LEVEL II SCOUR ANALYSIS FOR BRIDGE 43 (BETHTH00070043) on TOWN HIGHWAY 7, crossing GILEAD BROOK, BETHEL, VERMONT

U.S. Geological Survey
Open-File Report 96-307

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

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By MICHAEL A. IVANOFF and SCOTT A. OLSON

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Pembroke, New Hampshire

1996

U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 43 (BETHTH00070043) ON TOWN HIGHWAY 7, CROSSING GILEAD BROOK, BETHEL, VERMONT

By Michael A. Ivanoff and Scott A. Olson

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BETHTH00070043 on town highway 7 crossing Gilead Brook, Bethel, 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge available from VTAOT files was compiled prior to conducting Level I and Level II analyses and can be found in Appendix D.

The site is in the Green Mountain physiographic province of central Vermont in the town of Bethel. The 6.81-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the banks have dense woody vegetation coverage except for the downstream right bank near the bridge, which is grass covered.

In the study area, Gilead Brook has an incised, slightly sinuous channel with a slope of approximately 0.0181 ft/ft, an average channel top width of 36 ft and an average channel depth of 4.0 ft. The predominant channel bed material is cobble (D_{50} is 79.6 mm or 0.261 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 19, 1994, indicated that the reach was stable.

The town highway 7 crossing of Gilead Brook is a 31-ft-long, two-lane bridge consisting of one 27-foot concrete slab type superstructure (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 15 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed at the right side of the downstream bridge face during the Level I assessment. The scour protection measures in place at the site were type-1 stone fill (less than 12 inches diameter) along the right abutment and both downstream banks, type-2 stone fill (less than 36 inches diameter) on all of the road approach embankments, both upstream banks, and along the entire base length of the wingwalls. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 1.4 ft. The worst-case contraction scour occurred at the incipient overtopping discharge, which was between the 100- and 500-year discharges. Abutment scour ranged from 6.6 to 11.0 ft. with the worst-case scenario occurring at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). Many factors, including historical performance during flood events, the geomorphic assessment, scour protection measures, and the results of the hydraulic analyses, must be considered to properly assess the validity of abutment scour results. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein, based on the consideration of additional contributing factors and experienced engineering judgement.

Randolph, VT. Quadrangle, 1:24,000, 1981

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 BETHTH00070043 *Stream* Gilead Brook

County Windsor *Road* TH 7 *District* 04

Description of Bridge

Bridge length 31.0 *ft* *Bridge width* 26.0 *ft* *Max span length* 27.0 *ft*

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

Abutment type Vertical *Embankment type* Sloping

Stone fill on abutment? Yes *Date of inspection* 10/19/94

Description of stone fill Type-1, along the right abutment and both downstream banks. Type-2, on all of the road approach embankments, both upstream banks, and along the entire base length of all wingwalls.

Abutments and wingwalls are concrete. There is a 0.5 feet deep scour hole near the downstream end of right abutment.

Y 30

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

There is a mild channel bend in the upstream reach.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	10/19/94	0	0
Level II	10/19/94	--	--

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date) 10/19/94 -- There is a point bar along the left abutment under the bridge.

Description of the Geomorphic Setting

General topography The channel has a flat to slightly irregular flood plain with steep valley walls on both sides.

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

Date of inspection 10/19/94

DS left: Steep valley wall

DS right: Steep channel bank to a narrow floodplain

US left: Steep channel bank to a narrow floodplain

US right: Steep channel bank to a narrow floodplain

Description of the Channel

Average top width 36.0 *ft* ***Average depth*** 4.0 *ft*

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

Slightly sinuous with non-alluvial channel boundaries and a narrow flood plain.

10/19/94

Vegetative co Forest

DS left: Brush with short grass on the floodplain

DS right: Trees and brush

US left: Short grass and brush with a few trees.

US right:

Do banks appear stable? Y -

date of observation.

The assessment of 10/19/94 noted a point bar along the left abutment under the bridge.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.81 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	*Percent of drainage area*
Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There is a house on both the upstream right overbank area and on the downstream right overbank area.

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

USGS gage description -

USGS gage number -

Gage drainage area - ***mi***^{2}

Is there a lake/p - No

-

Calculated Discharges

Q100 1,750 ***ft***^{3}***/s*** ***Q500*** 2,300 ***ft***^{3}***/s***

The 100- and 500-year discharges were selected by a range of empirical methods (NEHL, FFF1, Benson, FHWA, Talbot, and a drainage area relationship [(6.8/8.8)exp 0.7] with bridge number 38 in Bethel). Bridge number 38 crosses Gilead Brook downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 38 is 8.8 square miles (VTAOT, written communication, 1995).

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 9 ft. to USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont brass tablet on top of the DS end of the right abutment (elev. 500.88 ft, arbitrary survey datum). RM2 is a chiseled X in a chiseled square on top of the US end of the left abutment (elev. 501.75 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXTEM	-60	1	Exit section as surveyed (Used as a template)
EXITX	-60	3	Modelled Exit section (Templated from EXTEM)
FULLV	0	2	Downstream Full-valley section (Templated from EXTEM)
BRIDG	0	1	Bridge section
RDWAY	16	1	Road Grade section
APPRO	57	2	Modelled Approach section (Templated from APTEM)
APTEM	80	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 analysis 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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.065, and overbank "n" values ranged from 0.060 to 0.080.

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 0.0181 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1966). The surveyed exit section (EXTEM) was truncated at station 36.6 to reduce excessive flow over the floodplain.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.022 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.

The incipient overtopping discharge is 1980 cfs.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.5 *ft*
Average low steel elevation 499.7 *ft*

100-year discharge 1,750 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 140 *ft²*
Average velocity in bridge opening 12.5 *ft/s*
Maximum WSPRO tube velocity at bridge 15.5 *ft/s*

Water-surface elevation at Approach section with bridge 499.3
Water-surface elevation at Approach section without bridge 498.1
Amount of backwater caused by bridge 1.2 *ft*

500-year discharge 2,300 *ft³/s*
Water-surface elevation in bridge opening 499.9 *ft*
Road overtopping? Y *Discharge over road* 306 *ft³/s*
Area of flow in bridge opening 221 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 10.5 *ft/s*

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 499.1
Amount of backwater caused by bridge 2.5

Incipient overtopping discharge 1,980 *ft³/s*
Water-surface elevation in bridge opening 496.7 *ft*
Area of flow in bridge opening 147 *ft²*
Average velocity in bridge opening 13.5 *ft/s*
Maximum WSPRO tube velocity at bridge 16.7 *ft/s*

Water-surface elevation at Approach section with bridge 500.0
Water-surface elevation at Approach section without bridge 498.5
Amount of backwater caused by bridge 1.5 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the 100-year and incipient road-overflow discharges. Contraction scour was computed for the 500-year discharge by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146). There was orifice flow at the bridge for the 500-year modelled discharge. 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). The results of Laursen's clear-water contraction scour (Richardson and others, 1995, p. 32, equation 20) were also computed for the 500-year discharge and can be found in appendix F. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the incipient road-overflow model resulted in the worst case contraction scour with a scour depth of 1.4 ft.

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.

The incipient road-overflow model resulted in the worst case total scour with depths of 12.1 ft. and 12.6 ft. respectively for the left and right abutments.

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	0.9	0.0	1.4
Depth to armoring	21.0	1.6	30.5
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	8.8	11.0	10.0
Right abutment	9.6	6.6	10.5
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	2.3	1.6	2.4
Right abutment	2.3	1.6	2.4
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

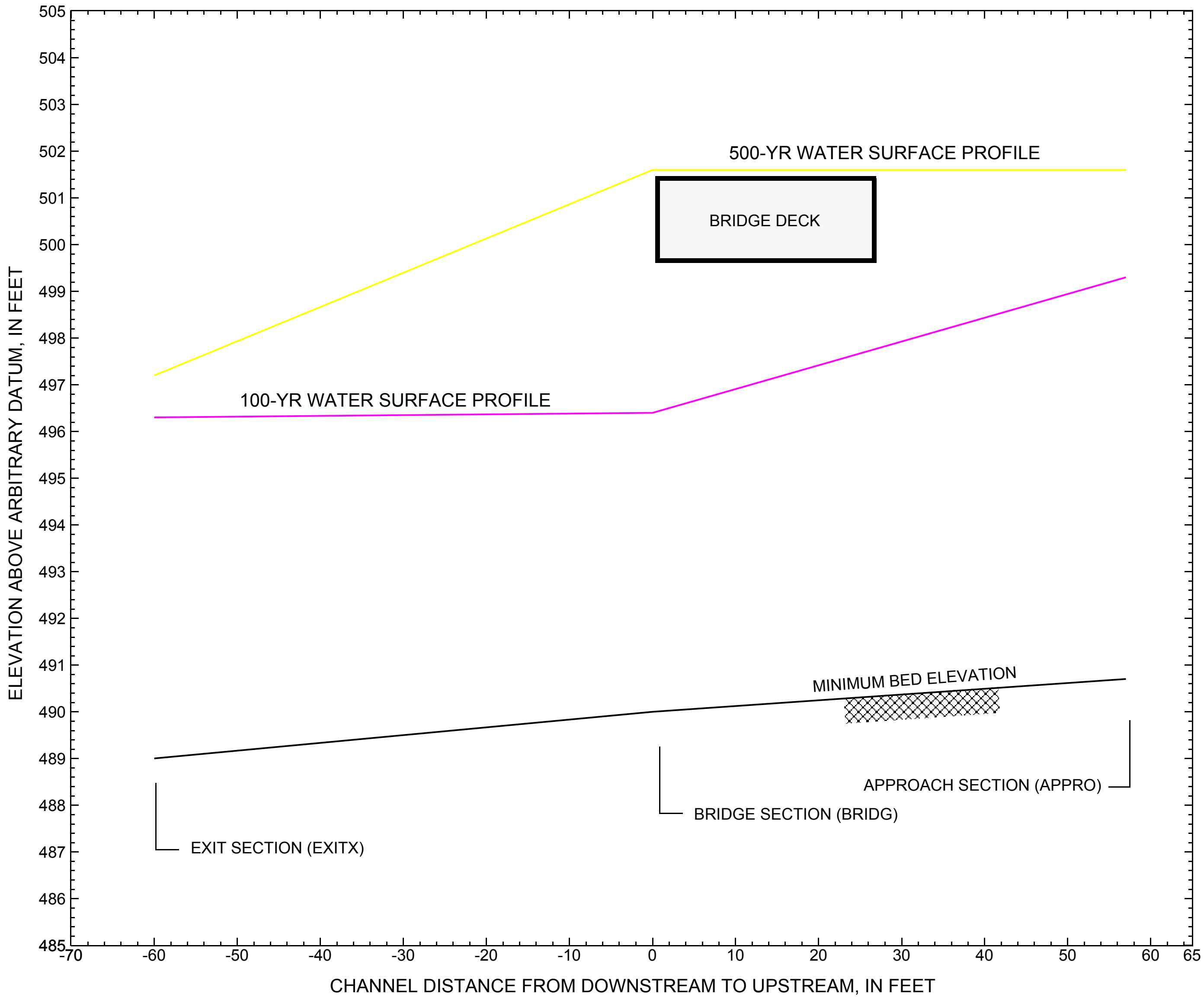

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BETHTH00070043 on town highway 7, crossing Gilead Brook, Bethel, Vermont.

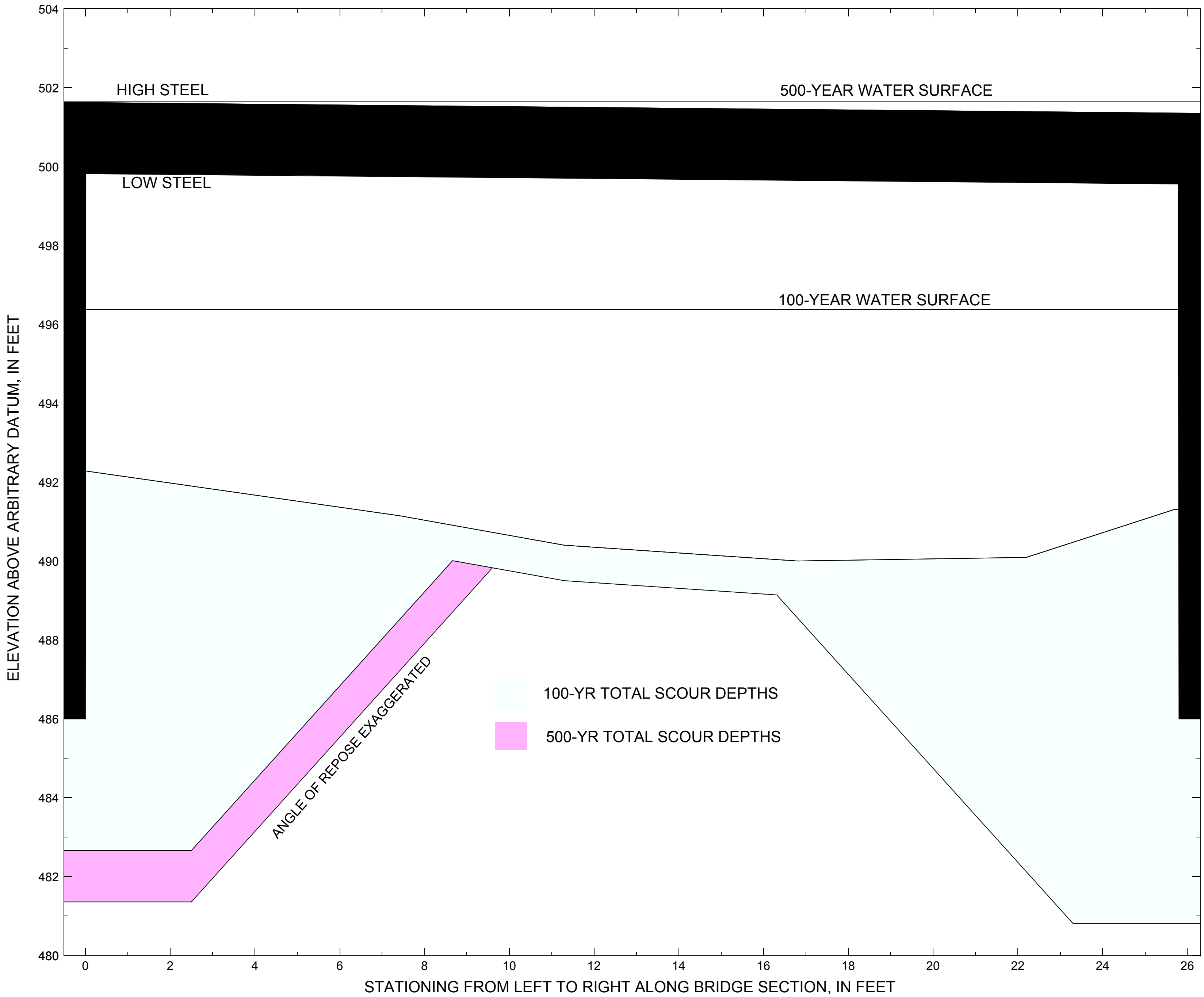

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BETHTH00070043 on town highway 7, crossing Gilead Brook, Bethel, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00070043 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,750 cubic-feet per second											
Left abutment	0.0	509.3	500.0	486	492.4	0.9	8.8	--	9.7	482.7	-3
Right abutment	25.8	508.5	499.4	486	491.3	0.9	9.6	--	10.5	480.8	-5

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 BETHTH00070043 on Town Highway 7, crossing Gilead Brook, Bethel, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,300 cubic-feet per second											
Left abutment	0.0	509.3	500.0	486	492.4	0	11.0	--	11.0	481.4	-5
Right abutment	25.8	508.5	499.4	486	491.3	0	6.6	--	6.6	484.7	-1

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, 1981, Randolph, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File beth043.wsp
T2        Hydraulic analysis for structure BETHTH00070043   Date: 08-FEB-96
T3        Hydrologic analysis for Bethel bridge 43 over Gilead Brook by MAI
Q           1750.0,   2300.0,   1980.0
SK          0.0181,   0.0181,   0.0181
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XT   EXTEM    -60
GR          -16.2, 503.66     -5.9, 493.41     -1.1, 490.21      0.0, 489.51
GR            5.3, 489.68      9.0, 489.00     12.1, 489.73     24.4, 491.19
GR           31.4, 495.05     36.6, 496.88    238.1, 497.45    248.5, 504.03
*
XS   EXITX    -60
GT              0  -16.2  36.6
N           0.065
*
XS   FULLV      0  * * *  0.0117
*
*             SRD     LSEL    XSSKEW
BR   BRIDG    0     499.9      15.0
GR            0.0, 499.96      0.0, 492.36      7.4, 491.15     11.3, 490.40
GR           16.8, 490.00     22.2, 490.09     25.7, 491.31     25.8, 491.31
GR           25.8, 499.36      0.0, 499.96
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      42.5 * *     50.0      9.5
N           0.0450
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     16      26.0     2
GR         -220.0, 510.36   -139.0, 505.50      0.0, 501.83     26.9, 501.15
GR           79.7, 500.50    223.5, 506.20
*
XT   APTEM     80
GR          -65.8, 504.21    -25.2, 501.39     -9.6, 498.42     -5.1, 496.21
GR            5.1, 492.36      8.8, 492.16     12.4, 491.20     15.3, 491.18
GR           19.9, 491.48     22.3, 491.83     22.3, 491.83     29.1, 495.53
GR           37.7, 501.16     83.3, 501.57    168.2, 502.77    174.6, 507.33
*
AS   APPRO     57
GT          -0.51
N           0.080        0.055        0.060
SA                -14.7         32.6
*
HP 1 BRIDG   496.37 1 496.37
HP 2 BRIDG   496.37 * * 1750
HP 1 APPRO   499.26 1 499.26
HP 2 APPRO   499.26 * * 1750
*
HP 1 BRIDG   499.90 1 499.90
HP 2 BRIDG   499.90 * * 1986
HP 2 RDWAY   501.63 * * 306
HP 1 APPRO   501.63 1 501.63
HP 2 APPRO   501.63 * * 2300
*
HP 1 BRIDG   496.66 1 496.66
HP 2 BRIDG   496.66 * * 1980
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File beth043.wsp
        Hydraulic analysis for structure BETHTH00070043   Date: 08-FEB-96
        Hydrologic analysis for Bethel bridge 43 over Gilead Brook by MAI
           *** RUN DATE & TIME: 03-07-96  09:52
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =      0.
     WSEL  SA#    AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     139     11746     25     34                         1873
   496.37          139     11746     25     34  1.00      0     26     1873

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =      0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.37     0.0    25.8   139.5   11746.    1750.  12.55

X STA.        0.0        3.0        4.9        6.4        7.8        9.0
  A(I)            12.5        8.2        7.3        6.8        6.5
  V(I)            6.99      10.67      12.05      12.84      13.39

X STA.        9.0       10.1       11.2       12.2       13.2       14.2
  A(I)             6.1        6.0        5.9        5.7        5.8
  V(I)           14.26      14.49      14.86      15.38      15.20

X STA.       14.2       15.1       16.0       17.0       17.9       18.9
  A(I)             5.7        5.7        5.6        5.7        5.8
  V(I)           15.46      15.30      15.50      15.22      14.97

X STA.       18.9       19.8       20.9       22.0       23.3       25.8
  A(I)             6.0        6.4        6.7        8.1       12.9
  V(I)           14.69      13.67      13.09      10.87       6.76

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     57.
     WSEL  SA#    AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       0         2      2      2                            1
             2     264     21536     47     50                         3534
             3       3        63      3      4                           16
   499.26          267     21601     52     56  1.02    -16     36     3398

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     57.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.26   -16.7    35.6   267.0   21601.    1750.   6.55

X STA.      -16.7       -2.3        1.1        3.5        5.4        7.1
  A(I)            27.5       17.5       15.2       13.7       12.7
  V(I)            3.19       5.01       5.77       6.41       6.87

X STA.        7.1        8.7       10.2       11.6       12.8       14.1
  A(I)            12.0       11.9       11.2       10.9       10.7
  V(I)            7.28       7.37       7.81       8.01       8.19

X STA.       14.1       15.3       16.5       17.8       19.0       20.3
  A(I)            10.4       10.4       10.4       10.7       10.7
  V(I)            8.38       8.41       8.39       8.19       8.18

X STA.       20.3       21.7       23.2       25.0       27.5       35.6
  A(I)            11.1       11.7       12.8       14.6       21.1
  V(I)            7.89       7.51       6.85       6.01       4.14
```

WSPRO OUTPUT FILE (continued)

```
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      221     16883      2     63                        11842
    499.90           221     16883      2     63  1.00      0     26    11842

     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        499.90     0.0    25.8   221.4   16883.    1986.   8.97

 X STA.        0.0        2.4        3.9        5.3        6.6        7.8
   A(I)            17.8       11.6       11.1       10.4       10.3
   V(I)            5.57       8.59       8.94       9.51       9.67

 X STA.        7.8        8.9       10.1       11.2       12.2       13.3
   A(I)             9.8       10.0        9.5        9.5        9.6
   V(I)           10.09       9.93      10.47      10.45      10.39

 X STA.       13.3       14.3       15.4       16.4       17.4       18.5
   A(I)             9.4        9.5        9.6        9.6        9.8
   V(I)           10.53      10.47      10.29      10.34      10.17

 X STA.       18.5       19.6       20.7       21.9       23.4       25.8
   A(I)             9.9       10.3       11.0       12.6       20.0
   V(I)           10.00       9.61       8.99       7.90       4.96

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      16.
          WSEL     LEW     REW    AREA        K        Q    VEL
        501.63     7.9   108.2    63.2    1064.     306.   4.84

 X STA.        7.9       29.5       36.8       42.5       47.4       51.5
   A(I)             5.8        4.1        3.6        3.4        3.1
   V(I)            2.63       3.73       4.21       4.52       4.91

 X STA.       51.5       55.2       58.5       61.6       64.5       67.2
   A(I)             3.0        2.9        2.7        2.7        2.6
   V(I)            5.15       5.31       5.65       5.71       5.86

 X STA.       67.2       69.8       72.2       74.6       76.8       79.1
   A(I)             2.5        2.5        2.5        2.4        2.5
   V(I)            6.06       6.06       6.15       6.27       6.21

 X STA.       79.1       81.4       84.1       87.5       92.2      108.2
   A(I)             2.6        2.7        3.0        3.4        5.1
   V(I)            5.95       5.61       5.05       4.49       3.01

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      57.
      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1       22       429     21     22                          131
              2      376     38864     47     50                         6012
              3       60      1131     91     92                          279
    501.63           459     40425    160    164  1.32    -35    124     3832

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      57.
          WSEL     LEW     REW    AREA        K        Q    VEL
        501.63   -36.0   123.6   458.6   40425.    2300.   5.02

 X STA.      -36.0       -7.1       -2.8        0.4        2.8        4.9
   A(I)            49.8       25.6       23.3       20.6       19.9
   V(I)            2.31       4.49       4.94       5.59       5.77

 X STA.        4.9        6.8        8.5       10.3       11.8       13.3
   A(I)            18.0       17.3       17.6       16.8       16.3
   V(I)            6.38       6.65       6.55       6.83       7.05

 X STA.       13.3       14.8       16.3       17.8       19.3       20.8
   A(I)            16.0       16.0       16.1       16.5       16.5
   V(I)            7.17       7.18       7.15       6.98       6.97

 X STA.       20.8       22.5       24.4       26.8       30.1      123.6
   A(I)            17.1       18.4       20.6       23.2       72.9
   V(I)            6.73       6.25       5.58       4.95       1.58
```

WSPRO OUTPUT FILE (continued)

```
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      147     12636     25     35                         2020
   496.66           147     12636     25     35  1.00      0     26     2020

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       496.66     0.0    25.8   146.7   12636.    1980.  13.50

X STA.         0.0         3.0         4.8         6.4         7.7         8.9
  A(I)            13.3         8.7         7.6         7.0         6.9
  V(I)            7.45       11.43       12.96       14.16       14.42

X STA.         8.9        10.1        11.1        12.1        13.1        14.1
  A(I)             6.4         6.3         6.2         6.0         5.9
  V(I)           15.39       15.66       16.06       16.37       16.71

X STA.        14.1        15.0        16.0        16.9        17.9        18.8
  A(I)             6.0         6.0         5.9         6.0         6.2
  V(I)           16.62       16.45       16.67       16.37       16.09

X STA.        18.8        19.8        20.8        22.0        23.3        25.8
  A(I)             6.3         6.7         7.0         8.5        13.7
  V(I)           15.78       14.69       14.06       11.65        7.22

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      57.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1        4        45      6      6                           15
             2      301     26788     47     50                         4301
             3        6       154      4      5                           38
   500.04           310     26987     58     62  1.04    -20     37     4001

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      57.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.04   -20.8    36.8   309.8   26987.    1980.   6.39

X STA.       -20.8        -3.9        -0.3         2.3         4.5         6.2
  A(I)            31.8        20.0        17.5        16.1        14.5
  V(I)            3.12        4.95        5.67        6.14        6.85

X STA.         6.2         7.9         9.5        11.0        12.4        13.7
  A(I)            14.1        13.3        13.3        12.7        12.2
  V(I)            7.04        7.44        7.47        7.78        8.12

X STA.        13.7        15.0        16.3        17.6        19.0        20.4
  A(I)            12.2        12.2        12.2        12.5        12.2
  V(I)            8.11        8.13        8.11        7.92        8.09

X STA.        20.4        21.8        23.4        25.4        28.0        36.8
  A(I)            12.9        13.5        14.8        17.0        24.9
  V(I)            7.66        7.32        6.68        5.83        3.98
```

WSPRO OUTPUT FILE (continued)

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File beth043.wsp
        Hydraulic analysis for structure BETHTH00070043   Date: 08-FEB-96
        Hydrologic analysis for Bethel bridge 43 over Gilead Brook by MAI
           *** RUN DATE & TIME: 03-07-96  09:52

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

EXITX:XS   ******     -8      210  1.08 *****  497.34  494.90    1750  496.26
       -59 ******     35    13007  1.00 ***** *******    0.67    8.33

FULLV:FV       60     -8      230  0.90  0.96  498.30 *******    1750  497.40
         0     60     36    14686  1.00  0.00    0.00    0.60    7.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       57    -10      210  1.08  0.76  499.16 *******    1750  498.08
        57     57     34    15600  1.00  0.09    0.01    0.67    8.33
         <<<<<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       60      0      140  2.45  1.20  498.82  496.12    1750  496.37
         0     60     26    11747  1.00  0.28    0.00    0.93   12.54

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.90 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.        <<<<<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       15    -16      267  0.68  0.18  499.94  496.75    1750  499.26
        57     15     36    21591  1.02  0.94    0.01    0.52    6.56

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.417  0.061   20189.     0.    26.   499.05

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.    -9.    35.   1750.   13007.     210.    8.33  496.26
   FULLV:FV       0.    -9.    36.   1750.   14686.     230.    7.62  497.40
   BRIDG:BR       0.     0.    26.   1750.   11747.     140.   12.54  496.37
   RDWAY:RG      16.**************      0.*****************    2.00********
   APPRO:AS      57.   -17.    36.   1750.   21591.     267.    6.56  499.26

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    494.90    0.67  489.00  504.03************  1.08  497.34  496.26
   FULLV:FV  ********    0.60  489.70  504.73  0.96  0.00  0.90  498.30  497.40
   BRIDG:BR    496.12    0.93  490.00  499.96  1.20  0.28  2.45  498.82  496.37
   RDWAY:RG ****************  500.50  510.36**********************************
   APPRO:AS    496.75    0.52  490.67  506.82  0.18  0.94  0.68  499.94  499.26
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -9      255  1.27 *****  498.51  495.79    2300  497.25
       -59 ******     37    17086  1.00 ***** *******    0.68    9.02

FULLV:FV       60     -9      276  1.08  0.96  499.49 *******    2300  498.41
         0     60     37    19255  1.00  0.00    0.01    0.60    8.32
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       57    -15      259  1.24  0.76  500.34 *******    2300  499.10
        57     57     35    20566  1.01  0.08    0.01    0.70    8.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.00       0.00     497.19     500.50

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   503.98         0.      2300.

 ===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       60      0      221  1.25 *****  501.15  496.61    1986  499.90
         0 ******     26    16883  1.00 ***** *******    0.54    8.97

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.441 ******  499.90 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.    31.  0.10  0.52  502.05    0.00    306.  501.63

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    59.   -45.    14.   1.5   0.8   5.0   5.5   1.3   3.0
   RT:    306.    94.    14.   108.   1.1   0.7   4.5   4.9   1.1   2.9

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

APPRO:AS       15    -35      459  0.52  0.10  502.15  497.61    2300  501.63
        57     15    124    40425  1.32  0.00    0.00    0.60    5.02

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.   -10.    37.   2300.   17086.     255.    9.02  497.25
   FULLV:FV       0.   -10.    37.   2300.   19255.     276.    8.32  498.41
   BRIDG:BR       0.     0.    26.   1986.   16883.     221.    8.97  499.90
   RDWAY:RG      16.*******     0.    306.       0.*********    2.00  501.63
   APPRO:AS      57.   -36.   124.   2300.   40425.     459.    5.02  501.63

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.79    0.68  489.00  504.03************  1.27  498.51  497.25
   FULLV:FV  ********    0.60  489.70  504.73  0.96  0.00  1.08  499.49  498.41
   BRIDG:BR    496.61    0.54  490.00  499.96************  1.25  501.15  499.90
   RDWAY:RG  ****************  500.50  510.36  0.10******  0.52  502.05  501.63
   APPRO:AS    497.61    0.60  490.67  506.82  0.10  0.00  0.52  502.15  501.63
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -8      230  1.15 *****  497.86  495.29    1980  496.71
      -59 ******     36    14706  1.00 ***** *******    0.67    8.61

FULLV:FV       60     -9      250  0.97  0.96  498.82 *******    1980  497.85
         0     60     37    16627  1.00  0.00    0.00    0.60    7.91
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       57    -12      231  1.15  0.77  499.69 *******    1980  498.53
        57     57     34    17554  1.01  0.09    0.01    0.69    8.58
         <<<<<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       60      0      147  2.83  1.26  499.49  496.59    1980  496.66
         0     60     26    12650  1.00  0.37    0.00    0.98   13.48

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.90 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      16.        <<<<<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       15    -20      310  0.66  0.17  500.70  497.13    1980  500.04
        57     15     37    26990  1.04  1.04    0.02    0.50    6.39

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.455  0.116   23736.     0.    26.   499.87

  FIRST USER DEFINED TABLE.

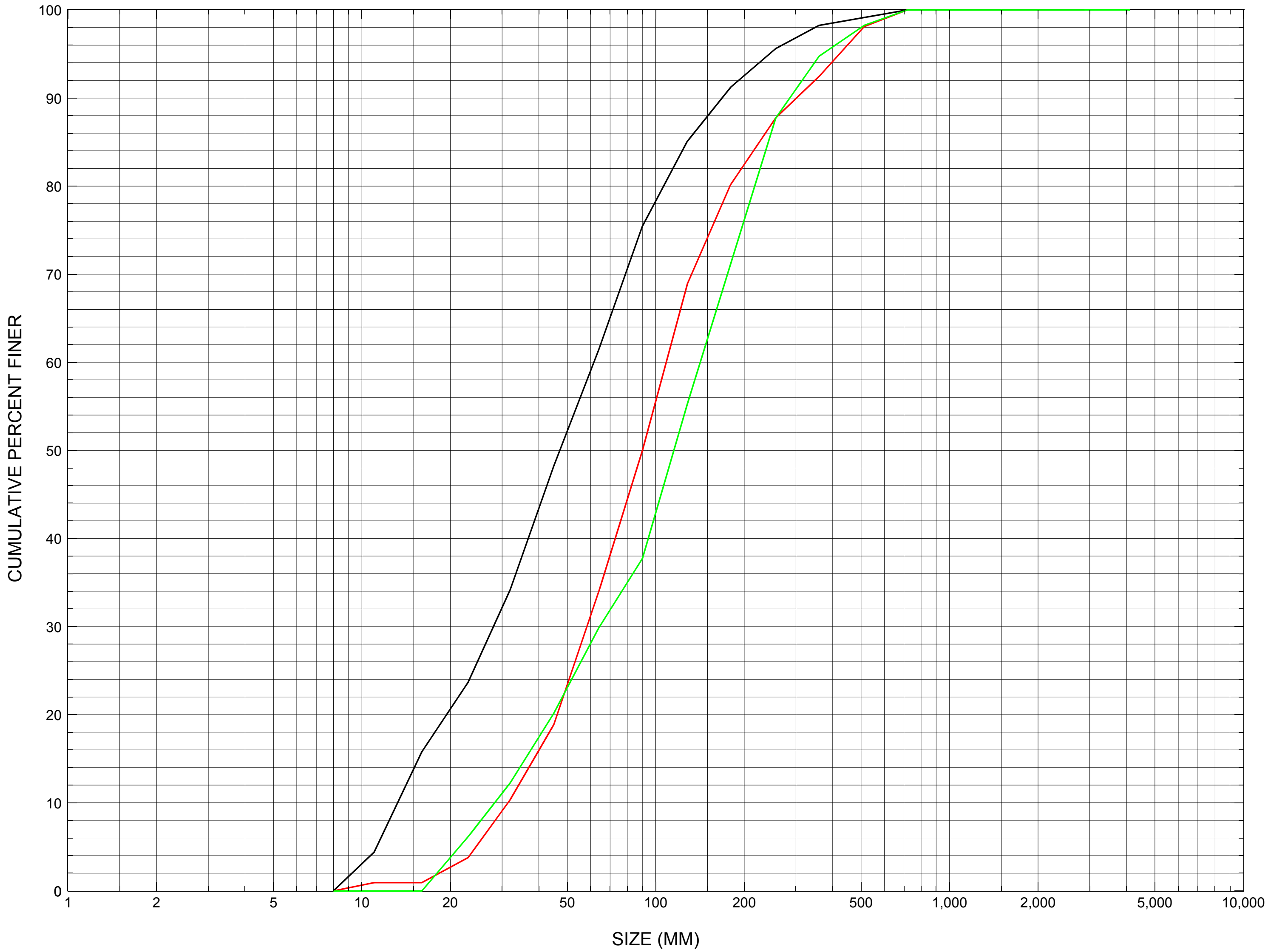
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -60.    -9.    36.   1980.   14706.     230.    8.61  496.71
   FULLV:FV       0.   -10.    37.   1980.   16627.     250.    7.91  497.85
   BRIDG:BR       0.     0.    26.   1980.   12650.     147.   13.48  496.66
   RDWAY:RG      16.**************       0.*****************    2.00********
   APPRO:AS      57.   -21.    37.   1980.   26990.     310.    6.39  500.04

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    495.29    0.67  489.00  504.03************  1.15  497.86  496.71
   FULLV:FV  ********    0.60  489.70  504.73  0.96  0.00  0.97  498.82  497.85
   BRIDG:BR    496.59    0.98  490.00  499.96  1.26  0.37  2.83  499.49  496.66
   RDWAY:RG  ****************  500.50  510.36**********************************
   APPRO:AS    497.13    0.50  490.67  506.82  0.17  1.04  0.66  500.70  500.04
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure BETHTH00070043, in Bethel, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BETHTH00070043

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 24 / 94

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 05800

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

Waterway *(I - 6)* GILEAD BROOK

Road Name *(I - 7):* -

Route Number TH007

Vicinity *(I - 9)* 0.1 MI JCT TH 7 + TH 22

Topographic Map Randolph

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43527

Longitude *(i - 17; nnnnn.n)* 72422

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140400431404

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

Maximum span length *(I - 48; nnnn)* 0027

Year built *(I - 27; YYYY)* 1986

Structure length *(I - 49; nnnnnn)* 000031

Average daily traffic, ADT *(I - 29; nnnnnn)* 000060

Deck Width *(I - 52; nn.n)* 260

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)* 7

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 025.0

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

Vertical clearance from streambed (*nnn.n ft*) 007.0

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

Waterway of full opening (*nnn.n* ft^2) 175.0

Comments:

Structural inspection report of 5/25/94 indicates a concrete slab type bridge with a gravel roadway surface on the approaches. Abutment and wingwall concrete reported in like new condition. Footings are noted as not in view and settlement is not apparent. A minor channel scour pocket is reported at the outlet. Report indicates very little embankment erosion present. There is a shallow sand/gravel bar along the left abutment. The channel alignment is reported as slightly skewed with the bridge. Large riprap is noted but condition was not addressed.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 8.3

Terrain character: Hilly and forested

Stream character & type: -

Streambed material: Coarse gravel and boulders

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 950 Q_{25} 1325

Q_{50} 1625 Q_{100} 1925 Q_{500} -

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

Estimated Discharge *(cfs)*: - Velocity at Q 25 *(ft/s)*: 14.2

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*)	-	505.5	506.9	508.1	509.4
Velocity (*ft / sec*)	-	-	14.2	-	-

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*): Y *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): - Town: Bethel Year Built: 1973

Highway No. : TH07 Structure No. : 37 Structure Type: I-Beam

Clear span (*ft*): 28.0 Clear Height (*ft*): 10.0 Full Waterway (*ft²*): -

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

Highway No. : **TH07** Structure No. : **38** Structure Type: **Steel beam**

Clear span (*ft*): **41.0** Clear Height (*ft*): **6.0** Full Waterway (*ft*^{2}): **-**

Comments:

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.81** mi^2 Lake and pond area **0.04** mi^2

Watershed storage *(ST)* **0.6** %

Bridge site elevation **970.0** ft Headwater elevation **2700.0** ft

Main channel length **4.73** mi

10% channel length elevation **1035** ft 85% channel length elevation **1710.0** ft

Main channel slope *(S)* **190.28** 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)*: 07 / 1985

Project Number BRZ 1444(14) Minimum channel bed elevation: 500.0

Low superstructure elevation: USLAB 509.26 DSLAB 509.08 USRAB 508.48 DSRAB 508.30

Benchmark location description:

BM#1, S.I.R. (Spike in root) of 8 inch poplar, 500 feet from bridge, station 9+50, elevation 500.00. BM#2, S.I.T. (railroad spike) in 12 inch ash at right road approach, far corner of intersection of TH22 and TH7, elevation 509.00.

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

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

If 1: Footing Thickness bitra Footing bottom elevation: ry

If 2: Pile Type: 1 (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: 2.0

If 3: Footing bottom elevation: 495.0

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:

N

-

3

NO FOUNDATION MATERIAL INFORMATION

Comments:

Cross-sectional Data

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

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

Comments: **points: 1 the top streamward edge of the upstream right wingwall where the slope begins to decline, elevation 510.73; 2 the same location as described above on the upstream left**

Station	wing	1.	Y	tion	tions	with	data	stud	com-	not	
Feature	wall,		VTA	of	is	any	sur-	y	par-	retri	
Low cord elevation	eleva		OT	the	inco	cross	veye	and	able.	eved.	
Bed elevation	tion		Ori-	cross	nsis-	sec-	d for	is	Data		
Low cord to bed length	511.5		enta-	sec-	tent	tion	this	not	was		

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: **DLS** Date: **01/31/95**
Computerized by: **MAW** Date: **03/07/95**
Reviewd by: **MAI** Date: **04/12/96**

Structure Number **BETHTH00070043**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **S**. **OLSON** Date *(MM/DD/YY)* **10** / **19** / 19**94**

2. Highway District Number **04** Mile marker **000000**

County **027 (WINDSOR)** Town **05800 (BETHEL)**

Waterway *(I - 6)* **GILEAD BROOK** Road Name **GILEAD ROAD**

Route Number **TH007** Hydrologic Unit Code: **01080105**

3. Descriptive comments:
The bridge is on a gravel road 0.1 miles from the junction of TH 7 and TH 22. On the topographic map the bridge is shown as being at the intersection of TH 7 and Byam road.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **4** LBDS **6** RBDS **4** 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 **31** *(feet)* Span length **27** *(feet)* Bridge width **26** *(feet)*

Road approach to bridge:

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

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

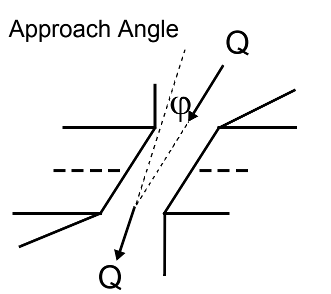
10. Embankment slope (*run / rise in feet / foot*):
US left **3.3:1** US right **6.5:1**

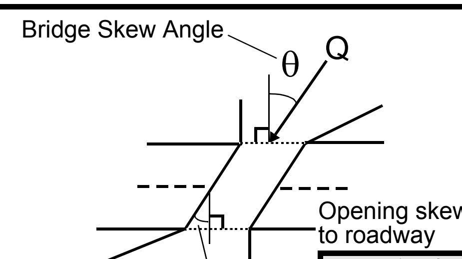
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	1	0	0
RBUS	2	1	0	0
RBDS	2	1	0	0
LBDS	2	1	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **30**





α= **15.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **10** feet **US** *(US, UB, DS)* to **5** feet **UB**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **40** feet **DS** *(US, UB, DS)* to **50** feet **DS**

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

18. Level II Bridge Type: **4**

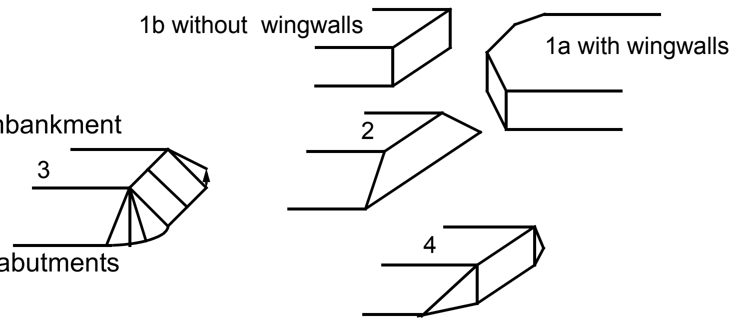
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

#4. Notes on surface cover: left bank upstream becomes forest greater than 2 bridge lengths upstream; right bank upstream is called pasture but is primarily mowed lawn. There is a house about 2 bridge lengths by 2 bridge lengths, beyond that is forest; right bank downstream is primarily lawn or overbank with a small dense growth of trees; left bank downstream is forest primarily with pasture type cover within one bridge length.
#7. The values are from VTAOT files (written communication, August 24, 1994).
#18. The Level II bridge type is 1a or 4 depending on the elevation of the water surface.
Everything at the bridge including stone fill is in like new condition.

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
49.0	**4.0**			**3.5**	**3**	**3**	**4**	**4**	**2**	**2**

23. Bank width **20.0** 24. Channel width **30.0** 25. Thalweg depth **34.5** 29. Bed Material **4**

30 .Bank protection type: LB **2** RB **2** 31. Bank protection condition: LB **1** RB **1**

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

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

#30. Bank protection extends upstream about 1 bridge length.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **UB** 35. Mid-bar width: **10**

36. Point bar extent: **6** feet **US** (US, UB) to **25** feet **DS** (US, UB, DS) positioned **0** %LB to **30** %RB

37. Material: **4**

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

The mid-bar distance is 20 ft. under the bridge from the upstream face. Primarily grassy vegetation covers about 20% of the point bar.

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

41. Mid-bank distance: **80** 42. Cut bank extent: **40** feet **US** (US, UB) to **105** 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.):

There is also a cut-bank on the right bank 65 ft. to >200 ft. upstream. These cut-banks are not due to channel bends, it is a fairly straight, steep channel.

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

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

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

NO CHANNEL SCOUR

49. Are there major confluences? **Y** (Y or if N type ctrl-n mc) 50. How many? **1**

51. Confluence 1: Distance **125** 52. Enters on **RB** (LB or RB) 53. Type **1** (*1*- perennial; *2*- ephemeral)

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

54. Confluence comments (eg. confluence name):

Banks of the confluence are 10 ft. to 15 ft. wide and 4 ft. to 5 ft. high.
There is significant stone fill in place to protect the house on the upstream right bank.

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
18.0		**1.0**		**2**	**7**	**7**	**-**

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

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

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

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

4
-

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

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

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

70. Debris and Ice Comments:

1

Neighbors said ice jamming is not a big problem, and that the old bridge was overtopped in 1973 (roadway overtopped) but the new bridge is significantly higher. There is a tree which has fallen across the stream about 10 ft. upstream. A piece of the wooden abutment form is smashed possibly due to ice.

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		**-**	**90**	**2**	**0**	**0**	**-**	**90.0**
RABUT	**1**	**15**	**90**			**2**	**1**	**25.0**

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.):

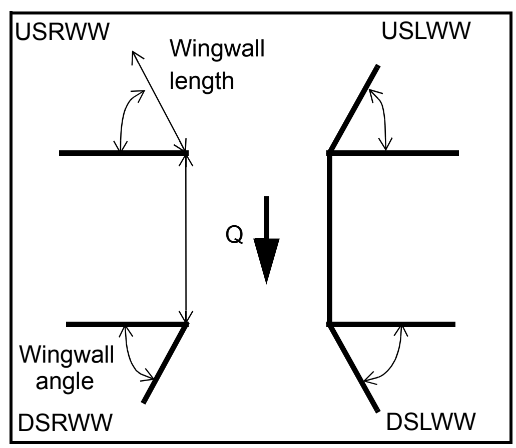
0.5
0
1

Scour depth at the right abutment was calculated in the office. The thalweg depth was estimated at about 1.0 ft. and the downstream bridge face survey indicates that the bottom of the right abutment is about 1.5 ft. underwater thus the scour depth of 0.5 ft. Wooden beams used to support concrete forms are exposed along the right abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**25.0**	
USRWW:	**Y**		**1**		**0**	**1.0**	
DSLWW:	**0**		**-**		**Y**	**31.5**	
DSRWW:	**1**		**0**		**0**	**30.5**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**0**	**Y**	**0**	**1**	**1**	**-**	**1**
Condition	**Y**	**0**	**1**	**-**	**1**	**1**	**-**	**4**
Extent	**1**	**-**	**0**	**2**	**2**	**0**	**1**	**-**

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

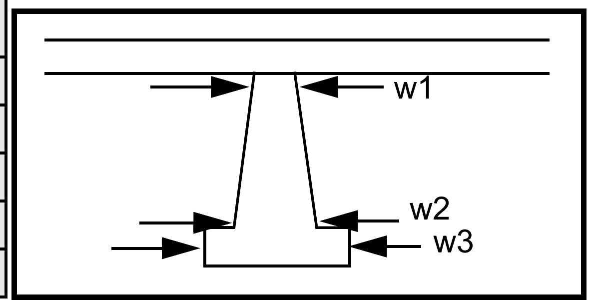
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
2
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				**45.0**	**16.5**	**55.0**
Pier 2				**13.0**	**20.0**	**12.5**
Pier 3			**-**	**45.0**	**13.5**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ne**	**occu**	**place**	**ge is**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**fill is**	**rred**	**d in**	**well**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**scat-**	**betw**	**a**	**pro-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**tered**	**een**	**pre-**	**tecte**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**alon**	**the**	**vious**	**d**	*Y- yes; N- no*
91. Attack ∠ (BF)	**g the**	**stone**	**ly**	**with**	
92. Pushed	**right**	**fill**	**scou**	**“new**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**abut**	**or**	**red**	**”**	
95. Cross-members	**ment**	**the**	**loca-**	**stone**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**and**	**stone**	**tion.**	**fill.**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**scou**	**fill**	**The**	**Som**	
98. Exposure depth	**r has**	**was**	**brid**	**e**	

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

stone fill may be needed along the right abutment.

N

E. Downstream Channel Assessment

100.

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

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

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB -

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

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

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

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

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

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

-
-
-
-
-
-

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

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

Material: _-_

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

-
-
-
-

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

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

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: _2_

Scour dimensions: Length _1_ Width _7_ Depth: _7_ Positioned _1_ %LB to _1_ %RB

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

4
1
1
1

Are there major confluences? _1_ (Y or if N type ctrl-n mc) How many? _The_

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

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

Confluence comments (eg. confluence name):

to 100 ft. downstream. Stone fill is scattered along both banks with cobbles beyond the protected area.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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

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

N

-

109. G. Plan View Sketch

\- N

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:	BETHTH00070043	Town:	Bethel
Road Number:	TH 7	County:	Windsor
Stream:	Gilead Brook		

Initials MAI Date: 3/18/96 Checked: EMB Date: 4/9/96

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1750	2300	1980
Main Channel Area, ft2	264	376	301
Left overbank area, ft2	0	22	4
Right overbank area, ft2	3	60	6
Top width main channel, ft	47	47	47
Top width L overbank, ft	2	21	6
Top width R overbank, ft	3	91	4
D50 of channel, ft	0.261	0.261	0.261
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	5.6	8.0	6.4
y1, average depth, LOB, ft	0.0	1.0	0.7
y1, average depth, ROB, ft	1.0	0.7	1.5
Total conveyance, approach	21601	40425	26987
Conveyance, main channel	21536	38864	26788
Conveyance, LOB	2	429	45
Conveyance, ROB	63	1131	154
Percent discrepancy, conveyance	0	0.002474	0
Qm, discharge, MC, cfs	1744.734	2211.186	1965.4
Ql, discharge, LOB, cfs	0.16203	24.40816	3.30159
Qr, discharge, ROB, cfs	5.10393	64.34879	11.29877
Vm, mean velocity MC, ft/s	6.6	5.9	6.5
Vl, mean velocity, LOB, ft/s	ERR	1.1	0.8
Vr, mean velocity, ROB, ft/s	1.7	1.1	1.9
Vc-m, crit. velocity, MC, ft/s	9.6	10.1	9.8
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

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

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	264	376	301
Main channel width, ft	47	47	47
y1, main channel depth, ft	5.617021	8	6.404255
Bridge Section			
(Q) total discharge, cfs	1750	2300	1980
(Q) discharge thru bridge, cfs	1750	1986	1980
Main channel conveyance	11746	16883	12636
Total conveyance	11746	16883	12636
Q2, bridge MC discharge,cfs	1750	1986	1980
Main channel area, ft2	140	221	147
Main channel width (skewed), ft	24.9	24.9	24.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.9	24.9	24.9
y_bridge (avg. depth at br.), ft	5.60241	8.891566	5.891566
Dm, median (1.25*D50), ft	0.32625	0.32625	0.32625
y2, depth in contraction,ft	6.525115	7.272448	7.253612
ys, scour depth (y2-ybridge), ft	0.92	-1.62	1.36
ys, scour depth (y2-y1), ft	0.91	-0.73	0.85
ys, scour depth (y2-yfullv), ft	N/A	-0.35	N/A
ARMORING			
D90	0.827	0.827	0.827
D95	1.164	1.164	1.164
Critical grain size,Dc, ft	0.814052	0.341192	0.921216
Decimal-percent coarser than Dc	0.104	0.392	0.083
Depth to armoring,ft	21.04011	1.587588	30.53332

PRESSURE FLOW SCOUR COMPUTATION

Structure Number: BETH043 Town: Bethel
Road Number: TH 7 County: Windsor
Stream:
Initial: SAO Date: 10/10/96 Checked:
Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1)
Chang Equation Cc=SQRT[0.10*(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richardson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	0	1986	0
Vc, critical velocity, ft/s	0	10.1	0
Vc, critical velocity, m/s	0	3.07833	0
Main channel width (skewed), ft	0	24.9	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	0	24.9	0
qbr, unit discharge, ft^2/s	ERR	79.75904	ERR
qbr, unit discharge, m^2/s	N/A	7.409134	N/A
Area of full opening, ft^2	0	221	0
Hb, depth of full opening, ft	ERR	8.875502	ERR
Hb, depth of full opening, m	N/A	2.705121	N/A
Fr, Froude number MC	1	0.54	1
Cf, Fr correction factor (<=1.0)	1.5	1	1.5
Elevation of Low Steel, ft	0	499.66	0
Elevation of Bed, ft	N/A	490.7845	N/A
Elevation of approach WS, ft	0	501.63	0
HF, bridge to approach, ft	0	0.1	0
Elevation of WS immediately US, ft	0	501.53	0
ya, depth immediately US, ft	N/A	10.7455	N/A
ya, depth immediately US, m	N/A	3.339186	N/A
Mean elev. of deck, ft	0	501.49	0
w, depth of overflow, ft (>=0)	0	0.04	0
Cc, vert contrac correction (<=1.0)	ERR	0.95403	ERR
Ys, depth of scour (chang), ft	N/A	-0.59806	N/A

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	1750	2300	1980	1750	2300	1980
a’, abut.length blocking flow, ft	16.7	35.3	19.8	10.7	95.2	11.6
Ae, area of blocked flow ft2	39.22	93.79	50.14	36.74	53.71	43.21
Qe, discharge blocked abut.,cfs	167.05	341.17	234.08	158.17	--	197.8
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	4.259306	3.637595	4.668528	4.305117	3.64	4.577644
ya, depth of f/p flow, ft	2.35	2.66	2.53	3.43	0.56	3.73
--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	75	75	75	105	105	105
K2	0.976577	0.976577	0.976577	1.020242	1.020242	1.020242
Fr, froude number f/p flow	0.49	0.39	0.52	0.41	0.46	0.42
ys, scour depth, ft	8.77	10.97	9.99	9.60	6.62	10.50

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)	16.7	35.3	19.8	10.7	95.2	11.6
y1 (depth f/p flow, ft)	2.35	2.66	2.53	3.43	0.56	3.73
a'/y1	7.11	13.29	7.82	3.12	168.74	3.11
Skew Correction	0.96	0.96	0.96	1.05	1.05	1.05
Froude no. f/p flow	0.49	0.39	0.52	0.41	0.46	0.42
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	2.73	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.93	0.54	0.98	0.93	0.54	0.98
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.6	8.88	5.88	5.6	8.88	5.88
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.60	ERR	ERR	1.60	ERR
Fr>0.8 (vertical abut.)	2.29	ERR	2.45	2.29	ERR	2.45
Fr<=0.8 (spillthrough abut.)	ERR	1.40	ERR	ERR	1.40	ERR
Fr>0.8 (spillthrough abut.)	2.03	ERR	2.16	2.03	ERR	2.16