U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

LEVEL II BRIDGE SCOUR ANALYSIS FOR STRUCTURE 124000900600 ON ROUTE SC 9, CROSSING THE SANDY RIVER IN CHESTER COUNTY, SOUTH CAROLINA

By Andy W. Caldwell and J. Mike Sullivan

Prepared in cooperation with the

SOUTH CAROLINA DEPARTMENT
OF TRANSPORTATION

Columbia, South Carolina

1995

UNIT ABBREVIATIONS

cubic foot per second	ft^3/s
feet per second	ft/s
foot	ft
mile	mi
millimeter	mm
square foot	ft^2
square mile	mi^2

OTHER ABBREVIATIONS

downstream	D/S
upstream	U/S
flood plain	f/p
Water-Surface Profile computation model	WSPRO
median diameter of bed material	D_{50}
South Carolina Department of Transportation	SCDOT

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 124000900600 on Route SC 9, 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 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina (figure 1 in pocket; figures 5-8). The site is located in the Piedmont physiographic province near the town of Chester in the central part of Chester County. The drainage area for the site is 16.7 mi^2, 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 hardwoods upstream and grassy fields turning into moderate hardwoods approximately 400 ft downstream.

In the study area, the Sandy River has a meandering channel with a slope of approximately 0.0013 ft/ft (6.9 ft/mi), an average channel top width of 80 ft and an average channel depth of 9 ft. The predominant channel bed material is sand (D_{50} is 0.28 mm) and the predominant bank material is a coarser sand (D_{50} is 0.46 mm). In general, the banks have moderate woody vegetative cover with some bank failure noted at the time of the Level I site visit on July 17, 1990.

The Route SC 9 crossing of the Sandy River is a 180-ft-long, two-lane bridge consisting of two 40-ft and two 50-ft concrete spans, supported by steel and concrete bents with spillthrough abutments. The abutments are protected by riprap. 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 and 2 and a graph of the scour depths is shown on figure 2.

Pile penetration depths were obtained from the SCDOT bridge plans (docket number 12.388). Pile tip exposure of 9.4 ft and 16.3 ft occurs for the 100- and 500-year discharges, respectively. This exposure occurs at bent 3.

Table 1. --*Remaining pile/footing penetration at piers/bents for the 100- and 500-year discharges at structure 124000900600 on Route SC 9, 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 [5] pile/footing penetration (feet)
100-year discharge is 4,400 cubic feet per second							
4	40	403.2	402.5	416.1	0.0	416.1	13.6
3	90	398.6	397.9	410.6	22.1	388.5	-9.4
2	140	395.5	394.8	409.8	22.1	387.7	-7.1
500-year discharge is 6,600 cubic feet per second							
4	40	403.2	402.5	416.1	6.5	409.6	7.1
3	90	398.6	397.9	410.6	29.0	381.6	-16.3
2	140	395.5	394.8	409.8	29.0	380.8	-14.0

[1] Pier/bent number corresponds to the South Carolina Department of Transportation (SCDOT) bridge plans (docket number 12.388).

[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.

[5] A negative number signifies undermining of pile tip/footing.

Table 2. --*Cumulative scour depths at piers/bents for the 100- and 500-year discharges at structure 124000900600 on Route SC 9, 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 discharge is 4,400 cubic feet per second				
4	40	0.0	0.0	0.0
3	90	14.5	7.6	22.1
2	140	14.5	7.6	22.1
500-year discharge is 6,600 cubic feet per second				
4	40	1.9	4.6	6.5
3	90	21.1	7.9	29.0
2	140	21.1	7.9	29.0

[1] Pier/bent number corresponds to the South Carolina Department of Transportation bridge plans (docket number 12.388).

[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.

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.

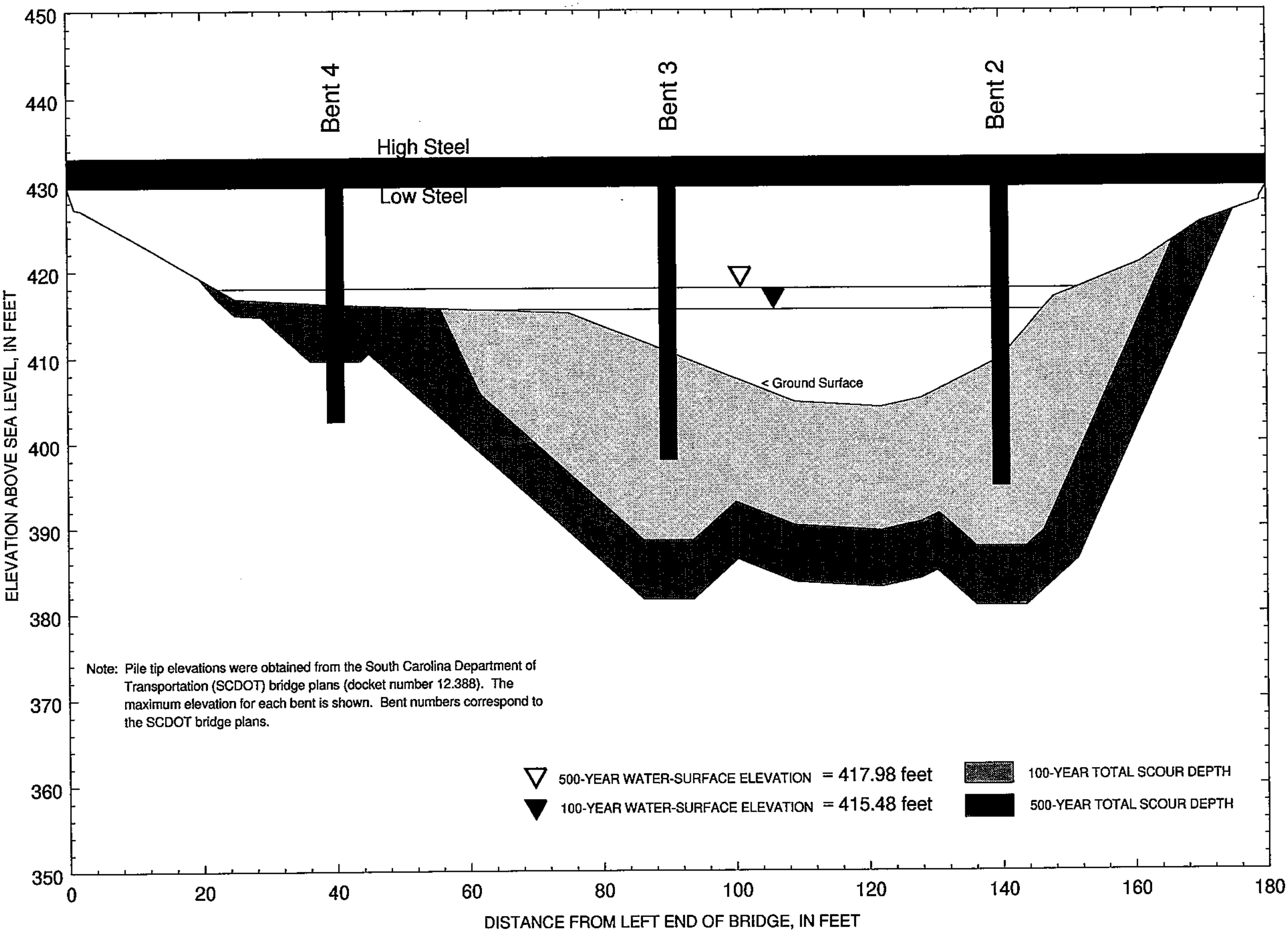

Figure 2.--Total scour depths for the 100- and 500-year discharges at the downstream face of structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina.

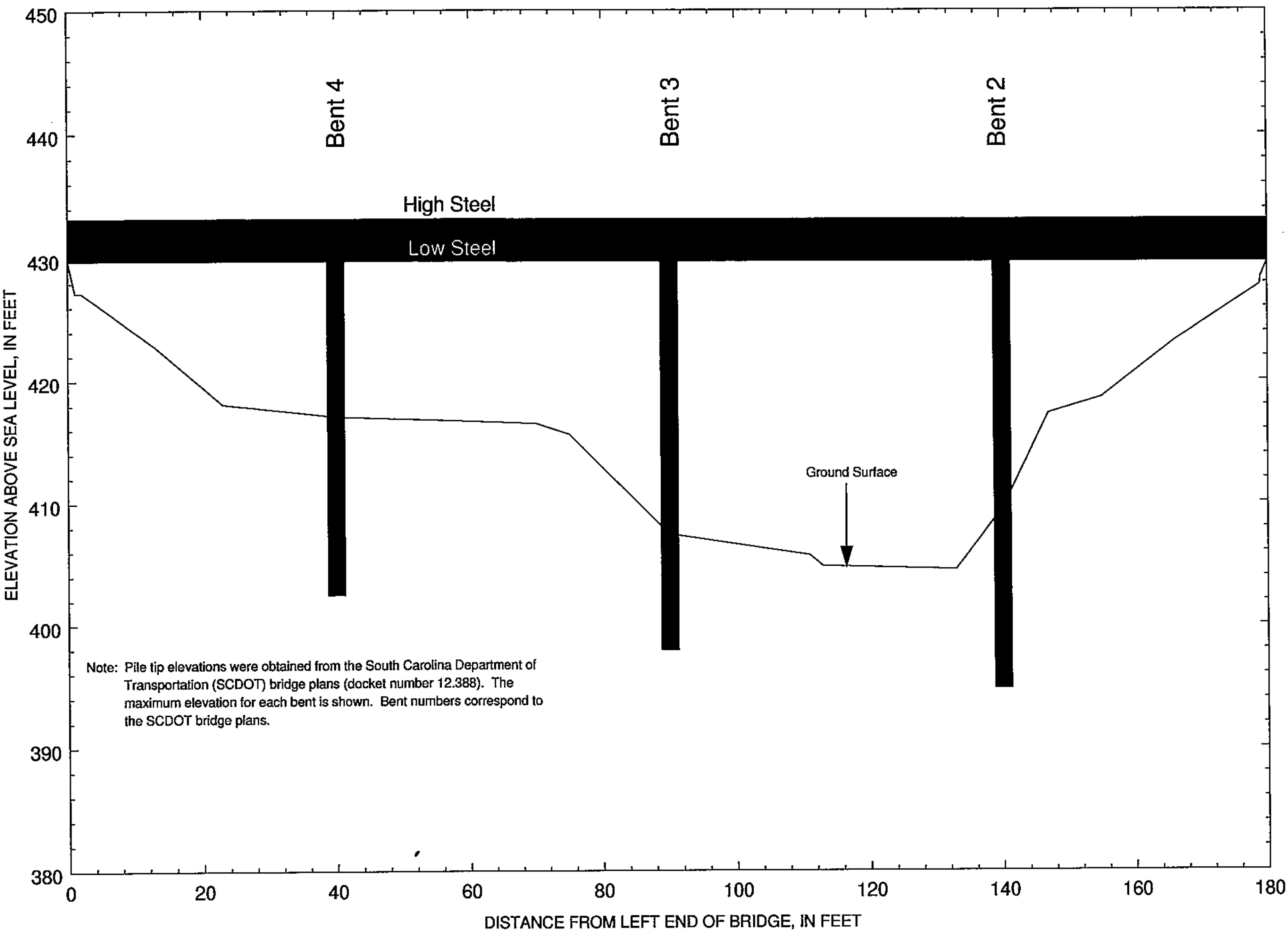

Figure 3.--The upstream face of structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina.

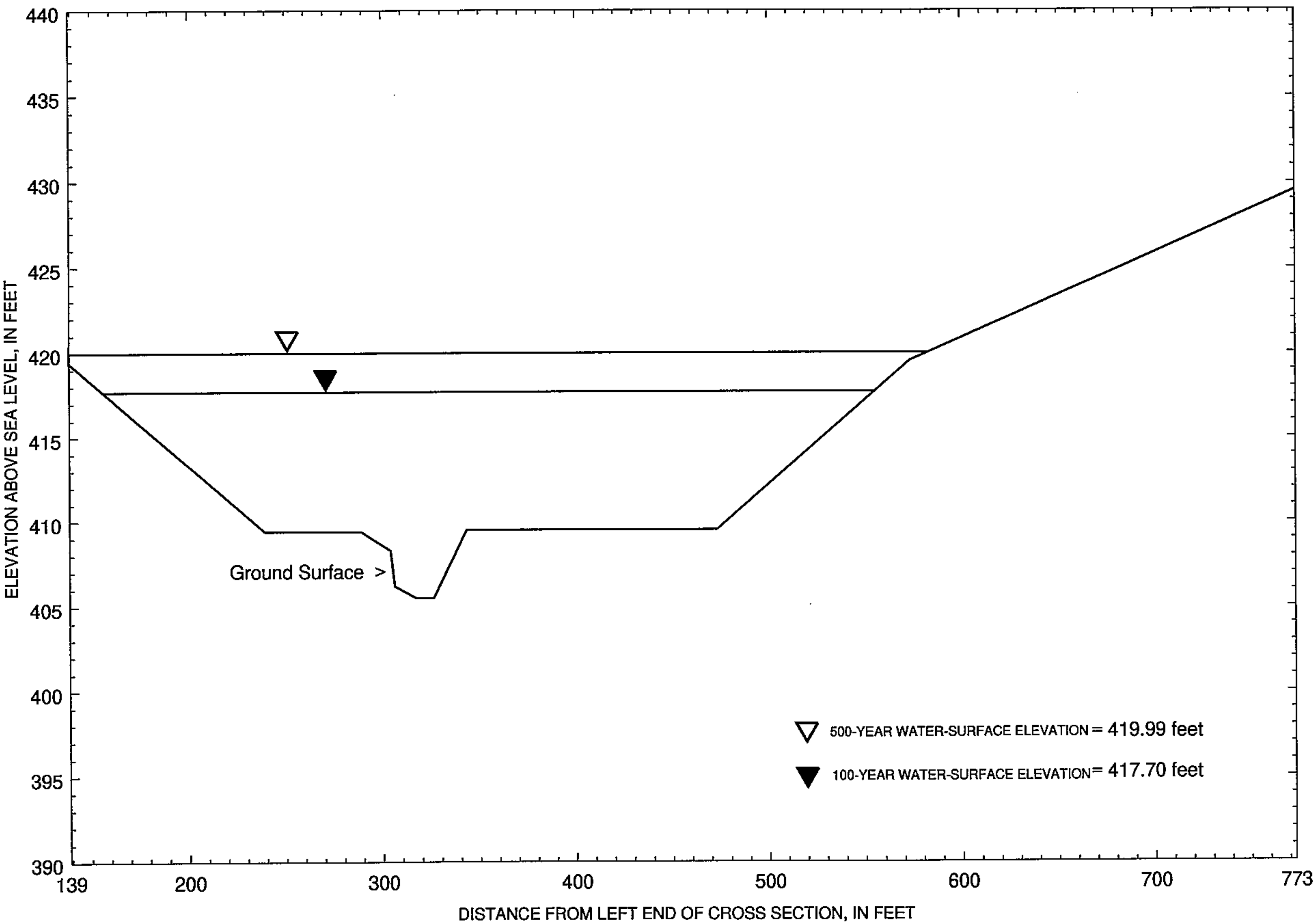

Figure 4.--Approach cross section at structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina.

Figure 5.--Structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina as viewed from the upstream channel (July 17, 1990).

Figure 6.--Upstream channel as viewed from the approach cross section of structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina (September 7, 1993).

Figure 7.--Structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina as viewed from the downstream channel (July 17, 1990).

Figure 8.--Downstream channel as viewed from structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina (July 17, 1990).

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SCOUR REPORT SUMMARY

Structure Number 124000900600 *Stream* Sandy River

County Chester *Road* SC 9 *District* 4

Description of Bridge

Bridge length 180 *ft* *Bridge width* 35 *ft* *Max span length* 50 *ft*

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

Abutment type Spillthrough *Embankment type* Sloping

Riprap on abutment? Yes *Date of inspection* 7-17-1990

Description of riprap Both abutments are protected by 6- to 16-inch granite riprap.

Brief description of piers/pile bents Three interior bents support the bridge. The existing structure is supported by two 2.8-ft by 2.5-ft concrete columns and the widened part of the structure is supported by tower bents on the U/S and D/S ends consisting of two 0.8-ft-square steel H-piles.

Is bridge skewed to flood plain according to USGS topo map? Yes *Angle* 15

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

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

	Date of inspection	Percent of channel blocked horizontally	Percent of channel blocked vertically
Level I	7-17-1990	0	0
Level II	8-31-1993	0	0

Potential for debris Low: Chester Reservoir is located approximately 1,100 ft upstream of the Route SC 9 crossing.

Describe any features near or at the bridge that may affect flow (include observation date).
The Chester Reservoir is located approximately 1,100 ft upstream of the Route SC 9 crossing.

Description of Flood Plain

General topography Typical Piedmont topography with rolling hills

Flood-plain conditions at bridge site: downstream (D/S), upstream (U/S)

Date of inspection 8-31-1993

D/S left: Two- to 3-ft high grass

D/S right: Two- to 3-ft high grass

U/S left: Moderate hardwoods with moderate undergrowth

U/S right: Sparse hardwoods with thick undergrowth

Description of Channel

Average top width 80 *ft* *Average depth* 9.0 *ft*

Predominant bed material sand *Bank material* sand

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

Vegetative cover on channel banks near bridge: *Date of inspection* 8-31-1993

D/S left: Thin woody vegetation

D/S right: Thin woody vegetation

U/S left: Moderate woody vegetation

U/S right: Moderate woody vegetation

Do banks appear stable? Yes* *If not, describe location and type of instability and date of observation.* * Some bank failure was noted on the upstream left and downstream right bank at the time of the Level I site visit on 7-17-1990.

Describe any obstructions in channel and date of observation. None observed.

Hydrology

Drainage area 16.7 *mi²*

Percentage of drainage area in physiographic provinces:

Physiographic province	*Percent of drainage area*
Piedmont (high-flow area)	100

Is drainage area considered rural or urban? Rural *Describe any significant urbanization and potential for development.* No significant urbanization exists in the basin but there is a potential for future development as the city of Chester expands.

Is there a USGS gage on the stream of interest? No

USGS gage description ________

USGS gage number ________

Gage drainage area ________ mi^2

Is there a lake/pond that will significantly affect hydrology/hydraulics? Yes

If so, describe The Chester Reservoir is approximately 1,100 ft upstream of the Route SC 9 bridge. A flood hydrograph routing was done and it was concluded that the reservoir would not affect the 100- and 500-year discharges.

Calculated Discharges

Q100 4,400 ft^3/s *Q500* 6,600 ft^3/s

Method used to determine discharges Because the basin is in the high-flow region of South Carolina, the 100- and 500-year discharges were determined by using the North Carolina rural regression equations (WRIR 87-4096) and methods described in USGS Bulletin 17B. A flood hydrograph routing was done and it was concluded that the reservoir would not affect the 100- and 500-year discharges

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

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

Datum tie between USGS survey and SCDOT plans Add 0.7 ft to the USGS survey datum to obtain the SCDOT plan's datum (docket number 12.388).

Description of reference marks used to determine USGS datum. BM (15 DOP 1968) is a tablet on the upstream right abutment headwall of the Route SC 9 bridge with an established elevation of 431.44 ft. RM 2 is a chiseled square on the downstream left abutment headwall of the Route SC 9 bridge with a surveyed elevation of 431.38 ft.

Cross Sections Used in WSPRO Analysis

*Cross section ID	Section Reference Distance (SRD) in feet	**How cross section was developed	Comments
EXITA	-400	2	Starting cross section
EXITB	-390	2	Transition cross section
EXIT	-180	2	Exit cross section
FULV	0	2	Full-valley cross section
BRIDG	0	1	D/S bridge face
APPR	215	4	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 SC 9 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 cross section one bridge width downstream of the bridge, a full-valley cross section at the downstream bridge face, the bridge cross section, and an approach cross 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 (downstream) bridge face was used in the WSPRO model. The section reference distance (SRD) at the downstream face of the bridge was set to zero. An exit cross section was surveyed approximately 372 ft downstream of the downstream bridge face and an approach channel cross section was surveyed approximately 199 ft upstream of the upstream bridge face. The approach cross section was synthesized by the slope of the contours on the USGS topographic map. These cross sections were shifted by the channel slope to the appropriate SRD to represent the exit, full-valley, and approach cross sections required by the WSPRO model. In addition, the exit cross section was shifted by the channel slope to SRD -400 and -390 to represent cross sections EXITA and EXITB. Cross section EXITA is the starting cross section which represents the wooded flood plain. Cross section EXITB is a transition cross section to show the change from a wooded flood plain to a grassy flood plain.

Bridge Hydraulics

Average embankment elevation 431.0 *ft*

Average low steel elevation 429.7 *ft*

100-year discharge 4,400 ft^3/s

Water-surface elevation at D/S bridge face 415.48 *ft*

Area of flow at D/S bridge face 515 ft^2

Average velocity in bridge opening 8.55 *ft/s*

Maximum WSPRO tube velocity at bridge 10.29 *ft/s*

Water-surface elevation at Approach section with bridge 417.70 *ft*

Water-surface elevation at Approach section without bridge 416.22 *ft*

Amount of backwater caused by bridge 1.48 *ft*

500-year discharge 6,600 ft^3/s

Water-surface elevation at D/S bridge face 417.98 *ft*

Area of flow at D/S bridge face 803 ft^2

Average velocity in bridge opening 8.22 *ft/s*

Maximum WSPRO tube velocity at bridge 10.71 *ft/s*

Water-surface elevation at Approach section with bridge 419.99 *ft*

Water-surface elevation at Approach section without bridge 418.68 *ft*

Amount of backwater caused by bridge 1.31 *ft*

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 and 2 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). Bent 4 is located on the left overbank and was analyzed using the maximum left overbank WSPRO tube velocity and the depth of flow at the bent. Bents 2 and 3 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 bridge is skewed approximately 15 degrees to the channel. However, because the columns are spaced far apart, they function as if there were no skew.

The left overbank at the bridge was analyzed for contraction scour using Laursen's clear-water contraction scour equation (Richardson and others, 1993).

Chester Reservoir is located approximately 1,100 ft upstream of the Route SC 9 bridge. Therefore, sediment transport is likely to be minimal and it was decided that clear-water scour would best represent the contraction scour processes at the bridge; consequently, the potential contraction scour was determined using Laursen's clear-water contraction scour equation (Richardson and others, 1993). In addition, it was decided to neglect subtracting the pier widths and to use the higher flood plain D_{50} to try to obtain more reasonable contraction scour results. However, the clear-water contraction scour results, 14.5 ft and 21.1 ft for the 100- and 500-year discharges, respectively, appear excessive and therefore, engineering judgement should be exercised when interpreting these results.

No abutment scour computations were made because the abutments are protected by riprap.

WSPRO OUTPUT

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094            MODEL   FOR   WATER-SURFACE   PROFILE   COMPUTATIONS

          Structure #124000900600             (180 ft. bridge)
          Sandy River at SC 9                  file: sandy.sc9
          Chester County, South Carolina        AWC    September 1994
           *** RUN DATE & TIME: 03-15-95  15:25
      CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = BRIDG;  SRD =        0.

       WSEL   SA#      AREA          K    TOPW     WETP  ALPH     LEW     REW       QCR
                1         3         25      13       13                                6
                2       512      54391      71       76                             7782
     415.48             515      54416      85       89  1.01      62     146       7167


      VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = BRIDG;  SRD =        0.

             WSEL      LEW      REW      AREA         K        Q      VEL
           415.88     47.7    146.9     551.4    59414.    4400.     7.98

 X STA.         47.7        90.4        96.1       100.1       103.2       105.9
   A(I)              58.4        35.9        31.0        27.7        26.0
   V(I)              3.77        6.12        7.10        7.93        8.45

 X STA.        105.9       108.2       110.3       112.3       114.2       116.1
   A(I)              24.4        23.3        22.4        21.6        21.8
   V(I)              9.02        9.43        9.81       10.19       10.11

 X STA.        116.1       117.9       119.8       121.6       123.5       125.4
   A(I)              21.6        21.7        21.4        21.6        22.5
   V(I)             10.20       10.13       10.29       10.17        9.77

 X STA.        125.4       127.5       129.9       132.7       136.5       146.9
   A(I)              22.7        24.9        26.5        31.4        44.5
   V(I)              9.69        8.82        8.30        7.00        4.95
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          Structure #124000900600             (180 ft. bridge)
          Sandy River at SC 9                  file: sandy.sc9
          Chester County, South Carolina        AWC   September 1994
           *** RUN DATE & TIME: 03-15-95  15:25
   CROSS-SECTION PROPERTIES:  ISEQ =   6;  SECID = APPR ;  SRD =      215.

     WSEL   SA#      AREA        K    TOPW    WETP  ALPH    LEW    REW     QCR
              1       763    22682     133     134                       10355
              2       569    72722      54      55                       10469
              3      1407    52803     212     213                       20566
   417.70            2739   148207     399     402  2.96    156    555   23657


   VELOCITY DISTRIBUTION:  ISEQ =   6;  SECID = APPR ;  SRD =      215.

         WSEL     LEW     REW    AREA        K        Q     VEL
       417.70   155.8   555.2  2738.8  148207.    4400.    1.61

X STA.      155.8      235.7      262.6      287.5      296.3      303.1
  A(I)          319.5      223.4      207.1       75.1       61.9
  V(I)           0.69       0.98       1.06       2.93       3.55

X STA.      303.1      308.9      313.4      317.7      322.0      326.3
  A(I)           63.1       53.2       52.7       52.5       52.5
  V(I)           3.49       4.13       4.18       4.19       4.19

X STA.      326.3      331.0      336.7      345.7      366.9      388.2
  A(I)           54.9       59.2       78.1      175.0      175.1
  V(I)           4.01       3.71       2.82       1.26       1.26

X STA.      388.2      409.7      431.5      454.6      478.3      555.2
  A(I)          176.9      179.2      189.6      194.0      295.8
  V(I)           1.24       1.23       1.16       1.13       0.74
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094              MODEL   FOR   WATER-SURFACE   PROFILE   COMPUTATIONS

         Structure #124000900600             (180 ft. bridge)
         Sandy River at SC 9                  file: sandy.sc9
         Chester County, South Carolina       AWC    September 1994
          *** RUN DATE & TIME: 03-15-95  15:25
   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = BRIDG;  SRD =        0.

     WSEL   SA#      AREA         K    TOPW    WETP  ALPH     LEW     REW       QCR
              1       108      5163      53      53                              876
              2       693     88503      73      78                            12128
              3         2        36       4       4                                8
   417.98             803     93703     129     135  1.14      22     152     10647


   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = BRIDG;  SRD =        0.

          WSEL      LEW     REW     AREA        K        Q     VEL
        418.26     21.8   152.4    839.5   99306.    6600.   7.86

X STA.       21.8        67.7        84.9        91.9        96.7       100.5
  A(I)           100.3        68.5        50.0        42.8        39.8
  V(I)            3.29        4.82        6.60        7.71        8.30

X STA.      100.5       103.7       106.5       109.1       111.4       113.7
  A(I)            36.4        34.6        33.9        31.2        31.5
  V(I)            9.07        9.53        9.72       10.56       10.48

X STA.      113.7       115.9       118.2       120.4       122.6       124.9
  A(I)            31.1        31.3        30.8        31.5        32.3
  V(I)           10.62       10.54       10.71       10.48       10.22

X STA.      124.9       127.4       130.1       133.4       137.6       152.4
  A(I)            33.2        34.6        38.8        43.0        63.9
  V(I)            9.94        9.53        8.51        7.67        5.17
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WSPRO           FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094              MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          Structure #124000900600              (180 ft. bridge)
          Sandy River at SC 9                   file: sandy.sc9
          Chester County, South Carolina         AWC    September 1994
           *** RUN DATE & TIME: 03-15-95   15:25
      CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPR ;  SRD =      215.

       WSEL   SA#      AREA        K    TOPW    WETP  ALPH     LEW     REW      QCR
                1      1092    38022     150     151                          16724
                2       692   100950      54      55                          14064
                3      1921    81627     240     241                          30822
     419.99            3705   220600     444     447  2.99     139     583    35098



      VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPR ;  SRD =      215.

            WSEL     LEW     REW    AREA        K        Q     VEL
          419.99   139.0   583.3  3705.5  220600.    6600.    1.78

 X STA.       139.0      224.1      253.0      278.4      293.3      300.6
  A(I)            414.4      295.5      269.4      159.4       82.1
  V(I)             0.80       1.12       1.23       2.07       4.02

 X STA.       300.6      307.4      312.4      317.2      322.0      326.8
  A(I)             83.7       70.4       69.6       69.5       69.4
  V(I)             3.94       4.69       4.74       4.75       4.76

 X STA.       326.8      332.1      338.4      351.2      372.7      394.3
  A(I)             72.1       78.3      136.5      225.9      227.1
  V(I)             4.58       4.21       2.42       1.46       1.45

 X STA.       394.3      415.8      438.0      461.7      488.1      583.3
  A(I)            226.6      232.8      249.2      266.8      406.6
  V(I)             1.46       1.42       1.32       1.24       0.81
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          Structure #124000900600           (180 ft. bridge)
          Sandy River at SC 9                file: sandy.sc9
          Chester County, South Carolina      AWC   September 1994
           *** RUN DATE & TIME: 03-15-95  15:25

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

EXITA:XS   ******     42     1197   0.30 *****  415.65  407.68   4400  415.35
      -399 ******    274   121966   1.43 ***** *******    0.34   3.68

EXITB:XS       10     42     1210   0.24  0.01  415.66 *******   4400  415.42
      -389     10    276   132480   1.18  0.00    0.00    0.31   3.64

EXIT :XS      210     42     1202   0.25  0.23  415.90 *******   4400  415.66
      -179    210    275   131547   1.18  0.00    0.01    0.31   3.66

FULV :FV      180     42     1196   0.25  0.20  416.11 *******   4400  415.87
         0    180    274   130869   1.18  0.00    0.01    0.31   3.68
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS      215    171     2168   0.19  0.29  416.41 *******   4400  416.22
       215    215    540   108811   2.95  0.00    0.00    0.25   2.03
         <<<<<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

BRIDG:BR      180     62      515   1.47  0.49  416.95  412.83   4400  415.48
         0    180    146    54429   1.30  0.56    0.00    0.70   8.55

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   1.   1.  0.878  0.051  429.70 ****** ****** ******

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

APPR :AS      180    156     2739   0.12  0.46  417.82  412.03   4400  417.70
       215    193    555   148198   2.96  0.40    0.01    0.19   1.61

       M(G)   M(K)      KQ   XLKQ   XRKQ    OTEL
      0.733  0.440  82905.   271.   356.  417.54

                  <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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WSPRO OUTPUT --Continued

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

           Structure #124000900600            (180 ft. bridge)
           Sandy River at SC 9                 file: sandy.sc9
           Chester County, South Carolina       AWC   September 1994
            *** RUN DATE & TIME: 03-15-95   15:25

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

EXITA:XS    ******       34     1895   0.35  *****   418.30   409.37     6600   417.95
      -399  ******      324   182886   1.86  ***** *******     0.33     3.48

EXITB:XS        10       30     1937   0.20   0.01   418.30  *******     6600   418.10
      -389      10      325   233483   1.11   0.00     0.00     0.25     3.41

EXIT :XS       210       33     1907   0.21   0.17   418.48  *******     6600   418.27
      -179     210      324   228539   1.12   0.00     0.00     0.25     3.46

FULV :FV       180       35     1884   0.21   0.15   418.64  *******     6600   418.43
         0     180      324   224687   1.12   0.00     0.00     0.26     3.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR :AS       215      146     3138   0.20   0.23   418.88  *******     6600   418.68
       215     215      565   177415   2.97   0.00     0.00     0.23     2.10
         <<<<<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

BRIDG:BR       180       22      803   1.47   0.37   419.45   414.86     6600   417.98
         0     180      152    93709   1.40   0.60     0.00     0.69     8.22

     TYPE PPCD FLOW      C      P/A     LSEL    BLEN    XLAB    XRAB
       3.   1.   1.  0.844   0.054   429.70 ****** ****** ******

===140 AT SECID "APPR ":  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =    419.99       419.4       429.5

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

APPR :AS       180      139     3707   0.15   0.41   420.14   412.96     6600   419.99
       215     193      583   220721   2.99   0.28     0.01     0.19     1.78

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
      0.686  0.374   137904.   236.   365.   419.83

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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PIER SCOUR COMPUTATIONS
FOR
Sandy River at Str. 124000900600 in Chester Cty., SC
Q100 AWC 3-16-1995

HYDRAULIC VARIABLES USED IN CSU EQUATION

PIER NUMBER	4	3	2
PIER STATION (FT)	40	90	140
LOCATION OF PIER	lfp	mcl	mcr
Y1: DEPTH (FT)	0.0	11.8	11.8
V1: VEL. (FPS)	0.0	9.3	9.3
a: PIER WIDTH (FT)	2.5	2.5	2.5
L: PIER LENGTH (FT)	7.2	7.2	7.2
PIER SHAPE	1	1	1
ATTACK ANGLE	0	0	0
K1 (SHAPE COEF.)	1.10	1.10	1.10
K2 (ANGLE COEF.)	1.00	1.00	1.00
FROUDE NO.	0.00	0.48	0.48

COMPUTED SCOUR DEPTHS USING CSU EQUATION

SCOUR DEPTH (FT)	0.00	6.87	6.87
MAX SCOUR DEPTH (FT)	0.00	7.56	7.56

"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 Str. 124000900600 in Chester Cty., SC
Q100 AWC 3-16-1995

MAIN CHANNEL IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	4400.
WIDTH OF CONTRACTED SECTION (FT)	=	73.0
MEDIAN GRAIN SIZE (FT)	=	0.0019
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	25.8
AVERAGE FLOOD PLAIN DEPTH (FT)	=	11.3
DEPTH OF CONTRACTION SCOUR (FT)	=	14.5

PIER SCOUR COMPUTATIONS
FOR
Sandy River at Str. 124000900600 in Chester Cty., SC
Q500 AWC 3-16-1995

HYDRAULIC VARIABLES USED IN CSU EQUATION

PIER NUMBER	4	3	2
PIER STATION (FT)	40	90	140
LOCATION OF PIER	lfp	mcl	mcr
Y1: DEPTH (FT)	2.2	14.2	14.2
V1: VEL. (FPS)	4.8	9.6	9.6
a: PIER WIDTH (FT)	2.5	2.5	2.5
L: PIER LENGTH (FT)	7.2	7.2	7.2
PIER SHAPE	1	1	1
ATTACK ANGLE	0	0	0
K1 (SHAPE COEF.)	1.10	1.10	1.10
K2 (ANGLE COEF.)	1.00	1.00	1.00
FROUDE NO.	0.57	0.45	0.45

COMPUTED SCOUR DEPTHS USING CSU EQUATION

SCOUR DEPTH (FT)	4.14	7.17	7.17
MAX SCOUR DEPTH (FT)	4.55	7.89	7.89

"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 Str. 124000900600 in Chester Cty., SC
Q500 AWC 3-16-1995

LEFT OVERBANK IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	364.
WIDTH OF CONTRACTED SECTION (FT)	=	50.0
MEDIAN GRAIN SIZE (FT)	=	0.0019
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	4.2
AVERAGE FLOOD PLAIN DEPTH (FT)	=	2.3
DEPTH OF CONTRACTION SCOUR (FT)	=	1.9

MAIN CHANNEL IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	6236.
WIDTH OF CONTRACTED SECTION (FT)	=	73.0
MEDIAN GRAIN SIZE (FT)	=	0.0019
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	34.8
AVERAGE FLOOD PLAIN DEPTH (FT)	=	13.7
DEPTH OF CONTRACTION SCOUR (FT)	=	21.1

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Water Resources Division
Stephenson Center, Suite 129
720 Gracern Road
Columbia, SC 29210-7651

March 21, 1995

William H. Hulbert, P.E.
Hydraulic Engineer
South Carolina Department of Transportation
955 Park Street
Columbia, South Carolina 29202

Dear Mr. Hulbert:

We are pleased to transmit to you another report of the Level II Bridge Scour Program titled, "Level II bridge scour analysis for structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina," by Andy W. Caldwell and J. Mike Sullivan. The technical aspects of the report have been reviewed by the South Carolina District Surface-Water Specialist and the editorial aspects of the report have been reviewed and approved by the South Carolina District Hydraulics Section Chief.

If you have any questions concerning this report please contact me (750-6101) or J. Mike Sullivan (750-6165) and we will be glad to assist you.

Sincerely,

Andy W. Caldwell

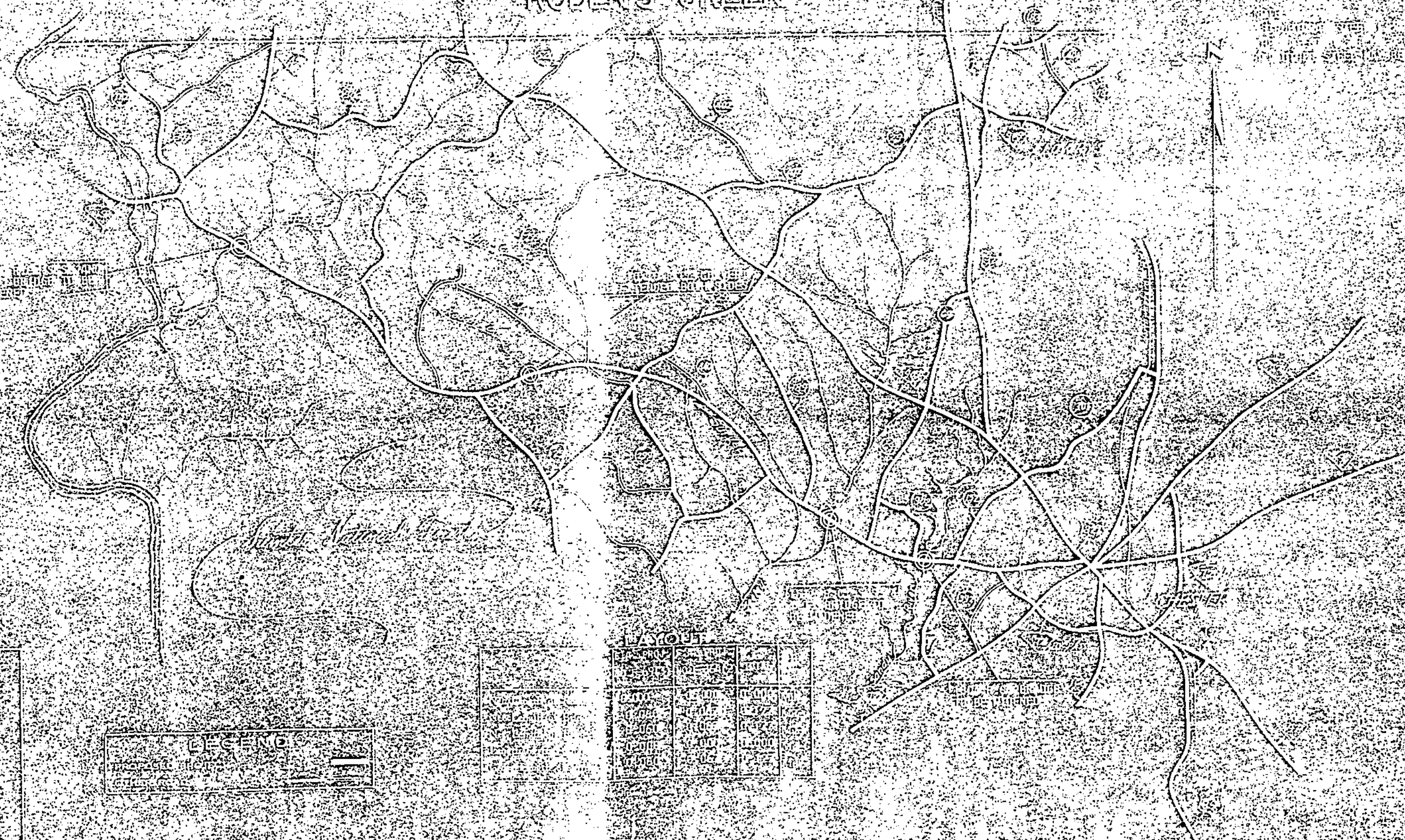
Andy W. Caldwell
Civil Engineer

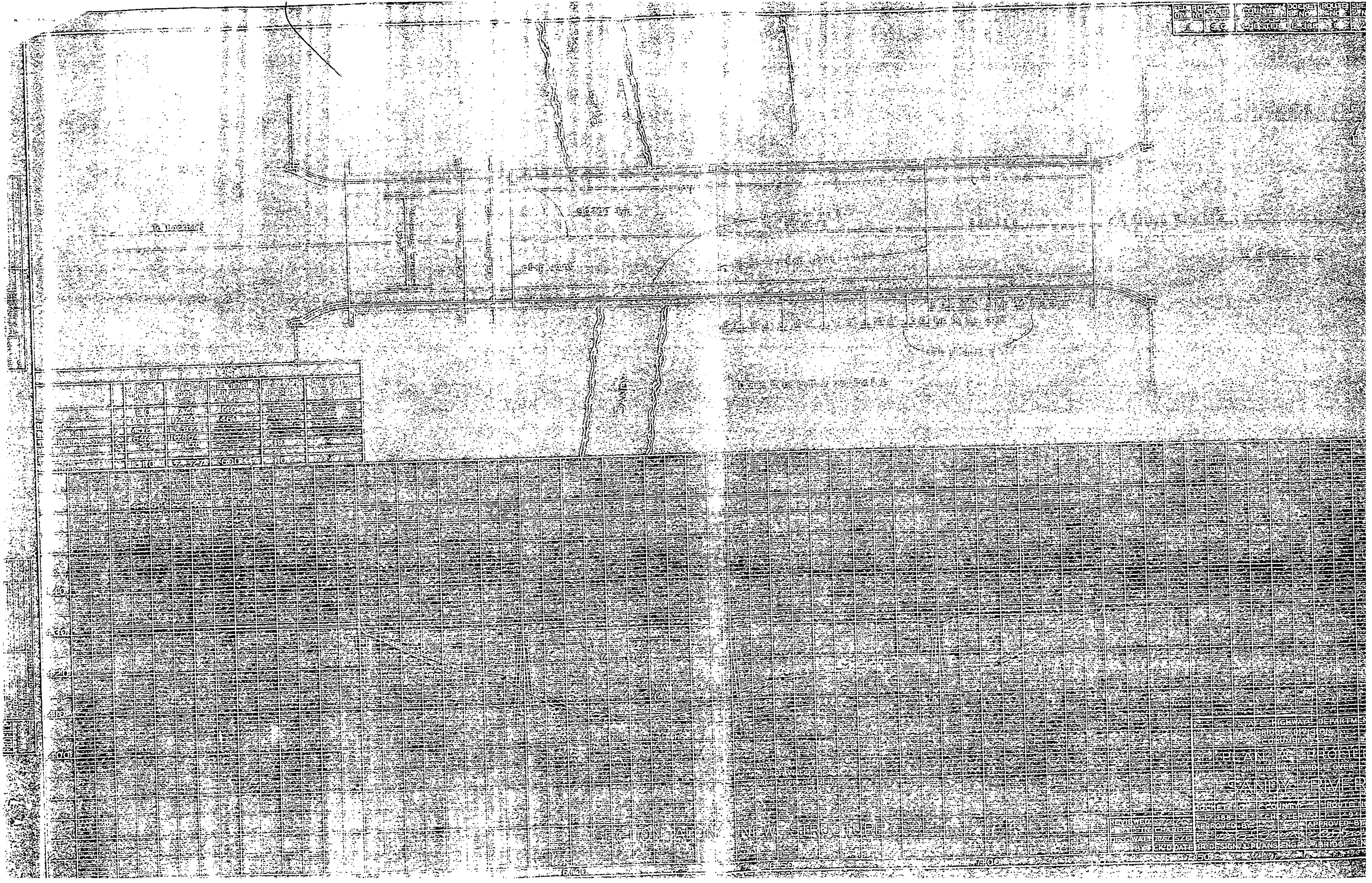
Enclosure

South Carolina
State Highway Department
Columbia

Plan and Profile of Proposed
State Highway

S C DOCKET NO. 12.366
CHESTER COUNTY
ROUTE NO. 9
F. A. P. NO. E-69(G)
WIDENING BRIDGE OVER
TURKEY CREEK
F. A. P. NO. E-364(2)
WIDENING BRIDGES OVER
SEELEY CREEK & SANDY RIVER &
WIDENING CULVERT AT
RODEN'S CREEK




FED. RD. DIV. NO.
STATE
COUNTY
DOCKET NO.
ROUTE NO.
S.C.
CHESTER
E-388
BRIDGE DIVISION
COLUMBIA
FOR WIDENING BRIDGE OVER
SANDY RIVER
APPROVED BY
BY
CK'D
DATE
SECTION ALONG NEW STRUCTURE
6+00
7+00

PILE RECORD ON DOCKET NO. 12.388

SANDY RIVER BRIDGE

FED. ROAD DIV. NO.	STATE	COUNTY	DOCKET NO.	ROUTE NO.	SHEET NO.
3	S.C.	Chester	12.388	9	41

WEIGHT OF HAMMER 3,860 Lbs. TYPE GRAVITY

DATE	BENT NO.	FOOTING	PILE NO.	DIAM. AT BUTT.	DIAM. AT TIP	ORIG. LENGTH	BUILD-UP OR SPLICE	TOTAL LENGTH	LENGTH C. O.	NET LENGTH	ELEV. C. O.	ELEV. PILE TIP	ELEV. ORIG. GROUND OR BOTTOM OF FOOTING	PEN. IN GROUND OR BELOW FOOTING	PEN. PER BLOW	FALL OF HAMMER	BEARING VALUE	PAY LENGTH	C.O. @ 40 %	C.O. @ 25 %
TOTAL																				

DATE	BENT NO.	FOOTING	PILE NO.	DIAM. AT BUTT.	DIAM. AT TIP	ORIG. LENGTH	BUILD-UP OR SPLICE	TOTAL LENGTH	LENGTH C. O.	NET LENGTH	ELEV. C. O.	ELEV. PILE TIP	ELEV. ORIG. GROUND OR BOTTOM OF FOOTING	PEN. IN GROUND OR BELOW FOOTING	PEN. PER BLOW	FALL OF HAMMER	BEARING VALUE	PAY LENGTH	C.O. 40
5-9	1		1			35.00		35.00	6.09	28.91	427.27	398.36	425.70	27.34	.583	15'	36.58	28.91	
5-9	1		2*			35.00		35.00	6.07	28.93	427.27	398.34	425.70	27.36	.583		36.58	30.93	
											Av. =	399.35							
5-8	2		1			35.00		35.00	4.16	30.84	426.37	395.53	414.94	19.41	.458		39.71	30.84	
5-9	2		2			35.00		35.00	4.10	30.90	426.37	395.47	413.54	18.07	.708		33.90	30.90	
5-9	2		3			35.00		35.00	3.60	31.40	426.37	394.97	413.04	18.07	.583		36.58	31.40	
5-8	2		4			35.00		35.00	3.16	31.84	426.37	394.53	411.14	16.61	.542		37.55	31.84	
											Av. =	395.12							
5-8	3		1			35.00		35.00	4.89	30.11	426.37	396.26	408.54	12.28	.500		38.60	30.11	
5-9	3		2			35.00		35.00	7.21	27.79	426.37	398.58	409.14	10.56	.583		36.58	27.79	
5-9	3		3			35.00		35.00	5.71	29.29	426.37	397.08	411.64	14.56	.625		35.63	29.29	
5-8	3		4			35.00		35.00	6.44	28.56	426.37	397.81	412.44	14.63	.458		39.71	28.56	
											Av. =	397.43							
5-8	4		1			35.00		35.00	9.64	25.36	426.37	401.01	417.54	16.53	.667		34.73	25.36	
5-9	4		2			35.00		35.00	11.85	23.15	426.37	403.22	417.54	14.32	.792		32.31	23.15	
5-9	4		3			35.00		35.00	9.33	25.67	426.37	400.70	416.54	15.84	.458		39.71	25.67	
5-8	4		4			35.00		35.00	8.29	26.71	426.37	399.66	416.54	16.88	.667		34.73	26.71	
											Av. =	401.15							
5-9	5		1			35.00		35.00	10.86	24.14	427.27	403.13	425.70	22.57	.583		36.58	24.14	
5-9	5		2			35.00		35.00	10.09	24.91	427.27	402.36	425.70	23.34	.542	15'	37.55	24.91	
											Av. =	402.75							
TOTAL								560.00	111.49	448.51								450.51	
GRAND TOTAL								560.00	111.49	448.51								450.51	

NOTES CONCERNING ANY UNUSUAL FOUNDATION CONDITIONS

BENT NO.	FOOTING	PILE NO.	REMARKS
1		2	Due to an engineering error, this pile was cut off 0.90 below cut off elevation. 0.90 was spliced on to bring pile head to proper elevation. This amount was deducted from the original cut-off length and only the remainder was shown above. A 2' allowance was made in the pay length for the splice.

NOTES:

PAY LENGTH SHOULD INCLUDE ALLOWANCE FOR SPLICING STEEL PILES AND ANY OTHER AUTHORIZE ALLOWANCES.

NUMBERING PILES: A SKETCH OF BENT OR FOOTING T BE DRAWN ON THIS SHEET AND PI TO BE NUMBERED, ALSO FLOW OF STREAM TO BE SHOWN.

PENETRATION PER BLOW: GIVE THIS INFORMATION IN DECIMAL OF AN INCH.

PILE RECORD Book No. 1 DOCKET NO. 12.

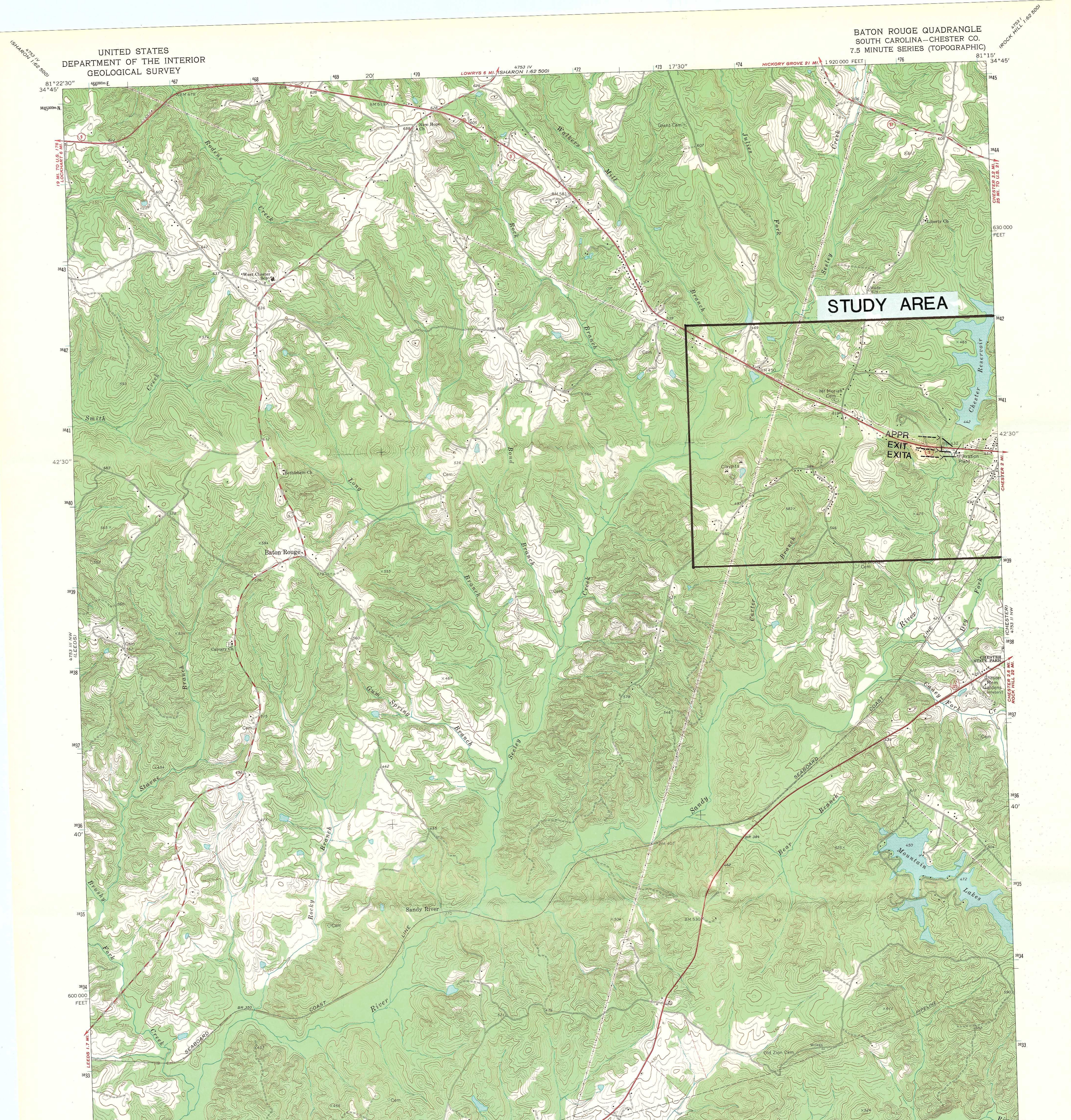


Figure 1.--Topography of study area and location of cross sections used in WSPRO analysis for structure 124000900600 on Route SC 9, crossing the Sandy River in Chester County, South Carolina.