LEVEL II SCOUR ANALYSIS FOR BRIDGE 96 (BLOOVT01050096) on VERMONT ROUTE 105, crossing the NULHEGAN RIVER, BLOOMFIELD, VERMONT

U.S. Geological Survey
Open-File Report 96-566

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

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By JOSEPH D. AYOTTE AND MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1996

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	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 96 (BLOOVT01050096) ON VERMONT ROUTE 105, CROSSING THE NULHEGAN RIVER, BLOOMFIELD, VERMONT

***By* Joseph D. Ayotte And Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BLOOVT01050096 on Vermont Route 105 crossing the Nulhegan River, Bloomfield, 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 of north-east Vermont in the town of Bloomfield. The 103-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is shrub and brushland upstream. Downstream of the bridge, the surface cover is forest.

In the study area, the Nulhegan River has an incised, sinuous channel with a slope of approximately 0.015 ft/ft, an average channel top width of 78 ft and an average channel depth of 5 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 133 mm (0.435 ft). About 100 feet upstream, the streambed and bank materials abruptly change predominantly to sand. The geomorphic assessment at the time of the Level I and Level II site visit on July 6, 1995, indicated that the upstream reach, which is experiencing channel scour and severe bank cutting into the alluvial channel boundaries, is not stable. The downstream reach is semi- to non-alluvial and is assessed as stable.

The Vermont Route 105 crossing of the Nulhegan River is a 74-ft-long, two-lane bridge consisting of one 71-foot steel stringer type superstructure with a concrete deck (Vermont Agency of Transportation, written communication, August 5, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 25 degrees.

A scour hole 4.0 ft deeper than the mean thalweg depth was observed along the upstream channel during the Level I assessment. Scour protection measures at the site consist of type-2 stone fill (less than 24 inches diameter) along the entire base length of both abutments and all wingwalls. 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 0.5 to 1.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 10.5 to 16.2 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.

Bloomfield V.T.-N.H. 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 BLOOVT01050096 *Stream* Nulhegan River

County Essex *Road* VT105 *District* 9

Description of Bridge

Bridge length 74 *ft* *Bridge width* 42.6 *ft* *Max span length* 71 *ft*

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

Abutment type Vertical *Embankment type* Sloping

Stone fill on abutment? Yes *Date of inspection* 7/6/95

Description of stone fill Type-2, around the entire base length of both abutments and all wingwalls, reported to be in good condition.

Abutments and wingwalls are concrete. There is a four foot deep scour hole approximately 125 ft US of the bridge.

Is bridge skewed to flood flow according to Y *survey?* Y *Angle* 10

There is a moderate channel bend in the downstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	7/6/95	0	0
Level II	7/6/95	--	--

Potential for debris High. There is some debris in the channel upstream. Also, historically, debris has been a problem.

Describe any features near or at the bridge that may affect flow (include observation date) The US channel becomes significantly shallower than normal at a distance of less than one bridge length US-- 7/6/95.

Description of the Geomorphic Setting

General topography The channel is located at the head of a natural constriction between two small mountains with steep valley walls. The valley is irregular in width elsewhere.

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

Date of inspection 7/6/95

DS left: Terraced overbank area (450 ft wide) to steep sloped valley wall

DS right: Narrow overbank area to moderately sloped valley wall

US left: Narrow overbank area to moderately sloped valley wall

US right: Sand and swamp overbank area to steep sloped valley wall

Description of the Channel

Average top width 78 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Cobbles ***Bank material*** Gravel

Sinuous with predominately alluvial channel boundaries and a variable-width flood plain.

7/6/95

Vegetative co Forest

DS left: Forest

DS right: Shrub and brushland

US left: Shrub and brushland

US right:

N

Do banks appear stable? There is a major cut bank with block failure US on the RB and a cut bank on the DS LB with lesser amounts of erosion

If not, describe location and type of instability and date of observation.

The assessment of 7/6/95 noted flow conditions up to bank-full level are influenced boulders 100 ft US of the bridge with scour in the channel closer to the bridge.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 103 ***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? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 5,100 ***ft³/s*** ***Q500*** 7,000 ***ft³/s***

The 100- and 500-year discharges were the median value of several empirical estimation methods applicable to this basin's size and region, some of which were graphically extrapolated (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 datum

Datum tie between USGS survey and VTAOT plans Subtract 0.05 from USGS survey to obtain VTAOT plans datum and sea level.

Description of reference marks used to determine USGS datum.
RM1 is the end of a spike in a pole 125 ft from right abutment on the DS right road approach embankment (elev. 1050.94 ft, arbitrary datum). RM2 is the center of the triangle of a brass tablet at the junction of the DS right abutment and DS right wingwall (elev. 1050.30 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-96	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section (data from US face)
RDWAY	22	1	Road Grade section
APPRO	113	2	Approach section (Surveyed at SRD of 82. No shift of elevation data required.)

[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 0.040 to 0.060, and overbank "n" values ranged from 0.040 to 0.100.

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 0.0154 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1988).

The surveyed approach section was moved 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. Upstream of the surveyed approach section, which had a station reference distance (SRD) of 82, the channel became deeper. Thus an adjustment for slope was not made when the SRD was changed to 113.

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 was determined that the water surface profiles passed 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 1051.1 *ft*
Average low steel elevation 1046.1 *ft*

100-year discharge 5,100 *ft³/s*
Water-surface elevation in bridge opening 1041.3 *ft*
Road overtopping? N *Discharge over road* 0 *ft³/s*
Area of flow in bridge opening 368 *ft²*
Average velocity in bridge opening 13.9 *ft/s*
Maximum WSPRO tube velocity at bridge 16.4 *ft/s*

Water-surface elevation at Approach section with bridge 1044.8
Water-surface elevation at Approach section without bridge 1042.9
Amount of backwater caused by bridge 1.9 *ft*

500-year discharge 7,000 *ft³/s*
Water-surface elevation in bridge opening 1042.8 *ft*
Road overtopping? N *Discharge over road* 0 *ft³/s*
Area of flow in bridge opening 455 *ft²*
Average velocity in bridge opening 15.4 *ft/s*
Maximum WSPRO tube velocity at bridge 18.3 *ft/s*

Water-surface elevation at Approach section with bridge 1046.7
Water-surface elevation at Approach section without bridge 1044.0
Amount of backwater caused by bridge 2.7

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.

About 100 feet upstream of bridge 96 in Bloomfield, the bed material is primarily sand. Samples taken of the the sand had a median grain size of about
0.80 mm. Using this material size, live-bed conditions would control scour. However, the channel is cobble through the bridge opening to about 75 feet upstream. Using the median grain size of this coarse material, 133 mm, clear-water conditions would control scour. Since the coarse material size best represents the bed under the structure, contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. Streambed armoring depths computed suggest that the depths of contraction scour will not be limited by armoring

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.5	1.1	--
Depth to armoring	26.0	36.9	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	14.5	16.2	--
Right abutment	10.5	11.3	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.5	3.1	--
Right abutment	2.5	3.1	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

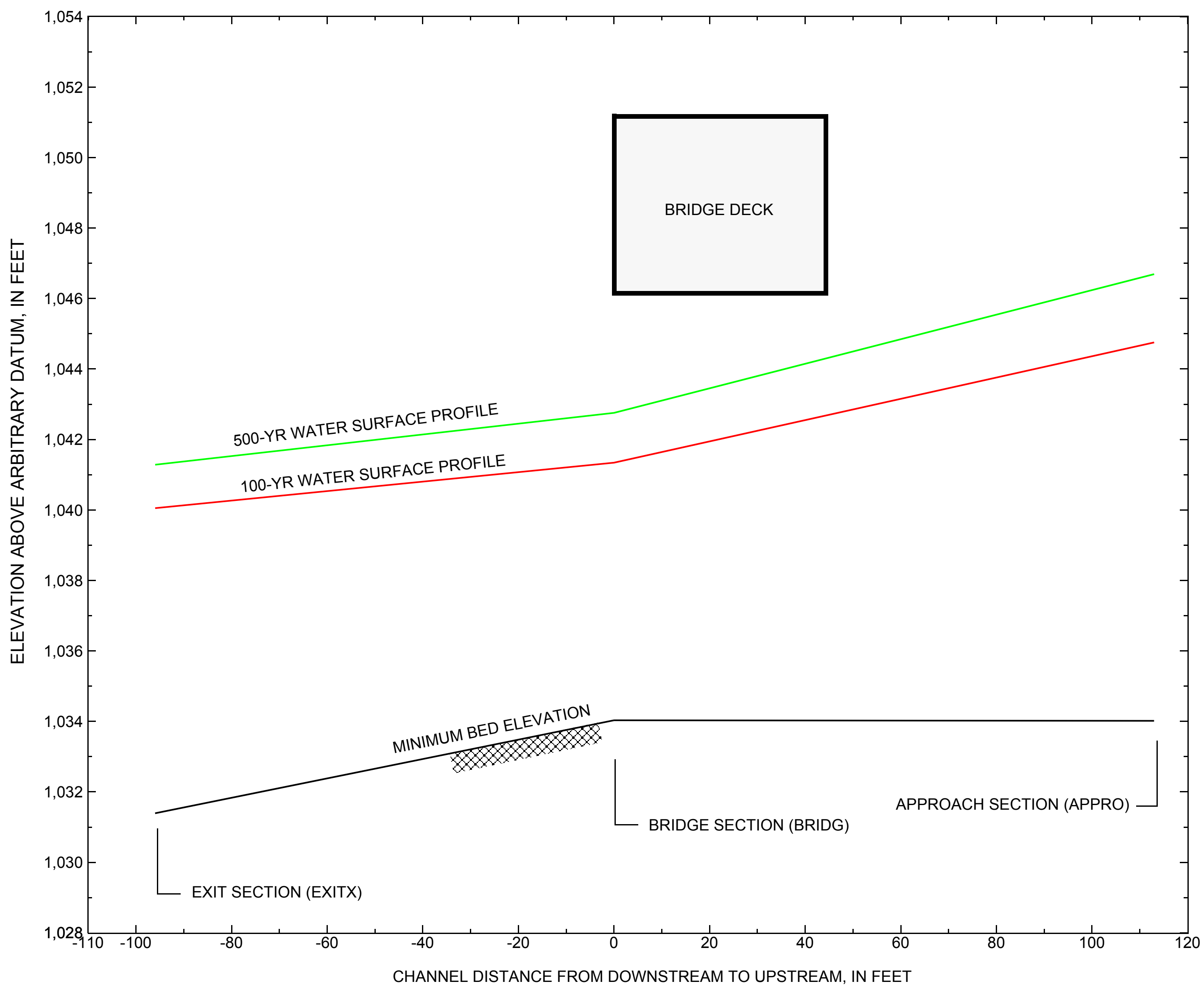

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BLOOVT01050096 on Vermont Route 105, crossing Nulhegan River, Bloomfield, Vermont.

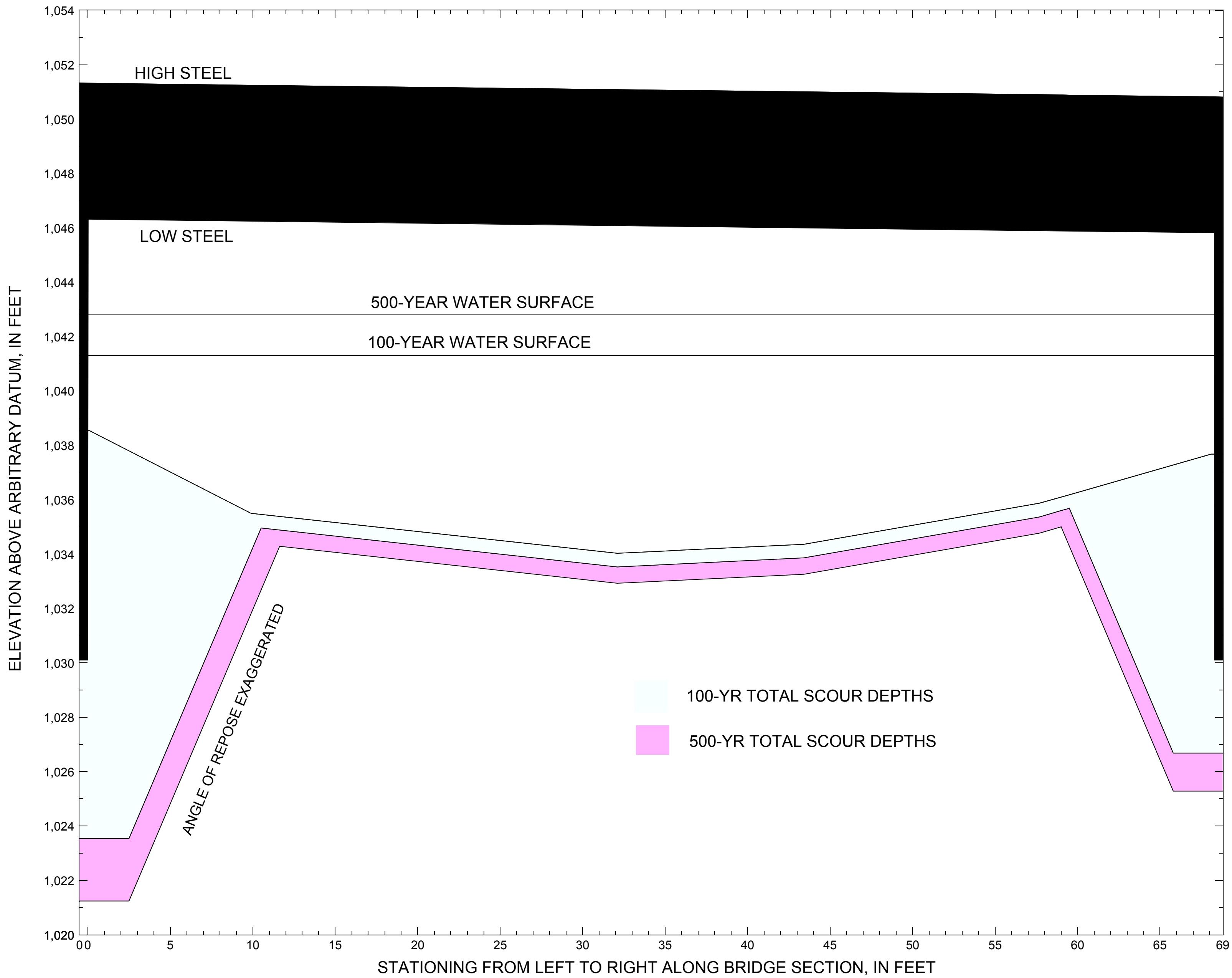

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BLOOVT01050096 on Vermont Route 105, crossing Nulhegan River, Bloomfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BLOOVT01050096 on Vermont Route 105, crossing Nulhegan River, Bloomfield, 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 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 5,100 cubic-feet per second											
Left abutment	0.0	1046.26	1046.31	1030.1	1038.5	0.5	14.5	--	15.0	1023.5	-6.6
Right abutment	68.3	1045.80	1045.85	1030.1	1037.7	0.5	10.5	--	11.0	1026.7	-3.4

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BLOOVT01050096 on Vermont Route 105, crossing Nulhegan River, Bloomfield, 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 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 7,000 cubic-feet per second											
Left abutment	0.0	1046.26	1046.31	1030.1	1038.5	1.1	16.2	--	17.3	1021.2	-8.9
Right abutment	68.3	1045.80	1045.85	1030.1	1037.7	1.1	11.3	--	12.4	1025.3	-4.8

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

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T1        U.S. Geological Survey WSPRO Input File bloo096.wsp
T2        Hydraulic analysis for structure BLOOVT01050096   Date: 17-APR-96
T3        Bloomfield br 96, Vt Rte 102 crossing Nulhegan R.            JDA
Q           5100 7000
SK          0.0154 0.0154
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX      -96
GR         -376.9,1070.25   -343.3,1057.53   -142.8,1051.38    -67.4,1045.14
GR          -62.1,1045.71    -26.4,1045.48    -17.2,1039.97    -12.2,1035.39
GR            0.0,1034.12      8.3,1032.68     15.5,1032.90     21.1,1031.39
GR           38.3,1032.24     45.8,1033.80     49.9,1035.01     57.0,1037.88
GR          101.9,1038.33    126.8,1043.05    146.1,1044.09    187.8,1050.10
GR          205.9,1050.25    216.4,1045.73    229.6,1048.45    242.1,1048.97
GR          250.1,1047.50    256.1,1046.79    258.1,1045.57    262.2,1045.59
GR          266.3,1047.48    287.8,1049.11    312.7,1058.95
N           0.050        0.060        0.100
SA                 -26.4        57.0
*
XS   FULLV      0  * * *  0.0154
*
BR   BRIDG     0 1046.3 25
GR            0.0,1046.31      0.1,1038.54      9.9,1035.50     32.1,1034.03
GR           43.4,1034.36     57.7,1035.87     68.1,1037.68     68.3,1045.85
GR            0.0,1046.31
N             0.040
CD            1 58.4 * * 32 13
*
XR   RDWAY     22 42.6
GR         -322.3,1061.59   -119.2,1053.85      0.0,1051.41     72.1,1050.74
GR          257.6,1050.78    424.5,1053.39    636.7,1054.81
*
AS   APPRO    113
GR          -92.0,1059.72    -63.4,1046.86    -20.1,1046.25    -14.5,1041.92
GR           -3.6,1037.37      8.0,1035.89     15.9,1035.24     23.5,1034.04
GR           30.4,1034.01     43.3,1035.77     57.5,1036.56     67.5,1041.34
GR           71.7,1045.18     88.0,1047.81    177.3,1048.04    226.2,1048.29
GR          226.5,1048.28    286.9,1049.64    357.6,1049.83    526.5,1052.04
N           0.050        0.045        0.040
SA                -20.1        88.0
*
HP 1 BRIDG  1041.34 1 1041.34
HP 2 BRIDG  1041.34 * * 5100
HP 1 APPRO  1044.75 1 1044.75
HP 2 APPRO  1044.75 * * 5100
*
HP 1 BRIDG  1042.75 1 1042.75
HP 2 BRIDG  1042.75 * * 7000
HP 1 APPRO  1046.69 1 1046.69
HP 2 APPRO  1046.69 * * 7000
*
EX
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File bloo096.wsp
        Hydraulic analysis for structure BLOOVT01050096   Date: 17-APR-96
        Bloomfield br 96, Vt Rte 102 crossing Nulhegan R.            JDA
           *** RUN DATE & TIME: 08-14-96  09:19
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     368.  41828.    62.    69.                        5092.
  1041.34          368.  41828.    62.    69.  1.00     0.    68.   5092.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1041.34     0.1    68.2   367.7   41828.    5100.  13.87
X STA.         0.1         8.0        12.0        15.3        18.4        21.3
  A(I)             28.9        20.6        18.5        17.5        17.2
  V(I)             8.82       12.41       13.79       14.60       14.82

X STA.        21.3        24.1        26.7        29.2        31.6        34.0
  A(I)             16.8        16.4        15.9        15.6        15.7
  V(I)            15.19       15.59       16.01       16.40       16.20

X STA.        34.0        36.4        38.8        41.3        43.8        46.5
  A(I)             15.7        15.6        16.2        16.2        16.6
  V(I)            16.21       16.37       15.78       15.79       15.34

X STA.        46.5        49.4        52.6        56.3        60.7        68.2
  A(I)             17.1        18.0        19.3        21.1        29.0
  V(I)            14.93       14.19       13.20       12.07        8.79

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     113.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     692.  86664.    89.    94.                       10923.
  1044.75          692.  86664.    89.    94.  1.00   -18.    71.  10923.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     113.

         WSEL     LEW     REW    AREA        K        Q    VEL
      1044.75   -18.2    71.2   691.9   86664.    5100.   7.37

X STA.       -18.2        -4.0         1.1         5.5         9.4        12.9
  A(I)             57.6        39.7        35.8        34.1        32.4
  V(I)             4.43        6.43        7.12        7.48        7.86

X STA.        12.9        16.2        19.3        22.2        24.9        27.6
  A(I)             31.2        30.4        29.8        28.5        28.6
  V(I)             8.17        8.39        8.56        8.95        8.91

X STA.        27.6        30.3        33.0        35.9        39.0        42.4
  A(I)             28.8        29.3        29.1        30.6        31.3
  V(I)             8.85        8.71        8.76        8.34        8.15

X STA.        42.4        46.0        49.8        53.9        58.6        71.2
  A(I)             32.1        33.3        35.0        38.8        55.5
  V(I)             7.94        7.66        7.29        6.57        4.59
```

```
       U.S. Geological Survey WSPRO Input File bloo096.wsp
       Hydraulic analysis for structure BLOOVT01050096   Date: 17-APR-96
       Bloomfield br 96, Vt Rte 102 crossing Nulhegan R.              JDA
          *** RUN DATE & TIME: 08-14-96  09:19
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     455.   58037.    62.    72.                       7002.
 1042.75          455.   58037.    62.    72.  1.00     0.    68.   7002.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1042.75     0.0    68.2   454.8   58037.    7000.  15.39
X STA.         0.0        7.6       11.5       14.9       18.1       21.0
  A(I)            36.6       25.1       23.2       21.8       20.9
  V(I)            9.56      13.97      15.11      16.09      16.76

X STA.        21.0       23.8       26.5       29.1       31.5       34.0
  A(I)            20.4       20.3       19.7       19.2       19.4
  V(I)           17.13      17.26      17.79      18.27      18.07

X STA.        34.0       36.4       39.0       41.5       44.1       46.9
  A(I)            19.3       19.7       19.5       20.0       20.6
  V(I)           18.15      17.74      17.96      17.54      17.00

X STA.        46.9       49.9       53.1       56.8       61.0       68.2
  A(I)            21.3       22.0       23.7       25.5       36.9
  V(I)           16.44      15.93      14.74      13.72       9.49

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     113.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1       7.      75.    31.    31.                         18.
            2     875.  117997.   101.   107.                      14615.
 1046.69          882.  118072.   132.   138.  1.01   -51.    81.  12837.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     113.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1046.69   -51.3    81.1   882.3  118072.    7000.   7.93
X STA.       -51.3       -6.1       -0.9        3.5        7.4       11.0
  A(I)            76.2       47.6       43.4       41.2       38.8
  V(I)            4.59       7.35       8.06       8.49       9.03

X STA.        11.0       14.3       17.6       20.6       23.5       26.4
  A(I)            37.7       37.8       36.0       36.2       35.8
  V(I)            9.28       9.25       9.73       9.66       9.79

X STA.        26.4       29.2       32.0       35.0       38.3       41.7
  A(I)            35.3       36.3       36.4       38.4       39.6
  V(I)            9.91       9.64       9.62       9.11       8.84

X STA.        41.7       45.5       49.4       53.9       59.1       81.1
  A(I)            40.8       42.4       47.3       51.5       83.7
  V(I)            8.59       8.26       7.40       6.80       4.18
```

```
        U.S. Geological Survey WSPRO Input File bloo096.wsp
        Hydraulic analysis for structure BLOOVT01050096   Date: 17-APR-96
        Bloomfield br 96, Vt Rte 102 crossing Nulhegan R.            JDA
           *** RUN DATE & TIME: 08-14-96  09:19

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

EXITX:XS   ******   -17.     567.  1.57 ***** 1041.62 1039.23   5100. 1040.05
      -96. ******   111.   41088.  1.24 ***** *******    0.84    9.00

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.84    1041.55    1040.71

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =  1039.55    1071.73    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =  1039.55    1071.73    1040.71

FULLV:FV      96.   -17.     568.  1.56  1.47 1043.10 1040.71   5100. 1041.54
        0.    96.   111.   41208.  1.24  0.00    0.01    0.84    8.98
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

APPRO:AS     113.   -16.     531.  1.43  1.23 1044.34 *******   5100. 1042.91
      113.   113.    69.   58205.  1.00  0.00    0.02    0.68    9.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    5100.    1041.34

            <<<<<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      96.     0.     368.  2.99 ***** 1044.33 1041.34   5100. 1041.34
        0.    96.    68.   41849.  1.00 ***** *******    1.00   13.86

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    1.  1.000 ****** 1046.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.        <<<<<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      55.   -18.     692.  0.84  0.40 1045.60 1041.37   5100. 1044.75
      113.    56.    71.   86717.  1.00  0.87    0.01    0.47    7.37

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.198  0.000   87561.    -6.    62.  1044.51

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -96.   -17.   111.   5100.   41088.     567.    9.00 1040.05
   FULLV:FV       0.   -17.   111.   5100.   41208.     568.    8.98 1041.54
   BRIDG:BR       0.     0.    68.   5100.   41849.     368.   13.86 1041.34
   RDWAY:RG      22.**************      0.*****************    1.00********
   APPRO:AS     113.   -18.    71.   5100.   86717.     692.    7.37 1044.75
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    62.   87561.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS   1039.23    0.84 1031.39 1070.25************  1.57 1041.62 1040.05
   FULLV:FV   1040.71    0.84 1032.87 1071.73  1.47  0.00  1.56 1043.10 1041.54
   BRIDG:BR   1041.34    1.00 1034.03 1046.31************  2.99 1044.33 1041.34
   RDWAY:RG  *************** 1050.74 1061.59**********************************
   APPRO:AS   1041.37    0.47 1034.01 1059.72  0.40  0.87  0.84 1045.60 1044.75
```

```
        U.S. Geological Survey WSPRO Input File bloo096.wsp
        Hydraulic analysis for structure BLOOVT01050096   Date: 17-APR-96
        Bloomfield br 96, Vt Rte 102 crossing Nulhegan R.            JDA
           *** RUN DATE & TIME: 08-14-96  09:19

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

EXITX:XS   ******   -19.     730.  1.85 ***** 1043.13 1040.41   7000. 1041.28
      -96. ******   117.   56407.  1.29 ***** *******    0.83    9.59

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.83    1042.78    1041.89

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =  1040.78    1071.73    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =  1040.78    1071.73    1041.89

FULLV:FV      96.   -19.     731.  1.84  1.48 1044.61 1041.89   7000. 1042.77
        0.    96.   118.   56528.  1.29  0.00    0.01    0.83    9.58
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS     113.   -17.     629.  1.92  1.30 1045.97 *******   7000. 1044.04
      113.   113.    70.   75191.  1.00  0.04    0.01    0.73   11.12
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    7000.    1042.75

            <<<<<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      96.     0.     455.  3.68 ***** 1046.43 1042.75   7000. 1042.75
        0.    96.    68.   58056.  1.00 ***** *******    1.00   15.39

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ****** 1046.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      22.        <<<<<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      55.   -51.     882.  0.99  0.40 1047.68 1042.60   7000. 1046.69
      113.    56.    81.  118047.  1.01  0.85    0.01    0.55    7.94

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.223  0.000  121074.    -6.    62.  1046.44

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

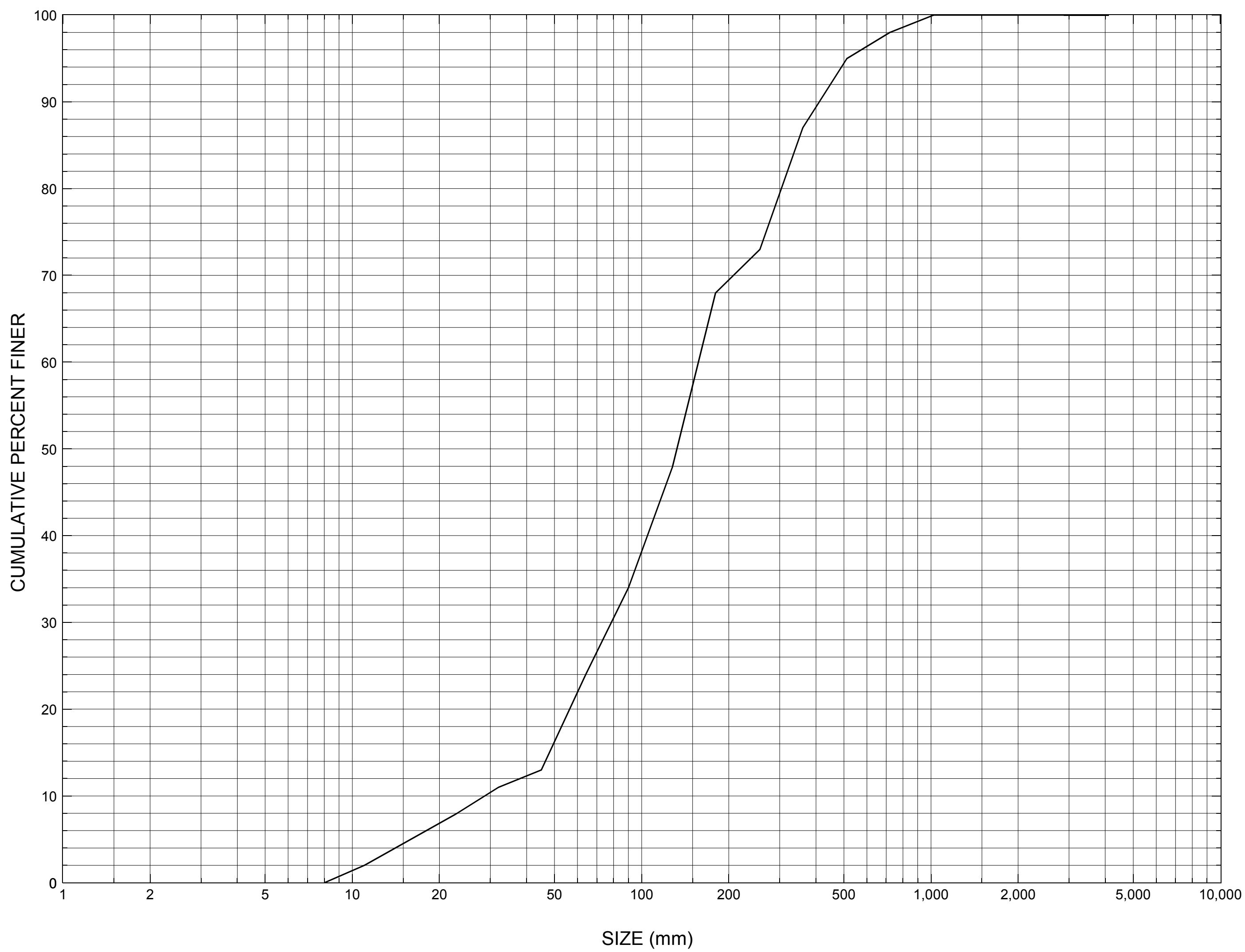
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -96.   -19.   117.   7000.   56407.     730.    9.59 1041.28
   FULLV:FV       0.   -19.   118.   7000.   56528.     731.    9.58 1042.77
   BRIDG:BR       0.     0.    68.   7000.   58056.     455.   15.39 1042.75
   RDWAY:RG      22.**************      0.*****************    1.00********
   APPRO:AS     113.   -51.    81.   7000.  118047.     882.    7.94 1046.69
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    62.  121074.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS   1040.41    0.83 1031.39 1070.25************  1.85 1043.13 1041.28
   FULLV:FV   1041.89    0.83 1032.87 1071.73  1.48  0.00  1.84 1044.61 1042.77
   BRIDG:BR   1042.75    1.00 1034.03 1046.31************  3.68 1046.43 1042.75
   RDWAY:RG   *************** 1050.74 1061.59**********************************
   APPRO:AS   1042.60    0.55 1034.01 1059.72  0.40  0.85  0.99 1047.68 1046.69
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count transect at the approach cross-section for structure BLOOVT01050096, in Bloomfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BLOOVT01050096

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 05 / 94

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 06325

Mile marker *(I - 11; nnn.nnn)* 000750

Waterway *(I - 6)* NULHEGAN RIVER

Road Name *(I - 7)*: -

Route Number VT105

Vicinity *(I - 9)* 3.4 MI W JCT. VT.102

Topographic Map Bloomfield

Hydrologic Unit Code: 01080101

Latitude *(I - 16; nnnn.n)* 44468

Longitude *(i - 17; nnnnn.n)* 71406

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20003400960503

Maintenance responsibility *(I - 21; nn)* 01

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

Year built *(I - 27; YYYY)* 1992

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

Average daily traffic, ADT *(I - 29; nnnnnn)* 001340

Deck Width *(I - 52; nn.n)* 426

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

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

Opening skew to Roadway *(I - 34; nn)* 24

Waterway adequacy *(I - 71; n)* 7

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*) 060.0

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*) 716.0

Comments:

Structural inspection report of 10/19/93 indicates the bridge is a steel stringer type. The abutments and wingwalls are in "like new" condition with footings not exposed and no settlement apparent. Additionally, there were no problems indicated for channel scour or embankment erosion.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 103.0

Terrain character: Hilly

Stream character & type: Straight

Streambed material: Cobbles and boulders

Discharge Data *(cfs)*: $Q_{2.33}$ 600 Q_{10} 1700 Q_{25} 2300

Q_{50} 2800 Q_{100} 3250 Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 50 *(ft/s)*: 8.4

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

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: -

Watershed storage area (*in percent*): 18.3 %

The watershed storage area is: 2 (*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*)	1038.0	1040.3	1041.1	1041.8	1042.3
Velocity (*ft / sec*)	5.0	6.9	7.7	8.4	8.9

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: - Year Built: -

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

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

Downstream distance (*miles*): **3.4** Town: **Bloomfield** Year Built: **-**

Highway No. : **VT102** Structure No. : **9** Structure Type: **-**

Clear span (*ft*): **128** Clear Height (*ft*): **10.0** Full Waterway (ft^2): **-**

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **103.2** mi^2 Lake and pond area **7.65** mi^2

Watershed storage *(ST)* **7.4** %

Bridge site elevation **1051** ft Headwater elevation **2948** ft

Main channel length **17.60** mi

10% channel length elevation **1070** ft 85% channel length elevation **1300** ft

Main channel slope *(S)* **17.43** 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)*: 06 / 1990

Project Number BRF 034 - 3(13) S Minimum channel bed elevation: 1033.0

Low superstructure elevation: USLAB 1046.31 DSLAB 1046.55 USRAB 1045.63 DSRAB 1045.74

Benchmark location description:

BM#1, pole, NET&T no. 180/679/82, elevation 1050.89, 125 feet from rabut on left side of roadway going away from the bridge.

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 - Footing bottom elevation: 1030.0

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? N *If no, type ctrl-n bi* Number of borings taken: _____

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

-

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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: **NO CROSS SECTION INFORMATION**

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: **TS** Date: **10-26-95**
Computerized by: **TS** Date: **10-27-95**
Reviewd by: **JDA** Date: **6-26-96**

Structure Number **BLOOVT01050096**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M. IVANOFF** Date *(MM/DD/YY)* **07** / **06** / 19**95**
2. Highway District Number **09** Mile marker **000750**
   County **Essex (009)** Town **Bloomfield**
   Waterway *(I - 6)* **Nulhegan River** Road Name **VT 105**
   Route Number **VT 105** Hydrologic Unit Code: **01080101**
3. Descriptive comments:

Bridge is located 3.4 miles west of junction with VT 102

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **5** 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 **1** 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 **74** *(feet)* Span length **71** *(feet)* Bridge width **42.6** *(feet)*

Road approach to bridge:

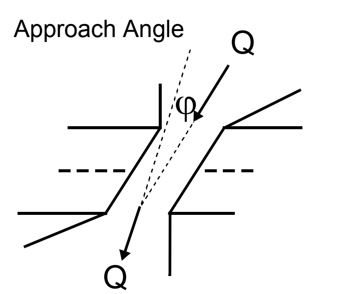
8. LB **2** RB **0** *(**0** even, **1**- lower, **2**- higher)*
9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
    US left **0.0:1** US right **0.0:1**

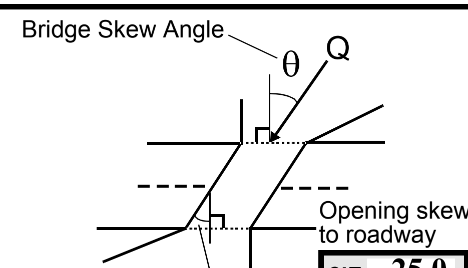
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	1	1	0	-
LBDS	2	1	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **40** 16. Bridge skew: **10**





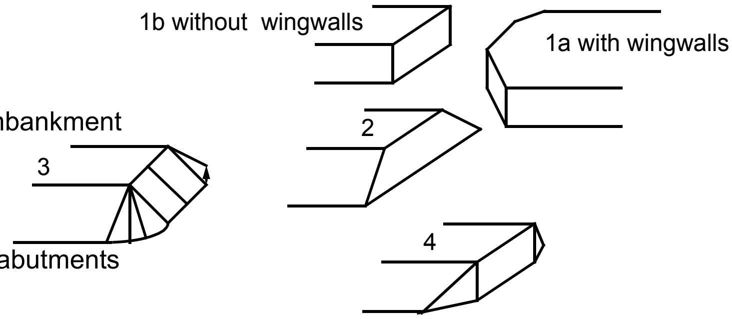
α= **25.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
    Where? **RB** *(LB, RB)* Severity **2**
    Range? **80** feet **US** *(US, UB, DS)* to **150** feet **US**

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

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

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



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- gravel road runs along top of bank
RBUS- gravel parking area above bank in vicinity of bridge

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
78.7	**6.0**			**5.0**	**2**	**1**	**1 2**	**1 2**	**0**	**3**

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **82.0** 29. Bed Material **2 1**

30 .Bank protection type: LB **2** RB **2** 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. Channel bed is cobble from the bridge to 75 feet US.
30. Left bank protection extends from bridge deck to 125 feet US. Right bank protection extends from bridge deck to 75 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **210** 35. Mid-bar width: **50**

36. Point bar extent: **150** feet **US** (US, UB) to **300** feet **US** (US, UB, DS) positioned **0** %LB to **40** %RB

37. Material: **2**

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

Point bar composed of sand.

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

41. Mid-bank distance: **250** 42. Cut bank extent: **80** feet **US** (US, UB) to **>400** feet **DS** (US, UB, DS)

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

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

Cut bank is opposite of point bar.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **125**

47. Scour dimensions: Length **150** Width **40** Depth : **4** Position **15** %LB to **25** %RB

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

Channel scour starts at channel center, 50 feet US of bridge, and continues some 200 feet US of bridge along base of stone fill on left bank.

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
65.0		2.0		2	7	7	-

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

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

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

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

4 5 3

NO COMMENTS

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

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

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

70. Debris and Ice Comments:

2

67. Debris noted along US right bank, also mentioned in historical form.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**0**	**0**	**0**	**90.0**
RABUT	**1**	**0**	**90**			**2**	**0**	**75.0**

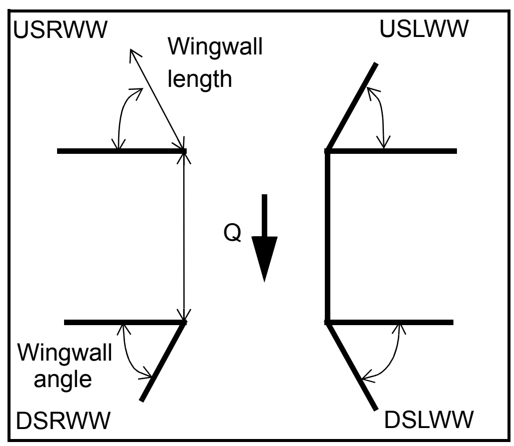
Pushed: LB or RB   *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: ***1***- Concrete; ***2***- Stone masonry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

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

0
0
1
NO COMMENTS

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**75.0**	
USRWW:	**Y**		**1**		**0**	**1.5**	
DSLWW:	**0**		**0**		**Y**	**49.5**	
DSRWW:	**1**		**0**		**0**	**52.5**	



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

82. Bank / Bridge Protection:

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

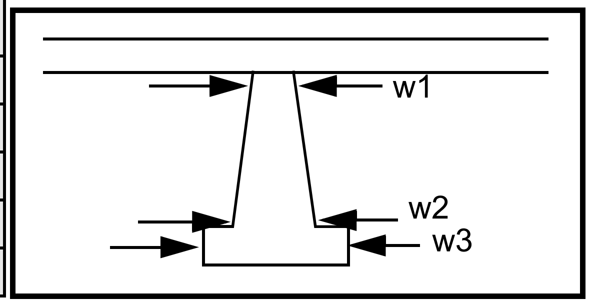
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? **NO** *(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				**45.0**	**12.5**	**20.0**
Pier 2		**5.0**		**18.0**	**39.5**	**40.0**
Pier 3		**-**	**-**	**13.0**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



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

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

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - Bed Material PIE

Bank protection type (Qmax): LB RS 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.):

4
4
4 3 1
5 4
1
0
5 4 3
2
2

101. Is a drop structure present? **1** *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

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

Bank protection consists of stone fill. Left bank protection extends 80 feet downstream, while right bank protection extends 50 feet downstream. Beyond protection banks are lined with native stone and boulder. Left bank is eroded DS of protection, a description follows in "cut-bank" section.

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

Point bar extent: ______ feet ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned ____ %LB to _____ %RB

Material: **N**

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

-

NO DROP STRUCTURE

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

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

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

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

-
-
-
-

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

Scour dimensions: Length **POI** Width **NT** Depth: **BA** Positioned **RS** %LB to ____ %RB

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

Y

LB

Are there major confluences? **12** *(Y or if N type ctrl-n mc)* How many? **0**

Confluence 1: Distance **90** Enters on **DS** *(LB or RB)* Type **150** (***1***- *perennial;* ***2***- *ephemeral)*

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

Confluence comments (eg. confluence name):

domly placed boulder and stone along base of cut-bank, boulder/stone density increases beyond 150 feet DS.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N
-

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: BLOOVT01050096 Town: Bloomfield
Road Number: VT 105 County: Essex
Stream: Nulhegan R.

Initials JDA Date: 4/30/96 Checked: EMB 5/2/96

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	5100	7000	0
Main Channel Area, ft2	692	875	0
Left overbank area, ft2	0	7	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	89	101	0
Top width L overbank, ft	0	31	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.43451	0.43451	0
D50 left overbank, ft	--	--	0
D50 right overbank, ft	--	--	0
y1, average depth, MC, ft	7.8	8.7	ERR
y1, average depth, LOB, ft	ERR	0.2	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	86664	118072	0
Conveyance, main channel	86664	117997	0
Conveyance, LOB	0	75	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	5100.0	6995.6	ERR
Ql, discharge, LOB, cfs	0.0	4.4	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	7.4	8.0	ERR
Vl, mean velocity, LOB, ft/s	ERR	0.6	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	12.0	12.2	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	N/A
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	N/A

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	692	875	0
Main channel width, ft	89	101	0
y1, main channel depth, ft	7.78	8.66	ERR
Bridge Section			
(Q) total discharge, cfs	5100	7000	0
(Q) discharge thru bridge, cfs	5100	7000	
Main channel conveyance	41828	58037	
Total conveyance	41828	58037	
Q2, bridge MC discharge,cfs	5100	7000	ERR
Main channel area, ft2	368	455	0
Main channel width (skewed), ft	61.7	61.8	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	61.7	61.8	0
y_bridge (avg. depth at br.), ft	5.96	7.36	ERR
Dm, median (1.25*D50), ft	0.543138	0.543138	0
y2, depth in contraction,ft	6.48	8.49	ERR
ys, scour depth (y2-ybridge), ft	0.52	1.13	N/A

ARMORING			
D90	1.347877	1.347877	
D95	1.67979	1.67979	
Critical grain size,Dc, ft	1.2166	1.3529	ERR
Decimal-percent coarser than Dc	0.123	0.0992	
Depth to armoring,ft	26.02	36.86	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)

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	5100	7000	0	5100	7000	0
a', abut.length blocking flow, ft	18.3	51.3	0	9.4	19.3	0
Ae, area of blocked flow ft2	89.5	132.7	0	41.4	73.4	0
Qe, discharge blocked abut.,cfs	460.0	771.6	0	190.2	307.1	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	5.14	5.81	ERR	4.59	4.18	ERR
ya, depth of f/p flow, ft	4.89	2.59	ERR	4.40	3.80	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0	0.82	0.82	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	115	115	0	65	65	0
K2	1.03	1.03	0.00	0.96	0.96	0.00
Fr, froude number f/p flow	0.410	0.637	ERR	0.386	0.378	ERR
ys, scour depth, ft	14.51	16.23	N/A	10.49	11.34	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)	18.3	51.3	0	9.4	19.3	0
y1 (depth f/p flow, ft)	4.89	2.59	ERR	4.40	3.80	ERR
a'/y1	3.74	19.83	ERR	2.13	5.07	ERR
Skew correction	1.1	1.1		0.9	0.9	
Froude no. f/p flow	0.41	0.64	N/A	0.39	0.38	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	1.0	1.0		1.0	1.0	
(Fr from the characteristic V and y in contracted section--mc, bridge section)						

y, depth of flow in bridge, ft	6.0	7.4		6.0	7.4	
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0
Fr>0.8 (vertical abut.)	2.51	3.09	ERR	2.51	3.09	ERR