LEVEL II SCOUR ANALYSIS FOR BRIDGE 7 (MORRTH00020007) on TOWN HIGHWAY 2 (FAS 239), crossing RYDER BROOK, MORRISTOWN, VERMONT

U.S. Geological Survey
Open-File Report 97-190

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

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By Erick M. Boehmler and Robert E. Hammond

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Pembroke, New Hampshire

1997

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 7 (MORRTH00020007) ON TOWN HIGHWAY 2 (FAS 239), CROSSING RYDER BROOK, MORRISTOWN, VERMONT

By **Erick M. Boehmler and Robert E. Hammond**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MORRTH00020007 on Town Highway 2 crossing Ryder Brook, Morristown, 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 18.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture and forest.

In the study area, Ryder Brook generally is straight and incised with a slope of approximately 0.002 ft/ft, an average channel top width of 48 ft and an average channel depth of 3 ft. The channel bed is bedrock with pockets of sand and gravel in several locations through the reach. The gravel has a median grain size (D_{50}) of 17.7 mm (0.0581 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 16, 1996 indicated that the reach was stable.

The Town Highway 2 crossing of Ryder Brook is a 84-ft-long, two-lane bridge consisting of one 84-foot steel-beam span (Vermont Agency of Transportation, written communication, January 31, 1996). The bridge is supported by vertical, concrete abutment walls with spill-through embankments. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 15 degrees.

The only scour protection measure at the site was type-3 stone fill (less than 48 inches diameter) on the spill-through embankments of each abutment. 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 predictions for all modelled flows at this site were zero. Abutment scour predictions ranged from 5.6 to 8.1 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. However, historical bridge records and field notes indicate the abutment footings may be set on bedrock.

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.

Morrisville, VT. Quadrangle, 1:24,000, 1986
Aerial photography, 1981; Contour interval, 6 meters

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 MORRTH00020007 ***Stream*** Ryder Brook

County Lamoille ***Road*** TH 2 ***District*** 6

Description of Bridge

Bridge length 84 ***ft*** ***Bridge width*** 33.6 ***ft*** ***Max span length*** 84 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/16/96

Description of stone fill Type-3 on the spill-through embankments of each abutment.

Abutments are vertical concrete walls with spill-through embankments.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 10

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	7/16/96	0	0
Level II	7/16/96	0	0

Potential for debris Moderate. There is vegetation leaning toward the channel and moderate to heavy bank erosion upstream.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on 7/16/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow, irregular overbank areas and steep valley walls.

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

Date of inspection 7/16/96

DS left: Steep channel bank to valley wall.

DS right: Steep channel bank to a narrow overbank.

US left: Steep channel bank to valley wall.

US right: Steep channel bank to moderately sloping overbank.

Description of the Channel

Average top width 48 ***ft*** ***Average depth*** 3 ***ft***

Predominant bed material Bedrock ***Bank material*** Sand / Bedrock

Incised, straight, and stable with non-alluvial channel boundaries.

7/16/96

Vegetative co Trees, shrubs, and brush with grass on the overbank

DS left: Trees, shrubs, and brush with grass on the overbank

DS right: Grass and brush with a few shrubs to only grass on the overbank.

US left: Trees, shrubs and brush.

US right:

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

None evident on 7/16/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 18.5 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,200 ***ft³/s*** ***Q500*** 3,050 ***ft³/s***

The 100- and 500-year discharges were computed with a drainage area relationship [(18.5/17.1)exp 0.67] with bridge number 213 in Morristown. Bridge number 213 crosses Ryder Brook upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 213 is 17.1 square miles. The computed discharges were within a range defined by flood frequency curves computed by use of several empirical methods (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Add 98.5 feet to the USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled "X" on top of the concrete at the downstream end of the right abutment (elev. 499.55 ft, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of the concrete at the upstream end of the left abutment (elev. 499.60 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-83	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APPRO	112	2	Modelled Approach section (Templated from APTEM)
APTEM	118	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 0.035 to 0.040, and overbank "n" values ranged from 0.035 to 0.130.

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 0.0019 ft/ft, which was estimated from available data documented in the Flood Insurance Study for the Town of Morristown, Vermont (FEMA, 1987).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0142 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.0 ***ft***
Average low steel elevation 495.6 ***ft***

100-year discharge 2,200 ***ft^3/s***
Water-surface elevation in bridge opening 488.2 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 347 ***ft^2***
Average velocity in bridge opening 6.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.2 ***ft/s***

Water-surface elevation at Approach section with bridge 488.8
Water-surface elevation at Approach section without bridge 488.6
Amount of backwater caused by bridge 0.2 ***ft***

500-year discharge 3,050 ***ft^3/s***
Water-surface elevation in bridge opening 489.9 ***ft***
Road overtopping? No ***Discharge over road*** --
Area of flow in bridge opening 446 ***ft^2***
Average velocity in bridge opening 6.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.9 ***ft/s***

Water-surface elevation at Approach section with bridge 490.5
Water-surface elevation at Approach section without bridge 490.4
Amount of backwater caused by bridge 0.1

Incipient overtopping discharge -- ***ft^3/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft^2***
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. 30, equation 17). 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 for each modeled discharge 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.

The HIRE equation (Richardson and others, 1993, p. 50, equation 25) generally is applicable when the length to depth ratio of the embankment blocking flow exceeds 25. However, the results from the HIRE equation were not used. Hydraulic Engineering Circular 18 recommends that the HIRE equation be used only when field conditions at the bridge site are similar to those for which the HIRE equation was derived (Richardson and others, 1993). Since the equation was developed from Army Corp. of Engineers' data obtained for spurs dikes in the Mississippi River, the HIRE equation was not adopted for the narrow, incised, upland valley at this site.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	0.8	1.2	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	5.6	7.9	--
Right abutment	7.1	8.1	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.0	1.1	--
Right abutment	1.0	1.1	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

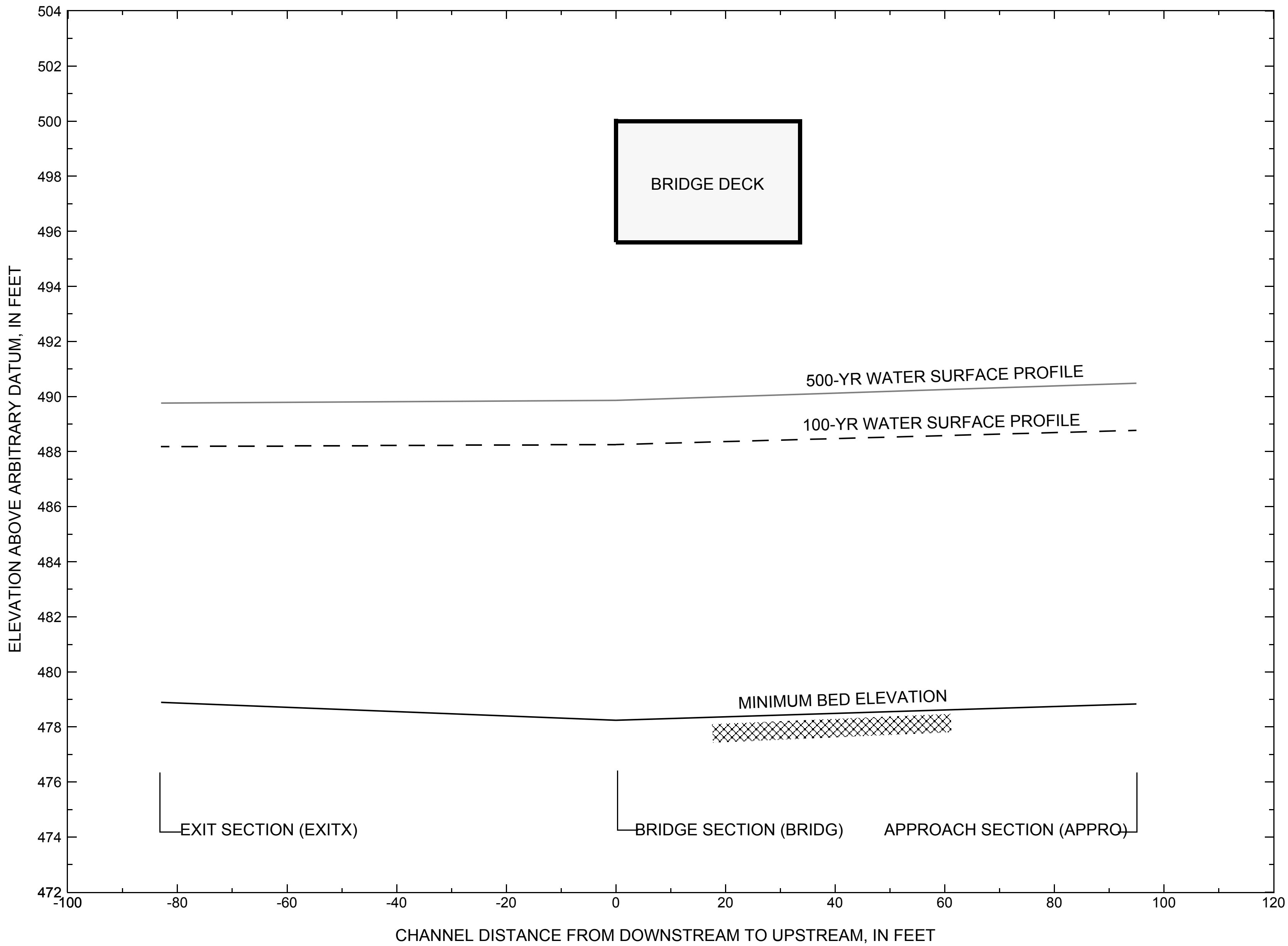

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure MORRTH00020007 on Town Highway 2, crossing Ryder Brook, Morristown, Vermont.

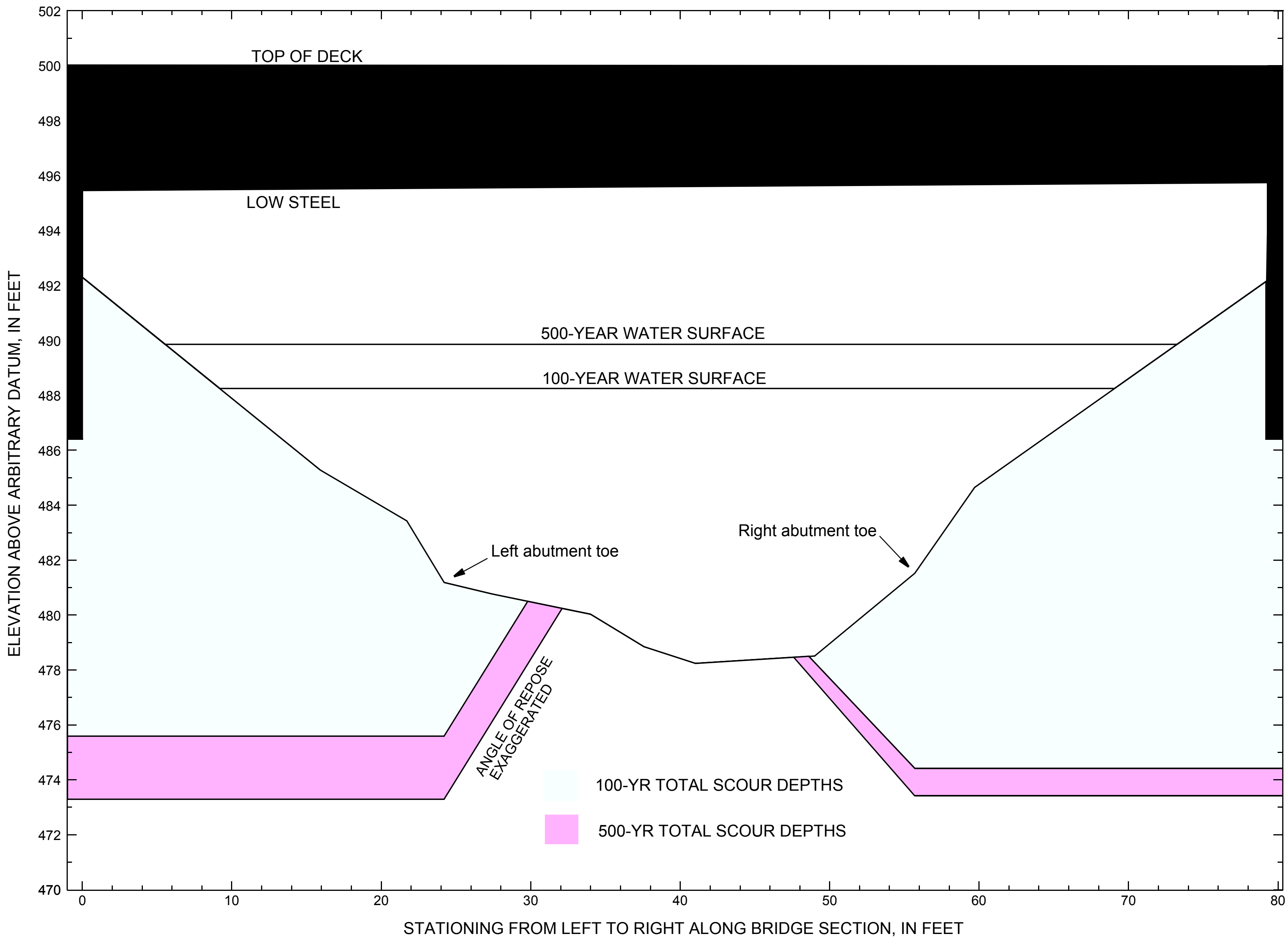

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure MORRTH00020007 on Town Highway 2, crossing Ryder Brook, Morristown, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MORRTH00020007 on Town Highway 2, crossing Ryder Brook, Morristown, 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 2,200 cubic-feet per second											
Left abutment	0.0	594.0	495.5	486.4	492.3	--	--	--	--	--	-10.0
Left abutment toe	24.2	--	--	--	481.2	0.0	5.6	--	5.6	475.6	--
Right abutment toe	55.7	--	--	--	481.5	0.0	7.1	--	7.1	474.4	--
Right abutment	79.3	593.9	495.8	486.4	492.2	--	--	--	--	--	-12.0

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure MORRTH00020007 on Town Highway 2, crossing Ryder Brook, Morristown, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT bridge-seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 3,050 cubic-feet per second											
Left abutment	0.0	594.0	495.5	486.4	492.3	--	--	--	--	--	-13.1
Left abutment toe	24.2	--	--	--	481.2	0.0	7.9	--	7.9	473.3	--
Right abutment toe	55.7	--	--	--	481.5	0.0	8.1	--	8.1	473.4	--
Right abutment	79.3	593.9	495.8	486.4	492.2	--	--	--	--	--	-13.0

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, Sterling Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1981; Contour interval, 6 meters, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File morr007.wsp
T2        Hydraulic analysis for structure MORRTH00020007   Date: 06-DEC-96
T3        Town Highway 2 (FAS 239) crossing of Ryder Brook, Morristown, VT   EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2200.0   3050.0
SK          0.0019   0.0019
*
XS   EXITX    -83
GR         -280.0, 504.86   -258.1, 504.15   -241.0, 501.39   -100.2, 496.69
GR          -75.4, 496.67    -23.2, 492.14      0.0, 488.60     15.6, 486.08
GR           21.9, 483.37     26.2, 481.51     29.1, 478.89     42.9, 479.52
GR           50.2, 479.82     57.7, 479.08     63.4, 481.52     63.5, 480.28
GR           64.2, 483.65     70.0, 485.24     78.9, 489.23    144.0, 491.31
GR          242.3, 495.43    279.6, 502.54    336.1, 504.70    355.3, 511.23
*
N           0.075         0.040         0.110
SA                  15.6          64.2
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.60      15.0
GR            0.0, 495.46      0.0, 492.30     15.9, 485.29     21.7, 483.43
GR           24.2, 481.19     27.4, 480.77     34.0, 480.03     37.6, 478.84
GR           41.0, 478.24     49.0, 478.51     55.7, 481.52     59.7, 484.65
GR           79.2, 492.15     79.3, 495.75      0.0, 495.46
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      35.8      2.1    500.0
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      33.6     1
GR         -289.8, 505.20   -245.9, 501.09    -47.7, 499.79      0.0, 500.03
GR           82.0, 500.00    254.3, 499.64    492.4, 514.08
*
XT   APTEM    118
GR         -443.1, 508.80   -303.2, 501.92   -225.2, 500.93   -113.4, 497.58
GR         -105.8, 493.04     15.0, 486.26     22.3, 485.01     26.2, 480.61
GR           26.8, 481.53     33.3, 479.16     45.0, 480.03     58.6, 480.01
GR           62.9, 481.57     66.3, 483.39     69.3, 486.03    118.1, 486.64
GR          301.8, 494.63    308.0, 497.68    314.3, 500.99    340.2, 501.91
GR          360.8, 503.87    489.6, 515.75
*
AS   APPRO     95 *  *  *  0.0142
GT
N           0.035         0.035         0.130
SA                  22.3          69.3
BP          0.0
*
HP 1 BRIDG 488.25 1 488.25
HP 2 BRIDG 488.25 * * 2200
HP 1 APPRO 488.77 1 488.77
HP 2 APPRO 488.77 * * 2200
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File morr007.wsp
     Hydraulic analysis for structure MORRTH00020007   Date: 06-DEC-96
     Town Highway 2 (FAS 239) crossing of Ryder Brook, Morristown, VT   EMB
        *** RUN DATE & TIME: 12-19-96  09:42

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      347     46259     58     62                         4815
 488.25           347     46259     58     62  1.00      9     69     4815

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   488.25     9.2    69.1   346.6   46259.    2200.   6.35

X STA.        9.2       21.7       25.3       27.9       30.2       32.2
  A(I)           31.2       22.4       18.1       16.8       15.7
  V(I)           3.52       4.91       6.06       6.56       6.99

X STA.       32.2       34.2       35.9       37.6       39.1       40.5
  A(I)           15.2       14.8       14.5       13.7       13.6
  V(I)           7.21       7.45       7.61       8.05       8.09

X STA.       40.5       41.9       43.3       44.7       46.2       47.7
  A(I)           13.4       13.4       13.5       13.9       14.3
  V(I)           8.18       8.20       8.14       7.92       7.67

X STA.       47.7       49.2       51.1       53.2       56.3       69.1
  A(I)           14.8       16.2       17.6       21.3       32.2
  V(I)           7.43       6.80       6.24       5.17       3.41

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      95.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1       97      5811     58     58                          712
           2      392     64500     47     52                         6429
           3      204      3637    105    105                         1613
 488.77           693     73948    210    215  2.10    -35    175     4932

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      95.

     WSEL     LEW     REW    AREA        K        Q    VEL
   488.77   -35.5   174.6   693.3   73948.    2200.   3.17

X STA.      -35.5       14.2       25.1       28.7       31.3       33.5
  A(I)           69.4       43.7       28.1       23.0       21.0
  V(I)           1.59       2.52       3.92       4.78       5.24

X STA.       33.5       35.6       37.6       39.7       41.9       44.0
  A(I)           20.2       19.9       20.1       20.2       19.9
  V(I)           5.44       5.54       5.48       5.44       5.54

X STA.       44.0       46.3       48.5       50.8       53.0       55.3
  A(I)           20.3       20.3       20.5       20.4       20.8
  V(I)           5.41       5.42       5.35       5.39       5.29

X STA.       55.3       57.6       60.1       63.2       69.0      174.6
  A(I)           21.3       21.8       24.5       32.8      205.1
  V(I)           5.17       5.04       4.49       3.35       0.54
```

```
       U.S. Geological Survey WSPRO Input File morr007.wsp
       Hydraulic analysis for structure MORRTH00020007   Date: 06-DEC-96
       Town Highway 2 (FAS 239) crossing of Ryder Brook, Morristown, VT   EMB
          *** RUN DATE & TIME: 12-19-96  09:42

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      446     64795     65     71                          6605
  489.86           446     64795     65     71  1.00      6     73      6605

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

        WSEL     LEW     REW    AREA       K        Q    VEL
      489.86     5.5    73.2   445.8   64795.    3050.   6.84

X STA.        5.5        19.4       23.9       26.5       29.0       31.2
  A(I)           40.0        29.0       22.8       21.7       19.9
  V(I)           3.81        5.25       6.68       7.02       7.65

X STA.       31.2        33.3       35.2       37.0       38.7       40.2
  A(I)           19.1        18.9       18.0       17.9       17.3
  V(I)           8.00        8.07       8.48       8.50       8.81

X STA.       40.2        41.8       43.3       44.9       46.5       48.1
  A(I)           17.2        17.2       17.3       17.8       18.4
  V(I)           8.88        8.89       8.82       8.57       8.31

X STA.       48.1        49.9       52.0       54.5       58.3       73.2
  A(I)           19.3        20.9       22.8       28.4       41.9
  V(I)           7.90        7.31       6.68       5.36       3.64

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      95.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      222     17430     88     89                          1996
            2      473     88001     47     52                          8503
            3      418      9710    145    145                          4030
  490.48          1112    115141    280    285  2.56    -65    214      7857

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      95.

        WSEL     LEW     REW    AREA       K        Q    VEL
      490.48   -66.0   213.9  1112.3  115141.    3050.   2.74

X STA.      -66.0        -7.1       10.6       22.0       27.5       30.7
  A(I)           97.2        67.3       55.8       45.0       32.3
  V(I)           1.57        2.27       2.73       3.39       4.73

X STA.       30.7        33.3       35.7       38.2       40.6       43.2
  A(I)           29.5        27.6       27.9       27.7       28.1
  V(I)           5.17        5.52       5.46       5.50       5.43

X STA.       43.2        45.8       48.4       51.0       53.6       56.3
  A(I)           28.1        28.0       28.4       28.2       28.7
  V(I)           5.42        5.44       5.37       5.42       5.31

X STA.       56.3        59.0       62.1       66.6       99.2      213.9
  A(I)           29.3        31.3       37.8      153.3      280.5
  V(I)           5.20        4.87       4.03       0.99       0.54
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File morr007.wsp
        Hydraulic analysis for structure MORRTH00020007   Date: 06-DEC-96
        Town Highway 2 (FAS 239) crossing of Ryder Brook, Morristown, VT   EMB
           *** RUN DATE & TIME: 12-19-96  09:42

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

EXITX:XS   ******      3      416  0.51 *****  488.70  484.38    2200  488.18
       -82 ******     77    50436  1.18 ***** *******    0.43    5.28

FULLV:FV       83      1      430  0.49  0.15  488.86 *******    2200  488.37
         0     83     77    52614  1.20  0.00    0.01    0.41    5.11
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       95    -32      663  0.35  0.12  488.98 *******    2200  488.62
        95     95    171    71079  2.05  0.00   -0.01    0.46    3.32
         <<<<<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       83      9      347  0.63  0.17  488.88  485.05    2200  488.25
         0     83     69    46281  1.00  0.01    0.00    0.46    6.34

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  495.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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       59    -35      693  0.33  0.09  489.10  484.45    2200  488.77
        95     62    175    73933  2.10  0.13    0.01    0.45    3.17

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.704  0.084  67601.    13.    73.   488.71

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -83.     3.    77.   2200.   50436.     416.    5.28  488.18
   FULLV:FV       0.     1.    77.   2200.   52614.     430.    5.11  488.37
   BRIDG:BR       0.     9.    69.   2200.   46281.     347.    6.34  488.25
   RDWAY:RG      18.**************       0.*****************    1.00********
   APPRO:AS      95.   -36.   175.   2200.   73933.     693.    3.17  488.77

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      13.    73.   67601.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    484.38    0.43  478.89  511.23************  0.51  488.70  488.18
   FULLV:FV  ********    0.41  478.89  511.23  0.15  0.00  0.49  488.86  488.37
   BRIDG:BR    485.05    0.46  478.24  495.75  0.17  0.01  0.63  488.88  488.25
   RDWAY:RG  ****************  499.64  514.08**********************************
   APPRO:AS    484.45    0.45  478.83  515.42  0.09  0.13  0.33  489.10  488.77
```

```
       U.S. Geological Survey WSPRO Input File morr007.wsp
       Hydraulic analysis for structure MORRTH00020007   Date: 06-DEC-96
       Town Highway 2 (FAS 239) crossing of Ryder Brook, Morristown, VT   EMB
          *** RUN DATE & TIME: 12-19-96  09:42

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

EXITX:XS   ******     -7      548  0.65 *****  490.41  485.49    3050  489.76
       -82 ******     96    69917  1.35 ***** *******    0.49    5.57

FULLV:FV       83     -8      569  0.62  0.15  490.57 *******    3050  489.96
         0     83    102    72574  1.38  0.00    0.01    0.49    5.36
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "APPRO"     KRATIO =  1.54

APPRO:AS       95    -63     1081  0.31  0.11  490.68 *******    3050  490.37
        95     95    211   111948  2.54  0.00    0.00    0.40    2.82
         <<<<<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       83      6      446  0.73  0.17  490.58  486.26    3050  489.86
         0     83     73    64742  1.00  0.00   -0.01    0.46    6.85

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   1.  1.000 ******  495.60 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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       59    -65     1113  0.30  0.08  490.78  485.55    3050  490.48
        95     63    214   115180  2.56  0.12    0.02    0.39    2.74

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.752  0.157   96705.     9.    76.   490.44

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -83.    -8.    96.   3050.   69917.     548.    5.57  489.76
   FULLV:FV       0.    -9.   102.   3050.   72574.     569.    5.36  489.96
   BRIDG:BR       0.     6.    73.   3050.   64742.     446.    6.85  489.86
   RDWAY:RG      18.**************       0.*****************    1.00********
   APPRO:AS      95.   -66.   214.   3050.  115180.    1113.    2.74  490.48

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       9.    76.   96705.

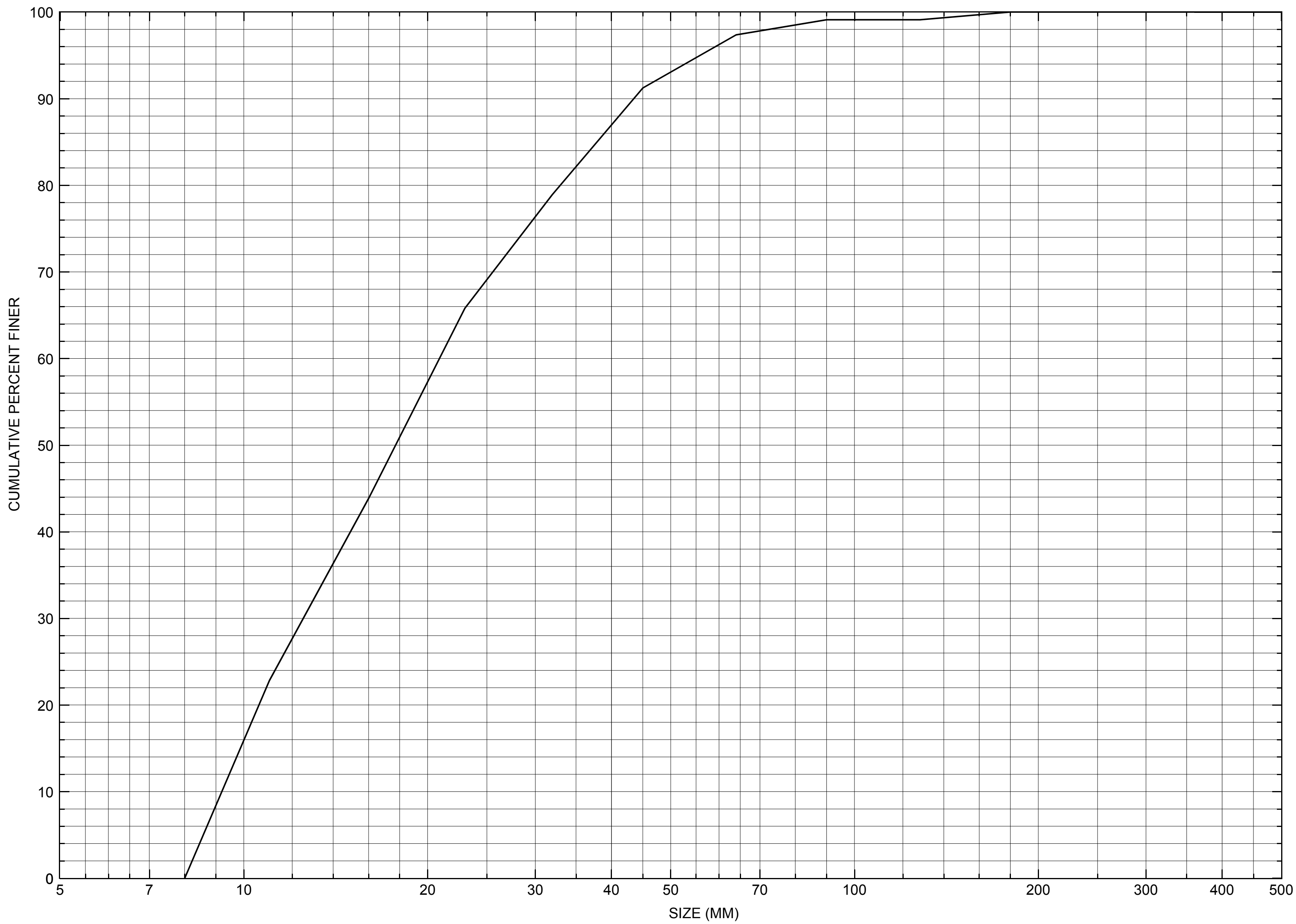
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     485.49    0.49  478.89  511.23************  0.65  490.41  489.76
   FULLV:FV   ********    0.49  478.89  511.23  0.15  0.00  0.62  490.57  489.96
   BRIDG:BR     486.26    0.46  478.24  495.75  0.17  0.00  0.73  490.58  489.86
   RDWAY:RG   ***************  499.64  514.08**********************************
   APPRO:AS     485.55    0.39  478.83  515.42  0.08  0.12  0.30  490.78  490.48
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MORRTH00020007, in Morristown, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **MORRTH00020007**

General Location Descriptive

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

Date *(MM/DD/YY)* **01** / **31** / **96**

Highway District Number *(I - 2; nn)* **06**

County *(FIPS county code; I - 3; nnn)* **015**

Town *(FIPS place code; I - 4; nnnnn)* **46675**

Mile marker *(I - 11; nnn.nnn)* **000090**

Waterway *(I - 6)* **RYDER BROOK**

Road Name *(I - 7)*: **TR 02**

Route Number **FAS 239**

Vicinity *(I - 9)* **0.1 MI W JCT. VT.100**

Topographic Map **Morrisville**

Hydrologic Unit Code: **2010005**

Latitude *(I - 16; nnnn.n)* **44333**

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

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **20023900070807**

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

Maximum span length *(I - 48; nnnn)* **0084**

Year built *(I - 27; YYYY)* **1949**

Structure length *(I - 49; nnnnnn)* **000084**

Average daily traffic, ADT *(I - 29; nnnnnn)* **001255**

Deck Width *(I - 52; nn.n)* **336**

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

Channel & Protection *(I - 61; n)* **7**

Opening skew to Roadway *(I - 34; nn)* **15**

Waterway adequacy *(I - 71; n)* **6**

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

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

Structure type *(I - 43; nnn)* **302**

Year Reconstructed *(I - 106)* **0000**

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

Clear span (*nnn.n ft*) **77.3**

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

Vertical clearance from streambed (*nnn.n ft*) **14.9**

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

Waterway of full opening (*nnn.n* ft^2) **1153**

Comments:

According to the structural inspection report dated 7/29/94, the structure is a single span rolled beam bridge. The curtain wall at the right abutment has some minor cracking and scaling. The stem of the right abutment has areas of staining, scaling, and some cracking at the left fascia line. The upstream wingwall is in good condition with only minor scaling and cracking. The downstream wingwall has an area of spalling at mid-height at the end of the wingwall. The curtain wall at the left abutment has some minor leakage at the top. There are also areas of minor cracking and scaling. There are break outs at some of the bearing block-outs. The bridge seat area has some chip outs at the front face of the **(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: -

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*): N 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:

abutment. There is also a spalled area at the right fascia. The stem of the left abutment has some staining and hairline vertical cracking. The short wingwalls have areas of staining and cracking with leakage. There is stone fill in front of each abutment. The channel takes a moderate turn into and a slight turn out of the structure. There are some logs and debris in the channel downstream.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **18.47** mi^2 Lake and pond area **0.26** mi^2

Watershed storage *(ST)* **1.4** %

Bridge site elevation **640** ft Headwater elevation **2730** ft

Main channel length **9.51** mi

10% channel length elevation **669** ft 85% channel length elevation **1220** ft

Main channel slope *(S)* **77.25** 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)*: ___ / 1948

Project Number SA35-1948 Minimum channel bed elevation: 579

Low superstructure elevation: USLAB 593.95 DSLAB 593.96 USRAB 593.92 DSRAB 593.94

Benchmark location description:

B.M. #1, elev. 600', at 36" elm next to right road approach, upstream side, about 200' from the bridge.

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

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

If 1: Footing Thickness 2 Footing bottom elevation: 584.9

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

Briefly describe material at foundation bottom elevation or around piles:

The structural inspection report of 7/29/94 indicates that both abutments appear to be founded on ledge.

Comments:

The low superstructure elevations are wingwall-abutment top corner elevations from the bridge plans. The average low superstructure elevation is 593.9'.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTIONAL 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: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 9/30/96
Computerized by: EW Date: 9/30/96
Reviewd by: EMB Date: 12/6/96

Structure Number MORRTH00020007

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 07 / 16 / 1996
2. Highway District Number 06 Mile marker 000090
County Lamoille (015) Town Morristown (46675)
Waterway *(I - 6)* Ryder Brook Road Name -
Route Number FAS 239 Hydrologic Unit Code: 02010005
3. Descriptive comments:
Located 0.1 miles from the junction of TH 2 with VT 100. This is a single span, rolled beam bridge.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 5 LBDS 4 RBDS 4 Overall 4
*(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 1 DS 1 *(**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 84 *(feet)* Span length 77 *(feet)* Bridge width 33.6 *(feet)*

Road approach to bridge:

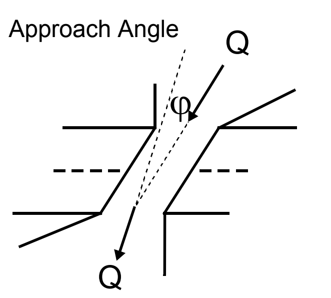
8. LB 0 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

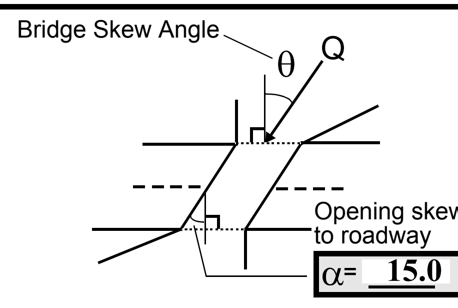
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	2	1
RBDS	0	-	2	1
LBDS	0	-	2	1

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

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 10





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

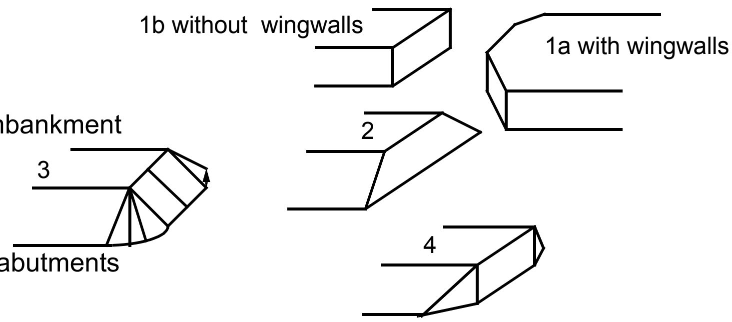
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#7: During site visit, measured bridge length = 86 feet; span length = 80 feet; and bridge width = 32 feet.

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
83.0	**3.5**			**2.5**	**1**	**2**	**2**	**62**	**2**	**2**

23. Bank width **40.0** 24. Channel width **40.0** 25. Thalweg depth **47.5** 29. Bed Material **632**

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.):

#28: Moderate bank erosion from 200 feet upstream to upstream bridge face.

#30: Left bank protection extends from 200 feet upstream to 150 feet upstream. It consists of dumped rock to protect the field from fluvial erosion.

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

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

37. Material: **-**

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? **Y** (*Y or if N type ctrl-n cs*) 46. Mid-scour distance: **10 UB**

47. Scour dimensions: Length **40** Width **10** Depth : **1.5** Position **50** %LB to **65** %RB

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

Bedrock outcrop extends into channel from right bank near scour hole.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB ____ (*1- natural bank; 2- abutment; 3- artificial levee*)

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
39.5		1.5		2	76	76	0

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

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

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

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

613

#55: Bedrock exists underneath the placed boulders which form spill through abutments.

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

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

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

70. Debris and Ice Comments:

1

Both banks have significant vegetation cover upstream and both banks show evidence of moderate erosion with vegetation leaning toward the channel and some bank material slumping. Therefore, the potential for debris is moderate.

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	45	2	0	-	-	90.0
RABUT	2	0	45			2	0	76.5

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.):

-

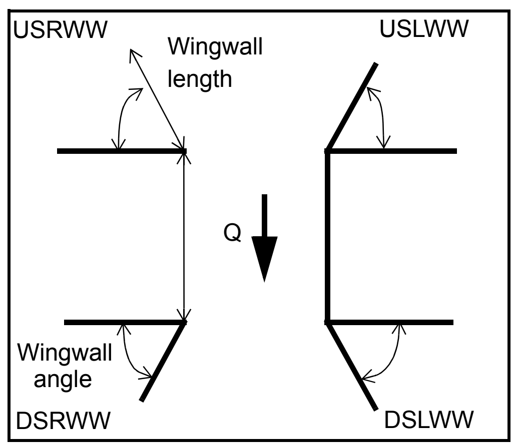
-

2

#77: Spill-through abutments consist of flat boulders arranged on top of bedrock.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						31.5	
USRWW:	N		-		-	2.5	
DSLWW:	-		-		N	36.0	
DSRWW:	-		-		-	36.0	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	0	0	3	3	-

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

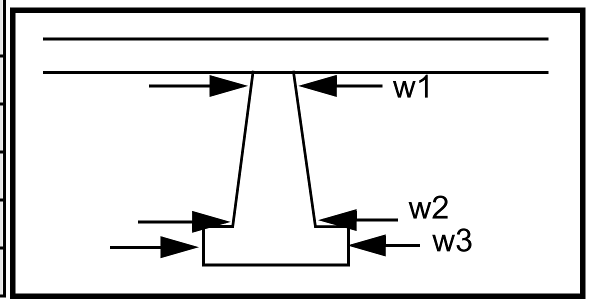
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
0
-
-

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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**:**	**ment**	**tec-**	**front**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**Win**	**s.**	**tion**	**of**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**gwal**		**set**	**each**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**ls**	**#82:**	**on**	**abut**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**are**	**Ther**	**the**	**ment**	*Y- yes; N- no*
91. Attack ∠ (BF)	**short**	**e is**	**spill-**	**. The**	
92. Pushed	**exte**	**type-**	**thro**	**low-**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**nsio**	**3**	**ugh**	**est**	
95. Cross-members	**ns of**	**stone**	**emb**	**10%**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**con-**	**rip-**	**ank-**	**of**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**crete**	**rap**	**ment**	**each**	
98. Exposure depth	**abut**	**pro-**	**s in**	**spill-**	

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

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.):

-
-
-
NO PIERS

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

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

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

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

3
2
612

Is channel scour present? __**126**__ *(Y or if N type ctrl-n cs)* Mid-scour distance: __**2**__

Scour dimensions: Length __**2**__ Width __**613**__ Depth: __**0**__ Positioned __**0**__ %LB to __-__ %RB

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

-
Bank erosion along both banks is moderate from downstream bridge face to 200 feet downstream.

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

__1__- Constructed
__2__- Stable
__3__- Aggraded
__4__- Degraded
__5__- Laterally unstable
__6__- Vertically and laterally unstable

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

N
-
NO DROP STRUCTURE

N
-
-
-

109. G. Plan View Sketch

-

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number:	MORRTH00020007	Town:	Morristown
Road Number:	TH 2 (FAS 239)	County:	Lamoille
Stream:	Ryder Brook		

Initials EMB   Date: 12/6/96   Checked: SAO

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	2200	3050	0
Main Channel Area, ft2	392	473	0
Left overbank area, ft2	97	222	0
Right overbank area, ft2	204	418	0
Top width main channel, ft	47	47	0
Top width L overbank, ft	58	88	0
Top width R overbank, ft	105	145	0
D50 of channel, ft	0.0581	0.0581	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.3	10.1	ERR
y1, average depth, LOB, ft	1.7	2.5	ERR
y1, average depth, ROB, ft	1.9	2.9	ERR
Total conveyance, approach	73948	115141	0
Conveyance, main channel	64500	88001	0
Conveyance, LOB	5811	17430	0
Conveyance, ROB	3637	9710	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1918.9	2331.1	ERR
Ql, discharge, LOB, cfs	172.9	461.7	ERR
Qr, discharge, ROB, cfs	108.2	257.2	ERR
Vm, mean velocity MC, ft/s	4.9	4.9	ERR
Vl, mean velocity, LOB, ft/s	1.8	2.1	ERR
Vr, mean velocity, ROB, ft/s	0.5	0.6	ERR
Vc-m, crit. velocity, MC, ft/s	6.2	6.4	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

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	392	473	0
Main channel width, ft	47	47	0
y1, main channel depth, ft	8.34	10.06	ERR
Bridge Section			
(Q) total discharge, cfs	2200	3050	0
(Q) discharge thru bridge, cfs	2200	3050	0
Main channel conveyance	46259	64795	0
Total conveyance	46259	64795	0
Q2, bridge MC discharge,cfs	2200	3050	ERR
Main channel area, ft2	347	446	0
Main channel width (skewed), ft	41.1	45.4	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	41.1	45.4	0
y_bridge (avg. depth at br.), ft	8.43	9.82	ERR
Dm, median (1.25*D50), ft	0.072625	0.072625	0
y2, depth in contraction,ft	7.94	9.64	ERR
ys, scour depth (y2-ybridge), ft	-0.50	-0.18	N/A
ARMORING			
D90	0.1427	0.1427	0
D95	0.1833	0.1833	0
Critical grain size,Dc, ft	0.0939	0.1042	ERR
Decimal-percent coarser than Dc	0.255	0.214	0
Depth to armoring,ft	0.82	1.15	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	2200	3050	0	2200	3050	0
a', abut.length blocking flow, ft	54	82.2	0	115	152.3	0
Ae, area of blocked flow ft2	86.6	191.9	0	266.8	476.6	0
Qe, discharge blocked abut.,cfs	153.4	379.9	0	352	482.1	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.77	1.98	ERR	1.32	1.01	ERR
ya, depth of f/p flow, ft	1.60	2.33	ERR	2.32	3.13	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	105	105	105	75	75	75
K2	1.02	1.02	1.02	0.98	0.98	0.98
Fr, froude number f/p flow	0.247	0.228	ERR	0.153	0.101	ERR
ys, scour depth, ft	5.55	7.92	N/A	7.13	8.13	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)	54	82.2	0	115	152.3	0
y1 (depth f/p flow, ft)	1.60	2.33	ERR	2.32	3.13	ERR
a'/y1	33.67	35.21	ERR	49.57	48.67	ERR
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.25	0.23	N/A	0.15	0.10	N/A
Ys w/ corr. factor K1/0.55:						
vertical	7.57	10.74	ERR	8.62	10.14	ERR
vertical w/ ww's	6.21	8.81	ERR	7.07	8.31	ERR
spill-through	4.16	5.91	ERR	4.74	5.58	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	0.46	0.46	0	0.46	0.46	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	8.43	9.82	0.00	8.43	9.82	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (spillthrough abut.)	0.96	1.12	0.00	0.96	1.12	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR