LEVEL II SCOUR ANALYSIS FOR BRIDGE 36 (STOWTH00430036) on TOWN HIGHWAY 43, crossing MILLER BROOK, STOWE, VERMONT

Open-File Report 97-780

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior
U.S. Geological Survey

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 36 (STOWTH00430036) on TOWN HIGHWAY 43, crossing MILLER BROOK, STOWE, VERMONT

By LORA K. STRIKER AND EMILY C. WILD

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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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CONTENTS

FIGURE-

TABLES

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 (STOWTH00430036) ON TOWN HIGHWAY 43, CROSSING MILLER BROOK, STOWE, VERMONT

By **Lora K. Striker and Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STOWTH00430036 on Town Highway 43 crossing the Miller Brook, Stowe, 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 5.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is predominantly forested.

In the study area, the Miller Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 43 ft and an average bank height of 7 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 70.4 mm (0.231 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 15, 1996, indicated that the reach was stable.

The Town Highway 43 crossing of the Miller Brook is a 24-ft-long, two-lane bridge consisting of one 21-foot steel-beam span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 21.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening and the computed opening-skew-to-roadway is also 10 degrees.

The footing on the left abutment was exposed 2.5 ft and the footing on the right abutment was exposed 3.0 ft during the Level I assessment. Scour protection measures at the site were type-4 stone fill (less than 60 inches diameter) on the left and right bank upstream, type-3 stone fill (less than 48 inches diameter) along the entire base length of the upstream right wingwall, right abutment, and type-2 stone fill (less than 36 inches diameter) along the entire base length of the downstream right wingwall, and left and right banks downstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.0 to 0.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 3.1 to 6.5 ft. The worst-case abutment scour occurred at the 100-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.

Bolton Mountain, VT. Quadrangle, 1:24,000, 1948
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 STOWTH00430036 ***Stream*** Miller Brook

County Lamoille ***Road*** TH43 ***District*** 6

Description of Bridge

Bridge length 24 ***ft*** ***Bridge width*** 21.4 ***ft*** ***Max span length*** 21 ***ft***

Alignment of bridge to road (on curve or straight) Curve, right; Straight, left

Abutment type Vertical, concrete ***Embankment type*** Sloping: near vertical

Stone fill on abutment? Yes ***Date of inspection*** 07/15/96

Description of stone fill Type-3, along the entire base length of the right abutment and upstream right wingwall, and type-2, along the entire base length of the downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. The road has been widened at the DS end placing both of the wingwalls under the deck. The RABUT and LABUT footings have been built up with sand bags full of concrete.

Y 10

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

There is a mild channel bend in the upstream reach. The flow impacts 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	07/15/96	0	0
Level II	07/15/96	0	0

Potential for debris Moderate. No debris problems were noted during assessment; however, moderate potential was noted due to low bridge clearance.

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

None as of 07/15/96.

Description of the Geomorphic Setting

General topography The channel is located within a high relief valley, with little or no flood plains with a steep valley wall on the right.

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

Date of inspection 07/15/96

DS left: Steep channel bank to dry stream bed channel

DS right: Moderately sloping channel bank to overbank

US left: Steep channel bank to moderately sloping overbank

US right: Steep channel bank and valley wall

Description of the Channel

Average top width 43 ***ft*** ***Average depth*** 7 ***ft***

Predominant bed material Cobble/Boulder ***Bank material*** Gravel/Boulder

Sinuous but stable with alluvial channel boundaries and little to no flood plain.

07/15/96

Vegetative co

Trees

DS left: Trees

DS right: Trees

US left: Trees

US right:

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

None as of 07/15/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 5.5 ***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***: None.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,200 ***ft³/s*** ***Q500*** 2,130 ***ft³/s***

The 100- and 500-year discharges were obtained flood frequency estimates available from the VTAOT database. The VTAOT discharges are within a range defined by the use of several empirical equations (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the upstream left wingwall (elev. 495.83 ft, arbitrary survey datum). RM2 is a chiseled X at the bankward end of the bridge seat on the downstream left bank end (elev. 499.74 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	-22	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	43	1	Approach section as surveyed

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.055 to 0.066, and overbank "n" values ranged from 0.085 to 0.090.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0307 ft/ft, which was obtained from points surveyed downstream of the site on July 15, 1996.

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

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for this discharge. After analyzing both the supercritical and subcritical profiles for the incipient-overtopping discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.1 ***ft***
Average low steel elevation 498.4 ***ft***

100-year discharge 1,200 ***ft^3/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Road overtopping? Y ***Discharge over road*** 67 ***ft^3/s***
Area of flow in bridge opening 134 ***ft^2***
Average velocity in bridge opening 8.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.1 ***ft/s***

Water-surface elevation at Approach section with bridge 500.1
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 3.4 ***ft***

500-year discharge 2,130 ***ft^3/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Road overtopping? Y ***Discharge over road*** 762 ***ft^3/s***
Area of flow in bridge opening 134 ***ft^2***
Average velocity in bridge opening 10.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.4 ***/s***

Water-surface elevation at Approach section with bridge 501.1
Water-surface elevation at Approach section without bridge 498.9
Amount of backwater caused by bridge 2.2 ***ft***

Incipient overtopping discharge 860 ***ft^3/s***
Water-surface elevation in bridge opening 495.8 ***ft***
Area of flow in bridge opening 78 ***ft^2***
Average velocity in bridge opening 11.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.9 ***ft/s***

Water-surface elevation at Approach section with bridge 498.7
Water-surface elevation at Approach section without bridge 496.0
Amount of backwater caused by bridge 2.7 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

Contraction scour for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of the 100- and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8. The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.9	0.5
Depth to armoring	30.0	22.3	23.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	5.8	3.1	4.8
Right abutment	6.5	5.1	5.9
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	1.9	2.2	1.6
Right abutment	1.9	2.2	1.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

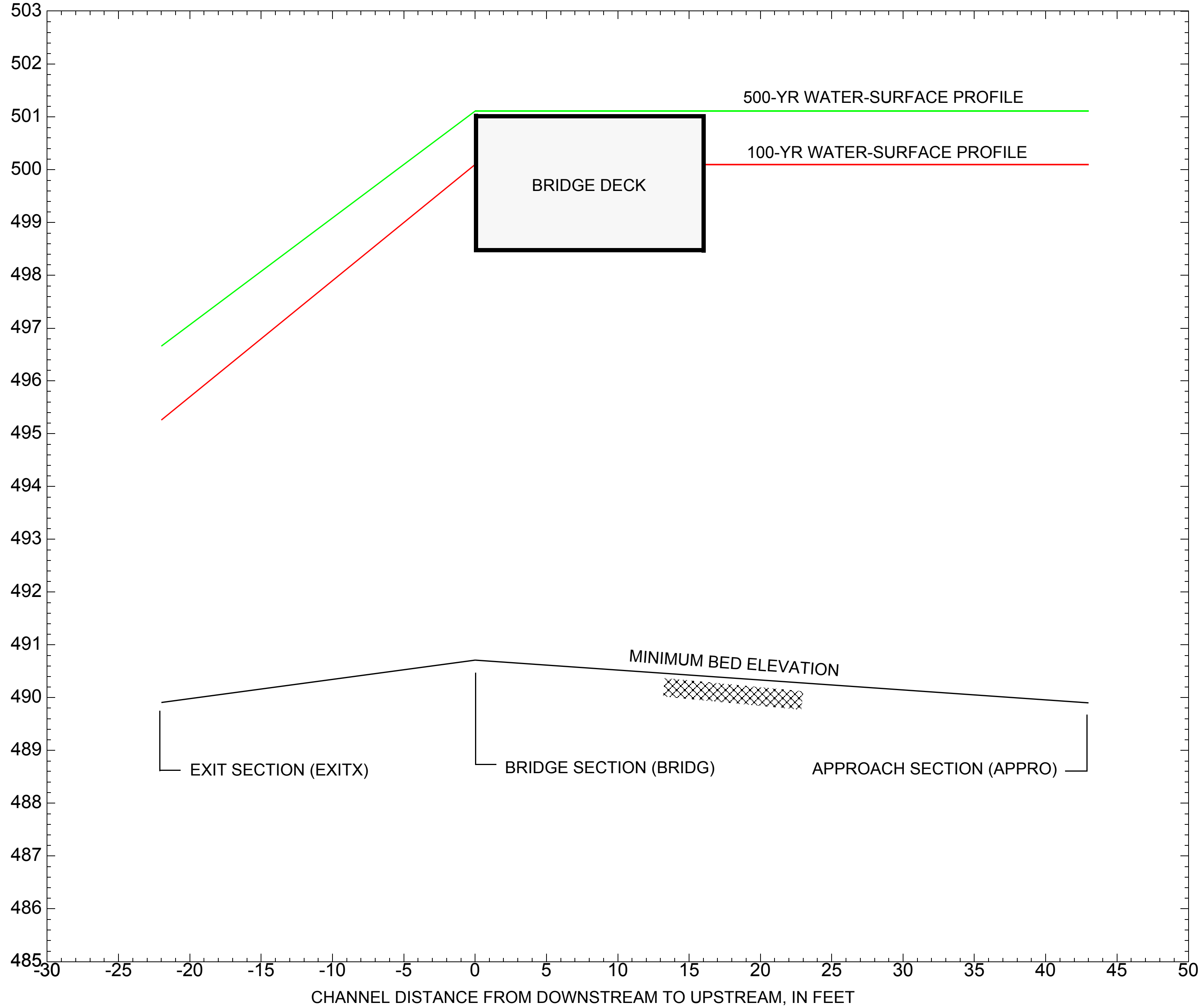

Figure 7. Water-surface profiles for the 100-year and 500-year discharges at structure STOWTH00430036 on Town Highway 43, crossing Miller Brook, Stowe, Vermont.

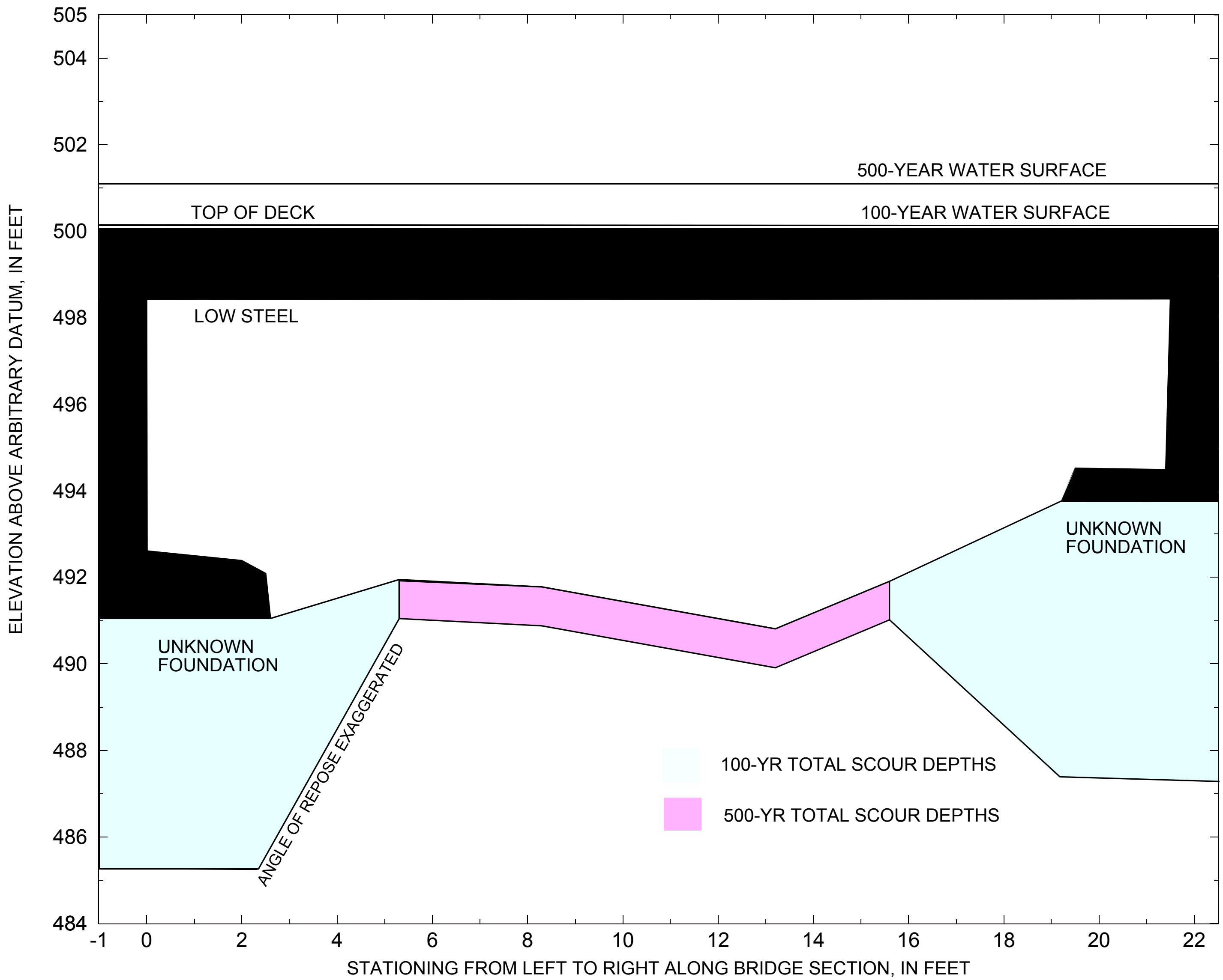

Figure 8. Scour elevations for the 100-year and 500-year discharges at structure STOWTH00430036 on Town Highway 43, crossing Miller Brook, Stowe, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure STOWTH00430036 on Town Highway 43, crossing Miller Brook, Stowe, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,200 cubic-feet per second											
Left abutment	0.0	--	498.4	--	491.1	0.0	5.8	--	5.8	485.3	--
Right abutment	21.5	--	498.4	--	493.8	0.0	6.5	--	6.5	487.3	--

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 STOWTH00430036 on Town Highway 43, crossing Miller Brook, Stowe, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,130 cubic-feet per second											
Left abutment	0.0	--	498.4	--	491.1	0.9	3.1	--	4.0	487.1	--
Right abutment	21.5	--	498.4	--	493.8	0.9	5.1	--	6.0	487.8	--

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, 1948, Bolton Mountain, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File stow036.wsp
T2        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
T3        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
*
J1           * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1200.0   2130.0    860.0
SK          0.0307   0.0307   0.0307
*
XS   EXITX    -22           0.
* GR         -148.0, 514.70   -125.4, 497.25   -65.7, 494.08    -29.4, 504.14
* GR          -29.4, 504.14
GR          -11.2, 503.52    -10.0, 496.21    -4.6, 493.04     -2.0, 491.79
GR            0.0, 489.91      6.4, 490.42     10.1, 490.85     14.4, 491.60
GR           16.9, 491.79     35.6, 493.63     40.1, 497.62
GR           99.8, 497.93
GR          129.2, 503.27    161.7, 508.39
*
N           0.090        0.066        0.090
SA                 -11.2         40.1
*
*
XS   FULLV      0  * * *   0.0178
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.43      10.0
GR            0.0, 498.43      0.2, 492.61      2.0, 492.39      2.5, 492.09
GR            2.6, 491.05      5.3, 491.95      6.6, 490.71      8.3, 491.78
GR           13.2, 490.81     15.6, 491.91     19.2, 493.76     19.5, 494.52
GR           21.4, 494.49     21.5, 498.44      0.0, 498.43
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD          1      29.1 * *     74.3      3.3
N           0.055
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      21.4     2
GR         -154.7, 514.06   -126.9, 503.82    -56.6, 501.18    -16.9, 500.23
GR            0.0, 500.15     16.6, 500.13     42.2, 499.06     63.0, 521.83
*
*
AS   APPRO     43           0.
GR         -229.1, 514.04   -160.0, 509.24    -74.0, 502.06    -31.7, 500.50
GR           -7.6, 500.32     -4.6, 499.45      4.5, 493.48      5.7, 492.89
GR            6.7, 491.14     10.5, 489.90     14.0, 490.15     16.0, 490.46
GR           19.8, 492.87     26.3, 500.42     37.4, 501.10     60.3, 525.83
*
N           0.085        0.060    0.085
SA                 -7.6      26.3
*
*   HP 1, and 2 BRIDG tables will not run with the water surface elevation
*   in the bridge. By lowering the water surface elevation by 0.01 ft the
*   tables are functional(for the Q100 and Q500). Raising the Low chord
*   elevation to 498.44 does not fix the problem.
*
HP 1 BRIDG   498.42 1 498.42
HP 2 BRIDG   498.42 * * 1132
HP 1 BRIDG   496.55 1 496.55
HP 2 RDWAY   500.10 * *   67
HP 1 APPRO   500.10 1 500.10
HP 2 APPRO   500.10 * * 1200
*
HP 1 BRIDG   498.43 1 498.43
HP 2 BRIDG   498.43 * * 1368
HP 1 BRIDG   497.53 1 497.53
HP 2 RDWAY   501.11 * *  762
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File stow036.wsp
        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
           *** RUN DATE & TIME: 09-17-97  08:45
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      134     9059     21     34                         1911
   498.42           134     9059     21     34  1.00      0     21     1911

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.42     0.0    21.5   133.9    9059.    1132.   8.45
X STA.         0.0         2.3         3.5         4.5         5.5         6.4
  A(I)             12.7         8.8         6.7         6.2         6.4
  V(I)             4.45        6.45        8.42        9.06        8.80

X STA.         6.4         7.2         8.0         8.8         9.6        10.4
  A(I)              5.8         5.8         5.4         5.4         5.2
  V(I)             9.79        9.83       10.48       10.45       10.88

X STA.        10.4        11.1        11.9        12.6        13.3        14.0
  A(I)              5.1         5.2         5.2         5.3         5.5
  V(I)            11.06       10.84       10.88       10.74       10.33

X STA.        14.0        14.9        15.8        16.9        18.4        21.5
  A(I)              5.8         6.2         6.8         7.9        12.5
  V(I)             9.75        9.10        8.37        7.18        4.53

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       94     5470     21     30                         1135
   496.55            94     5470     21     30  1.00      0     21     1135

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.10    17.3    43.2    13.4     184.      67.   4.99
X STA.        17.3        25.6        28.2        29.9        31.3        32.5
  A(I)              1.5         1.0         0.8         0.8         0.7
  V(I)             2.31        3.34        3.94        4.20        4.67

X STA.        32.5        33.5        34.4        35.3        36.0        36.7
  A(I)              0.7         0.6         0.6         0.6         0.5
  V(I)             5.02        5.23        5.62        5.77        6.09

X STA.        36.7        37.3        37.9        38.5        39.0        39.5
  A(I)              0.5         0.5         0.5         0.5         0.5
  V(I)             6.37        6.58        6.81        7.08        7.35

X STA.        39.5        40.0        40.6        41.2        41.8        43.2
  A(I)              0.4         0.6         0.6         0.6         0.9
  V(I)             7.48        6.06        5.54        5.35        3.76

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.10    -6.8    26.0   196.0   14009.    1200.   6.12
X STA.        -6.8         2.1         4.3         5.9         7.2         8.1
  A(I)             19.7        13.0        11.3        10.6         8.8
  V(I)             3.05        4.62        5.32        5.67        6.85

X STA.         8.1         9.0         9.8        10.6        11.3        12.0
  A(I)              8.4         7.9         7.7         7.4         7.3
  V(I)             7.11        7.63        7.82        8.14        8.18

X STA.        12.0        12.7        13.5        14.2        15.0        15.8
  A(I)              7.3         7.2         7.5         7.5         7.7
  V(I)             8.25        8.29        7.96        7.95        7.77

X STA.        15.8        16.6        17.7        18.9        20.4        26.0
  A(I)              8.2         9.0         9.9        11.5        18.1
  V(I)             7.28        6.64        6.07        5.23        3.32
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File stow036.wsp
       Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
       C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
          *** RUN DATE & TIME: 09-17-97  08:45
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      134      9059     21     34                         1911
  498.42           134      9059     21     34  1.00      0     21     1911

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.42     0.0    21.5   133.9    9059.    1368.  10.21
X STA.         0.0        2.3        3.5        4.5        5.5        6.4
  A(I)            12.7        8.8        6.7        6.2        6.4
  V(I)            5.37       7.80      10.17      10.95      10.64

X STA.         6.4        7.2        8.0        8.8        9.6       10.4
  A(I)             5.8        5.8        5.4        5.4        5.2
  V(I)           11.83      11.88      12.66      12.63      13.15

X STA.        10.4       11.1       11.9       12.6       13.3       14.0
  A(I)             5.1        5.2        5.2        5.3        5.5
  V(I)           13.36      13.10      13.15      12.98      12.49

X STA.        14.0       14.9       15.8       16.9       18.4       21.5
  A(I)             5.8        6.2        6.8        7.9       12.5
  V(I)           11.78      11.00      10.11       8.68       5.47

   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      115      7296     21     32                         1525
  497.53           115      7296     21     32  1.00      0     21     1525

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.
       WSEL     LEW     REW    AREA        K        Q    VEL
      501.11   -53.7    44.1    88.5    1891.     762.   8.61

X STA.       -53.7      -23.2      -13.8       -8.1       -3.2        1.3
  A(I)            11.1        7.8        5.2        4.5        4.4
  V(I)            3.42       4.89       7.32       8.44       8.69

X STA.         1.3        5.9       10.5       15.1       19.5       22.9
  A(I)             4.4        4.5        4.4        4.5        4.0
  V(I)            8.70       8.46       8.62       8.51       9.52

X STA.        22.9       25.7       28.2       30.4       32.4       34.3
  A(I)             3.7        3.6        3.3        3.2        3.2
  V(I)           10.27      10.72      11.56      11.81      12.08

X STA.        34.3       36.0       37.6       39.1       40.6       44.1
  A(I)             3.0        2.8        2.9        3.0        5.2
  V(I)           12.82      13.50      13.30      12.83       7.39

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1       22       254     41     41                           91
            2      230     17945     34     41                         3402
            3        4        34     11     11                           13
  501.11           256     18233     86     93  1.18    -47     37     2311

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
        WSEL     LEW     REW    AREA        K        Q    VEL
      501.11   -48.2    37.4   255.9   18233.    2130.   8.32

X STA.       -48.2       -0.2        2.8        4.7        6.3        7.4
  A(I)            39.2       16.5       13.4       13.2       11.4
  V(I)            2.72       6.46       7.92       8.08       9.33

X STA.         7.4        8.4        9.3       10.1       10.9       11.7
  A(I)            10.1        9.5        9.2        9.0        9.0
  V(I)           10.51      11.26      11.54      11.85      11.88

X STA.        11.7       12.5       13.3       14.1       14.9       15.8
  A(I)             8.8        8.8        8.8        9.0        9.5
  V(I)           12.11      12.17      12.09      11.80      11.26

X STA.        15.8       16.8       17.9       19.2       21.0       37.4
  A(I)             9.9       10.8       11.6       14.2       24.1
  V(I)           10.77       9.83       9.22       7.50       4.41
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        U.S. Geological Survey WSPRO Input File stow036.wsp
        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
           *** RUN DATE & TIME: 09-17-97  08:45
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       78      4156     21     29                          860
   495.79            78      4156     21     29  1.00      0     21      860

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       495.79     0.1    21.4    78.4    4156.     860.  10.96

X STA.         0.1        2.2        3.4        4.3        5.2        6.1
  A(I)              6.7        4.9        4.0        3.6        3.8
  V(I)             6.39       8.76      10.86      11.94      11.17

X STA.         6.1        6.9        7.6        8.4        9.2       10.0
  A(I)              3.5        3.4        3.4        3.3        3.2
  V(I)            12.37      12.74      12.65      13.15      13.49

X STA.        10.0       10.7       11.4       12.1       12.7       13.4
  A(I)              3.2        3.1        3.1        3.2        3.2
  V(I)            13.46      13.89      13.87      13.51      13.51

X STA.        13.4       14.1       15.0       16.0       17.5       21.4
  A(I)              3.5        3.6        4.0        4.8        7.1
  V(I)            12.34      11.90      10.71       9.05       6.09

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      153     10237     28     34                         2019
   498.67           153     10237     28     34  1.00     -2     25     2019

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      43.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.67    -3.4    24.8   152.8   10237.     860.   5.63

X STA.        -3.4        3.2        5.2        6.7        7.7        8.5
  A(I)             14.5       10.0        9.5        7.4        6.8
  V(I)             2.96       4.30       4.52       5.83       6.29

X STA.         8.5        9.3       10.0       10.7       11.4       12.1
  A(I)              6.4        6.2        6.1        5.8        5.8
  V(I)             6.76       6.92       7.10       7.43       7.47

X STA.        12.1       12.7       13.4       14.1       14.8       15.5
  A(I)              5.8        5.8        5.8        6.0        6.1
  V(I)             7.37       7.41       7.36       7.19       7.03

X STA.        15.5       16.3       17.3       18.4       19.8       24.8
  A(I)              6.6        7.2        7.6        9.1       14.3
  V(I)             6.55       5.96       5.63       4.73       3.00
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File stow036.wsp
        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
           *** RUN DATE & TIME: 09-17-97  08:45

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******     -7      145  1.06 *****  496.32  494.82    1200  495.26
       -21 ******     37     6844  1.00 ***** *******    0.82    8.26

FULLV:FV       22     -8      163  0.85  0.57  496.87 *******    1200  496.02
         0     22     38     8110  1.00  0.00   -0.02    0.70    7.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.02     496.64     496.70
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.52     525.83    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.52     525.83     496.70
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   496.70     525.83     496.70

APPRO:AS       43      0      102  2.15 *****  498.86  496.70    1200  496.70
        43     43     23     5948  1.00 ***** *******    1.00   11.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.95       0.00     496.73     499.06
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   502.44         0.      1200.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
BRIDG:BR       22      0      134  1.11 *****  499.54  496.55    1132  498.43
         0 ******     21     9079  1.00 ***** *******    0.59    8.44

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.461  0.000  498.43 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG       8.    22.  0.16  0.58  500.53    0.00     67.  500.10

           Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:     0.    77.   -67.    10.   1.4   1.0   5.5   5.5   1.5   3.0
  RT:    67.    26.    17.    43.   1.0   0.5   4.1   5.0   0.9   2.8

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       14     -6      196  0.58  0.16  500.68  496.70    1200  500.10
        43     15     26    14016  1.00  0.00    0.00    0.44    6.12

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -22.    -8.    37.   1200.    6844.     145.    8.26  495.26
   FULLV:FV       0.    -9.    38.   1200.    8110.     163.    7.38  496.02
   BRIDG:BR       0.     0.    21.   1132.    9079.     134.    8.44  498.43
   RDWAY:RG       8.*******     0.     67.       0.       0.    2.00  500.10
   APPRO:AS      43.    -7.    26.   1200.   14016.     196.    6.12  500.10

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS     494.82    0.82  489.91  508.39************  1.06  496.32  495.26
   FULLV:FV   ********    0.70  490.30  508.78  0.57  0.00  0.85  496.87  496.02
   BRIDG:BR     496.55    0.59  490.71  498.44************  1.11  499.54  498.43
   RDWAY:RG   ***************  499.06  521.83  0.16******  0.58  500.53  500.10
   APPRO:AS     496.70    0.44  489.90  525.83  0.16  0.00  0.58  500.68  500.10
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        U.S. Geological Survey WSPRO Input File stow036.wsp
        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
           *** RUN DATE & TIME: 09-17-97  08:45

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******     -9      213  1.56 *****  498.23  496.20    2130  496.66
       -21 ******     39    12151  1.00 ***** *******    0.85   10.02

FULLV:FV       22     -9      236  1.26  0.58  498.80 *******    2130  497.53
         0     22     40    14273  1.00  0.00    0.00    0.73    9.02
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.35     497.67     498.90
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   497.03     525.83    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   497.03     525.83     498.90
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   498.90     525.83     498.90

APPRO:AS       43     -3      159  2.78 *****  501.68  498.90    2130  498.90
        43     43     25    10823  1.00 ***** *******    1.00   13.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===210 QUESTIONABLE CRITICAL-FLOW SOLUTION.
                   SECID "BRIDG"     Q,CRWS =  2130.00     498.44
 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   505.39        0.00     498.44
                      CRWS =   498.90   ********     498.44
                      YMAX =   525.83   ********     498.44
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   503.21         0.      2130.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
BRIDG:BR       22      0      134  1.62 *****  500.05  497.15    1368  498.43
         0 ******     21     9079  1.00 ***** *******    0.71   10.20

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.488  0.000  498.43 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    22.  0.30  1.27  502.08    0.00    762.  501.11

            Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    392.    64.   -53.    10.   1.0   0.6   5.7   9.5   1.6   3.0
   RT:    370.    34.    10.    44.   2.0   1.4   7.0   7.9   2.4   3.0

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       14    -47      256  1.27  0.27  502.38  498.90    2130  501.11
        43     15     37    18211  1.18  0.00    0.00    0.92    8.34

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -22.   -10.    39.   2130.   12151.     213.   10.02  496.66
   FULLV:FV       0.   -10.    40.   2130.   14273.     236.    9.02  497.53
   BRIDG:BR       0.     0.    21.   1368.    9079.     134.   10.20  498.43
   RDWAY:RG       8.*******   392.    762.       0.*********    2.00  501.11
   APPRO:AS      43.   -48.    37.   2130.   18211.     256.    8.34  501.11

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    496.20    0.85  489.91  508.39************  1.56  498.23  496.66
   FULLV:FV  ********    0.73  490.30  508.78  0.58  0.00  1.26  498.80  497.53
   BRIDG:BR    497.15    0.71  490.71  498.44************  1.62  500.05  498.43
   RDWAY:RG  ****************  499.06  521.83  0.30******  1.27  502.08  501.11
   APPRO:AS    498.90    0.92  489.90  525.83  0.27  0.00  1.27  502.38  501.11
1
```
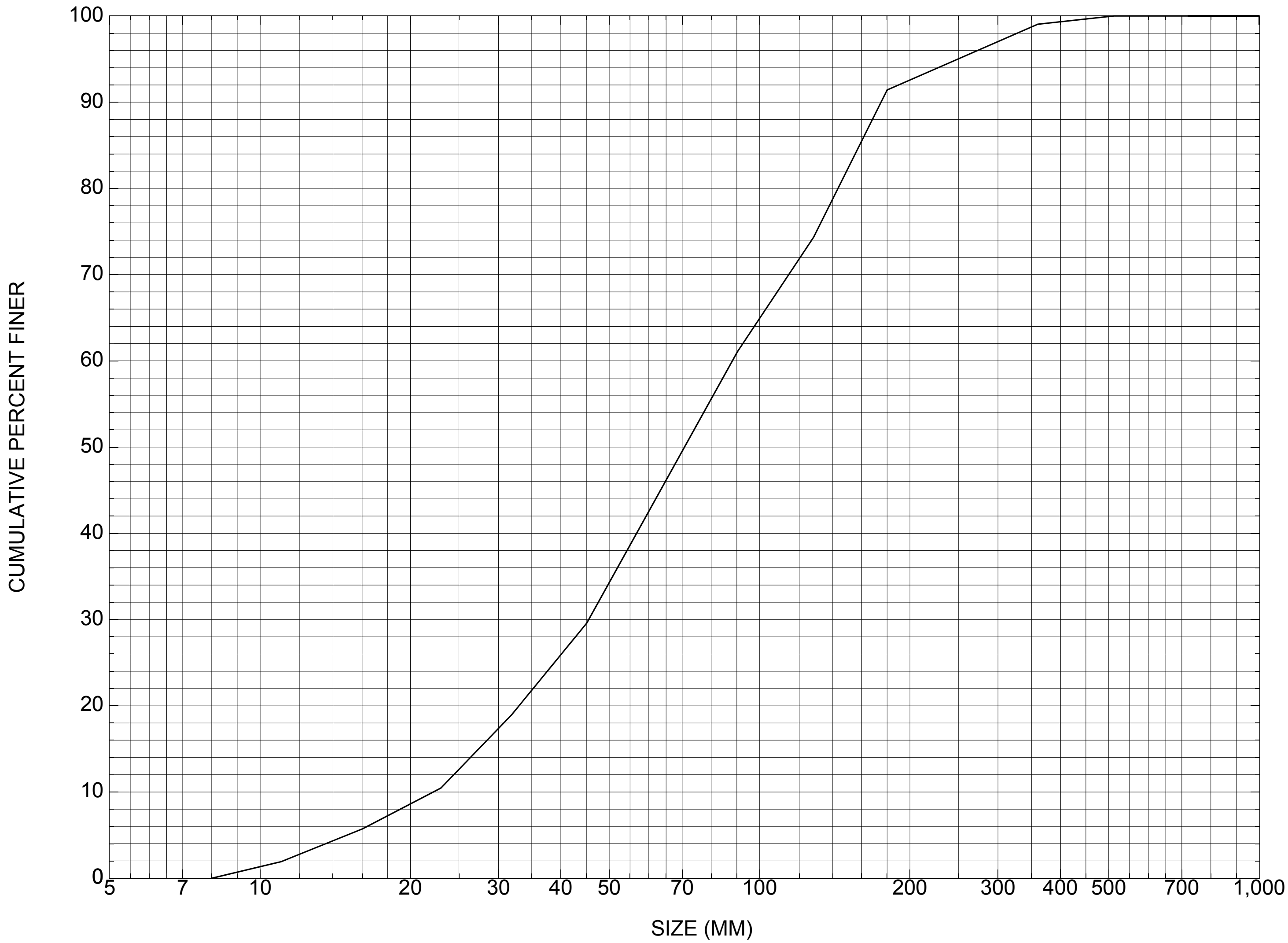

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File stow036.wsp
        Hydraulic analysis for structure STOWTH00430036   Date: 07-JUL-97
        C3043 CROSSING MILLER BROOK, 0.07 MILES TO JUNCTION WITH C3 TH 33
           *** RUN DATE & TIME: 09-17-97  08:45

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******     -6      117  0.84 *****  495.46  494.22     860  494.62
       -21 ******     37     4904  1.00 ***** *******    0.80    7.36

FULLV:FV       22     -7      132  0.66  0.56  496.01 *******     860  495.35
         0     22     37     5900  1.00  0.00   -0.01    0.67    6.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.88    496.04     495.64
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.85    525.83    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.85    525.83    495.64

APPRO:AS       43      1       87  1.52  1.12  497.56  495.64     860  496.04
        43     43     23     4796  1.00  0.43    0.00    0.88    9.90
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =     860.     495.79

            <<<<<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       22      0       79  1.87 *****  497.66  495.79     860  495.79
         0     22     21     4162  1.00 ***** *******    1.00   10.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.43 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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       14     -2      153  0.49  0.26  499.16  495.64     860  498.67
        43     15     25    10234  1.00  1.24   -0.02    0.43    5.63

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.028  0.000   10821.     3.    24.   498.52

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -22.    -7.    37.    860.    4904.     117.    7.36  494.62
   FULLV:FV       0.    -8.    37.    860.    5900.     132.    6.52  495.35
   BRIDG:BR       0.     0.    21.    860.    4162.      79.   10.95  495.79
   RDWAY:RG       8.**************      0.*****************     2.00********
   APPRO:AS      43.    -3.    25.    860.   10234.     153.    5.63  498.67

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    24.   10821.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    494.22    0.80  489.91  508.39************  0.84   495.46  494.62
   FULLV:FV  ********    0.67  490.30  508.78  0.56  0.00  0.66   496.01  495.35
   BRIDG:BR    495.79    1.00  490.71  498.44************  1.87   497.66  495.79
   RDWAY:RG  ****************  499.06  521.83**********************************
   APPRO:AS    495.64    0.43  489.90  525.83  0.26  1.24  0.49   499.16  498.67
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STOWTH00430036, in Stowe, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STOWTH00430036

General Location Descriptive

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

Date *(MM/DD/YY)* 10 / 13 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 70525

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

Waterway *(I - 6)* MILLER BROOK

Road Name *(I - 7):* -

Route Number C3043

Vicinity *(I - 9)* 0.07 MI TO JCT W C3 TH44

Topographic Map Bolton Mountain

Hydrologic Unit Code: 2010003

Latitude *(I - 16; nnnn.n)* 44282

Longitude *(i - 17; nnnnn.n)* 72482

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10080800360808

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

Maximum span length *(I - 48; nnnn)* 0021

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000024

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

Deck Width *(I - 52; nn.n)* 214

Year of ADT *(I - 30; YY)* 93

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

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)* 101

Year Reconstructed *(I - 106)* 1980

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

Clear span (*nnn.n ft*) 19

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

Vertical clearance from streambed (*nnn.n ft*) 6

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

Waterway of full opening (*nnn.n ft*^{2}) 114

Comments:

According to the structural inspection report dated 5/22/95, the deck is a concrete slab and the rails have collision damage. There are minor cracks and spalls at the abutments and wingwalls. Past undermining problems have been repaired. Footings are made from concrete and concrete filled burlap bags. Channel scour is normal at the present time. Embankments have boulders and small areas of erosion. Debris and gravel bars are mostly boulders. The stone fill is partially washed away at the LABUT.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **5.51** mi^2

Lake/pond/swamp area **0.06** mi^2

Watershed storage *(ST)* **1.1** %

Bridge site elevation **1000** ft

Headwater elevation **3360** ft

Main channel length **3.37** mi

10% channel length elevation **1050** ft

85% channel length elevation **2020** ft

Main channel slope *(S)* **383.77** ft / mi

Watershed Precipitation Data

Average site precipitation - in

Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number -

Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:

There is no benchmark information available.

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness - Footing bottom elevation: -

If 2: Pile Type: - (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: -

If 3: Footing bottom elevation: -

Is boring information available? - *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:

There is no foundation information available.

Comments:

-

Cross-sectional Data

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

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

Comments: **This cross-section is of the upstream face. The low chord elevation is from the survey log done for this report on 07/15/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 06/21/93.**

Station	0	2	8	12	19	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	498.4				498.4	-	-	-	-	-	-
Bed elevation	492.5	491.6	491.6	491.8	494.4	-	-	-	-	-	-
Low chord-bed	5.9	6.8	6.8	6.6	4.0	-	-	-	-	-	-

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

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

Comments:

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/18/96
Computerized by: RB Date: 10/21/96
Reviewd by: LKS Date: 09/19/97

Structure Number STOWTH00430036

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. WILD Date *(MM/DD/YY)* 07 / 15 / 1996

2. Highway District Number 06 Mile marker 0000

County Lamoille (015) Town Stowe (70525)

Waterway *(I - 6)* Miller Brook Road Name -

Route Number C3043 Hydrologic Unit Code: 2010003

3. Descriptive comments:

The bridge is located 0.07 miles to the junction with C3 TH44. This bridge has a concrete deck with concrete abutments and wingwalls. The footings are concrete and concrete filled burlap bags.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 6 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US 2 UB 2 DS 2 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 24 *(feet)* Span length 21 *(feet)* Bridge width 21.4 *(feet)*

Road approach to bridge:

8. LB 2 RB 0 *(**0** even, **1**- lower, **2**- higher)*

9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*

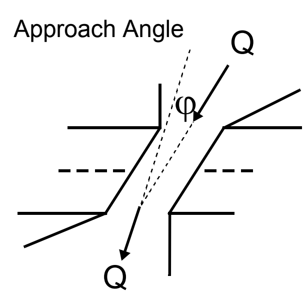
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

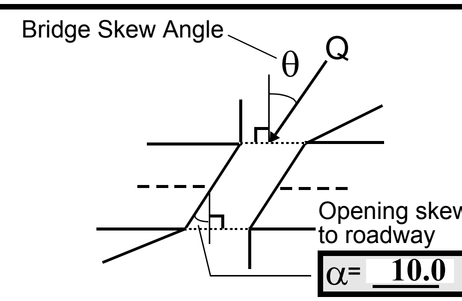
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	3	1	2	1
RBUS	0	-	2	1
RBDS	0	-	2	1
LBDS	0	-	2	1

*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: 5 16. Bridge skew: 10





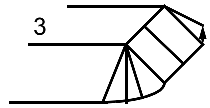
17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 53.2 feet US *(US, UB, DS)* to 14 feet UB

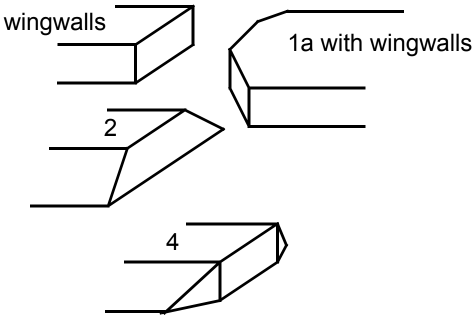
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: 1a

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face
3- Spill through abutments
4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





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

7. The values are from the VTAOT files. The measured bridge length is 23.3 ft and bridge width is 21.3 ft.
11. There is no left bank DS road approach protection, however, a 5 ft x 4 ft boulder exists 8 ft from the DS end of the left abutment.
17. The US channel impact zone is low due to extensive channel protection which is boulders along both banks.
18. The bridge used to be a one lane bridge with a wooden deck, the deck was replaced and widened and now extends over the downstream wingwalls. The abutments are not parallel.

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
21.5	7.0			7.5	3	4	324	324	1	1

23. Bank width 35.0   24. Channel width 50.0   25. Thalweg depth 34.0   29. Bed Material 453

30 .Bank protection type: LB 4 RB 4   31. Bank protection condition: LB 1 RB 1

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

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

30. The right bank protection extends from 23.2 ft US to 0 ft US. The left bank protection extends from 32.0 ft US to 0 ft US.
31. The protection on both the left and the right banks protrudes into the channel.
28. The left bank is eroded from road wash and channel erosion from 59 ft US to 45 ft US.
There is a dam approximately 450 ft US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **79** 35. Mid-bar width: **29.5**

36. Point bar extent: **132** feet **US** (US, UB) to **40** feet **US** (US, UB, DS) positioned **40** %LB to **100** %RB

37. Material: **43**

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

Vegetation on the point bar includes ferns, small plants, small trees, and several large trees. Debris has also accumulated on the point bar.

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

41. Mid-bank distance: **25.3** 42. Cut bank extent: **53.2** feet **US** (US, UB) to **23.2** feet **US** (US, UB, DS)

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

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

The cut bank ends where the right bank protection begins, though there is road wash on top of the protection.

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.):

There is no channel scour present upstream at the site.
There is some local scour behind boulders.

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

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

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

54. Confluence comments (eg. confluence name):

There are no major confluences upstream at this site.

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
15.5		**3.0**		**2**	**7**	**7**	**-**

58. Bank width (BF) **-** 59. Channel width **-** 60. Thalweg depth **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

The right abutment protection protrudes into the channel, therefore the bed material on the right side is mostly boulders.

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? 2___ (*Y or N*) Ice Blockage Potential N____ (*1- Low; 2- Moderate; 3- High*)

70. Debris and Ice Comments:

2

The capture efficiency is moderate due to the low bridge clearance.

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	2	0	2.5	90.0
RABUT	1	25	90			2	2	16.0

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

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

0

3

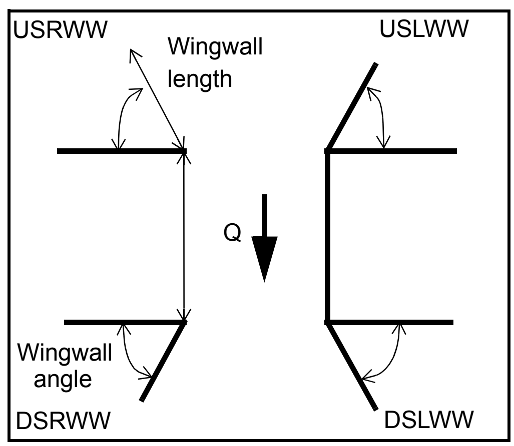
1

There is some local scour behind boulders in the channel under the bridge.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						16.0	
USRWW:	Y		1		2	1.5	
DSLWW:	-		1		Y	15.5	
DSRWW:	1		2		-	16.0	

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	1.2	2	Y	-	-	1	-	1
Condition	Y	-	1	2.5	-	1	-	1
Extent	1	1	2	0	3	0	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

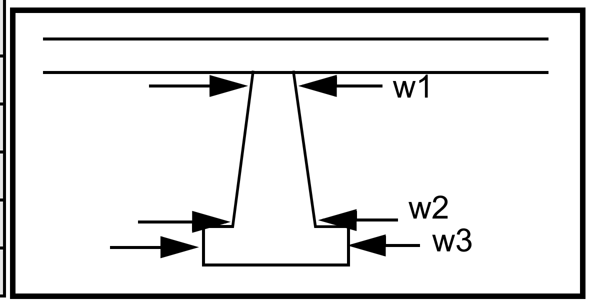
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
2
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				60.0	12.5	90.0
Pier 2	2.5	4.0	7.0	70.0	60.0	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	The	re	are	no	pier

Bank width (BF) -　　Channel width -　　Thalweg depth -　　Bed Material s.

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.):

3
3
34
34
1
1
453
2
2
2

101. Is a drop structure present? **2** *(Y or N, if N type ctrl-n ds)*　　102. Distance: - feet

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

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

e bank protection on both sides protrudes into the channel. The right bank protection extends from 0 ft DS to 13 ft DS. The left bank protection extends from 0 ft DS to 11 ft DS.

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

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

Material: **N**

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

-

There is no drop structure.

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

Cut bank extent: **Y** feet **57** *(US, UB, DS)* to **22** feet **29.** *(US, UB, DS)*

Bank damage: **5** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
73
DS
70

Is channel scour present? **100** *(Y or if N type ctrl-n cs)* Mid-scour distance: **403**

Scour dimensions: Length **The** Width **point** Depth: **bar** Positioned **is** %LB to **veg** %RB

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

etated with grass and very small bushes. A channel bar is located from 52 ft DS to 160 ft DS. The bar is positioned from 20% LB to 50% RB. The material is cobble and gravel. There are several trees and some small plants present at the US end and center of the channel bar.

Are there major confluences? **N** *(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):

There are no cut-banks downstream at this site.

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
-
-
-
-
-
-
There is no channel scour present downstream at this site.

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: STOWTH00430036 Town: STOWE
Road Number: C30 43 County: LAMOILLE
Stream: MILLER BROOK

Initials LKS Date: 09/15/97 Checked: MAI

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	1200	2130	860
Main Channel Area, ft2	196	230	153
Left overbank area, ft2	0	22	0
Right overbank area, ft2	0	4	0
Top width main channel, ft	33	34	28
Top width L overbank, ft	0	41	0
Top width R overbank, ft	0	11	0
D50 of channel, ft	0.2311	0.2311	0.2311
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.9	6.8	5.5
y1, average depth, LOB, ft	ERR	0.5	ERR
y1, average depth, ROB, ft	ERR	0.4	ERR
Total conveyance, approach	14009	18233	10237
Conveyance, main channel	14009	17945	10237
Conveyance, LOB	0	254	0
Conveyance, ROB	0	34	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1200.0	2096.4	860.0
Ql, discharge, LOB, cfs	0.0	29.7	0.0
Qr, discharge, ROB, cfs	0.0	4.0	0.0
Vm, mean velocity MC, ft/s	6.1	9.1	5.6
Vl, mean velocity, LOB, ft/s	ERR	1.3	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.0	ERR
Vc-m, crit. velocity, MC, ft/s	9.3	9.5	9.1
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

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	1200	2130	860	0	1368	0
Total conveyance	14009	18233	10237	0	9059	0
Main channel conveyance	14009	17945	10237	0	9059	0
Main channel discharge	1200	2096	860	ERR	1368	ERR
Area - main channel, ft2	196	230	153	0	133.9	0
(W1) channel width, ft	33	34	28	0	21.2	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	33	34	28	0	21.2	0
D50, ft	0.2311	0.2311	0.2311			
w, fall velocity, ft/s (p. 32)	0	3.93	0			
y, ave. depth flow, ft	5.94	6.76	5.46	ERR	6.32	ERR
S1, slope EGL	0	0.07	0			
P, wetted perimeter, MC, ft	0	39	0			
R, hydraulic Radius, ft	ERR	5.897	ERR			
V*, shear velocity, ft/s	N/A	3.646	N/A			
V*/w	ERR	0.928	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	0.69	0			
y2,depth in contraction, ft	ERR	6.50	ERR			
ys, scour depth, ft (y2-y_bridge)	N/A	0.18	N/A			

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1200	2130	860
(Q) discharge thru bridge, cfs	1132	1368	860
Main channel conveyance	9059	9059	4156
Total conveyance	9059	9059	4156
Q2, bridge MC discharge,cfs	1132	1368	860
Main channel area, ft2	134	134	78
Main channel width (normal), ft	21.2	21.2	21.0
Cum. width of piers in MC, ft	0.0	0.0	0.0

W, adjusted width, ft	21.2	21.2	21
y_bridge (avg. depth at br.), ft	6.32	6.32	3.71
Dm, median (1.25*D50), ft	0.288875	0.288875	0.288875
y2, depth in contraction,ft	5.34	6.28	4.25
ys, scour depth (y2-ybridge), ft	-0.98	-0.04	**0.54**

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1) Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	1200	2130	860
Q, thru bridge MC, cfs	1132	1368	860
Vc, critical velocity, ft/s	9.26	9.46	9.13
Va, velocity MC approach, ft/s	6.12	9.11	5.62
Main channel width (normal), ft	21.2	21.2	21.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	21.2	21.2	21.0
qbr, unit discharge, ft2/s	53.4	64.5	41.0
Area of full opening, ft2	133.9	133.9	78.0
Hb, depth of full opening, ft	6.32	6.32	3.71
Fr, Froude number, bridge MC	0.59	0.71	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	94	115	N/A
**Hb, depth at downstream face, ft	4.43	5.42	N/A
**Fr, Froude number at DS face	1.01	0.90	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A
Elevation of Low Steel, ft	498.43	498.43	0
Elevation of Bed, ft	492.11	492.11	-3.71
Elevation of Approach, ft	500.1	501.11	0
Friction loss, approach, ft	0.16	0.27	0
Elevation of WS immediately US, ft	499.94	500.84	0.00
ya, depth immediately US, ft	7.83	8.73	3.71
Mean elevation of deck, ft	500.14	500.14	0
w, depth of overflow, ft (>=0)	0.00	0.70	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.94	1.00
**Cc, for downstream face (<=1.0)	0.815623	0.897641	ERR
Ys, scour w/Chang equation, ft	**-0.23**	**0.94**	N/A
Ys, scour w/Umbrell equation, ft	0.41	2.62	N/A

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

**Ys, scour w/Chang equation, ft	2.64	2.17	N/A

**Ys, scour w/Umbrell equation, ft	2.29	3.52	ERR

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	5.34	LOOK-UP	4.25
WSEL at downstream face, ft	496.55	497.53	--
Depth at downstream face, ft	4.43	5.42	N/A
Ys, depth of scour (Laursen), ft	0.90	ERR	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]

Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1132	1368	860
Main channel area (DS), ft2	94	115	78
Main channel width (normal), ft	21.2	21.2	21.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	21.2	21.2	21.0
D90, ft	0.5740	0.5740	0.5740
D95, ft	0.8216	0.8216	0.8216
Dc, critical grain size, ft	0.7075	0.6330	0.6421
Pc, Decimal percent coarser than Dc	0.066	0.078	0.077
Depth to armoring, ft	**30.05**	**22.34**	**23.20**

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1200	2130	860	1200	2130	860
a', abut.length blocking flow, ft	6.9	48.3	3.6	4.7	16.1	3.8
Ae, area of blocked flow ft2	15.27	11.02	7.91	14.26	13.45	10.87
Qe, discharge blocked abut.,cfs	46.52	--	23.45	--	--	32.68
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.05	2.87	2.97	3.31	4.42	3.01
ya, depth of f/p flow, ft	2.21	0.23	2.20	3.03	0.84	2.86
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	80	80	80	100	100	100
K2	0.98	0.98	0.98	1.01	1.01	1.01
Fr, froude number f/p flow	0.361	0.550	0.353	0.325	0.642	0.313
ys, scour depth, ft	**5.77**	**3.13**	**4.84**	**6.52**	**5.13**	**5.87**

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)	6.9	48.3	3.6	4.7	16.1	3.8
y1 (depth f/p flow, ft)	2.21	0.23	2.20	3.03	0.84	2.86
a'/y1	3.12	211.70	1.64	1.55	19.27	1.33
Skew correction (p. 49, fig. 16)	0.97	0.97	0.97	1.02	1.02	1.02
Froude no. f/p flow	0.36	0.55	0.35	0.33	0.64	0.31
Ys w/ corr. factor K1/0.55:						
vertical	ERR	1.32	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	1.08	ERR	ERR	ERR	ERR
spill-through	ERR	0.72	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1.01	0.9	1	1.01	0.9	1
y, depth of flow in bridge, ft	4.43	5.42	3.71	4.43	5.42	3.71
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	**1.86**	**2.20**	**1.55**	**1.86**	**2.20**	**1.55**