LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (STJOTH00080027) on TOWN HIGHWAY 8, crossing the SLEEPERS RIVER, ST. JOHNSBURY, VERMONT

Open-File Report 97-779

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

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Pembroke, New Hampshire

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U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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
FEMA	Federal Emergency Management Agency		

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 27 (STJOTH00080027) ON TOWN HIGHWAY 8, CROSSING THE SLEEPERS RIVER, ST. JOHNSBURY, VERMONT

By **Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STJOTH00080027 on Town Highway 8 crossing the Sleepers River, St. Johnsbury, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in northeastern Vermont. The 40.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the upstream right bank with some pasture on the upstream left bank. The downstream right overbank cover is comprised of cut grass, trees and shrubs while the immediate banks have dense woody vegetation. The downstream left bank is forested with some pasture.

In the study area, the Sleepers River has an incised, sinuous channel with a slope of approximately 0.007 ft/ft, an average channel top width of 72 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to cobble with a median grain size (D_{50}) of 48.5 mm (0.159 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 10, 1995, indicated that the reach was stable.

The Town Highway 8 crossing of the Sleepers River is a 74-ft-long, two-lane bridge consisting of one 71-foot steel-beam span (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 68 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 50 degrees to the opening while the computed opening-skew-to-roadway is 45 degrees. The VTAOT database states the opening-skew-to-roadway as 30 degrees.

A scour hole 2.5 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. There is also a three to four foot deep scour hole in the channel adjacent to the upstream right wingwall. The scour protection at the site included type-3 stone fill (less than 48 inches diameter) at the upstream end of the upstream left wingwall, at the downstream end of the downstream right wingwall, and along the downstream left bank. There was also type-2 stone fill (less than 36 inches diameter) at the downstream end of the downstream left wingwall, along the upstream left bank, and along the downstream right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour computed for all modelled flows was zero ft. Abutment scour ranged from 6.2 to 9.7 ft. The worst-case abutment scour occurred at the 100-year discharge at the right abutment and at the 500-year discharge at the left abutment. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and 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.

St. Johnsbury, VT. Quadrangle, 1:25,000, 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 STJOTH00080027 ***Stream*** Sleepers River

County Caledonia ***Road*** TH 8 ***District*** 7

Description of Bridge

Bridge length 74 ***ft*** ***Bridge width*** 24.0 ***ft*** ***Max span length*** 71 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 8/10/95

Description of stone fill Type-3, around the upstream end of the upstream left wingwall, downstream end of the downstream right wingwall, and DS left bank. Type-2, around the downstream end of the downstream left wingwall, US left bank, and DS right bank.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a three to four foot deep scour hole in the channel adjacent to the US right wingwall. A scour hole 2.5 ft deeper than the mean thalweg depth was observed along the right abutment.

Is bridge skewed to flood flow according to Level I survey? Yes ***Angle*** 50

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe) No

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	8/10/95	0	0
Level II	8/10/95	0	0

Potential for debris Moderate. There is some debris caught on boulders upstream and trees are leaning over the channel upstream along the right bank.

Describe any features near or at the bridge that may affect flow (include observation date) None, 8/10/95.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with steep valley walls on both sides.

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

Date of inspection 8/10/95

DS left: Steep channel bank to a narrow overbank.

DS right: Steep channel bank to the flat overbank.

US left: Steep channel bank to a narrow overbank.

US right: Steep valley wall.

Description of the Channel

Average top width 72 ***ft*** ***Average depth*** 5 ***ft***

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

Sinuous but stable with non-alluvial channel boundaries and no flood plain.

8/10/95

Vegetative co Trees and brush with some pasture.

DS left: Cut grass, some trees, and brush.

DS right: Pasture with trees and brush.

US left: Trees and brush.

US right:

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

The assessment of 8/10/95 noted some debris caught on boulders in the channel upstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 40.4 ***mi²***

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 Sleepers River near St. Johnsbury, VT

USGS gage number 01135300

Gage drainage area 42.9 ***mi²***

Is there a lake/p - No

-

Calculated Discharges

Q100 4,990 ***ft³/s*** ***Q500*** 7,480 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(40.4/42.9)exp 0.7] with gage 01135300 in St. Johnsbury. The 100- and 500- year discharges at the gage were developed using a log-Pearson type-III analysis of annual peak-flow data (Interagency Advisory Committee on Water Data, 1982). These discharge values are within a range of several flood frequency curves based on empirical relationships for this site (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 Add 176.0 ft to the USGS arbitrary survey datum to obtain VTAOT plans' datum and National Geodetic Vertical Datum 29.

Description of reference marks used to determine USGS datum. RM1 is the center of an old chiseled square on top of the downstream end of the left abutment (elev. 501.22 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 501.16 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-235	5	Downstream Exit section as surveyed in the Flood Insurance Study
EXITX	-60	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	5	Bridge section as surveyed in the Flood Insurance Study
RDWAY	18	1	Road Grade section
APPRO	85	2	Modelled Approach section (Templated from APTEM)
APTEM	120	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.055, and the overbank "n" value was 0.030.

The starting water surface elevations at the exit section (EXIT1) were taken from the Flood Insurance Study (FIS) for St. Johnsbury, VT (Federal Emergency Management Agency, 1986). The exit section (EXIT1) 235 ft downstream of the bridge and the downstream bridge section (BRIDG) were also obtained from the survey completed for the Flood Insurance Study.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.020 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 501.7 ***ft***
Average low steel elevation 498.3 ***ft***

100-year discharge 4,990 ***ft³/s***
Water-surface elevation in bridge opening 498.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,689 ***ft³/s***
Area of flow in bridge opening 420 ***ft²***
Average velocity in bridge opening 7.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.7 ***ft/s***

Water-surface elevation at Approach section with bridge 502.9
Water-surface elevation at Approach section without bridge 501.8
Amount of backwater caused by bridge 1.1 ***ft***

500-year discharge 7,480 ***ft³/s***
Water-surface elevation in bridge opening 498.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 4,807 ***ft³/s***
Area of flow in bridge opening 420 ***ft²***
Average velocity in bridge opening 6.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.1 ***/s***

Water-surface elevation at Approach section with bridge 504.4
Water-surface elevation at Approach section without bridge 503.8
Amount of backwater caused by bridge 0.6 ***ft***

Incipient overtopping discharge 3,130 ***ft³/s***
Water-surface elevation in bridge opening 498.3 ***ft***
Area of flow in bridge opening 420 ***ft²***
Average velocity in bridge opening 7.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.2 ***ft/s***

Water-surface elevation at Approach section with bridge 500.7
Water-surface elevation at Approach section without bridge 499.6
Amount of backwater caused by bridge 1.1 ***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 100-year and 500-year discharges scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, each 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 was computed (Table 1, 2, and Figure 8) by use of the Chang equation (Richardson and others, 1995, p. 145-146).

For comparison, contraction scour also was computed for the discharges resulting in orifice flow by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144). The results are presented in Appendix F.

Abutment scour for the right 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.

Scour at the left 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	0.0
Depth to armoring	1.6	0.5	1.2
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	8.4	9.2	6.2
Right abutment	9.7	8.9	9.5
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.7	1.1	1.5
Right abutment	1.7	1.1	1.5
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

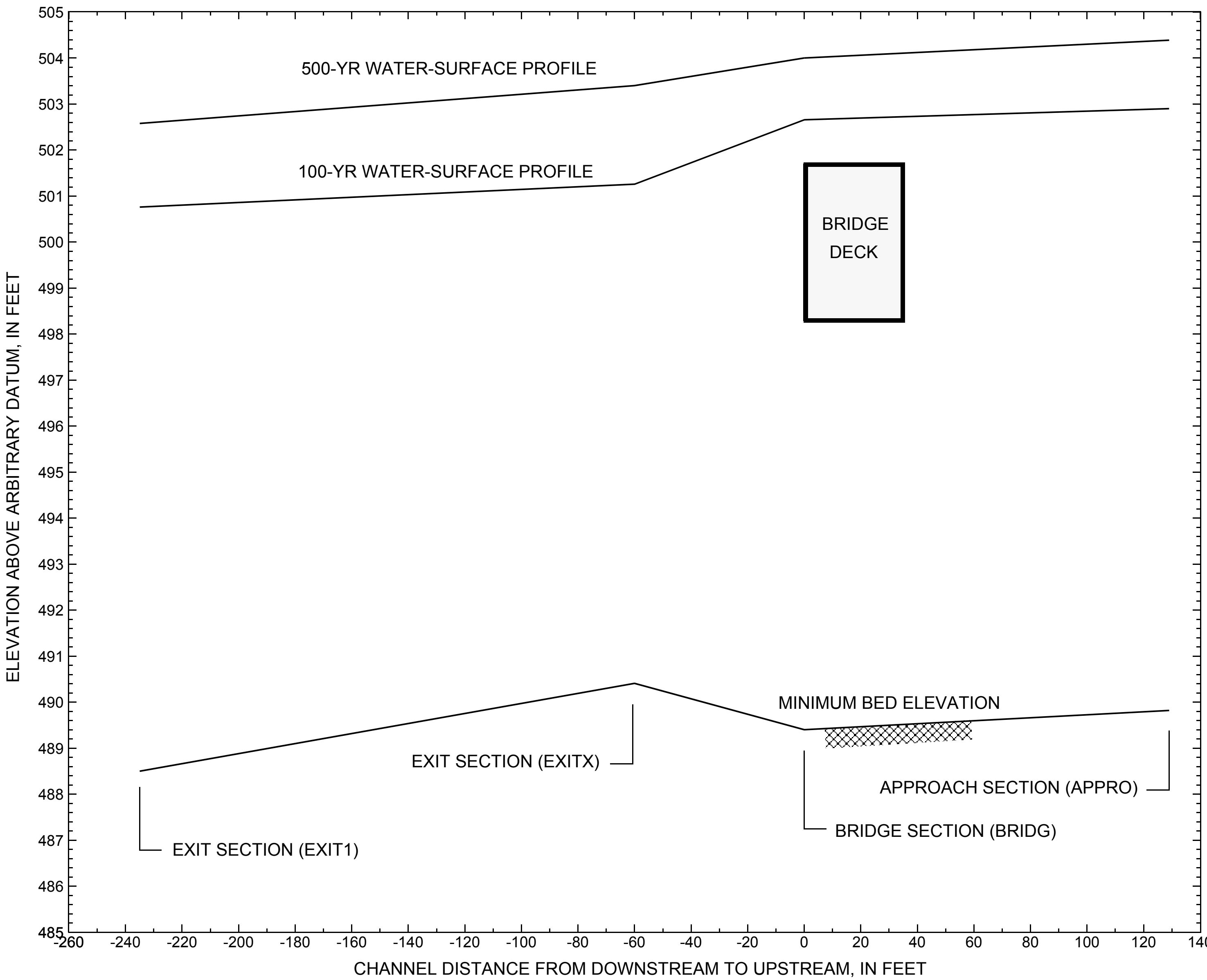

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure STJOTH00080027 on Town Highway 8, crossing the Sleepers River, St. Johnsbury, Vermont.

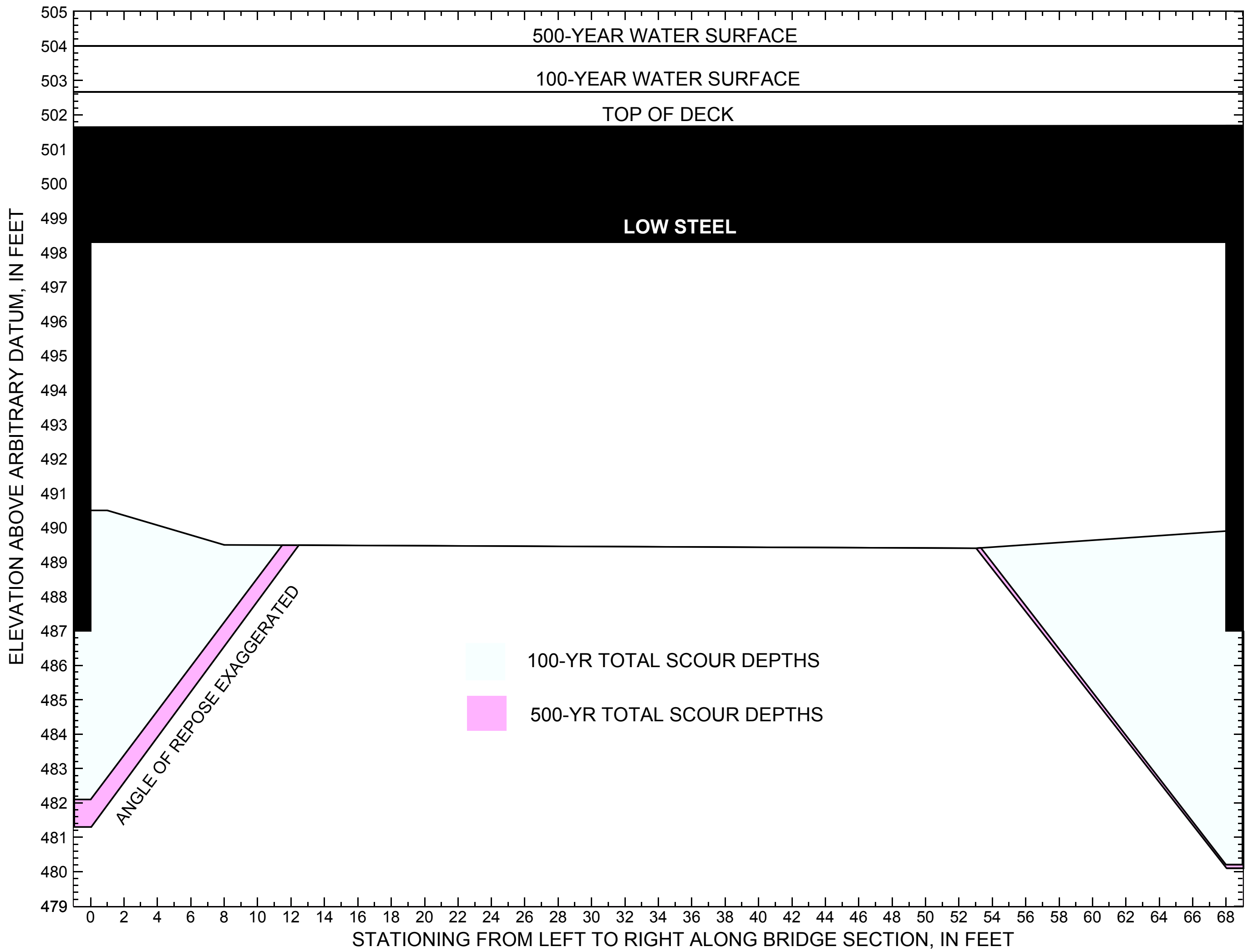

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure STJOTH00080027 on Town Highway 8, crossing the Sleepers River, St. Johnsbury, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure STJOTH00080027 on Town Highway 8, crossing the Sleepers River, St. Johnsbury, Vermont.

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

Description	Station[1]	FEMA minimum low steel elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 4,990 cubic-feet per second											
Left abutment	0.0	674.3	498.3	487.0	490.5	0.0	8.4	--	8.4	482.1	-4.9
Right abutment	68.0	674.3	498.3	487.0	489.9	0.0	9.7	--	9.7	480.2	-6.8

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 STJOTH00080027 on Town Highway 8, crossing the Sleepers River, St. Johnsbury, Vermont.

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

Description	Station[1]	FEMA minimum low steel elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 7,480 cubic-feet per second											
Left abutment	0.0	674.3	498.3	487.0	490.5	0.0	9.2	--	9.2	481.3	-5.7
Right abutment	68.0	674.3	498.3	487.0	489.9	0.0	8.9	--	8.9	481.0	-6.0

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, 1983, St. Johnsbury, Vermont 7.5 X 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File stjo027.wsp
T2        Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
T3        Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by MAI
*
J1          * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           4990.0   7480.0   3130.0
WS          500.76   502.58   499.05
*
XS   EXIT1   -235
GR          -78.0, 503.50    -55.0, 507.50    -24.0, 502.50    -12.0, 502.90
GR            0.0, 502.50     29.0, 489.90     34.0, 489.10     41.0, 488.50
GR           67.0, 488.60     78.0, 489.20     81.0, 489.90     94.0, 500.30
GR          151.0, 503.60    205.0, 503.00    227.0, 503.00    321.0, 507.80
N            0.045
*
XS   EXITX    -60
GR          -93.2, 513.80    -75.2, 507.24    -54.9, 499.37
GR          -37.2, 499.67    -24.6, 500.32    -13.8, 499.98     -9.0, 499.67
GR            0.0, 495.88      5.0, 493.77     12.9, 491.64     13.9, 491.31
GR           23.3, 491.40     31.5, 490.93     45.0, 490.42     55.0, 490.41
GR           64.0, 491.11     70.3, 491.61     73.3, 494.24     81.0, 498.32
GR           85.5, 500.17     99.3, 501.84    138.2, 501.42    148.3, 503.36
GR          163.2, 506.26    182.5, 508.88
N             0.045
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.30      45.0
GR            0.0, 498.30      0.0, 491.50      1.0, 490.50      8.0, 489.50
GR           53.0, 489.40     68.0, 489.90     68.0, 498.30      0.0, 498.30
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      44.2 * *     45.0      9.2
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      24.0     1
GR         -139.7, 503.98   -110.4, 501.82    -77.5, 500.46    -40.9, 501.18
GR            0.0, 501.64     71.9, 501.69    138.2, 501.69    148.3, 503.36
*
XT   APTEM    120
GR         -140.9, 511.74   -106.8, 499.29    -42.7, 500.46    -20.0, 500.74
GR           -8.6, 500.34     -4.1, 499.71      0.0, 496.79      5.6, 493.65
GR            9.0, 492.11     10.8, 491.71     13.3, 491.31     26.3, 490.52
GR           33.3, 490.83     43.2, 490.98     51.0, 491.61     56.0, 491.88
GR           60.1, 495.39     61.9, 496.89     64.9, 499.22     71.7, 502.63
GR           83.7, 507.16
*
AS   APPRO    85  * * * 0.020
GT
N           0.030       0.055
SA                -4.1
*
HP 1 BRIDG   498.30 1 498.30
HP 2 BRIDG   498.30 * * 3306
HP 2 RDWAY   502.66 * * 1689
HP 1 APPRO   502.90 1 502.90
HP 2 APPRO   502.90 * * 4990
*
HP 1 BRIDG   498.30 1 498.30
HP 2 BRIDG   498.30 * * 2687
HP 2 RDWAY   504.00 * * 4807
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File stjo027.wsp
        Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
        Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
           *** RUN DATE & TIME: 07-23-97  10:38
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     420.  33806.   -20.   132.                            0.
   498.30          420.  33806.   -20.   132.  1.00     0.    68.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.30     0.0    68.0   419.6   33806.    3306.   7.88

X STA.         0.0        5.5        9.0       12.3       15.5       18.7
  A(I)            30.8       22.0       20.1       20.2       19.5
  V(I)            5.37       7.52       8.21       8.18       8.48

X STA.        18.7       21.8       24.9       28.0       31.1       34.1
  A(I)            19.6       19.3       19.4       19.2       19.2
  V(I)            8.42       8.58       8.51       8.60       8.59

X STA.        34.1       37.2       40.3       43.4       46.4       49.6
  A(I)            19.4       19.4       19.0       19.3       19.7
  V(I)            8.51       8.51       8.70       8.56       8.39

X STA.        49.6       52.7       55.9       59.3       62.8       68.0
  A(I)            19.6       20.2       20.6       21.9       31.0
  V(I)            8.43       8.16       8.01       7.55       5.34

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      18.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.66  -121.8   144.1   312.0   11487.    1689.   5.41

X STA.      -121.8      -96.8      -87.7      -81.1      -75.5      -70.0
  A(I)            20.0       14.6       12.6       12.0       11.5
  V(I)            4.22       5.80       6.72       7.04       7.32

X STA.       -70.0      -64.0      -57.5      -50.2      -41.7      -31.7
  A(I)            11.9       12.3       12.6       13.5       14.3
  V(I)            7.07       6.87       6.72       6.26       5.90

X STA.       -31.7      -20.1       -6.0       11.0       29.0       47.2
  A(I)            15.3       16.4       17.5       18.1       18.1
  V(I)            5.53       5.15       4.82       4.66       4.67

X STA.        47.2       65.4       83.9      102.9      120.7      144.1
  A(I)            17.9       18.0       18.4       17.3       19.8
  V(I)            4.73       4.70       4.60       4.87       4.27

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     383.  42394.   115.   115.                         3979.
             2     783.  93839.    78.    84.                        14051.
   502.90         1167.  136233.   193.   200.  1.00  -119.    74.  16246.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.90  -118.6    74.3  1166.5  136233.    4990.   4.28

X STA.      -118.6      -97.2      -83.2      -68.1      -50.5      -29.5
  A(I)            66.0       56.1       56.4       60.5       65.5
  V(I)            3.78       4.45       4.42       4.12       3.81

X STA.       -29.5       -7.8        5.1       10.3       14.5       18.4
  A(I)            65.3       77.5       56.5       50.7       49.1
  V(I)            3.82       3.22       4.42       4.92       5.09

X STA.        18.4       22.3       26.0       29.7       33.4       37.4
  A(I)            48.9       48.2       48.1       48.2       49.9
  V(I)            5.11       5.17       5.19       5.17       5.00

X STA.        37.4       41.3       45.5       50.1       55.3       74.3
  A(I)            49.8       53.3       56.1       61.7       98.7
  V(I)            5.01       4.69       4.45       4.04       2.53
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       U.S. Geological Survey WSPRO Input File stjo027.wsp
       Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
       Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
          *** RUN DATE & TIME: 07-23-97  10:38
   CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     420.  33806.   -20.   132.                           0.
  498.30          420.  33806.   -20.   132.  1.00     0.    68.       0.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.30     0.0    68.0   419.6   33806.    2687.   6.40

X STA.         0.0        5.5        9.0       12.3       15.5       18.7
  A(I)            30.8       22.0       20.1       20.2       19.5
  V(I)            4.36       6.11       6.67       6.65       6.89

X STA.        18.7       21.8       24.9       28.0       31.1       34.1
  A(I)            19.6       19.3       19.4       19.2       19.2
  V(I)            6.84       6.97       6.91       6.99       6.98

X STA.        34.1       37.2       40.3       43.4       46.4       49.6
  A(I)            19.4       19.4       19.0       19.3       19.7
  V(I)            6.92       6.91       7.07       6.96       6.82

X STA.        49.6       52.7       55.9       59.3       62.8       68.0
  A(I)            19.6       20.2       20.6       21.9       31.0
  V(I)            6.85       6.64       6.51       6.13       4.34

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      18.

        WSEL     LEW     REW    AREA        K        Q    VEL
      504.00  -139.7   148.3   684.6   40287.    4807.   7.02

X STA.      -139.7     -102.5      -89.9      -80.2      -71.7      -62.9
  A(I)            50.7       34.9       31.2       29.7       29.3
  V(I)            4.74       6.89       7.71       8.10       8.20

X STA.       -62.9      -53.9      -43.7      -32.4      -20.5       -7.5
  A(I)            28.8       30.2       31.6       31.5       32.8
  V(I)            8.35       7.97       7.61       7.62       7.33

X STA.        -7.5        7.1       21.7       36.5       51.4       66.4
  A(I)            34.7       34.3       34.6       34.9       34.8
  V(I)            6.92       7.01       6.96       6.90       6.90

X STA.        66.4       81.4       96.9      111.8      127.0      148.3
  A(I)            34.5       35.8       34.4       35.2       40.8
  V(I)            6.97       6.72       6.98       6.83       5.89

   CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     557.  77104.   119.   120.                        6849.
            2     903. 115128.    82.    88.                       16970.
  504.39         1460. 192232.   201.   208.  1.00  -123.    78.  22277.

   VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

        WSEL     LEW     REW    AREA        K        Q    VEL
      504.39  -122.7    78.2  1459.9  192232.    7480.   5.12

X STA.      -122.7     -100.3      -88.5      -76.7      -63.9      -50.3
  A(I)            83.1       66.0       63.1       65.8       66.7
  V(I)            4.50       5.67       5.93       5.69       5.61

X STA.       -50.3      -35.2      -19.0       -4.3        6.5       11.9
  A(I)            69.9       71.9       69.4       94.4       70.0
  V(I)            5.35       5.20       5.39       3.96       5.34

X STA.        11.9       16.6       21.1       25.5       29.9       34.4
  A(I)            65.2       62.6       64.3       63.2       64.1
  V(I)            5.73       5.97       5.81       5.92       5.84

X STA.        34.4       39.0       43.9       49.3       55.4       78.2
  A(I)            66.2       68.9       74.8       82.1      128.2
  V(I)            5.65       5.43       5.00       4.56       2.92
```

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        U.S. Geological Survey WSPRO Input File stjo027.wsp
        Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
        Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
           *** RUN DATE & TIME: 07-23-97  10:38
    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     420.   33806.   -20.   132.                          0.
   498.30          420.   33806.   -20.   132.  1.00     0.    68.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.30     0.0    68.0   419.6   33806.    3130.   7.46

X STA.        0.0        5.5        9.0       12.3       15.5       18.7
  A(I)           30.8       22.0       20.1       20.2       19.5
  V(I)           5.08       7.12       7.77       7.74       8.03

X STA.       18.7       21.8       24.9       28.0       31.1       34.1
  A(I)           19.6       19.3       19.4       19.2       19.2
  V(I)           7.97       8.12       8.05       8.14       8.14

X STA.       34.1       37.2       40.3       43.4       46.4       49.6
  A(I)           19.4       19.4       19.0       19.3       19.7
  V(I)           8.06       8.05       8.24       8.10       7.94

X STA.       49.6       52.7       55.9       59.3       62.8       68.0
  A(I)           19.6       20.2       20.6       21.9       31.0
  V(I)           7.99       7.73       7.58       7.15       5.06


    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     136.    7819.   108.   109.                        863.
             2     615.   65669.    73.    79.                      10115.
   500.68          751.   73488.   182.   188.  1.10  -113.    69.   8261.


    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      85.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.68  -112.5    69.2   751.1   73488.    3130.   4.17

X STA.     -112.5      -81.9      -10.0        5.8       10.0       13.4
  A(I)           52.4       75.9       56.1       37.4       33.1
  V(I)           2.98       2.06       2.79       4.18       4.72

X STA.       13.4       16.5       19.4       22.3       25.0       27.7
  A(I)           31.2       30.3       29.9       29.0       29.4
  V(I)           5.02       5.16       5.23       5.39       5.33

X STA.       27.7       30.4       33.2       36.0       38.8       41.7
  A(I)           29.1       29.6       29.3       30.2       30.4
  V(I)           5.39       5.28       5.34       5.19       5.14

X STA.       41.7       44.8       48.0       51.5       55.6       69.2
  A(I)           32.0       32.2       35.0       38.8       59.8
  V(I)           4.90       4.86       4.48       4.03       2.62
```

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        U.S. Geological Survey WSPRO Input File stjo027.wsp
        Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
        Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
           *** RUN DATE & TIME: 07-23-97  10:38

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

EXIT1:XS   ******     4.     833.  0.56 *****  501.32  495.15   4990.  500.76
     -235. ******   102.  110316.  1.00 ***** *******    0.36    5.99

EXITX:XS     175.   -60.     873.  0.51  0.44  501.77 *******   4990.  501.26
      -60.   175.    95.   90000.  1.00  0.00    0.01    0.42    5.72

FULLV:FV      60.   -60.     910.  0.47  0.18  501.97 *******   4990.  501.50
        0.    60.   139.   92528.  1.00  0.00    0.02    0.41    5.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      85.  -115.     950.  0.45  0.23  502.20 *******   4990.  501.76
       85.    85.    71.  100772.  1.04  0.00    0.01    0.42    5.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    501.50     498.30

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

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

BRIDG:BR      60.     0.     420.  0.97 *****  499.27  494.85   3306.  498.30
        0. ******    68.   33806.  1.00 ***** *******    0.56    7.88

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  498.30 ****** ****** ******

    XSID:CODE     SRD   FLEN     HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG       18.    61.  0.08  0.29  503.10     0.00   1689.  502.66

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1141.   156.  -122.    34.   2.2   1.3   6.2   5.5   1.8   3.1
   RT:    549.   110.    34.   144.   1.0   0.9   5.4   5.3   1.4   3.0

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

APPRO:AS      41.  -119.    1166.  0.29  0.18  503.18  497.13   4990.  502.90
       85.    47.    74.  136151.  1.00  0.00    0.00    0.31    4.28


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXIT1:XS    -235.     4.   102.   4990.  110316.     833.    5.99  500.76
   EXITX:XS     -60.   -60.    95.   4990.   90000.     873.    5.72  501.26
   FULLV:FV       0.   -60.   139.   4990.   92528.     910.    5.48  501.50
   BRIDG:BR       0.     0.    68.   3306.   33806.     420.    7.88  498.30
   RDWAY:RG      18.*******  1141.   1689.******************    1.00  502.66
   APPRO:AS      85.  -119.    74.   4990.  136151.    1166.    4.28  502.90


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    495.15    0.36  488.50  507.80************  0.56  501.32  500.76
   EXITX:XS  ********    0.42  490.41  513.80  0.44  0.00  0.51  501.77  501.26
   FULLV:FV  ********    0.41  490.41  513.80  0.18  0.00  0.47  501.97  501.50
   BRIDG:BR    494.85    0.56  489.40  498.30************  0.97  499.27  498.30
   RDWAY:RG  ****************  500.46  503.98  0.08******  0.29  503.10  502.66
   APPRO:AS    497.13    0.31  489.82  511.04  0.18  0.00  0.29  503.18  502.90
```

```
       U.S. Geological Survey WSPRO Input File stjo027.wsp
       Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
       Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
          *** RUN DATE & TIME: 07-23-97  10:38

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

EXIT1:XS   ******   -24.    1044.  0.80 *****  503.38  496.95   7480.  502.58
     -235. ******   133.  128684.  1.00 ***** *******    0.46    7.17

EXITX:XS     175.   -65.    1297.  0.52  0.54  503.92 *******   7480.  503.40
      -60.   175.   149.  140563.  1.00  0.00    0.00    0.41    5.77

FULLV:FV      60.   -66.    1340.  0.48  0.16  504.09 *******   7480.  503.60
        0.    60.   150.  147780.  1.00  0.00    0.01    0.39    5.58
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      85.  -121.    1344.  0.48  0.19  504.29 *******   7480.  503.81
       85.    85.    77.  169031.  1.00  0.00    0.01    0.38    5.57
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    503.60     498.30

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =     4807.      4802.    1.00

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

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

BRIDG:BR      60.     0.     420.  0.64 *****  498.94  494.18   2687.  498.30
        0. ******    68.   33806.  1.00 ***** *******    0.45    6.40

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  498.30 ****** ****** ******

   XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG       18.    61.  0.09  0.41  504.71    0.00   4807.  504.00

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:   3045.   174.  -140.    34.   3.5   2.5   8.3   7.1   3.2   3.1
  RT:   1762.   114.    34.   148.   2.3   2.2   7.9   6.9   2.9   3.1

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

APPRO:AS      41.  -123.    1459.  0.41  0.20  504.80  500.49   7480.  504.39
       85.    50.    78.  192114.  1.00  0.00    0.00    0.34    5.13


  FIRST USER DEFINED TABLE.

   XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
  EXIT1:XS    -235.   -24.   133.   7480.  128684.    1044.    7.17  502.58
  EXITX:XS     -60.   -65.   149.   7480.  140563.    1297.    5.77  503.40
  FULLV:FV       0.   -66.   150.   7480.  147780.    1340.    5.58  503.60
  BRIDG:BR       0.     0.    68.   2687.   33806.     420.    6.40  498.30
  RDWAY:RG      18.******* 3045.   4807.******************    1.00  504.00
  APPRO:AS      85.  -123.    78.   7480.  192114.    1459.    5.13  504.39


 SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXIT1:XS    496.95    0.46  488.50  507.80************  0.80  503.38  502.58
  EXITX:XS  ********    0.41  490.41  513.80  0.54  0.00  0.52  503.92  503.40
  FULLV:FV  ********    0.39  490.41  513.80  0.16  0.00  0.48  504.09  503.60
  BRIDG:BR    494.18    0.45  489.40  498.30************  0.64  498.94  498.30
  RDWAY:RG  ****************  500.46  503.98  0.09******  0.41  504.71  504.00
  APPRO:AS    500.49    0.34  489.82  511.04  0.20  0.00  0.41  504.80  504.39
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        U.S. Geological Survey WSPRO Input File stjo027.wsp
        Hydraulic analysis for structure STJOTH00080027   Date: 09-JUN-97
        Bridge 27 on Town Highway 8 over Sleepers River, St.Johnsbury, VT by M
           *** RUN DATE & TIME: 07-23-97  10:38

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

EXIT1:XS   ******     8.     681.  0.33 *****  499.38  493.55   3130.  499.05
     -235. ******    92.   87109.  1.00 ***** *******    0.29    4.59

EXITX:XS     175.    -8.     614.  0.40  0.28  499.71 *******   3130.  499.31
      -60.   175.    83.   70384.  1.00  0.04    0.01    0.35    5.10

FULLV:FV      60.   -55.     628.  0.39  0.12  499.85 *******   3130.  499.46
        0.    60.    84.   70079.  1.00  0.00    0.02    0.35    4.98
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      85.  -110.     571.  0.50  0.22  500.12 *******   3130.  499.62
       85.    85.    67.   54706.  1.06  0.06    0.00    0.48    5.48
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =    499.46     498.30

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

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

BRIDG:BR      60.     0.     420.  0.86 *****  499.16  494.65   3115.  498.30
        0. ******    68.   33806.  1.00 ***** *******    0.53    7.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  498.30 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<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      41.  -113.     751.  0.30  0.18  500.98  495.42   3130.  500.68
       85.    46.    69.   73506.  1.10  0.00    0.00    0.38    4.17
```

FIRST USER DEFINED TABLE.

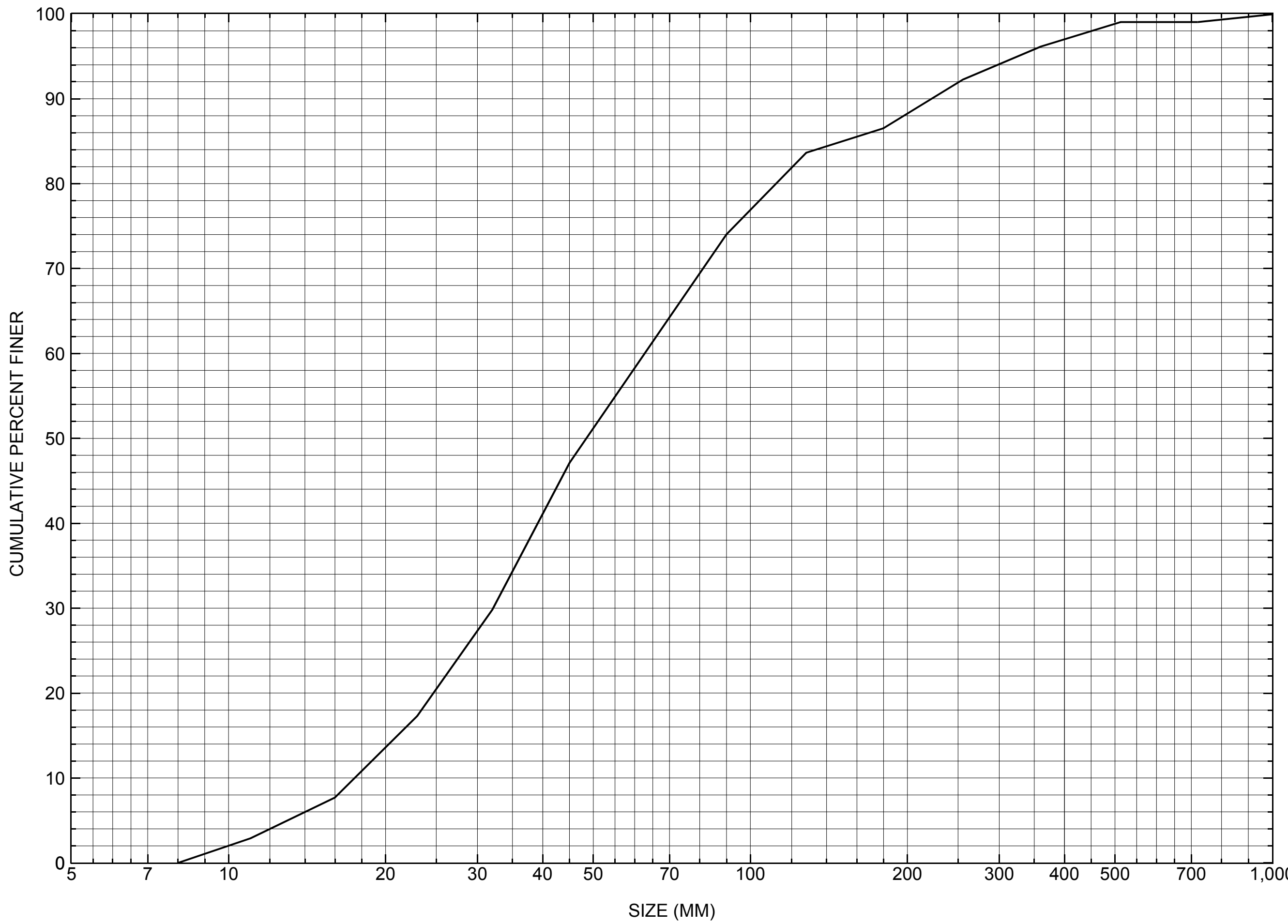
XSID:CODE	SRD	LEW	REW	Q	K	AREA	VEL	WSEL
EXIT1:XS	-235.	8.	92.	3130.	87109.	681.	4.59	499.05
EXITX:XS	-60.	-8.	83.	3130.	70384.	614.	5.10	499.31
FULLV:FV	0.	-55.	84.	3130.	70079.	628.	4.98	499.46
BRIDG:BR	0.	0.	68.	3115.	33806.	420.	7.42	498.30
RDWAY:RG	18.**************			0.	0.	0.	1.00********	
APPRO:AS	85.	-113.	69.	3130.	73506.	751.	4.17	500.68

SECOND USER DEFINED TABLE.

XSID:CODE	CRWS	FR#	YMIN	YMAX	HF	HO	VHD	EGL	WSEL
EXIT1:XS	493.55	0.29	488.50	507.80************			0.33	499.38	499.05
EXITX:XS	********	0.35	490.41	513.80	0.28	0.04	0.40	499.71	499.31
FULLV:FV	********	0.35	490.41	513.80	0.12	0.00	0.39	499.85	499.46
BRIDG:BR	494.65	0.53	489.40	498.30************			0.86	499.16	498.30
RDWAY:RG	****************		500.46	503.98************			0.30	500.87********	
APPRO:AS	495.42	0.38	489.82	511.04	0.18	0.00	0.30	500.98	500.68

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STJOTH00080027, in St. Johnsbury, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STJOTH00080027

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 28 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 005

Town *(FIPS place code; I - 4; nnnnn)* 62200

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

Waterway *(I - 6)* Sleepers River

Road Name *(I - 7):* -

Route Number TH008

Vicinity *(I - 9)* At the junction with TH44

Topographic Map St.Johnsbury

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44267

Longitude *(i - 17; nnnnn.n)* 72032

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10031100270311

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

Maximum span length *(I - 48; nnnn)* 0071

Year built *(I - 27; YYYY)* 1929

Structure length *(I - 49; nnnnnn)* 000074

Average daily traffic, ADT *(I - 29; nnnnnn)* 000500

Deck Width *(I - 52; nn.n)* 240

Year of ADT *(I - 30; YY)* 92

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

Opening skew to Roadway *(I - 34; nn)* 30

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 060.5

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

Vertical clearance from streambed (*nnn.n ft*) 008.3

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

Waterway of full opening (*nnn.n* ft^2) 503.0

Comments:

The structural inspection report of 8/22/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt roadway surface. The abutment walls and wingwalls are concrete, which has fine cracks, and small leaks reported overall. The left abutment has two random vertical cracks noted on its face. The channel is reported as having scoured down 3 to 4 feet as the right abutment concrete footing is exposed. While the right abutment footing is exposed, the report indicates there has been no undermining or settling at this point. Some stone fill is reported at the ends of the wingwalls. Point bar development problems are reported as minor. **(Continued, page 33)**

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: -

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

Debris accumulation is noted as small piles of brush at the ends of the wingwalls. The foundation type recorded for this bridge is an unknown foundation. The plans show a wooden pile foundation.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **40.38** mi^2 Lake/pond/swamp area **0.093** mi^2

Watershed storage *(ST)* **0.23** %

Bridge site elevation **676** ft Headwater elevation **2244** ft

Main channel length **7.435** mi

10% channel length elevation **705** ft 85% channel length elevation **1572** ft

Main channel slope *(S)* **155.5** 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)*: 08 / 1929

Project Number - Minimum channel bed elevation: 667.0

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

Benchmark location description:

BM#2, [spike in root or truck of] a 20 inch elm tree, located about 175 feet right-bankward from the right abutment and about 50 feet perpendicular to the centerline of the roadway toward the downstream right bank of the Sleepers river (on the downstream edge of the old roadway approach to the right abutment of the original structure, elevation 678.10.

Reference Point (*MSL, Arbitrary, Other*): MSL Datum (*NAD27, NAD83, Other*): NGVD1929

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 663.0

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

A high water elevation is shown on plans for the Flood of Nov. 1927, elevation 674.1

Cross-sectional Data

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

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

Comments: **This cross-section is the downstream face.**

Station	1297	1297	1305	1350	1365	1369	-	-	-	-	-
Feature	LAB	-	-	-		RAB	-	-	-	-	-
Low chord elevation	674.3	674.3	674.3	674.3	674.3	674.3	-	-	-	-	-
Bed elevation	667.5	666.5	665.5	665.4	665.9	665.9	-	-	-	-	-
Low chord-bed	6.8	7.8	8.8	8.9	8.4	8.4	-	-	-	-	-

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: 03/21/96
Computerized by: EW Date: 03/22/96
Reviewd by: MAL Date: 8/5/97

Structure Number STJOTH00080027

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. IVANOFF Date *(MM/DD/YY)* 08 / 10 / 1995
2. Highway District Number 07 Mile marker -
County CALENDONIA 005 Town ST. JOHNSBURY 62200
Waterway *(I - 6)* SLEEPERS RIVER Road Name -
Route Number TH08 Hydrologic Unit Code: 01080102
3. Descriptive comments:

The site is located at the junction with town highway 44.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 6 LBDS 6 RBDS 4 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 1 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 74 *(feet)* Span length 71 *(feet)* Bridge width 24 *(feet)*

Road approach to bridge:

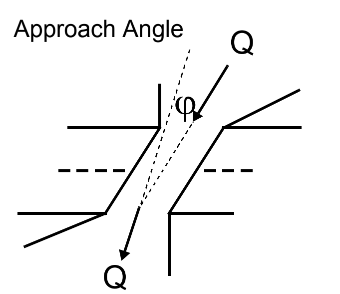
8. LB 0 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope *(run / rise in feet / foot)*:
US left -- US right --

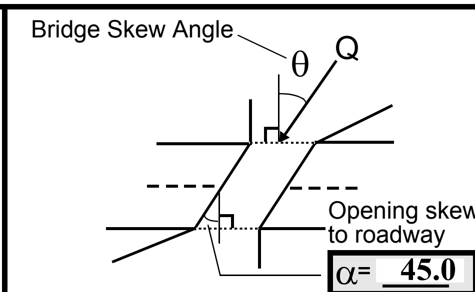
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	3	1	0	-
RBUS	0	-	0	-
RBDS	2	1	0	-
LBDS	2	1	0	-

*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: 50



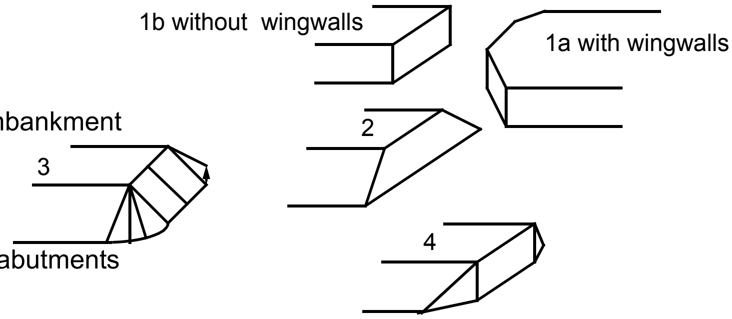


17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 30 feet US *(US, UB, DS)* to 5 feet DS
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: **1a**

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



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

#4: The surface cover on the upstream left bank consists of a road embankment, paved town highway 44, a house with a lawn, and forest. On the downstream left bank there are trees, route 2 and forest area. The downstream right bank has trees along the immediate bank and a house with a lawn. The upstream right bank is forest.
#11: The protection on the downstream left bank is for town highway 44.

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
88.0	**4.5**			**5.0**	**1**	**4**	**453**	**432**	**0**	**1**

23. Bank width **25.0** 24. Channel width **35.0** 25. Thalweg depth **62.0** 29. Bed Material **453**

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.):

The left bank material is the embankment for town highway 44 with cobbles, boulders, and gravel. The right bank consists of cobbles, gravel and sand.
The bed material is cobbles, boulders and gravel
The left bank protection extends from 105 feet US to the US end of the junction between the left abutment and wingwall.

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

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

37. Material: **-**

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **10**

47. Scour dimensions: Length **160** Width **60** Depth : **4** Position **0** %LB to **100** %RB

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

The maximum scour depth is 4.5 feet located 10 feet US from the bridge face.
At the US bridge face there is 3.5 feet of scour.
The US scour extent is from the bridge face to 70 feet US.

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
47.0		**1.0**		**2**	**7**	**7**	**-**

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

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

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

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

453

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

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

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

70. Debris and Ice Comments:

1

A log exists in the channel along the right bank. Trees on the right bank lean toward the channel.

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	1	0.5	0	90.0
RABUT	1	20	90			2	2	49.5

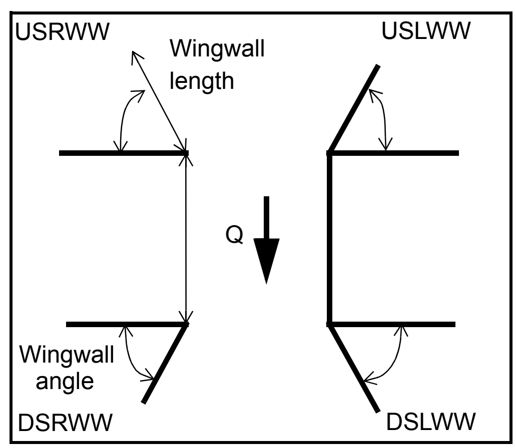
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

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

2.5
0.6
1
Maximum exposure of the right abutment footing is at the US and DS ends.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						49.5	
USRWW:	Y		1		0	3.0	
DSLWW:	-		-		Y	35.5	
DSRWW:	1		2		3	35.5	



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

82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0.6	0	Y	1.5	1	-	-	-
Condition	Y	-	1	0	2	-	-	-
Extent	1	-	1	3	0	0	0	0

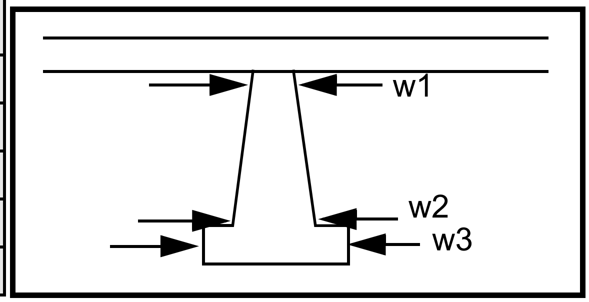
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
0
-
-
2
1
3
3
1
3

Piers:

84. Are there piers? **Ma** *(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	180.0			17.5	90.0	17.5
Pier 2		7.5		90.0	180.0	20.0
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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: -___ *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

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

NO 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 ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned 3 %LB to 3 %RB

Material: 453

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

453
0
0
453

Is a cut-bank present? 3 *(Y or if N type ctrl-n cb)* Where? 2 *(LB or RB)* Mid-bank distance: 1

Cut bank extent: 1 feet Th *(US, UB, DS)* to e left feet ba *(US, UB, DS)*

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

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

protection extends 55 feet DS from bridge. Some bank protection exists beyond 55 ft downstream with the embankment of town highway 44 along channel.
The right bank protection extends 20 feet DS to a concrete faced culvert within the bank.

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
5 UB
17
0
US
15
DS
0
25
23

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: STJOTH00080027 Town: St. Johnsbury
Road Number: TH 8 County: Caledonia
Stream: Sleepers River

Initials MAI Date: 07/02/97 Checked: EMB

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	4990	7480	3130
Main Channel Area, ft2	783	903	615
Left overbank area, ft2	383	557	136
Right overbank area, ft2	0	0	0
Top width main channel, ft	78	82	73
Top width L overbank, ft	115	119	108
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.1592	0.1592	0.1592
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.0	11.0	8.4
y1, average depth, LOB, ft	3.3	4.7	1.3
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	136233	192232	73488
Conveyance, main channel	93839	115128	65669
Conveyance, LOB	42394	77104	7819
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	3437.2	4479.8	2797.0
Ql, discharge, LOB, cfs	1552.8	3000.2	333.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	4.4	5.0	4.5
Vl, mean velocity, LOB, ft/s	4.1	5.4	2.4
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	8.9	9.1	8.7
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	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	4990	7480	3130
(Q) discharge thru bridge, cfs	3306	2687	3130
Main channel conveyance	33806	33806	33806
Total conveyance	33806	33806	33806
Q2, bridge MC discharge,cfs	3306	2687	3130
Main channel area, ft2	420	420	420
Main channel width (normal), ft	48.1	48.1	48.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	48.1	48.1	48.1
y_bridge (avg. depth at br.), ft	8.72	8.72	8.72
Dm, median (1.25*D50), ft	0.199	0.199	0.199
y2, depth in contraction,ft	7.37	6.17	7.04
ys, scour depth (y2-ybridge), ft	-1.35	-2.55	-1.69

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	4990	7480	3130
Q, thru bridge MC, cfs	3306	2687	3130
Vc, critical velocity, ft/s	8.92	9.06	8.67
Va, velocity MC approach, ft/s	4.39	4.96	4.55
Main channel width (normal), ft	48.1	48.1	48.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	48.1	48.1	48.1
qbr, unit discharge, ft2/s	68.7	55.9	65.1
Area of full opening, ft2	419.6	419.6	419.6
Hb, depth of full opening, ft	8.72	8.72	8.72
Fr, Froude number, bridge MC	0.56	0.45	0.53
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A

Elevation of Low Steel, ft	498.3	498.3	498.3
Elevation of Bed, ft	489.58	489.58	489.58
Elevation of Approach, ft	502.9	504.39	500.68
Friction loss, approach, ft	0.18	0.2	0.18
Elevation of WS immediately US, ft	502.72	504.19	500.50
ya, depth immediately US, ft	13.14	14.61	10.92
Mean elevation of deck, ft	501.66	501.66	501.66
w, depth of overflow, ft (>=0)	1.06	2.53	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.92	0.94
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	-0.33	-2.00	-0.77
Ys, scour w/Umbrell equation, ft	0.25	1.26	-0.56

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	3306	2687	3130
Main channel area (DS), ft2	419.6	419.6	419.6
Main channel width (normal), ft	48.1	48.1	48.1
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	48.1	48.1	48.1
D90, ft	0.7295	0.7295	0.7295
D95, ft	1.0663	1.0663	1.0663
Dc, critical grain size, ft	0.2521	0.1665	0.2260
Pc, Decimal percent coarser than Dc	0.322	0.483	0.365
Depth to armoring, ft	1.59	0.53	1.18

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	4990	7480	3130	4990	7480	3130
a', abut.length blocking flow, ft	128.6	132.7	122.5	16.2	20.1	11.1
Ae, area of blocked flow ft2	319.6	346.6	221.8	68.3	66.6	48.8
Qe, discharge blocked abut.,cfs	--	--	626	--	--	127.7
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.96	5.19	2.82	2.53	2.92	2.62
ya, depth of f/p flow, ft	2.49	2.61	1.81	4.22	3.31	4.40
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	45	45	45	135	135	135
K2	0.91	0.91	0.91	1.05	1.05	1.05
Fr, froude number f/p flow	0.354	0.399	0.370	0.195	0.217	0.220
ys, scour depth, ft	14.73	16.35	12.09	9.66	8.87	9.50

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

a’(abut length blocked, ft)	128.6	132.7	122.5	16.2	20.1	11.1
y1 (depth f/p flow, ft)	2.49	2.61	1.81	4.22	3.31	4.40
a’/y1	51.75	50.81	67.66	3.84	6.07	2.52
Skew correction (p. 49, fig. 16)	0.80	0.80	0.80	1.10	1.10	1.10
Froude no. f/p flow	0.35	0.40	0.37	0.20	0.22	0.22
Ys w/ corr. factor K1/0.55:						
vertical	10.26	11.22	7.59	ERR	ERR	ERR
vertical w/ ww’s	8.42	9.20	6.22	ERR	ERR	ERR
spill-through	5.65	6.17	4.17	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.56	0.45	0.53	0.56	0.45	0.53
y, depth of flow in bridge, ft	8.72	8.72	8.72	8.72	8.72	8.72
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.69	1.09	1.51	1.69	1.09	1.51
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR