LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (TUNBTH00600032) on TOWN HIGHWAY 60, crossing the FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT

Open-File Report 98-013

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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By EMILY C. WILD

U.S. Geological Survey
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Pembroke, New Hampshire

1998

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	Max	maximum
D_{50}	median diameter of bed material	MC	main channel
DS	downstream	RAB	right abutment
elev.	elevation	RABUT	face of right abutment
f/p	flood plain	RB	right bank
ft^2	square feet	ROB	right overbank
ft/ft	feet per foot	RWW	right wingwall
FEMA	Federal Emergency Management Agency	TH	town highway
FHWA	Federal Highway Administration	UB	under bridge
JCT	junction	US	upstream
LAB	left abutment	USGS	United States Geological Survey
LABUT	face of left abutment	VTAOT	Vermont Agency of Transportation
LB	left bank	WSPRO	water-surface profile model
LOB	left overbank	yr	year

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.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (TUNBTH00600032) ON TOWN HIGHWAY 60, CROSSING THE FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure TUNBTH00600032 on Town Highway 60 crossing the First Branch White River, Tunbridge, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in central Vermont. The 92.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream and downstream of the bridge, while woody vegetation sparsely covers the immediate banks.

In the study area, the First Branch White River has a sinuous channel with a slope of approximately 0.001 ft/ft, an average channel top width of 82 ft and an average bank height of 7 ft. The channel bed material ranges from sand to gravel with a median grain size (D_{50}) of 24.4 mm (0.08 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 18, 1995, indicated that the reach was laterally unstable, as a result of block failure of moderately eroded banks.

The Town Highway 60 crossing of the First Branch White River is a 74-ft-long, one-lane bridge consisting of a 71-foot timber thru-truss span (Vermont Agency of Transportation, written communication, August 24, 1994). The opening length of the structure parallel to the bridge face is 64 ft.The bridge is supported by vertical, laid-up stone abutments with upstream wingwalls. The channel is not skewed to the opening. The computed opening-skew-to-roadway is 5 degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed in the upstream reach during the Level I assessment. Scour countermeasures at the site includes type-1 stone fill (less than 12 inches diameter) along the upstream right bank. Type-2 stone fill (less than 36 inches diameter) is present along the upstream right wingwall, the left abutment and the right abutment. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the maximum free-surface discharge was determined and analyzed as another potential worst-case scour scenarios. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 2.2 to 6.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 20.6 to 30.4 ft. Right abutment scour ranged from 9.7 to 19.5 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number TUNBTH00600032 ***Stream*** First Branch White River

County Orange ***Road*** TH60 ***District*** 4

Description of Bridge

Bridge length 74 ***ft*** ***Bridge width*** 13.5 ***ft*** ***Max span length*** 71 ***ft***

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

Abutment type Vertical, Laid-up Stone ***Embankment type*** None

Stone fill on abutment? Yes ***Date of inspection*** 10/18/95

Description of stone fill Type-1, along the upstream right bank. Type-2, along the upstream right wingwall, the left abutment and the right abutment.

Abutments and wingwalls are laid-up stone.

Yes 5

Is bridge skewed to flood flow according to No ***survey?*** ***Angle***

There is a mild channel bend in the upstream reach. A scour hole has developed in the location where the bend impacts the right channel bank.

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	10/18/95	0	0
Level II	10/18/95	0	0

Potential for debris Low. Some debris is caught on boulders. In the upstream reach, trees have fallen from the banks into the channel.

Describe any features near or at the bridge that may affect flow (include observation date) None, 10/18/95.

Description of the Geomorphic Setting

General topography The channel is located within a narrow, irregular flood plain with moderately sloped valley walls on both sides.

Geomorphic conditions at bridge site: downstream (DS), upstream (US)

Date of inspection 10/18/95

DS left: Steep channel bank to a narrow flood plain.

DS right: Steep channel bank to a moderately sloped overbank.

US left: Steep channel bank to a narrow flood plain.

US right: Steep channel bank to a moderately sloped overbank.

Description of the Channel

Average top width 82 ***ft*** ***Average depth*** 7 ***ft***

Predominant bed material Sand/ Gravel ***Bank material*** Silt/ Clay/ Sand

Sinuous but stable with alluvial channel boundaries and a narrow flood plain.

10/18/95

Vegetative co

DS left: Pasture.

DS right: Pasture and Vermont 110.

US left: Pasture.

US right: Pasture and Vermont 110.

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

Evidence of block failure, via moderate fluvial erosion, was reported along the banks in the vicinity of the bridge during the 10/18/95 site visit.

Describe any obstructions in channel and date of observation. None, 10/18/95.

Hydrology

Drainage area 92.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/New England Upland	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***:

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 14,660 ***ft³/s*** ***Q500*** 21,500 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(92.9/96)exp 0.7] with Flood Insurance Study discharge values at the Royalton/ Tunbridge corporate limits (Federal Emergency Management Agency, 1989). The Royalton/ Tunbridge corporate limits is downstream of this site on the First Branch White River.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a spike in a telephone pole, fifty feet from the right abutment (elev. 508.49 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the upstream left wingwall (elev. 504.21 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-71	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPR1	85	1	Approach section

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E.
For more detail on how cross-sections were developed see WSPRO input file.

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). The analyses reported herein reflect conditions existing at the site at the time of the study. Furthermore, in the development of the model it was necessary to assume no accumulation of debris or ice at the site. Results of the hydraulic model are presented in the Bridge Hydraulic Summary, appendix B, and figure 7.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.030 to 0.038, and overbank "n" values ranged from 0.030 to 0.060.

Normal depth at the exit section (EXIT1) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0013 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1981).

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face, as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 507.9 ***ft***
Average low steel elevation 505.9 ***ft***

100-year discharge 14,660 ***ft³/s***
Water-surface elevation in bridge opening 506.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 5,760 ***ft³/s***
Area of flow in bridge opening 827 ***ft²***
Average velocity in bridge opening 10.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.3 ***ft/s***

Water-surface elevation at Approach section with bridge 511.3
Water-surface elevation at Approach section without bridge 509.1
Amount of backwater caused by bridge 2.2 ***ft***

500-year discharge 21,500 ***ft³/s***
Water-surface elevation in bridge opening 506.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 13,150 ***ft³/s***
Area of flow in bridge opening 827 ***ft²***
Average velocity in bridge opening 10.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.0 ***/s***

Water-surface elevation at Approach section with bridge 513.9
Water-surface elevation at Approach section without bridge 512.1
Amount of backwater caused by bridge 1.8 ***ft***

Maximum free-surface discharge 7,510 ***ft³/s***
Water-surface elevation in bridge opening 504.4 ***ft***
Area of flow in bridge opening 735 ***ft²***
Average velocity in bridge opening 9.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.7 ***ft/s***

Water-surface elevation at Approach section with bridge 506.1
Water-surface elevation at Approach section without bridge 505.5
Amount of backwater caused by bridge 0.6 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the 100-year and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the maximum free-surface discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 100-year and 500-year discharges was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). For comparison, contraction scour for the 100-year and 500-year discharges also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). The results are presented in appendix F.

Abutment scour for the left abutment was computed by use of the Froehlich equation (Richardson and Davis, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour at the right abutment was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Maximum free-surface discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	6.7	6.8	2.2
Depth to armoring	N/A N/–	A N/–	A–
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Maximum free-surface discharge
Abutment scour			
Left abutment	28.2	30.4	20.6
Right abutment	16.7–	19.5-	9.7-
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Maximum free-surface discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.3	2.1	2.3
Right abutment	2.3	2.1	2.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

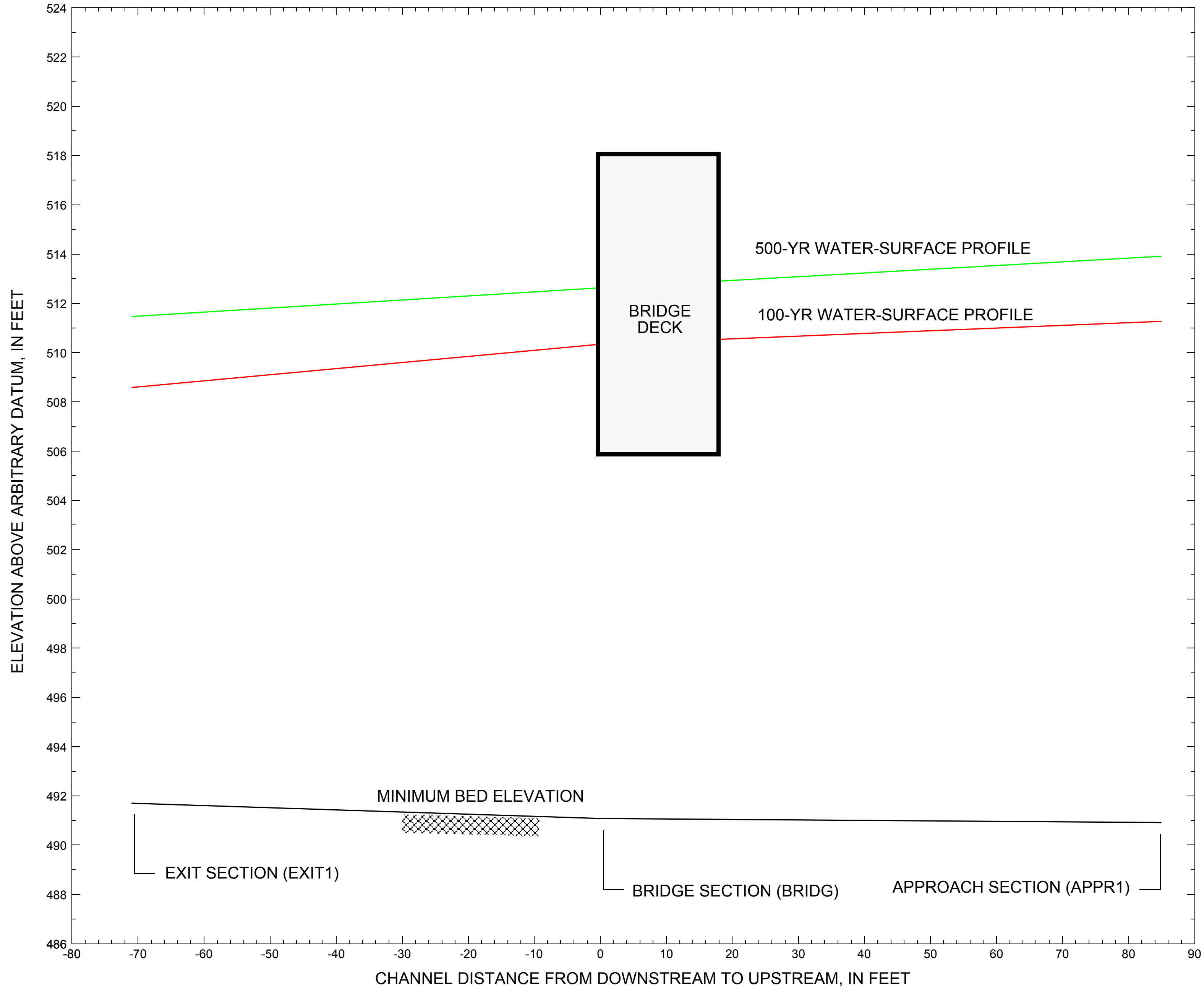

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure TUNBTH00600032 on Town Highway 60, crossing the First Branch White River, Tunbridge, Vermont.

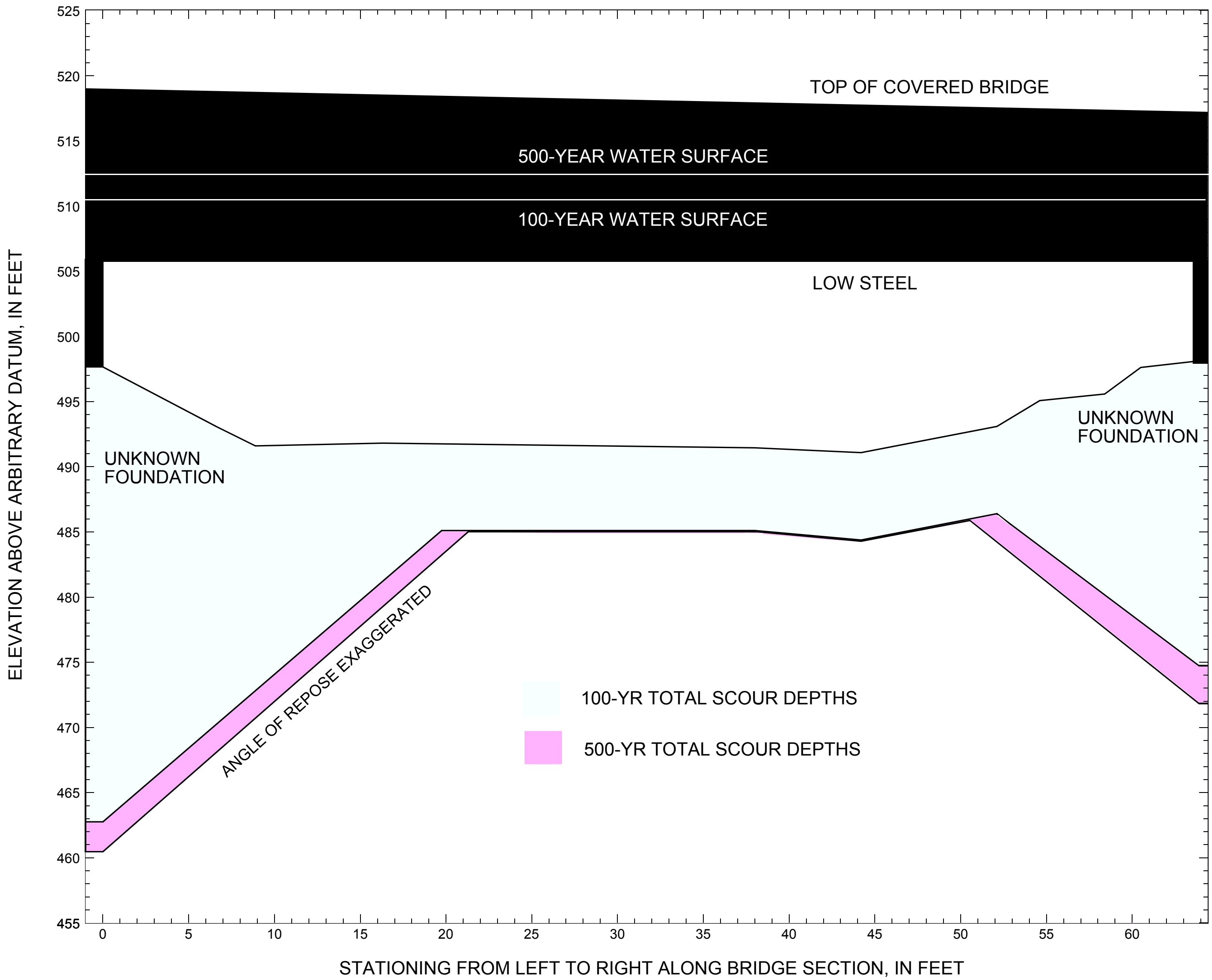

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure TUNBTH00600032 on Town Highway 60, crossing the First Branch White River, Tunbridge, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure TUNBTH00600032 on Town Highway 60, crossing the First Branch White River, Tunbridge, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 14,660 cubic-feet per second											
Left abutment	0.0	--	506.0	--	497.7	6.7	28.2	--	34.9	462.8	--
Right abutment	64.0	--	505.8	--	498.1	6.7	16.7	--	23.4	474.7	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-yr discharge at structure TUNBTH00600032 on Town Highway 60, crossing the First Branch White River, Tunbridge, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 21,500 cubic-feet per second											
Left abutment	0.0	--	506.0	--	497.7	6.8	30.4	--	37.2	460.5	--
Right abutment	64.0	--	505.8	--	498.1	6.8	19.5	--	26.3	471.8	--

1.Measured along the face of the most constricting side of the bridge.
2.Arbitrary datum for this study.

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U.S. Geological Survey, 1981, South Royalton, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File tunb032.wsp
T2        Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
T3        TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           14660.0  21500.0   7510.0
SK          0.0013   0.0013    0.0013
*
XS   EXIT1    -71           0.
GR         -219.3, 516.27   -204.3, 510.49   -165.1, 509.90   -139.7, 511.04
GR         -124.3, 511.97    -92.1, 511.92    -52.7, 501.80      0.0, 500.86
GR            9.4, 493.08     13.1, 491.83     22.4, 491.70     37.4, 491.88
GR           46.3, 492.05     60.9, 492.79     62.6, 493.08     69.3, 497.91
GR           82.1, 501.50    111.6, 501.04    120.5, 503.94    142.7, 503.89
GR          200.0, 518.36
*
N           0.030        0.038        0.030       0.060
SA                   0.0         82.1       142.7
*
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    505.86       5.0
GR            0.0, 505.95      0.0, 497.66      6.6, 493.10      8.9, 491.60
GR           16.3, 491.81     38.0, 491.45     44.2, 491.08     52.1, 493.09
GR           54.6, 495.08     58.4, 495.58     60.5, 497.62     63.9, 498.13
GR           64.0, 505.78      0.0, 505.95
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      25.9 * *     49.2      7.0
N           0.030
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      13.5     2
GR         -259.2, 515.14   -193.6, 512.64    -91.6, 509.46    -18.1, 507.55
GR           -5.9, 507.82     -5.9, 518.98     70.7, 517.15     70.7, 508.00
GR          113.6, 504.91    125.7, 504.54    146.6, 504.15    200.0, 518.36
*
*
*
AS   APPR1     85           0.
GR         -221.6, 514.73   -126.6, 514.36   -103.9, 504.15    -93.1, 501.49
GR          -11.6, 500.72     -5.2, 498.85      0.0, 497.95      7.2, 493.06
GR            9.7, 491.76     17.1, 491.75     26.4, 492.19     41.9, 490.92
GR           46.3, 491.05     49.0, 491.78     52.4, 492.03     52.8, 493.09
GR           55.3, 495.49     59.6, 495.42     69.0, 500.37    119.8, 501.23
GR          125.3, 504.05    129.3, 504.33    149.5, 504.05    162.8, 506.80
GR          182.3, 507.94    219.3, 518.36
*
N           0.030        0.038        0.030       0.060
SA                 -11.6         69.0       162.8
*
*
HP 1 BRIDG 505.95 1 505.95
HP 2 BRIDG 505.95 * * 8868
HP 2 RDWAY 510.34 * * 5756
HP 1 APPR1 511.27 1 511.27
HP 2 APPR1 511.27 * * 14660
*
HP 1 BRIDG 505.95 1 505.95
HP 2 BRIDG 505.95 * * 8662
HP 2 RDWAY 512.63 * * 13154
HP 1 APPR1 513.91 1 513.91
HP 2 APPR1 513.91 * * 21500
*
HP 1 BRIDG 504.42 1 504.42
HP 2 BRIDG 504.42 * * 7190
HP 2 RDWAY 506.00 * * 320
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File tunb032.wsp
        Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
        TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT      ECW
           *** RUN DATE & TIME: 10-14-97  16:56
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      827    129788      0    147                            0
   505.95           827    129788      0    147  1.00      0     64        0
    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       505.95     0.0    64.0   826.7  129788.    8868.  10.73

X STA.         0.0        6.2        9.6       12.4       15.1       17.7
  A(I)            64.6       45.3       39.8       38.3       37.6
  V(I)            6.86       9.79      11.15      11.58      11.80

X STA.        17.7       20.4       23.0       25.5       28.1       30.6
  A(I)            36.9       36.8       36.4       36.1       36.2
  V(I)           12.03      12.05      12.17      12.29      12.26

X STA.        30.6       33.2       35.7       38.3       40.8       43.3
  A(I)            36.2       36.3       36.8       36.7       36.9
  V(I)           12.26      12.23      12.06      12.07      12.00

X STA.        43.3       46.0       48.8       52.0       56.4       64.0
  A(I)            38.4       39.5       41.6       49.9       66.6
  V(I)           11.56      11.24      10.66       8.89       6.66
    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA        K        Q    VEL
       510.34  -119.8   169.9   611.6   63800.    5756.   9.41

X STA.      -119.8      -53.1      -32.2      -17.1       76.7       87.4
  A(I)            65.5       45.0       39.7       44.9       33.7
  V(I)            4.39       6.40       7.26       6.41       8.54

X STA.        87.4       94.5      100.5      105.6      110.0      114.1
  A(I)            27.0       25.5       23.9       22.1       22.0
  V(I)           10.67      11.27      12.04      13.05      13.09

X STA.       114.1      117.9      121.6      125.1      128.7      132.0
  A(I)            20.9       20.7       20.2       20.5       19.7
  V(I)           13.76      13.91      14.25      14.05      14.58

X STA.       132.0      135.3      138.6      141.8      147.9      169.9
  A(I)            19.7       19.5       19.7       37.1       64.3
  V(I)           14.61      14.76      14.62       7.76       4.47
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      976    207798    108    110                        16641
             2     1383    345844     81     86                        32506
             3      828    174581     94     95                        13970
             4       96      4955     31     32                          950
   511.27          3283    733179    314    322  1.06   -119    194    58483
    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
         WSEL     LEW     REW    AREA        K        Q    VEL
       511.27  -119.7   194.1  3283.2  733179.   14660.   4.47

X STA.      -119.7      -85.8      -68.5      -52.0      -36.5      -21.5
  A(I)           219.4      171.5      166.6      159.1      155.8
  V(I)            3.34       4.28       4.40       4.61       4.70

X STA.       -21.5       -5.8        6.5       13.9       20.7       27.5
  A(I)           170.1      174.2      141.8      133.1      131.2
  V(I)            4.31       4.21       5.17       5.51       5.59

X STA.        27.5       34.4       40.8       47.2       55.6       67.0
  A(I)           132.8      128.2      131.0      154.6      166.2
  V(I)            5.52       5.72       5.60       4.74       4.41

X STA.        67.0       81.8       96.6      112.6      134.3      194.1
  A(I)           161.4      156.7      164.2      183.3      281.9
  V(I)            4.54       4.68       4.46       4.00       2.60
```

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        U.S. Geological Survey WSPRO Input File tunb032.wsp
        Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
        TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
           *** RUN DATE & TIME: 10-14-97  16:56
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      827    129788      0    147                            0
   505.95           827    129788      0    147  1.00      0     64        0

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       505.95     0.0    64.0   826.7  129788.    8662.  10.48

X STA.         0.0         6.2         9.6        12.4        15.1        17.7
  A(I)             64.6        45.3        39.8        38.3        37.6
  V(I)             6.70        9.56       10.89       11.31       11.52

X STA.        17.7        20.4        23.0        25.5        28.1        30.6
  A(I)             36.9        36.8        36.4        36.1        36.2
  V(I)            11.75       11.77       11.89       12.00       11.97

X STA.        30.6        33.2        35.7        38.3        40.8        43.3
  A(I)             36.2        36.3        36.8        36.7        36.9
  V(I)            11.97       11.95       11.78       11.79       11.73

X STA.        43.3        46.0        48.8        52.0        56.4        64.0
  A(I)             38.4        39.5        41.6        49.9        66.6
  V(I)            11.29       10.97       10.42        8.69        6.50

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA        K        Q    VEL
       512.63  -193.3   178.5  1193.5  150523.   13154.  11.02

X STA.      -193.3      -103.6       -77.2       -57.7       -41.9       -28.5
  A(I)            125.4        84.1        74.1        67.3        62.2
  V(I)             5.24        7.82        8.88        9.77       10.58

X STA.       -28.5       -16.3        75.9        86.8        94.4       101.1
  A(I)             60.3        76.3        58.5        46.3        44.4
  V(I)            10.91        8.62       11.24       14.19       14.82

X STA.       101.1       107.0       112.4       117.5       122.3       127.1
  A(I)             41.5        40.0        39.7        38.0        38.4
  V(I)            15.84       16.45       16.55       17.30       17.12

X STA.       127.1       131.6       136.2       140.6       148.3       178.5
  A(I)             36.9        37.2        37.2        64.1       121.4
  V(I)            17.81       17.68       17.66       10.26        5.42

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1269    309959    114    116                        24033
             2     1596    439007     81     86                        40290
             3     1076    269961     94     95                        20681
             4      191     13090     41     42                         2344
   513.91          4132   1032017    329    339  1.07   -125    203    80386

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
         WSEL     LEW     REW    AREA        K        Q    VEL
       513.91  -125.6   203.5  4131.8 1032017.   21500.   5.20

X STA.      -125.6       -88.4       -72.0       -56.0       -40.9       -26.1
  A(I)            284.2       205.3       203.4       193.9       192.3
  V(I)             3.78        5.24        5.28        5.54        5.59

X STA.       -26.1       -11.7         3.2        12.5        20.1        28.0
  A(I)            188.6       226.9       194.0       169.1       172.3
  V(I)             5.70        4.74        5.54        6.36        6.24

X STA.        28.0        35.6        43.0        50.6        61.2        75.7
  A(I)            168.5       167.7       171.0       205.9       212.5
  V(I)             6.38        6.41        6.29        5.22        5.06

X STA.        75.7        89.7       104.6       119.7       142.5       203.5
  A(I)            185.9       195.5       192.6       229.9       372.4
  V(I)             5.78        5.50        5.58        4.68        2.89
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      U.S. Geological Survey WSPRO Input File tunb032.wsp
      Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
      TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
         *** RUN DATE & TIME: 10-14-97  16:56
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      735    159383     64     80                        14151
 504.42           735    159383     64     80  1.00      0     64    14151

  VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
       WSEL     LEW     REW    AREA        K        Q    VEL
     504.42     0.0    64.0   734.6  159383.    7190.   9.79

X STA.        0.0        7.0       10.3       13.1       15.8       18.4
  A(I)            63.6       41.5       35.5       33.9       33.1
  V(I)            5.65       8.67      10.14      10.61      10.87

X STA.       18.4       20.9       23.5       25.9       28.3       30.7
  A(I)            31.6       32.1       31.1       30.8       30.9
  V(I)           11.38      11.22      11.56      11.66      11.62

X STA.       30.7       33.1       35.5       37.9       40.3       42.8
  A(I)            30.7       30.8       31.2       31.2       32.1
  V(I)           11.73      11.69      11.52      11.53      11.18

X STA.       42.8       45.3       48.1       51.2       55.5       64.0
  A(I)            33.0       35.1       37.1       44.9       64.5
  V(I)           10.88      10.23       9.69       8.01       5.57
  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
       WSEL     LEW     REW    AREA        K        Q    VEL
     506.00    98.5   153.6    64.7    3183.     320.   4.95

X STA.       98.5      111.2      114.9      117.9      120.5      122.8
  A(I)             5.8        3.9        3.5        3.3        3.1
  V(I)            2.75       4.11       4.53       4.90       5.23

X STA.      122.8      124.9      126.8      128.6      130.4      132.0
  A(I)             2.9        2.8        2.7        2.7        2.6
  V(I)            5.47       5.62       6.01       5.97       6.23

X STA.      132.0      133.6      135.1      136.6      138.0      139.4
  A(I)             2.5        2.5        2.4        2.3        2.3
  V(I)            6.36       6.45       6.62       6.82       6.82

X STA.      139.4      140.7      142.0      143.7      146.4      153.6
  A(I)             2.3        2.2        3.1        4.9        6.8
  V(I)            7.01       7.12       5.18       3.26       2.35
  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      444     60631     97     97                         5400
           2      964    189468     81     86                        18913
           3      342     40996     90     91                         3777
 506.07          1750    291094    267    274  1.12   -107    159    23971

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      85.
       WSEL     LEW     REW    AREA        K        Q    VEL
     506.07  -108.2   159.3  1749.6  291094.    7510.   4.29

X STA.     -108.2      -75.3      -53.5      -33.2      -14.7        1.6
  A(I)           122.4      105.4      102.6       97.2      109.9
  V(I)            3.07       3.56       3.66       3.86       3.42

X STA.        1.6        8.8       13.7       18.3       23.0       27.7
  A(I)            84.2       69.5       65.9       66.7       65.7
  V(I)            4.46       5.40       5.70       5.63       5.71

X STA.       27.7       32.3       36.7       41.0       45.3       49.8
  A(I)            65.1       64.7       63.5       64.2       67.2
  V(I)            5.77       5.80       5.91       5.85       5.59

X STA.       49.8       56.3       65.7       83.6      103.8      159.3
  A(I)            81.9       89.7      103.1      106.7      154.0
  V(I)            4.59       4.19       3.64       3.52       2.44
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       U.S. Geological Survey WSPRO Input File tunb032.wsp
       Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
       TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
          *** RUN DATE & TIME: 10-14-97  16:56

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

EXIT1:XS   ******    -78     2077  0.85 *****  509.43  504.69   14660  508.58
       -70 ******    161   406237  1.10 ***** *******    0.44    7.06

FULLV:FV       71    -79     2108  0.82  0.09  509.53 *******   14660  508.71
         0     71    162   414974  1.10  0.00    0.01    0.43    6.95
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       85   -114     2613  0.52  0.08  509.61 *******   14660  509.09
        85     85    186   523040  1.07  0.00    0.00    0.35    5.61
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   508.71     505.86

            <<<<<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       71      0      827  1.79 *****  507.74  501.35    8868  505.95
         0 ******     64   129788  1.00 ***** *******    0.53   10.73

    TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
      1. ****   6.  0.800  0.000  505.86 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG       9.    72.  0.03  0.33  511.57    0.00   5756.  510.34

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:   1651.   114.  -120.    -6.   2.8   1.6   7.7   9.2   2.8   3.1
  RT:   4105.    99.    71.   170.   6.2   4.4  11.1   9.5   5.6   3.1

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

APPR1:AS       59   -119     3284  0.33  0.10  511.60  504.04   14660  511.27
        85     69    194   733385  1.06  0.00    0.00    0.25    4.46

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

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
  EXIT1:XS     -71.   -79.   161.  14660.  406237.    2077.    7.06  508.58
  FULLV:FV       0.   -80.   162.  14660.  414974.    2108.    6.95  508.71
  BRIDG:BR       0.     0.    64.   8868.  129788.     827.   10.73  505.95
  RDWAY:RG       9.******* 1651.   5756.******************    2.00  510.34
  APPR1:AS      85.  -120.   194.  14660.  733385.    3284.    4.46  511.27

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXIT1:XS    504.69    0.44  491.70  518.36************  0.85  509.43  508.58
  FULLV:FV  ********    0.43  491.70  518.36  0.09  0.00  0.82  509.53  508.71
  BRIDG:BR    501.35    0.53  491.08  505.95************  1.79  507.74  505.95
  RDWAY:RG  ****************  504.15  518.98  0.03******  0.33  511.57  510.34
  APPR1:AS    504.04    0.25  490.92  518.36  0.10  0.00  0.33  511.60  511.27
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       U.S. Geological Survey WSPRO Input File tunb032.wsp
       Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
       TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
          *** RUN DATE & TIME: 10-14-97  16:56

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

EXIT1:XS   ******   -206     2881  1.04 *****  512.50  506.37   21500  511.46
       -70 ******    173   596153  1.20 ***** *******    0.49    7.46

FULLV:FV       71   -206     2920  1.01  0.09  512.59 *******   21500  511.58
         0     71    173   606184  1.20  0.00    0.00    0.49    7.36
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       85   -121     3539  0.61  0.08  512.69 *******   21500  512.08
        85     85    197   819648  1.06  0.00    0.02    0.33    6.08
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   511.58     505.86

           <<<<<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       71      0      827  1.71 *****  507.66  501.20    8662  505.95
         0 ******     64   129788  1.00 ***** *******    0.51   10.48

     TYPE PPCD FLOW       C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  505.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    72.  0.03  0.45  514.33    0.01  13154.  512.63

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   5658.   187.  -193.    -6.   5.1   2.8  10.1  10.8   4.5   3.2
   RT:   7496.   108.    71.   178.   8.5   6.2  13.2  11.2   7.9   3.1

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

APPR1:AS       59   -125     4132  0.45  0.12  514.36  505.80   21500  513.91
        85     71    203  1031980  1.07  0.00    0.01    0.27    5.20

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -71.  -207.   173.  21500.  596153.    2881.    7.46  511.46
   FULLV:FV       0.  -207.   173.  21500.  606184.    2920.    7.36  511.58
   BRIDG:BR       0.     0.    64.   8662.  129788.     827.   10.48  505.95
   RDWAY:RG       9.*******  5658.  13154.*****************    2.00  512.63
   APPR1:AS      85.  -126.   203.  21500. 1031980.    4132.    5.20  513.91

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    506.37    0.49  491.70  518.36************  1.04  512.50  511.46
   FULLV:FV  ********    0.49  491.70  518.36  0.09  0.00  1.01  512.59  511.58
   BRIDG:BR    501.20    0.51  491.08  505.95************  1.71  507.66  505.95
   RDWAY:RG  ****************  504.15  518.98  0.03******  0.45  514.33  512.63
   APPR1:AS    505.80    0.27  490.92  518.36  0.12  0.00  0.45  514.36  513.91

      U.S. Geological Survey WSPRO Input File tunb032.wsp
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```
        Hydraulic analysis for structure TUNBTH00600032   Date: 04-SEP-97
        TOWN HIGHWAY 60, FIRST BRANCH WHITE RIVER, TUNBRIDGE, VERMONT     ECW
           *** RUN DATE & TIME: 10-14-97  16:56

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

EXIT1:XS   ******    -65     1289  0.61 *****  505.71  500.34    7510  505.10
       -70 ******    148   208279  1.16 ***** *******    0.45    5.83

FULLV:FV       71    -65     1316  0.58  0.09  505.81 *******    7510  505.23
         0     71    148   214273  1.15  0.00    0.01    0.44    5.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       85   -106     1599  0.39  0.09  505.90 *******    7510  505.50
        85     85    157   256069  1.14  0.00   -0.01    0.36    4.70
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   506.12       0.00     504.28     504.15

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   504.42     506.00     506.07     505.86

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

 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.10     507.11     507.18

 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       71      0      735  1.85  0.12  506.27  500.24    7190  504.42
         0     71     64   159390  1.24  0.44    0.00    0.57    9.79

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.898 ******  505.86 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG       9.    72.  0.05  0.32  506.36    0.00    320.  506.00

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    40.   -46.    -6.   0.7   0.4   4.9   9.4   1.3   2.9
   RT:   320.    55.    99.   154.   1.8   1.2   5.7   5.0   1.5   3.0

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

APPR1:AS       59   -107     1751  0.32  0.08  506.40  501.82    7510  506.07
        85     66    159   291397  1.12  0.05    0.00    0.31    4.29

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.757  0.389  178021.    -3.    61. ********

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -71.   -66.   148.   7510.  208279.    1289.    5.83  505.10
   FULLV:FV       0.   -66.   148.   7510.  214273.    1316.    5.71  505.23
   BRIDG:BR       0.     0.    64.   7190.  159390.     735.    9.79  504.42
   RDWAY:RG       9.*******     0.    320.       0.*********    2.00  506.00
   APPR1:AS      85.  -108.   159.   7510.  291397.    1751.    4.29  506.07

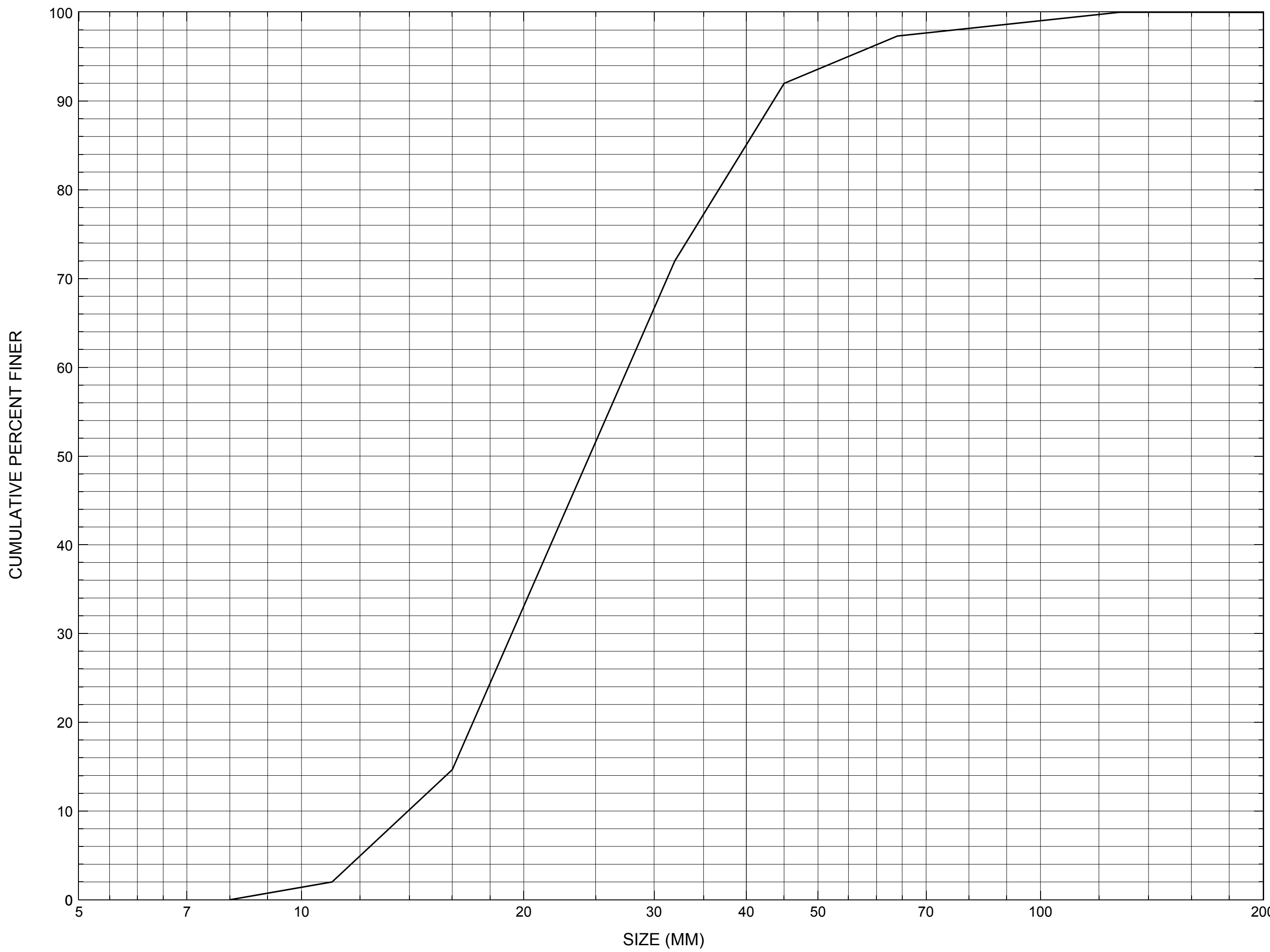
    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS      -3.    61.  178021.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO  VHD      EGL    WSEL
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure TUNBTH00600032, in Tunbridge, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number TUNBTH00600032

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 23 / 95

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 017

Town *(FIPS place code; I - 4; nnnnn)* 73675

Mile marker *(I - 11; nnn.nnn)* 000000

Waterway *(I - 6)* FIRST BRANCH WHITE RIVER

Road Name *(I - 7):* -

Route Number TH060

Vicinity *(I - 9)* AT JCT TH 60 + VT 110

Topographic Map Sharon

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43518

Longitude *(i - 17; nnnnn.n)* 72299

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10091300320913

Maintenance responsibility *(I - 21; nn)* 03

Maximum span length *(I - 48; nnnn)* 0071

Year built *(I - 27; YYYY)* 1879

Structure length *(I - 49; nnnnnn)* 000074

Average daily traffic, ADT *(I - 29; nnnnnn)* 000050

Deck Width *(I - 52; nn.n)* 135

Year of ADT *(I - 30; YY)* 91

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 00

Waterway adequacy *(I - 71; n)* 6

Operational status *(I - 41; X)* P

Underwater Inspection Frequency *(I - 92B; XYY)* N

Structure type *(I - 43; nnn)* 710

Year Reconstructed *(I - 106)* 0000

Approach span structure type *(I - 44; nnn)* 000

Clear span (*nnn.n ft*) -

Number of spans *(I - 45; nnn)* 001

Vertical clearance from streambed (*nnn.n ft*) 013.5

Number of approach spans *(I - 46; nnnn)* 0000

Waterway of full opening (*nnn.n ft*^{2}) -

Comments:

The structural inspection report of 11/1/93 indicates the structure is a timber thru-truss, multiple king post type covered bridge. The abutments are constructed of "laid-up" stone, which are reported in stable condition. There is a concrete wingwall extending from the upstream end of the left abutment, which has a few random cracks noted. The type of foundation recorded is an unknown foundation below the abutments. The report indicates the footings are not exposed, or undermined, and the abutments show no signs of settling significantly. Channel scour, bank erosion, and debris accumulation are reported as not a problem at this site. There is no indication on the report of any stonefill protection **(Continued, page 35)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

Record flood date *(MM / DD / YY)*: - / / Water surface elevation *(ft)*: -

Estimated Discharge *(cfs)*: - Velocity at Q - *(ft/s)*: -

Ice conditions *(Heavy, Moderate, Light)* : - Debris *(Heavy, Moderate, Light)*: -

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

Watershed storage area (*in percent*): -%

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): U Frequency: -

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft³/ sec*): -

Are there other structures nearby? (*Yes, No, Unknown*): U *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : - Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

Downstream distance (*miles*): - Town: - Year Built: -

Highway No. : - Structure No. : - Structure Type: -

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

at this site. The report does note that the waterway has a slight bend into the crossing and the streambed consists of sand and stone.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **92.87** mi^2 Lake/pond/swamp area **0.09** mi^2

Watershed storage *(ST)* **0.1** %

Bridge site elevation **500** ft Headwater elevation **1700** ft

Main channel length **19.30** mi

10% channel length elevation **520** ft 85% channel length elevation **1220** ft

Main channel slope *(S)* **48.36** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:
NO BENCHMARK INFORMATION

Reference Point (*MSL, Arbitrary, Other*): - Datum (*NAD27, NAD83, Other*): -

Foundation Type: 4 (*1-Spreadfooting; 2-Pile; 3- Gravity; 4-Unknown*)

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

Foundation Material Type: 3 (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS.

Cross-sectional Data

Is cross-sectional data available? N *If no, type ctrl-n xs*

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

Source (*FEMA, VTAOT, Other*)? -

Comments: **NO CROSS SECTION INFORMATION**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

U. S. Geological Survey
Bridge Field Data Collection and Processing Form

Qa/Qc Check by: **RB** Date: **4/10/96**
Computerized by: **RB** Date: **4/10/96**
Reviewd by: **EW** Date: **10/17/97**

Structure Number **TUNBTH00600032**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **10** / **18** / 19**95**

2. Highway District Number **04** Mile marker **000**

County **ORANGE (017)** Town **TUNBRIDGE (73675)**

Waterway *(I - 6)* **FIRST BRANCH WHITE RIVER** Road Name **-**

Route Number **TH60** Hydrologic Unit Code: **01080105**

3. Descriptive comments:
Located at the junction with VT 110. The bridge deck structure was replaced in 1994 and stone fill was added at the abutments.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** Overall **4**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **1** UB **1** DS **1** *(**1**- pool; **2**- riffle)*

6. Bridge structure type **1** *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length **74** *(feet)* Span length **71** *(feet)* Bridge width **13.5** *(feet)*

Road approach to bridge:

8. LB **0** RB **1** *(**0** even, **1**- lower, **2**- higher)*

9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*

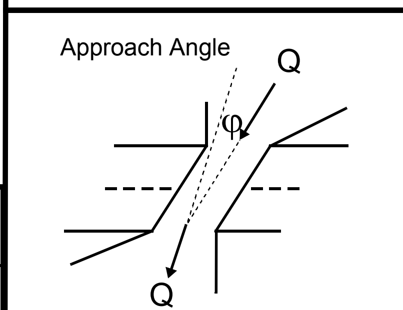
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

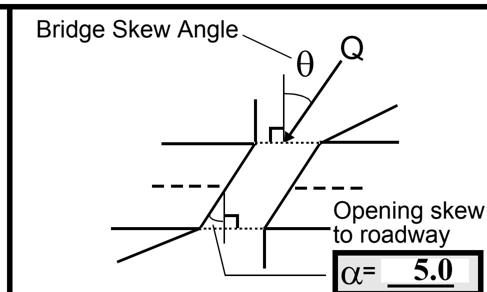
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	5	1	0	-
RBUS	5	1	0	-
RBDS	5	1	0	-
LBDS	5	1	0	-

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **0** 16. Bridge skew: **0**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **20** feet **US** *(US, UB, DS)* to **90** feet **US**

Channel impact zone 2: Exist? **N** *(Y or N)*
Where? **-** *(LB, RB)* Severity **-**
Range? **-** feet **-** *(US, UB, DS)* to **-** feet **-**

*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **1a**

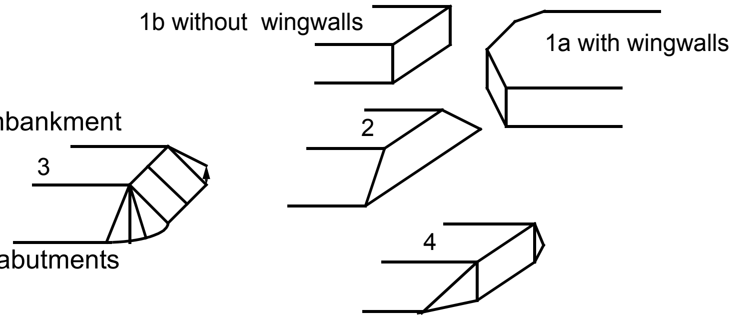
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

7. Values are from the VT AOT database.

4. VT 110 is 50 feet from the right abutment and runs along the right bank.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
68.5	**7.5**			**5.0**	**2**	**2**	**12**	**12**	**2**	**2**

23. Bank width **20.0** 24. Channel width **30.0** 25. Thalweg depth **80.5** 29. Bed Material **23**

30 .Bank protection type: LB **0** RB **1** 31. Bank protection condition: LB **-** RB **1**

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

32. Comments (bank material variation, minor inflows, protection extent, etc.):

30. The right bank protection extends 18 feet US of the bridge beyond the end of the wingwall. There is a spattering of stone fill protection along both banks US extending beyond 300 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **110** 35. Mid-bar width: **18**

36. Point bar extent: **100** feet **US** (US, UB) to **125** feet **US** (US, UB, DS) positioned **40** %LB to **60** %RB

37. Material: **3**

38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):

This is a gravel, mid-channel bar.

39. Is a cut-bank present? **Y** (Y or if N type ctrl-n cb) 40. Where? **RB** (LB or RB)

41. Mid-bank distance: **66** 42. Cut bank extent: **18** feet **US** (US, UB) to **100** feet **US** (US, UB, DS)

43. Bank damage: **3** (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

44. Cut bank comments (eg. additional cut banks, protection condition, etc.):

There is block failure from 45 to 82 feet US. The banks are over steepened US to the stone fill bridge protection. The left bank is also eroded beyond 300 feet US.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **80**

47. Scour dimensions: Length **50** Width **10** Depth : **1** Position **80** %LB to **100** %RB

48. Scour comments (eg. additional scour areas, local scouring process, etc.):

The channel is deepened 120 feet US to 70 feet US along the right bank at the bend in the channel.

49. Are there major confluences? **N** (Y or if N type ctrl-n mc) 50. How many? **-**

51. Confluence 1: Distance **-** 52. Enters on **-** (LB or RB) 53. Type **-** (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance **-** Enters on **-** (LB or RB) Type **-** (**1**- perennial; **2**- ephemeral)

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB ____ (**1**- natural bank; **2**- abutment; **3**- artificial levee)

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
52.5		2.0		2	7	7	-

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **90.0** 63. Bed Material **-**

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*

*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):

2

-

65. Debris and Ice Is there debris accumulation? ____ *(Y or N)* 66. Where? **Y** *(1- Upstream; 2- At bridge; 3- Both)*

67. Debris Potential **1** *(1- Low; 2- Moderate; 3- High)* 68. Capture Efficiency **1** *(1- Low; 2- Moderate; 3- High)*

69. Is there evidence of ice build-up? **1** *(Y or N)* Ice Blockage Potential **N** *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

1

There are fallen trees along the US banks.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**0**	**0**	**0**	**90.0**
RABUT	**2**	**0**	**90**			**2**	**0**	**64.0**

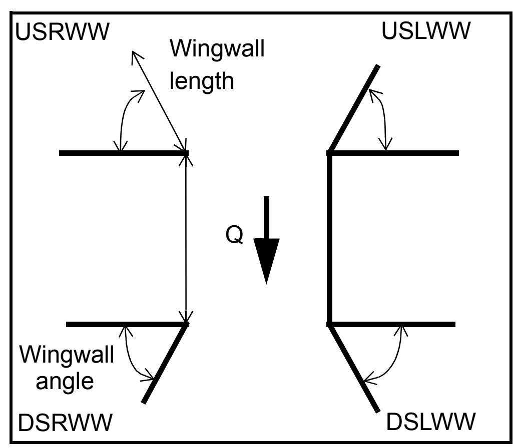
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0
2
-

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**64.0**	
USRWW:	**Y**		**1**		**0**	**1.5**	
DSLWW:	**0**		**0**		**Y**	**18.0**	
DSRWW:	**2**		**0**		**0**	**17.5**	



Wingwall materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**0**	**-**	**N**	**-**	**-**	**1**	**1**	**1**
Condition	**N**	**-**	**-**	**-**	**-**	**1**	**1**	**1**
Extent	**-**	**-**	**-**	**0**	**2**	**2**	**2**	**-**

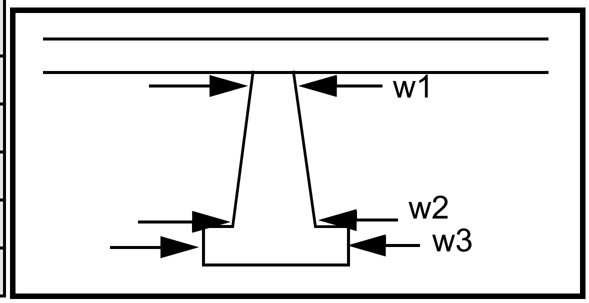
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
-
-
-

Piers:

84. Are there piers? ___-___ *(Y or if N type ctrl-n pr)*

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**9.5**		**50.0**	**50.0**	**11.5**
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**N**	-	-	-	
98. Exposure depth	-	-	-	-	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	NO	PIE	RS		

Bank width (BF) - Channel width - Thalweg depth - Bed Material ____

Bank protection type (Qmax): LB ____ RB ____ Bank protection condition: LB ____ RB ____

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover:* ***1****- 0 to 25%;* ***2****- 26 to 50%;* ***3****- 51 to 75%;* ***4****- 76 to 100%*
Bed and bank Material: ***0****- organics;* ***1****- silt / clay, < 1/16mm;* ***2****- sand, 1/16 - 2mm;* ***3****- gravel, 2 - 64mm;* ***4****- cobble, 64 - 256mm;* ***5****- boulder, > 256mm;* ***6****- bedrock;* ***7****- manmade*
Bank Erosion: ***0****- not evident;* ***1****- light fluvial;* ***2****- moderate fluvial;* ***3****- heavy fluvial / mass wasting*
Bank protection types: ***0****- absent;* ***1****- < 12 inches;* ***2****- < 36 inches;* ***3****- < 48 inches;* ***4****- < 60 inches;* ***5****- wall / artificial levee*
Bank protection conditions: ***1****- good;* ***2****- slumped;* ***3****- eroded;* ***4****- failed*

Comments (eg. bank material variation, minor inflows, protection extent, etc.):

1
1
12
12
2
2
23
0
0
-
-
The bed material consists of sand and some gravel. The banks are silt, clay and sand.
Protection along the right bank begins 350 feet DS of the bridge for the VT 110 road embankment.

101. Is a drop structure present? ____ *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: ____ *(****1****- steel sheet pile;* ***2****- wood pile;* ***3****- concrete;* ***4****- other)*

105. Drop structure comments (eg. downstream scour depth):

106. Point/Side bar present? _____ *(Y or N. if N type ctrl-n pb)* Mid-bar distance: ______ Mid-bar width: ______

Point bar extent: _______ feet _____ *(US, UB, DS)* to **N** feet **-** *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

Point or side bar comments (Circle Point or Side; note additional bars, material variation, status, etc.):

STRUCTURE

Is a cut-bank present? _____ *(Y or if N type ctrl-n cb)* Where? _____ *(LB or RB)* Mid-bank distance: **N**

Cut bank extent: **-** feet **-** *(US, UB, DS)* to **-** feet **-** *(US, UB, DS)*

Bank damage: **-** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

Cut bank comments (eg. additional cut banks, protection condition, etc.):

-
-
-
-

Is channel scour present? **NO** *(Y or if N type ctrl-n cs)* Mid-scour distance: **POIN**

Scour dimensions: Length **T** Width **BAR** Depth: **S** Positioned ____ %LB to ____ %RB

Scour comments (eg. additional scour areas, local scouring process, etc.):

Y
RB
140

Are there major confluences? **10** *(Y or if N type ctrl-n mc)* How many? **DS**

Confluence 1: Distance **235** Enters on **DS** *(LB or RB)* Type **3** *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance **The** Enters on **left** *(LB or RB)* Type **ban** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

k is also cut with moderate fluvial erosion from the bridge to over 300 feet DS.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

1- *Constructed*
2- *Stable*
3- *Aggraded*
4- *Degraded*
5- *Laterally unstable*
6- *Vertically and laterally unstable*

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

- -

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: TUNBTH00600032 Town: TUNBRIDGE
Road Number: TH 6 County: ORANGE
Stream: FIRST BRANCH WHITE RIVER

Initials ECW Date: 10/15/97 Checked: MAI

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	Maximum Free-Surface
Total discharge, cfs	14660	21500	7510
Main Channel Area, ft2	1383	1596	964
Left overbank area, ft2	976	1269	444
Right overbank area, ft2	924	1267	342
Top width main channel, ft	81	81	81
Top width L overbank, ft	108	114	97
Top width R overbank, ft	125	135	90
D50 of channel, ft	0.0799	0.0799	0.0799
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	17.1	19.7	11.9
y1, average depth, LOB, ft	9.0	11.1	4.6
y1, average depth, ROB, ft	7.4	9.4	3.8
Total conveyance, approach	733179	1032017	291094
Conveyance, main channel	345844	439007	189468
Conveyance, LOB	207798	309959	60631
Conveyance, ROB	179536	283051	40996
Percent discrepancy, conveyance	0.0001	0.0000	-0.0003
Qm, discharge, MC, cfs	6915.2	9145.8	4888.1
Ql, discharge, LOB, cfs	4154.9	6457.4	1564.2
Qr, discharge, ROB, cfs	3589.8	5896.8	1057.7
Vm, mean velocity MC, ft/s	5.0	5.7	5.1
Vl, mean velocity, LOB, ft/s	4.3	5.1	3.5
Vr, mean velocity, ROB, ft/s	3.9	4.7	3.1
Vc-m, crit. velocity, MC, ft/s	7.7	7.9	7.3
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Maximum Free-Surface
(Q) total discharge, cfs	14660	21500	7510
(Q) discharge thru bridge, cfs	8868	8662	7190
Main channel conveyance	129788	129788	159383
Total conveyance	129788	129788	159383
Q2, bridge MC discharge,cfs	8868	8662	7190
Main channel area, ft2	827	827	735
Main channel width (normal), ft	63.8	63.8	63.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	63.8	63.8	63.8
y_bridge (avg. depth at br.), ft	12.96	12.96	11.52
Dm, median (1.25*D50), ft	0.099875	0.099875	0.099875
y2, depth in contraction,ft	16.42	16.09	13.72
ys, scour depth (y2-ybridge), ft	3.46	3.13	2.20

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Maximum Free-Surface
Q, discharge thru bridge MC, cfs	8868	8662	7190
Main channel area (DS), ft2	827	827	735
Main channel width (normal), ft	63.8	63.8	63.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	63.8	63.8	63.8
D90, ft	0.1427	0.1427	0.1427
D95, ft	0.1800	0.1800	0.1800
Dc, critical grain size, ft	0.2361	0.2252	0.2032
Pc, Decimal percent coarser than Dc	0.022	0.024	0.032
Depth to armoring, ft	N/A	N/A	N/A

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	Maximum Free-Surface
Q, total, cfs	14660	21500	7510
Q, thru bridge MC, cfs	8868	8662	7190
Vc, critical velocity, ft/s	7.75	7.93	7.30
Va, velocity MC approach, ft/s	5.00	5.73	5.07
Main channel width (normal), ft	63.8	63.8	63.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	63.8	63.8	63.8
qbr, unit discharge, ft2/s	139.0	135.8	112.7
Area of full opening, ft2	827.0	827.0	735.0
Hb, depth of full opening, ft	12.96	12.96	11.52
Fr, Froude number, bridge MC	0.53	0.51	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	505.86	505.86	0
Elevation of Bed, ft	492.90	492.90	-11.52
Elevation of Approach, ft	511.27	513.91	0
Friction loss, approach, ft	0.1	0.12	0
Elevation of WS immediately US, ft	511.17	513.79	0.00
ya, depth immediately US, ft	18.27	20.89	11.52
Mean elevation of deck, ft	518.1	518.1	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.91	0.87	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	6.70	6.76	N/A
Ys, scour w/Umbrell equation, ft	2.50	5.96	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Max-F.S.	Right Abutment 100 yr Q	500 yr Q	Max-F.S.
(Qt), total discharge, cfs	14660	21500	7510	14660	21500	7510
a', abut.length blocking flow, ft	119.8	125.7	108.3	130.2	139.6	95.4
Ae, area of blocked flow ft2	970.5	1060.02	527.39	573.32	701.33	234.18
Qe, discharge blocked abut.,cfs	--	--	1842.94	--	--	--
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.22	5.04	3.49	3.89	4.63	3.15
ya, depth of f/p flow, ft	8.10	8.43	4.87	4.40	5.02	2.45
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	85	85	85	95	95	95
K2	0.99	0.99	0.99	1.01	1.01	1.01
Fr, froude number f/p flow	0.242	0.262	0.279	0.248	0.263	0.277
ys, scour depth, ft	**28.16**	**30.43**	**20.55**	19.53	22.44	12.60

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	119.8	125.7	108.3	130.2	139.6	95.4
y1 (depth f/p flow, ft)	8.10	8.43	4.87	4.40	5.02	2.45
a'/y1	14.79	14.91	22.24	29.57	27.79	38.86
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.24	0.26	0.28	0.25	0.26	0.28
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	20.42	23.75	11.80
vertical w/ ww's	ERR	ERR	ERR	**16.74**	**19.47**	**9.68**
spill-through	ERR	ERR	ERR	11.23	13.06	6.49

Abutment riprap Sizing

Isbash Relationship

D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)

(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Max.F.S.	Q100	Q500	Max.F.S.
Fr, Froude Number	0.53	0.51	0.57	0.53	0.51	0.57
y, depth of flow in bridge, ft	12.96	12.96	11.52	12.96	12.96	11.52
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.25	2.08	2.31	2.25	2.08	2.31
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR