LEVEL II SCOUR ANALYSIS FOR BRIDGE 39 (BETHTH00060039) on TOWN HIGHWAY 6, crossing the SECOND BRANCH WHITE RIVER, BETHEL, VERMONT

Open-File Report 98-060

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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By LORA K. STRIKER AND MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1998

U.S. DEPARTMENT OF THE INTERIOR
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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	Max	maximum
D_{50}	median diameter of bed material	MC	main channel
DS	downstream	RAB	right abutment
elev.	elevation	RABUT	face of right abutment
f/p	flood plain	RB	right bank
ft^2	square feet	ROB	right overbank
ft/ft	feet per foot	RWW	right wingwall
FEMA	Federal Emergency Management Agency	TH	town highway
FHWA	Federal Highway Administration	UB	under bridge
JCT	junction	US	upstream
LAB	left abutment	USGS	United States Geological Survey
LABUT	face of left abutment	VTAOT	Vermont Agency of Transportation
LB	left bank	WSPRO	water-surface profile model
LOB	left overbank	yr	year

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.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 39 (BETHTH00060039) ON TOWN HIGHWAY 6, CROSSING THE SECOND BRANCH WHITE RIVER, BETHEL, VERMONT

By **Lora K. Striker and Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BETHTH00060039 on Town Highway 6 crossing the Second Branch White River, 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 (FHWA, 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 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 central Vermont. The 64.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is predominantly shrub and brushland.

In the study area, the Second Branch White River has a meandering channel with a slope of approximately 0.003 ft/ft, an average channel top width of 73 ft and an average bank height of 6 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 1.26 mm (0.00412 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 11, 1996, indicated that the reach was stable.

The Town Highway 6 crossing of the Second Branch White River is a 52-ft-long, two-lane bridge consisting of one 49 foot steel beam span (VTAOT, written communication, August 24, 1994). The opening length of the structure parallel to the bridge face is 46.6 ft. The bridge is supported by vertical, concrete abutments. The channel is skewed approximately 20 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

A scour hole 3.0 ft deeper than the mean thalweg depth was observed along the left and right abutments during the Level I assessment. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the right bank upstream and the left bank 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 6 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was 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 5.1 to 10.3 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 19.0 to 26.2 ft. The worst-case abutment scour occurred at the 500-year discharge at the left abutment and the 100-year discharge at the right abutment. 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 Davis, 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.

Chelsea, 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 BETHTH00060039 ***Stream*** Second Branch White River

County Windsor ***Road*** TH 6 ***District*** 4

Description of Bridge

Bridge length 52 ***ft*** ***Bridge width*** 23.0 ***ft*** ***Max span length*** 49 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 07/11/96

Description of stone fill -

Abutments are concrete. There is a 3.0 ft deep scour hole underneath the bridge that extends upstream and downstream. The left abutment footing is exposed 3.0 ft.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 20

There is a moderate channel bend in the upstream reach. The left abutment footing is exposed in the location where the flow impacts the left 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	07/11/96	0	0
Level II	07/11/96	0	0

Potential for debris Moderate. There are some dead tress along the banks upstream. In addition, the bridge is a constriction in the river.

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

None as of 07/11/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain and steep valley walls on both sides.

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

Date of inspection 07/11/96

DS left: Steep channel bank to moderately sloping and irregular overbank

DS right: Moderately sloping channel bank and overbank

US left: Moderately sloping channel bank to narrow flood plain

US right: Steep channel bank and valley wall

Description of the Channel

Average top width 73 ft ***Average depth*** 6 ft

Predominant bed material Silt/ Gravel ***Bank material*** Silt to Gravel

Meandering with alluvial boundaries and narrow point bars.

07/11/96

Vegetative co Trees and brush

DS left: Brush and trees

DS right: Brush

US left: Tall grasses and brush with a few trees, overbank area is marsh

US right: Yes

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

None as of 07/11/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 64.4 ***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 8,950 ***ft³/s*** ***Q500*** 13,800 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(64.4/46.0)exp 0.67] with bridge number 34 in Randolph. Bridge number 34 crosses the Second Branch of the White River upstream of this site and has flood frequency estimates available from the VTAOT database (VTAOT, written communication, May 1995). The drainage area above bridge number 34 is 46.0 square miles. The discharges are within a range defined by several other empirical methods (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. RM 1- center of chiseled square on top of the DS corner at the LB end of the US curb (elev. 500.63 ft, arbitrary survey datum). RM 2- chiseled X on the top RB DS corner of concrete walkway (elev. 500.67 ft, arbitrary survey datum). RM 3 is a nail in telephone pole #771/2- 771/1, 6' above ground, on LB US (elev. 500.61 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in ft*	*[2]Cross-section development*	*Comments*
EXT1	-90	1	Exit section (dam section)
EXITX	-30	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	73	2	Modelled Approach section (Templated from APTEM)
APTEM	107	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.045 and overbank "n" values ranged from 0.060 to 0.086.

Critical depth at the exit section (EXT1) was assumed as the starting water surface for the discharges modelled. The EXT1 section was surveyed across the crest of the dam located approximately 90 ft downstream of this site. The water surface profile from the Flood Insurance Study (FIS) for the town of Bethel shows that the flow may submerge the crest of the dam for the discharges modelled (Federal Emergency Management Agency, 1991). Thus, the actual starting water surface may be slightly above critical depth.

The surveyed approach section (APTEM) was moved without a bed slope correction to establish the modelled approach section (APPRO) 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.2 *ft*
Average low steel elevation 496.4 *ft*

100-year discharge 8,950 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Road overtopping? Yes *Discharge over road* 2,430 *ft³/s*
Area of flow in bridge opening 542 *ft²*
Average velocity in bridge opening 12.0 *ft/s*
Maximum WSPRO tube velocity at bridge 14.8 *ft/s*

Water-surface elevation at Approach section with bridge 501.0
Water-surface elevation at Approach section without bridge 498.7
Amount of backwater caused by bridge 2.3 *ft*

500-year discharge 13,800 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Road overtopping? Yes *Discharge over road* 7,000 *ft³/s*
Area of flow in bridge opening 542 *ft²*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.5 *ft/s*

Water-surface elevation at Approach section with bridge 502.5
Water-surface elevation at Approach section without bridge 500.1
Amount of backwater caused by bridge 2.4 *ft*

Incipient overtopping discharge 5,440 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Area of flow in bridge opening 542 *ft²*
Average velocity in bridge opening 10.0 *ft/s*
Maximum WSPRO tube velocity at bridge 14.6 *ft/s*

Water-surface elevation at Approach section with bridge 498.7
Water-surface elevation at Approach section without bridge 497.0
Amount of backwater caused by bridge 1.7 *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 6 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis for the 100- and 500-year discharges are shown in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Contraction scour for the 100-year, 500-year, and incipient roadway-overtopping discharges was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17). At this site, each modeled discharge resulted in submerged orifice flow. The Chang equation for pressure flow scour (Richardson and Davis, 1995, p. 145-146) was derived solely with data for clear-water scour. Therefore, it is not currently understood how well it would predict in live-bed conditions. Although pressure flow conditions exist for the modeled discharges, the reported scour depths are those computed by use of Laursen's live-bed contraction scour equation. For comparison, estimates of contraction scour were computed by use of the Chang equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144) for each discharge. These contraction scour results are provided in appendix F.

Abutment scour was computed by use of the Froehlich equation (Richardson and Davis, 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	8.2	5.1	10.3
Clear-water scour	--	--	--
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	22.1	26.2	22.5
Right abutment	20.9	20.6	19.0
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	2.8	3.1	2.0
Right abutment	2.8	3.1	2.0
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

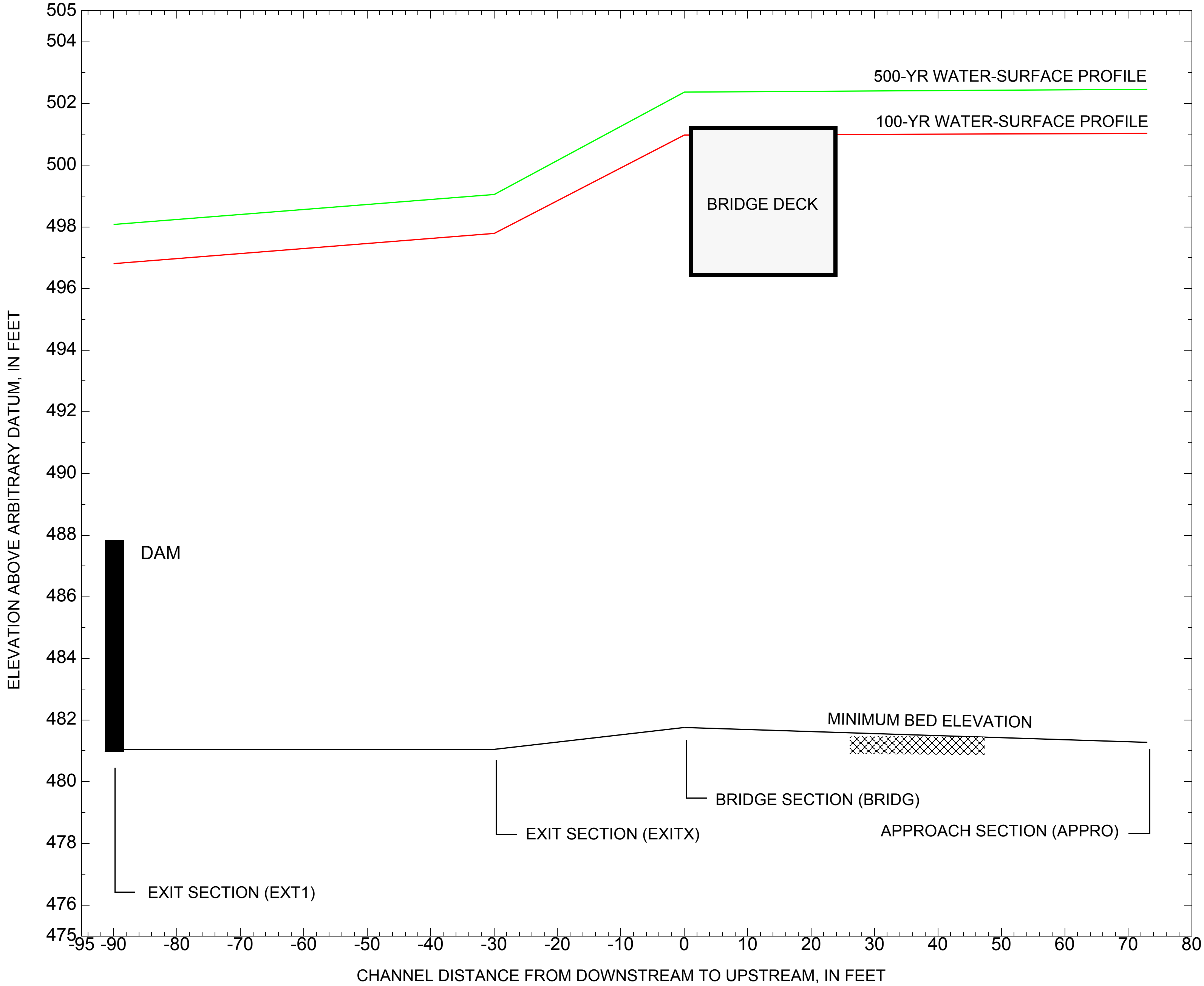

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BETHTH00060039 on Town Highway 6, crossing the Second Branch White River, Bethel, Vermont.

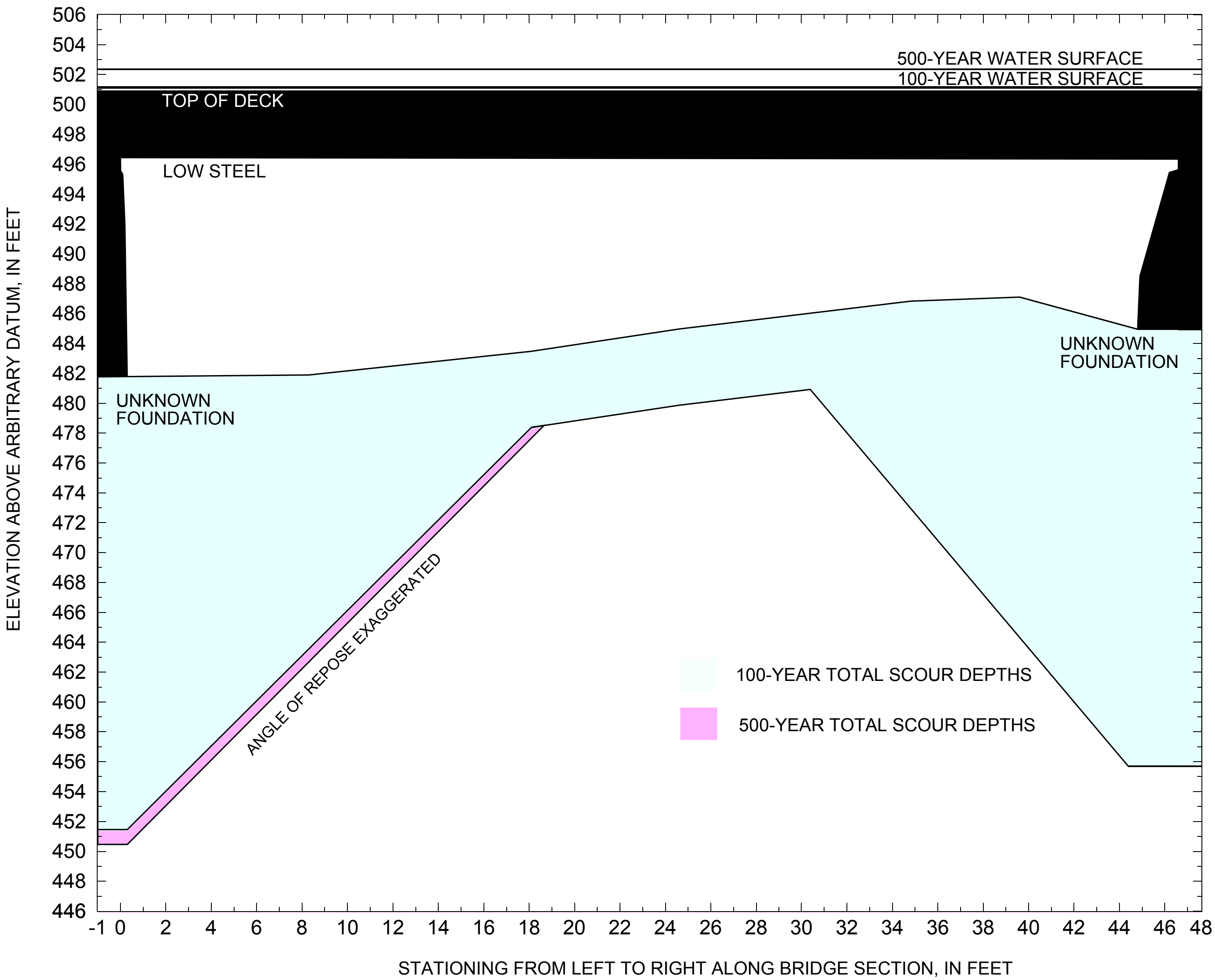

Figure 8. Scour elevations for the 100- and 500-year discharges at structure BETHTH00060039 on Town Highway 6, crossing the Second Branch White River, Bethel, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BETHTH00060039 on Town Highway 6, crossing the Second Branch White River, Bethel, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (ft)	Surveyed minimum low-chord elevation[2] (ft)	Bottom of footing elevation[2] (ft)	Channel elevation at abutment/ pier[2] (ft)	Contraction scour depth (ft)	Abutment scour depth (ft)	Pier scour depth (ft)	Depth of total scour (ft)	Elevation of scour[2] (ft)	Remaining footing/pile depth (ft)
100-year discharge is 8,950 cubic-ft per second											
Left abutment	0.0	--	496.4	--	481.8	8.2	22.1	--	30.3	451.5	--
Right abutment	46.6	--	496.4	--	485.0	8.2	20.9	--	29.1	455.9	--

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 BETHTH00060039 on Town Highway 6, crossing the Second Branch White River, Bethel, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (ft)	Surveyed minimum low-chord elevation[2] (ft)	Bottom of footing elevation[2] (ft)	Channel elevation at abutment/ pier[2] (ft)	Contraction scour depth (ft)	Abutment scour depth (ft)	Pier scour depth (ft)	Depth of total scour (ft)	Elevation of scour[2] (ft)	Remaining footing/pile depth (ft)
500-year discharge is 13,800 cubic-ft per second											
Left abutment	0.0	--	496.4	--	481.8	5.1	26.2	--	31.3	450.5	--
Right abutment	46.6	--	496.4	--	485.0	5.1	20.6	--	25.7	459.3	--

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File beth039.wsp
T2        Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
T3        TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
*
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           8950.0  13800.0    5440.0
SK              -1       -1       -1
*
XS   EXT1     -90           0.
GR         -137.8, 500.39   -120.2, 494.86    -92.2, 492.63    -43.4, 494.88
GR          -26.7, 493.98    -26.6, 492.58    -19.0, 492.59    -18.7, 491.15
GR          -13.6, 491.15    -13.4, 492.59     -2.3, 492.65     -2.3, 488.52
GR            0.0, 487.86     44.5, 487.83     44.8, 488.52     45.6, 489.69
GR           46.7, 489.96     48.0, 490.90
GR           58.8, 490.94     74.3, 491.59     88.6, 492.21    121.6, 495.00
GR          172.2, 496.58    173.0, 501.43    185.2, 504.27
*
N           0.080        0.045        0.070
SA                  -2.3         48.0
*
XS   EXITX    -30           0.
GR         -231.3, 515.52   -178.8, 505.50   -153.6, 502.20   -119.7, 500.75
GR          -89.6, 495.55    -61.1, 496.43     -9.9, 493.23      0.0, 488.36
GR            1.6, 481.42      8.2, 481.05     15.4, 483.02     28.0, 486.20
GR           36.4, 486.80     39.3, 487.40     43.5, 488.41     47.5, 489.53
GR           75.3, 493.01    121.6, 495.87    172.2, 497.45    173.0, 502.30
GR          185.2, 505.14
*
N           0.065        0.045        0.070
SA                  -9.9         75.3
*
*
XS   FULLV      0  * * *   0.0145
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.39       5.0
GR            0.0, 496.44      0.1, 495.55      0.1, 495.31      0.2, 491.92
GR            0.3, 481.76      8.3, 481.89     18.1, 483.48     24.6, 484.96
GR           34.8, 486.83     39.6, 487.10     44.8, 484.95     44.8, 488.49
GR           46.2, 495.44     46.4, 495.63     46.6, 496.35      0.0, 496.44
*
*         BRTYPE  BRWDTH
CD          1      26.4
N           0.035
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      23.0     1
GR         -343.3, 514.14   -301.2, 510.73   -254.3, 503.45   -170.5, 501.14
GR         -105.0, 498.65    -79.9, 499.79    -45.1, 499.70      0.0, 499.79
GR            0.2, 500.63      0.6, 500.64      0.7, 500.02      3.1, 501.17
GR           49.3, 501.17     51.9, 500.66     52.3, 500.65     52.4, 499.74
GR           90.6, 498.91    150.5, 499.07    214.1, 502.39    269.6, 506.59
*
*
*
XT   APTEM    107           0.
GR         -344.4, 508.14   -296.5, 501.73   -218.5, 500.08   -177.6, 499.62
GR         -151.2, 499.63   -112.7, 498.82   -100.8, 498.41    -86.8, 495.15
GR          -55.1, 489.79      0.0, 489.86      4.1, 488.51     14.4, 486.37
GR           21.1, 484.63     43.4, 481.28     48.8, 483.61     57.9, 488.56
GR           61.5, 491.56     96.6, 500.93    112.7, 504.06    142.0, 509.33
*
AS   APPRO     73  * * * 0.000
GT
N           0.060      0.045        0.086
SA                0.0        61.5
*
HP 1 BRIDG   496.44 1 496.44
HP 2 BRIDG   496.44 * * 6507
HP 2 RDWAY   500.98 * * 2434
HP 1 APPRO   501.03 1 501.03
HP 2 APPRO   501.03 * * 8950
*
HP 1 BRIDG   496.44 1 496.44
HP 2 BRIDG   496.44 * * 6815
HP 2 RDWAY   502.37 * * 6995
HP 1 APPRO   502.46 1 502.46
HP 2 APPRO   502.46 * *13800
*
HP 1 BRIDG   496.41 1 496.41
HP 2 BRIDG   496.41 * * 5440
HP 1 APPRO   498.70 1 498.70
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File beth039.wsp
        Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
        TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
           *** RUN DATE & TIME: 09-05-97  14:52
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      542     63759      0    118                            0
   496.44           542     63759      0    118  1.00      0     47        0

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.44     0.0    46.6   542.0   63759.    6507.  12.01

 X STA.        0.0        3.3        5.3        7.0        8.6       10.2
   A(I)            45.5       28.5       24.8       23.5       22.7
   V(I)            7.15      11.42      13.14      13.86      14.34

 X STA.       10.2       11.8       13.4       15.1       16.7       18.5
   A(I)            22.4       22.4       22.1       22.2       23.1
   V(I)           14.55      14.50      14.75      14.64      14.06

 X STA.       18.5       20.4       22.3       24.4       26.7       29.0
   A(I)            23.0       23.7       24.8       24.9       25.7
   V(I)           14.12      13.74      13.13      13.05      12.66

 X STA.       29.0       31.7       34.5       37.7       41.0       46.6
   A(I)            27.0       28.2       29.6       31.3       46.5
   V(I)           12.04      11.52      10.98      10.39       7.00
1
   HP 2 RDWAY   500.98 * * 2434

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.98  -166.3   187.1   433.4   12713.    2434.   5.62

 X STA.     -166.3     -124.8     -112.4     -103.7      -94.7      -81.2
   A(I)            32.7       22.5       19.2       18.7       20.9
   V(I)            3.72       5.41       6.35       6.50       5.81

 X STA.      -81.2      -61.1      -42.3      -23.2       -5.2       62.0
   A(I)            24.5       23.7       24.0       21.9       20.9
   V(I)            4.98       5.14       5.06       5.56       5.82

 X STA.       62.0       71.4       81.2       90.9      100.2      109.7
   A(I)            14.7       17.2       19.2       19.0       19.3
   V(I)            8.30       7.09       6.35       6.40       6.31

 X STA.      109.7      119.6      129.6      140.3      151.9      187.1
   A(I)            19.9       19.9       20.9       22.2       32.3
   V(I)            6.13       6.13       5.82       5.48       3.77
1
   HP 1 APPRO   501.03 1 501.03

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      73.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1153     76471    263    264                        13691
             2      972    194715     62     65                        21911
             3      168      8001     36     37                         2070
   501.03          2293    279187    361    366  1.97   -262     97    23345
1
   HP 2 APPRO   501.03 * * 8950

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      73.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.03  -263.4    97.1  2292.7  279187.    8950.   3.90

 X STA.     -263.4      -69.5      -48.8      -33.0      -18.8       -5.9
   A(I)           391.4      215.3      177.5      158.2      144.4
   V(I)            1.14       2.08       2.52       2.83       3.10

 X STA.       -5.9        3.7        9.8       14.9       19.5       23.5
   A(I)           110.3       78.8       73.5       70.3       66.2
   V(I)            4.06       5.68       6.09       6.36       6.76

 X STA.       23.5       27.4       31.0       34.4       37.7       41.0
   A(I)            65.5       63.6       61.4       61.8       62.5
   V(I)            6.83       7.04       7.29       7.24       7.16

 X STA.       41.0       44.1       47.7       51.9       57.6       97.1
   A(I)            61.3       66.9       71.0       81.2      211.3
   V(I)            7.30       6.69       6.30       5.51       2.12
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File beth039.wsp
        Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
        TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
           *** RUN DATE & TIME: 09-05-97  14:52
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      542     63759      0    118                            0
   496.44           542     63759      0    118  1.00      0     47        0

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.44     0.0    46.6   542.0   63759.    6815.  12.57

X STA.        0.0        3.3        5.3        7.0        8.6       10.2
  A(I)            45.5       28.5       24.8       23.5       22.7
  V(I)            7.49      11.96      13.76      14.51      15.02

X STA.       10.2       11.8       13.4       15.1       16.7       18.5
  A(I)            22.4       22.4       22.1       22.2       23.1
  V(I)           15.24      15.18      15.45      15.34      14.73

X STA.       18.5       20.4       22.3       24.4       26.7       29.0
  A(I)            23.0       23.7       24.8       24.9       25.7
  V(I)           14.79      14.39      13.75      13.66      13.26

X STA.       29.0       31.7       34.5       37.7       41.0       46.6
  A(I)            27.0       28.2       29.6       31.3       46.5
  V(I)           12.61      12.06      11.50      10.88       7.33

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.37  -215.1   213.7   967.2   39574.    6995.   7.23

X STA.     -215.1     -139.3     -119.9     -106.3      -93.9      -78.0
  A(I)            84.4       54.1       46.2       43.4       45.4
  V(I)            4.14       6.47       7.57       8.06       7.70

X STA.      -78.0      -60.0      -42.8      -25.3       -8.5       16.0
  A(I)            47.0       45.7       46.2       43.9       43.1
  V(I)            7.45       7.65       7.56       7.96       8.11

X STA.       16.0       56.6       67.7       78.4       91.3      103.7
  A(I)            55.8       31.5       33.0       43.2       42.4
  V(I)            6.27      11.10      10.60       8.10       8.25

X STA.      103.7      116.2      129.5      143.4      159.7      213.7
  A(I)            42.7       44.8       46.5       51.6       76.2
  V(I)            8.20       7.80       7.52       6.78       4.59

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      73.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1568    116479    302    303                        20267
             2     1059    224970     62     65                        24953
             3      224     11439     43     44                         2905
   502.46          2851    352888    406    412  2.00   -301    104    30294

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      73.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.46  -302.0   104.5  2851.2  352888.   13800.   4.84

X STA.     -302.0     -108.3      -67.2      -49.5      -34.3      -20.7
  A(I)           445.9      284.9      212.1      192.3      171.5
  V(I)            1.55       2.42       3.25       3.59       4.02

X STA.      -20.7       -7.6        3.1        9.6       15.0       20.0
  A(I)           164.6      136.4       93.5       85.8       84.4
  V(I)            4.19       5.06       7.38       8.04       8.18

X STA.       20.0       24.4       28.6       32.4       36.2       39.9
  A(I)            79.1       77.0       74.6       75.3       74.3
  V(I)            8.72       8.96       9.25       9.16       9.29

X STA.       39.9       43.3       47.3       51.9       58.0      104.5
  A(I)            72.4       80.2       84.7       94.3      267.9
  V(I)            9.53       8.61       8.15       7.32       2.58
```

```
        U.S. Geological Survey WSPRO Input File beth039.wsp
        Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
        TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
           *** RUN DATE & TIME: 09-05-97  14:52
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      542     69987     15    102                        18193
   496.41           542     69987     15    102  1.00      0     47    18193
1
    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.41     0.0    46.6   541.8   69987.    5440.  10.04

 X STA.        0.0        3.3        5.1        6.5        7.9        9.2
   A(I)           44.9       25.6       21.5       19.7       19.2
   V(I)           6.06      10.61      12.67      13.82      14.19

 X STA.        9.2       10.5       11.9       13.2       14.6       16.2
   A(I)           18.6       18.6       18.7       19.0       21.1
   V(I)          14.64      14.63      14.56      14.35      12.89

 X STA.       16.2       18.1       20.2       22.4       24.9       27.4
   A(I)           25.2       26.0       27.2       28.3       28.2
   V(I)          10.78      10.45       9.99       9.60       9.63

 X STA.       27.4       30.3       33.5       36.8       40.7       46.6
   A(I)           30.3       31.8       32.2       35.7       49.8
   V(I)           8.97       8.55       8.44       7.61       5.46

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      73.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      715     61767    109    110                        10372
             2      828    149243     62     65                        17247
             3       95      3777     27     28                         1024
   498.70          1638    214787    197    203  1.44   -108     88    22321

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      73.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.70  -109.2    88.2  1638.3  214787.    5440.   3.32

 X STA.     -109.2      -59.6      -46.0      -33.0      -20.7       -8.7
   A(I)          187.4      119.2      115.3      109.1      106.3
   V(I)           1.45       2.28       2.36       2.49       2.56

 X STA.       -8.7        2.2        8.9       14.4       19.0       23.2
   A(I)           97.8       70.2       64.1       60.3       57.7
   V(I)           2.78       3.88       4.25       4.51       4.71

 X STA.       23.2       27.0       30.5       33.9       37.1       40.2
   A(I)           55.6       54.2       52.6       52.0       52.2
   V(I)           4.89       5.02       5.17       5.23       5.21

 X STA.       40.2       43.3       46.5       50.4       55.7       88.2
   A(I)           52.5       55.1       58.2       68.3      150.2
   V(I)           5.18       4.93       4.68       3.98       1.81
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File beth039.wsp
       Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
       TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
          *** RUN DATE & TIME: 09-05-97  14:52

 ===010 WSI BELOW YMIN AT SECID "EXT1 ":  USED WSI = CRWS.
                     YMIN,WSI,CRWS =     487.8   ********     496.81

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

EXT1 :XS   ******   -125     1212  1.79 *****  498.61  496.81    8950  496.81
       -89 ******    172    90562  2.12 ***** *******    0.94    7.38

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "EXITX"     KRATIO =  1.57

EXITX:XS       60   -102     1292  1.17  0.37  498.96 *******    8950  497.79
       -29     60    172   142339  1.57  0.00   -0.02    0.71    6.93

FULLV:FV       30    -99     1182  1.36  0.13  499.19 *******    8950  497.82
         0     30    170   129828  1.53  0.10    0.00    0.79    7.57
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "APPRO"     KRATIO =  1.66

APPRO:AS       73   -109     1643  0.67  0.21  499.39 *******    8950  498.72
        73     73     88   215340  1.44  0.00   -0.01    0.40    5.45
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                     WS3N,LSEL =    497.82     496.39

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                 QRD,QRDMAX,RATIO =     2434.      2099.    1.16

           <<<<<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       30      0      542  2.24 *****  498.68  493.09    6507  496.44
         0 ******     47    63759  1.00 ***** *******    0.62   12.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    50.  0.05  0.47  501.44    0.00   2434.  500.98

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1185.   169.  -166.     3.   2.3   1.3   6.0   5.5   1.7   3.1
   RT:   1249.   137.    50.   187.   2.1   1.6   6.7   5.7   2.1   3.1

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

APPRO:AS       47   -262     2291  0.47  0.17  501.49  493.64    8950  501.03
        73     52     97   279004  1.97  0.00    0.00    0.38    3.91

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

  FIRST USER DEFINED TABLE.
   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXT1 :XS     -90.  -126.   172.   8950.   90562.    1212.    7.38  496.81
   EXITX:XS     -30.  -103.   172.   8950.  142339.    1292.    6.93  497.79
   FULLV:FV       0.  -100.   170.   8950.  129828.    1182.    7.57  497.82
   BRIDG:BR       0.     0.    47.   6507.   63759.     542.   12.01  496.44
   RDWAY:RG      13.******* 1185.   2434.******************    1.00  500.98
   APPRO:AS      73.  -263.    97.   8950.  279004.    2291.    3.91  501.03
    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS  **********************

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXT1 :XS    496.81    0.94  487.83  504.27************  1.79  498.61  496.81
   EXITX:XS  ********    0.71  481.05  515.52  0.37  0.00  1.17  498.96  497.79
   FULLV:FV  ********    0.79  481.48  515.96  0.13  0.10  1.36  499.19  497.82
   BRIDG:BR    493.09    0.62  481.76  496.44************  2.24  498.68  496.44
   RDWAY:RG  ****************  498.65  514.14  0.05******  0.47  501.44  500.98
   APPRO:AS    493.64    0.38  481.28  509.33  0.17  0.00  0.47  501.49  501.03
```

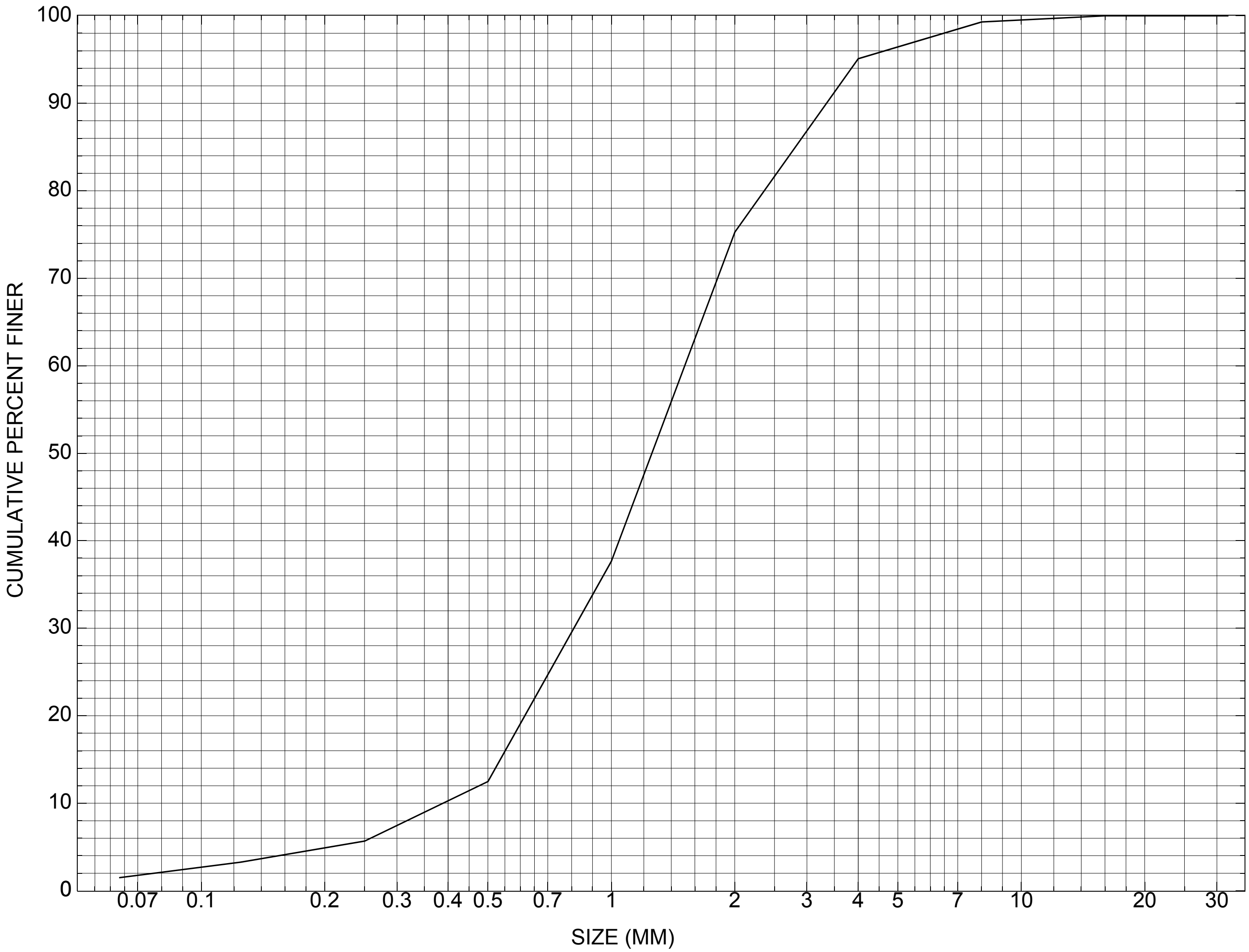
```
       U.S. Geological Survey WSPRO Input File beth039.wsp
       Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
       TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
          *** RUN DATE & TIME: 09-05-97  14:52

 ===010 WSI BELOW YMIN AT SECID "EXT1 ":  USED WSI = CRWS.
                        YMIN,WSI,CRWS =     487.8   ********     498.08

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

EXT1 :XS   ******   -129     1593  2.28 *****  500.36  498.08   13800  498.08
       -89 ******    172   129474  1.95 ***** *******    0.93    8.66

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXITX"     KRATIO =  1.44

EXITX:XS       60   -109     1644  1.77  0.47  500.83 *******   13800  499.05
       -29     60    172   186848  1.62  0.00    0.00    0.78    8.39

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    0.86     499.09     498.33

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   498.55     515.96    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =    498.55     515.96     498.33

FULLV:FV       30   -107     1535  2.03  0.18  501.13  498.33   13800  499.10
         0     30    172   172415  1.61  0.13    0.00    0.86    8.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       73   -215     1965  1.43  0.33  501.48 *******   13800  500.05
        73     73     93   240707  1.86  0.00    0.02    0.67    7.02
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    499.10     496.39

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                    QRD,QRDMAX,RATIO =     6995.      5444.    1.29

            <<<<<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       30      0      542  2.46 *****  498.90  493.38    6815  496.44
         0 ******     47    63759  1.00 ***** *******    0.65   12.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    50.  0.08  0.73  503.11    0.00   6995.  502.37

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3617.   234.  -215.    19.   3.7   2.1   8.0   7.2   2.9   3.2
   RT:   3378.   195.    19.   214.   3.5   2.4   8.3   7.3   3.1   3.1

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       47   -301     2850  0.73  0.25  503.19  495.66   13800  502.46
        73     53    104   352681  2.00  0.00    0.00    0.46    4.84

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

   FIRST USER DEFINED TABLE.
     XSID:CODE     SRD    LEW     REW       Q        K      AREA     VEL    WSEL
    EXT1 :XS      -90.  -130.   172.  13800.  129474.    1593.    8.66  498.08
    EXITX:XS      -30.  -110.   172.  13800.  186848.    1644.    8.39  499.05
    FULLV:FV        0.  -108.   172.  13800.  172415.    1535.    8.99  499.10
    BRIDG:BR        0.     0.    47.   6815.   63759.     542.   12.57  496.44
    RDWAY:RG       13.******* 3617.   6995.******************    1.00  502.37
    APPRO:AS       73.  -302.   104.  13800.  352681.    2850.    4.84  502.46

 SECOND USER DEFINED TABLE.
     XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO  VHD      EGL    WSEL
    EXT1 :XS     498.08    0.93  487.83  504.27************  2.28  500.36  498.08
    EXITX:XS   ********    0.78  481.05  515.52  0.47  0.00  1.77  500.83  499.05
    FULLV:FV     498.33    0.86  481.48  515.96  0.18  0.13  2.03  501.13  499.10
    BRIDG:BR     493.38    0.65  481.76  496.44************  2.46  498.90  496.44
    RDWAY:RG   ****************  498.65  514.14  0.08******  0.73  503.11  502.37
    APPRO:AS     495.66    0.46  481.28  509.33  0.25  0.00  0.73  503.19  502.46
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File beth039.wsp
        Hydraulic analysis for structure BETHTH00060039   Date: 23-JUL-97
        TH 6 Bridge Located at junction of TH 3 and 6, 2nd Br White River, LKS
           *** RUN DATE & TIME: 09-05-97  14:52

 ===010 WSI BELOW YMIN AT SECID "EXT1 ":  USED WSI = CRWS.
                        YMIN,WSI,CRWS =     487.8   ********     494.99

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

EXT1 :XS   ******   -120      715  1.76 *****  496.75  494.99    5440  494.99
       -89 ******    122    51456  1.95 ***** *******    1.09    7.61

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "EXITX"     KRATIO =  1.99

EXITX:XS       60    -93      925  0.73  0.34  497.09 *******    5440  496.36
       -29     60    137   102631  1.35  0.00    0.00    0.60    5.88

FULLV:FV       30    -91      842  0.82  0.09  497.23 *******    5440  496.41
         0     30    125    94013  1.27  0.05    0.00    0.62    6.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.75

APPRO:AS       73    -94     1326  0.36  0.14  497.37 *******    5440  497.01
        73     73     82   164604  1.39  0.00    0.00    0.31    4.10
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    496.41     496.39

            <<<<<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       30      0      542  1.57 *****  497.97  492.10    5435  496.41
         0 ******     47    70740  1.00 ***** *******    0.52   10.03

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  496.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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       47   -108     1639  0.25  0.10  498.95  491.76    5440  498.70
        73     52     88   214879  1.44  0.00    0.00    0.24    3.32

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   498.67

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXT1 :XS     -90.  -121.   122.   5440.   51456.     715.    7.61  494.99
   EXITX:XS     -30.   -94.   137.   5440.  102631.     925.    5.88  496.36
   FULLV:FV      0.    -92.   125.   5440.   94013.     842.    6.46  496.41
   BRIDG:BR      0.     0.     47.   5435.   70740.     542.   10.03  496.41
   RDWAY:RG      13.**************      0.       0.       0.    1.00********
   APPRO:AS      73.  -109.    88.   5440.  214879.    1639.    3.32  498.70

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXT1 :XS    494.99    1.09  487.83  504.27************  1.76  496.75  494.99
   EXITX:XS  ********    0.60  481.05  515.52  0.34  0.00  0.73  497.09  496.36
   FULLV:FV  ********    0.62  481.48  515.96  0.09  0.05  0.82  497.23  496.41
   BRIDG:BR    492.10    0.52  481.76  496.44************  1.57  497.97  496.41
   RDWAY:RG  ****************  498.65  514.14************  0.25  498.92********
   APPRO:AS    491.76    0.24  481.28  509.33  0.10  0.00  0.25  498.95  498.70
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for sediment sample from the channel approach of structure BETHTH00060039, in Bethel, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BETHTH00060039

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)* 00000

Waterway *(I - 6)* Second Branch of the White River

Road Name *(I - 7):* -

Route Number TH006

Vicinity *(I - 9)* At jct with TH 3 and TH 6

Topographic Map South Royalton

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43523

Longitude *(i - 17; nnnnn.n)* 72353

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10140400391404

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

Maximum span length *(I - 48; nnnn)* 0049

Year built *(I - 27; YYYY)* 1938

Structure length *(I - 49; nnnnnn)* 000052

Average daily traffic, ADT *(I - 29; nnnnnn)* 000075

Deck Width *(I - 52; nn.n)* 230

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

Channel & Protection *(I - 61; n)* 6

Opening skew to Roadway *(I - 34; nn)* 00

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

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

Underwater Inspection Frequency *(I - 92B; XYY)* Y48

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 012.5

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

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

Comments:

Underwater inspection report of 7/16/92 indicates that the bridge is a steel beam type bridge. Maximum water depths reach 7 ft at this site. The bridge is located about 100 ft upstream of a dam. Heavy concrete spalling was reported at the ends of both abutments and wingwalls with some exposed rebar. Undermining and settlement were not apparent. Minor silt channel bars are noted. Scour and embankment erosion were not addressed on the report. The channel makes a sharp bend into the bridge crossing. There was no riprap noted. The roadway is paved.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: **Silt, sand, and some small stones**

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: **There is a dam located approximately 100 ft downstream from this site.**

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 64.35 mi^2

Lake/pond/swamp area 0.47 mi^2

Watershed storage *(ST)* 0.7 %

Bridge site elevation 520 ft

Headwater elevation 1840 ft

Main channel length 20.78 mi

10% channel length elevation 550 ft

85% channel length elevation 720 ft

Main channel slope *(S)* 10.91 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: 4 (*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? N *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:
There is no foundation material information available.

Comments:
There are no bridge plans available.

Cross-sectional Data

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

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

Comments: **The elevation and station measurements are in ft.**

Station	**245**	**261**	**278**	**296**	-	-	-	-	-	-	-
Feature	**LAB**	-	-	**RAB**	-	-	-	-	-	-	-
Low cord elevation	**540**	**540**	**540**	**540**	-	-	-	-	-	-	-
Bed elevation	**526.7**	**527.4**	**525**	**527.3**	-	-	-	-	-	-	-
Low cord to bed length	**13.3**	**12.6**	**15**	**12.7**	-	-	-	-	-	-	-

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: **JRD** Date: **05/29/97**

Computerized by: **JRD** Date: **05/30/97**

Reviewd by: **LKS** Date: **10/22/97**

Structure Number **BETHTH00060039**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J**. **DEGNAN** Date *(MM/DD/YY)* **07** / **11** / 19**96**

2. Highway District Number **04** Mile marker **0**

County **Windsor (027)** Town **Bethel (05800)**

Waterway *(I - 6)* **Second Branch of the White River** Road Name **-**

Route Number **TH006** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

The structure is located at the junction of TH 3 and TH 6.

B. Bridge Deck Observations

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

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

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

7. Bridge length **49.0** *(feet)* Span length **52.0** *(feet)* Bridge width **23.0** *(feet)*

Road approach to bridge:

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

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

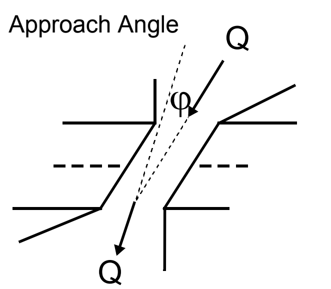
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

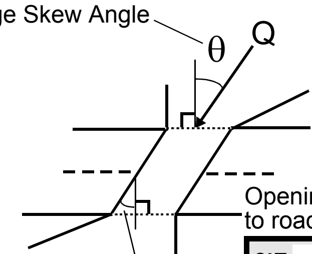
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	5	1	2	1
RBUS	5	1	0	-
RBDS	5	1	0	-
LBDS	5	1	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **20** 16. Bridge skew: **20**





α= **5.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **0** feet **US** *(US, UB, DS)* to **100** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **10** feet **US** *(US, UB, DS)* to **50** feet **DS**

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

18. Bridge Type: **1b**

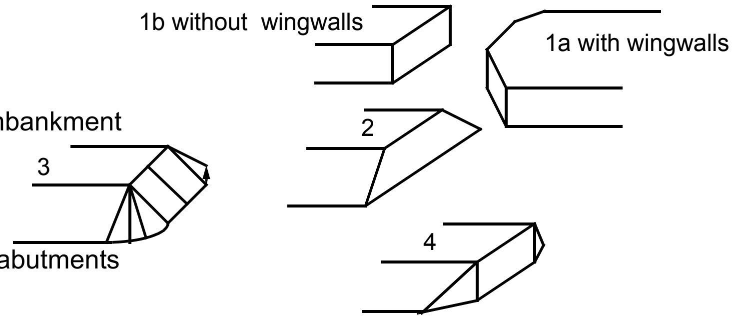
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. The measured bridge dimensions matched those from the VTAOT database.

11. Laid up stone walls continue on beyond where the concrete abutment side walls-protection ends.

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
90.0	**3.5**			**3.0**	**1**	**1**	**12**	**12**	**1**	**2**

23. Bank width **15.0** 24. Channel width **40.0** 25. Thalweg depth **61.5** 29. Bed Material **132**

30 .Bank protection type: LB **0** RB **2** 31. Bank protection condition: LB **-** RB **2**

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.):

27. & 29. Although the bed and bank material are composed primarily of silt and sand, there are a few small stones within the material.

30. The right bank protection extends from 50 ft upstream to 0 ft upstream. Much of the protection has slumped into the stream bed, with some along the steepened bank.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 75 35. Mid-bar width: 30

36. Point bar extent: 30 feet US (US, UB) to 110 feet US (US, UB, DS) positioned 0 %LB to 20 %RB

37. Material: 1

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

This point bar is composed primarily of silt.

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: 90 42. Cut bank extent: 0 feet US (US, UB) to 200 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 a steep slope along the entire length of the cut-bank.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 0

47. Scour dimensions: Length 240 Width 25 Depth : 3 Position 65 %LB to 97 %RB

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

The scour hole extends from 120 upstream to 100 ft downstream.

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) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
44.0		7.5		2	7	7	0

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

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

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

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

132

The bed material is silt and sand with a few pieces of gravel.

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

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

70. Debris and Ice Comments:

2

67. Standing dead trees along the banks create a high debris potential.

68. The bridge constricts the channel raising the capture efficiency.

69. Spalling of the concrete abutment walls indicates the possibility of ice build-up. The spalling is severe from the water level up 2.0 ft.

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		20	90	2	2	3	3	90.0
RABUT	1	0	90			2	1	46.0

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.):

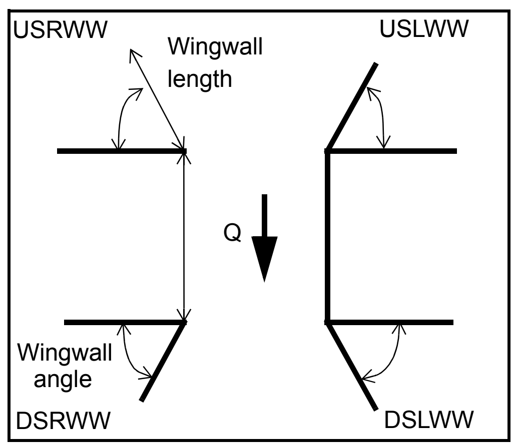
3
0
1

76. The left abutment footing has 3.0 ft of vertical exposure beginning at the upstream end, and extending to 8.0 ft upstream of the downstream face. The total water depth is 7.0 ft at the upstream end and 4.0 ft at the downstream end of the left abutment. The depths along the right abutment also decrease with increasing distance downstream.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						46.0	
USRWW:	N		-		-	6.5	
DSLWW:	-		-		N	26.5	
DSRWW:	-		-		-	26.5	

*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	-	-	N	-	-	-	-	-
Condition	N	-	-	-	-	-	-	-
Extent	-	-	-	0	0	0	0	0

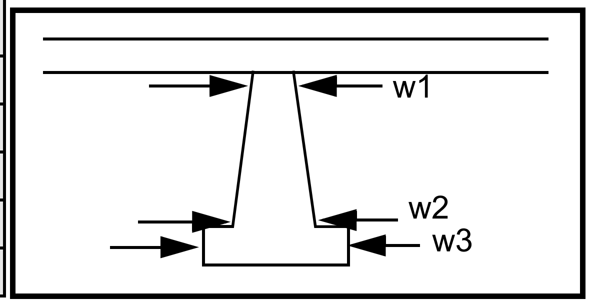
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
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 (Amb) - Thalweg depth (Amb) - 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.):

2
2
132
132
1
0
142
2
0
2

101. Is a drop structure present? - (*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 bed and bank material is silt and sand with a few pieces of gravel sized material.
The left bank protection extends from zero ft downstream to 60 ft downstream.

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: **Y**

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

3

There is a concrete dam 150 ft downstream of the structure which raises the water surface elevation.

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 **60** *(US, UB, DS)* to **40** feet **15** *(US, UB, DS)*

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

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

80
DS
40
100

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

Scour dimensions: Length **silt** Width **and** Depth: **sand** Positioned **side** %LB to **bar** %RB

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

extends from under the bridge to the dam downstream.

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

Confluence 1: Distance **60** Enters on **0** *(LB or RB)* Type **DS** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

The bank is over steepened with protection under water. The bank is silt above the protection. There is wood protruding out of the cut-bank in the last twenty ft. There is no stone protection found in this area of the cut-

F. Geomorphic Channel Assessment

107. Stage of reach evolution **ba**

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)*:

nk.

N

-

-

-

-

-

-

There is no channel scour present downstream at this site.

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:	BETHTH00060039	Town:	BETHEL
Road Number:	TH 6	County:	WINDSOR
Stream:	2ND BRANCH WHITE RIVER		

Initials LKS Date: 09/05/97 Checked: EMB

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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	8950	13800	5440
Main Channel Area, ft2	972	1059	828
Left overbank area, ft2	1153	1568	715
Right overbank area, ft2	168	224	95
Top width main channel, ft	62	62	62
Top width L overbank, ft	263	302	109
Top width R overbank, ft	36	43	27
D50 of channel, ft	0.004	0.004	0.004
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	15.7	17.1	13.4
y1, average depth, LOB, ft	4.4	5.2	6.6
y1, average depth, ROB, ft	4.7	5.2	3.5
Total conveyance, approach	279187	352888	214787
Conveyance, main channel	194715	224970	149243
Conveyance, LOB	76471	116479	61767
Conveyance, ROB	8001	11439	3777
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	6242.1	8797.7	3779.9
Ql, discharge, LOB, cfs	2451.5	4555.0	1564.4
Qr, discharge, ROB, cfs	256.5	447.3	95.7
Vm, mean velocity MC, ft/s	6.4	8.3	4.6
Vl, mean velocity, LOB, ft/s	2.1	2.9	2.2
Vr, mean velocity, ROB, ft/s	1.5	2.0	1.0
Vc-m, crit. velocity, MC, ft/s	2.8	2.9	2.7
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	**1**	**1**	**1**
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 Davis, 1995, p. 30, eq. 17 and 18)

Characteristic	Approach 100 yr	500 yr	Other Q	Bridge 100 yr	500 yr	Other Q
Q1, discharge, cfs	8950	13800	5440	6507	6815	5440
Total conveyance	279187	352888	214787	63759	63759	69987
Main channel conveyance	194715	224970	149243	63759	63759	69987
Main channel discharge	6242	8798	3780	6507	6815	5440
Area - main channel, ft2	972	1059	828	542	542	541.8
(W1) channel width, ft	62	62	62	46.4	46.4	46.4
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	62	62	62	46.4	46.4	46.4
D50, ft	0.004	0.004	0.004			
w, fall velocity, ft/s (p. 32)	0.4965	0.4965	0.4965			
y, ave. depth flow, ft	15.68	17.08	13.35	11.68	11.68	11.68
S1, slope EGL	0.0027	0.0048	0.0019			
P, wetted perimeter, MC, ft	65	65	65			
R, hydraulic Radius, ft	14.954	16.292	12.738			
V*, shear velocity, ft/s	1.140	1.587	0.883			
V*/w	2.297	3.196	1.778			
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	0.69	0.69	0.64			
y2,depth in contraction, ft	19.84	16.76	21.96			
ys, scour depth, ft (y2-y_bridge)	**8.16**	**5.08**	**10.29**			

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	6507	6815	5440
Main channel area (DS), ft2	542	542	541.8
Main channel width (normal), ft	46.4	46.4	46.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	46.4	46.4	46.4
D90, ft	0.0110	0.0110	0.0110
D95, ft	0.0131	0.0131	0.0131
Dc, critical grain size, ft	0.1622	0.1779	0.1135
Pc, Decimal percent coarser than Dc	0.000	0.000	0.000

Depth to armoring, ft	**N/A**	**N/A**	**N/A**

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	8950	13800	5440
Q, thru bridge MC, cfs	6507	6815	5440
Vc, critical velocity, ft/s	2.82	2.86	2.74
Va, velocity MC approach, ft/s	6.42	8.31	4.57
Main channel width (normal), ft	46.4	46.4	46.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	46.4	46.4	46.4
qbr, unit discharge, ft2/s	140.2	146.9	117.2
Area of full opening, ft2	542.0	542.0	541.8
Hb, depth of full opening, ft	11.68	11.68	11.68
Fr, Froude number, bridge MC	0.62	0.65	0.52
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	496.39	496.39	496.39
Elevation of Bed, ft	484.71	484.71	484.71
Elevation of Approach, ft	501.03	502.46	498.7
Friction loss, approach, ft	0.17	0.25	0.1
Elevation of WS immediately US, ft	500.86	502.21	498.60
ya, depth immediately US, ft	16.15	17.50	13.89
Mean elevation of deck, ft	501.17	501.17	501.17
w, depth of overflow, ft (>=0)	0.00	1.04	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.91	0.96
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	42.60	44.69	32.99
Ys, scour w/Umbrell equation, ft	17.59	23.71	9.14

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

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

**Ys, scour w/Umbrell equation, ft	N/A	N/A	N/A

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	19.84	16.76	21.96
WSEL at downstream face, ft	--	--	--
Depth at downstream face, ft	N/A	N/A	N/A
Ys, depth of scour (Laursen), ft	N/A	N/A	N/A

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 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	8950	13800	5440	8950	13800	5440
a', abut.length blocking flow, ft	263.6	302.2	109.4	50.5	57.9	41.6
Ae, area of blocked flow ft2	947.11	1099.13	717.15	315.38	294.36	275.21
Qe, discharge blocked abut.,cfs	--	--	1582.09	--	--	809.03
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.18	2.96	2.21	3.85	4.75	2.94
ya, depth of f/p flow, ft	3.59	3.64	6.56	6.25	5.08	6.62
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.183	0.228	0.152	0.246	0.297	0.201
ys, scour depth, ft	**22.08**	**26.21**	**22.48**	**20.94**	**20.63**	**18.98**

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a’(abut length blocked, ft)	263.6	302.2	109.4	50.5	57.9	41.6
y1 (depth f/p flow, ft)	3.59	3.64	6.56	6.25	5.08	6.62
a’/y1	73.37	83.09	16.69	8.09	11.39	6.29
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.18	0.23	0.15	0.25	0.30	0.20
Ys w/ corr. factor K1/0.55:						
vertical	15.07	16.40	ERR	ERR	ERR	ERR
vertical w/ ww’s	12.36	13.45	ERR	ERR	ERR	ERR
spill-through	8.29	9.02	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 Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.62	0.65	0.52	0.62	0.65	0.52
y, depth of flow in bridge, ft	11.68	11.68	11.68	11.68	11.68	11.68
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**2.78**	**3.05**	**1.95**	**2.78**	**3.05**	**1.95**
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR