LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (VICTTH00010006) on TOWN HIGHWAY 1, crossing the MOOSE RIVER, VICTORY, VERMONT

U.S. Geological Survey
Open-File Report 97-6

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

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1997

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

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (VICTTH00010006) ON TOWN HIGHWAY 1, CROSSING THE MOOSE RIVER, VICTORY, VERMONT

***By* Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure VICTTH00010006 on Town Highway 1 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 (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the White Mountain section of the New England physiographic province in northeastern Vermont. The 27.9-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, the Moose River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 108 ft and an average channel depth of 14 ft. The channel bed ranges from gravel to boulder with a median grain size (D_{50}) of 126 mm (0.412 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.

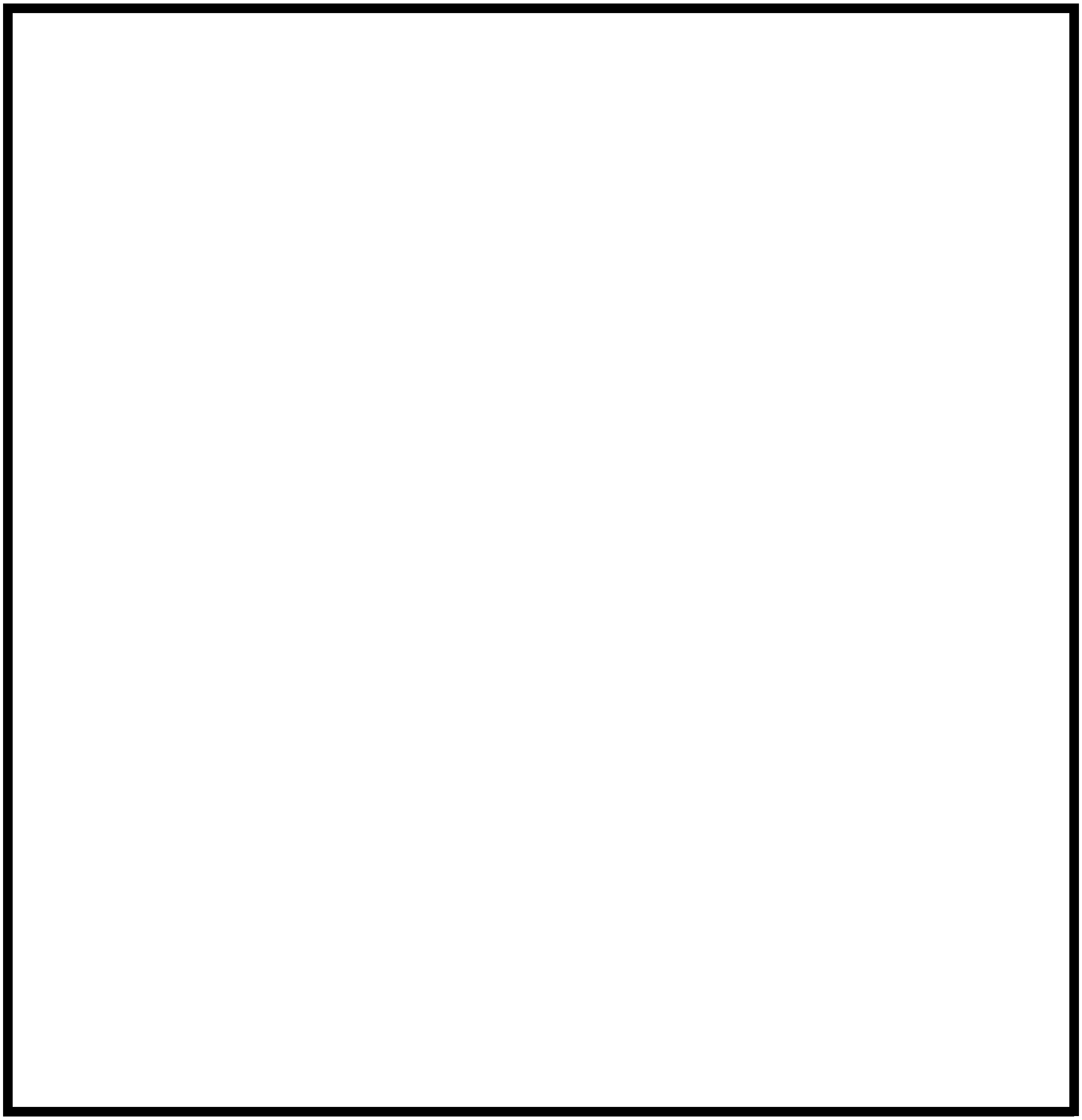
The Town Highway 1 crossing of the Moose River is a 101-ft-long, two-lane bridge consisting of one 98-foot steel-beam span (Vermont Agency of Transportation, written communication, March 28, 1995). The bridge is supported by vertical, concrete abutments with a spill-through slope at the face of each abutment consisting of type-3 stone fill (less than 48 inches diameter). The channel is skewed approximately 40 degrees to the opening while the opening-skew-to-roadway is 45 degrees.

A scour hole 3 ft deeper than the mean thalweg depth was observed under the bridge during the Level I assessment. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.2 to 0.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.3 to 8.2 ft. The worst-case abutment scour also 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 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.



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 VICTTH00010006 ***Stream*** Moose River

County Essex ***Road*** TH1 ***District*** 7

Description of Bridge

Bridge length 101 ***ft*** ***Bridge width*** 30.8 ***ft*** ***Max span length*** 98 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

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

Description of stone fill Type-3, on the spill-through slope of each abutment and wingwall.

Abutments are spill-through type with the toe of vertical, concrete part of the abutment located at the top of the bank.

Y

Is bridge skewed to flood flow according to ' survey? 40 ***Angle*** N

7/20/95

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	0	0	7/20/
Level II	95	0	0

Potential for debris Low.

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

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley and has a slope of approximately 0.02 ft/ft.

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

Date of inspection 7/20/95

DS left: Steep channel bank and mildly sloping overbank.

DS right: Steep channel bank and mildly sloping overbank.

US left: Steep channel bank and mildly sloping overbank.

US right: Steep channel bank and mildly sloping overbank.

Description of the Channel

Average top width 108 ***ft*** ***Average depth*** 14 ***ft***

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

Straight and stable with non-alluvial channel boundaries and little to no flood plains.

7/20/95

Vegetative co

Forested.

DS left: Forested.

DS right: Forested.

US left: Forested.

US right: Y

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

None, July 20, 1995.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 27.9 ***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***: None.

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

USGS gage description Moose River at Victory

USGS gage number 01134500

Gage drainage area 75.2 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 3,120 ***ft³/s*** ***Q500*** 3,870 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(27.9/75.2)exp 0.4] with the Moose River gage in Victory. The 100- and 500-year flood frequency estimates at the gage were made using a Log-Pearson type-3 analysis of the gage data (Interagency Advisory Committee on Water Data, 1982). The final calculated discharges were within a range defined by several empirical methods (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 Add 687.27 feet to arbitrary survey datum to obtain plans' datum and sea level.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the left abutment (elev. 500.20 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 499.83 ft, arbitrary survey datum). RM3 is a State of Vermont survey mark, set in the top of the downstream end of the right abutment (elev. 499.84 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	-67	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	23	1	Road Grade section
APPRO	114	2	Modelled Approach section (Templated from APTEM)
APTEM	137	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.060 to 0.064, and overbank "n" values ranged from 0.090 to 0.110.

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

The surveyed approach section (APTEM) was moved along the approach channel slope (0.015 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the 100- and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be 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 500.2 ***ft***
Average low steel elevation 494.7 ***ft***

100-year discharge 3,120 ***ft³/s***
Water-surface elevation in bridge opening 488.1 ***ft***
Road overtopping? N ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 250 ***ft²***
Average velocity in bridge opening 12.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.8 ***ft/s***

Water-surface elevation at Approach section with bridge 493.6
Water-surface elevation at Approach section without bridge 489.3
Amount of backwater caused by bridge 4.3 ***ft***

500-year discharge 3,870 ***ft³/s***
Water-surface elevation in bridge opening 488.9 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 295 ***ft²***
Average velocity in bridge opening 13.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 16.7 ***ft/s***

Water-surface elevation at Approach section with bridge 494.4
Water-surface elevation at Approach section without bridge 490.0
Amount of backwater caused by bridge 4.4 ***ft***

Incipient overtopping discharge -- ***ft³/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft²***
Average velocity in bridge opening -- ***ft/s***
Maximum WSPRO tube velocity at bridge -- ***ft/s***

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The depth to armoring values indicate that armoring will not limit the amount of contraction scour.

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

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment, as shown in figure 8.

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	0.2	0.4	--
Depth to armoring	22.7	25.7	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	8.1	8.2	--
Right abutment	7.3	8.0	--
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	1.8	2.0	--
Right abutment	1.8	2.0	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

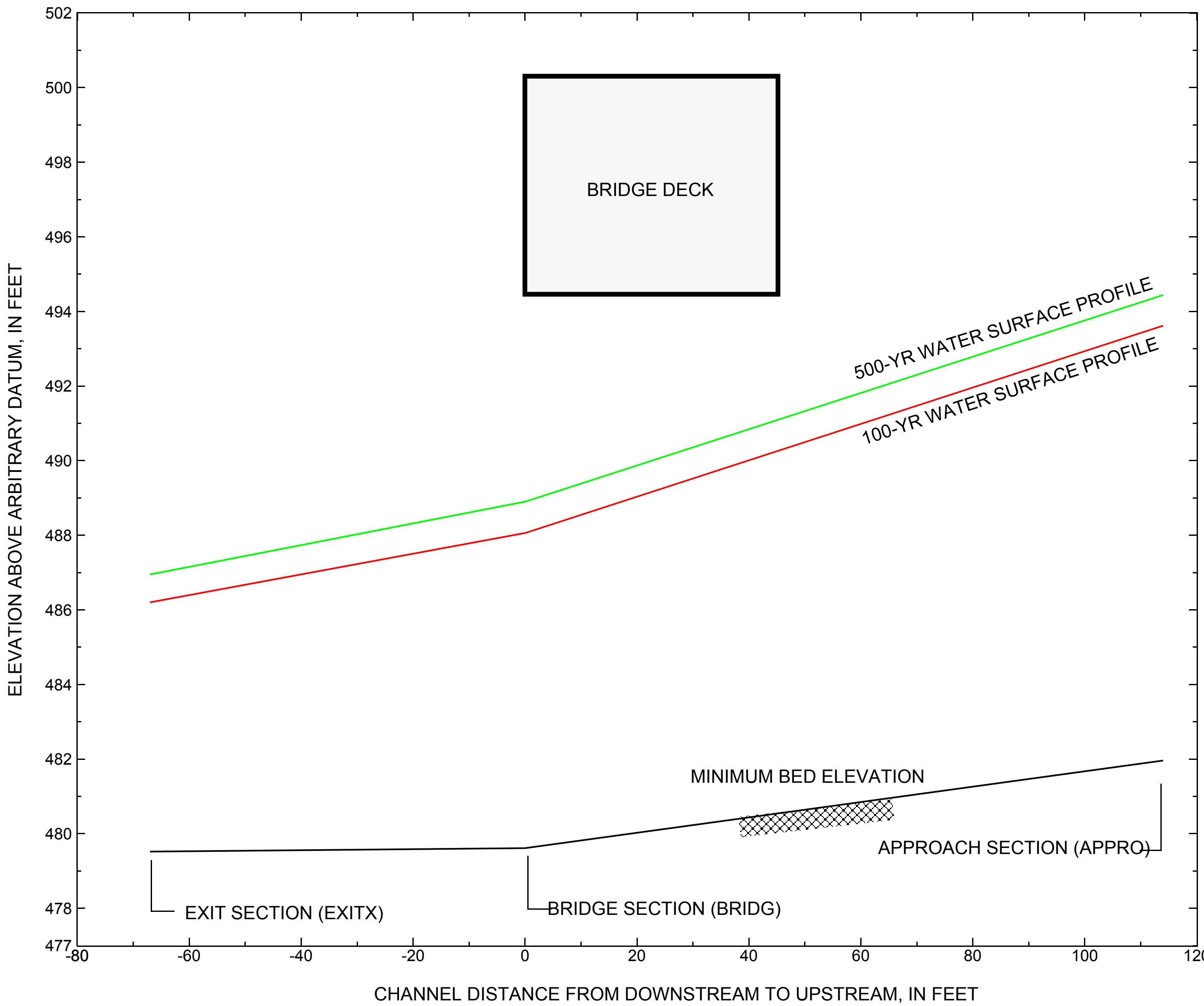


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure VICTTH00010006 on Town Highway 1, crossing the Moose River, Victory, Vermont.

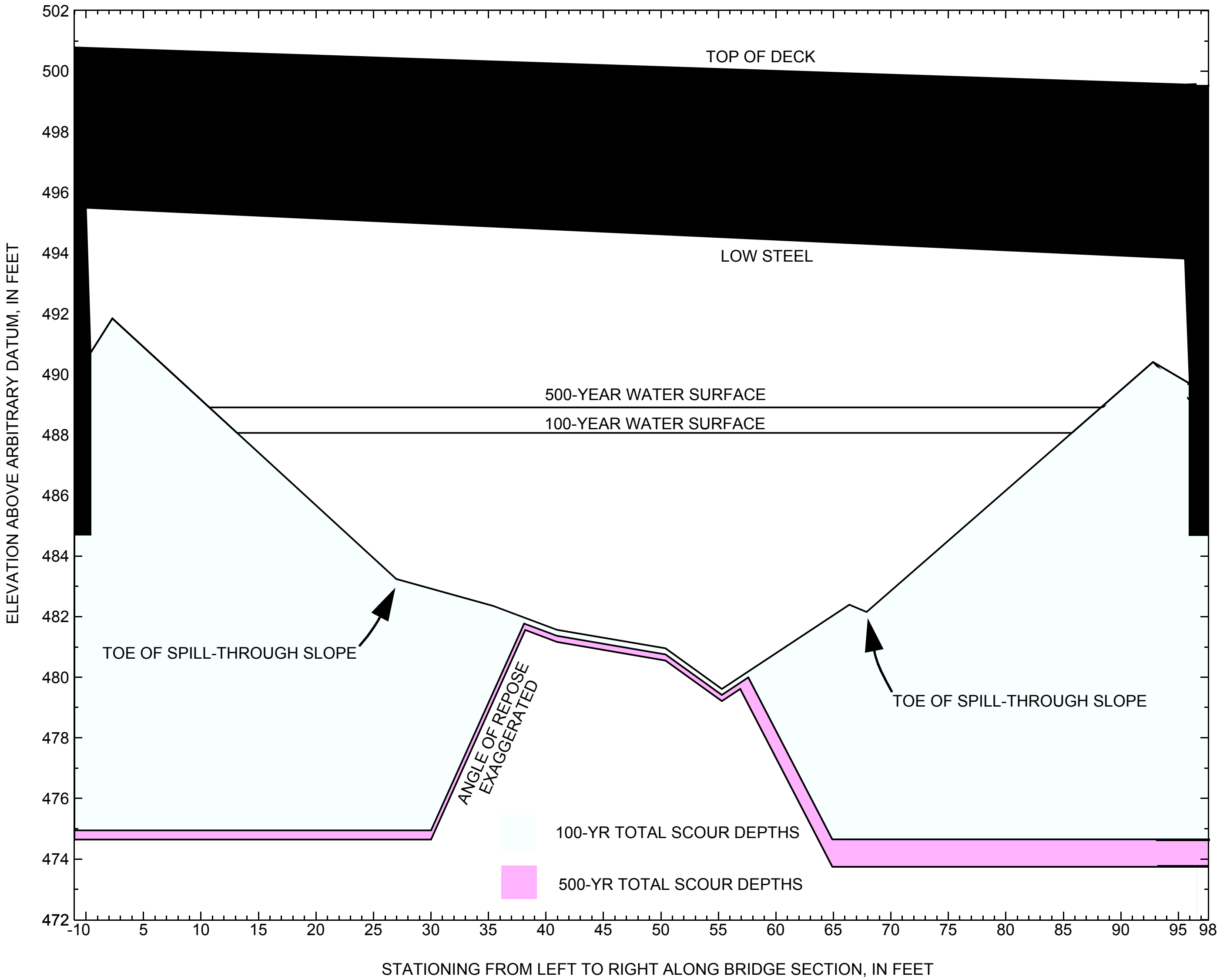


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure VICTTH00010006 on Town Highway 1, crossing the Moose River, Victory, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure VICTTH00010006 on Town Highway 1, crossing the Moose River, Victory, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing 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 3,120 cubic-feet per second											
Left abutment	0.0	1182.4	495.5	484.7	490.7	--	--	--	--	--	-9.8
Left embankment toe	27.0	--	--	--	483.2	0.2	8.1	--	8.3	474.9	--
Right embankment toe	67.9	--	--	--	482.2	0.2	7.3	--	7.5	474.7	--
Right abutment	96.0	1181.2	493.8	484.7	489.7	--	--	--	--	--	-10.0

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 VICTTH00010006 on Town Highway 1, crossing the Moose River, Victory, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing 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 3,870 cubic-feet per second											
Left abutment	0.0	1182.4	495.5	484.7	490.7	--	--	--	--	--	-10.1
Left embankment toe	27.0	--	--	--	483.2	0.4	8.2	--	8.6	474.6	--
Right embankment toe	67.9	--	--	--	482.2	0.4	8.0	--	8.4	473.8	--
Right abutment	96.0	1181.2	493.8	484.7	489.7	--	--	--	--	--	-10.9

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File vict006.wsp
T2        Hydraulic analysis for structure vict006          Date: 04-DEC-96
T3        Hydraulic Analysis of bridge 6 in Victory, VT over Moose River  SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3120 3870
SK          0.018 0.018
*
XS   EXITX    -67
GR         -107.5, 492.27    -78.5, 492.26    -32.9, 492.36    -13.8, 485.71
GR            0.0, 481.66      9.1, 481.01     17.3, 479.52     27.1, 479.92
GR           41.8, 480.02     50.3, 480.65     61.2, 487.17     77.9, 497.13
GR          153.1, 496.67    277.9, 494.46    390.1, 498.68
N           0.100        0.064        0.090
SA                -32.9         77.9
*
XS   FULLV     0 * * * 0.009
*
BR   BRIDG     0 494.65 45
GR            0.0, 495.49      0.4, 490.70      2.3, 491.84     27.0, 483.24
GR           35.5, 482.34     41.0, 481.56     50.4, 480.95     55.3, 479.61
GR           66.4, 482.39     67.9, 482.15     92.8, 490.40     96.0, 489.69
GR           96.0, 493.81      0.0, 495.49
CD           3 46.1 5.7 500.2
N           0.060
*
XR   RDWAY     23      31.0      2
GR         -475.6, 506.85   -312.8, 505.20   -192.3, 503.90      0.0, 500.77
GR            0.0, 501.16     97.0, 499.92     97.0, 499.56    290.1, 497.67
GR          308.6, 496.83    355.7, 501.63
*
XT   APTEM    137
GR         -444.5, 506.85   -272.0, 505.20   -258.1, 504.68   -161.7, 502.23
GR          -66.7, 501.20    -15.5, 498.66      0.0, 491.55      9.4, 487.72
GR           14.3, 484.45     14.5, 483.76     20.9, 484.49     26.3, 483.60
GR           31.9, 482.78     37.5, 482.31     42.0, 483.21     46.0, 484.39
GR           69.4, 489.11     89.0, 497.48
*
AS   APPRO    114
GT           -0.35
N           0.110        0.064        0.110
SA                -15.5         89.0
*
HP 1 BRIDG    488.06 1 488.06
HP 2 BRIDG    488.06 * * 3120
HP 1 APPRO    493.62 1 493.62
HP 2 APPRO    493.62 * * 3120
*
HP 1 BRIDG    488.90 1 488.90
HP 2 BRIDG    488.90 * * 3870
HP 1 APPRO    494.44 1 494.44
HP 2 APPRO    494.44 * * 3870
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File vict006.wsp
       Hydraulic analysis for structure vict006          Date: 04-DEC-96
       Hydraulic Analysis of bridge 6 in Victory, VT over Moose River  SAO

   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
            1     250.   17105.    51.    55.                      3132.
  488.06          250.   17105.    51.    55.  1.00    13.    86.   3132.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      488.06    13.2    85.7   250.0   17105.    3120.  12.48
X STA.       13.2       26.5       30.7       34.1       37.1       39.8
  A(I)            22.0       14.7       13.2       12.1       11.6
  V(I)            7.09      10.63      11.86      12.85      13.50

X STA.       39.8       42.2       44.5       46.6       48.7       50.8
  A(I)            11.0       10.7       10.4       10.1       10.3
  V(I)           14.20      14.57      15.01      15.41      15.10

X STA.       50.8       52.7       54.4       56.1       57.9       59.9
  A(I)            10.0       10.1        9.9       10.1       10.7
  V(I)           15.54      15.49      15.78      15.38      14.60

X STA.       59.9       62.2       64.8       67.9       72.1       85.7
  A(I)            11.3       11.9       12.7       15.4       21.9
  V(I)           13.82      13.08      12.28      10.16       7.13

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     114.
    WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
            2     616.   51467.    86.    91.                      9362.
  493.62          616.   51467.    86.    91.  1.00    -5.    81.   9362.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     114.
        WSEL     LEW     REW    AREA        K        Q    VEL
      493.62    -5.3    80.8   616.4   51467.    3120.   5.06
X STA.       -5.3       10.4       14.8       17.8       20.8       23.7
  A(I)            53.9       36.9       30.5       29.0       27.4
  V(I)            2.90       4.23       5.12       5.38       5.69

X STA.       23.7       26.2       28.7       31.0       33.2       35.3
  A(I)            25.8       25.8       24.9       24.8       24.4
  V(I)            6.04       6.04       6.27       6.30       6.38

X STA.       35.3       37.4       39.5       41.8       44.3       47.2
  A(I)            24.0       24.5       25.2       26.5       27.9
  V(I)            6.51       6.37       6.20       5.88       5.59

X STA.       47.2       50.4       54.2       58.5       64.4       80.8
  A(I)            28.7       31.2       32.6       38.2       54.2
  V(I)            5.44       5.00       4.78       4.08       2.88
```

```
        U.S. Geological Survey WSPRO Input File vict006.wsp
        Hydraulic analysis for structure vict006          Date: 04-DEC-96
        Hydraulic Analysis of bridge 6 in Victory, VT over Moose River  SAO

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     295.   21480.    55.    59.                       3876.
   488.90          295.   21480.    55.    59.  1.00    11.    88.   3876.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       488.90    10.7    88.3   294.6   21480.    3870.  13.14
X STA.        10.7       25.4       29.7       33.2       36.3       39.1
  A(I)            26.3       17.3       15.2       14.3       13.5
  V(I)            7.35      11.20      12.73      13.52      14.31

X STA.        39.1       41.6       44.0       46.3       48.4       50.6
  A(I)            12.8       12.5       12.2       12.0       11.9
  V(I)           15.07      15.43      15.91      16.11      16.32

X STA.        50.6       52.6       54.5       56.3       58.3       60.4
  A(I)            11.9       11.9       11.6       12.1       12.6
  V(I)           16.27      16.26      16.65      15.95      15.36

X STA.        60.4       62.8       65.6       68.9       73.2       88.3
  A(I)            13.0       14.1       15.4       17.5       26.4
  V(I)           14.86      13.74      12.56      11.06       7.32

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     114.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     689.   60107.    90.    95.                      10820.
   494.44          689.   60107.    90.    95.  1.00    -7.    83.  10820.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     114.
         WSEL     LEW     REW    AREA        K        Q    VEL
       494.44    -7.1    82.7   688.5   60107.    3870.   5.62
X STA.        -7.1        9.4       14.2       17.4       20.4       23.4
  A(I)            59.7       41.4       35.1       31.9       30.7
  V(I)            3.24       4.67       5.51       6.07       6.30

X STA.        23.4       26.1       28.6       31.0       33.2       35.5
  A(I)            29.4       28.3       28.4       26.9       27.3
  V(I)            6.58       6.84       6.82       7.20       7.09

X STA.        35.5       37.7       39.9       42.3       44.9       48.0
  A(I)            27.4       27.0       28.2       29.6       31.3
  V(I)            7.07       7.17       6.87       6.54       6.19

X STA.        48.0       51.3       55.1       59.7       65.7       82.7
  A(I)            32.3       34.4       36.8       42.4       60.0
  V(I)            5.99       5.63       5.26       4.56       3.22
```

```
       U.S. Geological Survey WSPRO Input File vict006.wsp
       Hydraulic analysis for structure vict006          Date: 04-DEC-96
       Hydraulic Analysis of bridge 6 in Victory, VT over Moose River  SAO

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

EXITX:XS   ******   -15.     359.  1.18 *****  487.38  485.05   3120.  486.20
      -67. ******    60.   23240.  1.00 ***** *******    0.70    8.70

FULLV:FV      67.   -17.     409.  0.90  1.00  488.37 *******   3120.  487.47
        0.    67.    61.   28187.  1.00  0.00    0.00    0.59    7.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.92     489.29     489.02

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   486.97     506.50    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   486.97     506.50     489.02

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.61

APPRO:AS     114.     5.     286.  1.85  2.28  491.13  489.02   3120.  489.28
      114.   114.    71.   17234.  1.00  0.47    0.00    0.92   10.90
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    3120.      488.06

            <<<<<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      67.    13.     250.  2.42 *****  490.48  488.06   3120.  488.06
        0.    67.    86.   17094.  1.00 ***** *******    1.00   12.48

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  494.65 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      23.        <<<<<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      68.    -5.     617.  0.40  0.76  494.02  489.02   3120.  493.62
      114.    68.    81.   51517.  1.00  2.79    0.01    0.33    5.06

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   52975.    -4.    69.   493.32

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -67.   -15.    60.   3120.   23240.     359.    8.70  486.20
   FULLV:FV       0.   -17.    61.   3120.   28187.     409.    7.62  487.47
   BRIDG:BR       0.    13.    86.   3120.   17094.     250.   12.48  488.06
   RDWAY:RG      23.**************      0.*****************    2.00********
   APPRO:AS     114.    -5.    81.   3120.   51517.     617.    5.06  493.62

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -4.    69.   52975.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     485.05    0.70  479.52  498.68************  1.18  487.38  486.20
   FULLV:FV   ********    0.59  480.12  499.28  1.00  0.00  0.90  488.37  487.47
   BRIDG:BR     488.06    1.00  479.61  495.49************  2.42  490.48  488.06
   RDWAY:RG   ****************  496.83  506.85**********************************
   APPRO:AS     489.02    0.33  481.96  506.50  0.76  2.79  0.40  494.02  493.62
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File vict006.wsp
       Hydraulic analysis for structure vict006          Date: 04-DEC-96
       Hydraulic Analysis of bridge 6 in Victory, VT over Moose River  SAO

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

EXITX:XS   ******   -17.     416.  1.35 *****  488.29  485.73   3870.  486.95
      -67. ******    61.   28832.  1.00 ***** *******    0.71    9.31

FULLV:FV      67.   -19.     472.  1.05  1.01  489.30 *******   3870.  488.25
        0.    67.    62.   34601.  1.00  0.00    0.00    0.60    8.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.92     490.02     489.75

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   487.75     506.50    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   487.75     506.50     489.75

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.63

APPRO:AS     114.     3.     336.  2.06  2.27  492.08  489.75   3870.  490.02
      114.   114.    72.   21714.  1.00  0.51    0.00    0.92   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 =    3870.     488.90

            <<<<<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      67.    11.     295.  2.68 *****  491.58  488.90   3870.  488.90
        0.    67.    88.   21504.  1.00 ***** *******    1.00   13.12

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  494.65 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      23.        <<<<<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      68.    -7.     688.  0.49  0.79  494.93  489.75   3870.  494.44
      114.    69.    83.   60104.  1.00  2.55   -0.02    0.36    5.62

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000   62603.    -6.    72.   494.10

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

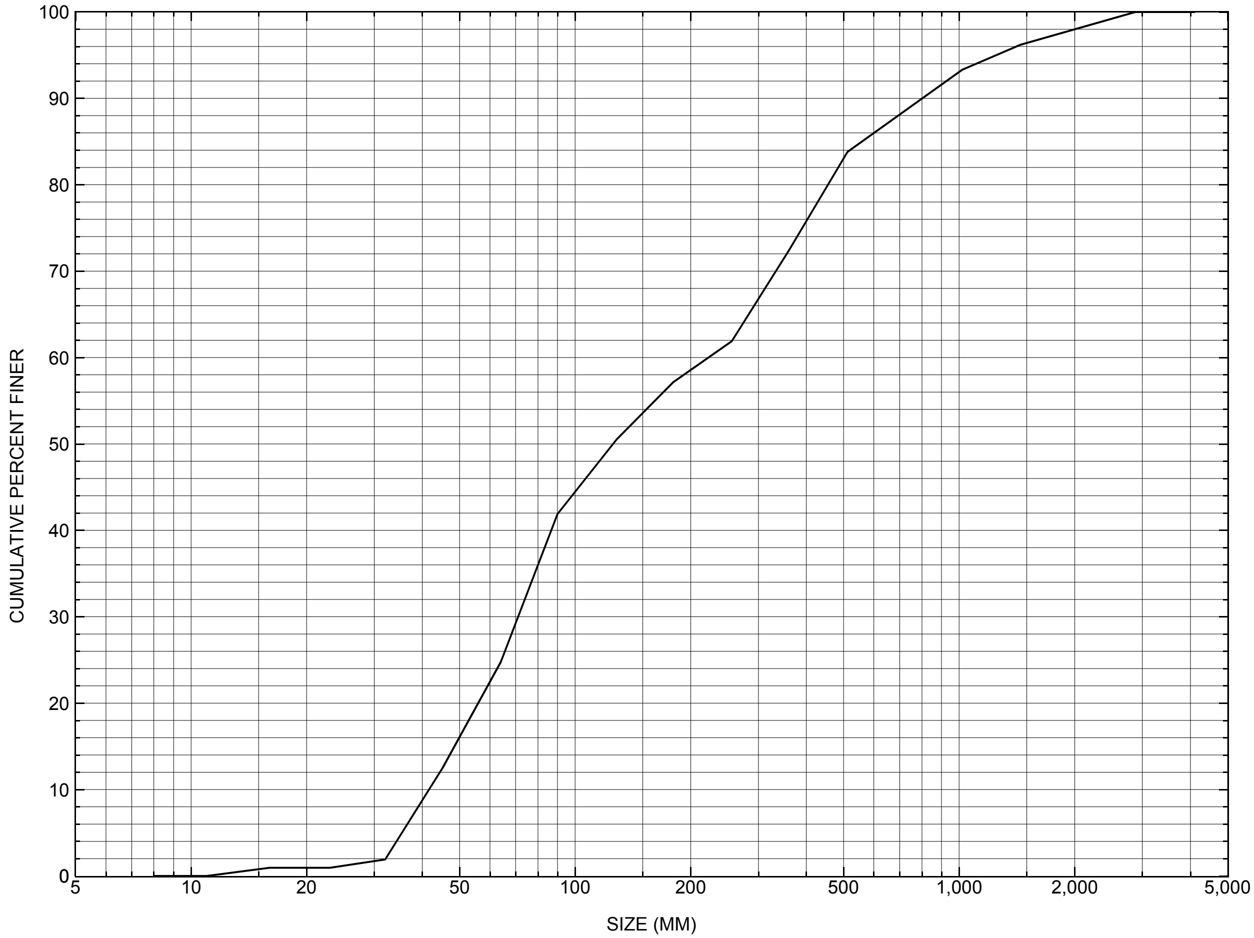
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -67.   -17.    61.   3870.   28832.     416.    9.31  486.95
   FULLV:FV       0.   -19.    62.   3870.   34601.     472.    8.20  488.25
   BRIDG:BR       0.    11.    88.   3870.   21504.     295.   13.12  488.90
   RDWAY:RG      23.**************      0.*****************     2.00********
   APPRO:AS     114.    -7.    83.   3870.   60104.     688.    5.62  494.44

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    72.   62603.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     485.73    0.71  479.52  498.68************  1.35  488.29  486.95
   FULLV:FV   ********    0.60  480.12  499.28  1.01  0.00  1.05  489.30  488.25
   BRIDG:BR     488.90    1.00  479.61  495.49************  2.68  491.58  488.90
   RDWAY:RG   ****************  496.83  506.85**********************************
   APPRO:AS     489.75    0.36  481.96  506.50  0.79  2.55  0.49  494.93  494.44
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure VICTTH00010006, in Victory, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number VICTTH00010006

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)* 006040

Waterway *(I - 6)* MOOSE RIVER

Road Name *(I - 7):* -

Route Number TH001

Vicinity *(I - 9)* 8.9 MI N JCT. U.S.2

Topographic Map Gallup.Mills

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44334

Longitude *(i - 17; nnnnn.n)* 71471

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20027700060517

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

Maximum span length *(I - 48; nnnn)* 0098

Year built *(I - 27; YYYY)* 1975

Structure length *(I - 49; nnnnnn)* 000101

Average daily traffic, ADT *(I - 29; nnnnnn)* 000170

Deck Width *(I - 52; nn.n)* 308

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

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

Opening skew to Roadway *(I - 34; nn)* 46

Waterway adequacy *(I - 71; n)* 8

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*) 070.0

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

Vertical clearance from streambed (*nnn.n ft*) 012.0

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

Waterway of full opening (*nnn.n ft*^{2}) 860.0

Comments:

The structural inspection report of 5/4/94 indicates the structure is a single span, steel stringer type bridge with a concrete deck. This bridge is on the Federal Aid System under the route number, FAS 277. The abutments and wingwalls are concrete, which have hairline shrinkage cracks and some leaks. Both abutments are reported and appear in photographs to be flow through type abutments, with a short section of the concrete abutment walls exposed at the top and the bottoms covered with an earth embankment and protected with heavy stone fill. The river proceeds straight thought the structure. The streambed consists of mainly boulders and gravel. The footings are noted as not in view at the **(Continued, page 31)**

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 27.9

Terrain character: Mountainous

Stream character & type: -

Streambed material: Gravel with large boulders

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 3000 Q_{25} 4000
Q_{50} 4800 Q_{100} - Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 12.7

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: Possible backwater from victory dam reservoir, if it is ever built.

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*)	-	-	1178.5	-	-
Velocity (*ft / sec*)	-	-	12.7	-	-

Long term stream bed changes: -

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

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

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

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

Highway No. : TH02 Structure No. : 04 Structure Type: -

Clear span (*ft*): 40.0 Clear Height (*ft*): 12.0 Full Waterway (*ft²*): 480.0

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

Highway No. : **TH01** Structure No. : **37** Structure Type: **-**

Clear span (*ft*): **70.0** Clear Height (*ft*): **11.0** Full Waterway (ft^2): **770.0**

Comments:

surface and there has been no settling reported. There has been no channel scour noted. The bridge is in good condition.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **27.9** mi^2

Lake and pond area **0.21** mi^2

Watershed storage *(ST)* **0.7** %

Bridge site elevation **1186** ft

Headwater elevation **3174** ft

Main channel length **12.77** mi

10% channel length elevation **1265** ft

85% channel length elevation **2380** ft

Main channel slope *(S)* **117.07** 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? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **04** / **1974**

Project Number **RS 0277(1) SA** Minimum channel bed elevation: **1169.0**

Low superstructure elevation: USLAB **1182.44** DSLAB **1183.41** USRAB **1181.21** DSRAB **1182.23**

Benchmark location description:

State of Vermont survey mark, set in top of concrete at downstream end of the right abutment, elevation 1187.11 feet

Reference Point (*MSL, Arbitrary, Other*): **MSL** Datum (*NAD27, NAD83, Other*): **NGVD 1929**

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

If 1: Footing Thickness **2.0** Footing bottom elevation: **1172.0**

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? **Y** *If no, type ctrl-n bi* Number of borings taken: **2**

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

Briefly describe material at foundation bottom elevation or around piles:

The abutment footings are set in a sand, silt, and stone material.

Comments:

Other points shown on the plans with elevations are: 1) the point on the top streamward edge of the upstream right wingwall concrete where the concrete slope changes from horizontal to downward, elevation 1186.23, and 2) the point at the same location, but on the upstream left wingwall, elevation 1187.46.

Cross-sectional Data

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

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

Comments: **Orientation of the cross sections is inconsistent with any cross section data surveyed for this study and is not comparable. Data was not retrieved.**

Station	--	--	--	--	--	--	--	--	--	--	--
Feature	--	--	--	--	--	--	--	--	--	--	--
Low cord elevation	--	--	--	--	--	--	--	--	--	--	--
Bed elevation	--	--	--	--	--	--	--	--	--	--	--
Low cord to bed length	--	--	--	--	--	--	--	--	--	--	--

Station	--	--	--	--	--	--	--	--	--	--	--
Feature	--	--	--	--	--	-	--	--	--	--	--
Low cord elevation	--	--	--	--	--	--	--	--	--	--	--
Bed elevation	--	--	--	--	--	--	--	--	--	--	--
Low cord to bed length	--	--	--	--	--	--	--	--	--	--	--

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

Comments: --

Station	--	--	--	--	--	--	--	--	--	--	--
Feature	--	--	--	--	--	--	--	--	--	--	--
Low cord elevation	--	--	--	--	--	--	--	--	--	--	--
Bed elevation	--	--	--	--	--	--	--	--	--	--	--
Low cord to bed length	--	--	--	--	--	--	--	--	--	--	--

Station	--	--	--	--	--	--	--	--	--	--	--
Feature	--	--	--	--	--	--	--	--	--	--	--
Low cord elevation	--	--	--	--	-	--	--	--	--	--	--
Bed elevation	--	--	--	--	--	--	--	--	--	--	--
Low cord to bed length	--	--	--	--	--	--	--	--	--	--	--

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 04/03/96
Computerized by: EW Date: 04/04/96
Reviewd by: SAO Date: 12/10/96

Structure Number VICTTH00010006

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 07 / 20 / 1995
2. Highway District Number 07 Mile marker 066040
County 009 Town VICTORY 75175
Waterway *(I - 6)* MOOSE RIVER Road Name -
Route Number TH001 Hydrologic Unit Code: 01080102
3. Descriptive comments:
8.9 MILES NORTH OF JUNCTION WITH US 2.
Federal Aid System Bridge (#277).

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 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 101 *(feet)* Span length 98 *(feet)* Bridge width 30.8 *(feet)*

Road approach to bridge:

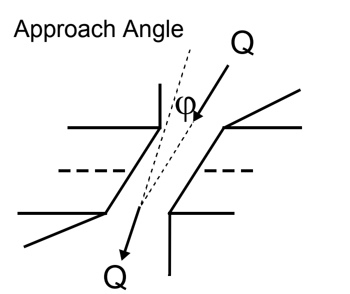
8. LB 2 RB 2 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 3.1:1 US right 8.4:1

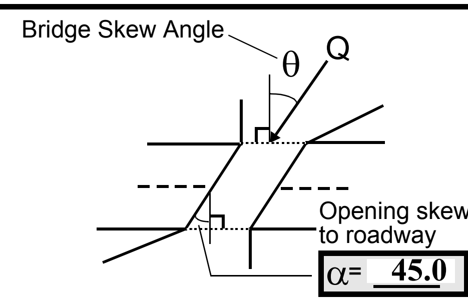
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 40





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 20 feet DS *(US, UB, DS)* to 75 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/3

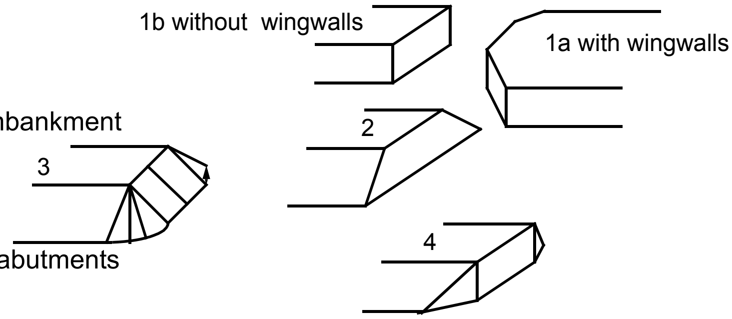
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular 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: LBUS and RBDS surface cover includes road TH 1.

#8: Road is slightly higher than bridge.

#18: The bridge has spill-through type abutments with wingwalls. The spill-through slope extends up wingwalls.

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
86.5	**14.0**			**13.0**	**2**	**4**	**543**	**543**	**0**	**0**

23. Bank width **25.0** 24. Channel width **15.0** 25. Thalweg depth **104.5** 29. Bed Material **453**

30 .Bank protection type: LB **3** RB **3** 31. Bank protection condition: LB **1** RB **1**

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

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

#29: Bed is very well packed with boulders.

#30: Bank protection within one bridge length is both man-placed and natural. Beyond one bridge length, bank protection is natural.

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

Local point/side bars occur at downstream end of boulders.

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? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 25

47. Scour dimensions: Length 60 Width 10 Depth : 3 Position 50 %LB to 70 %RB

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

Scour is UB; could be a result of scour behind/beside large boulder and contraction through bridge.
Many local scour holes exist behind large boulders.

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
31.5		2.0		2	5	5	0

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 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
#61: Under conditions of extreme high flows, channel restraint is concrete abutment.
#63: refer to #29 comments

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

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

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**	**1**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**0**	**90**			**1**	**0**	**67.5**

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.):

-

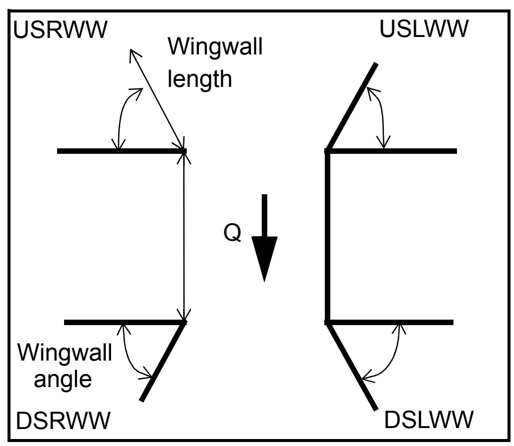
-

1

#73: The vertical, concrete abutment walls are set back. However, during high flows, the abutment walls will act as a channel restraint. The toe of the spill-through slope protrude into the channel at normal flows.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**67.5**	
USRWW:	**Y**		**1**		**0**	**3.0**	
DSLWW:	**0**		**0**		**Y**	**48.5**	
DSRWW:	**1**		**0**		**0**	**44.0**	



*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**	**0**	**Y**	**0**	**1**	**1**	**1**	**1**
Condition	**Y**	**0**	**1**	**0**	**1**	**1**	**1**	**1**
Extent	**1**	**0**	**0**	**3**	**3**	**3**	**3**	**-**

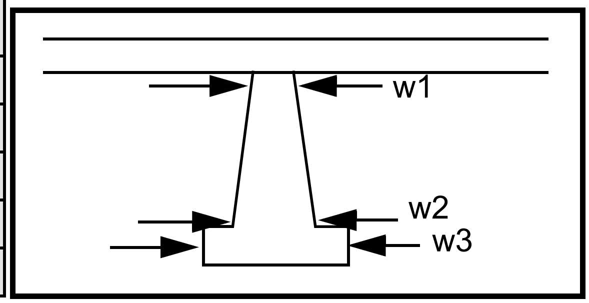
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? La (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				15.0	13.0	105.0
Pier 2	8.5	8.5		105.0	15.0	31.0
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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 (Amb) - Thalweg depth (Amb) - 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.):
-
-
-
-
-
-
-
NO PIERS

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):
4
2
543
543
1
1

106. Point/Side bar present? __54__ *(Y or N. if N type ctrl-n pb)* Mid-bar distance: __3__ Mid-bar width: __0__

Point bar extent: __0__ feet __-__ *(US, UB, DS)* to __-__ feet __Ba__ *(US, UB, DS)* positioned __nk__ %LB to __ero__ %RB

Material: __sio__

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

n due to redirection of local flow by boulders along edge of channel. There also may be some bank steepening (erosion) due to ice.
Bed material: refer to comments of #29.

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

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

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

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

N

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

Scour dimensions: Length __DRO__ Width __P__ Depth: __STR__ Positioned __UC__ %LB to __TU__ %RB

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

RE

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

Confluence 1: Distance __Y__ Enters on __20__ *(LB or RB)* Type __8__ *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance __160__ Enters on __DS__ *(LB or RB)* Type __200__ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

\+

DS

F. Geomorphic Channel Assessment

107. Stage of reach evolution __90__

- ***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)*:

100

4

Natural - occurs on outside of bend in channel.

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: VICTTH00010006 Town: Victory
Road Number: TH1 County: Essex
Stream: Moose River

Initials SAO Date: 12/5/96 Checked:RF

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	3120	3870	0
Main Channel Area, ft2	616	689	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	86.1	89.8	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.412	0.412	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.2	7.7	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	51467	60107	0
Conveyance, main channel	51467	60107	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	3120.0	3870.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	5.1	5.6	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	11.6	11.7	N/A
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	N/A
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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	616	689	0
Main channel width, ft	86.1	89.8	0
y1, main channel depth, ft	7.15	7.67	ERR

Bridge Section			
(Q) total discharge, cfs	3120	3870	0
(Q) discharge thru bridge, cfs	3120	3870	0
Main channel conveyance	17105	21480	0
Total conveyance	17105	21480	0
Q2, bridge MC discharge,cfs	3120	3870	ERR
Main channel area, ft2	250	295	0
Main channel width (skewed), ft	51.3	54.9	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	51.3	54.9	0
y_bridge (avg. depth at br.), ft	4.87	5.37	ERR
Dm, median (1.25*D50), ft	0.515	0.515	0
y2, depth in contraction,ft	5.06	5.74	ERR
ys, scour depth (y2-ybridge), ft	0.19	0.37	N/A

ARMORING			
D90	2.622	2.622	0
D95	4.092	4.092	0
Critical grain size,Dc, ft	1.6099	1.6728	ERR
Decimal-percent coarser than Dc	0.1757	0.1633	0
Depth to armoring,ft	22.66	25.71	ERR

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	3120	3870	0	3120	3870	0
a’, abut.length blocking flow, ft	18.5	17.8	0	16.3	17.1	0
Ae, area of blocked flow ft2	77.4	70.9	0	53.9	60.7	0
Qe, discharge blocked abut.,cfs	225.3	245.9	0	155.1	196.7	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.91	3.47	ERR	2.88	3.24	ERR
ya, depth of f/p flow, ft	4.18	3.98	ERR	3.31	3.55	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	45	45	45	135	135	135
K2	0.91	0.91	0.91	1.05	1.05	1.05
Fr, froude number f/p flow	0.251	0.306	ERR	0.279	0.303	ERR
ys, scour depth, ft	8.07	8.19	N/A	7.27	7.98	N/A

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)	18.5	17.8	0	16.3	17.1	0
y1 (depth f/p flow, ft)	4.18	3.98	ERR	3.31	3.55	ERR
a’/y1	4.42	4.47	ERR	4.93	4.82	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.25	0.31	N/A	0.28	0.30	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww’s	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	1	1	0	1	1	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.87	5.37	0.00	4.87	5.37	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	2.04	2.25	ERR	2.04	2.25	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	1.80	1.99	ERR	1.80	1.99	ERR