LEVEL II SCOUR ANALYSIS FOR BRIDGE 64 (MTHOTH00170064) on TOWN HIGHWAY 17, crossing an unnamed tributary of MILL RIVER, MOUNT HOLLY, VERMONT

Open-File Report 98-010

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 MICHAEL A. IVANOFF AND ERICK M. BOEHMLER

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Pembroke, New Hampshire
1998

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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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 64 (MTHOTH00170064) ON TOWN HIGHWAY 17, CROSSING AN UNNAMED TRIBUTARY OF MILL RIVER, MOUNT HOLLY, VERMONT

By **Michael A. Ivanoff 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 MTHOTH00170064 on Town Highway 17 crossing an unnamed tributary of Mill River (listed as a Branch of Mill River in the Vermont Agency of Transportation (VTAOT) files), Mount Holly, 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 (FHWA, 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 VTAOT files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in south-central Vermont. The 12.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, this unnamed tributary of Mill River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 61 ft and an average bank height of 7 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 160.6 mm (0.527 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 10, 1995, indicated that the reach was stable.

The Town Highway 17 crossing of this unnamed tributary of Mill River is a 31-ft-long, one-lane bridge consisting of one 29-foot steel-beam span (Vermont Agency of Transportation, written communication, March 21, 1995). The opening length of the structure parallel to the bridge face is 27.7 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 20 degrees to the opening while the computed opening-skew-to-roadway is 25 degrees.

The footings are exposed along both left and right abutments. The scour protection measures at the site include type-2 stone fill (less than 36 inches diameter) along the upstream right bank and the upstream left wingwall, type-3 stone fill (less than 48 inches diameter) along the upstream right wingwall, and a stone wall at the downstream end of the right wingwall extending along the downstream right bank. 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 incipient roadway-overtopping discharge was 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 0.0 to 0.6 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was greater than the 100-year discharge. Left abutment scour ranged from 8.8 to 10.4 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 11.8 to 14.8 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 Davis 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.

Mount Holly, VT. Quadrangle, 1:24,000, 1986

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 MTHOTH00170064 ***Stream*** unnamed tributary of Mill River

County Rutland ***Road*** TH 17 ***District*** 3

Description of Bridge

Bridge length 31.0 ***ft*** ***Bridge width*** 14.4 ***ft*** ***Max span length*** 29.0 ***ft***

Alignment of bridge to road (on curve or straight) Straight, between intersections.

Abutment type Vertical, concrete ***Embankment type*** Sloping

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

Description of stone fill Type-2, around the upstream left wingwall. Type-3, along the upstream right wingwall and a stone wall extending downstream from the downstream end of the downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a 2 ft exposure depth of the footings along the left and right abutments and 1 ft exposure depth along all four wingwalls.

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

Is there a channel bend? No

There is a mild channel bend in the upstream reach.

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

Potential for debris Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date)

None as of 10/10/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley.

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

Date of inspection 10/10/95

DS left: Steep valley wall.

DS right: Steep channel bank to overbank.

US left: Steep valley wall.

US right: Steep channel bank to overbank.

Description of the Channel

Average top width 61 *ft* ***Average depth*** 7 *ft*

Predominant bed material Gravel / Boulders ***Bank material*** Gravel/Boulders

Sinuous but stable with non-alluvial channel boundaries and no flood plain.

10/10/95

Vegetative co Trees and brush.

DS left: Trees and brush.

DS right: Trees and brush.

US left: Trees and brush.

US right:

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

None, 10/10/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 12.5 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	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 2,520 ***ft³/s*** ***Q500*** 3,500 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(12.5/13.7)exp 0.67] with those discharges in the VTAOT database for bridge number 11 in Wallingford. Bridge number 11 crosses this unnamed tributary of Mill River downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 11 is 13.7 square miles. The drainage area adjusted discharge values are within a range defined by several empirical flood frequency curves (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 curbing above the DS end of the left abutment (elev. 500.24 ft, arbitrary survey datum). RM2 is a chiseled X on top of the curbing above the US end of the right abutment (elev. 499.39 ft, arbitrary survey datum). RM3 is a nail 5 ft above the base in a telephone pole on the DS RB at the edge of Route 103 (elev. 502.53 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	-65	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	45	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 0.045 to 0.055, and the overbank "n" value was 0.040.

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 0.015 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

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.

For the 100-year and incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it was determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.8 ***ft***
Average low steel elevation 497.0 ***ft***

100-year discharge 2,520 ***ft³/s***
Water-surface elevation in bridge opening 492.9 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 169 ***ft²***
Average velocity in bridge opening 15.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.7 ***ft/s***

Water-surface elevation at Approach section with bridge 496.7
Water-surface elevation at Approach section without bridge 493.3
Amount of backwater caused by bridge 3.4 ***ft***

500-year discharge 3,500 ***ft³/s***
Water-surface elevation in bridge opening 497.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 762 ***ft³/s***
Area of flow in bridge opening 266 ***ft²***
Average velocity in bridge opening 10.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.8 ***/s***

Water-surface elevation at Approach section with bridge 499.7
Water-surface elevation at Approach section without bridge 494.5
Amount of backwater caused by bridge 5.2 ***ft***

Incipient overtopping discharge 2,710 ***ft³/s***
Water-surface elevation in bridge opening 493.3 ***ft***
Area of flow in bridge opening 177 ***ft²***
Average velocity in bridge opening 15.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 20.3 ***ft/s***

Water-surface elevation at Approach section with bridge 497.2
Water-surface elevation at Approach section without bridge 493.6
Amount of backwater caused by bridge 3.6 ***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 scour analysis for the 100-year and 500-year discharges are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the 100-year and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 500-year 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 this discharge was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the 500-year discharge 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. Furthermore, for the 500-year discharge, contraction scour was computed by substituting an estimate for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to this substitution are provided in appendix F.

Abutment scour 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 Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.5	0.0	0.6
Depth to armoring	26.2	9.7	27.8
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	8.8	10.4	9.1
Right abutment	14.4	11.8	14.8
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.9	3.3	3.1
Right abutment	2.9	3.3	3.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

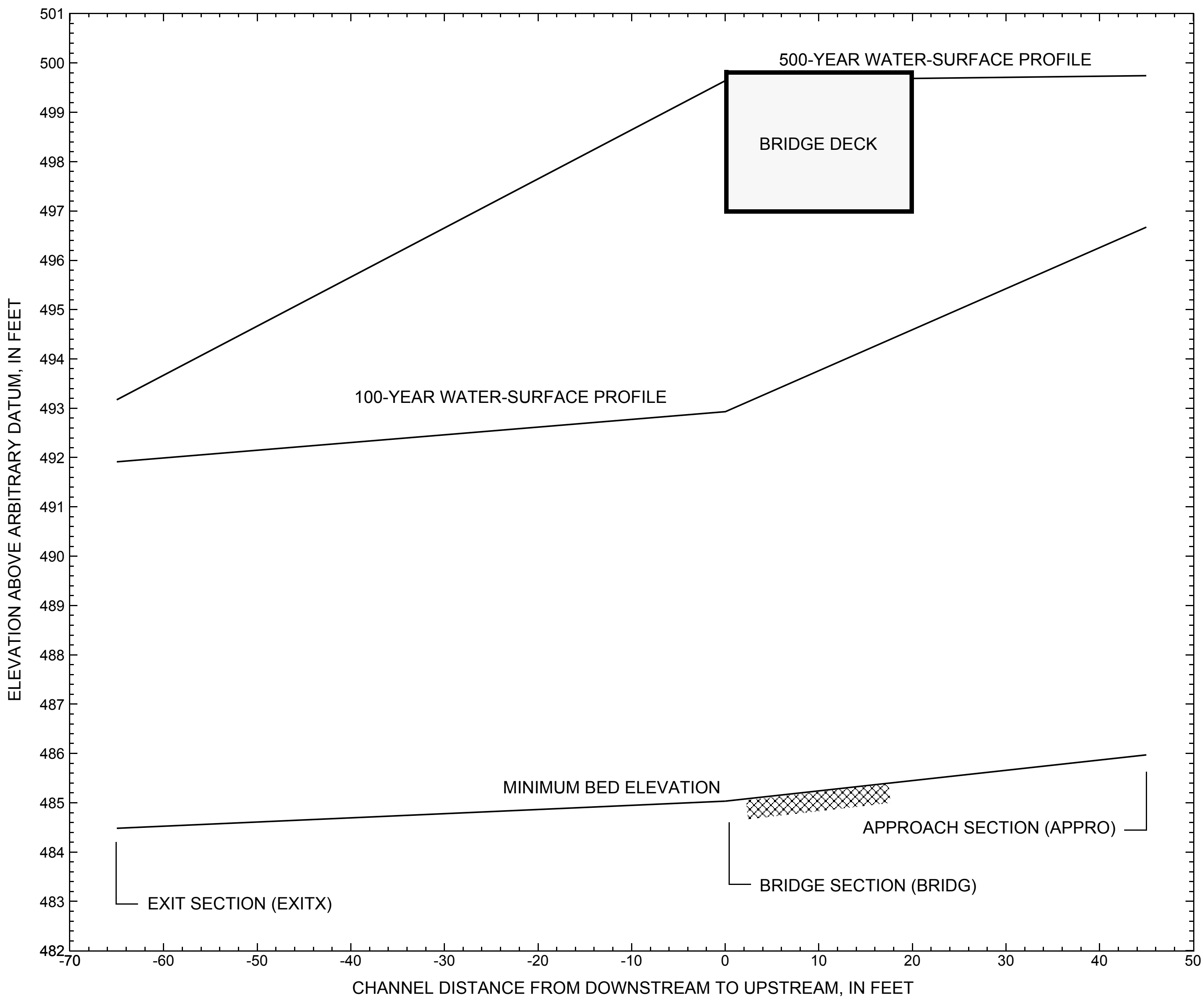

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure MTHOTH00170064 on Town Highway 17, crossing an unnamed tributary of Mill River, Mount Holly, Vermont.

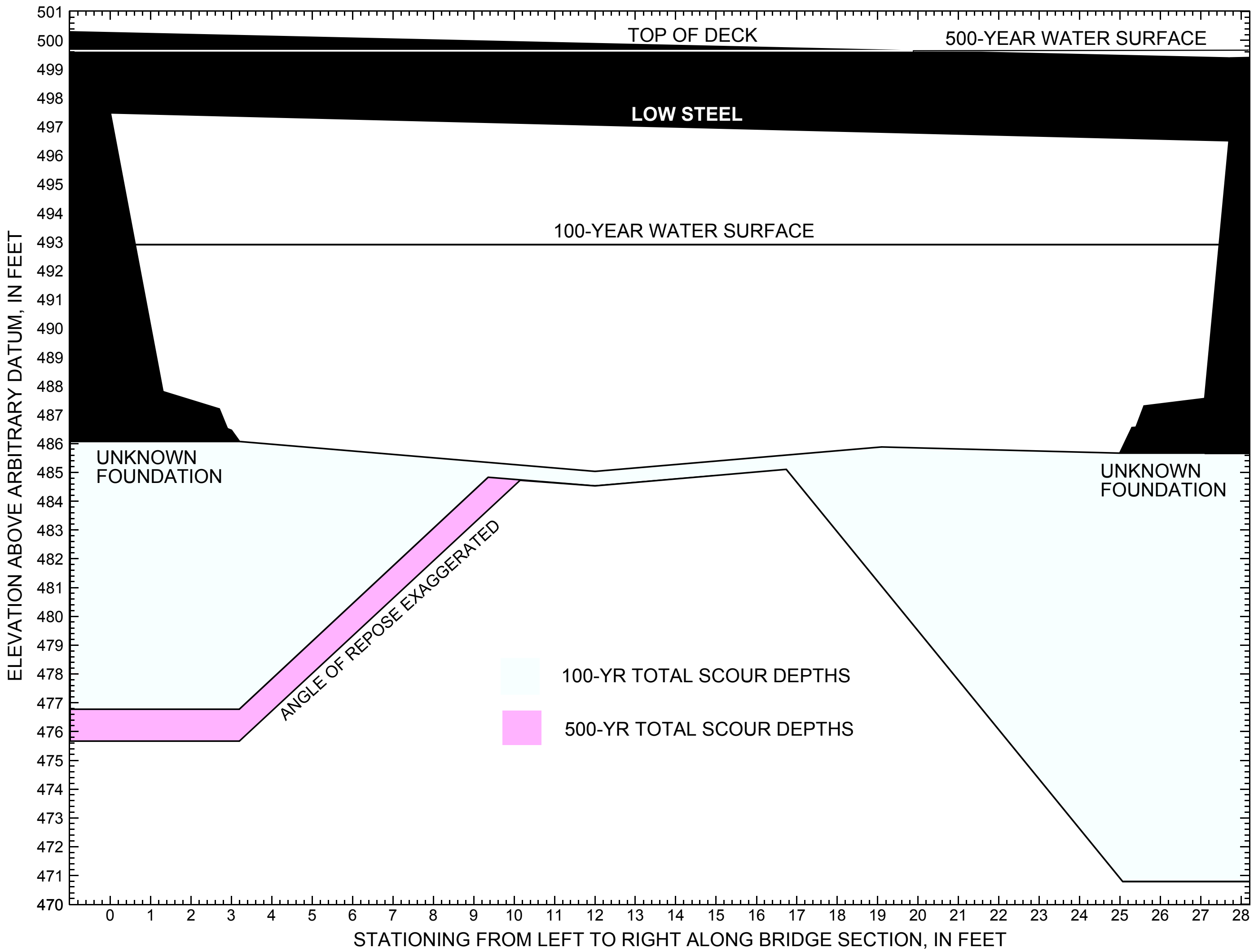

Figure 8. Scour elevations for the 100- and 500-year discharges at structure MTHOTH00170064 on Town Highway 17, crossing an unnamed tributary of Mill River, Mount Holly, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MTHOTH00170064 on Town Highway 17, crossing an unnamed tributary of Mill River, Mount Holly, 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-year. discharge is 2,520 cubic-feet per second											
Left abutment	0.0	--	497.5	--	486.1	0.5	8.8	--	9.3	476.8	--
Right abutment	27.7	--	496.5	--	485.7	0.5	14.4	--	14.9	470.8	--

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 MTHOTH00170064 on Town Highway 17, crossing an unnamed tributary of Mill River, Mount Holly, 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-year. discharge is 3,500 cubic-feet per second											
Left abutment	0.0	--	497.5	--	486.1	0.0	10.4	--	10.4	475.7	--
Right abutment	27.7	--	496.5	--	485.7	0.0	11.8	--	11.8	473.9	--

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, Mount Holly, 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 mtho064.wsp
T2        Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
T3        Brg.64 on Bowlsville Rd(TH 17)over an Unnamed Trib.Mill River Mount Holly,VT
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2520.0   3500.0   2710.0
SK          0.015    0.015    0.015
*
XS   EXITX    -65
GR          -43.1, 512.17      0.0, 491.98      3.2, 488.42      9.2, 487.25
GR           25.3, 486.48     28.8, 485.35     31.5, 484.65     34.6, 484.48
GR           38.5, 484.56     44.3, 485.29     48.7, 489.83     74.8, 498.03
GR           85.4, 498.48    119.8, 496.81    194.5, 498.23    245.4, 508.23
N           0.055        0.040
SA                  74.8
*
XS   FULLV      0  * * *   0.0070
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.99      25.0
GR            0.0, 497.48      1.3, 487.80      2.7, 487.20      2.9, 486.51
GR            3.0, 486.46      3.2, 486.07      7.0, 485.60     12.0, 485.03
GR           19.1, 485.88     25.0, 485.67     25.3, 486.55     25.4, 486.56
GR           25.6, 487.30     27.1, 487.56     27.7, 496.51      0.0, 497.48
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      26.2 * *     65.5      2.9
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      14.4     2
GR         -101.9, 514.70    -20.0, 501.76      0.0, 499.68      0.0, 500.26
GR           31.2, 499.39     31.4, 498.77
GR           74.5, 498.72    104.6, 497.34    168.2, 500.39    256.0, 509.48
*
AS   APPRO     45
GR          -47.2, 516.57    -13.0, 498.20      0.0, 490.29      9.8, 487.43
GR           12.3, 486.74     17.9, 486.48     22.8, 485.98     26.5, 485.97
GR           30.4, 487.20     32.8, 488.04     36.0, 491.93     45.7, 496.26
GR           72.7, 498.87    106.5, 497.63    175.7, 500.81    203.8, 505.28
GR          245.6, 509.00
N           0.055        0.040
SA                  45.7
*
HP 1 BRIDG   492.93 1 492.93
HP 2 BRIDG   492.93 * * 2520
HP 1 APPRO   496.68 1 496.68
HP 2 APPRO   496.68 * * 2520
*
HP 1 BRIDG   496.99 1 496.99
HP 2 BRIDG   496.99 * * 2805
HP 1 BRIDG   494.45 1 494.45
HP 2 RDWAY   499.64 * * 762
HP 1 APPRO   499.74 1 499.74
HP 2 APPRO   499.74 * * 3500
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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       U.S. Geological Survey WSPRO Input File mtho064.wsp
       Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
       Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib.Mill River Mount Holly, VT
          *** RUN DATE & TIME: 01-05-98  13:23
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     169.   15551.    24.    36.                       2517.
  492.93          169.   15551.    24.    36.  1.00     1.    27.   2517.


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      492.93     0.6    27.5   168.6   15551.    2520.  14.95

 X STA.         0.6        5.2        6.2        7.2        8.2        9.1
   A(I)            24.1        6.8        6.5        6.6        6.4
   V(I)            5.23      18.57      19.51      19.15      19.58

 X STA.         9.1       10.1       11.0       11.9       12.9       13.8
   A(I)             6.6        6.5        6.5        6.5        6.8
   V(I)           19.18      19.29      19.33      19.47      18.55

 X STA.        13.8       14.8       15.7       16.7       17.7       18.8
   A(I)             6.5        6.6        6.5        6.6        6.8
   V(I)           19.26      18.95      19.32      18.99      18.63

 X STA.        18.8       19.8       20.8       21.8       22.8       27.5
   A(I)             6.6        6.5        6.7        6.4       26.1
   V(I)           19.17      19.42      18.87      19.71       4.83

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     389.   35996.    56.    62.                       5807.
            2       1.      12.     4.     4.                          2.
  496.68          390.   36008.    61.    66.  1.00   -11.    50.   5604.


   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

        WSEL     LEW     REW    AREA        K        Q    VEL
      496.68   -10.5    50.0   389.9   36008.    2520.   6.46

 X STA.       -10.5        2.7        5.1        7.2        9.0       10.7
   A(I)            51.9       18.0       17.0       16.1       15.6
   V(I)            2.43       7.01       7.42       7.83       8.08

 X STA.        10.7       12.3       13.8       15.4       16.9       18.4
   A(I)            15.8       15.1       15.4       15.3       15.4
   V(I)            7.99       8.32       8.20       8.24       8.18

 X STA.        18.4       19.9       21.3       22.7       24.1       25.5
   A(I)            15.4       15.1       15.2       14.9       14.6
   V(I)            8.20       8.34       8.29       8.45       8.64

 X STA.        25.5       26.9       28.3       29.9       31.6       50.0
   A(I)            14.9       14.9       15.6       16.0       57.9
   V(I)            8.44       8.46       8.09       7.90       2.18
```

WSPRO OUTPUT FILE (continued)

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      U.S. Geological Survey WSPRO Input File mtho064.wsp
      Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
      Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib. Mill River Mount Holly, VT
         *** RUN DATE & TIME: 01-05-98  13:23
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     266.   24764.    13.    56.                        6924.
 496.99          266.   24764.    13.    56.  1.00     0.    28.   6924.

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

       WSEL     LEW     REW    AREA         K        Q    VEL
     496.99     0.1    27.7   265.9   24764.    2805.  10.55

X STA.         0.1        4.4        5.3        6.2        7.1        8.0
  A(I)            33.8        9.2        9.1        9.3        9.5
  V(I)            4.15      15.26      15.44      15.12      14.72

X STA.         8.0        8.9        9.8       10.7       11.6       12.4
  A(I)             9.4        9.6        9.6        9.9        8.6
  V(I)           14.91      14.61      14.63      14.09      16.39

X STA.        12.4       13.1       13.9       14.9       16.1       17.3
  A(I)             7.1        8.5       11.2       11.9       12.0
  V(I)           19.81      16.54      12.53      11.80      11.72

X STA.        17.3       18.4       19.6       20.9       22.1       27.7
  A(I)            11.8       12.0       12.4       12.0       49.2
  V(I)           11.88      11.67      11.28      11.72       2.85

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     206.   20543.    25.    39.                        3376.
 494.45          206.   20543.    25.    39.  1.00     0.    28.   3376.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

       WSEL     LEW     REW    AREA         K        Q    VEL
     499.64    22.2   152.6   143.4    5551.     762.   5.31

X STA.        22.2       47.8       60.1       72.0       80.1       85.0
  A(I)            15.7       11.0       10.8        8.2        6.3
  V(I)            2.43       3.46       3.52       4.64       6.09

X STA.        85.0       88.9       92.1       95.1       97.8      100.2
  A(I)             5.8        5.4        5.3        5.2        4.9
  V(I)            6.53       7.07       7.21       7.35       7.85

X STA.       100.2      102.3      104.3      106.3      108.4      110.7
  A(I)             4.5        4.5        4.6        4.6        4.7
  V(I)            8.48       8.38       8.35       8.24       8.16

X STA.       110.7      113.2      116.0      119.1      122.9      152.6
  A(I)             4.9        5.1        5.2        5.8       21.1
  V(I)            7.84       7.53       7.31       6.59       1.80

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     569.   63647.    62.    68.                        9814.
           2     158.    7598.   107.   107.                        1086.
 499.74          726.   71245.   168.   175.  1.19   -16.   152.   7857.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

       WSEL     LEW     REW    AREA         K        Q    VEL
     499.74   -15.9   152.4   726.5   71245.    3500.   4.82

X STA.       -15.9        2.1        4.7        7.2        9.4       11.4
  A(I)            93.7       27.6       27.5       26.6       25.1
  V(I)            1.87       6.35       6.37       6.57       6.98

X STA.        11.4       13.3       15.2       17.1       19.0       20.8
  A(I)            24.8       25.0       24.8       24.7       25.1
  V(I)            7.06       7.01       7.05       7.08       6.99

X STA.        20.8       22.7       24.5       26.3       28.2       30.2
  A(I)            25.1       25.3       24.7       25.7       25.5
  V(I)            6.97       6.91       7.08       6.80       6.87

X STA.        30.2       32.3       36.5       47.2       84.6      152.4
  A(I)            26.4       40.5       56.1       66.4       85.9
  V(I)            6.63       4.32       3.12       2.63       2.04
```

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        U.S. Geological Survey WSPRO Input File mtho064.wsp
        Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
        Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib. Mill River Mount Holly, VT
           *** RUN DATE & TIME: 01-05-98  13:23
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     177.   16669.    24.    37.                        2707.
   493.28          177.   16669.    24.    37.  1.00     1.    27.   2707.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.28     0.6    27.5   177.1   16669.    2710.  15.30

X STA.         0.6        5.3        6.3        7.2        8.2        9.2
  A(I)            25.9        6.9        6.8        6.9        6.7
  V(I)            5.24      19.77      20.03      19.68      20.14

X STA.         9.2       10.1       11.0       12.0       12.9       13.8
  A(I)             6.9        6.8        6.8        6.9        7.0
  V(I)           19.74      19.86      19.92      19.75      19.40

X STA.        13.8       14.8       15.8       16.7       17.7       18.8
  A(I)             7.0        6.9        6.8        7.0        6.9
  V(I)           19.48      19.77      19.83      19.48      19.54

X STA.        18.8       19.8       20.8       21.8       22.8       27.5
  A(I)             6.9        7.0        6.8        6.7       27.8
  V(I)           19.72      19.38      20.04      20.30       4.87


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     418.   40217.    57.    63.                        6430.
             2       5.     103.    10.    10.                          18.
   497.20          423.   40320.    67.    72.  1.01   -11.    55.   5999.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.20   -11.4    55.4   423.0   40320.    2710.   6.41

X STA.       -11.4        2.5        4.9        7.0        8.9       10.7
  A(I)            57.6       19.0       18.4       17.4       17.2
  V(I)            2.35       7.14       7.36       7.79       7.87

X STA.        10.7       12.3       13.9       15.4       17.0       18.5
  A(I)            16.9       16.2       16.5       16.4       16.5
  V(I)            8.00       8.35       8.23       8.27       8.21

X STA.        18.5       20.1       21.6       23.0       24.4       25.9
  A(I)            16.9       16.6       16.1       16.1       16.2
  V(I)            8.04       8.18       8.43       8.40       8.38

X STA.        25.9       27.3       28.9       30.5       32.3       55.4
  A(I)            16.1       16.5       16.8       17.1       62.6
  V(I)            8.40       8.22       8.08       7.91       2.17
```

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        U.S. Geological Survey WSPRO Input File mtho064.wsp
        Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
        Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib. Mill River Mount Holly, VT
           *** RUN DATE & TIME: 01-05-98  13:23

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

EXITX:XS   ******     0.     275.  1.30 *****  493.33  490.93   2520.  492.02
      -65. ******    56.   20565.  1.00 ***** *******    0.73    9.16

FULLV:FV      65.    -1.     312.  1.01  0.82  494.14 *******   2520.  493.12
        0.    65.    58.   24403.  1.00  0.00   -0.01    0.62    8.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.92     493.30     492.96

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.62     516.57    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.62     516.57     492.96

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.67

APPRO:AS      45.    -5.     219.  2.06  0.72  495.38  492.96   2520.  493.31
       45.    45.    39.   16313.  1.00  0.53    0.00    0.91   11.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    2520.     492.93

            <<<<<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      65.     1.     169.  3.47 *****  496.41  492.93   2520.  492.93
        0.    65.    27.   15557.  1.00 ***** *******    1.00   14.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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      19.   -11.     390.  0.65  0.24  497.34  492.96   2520.  496.68
       45.    21.    50.   36046.  1.00  0.69    0.00    0.45    6.46

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.390  0.093   32682.     6.    33.   496.54

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -65.     0.    56.   2520.   20565.     275.    9.16  492.02
   FULLV:FV       0.    -1.    58.   2520.   24403.     312.    8.07  493.12
   BRIDG:BR       0.     1.    27.   2520.   15557.     169.   14.95  492.93
   RDWAY:RG      10.**************      0.*****************     2.00********
   APPRO:AS      45.   -11.    50.   2520.   36046.     390.    6.46  496.68

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      6.    33.   32682.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    490.93    0.73  484.48  512.17************  1.30  493.33  492.02
   FULLV:FV  ********    0.62  484.93  512.63  0.82  0.00  1.01  494.14  493.12
   BRIDG:BR    492.93    1.00  485.03  497.48************  3.47  496.41  492.93
   RDWAY:RG  ****************  497.34  514.70**********************************
   APPRO:AS    492.96    0.45  485.97  516.57  0.24  0.69  0.65  497.34  496.68
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File mtho064.wsp
        Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
        Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib. Mill River Mount Holly, VT
           *** RUN DATE & TIME: 01-05-98  13:23

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

EXITX:XS   ******    -3.     351.  1.55 *****  494.85  492.08   3500.  493.30
      -65. ******    60.   28558.  1.00 ***** *******    0.74    9.98

FULLV:FV      65.    -4.     395.  1.22  0.83  495.67 *******   3500.  494.45
        0.    65.    62.   33554.  1.00  0.00   -0.01    0.64    8.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.95     494.51     494.28

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   493.95     516.57    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   493.95     516.57     494.28

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.67

APPRO:AS      45.    -7.     275.  2.51  0.74  497.04  494.28   3500.  494.53
       45.    45.    42.   22321.  1.00  0.65    0.00    0.94   12.71
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.32       0.00     494.67     497.34

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   502.21         0.      3500.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

 ===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      65.     0.     266.  1.73 *****  498.72  493.47   2805.  496.99
        0. ******    28.   24764.  1.00 ***** *******    0.60   10.55

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.469 ******  496.99 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG       10.    31.  0.07  0.43  500.10     0.02     762.  499.64

             Q    WLEN     LEW     REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.      2.     -2.      0.   0.2   0.1   3.1  14.0   0.6   2.7
   RT:    762.    130.     22.    153.   2.3   1.1   5.6   5.3   1.6   3.0

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

APPRO:AS      19.   -16.     727.  0.43  0.12  500.17  494.28   3500.  499.74
       45.    21.   152.   71306.  1.19  0.00    0.02    0.45    4.81

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -65.    -3.    60.   3500.   28558.     351.    9.98  493.30
   FULLV:FV       0.    -4.    62.   3500.   33554.     395.    8.85  494.45
   BRIDG:BR       0.     0.    28.   2805.   24764.     266.   10.55  496.99
   RDWAY:RG      10.*******     0.    762.       0.*********    2.00  499.64
   APPRO:AS      45.   -16.   152.   3500.   71306.     727.    4.81  499.74

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     492.08    0.74  484.48  512.17************  1.55  494.85  493.30
   FULLV:FV   ********    0.64  484.93  512.63  0.83  0.00  1.22  495.67  494.45
   BRIDG:BR     493.47    0.60  485.03  497.48************  1.73  498.72  496.99
   RDWAY:RG   ****************  497.34  514.70  0.07******  0.43  500.10  499.64
   APPRO:AS     494.28    0.45  485.97  516.57  0.12  0.00  0.43  500.17  499.74
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        U.S. Geological Survey WSPRO Input File mtho064.wsp
        Hydraulic analysis for structure MTHOTH00170064   Date: 18-DEC-97
        Bridge 64 on Bowlsville Rd TH 17 over the Unnamed Trib. Mill River Mount Holly, VT
           *** RUN DATE & TIME: 01-05-98  13:23

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

EXITX:XS   ******    -1.     290.  1.35 *****  493.65  491.15   2710.  492.29
      -65. ******    57.   22111.  1.00 ***** *******    0.73    9.33

FULLV:FV      65.    -2.     329.  1.06  0.82  494.46 *******   2710.  493.40
        0.    65.    59.   26181.  1.00  0.00   -0.01    0.62    8.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.92     493.55     493.24

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.90     516.57    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.90     516.57     493.24

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.67

APPRO:AS      45.    -5.     230.  2.15  0.72  495.72  493.24   2710.  493.57
       45.    45.    40.   17491.  1.00  0.55    0.00    0.92   11.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    2710.     493.28

            <<<<<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      65.     1.     177.  3.64 *****  496.92  493.28   2710.  493.28
        0.    65.    27.   16682.  1.00 ***** *******    1.00   15.30

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      10.        <<<<<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      19.   -11.     423.  0.65  0.23  497.85  493.24   2710.  497.20
       45.    21.    55.   40303.  1.01  0.69    0.00    0.45    6.41

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.402  0.116   35613.     6.    33.   497.06

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -65.    -1.    57.   2710.   22111.     290.    9.33  492.29
   FULLV:FV       0.    -2.    59.   2710.   26181.     329.    8.24  493.40
   BRIDG:BR       0.     1.    27.   2710.   16682.     177.   15.30  493.28
   RDWAY:RG      10.**************      0.******************    2.00********
   APPRO:AS      45.   -11.    55.   2710.   40303.     423.    6.41  497.20

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       6.    33.   35613.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    491.15    0.73  484.48  512.17************  1.35  493.65  492.29
   FULLV:FV  ********    0.62  484.93  512.63  0.82  0.00  1.06  494.46  493.40
   BRIDG:BR    493.28    1.00  485.03  497.48************  3.64  496.92  493.28
   RDWAY:RG  ****************  497.34  514.70************************************
   APPRO:AS    493.24    0.45  485.97  516.57  0.23  0.69  0.65  497.85  497.20
```
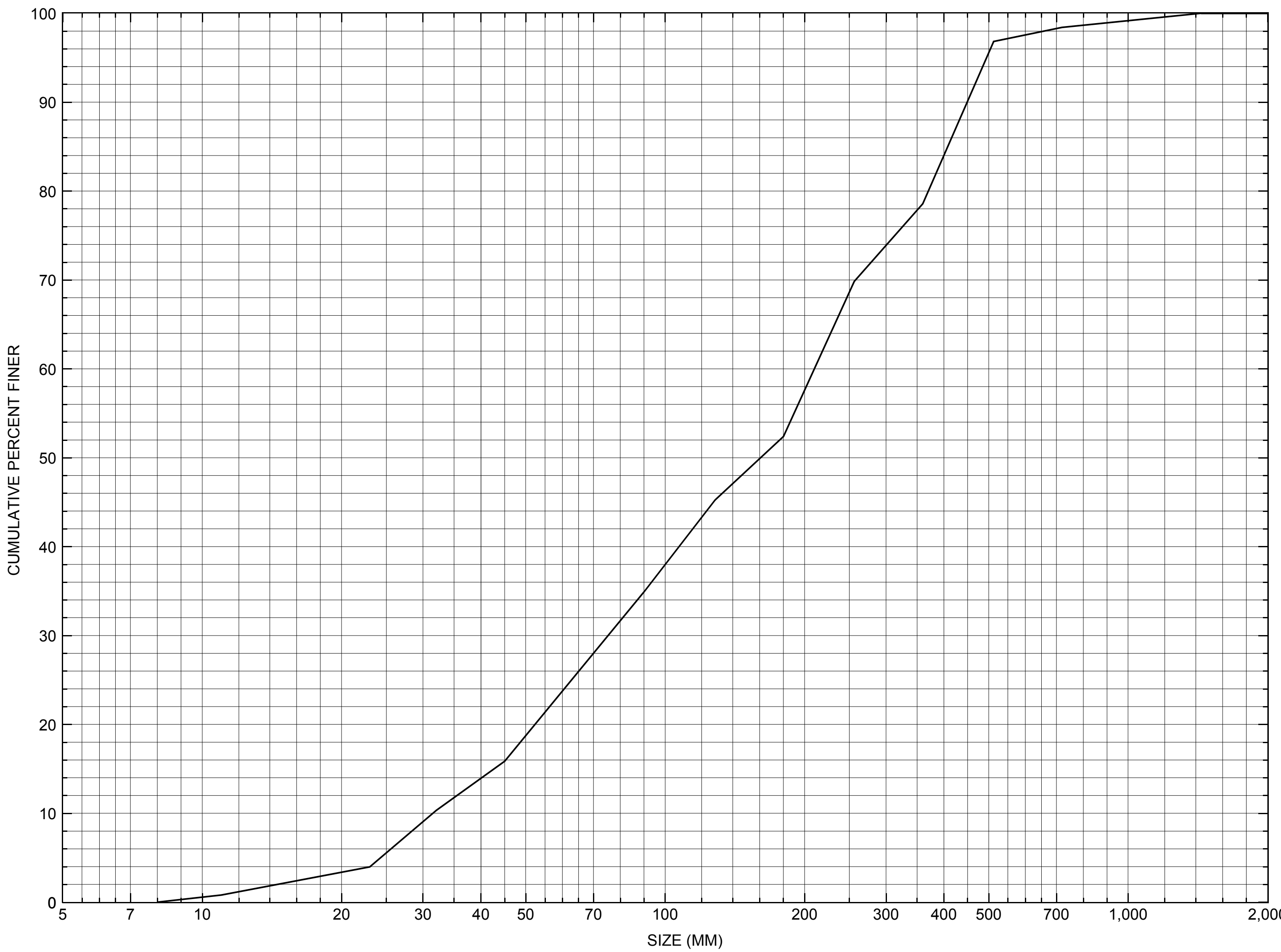

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MTHOTH00170064, in Mount Holly, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MTHOTH00170064

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 21 / 95

Highway District Number *(I - 2; nn)* 03

County *(FIPS county code; I - 3; nnn)* 021

Town *(FIPS place code; I - 4; nnnnn)* 47200

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

Waterway *(I - 6)* BRANCH OF MILL RIVER

Road Name *(I - 7)*: BOWLSVILLE ROAD

Route Number TH017

Vicinity *(I - 9)* 0.05 MI JCT VT 103

Topographic Map Mount.Holly

Hydrologic Unit Code: 02010001

Latitude *(I - 16; nnnn.n)* 43268

Longitude *(i - 17; nnnnn.n)* 72512

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10111200641112

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

Maximum span length *(I - 48; nnnn)* 0029

Year built *(I - 27; YYYY)* 1934

Structure length *(I - 49; nnnnnn)* 000031

Average daily traffic, ADT *(I - 29; nnnnnn)* 000100

Deck Width *(I - 52; nn.n)* 144

Year of ADT *(I - 30; YY)* 92

Channel & Protection *(I - 61; n)* 6

Opening skew to Roadway *(I - 34; nn)* 20

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*) 027.0

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

Vertical clearance from streambed (*nnn.n ft*) 009.0

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

Waterway of full opening (*nnn.n* ft^2) 243.0

Comments:

The structural inspection report of 6/23/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt road surface. The abutment walls and wingwalls are concrete with random spalling, cracking, and leaking reported overall. Both abutment footings are reported exposed above the streambed with heavy concrete spalling, scaling, and "break-ups" along them. While both footings are exposed, the report indicates there has been no undermining or settlement. One of the right abutment wingwalls and both left abutment wingwalls are extended with stone walls. Some of the stones are displaced from the walls toward the stream. The channel bed consists of gravel, cobbles, and boulders. There is some debris noted in the channel consisting of small logs.

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:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **12.47** mi^2

Lake/pond/swamp area **0.22** mi^2

Watershed storage *(ST)* **1.8** %

Bridge site elevation **1260** ft

Headwater elevation **3286** ft

Main channel length **6.84** mi

10% channel length elevation **1378** ft

85% channel length elevation **1850** ft

Main channel slope *(S)* **92.11** 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? **Yes** *If no, type ctrl-n xs*

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

Comments: **This cross section was created from a sketch dated 8/2/92 that was attached to a bridge inspection report. The low chord elevations, are set to the vertical coordinate surveyed on 10/10/95. This section is from the US face.**

Station	0	2.32	2.33	9.83	19.86	27.51	27.52	28.94	-	-	-
Feature	LAB	-	-	-	-	-	-	RAB	-	-	-
Low chord elevation	497.50	497.42	497.42	497.16	496.81	496.55	496.55	496.50	-	-	-
Bed elevation	487.80	487.72	485.84	485.24	485.48	485.47	487.65	487.60	-	-	-
Low chord to bed	9.70	9.70	11.58	11.92	11.33	11.08	8.90	8.90	-	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **CG** Date: **02/06/96**
Computerized by: **CG** Date: **02/06/96**
Reviewd by: **MAL** Date: **01/09/98**

Structure Number **MTHOTH00170064**

A. General Location Descriptive

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

2. Highway District Number **03** Mile marker **0**

County **Rutland (021)** Town **Mount Holly (47200)**

Waterway *(I - 6)* **unnamed tributary of Mill River** Road Name **Bowlsville Road**

Route Number **TH 17** Hydrologic Unit Code: **02010001**

3. Descriptive comments:

The site is located 0.05 miles from the junction with VT 103.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **6** RBDS **6** Overall **6**
*(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 **2** UB **1** DS **2** *(**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 **31.0** *(feet)* Span length **29.0** *(feet)* Bridge width **14.4** *(feet)*

Road approach to bridge:

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

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

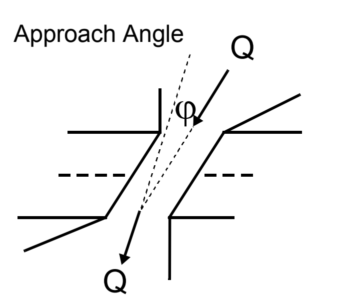
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

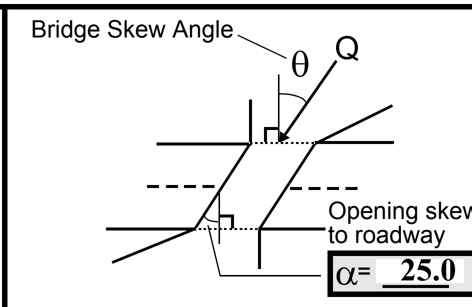
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	2	2
RBUS	2	1	1	2
RBDS	2	2	2	3
LBDS	0	-	2	2

*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: **20**





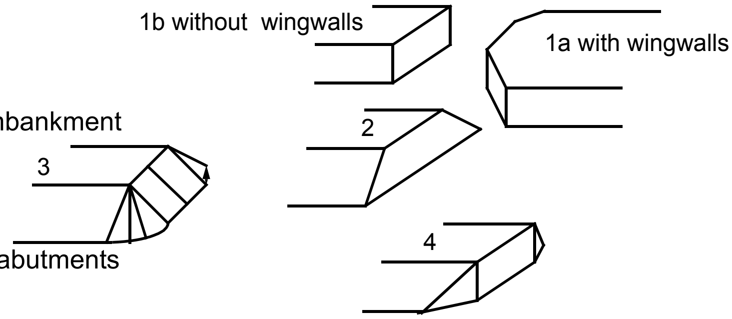
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **70** feet **US** *(US, UB, DS)* to **25** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **0** feet **DS** *(US, UB, DS)* to **45** feet **DS**

*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.)

The bridge dimensions measured are the same as the values taken from the VTAOT files.
The upstream left bank coverage is forest up the left bank slope. There is a roadway where the slope flattens and a home with a lawn.
The downstream left bank coverage is the same as the upstream left bank.
The upstream right bank coverage consists of a strip of trees and brush closest to the channel along the right bank, State Route 103, and a lawn and homes. The downstream right bank coverage is mainly forest bisected by State Route 103.

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
29.5	**3.0**			**9.0**	**2**	**3**	**543**	**7**	**1**	**1**

23. Bank width **15.0** 24. Channel width **30.0** 25. Thalweg depth **46.0** 29. Bed Material **453**

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.):

The right bank is protected from 0 ft upstream to 45 ft upstream.
The channel bed has a distinctly higher fraction of medium to large boulders. A few are larger than 12 ft in diameter. The right bank material is not native as it is the roadway embankment material of State Route 103. State Route 103 follows the channel's right bank for at least 0.2 miles.
The upstream channel is a series of pools and riffles with depths between 2 and 0.5 ft deep respectively. The channel upstream of the approach is flatter and pooled, then steepens and is constant riffle from 65 ft upstream to about 10 ft upstream where the slope flattens and the channel is pooled under the bridge.

33. Point/Side bar present? **Y** (*Y or N. if N type ctrl-n pb*) 34. Mid-bar distance: **80.0** 35. Mid-bar width: **10.0**
36. Point bar extent: **120** feet **US** (*US, UB*) to **35** feet **US** (*US, UB, DS*) positioned **0** %LB to **30** %RB
37. Material: **54**
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):
The area between the boulders has filled in with sand, gravel and silt. Both bars have nearly 90% vegetation coverage by mainly grasses and small shrubs. The additional side bar is on the right bank between 135 ft upstream and 100 ft upstream and is about 12 ft wide at 120 ft upstream. It is positioned 50% LB to 100% RB.

39. Is a cut-bank present? **N** (*Y or if N type ctrl-n cb*) 40. Where? **-** (*LB or RB*)
41. Mid-bank distance: **-** 42. Cut bank extent: **-** feet **-** (*US, UB*) to **-** feet **-** (*US, UB, DS*)
43. Bank damage: **-** (*1- eroded and/or creep; 2- slip failure; 3- block failure*)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):
NO CUT BANKS

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
21.0		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.):
453
The under bridge channel is pooled.

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 2____ *(1- Low; 2- Moderate; 3- High)*

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

70. Debris and Ice Comments:

2

There are whole trees and branches piled up on the side bar upstream on the left bank. Debris is likely to build up here as well as ice, however the banks are stable and moderately vegetated right along the channel edges. There are trees leaning over the channel upstream.

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	2	0	2.0	90.0
RABUT	1	-	90			2	2	25.0

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

2.0

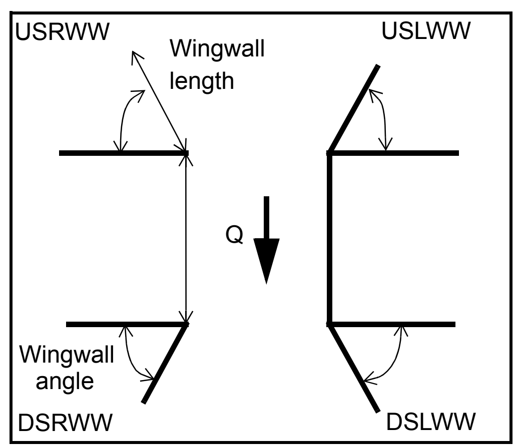
1

The footings are exposed on both abutments between 1.5 ft and 2.0 ft over the entire base length of each abutment. The footings and abutment walls are not protected.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						25.0	1.5
USRWW:	Y		1		2	20.0	
DSLWW:	0		1.0		Y	20.0	
DSRWW:	1		2		0	90.0	

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	1.0	2	Y	0	2	1	-	-
Condition	Y	0	1	1.0	1	1	-	-
Extent	1	1.0	2	2	3	0	0	-

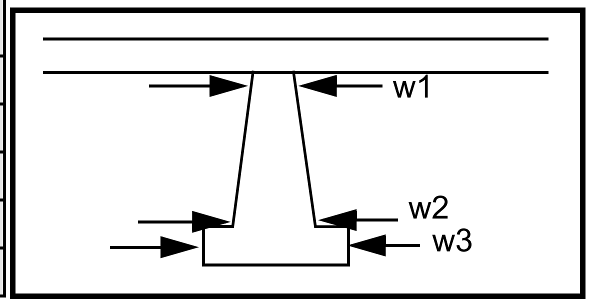
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
5
2
3

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	6.0	7.5	3.0	40.0	65.0	120.0
Pier 2	3.5	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e rock	right	poor	out	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	walls	wing	con-	fines	**1**- Solid pier, **2**- column, **3**- bent
88. Material	exte	wall	ditio	from	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	ndin	and	n.	betw	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	g	dow	Seep	een	Y- yes; N- no
91. Attack ∠ (BF)	from	nstre	age	stone	
92. Pushed	the	am	from	bloc	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	ends	left	road	ks	
95. Cross-members	of	wing	way	and	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	the	wall	has	con-	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	upst	are	wash	sequ	
98. Exposure depth	ream	in	ed	ently	

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

most stone blocks have slumped down and settled together. The stone fill has slumped and eroded from behind the downstream right wingwall. Just downstream of the eroded area, behind the downstream right wingwall a stone block wall begins.

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: **64.5** 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.):

-
-
-
-

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

Cut bank extent: RS 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? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 4

Scour dimensions: Length 4 Width 543 Depth: 453 Positioned 1 %LB to 2 %RB

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

354
0
5
-

Are there major confluences? 1 (Y or if N type ctrl-n mc) How many? The

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

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

Confluence comments (eg. confluence name):

flat and pooled from 0 ft downstream to 50 ft downstream where the gradient steepens. This steeper area continues to about 90 ft downstream where the channel flattens and is pooled once again. Like upstream the

F. Geomorphic Channel Assessment

107. Stage of reach evolution po

__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)*:

oled areas are no deeper than 2 ft and the riffled depths are around 0.5 ft. The downstream channel also has a high boulder component. The right bank downstream is impacted with slight severity from 50 ft downstream to 105 ft downstream.

The right bank is protected by a stone block and boulder wall extending from 5 ft downstream to 75 ft downstream.

There is some erosion on the right bank side downstream in range of the impact zone where some tree roots are exposed and the bank material is slightly to moderately eroded.

109. G. Plan View Sketch

N

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: MTHOTH00170064 Town: Mount Holly
Road Number: TH 17 County: Rutland
Stream: unnamed tributary of Mill River

Initials MAI Date: 01/05/98 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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2520	3500	2710
Main Channel Area, ft2	389	569	418
Left overbank area, ft2	0	0	0
Right overbank area, ft2	1	158	5
Top width main channel, ft	56	62	57
Top width L overbank, ft	0	0	0
Top width R overbank, ft	4	107	10
D50 of channel, ft	0.5271	0.5271	0.5271
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.9	7.3	7.3
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	0.3	0.5	0.5
Total conveyance, approach	36008	71245	40320
Conveyance, main channel	35996	63647	40217
Conveyance, LOB	0	0	0
Conveyance, ROB	12	7598	103
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2519.2	3126.7	2703.1
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	0.8	373.3	6.9
Vm, mean velocity MC, ft/s	6.5	7.5	6.5
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	0.8	74.7	1.4
Vc-m, crit. velocity, MC, ft/s	12.5	12.6	12.6
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 Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2520	3500	2710
(Q) discharge thru bridge, cfs	2520	2804	2710
Main channel conveyance	15551	24764	16734
Total conveyance	15551	24764	16734
Q2, bridge MC discharge,cfs	2520	2804	2710
Main channel area, ft2	169	266	178
Main channel width (normal), ft	24.4	25.0	24.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.4	25	24.4
y_bridge (avg. depth at br.), ft	6.91	10.64	7.30
Dm, median (1.25*D50), ft	0.658875	0.658875	0.658875
y2, depth in contraction,ft	7.42	7.97	7.90
ys, scour depth (y2-ybridge), ft	**0.51**	-2.67	**0.61**

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	2520	3500	2710
Q, thru bridge MC, cfs	2520	2804	2710
Vc, critical velocity, ft/s	12.51	12.62	12.62
Va, velocity MC approach, ft/s	6.48	7.48	6.47
Main channel width (normal), ft	24.4	25.0	24.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.4	25.0	24.4
qbr, unit discharge, ft2/s	103.3	112.2	111.1
Area of full opening, ft2	168.6	266.0	178.0
Hb, depth of full opening, ft	6.91	10.64	7.30
Fr, Froude number, bridge MC	0	0.6	0
Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
**Area at downstream face, ft2	N/A	206	N/A
**Hb, depth at downstream face, ft	N/A	8.24	N/A
**Fr, Froude number at DS face	ERR	0.84	ERR

**Cf, for downstream face (<=1.0)	N/A	1.00	N/A
Elevation of Low Steel, ft	0	496.99	0
Elevation of Bed, ft	-6.91	486.35	-7.30
Elevation of Approach, ft	0	499.74	0
Friction loss, approach, ft	0	0.12	0
Elevation of WS immediately US, ft	0.00	499.62	0.00
ya, depth immediately US, ft	6.91	13.27	7.30
Mean elevation of deck, ft	0	499.82	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.95	1.00
**Cc, for downstream face (<=1.0)	ERR	0.86807	ERR
Ys, scour w/Chang equation, ft	N/A	**-1.24**	N/A
Ys, scour w/Umbrell equation, ft	N/A	0.03	N/A

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

**Ys, scour w/Chang equation, ft	N/A	2.00	N/A
**Ys, scour w/Umbrell equation, ft	ERR	2.43	ERR

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	7.42	7.97	7.90
WSEL at downstream face, ft	--	494.45	--
Depth at downstream face, ft	N/A	8.24	N/A
Ys, depth of scour (Laursen), ft	N/A	-0.27	N/A

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	2520	2804	2710
Main channel area (DS), ft2	168.6	206	178
Main channel width (normal), ft	24.4	25	24.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	24.4	25.0	24.4
D90, ft	1.4730	1.4730	1.4730
D95, ft	1.6220	1.6220	1.6220
Dc, critical grain size, ft	1.3747	1.0471	1.3889
Pc, Decimal percent coarser than Dc	0.136	0.245	0.130
Depth to armoring, ft	**26.20**	**9.68**	**27.81**

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and Davis, 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	2520	3500	2710	2520	3500	2710
a', abut.length blocking flow, ft	12.4	17.3	13.3	23.7	126	29.1
Ae, area of blocked flow ft2	48.75	90.06	55.11	110.79	184.92	124.5
Qe, discharge blocked abut.,cfs	118.36	168.19	129.65	558	--	638.79
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.43	1.87	2.35	5.04	3.74	5.13

ya, depth of f/p flow, ft	3.93	5.21	4.14	4.67	1.47	4.28

--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	115	115	115	65	65	65
K2	1.03	1.03	1.03	0.96	0.96	0.96
Fr, froude number f/p flow	0.216	0.144	0.204	0.411	0.410	0.437
ys, scour depth, ft	**8.79**	**10.35**	**9.12**	**14.41**	**11.78**	**14.79**

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

a'(abut length blocked, ft)	12.4	17.3	13.3	23.7	126	29.1
y1 (depth f/p flow, ft)	3.93	5.21	4.14	4.67	1.47	4.28
a'/y1	3.15	3.32	3.21	5.07	85.85	6.80
Skew correction (p. 49, fig. 16)	1.06	1.06	1.06	0.92	0.92	0.92
Froude no. f/p flow	0.22	0.14	0.20	0.41	0.41	0.44
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	7.29	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	5.98	ERR
spill-through	ERR	ERR	ERR	ERR	4.01	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 Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	0.84	1	1	0.84	1
y, depth of flow in bridge, ft	6.91	8.24	7.30	6.91	8.24	7.30
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	**2.89**	**3.28**	**3.05**	**2.89**	**3.28**	**3.05**