LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (ROYATH00060030) on TOWN HIGHWAY 6, crossing the WHITE RIVER, ROYALTON, VERMONT

Open-File Report 98-264

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 MICHAEL A. IVANOFF AND ROBERT E. HAMMOND

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Pembroke, New Hampshire

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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.

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 30 (ROYATH00060030) ON TOWN HIGHWAY 6, CROSSING THE WHITE RIVER, ROYALTON, VERMONT

By Michael A. Ivanoff and Robert E. Hammond

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ROYATH00060030 on Town Highway 6 crossing the White River, Royalton, 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 (Federal Highway Administration, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in central Vermont. The 479-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the right bank is pasture and on the left bank there is shrub and brush while the immediate banks have dense woody vegetation.

In the study area, the White River has an incised, meandering channel with a slope of approximately 0.003 ft/ft, an average channel top width of 308 ft and an average bank height of 15 ft. The channel bed material ranges from gravel to cobble with a median grain size (D_{50}) of 68.3 mm (0.224 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 8, 1996, indicated that the reach was stable.

The Town Highway 6 crossing of the White River is a 165-ft-long, two-lane bridge consisting of one 159-foot steel thru-truss span (Vermont Agency of Transportation, written communication, May 24, 1995). The opening length of the structure parallel to the bridge face is 161 ft. The bridge is supported by vertical, concrete abutments with wingwalls only on the right bank. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 12 ft deeper than the mean thalweg depth was observed in the channel along the left bank upstream of bridge during the Level I assessment. A second scour hole 5 ft deeper than the mean thalweg is just downstream of the bridge along the left bank. The scour protection measures at the site included type-2 stone fill (less than 36 inches diameter) along the upstream right wingwall and type-3 stone fill (less than 48 inches diameter) along the downstream right wingwall. There are also stacked concrete bags along the base of the footing on the left and right abutments. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 3.3 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge. Left abutment scour ranged from 38.5 to 41.2 ft. The worst-case left abutment scour occurred at the 500-year discharge, however, the left abutment footing is on a ledge outcrop which may limit the scour depth. Right abutment scour ranged from 11.2 to 28.1 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

South Royalton, VT. Quadrangle, 1:24,000, 1981, photoinspected 1983

NORTH

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

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

LEVEL II SUMMARY

Structure Number ROYATH00060030 ***Stream*** White River

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

Description of Bridge

Bridge length 165 ***ft*** ***Bridge width*** 17.5 ***ft*** ***Max span length*** 159 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No ***Date of inspection*** 7/8/96

Description of stone fill Type-2, along the upstream right wingwall. Type-3, along the downstream right wingwall.

Abutments and wingwalls on the right abutment are concrete. There are large concrete filled bags at the base of the left and right abutment footings. There is a 12 ft deep scour hole upstream of the bridge along the left bank.

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

There is a moderate 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	7/8/96	0	0
Level II	7/8/96	0	0

Potential for debris Low. There are trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) A large ledge outcrop in the channel along the upstream left bank forms an eddy current resulting in a significant scour hole as of 7/8/96. There is an additional ledge outcrop and scour hole downstream.

Description of the Geomorphic Setting

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

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

Date of inspection 7/8/96

DS left: Moderately sloped channel bank to the overbank.

DS right: Steep channel bank to a narrow flood plain.

US left: Moderately sloped channel bank to the overbank.

US right: Moderately sloped channel bank to a narrow flood plain.

Description of the Channel

Average top width 308 ft ***Average depth*** 15 ft

Predominant bed material Gravel / Cobbles ***Bank material*** Silt / Sand

Meandering but stable with semi-alluvial channel boundaries and a narrow flood plain.

7/8/96

Vegetative co Short grass brush with a few trees.

DS left: Trees and brush with pasture on the flood plain.

DS right: Short grass and brush with a few trees.

US left: Trees and brush with pasture on the flood plain.

US right:

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

None, 7/8/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 479 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? Yes

USGS gage description White River at West Hartford, VT

USGS gage number 01144000

Gage drainage area 690 ***mi***^{2}

Is there a lake/p No

Calculated Discharges

Q100 51,600 ***ft***^{3}***/s*** ***Q500*** 79,300 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(479/690)exp 0.67] with the gage (01144000) on the White River at West Hartford, VT. The drainage area adjusted discharges are within a range of several flood frequency curves based on 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 Subtract 404 ft from the USGS arbitrary survey datum to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the DS end of the right abutment bridge seat (elev. 502.57 ft, arbitrary survey datum). RM2 is a chiseled X on top of the US end of the left abutment at the road surface elevation (elev. 506.37 ft, arbitrary survey datum). RM3 is a chiseled X in a chiseled square in the bedrock on the left bank US at the bottom of a wooden staircase (elev. 491.14 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-119	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APPRO	201	1	Approach section

[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.

[2] Cross-section development: (1) survey at SRD, (2) shift of survey data to SRD, (3) modification of survey data, (4) composite bridge section, (5) other.

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 0.040 to 0.060, and overbank "n" values ranged from 0.050 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 0.0027 ft/ft, which was estimated from the water surface profile for the 100-year event downstream of the site in the Flood Insurance Study for Royalton, VT (Federal Emergency Management Agency, 1989).

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

Bridge Hydraulics Summary

Average bridge embankment elevation 507.2 ***ft***
Average low steel elevation 503.3 ***ft***

100-year discharge 51,610 ***ft³/s***
Water-surface elevation in bridge opening 500.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 14,430 ***ft³/s***
Area of flow in bridge opening 3,250 ***ft²***
Average velocity in bridge opening 11.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.5 ***ft/s***

Water-surface elevation at Approach section with bridge 502.9
Water-surface elevation at Approach section without bridge 501.0
Amount of backwater caused by bridge 1.9 ***ft***

500-year discharge 79,320 ***ft³/s***
Water-surface elevation in bridge opening 503.4 ***ft***
Road overtopping? Yes ***Discharge over road*** 39,680 ***ft³/s***
Area of flow in bridge opening 3,770 ***ft²***
Average velocity in bridge opening 10.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.0 ***ft/s***

Water-surface elevation at Approach section with bridge 505.9
Water-surface elevation at Approach section without bridge 504.1
Amount of backwater caused by bridge 1.8 ***ft***

Incipient overtopping discharge 38,490 ***ft³/s***
Water-surface elevation in bridge opening 495.7 ***ft***
Area of flow in bridge opening 2,606 ***ft²***
Average velocity in bridge opening 14.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.2 ***ft/s***

Water-surface elevation at Approach section with bridge 499.8
Water-surface elevation at Approach section without bridge 498.1
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 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. However, bedrock was observed in contact with the left abutment. The results of the 100-year and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the 100-year and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 500-year discharge resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for this discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The contraction scour result for the 100-year and 500-year discharges was zero ft.

For comparison, contraction scour for the 500-year discharge resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in appendix F.

Abutment scour for the left abutment 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 left abutment footing is on a ledge outcrop which may limit the scour depth.

Scour at the right abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	3.3
Depth to armoring	2.8	1.2	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	38.6	41.2	38.5
Right abutment	11.2	14.2	28.1
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	3.8	2.1	5.1
Right abutment	3.8	2.1	5.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

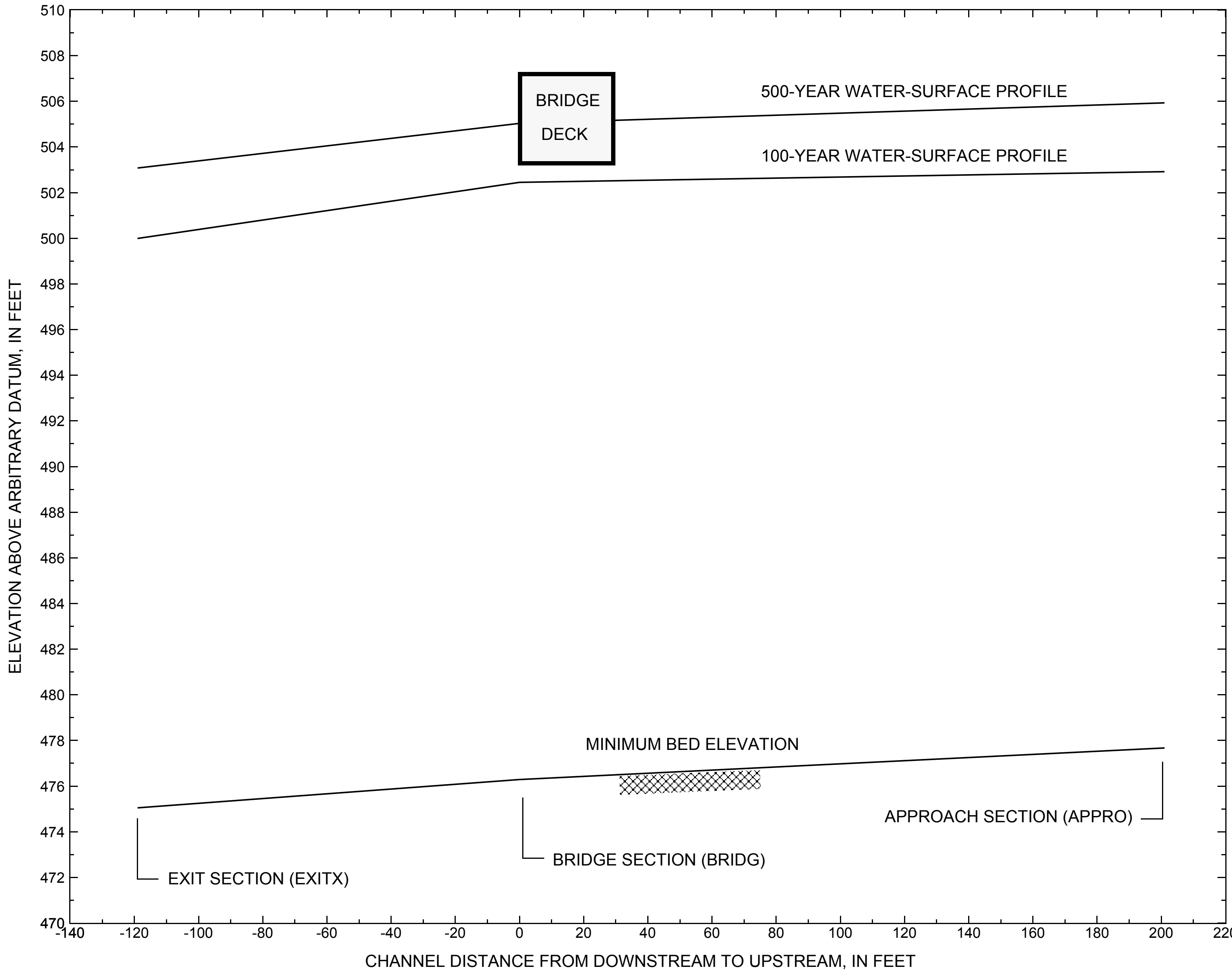

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure ROYATH00060030 on Town Highway 6, crossing the White River, Royalton, Vermont.

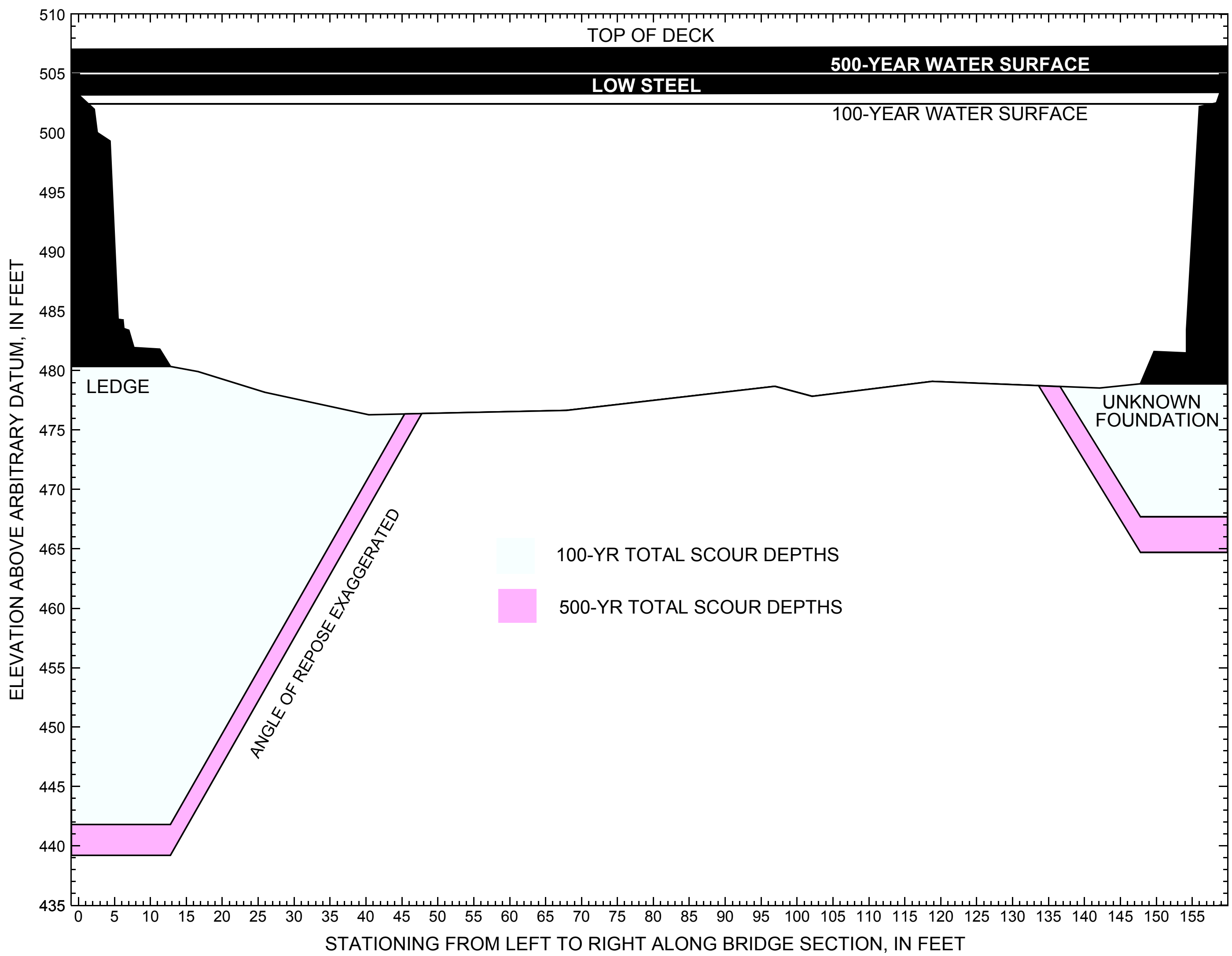

Figure 8. Scour elevations for the 100- and 500-year discharges at structure ROYATH00060030 on Town Highway 6, crossing the White River, Royalton, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ROYATH00060030 on Town Highway 6, crossing the White River, Royalton, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 51,610 cubic-feet per second											
Left abutment	0.0	97.9	503.2	--	480.4	0.0	38.6	--	38.6	441.8	--
Right abutment	158.9	98.2	503.4	--	478.9	0.0	11.2	--	11.2	467.7	--

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 ROYATH00060030 on Town Highway 6, crossing the White River, Royalton, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 79,320 cubic-feet per second											
Left abutment	0.0	97.9	503.2	--	480.4	0.0	41.2	--	41.2	439.2	--
Right abutment	158.9	98.2	503.4	--	478.9	0.0	14.2	--	14.2	464.7	--

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

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File roya030.wsp
T2        Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
T3        Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          51610.0  79320.0   38490.0
SK          0.0027   0.0027   0.0027
*
XS   EXITX   -119
GR         -294.6, 508.23   -277.9, 501.93   -182.3, 500.26    -88.8, 500.11
GR          -83.6, 497.14    -17.5, 487.63      0.0, 483.36     12.0, 482.80
GR           30.1, 479.44     56.1, 475.05     77.2, 476.77     99.5, 479.61
GR          123.9, 481.61    146.9, 481.00    165.0, 481.00    194.7, 480.80
GR          205.0, 480.23    211.5, 480.22    219.7, 483.32    230.0, 489.24
GR          234.4, 495.03    256.7, 495.77    260.9, 498.77    272.8, 499.59
GR          294.9, 499.55    427.5, 499.87
GR          600.3, 500.10    878.0, 498.11    931.6, 500.88   1037.6, 511.62
N           0.054        0.050        0.050
SA                 -88.8        272.8
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    503.31       0.0
GR           -1.7, 502.15     -1.1, 502.16      0.2, 502.15
GR            2.2, 502.00      2.6, 500.05      4.4, 499.33      5.5, 484.32
GR            6.2, 484.27      6.3, 483.54      7.0, 483.39      7.7, 481.94
GR           11.3, 481.81     12.8, 480.35     16.6, 479.92     25.9, 478.18
GR           40.4, 476.29     67.9, 476.65     96.9, 478.68    102.1, 477.84
GR          118.8, 479.10    142.1, 478.53    147.8, 478.89    149.7, 481.61
GR          154.2, 481.49    154.2, 483.43    156.0, 502.22    158.4, 502.53
GR          158.9, 503.42      0.0, 503.20     -1.7, 502.15
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      32.6 * *     10.0     21.1
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      17.5     1
GR         -383.0, 522.24   -280.4, 509.33   -266.2, 508.69   -260.3, 508.74
GR         -220.5, 506.29   -141.1, 503.53    -64.1, 504.03     -6.7, 506.37
GR           -6.6, 506.96      0.0, 507.05    151.8, 507.31    157.0, 507.13
GR          157.3, 506.57    200.0, 504.93    259.4, 501.61    315.8, 500.09
GR          600.3, 500.10    878.0, 498.11    931.6, 500.88   1037.6, 511.62
*
AS   APPRO    201
GR         -299.2, 514.48   -198.2, 508.17   -158.9, 502.94    -59.1, 501.12
GR          -39.3, 491.98    -23.5, 486.84      0.0, 485.32     16.6, 486.53
GR           21.8, 483.71     25.7, 481.49     33.2, 479.11     42.4, 480.90
GR           57.8, 480.35     60.2, 481.91     72.6, 479.45     75.2, 479.90
GR           84.1, 479.29     90.1, 477.91    105.0, 477.67    113.1, 483.60
GR          150.0, 486.52    154.9, 486.67    169.5, 490.57    190.1, 493.51
GR          322.8, 492.08    359.5, 496.85    370.4, 501.44    407.0, 501.26
*
* The following points were omited to determine the incipient roadway-overtopping
```

```
* discharge. This prevents excessive flows on the overbank at a water surface
* below the top of the bank.
*
GR          432.9, 501.20    509.5, 499.32    641.7, 499.39    836.5, 498.56
GR          948.1, 500.48    987.5, 506.09   1034.0, 509.21
*
N           0.053        0.060        0.080        0.050
SA                 -59.1        190.1        370.4
*

HP 1 BRIDG  499.96 1 499.96
HP 2 BRIDG  499.96 * * 37185
HP 2 RDWAY  502.45 * * 14425
HP 1 APPRO  502.92 1 502.92
HP 2 APPRO  502.92 * * 51610
*
HP 1 BRIDG  503.42 1 503.42
HP 2 BRIDG  503.42 * * 39300
HP 2 RDWAY  505.03 * * 39682
HP 1 APPRO  505.93 1 505.93
HP 2 APPRO  505.93 * * 79320
*
HP 1 BRIDG  495.70 1 495.70
HP 2 BRIDG  495.70 * * 38490
HP 1 APPRO  499.75 1 499.75
HP 2 APPRO  499.75 * * 38490
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File roya030.wsp
       Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
       Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
          *** RUN DATE & TIME: 10-14-97  10:45
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW      QCR
            1    3250   809080    153    188                         85003
  499.96         3250   809080    153    188  1.00      3    156    85003

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      499.96     2.8   155.8  3249.8  809080.   37185.  11.44

X STA.        2.8       19.5       27.8       35.0       41.3       47.5
  A(I)           272.4      179.1      161.5      147.4      146.9
  V(I)            6.83      10.38      11.51      12.61      12.66

X STA.       47.5       53.5       59.5       65.4       71.5       77.5
  A(I)           140.5      140.7      138.1      140.5      138.1
  V(I)           13.23      13.21      13.47      13.23      13.46

X STA.       77.5       83.8       90.4       97.1      103.9      110.6
  A(I)           141.8      143.3      144.7      148.3      146.1
  V(I)           13.11      12.97      12.85      12.54      12.72

X STA.      110.6      117.7      125.1      132.9      141.1      155.8
  A(I)           149.8      155.7      164.5      174.7      275.8
  V(I)           12.41      11.94      11.31      10.64       6.74

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

        WSEL     LEW     REW    AREA        K        Q    VEL
      502.45   244.4   947.1  1866.0  108111.   14425.   7.73

X STA.      244.4      328.5      373.8      417.4      461.9      505.2
  A(I)           126.5      106.8      102.9      104.9      101.7
  V(I)            5.70       6.75       7.01       6.87       7.09

X STA.      505.2      549.9      595.2      637.1      671.8      702.4
  A(I)           105.2      106.5      103.3       95.1       91.1
  V(I)            6.86       6.77       6.98       7.58       7.92

X STA.      702.4      729.7      754.6      777.5      798.5      818.4
  A(I)            86.8       83.7       80.9       77.6       76.6
  V(I)            8.31       8.62       8.92       9.29       9.42

X STA.      818.4      837.4      855.3      872.9      892.6      947.1
  A(I)            75.5       73.7       74.8       79.8      112.6
  V(I)            9.55       9.79       9.64       9.04       6.40

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

    WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      89     2328     99     99                           478
            2    4382   719628    249    258                        104270
            3    1695   139983    180    182                         29492
            4    1945   127670    595    595                         19959
  502.92         8111   989609   1123   1133  1.42   -157    965   103809

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

        WSEL     LEW     REW    AREA        K        Q    VEL
      502.92  -157.8   965.2  8111.0  989609.   51610.   6.36

X STA.     -157.8      -18.3        1.3       20.0       33.3       45.2
  A(I)           513.2      333.6      318.1      284.8      270.4
  V(I)            5.03       7.73       8.11       9.06       9.54

X STA.       45.2       57.0       69.4       80.5       91.1      101.0
  A(I)           263.0      271.8      258.2      255.2      249.7
  V(I)            9.81       9.49       9.99      10.11      10.34

X STA.      101.0      112.5      128.3      145.7      167.6      216.1
  A(I)           269.4      295.3      304.3      335.1      497.0
  V(I)            9.58       8.74       8.48       7.70       5.19

X STA.      216.1      272.3      327.0      571.4      762.7      965.2
  A(I)           561.6      578.4      833.6      707.6      710.6
  V(I)            4.59       4.46       3.10       3.65       3.63
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File roya030.wsp
        Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
        Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
           *** RUN DATE & TIME: 10-14-97  10:45
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     3770    671271      0    361                            0
   503.42          3770    671271      0    361  1.00     -1    159        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.42    -1.7   158.9  3770.4  671271.   39300.  10.42

X STA.        -1.7       18.3       26.7       34.0       40.7       47.0
  A(I)           304.0      206.0      185.9      179.3      169.8
  V(I)            6.46       9.54      10.57      10.96      11.57

X STA.        47.0       53.4       59.5       65.7       72.0       78.3
  A(I)           170.4      164.1      164.5      167.5      164.9
  V(I)           11.53      11.98      11.95      11.73      11.92

X STA.        78.3       84.8       91.6       98.5      105.3      112.2
  A(I)           168.2      170.5      172.9      170.8      172.2
  V(I)           11.68      11.53      11.36      11.50      11.41

X STA.       112.2      119.4      126.8      134.5      142.5      158.9
  A(I)           177.1      180.2      188.8      198.9      294.3
  V(I)           11.10      10.90      10.41       9.88       6.68

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      15.

         WSEL     LEW     REW    AREA        K        Q    VEL
       505.03  -184.3   972.6  3912.4  332923.   39682.  10.14

X STA.      -184.3      291.9      334.6      373.4      412.7      451.7
  A(I)           370.9      203.5      191.6      193.8      192.6
  V(I)            5.35       9.75      10.36      10.24      10.30

X STA.       451.7      490.9      529.4      569.1      608.2      644.9
  A(I)           193.7      189.9      195.8      192.9      187.9
  V(I)           10.24      10.45      10.13      10.28      10.56

X STA.       644.9      679.4      710.7      740.6      768.6      795.7
  A(I)           185.0      175.8      174.2      169.1      168.9
  V(I)           10.73      11.29      11.39      11.73      11.75

X STA.       795.7      821.2      846.4      871.1      898.3      972.6
  A(I)           163.6      166.3      167.8      177.5      251.6
  V(I)           12.13      11.93      11.83      11.18       7.88

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      423     27150    122    122                         4462
             2     5132    936437    249    258                       132157
             3     2238    222395    180    182                        44735
             4     3767    375293    616    616                        52869
   505.93         11560   1561275   1168   1178  1.31   -180    986   180557

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

         WSEL     LEW     REW    AREA        K        Q    VEL
       505.93  -181.4   986.4 11560.0 1561275.   79320.   6.86

X STA.      -181.4      -25.0       -1.3       20.6       36.8       51.9
  A(I)           841.1      467.6      442.4      403.2      382.0
  V(I)            4.72       8.48       8.96       9.84      10.38

X STA.        51.9       67.3       81.7       94.8      107.9      126.5
  A(I)           386.9      375.0      360.9      367.3      417.8
  V(I)           10.25      10.58      10.99      10.80       9.49

X STA.       126.5      147.4      175.1      230.1      288.2      346.6
  A(I)           426.3      481.8      707.9      764.6      766.3
  V(I)            9.30       8.23       5.60       5.19       5.18

X STA.       346.6      507.2      623.8      732.7      831.9      986.4
  A(I)           910.4      766.8      730.0      708.1      853.7
  V(I)            4.36       5.17       5.43       5.60       4.65
```

```
      U.S. Geological Survey WSPRO Input File roya030.wsp
      Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
      Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
         *** RUN DATE & TIME: 10-14-97  10:44

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     2606    579854    151    178                        61485
 495.70          2606    579854    151    178  1.00      5    155    61485


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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.70     4.7   155.4  2605.8  579854.   38490.  14.77

X STA.        4.7       19.3       27.6       34.7       40.9       46.9
  A(I)          205.5      141.3      129.1      118.8      116.3
  V(I)           9.37      13.62      14.91      16.20      16.55

X STA.       46.9       52.8       58.8       64.6       70.6       76.6
  A(I)          114.3      114.4      112.1      114.1      111.9
  V(I)          16.84      16.83      17.17      16.87      17.20

X STA.       76.6       83.1       89.7       96.5      103.4      110.3
  A(I)          117.0      117.7      118.1      120.8      119.5
  V(I)          16.45      16.36      16.29      15.93      16.10

X STA.      110.3      117.6      125.2      133.2      141.2      155.4
  A(I)          124.9      126.5      134.0      137.7      212.1
  V(I)          15.40      15.21      14.37      13.98       9.07


  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           2     3594    521586    246    254                        77916
           3     1127     72044    176    177                        16167
 499.75          4721    593630    423    432  1.20    -55    366    81685

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     201.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.75   -56.1   366.4  4720.9  593630.   38490.   8.15

X STA.      -56.1      -16.8       -0.4       16.0       28.7       37.9
  A(I)          316.0      228.5      227.2      206.4      184.8
  V(I)           6.09       8.42       8.47       9.32      10.41

X STA.       37.9       47.2       56.5       66.2       75.2       83.5
  A(I)          177.2      180.0      180.5      176.5      168.7
  V(I)          10.86      10.69      10.66      10.91      11.41

X STA.       83.5       91.5       99.2      107.1      118.6      131.8
  A(I)          168.6      168.8      172.8      197.8      200.5
  V(I)          11.42      11.40      11.13       9.73       9.60

X STA.      131.8      147.2      166.7      221.8      284.6      366.4
  A(I)          216.8      237.4      388.7      434.9      488.9
  V(I)           8.88       8.11       4.95       4.43       3.94
```

```
        U.S. Geological Survey WSPRO Input File roya030.wsp
        Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
        Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
           *** RUN DATE & TIME: 10-14-97  10:45

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

EXITX:XS   ******    -88     5817  1.35 *****  501.34  491.77   51610  499.99
      -118 ******    914   992695  1.10 ***** *******    0.65    8.87

FULLV:FV      119   -190     6253  1.24  0.30  501.65 *******   51610  500.41
         0    119    922  1047638  1.17  0.00    0.01    0.66    8.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS
                           "APPRO"     KRATIO =  0.69

APPRO:AS      201    -58     6041  1.58  0.71  502.53 *******   51610  500.95
       201    201    951   718918  1.39  0.17    0.00    0.70    8.54
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   504.32       0.00     497.28     498.11

 ===260 ATTEMPTING FLOW CLASS 4 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      119      3     3249  3.14  0.41  503.10  490.74   37185  499.96
         0    119    156   808940  1.54  1.35    0.00    0.54   11.44

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.805 ******  503.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.   184.  0.50  0.89  503.32    0.00  14425.  502.45

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.   148.  -186.   -38.   1.6   1.0   7.1  11.3   2.4   3.1
   RT:  14425.   703.   244.   947.   4.3   2.7   8.7   7.7   3.5   3.1

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

APPRO:AS      168   -157     8115  0.89  0.65  503.82  496.47   51610  502.92
       201    188    965   990134  1.42  0.07    0.01    0.50    6.36

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.848  0.420  573480.    15.   168. ********

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -119.   -89.   914.  51610.  992695.    5817.    8.87  499.99
   FULLV:FV       0.  -191.   922.  51610. 1047638.    6253.    8.25  500.41
   BRIDG:BR       0.     3.   156.  37185.  808940.    3249.   11.44  499.96
   RDWAY:RG      15.*******     0.  14425.        0.*********    1.00  502.45
   APPRO:AS     201.  -158.   965.  51610.  990134.    8115.    6.36  502.92

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      15.   168.  573480.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    491.77    0.65  475.05  511.62************  1.35  501.34  499.99
   FULLV:FV  ********    0.66  475.05  511.62  0.30  0.00  1.24  501.65  500.41
   BRIDG:BR    490.74    0.54  476.29  503.42  0.41  1.35  3.14  503.10  499.96
   RDWAY:RG  ****************  498.11  522.24  0.50******  0.89  503.32  502.45
   APPRO:AS    496.47    0.50  477.67  514.48  0.65  0.07  0.89  503.82  502.92
```

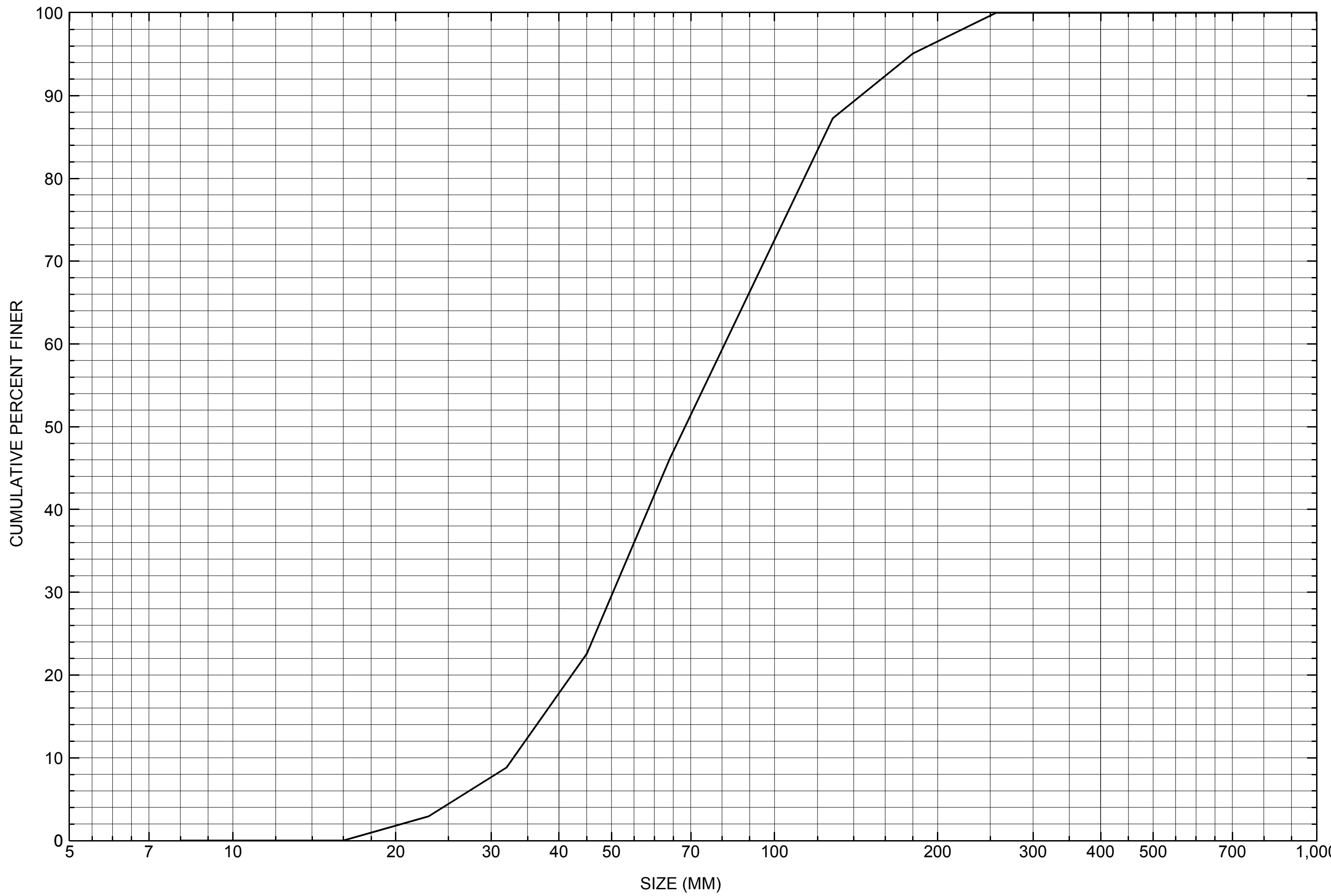
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File roya030.wsp
        Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
        Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
           *** RUN DATE & TIME: 10-14-97  10:45

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

EXITX:XS   ******   -280     9430  1.55 *****  504.62  495.72   79320  503.07
      -118 ******    953  1525657  1.41 ***** *******    0.64    8.41

FULLV:FV      119   -281    10013  1.38  0.30  504.92 *******   79320  503.54
         0    119    958  1629097  1.41  0.00    0.00    0.58    7.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      201   -167     9486  1.50  0.65  505.63 *******   79320  504.13
       201    201    974  1199920  1.38  0.06    0.01    0.60    8.36
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   503.54      503.31

            <<<<<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      119     -1     3770  1.69 *****  505.11  491.21   39300  503.42
         0 ******    159   671271  1.00 ***** *******    0.38   10.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800 ******  503.31 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.   184.  0.47  0.96  506.42    0.00  39682.  505.03

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1600.   145.  -184.   -40.   1.5   1.0   7.0  11.3   2.4   3.1
   RT:  38081.   775.   197.   973.   6.9   4.9  11.8  10.1   6.3   3.1

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

APPRO:AS      168   -180    11564  0.96  0.71  506.89  501.12   79320  505.93
       201    211    986  1562030  1.31  0.07    0.00    0.44    6.86

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW        Q        K     AREA     VEL    WSEL
   EXITX:XS    -119.  -281.   953.  79320. 1525657.    9430.    8.41  503.07
   FULLV:FV       0.  -282.   958.  79320. 1629097.   10013.    7.92  503.54
   BRIDG:BR       0.    -2.   159.  39300.  671271.    3770.   10.42  503.42
   RDWAY:RG      15.*******  1600.  39682.******************    1.00  505.03
   APPRO:AS     201.  -181.   986.  79320. 1562030.   11564.    6.86  505.93

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    495.72    0.64  475.05  511.62************  1.55  504.62  503.07
   FULLV:FV  ********    0.58  475.05  511.62  0.30  0.00  1.38  504.92  503.54
   BRIDG:BR    491.21    0.38  476.29  503.42************  1.69  505.11  503.42
   RDWAY:RG  ****************  498.11  522.24  0.47******  0.96  506.42  505.03
   APPRO:AS    501.12    0.44  477.67  514.48  0.71  0.07  0.96  506.89  505.93
```

```
        U.S. Geological Survey WSPRO Input File roya030.wsp
        Hydraulic analysis for structure ROYATH00060030   Date: 26-SEP-97
        Bridge 30 on Sewall Brook Rd over White River Royalton, VT by MAI
           *** RUN DATE & TIME: 10-14-97  10:44

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

EXITX:XS   ******    -83     4516  1.13 *****  498.35  489.75   38490  497.22
      -118 ******    259   740087  1.00 ***** *******    0.41    8.52

FULLV:FV      119    -83     4644  1.07  0.31  498.66 *******   38490  497.60
         0    119    259   773354  1.00  0.00    0.00    0.40    8.29
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.62

APPRO:AS      201    -52     4029  1.71  0.81  499.81 *******   38490  498.10
       201    201    362   476786  1.21  0.32    0.01    0.59    9.55
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.75       0.00     495.70     498.11
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   499.68     38490.         0.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.02     503.74     503.92
 ===270 REJECTED 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      119      5     2605  4.15  0.54  499.85  491.03   38490  495.70
         0    119    155   579657  1.22  0.95    0.00    0.69   14.77

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.904 ******  503.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<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      168    -55     4722  1.24  1.00  500.99  494.57   38490  499.75
       201    176    366   593753  1.20  0.14    0.00    0.47    8.15

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.636  0.263  437396.     8.   159.   498.98

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -119.   -84.   259.  38490.  740087.    4516.    8.52  497.22
   FULLV:FV       0.   -84.   259.  38490.  773354.    4644.    8.29  497.60
   BRIDG:BR       0.     5.   155.  38490.  579657.    2605.   14.77  495.70
   RDWAY:RG      15.**************      0.       0.       0.    1.00********
   APPRO:AS     201.   -56.   366.  38490.  593753.    4722.    8.15  499.75

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       8.   159.  437396.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS      FR#    YMIN    YMAX     HF    HO  VHD      EGL    WSEL
   EXITX:XS    489.75     0.41  475.05  511.62************  1.13  498.35  497.22
   FULLV:FV  ********     0.40  475.05  511.62  0.31  0.00  1.07  498.66  497.60
   BRIDG:BR    491.03     0.69  476.29  503.42  0.54  0.95  4.15  499.85  495.70
   RDWAY:RG  ****************  498.11  522.24************  0.62  504.25********
   APPRO:AS    494.57     0.47  477.67  514.48  1.00  0.14  1.24  500.99  499.75
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ROYATH00060030, in Royalton, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ROYATH00060030

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. Ivanoff

Date *(MM/DD/YY)* 05 / 24 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 60850

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

Waterway *(I - 6)* White River

Road Name *(I - 7)*: Sewall Brook Road

Route Number TH006

Vicinity *(I - 9)* 0.15 miles to jct. with VT 14

Topographic Map South Royalton

Hydrologic Unit Code: 01080105

Latitude *(I - 16; nnnn.n)* 43493

Longitude *(i - 17; nnnnn.n)* 72349

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10141600301416

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

Maximum span length *(I - 48; nnnn)* 0159

Year built *(I - 27; YYYY)* 1928

Structure length *(I - 49; nnnnnn)* 000165

Average daily traffic, ADT *(I - 29; nnnnnn)* 000450

Deck Width *(I - 52; nn.n)* 175

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 8

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

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

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

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

Structure type *(I - 43; nnn)* 310

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*) 25.0

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

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

Comments:

The structural inspection report of 6/23/94 indicates that the structure is a steel thru-truss bridge with an asphalt surface and approaches. The left abutment concrete was poured on ledge. The right abutment sits on silt. The timber pile tops were exposed from undermining (6-12 feet in from face) at the downstream end of the right abutment. Both footings had voids beneath them at one time which have been filled in with bags of concrete; in good condition. The waterway makes a moderate turn upstream. There is a ledge outcrop along the left abutment and stone and gravel bars along the right abutment. The channel scour along the left abutment has been remedied. Gravel bars were noted upstream and downstream. There is very little stone fill along the abutments. No embankment erosion was noted.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: **The elevations of high water: extreme 101.2 ft and normal 92.2 ft. The extreme low water elevation was at 80.6 ft.**
The plans of 1928 indicated little drift and medium water velocity.

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

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

Highway No. : **I-89** Structure No. : - Structure Type: **multi-span concrete**

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)* **478.97** mi^2

Lake/pond/swamp area **0.92** mi^2

Watershed storage *(ST)* **0.19** %

Bridge site elevation **480** ft

Headwater elevation **3780** ft

Main channel length **25.22** mi

10% channel length elevation **510** ft

85% channel length elevation **990** ft

Main channel slope *(S)* **18.17** 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)*: **03** / **1928**

Project Number **TH 6 B30 15-5-175** Minimum channel bed elevation: **80**

Low superstructure elevation: USLAB **97.87** DSLAB **97.87** USRAB **98.17** DSRAB **98.17**

Benchmark location description:

BM#1-Spike in root of a 14 inch poplar 218 ft behind the left abutment on the upstream side and edge of the roadway, elevation 100.0 ft. BM#2-Spike in trunk of a 12 inch elm on the upstream right bank 18 ft behind the right abutment and 55 feet from the centerline of the roadway, elevation 97.26 ft.

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

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

If 1: Footing Thickness **-** Footing bottom elevation: **-**

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

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:

-

Comments:

The plans were for the replacement of the bridge seats in 1928 with about 2 ft of the abutment tops excavated to set in the new concrete. The road approaches behind the abutments washed out in the flood prior to replacing the bridge deck. Piles may not have been used for the left abutment because the footing sits on bedrock.

Cross-sectional Data

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

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

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

Station	**1008**	**1041**	**1082**	**1156**	-	-	-	-	-	-	-
Feature	**LAB**	-	-	**RAB**	-	-	-	-	-	-	-
Low chord elevation	**501**	**501.5**	**502**	**501**	-	-	-	-	-	-	-
Bed elevation	**482**	**478**	**478**	**478**	-	-	-	-	-	-	-
Low chord-bed	**19**	**23.5**	**24**	**23**	-	-	-	-	-	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **11/5/96**

Computerized by: **EW** Date: **11/13/96**

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

Structure Number **ROYATH00060030**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. Hammond** Date *(MM/DD/YY)* **07** / **08** / 19**96**

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

County **Windsor (027)** Town **Royalton (60850)**

Waterway *(I - 6)* **White River** Road Name **Sewall Brook Road**

Route Number **TH 6** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

The site is located 0.15 miles from the junction with State Route 14.

B. Bridge Deck Observations

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

5. Ambient water surface... US **2** 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 **165** *(feet)* Span length **159** *(feet)* Bridge width **17.5** *(feet)*

Road approach to bridge:

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

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

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

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

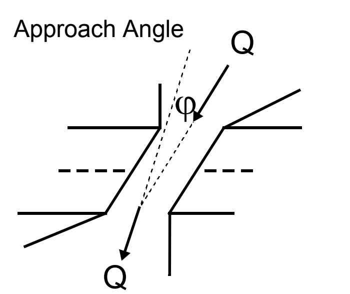
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

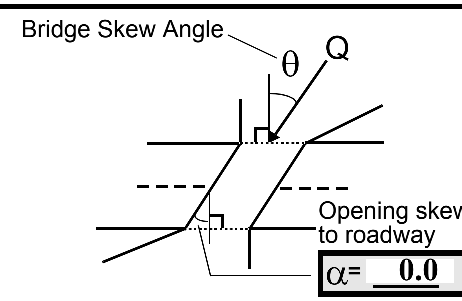
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **LB** *(LB, RB)* Severity **2**

Range? **300** feet **US** *(US, UB, DS)* to **170** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **2**

Range? **150** feet **DS** *(US, UB, DS)* to **250** feet **DS**

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

18. Bridge Type: **1b/ 1a**

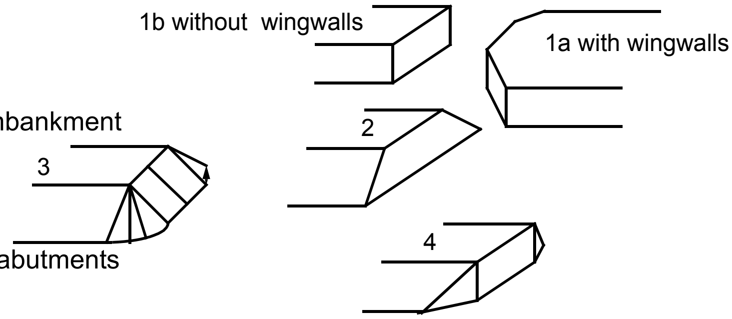
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4: The right bank surface cover is trees to the road, then it is an alfalfa field. The left bank surface cover is a combination of scattered trees, shrubs and lawn.

7: The bridge dimension values are from VTAOT. The measured values during the site visit are: bridge length = 162 ft; bridge span = 154 ft; and bridge width = 17.4 ft.

18: The bridge type is 1b on the left side of the channel, and 1a on the right side of the channel.

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
157.0	**17.5**			**10.0**	**2**	**4**	**6**	**2/ 1**	**2**	**0**

23. Bank width **10.0** 24. Channel width **5.0** 25. Thalweg depth **252.0** 29. Bed Material **436**

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

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

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

27: There is ledge outcrops all along the upstream left bank.

33. **Point/Side bar present?** Y (*Y or N. if N type ctrl-n pb*) 34. Mid-bar distance: 300 35. Mid-bar width: 50

36. Point bar extent: >500 feet US (*US, UB*) to 150 feet US (*US, UB, DS*) positioned 70 %LB to 100 %RB

37. Material: 43

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

-

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: 120 42. Cut bank extent: 140 feet US (*US, UB*) to 100 feet US (*US, UB, DS*)

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

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

The cut-bank is downstream of a rock outcrop, upstream of the left abutment and road embankment on ledge which forms a large eddy and cuts into the left bank ledge.

45. **Is channel scour present?** Y (*Y or if N type ctrl-n cs*) 46. Mid-scour distance: 100

47. Scour dimensions: Length 80 Width 140 Depth : 12 Position 10 %LB to 80 %RB

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

The scour hole exists between two ledge outcrops, refer to the plan view sketch.

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

51. Confluence 1: Distance 900 US 52. Enters on LB (*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):

The tributary is the Third Branch of the White River.

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
97.5		5.5		2	7	7	-

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

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

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

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

43

62: The right abutment shows some signs of deterioration comprised of spalled/ broken concrete off the top of footing, at the downstream end, exposing the tops of logs. Bags of concrete have been placed along the abutment footing for protection. The bag dimensions are 4 ft X 4 ft X 1.5 ft.

The left abutment also shows some signs of deterioration of the concrete footing.

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

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

70. Debris and Ice Comments:

2

There are trees leaning over the upstream channel. There is evidence of ice build-up along the faces and the upstream corners of the abutments.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	2	0	2	90.0
RABUT	1	10	90			2	2	159.0

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.):

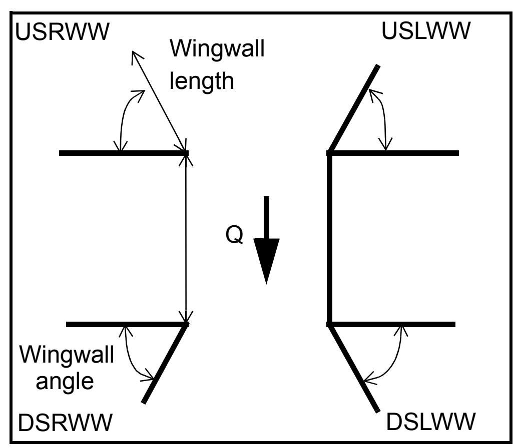
0
1
1

74/ 75: There is a bedrock ledge visible at the base of the concrete bags in front of the left abutment footing.

74/ 75: The concrete bags protect the abutment footings. There is no observable scour near the bags.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						159.0	
USRWW:	N		-		-	4.5	
DSLWW:	-		-		Y	32.5	
DSRWW:	1		0		-	26.0	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	Y	-	-	1	1	1
Condition	N	-	1	-	-	1	1	1
Extent	-	-	0	-	2	5	5	-

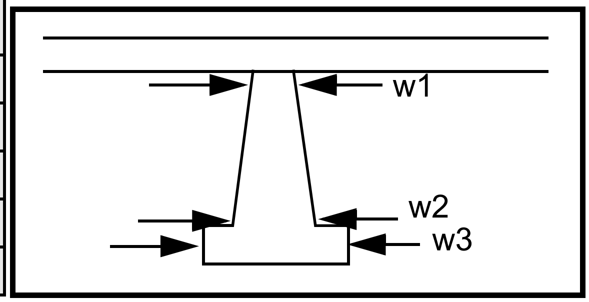
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
-
-
-
3
1
1

Piers:

84. Are there piers? Th (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	--			--	20.0	19.0
Pier 2	--			--	40.0	22.0
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e left	crete	of the	N	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	and	bags	foot-	-	**1**- Solid pier, **2**- column, **3**- bent
88. Material	right	that	ings.	-	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	abut	are		-	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	ment	stack		-	Y- yes; N- no
91. Attack ∠ (BF)	pro-	ed		-	
92. Pushed	tec-	ver-		-	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	tion	ticall		-	
95. Cross-members	con-	y		-	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	sist	alon		-	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	of	g the		-	
98. Exposure depth	con-	base		-	

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
-	-			-	-	-	-	-	-	-

Bank width (BF) - Channel width - Thalweg depth - 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: **NO** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*
105. Drop structure comments (eg. downstream scour depth):
PIERS

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

Point bar extent: ______ feet **3** (US, UB, DS) to **3** feet **216** (US, UB, DS) positioned **213** %LB to **1** %RB

Material: **1**

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

432
0
0
-

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

Cut bank extent: **bank** feet **ero** *(US, UB, DS)* to **sion** feet **is a** *(US, UB, DS)*

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

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

ult of eddy currents.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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)*:

Y
350
80
160
DS
>500
DS
0
60
43

109. G. Plan View Sketch

- T

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: ROYATH00060030 Town: Royalton
Road Number: Sewall Brook Road County: Windsor
Stream: White River

Initials MAI Date: 10/8/97 Checked: RLB

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	51610	79320	38490
Main Channel Area, ft2	4382	5132	3594
Left overbank area, ft2	89	423	0
Right overbank area, ft2	3640	6005	1127
Top width main channel, ft	249	249	246
Top width L overbank, ft	99	122	0
Top width R overbank, ft	775	796	176
D50 of channel, ft	0.2241	0.2241	0.2241
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	17.6	20.6	14.6
y1, average depth, LOB, ft	0.9	3.5	ERR
y1, average depth, ROB, ft	4.7	7.5	6.4
Total conveyance, approach	989609	1561275	593630
Conveyance, main channel	719628	936437	521586
Conveyance, LOB	2328	27150	0
Conveyance, ROB	267653	597688	72044
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	37530.0	47575.3	33818.8
Ql, discharge, LOB, cfs	121.4	1379.3	0.0
Qr, discharge, ROB, cfs	13958.6	30365.3	4671.2
Vm, mean velocity MC, ft/s	8.6	9.3	9.4
Vl, mean velocity, LOB, ft/s	1.4	3.3	ERR
Vr, mean velocity, ROB, ft/s	3.8	5.1	4.1
Vc-m, crit. velocity, MC, ft/s	11.0	11.3	10.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	51610	79320	38490
(Q) discharge thru bridge, cfs	37185	39300	38490
Main channel conveyance	809080	671271	579854
Total conveyance	809080	671271	579854
Q2, bridge MC discharge,cfs	37185	39300	38490
Main channel area, ft2	3250	3770	2606
Main channel width (normal), ft	153.0	160.6	150.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	153	160.6	150.7
y_bridge (avg. depth at br.), ft	21.24	23.48	17.29
Dm, median (1.25*D50), ft	0.280125	0.280125	0.280125
y2, depth in contraction,ft	19.74	19.86	20.60
ys, scour depth (y2-ybridge), ft	**-1.50**	-3.62	**3.31**

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	51610	79320	38490
Q, thru bridge MC, cfs	37185	39300	38490
Vc, critical velocity, ft/s	10.98	11.27	10.65
Va, velocity MC approach, ft/s	8.56	9.27	9.41
Main channel width (normal), ft	153.0	160.6	150.7
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	153.0	160.6	150.7
qbr, unit discharge, ft2/s	243.0	244.7	255.4
Area of full opening, ft2	3249.8	3770.4	2605.8
Hb, depth of full opening, ft	21.24	23.48	17.29
Fr, Froude number, bridge MC	0	0.38	0
Cf, Fr correction factor (<=1.0)	0.00	0.99	0.00
**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	0	503.31	0
Elevation of Bed, ft	-21.24	479.83	-17.29
Elevation of Approach, ft	0	505.93	0
Friction loss, approach, ft	0	0.71	0
Elevation of WS immediately US, ft	0.00	505.22	0.00
ya, depth immediately US, ft	21.24	25.39	17.29
Mean elevation of deck, ft	0	507.18	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.98	1.00
**Cc, for downstream face (<=1.0)	ERR	0.79	ERR
Ys, scour w/Chang equation, ft	N/A	**-1.12**	N/A
Ys, scour w/Umbrell equation, ft	N/A	1.39	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	37185	39300	38490
Main channel area (DS), ft2	3249.8	3770.4	2605.8
Main channel width (normal), ft	153.0	160.6	150.7
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	153.0	160.6	150.7
D90, ft	0.4732	0.4732	0.4732
D95, ft	0.5880	0.5880	0.5880
Dc, critical grain size, ft	0.3322	0.2671	0.5915
Pc, Decimal percent coarser than Dc	0.264	0.394	0.049
Depth to armoring, ft	**2.77**	**1.23**	**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	51610	79320	38490	51610	79320	38490
a', abut.length blocking flow, ft	160.6	179.7	60.8	809.4	827.5	211
Ae, area of blocked flow ft2	872.32	1158.59	615.15	2203.36	2844.49	1450.07
Qe, discharge blocked abut.,cfs	5367.99	--	4447.47	--	--	6888.72
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	6.15	6.05	7.23	4.15	5.25	4.75
ya, depth of f/p flow, ft	5.43	6.45	10.12	2.72	3.44	6.87
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	0.82	0.82	0.82

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.465	0.396	0.401	0.326	0.330	0.319
ys, scour depth, ft	**38.60**	**41.23**	**38.54**	32.32	37.83	34.67

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)	160.6	179.7	60.8	809.4	827.5	211
y1 (depth f/p flow, ft)	5.43	6.45	10.12	2.72	3.44	6.87
a'/y1	29.57	27.87	6.01	297.33	240.73	30.70
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.47	0.40	0.40	0.33	0.33	0.32
Ys w/ corr. factor K1/0.55:						
vertical	30.69	34.54	ERR	13.68	17.34	34.29
vertical w/ ww's	25.16	28.32	ERR	**11.21**	**14.22**	**28.12**
spill-through	16.88	19.00	ERR	7.52	9.54	18.86

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.54	0.38	0.69	0.54	0.38	0.69
y, depth of flow in bridge, ft	21.24	23.48	17.29	21.24	23.48	17.29
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**3.83**	**2.10**	**5.09**	**3.83**	**2.10**	**5.09**
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR