LEVEL II SCOUR ANALYSIS FOR BRIDGE 36 (RICHVT01050036) on STATE ROUTE 105, crossing STANHOPE BROOK, RICHFORD, VERMONT

U.S. Geological Survey
Open-File Report 96-584

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

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By Erick M. Boehmler 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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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 36 (RICHVT01050036) ON STATE ROUTE 105, CROSSING STANHOPE BROOK, RICHFORD, VERMONT

By **Erick M. Boehmler 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 RICHVT01050036 on State Route 105 crossing Stanhope Brook, Richford, 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 Green Mountain section of the New England physiographic province in north-central Vermont. The 7.03-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is short grass except for the upstream left overbank area which is forested.

In the study area, Stanhope Brook has a steep, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 47 ft and an average channel depth of 5 ft. The predominant channel bed material is cobble with a median grain size (D_{50}) of 132 mm (0.432 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 28, 1995, indicated that the reach was laterally unstable.

The State Route 105 crossing of Stanhope Brook is a 42-ft-long, two-lane bridge consisting of one 38-foot concrete T-beam span (Vermont Agency of Transportation, written communication, March 8, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 20 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed along the downstream end of the right abutment wall during the Level I assessment. The scour protection measures at this site were type-2 stone fill (less than 36 inches diameter) along the entire lengths of the upstream wingwalls, at the corner of the downstream left abutment and downstream left wingwall and the downstream end of the downstream right wingwall. 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 0.0 to 0.3 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.6 to 9.4 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number RICHVT01050036 **Stream** Stanhope Brook

County Franklin **Road** VT 105 **District** 8

Description of Bridge

Bridge length 42 ***ft*** ***Bridge width*** 39.9 ***ft*** ***Max span length*** 38 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 6/28/95

Description of stone fill Type-2 on the entire length of the upstream wingwalls, at the corner of the downstream end of the left abutment and the downstream left wingwall, and at the downstream end of the downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a one half foot deep scour hole along the downstream end of the right abutment.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***Angle*** 15

There is a mild channel bend through the bridge. A scour hole has developed in the location where the bend impacts the downstream end of the right abutment.

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	6/28/95	0	0
Level II	6/28/95	0	0

Potential for debris High. There was a landslide noted on the left bank upstream, which is likely to contribute debris during flood events.

Describe any features near or at the bridge that may affect flow (include observation date) Field notes taken on 6/28/95.indicate there is a pile of boulders at the upstream end of the right abutment, which may contribute to eddy development immediately downstream of the pile where the remnant scour is evident.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with flat to slightly irregular flood plains and steep valley walls on both sides.

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

Date of inspection 6/28/95

DS left: Steep channel bank to a narrow flood plain and VT 105 road embankment.

DS right: Steep channel bank to flood plain and VT 105 road embankment.

US left: Moderately sloping channel bank to valley wall.

US right: Moderately sloping channel bank to flood plain.

Description of the Channel

Average top width 47 ft ***Average depth*** 5 ft

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

Perennial and sinuous with semi-alluvial channel boundaries.

6/28/95

Vegetative co Trees with pasture on the flood plain.

DS left: Trees with a grass lawn and a house on the flood plain.

DS right: Brush and trees.

US left: A few trees with a lawn and a house on the flood plain.

US right: N

Do banks appear stable? On 6/28/95 there was a landslide feature noted on the upstream left bank.

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

The assessment of 6/28/95 noted flow is influenced by a pile of boulders at the upstream end of the right abutment.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 7.03 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: -

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p - No

Calculated Discharges

Q100 1,950 ***ft³/s*** ***Q500*** 2,620 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957; Talbot, 1887) and those published in the flood insurance study for the town of Richford at the mouth of Stanhope Brook (FEMA, 1980). Due to the central tendency of the curve from the flood insurance study values to the others, the 100- and 500-year discharges from the flood insurance study were selected for this analysis.

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) VTAOT plans

Datum tie between USGS survey and VTAOT plans The average accuracy of the datum tie is approximately 0.6 feet.

Description of reference marks used to determine USGS datum. RM1 is a National Geodetic Survey brass tablet marked “Y49, 1978” on top of the concrete right abutment, downstream end (elev. 142.74 feet, VTAOT plans’ datum). RM2 is the center point of a chiseled “X” at the upstream end of the left abutment (elev. 144.85 ft, VTAOT plans’ datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-37	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	82	2	Modelled Approach section (Templated from APTEM)
APTEM	87	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 0.050 to 0.055, and overbank "n" values ranged from 0.035 to 0.070.

The slope-conveyance method, outlined in the user's manual for WSPRO (Shearman, 1990), was used to compute a starting water surface. The slope used was 0.033 ft/ft, which was estimated from the 100-year discharge water surface downstream of this site graphically displayed in the Flood Insurance Study for the town of Richford (FEMA, 1980, exhibit 1, panel 13p). However, for the 100- and 500-year discharges, WSPRO assumes critical depth at the exit section for the starting water surface. Analysis of the supercritical and subcritical profiles for the exit section at each discharge indicates that the slope used is a supercritical slope. Since the supercritical solution was close to critical depth, the starting water surface at critical depth was assumed to be a satisfactory solution.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0397 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 method also provides a consistent approach for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 144.8 *ft*
Average low steel elevation 139.9 *ft*

100-year discharge 1,950 *ft³/s*
Water-surface elevation in bridge opening 135.7 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 187 *ft²*
Average velocity in bridge opening 10.4 *ft/s*
Maximum WSPRO tube velocity at bridge 13.5 *ft/s*

Water-surface elevation at Approach section with bridge 137.5
Water-surface elevation at Approach section without bridge 137.4
Amount of backwater caused by bridge 0.1 *ft*

500-year discharge 2,620 *ft³/s*
Water-surface elevation in bridge opening 136.0 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 199 *ft²*
Average velocity in bridge opening 13.2 *ft/s*
Maximum WSPRO tube velocity at bridge 16.9 *ft/s*

Water-surface elevation at Approach section with bridge 139.7
Water-surface elevation at Approach section without bridge 138.4
Amount of backwater caused by bridge 1.3

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). Laursen's live-bed scour equation (Richardson and others, 1995, p. 30, equation 17) was also computed for the 100-year modelled discharge and can be found in appendix F. 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.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	0.0	--	--
Clear-water scour	0.0	0.3	--
Depth to armoring	4.8	26.3	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	6.6	8.8	--
Right abutment	6.7	9.4	--
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	2.0	2.3	--
Right abutment	2.0	2.3	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

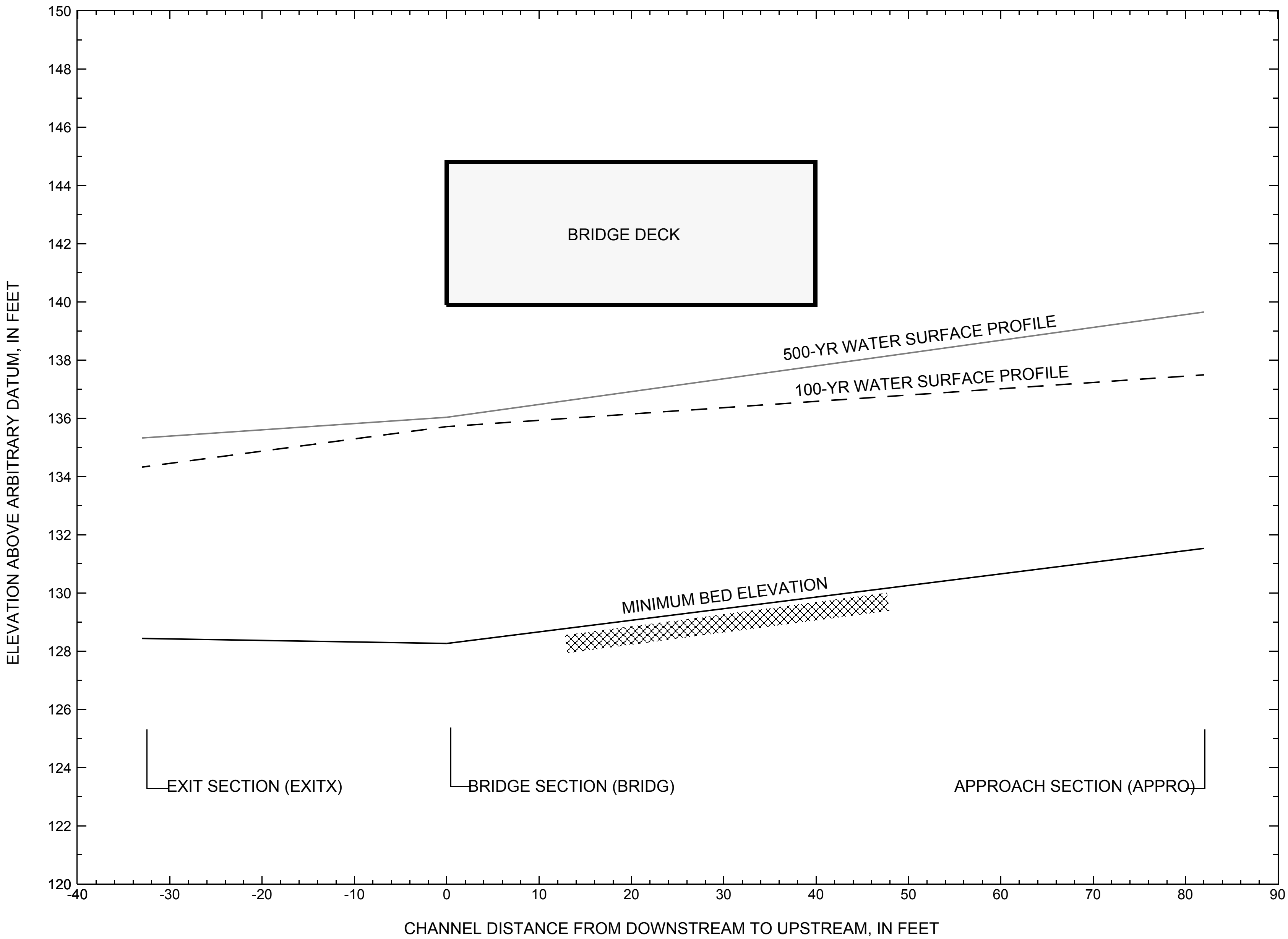

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure RICHVT01050036 on State Route 105, crossing Stanhope Brook, Richford, Vermont.

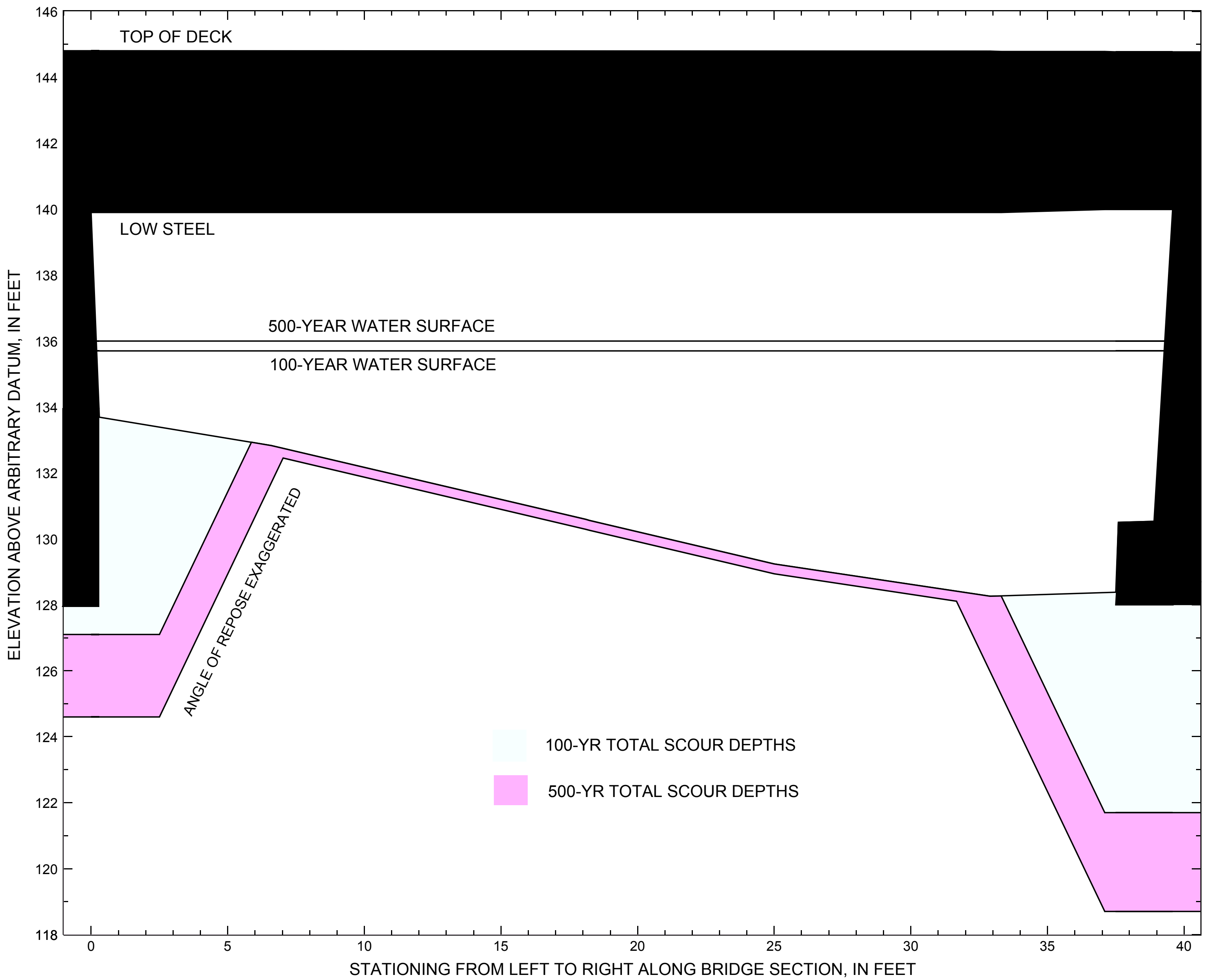

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure RICHVT01050036 on State Route 105, crossing Stanhope Brook, Richford, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure RICHVT01050036 on State Route 105, crossing Stanhope Brook, Richford, 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 1,950 cubic-feet per second											
Left abutment	0.0	140.8	139.8	128	133.7	0.0	6.6	--	6.6	127.1	-1
Right abutment	38.9	140.6	140.0	128	128.4	0.0	6.7	--	6.7	121.7	-6

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 RICHVT01050036 on State Route 105, crossing Stanhope Brook, Richford, 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 2,620 cubic-feet per second											
Left abutment	0.0	140.8	139.8	128	133.7	0.3	8.8	--	9.1	124.6	-3
Right abutment	38.9	140.6	140.0	128	128.4	0.3	9.4	--	9.7	118.7	-9

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

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U.S. Geological Survey, 1986, Jay Peak, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photography, 1980; Contour interval, 6 meters; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File rich036.wsp
T2        Hydraulic analysis for structure RICHVT01050036   Date: 11-SEP-96
T3        State Route 105 Crossing Stanhope Brook, Richford, VT              EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1950.0   2620.0
SK          0.0330   0.0330
*
XS   EXITX    -33
GR          -76.8, 140.95    -56.6, 136.99    -22.8, 136.56    -11.9, 138.24
GR           -8.2, 134.31      0.0, 128.54     10.1, 128.43     17.1, 128.86
GR           23.0, 130.23     36.0, 136.72     47.9, 136.24     64.6, 137.33
GR           81.9, 141.78
*
N           0.045        0.055        0.035
SA                 -11.9         36.0
*
XS   FULLV      0  * * *   0.0164
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    139.91      20.0
GR            0.0, 139.83      0.3, 133.69      6.6, 132.83     25.0, 129.24
GR           32.9, 128.26     37.5, 128.38     37.6, 129.26     37.6, 130.50
GR           38.9, 130.53     39.6, 140.00      0.0, 139.83
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      54.2 * *     51       7.0
N           0.050
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     23      39.9     1
GR          -61.6, 144.31     -1.7, 144.80     -1.5, 145.75      0.0, 145.77
GR           39.9, 145.69     40.2, 145.63     40.2, 144.77    239.5, 144.88
GR          325.8, 145.99
*
XT   APTEM     87
GR          -44.3, 145.36    -23.0, 144.17    -13.2, 142.84     -4.4, 137.03
GR            8.0, 133.56      9.3, 132.26     17.1, 131.73     24.9, 132.08
GR           31.3, 133.08     47.5, 138.56    110.3, 141.84    221.8, 143.37
*
AS   APPRO     82   *  *  *  0.0398
GT
N           0.070       0.055        0.035
SA               -4.4           47.5
BP          0.0
*
HP 1 BRIDG  135.71 1 135.71
HP 2 BRIDG  135.71 * * 1950
HP 1 APPRO  137.49 1 137.49
HP 2 APPRO  137.49 * * 1950
*
HP 1 BRIDG  136.03 1 136.03
HP 2 BRIDG  136.03 * * 2620
HP 1 APPRO  139.65 1 139.65
HP 2 APPRO  139.65 * * 2620
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File rich036.wsp
       Hydraulic analysis for structure RICHVT01050036   Date: 11-SEP-96
       State Route 105 Crossing Stanhope Brook, Richford, VT              EMB
          *** RUN DATE & TIME: 09-24-96  07:56

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      187     14187     37     46                          2394
  135.71           187     14187     37     46  1.00      0     39     2394

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      135.71     0.2    39.3   187.0   14187.    1950.  10.43

X STA.         0.2        7.1       11.0       13.8       16.2       18.1
  A(I)            16.0       12.3       10.7        9.9        9.2
  V(I)            6.08       7.95       9.11       9.86      10.64

X STA.        18.1       19.9       21.5       22.9       24.3       25.5
  A(I)             8.8        8.4        8.1        7.8        7.6
  V(I)           11.12      11.65      12.06      12.54      12.84

X STA.        25.5       26.7       27.9       29.0       30.1       31.2
  A(I)             7.5        7.4        7.2        7.4        7.5
  V(I)           13.03      13.15      13.45      13.22      12.94

X STA.        31.2       32.4       33.5       34.8       36.2       39.3
  A(I)             7.7        7.8        8.8        9.8       17.1
  V(I)           12.63      12.46      11.09       9.94       5.69

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1        0         3      1      1                             1
            2      190     12286     49     51                          2108
  137.49           190     12289     50     52  1.00     -4     45     2090

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

        WSEL     LEW     REW    AREA        K        Q    VEL
      137.49    -5.4    44.9   189.9   12289.    1950.  10.27

X STA.        -5.4        4.1        7.4        9.7       11.2       12.7
  A(I)            16.0       11.7       10.5        8.8        8.2
  V(I)            6.11       8.34       9.29      11.13      11.93

X STA.        12.7       14.1       15.5       16.8       18.1       19.3
  A(I)             8.0        7.8        7.7        7.7        7.6
  V(I)           12.18      12.43      12.65      12.70      12.81

X STA.        19.3       20.6       22.0       23.4       24.8       26.3
  A(I)             7.5        7.7        7.9        8.0        8.2
  V(I)           12.93      12.66      12.40      12.16      11.91

X STA.        26.3       27.9       29.7       31.9       34.8       44.9
  A(I)             8.6        9.1       10.1       11.6       17.2
  V(I)           11.31      10.70       9.69       8.40       5.66
```

```
        U.S. Geological Survey WSPRO Input File rich036.wsp
        Hydraulic analysis for structure RICHVT01050036   Date: 11-SEP-96
        State Route 105 Crossing Stanhope Brook, Richford, VT              EMB
           *** RUN DATE & TIME: 09-24-96  07:56

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      199     15561     37     47                         2622
   136.03           199     15561     37     47  1.00      0     39     2622

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       136.03     0.2    39.3   198.7   15561.    2620.  13.18

X STA.         0.2        6.8       10.6       13.3       15.7       17.7
  A(I)            17.2       12.7       10.9       10.6        9.8
  V(I)            7.60      10.35      11.97      12.41      13.42

X STA.        17.7       19.5       21.1       22.6       23.9       25.2
  A(I)             9.2        8.9        8.6        8.3        8.1
  V(I)           14.29      14.68      15.20      15.82      16.20

X STA.        25.2       26.4       27.6       28.8       29.9       31.1
  A(I)             8.0        7.9        7.7        7.9        8.0
  V(I)           16.39      16.55      16.93      16.64      16.29

X STA.        31.1       32.2       33.4       34.7       36.1       39.3
  A(I)             8.2        8.4        9.4       10.5       18.5
  V(I)           15.91      15.69      13.93      12.49       7.10

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        6       143      4      5                           41
             2      301     25590     52     54                         4103
             3       16       505     25     25                           72
   139.65           322     26238     81     84  1.07     -8     72     3530

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      82.

         WSEL     LEW     REW    AREA        K        Q    VEL
       139.65    -8.7    72.2   322.4   26238.    2620.   8.13

X STA.        -8.7        1.0        4.7        7.5        9.8       11.5
  A(I)            25.1       18.0       16.2       15.8       13.6
  V(I)            5.21       7.27       8.11       8.31       9.60

X STA.        11.5       13.3       14.9       16.5       18.1       19.7
  A(I)            13.3       13.1       12.8       12.8       12.7
  V(I)            9.82      10.03      10.23      10.26      10.33

X STA.        19.7       21.3       22.9       24.6       26.4       28.3
  A(I)            13.0       12.8       13.3       13.8       14.0
  V(I)           10.11      10.20       9.83       9.52       9.38

X STA.        28.3       30.4       32.7       35.8       40.4       72.2
  A(I)            14.8       15.6       17.8       20.2       33.7
  V(I)            8.83       8.38       7.34       6.47       3.89
```

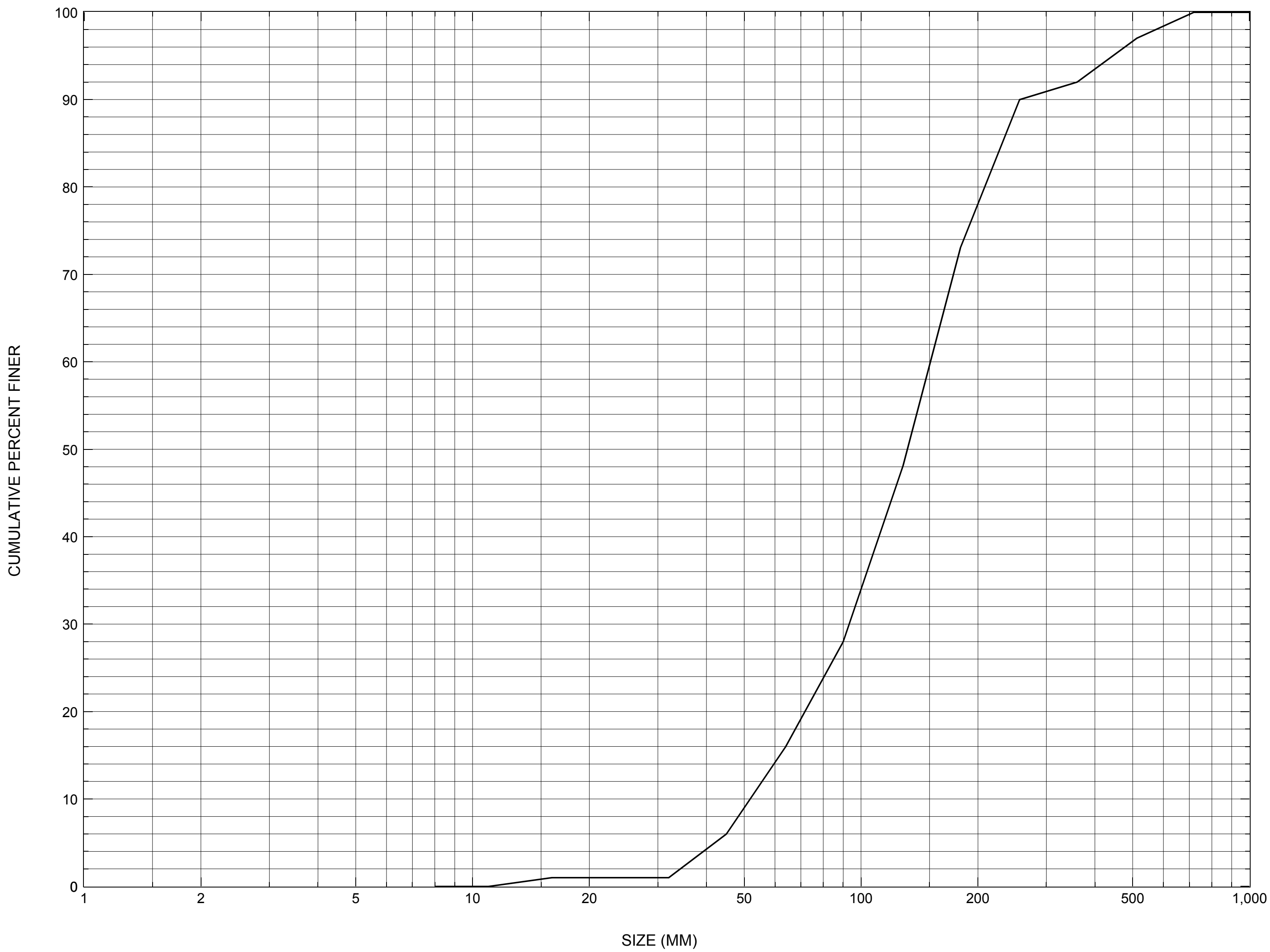
```
+++ BEGINNING PROFILE CALCULATIONS --   2
        U.S. Geological Survey WSPRO Input File rich036.wsp
        Hydraulic analysis for structure RICHVT01050036   Date: 11-SEP-96
        State Route 105 Crossing Stanhope Brook, Richford, VT              EMB
           *** RUN DATE & TIME: 09-24-96  07:56

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                            WSI,CRWS =   134.16     134.32

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

EXITX:XS   ******     -7      167  2.12 *****  136.43  134.32    1950  134.32
       -32 ******     31    11315  1.00 ***** *******    1.00   11.66

FULLV:FV       33     -8      203  1.44  0.75  137.17 *******    1950  135.73
         0     33     33    14853  1.00  0.00   -0.01    0.77    9.63
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.98     137.37     137.28

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   135.23     145.16    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =   135.23     145.16     137.28

APPRO:AS       82     -4      184  1.75  1.79  139.12  137.28    1950  137.37
        82     82     45    11705  1.00  0.16    0.00    0.97   10.61
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR       33      0      187  1.69  0.94  137.40  135.06    1950  135.71
         0     33     39    14200  1.00  0.02   -0.01    0.81   10.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  139.91 ****** ****** ******

    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       28     -4      190  1.64  0.74  139.14  137.28    1950  137.49
        82     28     45    12292  1.00  1.01    0.02    0.93   10.27

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.215  0.034   11801.    -6.    33.   136.42

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD     LEW     REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -33.     -8.     31.   1950.   11315.     167.   11.66  134.32
   FULLV:FV       0.     -9.     33.   1950.   14853.     203.    9.63  135.73
   BRIDG:BR       0.      0.     39.   1950.   14200.     187.   10.42  135.71
   RDWAY:RG      23.**************       0.*****************    1.00********
   APPRO:AS      82.     -5.     45.   1950.   12292.     190.   10.27  137.49

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    33.   11801.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO  VHD      EGL    WSEL
   EXITX:XS    134.32    1.00  128.43  141.78************  2.12  136.43  134.32
   FULLV:FV  ********    0.77  128.97  142.32  0.75  0.00  1.44  137.17  135.73
   BRIDG:BR    135.06    0.81  128.26  140.00  0.94  0.02  1.69  137.40  135.71
   RDWAY:RG ****************  144.31  145.99**********************************
   APPRO:AS    137.28    0.93  131.53  145.16  0.74  1.01  1.64  139.14  137.49
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File rich036.wsp
        Hydraulic analysis for structure RICHVT01050036   Date: 11-SEP-96
        State Route 105 Crossing Stanhope Brook, Richford, VT              EMB
           *** RUN DATE & TIME: 09-24-96  07:56

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   135.09     135.32

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

EXITX:XS   ******     -8      208  2.46 *****  137.78  135.32    2620  135.32
       -32 ******     33    15450  1.00 ***** *******    1.00   12.58

FULLV:FV       33     -9      250  1.70  0.73  138.53 *******    2620  136.82
         0     33     49    19987  1.00  0.00    0.01    0.80   10.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.94     138.38     138.15

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   136.32     145.16    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   136.32     145.16     138.15

APPRO:AS       82     -6      236  1.94  1.67  140.31  138.15    2620  138.37
        82     82     48    16881  1.01  0.12   -0.01    0.95   11.12
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR       33      0      199  2.70  0.94  138.73  136.02    2620  136.03
         0     33     39    15567  1.00  0.01    0.00    1.00   13.18

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  139.91 ****** ****** ******

    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       28     -8      322  1.10  0.50  140.75  138.15    2620  139.65
        82     29     72    26224  1.07  1.53    0.02    0.74    8.13

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.278  0.105   23359.    -5.    34.   139.22

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33.    -9.    33.   2620.   15450.     208.   12.58  135.32
   FULLV:FV       0.   -10.    49.   2620.   19987.     250.   10.47  136.82
   BRIDG:BR       0.     0.    39.   2620.   15567.     199.   13.18  136.03
   RDWAY:RG      23.**************      0.******************     1.00********
   APPRO:AS      82.    -9.    72.   2620.   26224.     322.    8.13  139.65

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -5.    34.   23359.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    135.32    1.00  128.43  141.78************  2.46  137.78  135.32
   FULLV:FV  ********    0.80  128.97  142.32  0.73  0.00  1.70  138.53  136.82
   BRIDG:BR    136.02    1.00  128.26  140.00  0.94  0.01  2.70  138.73  136.03
   RDWAY:RG ****************  144.31  145.99**********************************
   APPRO:AS    138.15    0.74  131.53  145.16  0.50  1.53  1.10  140.75  139.65
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect in the channel approach of structure RICHVT01050036, in Richford, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number RICHVT01050036

General Location Descriptive

Data collected by *(First Initial, Full last name)* L. MEDALIE

Date *(MM/DD/YY)* 03 / 08 / 95

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 011

Town *(FIPS place code; I - 4; nnnnn)* 59125

Mile marker *(I - 11; nnn.nnn)* 005360

Waterway *(I - 6)* STANHOPE BROOK

Road Name *(I - 7)*: -

Route Number VT105

Vicinity *(I - 9)* 0.1 MI W JCT. VT.105A E

Topographic Map Jay Peak

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44597

Longitude *(i - 17; nnnnn.n)* 72368

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20003400360611

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

Maximum span length *(I - 48; nnnn)* 0038

Year built *(I - 27; YYYY)* 1930

Structure length *(I - 49; nnnnnn)* 000042

Average daily traffic, ADT *(I - 29; nnnnnn)* 001030

Deck Width *(I - 52; nn.n)* 399

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

Channel & Protection *(I - 61; n)* 5

Opening skew to Roadway *(I - 34; nn)* 22

Waterway adequacy *(I - 71; n)* 5

Operational status *(I - 41; X)* A

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

Structure type *(I - 43; nnn)* 104

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 40.0

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

Vertical clearance from streambed (*nnn.n ft*) 010.5

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

Waterway of full opening (*nnn.n ft*^{2}) 420.0

Comments:

The structural inspection report of 7/26/93 indicates the structure is a concrete T-beam bridge. Both concrete abutment walls have minor vertical shrinkage cracks. The left abutment has some minor scaling along flow line. The concrete wingwalls are in good condition, but with minor shrinkage cracks. The waterway has a slightly skewed alignment through structure. The streambed consists of stone and boulders. There is some scour along right abutment, with no apparent undermining. The structure is in generally good condition. There has been no apparent settlement. Very minor bank erosion is reported. Stone fill is noted along both abutment wingwalls. **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: **Stone and boulders**

Discharge Data (*cfs*): $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

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

The watershed storage area is: - (*1-mainly at the headwaters; 2- uniformly distributed; 3-immediatly upstream oi the site*)

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	-	-	-	-
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (ft^3/sec): -

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

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

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

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

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

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

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

Comments:

Possibly up to 3 feet of channel scour has occurred along right abutment according to the report.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **7.03** mi^2 Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **499** ft Headwater elevation **3438** ft

Main channel length **5.7** mi

10% channel length elevation **584** ft 85% channel length elevation **1818** ft

Main channel slope *(S)* **288.65** 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):* - / 1930

Project Number F 034-2(1) Minimum channel bed elevation: 131.0

Low superstructure elevation: USLAB 143.03 DSLAB 140.82 USRAB 141.57 DSRAB 140.57

Benchmark location description:

B.M. #28, F.R.P. 20C, about 100 feet on the roadway right bankward from the right abutment and 20 feet from the roadway centerline downstream on the right overbank. The benchmark is also across VT105 from a driveway to a home, elevation 142.13

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

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 128.0

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:

Notes on plans show bridge was widened later in 1960; plans for widening do not exist. Other reference points: 1) end of the downstream left wingwall where the slope of the wingwall changes from slight to nearly vertical, elevation 138.00; 2) end of the upstream right wingwall where slope of the wingwall changes from slightly to nearly vertical, elevation 139.50; 3) top of the upstream right wingwall at the corner where it meets the right abutment wall on the stream side, elevation 144.85. Undated page size plan in folder shows 3 timber pilings placed within left abutment, about 21 feet long, bottom elevation of both abutments are 488.5; maybe from 1960s.

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: RB Date: 3/6/96
Computerized by: RB Date: 3/6/96
Reviewd by: ______ Date: ______

Structure Number RICHVT01050036

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. IVANOFF Date *(MM/DD/YY)* 6 / 28 / 1995

2. Highway District Number 8 Mile marker 005360

County FRANKLIN (011) Town RICHFORD (59125)

Waterway *(I - 6)* STANHOPE BROOK Road Name VT 105

Route Number VT 105 Hydrologic Unit Code: 02010007

3. Descriptive comments:
Located 0.1 mile west of the junction with VT 105 A East. June 1993 flash flood came up to high bank behind US right residence. Bridge project number F034-2(1), 1958.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 4 LBDS 5 RBDS 4 Overall 5
*(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 42 *(feet)* Span length 38 *(feet)* Bridge width 39.9 *(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)*

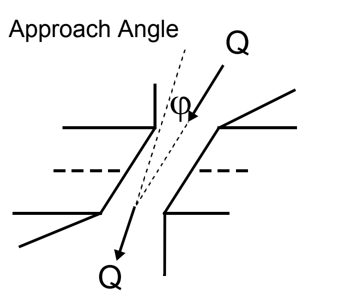
10. Embankment slope (*run / rise in feet / foot*):
US left 2.7:1 US right 2.4:1

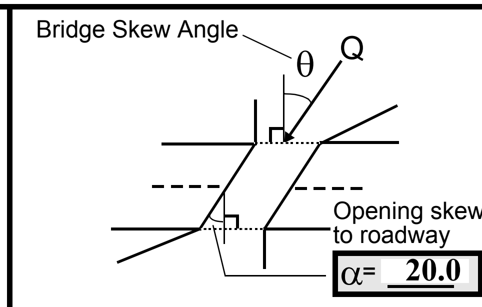
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	0	-
RBUS	2	1	0	-
RBDS	3	1	2	2
LBDS	0	0	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: 25 16. Bridge skew: 15





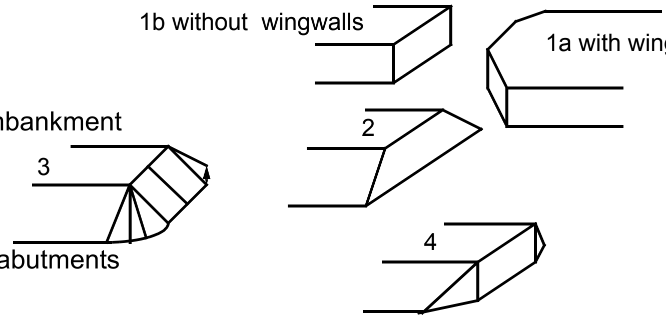
17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 10 feet UB *(US, UB, DS)* to 0 feet DS

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: **4/1a**

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. Houses are near the vicinity of the bridge except the forested US left bank.
7. Values are from the VT AOT files.
15. Angle of approach is from the center concrete pillar of the bridge rail. The US face of the bridge is curved.

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
40.5	**3.5**			**5.5**	**4**	**2**	**453**	**453**	**0**	**0**

23. Bank width **15.0**   24. Channel width **15.0**   25. Thalweg depth **49.5**   29. Bed Material **453**

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

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

Some stone fill extends 3 feet at the US wingwall ends and 10 feet from the DS right wingwall end.

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

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

37. Material: -

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

NO POINT BARS

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

41. Mid-bank distance: 130 42. Cut bank extent: 200 feet US (US, UB) to 90 feet US (US, UB, DS)

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

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

On the left bank there is mass wasting with trees uprooted and 5 feet depth of slippage plane where trees are still remaining on the slope. Another cut bank is 300 feet from the bridge on the right bank.

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

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

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

NO CHANNEL SCOUR

49. Are there major confluences? N (Y or if N type ctrl-n mc) 50. How many? -

51. Confluence 1: Distance - 52. Enters on - (LB or RB) 53. Type - (1- perennial; 2- ephemeral)

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES. There is a dry channel entering the left bank 250 feet from the bridge. This is a meander cut off type channel for higher flows.

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
23.5		0.5		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.):

453

-

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 N____ (1- Low; 2- Moderate; 3- High)

70. Debris and Ice Comments:

1

Debris potential is high as further slippage of the left bank is likely. See comments for the US cut bank. Resident commented on the ice buildup as slight but it would prevent visually seeing the water surface.

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	15	90			2	2	36.5

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

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

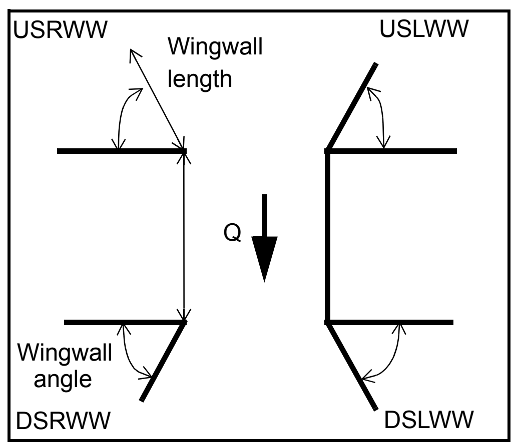
0.5
2
1

75. The right abutment scour depth is about 0.5 feet with an average thalweg depth of 0.5 feet. Maximum water depth below the bridge is 1 foot.

76. The top of the right abutment footing is exposed at the DS end to the DS right wingwall.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						36.5	
USRWW:	Y		1		0	1.0	
DSLWW:	-		-		Y	47.0	
DSRWW:	1		0		-	43.5	



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

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

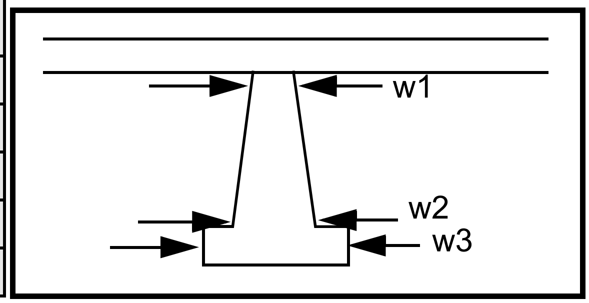
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
2
2
1
3

Piers:

84. Are there piers? **80.** *(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				**35.0**	**11.0**	**65.0**
Pier 2				**12.5**	**60.0**	**10.5**
Pier 3			**-**	**35.0**	**18.0**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**The**	**at**	**ner**	**tec-**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**top**	**the**	**with**	**tion**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**of**	**strea**	**the**	**con-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**the**	**m**	**abut**	**sists**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**DS**	**bed**	**ment**	**of a**	*Y- yes; N- no*
91. Attack ∠ (BF)	**right**	**level**	**.**	**pile**	
92. Pushed	**wing**	**and**	**82.**	**of**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**wall**	**only**	**The**	**large**	
95. Cross-members	**foot-**	**expo**	**right**	**, <48**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ing is**	**sed**	**abut**	**in.,**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**expo**	**at its**	**ment**	**boul-**	
98. Exposure depth	**sed**	**cor-**	**pro-**	**ders**	

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

at the US end.

N

E. Downstream Channel Assessment

100.

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

Bank width (BF) -____ Channel width (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.):

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

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

Material: -

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

-
-
-
-

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

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

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

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

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: 3

Scour dimensions: Length 3 Width 453 Depth: 453 Positioned 1 %LB to 0 %RB

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

453
0
0
-

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

Confluence 1: Distance e fill Enters on exte (LB or RB) Type nds (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance 10 Enters on feet (LB or RB) Type bey (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

ond the end of the right wingwall with large boulders along both banks.

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

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: RICHVT01050036 Town: Richford
Road Number: VT 105 County: Franklin
Stream: Stanhope Brook

Initials EMB Date: 9/11/96 Checked:

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1950	2620	0
Main Channel Area, ft2	190	301	0
Left overbank area, ft2	0	6	0
Right overbank area, ft2	0	16	0
Top width main channel, ft	49	52	0
Top width L overbank, ft	1	4	0
Top width R overbank, ft	0	25	0
D50 of channel, ft	0.432	0.432	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	3.9	5.8	ERR
y1, average depth, LOB, ft	0.0	1.5	ERR
y1, average depth, ROB, ft	ERR	0.6	ERR
Total conveyance, approach	12289	26238	0
Conveyance, main channel	12286	25590	0
Conveyance, LOB	3	143	0
Conveyance, ROB	0	505	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1949.5	2555.3	ERR
Ql, discharge, LOB, cfs	0.5	14.3	ERR
Qr, discharge, ROB, cfs	0.0	50.4	ERR
Vm, mean velocity MC, ft/s	10.3	8.5	ERR
Vl, mean velocity, LOB, ft/s	ERR	2.4	ERR
Vr, mean velocity, ROB, ft/s	ERR	3.2	ERR
Vc-m, crit. velocity, MC, ft/s	10.6	11.4	N/A
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	0.0	N/A

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	N/A
Left Overbank	N/A	1	N/A
Right Overbank	N/A	1	N/A

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	1950	2620	0	1950	2620	0
Total conveyance	12289	26238	0	14187	15561	0
Main channel conveyance	12286	25590	0	14187	15561	0
Main channel discharge	1950	2555	ERR	1950	2620	ERR
Area - main channel, ft2	190	301	0	187	198.7	0
(W1) channel width, ft	49	52	0	36.7	36.7	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	49	52	0	36.7	36.7	0
D50, ft	0.432	0.432	0.432			
w, fall velocity, ft/s (p. 32)	5.37	5.37	0			
y, ave. depth flow, ft	3.88	5.79	N/A	5.10	5.41	ERR
S1, slope EGL	0.024	0.022	0			
P, wetted perimeter, MC, ft	51	54	0			
R, hydraulic Radius, ft	3.725	5.574	ERR			
V*, shear velocity, ft/s	1.697	1.987	N/A			
V*/w	0.316	0.370	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.59	0.59	0			
y2,depth in contraction, ft	4.60	7.26	ERR			
ys, scour depth, ft (y2-y_bridge)	-0.50	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	190	301	0
Main channel width, ft	49	52	0
y1, main channel depth, ft	3.88	5.79	ERR

Bridge Section

(Q) total discharge, cfs	1950	2620	0
(Q) discharge thru bridge, cfs	1950	2620	
Main channel conveyance	14187	15561	
Total conveyance	14187	15561	
Q2, bridge MC discharge,cfs	1950	2620	ERR
Main channel area, ft2	187	199	0
Main channel width (skewed), ft	36.7	36.7	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	36.7	36.7	0
y_bridge (avg. depth at br.), ft	5.10	5.41	ERR
Dm, median (1.25*D50), ft	0.54	0.54	0
y2, depth in contraction,ft	4.45	5.73	ERR
ys, scour depth (y2-ybridge), ft	-0.65	0.31	N/A

ARMORING			
D90	0.839895	0.839895	
D95	1.459	1.459	
Critical grain size,Dc, ft	0.5917	0.9199	ERR
Decimal-percent coarser than Dc	0.269	0.095	
Depth to armoring,ft	4.82	26.29	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	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1950	2620	0	1950	2620	0
a', abut.length blocking flow, ft	6.8	10.1	0	6.8	34.1	0
Ae, area of blocked flow ft2	11.5	27.1	0	11.6	43.8	0
Qe, discharge blocked abut.,cfs	69.8	145.2	0	65.6	196.5	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	6.07	5.36	ERR	5.66	4.49	ERR
ya, depth of f/p flow, ft	1.69	2.68	ERR	1.71	1.28	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	70	70	0	110	110	0
K2	0.97	0.97	0.00	1.03	1.03	0.00
Fr, froude number f/p flow	0.822	0.576	ERR	0.763	0.698	ERR
ys, scour depth, ft	6.61	8.79	N/A	6.71	9.35	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)	6.8	10.1	0	6.8	34.1	0
y1 (depth f/p flow, ft)	1.69	2.68	ERR	1.71	1.28	ERR
a'/y1	4.02	3.76	ERR	3.99	26.55	ERR
Skew correction (p. 49, fig. 16)	0.93	0.93	0.00	1.04	1.04	0.00
Froude no. f/p flow	0.82	0.58	N/A	0.76	0.70	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	8.63	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	7.07	ERR
spill-through	ERR	ERR	ERR	ERR	4.74	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	0.81	1		0.81	1	
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.1	5.4		5.1	5.4	
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.)	2.01	2.26	ERR	2.01	2.26	ERR