LEVEL II SCOUR ANALYSIS FOR BRIDGE 51 (JERITH00590051) on TOWN HIGHWAY 59, crossing THE CREEK, JERICHO, VERMONT

Open-File Report 98-89

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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LEVEL II SCOUR ANALYSIS FOR BRIDGE 51 (JERITH00590051) on TOWN HIGHWAY 59, crossing THE CREEK, JERICHO, VERMONT

By EMILY C. WILD

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information write to:

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

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Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	Max	maximum
D50	median diameter of bed material	MC	main channel
DS	downstream	RAB	right abutment
elev.	elevation	RABUT	face of right abutment
f/p	flood plain	RB	right bank
ft2	square feet	ROB	right overbank
ft/ft	feet per foot	RWW	right wingwall
FEMA	Federal Emergency Management Agency	TH	town highway
FHWA	Federal Highway Administration	UB	under bridge
JCT	junction	US	upstream
LAB	left abutment	USGS	United States Geological Survey
LABUT	face of left abutment	VTAOT	Vermont Agency of Transportation
LB	left bank	WSPRO	water-surface profile model
LOB	left overbank	yr	year

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 51 (JERITH00590051) ON TOWN HIGHWAY 59, CROSSING THE CREEK, JERICHO, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JERITH00590051 on Town Highway 59 crossing The Creek, Jericho, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (Federal Highway Administration, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province and the Champlain section of the St. Lawrence physiographic province in northwestern Vermont. The 10.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the left and right overbanks, upstream and downstream of the bridge while the immediate banks have dense woody vegetation.

In the study area, The Creek has a sinuous channel with a slope of approximately 0.004 ft/ft, an average channel top width of 45 ft and an average bank height of 6 ft. The channel bed material ranges from silt to cobble with a median grain size (D_{50}) of 58.6 mm (0.192 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 3, 1996, indicated that the reach was stable.

The Town Highway 59 crossing of The Creek is a 33-ft-long, two-lane bridge consisting of a 28-foot steel-stringer span (Vermont Agency of Transportation, written communication, December 11, 1995). The opening length of the structure parallel to the bridge face is 26 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

A scour hole 3 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. Scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) at the left and right upstream road embankments. Type-2 stone fill (less than 36 inches diameter) was along the upstream right bank and along the upstream right wingwall. 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 Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows was zero ft. Left abutment scour ranged from 2.4 to 3.2 ft. Right abutment scour ranged from 4.1 to 4.5 ft.The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 JERITH00590051 ***Stream*** The Creek

County Chittenden ***Road*** TH59 ***District*** 5

Description of Bridge

Bridge length 33 ***ft*** ***Bridge width*** 27.9 ***ft*** ***Max span length*** 28 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 7/3/96

Description of stone fill Type-1 stone fill extends along the left and right upstream road embankments. Type-2 stone fill extends along the upstream right bank and along the upstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a two foot deep scour hole along the right abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 10

There is a mild channel bend in the upstream reach. The scour hole has developed in the location where the bend impacts the upstream end of the right abutment.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/3/96	0	0
Level II	7/3/96	0	0

Potential for debris Moderate. There is some debris caught within the vegetation along the banks and in the I-beams underneath the bridge.

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

No features affecting flow were noted during the July 3, 1996 site visit.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a wide flood plain.

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

Date of inspection 7/3/96

DS left: Wide flood plain.

DS right: Moderately sloped overbank.

US left: Wide flood plain.

US right: Narrow flood plain.

Description of the Channel

Average top width 45 ft

Average depth 6 ft

Predominant bed material Sand/ Gravel

Bank material Sand/ Gravel

Sinuous but stable with semi-alluvial channel boundaries and a wide flood plain.

7/3/96

Vegetative co Trees and brush with grass on the overbank.

DS left: Trees, brush and grass on the overbank.

DS right: Trees, brush and grass on the overbank.

US left: Trees, brush and grass on the overbank.

US right: Yes

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

The assessment of July 3, 1996 noted low clearance along the left abutment from the point bar sediment deposition.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 10.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	80
St. Lawrence Valley/ Champlain	20

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: The drainage area is rural, but the bridge itself is located in a suburban setting.

No

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

USGS gage description --

USGS gage number --

Gage drainage area No ***mi²***

-

Is there a lake/p

-

1,560

Calculated Discharges

Q100 2,130 ***ft³/s*** ***Q500*** ***ft³/s***

The 100- and 500-year discharges are the median curve values from a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans) USGS survey

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the downstream right wingwall (elev. 498.90 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 497.78 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-32	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	14	1	Road Grade section
APPRO	54	1	Approach section as surveyed

[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 overbank "n" values ranged from 0.030 to 0.045.

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 0.0041 ft/ft, which was estimated from the 100-year discharge water-surface profile slope downstream of the bridge in the Flood Insurance Study for Jericho, VT (Federal Emergency Management Agency, 1980).

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

Bridge Hydraulics Summary

Average bridge embankment elevation 499.7 ***ft***
Average low steel elevation 497.7 ***ft***

100-year discharge 1,560 ***ft³/s***
Water-surface elevation in bridge opening 497.8 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,080 ***ft³/s***
Area of flow in bridge opening 110 ***ft²***
Average velocity in bridge opening 4.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 5.0 ***ft/s***

Water-surface elevation at Approach section with bridge 500.7
Water-surface elevation at Approach section without bridge 500.5
Amount of backwater caused by bridge 0.2 ***ft***

500-year discharge 2,130 ***ft³/s***
Water-surface elevation in bridge opening 497.8 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,700 ***ft³/s***
Area of flow in bridge opening 110 ***ft²***
Average velocity in bridge opening 3.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.6 ***ft/s***

Water-surface elevation at Approach section with bridge 501.1
Water-surface elevation at Approach section without bridge 501.0
Amount of backwater caused by bridge 0.1 ***ft***

Incipient overtopping discharge 540 ***ft³/s***
Water-surface elevation in bridge opening 497.8 ***ft***
Area of flow in bridge opening 110 ***ft²***
Average velocity in bridge opening 4.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 5.7 ***ft/s***

Water-surface elevation at Approach section with bridge 499.3
Water-surface elevation at Approach section without bridge 499.0
Amount of backwater caused by bridge 0.3 ***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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

The modeled discharges resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146). For comparison, contraction scour was computed for these discharges by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). The additional contraction scour results are presented in appendix F.

Scour for the right abutment was computed by use of the Froehlich equation (Richardson and Davis, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour at the left abutment was computed by use of the HIRE equation (Richardson and Davis, 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	0.1 0.0	0.1	--
Left overbank	--	--	--
Right overbank	--	--	3.0 3.2

Local scour:			
Abutment scour	2.4	4.3	4.5
Left abutment	4.1	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	0.4	0.3
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	0.5	0.4	0.3
Left abutment	0.5	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

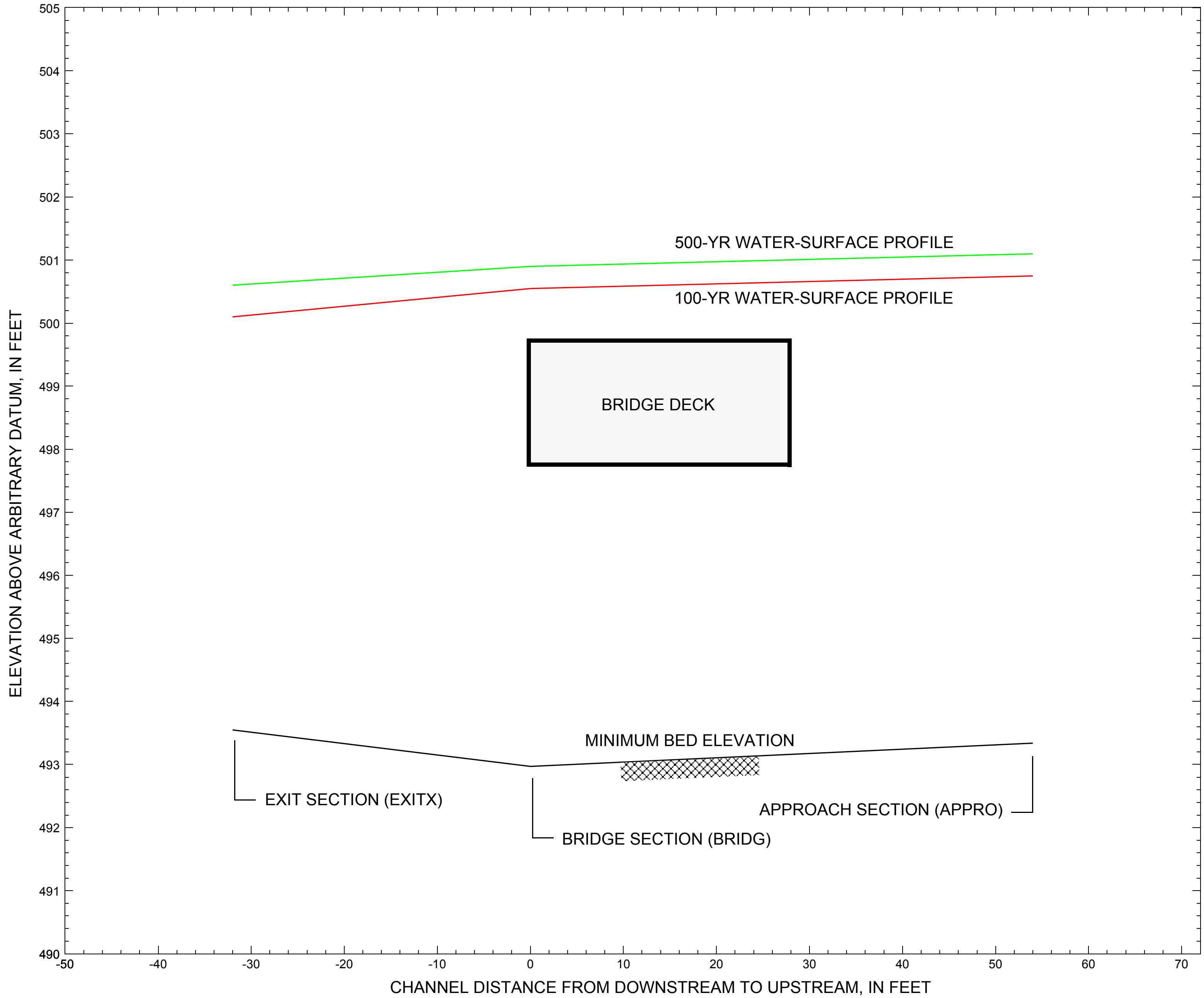

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JERITH00590051 on Town Highway 59, crossing The Creek, Jericho, Vermont.

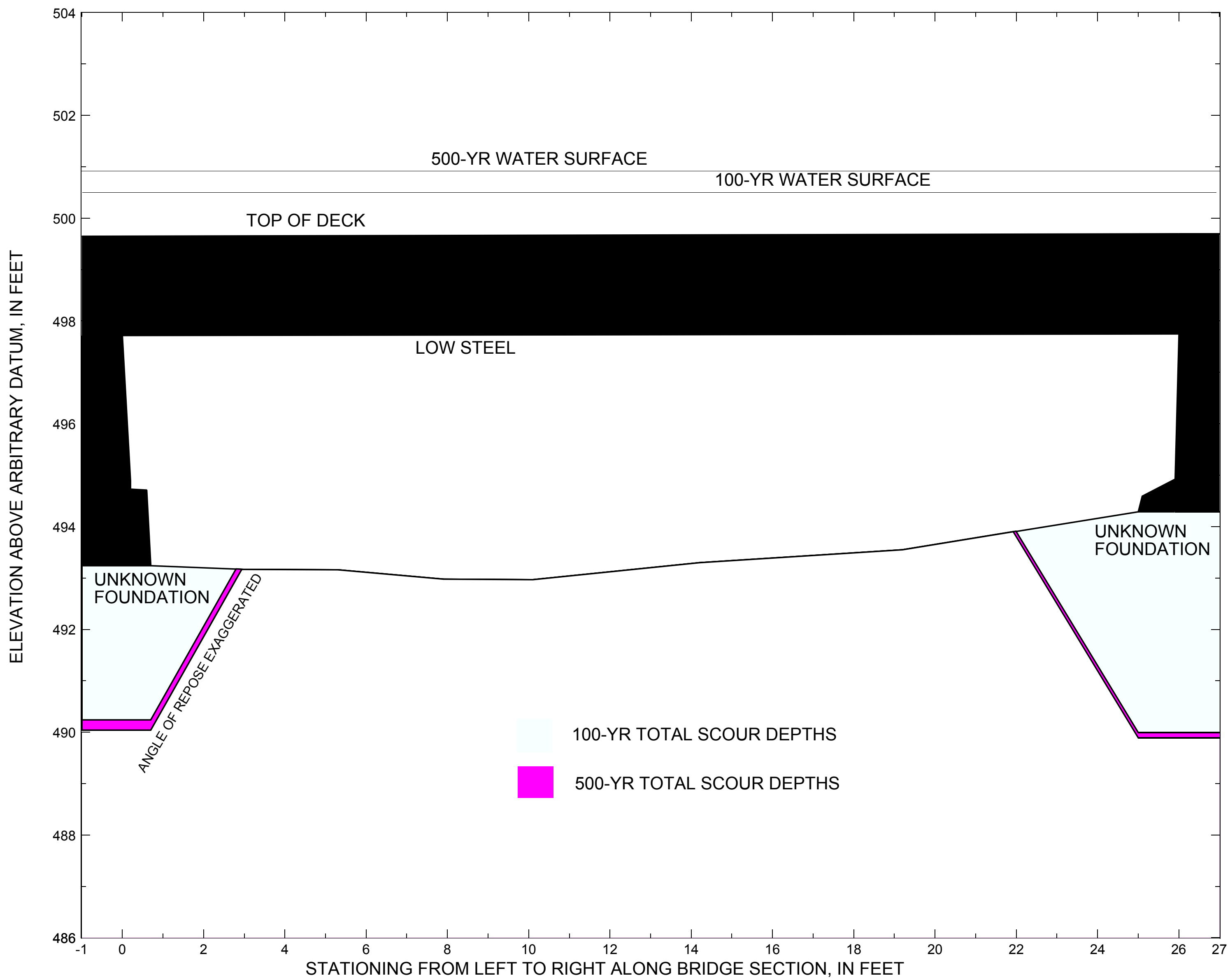

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure JERITH00590051 on Town Highway 59, crossing The Creek, Jericho, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure JERITH00590051 on Town Highway 59, crossing The Creek, Jericho, 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/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 1,560 cubic-feet per second											
Left abutment	0.0	--	497.7	--	493.2	0.0	3.0	--	3.0	490.2	--
Right abutment	26.0	--	497.8	--	494.3	0.0	4.3	--	4.3	490.0	--

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-yr discharge at structure JERITH00590051 on Town Highway 59, crossing The Creek, Jericho, 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/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 2,130 cubic-feet per second											
Left abutment	0.0	--	497.7	--	493.2	0.0	3.2	--	3.2	490.0	--
Right abutment	26.0	--	497.8	--	494.3	0.0	4.5	--	4.5	489.8	--

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, 1948, Underhill, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Photorevised 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jeri051.wsp
T2        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
T3        Town Highway 59, The Creek, Jericho, Vermont             ECW
*
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           1560.0   2130.0   540.0
SK          0.0041   0.0041   0.0041
*
XS   EXITX    -32           0.
GR         -364.7, 504.51   -252.8, 500.63    -96.1, 498.79    -48.8, 498.59
GR           -5.9, 498.35      0.0, 495.01      2.4, 494.17      5.1, 493.93
GR            8.4, 493.70     11.3, 493.72     13.4, 493.55     17.7, 494.29
GR           25.2, 494.73     31.2, 498.27     43.3, 505.39    160.7, 504.38
*
N           0.035        0.055        0.045
SA                  -5.9         43.3
*
*
XS   FULLV      0  * * *   0.0041
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.74       5.0
GR            0.0, 497.72      0.2, 494.89      0.2, 494.73      0.6, 494.71
GR            0.7, 493.24      3.0, 493.17      5.3, 493.16      7.9, 492.98
GR           10.1, 492.97     14.2, 493.30     19.2, 493.55     25.0, 494.29
GR           25.1, 494.59     25.9, 494.92     25.9, 494.64     26.0, 497.75
GR            0.0, 497.72
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      33.9 * *     67.8      2.4
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     14      27.9     1
GR         -526.0, 508.27   -347.3, 503.75   -224.4, 500.63   -121.8, 499.30
GR          -41.1, 499.17      0.0, 499.65     25.3, 499.70     93.8, 502.17
GR          169.1, 505.82
*
*
AS   APPRO     54           0.
GR         -471.7, 506.95   -364.8, 504.37   -237.8, 500.50   -128.3, 499.01
GR          -11.4, 498.55     -5.8, 496.76      0.0, 494.87      1.8, 494.25
GR            7.6, 493.58     12.8, 493.34     16.9, 493.47     20.5, 493.58
GR           22.4, 494.81     29.7, 499.20     41.3, 500.07     71.3, 501.07
GR          140.4, 503.40    192.3, 507.05    242.9, 512.19
*
N           0.030        0.055        0.045
SA                 -11.4         29.7
*
HP 1 BRIDG 497.75 1 497.75
HP 2 BRIDG 497.75 * * 481
HP 2 RDWAY 500.54 * * 1079
HP 1 APPRO 500.74 1 500.74
HP 2 APPRO 500.74 * * 1560
*
HP 1 BRIDG 497.75 1 497.75
HP 2 BRIDG 497.75 * * 435
HP 2 RDWAY 500.89 * * 1696
HP 1 APPRO 501.13 1 501.13
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File jeri051.wsp
       Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
       Town Highway 59, The Creek, Jericho, Vermont             ECW
          *** RUN DATE & TIME: 01-08-98  10:29

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

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      110.    6199.     0.    60.                           0.
  497.75           110.    6199.     0.    60.  1.00     0.    26.      0.


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.75     0.0    26.0   110.4    6199.     481.   4.36

X STA.        0.0        2.6        3.7        4.7        5.8        6.9
  A(I)           10.5        4.8        4.9        4.9        4.8
  V(I)           2.30       5.01       4.95       4.92       5.04

X STA.        6.9        7.9        8.9        9.9       10.9       12.0
  A(I)            4.8        4.9        4.8        4.8        4.9
  V(I)           5.03       4.96       5.03       5.02       4.94

X STA.       12.0       13.0       14.1       15.3       16.4       17.6
  A(I)            4.8        4.9        5.0        5.0        5.1
  V(I)           4.97       4.91       4.84       4.85       4.74

X STA.       17.6       18.8       20.0       21.3       22.7       26.0
  A(I)            4.9        5.2        5.3        5.3       11.1
  V(I)           4.88       4.62       4.58       4.55       2.17


   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.54  -217.5    48.6   242.7    9406.    1079.   4.45

X STA.     -217.5     -137.9     -128.4     -120.3     -112.5     -105.1
  A(I)           41.0       10.4        9.8        9.7        9.3
  V(I)           1.32       5.21       5.49       5.55       5.79

X STA.     -105.1      -97.7      -90.4      -83.3      -76.2      -70.5
  A(I)            9.5        9.3        9.3        9.3        7.5
  V(I)           5.69       5.81       5.80       5.81       7.18

X STA.      -70.5      -64.3      -56.9      -49.8      -42.7      -35.5
  A(I)            8.2        9.9        9.6        9.6        9.7
  V(I)           6.61       5.43       5.62       5.63       5.54

X STA.      -35.5      -27.9      -19.0       -8.9        9.5       48.6
  A(I)            9.6       10.3       10.6       16.8       23.3
  V(I)           5.59       5.24       5.07       3.21       2.32

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      338.   21425.   234.   234.                        2303.
            2      230.   18957.    41.    43.                        3091.
            3       20.     469.    32.    32.                          87.
  500.74           588.   40851.   307.   309.  1.09  -246.    61.   4420.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.74  -245.7    61.4   587.6   40851.    1560.   2.65

X STA.     -245.7     -142.1     -124.5     -108.6      -93.6      -79.2
  A(I)           86.2       29.1       28.3       27.6       27.2
  V(I)           0.90       2.68       2.75       2.83       2.87

X STA.      -79.2      -65.6      -52.7      -40.5      -28.4      -17.1
  A(I)           26.5       25.8       25.1       25.3       24.3
  V(I)           2.94       3.02       3.10       3.08       3.21

X STA.      -17.1       -5.4        0.1        3.8        7.1       10.0
  A(I)           31.2       27.4       24.1       22.5       21.4
  V(I)           2.50       2.84       3.24       3.47       3.65

X STA.       10.0       12.8       15.7       18.6       21.6       61.4
  A(I)           20.6       20.7       21.3       21.3       51.7
  V(I)           3.79       3.77       3.67       3.66       1.51
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        U.S. Geological Survey WSPRO Input File jeri051.wsp
        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
        Town Highway 59, The Creek, Jericho, Vermont             ECW
           *** RUN DATE & TIME: 01-08-98  10:29

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     110.    6199.     0.    60.                            0.
  497.75           110.    6199.     0.    60.  1.00     0.    26.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.75     0.0    26.0   110.4    6199.     435.   3.94

 X STA.         0.0         2.6         3.7         4.7         5.8         6.9
   A(I)            10.5         4.8         4.9         4.9         4.8
   V(I)            2.08        4.53        4.48        4.45        4.55

 X STA.         6.9         7.9         8.9         9.9        10.9        12.0
   A(I)             4.8         4.9         4.8         4.8         4.9
   V(I)            4.54        4.48        4.55        4.54        4.47

 X STA.        12.0        13.0        14.1        15.3        16.4        17.6
   A(I)             4.8         4.9         5.0         5.0         5.1
   V(I)            4.49        4.44        4.38        4.39        4.28

 X STA.        17.6        18.8        20.0        21.3        22.7        26.0
   A(I)             4.9         5.2         5.3         5.3        11.1
   V(I)            4.41        4.17        4.14        4.11        1.96


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      14.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.89  -234.6    58.3   341.0   15498.    1696.   4.97

 X STA.      -234.6      -151.4      -139.2      -128.9      -120.2      -111.8
   A(I)            54.8        15.7        14.7        13.5        13.5
   V(I)            1.55        5.40        5.75        6.28        6.29

 X STA.      -111.8      -103.7       -95.6       -87.6       -79.8       -73.3
   A(I)            13.1        13.1        13.1        12.9        10.8
   V(I)            6.47        6.46        6.45        6.57        7.87

 X STA.       -73.3       -66.5       -58.2       -50.3       -42.3       -34.2
   A(I)            11.4        13.9        13.4        13.7        13.6
   V(I)            7.41        6.10        6.32        6.20        6.22

 X STA.       -34.2       -25.5       -16.1        -4.5        15.6        58.3
   A(I)            14.0        13.9        15.7        24.9        31.2
   V(I)            6.08        6.09        5.40        3.41        2.72

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     432.   31113.   247.   247.                         3239.
             2     246.   21209.    41.    43.                         3419.
             3      34.     965.    43.    43.                          172.
  501.13           712.   53287.   332.   334.  1.07  -258.    73.   5721.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.13  -258.5    73.1   712.2   53287.    2130.   2.99

 X STA.      -258.5      -158.1      -138.3      -122.4      -107.7       -93.7
   A(I)            99.9        36.7        33.1        31.7        31.4
   V(I)            1.07        2.90        3.22        3.35        3.40

 X STA.       -93.7       -80.0       -67.0       -54.4       -42.2       -31.1
   A(I)            31.3        30.3        30.1        29.7        27.5
   V(I)            3.41        3.51        3.54        3.59        3.87

 X STA.       -31.1       -19.4        -6.9        -0.1         4.3         8.0
   A(I)            29.6        35.4        34.7        30.2        27.1
   V(I)            3.59        3.01        3.07        3.53        3.94

 X STA.         8.0        11.5        14.9        18.3        22.0        73.1
   A(I)            26.7        26.5        25.9        27.5        66.8
   V(I)            3.99        4.02        4.11        3.87        1.59
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        U.S. Geological Survey WSPRO Input File jeri051.wsp
        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
        Town Highway 59, The Creek, Jericho, Vermont             ECW
           *** RUN DATE & TIME: 01-08-98  10:29

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     110.    6199.     0.    60.                          0.
   497.75          110.    6199.     0.    60.  1.00     0.    26.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.75     0.0    26.0   110.4    6199.     540.   4.89

X STA.         0.0         2.6         3.7         4.7         5.8         6.9
  A(I)            10.5         4.8         4.9         4.9         4.8
  V(I)            2.58        5.62        5.56        5.53        5.65

X STA.         6.9         7.9         8.9         9.9        10.9        12.0
  A(I)             4.8         4.9         4.8         4.8         4.9
  V(I)            5.64        5.57        5.65        5.63        5.55

X STA.        12.0        13.0        14.1        15.3        16.4        17.6
  A(I)             4.8         4.9         5.0         5.0         5.1
  V(I)            5.58        5.51        5.43        5.44        5.32

X STA.        17.6        18.8        20.0        21.3        22.7        26.0
  A(I)             4.9         5.2         5.3         5.3        11.1
  V(I)            5.48        5.18        5.14        5.10        2.44

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      58.    1657.   135.   135.                        218.
             2     169.   11366.    41.    43.                       1950.
             3       0.       0.     1.     1.                          0.
   499.26          228.   13024.   177.   179.  1.23  -147.    30.   1319.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.26  -146.7    30.5   227.8   13024.     540.   2.37

X STA.      -146.7       -56.7       -24.9        -3.1        -0.3         1.6
  A(I)            30.3        18.9        26.3        10.5         8.9
  V(I)            0.89        1.43        1.03        2.58        3.04

X STA.         1.6         3.2         4.7         6.2         7.7         9.0
  A(I)             8.2         8.1         8.1         7.9         7.6
  V(I)            3.29        3.35        3.34        3.40        3.55

X STA.         9.0        10.3        11.7        13.1        14.4        15.7
  A(I)             7.9         8.0         7.9         8.0         7.7
  V(I)            3.42        3.38        3.42        3.38        3.50

X STA.        15.7        17.1        18.4        19.8        21.3        30.5
  A(I)             7.9         7.7         7.7         8.3        22.0
  V(I)            3.41        3.53        3.50        3.27        1.23
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        U.S. Geological Survey WSPRO Input File jeri051.wsp
        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
        Town Highway 59, The Creek, Jericho, Vermont             ECW
           *** RUN DATE & TIME: 01-08-98  10:29

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

EXITX:XS   ******  -211.     414.  0.27 *****  500.40  499.44   1560.  500.14
      -32. ******    34.   24340.  1.20 ***** *******    0.56    3.77

FULLV:FV      32.  -211.     415.  0.26  0.13  500.54 *******   1560.  500.27
        0.    32.    34.   24413.  1.20  0.00    0.00    0.56    3.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.43

APPRO:AS      54.  -239.     525.  0.15  0.15  500.68 *******   1560.  500.53
       54.    54.    55.   34970.  1.11  0.00   -0.01    0.41    2.97
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   500.27     497.74

            <<<<<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      32.     0.     110.  0.29 *****  498.04  495.66    481.  497.75
        0. ******    26.    6199.  1.00 ***** *******    0.37    4.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      14.    26.  0.04  0.12  500.82    0.00   1079.  500.54

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    989.   230.  -218.    12.   1.4   1.0   5.2   4.4   1.2   3.1
   RT:     90.    37.    12.    49.   0.9   0.6   4.3   4.2   0.9   3.1

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

APPRO:AS      20.  -246.     587.  0.12  0.13  500.86  499.47   1560.  500.74
       54.    30.    61.   40749.  1.09  0.00    0.00    0.35    2.66

       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     -32.  -211.    34.   1560.   24340.     414.    3.77  500.14
   FULLV:FV       0.  -211.    34.   1560.   24413.     415.    3.76  500.27
   BRIDG:BR       0.     0.    26.    481.    6199.     110.    4.35  497.75
   RDWAY:RG      14.*******   989.   1079.******************    1.00  500.54
   APPRO:AS      54.  -246.    61.   1560.   40749.     587.    2.66  500.74

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    499.44    0.56  493.55  505.39************  0.27  500.40  500.14
   FULLV:FV  ********    0.56  493.68  505.52  0.13  0.00  0.26  500.54  500.27
   BRIDG:BR    495.66    0.37  492.97  497.75************  0.29  498.04  497.75
   RDWAY:RG  ****************  499.17  508.27  0.04******  0.12  500.82  500.54
   APPRO:AS    499.47    0.35  493.34  512.19  0.13  0.00  0.12  500.86  500.74
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        U.S. Geological Survey WSPRO Input File jeri051.wsp
        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
        Town Highway 59, The Creek, Jericho, Vermont             ECW
           *** RUN DATE & TIME: 01-08-98  10:29

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

EXITX:XS   ******  -250.     536.  0.28 *****  500.88  499.86   2130.  500.60
      -32. ******    35.   33248.  1.14 ***** *******    0.55    3.98

FULLV:FV      32.  -250.     538.  0.28  0.13  501.01 *******   2130.  500.73
        0.    32.    35.   33406.  1.14  0.00    0.01    0.54    3.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.45

APPRO:AS      54.  -254.     666.  0.17  0.15  501.16 *******   2130.  500.99
       54.    54.    69.   48511.  1.08  0.00   -0.01    0.41    3.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    500.73     497.74

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =    1696.      1643.    1.03

            <<<<<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      32.     0.     110.  0.24 *****  497.99  495.52    435.  497.75
        0. ******    26.    6199.  1.00 ***** *******    0.34    3.94

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.    26.  0.04  0.15  501.23    0.00   1696.  500.89

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1527.   247.  -235.    12.   1.7   1.2   5.9   5.0   1.6   3.1
   RT:    169.    46.    12.    58.   1.2   0.8   4.9   4.7   1.1   3.1

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

APPRO:AS      20.  -258.     711.  0.15  0.16  501.28  499.84   2130.  501.13
       54.    33.    73.   53130.  1.07  0.00    0.00    0.37    3.00

       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     -32.  -250.    35.   2130.   33248.     536.    3.98  500.60
   FULLV:FV       0.  -250.    35.   2130.   33406.     538.    3.96  500.73
   BRIDG:BR       0.     0.    26.    435.    6199.     110.    3.94  497.75
   RDWAY:RG      14.******* 1527.   1696.******************    1.00  500.89
   APPRO:AS      54.  -258.    73.   2130.   53130.     711.    3.00  501.13

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    499.86    0.55  493.55  505.39************  0.28  500.88  500.60
   FULLV:FV  ********    0.54  493.68  505.52  0.13  0.00  0.28  501.01  500.73
   BRIDG:BR    495.52    0.34  492.97  497.75************  0.24  497.99  497.75
   RDWAY:RG  ****************  499.17  508.27  0.04******  0.15  501.23  500.89
   APPRO:AS    499.84    0.37  493.34  512.19  0.16  0.00  0.15  501.28  501.13
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        U.S. Geological Survey WSPRO Input File jeri051.wsp
        Hydraulic analysis for structure JERITH00590051   Date: 11-JUL-97
        Town Highway 59, The Creek, Jericho, Vermont             ECW
           *** RUN DATE & TIME: 01-08-98  10:29

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

EXITX:XS   ******   -46.     141.  0.24 *****  498.82  496.51    540.  498.58
      -32. ******    32.    8428.  1.05 ***** *******    0.52    3.84

FULLV:FV      32.   -47.     141.  0.24  0.13  498.95 *******    540.  498.71
        0.    32.    32.    8439.  1.05  0.00    0.00    0.52    3.83
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      54.  -119.     180.  0.16  0.18  499.14 *******    540.  498.97
       54.    54.    29.   10551.  1.17  0.00    0.01    0.52    3.00
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =   498.71     497.74

            <<<<<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      32.     0.     110.  0.37 *****  498.12  495.84    538.  497.75
        0. ******    26.    6199.  1.00 ***** *******    0.42    4.87

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800  0.000  497.74 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      14.        <<<<<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      20.  -147.     228.  0.11  0.08  499.37  496.37    540.  499.26
       54.    23.    30.   13019.  1.23  0.00    0.00    0.41    2.37

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.21

                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXITX:XS     -32.   -46.    32.    540.    8428.     141.    3.84  498.58
   FULLV:FV       0.   -47.    32.    540.    8439.     141.    3.83  498.71
   BRIDG:BR       0.     0.    26.    538.    6199.     110.    4.87  497.75
   RDWAY:RG      14.**************      0.       0.       0.    1.00********
   APPRO:AS      54.  -147.    30.    540.   13019.     228.    2.37  499.26

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.51    0.52  493.55  505.39************  0.24  498.82  498.58
   FULLV:FV  ********    0.52  493.68  505.52  0.13  0.00  0.24  498.95  498.71
   BRIDG:BR    495.84    0.42  492.97  497.75************  0.37  498.12  497.75
   RDWAY:RG  ****************  499.17  508.27************  0.11  499.32********
   APPRO:AS    496.37    0.41  493.34  512.19  0.08  0.00  0.11  499.37  499.26
  ER

  NORMAL  END  OF  WSPRO  EXECUTION.
```
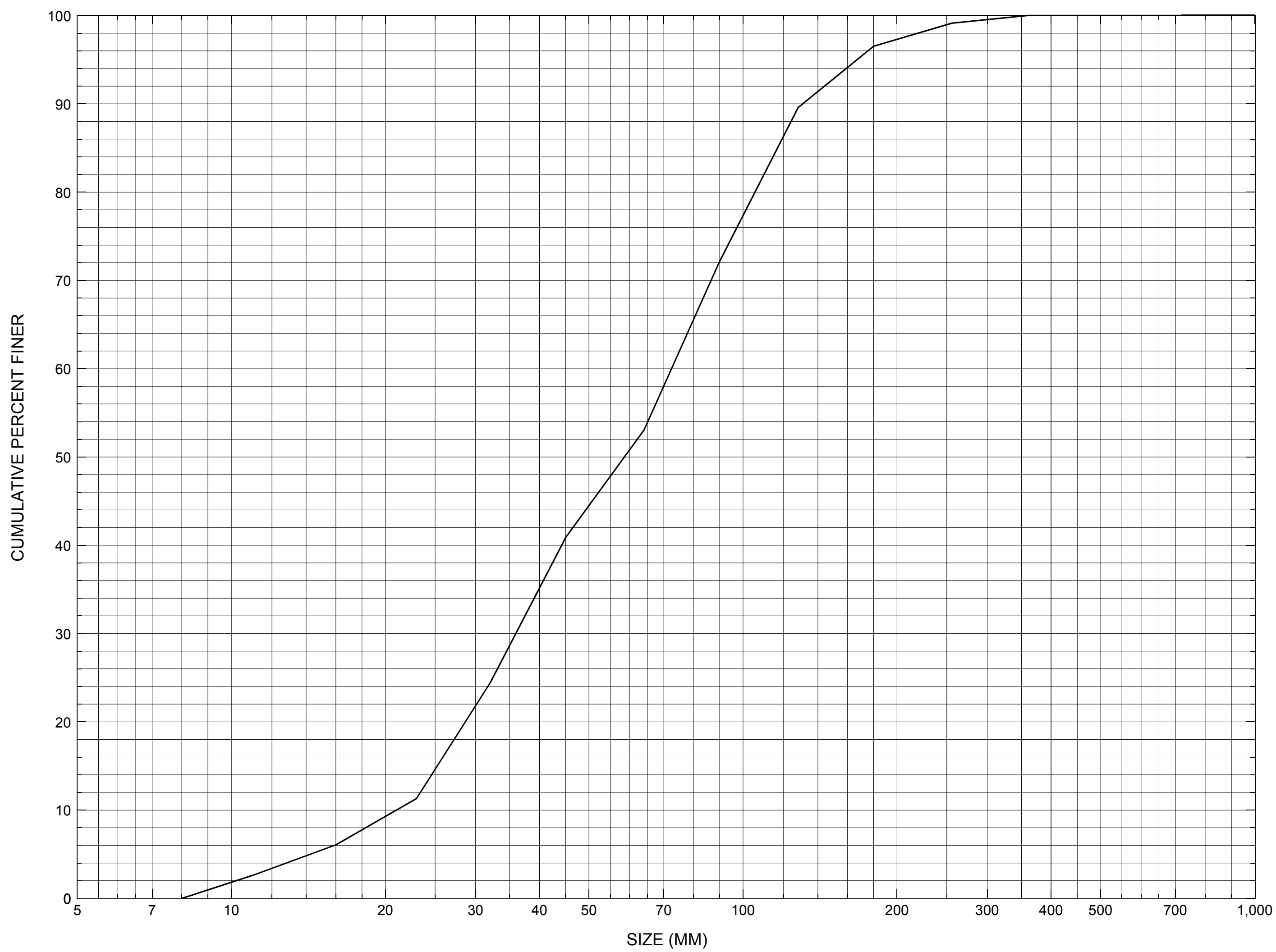

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JERITH00590051, in Jericho, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JERITH00590051

General Location Descriptive

Data collected by (First Initial, Full last name) L. Medalie

Date (MM/DD/YY) 12 / 11 / 95

Highway District Number (I - 2; nn) 05

County (FIPS county code; I - 3; nnn) 007

Town (FIPS place code; I - 4; nnnnn) 36700

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

Waterway (I - 6) ROARING BROOK (THE CREEK)

Road Name (I - 7): -

Route Number C3059

Vicinity (I - 9) 0.17 MI TO JCT W C3 TH13

Topographic Map Underhill

Hydrologic Unit Code: 02010005

Latitude (I - 16; nnnn.n) 44313

Longitude (i - 17; nnnnn.n) 72573

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10040900510409

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0028

Year built (I - 27; YYYY) 1972

Structure length (I - 49; nnnnnn) 000033

Average daily traffic, ADT (I - 29; nnnnnn) 000050

Deck Width (I - 52; nn.n) 279

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

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

Waterway adequacy (I - 71; n) 5

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) 28

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 4

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

Waterway of full opening (nnn.n ft^2) 112

Comments:

According to the structural inspection report dated 9/18/95, the structure is a steel stringer with concrete deck and abutments. The US end of the RABUT has settled approx. 9.5" from past undermining. A concrete shim has been placed under the stringer ends along the entire top of the abutment. The USRWW is cracked off vertically approx. 1' past the end of the abutment. The RABUT at the US end is tipped and the scour depth is 1.5'. The crack is 0.25" at the top and 2" at the bottom with 1.5" movement in the end of the USRWW along the bottom of the crack line. The footing on the RABUT is about 20" wide, and is exposed. The US half of the RABUT is undermined 15-18" under by up to 6" deep. A large section of

(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: **Sand and silt**

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: **According to a letter to the Jericho Town Clerk dated 1-24-94, some debris has accumulated under the bridge, including a large log near the LABUT (southerly) and a beaver dam has started on the downstream side.**

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:
embankment in front of the Labut has recently eroded during flooding, exposing the footing. The channel is scoured down 2-5 ft deep along most of the RABUT, with the greatest amount near the mid-point. The bottom of the abutment footings are at the streambed elevation.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **10.89** mi^2 Lake/pond/swamp area **0.05** mi^2
Watershed storage *(ST)* **0.46** %
Bridge site elevation **660** ft Headwater elevation **1560** ft
Main channel length **6.07** mi
10% channel length elevation **670** ft 85% channel length elevation **980** ft
Main channel slope *(S)* **68.09** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in
Maximum 2yr-24hr precipitation event *(I24,2)* - in
Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* - / -

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

-

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

-

Cross-sectional Data

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

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

Comments: **This cross section is from the upstream face. The low chord elevations are from the survey log done for this report on 7/3/96. The low chord to bed elevations are from the sketch attached to bridge inspecton report dated 9/18/95. The sketch was done on 11/18/93.**

Station	a	1.8	4.0	5.3	5.2	3.3	-	-	-	-	-
Feature	0	12	18	24	26	-	-	-	-	-	-
Low chord elevation	LAB				RAB	-	-	-	-	-	-
Bed elevation	497.7	497.7	497.8	497.8	497.8	-	-	-	-	-	-
Low chord-bed	495.9	493.7	492.5	492.6	494.5	-	-	-	-	-	-

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: **RB** Date: **8/96**
Computerized by: **RB** Date: **8/96**
Reviewd by: **EW** Date: **8/28/97**

Structure Number **JERITH00590051**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. WILD** Date *(MM/DD/YY)* **07** / **03** / 19**96**

2. Highway District Number **05** Mile marker **-**

County **CHITTENDEN (007)** Town **JERICH0 (36700)**

Waterway *(I - 6)* **ROARING BROOK (THE CREEK)** Road Name **-**

Route Number **C3059** Hydrologic Unit Code: **02010005**

3. Descriptive comments:
Bridge is located 0.17 miles from junction with C3 TH13.

B. Bridge Deck Observations

4. Surface cover... LBUS **2** RBUS **4** LBDS **2** 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 **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 **33** *(feet)* Span length **28** *(feet)* Bridge width **27.9** *(feet)*

Road approach to bridge:

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

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

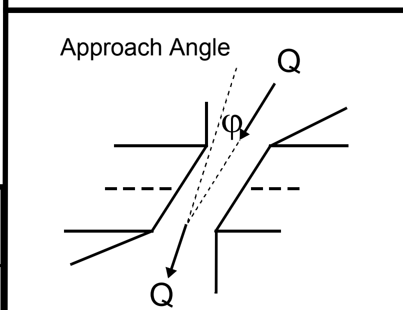
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

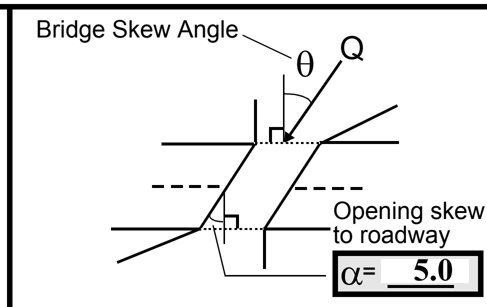
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	1	1	0	-
RBUS	1	1	0	-
RBDS	0	-	3	2
LBDS	0	-	3	2

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

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **95** feet **US** *(US, UB, DS)* to **0** feet **UB**

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**

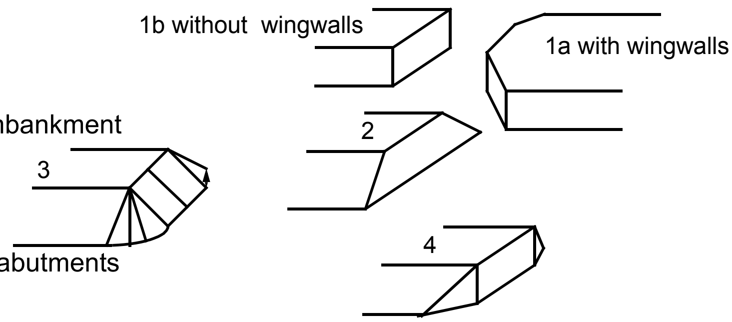
1a- Vertical abutments with wingwalls

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.)

7: The values are from the VTAOT database. The measured bridge length was 33.8 feet, during the site visit.

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
26.0	**3.5**			**4.5**	**2**	**2**	**213**	**234**	**2**	**1**

23. Bank width **20.0** 24. Channel width **30.0** 25. Thalweg depth **41.5** 29. Bed Material **324**

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

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover:* ***1****- 0 to 25%;* ***2****- 26 to 50%;* ***3****- 51 to 75%;* ***4****- 76 to 100%*

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

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

Bank protection types: ***0****- absent;* ***1****- < 12 inches;* ***2****- < 36 inches;* ***3****- < 48 inches;* ***4****- < 60 inches;* ***5****- wall / artificial levee*

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

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

28: The right bank erosion is limited due to stone fill protection.
The left bank has a moderate amount of fluvial erosion.

30: The right bank protection extends from 76 feet upstream to the upstream bridge face.

31: Stone fill has slumped into the channel from 25% LB to 100% RB.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 26 US 35. Mid-bar width: 9
36. Point bar extent: 45 feet US (US, UB) to 3 feet US (US, UB, DS) positioned 0 %LB to 25 %RB
37. Material: 210
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):

There is tall grass on the point bar.

An additional point bar exists along the left abutment, from 4 feet under the bridge to 13 feet under the bridge. It is a sand and clay bar, which is positioned zero percent left bank to forty percent right bank.

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 56 feet US (US, UB, DS)
43. Bank damage: 1 (1- eroded and/or creep; 2- slip failure; 3- block failure)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):

On the inside corner of a small bend in the chanel, a cut-bank is present. Opposite of the cut-bank, the right bank stone fill protection is slumped into the channel. (Please refer back to #32.)

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 13 UB
47. Scour dimensions: Length 30 Width 7 Depth : 3 Position 60 %LB to 95 %RB
48. Scour comments (eg. additional scour areas, local scouring process, etc.):

Scour depth is three feet, assuming a one foot thalweg depth.

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) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
22.5		1.5		2	7	7	-

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

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

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

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

213

55: The right abutment has settled. Concrete was poured to fill the 0.6 foot void.

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

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

70. Debris and Ice Comments:

2

65: Debris has accumulated along the banks in the trees, as well as in the I-beams under the bridge.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**2**	**-**	**1.2**	**90.0**
RABUT	**1**	**10**	**90**			**2**	**2**	**26.0**

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

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

3
2.9
1

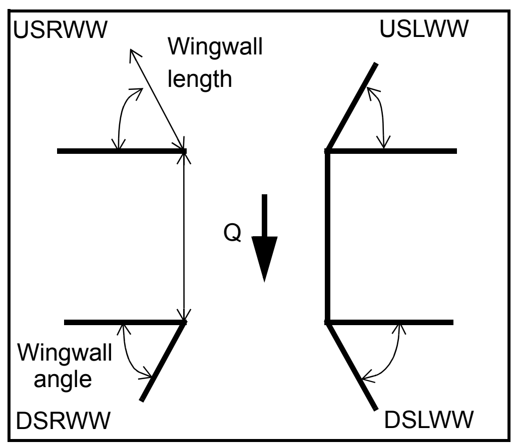
75-76: Along the upstream end of the right abutment, the water depth is four feet in front of the abutment where the water surface is 0.1 feet above the top of the footing. The downstream end of the right abutment footing exposure depth is 0.2 feet.

The left abutment footing is exposed from the end of the sand point bar to 13 feet downstream.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**26.0**	
USRWW:	**Y**		**1**		**0**	**2.0**	
DSLWW:	**-**		**-**		**Y**	**28.0**	
DSRWW:	**1**		**0**		**-**	**30.0**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**2**	**Y**	**-**	**-**	**2**	**-**	**-**
Condition	**Y**	**-**	**1**	**-**	**-**	**1**	**-**	**-**
Extent	**1**	**0.1**	**0**	**0**	**2**	**0**	**0**	**-**

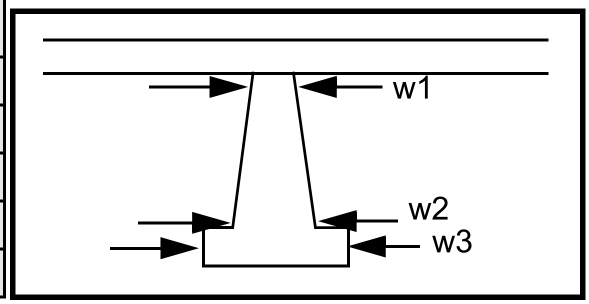
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **Poi** (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		**4.5**	**7.0**	**85.0**	**50.0**	**60.0**
Pier 2	**6.5**	**5.0**	-	**65.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**nt bar**	**abut-**	**ing is**	**nding**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**“pro**	**ment**	**expo**	**alon**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**tects**	**.**	**sed**	**g the**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**” the**		**0.1**	**entir**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**upst**	**The**	**feet.**	**e**	*Y- yes; N- no*
91. Attack ∠ (BF)	**ream**	**dow**	**A log**	**base**	
92. Pushed	**left**	**nstre**	**acts**	**of**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**wing**	**am**	**like**	**the**	
95. Cross-members	**wall**	**left**	**pro-**	**foot-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**and**	**wing**	**tec-**	**ing.**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**the**	**wall**	**tion**		
98. Exposure depth	**left**	**foot-**	**exte**		

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

N
-
-
-
-

E. Downstream Channel Assessment

100.

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

Bank width (BF) -____ Channel width -____ 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):
-
-
-
-
-
-

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

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

Material: -

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

NO PIERS

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

Cut bank extent: _____ feet ____ (US, UB, DS) to _____ feet 2 (US, UB, DS)

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

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

231
231
2
1

Is channel scour present? 342 (Y or if N type ctrl-n cs) Mid-scour distance: 0

Scour dimensions: Length 0 Width - Depth: - Positioned ____ %LB to ____ %RB

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

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

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

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

Confluence comments (eg. confluence name):

N

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)*:

NO DROP STRUCTURE

Y
30
11
6
DS
45
DS

109. G. Plan View Sketch

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: JERITH00590051 Town: JERICHO
Road Number: TH 59 County: CHITTENDEN
Stream: THE CREEK

Initials ECW Date: 8/26/97 Checked: RLB

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1560	2130	540
Main Channel Area, ft2	230	246	169
Left overbank area, ft2	338	432	58
Right overbank area, ft2	20	34	0
Top width main channel, ft	41	41	41
Top width L overbank, ft	234	247	135
Top width R overbank, ft	32	43	0
D50 of channel, ft	0.192	0.192	0.192
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.6	6.0	4.1
y1, average depth, LOB, ft	1.4	1.7	0.4
y1, average depth, ROB, ft	0.6	0.8	ERR
Total conveyance, approach	40851	53287	13024
Conveyance, main channel	18957	21209	11366
Conveyance, LOB	21425	31113	1657
Conveyance, ROB	469	965	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0077
Qm, discharge, MC, cfs	723.9	847.8	471.3
Ql, discharge, LOB, cfs	818.2	1243.7	68.7
Qr, discharge, ROB, cfs	17.9	38.6	0.0
Vm, mean velocity MC, ft/s	3.1	3.4	2.8
Vl, mean velocity, LOB, ft/s	2.4	2.9	1.2
Vr, mean velocity, ROB, ft/s	0.9	1.1	ERR
Vc-m, crit. velocity, MC, ft/s	8.6	8.7	8.2
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	1560	2130	540
(Q) discharge thru bridge, cfs	481	435	540
Main channel conveyance	6199	6199	6199
Total conveyance	6199	6199	6199
Q2, bridge MC discharge,cfs	481	435	540
Main channel area, ft2	110	110	110
Main channel width (normal), ft	25.9	25.9	25.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.9	25.9	25.9
y_bridge (avg. depth at br.), ft	4.25	4.25	4.25
Dm, median (1.25*D50), ft	0.24	0.24	0.24
y2, depth in contraction,ft	2.28	2.09	2.51
ys, scour depth (y2-ybridge), ft	-1.97	-2.16	-1.73

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	481	435	540
Main channel area (DS), ft2	110	110	110
Main channel width (normal), ft	25.9	25.9	25.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.9	25.9	25.9
D90, ft	0.4290	0.4290	0.4290
D95, ft	0.5481	0.5481	0.5481
Dc, critical grain size, ft	0.0839	0.0686	0.1057
Pc, Decimal percent coarser than Dc	0.845	0.901	0.753
Depth to armoring, ft	0.05	0.02	0.10

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	1560	2130	540
Q, thru bridge MC, cfs	481	435	540
Vc, critical velocity, ft/s	8.62	8.72	8.19
Va, velocity MC approach, ft/s	3.15	3.45	2.79
Main channel width (normal), ft	25.9	25.9	25.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.9	25.9	25.9
qbr, unit discharge, ft2/s	18.6	16.8	20.8
Area of full opening, ft2	110.0	110.0	110.0
Hb, depth of full opening, ft	4.25	4.25	4.25
Fr, Froude number, bridge MC	0.37	0.34	0.42
Cf, Fr correction factor (<=1.0)	0.98	0.94	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	497.74	497.74	497.74
Elevation of Bed, ft	493.49	493.49	493.49
Elevation of Approach, ft	500.74	501.13	499.26
Friction loss, approach, ft	0.13	0.16	0.08
Elevation of WS immediately US, ft	500.61	500.97	499.18
ya, depth immediately US, ft	7.12	7.48	5.69
Mean elevation of deck, ft	499.7	499.7	499.7
w, depth of overflow, ft (>=0)	0.91	1.27	0.00
Cc, vert contrac correction (<=1.0)	0.90	0.90	0.93
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	-1.80	-1.98	-1.50
Ys, scour w/Umbrell equation, ft	-0.31	-0.04	-0.97

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	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	1560	2130	540	1560	2130	540
a', abut.length blocking flow, ft	245.8	258.6	146.8	35.4	47.1	4.5
Ae, area of blocked flow ft2	173.27	192.4	87.87	32.51	37.97	10.76
Qe, discharge blocked abut.,cfs	--	--	113.68	--	--	13.21
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.44	2.88	1.29	1.51	1.59	1.23
ya, depth of f/p flow, ft	0.70	0.74	0.60	0.92	0.81	2.39
--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	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.344	0.371	0.295	0.233	0.246	0.140
ys, scour depth, ft	9.25	10.17	6.27	4.27	4.45	4.14

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)	245.8	258.6	146.8	35.4	47.1	4.5
y1 (depth f/p flow, ft)	0.70	0.74	0.60	0.92	0.81	2.39
a'/y1	348.69	347.58	245.25	38.55	58.43	1.88
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.34	0.37	0.29	0.23	0.25	0.14
Ys w/ corr. factor K1/0.55:						
vertical	3.64	3.94	2.94	4.06	3.63	ERR
vertical w/ ww's	2.99	3.23	2.41	3.33	2.98	ERR
spill-through	2.00	2.17	1.62	2.23	2.00	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	0.37	0.34	0.42	0.37	0.34	0.42
y, depth of flow in bridge, ft	4.25	4.25	4.25	4.25	4.25	4.25
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.36	0.30	0.46	0.36	0.30	0.46
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR