U.S. DEPARTMENT OF THE INTERIOR

U.S. GEOLOGICAL SURVEY

LEVEL II BRIDGE SCOUR ANALYSIS FOR STRUCTURE 124007200700 ON ROUTE SC 72, CROSSING ROCKY CREEK IN CHESTER COUNTY, SOUTH CAROLINA

By Noel M. Hurley, Jr. and Stephen T. Benedict

Prepared in cooperation with the
SOUTH CAROLINA DEPARTMENT
OF TRANSPORTATION

Columbia, South Carolina

1994

UNIT ABBREVIATIONS

cubic foot per second	ft^3/s
foot 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
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 124007200700 on Route SC 72, crossing Rocky Creek 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 124007200700 on Route SC 72, crossing Rocky Creek 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 8.0 mi^2, and is a predominantly rural drainage basin with little development in recent years. In the vicinity of the study site, the flood plain is covered by moderate to dense woods consisting of small to medium hardwoods and occasional pines and moderate to thick undergrowth.

In the study area, Rocky Creek has a meandering channel with a slope of approximately 0.0039 ft/ft (20.6 ft/mi), an average channel top width of 32 ft and an average channel depth of 7.9 ft. The predominant channel bed materials are sand and gravel (D_{50} is 1.3 mm) and the channel banks consist of a silty clayey sand (D_{50} is 0.50 mm). In general, the banks have sparse to moderate woody vegetative cover and were noted to be relatively unstable at the time of the Level I and Level II site visits, July 18, 1990 and February 11, 1992, respectively.

The Route SC 72 crossing of Rocky Creek is a 100-ft long, two-lane bridge consisting of four 25-ft concrete spans, supported by a combination of two 2.1 ft square concrete piers and, where the bridge has been widened, by two 0.9 ft steel H-piles. Both abutments are the spillthrough type and are protected by riprap. Some riprap has slumped off of both abutments. This appears to be caused by a combination of high flow and human activity. 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 graphs of the scour depths are shown in figures 2 and 3.

Footing and pile penetration depths were obtained from SCDOT bridge plans, file number 12.344. At the direction of the SCDOT (R. Williamson, oral commun. 6-93), the proposed construction elevations at the base of the pier footings is shown instead of the pile tip elevations in tables 1 and 2 and on figures 2 and 3. The maximum scour occurs at bent 3. The plans noted the base of the footings to be located at elevation 74.6 ft (USGS datum). The base of the footing at bent 3 is undermined by 3.5 and 5.5 ft by the scour caused by the 100- and 500-year discharges, respectively. Additionally, the footings of bents 2 and 4 are undermined by 0.1 and 0.2 ft, respectively, by the scour caused by the 500-year discharge.

The original structure was built in 1928 and widened in 1956. The widened parts of the structure are supported by one 0.9 ft H pile U/S and D/S of the two interior 2.1 ft square concrete piers, respectively. The maximum pile tip elevations for the widened parts of the bridge are 70.5, 67.7, and 69.9 ft (USGS datum) for bents 2, 3, and 4, respectively. The scour caused by the 100-year discharge will result in remaining pile penetration depths of 6.0, 3.4, and 6.9 ft for bents 2, 3, and 4, respectively, and the scour caused by the 500-year discharge will result in remaining pile penetration depths of 4.0, 1.4, and 4.5 ft for bents 2, 3, and 4, respectively.

The 1928 SCDOT road plans show subsurface rock at an approximate elevation of 78.8 ft (USGS) that could reduce the amount of scour at the site. However, when the structure was widened in 1956, piles were driven 8- 9 ft below the approximate rock elevation. For more information, see the 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 124007200700 on Route SC 72, crossing Rocky Creek 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 2,740 cubic feet per second							
4	25	122.8	74.6	83.7	6.9	76.8	2.2
3	50	122.8	74.6	79.6	8.5	71.1	-3.5
2	75	122.8	74.6	85.0	8.5	76.5	1.9

[1] Pier/bent number corresponds to South Carolina Department of Transportation bridge plans, file number 12.344.

[2] Stations are determined from left to right looking downstream.

[3] Pile tip/footing elevations obtained from 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.

Note: The SCDOT bridge plan botings show subsurface rock that could reduce the scour depths presented in this table. For more information, see the bridge plans in the pocket at the back of the report.

Table 2. *--Remaining pile/footing penetration at piers/bents for the 500-year discharge at structure 124007200700 on Route SC 72, crossing Rocky Creek 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)
500-year discharge is 4,150 cubic feet per second							
4	25	122.8	74.6	83.7	9.3	74.4	-0.2
3	50	122.8	74.6	79.6	10.5	69.1	-5.5
2	75	122.8	74.6	85.0	10.5	74.5	-0.1

[1] Pier/bent number corresponds to South Carolina Department of Transportation bridge plans, file number 12.344.

[2] Stations are determined from left to right looking downstream.

[3] Pile tip/footing elevations obtained from 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.

Note: The SCDOT bridge plan botings show subsurface rock that could reduce the scour depths presented in this table. For more information, see the bridge plans in the pocket at the back of the report.

Table 3. --*Cumulative scour depths at piers/bents for the 100-year discharge at structure 124007200700 on Route SC 72, crossing Rocky Creek 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 2,740 cubic feet per second				
4	25	1.8	5.1	6.9
3	50	0.4	8.1	8.5
2	75	0.4	8.1	8.5

Table 4. --*Cumulative scour depths at piers/bents for the 500-year discharge at structure 124007200700 on Route SC 72, crossing Rocky Creek 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 discharge is 4,150 cubic feet per second				
4	25	3.8	5.5	9.3
3	50	1.3	9.2	10.5
2	75	1.3	9.2	10.5

[1] Pier/bent number corresponds to South Carolina Department of Transportation bridge plans.

[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 SCDOT bridge plan botings show subsurface rock that could reduce the scour depths presented in this table. For more information, see the bridge plans in the pocket at the back of the report.

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.

Table 5. *--Abutment scour depths for the 100- and 500-year discharges at structure 124007200700 on Route SC 72, crossing Rocky Creek 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	2,740	5.8	5.3
500-year	4,150	8.1	6.6

[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.

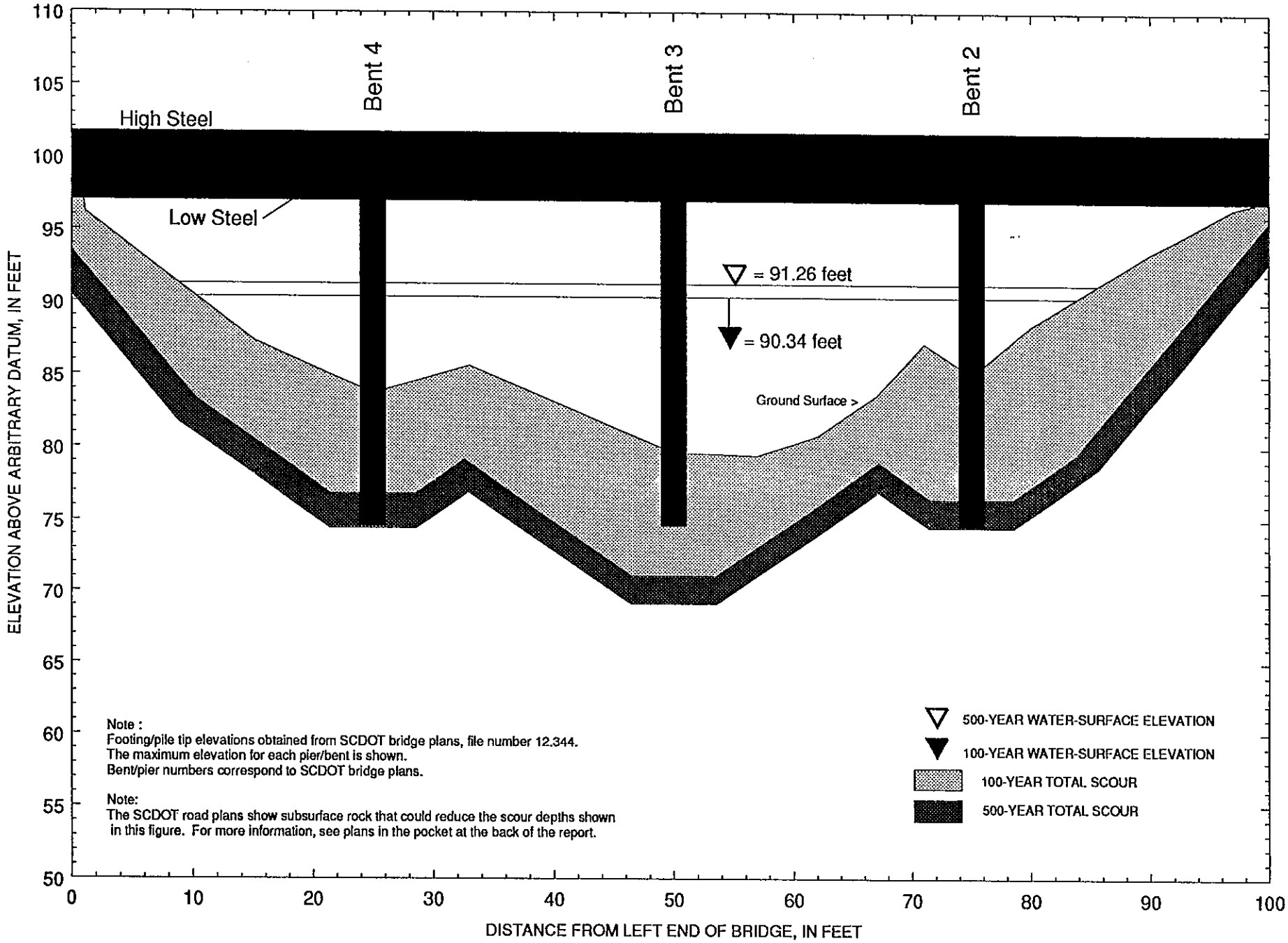

Figure 2.--Total scour depths for the 100- and 500-year discharges at the upstream face of structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina.

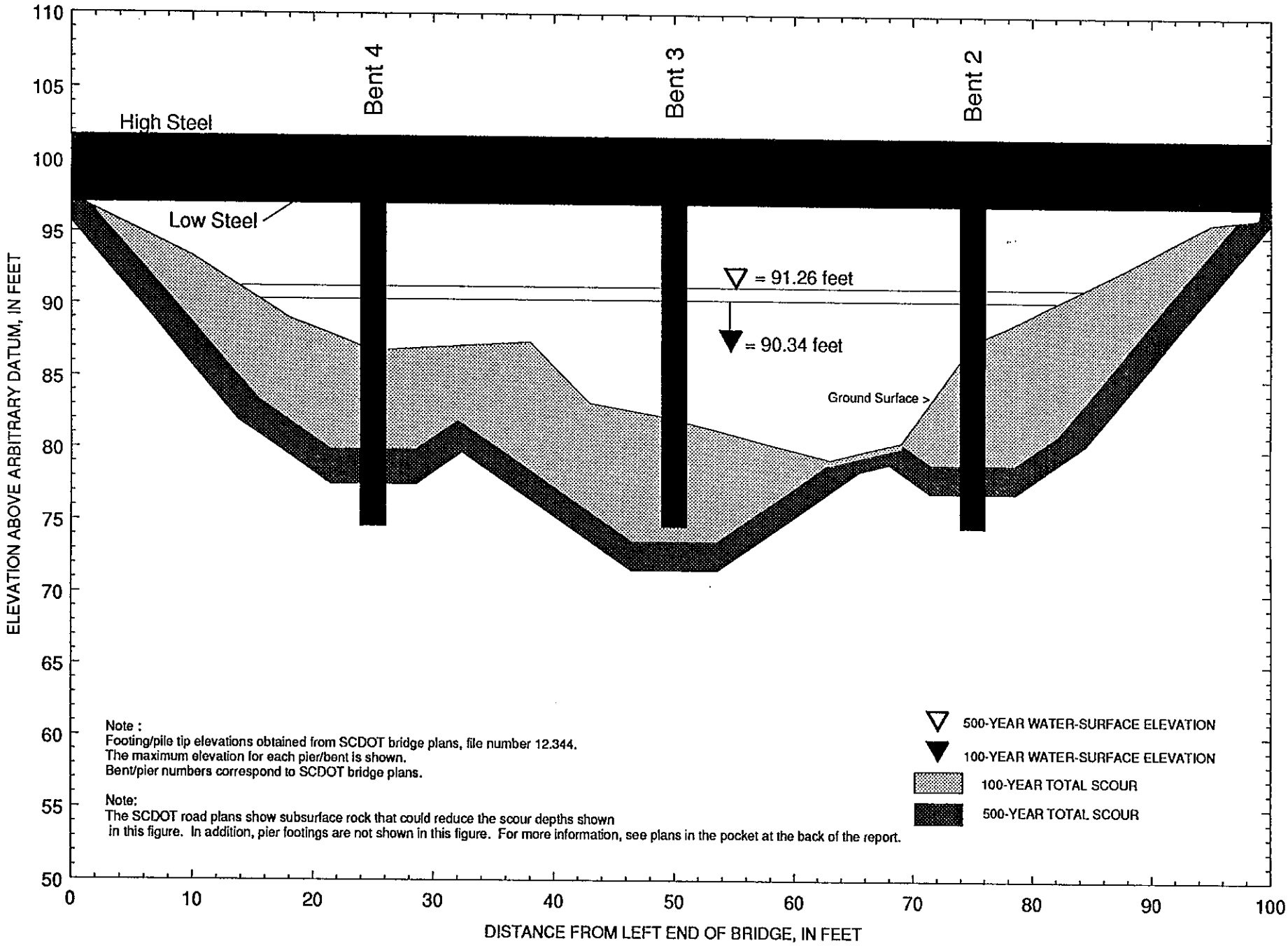

Figure 3.--Total scour depths for the 100- and 500-year discharges at the downstream face of structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina.

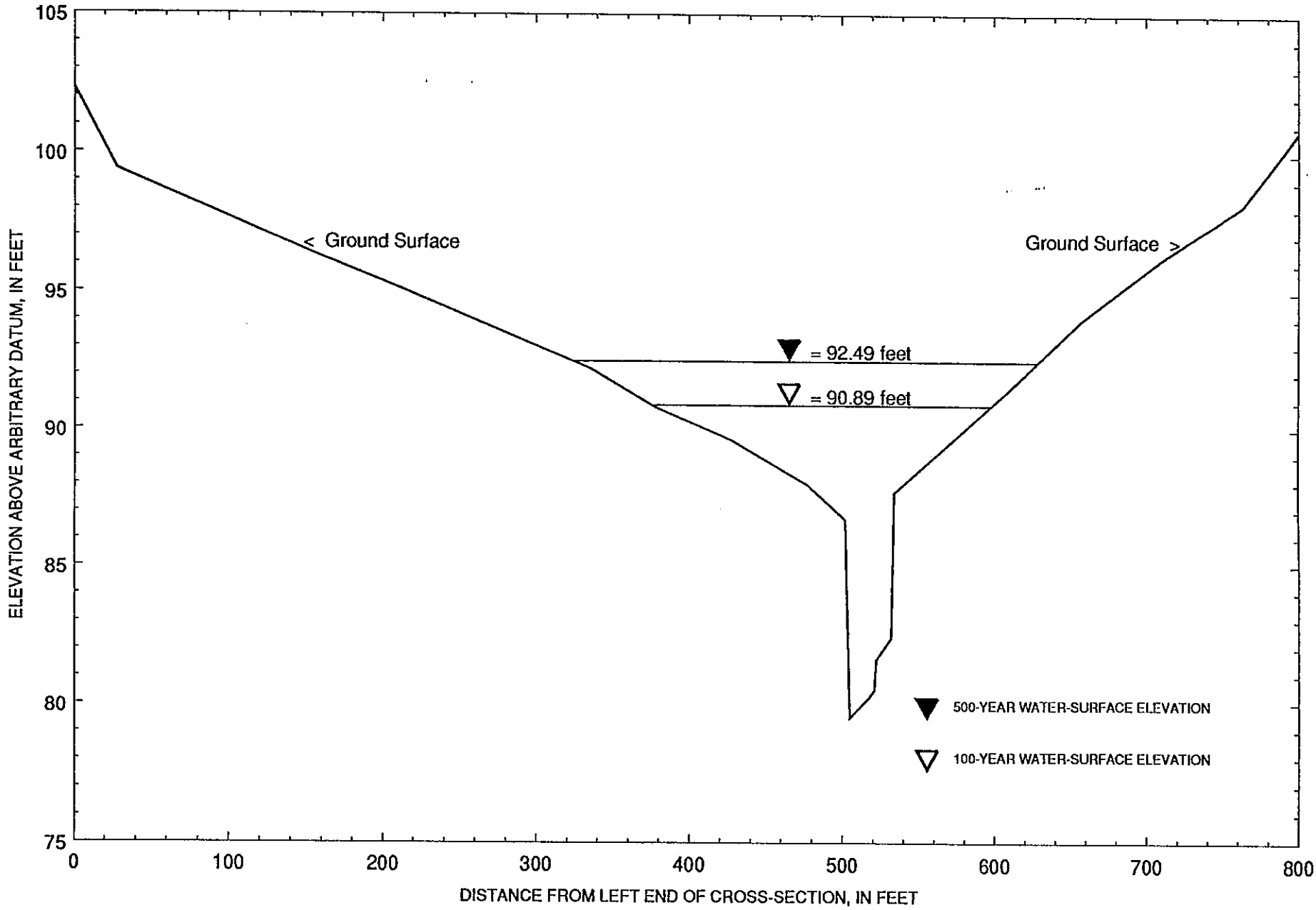

Figure 4.--Approach cross section at structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina.

Figure 5.--Structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina as viewed from upstream (February 11, 1992).

Figure 6.--Upstream channel as viewed from the approach cross section of structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina (February 11, 1992).

Figure 7.--Downstream channel as viewed from the exit cross section of structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina (February 11, 1992).

Figure 8.--Erosion of right bank at structure 124007200700 on Route SC 72 crossing Rocky Creek in Chester County, South Carolina (July 18, 1990).

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SCOUR REPORT SUMMARY

Structure Number 124007200700 *Stream* Rocky Creek

County Chester *Road* SC 72 *District* 4

Description of Bridge

Bridge length 100 *ft* *Bridge width* 30 *ft* *Max span length* 25 *ft*

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

Abutment type Spillthrough *Embankment type* Sloping

Riprap on abutment? Yes *Date of inspection* 7-18-1990

Description of riprap Six to 16-inch rocks on both abutments. The riprap has slumped. The right abutment is eroding and people have been moving the riprap in order to sleep on the left abutment.

Brief description of piers/pile bents Three interior bents; the middle part of each bent consists of two 2.1 ft square concrete columns spaced 18 ft on center. The U/S and D/S part of each bent has one 0.9 ft H pile, respectively.

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

Is bridge located on a bend in channel? Yes *If so, describe (mild, moderate, severe)* A moderate bend in the channel impacts the right bank at the bridge.

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	7-18-1990	0	0
Level II	2-11-1992	-	-

Potential for debris High: Large amount of debris in the channel and on the flood plain U/S of the bridge that can be transported during high flow.

Describe any features near or at the bridge that may affect flow (include observation date). An old road embankment with vertical concrete abutments is located 130 ft U/S of the bridge and constricts high flows.

Description of Flood Plain

General topography Roling hills with a relatively narrow flood plain

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

Date of inspection 2-11-1992

D/S left: Small to medium-sized hardwoods with light to moderate underbrush

D/S right: Small to medium-sized hardwoods with moderate to thick underbrush

U/S left: Small to medium-sized hardwoods with moderate to thick underbrush

U/S right: Small hardwoods with thick underbrush

Description of Channel

Average top width 32 *ft* *Average depth* 7.9 *ft*

Predominant bed material Coarse sand *Bank material* Silt/clay

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

Vegetative cover on channel banks near bridge: Date of inspection 2-11-1992

D/S left: Some herbaceous cover and sparse woody vegetative cover

D/S right: Some large trees with roots exposed by fluvial erosion

U/S left: Few small to medium hardwoods on bank

U/S right: Some medium hardwoods with roots exposed by fluvial erosion

Do banks appear stable? No *If not, describe location and type of instability and date of observation.* Heavy fluvial erosion occurring along both banks U/S and D/S of the bridge. Bank failure also observed at flow impact points on the right bank at the bridge and on the left bank approximately 90 ft D/S of the bridge. These conditions were observed on July 18, 1990 and February 11, 1992.

Describe any obstructions in channel and date of observation. An old road embankment with vertical concrete abutments is located 130 feet U/S of the bridge. Additionally, there are many fallen trees in the channel and on the flood plains.

Hydrology

Drainage area 8.0 mi^2

Percentage of drainage area in physiographic 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.* Moderate potential for basin development; the site is located just east of the town of Chester.

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? No

If so, describe _____

Calculated Discharges

Q100 2,740 ft^3/s *Q500* 4,150 ft^3/s

Method used to determine discharges The site is located in the high-flow region of the north, central Piedmont of South Carolina. Therefore, the methods described by C.L. Sanders were used (w. cmm., 12-93). The peak flows were estimated using equations published in WRIR 87-4096, "Magnitude and frequency of floods in rural and urban basins of North Carolina", by Gunter, Mason, and Stamey and by methods described in USGS Bulletin 17B.

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

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

Datum tie between USGS survey and SCDOT plans Add 48.18 ft to the USGS datum to obtain the SCDOT plan's datum. (file number 12.344)

Description of reference marks used to determine USGS datum. RM 1: Chiseled square on U/S right bridge curb, elevation: 99.99 ft. RM 2: Chiseled square on D/S left bridge curb, elevation: 100.00 ft (assumed).

Cross-Sections Used in WSPRO Analysis

*Cross-section ID	*Section Reference Distance (SRD) in feet*	**How cross-section was developed*	*Comments*
T2	-1000	2	Shifted to SRD
T1	-500	2	Shifted to SRD
EXIT	-100	2	Exit section
FULV	0	2	Full valley section
BRDGD	0	1	D/S bridge section
APP	130	2	Approach 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 survey data collected at the site includes an Exit cross section 196 ft D/S of the D/S bridge face, a cross section of an old road embankment 130 ft U/S of the U/S bridge face, and a natural approach cross-section just U/S of the old embankment. Cross sections also were surveyed at the U/S and D/S faces of the bridge and pier/bridge geometry was measured. The cross section elevations are relative to USGS Reference Marks 1 and 2.

Cross sections T2, T1, EXIT and FULV (full valley) were developed by locating the D/S surveyed cross section at the appropriate Section Reference Distance (SRD) and adjusting the cross section elevations by the channel slope (0.0039 ft/ft). The APP (approach) cross-section was developed by locating the cross section survey just U/S of the old road embankment at the appropriate SRD and adjusting the cross section elevations by the channel slope. The old road embankment is located beyond one-bridge width U/S of the bridge and was assumed to have little influence on the bridge hydraulics. Therefore, the old embankment was not included in the final WSPRO Model. To verify this assumption, a separate WSPRO Model was run with the old embankment cross section located at one-bridge width upstream and the results of these two scenarios were compared. The difference in the water-surface elevations at the bridge and approach cross sections was 0.2 ft or less, verifying the assumption that the old embankment had little influence. A skew angle of 15 degrees was determined during the Level I and Level II site visits and was confirmed by the USGS topographic map of the area.

The starting water-surface elevation used by the WSPRO Model was determined by the model using slope-conveyance. Tests for water-surface convergence indicated that using slope conveyance to estimate the starting water-surface elevation for cross-section T2 was valid.

Bridge Hydraulics

Average embankment elevation 99.9 *ft*

Average low steel elevation 97.0 *ft*

100-year discharge 2,740 ft^3/s

Water-surface elevation at D/S bridge face 90.34 *ft*

Area of flow at D/S bridge face 364 ft^2

Average velocity in bridge opening 7.53 *ft/s*

Maximum WSPRO tube velocity at bridge 10.63 *ft/s*

Water-surface elevation at Approach section with bridge 90.89 *ft*

Water-surface elevation at Approach section without bridge 90.80 *ft*

Amount of backwater caused by bridge 0.09 *ft*

500-year discharge 4,150 ft^3/s

Water-surface elevation at D/S bridge face 91.26 *ft*

Area of flow at D/S bridge face 425 ft^2

Average velocity in bridge opening 9.77 *ft/s*

Maximum WSPRO tube velocity at bridge 13.90 *ft/s*

Water-surface elevation at Approach section with bridge 92.49 *ft*

Water-surface elevation at Approach section without bridge 91.81 *ft*

Amount of backwater caused by bridge 0.68 *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 through 5 and graphs of the scour depths are shown in figures 2 and 3 for the U/S and D/S bridge faces, respectively.

The site is located in the high-flow region of the north, central Piedmont of South Carolina. Contraction scour was analyzed by using the live-bed scour equation for the channel and the clear-water scour equation for the left and right overbank areas. The left and right overbank areas of the approach cross section are triangular in shape instead of rectangular. Therefore, the average depth of the respective flood plains was estimated by using the depth of flow at the centroids of these right triangles.

The more restrictive bridge face (D/S face of bridge) was used in the WSPRO and scour analyses. However, when comparing the U/S and D/S bridge face cross sections it was noted that the ground elevations at the bents were approximately 3 ft lower in the U/S bridge face because of a moderate change in cross-section geometry. Therefore, to assure the worst-case conditions for determining scour elevations, the calculated scour elevations were determined from the U/S bridge face as shown in tables 1 and 2 and in figure 2. A plot of the scour depths at the D/S bridge face is provided for information in figure 3.

It should be noted that the following pile tip/footing information was provided by the SCDOT bridge plans, file number 12.344 for Route SC 72 crossing Rocky Creek: the pile tip elevations for the piles that were added during the widening of the structure in 1956 and proposed construction elevations (no as-built elevations available) for the footings at the original structure built in 1928. The SCDOT bridge plans did not provide detailed

dimensions of the pier footings. The plans noted the proposed construction elevation for the base of the footings to be located at elevation 74.6 ft (USGS datum). The maximum pile tip elevation for the widened parts of the bridge were 70.5, 67.7, and 69.9 ft (USGS datum) for bents 2, 3, and 4, respectively. At the direction of the SCDOT (R. Williamson, oral commun. 6-93), the proposed construction elevations at the base of the pier footings is shown instead of the pile tip elevations in tables 1 and 2 and on figures 2 and 3.

Because the lack of detailed information and because the minimum ground surface elevation caused by the 100- and 500-year contraction scour is 4.6 and 3.7 ft above the base of the footing of bent 3, the local scour caused by exposed footings was not determined. Therefore, the 2.1-ft wide square concrete columns were used in the local pier-scour analyses.

The riprap on both abutments is slumped. Consequently, an analysis for abutment scour was made. The results of this analysis are presented in table 5.

Finally, the SCDOT bridge plans show subsurface rock at an approximate elevation of 78.8 ft (USGS) that could reduce the amount of scour at the site. For more information, see the plans in the pocket at the back of the report.

WSPRO INPUT FILE

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T1          WSPRO PROFILES--STRUCTURE 124007200700,
T2          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
T3          LEVEL II BRIDGE SCOUR ANALYSIS
J1          * * * 0.85
*
*           THIS SITE IS LOCATED IN THE HIGH FLOW REGION OF SOUTH
*           CAROLINA. THEREFORE, THE METHODS DESCRIBED BY C.L. SANDERS, 12-93
*           WERE USED TO ESTIMATE THE Q100 AND Q500 FLOWS.
*
Q            2740    4150
SK           0.0039  0.0039
*
XT   TEMP    -196
GR            0 102.0   60 91.4  103 87.2  130 87.1  175 87.9
GR          224  89.3  261 88.6  297 88.2  302 85.5  304 85.5
GR          311  88.5  337 87.8  351 87.6  354 80.2  367 80.3
GR          380  80.0  383 88.6  393 88.9  438 87.3  486 87.2
GR          556  89.2  609 92.3  653 93.0  697 99.1  729 102.7
*
*           THE CROSS SECTIONS DOWNSTREAM OF THE BRIDGE WERE DEVELOPED
*           BY LOCATING THE SURVEYED SECTION AT THE APPROPRIATE SRD AND
*           ADJUSTING THE ELEVATIONS BY THE VALLEY SLOPE.
*
XS   T2      -1000 * * * 0.0039
GT
N           0.14      0.042      0.18
SA               351         383
*
XS   T1      -500 * * * 0.0039
GT
*
XS   EXIT    -100 * * * 0.0039
GT
N           0.14       0.042     0.18
SA               351         383
*
XS   FULV    0 * * * 0.0039
GT
N           0.14       0.042     0.18
SA               351         383
*
*            THE DOWNSTREAM BRIDGE FACE WAS USED IN THE ANALYSIS BECAUSE
*            IT WAS THE MORE RESTRICTIVE OF THE TWO BRIDGE FACES.
*
BR   BRDGD    0 97.0 15
GR            0  97.0   1  96.4   10 93.3  18  89.0  25  86.8
GR           38  87.4  43  83.2  50  82.1  58  80.3  63  79.3
GR           69  80.5  75  87.5  78  88.6  88  92.8  95  95.9
GR           99  96.3  99  97.0  99.1 97.0  100 97.0  0   97.0
N           0.08      0.042     0.08
SA               38         75
PW 0        79.6  2.1  83.7 2.1  83.7 4.2  85.0 4.2 85.0 6.4
CD          3 30 2 99.9
```

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*           THE APPROACH CROSS SECTION WAS DEVELOPED FROM A CROSS SECTION THAT
*           WAS SURVEYED JUST U/S OF AN OLD ROAD EMBANKMENT. THE CROSS SECTION
*           WAS LOCATED AT THE APPROPRIATE SRD AND THE ELEVATIONS WERE ADJUSTED
*           BY THE VALLEY SLOPE.  THE OLD ROAD EMBANKMENT IS LOCATED 130 FT
*           U/S OF THE BRIDGE, AT SRD 160.
*
AS   APP    130
BP          469
GR            0 102.3   28  99.4  157  96.3  212  95.1  336  92.2
GR          378  90.8  428  89.6  477  88.0  502  86.7  505  79.5
GR          517  80.2  521  80.5  522  81.6  532  82.4  534  87.7
GR          608  91.4  657  94.0  709  96.2  763  98.2  813 101.8
N           0.18        0.042       0.18
SA                 502         534
*
HP 1 BRDGD   90.34, ,90.34,2740
HP 2 BRDGD   90.55, ,90.55,2740
HP 1 APP     90.89, ,90.89,2740
HP 2 APP     90.89, ,90.89,2740
HP 1 BRDGD   91.26, ,91.26,4150
HP 2 BRDGD   91.56, ,91.56,4150
HP 1 APP     92.49, ,92.49,4150
HP 2 APP     92.49, ,92.49,4150
*
EX
ER
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WSPRO OUTPUT

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = BRDGD;  SRD =        0.

      WSEL  SA#      AREA         K    TOPW    WETP  ALPH     LEW     REW      QCR
              1       59.     2081.    22.     22.                              549.
              2      295.    38953.    36.     41.                             4812.
              3       10.      231.     7.      7.                               70.
     90.34           364.    41265.    64.     71.  1.28     16.     82.     4334.


WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08


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

          WSEL      LEW      REW     AREA         K         Q      VEL
         90.55     15.1     82.6    377.6    43226.    2740.     7.26

X STA.        15.1        36.4        43.7        45.9        47.9        49.8
  A(I)            58.4        35.3        16.1        15.6        14.9
  V(I)            2.35        3.88        8.53        8.81        9.20

X STA.        49.8        51.5        53.2        54.8        56.3        57.6
  A(I)            14.8        14.5        14.1        13.9        13.5
  V(I)            9.24        9.47        9.74        9.88       10.18

X STA.        57.6        59.0        60.3        61.6        62.8        64.0
  A(I)            13.7        13.6        13.3        13.0        12.9
  V(I)           10.03       10.08       10.27       10.51       10.61

X STA.        64.0        65.3        66.5        67.9        69.4        82.6
  A(I)            13.2        12.9        13.2        14.7        46.1
  V(I)           10.36       10.63       10.35        9.31        2.97
```

WSPRO OUTPUT --Continued

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08
     CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APP  ;  SRD =     130.

      WSEL  SA#      AREA         K   TOPW   WETP  ALPH     LEW     REW      QCR
              1      226.     2741.   127.   127.                             1707.
              2      308.    41999.    32.    41.                             5434.
              3      102.     1149.    64.    64.                              729.
     90.89           636.    45889.   222.   232.  3.26    375.    598.     3378.
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08
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```
     VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APP  ;  SRD =     130.

          WSEL      LEW      REW      AREA         K         Q      VEL
         90.89    375.3    597.8    635.7   45889.    2740.    4.31

X STA.       375.3       496.3       506.1       507.3       508.5       509.7
  A(I)           202.4        59.4        13.6        13.4        13.5
  V(I)            0.68        2.31       10.09       10.23       10.18

X STA.       509.7       511.0       512.2       513.5       514.8       516.1
  A(I)            13.7        13.6        13.9        14.1        14.0
  V(I)           10.00       10.09        9.89        9.73        9.80

X STA.       516.1       517.4       518.7       520.0       521.4       523.2
  A(I)            14.0        13.8        13.9        15.0        16.1
  V(I)            9.81        9.90        9.88        9.14        8.52

X STA.       523.2       524.8       526.5       528.2       530.0       597.8
  A(I)            14.9        15.0        15.1        15.6       131.0
  V(I)            9.16        9.14        9.08        8.77        1.05
```

WSPRO OUTPUT --Continued

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08
     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = BRDGD;  SRD =       0.

      WSEL  SA#      AREA         K   TOPW   WETP  ALPH     LEW     REW      QCR
              1       80.      3264.   23.    24.                             833.
              2      328.     46451.   36.    41.                            5639.
              3       17.       478.    9.    10.                             138.
     91.26            425.     50193.   68.    75.  1.34     14.     84.     5205.


WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08


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

          WSEL      LEW      REW     AREA          K         Q     VEL
         91.56     13.2     85.0    445.6    53294.     4150.    9.31

X STA.         13.2        32.8        42.5        44.8        46.9        48.9
  A(I)             65.3        47.4        19.3        17.8        17.4
  V(I)             3.18        4.37       10.77       11.69       11.90

X STA.         48.9        50.8        52.5        54.2        55.8        57.3
  A(I)             17.3        16.3        16.5        16.2        15.7
  V(I)            12.01       12.73       12.61       12.80       13.19

X STA.         57.3        58.7        60.1        61.5        62.8        64.0
  A(I)             15.7        15.6        15.3        15.3        14.9
  V(I)            13.20       13.27       13.54       13.56       13.90

X STA.         64.0        65.4        66.7        68.1        69.8        85.0
  A(I)             15.3        14.9        15.3        18.0        55.9
  V(I)            13.56       13.90       13.53       11.51        3.71
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WSPRO OUTPUT --Continued

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08
     CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APP  ;  SRD =      130.

      WSEL  SA#      AREA         K    TOPW   WETP  ALPH     LEW     REW      QCR
              1      467.     7345.    178.   179.                             4290.
              2      360.    54250.     32.    41.                             6841.
              3      229.     3410.     95.    95.                             2019.
     92.49           1056.    65005.    305.   314.  5.02    324.    629.     4975.
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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08


     VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APP  ;  SRD =      130.

          WSEL      LEW      REW     AREA         K         Q     VEL
         92.49    323.6    628.5   1055.6    65005.    4150.    3.93

X STA.       323.6      467.8      496.3      506.1      507.4      508.8
  A(I)           298.6      136.4       74.1       17.7       17.2
  V(I)            0.69       1.52       2.80      11.73      12.06

X STA.       508.8      510.2      511.5      512.9      514.4      515.8
  A(I)            17.5       17.4       17.7       18.0       17.9
  V(I)           11.85      11.95      11.71      11.52      11.59

X STA.       515.8      517.3      518.8      520.2      522.0      523.8
  A(I)            18.1       17.9       18.0       21.0       18.8
  V(I)           11.48      11.57      11.54       9.89      11.02

X STA.       523.8      525.6      527.4      529.3      531.1      628.5
  A(I)            19.1       19.0       19.6       19.0      252.5
  V(I)           10.86      10.91      10.57      10.94       0.82
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WSPRO OUTPUT --Continued

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08

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

T2    :XS    ******    78.     1001.  0.73  *****   87.24    83.90    2740.    86.51
    -1000.   ******   564.    43844.  6.22  *****  *******    0.84     2.74

T1    :XS      500.    78.     1006.  0.72   1.94   89.19  *******    2740.    88.48
     -500.     500.   564.    44026.  6.24   0.00    0.01     0.83     2.72

EXIT  :XS      400.    78.     1007.  0.72   1.55   90.76  *******    2740.    90.04
     -100.     400.   564.    44045.  6.24   0.00    0.01     0.83     2.72

FULV  :FV      100.    78.     1016.  0.71   0.38   91.15  *******    2740.    90.45
        0.     100.   564.    44363.  6.26   0.00    0.01     0.82     2.70
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APP   :AS      130.   378.      616.  0.97   0.49   91.77  *******    2740.    90.80
      130.     130.   596.    44984.  3.16   0.13    0.00     0.83     4.45
          <<<<<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

BRDGD:BR       100.    16.      364.  0.88   0.41   91.22    88.70    2740.    90.34
         0.    100.    82.    41222.  1.00   0.05    0.00     0.56     7.53

      TYPE PPCD FLOW       C     P/A     LSEL   BLEN   XLAB   XRAB
         3.   0.    1.  0.999   0.133    97.00 ****** ****** ******

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

APP   :AS      100.   375.      636.  0.94   0.41   91.83    87.42    2740.    90.89
      130.     103.   598.    45924.  3.26   0.21    0.02     0.81     4.30

        M(G)    M(K)        KQ    XLKQ    XRKQ     OTEL
       0.692   0.037    44080.    474.    541.    90.53

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

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WSPRO          FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          WSPRO PROFILES--STRUCTURE 124007200700,
          ROCKY CREEK AT SC HWY 72, NEAR CHESTER
          LEVEL II BRIDGE SCOUR ANALYSIS
            *** RUN DATE & TIME: 01-14-94  10:08

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

T2    :XS    ******    66.     1605.  0.71  *****   88.43    86.78   4150.   87.72
    -1000.   ******   584.    66448.  6.83  *****  *******    0.68    2.59

T1    :XS     500.     66.     1609.  0.71   1.95   90.38  *******   4150.   89.68
     -500.    500.    584.    66611.  6.83   0.00    0.01     0.67    2.58

EXIT  :XS     400.     65.     1611.  0.71   1.55   91.94  *******   4150.   91.24
     -100.    400.    584.    66674.  6.83   0.00    0.01     0.67    2.58

FULV  :FV     100.     65.     1618.  0.70   0.39   92.34  *******   4150.   91.64
        0.    100.    585.    66954.  6.83   0.00    0.01     0.67    2.57
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APP  ":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.85    0.98      91.81      89.98

 ===110 WSEL NOT FOUND AT SECID "APP  ":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =    91.14     102.30    0.50

 ===115 WSEL NOT FOUND AT SECID "APP  ":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    91.14     102.30     89.98

APP   :AS      130.    348.      863.  1.54   0.59   93.35    89.98   4150.   91.81
       130.    130.    616.    56320.  4.27   0.42    0.00     0.98    4.81
          <<<<<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

BRDGD:BR      100.     14.      425.  1.59   0.51   92.85    90.58   4150.   91.26
        0.    100.     84.    50174.  1.07   0.39   -0.01     0.71    9.77

     TYPE PPCD FLOW      C     P/A     LSEL   BLEN   XLAB   XRAB
       3.    0.   1.  0.965   0.127   97.00 ****** ****** ******

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

APP   :AS      100.    324.     1056.  1.21   0.54   93.70    89.98   4150.   92.49
       130.    103.    629.    65016.  5.02   0.30   -0.01     0.83    3.93

       M(G)    M(K)        KQ    XLKQ    XRKQ     OTEL
      0.731   0.096     58939.    472.    543.    92.09

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

PIER SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q100 No debris accumulation. Computed by NMH

HYDRAULIC VARIABLES USED IN CSU EQUATION

PIER NUMBER	4	3	2
PIER STATION (FT)	25	50	75
LOCATION OF PIER	lfp	mcl	rtb
Y1: DEPTH (FT)	6.9	11.3	11.3
V1: VEL. (FPS)	3.9	9.6	9.6
a: PIER WIDTH (FT)	2.1	2.1	2.1
L: PIER LENGTH (FT)	6.0	6.0	6.0
PIER SHAPE	1	1	1
ATTACK ANGLE	15	15	15
K1 (SHAPE COEF.)	1.00	1.00	1.00
K2 (ANGLE COEF.)	1.31	1.31	1.31
FROUDE NO.	0.26	0.50	0.50

COMPUTED SCOUR DEPTHS USING CSU EQUATION

SCOUR DEPTH (FT)	4.68	7.37	7.37
MAX SCOUR DEPTH (FT)	5.14	8.10	8.10

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

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 4

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 3

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 2

CONTRACTION SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q100 No debris accumulation. Computed by NMH

LEFT OVERBANK IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	138.
WIDTH OF CONTRACTED SECTION (FT)	=	19.3
MEDIAN GRAIN SIZE (FT)	=	0.0021
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	4.1
AVERAGE FLOOD PLAIN DEPTH (FT)	=	2.3
DEPTH OF CONTRACTION SCOUR (FT)	=	1.8

RIGHT OVERBANK IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	15.
WIDTH OF CONTRACTED SECTION (FT)	=	2.9
MEDIAN GRAIN SIZE (FT)	=	0.0021
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	3.1
AVERAGE FLOOD PLAIN DEPTH (FT)	=	2.1
DEPTH OF CONTRACTION SCOUR (FT)	=	1.0

LIVE-BED SCOUR COMPUTATIONS

	MAIN CHANNEL	CONTRACTED SECTION
DISCHARGE (CFS)	2510.	2590.
BOTTOM WIDTH (FT)	32.0	31.5
MANNINGS n	0.042	0.042
AVERAGE DEPTH (FT)	10.6	

ENERGY SLOPE	0.00590
D50 (FT)	0.0043
FALL VELOCITY (FPS)	0.60
K1 COEF.	0.69
K2 COEF.	0.37

COMPUTED DEPTH AT CONTRACTED SECTION (FT)	=	11.0
DEPTH AT MAIN CHANNEL (FT)	=	10.6
DEPTH OF CONTRACTION SCOUR (FT)	=	0.4

ABUTMENT SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q100 No debris accumulation. Computed by NMH

LEFT ABUTMENT
SCOUR COMPUTATIONS

ABUTMENT TYPE	3 -SPILL THROUGH
DISCHARGE BLOCKED BY ABUTMENT (CFS)	122.
AREA BLOCKED BY ABUTMENT (SQ FT)	180.0
DEPTH OF FLOW AT ABUTMENT (FT)	3.2
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	108.0
ABUTMENT SKEW (DEG)	-15
AJUSTED ABUTMENT LENGTH (FT)	56.3
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	0.7
FROUDE NUMBER	0.067
K1 COEF.	0.6
K2 COEF.	1.0

DESIGN DEPTH OF SCOUR (FROELICH EQUATION, 1989) (FT) = 5.8

RIGHT ABUTMENT
SCOUR COMPUTATIONS

ABUTMENT TYPE	3 -SPILL THROUGH
DISCHARGE BLOCKED BY ABUTMENT (CFS)	124.
AREA BLOCKED BY ABUTMENT (SQ FT)	118.0
DEPTH OF FLOW AT ABUTMENT (FT)	2.2
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	61.6
ABUTMENT SKEW (DEG)	15
AJUSTED ABUTMENT LENGTH (FT)	53.6
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	1.1
FROUDE NUMBER	0.125
K1 COEF.	0.6
K2 COEF.	1.0

DESIGN DEPTH OF SCOUR (FROELICH EQUATION, 1989) (FT) = 5.3

PIER SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q500 No debris accumulation. Computed by NMH

HYDRAULIC VARIABLES USED IN CSU EQUATION

PIER NUMBER	4	3	2
PIER STATION (FT)	25	50	75
LOCATION OF PIER	lfp	mcl	rtb
Y1: DEPTH (FT)	7.9	12.3	12.3
V1: VEL. (FPS)	4.4	12.5	12.5
a: PIER WIDTH (FT)	2.1	2.1	2.1
L: PIER LENGTH (FT)	6.0	6.0	6.0
PIER SHAPE	1	1	1
ATTACK ANGLE	15	15	15
K1 (SHAPE COEF.)	1.00	1.00	1.00
K2 (ANGLE COEF.)	1.31	1.31	1.31
FROUDE NO.	0.27	0.63	0.63

COMPUTED SCOUR DEPTHS USING CSU EQUATION

SCOUR DEPTH (FT)	5.01	8.36	8.36
MAX SCOUR DEPTH (FT)	5.51	9.20	9.20

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

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 4

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 3

THE COMPUTED PIER SKEW CORRECTION COEFFICIENT WAS FOUND
BY EXTRAPOLATING THE LEFT END OF THE TABLE BACK TO 1 AT PIER NO. 2

CONTRACTION SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q500 No debris accumulation. Computed by NMH

LEFT OVERBANK IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	270.
WIDTH OF CONTRACTED SECTION (FT)	=	19.3
MEDIAN GRAIN SIZE (FT)	=	0.0021
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	7.2
AVERAGE FLOOD PLAIN DEPTH (FT)	=	3.4
DEPTH OF CONTRACTION SCOUR (FT)	=	3.8

RIGHT OVERBANK IN BRIDGE OPENING
CLEAR-WATER CONTRACTION SCOUR COMPUTATIONS

DISCHARGE IN CONTRACTED SECTION (CFS)	=	40.
WIDTH OF CONTRACTED SECTION (FT)	=	2.9
MEDIAN GRAIN SIZE (FT)	=	0.0021
COMPUTED DEPTH OF CONTRACTED SECTION (FT)	=	7.1
AVERAGE FLOOD PLAIN DEPTH (FT)	=	3.2
DEPTH OF CONTRACTION SCOUR (FT)	=	3.9

LIVE-BED SCOUR COMPUTATIONS

	MAIN CHANNEL	CONTRACTED SECTION
DISCHARGE (CFS)	3460.	3840.
BOTTOM WIDTH (FT)	32.0	31.5
MANNINGS n	0.042	0.042
AVERAGE DEPTH (FT)	12.2	

ENERGY SLOPE	0.00830
D50 (FT)	0.0043
FALL VELOCITY (FPS)	0.60
K1 COEF.	0.69
K2 COEF.	0.37

COMPUTED DEPTH AT CONTRACTED SECTION (FT)	=	13.5
DEPTH AT MAIN CHANNEL (FT)	=	12.2
DEPTH OF CONTRACTION SCOUR (FT)	=	1.3

ABUTMENT SCOUR COMPUTATIONS
FOR
Rocky Creek at SC 72, Str. 124007200700, Chester Co., SC
Q500 No debris accumulation. Computed by NMH

LEFT ABUTMENT
SCOUR COMPUTATIONS

ABUTMENT TYPE	3 -SPILL THROUGH
DISCHARGE BLOCKED BY ABUTMENT (CFS)	313.
AREA BLOCKED BY ABUTMENT (SQ FT)	368.0
DEPTH OF FLOW AT ABUTMENT (FT)	4.3
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	159.0
ABUTMENT SKEW (DEG)	-15
AJUSTED ABUTMENT LENGTH (FT)	85.6
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	0.9
FROUDE NUMBER	0.072
K1 COEF.	0.6
K2 COEF.	1.0

DESIGN DEPTH OF SCOUR (FROELICH EQUATION, 1989) (FT) = 8.1

RIGHT ABUTMENT
SCOUR COMPUTATIONS

ABUTMENT TYPE	3 -SPILL THROUGH
DISCHARGE BLOCKED BY ABUTMENT (CFS)	196.
AREA BLOCKED BY ABUTMENT (SQ FT)	239.0
DEPTH OF FLOW AT ABUTMENT (FT)	3.2
LENGTH OF ABUT. 90 DEG. TO FLOW (FT)	92.1
ABUTMENT SKEW (DEG)	15
AJUSTED ABUTMENT LENGTH (FT)	74.7
AVERAGE F/P VELOCITY U/S OF ABUT. (FPS)	0.8
FROUDE NUMBER	0.081
K1 COEF.	0.6
K2 COEF.	1.0

DESIGN DEPTH OF SCOUR (FROELICH EQUATION, 1989) (FT) = 6.6

FED. ROAD DIST. No.	STATE	COUNTY	FED. AID PROJ. No.	ROUTE No.	SHEET No.	TOTAL SHEETS
8	S. C.	CHESTER	11-REOP	21	1	22

STATE OF SOUTH CAROLINA
STATE HIGHWAY DEPARTMENT

PLAN AND PROFILE OF PROPOSED STATE HIGHWAY

FEDERAL AID PROJECT

No. 11-REOP.
CONTRACT NO. 2
~~U.S.~~ ROUTE NO. ~~21~~ 72/121 85-275

CHESTER COUNTY

CITY LIMITS OF CHESTER TO YORK COUNTY LINE

SCALES: PLAN AND PROFILE, 1 INCH = 100 FEET HORIZONTAL; 1 INCH = 10 FEET VERTICAL.

INDEX OF SHEETS

SUMMARY OF ESTIMATED QUANTITIES

STATION	SHEET NO.	ITEM	CONCRETE (CUBIC YARDS) CLASS "C"	CLASS "A"	CLASS "B"	REINFORCING STEEL (LBS.)	EXCAVATION (CU. YDS.) STRUCT.	DRY	PILES (LINEAL FEET) TREATED	UNTREATED		
	3	ENDWALLS FOR PIPE CULVERTS			50.60	99						
166+35	12 & 27	4×3×37 R.C. BOX CULVERT		17.70		1416	32					
184+65	13 & 27	4×3×37 R.C. BOX CULVERT		17.70		1416	16					
199+66	13 & 28	6×6×43 R.C. BOX CULVERT		46.00		3044	57					
212+60	14 & 29	4×4×43 R.C. BOX CULVERT		23.80		1838	19					
234+19	14 & 30	5×5×36 R.C. BOX CULVERT		29.70		2103	63					
237+15	14 & 31	4×3×28 R.C. BOX CULVERT		14.30		1116	26					
261+20	15 & 31	4×3×28 R.C. BOX CULVERT		14.30		1116	13					
271+40	16 & 32	3×3×40 R.C. BOX CULVERT		14.06		812	30					
~~281+05~~	~~16 & 33~~	~~5×5×28 R.C. BOX CULVERT~~		~~25.50~~		~~1150~~	~~46~~					
296+30	16 & 34	4×4×28 R.C. BOX CULVERT.		17.50		1250	28					
319+25	17 & 32	3×3×34 R.C. BOX CULVERT		12.44		704	25					
335+00	18 & 35	DOUBLE 4×4×28 R.C. BOX CULVERT		26.75		2151	44					
346+65	18 & 36	8×5×34 R.C. BOX CULVERT		46.00		3412	52					
		TOTALS		305.05	50.60	22,227	451					

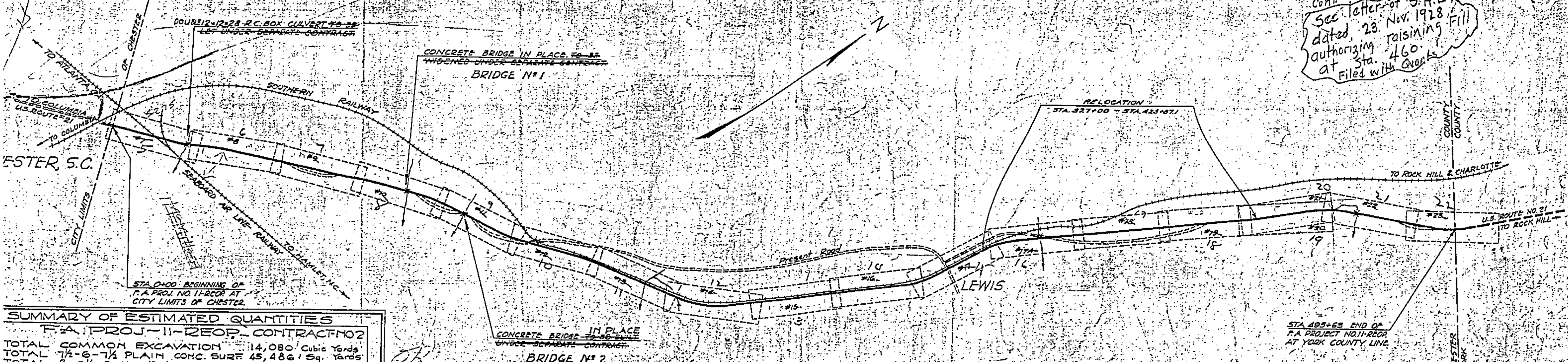
TOTAL PIPE FOR CULVERTS

DIAM.	GALVANIZED IRON	VITRIFIED CLAY	REINF. CONCRETE
15"	546 LINEAL FEET	—— LINEAL FEET	33 LINEAL FEET
18"	720 "	—— "	657 "
24"	150 "	—— "	186 "
30"	—— "	—— "	33 "
36"	—— "	—— "	33 "

TOTAL CLEARING & GRUBBING ON PITS	=	3.00 ACRES
TOTAL ROCK EXCAVATION	=	1015 CUBIC YARDS
TOTAL OVERHAUL ON EXCAVATION	=	15,515 CUBIC YARD STATIONS
TOTAL EXCAVATION — COMMON	=	* 81,251 CUBIC YARDS
TOTAL FINISHING EARTH GRADED ROADS	=	† 49,212 LINEAL FEET.
TOTAL CLEARING & GRUBBING WITHIN R/W	=	3.51 ACRES
TOTAL RIP RAP	=	225 TONS
TOTAL CATCH BASIN WITH GRATING	=	1 ONLY
TOTAL FEDERAL AID MARKERS	=	2 ONLY
TOTAL FEDERAL AID NUMBER PLATES	=	2 ONLY

~~* INCLUDES 560 C.Y. FOR DITCHES AND RAMPS.~~
~~* DOES NOT INCLUDE 1016 C.Y. ROCK EXCAVATION OR 819 C.Y. ESTIMATED SHELL.~~
~~† 353 LIN. FT. OMITTED FOR BRIDGES AND CULVERTS & R.R. CROSSINGS.~~

Cont. #1
See letter of S.H.E. dated 23 Nov. 1928 authorizing raisining Fill at sta. 460. Filed with Quants.



SUMMARY OF ESTIMATED QUANTITIES
F.A. PROJ-11-REOP. CONTRACT NO 2

TOTAL COMMON EXCAVATION	14,080 Cubic Yards
TOTAL 7½-6-7½ PLAIN CONC. SURF.	45,486 Sq. Yards
TOTAL 8-6½-8 " " "	52,655 Sq. Yards.
TOTAL LONG. JOINT SEPARATOR	26,327.5 Lin. Feet.
TOTAL TOP-SOIL (FOR SHOULDERS)	3,685 Cubic Yards
TOTAL OVERHAUL ON TOP-SOIL (C.Y.S.)	3,968 Cu. Yds. Sta.
TOTAL OVERHAUL ON TOP-SOIL (H.M.H.)	7,363 C.Y. H.Mi. Haul.
TOTAL LOW WOOD GUARD RAIL	4,460 Lin. Feet.

OK
OK H.J.B.

SUMMARY OF ESTIMATED QUANTITIES-BRIDGES

STATION	SHEET NO	ITEM	CONC "A" CU.YD.	STEEL LBS	EXCAVATION C.Y. DRY	WET	ROCK	RIP RAP TONS	PAVING SQ YD.	PILES	
27+10	7 & 24	12×12 Culvert	86	7935		150					
107+40	10 & 25	Bridge No 1	8	942							
129+25	11 & 26	" " 2	144	26968	87	130	7	200	164.4		
		Total	238	35645	87	280	7	200	164.4		

RELOCATION
STA 327+00 — STA 423+87.1

APPROVED DATE
[signature] 7-3-28
STATE HIGHWAY ENGR.

APPROVED DATE
[signature] 5-?-28
STATE HIGHWAY ENGINEER

CONTRACT NO. 2. 11-REOP APPROVED DATE
[signature] 3-13-29
STATE HIGHWAY ENGINEER.

CONVENTIONAL SIGNS

State Line, County Line, City or Town Limits, Property Line, Fence, Retaining Wall, Existing Road, C. and R.O.W. Lines of Proposed Road, Railroad, Levee or Embankment, Guard Rail, Point of Intersection (P.I.), Trolley Poles, Power Poles, Telephone or Telegraph Poles, Marsh, Trees, Brush, Stumps, Buildings, Bridge, Concrete Box Culvert, Pipe Culvert, Drop Inlet and Culvert, Hub on Center Line

LEGEND

PROPOSED PROJECT
OTHER ROADS

LAYOUT

Scale: 1 Inch = 1800 Feet.

Gross Length of Project =	9.387	Miles
Exceptions =	NONE	Miles
Net Length of Project =	9.387	Miles

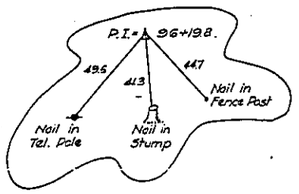
Equalities in Stationing
423+89.6=423+87.1

Note: All workmanship and material on this project to conform with South Carolina State Highway Department Specifications, Contract and Bond; for Roads and Culverts, revised May 1st, 1921 and for Bridges, revised Dec. 1st, 1921, as amended and approved by the U. S. Secretary of Agriculture.

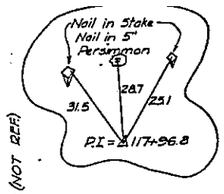
RECOMMENDED FOR APPROVAL DATE
[redacted]
DISTRICT ENGINEER — BUREAU OF PUBLIC ROADS
RECOMMENDED FOR APPROVAL DATE
[redacted]
CHIEF ENGINEER — BUREAU OF PUBLIC ROADS
APPROVED DATE
[redacted]
DIRECTOR — BUREAU OF PUBLIC ROADS

FED. ROAD DIST. NO.	STATE	COUNTY	FED. AID PROJ. NO.	ROUTE NO.	SHEET NO.	TOTAL SHEETS
8	S.C.	CHESTER	11-2(20)R	21	~~19~~ 8	~~30~~ 22

NOTE:
ON CONTRACT NO.2 SLAB IS TO BE REINFORCED FROM STA. 91+00 TO STA. 93+50

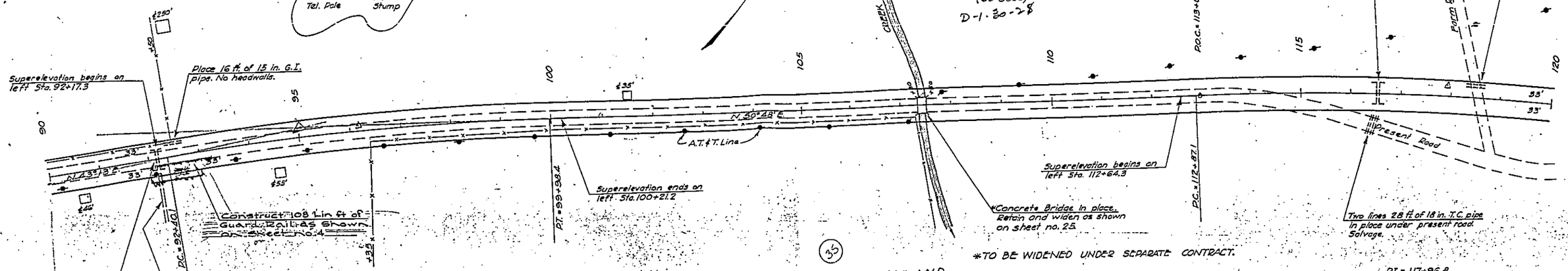


NOTE:
ON CONTRACT NO.2 SLAB IS TO BE REINFORCED ACROSS BRIDGE AND 25 FT. EACH SIDE.



(25) H. McCANDLESS [redacted] AND W.T. McCANDLESS (66' Deed) D-1-30-28

(35) H. McCANDLESS [redacted] AND W.T. McCANDLESS (66' Deed) D-1-30-29



Use 7½-6-7½ from Sta. 93+00 to Sta 107+30

Use 7½-6-7½ from Sta. 107+50 to Sta. 114+50

Use 8-6½-8 with Longitudinal Joint Separator from Sta. 114+50 to Sta. 119+50

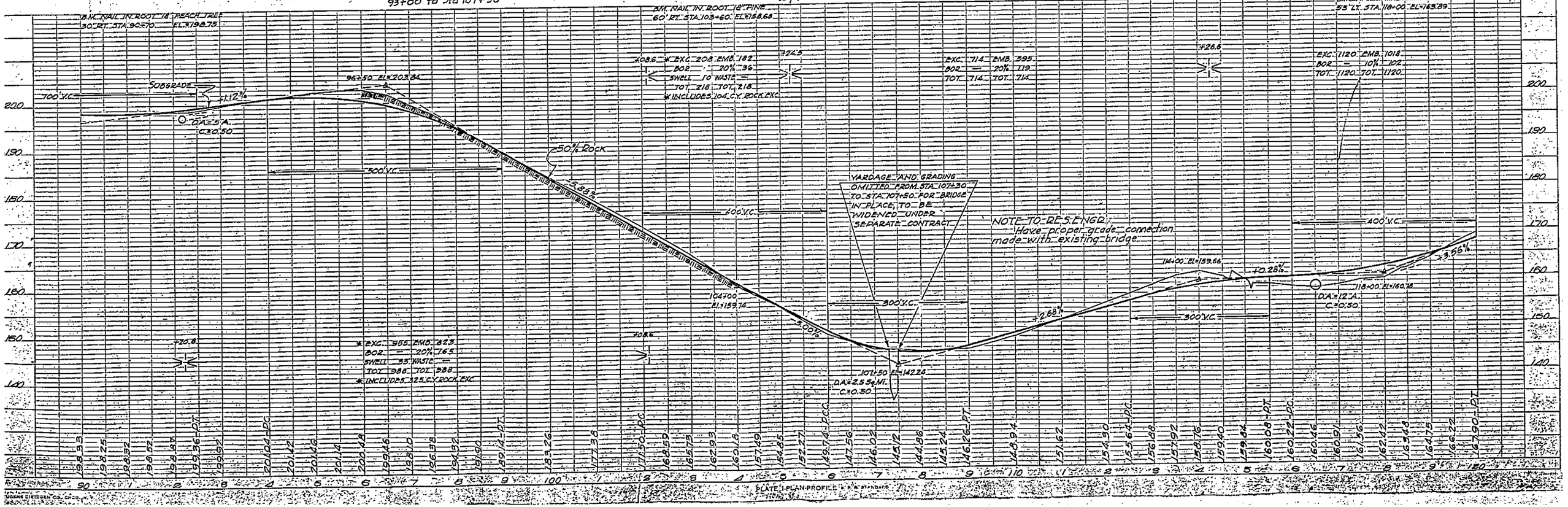
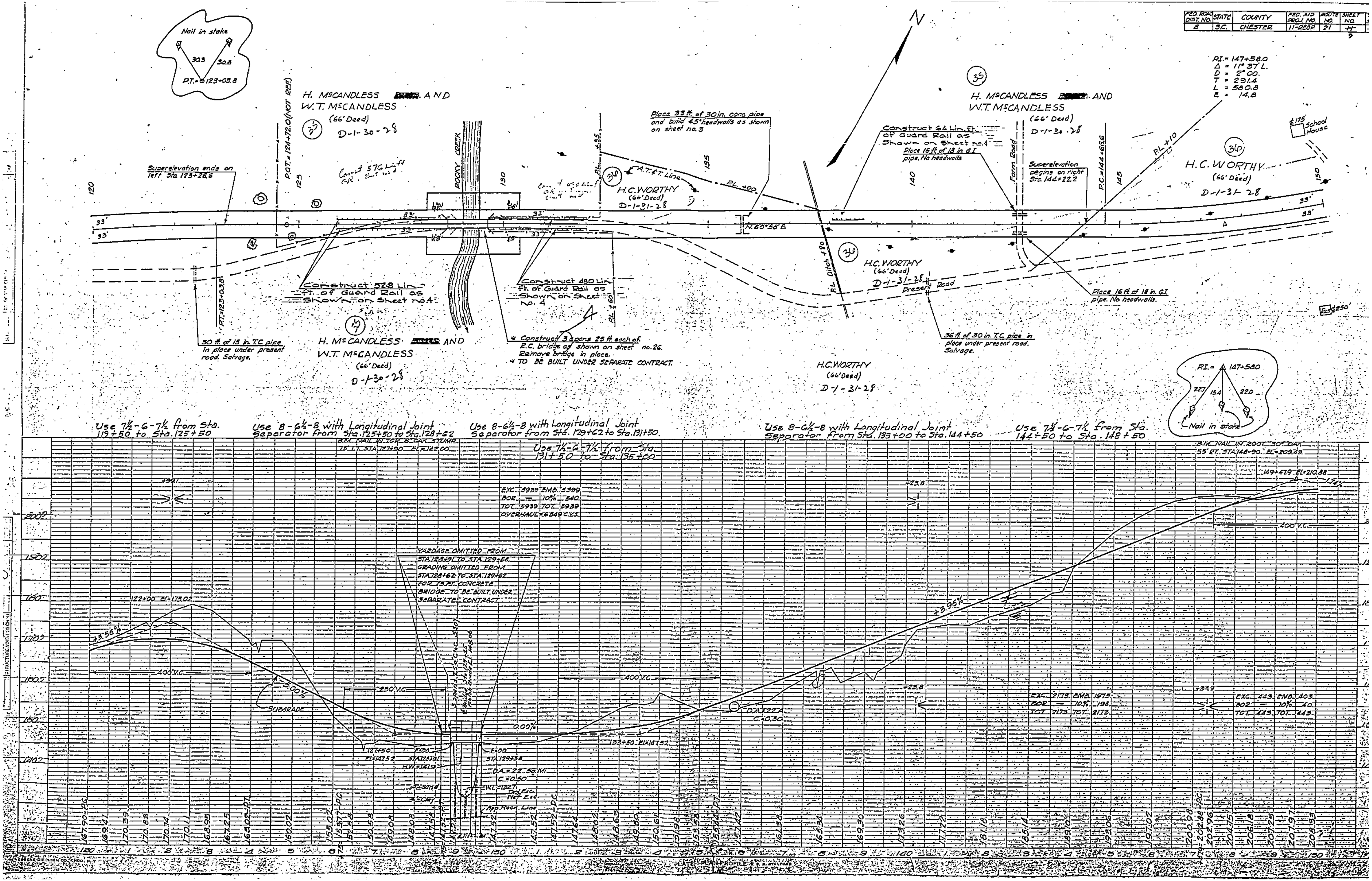


PLATE 1-PLAN-PROFILE

EUGENE DIETZGEN CO. CHICAGO


FED. ROAD DIST. NO. 8 | STATE S.C. | COUNTY CHESTER | FED. AID PROJ. NO. 11-REOP | ROUTE NO. 21 | SHEET NO. 9
Nail in stake
P.T. = 123+03.8
N
H. McCANDLESS AND W.T. McCANDLESS (66' Deed) D-1-30-28
H.C. WORTHY (66' Deed) D-1-31-28
P.I. = 147+58.0
Δ = 11° 37' L.
D = 2° 00.
T = 291.4
L = 580.8
E = 14.8
School House
Superelevation ends on left Sta. 123+26.6
Place 33 ft. of 30 in. conc. pipe and build 45° headwalls as shown on sheet no. 3
Construct 64 Lin. ft. of Guard Rail as Shown on Sheet no. 4
Place 16 ft. of 18 in. G.I. pipe. No headwalls
Superelevation begins on right Sta. 144+22.2
Farm Road
P.C. = 144+65.6
ROCKY CREEK
Construct 528 Lin. ft. of Guard Rail as Shown on Sheet no. 4
Construct 480 Lin. ft. of Guard Rail as Shown on Sheet no. 4
30 ft. of 15 in. T.C. pipe in place under present road. Salvage.
Construct 3 spans 25 ft. each of R.C. bridge as shown on sheet no. 26. Remove bridge in place.
TO BE BUILT UNDER SEPARATE CONTRACT.
Present Road
36 ft. of 30 in. T.C. pipe in place under present road. Salvage.
Place 16 ft. of 18 in. G.I. pipe. No headwalls.
N. 60° 58' E
Use 7½-6-7½ from Sta. 119+50 to Sta. 125+50
Use 8-6½-8 with Longitudinal Joint Separator from Sta. 125+50 to Sta. 128+62
Use 8-6½-8 with Longitudinal Joint Separator from Sta. 129+62 to Sta. 131+50.
Use 7½-6-7½ from Sta. 131+50 to Sta. 135+00
Use 8-6½-8 with Longitudinal Joint Separator from Sta. 135+00 to Sta. 144+50
Use 7½-6-7½ from Sta. 144+50 to Sta. 148+50
B.M. NAIL IN TOP 8" OAK STUMP 75' LT. STA. 127+90 EL = 147.00
B.M. NAIL IN ROOT 30" OAK 55' RT. STA. 148+90 EL = 209.29
EXC. 5939 EMB. 5399
BOR. 10% 540
TOT. 5939 TOT. 5939
OVERHAUL = 6349 C.Y.S.
YARDAGE OMITTED FROM STA. 128+91 TO STA. 129+58
GRADING OMITTED FROM STA. 128+62 TO STA. 129+62
FOR 75 FT. CONCRETE BRIDGE TO BE BUILT UNDER SEPARATE CONTRACT
122+00 EL = 175.02
+3.56%
-3.00%
400' V.C.
250' V.C.
SUBGRADE
0.00%
127+50 EL = 147.52
133+50 EL = 147.52
D.A. = 22.52 MI.
C = 0.50
400' V.C.
+3.96%
149+67.9 EL = 210.88
200' V.C.
EXC. 2173 EMB. 1975
BOR. 10% 198
TOT. 2173 TOT. 2173
EXC. 443 EMB. 403
BOR. 10% 40
TOT. 443 TOT. 443
D.A. = 22 A
C = 0.50
App. Rock Line
200
190
180
170
160
150
140
120
130
140
150

FED. ROAD DIV. NO.	STATE	COUNTY	DOCKET NO.	ROUTE NO.	SHEET NO.	TOTAL SHEETS
3	S.C.	Chester	12344	72	32	51

PILE RECORD ON DOCKET NO. 12344

ROCKY CREEK

WEIGHT OF HAMMER 3,300 lbs. TYPE Drop

DATE 1956	BENT NO.	FOOTING	Lt. or Rt.	DIAM AT BUTT.	DIAM. AT TIP	ORIG. LENGTH	BUILD-UP OR SPLICE	TOTAL LENGTH	LENGTH C.O.	NET LENGTH	ELEV. C.O. (Acc.)	ELEV. PILE TIP	ELEV. ORIG. GROUND OR BOTTOM OF FOOTING	PEN. IN GROUND OR BELOW FOOTING	PEN. PER BLOW	FALL OF HAMMER	BEARING VALUE Tons	PAY LENGTH L.F.	C.O. @ 40 %	C.O. @ 25 %
10-9	5	—	Lt.	10" "H"	—	30.00'	—	30.00'	1.17'	28.83'	144.69	115.96	143.44	27.48	0.65"	15'	30.0	28.83		
"	5	—	Rt.	"	—	30.00'	—	30.00'	2.50'	27.50'	"	117.79	143.44	26.15	0.65"	"	30.0	27.50'		
"	1	—	Rt.	"	—	30.00'	—	30.00'	2.21'	27.79'	"	117.00	143.44	26.44	0.53"	"	32.4	27.79		
"	1	—	Lt.	"	—	31.50'	—	31.50'	0.00'	31.50'	"	113.30	143.44	30.14	0.65"	"	30.0	31.50		
"	2	—	Lt.	"	—	30.40'	—	30.40'	0.00'	30.40'	"	114.40	135.64	21.24	0.63"	"	30.3	30.40		
"	3	—	Lt.	"	—	34.70'	2.00'	36.70'	0.00'	36.70'	"	108.12	131.74	23.62	0.65"	"	30.0	38.70		
"	4	—	Lt.	"	—	30.00'	—	30.00'	3.27'	26.73'	"	118.05	135.34	17.29	0.65"	"	30.0	26.73		
"	4	—	Rt.	"	—	30.00'	—	30.00'	2.12'	27.88'	"	116.91	135.24	18.33	0.58"	"	31.2	27.88		
"	3	—	Rt.	"	—	30.00'	—	30.00'	1.08'	28.92'	"	115.87	131.54	15.67	0.65"	"	30.0	28.92		
"	2	—	Rt.	"	—	30.00'	—	30.00'	3.93'	26.07'	"	118.71	136.94	18.23	0.63"	"	30.3	26.07		
																		294.32'		

	TOTAL LENGTH	LENGTH C.O.	NET LENGTH	PAY LENGTH
TOTAL	308.60'	16.28'	292.32'	294.32'
GRAND TOTAL	308.60'	16.28'	292.32'	294.32'

NOTES CONCERNING ANY UNUSUAL FOUNDATION CONDITIONS

BENT NO.	FOOTING	PILE NO.	REMARKS
2	—	Lt.	Pile driven 5" below cut-off before minimum bearing obtained – No splice.
3	—	Lt.	Pile driven 2' below cut-off before minimum bearing obtained – 2' splice necessary

NOTES:

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

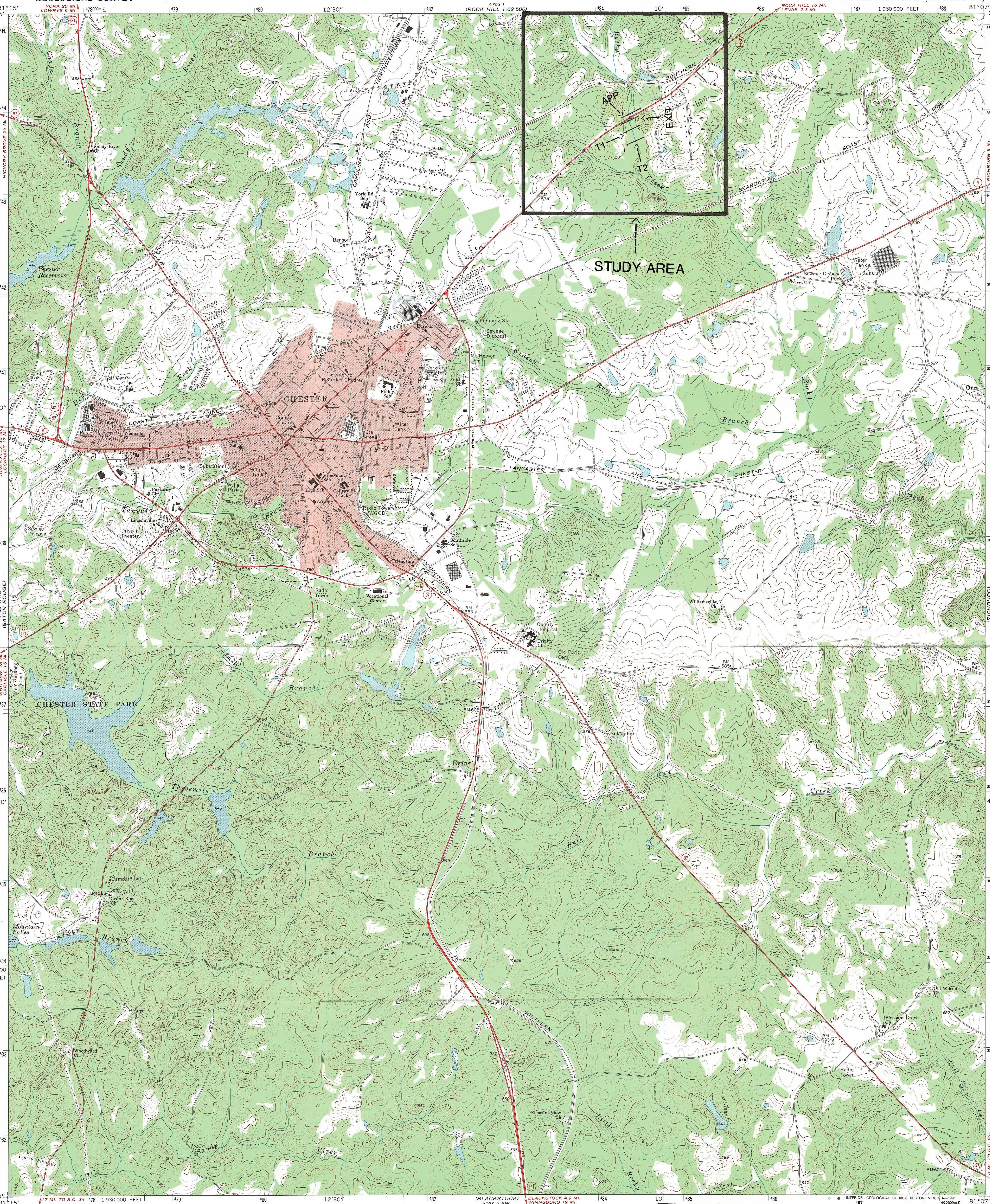
NUMBERING PILES: A SKETCH OF BENT OR FOOTING TO BE DRAWN ON THIS SHEET AND PILES TO BE NUMBERED, ALSO FLOW OF STREAM TO BE SHOWN.

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

PILE RECORD — DOCKET NO. 12344

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

CHESTER QUADRANGLE
SOUTH CAROLINA–CHESTER CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)



Mapped, edited, and published by the Geological Survey

Control by USGS and USC&GS

Topography by photogrammetric methods from aerial photographs taken 1968. Field checked 1969.

Polyconic projection. 1927 North American datum
10,000-foot grid based on South Carolina coordinate system, north zone
1000-meter Universal Transverse Mercator grid ticks, zone 17, shown in blue
The difference between 1927 North American Datum and North American Datum of 1983 (NAD 83) for 7.5-minute intersections is given in USGS Bulletin 1875. The NAD 83 is shown by dashed corner ticks

Fine red dashed lines indicate selected fence and field lines where generally visible on aerial photographs. This information is unchecked

Red tint indicates areas in which only landmark buildings are shown

UTM GRID AND 1969 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

Map photoinspected 1983
No major culture or drainage changes observed

SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

EXPLANATION

—— EXIT **cross section**

QUADRANGLE LOCATION

ROAD CLASSIFICATION

Primary highway, hard surface
Light-duty road, hard or improved surface
Secondary highway, hard surface
Unimproved road
Interstate Route
U. S. Route
State Route

INTERIOR—GEOLOGICAL SURVEY, RESTON, VIRGINIA—1991

CHESTER, S. C.
34081-F2-TF-024

1969
PHOTOINSPECTED 1983
DMA 4753 II NW—SERIES V846

36A

Figure 1.--Topography of study area and location of cross sections used in WSPRO analysis for structure 124007200700 on Route SC 72, crossing Rocky Creek in Chester County, South Carolina.