
10	270	0.0^{4}	3.6	3.6
11	300	0.0^{4}	7.3	7.3
12	330	0.04	7.3	7.3
13	360	0.04	7.3	7.3
14	390	13.4	3.4	16.8
15	420	13,4	3.3	16.7

Pier/bent number corresponds to the South Carolina Department of Transportation (SCDOT) bridge plans.

NOTE: The SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could reduce the scour depths shown in the above table. For more information, see the SCDOT plans in report pocket.

NOTE: The pier and contraction scour equations used in this scour analysis were those recommended in Hydraulic Engineering
Circular 18 (Richardson and others, 1993). Scour depths were calculated assuming an infinite depth of erosive material and a
homogeneous particle-size distribution.

² Stations are determined from left to right looking downstream.

³ Total scour depth is the sum of the contraction and pier/bent scour depths.

⁴ The calculated contraction scour is a negative value, but was set equal to zero to reflect a more reasonable estimate of scour during peak flood conditions.

Table 5. -- Abutment scour depths for the 100- and 500-year discharges at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina

Recurrence interval for discharge	Discharge (cubic feet per second)	Depth of scour ^{1, 2} at left abutment (feet)	Depth of scour ^{1, 2} at right abutment (feet)
100-year	18,000	0_3	25.2
500-year	26,400	0^3	30.7

¹ Abutment scour depths were calculated using the Froehlich (1989) live-bed abutment scour equation, assuming no abutment protection.

² The words "right" and "left" refer to directions that would be reported by an observer facing downstream.

³ Scour was not computed for the left abutment because of adequate riprap protection.

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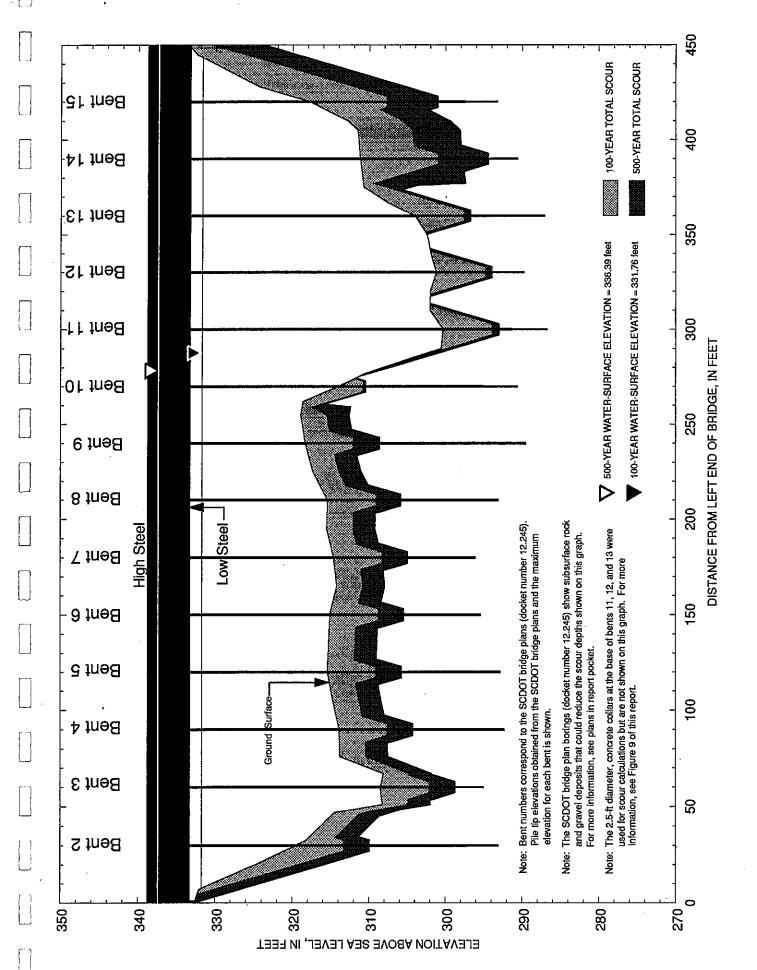


Figure 2.--Total scour depths for the 100- and 500-year discharges at the upstream face of structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina.

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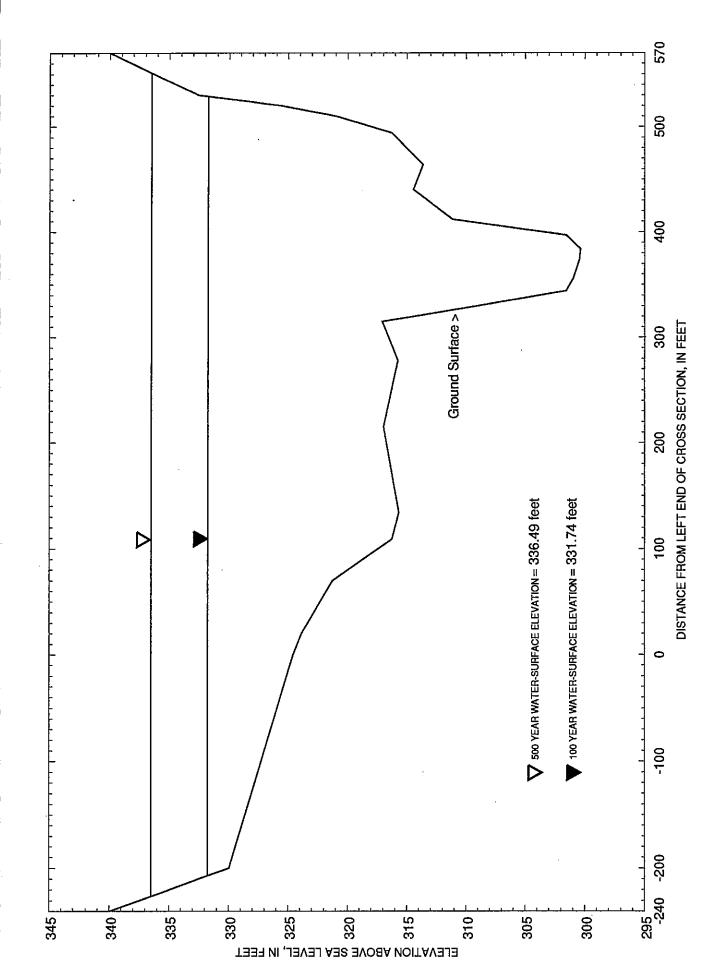


Figure 3.--Approach cross section at structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina.

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Figure 4.--Approximately 500 ft upstream of structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina facing downstream (April 20, 1993).



Figure 5.--Approximately 650 ft downstream of structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina facing upstream (April 20, 1993).



Figure 6.--Upstream channel as viewed from structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina (July 16, 1990).



Figure 7.--Structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina as viewed from the upstream channel (July 16, 1990).

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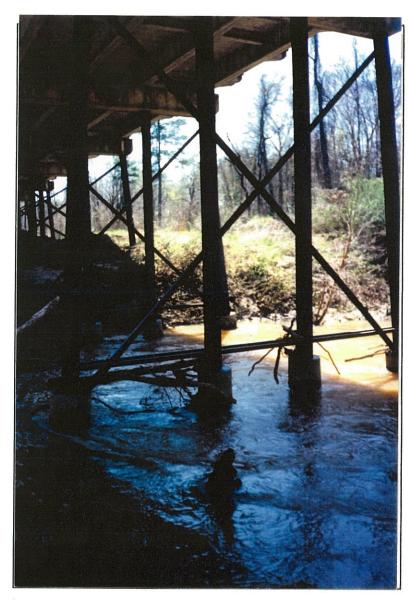


Figure 8.--Bents 11 and 12 of structure 124021500200 on Route SC 215, crossing the Sandy River in Chester County, South Carolina, showing the 2.5-ft diameter, concrete collars at the pile bases (April 20, 1993).

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SCOUR REPORT SUMMARY

cture Number	12402150020	0 Stream	Sandy Ri	ver	
nty Ches	ter	Road	SC 215	District	4
	1	Description of Brid	<u>dge</u>		
Bridge length		Bridge width33	_ ft Max	span length _	30 f
Alignment of	bridge to road (or	n curve or straight)	straight		
Abutment typ	e spillthrough	Embankı	nent type	sloping	
Riprap on abu	tment? <u>yes/1</u>	no Date of ins	pection 04-	20-1993	
Description o		eft abutment is protect			e riprap.
The right abu	tment is not prot	ected with riprap.			
_		n according to USGS t channel? <u>no</u> If s			
Debris accum	ulation on bridge Date of insp		f channel	Percent	
	05.46.46	blocked he	•		of chann vertically
Level I	07-16-19	9901	•		
Level II	04-20-19	990 1.	5	1	verticall 5
Level II	04-20-19 l for debris <u>Mo</u> o	9901	5	1	verticall; 5

Description of Flood Plain

General top	ography	Relati	vely narrow v	valley sect	ions that rise	quick	ly in eleva	tion
Flood-plai	n conditi	ons at b	ridge site: dov	wnstream	(D/S), upstrea	am (U	7/S)	
Date of ins	pection	04-20-1	993				•	
D/S left:	Modera	ate to he	avy coverage	of hardw	oods and mo	derate	undergro	wth
D/S right:	Modera	ite to hea	vy coverage	of hardwo	oods and mod	lerate	undergro	wth
U/S left:	Modera	te to hea	vy coverage (of hardwo	ods and mod	lerate	undergrov	vth
U/S right:	Light to	modera	ate coverage o	of hardwo	ods and mod	erate	undergrov	vth _.
			Description	n of Cha	nnel			
Average to	o width	87	ft		Average d	epth	15	. ft
Predomina			sand		Bank mater		silty sand	<u> </u>
Stream typ	e (straigh	t, mean	lering, braide	ed, swamp	y, channelize	d) _m	eandering	
Vegetative :	cover on	channel	banks near bi	ridge: De	ate of inspect	ion	04-20-1	993
D/S left:	Modera	ate to he	avy coverage	of hardw	oods and moo	derate	undergro	wth
D/S right:	Modera	ate to he	avy coverage	of hardw	oods and moo	derate	undergro	wth
U/S left:	Modera	te to he	avy coverage	of hardw	oods and mod	derate	undergro	wth
U/S right:	Light to	modera	ite coverage c	of hardwo	ods and mod	erate	undergrov	vth
Do banks a	ppear sta	ble? <u>n</u>	O If no	ot, describ	e location an	ıd typ	e of instal	bility and
date of obs	ervation.	The b	anks were no	oted as hav	ing heavy flu	ıvial e	rosion and	l some
failure. M	any tree i	roots are	exposed and	the trees	are leaning o	ver th	e upstrean	n and
downstrea	m channe	el. This	was observed	during tl	ne Level I site	visit	on July 16,	1990,
and during	ς the Leve	el II site	visit on April	20, 1993.				
Describe an	y obstruc	tions in	channel and	date of ob	servation.	Non	e observe	<u>d.</u>
								
				······································				

Hydrology

Drainage area 150 mi ²					
Percentage of drainage area in physiographic p	provinces:				
Physiographic province	Percent of drainage area				
Piedmont (high-flow)	100				
	·				
	·				
Is drainage area considered rural or urban?	rural Describe any significant				
urbanization and potential for development.	The drainage area encompasses a				
predominately rural area with little developm					
Is there a USGS gage on the stream of interest:	No No				
USGS gage description _					
USGS gage number					
Gage drainage area	; ²				
<u> </u>	* •				
Is there a lake/pond that will significantly affe	ct nyurowsyrnyurumes.				
If so, describe					
Calculated I	Discharges				
Q100 $18,000$ ft^3/s	$Q500 = \frac{26,400}{100} ft^3/s$				
Method used to determine discharges The dra	ainage basin is located in the "high-flow"				
area of South Carolina; therefore, the method	described by C.L. Sanders (written				
commun., 11-1993) was used to compute flood	discharges. In general, this method uses				
North Carolina USGS flood discharge equation	ons (WRIR 87-4096) to compute the 100-				
year discharge, and extrapolates the 500-year					
discharges (USGS Bulletin 17B, p. 5-2).	•				
					

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

Datum for WSPRO analysis (USGS survey, sea level, SCI	OOT plan	sea level
Datum tie between USGS survey and SCDOT plans	Subtrac	et 0.1 ft from USGS
survey datum to obtain SCDOT plans' datum (docket n	umber 1	2.245).
Description of reference marks used to determine USGS	datum.	USGS Benchmark
J185 (elevation=372.38 ft above sea level) is located on R	loute SC 2	215 approximately 850
ft northwest of the Route SC 215 crossing of the Sandy I	River. RN	11 is a chiseled square
on the upstream, left abutment headwall of the Route S	C 215 cro	ssing and has a
surveyed elevation of 336.01 ft. RM2 is a chiseled squar	e on the	downstream, right
abutment headwall of the Route SC 215 crossing and ha	s an eleva	ation of 336.04 ft.
Cross Sections Used in WSPRO	Analysis	}

*Cross section ID	Section Reference Distance (SRD) in feet	**How cross section was developed	Comments
EXIT	-450	2 & 3	Exit cross section
FULLV	0	3	Full valley cross section
BRIDG	0	1	Upstream bridge face
ROAD	16	1	Road grade section
APPRO	483	2 & 3	Approach cross section
· · · · · · · · · · · · · · · · · · ·			

^{*} For location of cross sections see topographic map included with report (figure 1).
For more detail on how cross sections were developed see WSPRO input file.

** 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 5) other

Description of data and assumptions used in developing WSPRO model.

The Sandy River has a relatively uniform flood plain width in the study area, with no downstream natural or man-made contractions of flow that cause significant backwater at the Route US 215 crossing. Therefore, it was assumed that slope-conveyance methodology would be adequate for estimating the starting-water-surface elevation for the water-surface profile computations.

For this study, the WSPRO model requires, as a minimum, an exit section one bridge width downstream of the bridge, a full-valley section at the downstream face of the bridge, the bridge section, and an approach section one bridge width upstream of the bridge. Cross sections at the upstream and downstream faces of the bridge were directly surveyed and the more constricted (upstream) bridge face was used in the WSPRO model. A 12 degree bridge skew was determined by averaging the 10 degree skew noted on the Level I Inspection Form. dated July 16, 1990, and the 14 degree skew measured from the USGS topographic map. The section reference distance (SRD) at the downstream face of the bridge was set to zero. An exit cross section was surveyed 670 ft downstream of the downstream bridge face, an approach cross section was surveyed 560 ft upstream of the upstream bridge face, and a full-valley cross section was surveyed at the toe of the downstream road embankment. These cross sections were shifted by the channel slope to the appropriate SRD to represent the exit, fullvalley, and approach cross sections required by the WSPRO model. The cross sections were extended using the slope of the contour lines from the USGS topographic map. In addition, the centerline of Route SC 215 was surveyed and included in the analysis to model flow over the road.

Bridge Hydraulics

Average embankment elevation 335.6 ft

Average low steel elevation 333.3 ft

100-year discharge 18,000 ft³/s

Water-surface elevation at D/S bridge face 331.76 ft

Area of flow at D/S bridge face 7,952 ft²

Average velocity in bridge opening 2.26 ft/s

Maximum WSPRO tube velocity at bridge 2.91 ft/s

Water-surface elevation at Approach section with bridge 331.74 ft

Water-surface elevation at Approach section without bridge 331.72 ft

Amount of backwater caused by bridge 0.02 ft

500-year discharge 26,400 ft³/s

Water-surface elevation at D/S bridge face 336.39+ ft

Area of flow at D/S bridge face 8,364 ft²

Average velocity in bridge opening 3.14 ft/s

Maximum WSPRO tube velocity at bridge 3.86 ft/s

Water-surface elevation at Approach section with bridge 336.49 ft

Water-surface elevation at Approach section without bridge 336.55 ft

Amount of backwater caused by bridge 0^* ft

⁺The water-surface elevation at the downstream bridge face is determined from the full-valley section because the bridge is in pressure flow.

*Backwater for the 500-year discharge is -0.06 ft. Since negative backwater is unlikely, it was set to zero.

Scour

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

Scour depths were computed using engineering judgement and the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993) and the Transportation Research Board Draft Paper, "Evaluating scour at bridges using WSPRO" (Arneson and others, 1992). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 through 5 and a graph of the scour depths is shown on figure 2.

The local pier scour was determined using the Colorado State University pier scour equation (Richardson and others, 1993). Bents 2 through 9 are located on the left overbank and were analyzed using the maximum left overbank WSPRO tube velocity and the depth of flow at each bent. Bents 14 and 15 are located on the right overbank and were analyzed using the maximum right overbank WSPRO tube velocity and the depth of flow at each bent. Bents 10, 11, 12, and 13 are located in the channel and were analyzed using 90 percent of the maximum WSPRO tube velocity and the maximum depth within the channel at the bridge. The maximum depth within the channel was used to account for possible changes in the thalweg during a flood. The width of the concrete collars (2.5 ft) was used as the pile width and a pier length of 10 ft, using the cumulative collar widths, was used on bents 11, 12, and 13 as recommended in Hydraulic Engineering Circular 18 (Richardson and others, 1993) because of the round, concrete collars at the base of each of the piles in those bents.

The left and right overbanks at the bridge were analyzed for contraction scour using Laursen's clear-water contraction scour equation (Richardson and others, 1993). The channel contraction scour was analyzed using Laursen's modified live-bed contraction scour equation (Richardson and others, 1993).

The live-bed contraction scour equation indicates the deposition of sediment in the channel at the bridge during the 100- and 500-year floods. (See negative scour values determined in scour calculations included at the end of the report). However, it seems unreasonable to expect sediment deposition at the bridge during peak flood conditions. Therefore, the negative scour values were set equal to zero as reflected in tables 3 through 4 and figure 2.

The right abutment is not protected by riprap, therefore abutment scour was calculated using the Froehlich (1989) live-bed abutment scour equation. The left abutment is protected by 6- to 12-inch granite riprap; therefore, no abutment scour computations were made.

It should be noted that the SCDOT bridge plan borings (docket number 12.245) show subsurface rock and gravel deposits that could affect the scour depths shown in this study. For more information, see the SCDOT bridge plans in the pocket at the back of the report.

. 3

WSPRO INPUT FILE

```
Sandy River at SC 215 in Chester County
                                                       Structure 124021500200
T1
                   6 September 1994
T2
           JMS
*
                       0500
              Q100
                      26400
             18000
Q
           0.00054
                    0.00054
SK
                0.0025
J1
           Section TEMP1 was surveyed 670 ft downstream of the downstream
                         The distance was determined from the USGS field
*
           bridge face.
           survey notes in conjunction with the USGS topographic map.
           The right end of the cross section was extended by drawing
           the section on the USGS topographic map and scaling the stations
           for the 320 ft, 330 ft, and 340 ft contour lines.
ΧT
     TEMP1 -670
                  0.00054
                                                                    326.2
                                                                41
                           9
                                       16
                                           336.7
                                                    30
                                                        328.8
GR
              0
                  338.8
                               338.3
                                                    85
                                                        304.4
                                                                88
                                                                    300.5
             60
                  323.0
                          65
                               322.0
                                       78
                                           310.1
GR
                                                        300.8
                                                               136
                                                                    303.4
                         109
                               299.8
                                      117
                                           299.3
                                                   131
            100
                  299.8
GR
                               314.1
                                      181
                                           316.0
                                                   200
                                                        311.9
                                                               212
                                                                    312.8
            142
                  310.3
                         161
GR
                              316.9
                                      366
                                           320.0
                                                  666
                                                       330.0
                                                               866
            246
                  315.0 273
GR
             -450
XS
     EXIT
GT
            0.17
                   0.045
                           0.17
N
                65
                        142
SA
*
           Section FULLV is the full valley cross section surveyed at the
                                             The left end of the cross section
*
           downstream road embankment toe.
           was extended by drawing the section on the USGS topographic map and
           scaling the stations for the 330 ft and 340 ft contour lines on the
*
           left end and scaling the stations for the 340 ft contour line on the
*
*
           right end.
*
     FULLV
XS
                       -300 340.0
                                    -20
                                         330.0
GR
                                                              114
                                                                   309.5
                                         321.7
                                                  63
                                                      315.8
                        26
                            324.4
                                     42
GR
             0
                326.8
                                                              276
                                                                   316.2
                            310.7
                                    149
                                         311.2
                                                 222
                                                      316.1
GR
           118
                305.3
                       125
                                                      302.0
                                                                   300.4
                                                 337
                                                              344
                314.5
                       312
                            311.4
                                    328 , 305.0
GR
           297
                                                                   302.0
GR
           349
                300.9
                       357
                            300.9
                                    365
                                         302.0
                                                 372
                                                      305.4
                                                              379
                301.2
                       398
                            302.0
                                    411
                                         308.4
                                                 429
                                                      309.2
                                                              465
                                                                   313.6
           389
GR
                                    613
                                         341.8
                                                 628
                                                      345.9
                326.4
                       586
                            333.8
GR
           545
           0.17
                   0.045
                             0.17
N
               312
                         411
SA
            350 312 450 411 550
FL
*
*
          Upstream bridge face
          A 12 degree bridge skew was determined from averaging a 10 degree
*
*
           skew from the Level I Inspection Form and a 14 degree skew
*
          from the USGS topographic map.
*
     BRIDG 0
                333.3
                       12
BR
                                                            20
                                                                324.8
                                                                       30
                                                                            319.5
                           333.3
                                        332.6
                                                 7
                                                    332.1
            0
                333.3
                        1
                                   1.1
GR
                                                                308.5
                                                                            308.1
                                                    308.4
                                                            60
                                                                      67
                                        308.2 56
                318.1
                       47
                           314.5
                                   51
GR
           33
                                        314.7 120
                                                                            314.2
                                                    315.4
                                                           150
                                                                315.1 165
                313.8
                       90
                           313.9
                                  105
GR
           76
                                                           240
                                                                318.3 255
                                                                            318.9
                                        315.4 225
                                                    317.3
GR
          180
                314.6 195
                           315.5
                                  210
                                                           290
                                                                300.6 300
                                                                            300.3
          262
                318.6 270
                           314.0
                                   277
                                        310.4 285
                                                    304.5
GR
                                                                302.4 360
                                                                            304.0
               302.0 320
                           302.0
                                  330
                                        301.2 340
                                                    301.9
                                                           350
GR
          310
```

WSPRO INPUT FILE -- Continued

```
310.7 390 311.2 405
                                                          410
                                                               312.8 420
                                                                           317.7
                                                   311.5
GR
           367
                307.6 375
                                                                       0 333.3
                324.4 445 332.5 448.9 333.3 449 333.3 450
                                                               333.3
GR
           428
            0.04
                   0.045
                            0.04
N
                262
                        375
SA
           3 33
                  1.5
                       335.6
CD
                         301.2
                                 0.85
                                        301.2
                                               1.7
                                                     304.0
                                                            1.7
                                                                   304.0
           300.3
                  0.85
PW 1
                                               3.40
                                                     311.2
                                                            4.25
                                                                  313.9
                                                                          4.25
           308.5
                  2.55
                         308.5
                                 3.40
                                        311.2
PW 1
                                               7.65
                                                     315.4
                                                            7.65
                                                                  315.4
                                                                          9.35
                 5.95
                         314.8
                                5.95
                                        314.8
PW 1
           313.9
                                                     318.3 11.05 319.5
                                                                          11.05
                                        318.3
                                               10.2
                         317.7
                                10.2
PW 1
           317.7
                  9.35
                         333.3
                                11.9
                                        333.3
                                                0.0
PW 1
           319.5
                  11.9
           Centerline of SC 215 to model flow over the road.
           The same 12 degree skew used on the bridge section was used
*
*
           on the road section.
*
XR
     ROAD
           16
                33
                             12
                340.8
                        48
                             338.6
                                         337.4
                                                 116 336.8
                                                              148
                                                                   336.2
GR
             0
                                     88
                       202
                             335.6 202.1 338.8
                                                651.9 338.8
                                                              652
                                                                   335.6
GR
                335.9
                            336.4 770 338.8
                                                 808 340.6
                335.9
                       705
GR
           677
BP
           202
*
          Section TEMP2 was surveyed 560 ft upstream of the upstream bridge
*
                 The distance was determined from the USGS field survey
*
          notes. Both ends of the cross section were extended by drawing
          the section and scaling the stations for the 330 ft and 340 ft
*
          contour lines on the left end and the 340 ft contour line on the
*
          right end
     TEMP2 560 0.00054
XΤ
                            340.0 -200
                                         330.0
GR
                      -240
                            323.9
                                    70
                                         321.3
                                                 109
                                                      316.3
                                                              134
                                                                   315.7
             0
                324.6
                        20
GR
                            315.8
                                         317.1
                                                 344
                                                      301.6
                                                              356
                                                                   301.0
               317.0
                       278
                                   315
GR
          215
                                                      311.2
                                                              440
                                                                   314.5
          374
               300.5
                       384
                            300.4
                                    397
                                         301.6
                                                 412
GR
                            316.3 510
                                         321.0
                                                 520
                                                      325.6
                                                              530
                                                                   332.6
          464
               313.7
                       494
GR
GR
          570
               340.0
*
AS
     APPRO 483
GT
          0.17
                  0.045
                          0.11
N
               315
                       412
SA
ΒP
          53
HP 1 BRIDG 331.76, ,331.76,18000
HP 2 BRIDG 331.76, ,331.76,18000
HP 1 APPRO 331.74, ,331.74,18000
HP 2 APPRO 331.74, ,331.74,18000
HP 1 BRIDG 333.30, ,333.30,26253
HP 2 BRIDG 333.30, ,333.30,26253
HP 1 APPRO 336.49, ,336.49,26400
HP 2 APPRO 336.49, ,336.49,26400
EX
```

:

ER

WSPRO OUTPUT

		V	VSPRO OU	IPUI		
WSPRO V060188	FEDERAL MODE	HIGHWAY ADMI	NISTRATION -	- U. S. GEO PROFILE CO	LOGICAL SUR	VEY
S	andy River at	ember 1994			ire 1240215	00200
CROSS	-SECTION PROP	TE & TIME: 09 PERTIES: ISE	CQ = 3; SEC	CID = BRIDG	SRD =	0.
WSEL	1 3950 2 2999	CA K 0. 906498. 0. 859111. 2. 214881.	249. 258 111. 118			QCR 89302. 88641. 21983.
331.76	7950	1. 1980489.	426. 449	. 1.04	8. 443.	
						·
WSPRO V060188	FEDERAL MODE	HIGHWAY ADMI	NISTRATION ·	- U. S. GEO PROFILE CO	LOGICAL SUR MPUTATIONS	VEY
		SC 215 in (ember 1994 E & TIME: 09			ıre 1240215	
VELOC	ITY DISTRIBUT	CION: ISEQ =	3; SECID	= BRIDG;	SRD =	0.
33	WSEL LEW 1.76 7.6	REW 7 443.4 795	REA 1 0.5 1980489	X Q . 18000.	VEL 2.26	
A(I) V(I)	1.4	6 354.8 7 2.54	2.30	415.1 2.17	402.2 2.24	
X STA. A(I) V(I)	145.5 407. 2.2	169.9 9 400.4 1 2.25	430.9	458.3	504.2	
X STA. A(I) V(I)	284.3 330. 2.7	295.5 1 321.3 3 2.80	322.0	320.7	314.5	
X STA. A(I) V(I)	338.6 309. 2.9	349.3 4 335.4 1 2.68	361.3 385.0 2.34	378.2 351.7 2.56	395.6 584.6 1.54	443.4

WSPRO OUTPUT --Continued

WSPRO V060188	FEDE:	RAL HIGHWAY MODEL FOR					
	Sandy Rive	r at SC 215	in Chest	er County	Struct	ure 12402	150020
	JMS 6						
	*** RUN	DATE & TIN	Æ: 09-14-	94 12:50			
CROS	S-SECTION 1	PROPERTIES:	: ISEQ =	5; SECI	D = APPRO	; SRD =	48
WSE		AREA				LEW RE	
	1 !	5199. 2107	736. 522	523.			931
	2	2669. 7700)62. 97	. 104.			794
	3 :	2669. 7700 1780. 1449	944. 117	. 121.			394
331.7	4	9649. 11257	742. 736	747.	4.27 -2	07. 529	. 959
MADDO		ат. Итсимач	TOMINITE	RATTON - I	T S GRO	LOCICAL SI	TRVEY
IN C D D ()	ותרוקים	ייביוגודה דוד ודיבי				700101m 0	
	FEDER						
V060188	Ŋ	MODEL FOR	WATER-SU	RFACE PRO	OFILE CO	MPUTATION	S.
V060188	Sandy River JMS 6 S	MODEL FOR	WATER-SU in Chest 994	RFACE PRO	OFILE CO Struct	MPUTATION	S.
V060188	Sandy River JMS 6 S	MODEL FOR r at SC 215 September 1 DATE & TIM	WATER-SU in Chest 994 E: 09-14-	RFACE PROPERTY	OFILE CO Struct	MPUTATION	S 150020
V060188	Sandy River JMS 6 S *** RUN CITY DISTRI	MODEL FOR at SC 215 September 1 DATE & TIM	WATER-SU in Chest 994 E: 09-14- SEQ = 5;	RFACE PROPERTY 94 12:50 SECID =	Struct Struct APPRO;	MPUTATION ure 12402	s 150020
V060188	Sandy River JMS 6 S *** RUN CITY DISTRI	MODEL FOR at SC 215 September 1 DATE & TIM IBUTION: I	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA	RFACE PROPERTY 94 12:50 SECID = K	Struct APPRO;	MPUTATION ure 12402	s 150020
V060188 VELO	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207	MODEL FOR that SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6	RFACE PROPERTY 94 12:50 SECID = K 1125742.	Struct APPRO; Q 18000.	MPUTATION ure 12402 SRD = VEL 1.87	S . 150020 483.
VELO X STA.	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207	MODEL FOR that SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6	RFACE PROPERTY 94 12:50 SECID = K 1125742.	Struct APPRO; 18000.	MPUTATION ure 12402 SRD = VEL 1.87 321.6	S 150020 483.
VELO X STA. A(I)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207.1 23	MODEL FOR that SC 215 September 1 DATE & TIM TBUTION: I LEW REW 7.1 528.8 130.1	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196	RFACE PROPERTY 94 12:50 SECID = K 11257421 26 1038.5	OFILE CO Struct APPRO; 18000.	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259	S 150020 483. 333
VELO X STA.	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207.1 23	MODEL FOR that SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196	RFACE PROPERTY 94 12:50 SECID = K 11257421 26 1038.5	OFILE CO Struct APPRO; 18000.	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259	S
VELO: 3. X STA. A(I) V(I)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1	MODEL FOR the at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87	RFACE PRO er County 94 12:50 SECID = K 1125742. .1 20 1038.5 0.87	APPRO; 18000. 64.6 889.6 1.01	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4	\$
VELO X STA. A(I) V(I) X STA.	Sandy River JMS 6 5 *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23	MODEL FOR r at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87	RFACE PROPERTY 94 12:50 SECID = K 11257421 20 1038.5 0.87	OFILE CO Struct APPRO; 18000. 64.6 889.6 1.01	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4	\$ 150020 483. 333.6 47
VELO X STA. A(I) V(I) X STA. A(I)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7	MODEL FOR at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38 341.7	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9	RFACE PROPERTY PROPER	APPRO; 18000. 64.6 889.6 1.01	MPUTATION: ure 12402: SRD = VEL 1.87 321.6 259 3.4 359.1 170.	\$
VELO X STA. A(I) V(I) X STA.	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7	MODEL FOR r at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9	RFACE PROPERTY PROPER	APPRO; 18000. 64.6 889.6 1.01 53.5 174.8	MPUTATION: ure 12402: SRD = VEL 1.87 321.6 259 3.4 359.1 170.	\$
VELO X STA. A(I) V(I) X STA. A(I)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7	MODEL FOR at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38 341.7	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9 4.92	RFACE PRO er County 94 12:50 SECID = K 1125742. .1 20 1038.5 0.87 .8 35 172.7 5.21	APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4 359.1 170 5.2	333 483 483 333 47 364
VELO VELO X STA. A(I) V(I) X STA. A(I) V(İ) X STA.	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7 2	MODEL FOR The at SC 215 September 1 DATE & TIM TBUTION: I TEW REW 7.1 528.8 130.1 351.2 1 0.38 341.7 213.8 4.21 370.2	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9 4.92	RFACE PROPERTY er County 94 12:50 SECID = K 11257421 26 1038.5 0.87 .8 35 172.7 5.21	APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4 359.1 170 5.2	333 483 483 333 47 364 428
VELO X STA. A(I) V(I) X STA. A(I) V(İ)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7 2	AODEL FOR at SC 215 September 1 DATE & TIM IBUTION: I LEW REW 7.1 528.8 130.1 351.2 1 0.38 341.7 213.8 4.21	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9 4.92	RFACE PROPERTY er County 94 12:50 SECID = K 11257421 26 1038.5 0.87 .8 35 172.7 5.21	APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4 359.1 170 5.2	333 483 483 333 647 364 428
VELO VELO 3 X STA. A(I) V(I) X STA. A(I) V(I) X STA. A(I) V(I)	Sandy River JMS 6 S *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7 2	MODEL FOR The at SC 215 September 1 DATE & TIM TBUTION: I LEW REW 7.1 528.8 130.1 351.2 0.38 341.7 213.8 4.21 370.2 73.0 5.20	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 0.87 347 182.9 4.92 375 173.9 5.18	RFACE PROPERTY er County 94 12:50 SECID = K 1125742. .1 26 1038.5 0.87 .8 35 172.7 5.21 .8 38 176.4 5.10	APPRO; APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.6 359.1 170 5.2 387.0 175 5.2	483. 483. 483. 333. 47 364. 428 392. 712
VELO VELO 3 X STA. A(I) V(I) X STA. A(I) V(İ) X STA. A(I) V(I) X STA.	Sandy River JMS 6 5 *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7 2 364.7 1	MODEL FOR The at SC 215 September 1 DATE & TIM TRUTION: I TRUEW REW 7.1 528.8 130.1 351.2 1 0.38 341.7 213.8 4.21 370.2 73.0 5.20 398.7	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9 4.92 375 173.9 5.18	RFACE PROPERTY er County 94 12:50 SECID = K 1125742. .1 20 1038.5 0.87 .8 35 172.7 5.21 .8 38 176.4 5.10	APPRO; APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4 359.1 170 5.2 387.0 175.2	483. 483. 483. 483. 483. 483. 492. 392. 712. 528
VELO VELO 3 X STA. A(I) V(I) X STA. A(I) V(I) X STA. A(I) V(I)	Sandy River JMS 6 5 *** RUN CITY DISTRI WSEL I 31.74 -207 -207.1 23 333.7 2 364.7 1	MODEL FOR The at SC 215 September 1 DATE & TIM TBUTION: I LEW REW 7.1 528.8 130.1 351.2 0.38 341.7 213.8 4.21 370.2 73.0 5.20	WATER-SU in Chest 994 E: 09-14- SEQ = 5; AREA 9648.6 196 029.6 0.87 347 182.9 4.92 375 173.9 5.18	RFACE PROPERTY er County 94 12:50 SECID = K 1125742. .1 20 1038.5 0.87 .8 35 172.7 5.21 .8 38 176.4 5.10 .9 42 439.8	APPRO; APPRO; 18000. 64.6 889.6 1.01 53.5 174.8 5.15 81.4 174.9 5.15	MPUTATION ure 12402 SRD = VEL 1.87 321.6 259 3.4 359.1 170 5.2 387.0 175 5.2 463.4 836.4	333 483 483 333 47 364 428 392 712 528

WSPRO OUTPUT -- Continued

		WSPRO OUT	PUTContinu	ed	
WSPRO V060188		HIGHWAY ADMINISTRA L FOR WATER-SURE	TION - U. S. GE ACE PROFILE C	OLOGICAL SURV	ÆY
Č	JMS 6 Septe *** RUN DATI	SC 215 in Chester ember 1994 E & TIME: 09-14-94	12:50		
. CROSS	S-SECTION PROP	ERTIES: ISEQ = 3	; SECID = BRID	G; SRD =	0.
WSEI	2 3169	K TOPW -7. 6587497. 6016362. 1544553.	231.	LEW REW	QCR 0. 0. 0.
333.30		141483912.	911. 1.05	1. 449.	
	MODE: Sandy River at UMS 6 Septe	HIGHWAY ADMINISTRA L FOR WATER-SURF SC 215 in Chester ember 1994 E & TIME: 09-14-94	ACE PROFILE C	OMPUTATIONS	
VELO	CITY DISTRIBUT	ION: ISEQ = 3;	SECID = BRIDG;	SRD =	0.
33	WSEL LEW	REW AREA 448.9 8616.6 14	K Q 14839. 26253.	VEL 3.05	
X STA. A(I) V(I)	690.7	57.3 73.0 7 373.8 0 3.51	434.1 431.	3 443.9	144.7
X STA. A(I) V(I)	435.0	168.6 192.3 429.7 3.05	454.4 491.	4 520.9	
X STA. A(I) V(I)	361.7	293.0 303.9 7 348.9 3 3.76	349.8 354.	0 339.7	337.6
X STA. A(I) V(I)	351.1	349.1 361.1 . 350.7 . 3.74	407.5 390.	5 657.5	448.9

WSPRO OUTPUT -- Continued

]	wsPRO OUTPUTContinued
	'WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY V060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
	Sandy River at SC 215 in Chester County Structure 124021500200 JMS 6 September 1994 *** RUN DATE & TIME: 09-14-94 12:50 CROSS-SECTION PROPERTIES: ISEQ = 5; SECID = APPRO; SRD = 483.
\neg	
	WSEL SA# AREA K TOPW WETP ALPH LEW REW QCR 1 7725. 397768. 541. 542. 165615. 2 3130. 1004134. 97. 104. 100883. 3 2382. 209628. 139. 144. 55900.
]	3 2382. 209628. 139. 144. 55900. 336.49 13236. 1611530. 777. 790. 4.44 -226. 551. 147106.
	WSPRO FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY V060188 MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS
	Sandy River at SC 215 in Chester County Structure 124021500200 JMS 6 September 1994 *** RUN DATE & TIME: 09-14-94 12:50
	VELOCITY DISTRIBUTION: ISEQ = 5; SECID = APPRO; SRD = 483.
	WSEL LEW REW AREA K Q VEL 336.49 -226.1 551.3 13236.4 1611530. 26400. 1.99
	X STA226.1 62.4 134.4 194.4 257.8 316.9 A(I) 2758.9 1328.9 1218.8 1259.3 1195.8 V(I) 0.48 0.99 1.08 1.05 1.10
	X STA. 316.9 331.4 340.3 347.4 353.7 360.0 A(I) 352.1 273.5 243.8 222.4 224.2 V(I) 3.75 4.83 5.41 5.94 5.89
	X STA. 360.0 366.4 372.7 378.9 385.2 391.7 A(I) 227.3 228.4 223.9 227.8 229.9
	X STA. 391.7 398.2 407.1 429.3 463.1 551.3 A(I) 230.5 276.4 552.3 761.0 1201.2 V(I) 5.73 4.78 2.39 1.73 1.10

WSPRO OUTPUT --Continued

+++ BEGINNING PROFILE CALCULATIONS -- 2 FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY WSPRO MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS V060188 Sandy River at SC 215 in Chester County Structure 124021500200 JMS 6 September 1994 *** RUN DATE & TIME: 09-14-94 12:50 AREA VHD HF EGL CRWS Q WSEL XSID: CODE SRDL LEW VEL FR# ERR K ALPH HO SRD FLEN REW EXIT :XS ***** 26. 7538. 0.45 **** 331.67 316.22 18000. 331.23 -450. ***** 688. 774030. 5.04 **** ****** 0.28 2.39 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS. "FULLV" KRATIO = 1.53TV 450. -65. 10082. 0.22 0.15 331.83 ****** 18000. 331.61 0. 437. 574. 1184661. 4.48 0.00 0.00 0.17 1.79 FULLV:FV <><<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>> AS 483. -207. 9633. 0.23 0.12 331.95 ****** 18000. 331.72 483. 483. 529. 1123731. 4.27 0.00 0.00 0.19 1.87 APPRO: AS <><<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>> <><<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>> EGL CRWS Q XSID:CODE SRDL LEW AREA VHD HF WSEL K ALPH HO ERR FR# VEL SRD FLEN REW BR 450. 8. 7952. 0.08 0.17 331.84 313.79 18000. 0. 450. 443. 1981080. 1.00 0.00 0.00 0.09 2.26 7952. 0.08 0.17 331.84 313.79 18000. 331.76 BRIDG:BR TYPE PPCD FLOW C P/A LSEL BLEN XLAB XRAB 3. 1. 1.000 0.029 333.30 ***** ***** ***** XSID: CODE SRD FLEN HF VHD EGL ERR O WSEL 16. <<<<EMBANKMENT IS NOT OVERTOPPED>>>> ROAD : RG EGL CRWS Q ERR FR# VEL Q WSEL AREA VHD HF XSID:CODE SRDL LEW K ALPH HO SRD FLEN REW APPRO:AS 450. -207. 9647. 0.23 0.12 331.97 314.59 18000. 331.74 483. 468. 529. 1125480. 4.27 0.00 0.00 0.19 1.87 OTEL -KQ XLKQ XRKQ M(G) M(K) 0.409 0.016 1106990. 88. 523. 331.62

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

WSPRO OUTPUT -- Continued

FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY WSPRO MODEL FOR WATER-SURFACE PROFILE COMPUTATIONS V060188 Sandy River at SC 215 in Chester County Structure 124021500200 JMS 6 September 1994 *** RUN DATE & TIME: 09-14-94 12:50 AREA VHD $_{
m HF}$ LEW EGL CRWS WSEL XSID:CODE SRDL K ALPH HO SRD FLEN REW ERR FR# VEL EXIT :XS ***** 10967. 0.50 ***** 336.52 320.07 26400. 336.02 17. **-450.** ***** 784. 1135804. 5.54 **** ****** 0.26 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS. "FULLV" KRATIO = 1.42450. -199. 13511. 0.31 0.17 336.69 ****** 26400. 336.39 FULLV:FV 437. 595. 1609194. 5.14 0.00 0.00 0.19 1.95 0. <><<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>> 483. -226. 13281. 0.27 0.13 336.82 ****** 26400. 336.55 APPRO:AS 483. 483. 552. 1617869. 4.44 0.00 0.00 0.18 1.99 <><<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>> ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION. WS3N, LSEL = 336.39333.30 <><<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>> AREA VHD HF XSID:CODE SRDL EGL CRWS WSEL LEW SRD FLEN REW K ALPH ERR FR# VEL HO 1. 8364. 0.16 ***** 333.46 317.18 26253. BRIDG:BR 450. BR 450. 1. 8364. 0.16 ***** 333.46 317.18 0. ***** 449. 1414839. 1.05 **** ****** 0.13 TYPE PPCD FLOW C P/A LSEL BLEN XLAB 3. 1. 6. 0.800 0.029 333.30 ***** ***** XSID: CODE SRD FLEN \mathtt{HF} VHD EGL ERR ROAD : RG 16. 450. 0.12 0.27 336.64 0.00 202. 336.47 REW DMAX DAVG VMAX VAVG HAVG CAVG WLEN LEW Q 110. 67. 134. 202. 0.9 0.5 3.8 3.5 0.6 3.2 LT: 705. 0.9 0.5 3.5 0.7 3.1 91. 52. 652. 3.9 SRDL LEW AREA VHD HF EGL CRWS FLEN REW K ALPH HO ERR FR# XSID: CODE WSEL ERR FR# VEL SRD APPRO:AS 450. -226. 13236. 0.27 0.14 336.76 318.53 26400. 462. 551. 1611544. 4.44 0.00 0.00 0.18 483. M(G) M(K) KQ XLKQ XRKQ OTEL ***** ***** ****** ***** <<<<END OF BRIDGE COMPUTATIONS>>>>

ER

NORMAL END OF WSPRO EXECUTION.

PIER SCOUR COMPUTATIONS

FOR

Sandy River at SC 215 in Chester County, SC Structure 124021500200 Q100 scour computations including bents 2 through 9 JMS 14 Sept. 1994

			HYDI	RAULIC VA	RIABLES U	SED IN CSU	EQUATION	
PIER NUMBER	2	3	4	5	6	7	8	9
PIER STATION (FT)	30	60	90	120	150	180	210	240
LOCATION OF PIER	lfp	lfp	lfp	lfp	lfp	lfp	lfp	lfp
Y1: DEPTH (FT)	12.3	23.3	17.9	16.4	16.7	17.2	16.4	13.5
V1: VEL. (FPS)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
a: PIER WIDTH (FT)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
L: PIER LENGTH (FT)	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
PIER SHAPE	1	1	1	1	1	1	1	1
ATTACK ANGLE	12	12	12	12	12	12	12	12
K1 (SHAPE COEF.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K2 (ANGLE COEF.)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
FROUDE NO.	0.13	0.09	0.11	0.11	0.11	0.11	0.11	0.12
	COMPUTED	SCOUR DE	PTHS USI	NG CSU EQ	UATION			
SCOUR DEPTH (FT)	2.50	2.73	2.63	2,60	2.61	2.62	2.60	2.53
MAX SCOUR DEPTH (FT)	2.75	3.00	2.90	2.86	2.87	2.88	2.86	2.79

Q100 scour computations including bents 10 through 15 JMS 14 Sept. 1994

		F	HYDRAULIC	VARIABLES	USED IN	CSU EQUATION
PIER NUMBER	10	11	12	13	14	15
PIER STATION (FT)	270	300	330	360	390	420
LOCATION OF PIER	ltb	mcl	mcm	mcr	rfp	rfp
Y1: DEPTH (FT)	31.5	31.5	31.5	31.5	20.6	14.1
V1: VEL. (FPS)	2.6	2.6	2.6	2.6	2.6	2.6
a: PIER WIDTH (FT)	0.9	2.5	2.5	2.5	0.9	0.9
L: PIER LENGTH (FT)	3.4	10.0	10.0	10.0	3.4	3.4
PIER SHAPE	1	2	2	2	1	1
ATTACK ANGLE	12	12	12	12	12	12
K1 (SHAPE COEF.)	1.00	1.00	1.00		1.00	
K2 (ANGLE COEF.)	1.40	1.40	1.40		1.40	== :
FROUDE NO.	0.08	0.08	3 0.08	0.08	0.10	0.12
	COMPUTED	SCOUR	DEPTHS US	SING CSU E	QUATION	
SCOUR DEPTH (FT)	2.88	5.80	5.80	5.80	2.69	2.56
MAX SCOUR DEPTH (FT)	3.17	6.39	6.39	6.39	2.96	2.81

"MAX SCOUR DEPTH" includes an additional 10 percent of the computed CSU scour depth as recommended in HEC 18

CONTRACTION SCOUR COMPUTATIONS

FOR

Sandy River at SC 215 in Chester County, SC Structure 124021500200

LIVE-BED SCOUR COMPUTATIONS

MAIN CHANNEL CONTRACTED SECTION
DISCHARGE (CFS) 12300. 7810.
BOTTOM WIDTH (FT) 97.0 102.1
MANNINGS n 0.045 0.045

AVERAGE DEPTH (FT) 30.7

ENERGY SLOPE 0.00028
D50 (FT) 0.0036
FALL VELOCITY (FPS) 0.54
K1 COEF. 0.64
K2 COEF. 0.21

COMPUTED DEPTH AT CONTRACTED SECTION (FT) = 20.1
DEPTH AT MAIN CHANNEL (FT) = 30.7
DEPTH OF CONTRACTION SCOUR (FT) = -10.6

LEFT OVERBANK IN BRIDGE OPENING CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS) = 8240.
WIDTH OF CONTRACTED SECTION (FT) = 224.0
MEDIAN GRAIN SIZE (FT) = 0.0012

COMPUTED DEPTH OF CONTRACTED SECTION (FT) = 19.1

AVERAGE FLOOD PLAIN DEPTH (FT) = 15.7

DEPTH OF CONTRACTION SCOUR (FT) = 3.4

RIGHT OVERBANK IN BRIDGE OPENING CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS) = 1950.
WIDTH OF CONTRACTED SECTION (FT) = 34.0

MEDIAN GRAIN SIZE (FT) = 0.0012

COMPUTED DEPTH OF CONTRACTED SECTION (FT) = 27.9

AVERAGE FLOOD PLAIN DEPTH (FT) = 20.7

DEPTH OF CONTRACTION SCOUR (FT) = 7.2

4

ABUTMENT SCOUR COMPUTATIONS

FOR

Sandy River at	SC 2	215 in	Chester	County,	SC	Structure	124021500200
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RIGHT ABUTMENT SCOUR COMPUTATIONS

ABUTMENT TYPE	3 -SPILL THROUGH	
DISCHARGE BLOCKED BY ABUTMENT (CFS)	1350.	
AREA BLOCKED BY ABUTMENT (SQ FT)	1140.0	
DEPTH OF FLOW AT ABUTMENT (FT)	19.0	
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	83.0	
ABUTMENT SKEW (DEG)	12	
AJUSTED ABUTMENT LENGTH (FT)	60.0	
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	1.2	
FROUDE NUMBER	0.048	
K1 COEF.	0.6	
K2 COEF.	1.0	
DESIGN DEPTH OF SCOUR (FROELICH EQUATION	N, 1989) (FT) = 25.	2

PIER SCOUR COMPUTATIONS

FOR

Sandy River at SC 215 in Chester County, SC Structure 124021500200 Q500 scour computations including bents 2 through 9 JMS 14 Sept. 1994

			HVI.	D3 III T	מינות בים	SED IN CSU	፣ ምለበአጥ፣ለአ፣	
PIER NUMBER	2	3	4	KAULIC VA 5	6 KIMBHES C	7	8	9
PIER STATION (FT)	30	60	90	120	150	180	210	240
LOCATION OF PIER	lfp	lfp	lfp	lfp	lfp	lfp	lfp	lfp
Y1: DEPTH (FT)	16.8	27.8	22.4	21.0	21.8	21.0	18.0	22.4
V1: VEL. (FPS)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
a: PIER WIDTH (FT)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
L: PIER LENGTH (FT)	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
PIER SHAPE	1.	1	1	1	1	1	1	1
ATTACK ANGLE	12	12	12	12	12	12	12	12
K1 (SHAPE COEF.)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K2 (ANGLE COEF.)	1.40	1.40	1.40	1.40	1.40	1.40	1.40	1.40
FROUDE NO.	0.15	0.12	0.13	0.13	0.13	0.13	0.15	0.13
	COMPUTED	SCOUR DE	PTHS USI	NG CSU EQ	UATION			
SCOUR DEPTH (FT)	3.00	3.21	3.12	3.09	3.11	3.09	3.03	3.12
MAX SCOUR DEPTH (FT)	3.30	3.53	3.43	3.40	3.42	3.40	3.33	3.43

Q500 scour computations including bents 10 through 15 JMS 14 Sept. 1994

		н	YDRAULIC	VARIABLES	USED IN	CSU EQUATION
PIER NUMBER	10	11	12	13	14	15
PIER STATION (FT)	270	300	330	360	390	420
LOCATION OF PIER	ltb	mcl	mem	mcr	rfp	rfp
Y1: DEPTH (FT)	36.0	36.0	36.0	36.0	25.2	18.6
V1: VEL. (FPS)	3.5	3.5	3.5	3.5	3.4	3.4
a: PIER WIDTH (FT)	0.9	2.5	2.5	2.5	0.9	0.9
L: PIER LENGTH (FT)	3.4	10.0	10.0	10.0	3.4	3.4
PIER SHAPE	1	2	2	2	1	1
ATTACK ANGLE	12	12	12	12	12	12
K1 (SHAPE COEF.)	1.00	1.00	1.00	1.00	1.00	1.00
K2 (ANGLE COEF.)	1.40	1.40	1.40	1.40	1.40	1.40
FROUDE NO.	0.10	0.10	0.10	0.10	0.12	0.14
	COMPUTED	SCOUR I	EPTHS US	ING CSU EQ	UATION	
SCOUR DEPTH (FT)	3.31	6.67	6.67	6.67	3.11	2.98
MAX SCOUR DEPTH (FT)	3.64	7.34	7.34	7.34	3.42	3.28

"MAX SCOUR DEPTH" includes an additional 10 $\,$ percent of the computed CSU scour depth as recommended $\,$ in HEC 18 $\,$

CONTRACTION SCOUR COMPUTATIONS

FOR

Sandy River	at SC	215 in	Chester	County,	SC	Structure	124021500200
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LIVE-BED SCOUR COMPUTATIONS

M	AIN CHANNEL	CONTRACTED	SECTION
DISCHARGE (CFS)	16450.	1116	0.
BOTTOM WIDTH (FT)	97.0	10	2.1
MANNINGS n	0.045		0.045
AVERAGE DEPTH (FT)	35.5		
ENERGY SLOPE		0.00026	
D50 (FT)		0.0036	
FALL VELOCITY (FPS)		0.54	•
K1 COEF.		0.64	
K2 COEF.		0.21	
COMPUTED DEPTH AT CONTRACTED	SECTION (FT)	= 24.6	
DEPTH AT MAIN CHANNEL (FT)		⇒ 35.5	
DEPTH OF CONTRACTION SCOUR (FT)	= -10.9	

LEFT OVERBANK IN BRIDGE OPENING CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	_	12220.
WIDTH OF CONTRACTED SECTION (FT)	_	224.0
MEDIAN GRAIN SIZE (FT)	***	0.0012
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	-	26.8
AVERAGE FLOOD PLAIN DEPTH (FT)	=	20.5
DEPTH OF CONTRACTION SCOUR (FT)	=	6.3

RIGHT OVERBANK IN BRIDGE OPENING CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	2870.
WIDTH OF CONTRACTED SECTION (FT)	-	34.0
MEDIAN GRAIN SIZE (FT)	=	. 0.0012
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	-	38.9
AVERAGE FLOOD PLAIN DEPTH (FT)	*	25.5
DEPTH OF CONTRACTION SCOUR (FT)	=	13.4

ABUTMENT SCOUR COMPUTATIONS

FOR

Sandy River at SC 215 in Chester County, SC Structure 124021500200

RIGHT ABUTMENT SCOUR COMPUTATIONS

30.7

ABUTMENT TYPE	3 -SPILL THROUGH
DISCHARGE BLOCKED BY ABUTMENT (CFS)	1990.
AREA BLOCKED BY ABUTMENT (SQ FT)	1590.0
DEPTH OF FLOW AT ABUTMENT (FT)	23.6
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	105.0
ABUTMENT SKEW (DEG)	12
AJUSTED ABUTMENT LENGTH (FT)	67.4
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	1.3
FROUDE NUMBER	0.045
K1 COEF.	0.6
K2 COEF.	1.0
DESIGN DEPTH OF SCOUR (FROELICH EQUATION	N, 1989) (FT) =

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6 BRIDGE PLANT PROFILE

7 SUBSTRUCTURE DETAILS

8 SUPPRESENTATION SECTIONS

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STATE OF SOUTH CAROLINA STATE INGHWAY DEPARTMENT

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

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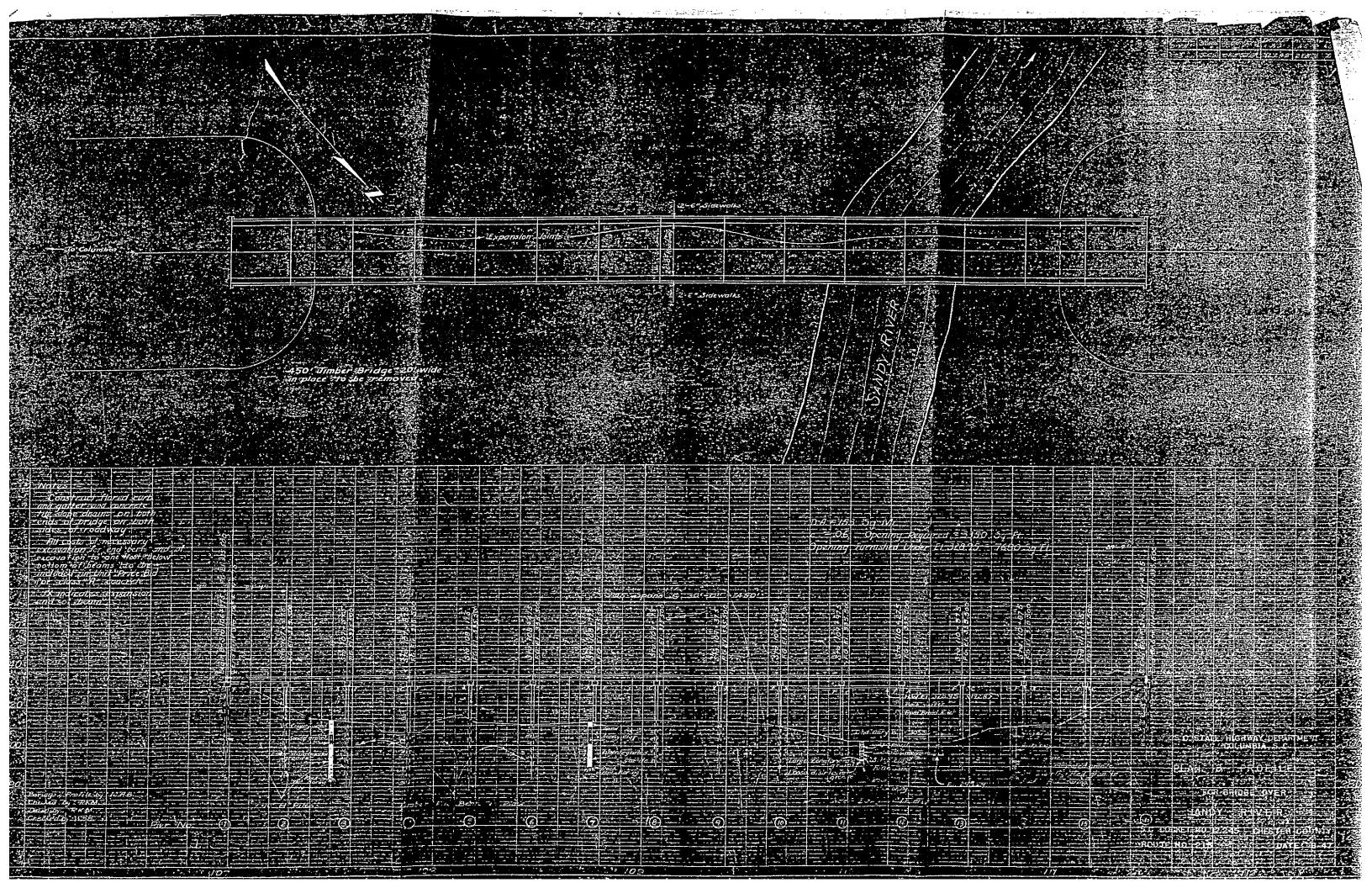


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