LEVEL II SCOUR ANALYSIS FOR BRIDGE 23 (CRAFTH00390023) on TOWN HIGHWAY 39, crossing the BLACK RIVER, CRAFTSBURY, VERMONT

U.S. Geological Survey
Open-File Report 97-217

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

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information
write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 23 (CRAFTH00390023) ON TOWN HIGHWAY 39, CROSSING THE BLACK RIVER, CRAFTSBURY, VERMONT

By **Erick M. Boehmler**

INTRODUCTION

This report provides the results of a detailed Level II analysis of scour potential at structure CRAFTH00390023 on town highway 39 crossing the Black River, Craftsbury, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). A Level I assessment is included in Appendix E of this report. A Level I assessment 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 provided in Appendix D.

The site is in the New England Upland physiographic province of North-central Vermont in the town of Craftsbury. The 30.9-mi^2 drainage area is in a predominantly rural and forested basin with some pasture grassland on the valley bottom. In the vicinity of the study site, the banks have very little woody vegetation coverage except for the downstream left bank, which has some trees and brush coverage.

In the study area, the Black River has an meandering channel with a slope of approximately 0.0004 ft/ft, an average channel top width of 62 ft and an average channel depth of 3 ft. The predominant channel bed materials are sand and gravel with a median grain size (D_{50}) of 0.73 mm (0.0024 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 6, 1995, indicated that the reach was laterally unstable.

The town highway 39 crossing of the Black River is a 65-ft-long, two-lane bridge consisting of three spans with a maximum span of 38-feet (Vermont Agency of Transportation, written communication, August 24, 1994). The bridge is supported by vertical, concrete abutments and two stone piers with concrete caps. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 10 degrees in the opposite direction.

The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the upstream left and right roadway embankments and between the right pier and right abutment wall. Type-2 (less than 36 inches diameter) stone fill was evident on the upstream left bank, downstream right bank, between the left pier and left abutment wall, and streamward of the right pier. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995).
Total scour at a highway crossing is comprised of three components: 1) long-term aggradation or degradation; 2) contraction scour (due to reduction in flow area caused by 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 scour depths for contraction and local scour and a summary of the results follows.

Contraction scour for all modelled flows ranged from 20.1 to 25.2 and the worst-case contraction scour occurred at the 500-year discharge. Although this bridge has two piers, the flow through the spans between each abutment and pier is assumed to be negligible. Hence, abutment scour was computed assuming the forces contributing to scour actually occur on the main-span sides of each pier in this case. Abutment scour ranged from 8.8 to 10.6 and the worst-case abutment scour occurred at the 500-year discharge. Scour depths and depths to armoring are summarized on p. 14 in the section titled "Scour Results". Scour elevations, based on the calculated depths are presented in tables 1 and 2. A graph of the scour elevations 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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
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 CRAFTH00390023 ***Stream*** Black River

County Orleans ***Road*** TH 39 ***District*** 09

Description of Bridge

Bridge length 65 ***ft*** ***Bridge width*** 25.4 ***ft*** ***Max span length*** 38 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 6/6/95

Description of stone fill Type-1, on each US roadway embankment and between the right pier and right abutment wall. Type-2 on the US left bank, DS right bank, between the left pier and left abutment wall, and on the stream’s side of the right pier.

The abutments are concrete and the piers are solid, cut stone walls. Each pier is located at the bank and the abutments are set back from the channel. There is some slight scouring along the toe of the stone fill on the right pier.

Is bridge skewed to flood flow according to Y ***survey?*** Y ***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	6/6/95	0	0
Level II	6/6/95	--	--

Potential for debris High. The channel is meandering and laterally unstable with some trees and shrubs at the edge of the channel.

Describe any features near or at the bridge that may affect flow (include observation date) Two small (2 by 8 foot) openings were noted on 6/6/95 between the piers and each abutment wall. These openings will not convey water significantly and are likely plugged with debris during a flood.

Description of the Geomorphic Setting

General topography The channel is located within a 1380 foot-wide, low to moderate relief valley setting with moderately sloping valley walls on both sides.

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

Date of inspection 6/6/95

DS left: Steep channel bank to a narrow flood plain

DS right: Steep channel bank to a wide, flat flood plain

US left: Steep channel bank to a narrow, hummocky flood plain

US right: Steep channel bank to a wide, flat flood plain

Description of the Channel

Average top width 62 *ft* ***Average depth*** 3 *ft*

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

Meandering with alluvial channel boundaries and a wide, flat to irregular, flood plain.

6/6/95

Vegetative co Trees, shrubs, and brush

DS left: Pasture grass

DS right: Pasture grass

US left: Pasture grass with a few trees.

US right: N

Do banks appear stable? Cut banks with slumping bank material and heavy fluvial erosion were evident on both upstream banks and the downstream right bank. The cut bank on the left bank upstream was located coincident with a point bar on the opposite bank.

date of observation.

The assessment of

6/6/95 noted debris in the channel reach upstream and on the right overbank.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 30.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None

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

USGS gage description Black River at Coventry, VT

USGS gage number 04296000

Gage drainage area 122 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,100 ***ft³/s*** ***Q500*** 2,850 ***ft³/s***

The 100-year discharge was taken from the VTAOT database (Written communication, VTAOT, May 4, 1995). The 500-year discharge was computed by use of a drainage area relationship [(30.9/122.)exp 0.5] with the gaged area above Coventry, VT. The exponent in the drainage relationship was computed based on gaged records and the VTAOT database value for the Q100 at this site.

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 20.4 feet from the USGS survey to obtain VTAOT plans' datum to the nearest 0.25 ft..

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the concrete curb at the DS left end (elev. 900.75 ft, arbitrary datum). RM2 is a chiseled X on top of the concrete curb at the US right end (elev. 900.64 ft, arbitrary datum). RM3 is a brass tablet, "VTAOT survey mark" set in the concrete curb at the DS right end (elev. 900.78, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXITX	-67	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	61	2	Modelled Approach section (Templated from APTEM)
APTEM	81	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.

A five foot diameter culvert under the right road approach and two, two by eight foot sections between the piers and each abutment wall were assumed to convey zero discharge. The culvert size for this site is similar to that found at bridge 30 in Albany further downstream on the Black River (Boehmler, 1996). The culvert at the Albany site was analyzed and found to convey less than 5 percent of the total discharge. Therefore, each discharge modeled for this site represents flow only through the main span of the bridge and over the roadway embankment.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.030 to 0.040, and overbank "n" values ranged from 0.045 to 0.050.

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 0.0004 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0072 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 900.0 ***ft***
Average low steel elevation 896.8 ***ft***

100-year discharge 2,100 ***ft³/s***
Water-surface elevation in bridge opening 896.9 ***ft***
Road overtopping? Y ***Discharge over road*** 17 ***ft³/s***
Area of flow in bridge opening 265 ***ft²***
Average velocity in bridge opening 7.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.5 ***ft/s***

Water-surface elevation at Approach section with bridge 898.2
Water-surface elevation at Approach section without bridge 896.5
Amount of backwater caused by bridge 1.7 ***ft***

500-year discharge 2,850 ***ft³/s***
Water-surface elevation in bridge opening 896.9 ***ft***
Road overtopping? Y ***Discharge over road*** 538 ***ft³/s***
Area of flow in bridge opening 265 ***ft²***
Average velocity in bridge opening 8.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.4 ***ft/s***

Water-surface elevation at Approach section with bridge 898.8
Water-surface elevation at Approach section without bridge 896.9
Amount of backwater caused by bridge 1.9

Incipient overtopping discharge 2,020 ***ft³/s***
Water-surface elevation in bridge opening 896.9 ***ft***
Area of flow in bridge opening 265 ***ft²***
Average velocity in bridge opening 7.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.0 ***ft/s***

Water-surface elevation at Approach section with bridge 898.0
Water-surface elevation at Approach section without bridge 896.5
Amount of backwater caused by bridge 1.5 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

The 100-year and the incipient road-overflow discharges resulted in unsubmerged orifice flow. 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). Therefore, contraction scour for each modeled discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour (Richardson and others, 1995, p. 32, equation 20) for all the modeled events were also computed and are provided in appendix F. The 500-year discharge model resulted in the worst contraction scour and was the worst case total scour.

Flow between each abutment and pier is assumed negligible relative to that through the main span. Overbank flow returning to the bridge opening will flow around each pier as if an abutment. Therefore, the spans between each pier and abutment wall were assumed to be a solid wall and the abutment scour equation was applied for scour depths at each pier. The scour depths are presented as abutment scour in the "Scour Results" section on the next page.

Abutment scour for the left and right abutments at each modelled discharge 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. Variables for the HIRE equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	21.8	25.2	20.1
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	9.1	10.6	8.8
Right abutment	9.2	10.6	8.8
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.2	1.5	1.1
Right abutment	1.2	1.5	1.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

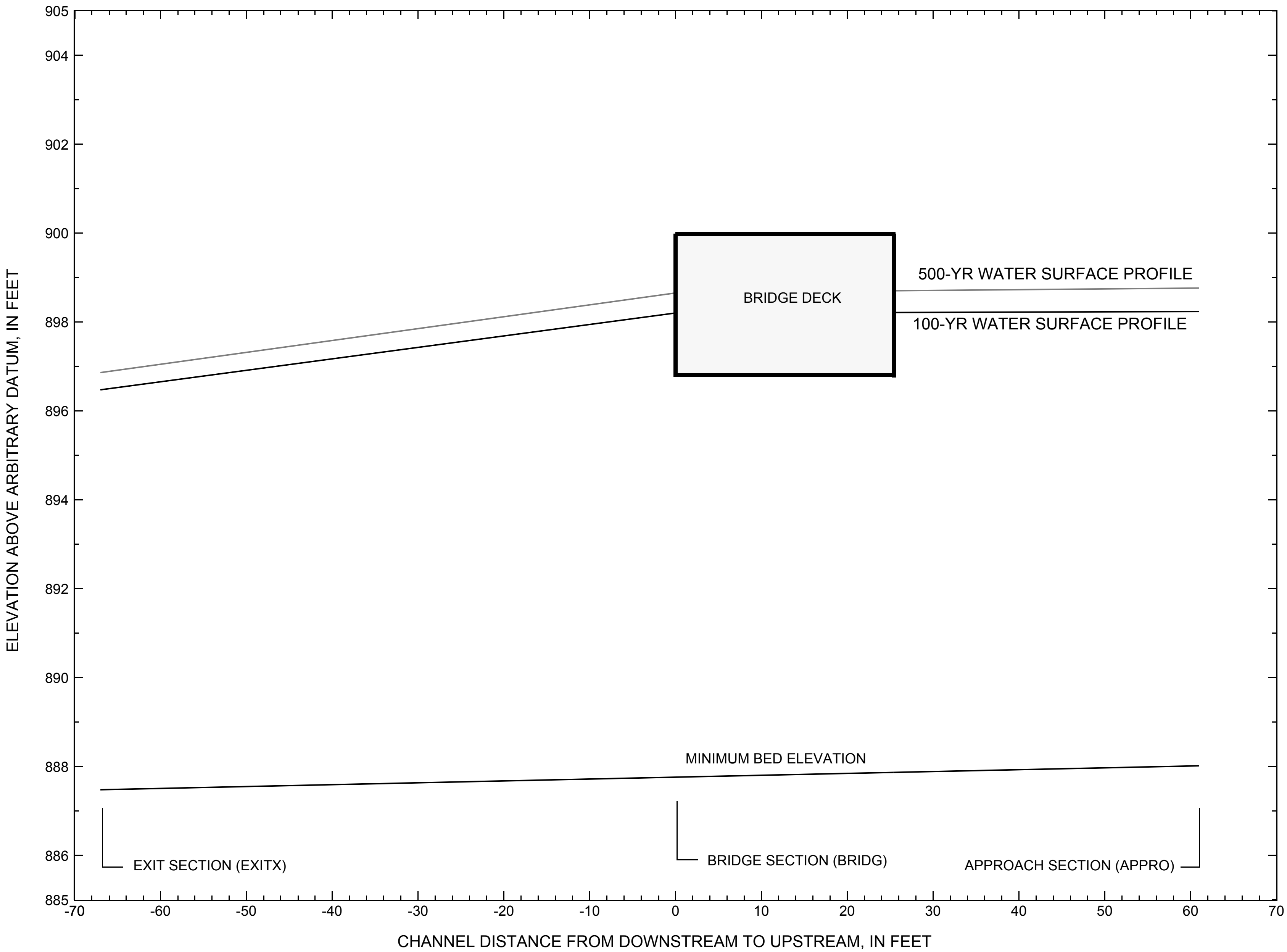

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CRAFTH00390023 on town highway 39, crossing Black River, Craftsbury, Vermont.

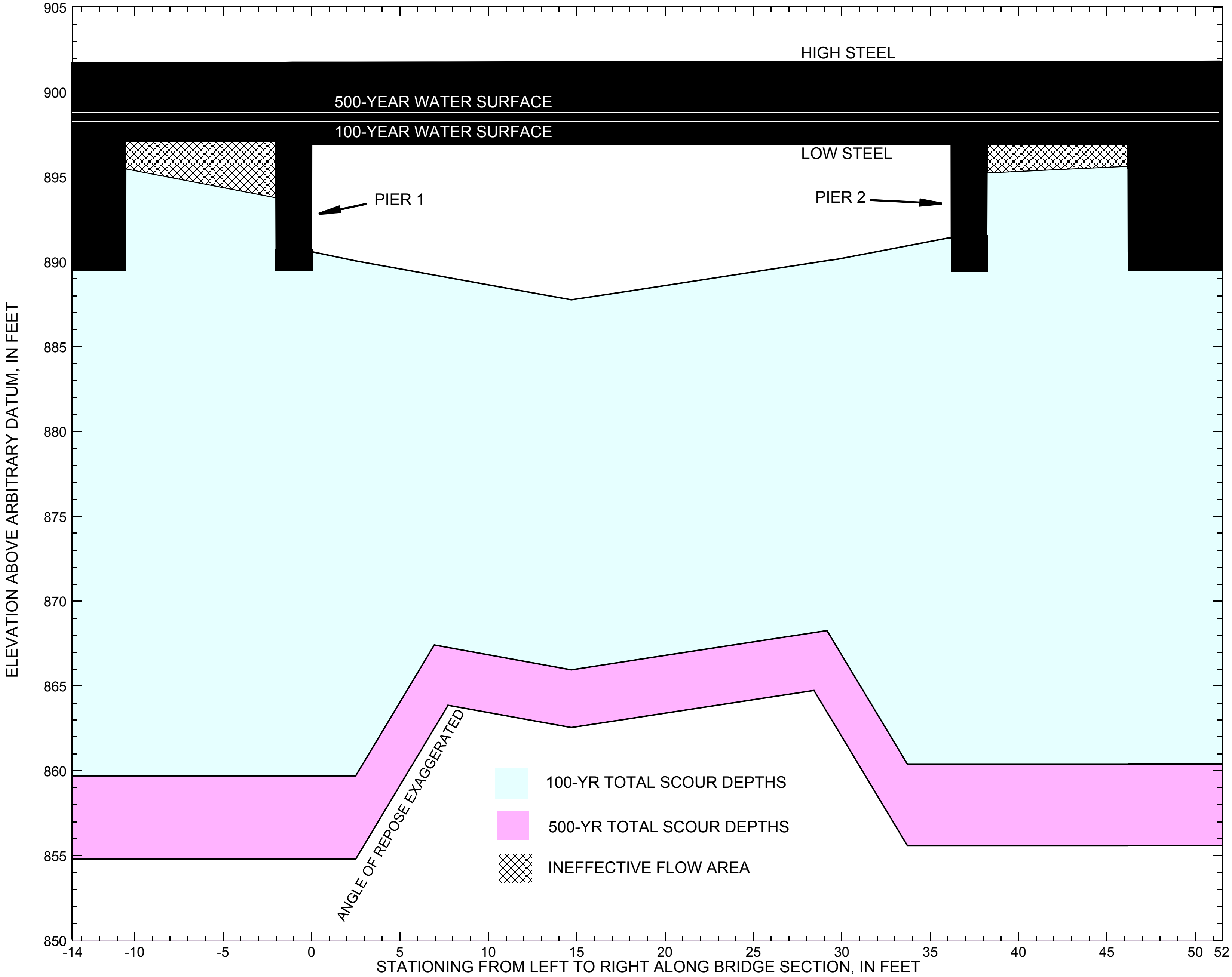

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure CRAFTH00390023 on town highway 39, crossing Black River, Craftsbury, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CRAFTH00390023 on Town Highway 39, crossing Black River, Craftsbury, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2,100 cubic-feet per second											
Left abutment (Pier 1)	0.0	879.7	896.9	889.4	890.6	21.8	9.1	--	30.9	859.7	-29.7
Right abutment (Pier 2)	36.2	879.6	896.8	889.4	891.4	21.8	9.2	--	31.0	860.4	-29.0

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure CRAFTH00390023 on Town Highway 39, crossing Black River, Craftsbury, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,850 cubic-feet per second											
Left abutment (Pier 1)	0.0	879.7	896.9	889.4	890.6	25.2	10.6	--	35.8	854.8	-34.6
Right abutment (Pier 2)	36.2	879.6	896.8	889.4	891.4	25.2	10.6	--	35.8	855.6	-33.8

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

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U.S. Geological Survey, 1986, Albany, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, aerial photographs 1980, contour interval, 6 meters, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File craf023.wsp
T2        Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
T3        Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
Q           2100.0   2850.0   2020.0
SK          0.0004   0.0004   0.0004
*
J3          6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -67
GR         -279.7, 901.64   -187.2, 899.32   -176.0, 895.89    -93.3, 895.20
GR           -5.8, 895.13      0.0, 890.26      8.9, 890.06     22.5, 887.47
GR           25.9, 887.62     27.7, 890.11     33.7, 895.82     72.4, 895.58
GR          348.6, 893.79    523.7, 894.19    882.2, 895.68   1118.0, 896.66
*
N           0.045        0.040        0.045
SA                  -5.8         33.7
*
XS   FULLV      0  * * *   0.0004
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    896.81      10.0
GR            0.0, 896.86      0.1, 890.59      2.4, 890.07     14.7, 887.75
GR           29.8, 890.16     36.0, 891.40     36.2, 896.76      0.0, 896.86
*
*         BRTYPE  BRWDTH
CD           1      25.4
N           0.030
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      25.4     2
GR         -339.9, 903.28   -187.5, 900.42    -53.4, 900.17    -53.3, 901.63
GR            0.0, 901.72     56.1, 901.82     95.1, 901.90    108.7, 901.92
GR          108.8, 900.07    281.0, 898.04    498.4, 898.70    882.2, 898.06
GR          937.2, 898.21   1118.3, 899.61
BP          9.95
*
XT   APTEM     81           0.
GR         -238.8, 900.73   -193.9, 899.67   -174.2, 899.16   -168.6, 897.91
GR         -145.1, 896.84   -124.8, 893.98    -50.2, 894.49    -32.6, 893.20
GR           -4.0, 893.92     -1.0, 890.19      0.0, 889.24      9.1, 888.15
GR           13.3, 888.75     20.3, 889.89     26.5, 890.56     38.5, 893.99
GR           55.2, 895.62    523.5, 893.68    656.6, 893.62    993.3, 896.14
GR         1118.0, 897.07
*
AS   APPRO     61  *  *  *   0.0072
GT
N           0.050        0.040        0.045
SA                  -4.0         55.2
*
HP 1 BRIDG   896.86 1 896.86
HP 2 BRIDG   896.86 * * 2097
HP 2 RDWAY   898.20 * *   17
HP 1 APPRO   898.23 1 898.23
HP 2 APPRO   898.23 * * 2100
*
HP 1 BRIDG   896.86 1 896.86
HP 2 BRIDG   896.86 * * 2300
HP 2 RDWAY   898.65 * *  538
HP 1 APPRO   898.76 1 898.76
HP 2 APPRO   898.76 * * 2850
*
```

```
HP 1 BRIDG   896.86 1 896.86
HP 2 BRIDG   896.86 * * 1987
HP 1 APPRO   897.99 1 897.99
HP 2 APPRO   897.99 * * 2020
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File craf023.wsp
        Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
        Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
           *** RUN DATE & TIME: 03-20-96  14:00

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      265     28455      0     83                            0
   896.86           265     28455      0     83  1.00      0     36        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       896.86     0.0    36.2   264.8   28455.    2097.   7.92

 X STA.         0.0        3.3        5.3        7.1        8.7       10.3
   A(I)            21.1       14.1       13.3       12.6       12.1
   V(I)            4.97       7.42       7.88       8.33       8.65

 X STA.        10.3       11.7       13.0       14.3       15.6       16.8
   A(I)            11.7       11.3       11.3       11.3       11.1
   V(I)            8.99       9.26       9.31       9.28       9.47

 X STA.        16.8       18.2       19.6       21.0       22.6       24.2
   A(I)            11.4       11.4       11.9       12.1       12.1
   V(I)            9.23       9.18       8.84       8.69       8.64

 X STA.        24.2       26.0       27.9       29.9       32.3       36.2
   A(I)            13.0       13.2       13.6       15.1       21.2
   V(I)            8.08       7.93       7.70       6.93       4.95
```

Incorrect HP functions resulted in multiple output tables for the roadway section for which none displayed the correct water surface elevation. Therefore, the tables were omitted.

```
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      610     43146    167    167                         6627
             2      404     52424     59     62                         5990
             3     3770    290064   1063   1064                        40287
   898.23          4784    385633   1289   1293  1.12   -170   1118    49345

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

         WSEL     LEW     REW    AREA        K        Q    VEL
       898.23  -170.7  1118.0  4784.1  385633.    2100.   0.44

 X STA.      -170.7      -71.8      -16.2        7.9       20.8       61.1
   A(I)           307.6      246.3      160.4      120.7      195.8
   V(I)            0.34       0.43       0.65       0.87       0.54

 X STA.        61.1      156.0      233.9      301.6      363.6      418.3
   A(I)           282.2      259.5      246.1      242.0      226.7
   V(I)            0.37       0.40       0.43       0.43       0.46

 X STA.       418.3      469.0      516.6      562.9      609.1      655.4
   A(I)           221.1      217.4      217.6      218.2      219.6
   V(I)            0.47       0.48       0.48       0.48       0.48

 X STA.       655.4      704.6      764.0      835.8      932.1     1118.0
   A(I)           225.3      247.9      264.2      294.1      371.2
   V(I)            0.47       0.42       0.40       0.36       0.28
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File craf023.wsp
       Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
       Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
          *** RUN DATE & TIME: 03-20-96  14:00

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      265     28455      0     83                            0
   896.86           265     28455      0     83  1.00      0     36        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       896.86     0.0    36.2   264.8   28455.    2300.   8.68

 X STA.         0.0        3.3        5.3        7.1        8.7       10.3
   A(I)            21.1       14.1       13.3       12.6       12.1
   V(I)            5.45       8.13       8.64       9.14       9.48

 X STA.        10.3       11.7       13.0       14.3       15.6       16.8
   A(I)            11.7       11.3       11.3       11.3       11.1
   V(I)            9.86      10.15      10.21      10.17      10.39

 X STA.        16.8       18.2       19.6       21.0       22.6       24.2
   A(I)            11.4       11.4       11.9       12.1       12.1
   V(I)           10.12      10.07       9.70       9.53       9.48

 X STA.        24.2       26.0       27.9       29.9       32.3       36.2
   A(I)            13.0       13.2       13.6       15.1       21.2
   V(I)            8.86       8.69       8.45       7.60       5.43

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       898.65   229.3   994.1   222.3    3367.     538.   2.42

 X STA.       229.3      275.0      289.3      303.7      319.5      338.5
   A(I)            12.3        8.4        8.1        8.2        8.8
   V(I)            2.18       3.20       3.32       3.29       3.06

 X STA.       338.5      362.6      679.3      723.6      755.1      780.5
   A(I)             9.6       40.6       12.8       11.1       10.1
   V(I)            2.79       0.66       2.11       2.42       2.66

 X STA.       780.5      802.3      821.5      838.8      854.8      869.4
   A(I)             9.6        9.1        8.7        8.5        8.1
   V(I)            2.81       2.96       3.09       3.17       3.32

 X STA.       869.4      883.4      898.2      914.4      934.9      994.1
   A(I)             8.2        8.3        8.5        9.7       13.6
   V(I)            3.29       3.23       3.16       2.77       1.98

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      699     53611    169    169                         8070
             2      435     59383     59     62                         6701
             3     4333    365725   1063   1065                        49647
   898.76          5468    478720   1291   1296  1.10   -172   1118    60968

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

         WSEL     LEW     REW    AREA        K        Q    VEL
       898.76  -173.1  1118.0  5467.7  478720.    2850.   0.52

 X STA.      -173.1      -74.8      -16.1        8.9       24.4       82.4
   A(I)           346.7      290.2      182.8      149.0      256.8
   V(I)            0.41       0.49       0.78       0.96       0.55

 X STA.        82.4      168.3      244.7      309.8      370.5      425.8
   A(I)           306.9      299.0      273.6      271.1      260.1
   V(I)            0.46       0.48       0.52       0.53       0.55

 X STA.       425.8      477.6      526.1      573.4      620.6      669.0
   A(I)           254.8      249.5      247.5      248.0      255.2
   V(I)            0.56       0.57       0.58       0.57       0.56

 X STA.       669.0      720.9      782.2      856.1      950.4     1118.0
   A(I)           259.2      280.1      300.8      324.0      412.3
   V(I)            0.55       0.51       0.47       0.44       0.35
```

```
        U.S. Geological Survey WSPRO Input File craf023.wsp
        Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
        Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
           *** RUN DATE & TIME: 03-20-96  14:00

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      265     28455      0     83                            0
   896.86           265     28455      0     83  1.00      0     36        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       896.86     0.0    36.2   264.8   28455.    1987.   7.50

 X STA.        0.0        3.3        5.3        7.1        8.7       10.3
   A(I)            21.1       14.1       13.3       12.6       12.1
   V(I)            4.71       7.03       7.47       7.90       8.19

 X STA.       10.3       11.7       13.0       14.3       15.6       16.8
   A(I)            11.7       11.3       11.3       11.3       11.1
   V(I)            8.51       8.77       8.82       8.79       8.97

 X STA.       16.8       18.2       19.6       21.0       22.6       24.2
   A(I)            11.4       11.4       11.9       12.1       12.1
   V(I)            8.75       8.70       8.38       8.23       8.19

 X STA.       24.2       26.0       27.9       29.9       32.3       36.2
   A(I)            13.0       13.2       13.6       15.1       21.2
   V(I)            7.66       7.51       7.30       6.56       4.69

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      570     38721    166    166                         6007
             2      390     49388     59     62                         5677
             3     3515    258136   1063   1064                        36268
   897.99          4475    346245   1288   1292  1.14   -169   1118    44333

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

         WSEL     LEW     REW    AREA        K        Q    VEL
       897.99  -169.6  1118.0  4474.9  346245.    2020.   0.45

 X STA.     -169.6      -71.6      -16.6        7.3       19.3       43.9
   A(I)           284.6      230.7      150.4      111.0      149.0
   V(I)            0.35       0.44       0.67       0.91       0.68

 X STA.       43.9      148.0      229.0      298.3      358.8      413.8
   A(I)           285.6      248.4      234.1      220.5      214.0
   V(I)            0.35       0.41       0.43       0.46       0.47

 X STA.      413.8      464.5      512.1      557.6      602.6      648.5
   A(I)           208.1      205.1      202.7      201.5      206.2
   V(I)            0.49       0.49       0.50       0.50       0.49

 X STA.      648.5      697.1      752.7      823.1      920.0     1118.0
   A(I)           213.6      222.5      248.4      281.5      357.0
   V(I)            0.47       0.45       0.41       0.36       0.28

   EX
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File craf023.wsp
        Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
        Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
           *** RUN DATE & TIME: 03-20-96  14:00

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

EXITX:XS   ******   -177     2021  0.03 *****  896.50  895.09    2100  896.47
       -66 ******   1072   104932  1.87 ***** *******    0.20    1.04

FULLV:FV       67   -177     2021  0.03  0.03  896.53 *******    2100  896.50
         0     67   1072   104888  1.87  0.00    0.00    0.20    1.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.46

APPRO:AS       61   -143     2623  0.01  0.02  896.54 *******    2100  896.53
        61     61   1065   153485  1.34  0.00    0.00    0.11    0.80
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   898.40       0.00     896.37     898.04

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   896.44     898.25     898.34     896.81

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       67      0      265  0.98 *****  897.84  894.13    2097  896.86
         0 ******     36    28455  1.00 ***** *******    0.52    7.92

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.440  0.000  896.81 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    36.  0.00  0.00  898.23    0.01     17.  898.20

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:    17.   197.   268.   932.   0.2   0.1   1.2   1.2   0.1   2.5

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   898.23      900.6      896.9

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

APPRO:AS       36   -170     4779  0.00  0.04  898.23  894.61    2100  898.23
        61    108   1118   384968  1.12  0.07    0.01    0.04    0.44

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********
                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>

   FIRST USER DEFINED TABLE.
     XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -67.  -178.  1072.   2100.  104932.    2021.    1.04  896.47
    FULLV:FV       0.  -178.  1072.   2100.  104888.    2021.    1.04  896.50
    BRIDG:BR       0.     0.    36.   2097.   28455.     265.    7.92  896.86
    RDWAY:RG      13.*******     0.     17.       0.*********    2.00  898.20
    APPRO:AS      61.  -171.  1118.   2100.  384968.    4779.    0.44  898.23

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

  SECOND USER DEFINED TABLE.
     XSID:CODE     CRWS      FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXITX:XS     895.09     0.20  887.47  901.64************  0.03  896.50  896.47
    FULLV:FV   ********     0.20  887.50  901.67  0.03  0.00  0.03  896.53  896.50
    BRIDG:BR     894.13     0.52  887.75  896.86************  0.98  897.84  896.86
    RDWAY:RG   ***************  898.04  903.28  0.00******  0.00  898.23  898.20
    APPRO:AS     894.61     0.04  888.01  900.59  0.04  0.07  0.00  898.23  898.23
```

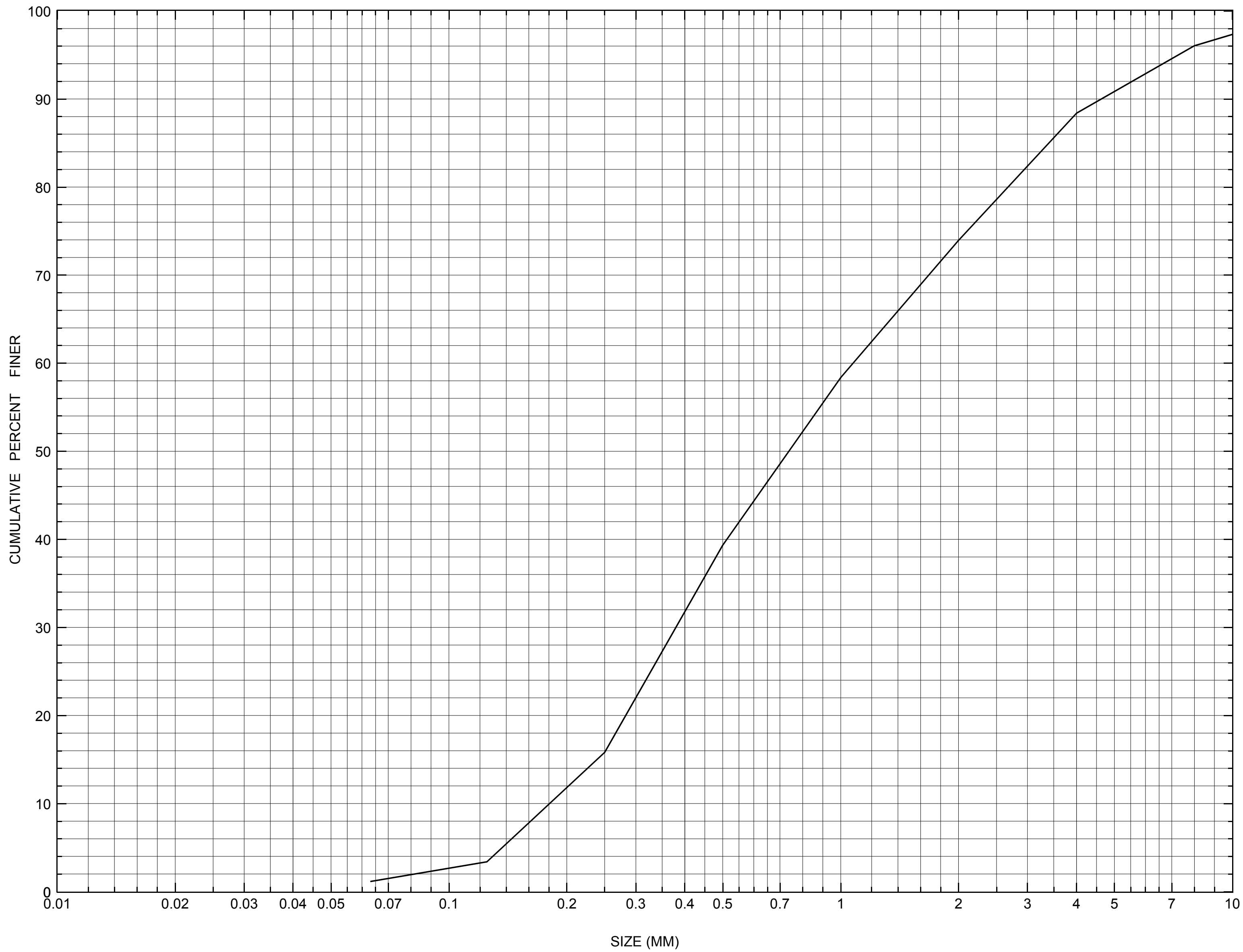
```
       U.S. Geological Survey WSPRO Input File craf023.wsp
       Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
       Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
          *** RUN DATE & TIME: 03-20-96  14:00

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

EXITX:XS   ******   -178     2520  0.03 *****  896.89  895.40    2850  896.86
       -66 ******   1118   142435  1.61 ***** *******    0.18    1.13

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                         WSEL,YLT,YRT =   896.89     901.67     896.69

FULLV:FV       67   -178     2521  0.03  0.03  896.92 *******    2850  896.89
         0     67   1118   142490  1.61  0.00    0.00    0.18    1.13
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       61   -149     3102  0.02  0.02  896.93 *******    2850  896.92
        61     61   1117   194617  1.27  0.00    0.00    0.12    0.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                    WS3N,LSEL =    896.89     896.81

            <<<<<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       67      0      265  1.17 *****  898.03  894.44    2300  896.86
         0 ******     36    28455  1.00 ***** *******    0.57    8.69

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  896.81 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    36.  0.00  0.00  898.77    0.00    538.  898.65

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:    538.   714.   230.   994.   0.6   0.3   2.6   2.4   0.4   2.7

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                         WSEL,YLT,YRT =   898.76      900.6      896.9

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

APPRO:AS       36   -172     5474  0.00  0.05  898.77  894.84    2850  898.76
        61    109   1118   479548  1.10  0.07    0.00    0.05    0.52

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -67.  -179.  1118.   2850.  142435.    2520.    1.13  896.86
   FULLV:FV       0.  -179.  1118.   2850.  142490.    2521.    1.13  896.89
   BRIDG:BR       0.     0.    36.   2300.   28455.     265.    8.69  896.86
   RDWAY:RG      13.*******     0.    538.       0.*********    2.00  898.65
   APPRO:AS      61.  -173.  1118.   2850.  479548.    5474.    0.52  898.76

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    895.40    0.18  887.47  901.64************  0.03  896.89  896.86
   FULLV:FV  ********    0.18  887.50  901.67  0.03  0.00  0.03  896.92  896.89
   BRIDG:BR    894.44    0.57  887.75  896.86************  1.17  898.03  896.86
   RDWAY:RG  ***************  898.04  903.28  0.00******  0.00  898.77  898.65
   APPRO:AS    894.84    0.05  888.01  900.59  0.05  0.07  0.00  898.77  898.76
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File craf023.wsp
       Hydraulic analysis for structure CRAFTH00390023   Date: 28-FEB-96
       Town Highway 39 Bridge Crossing the Black River, Craftsbury, VT    EMB
          *** RUN DATE & TIME: 03-20-96  14:00

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

EXITX:XS   ******   -177     1961  0.03 *****  896.45  895.05    2020  896.42
       -66 ******   1061   100950  1.91 ***** *******    0.20    1.03

FULLV:FV       67   -177     1960  0.03  0.03  896.48 *******    2020  896.45
         0     67   1060   100886  1.91  0.00    0.00    0.20    1.03
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  1.47

APPRO:AS       61   -143     2564  0.01  0.02  896.49 *******    2020  896.48
        61     61   1058   148638  1.35  0.00    0.00    0.11    0.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   898.26       0.00     896.34     898.04

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   896.35     898.16     898.25     896.81

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       67      0      265  0.88 *****  897.74  893.95    1987  896.86
         0 ******     36    28455  1.00 ***** *******    0.49    7.50

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.427  0.000  896.81 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.         <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>
===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   897.99      900.6      896.9

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

APPRO:AS       36   -169     4475  0.00  0.04  897.99  894.59    2020  897.99
        61    108   1118   346245  1.14  0.07   -0.02    0.05    0.45

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   897.99
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -67.  -178.  1061.   2020.  100950.    1961.    1.03  896.42
   FULLV:FV       0.  -178.  1060.   2020.  100886.    1960.    1.03  896.45
   BRIDG:BR       0.     0.    36.   1987.   28455.     265.    7.50  896.86
   RDWAY:RG      13.**************      0.       0.*********    2.00********
   APPRO:AS      61.  -170.  1118.   2020.  346245.    4475.    0.45  897.99

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    895.05    0.20  887.47  901.64************  0.03  896.45  896.42
   FULLV:FV  ********    0.20  887.50  901.67  0.03  0.00  0.03  896.48  896.45
   BRIDG:BR    893.95    0.49  887.75  896.86************  0.88  897.74  896.86
   RDWAY:RG  ****************  898.04  903.28************  0.00  898.23********
   APPRO:AS    894.59    0.05  888.01  900.59  0.04  0.07  0.00  897.99  897.99
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a channel composite sample transect at the approach cross-section for structure CRAFTH00390023, in Craftsbury, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CRAFTH00390023

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 04 / 94

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 019

Town *(FIPS place code; I - 4; nnnnn)* 16300

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

Waterway *(I - 6)* BLACK RIVER

Road Name *(I - 7):* -

Route Number TH039

Vicinity *(I - 9)* 0.03 MI TO JCT W C3 TH44

Topographic Map Albany

Hydrologic Unit Code: 01110000

Latitude *(I - 16; nnnn.n)* 44378

Longitude *(i - 17; nnnnn.n)* 72229

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10100600231006

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

Maximum span length *(I - 48; nnnn)* 0038

Year built *(I - 27; YYYY)* 1980

Structure length *(I - 49; nnnnnn)* 000065

Average daily traffic, ADT *(I - 29; nnnnnn)* 000150

Deck Width *(I - 52; nn.n)* 254

Year of ADT *(I - 30; YY)* 94

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

Opening skew to Roadway *(I - 34; nn)* 10

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

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

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

Structure type *(I - 43; nnn)* 402

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 035.0

Number of spans *(I - 45; nnn)* 003

Vertical clearance from streambed (*nnn.n ft*) 08.0

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

Waterway of full opening (*nnn.n ft*^{2}) 280.0

Comments:

Structural inspection report of 7/20/93 indicated a 3 span steel beam bridge. The abutments and wings in like new condition with no channel scour or road embankment erosion. The riprap coverage was good with a small point bar at the downstream left bank. There is a pier on either bank. At high flows water may move between the piers and abutments This flow is not accounted for in the clear span, vertical clearance from streambed, and waterway of full opening figures quoted above from bridge hydrologic data.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: 26.6

Terrain character:

Stream character & type:

Streambed material: Silt and mud

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 1000 Q_{25} 1400

Q_{50} 1800 Q_{100} 2100 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)* : Light Debris *(Heavy, Moderate, Light)*: Light

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*))	-	876.3	877.3	878.2	878.8
Velocity (*ft / sec*)	-	8.4	9.6	11.0	11.8

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **30.87** mi^2

Lake and pond area **0.82** mi^2

Watershed storage *(ST)* **2.7** %

Bridge site elevation **886** ft

Headwater elevation **1988** ft

Main channel length **11.30** mi

10% channel length elevation **906** ft

85% channel length elevation **1509** ft

Main channel slope *(S)* **71** 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)*: 01 / 1980

Project Number **BRZ 1449(3)** Minimum channel bed elevation: **871.0**

Low superstructure elevation: USLAB **N/A** DSLAB **N/A** USRAB **N/A** DSRAB **N/A**

Benchmark location description:

BM 1: USGS elevation 880.41 less than 10 feet from east (right bank) end of the bridge, then 12 feet upstream of the road, either in a tree or near a tree.

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

Foundation Type: **3** (*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: **869**

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:

New concrete pier caps were added to the bridge in 1980. Low superstructure elevations for the piers: pier 1 (left) upstream 879.66 and downstream 879.65; pier 2 (right) upstream 879.57 and downstream 879.59.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **CG** Date: **2/13/96**
Computerized by: **CG** Date: **2/14/96**
Reviewd by: **EMB** Date: **5/13/96**

Structure Number **CRAFTH00390023**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **Boehmler** Date *(MM/DD/YY)* **6** / **6** / 19**95**

2. Highway District Number **09** Mile marker **-**

County **Orleans (019)** Town **Craftsbury**

Waterway *(I - 6)* **Black River** Road Name **-**

Route Number **TH 039** Hydrologic Unit Code: **01110000**

3. Descriptive comments:

The bridge has a steel guard rail on both sides with a bare concrete deck. It is about 0.03 miles from ‘T’ intersection of TH 44 with TH 39.

B. Bridge Deck Observations

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

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

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

7. Bridge length **65.0** *(feet)* Span length **38.0** *(feet)* Bridge width **25.4** *(feet)*

Road approach to bridge:

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

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

10. Embankment slope (*run / rise in feet / foot*):
US left **2.5:1** US right **1.8:1**

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

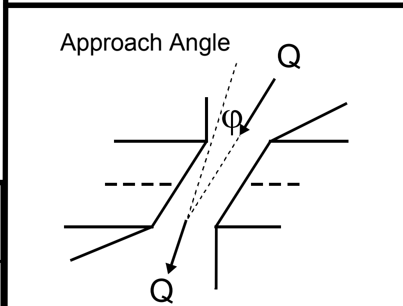
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

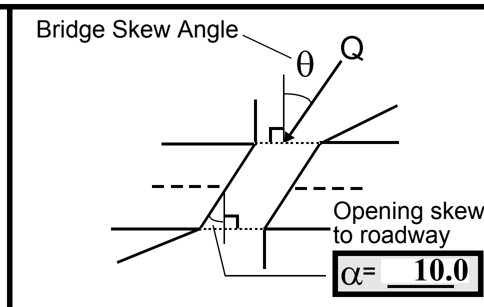
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **45** 16. Bridge skew: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **65** *(LB, RB)* Severity **2**
Range? **65** feet **US** *(US, UB, DS)* to **28** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **15** feet **UB** *(US, UB, DS)* to **75** feet **DS**

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

18. Level II Bridge Type: **1b**

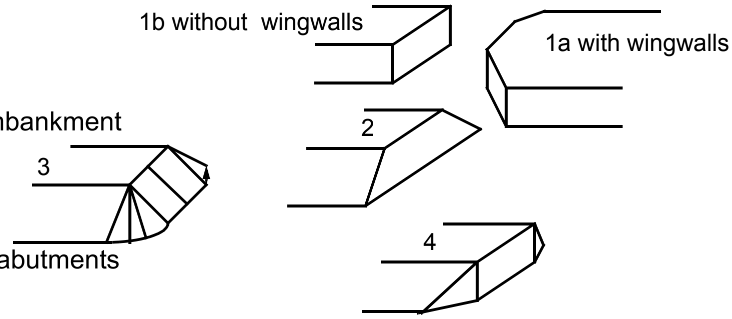
1a- Vertical abutments with wingwalls

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.)

There are some shrubs and brush on the left overbank downstream. The remaining locations are all pasture. Bridge dimensions measured: span length = 37.0; measured width = 25.4; measured length = 65.0; road overflow width = 23.0. The bridge type is 1b up to the bank full point and then 3 for when water is above the bank full point. The bridge has three spans. The area between each pier and abutment wall is approximately 2 feet high by 8 feet wide on each side with type 1 stone fill covering sand and gravel fill.

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	**1.5**			**2.5**	**1**	**1**	**12**	**12**	**3**	**1**

23. Bank width **40.0** 24. Channel width **15.0** 25. Thalweg depth **65.5** 29. Bed Material **312**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** 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.):

Sand material on banks is fine sand with silt and clay. There is no bank protection. The bed material is medium to fine sand and a little fine gravel (pea size). Whole trees and branches are debris in the channel upstream. Flow deflection from debris may have caused the small mid-channel bar upstream near 100 feet upstream where the cut bank begins. The range of left bank protection is from 10 feet upstream to upstream bridge face.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **50'** 35. Mid-bar width: **14'**
36. Point bar extent: **70** feet **US** (US, UB) to **5** feet **US** (US, UB, DS) positioned **75** %LB to **100** %RB
37. Material: **321**
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):
Point bar is narrow and composed of mainly fine (pea size gravel with medium to coarse sand and some fine sand, silt and mud material. The material gets coarser as you go upstream.

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: **66'** 42. Cut bank extent: **95** feet **US** (US, UB) to **28** feet **US** (US, UB, DS)
43. Bank damage: **3** (*1*- eroded and/or creep; *2*- slip failure; *3*- block failure)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):
Large clumps of grass and soil are lying near the toe of the bank and are separated from the rest of the bank material. The bank is on the outside of a meander bend upstream.

45. Is channel scour present? **N** (Y or if N type ctrl-n cs) 46. Mid-scour distance: -
47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB
48. Scour comments (eg. additional scour areas, local scouring process, etc.):
NO CHANNEL SCOUR

49. Are there major confluences? **N** (Y or if N type ctrl-n mc) 50. How many? -
51. Confluence 1: Distance - 52. Enters on - (LB or RB) 53. Type - (*1*- perennial; *2*- ephemeral)
Confluence 2: Distance - Enters on - (LB or RB) Type - (*1*- perennial; *2*- ephemeral)
54. Confluence comments (eg. confluence name):
NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
56.5		1.5		2	7	7	-

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

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):
132
Some material is present behind the piers and between the piers and abutment walls.

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

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

70. Debris and Ice Comments:

3

The debris potential is mainly due to the meandering channel with unstable banks and some trees growing at the immediate edge of the channel. A large tree and some other debris is lodged on the right bank at the upstream face of the bridge between the right pier and right abutment wall.

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	1	0	0	0	90.0
RABUT	1	15.0	0			1	0	41.0

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

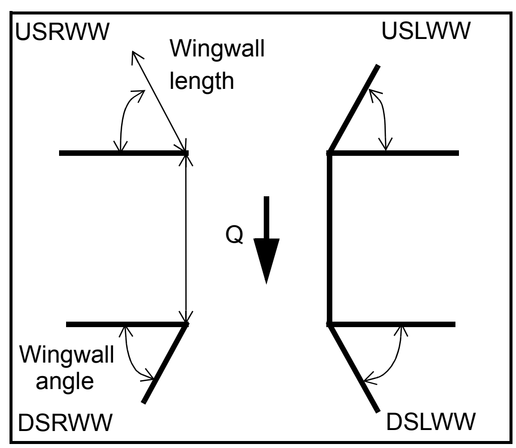
0

1

There are two 2 feet by 8 feet sections between the concrete abutment walls and the streamward end of the piers where the material has been filled with riprap on left and earth fill on the right leaving only a 2-3 foot clearance between fill and low cord. The streambed sides of each pier are nearly even with the bank's trend from the upstream to the downstream side of the bridge.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						41.0	
USRWW:	N		-		-	2.5	
DSLWW:	-		-		N	40.5	
DSRWW:	-		-		-	42.5	



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	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	2	1	-

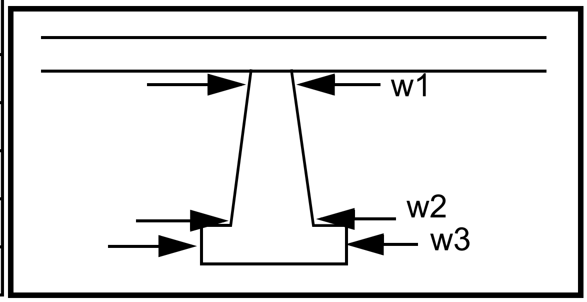
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? __Ty__ (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				95.0	20.5	10.0
Pier 2				15.5	15.0	23.5
Pier 3		14.5	-	130.0	-	-
Pier 4	-	-	-	-	-	-



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

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

Y
LB
1
4
2
N
0
-
0
0

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
-	-			-	0	0	0	RB	1	4

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - Bed Material 2

Bank protection type (Qmax): LB N RB 15 Bank protection condition: LB RB RB 0

*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.):

0
1
1.0
0
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

Point bar extent: - feet - (US, UB, DS) to The feet cha (US, UB, DS) positioned nn %LB to el %RB

Material: is

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

slightly scoured along the toe of stone fill on the streamward face of pier 2. Pier 2 is visibly well protected. A few stones may have rolled into channel due to the channel scour which eroded the sand material away from the toe of the riprap, but there aren't any signs of the riprap slumping. The piers are both capped with concrete. The deck and pier caps look nearly new. There is very little area between each pier and abutment wall

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

Cut bank extent: ing feet flo (US, UB, DS) to w. feet Mo (US, UB, DS)

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

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

overbank flow returning to the bridge opening probably procedes around each pier and through the center span.

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

Scour dimensions: Length 1 Width 1 Depth: 12 Positioned 12 %LB to 1 %RB

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

3
123
0
2

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

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

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

Confluence comments (eg. confluence name):

d and silt. The bed is mostly medium to coarse sand with some fine gravel and silt. The protection on the bank is only on the right bank from the downstream face to 15 feet downstream and is a continuation of stone fill

F. Geomorphic Channel Assessment

107. Stage of reach evolution alo

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)*:

ng pier 2.

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: CRAFTH00390023 Town: CRAFTSBURY
Road Number: TH 39 County: ORLEANS
Stream: BLACK RIVER

Initials EMB Date: 4/12/96 Checked: JDA Date: 4/15/96

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	2100	2850	2020
Main Channel Area, ft2	404	435	390
Left overbank area, ft2	610	699	570
Right overbank area, ft2	3770	4333	3515
Top width main channel, ft	59.2	59.2	59.2
Top width L overbank, ft	166.7	169.1	165.6
Top width R overbank, ft	1062.8	1062.8	1062.8
D50 of channel, ft	0.002419	0.002419	0.002419
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	6.8	7.3	6.6
y1, average depth, LOB, ft	3.7	4.1	3.4
y1, average depth, ROB, ft	3.5	4.1	3.3
Total conveyance, approach	385633	478720	346245
Conveyance, main channel	52424	59383	49388
Conveyance, LOB	43146	53611	38721
Conveyance, ROB	290064	365725	258136
Percent discrepancy, conveyeance	-0.00026	0.000209	0
Qm, discharge, MC, cfs	285.4797	353.5293	288.1305
Ql, discharge, LOB, cfs	234.9555	319.1664	225.8991
Qr, discharge, ROB, cfs	1579.57	2177.298	1505.97
Vm, mean velocity MC, ft/s	0.7	0.8	0.7
Vl, mean velocity, LOB, ft/s	0.4	0.5	0.4
Vr, mean velocity, ROB, ft/s	0.4	0.5	0.4
Vc-m, crit. velocity, MC, ft/s	2.1	2.1	2.1
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	404	435	390
Main channel width, ft	59.2	59.2	59.2
y1, main channel depth, ft	6.824324	7.347973	6.587838
Bridge Section			
(Q) total discharge, cfs	2100	2850	2020
(Q) discharge thru bridge, cfs	2097	2300	1987
Main channel conveyance	28455	28455	28455
Total conveyance	28455	28455	28455
Q2, bridge MC discharge,cfs	2097	2300	1987
Main channel area, ft2	265	265	265
Main channel width (skewed), ft	35.6	35.6	35.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	35.6	35.6	35.6
y_bridge (avg. depth at br.), ft	7.438202	7.438202	7.438202
Dm, median (1.25*D50), ft	0.003024	0.003024	0.003024
y2, depth in contraction,ft	21.36545	23.12644	20.40114
ys, scour depth (y2-ybridge), ft	13.93	15.69	12.96
ys, scour depth (y2-y1), ft	14.54	15.78	13.81
ys, scour depth (y2-yfullv), ft	14.24	16.05	15.82
ARMORING			
D90	0.01519	0.01519	0.01519
D95	0.02385	0.02385	0.02385
Critical grain size,Dc, ft	0.083726	0.100721	0.075173
Decimal-percent coarser than Dc	N/A	N/A	N/A
Depth to armoring,ft	ERR	ERR	ERR

Pressure Flow Scour (contraction scour for orifice flow condtions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	2097	2300	1987
Vc, critical velocity, ft/s	2.1	2.1	2.1
Vc, critical velocity, m/s	0.640049	0.640049	0.640049
Main channel width (skewed), ft	35.6	35.6	35.6
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	35.6	35.6	35.6
qbr, unit discharge, ft^2/s	58.90449	64.60674	55.81461
qbr, unit discharge, m^2/s	5.471873	6.001577	5.184841
Area of full opening, ft^2	264.8	264.8	264.8
Hb, depth of full opening, ft	7.438202	7.438202	7.438202
Hb, depth of full opening, m	2.267053	2.267053	2.267053
Fr, Froude number MC	0.52	0.57	0.49
Cf, Fr correction factor (<=1.0)	1	1	1
Elevation of Low Steel, ft	896.81	896.81	896.81
Elevation of Bed, ft	889.3718	889.3718	889.3718
Elevation of approach WS, ft	898.23	898.76	897.99
HF, bridge to approach, ft	0.04	0.05	0.04
Elevation of WS immediately US, ft	898.19	898.71	897.95
ya, depth immediately US, ft	8.818202	9.338202	8.578202
ya, depth immediately US, m	2.740274	2.901865	2.665694
Mean elev. of deck, ft	901.78	901.78	901.78
w, depth of overflow, ft (>=0)	0	0	0
Cc, vert contrac correction (<=1.0)	0.958376	0.943797	0.965244
Ys, depth of scour (chang), ft	21.8298	25.15898	20.0972

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	2100	2850	2020	2100	2850	2020
a', abut.length blocking flow, ft	170.7	173.1	169.6	1082.4	1082.3	1082.3
Ae, area of blocked flow ft2	661.7	754.6	619.7	3847	4225	3599
Qe, discharge blocked abut.,cfs	280.5	376.7	272.1	--	--	1549
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	0.423908	0.499205	0.439083	0.42	0.51	0.430397
ya, depth of f/p flow, ft	3.88	4.36	3.65	3.55	3.90	3.33
--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	80	80	80	100	100	100
K2	0.984805	0.984805	0.984805	1.013791	1.013791	1.013791
Fr, froude number f/p flow	0.04	0.04	0.04	0.04	0.05	0.04
ys, scour depth, ft	9.87	11.24	9.67	16.83	19.22	16.56

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)	170.7	173.1	169.6	1082.4	1082.3	1082.3
y1 (depth f/p flow, ft)	3.88	4.36	3.65	3.55	3.90	3.33
a'/y1	44.04	39.71	46.42	304.55	277.25	325.47
Skew correction (p. 49, fig. 16)	0.967	0.967	0.967	1.02	1.02	1.02
Froude no. f/p flow	0.04	0.04	0.04	0.04	0.05	0.04
Ys w/ corr. factor K1/0.55:						
vertical	9.12	10.62	8.78	9.18	10.59	8.76
vertical w/ ww's	7.73	9.00	7.45	7.38	8.51	7.04
spill-through	5.19	6.04	5.00	4.95	5.71	4.72

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.52	0.57	0.49	0.52	0.57	0.49
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	7.438202	7.438202	7.438202	7.438202	7.438202	7.438202
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	1.24	1.49	1.10	1.24	1.49	1.10
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR