LEVEL II SCOUR ANALYSIS FOR BRIDGE 4 (VICTTH00020004) on TOWN HIGHWAY 2, crossing the MOOSE RIVER, VICTORY, VERMONT

Open-File Report 98-082

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 MICHELLE M. SERRA AND JAMES R. DEGNAN

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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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 4 (VICTTH00020004) ON TOWN HIGHWAY 2, CROSSING THE MOOSE RIVER, VICTORY, VERMONT

By **Michelle M. Serra and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure VICTTH00020004 on Town Highway 2 crossing the Moose River, Victory, 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 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 22.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily shrub and brushland with trees on the immediate banks downstream and on the upstream left bank. The upstream right bank is forested.

In the study area, the Moose River has an incised, straight channel with a slope of approximately 0.013 ft/ft, an average channel top width of 93 ft and an average bank height of 3 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 72.1 mm (0.236 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 20, 1995, indicated that the reach was stable.

The Town Highway 2 crossing of the Moose River is a 43-ft-long, two-lane bridge consisting of one 41-ft steel-beam span (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 38 ft. The bridge is supported by vertical, stone- masonry abutments with wingwalls. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is 5 degrees.

A scour hole 1.5 ft deeper than the mean thalweg was observed in the middle of the channel at the downstream end of the bridge during the Level I assessment. The upstream left wingwall and left abutment are protected with type-1 stone fill (less than 12 inches diameter). The downstream left and right wingwalls are protected with type-2 stone fill (less than 36 inches diameter). 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 to 1.8 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Abutment scour ranged from 8.7 to 11.7 ft at the left abutment and from 6.9 to 9.2 ft at the right abutment. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Gallup Mills, VT. Quadrangle, 1:24,000, 1988

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 VICTTH00020004 ***Stream*** Moose River

County Essex ***Road*** TH2 ***District*** 7

Description of Bridge

Bridge length 43 ***ft*** ***Bridge width*** 21.7 ***ft*** ***Max span length*** 41 ***ft***

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

Abutment type Vertical, stone masonry ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 7/20/95

Description of stone fill The left abutment and the upstream left wingwall are protected by type-1 stone fill, both in good condition. The downstream right and left wingwalls are protected by type-2 stone fill, both slumped.

The abutment material is stone masonry, the right abutment has a concrete footing. The upstream left wingwall was replaced, or covered in concrete. The remaining wingwalls are made of mortared stone with concrete caps.

Yes 5

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

There is a mild channel bend through the bridge. It extends from approximately 15 ft upstream to 10 ft downstream.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/20/95	0	0
Level II	7/20/95	0	0

Potential for debris Debris potential is low, however there are small branches caught in between boulders and the protection on the left bank.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 7/20/95.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with little to no flood plains or natural levees and steep valley walls on both sides.

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

Date of inspection 7/20/95

DS left: Moderately sloping channel bank and steep valley wall

DS right: Steep channel bank to mildly sloping overbank

US left: Moderately sloping channel bank and steep valley wall

US right: Mildly sloping channel bank and overbank

Description of the Channel

Average top width 93 ***ft*** ***Average depth*** 3 ***ft***

Predominant bed material Boulders/Cobbles ***Bank material*** Cobbles/Boulders

Perennial and straight, probably incised with semi-alluvial channel boundaries, and a constant width.

Vegetative co 7/20/95

DS left: Trees and brush

DS right: Trees and brush

US left: Grass nearest the bridge, changing to trees and brush about 40 ft upstream

US right: Forest

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

Describe any obstructions in channel and date of observation. None as of 7/20/95

Hydrology

Drainage area 22.7 ***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***: No significant urbanization as of 7/20/95.

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

USGS gage description Moose River at Victory, Vermont

USGS gage number 01134500

Gage drainage area 75.2 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 3,800 ***ft³/s*** ***Q500*** 5,250 ***ft³/s***

The 100- and 500-yr discharges are taken from the flood frequency curve generated by use of the FHWA (1983) method and extended to the 500-yr event. These discharges were within the range defined by flood frequency curves developed from several other empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887) and a drainage-area relationship [(22.7/75.2)exp0.4] with VTAOT database values (written communication 3/28/95).

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 the downstream end of the left abutment (elev. 500.30 ft, arbitrary survey datum). RM2 is a chiseled X on the upstream corner of the right abutment and wingwall (elev. 500.76 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	-41	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	64	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 0.055 to 0.060, and overbank "n" values ranged from 0.040 to 0.090.

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 0.0133 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1988).

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

Bridge Hydraulics Summary

Average bridge embankment elevation 500.5 *ft*
Average low steel elevation 497.4 *ft*

100-year discharge 3,800 *ft³/s*
Water-surface elevation in bridge opening 497.6 *ft*
Road overtopping? Yes *Discharge over road* 150 *ft³/s*
Area of flow in bridge opening 405 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.7 *ft/s*

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 496.1
Amount of backwater caused by bridge 3.0 *ft*

500-year discharge 5,250 *ft³/s*
Water-surface elevation in bridge opening 497.6 *ft*
Road overtopping? Yes *Discharge over road* 1,010 *ft³/s*
Area of flow in bridge opening 405 *ft²*
Average velocity in bridge opening 10.5 *ft/s*
Maximum WSPRO tube velocity at bridge 12.4 */s*

Water-surface elevation at Approach section with bridge 500.1
Water-surface elevation at Approach section without bridge 497.9
Amount of backwater caused by bridge 2.2 *ft*

Incipient overtopping discharge 3,720 *ft³/s*
Water-surface elevation in bridge opening 493.9 *ft*
Area of flow in bridge opening 272 *ft²*
Average velocity in bridge opening 13.7 *ft/s*
Maximum WSPRO tube velocity at bridge 16.8 *ft/s*

Water-surface elevation at Approach section with bridge 497.7
Water-surface elevation at Approach section without bridge 496.0
Amount of backwater caused by bridge 1.7 *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 are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 100- and 500-year discharges 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 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 100- and 500-year discharges was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). These results are presented in appendix F. Furthermore, for those discharges resulting 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 for the left abutment was computed by use of the Froehlich equation (Richardson and Davis, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	1.0	1.8
Depth to armoring	10.0 6.7	25.0	--
Left overbank	--	--	--
Right overbank	--	--	8.7 11.7

Local scour:			
Abutment scour	9.6	8.6	9.2
Left abutment	6.9–	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	1.2	2.0
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	2.9	1.2	2.0
Left abutment	2.9	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

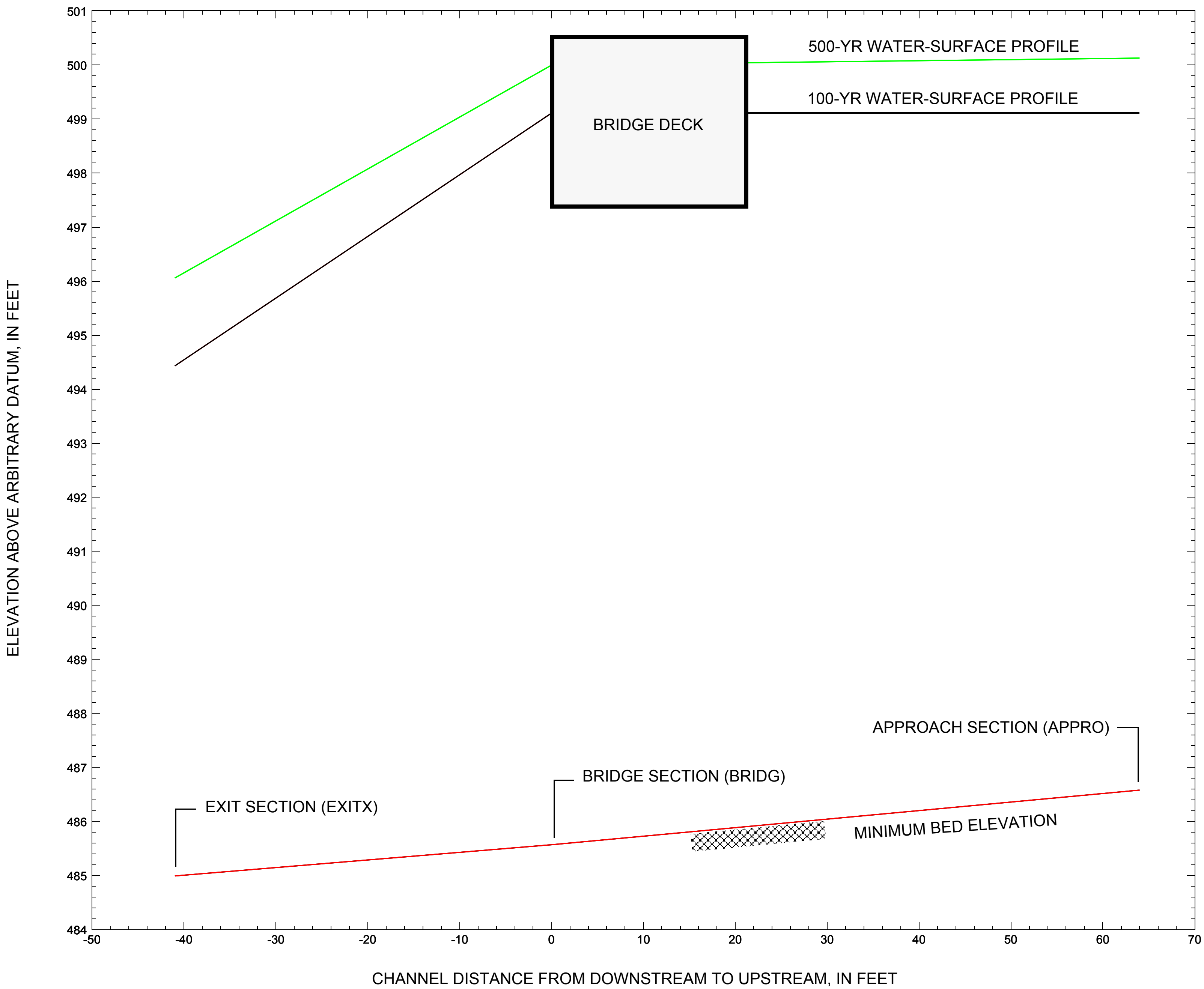

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure VICTTH00020004 on Town Highway 2, crossing the Moose River, Victory, Vermont.

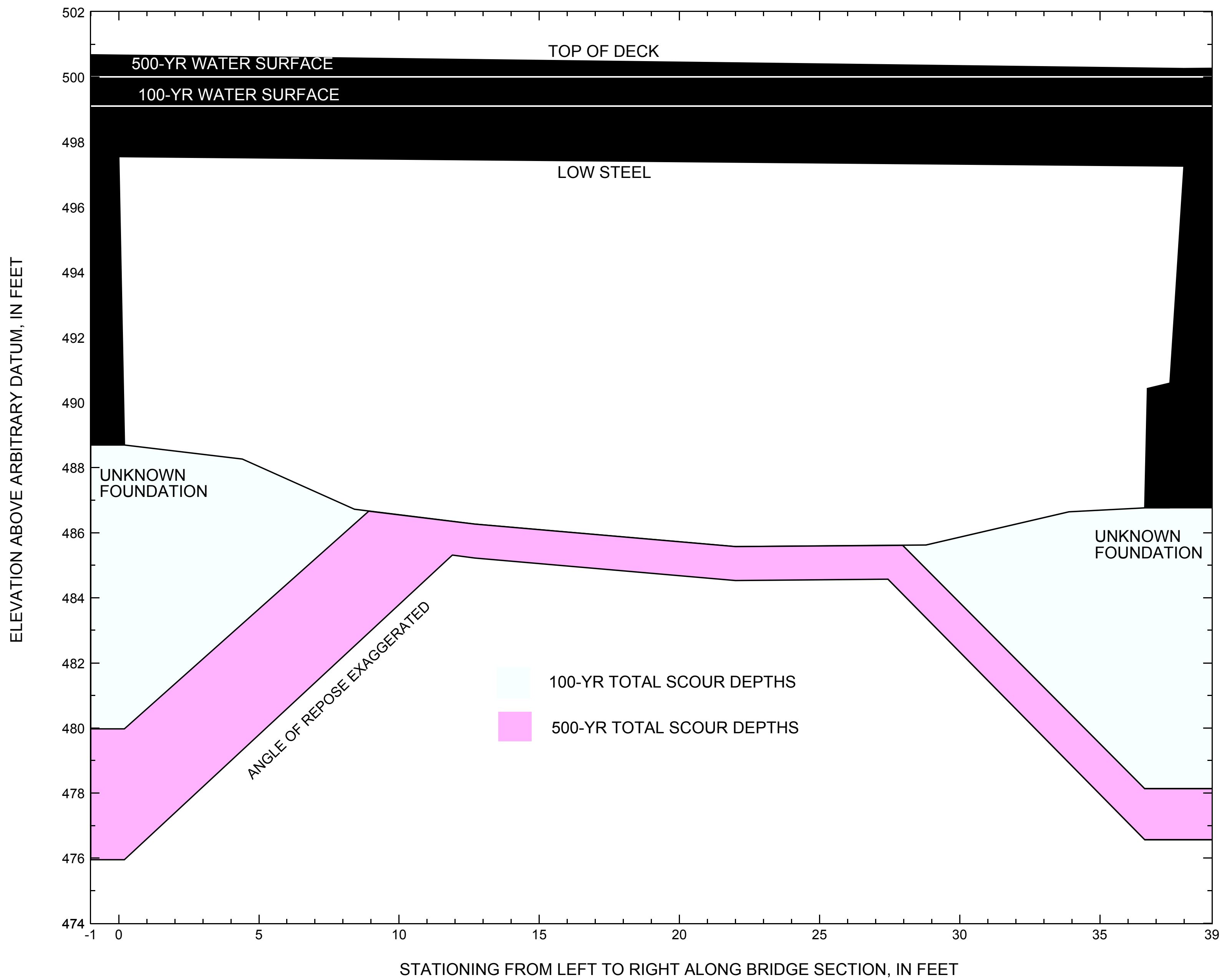

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure VICTTH00020004 on Town Highway 2, crossing the Moose River, Victory, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure VICTTH00020004 on Town Highway 2, crossing the Moose River, Victory, 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 3,800 cubic-feet per second											
Left abutment	0.0	--	497.6	--	488.7	0.0	8.7	--	8.7	480.0	--
Right abutment	38.0	--	497.3	--	486.8	0.0	8.6	--	8.6	478.2	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-yr discharge at structure VICTTH00020004 on Town Highway 2, crossing the Moose River, Victory, 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 5,250 cubic-feet per second											
Left abutment	0.0	--	497.6	--	488.7	1.0	11.7	--	12.7	476.0	--
Right abutment	38.0	--	497.3	--	486.8	1.0	9.2	--	10.2	476.6	--

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, 1988, Gallup Mills, 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 vict004.wsp
T2        Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
T3        hydraulic analysis of bridge 4 in victory over moose river
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3800.0   5250.0   3720.0
SK          0.0133   0.0133   0.0133
*
XS   EXITX    -41           0.
GR         -186.3, 513.36   -146.3, 507.65    -85.0, 502.78    -36.4, 501.23
GR          -28.1, 496.81    -16.0, 495.80     -3.2, 493.31      0.0, 488.19
GR            4.8, 486.56      9.7, 485.79     15.6, 485.02     19.7, 484.99
GR           25.9, 485.96     30.7, 486.58     34.5, 487.11     39.0, 488.95
GR           54.5, 492.43     66.1, 495.87     76.6, 497.34    140.3, 496.42
GR          212.7, 496.08    298.2, 498.77    427.9, 503.41    554.1, 510.32
*
N           0.055        0.040
SA                  76.6
*
XS   FULLV      0  * * *   0.0086
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.40       5.0
GR            0.0, 497.55      0.2, 488.69      4.4, 488.26      8.4, 486.72
GR           12.7, 486.26     18.9, 485.79     22.0, 485.57     28.8, 485.62
GR           33.9, 486.64     36.6, 486.76     36.7, 490.59     37.5, 490.43
GR           38.0, 497.26      0.0, 497.55
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      39.4 * *     55.6      8.8
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      21.7     2
GR         -213.9, 513.52   -112.9, 506.27    -56.1, 502.84      0.0, 500.67
GR           38.8, 500.26    101.6, 498.89    198.5, 498.48    308.9, 500.17
GR          458.3, 506.04    649.7, 512.94
*
AS   APPRO     64           0.
GR         -255.2, 514.89   -213.9, 508.92   -135.9, 503.43    -55.9, 498.01
GR          -37.5, 498.69    -19.4, 498.93     -3.4, 492.24      0.0, 490.53
GR            9.0, 487.12     12.6, 486.75     24.4, 486.58     31.4, 486.69
GR           41.4, 486.76     41.8, 487.40     55.7, 489.68     61.6, 495.25
GR           74.6, 497.82    122.9, 496.38    258.7, 496.85    399.8, 501.27
*
N            0.040       0.060        0.090
SA                 -19.4         74.6
*
HP 1 BRIDG  497.55 1 497.55
HP 2 BRIDG  497.55 * * 3657
*  Downstream bridge face
HP 1 BRIDG  495.07 1 495.07
HP 2 RDWAY  499.11 * *  150
HP 1 APPRO  499.11 1 499.11
HP 2 APPRO  499.11 * * 3800
*
HP 1 BRIDG  497.55 1 497.55
HP 2 BRIDG  497.55 * * 4247
*  Downstream bridge face
HP 1 BRIDG  496.77 1 496.77
HP 2 RDWAY  500.00 * * 1009
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File vict004.wsp
        Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
        hydraulic analysis of bridge 4 in victory over moose river
           *** RUN DATE & TIME: 08-22-97  11:40

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     405.   28883.     0.    95.                           0.
   497.55          405.   28883.     0.    95.  1.00     0.    38.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.55     0.0    38.0   405.2   28883.    3657.   9.03

X STA.         0.0         3.9         6.3         8.3        10.1        11.8
 A(I)             34.1        22.6        20.8        19.4        18.6
 V(I)             5.37        8.09        8.79        9.41        9.83

X STA.        11.8        13.4        15.0        16.5        18.0        19.5
 A(I)             18.2        17.7        17.3        17.2        17.4
 V(I)            10.06       10.32       10.58       10.60       10.51

X STA.        19.5        21.0        22.4        23.9        25.4        26.9
 A(I)             17.1        17.2        17.4        17.6        17.6
 V(I)            10.71       10.63       10.51       10.39       10.37

X STA.        26.9        28.5        30.1        31.9        34.0        38.0
 A(I)             18.0        19.2        20.1        21.9        35.8
 V(I)            10.17        9.54        9.10        8.33        5.11

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     317.   28518.    38.    52.                        5221.
   495.07          317.   28518.    38.    52.  1.00     0.    38.   5221.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.11    91.5   239.7    55.3    1066.     150.   2.71

X STA.        91.5       115.3       126.7       135.7       143.4       150.3
 A(I)              4.5         3.4         3.1         2.9         2.8
 V(I)             1.66        2.18        2.40        2.56        2.65

X STA.       150.3       156.3       161.8       166.9       171.6       176.0
 A(I)              2.6         2.5         2.5         2.4         2.3
 V(I)             2.84        2.97        3.02        3.15        3.23

X STA.       176.0       180.2       184.2       188.1       191.9       195.5
 A(I)              2.3         2.2         2.2         2.2         2.2
 V(I)             3.25        3.36        3.35        3.34        3.36

X STA.       195.5       199.2       203.2       208.2       215.3       239.7
 A(I)              2.3         2.4         2.6         3.0         4.5
 V(I)             3.32        3.15        2.87        2.49        1.65

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      28.     697.    53.    53.                         118.
             2     802.   80036.    94.    99.                       13281.
             3     517.   13683.   256.   256.                        4172.
   499.11         1347.   94417.   403.   408.  1.74   -72.   331.  10589.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.11   -72.1   330.8  1347.3   94417.    3800.   2.82

X STA.       -72.1        -1.3         4.6         8.9        12.4        15.7
 A(I)            100.1        54.8        47.3        42.3        40.9
 V(I)             1.90        3.47        4.01        4.49        4.65

X STA.        15.7        18.8        22.0        25.1        28.1        31.2
 A(I)             39.1        39.1        38.7        38.2        38.1
 V(I)             4.86        4.86        4.91        4.97        4.99

X STA.        31.2        34.3        37.4        40.7        44.4        48.5
 A(I)             38.8        38.8        40.5        43.7        44.4
 V(I)             4.89        4.90        4.69        4.35        4.27

X STA.        48.5        53.3        64.6       143.7       206.8       330.8
 A(I)             49.6        72.4       175.9       160.8       203.6
 V(I)             3.83        2.62        1.08        1.18        0.93
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     U.S. Geological Survey WSPRO Input File vict004.wsp
     Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
     hydraulic analysis of bridge 4 in victory over moose river
        *** RUN DATE & TIME: 08-22-97  11:40

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     405.   28883.     0.    95.                           0.
 497.55          405.   28883.     0.    95.  1.00     0.    38.      0.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.55     0.0    38.0   405.2   28883.    4247.  10.48

X STA.        0.0        3.9        6.3        8.3       10.1       11.8
 A(I)            34.1       22.6       20.8       19.4       18.6
 V(I)            6.23       9.39      10.21      10.93      11.42

X STA.       11.8       13.4       15.0       16.5       18.0       19.5
 A(I)            18.2       17.7       17.3       17.2       17.4
 V(I)           11.68      11.99      12.28      12.32      12.21

X STA.       19.5       21.0       22.4       23.9       25.4       26.9
 A(I)            17.1       17.2       17.4       17.6       17.6
 V(I)           12.44      12.35      12.20      12.07      12.04

X STA.       26.9       28.5       30.1       31.9       34.0       38.0
 A(I)            18.0       19.2       20.1       21.9       35.8
 V(I)           11.81      11.08      10.57       9.68       5.93

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     381.   37173.    38.    56.                        6868.
 496.77          381.   37173.    38.    56.  1.00     0.    38.   6868.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

       WSEL     LEW     REW    AREA        K        Q    VEL
     500.00    50.7   297.8   231.1    8488.    1009.   4.37

X STA.       50.7       91.7      103.3      112.8      121.5      130.1
 A(I)            18.3       11.7       10.8       10.3       10.4
 V(I)            2.75       4.30       4.66       4.91       4.84

X STA.      130.1      138.0      145.8      153.2      160.4      167.4
 A(I)             9.8       10.0        9.7        9.7        9.6
 V(I)            5.15       5.05       5.18       5.22       5.27

X STA.      167.4      174.2      181.0      187.7      194.2      201.1
 A(I)             9.6        9.8        9.7        9.7       10.3
 V(I)            5.27       5.16       5.18       5.22       4.89

X STA.      201.1      208.4      217.4      228.4      244.3      297.8
 A(I)            10.5       11.7       12.6       15.0       21.9
 V(I)            4.80       4.32       4.01       3.37       2.30

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      90.    4032.    68.    68.                         587.
           2     897.   96622.    94.    99.                       15734.
           3     795.   25869.   289.   289.                        7490.
 500.13         1783.  126523.   451.   456.  1.81   -87.   363.  14942.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

       WSEL     LEW     REW    AREA        K        Q    VEL
     500.13   -87.2   363.4  1782.6  126523.    5250.   2.95

X STA.      -87.2       -7.3        1.7        7.1       11.3       15.1
 A(I)           135.1       74.3       60.9       53.8       51.4
 V(I)            1.94       3.53       4.31       4.88       5.11

X STA.       15.1       18.8       22.4       26.0       29.6       33.2
 A(I)            49.2       48.4       49.0       48.3       48.1
 V(I)            5.34       5.42       5.36       5.44       5.46

X STA.       33.2       36.8       40.5       44.7       49.4       54.9
 A(I)            49.0       48.9       54.0       55.7       61.0
 V(I)            5.36       5.37       4.86       4.71       4.31

X STA.       54.9       81.6      136.5      183.5      235.7      363.4
 A(I)           117.1      180.1      170.1      180.1      248.1
 V(I)            2.24       1.46       1.54       1.46       1.06
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        U.S. Geological Survey WSPRO Input File vict004.wsp
        Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
        hydraulic analysis of bridge 4 in victory over moose river
           *** RUN DATE & TIME: 08-22-97  11:40

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     272.  22785.    38.    50.                         4154.
   493.87          272.  22785.    38.    50.  1.00     0.    38.    4154.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.87     0.1    37.8   271.9   22785.    3720.  13.68

X STA.         0.1        4.6        7.2        9.2       10.9       12.5
  A(I)            23.8       16.2       13.9       12.8       12.0
  V(I)            7.81      11.48      13.42      14.52      15.48

X STA.        12.5       14.1       15.6       17.1       18.5       19.9
  A(I)            12.2       11.4       11.5       11.3       11.1
  V(I)           15.20      16.26      16.19      16.48      16.78

X STA.        19.9       21.2       22.6       24.0       25.3       26.7
  A(I)            11.1       11.2       11.3       11.2       11.7
  V(I)           16.78      16.61      16.40      16.55      15.87

X STA.        26.7       28.2       29.7       31.5       33.6       37.8
  A(I)            11.7       12.5       13.9       15.6       25.4
  V(I)           15.85      14.82      13.39      11.93       7.33

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     667.  60643.    90.    95.                        10300.
             3     180.   2732.   205.   205.                          957.
   497.66          847.  63376.   295.   300.  1.41   -16.   285.    6853.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      64.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.66   -16.4   284.6   847.1   63376.    3720.   4.39

X STA.       -16.4        0.4        5.4        8.9       11.8       14.6
  A(I)            59.3       40.8       34.7       30.9       30.6
  V(I)            3.13       4.56       5.35       6.02       6.07

X STA.        14.6       17.2       19.8       22.4       24.9       27.4
  A(I)            28.5       29.0       28.1       27.9       27.8
  V(I)            6.52       6.42       6.62       6.67       6.68

X STA.        27.4       30.0       32.6       35.2       37.9       40.7
  A(I)            28.5       28.4       28.7       29.6       30.7
  V(I)            6.52       6.54       6.48       6.28       6.06

X STA.        40.7       44.0       47.6       52.0       59.6      284.6
  A(I)            33.3       34.8       39.6       54.2      201.4
  V(I)            5.58       5.34       4.70       3.43       0.92
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File vict004.wsp
        Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
        hydraulic analysis of bridge 4 in victory over moose river
           *** RUN DATE & TIME: 08-22-97  11:40

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

EXITX:XS   ******    -9.     398.  1.42 *****  495.85  492.85   3800.  494.43
      -41. ******    61.   32924.  1.00 ***** *******    0.71    9.54

FULLV:FV      41.   -10.     419.  1.28  0.51  496.35 *******   3800.  495.07
        0.    41.    62.   35026.  1.00  0.00   -0.01    0.67    9.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      64.   -13.     539.  0.77  0.57  496.91 *******   3800.  496.14
       64.    64.    66.   46373.  1.00  0.00   -0.01    0.48    7.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   493.93     497.57     497.83     497.40

 ===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      41.     0.     405.  1.27 *****  498.82  493.28   3657.  497.55
        0. ******    38.   28883.  1.00 ***** *******    0.49    9.03

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.422  0.000  497.40 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG      13.    42.  0.07  0.22  499.26    0.00    150.  499.11

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    35.   -15.    20.   0.8   0.5   4.5   6.2   1.1   2.9
   RT:   150.   148.    92.   240.   0.6   0.4   2.9   2.7   0.5   2.7

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

APPRO:AS      25.   -72.    1346.  0.22  0.14  499.32  492.82   3800.  499.11
       64.    27.   331.   94361.  1.74  1.07    0.00    0.36    2.82

       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      -41.     -9.     61.   3800.   32924.      398.    9.54  494.43
   FULLV:FV        0.    -10.     62.   3800.   35026.      419.    9.07  495.07
   BRIDG:BR        0.      0.     38.   3657.   28883.      405.    9.03  497.55
   RDWAY:RG       13.*******      0.    150.       0.        0.    2.00  499.11
   APPRO:AS       64.    -72.    331.   3800.   94361.     1346.    2.82  499.11

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD     EGL    WSEL
   EXITX:XS    492.85    0.71  484.99  513.36************  1.42  495.85  494.43
   FULLV:FV  ********    0.67  485.34  513.71  0.51  0.00  1.28  496.35  495.07
   BRIDG:BR    493.28    0.49  485.57  497.55************  1.27  498.82  497.55
   RDWAY:RG  ****************  498.48  513.52  0.07******  0.22  499.26  499.11
   APPRO:AS    492.82    0.36  486.58  514.89  0.14  1.07  0.22  499.32  499.11
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        U.S. Geological Survey WSPRO Input File vict004.wsp
        Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
        hydraulic analysis of bridge 4 in victory over moose river
           *** RUN DATE & TIME: 08-22-97  11:40

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

EXITX:XS   ******   -19.     524.  1.56 *****  497.62  494.32   5250.  496.06
      -41. ******    67.   45486.  1.00 ***** *******    0.72   10.02

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.92     496.77     494.67

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.56     513.71    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.56     513.71     494.67

FULLV:FV      41.   -23.     570.  1.37  0.52  498.14  494.67   5250.  496.77
        0.    41.   223.   47997.  1.04  0.00    0.00    0.92    9.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.41

APPRO:AS      64.   -17.     926.  0.75  0.54  498.67 *******   5250.  497.92
       64.    64.   293.   67716.  1.49  0.00   -0.01    0.71    5.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.67       0.00     495.11     498.48

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =  495.70     499.30     499.54     497.40

 ===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      41.     0.     405.  1.71 *****  499.26  493.98   4247.  497.55
        0. ******    38.   28883.  1.00 ***** *******    0.57   10.48

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.459  0.000  497.40 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    42.  0.07  0.24  500.30    0.00   1009.  500.00

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    36.   -16.    20.   0.8   0.5   4.6   6.2   1.1   2.9
   RT:  1009.   247.    51.   298.   1.5   0.9   4.9   4.4   1.2   3.0

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

APPRO:AS      25.   -87.    1784.  0.24  0.19  500.38  494.06   5250.  500.13
       64.    31.   363.  126621.  1.81  0.89    0.00    0.35    2.94

       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      -41.   -19.    67.   5250.   45486.     524.   10.02  496.06
   FULLV:FV        0.   -23.   223.   5250.   47997.     570.    9.22  496.77
   BRIDG:BR        0.     0.    38.   4247.   28883.     405.   10.48  497.55
   RDWAY:RG       13.*******     0.   1009.        0.*********    2.00  500.00
   APPRO:AS       64.   -87.   363.   5250.  126621.    1784.    2.94  500.13

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     494.32    0.72  484.99  513.36************  1.56  497.62  496.06
   FULLV:FV     494.67    0.92  485.34  513.71  0.52  0.00  1.37  498.14  496.77
   BRIDG:BR     493.98    0.57  485.57  497.55************  1.71  499.26  497.55
   RDWAY:RG   ****************  498.48  513.52  0.07******  0.24  500.30  500.00
   APPRO:AS     494.06    0.35  486.58  514.89  0.19  0.89  0.24  500.38  500.13
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       U.S. Geological Survey WSPRO Input File vict004.wsp
       Hydraulic analysis for structure VICTTH00020004   Date: 05-AUG-97
       hydraulic analysis of bridge 4 in victory over moose river
          *** RUN DATE & TIME: 08-22-97  11:40

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

EXITX:XS   ******    -8.     391.  1.40 *****  495.74  492.77   3720.  494.33
      -41. ******    61.   32231.  1.00 ***** *******    0.71    9.50

FULLV:FV      41.   -10.     412.  1.27  0.51  496.24 *******   3720.  494.97
        0.    41.    62.   34291.  1.00  0.00   -0.01    0.67    9.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      64.   -12.     531.  0.76  0.57  496.80 *******   3720.  496.04
       64.    64.    66.   45523.  1.00  0.00   -0.01    0.47    7.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR      41.     0.     272.  2.91  0.77  496.78  493.36   3720.  493.87
        0.    41.    38.   22808.  1.00  0.27   -0.01    0.89   13.67

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.40 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL      ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      25.   -16.     846.  0.42  0.26  498.08  492.74   3720.  497.66
       64.    27.   284.   63326.  1.41  1.05    0.02    0.54    4.40

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.516  0.223   49002.     7.    45.  497.51

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW     REW       Q        K      AREA     VEL    WSEL
   EXITX:XS      -41.    -8.     61.   3720.   32231.      391.    9.50  494.33
   FULLV:FV        0.   -10.     62.   3720.   34291.      412.    9.04  494.97
   BRIDG:BR        0.     0.     38.   3720.   22808.      272.   13.67  493.87
   RDWAY:RG       13.**************       0.******************     2.00********
   APPRO:AS       64.   -16.    284.   3720.   63326.      846.    4.40  497.66

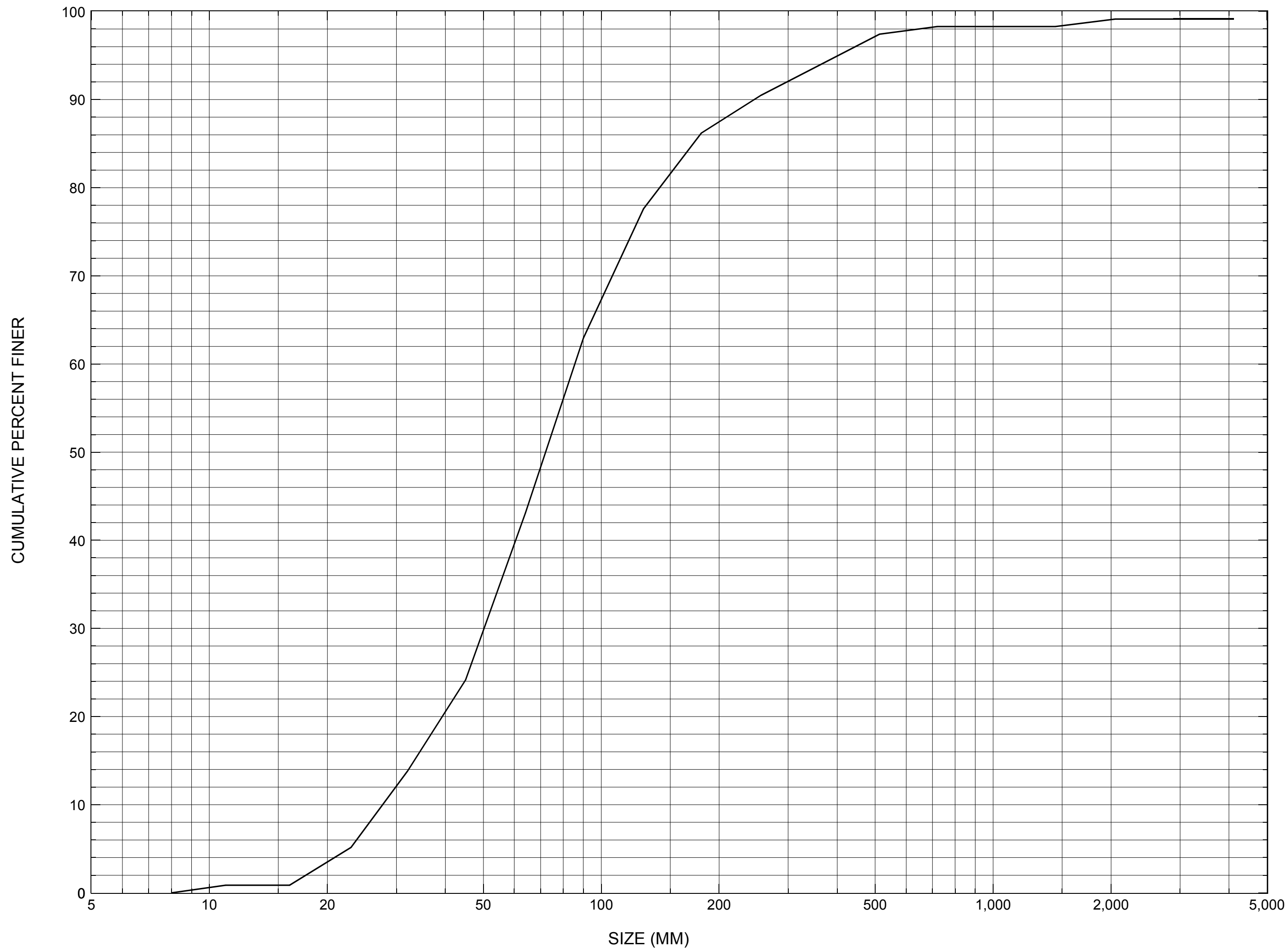
    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS       7.    45.   49002.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    492.77    0.71  484.99  513.36************  1.40  495.74  494.33
   FULLV:FV  ********    0.67  485.34  513.71  0.51  0.00  1.27  496.24  494.97
   BRIDG:BR    493.36    0.89  485.57  497.55  0.77  0.27  2.91  496.78  493.87
   RDWAY:RG  ***************  498.48  513.52********************************
   APPRO:AS    492.74    0.54  486.58  514.89  0.26  1.05  0.42  498.08  497.66
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure VICTTH00020004, in Victory, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number VICTTH00020004

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) 009

Town (FIPS place code; I - 4; nnnnn) 75175

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

Waterway (I - 6) MOOSE RIVER

Road Name (I - 7): -

Route Number TH002

Vicinity (I - 9) 0.05 MI JCT TH 2 + TH 1

Topographic Map Gallup.Mills

Hydrologic Unit Code: 01080102

Latitude (I - 16; nnnn.n) 44344

Longitude (i - 17; nnnnn.n) 71471

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10051700040517

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0041

Year built (I - 27; YYYY) 1940

Structure length (I - 49; nnnnnn) 000043

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

Deck Width (I - 52; nn.n) 217

Year of ADT (I - 30; YY) 92

Channel & Protection (I - 61; n) 5

Opening skew to Roadway (I - 34; nn) 05

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) 1973

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

Clear span (nnn.n ft) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 011.1

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

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

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt roadway surface. The abutment walls and wingwalls are grouted "laid-up" stone block walls with thin concrete caps. The upstream end of the left abutment and the upstream wingwall are reported as having been replaced with concrete recently. A concrete footing is noted as visible at the surface at the base of the right abutment. Some concrete replacement also was performed on the portion of the wingwalls at the tops near where they meet the abutment wall. The laid up stone of this abutment has a few fine cracks reported and some small voids where **(Continued, page 33)**

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:

the stone chinking and grouting has fallen out. Small sections of the right abutment cap have broken off along the front edge of the wall. The upstream wingwall of this abutment has been extended with laid-up stone blocks. Some stone and boulder riprap is reported around the ends of the wingwalls and on the banks. Channel scour is noted as normal. Debris accumulation problems are reported as minor at this site. Some boulder point bars may be present in the channel. There has been no undermining, according to the report, and only slight, if any, settling has occurred.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **22.73** mi^2

Lake/pond/swamp area **0.08** mi^2

Watershed storage *(ST)* **0.4** %

Bridge site elevation **1309** ft

Headwater elevation **3439** ft

Main channel length **10.94** mi

10% channel length elevation **1330** ft

85% channel length elevation **2500** ft

Main channel slope *(S)* **142.52** 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? **No** *If no, type ctrl-n xs*

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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: EW Date: 03/26/96
Computerized by: EW Date: 04/03/96
Reviewd by: MS Date: 01/05/98

Structure Number VICTTH00020004

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN   Date *(MM/DD/YY)* 7 / 20 / 1995
2. Highway District Number 07   Mile marker -
County ESSEX (009)   Town VICTORY (75175)
Waterway *(I - 6)* MOOSE RIVER   Road Name -
Route Number TH002   Hydrologic Unit Code: 01080102
3. Descriptive comments:

The Bridge has laid-up stone abutments which have been capped on top. A concrete footing exists on the right abutment. The bridge is located 0.05 miles from the junction with Town Highway 1.

B. Bridge Deck Observations

4. Surface cover... LBUS 5/6 RBUS 6 LBDS 5/6 RBDS 5/6 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 2 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 43 *(feet)*   Span length 41 *(feet)*   Bridge width 21.7 *(feet)*

Road approach to bridge:

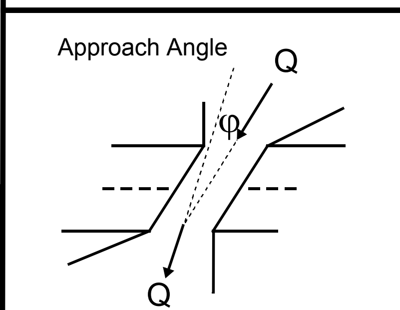
8. LB 2 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 0.0:1 US right 0.0:1

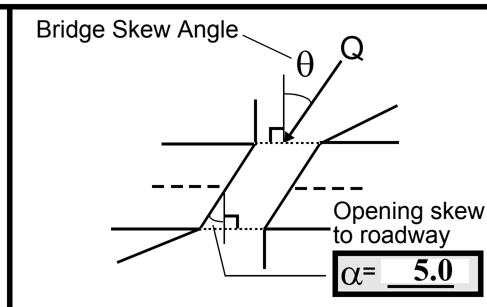
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	2
RBDS	0	-	0	0
LBDS	0	-	2	1

*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: 10   16. Bridge skew: 5





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 15 feet US *(US, UB, DS)* to 10 feet DS
Channel impact zone 2: Exist? N *(Y or N)*
Where? ____ *(LB, RB)* Severity ____
Range? ____ feet ____ *(US, UB, DS)* to ____ feet ____

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

18. Bridge Type: **1a**

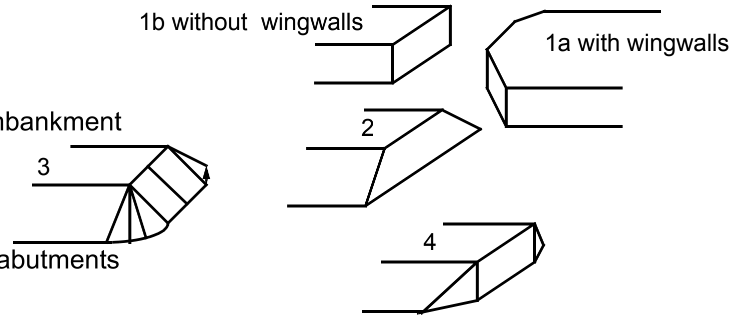
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#4: The left bank surface cover includes a road parallel with the channel; all immediate banks are forested.
#7: The bridge dimensions are from VTAOT files. The measured bridge dimensions were the same except for the bridge width which measured 26.0 ft. The bridge has cement curbing and fairly new galvanized steel guard rails.

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
38.0	**5.0**			**2.5**	**3**	**4**	**435**	**435**	**1**	**1**

23. Bank width **20.0** 24. Channel width **10.0** 25. Thalweg depth **59.0** 29. Bed Material **453**

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

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

The bank protection on left bank extends from the US bridge face to 30 feet US. It also protects the left wing-wall. The stone-fill also protects the Town Highway 1 road embankment.

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? 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
33.0		0.5		2	7	7	0

58. Bank width (BF) - 59. Channel width - 60. Thalweg depth 90.0 63. Bed Material 0

*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.):

543

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

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

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

70. Debris and Ice Comments:

1

The debris accumulation consists of small branches caught in between boulders and the protection on the left bank.

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		5	90	0	0	-	-	90.0
RABUT	2	-	90			2	0	37.5

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

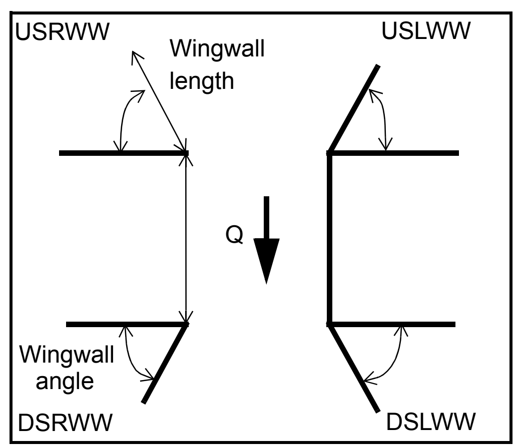
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
4
2
The right abutment has a concrete footing.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						37.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	29.0	
DSRWW:	1/2		0		-	22.0	

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

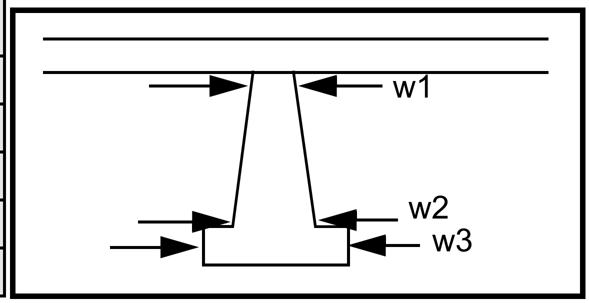
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**50.0**	**12.5**	**65.0**
Pier 2			**9.5**	**21.0**	**30.0**	**25.0**
Pier 3		-	-	**16.0**	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**There**	**foot in**	**bridge**	**tion).**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**is**	**dept**	**.**		***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**some**	**h. A**	**(Ref**		***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**local**	**large**	**er to**		***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**scou**	**r**	**DS**		*Y- yes; N- no*
91. Attack ∠ (BF)	**r**	**scou**	**chan**		
92. Pushed	**arou**	**r**	**nel**		*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**nd**	**hole**	**asses**		
95. Cross-members	**boul-**	**start**	**smen**		***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ders**	**s**	**t for**		***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**up to**	**unde**	**expl**	**N**	
98. Exposure depth	**1**	**r the**	**ana-**	**-**	

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

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	-	-	-	-	-

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: NO feet PI (US, UB, DS) to ERS 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? ____ (Y or if N type ctrl-n cb) Where? 3 (LB or RB) Mid-bank distance: 4

Cut bank extent: 543 feet 543 (US, UB, DS) to 1 feet 1 (US, UB, DS)

Bank damage: 543 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

5
0
1
-

Is channel scour present? Th (Y or if N type ctrl-n cs) Mid-scour distance: e

Scour dimensions: Length bank Width pro- Depth: tec- Positioned tion %LB to is a %RB

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

stone wall extending to 45 feet DS.

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

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

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

Confluence comments (eg. confluence name):

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

N

-

-

-

-

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: VICTTH00020004 Town: Victory
Road Number: TH2 County: Essex
Stream: Moose Ri ver

Initials MS Date: 08/21/97 Checked:

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	3800	5250	3720
Main Channel Area, ft2	802	897	667
Left overbank area, ft2	28	90	0
Right overbank area, ft2	517	795	180
Top width main channel, ft	94	94	90
Top width L overbank, ft	53	68	0
Top width R overbank, ft	256	289	205
D50 of channel, ft	0.236	0.236	0.236
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.5	9.5	7.4
y1, average depth, LOB, ft	0.5	1.3	ERR
y1, average depth, ROB, ft	2.0	2.8	0.9
Total conveyance, approach	94417	126523	63376
Conveyance, main channel	80036	96622	60643
Conveyance, LOB	697	4032	0
Conveyance, ROB	13683	25869	2732
Percent discrepancy, conveyance	0.0011	0.0000	0.0016
Qm, discharge, MC, cfs	3221.2	4009.3	3559.6
Ql, discharge, LOB, cfs	28.1	167.3	0.0
Qr, discharge, ROB, cfs	550.7	1073.4	160.4
Vm, mean velocity MC, ft/s	4.0	4.5	5.3
Vl, mean velocity, LOB, ft/s	1.0	1.9	ERR
Vr, mean velocity, ROB, ft/s	1.1	1.4	0.9
Vc-m, crit. velocity, MC, ft/s	9.9	10.1	9.7
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	3800	5250	3720
(Q) discharge thru bridge, cfs	3657	4247	3720
Main channel conveyance	28883	28883	22785
Total conveyance	28883	28883	22785
Q2, bridge MC discharge,cfs	3657	4247	3720
Main channel area, ft2	405	405	272
Main channel width (normal), ft	37.9	37.9	37.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.9	37.9	37.6
y_bridge (avg. depth at br.), ft	10.69	10.69	7.23
Dm, median (1.25*D50), ft	0.295	0.295	0.295
y2, depth in contraction,ft	8.81	10.02	9.00
ys, scour depth (y2-ybridge), ft	-1.87	-0.67	**1.77**

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	3657	4247	3720
Main channel area (DS), ft2	317	381	272
Main channel width (normal), ft	37.9	37.9	37.6
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	37.9	37.9	37.6
D90, ft	0.8051	0.8051	0.8051
D95, ft	1.3127	1.3127	1.3127
Dc, critical grain size, ft	0.5723	0.4960	0.8548
Pc, Decimal percent coarser than Dc	0.146	0.182	0.093
Depth to armoring, ft	10.04	6.69	25.01

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	3800	5250	3720
Q, thru bridge MC, cfs	3657	4247	3720
Vc, critical velocity, ft/s	9.90	10.09	9.67
Va, velocity MC approach, ft/s	4.02	4.47	5.34
Main channel width (normal), ft	37.9	37.9	37.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	37.9	37.9	37.6
qbr, unit discharge, ft2/s	96.5	112.1	98.9
Area of full opening, ft2	405.0	405.0	272.0
Hb, depth of full opening, ft	10.69	10.69	7.23
Fr, Froude number, bridge MC	0.49	0.57	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	317	381	N/A
**Hb, depth at downstream face, ft	8.36	10.05	N/A
**Fr, Froude number at DS face	0.70	0.62	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A
Elevation of Low Steel, ft	497.4	497.4	0
Elevation of Bed, ft	486.71	486.71	-7.23
Elevation of Approach, ft	499.11	500.13	0
Friction loss, approach, ft	0.14	0.19	0
Elevation of WS immediately US, ft	498.97	499.94	0.00
ya, depth immediately US, ft	12.26	13.23	7.23
Mean elevation of deck, ft	500.46	500.46	500.46
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.97	0.95	1.00
**Cc, for downstream face (<=1.0)	0.900657	0.931448	ERR
Ys, scour w/Chang equation, ft	**-0.61**	**1.04**	N/A
Ys, scour w/Umbrell equation, ft	-2.85	-1.77	N/A

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

**Ys, scour w/Chang equation, ft	2.45	1.87	N/A

**Ys, scour w/Umbrell equation, ft	-0.53	-1.13	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	8.81	10.02	9.00
WSEL at downstream face, ft	495.07	496.77	--
Depth at downstream face, ft	8.36	10.05	N/A
Ys, depth of scour (Laursen), ft	0.45	-0.04	N/A

Abutment Scour

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

	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	3800	5250	3720	3800	5250	3720
a', abut.length blocking flow, ft	72.1	87.2	16.5	292.9	325.5	246.9
Ae, area of blocked flow ft2	112.17	195.37	58.24	729.46	869.46	396.19
Qe, discharge blocked abut.,cfs	231.86	475.42	182.68	--	--	1129.78
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.07	2.43	3.14	1.90	2.08	2.85
ya, depth of f/p flow, ft	1.56	2.24	3.53	2.49	2.67	1.60
--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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.292	0.286	0.294	0.205	0.199	0.397
ys, scour depth, ft	**8.72**	**11.70**	**9.62**	16.08	17.21	16.31

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)	72.1	87.2	16.5	292.9	325.5	246.9
y1 (depth f/p flow, ft)	1.56	2.24	3.53	2.49	2.67	1.60
a'/y1	46.34	38.92	4.67	117.61	121.86	153.86
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.29	0.29	0.29	0.21	0.20	0.40
Ys w/ corr. factor K1/0.55:						
vertical	7.61	10.89	ERR	10.52	11.17	8.43
vertical w/ ww's	6.24	8.93	ERR	**8.63**	**9.16**	**6.91**
spill-through	4.19	5.99	ERR	5.79	6.15	4.64

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	0.49	0.57	0.89	0.49	0.57	0.89
y, depth of flow in bridge, ft	8.36	10.05	7.23	8.36	10.05	7.23
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.24	2.02	ERR	1.24	2.02	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.93	ERR	ERR	2.93