LEVEL II SCOUR ANALYSIS FOR BRIDGE 18 (SHEFTH00410018) on TOWN HIGHWAY 41, crossing MILLERS RUN, SHEFFIELD, VERMONT

Open-File Report 97-772

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

U.S. Department of the Interior
U.S. Geological Survey

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By EMILY C. WILD and ERICK M. BOEHMLER

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
Mark Schaefer, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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

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 18 (SHEFTH00410018) ON TOWN HIGHWAY 41, CROSSING MILLERS RUN, SHEFFIELD, VERMONT

By **Emily C. Wild and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SHEFTH00410018 on Town Highway 41 crossing Millers Run, Sheffield, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 16.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is grass upstream and downstream of the bridge while the immediate banks have dense woody vegetation.

In the study area, Millers Run has an incised, straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 50 ft and an average bank height of 6 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 50.9 mm (0.167 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 1, 1995, indicated that the reach was laterally unstable, which is evident in the moderate to severe fluvial erosion in the upstream reach.

The Town Highway 41 crossing of the Millers Run is a 30-ft-long, one-lane bridge consisting of a 28-foot steel-stringer span (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 22.2 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 20 degrees to the opening. The computed opening-skew-to-roadway is 5 degrees, while it is zero degrees in the historical form.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. The scour protection measure at the site includes type-1 stone fill (less than 12 inches diameter) along the upstream right wingwall and the upstream left wingwall. Type-2 stone fill (less than 36 inches diameter) extends along the downstream end of the downstream left wingwall, the upstream right bank and the downstream left bank. The downstream right bank is protected by type-2 stone fill and a stone masonry wall. 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 others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. 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 0.2 to 1.8 ft. The worst-case contraction scour occurred at the 100-year and 500-year discharges. Left abutment scour ranged from 14.1 to 16.4 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 6.9 to 9.3 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping 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 others, 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 SHEFTH00410018 ***Stream*** Millers Run

County Caledonia ***Road*** TH41 ***District*** 7

Description of Bridge

Bridge length 30 ***ft*** ***Bridge width*** 15.9 ***ft*** ***Max span length*** 28 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No ***Date of inspection*** 08/01/95

Description of stone fill Type-1, along the upstream left wingwall. Type-2 stone fill along the downstream end of the downstream left wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a one to one and a half foot (deep) scour hole in front of the upstream left wingwall and along the left abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** ***Angle*** 20

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

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	08/01/95	0	0
Level II	08/01/95	0	0

Potential for debris Moderate. A lot of vegetation is present along the channel banks.

Describe any features near or at the bridge that may affect flow (include observation date) None, 08/01/95.

Description of the Geomorphic Setting

General topography The channel is located within a narrow flood plain with steep valley walls on both sides.

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

Date of inspection 08/01/95

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

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

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

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

Description of the Channel

Average top width 50 *ft* ***Average depth*** 6 *ft*

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

Straight and laterally unstable with semi-alluvial boundaries and a narrow flood plain.

08/01/95

Vegetative co Trees and brush along immediate bank, while overbank is grass.

DS left: Trees and brush along immediate bank, while overbank is grass.

DS right: Trees and brush along immediate bank., while overbank is grass.

US left: Trees and brush along immediate bank, while overbank is grass.

US right:

Do banks appear stable? Yes ***If not, describe location and type of instability and date of observation.***

The assessment of 08/01/95 noted no obstructions in the channel.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 16.2 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization:*** There are a few houses on the upstream and downstream right overbanks.

No

Is there a USGS gage on the stream of interest? --

USGS gage description --

USGS gage number --

Gage drainage area ***mi²*** No

Is there a lake/p -

2,400

Calculated Discharges

Q100 2,950 ***ft³/s*** ***Q500*** ***ft³/s*** The 100- and 500-year discharges are the median values selected from those based on several empirical flood frequency curves, which were extrapolated to the 500-year event (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 chiseled X on top of the wooden bridge deck at the downstream right end (elev. 499.39 ft, arbitrary survey datum). RM2 is a chiseled X on top of the wooden bridge deck at the upstream left end (elev. 499.26 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-28	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	41	2	Modelled Approach section (Templated from APTEM)
APTEM	51	1	Approach section as surveyed (Used as a template)

[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 0.045 to 0.055, and overbank "n" values ranged from 0.045 to 0.060.

Normal depth at the exit section (EXITX) 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 0.0117 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1988).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.008 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.5 ***ft***
Average low steel elevation 497.8 ***ft***

100-year discharge 2,400 ***ft³/s***
Water-surface elevation in bridge opening 497.9 ***ft***
Road overtopping? Y ***Discharge over road*** 604 ***ft³/s***
Area of flow in bridge opening 177 ***ft²***
Average velocity in bridge opening 10.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.4 ***ft/s***

Water-surface elevation at Approach section with bridge 500.8
Water-surface elevation at Approach section without bridge 498.5
Amount of backwater caused by bridge 2.3 ***ft***

500-year discharge 2,950 ***ft³/s***
Water-surface elevation in bridge opening 497.9 ***ft***
Road overtopping? Y ***Discharge over road*** 1,091 ***ft³/s***
Area of flow in bridge opening 177 ***ft²***
Average velocity in bridge opening 10.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.5 ***/s***

Water-surface elevation at Approach section with bridge 501.1
Water-surface elevation at Approach section without bridge 498.9
Amount of backwater caused by bridge 2.2 ***ft***

Incipient overtopping discharge 1,490 ***ft³/s***
Water-surface elevation in bridge opening 497.9 ***ft***
Area of flow in bridge opening 177 ***ft²***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.2 ***ft/s***

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 497.5
Amount of backwater caused by bridge 1.9 ***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 others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, the 100-year and 500-year discharges resulted in submerged orifice flow, while the incipient roadway-overtopping discharge resulted in unsubmerged 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 these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of this scour analysis are shown in tables 1 and 2 and figure 8. The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for the incipient roadway-overtopping discharge, which resulted in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 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 Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.8	1.8	0.2
Depth to armoring	7.8 8.2	4.1	--
Left overbank	--	--	--
Right overbank	--	--	15.4

Local scour:			
Abutment scour			
Left abutment	16.4	14.1	8.6
Right abutment	6.9	9.3	---
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	2.0

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.1	1.6	2.0
Right abutment	2.1	1.6	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--
	--	--	

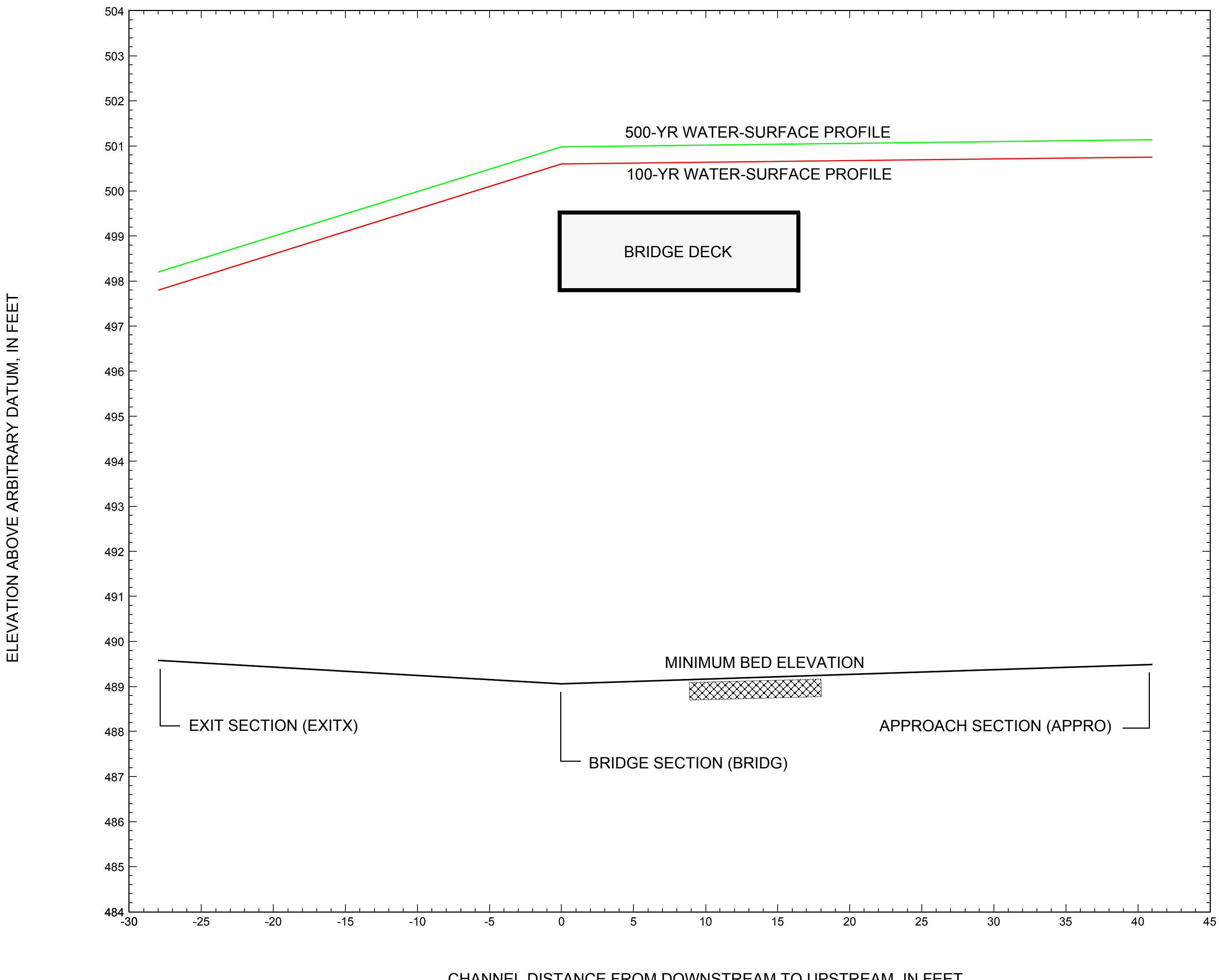

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure SHEFTH00410018 on Town Highway 41, crossing Millers Run, Sheffield, Vermont.

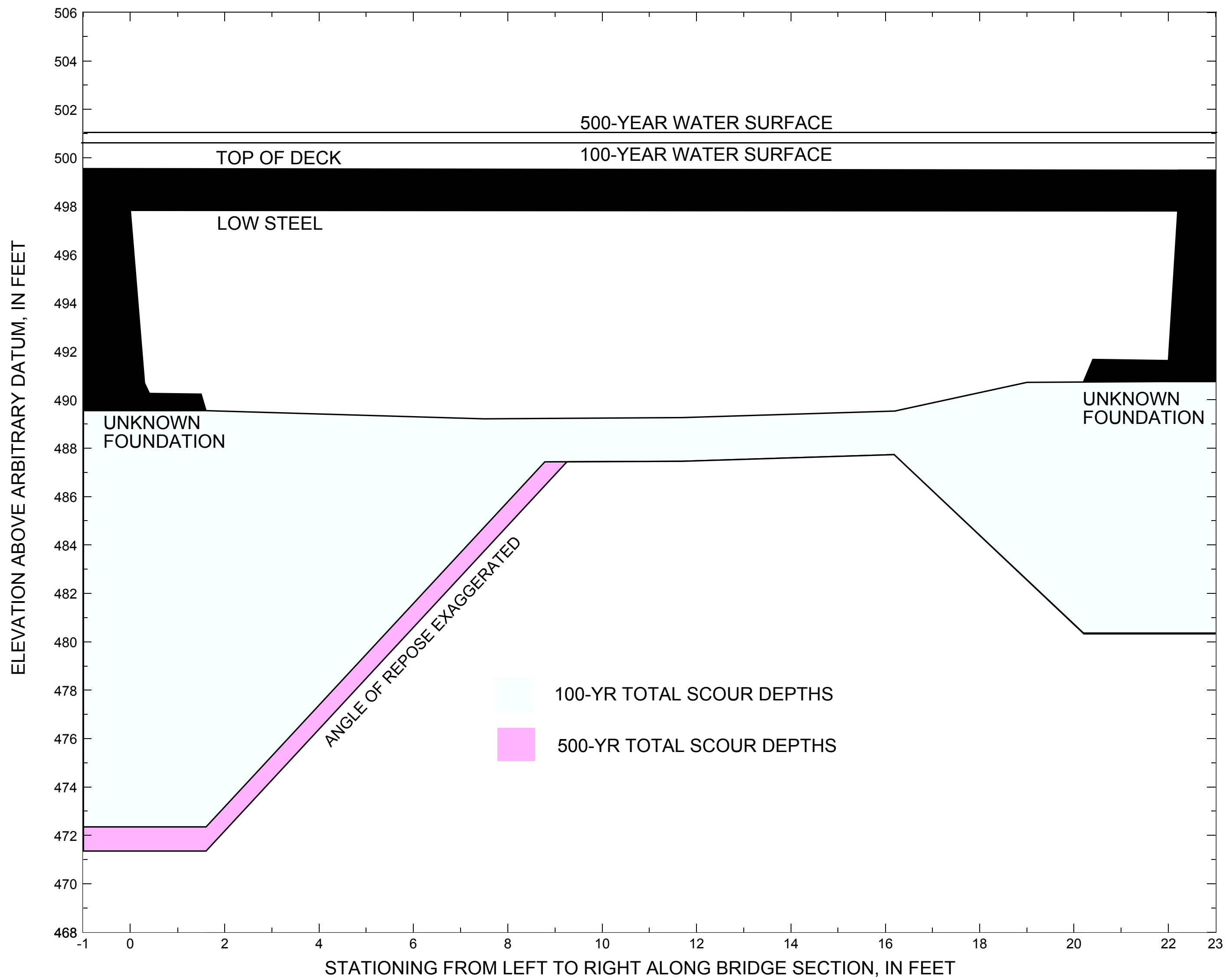

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure SHEFTH00410018 on Town Highway 41, crossing Millers Run, Sheffield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SHEFTH00410018 on Town Highway 41, crossing Millers Run, Sheffield, 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 2,400 cubic-feet per second											
Left abutment	0.0	--	497.9	--	489.6	1.8	15.4	--	17.2	472.4	--
Right abutment	22.2	--	497.8	--	490.8	1.8	8.6	--	10.4	480.4	--

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-year discharge at structure SHEFTH00410018 on Town Highway 41, crossing Millers Run, Sheffield, 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 2,950 cubic-feet per second											
Left abutment	0.0	--	497.9	--	489.6	1.8	16.4	--	18.2	471.4	--
Right abutment	22.2	--	497.8	--	490.8	1.8	6.9	--	8.7	482.1	--

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, 1986, Stannard, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File shef018.wsp
T2        Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
T3        Town Highway 41, Millers Run, Sheffield, Vermont          ECW
*
J1         * * 0.01
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2400.0   2950.0    1490.0
SK          0.0117   0.0117    0.0117
*
XS   EXITX    -28           0.
GR         -215.0, 503.00   -140.0, 502.18    -90.0, 502.18    -79.2, 500.20
GR          -66.0, 499.92    -51.7, 495.34     -4.0, 495.38      0.0, 493.67
GR            4.1, 490.65      7.5, 490.05     13.7, 489.58     17.5, 489.86
GR           20.9, 490.22     22.0, 490.66     26.3, 491.93     27.2, 496.64
GR           56.4, 497.22     82.6, 497.36    100.5, 496.76    122.5, 497.95
GR          146.1, 499.58    184.2, 500.18
*
N           0.045      0.055        0.060
SA                -4.0        56.4
*
XS   FULLV      0  * * *   0.0015
*              SRD     LSEL    XSSKEW
BR   BRIDG     0    497.76       5.0
GR            0.0, 497.86      0.3, 490.68      0.4, 490.26      1.5, 490.23
GR            1.6, 489.55      7.5, 489.21     11.7, 489.06     16.2, 489.53
GR           19.0, 490.72     20.2, 490.75     20.4, 491.66     22.0, 491.62
GR           22.2, 497.80      0.0, 497.86
*
N            0.045
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD            1      23.3 * *     71.4      2.9
*              SRD    EMBWID   IPAVE
XR   RDWAY      8      15.9     2
GR         -162.0, 512.71   -128.3, 502.49   -105.8, 501.33    -82.8, 500.65
GR          -77.5, 499.39    -70.7, 499.34    -22.6, 499.58      0.0, 499.55
GR           23.6, 499.48     32.2, 499.84     50.4, 500.16     94.6, 500.60
GR          136.4, 500.69    169.4, 501.05
*
XT   APTEM     51
GR         -148.0, 515.69   -100.1, 499.58    -88.9, 499.60    -71.3, 494.79
GR          -51.8, 494.80    -20.2, 495.55     -4.0, 494.52     -2.0, 494.86
GR            7.3, 490.68      8.8, 489.75     14.6, 489.51     18.4, 489.63
GR           21.3, 489.86     24.6, 490.73     25.9, 490.99     31.6, 496.53
GR           35.7, 498.90     42.9, 500.04     59.9, 501.07     93.0, 500.93
GR          132.7, 502.05
*
AS   APPRO     41      0.0080
GT
N            0.045       0.050        0.055
SA                 -4.0         35.7
*
HP 1 BRIDG 497.86 1 497.86
HP 2 BRIDG 497.86 * * 1818
HP 2 RDWAY 500.61 * * 604
HP 1 APPRO 500.75 1 500.75
HP 2 APPRO 500.75 * * 2400
*
HP 1 BRIDG 497.86 1 497.86
HP 2 BRIDG 497.86 * * 1830
HP 2 RDWAY 500.98 * * 1091
```

APPENDIX B:

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File shef018.wsp
       Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
       Town Highway 41, Millers Run, Sheffield, Vermont          ECW
          *** RUN DATE & TIME: 09-22-97  16:56
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      177     12184      0     59                        9674474
  497.86           177     12184      0     59  1.00      0     22  9674474

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

        WSEL     LEW     REW    AREA         K        Q    VEL
      497.86     0.0    22.2   177.0   12184.    1818.  10.27

X STA.         0.0        2.2        3.4        4.4        5.4        6.3
  A(I)            15.9        9.9        8.8        8.2        7.8
  V(I)            5.70       9.18      10.32      11.09      11.61

X STA.         6.3        7.2        8.1        8.9        9.8       10.6
  A(I)             7.6        7.5        7.4        7.3        7.4
  V(I)           11.89      12.16      12.28      12.38      12.34

X STA.        10.6       11.5       12.3       13.2       14.1       15.0
  A(I)             7.3        7.3        7.6        7.6        7.8
  V(I)           12.44      12.44      12.00      12.01      11.71

X STA.        15.0       16.0       17.0       18.2       19.6       22.2
  A(I)             8.0        8.5        9.0       10.3       15.8
  V(I)           11.41      10.72      10.07       8.83       5.76

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

        WSEL     LEW     REW    AREA         K        Q    VEL
      500.61   -82.6    99.2   145.8    4366.     604.   4.14

X STA.       -82.6      -74.1      -69.4      -64.8      -60.0      -55.2
  A(I)             7.3        5.9        5.9        5.8        5.9
  V(I)            4.13       5.13       5.15       5.20       5.15

X STA.       -55.2      -50.2      -45.0      -39.6      -33.9      -28.1
  A(I)             5.9        6.0        6.1        6.2        6.3
  V(I)            5.15       5.05       4.94       4.85       4.83

X STA.       -28.1      -21.9      -15.6       -9.5       -3.3        4.1
  A(I)             6.5        6.5        6.4        6.5        7.9
  V(I)            4.64       4.67       4.75       4.64       3.83

X STA.         4.1       11.3       18.6       26.1       38.5       99.2
  A(I)             7.8        8.1        8.2       10.1       16.8
  V(I)            3.85       3.74       3.68       3.00       1.80

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      464     42592    100    101                           5682
            2      341     39892     40     44                           5678
            3       14       294     19     19                             65
  500.75           819     82778    158    164  1.07   -103     55    10216

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

        WSEL     LEW     REW    AREA         K        Q    VEL
      500.75  -103.6    54.9   818.9   82778.    2400.   2.93

X STA.      -103.6      -71.9      -63.9      -56.6      -49.5      -42.5
  A(I)            74.5       47.8       43.4       42.6       40.8
  V(I)            1.61       2.51       2.77       2.82       2.94

X STA.       -42.5      -35.2      -27.6      -19.8      -12.4       -5.8
  A(I)            41.4       41.5       41.5       40.7       38.8
  V(I)            2.90       2.89       2.89       2.95       3.09

X STA.        -5.8        0.8        5.3        8.7       11.3       14.0
  A(I)            41.6       37.0       33.3       29.6       29.3
  V(I)            2.88       3.25       3.60       4.05       4.09

X STA.        14.0       16.6       19.4       22.4       26.0       54.9
  A(I)            30.0       30.7       32.4       36.6       65.6
  V(I)            4.00       3.91       3.71       3.28       1.83
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File shef018.wsp
       Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
       Town Highway 41, Millers Run, Sheffield, Vermont          ECW
          *** RUN DATE & TIME: 09-22-97  16:56

   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      177     12184      0     59                      9674474
  497.86           177     12184      0     59  1.00      0     22  9674474

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.86     0.0    22.2   177.0   12184.    1830.  10.34

X STA.         0.0         2.2         3.4         4.4         5.4         6.3
  A(I)            15.9         9.9         8.8         8.2         7.8
  V(I)            5.74        9.24       10.39       11.16       11.69

X STA.         6.3         7.2         8.1         8.9         9.8        10.6
  A(I)             7.6         7.5         7.4         7.3         7.4
  V(I)           11.97       12.24       12.36       12.47       12.43

X STA.        10.6        11.5        12.3        13.2        14.1        15.0
  A(I)             7.3         7.3         7.6         7.6         7.8
  V(I)           12.52       12.53       12.08       12.08       11.79

X STA.        15.0        16.0        17.0        18.2        19.6        22.2
  A(I)             8.0         8.5         9.0        10.3        15.8
  V(I)           11.49       10.79       10.14        8.89        5.80

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.98   -94.0   163.0   231.1    7445.    1091.   4.72

X STA.       -94.0       -72.7       -66.7       -61.0       -55.3       -49.7
  A(I)            14.6         9.8         9.2         9.0         8.7
  V(I)            3.73        5.54        5.94        6.09        6.29

X STA.       -49.7       -43.9       -38.1       -32.1       -25.8       -19.4
  A(I)             8.8         8.7         8.7         9.1         8.9
  V(I)            6.20        6.28        6.25        6.02        6.13

X STA.       -19.4       -13.1        -6.7         0.3         8.0        15.3
  A(I)             9.0         9.0         9.9        11.1        10.7
  V(I)            6.07        6.03        5.53        4.91        5.09

X STA.        15.3        22.7        31.4        44.4        67.5       163.0
  A(I)            11.0        11.8        13.5        17.8        31.8
  V(I)            4.96        4.61        4.04        3.07        1.71

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      503     48346    101    102                         6377
            2      357     42954     40     44                         6069
            3       28       440     65     65                          106
  501.14           888     91740    206    211  1.09   -104    101    10018

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

        WSEL     LEW     REW    AREA        K        Q    VEL
      501.14  -104.8   101.0   888.2   91740.    2950.   3.32

X STA.      -104.8       -73.2       -65.2       -57.7       -50.9       -43.9
  A(I)            79.4        50.3        47.5        43.8        43.6
  V(I)            1.86        2.93        3.11        3.37        3.39

X STA.       -43.9       -36.7       -29.4       -21.6       -14.0        -7.3
  A(I)            43.4        43.5        44.5        43.8        41.6
  V(I)            3.40        3.39        3.32        3.37        3.54

X STA.        -7.3        -0.7         4.4         8.0        10.9        13.7
  A(I)            43.1        41.3        36.0        32.3        32.2
  V(I)            3.42        3.57        4.10        4.56        4.58

X STA.        13.7        16.4        19.3        22.4        26.1       101.0
  A(I)            32.4        33.0        35.4        38.5        82.7
  V(I)            4.56        4.47        4.16        3.83        1.78
```

```
         U.S. Geological Survey WSPRO Input File shef018.wsp
         Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
         Town Highway 41, Millers Run, Sheffield, Vermont          ECW
            *** RUN DATE & TIME: 09-22-97  16:56

     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      177     12184      0     59                      9674474
    497.86           177     12184      0     59  1.00      0     22  9674474

     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

          WSEL     LEW     REW    AREA        K        Q    VEL
        497.86     0.0    22.2   177.0   12184.    1487.   8.40

 X STA.        0.0        2.2        3.4        4.4        5.4        6.3
  A(I)            15.9        9.9        8.8        8.2        7.8
  V(I)            4.66       7.51       8.44       9.07       9.50

 X STA.        6.3        7.2        8.1        8.9        9.8       10.6
  A(I)             7.6        7.5        7.4        7.3        7.4
  V(I)            9.72       9.95      10.04      10.13      10.10

 X STA.       10.6       11.5       12.3       13.2       14.1       15.0
  A(I)             7.3        7.3        7.6        7.6        7.8
  V(I)           10.17      10.18       9.81       9.82       9.58

 X STA.       15.0       16.0       17.0       18.2       19.6       22.2
  A(I)             8.0        8.5        9.0       10.3       15.8
  V(I)            9.33       8.76       8.24       7.22       4.71

     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      161     14597     22     35                         2465
    497.10           161     14597     22     35  1.00      0     22     2465

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      332     27264     84     85                         3737
              2      286     29800     40     44                         4367
              3        1         8      3      3                            2
    499.37           619     57072    127    132  1.04    -87     39     7591

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.37   -88.1    38.8   618.9   57072.    1490.   2.41

 X STA.      -88.1      -69.3      -61.8      -54.6      -47.4      -40.1
  A(I)            47.8       34.5       32.9       32.7       32.2
  V(I)            1.56       2.16       2.26       2.28       2.31

 X STA.      -40.1      -32.2      -23.8      -14.9       -7.6       -0.5
  A(I)            33.2       33.8       35.2       32.1       33.6
  V(I)            2.24       2.20       2.12       2.32       2.22

 X STA.       -0.5        4.3        7.5       10.0       12.4       14.6
  A(I)            30.2       25.7       24.1       22.5       22.0
  V(I)            2.47       2.90       3.09       3.31       3.38

 X STA.       14.6       17.0       19.4       22.0       25.3       38.8
  A(I)            23.5       23.5       25.2       28.7       45.1
  V(I)            3.17       3.17       2.95       2.60       1.65
```

WSPRO OUTPUT FILE (continued)

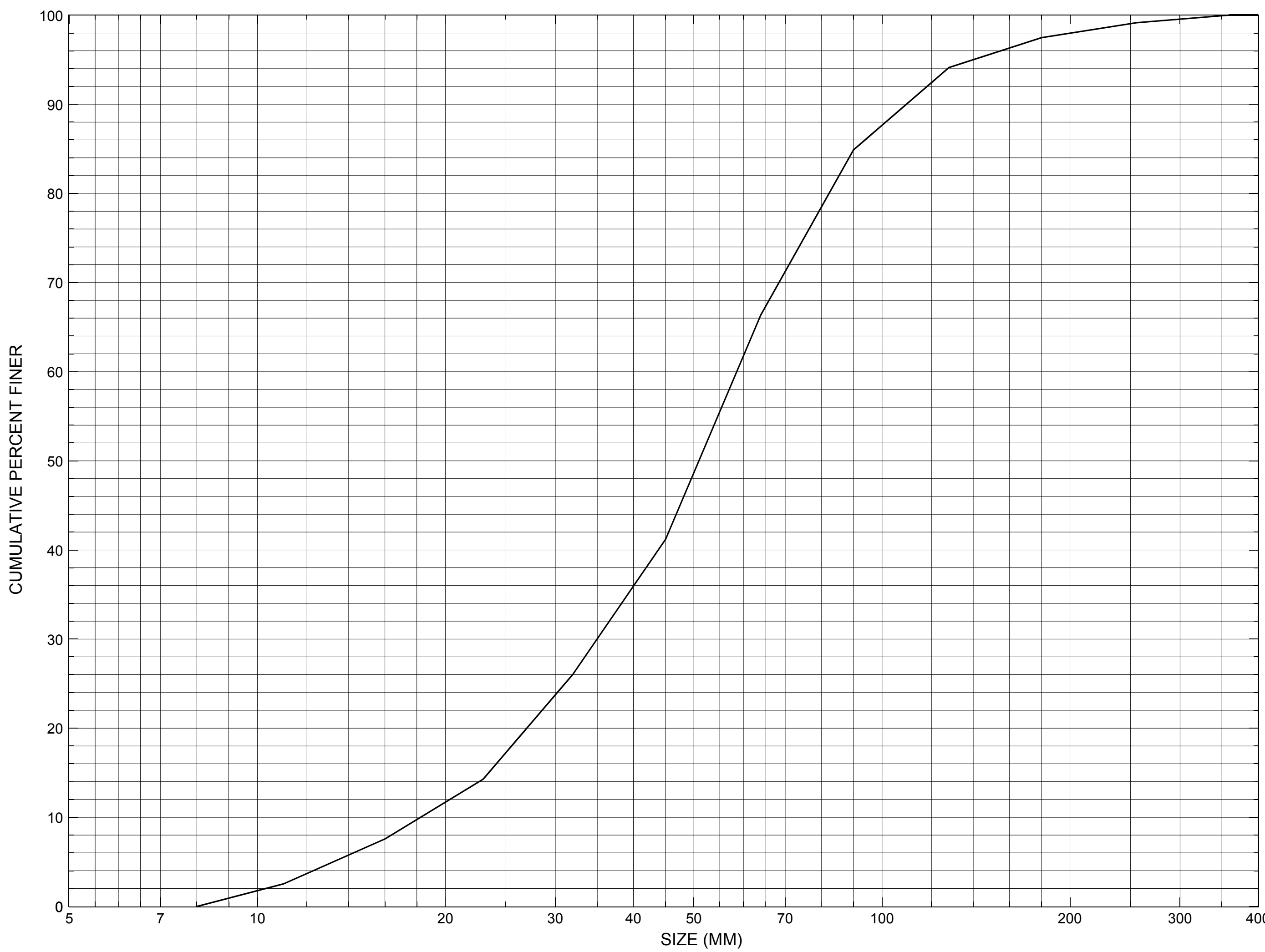
```
       U.S. Geological Survey WSPRO Input File shef018.wsp
       Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
       Town Highway 41, Millers Run, Sheffield, Vermont          ECW
          *** RUN DATE & TIME: 09-22-97  16:56

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

EXITX:XS   ******    -58      392  0.65 ***** 498.44  497.22    2400  497.78
       -27 ******    119    22169  1.12 ***** *******    0.77    6.12

FULLV:FV       28    -60      465  0.47  0.26  498.70 *******    2400  498.23
         0     28    126    27729  1.15  0.00    0.00    0.62    5.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  1.57

APPRO:AS       41    -84      516  0.36  0.20  498.89 *******    2400  498.54
        41     41     35    43543  1.06  0.00    0.00    0.41    4.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =    498.23     497.76

            <<<<<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       28      0      177  1.64 ***** 499.50  495.74    1818  497.86
         0 ******     22    12184  1.00 ***** *******    0.64   10.27

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.76 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    25.  0.02  0.14  500.87    0.01    604.  500.61

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    427.    93.   -83.    11.   1.3   1.1   5.1   4.2   1.4   2.9
   RT:    177.    91.    11.   101.   1.1   0.5   3.9   4.0   0.7   3.0

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

APPRO:AS       18   -103      819  0.14  0.10  500.89  496.68    2400  500.75
        41     24     55    82723  1.07  0.00    0.01    0.24    2.93

       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
   EXITX:XS     -28.   -59.   119.   2400.   22169.     392.    6.12  497.78
   FULLV:FV       0.   -61.   126.   2400.   27729.     465.    5.16  498.23
   BRIDG:BR       0.     0.    22.   1818.   12184.     177.   10.27  497.86
   RDWAY:RG       8.*******   427.    604.******************    2.00  500.61
   APPRO:AS      41.  -104.    55.   2400.   82723.     819.    2.93  500.75

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS   ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    497.22    0.77  489.58  503.00************  0.65  498.44  497.78
   FULLV:FV  ********    0.62  489.62  503.04  0.26  0.00  0.47  498.70  498.23
   BRIDG:BR    495.74    0.64  489.06  497.86************  1.64  499.50  497.86
   RDWAY:RG  ***************  499.34  512.71  0.02******  0.14  500.87  500.61
   APPRO:AS    496.68    0.24  489.49  515.67  0.10  0.00  0.14  500.89  500.75
```

```
        U.S. Geological Survey WSPRO Input File shef018.wsp
        Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
        Town Highway 41, Millers Run, Sheffield, Vermont          ECW
           *** RUN DATE & TIME: 09-22-97  16:56

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

EXITX:XS   ******    -59      459  0.74 *****  498.89  497.59    2950  498.15
      -27 ******    125    27256  1.15 ***** *******    0.77    6.42

FULLV:FV       28    -61      539  0.54  0.27  499.15 *******    2950  498.61
         0     28    131    33735  1.16  0.00    0.00    0.62    5.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.46

APPRO:AS       41    -85      563  0.45  0.21  499.37 *******    2950  498.92
        41     41     36    49377  1.05  0.00    0.00    0.44    5.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    498.61     497.76

            <<<<<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       28      0      177  1.66 *****  499.52  495.78    1830  497.86
         0 ******     22    12184  1.00 ***** *******    0.65   10.34

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.76 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    25.  0.03  0.19  501.31   -0.01   1091.  500.98

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    672.  105.   -94.    11.   1.6   1.3   5.8   4.9   1.6   3.0
   RT:    419.  152.    11.   163.   1.5   0.6   4.4   4.5   0.9   3.0

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

APPRO:AS       18   -104      889  0.19  0.13  501.33  497.04    2950  501.14
        41     24    101    91850  1.09  0.00   -0.01    0.29    3.32

       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
   EXITX:XS     -28.   -60.   125.   2950.   27256.     459.    6.42  498.15
   FULLV:FV      0.    -62.   131.   2950.   33735.     539.    5.48  498.61
   BRIDG:BR      0.      0.    22.   1830.   12184.     177.   10.34  497.86
   RDWAY:RG      8.*******    672.   1091.******************    2.00  500.98
   APPRO:AS     41.  -105.    101.   2950.   91850.     889.    3.32  501.14

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    497.59    0.77  489.58  503.00************  0.74  498.89  498.15
   FULLV:FV  ********    0.62  489.62  503.04  0.27  0.00  0.54  499.15  498.61
   BRIDG:BR    495.78    0.65  489.06  497.86************  1.66  499.52  497.86
   RDWAY:RG  ***************  499.34  512.71  0.03******  0.19  501.31  500.98
   APPRO:AS    497.04    0.29  489.49  515.67  0.13  0.00  0.19  501.33  501.14
```

```
        U.S. Geological Survey WSPRO Input File shef018.wsp
        Hydraulic analysis for structure SHEFTH00410018   Date: 19-AUG-97
        Town Highway 41, Millers Run, Sheffield, Vermont          ECW
           *** RUN DATE & TIME: 09-22-97  16:56

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

EXITX:XS   ******    -54      215  0.89 *****  497.29  496.03    1490  496.40
       -27 ******     27    13785  1.19 ***** *******    0.82    6.91

FULLV:FV       28    -56      276  0.48  0.30  497.58 *******    1490  497.10
         0     28    106    15138  1.05  0.00   -0.01    0.64    5.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  1.98

APPRO:AS       41    -80      398  0.25  0.20  497.77 *******    1490  497.53
        41     41     33    29964  1.13  0.00    0.00    0.38    3.75
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   496.06     498.08     498.19     497.76

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

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

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

BRIDG:BR       28      0      177  1.10 *****  498.96  494.99    1487  497.86
         0 ******     22    12184  1.00 ***** *******    0.52    8.40

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.442  0.000  497.76 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       18    -87      619  0.09  0.07  499.46  495.85    1490  499.37
        41     23     39    57065  1.04  0.37    0.00    0.20    2.41

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.35

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

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -28.   -55.    27.   1490.   13785.     215.    6.91  496.40
   FULLV:FV       0.   -57.   106.   1490.   15138.     276.    5.39  497.10
   BRIDG:BR       0.     0.    22.   1487.   12184.     177.    8.40  497.86
   RDWAY:RG       8.**************      0.       0.       0.    2.00********
   APPRO:AS      41.   -88.    39.   1490.   57065.     619.    2.41  499.37

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     496.03    0.82  489.58  503.00************  0.89  497.29  496.40
   FULLV:FV   ********    0.64  489.62  503.04  0.30  0.00  0.48  497.58  497.10
   BRIDG:BR     494.99    0.52  489.06  497.86************  1.10  498.96  497.86
   RDWAY:RG   ****************  499.34  512.71************  0.09  499.45********
   APPRO:AS     495.85    0.20  489.49  515.67  0.07  0.37  0.09  499.46  499.37
  ER

NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SHEFTH00410018, in Sheffield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SHEFTH00410018

General Location Descriptive

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

Date (MM/DD/YY) 03 / 28 / 95

Highway District Number (I - 2; nn) 07

County (FIPS county code; I - 3; nnn) 005

Town (FIPS place code; I - 4; nnnnn) 64075

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

Waterway (I - 6) MILLERS RUN

Road Name (I - 7): -

Route Number TH041

Vicinity (I - 9) 0.1 MI JCT TH 41 + VT122

Topographic Map Lyndonville

Hydrologic Unit Code: 01080102

Latitude (I - 16; nnnn.n) 44363

Longitude (i - 17; nnnnn.n) 72070

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10031200180312

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0028

Year built (I - 27; YYYY) 1973

Structure length (I - 49; nnnnnn) 000030

Average daily traffic, ADT (I - 29; nnnnnn) 000020

Deck Width (I - 52; nn.n) 159

Year of ADT (I - 30; YY) 92

Channel & Protection (I - 61; n) 5

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

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) A

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

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) 022.4

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 007.5

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

Waterway of full opening (nnn.n ft^2) 168.0

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls and wingwalls are concrete. Both wingwalls on the left abutment are reported as having alligator cracks and leaks with areas of spalling and section loss along their tops and ends. The right abutment is actually concrete faced “laid-up” stone blocks. The concrete facing is reported as fairly new. Stone and boulder fill is reported along the banks upstream and downstream of the bridge. There also are reported signs of bank erosion from previous flooding. Point bars and debris accumulation problems are noted as minor at this site.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area (*mi^2*): -

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} (*ft^3/ 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 (*ft^2*): -

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 16.24 mi^2

Lake/pond/swamp area 0.15 mi^2

Watershed storage *(ST)* 0.9 %

Bridge site elevation 925 ft

Headwater elevation 2720 ft

Main channel length 6.36 mi

10% channel length elevation 945 ft

85% channel length elevation 1565 ft

Main channel slope *(S)* 129.92 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:

-

Cross-sectional Data

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

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

Comments: **Cross section is of the downstream face. The low cord elevation is from the survey log done for this report dated 8/1/95. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 10/31/94, the sketch is dated 9/9/92.**

Station	0	2.25	6.65	11.9	16.7	22.4	-	-	-	-	-
Feature	RAB	-	-	-	-	LAB	-	-	-	-	-
Low chord elevation	497.80	497.81	497.82	497.84	497.85	497.86	-	-	-	-	-
Bed elevation	491.30	491.14	489.90	489.67	489.85	490.78	-	-	-	-	-
Low chord-bed	6.5	6.67	7.92	8.17	8	7.08	-	-	-	-	-

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

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

Comments: -

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: **EW** Date: **03/20/96**
Computerized by: **EW** Date: **03/20/96**
Reviewd by: **EW** Date: **9/29/97**

Structure Number **SHEFTH00410018**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. BOEHMLER** Date *(MM/DD/YY)* **08** / **01** / 19**95**

2. Highway District Number **07** Mile marker **-**

County **Calendonia (005)** Town **Sheffield (64075)**

Waterway *(I - 6)* **Millers Run** Road Name **-**

Route Number **TH041** Hydrologic Unit Code: **01080102**

3. Descriptive comments:

The bridge is located 0.1 mi from the intersection with TH41 and VT122.

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 **30** *(feet)* Span length **28** *(feet)* Bridge width **15.9** *(feet)*

Road approach to bridge:

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

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

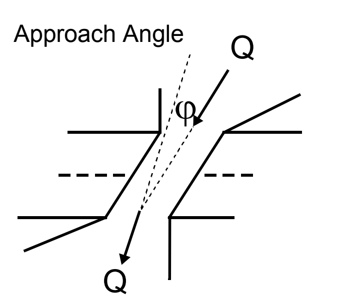
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

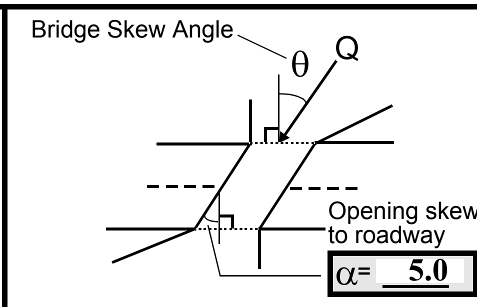
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	2
RBUS	0	-	2	2
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: **25** 16. Bridge skew: **20**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **20** feet **US** *(US, UB, DS)* to **10** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **30** feet **DS** *(US, UB, DS)* to **90** feet **DS**

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

18. Bridge Type: **1a, 4**

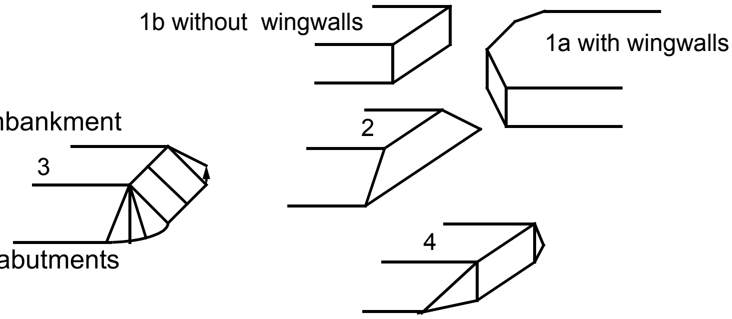
1a- Vertical abutments with wingwalls

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 VTAOT database. The measured bridge length equals 30 feet; bridge span equals 25.5 feet; bridge width equals 15.7 feet.

#18: The LABUT is bridge type 4, while the RABUT is bridge type 1a.

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
31.5	**4.0**			**8.0**	**4**	**3**	**213**	**213**	**3**	**2**

23. Bank width **15.0** 24. Channel width **40.0** 25. Thalweg depth **40.0** 29. Bed Material **3452**

30 .Bank protection type: LB **0** RB **2** 31. Bank protection condition: LB **-** RB **2**

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.):

A log type drop structure exists at 106 feet US.
The LB is moderately scalloped, and does not have protection.
The RB protection has slipped about 2 feet from the top of the bank. A slip face is visible in the bank material above the stone fill, extending to the top of the bank. The protection extends from 0 ft US to 40 ft US.

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

36. Point bar extent: **-** feet **-** (US, UB) to **-** feet **-** (US, UB, DS) positioned **-** %LB to **-** %RB

37. Material: **-**

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

NO POINT BARS

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

41. Mid-bank distance: **45** 42. Cut bank extent: **106** feet **US** (US, UB) to **7** 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.):

Block failure is evident. From 55 feet US to 7 feet US, the bank is additionally eroded and moderately scalloped between trees and tree trunks. Also at this location, tree roots are exposed along the edge of the channel.

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

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
18.5		**1.0**		**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.):

3452

The scour hole described in the downstream channel assessment extends under the bridge and along the left abutment.

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

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

With the significant amount of bank erosion and the dense vegetation on the banks, the potential of debris accumulation in the channel is moderate. The capture efficency and ice blockage potential are low because the channel is straight.

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		10	90	2	2	1	1	90.0
RABUT	1	-	90			2	2	24.5

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.):

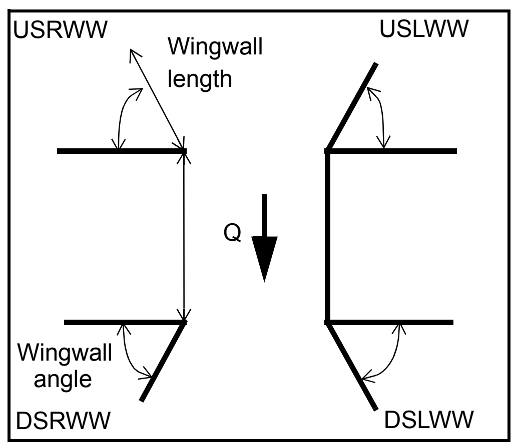
0
1.5
1

The original right abutment was a stone wall, which still exists behind a more recent concrete wall abutment. The newer concrete wall is 1.5 feet thick with an exposed step footing (1.5 feet) for almost its entire length. Some stone fill is present along the base of the right abutment under a sand and silt layer.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						24.5	
USRWW:	Y		1		2	1.5	
DSLWW:	0		0.5		Y	16.5	
DSRWW:	1		2		0	16.5	

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	0.5	2	Y	0	1	1	-	-
Condition	Y	0.5	1	0	1	1	-	-
Extent	1	0.5	0	1	1	0	0	-

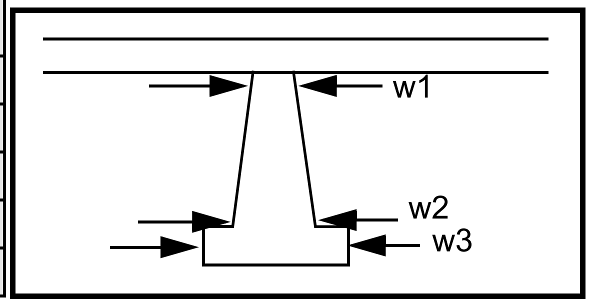
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
3
0
-
-

Piers:

84. Are there piers? **Th** *(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				**60.0**	**10.5**	**80.0**
Pier 2	**4.0**			**55.0**	**11.0**	**10.0**
Pier 3	**3.5**	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ere is**	**s an**	**tion as**	**WW**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**no**	**exte**	**the**	**has a**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**foot-**	**nsio**	**abut**	**con-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**ing**	**n to**	**ment**	**crete**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**on**	**the**	**wall.**	**foot-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**the**	**RAB**	**Like**	**ing**	
92. Pushed	**DSR**	**UT**	**the**	**expo**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**WW.**	**wall**	**right**	**sed**	
95. Cross-members	**The**	**in**	**abut**	**at**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**USR**	**the**	**ment**	**the**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**WW**	**same**	**, the**	**sur-**	
98. Exposure depth	**form**	**direc**	**USR**	**face.**	

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

There is some stone fill along and immediately upstream of the USRWW.

The USLWW is exposed for four feet (horizonally) from the left abutment. The remaining length of the USLWW furthest from the bridge is covered with road fill and channel material. The DSLWW also is exposed for four feet (horizontally) from the left abutment. Like the USLWW, the remaining length furthest from the bridge is covered with stone fill.

N

-

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
-	-			-	-	-	-	-	-	-

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.):
-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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 -_____ feet -____ *(US, UB, DS)* positioned -____ %LB to -____ %RB

Material: -_____

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

-
-
-
NO PIERS

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

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.):

3
1
213

Is channel scour present? **7**____ *(Y or if N type ctrl-n cs)* Mid-scour distance: **2**______

Scour dimensions: Length **1**_____ Width **3452**____ Depth: **2**_____ Positioned **5**___ %LB to **2**___ %RB

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

1
The right bank protection is stone fill extending from 35 feet DS to 100 feet DS. There is a stone dry masonry wall from 10 feet DS to 35 feet DS.
The left bank is protected along its base only from 15 feet DS to 60 feet DS.

Are there major confluences? **Th**____ *(Y or if N type ctrl-n mc)* How many? **e**____

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

Confluence 2: Distance **the**____ Enters on **DSL**____ *(LB or RB)* Type **B is**____ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

unclear due to the stone fill and stone wall covering. But is probably much like that of the LBDS.

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 DROP STRUCTURE

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: SHEFTH00410018 Town: SHEFFIELD
Road Number: TH 41 County: CALEDONIA
Stream: MILLERS RUN

Initials ECW Date: 9/23/97 Checked: RLB

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	other Q
Total discharge, cfs	2400	2950	1490
Main Channel Area, ft2	341	357	286
Left overbank area, ft2	464	503	332
Right overbank area, ft2	14	28	1
Top width main channel, ft	40	40	40
Top width L overbank, ft	100	101	84
Top width R overbank, ft	19	65	3
D50 of channel, ft	0.167	0.167	0.167
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.5	8.9	7.2
y1, average depth, LOB, ft	4.6	5.0	4.0
y1, average depth, ROB, ft	0.7	0.4	0.3
Total conveyance, approach	82778	91740	57072
Conveyance, main channel	39892	42954	29800
Conveyance, LOB	42592	48346	27264
Conveyance, ROB	294	440	8
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1156.6	1381.2	778.0
Ql, discharge, LOB, cfs	1234.9	1554.6	711.8
Qr, discharge, ROB, cfs	8.5	14.1	0.2
Vm, mean velocity MC, ft/s	3.4	3.9	2.7
Vl, mean velocity, LOB, ft/s	2.7	3.1	2.1
Vr, mean velocity, ROB, ft/s	0.6	0.5	0.2
Vc-m, crit. velocity, MC, ft/s	8.8	8.9	8.6
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	Other Q
(Q) total discharge, cfs	2400	2950	1490
(Q) discharge thru bridge, cfs	1818	1830	1490
Main channel conveyance	12184	12184	12184
Total conveyance	12184	12184	12184
Q2, bridge MC discharge,cfs	1818	1830	1490
Main channel area, ft2	177	177	177
Main channel width (normal), ft	22.1	22.1	22.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	22.1	22.1	22.1
y_bridge (avg. depth at br.), ft	8.01	8.01	8.01
Dm, median (1.25*D50), ft	0.20875	0.20875	0.20875
y2, depth in contraction,ft	8.48	8.53	7.15
ys, scour depth (y2-ybridge), ft	0.47	0.52	-0.86

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	Other Q
Q, discharge thru bridge MC, cfs	1818	1830	1490
Main channel area (DS), ft2	177	177	161
Main channel width (normal), ft	22.1	22.1	22.1
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	22.1	22.1	22.1
D90, ft	0.3590	0.3590	0.3590
D95, ft	0.4593	0.4593	0.4593
Dc, critical grain size, ft	0.3385	0.3430	0.2844
Pc, Decimal percent coarser than Dc	0.115	0.112	0.172
Depth to armoring, ft	7.79	8.17	4.11

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	OtherQ
Q, total, cfs	2400	2950	1490
Q, thru bridge MC, cfs	1818	1830	1490
Vc, critical velocity, ft/s	8.82	8.89	8.57
Va, velocity MC approach, ft/s	3.39	3.87	2.72
Main channel width (normal), ft	22.1	22.1	22.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	22.1	22.1	22.1
qbr, unit discharge, ft2/s	82.3	82.8	67.4
Area of full opening, ft2	177.0	177.0	177.0
Hb, depth of full opening, ft	8.01	8.01	8.01
Fr, Froude number, bridge MC	0.64	0.65	0.52
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	161
**Hb, depth at downstream face, ft	N/A	N/A	7.29
**Fr, Froude number at DS face	ERR	ERR	0.60
**Cf, for downstream face (<=1.0)	N/A	N/A	1.00
Elevation of Low Steel, ft	497.76	497.76	497.76
Elevation of Bed, ft	489.75	489.75	489.75
Elevation of Approach, ft	500.75	501.14	499.37
Friction loss, approach, ft	0.1	0.13	0.07
Elevation of WS immediately US, ft	500.65	501.01	499.30
ya, depth immediately US, ft	10.90	11.26	9.55
Mean elevation of deck, ft	499.52	499.52	499.52
w, depth of overflow, ft (>=0)	1.13	1.49	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.95	0.96
**Cc, for downstream face (<=1.0)	ERR	ERR	0.932447
Ys, scour w/Chang equation, ft	1.79	1.78	0.21
Ys, scour w/Umbrell equation, ft	-1.69	-1.11	-2.74

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	N/A	N/A	1.15

**Ys, scour w/Umbrell equation, ft	N/A	N/A	-2.02

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	8.48	8.53	7.15
WSEL at downstream face, ft	--	--	497.10
Depth at downstream face, ft	N/A	N/A	7.29
Ys, depth of scour (Laursen), ft	N/A	N/A	-0.13

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)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2400	2950	1490	2400	2950	1490
a', abut.length blocking flow, ft	103.65	104.85	88.15	32.75	78.85	16.65
Ae, area of blocked flow ft2	399.15	407.59	351.46	85.78	69.06	72.5
Qe, discharge blocked abut.,cfs	--	--	753.54	--	--	145.61
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.67	3.10	2.14	2.38	2.47	2.01
ya, depth of f/p flow, ft	3.85	3.89	3.99	2.62	0.88	4.35
--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	0.216	0.243	0.189	0.235	0.348	0.170
ys, scour depth, ft	15.36	16.38	14.09	8.63	6.85	9.28

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)	103.65	104.85	88.15	32.75	78.85	16.65
y1 (depth f/p flow, ft)	3.85	3.89	3.99	2.62	0.88	4.35
a'/y1	26.92	26.97	22.11	12.50	90.03	3.82
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.22	0.24	0.19	0.24	0.35	0.17
Ys w/ corr. factor K1/0.55:						
vertical	16.60	17.42	ERR	ERR	4.55	ERR
vertical w/ ww's	13.61	14.29	ERR	ERR	3.73	ERR
spill-through	9.13	9.58	ERR	ERR	2.50	ERR

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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.64	0.65	0.6	0.64	0.65	0.6
y, depth of flow in bridge, ft	8.01	8.01	7.29	8.01	8.01	7.29
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.03	2.09	1.62	2.03	2.09	1.62
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR