LEVEL II SCOUR ANALYSIS FOR BRIDGE 49 (FFIETH00290049) on TOWN HIGHWAY 29, crossing BLACK CREEK, FAIRFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-391

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

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By SCOTT A. OLSON

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 49 (FFIETH00290049) ON TOWN HIGHWAY 29, CROSSING BLACK CREEK, FAIRFIELD, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FFIETH00290049 on Town Highway 29 crossing Black Creek, Fairfield, 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 Green Mountain section of the New England physiographic province in northwestern Vermont. The 83.5-mi^2 drainage area is in a predominantly rural and forested basin. There is agricultural land in the basin as well, especially along the immediate river valley. In the vicinity of the study site, the surface cover is pasture except for on the downstream right bank which has row crops.

In the study area, Black Creek has an incised, meandering channel with a slope of approximately 0.0005 ft/ft, an average channel top width of 85 ft and an average bank height of 9 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 3.23 mm (0.0106 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 13, 1995, indicated that the reach was laterally unstable. This assessment was due to apparent long term lateral movement of the channel in the vicinity of the bridge.

The Town Highway 29 crossing of Black Creek is a 48-ft-long, one-lane bridge consisting of one 45-foot steel pony thru-truss type span (Vermont Agency of Transportation, written communication, March 8, 1995). The opening length of the structure parallel to the bridge face is 42.5 ft.The bridge is supported by vertical, concrete abutments. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is zero degrees.

Channel scour, approximately 6 ft deeper than the mean thalweg depth, was observed through the immediate channel reach including underneath the bridge. Type-2 stone fill (less than 36 inches diameter) has been placed as a scour countermeasure along both abutments, on the channel bed under the bridge and along immediate channel banks upstream and downstream of the bridge. 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). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.0 to 4.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.5 to 14.3 ft and 12.2 to 16.3 ft on the left and right abutments respectively. 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 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.

Fairfield, VT. Quadrangle, 1:24,000, 1986

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 FFIETH00290049 ***Stream*** Black Creek

County Franklin ***Road*** TH29 ***District*** 8

Description of Bridge

Bridge length 48 ***ft*** ***Bridge width*** 14.0 ***ft*** ***Max span length*** 45 ***ft***

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

Abutment type Stone ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 7/13/95

Description of stone fill Type-2, along both abutments on the channel bed under the bridge, and along immediate channel banks.

Brief description of piers/abutments Abutments are stone with concrete caps. There is a concrete kneewall in front of the right abutment.

Is bridge located on a bend in channel? Y ***If so, describe (mild, moderate, severe)***

There is a mild channel bend in the upstream reach.

Is bridge skewed to flood flow according to Y ***survey?*** ***Angle*** 30

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	7/13/95	0	0
Level II	7/13/95	0	0

Potential for debris Low.

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

None, July 13, 1995.

Description of the Geomorphic Setting

General topography The channel is located within a wide valley with moderately sloping valley walls on both sides. Floodplains are flat to irregular.

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

Date of inspection 7/13/95

DS left: Steep channel bank to flood plain.

DS right: Steep channel bank to flood plain.

US left: Moderately sloped channel bank to flood plain.

US right: Moderately sloped channel bank to flood plain.

Description of the Channel

Average top width 85 ***ft*** ***Average depth*** 9 ***ft***

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

Meandering with alluvial channel boundaries and a wide flood plain.

7/13/95

Vegetative co

DS left: Pasture.

DS right: Row crops.

US left: Pasture.

US right: Pasture.

Do banks appear stable? N

date of observation. July 13, 1995. The channel, upstream and downstream of the bridge widens and deepens due to erosion. Furthermore, field observation indicated long term lateral migration of the channel in the immediate vicinity of the structure.

None, 7/13/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 83.5 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

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

Is there a lake/p No

Calculated Discharges

Q100 7,860 ***ft***^{3}***/s***   ***Q500*** 11,000 ***ft***^{3}***/s***

Flood frequency estimates are based on a drainage area relationship [(83.5/82.5)exp 0.67] with bridge number 88 in Fairfield and are graphically extrapolated to the 500-year event. Bridge number 88 crosses Black Creek upstream of this site with a drainage area of 82.5 square miles and has flood frequency estimates available from the VTAOT database (written communication, VTAOT, May 1995). The discharges were within a range defined by several empirical methods for estimating flood frequency at ungaged sites (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 upstream end of the left abutment (elev. 498.51 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 498.08 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXIT2	-164	1/2	Downstream normal depth section
EXIT1	-39	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	59	2	Modelled Approach section (Templated from APTEM)
APTEM	80	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 0.032 to 0.035, and overbank "n" values ranged from 0.035 to 0.048.

Normal depth 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 0.00053 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986). Since the bridge exit section (EXIT1) was surveyed through a scour hole, computation of normal depth with this section was inappropriate. Thus, a section representative of channel and valley geometry (EXIT2) was generated using channel points surveyed 164 feet downstream of the bridge and the overbank channel points of the bridge exit section (EXIT1).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0005 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.

For the incipient roadway-overtopping model, the right end approach section was ended at station 125.1. This station was the top of a overbank feature that was acting as a levee and any flow right of this levee, must go over the road.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.0 ***ft***
Average low steel elevation 498.4 ***ft***

100-year discharge 7,860 ***ft^3/s***
Water-surface elevation in bridge opening 498.2 ***ft***
Road overtopping? Y ***Discharge over road*** 5, 950 ***ft^3/s***
Area of flow in bridge opening 527 ***ft^2***
Average velocity in bridge opening 3.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.9 ***ft/s***

Water-surface elevation at Approach section with bridge 498.7
Water-surface elevation at Approach section without bridge 498.1
Amount of backwater caused by bridge 0.6 ***ft***

500-year discharge 11,000 ***ft^3/s***
Water-surface elevation in bridge opening 498.5 ***ft***
Road overtopping? Y ***Discharge over road*** 9,150 ***ft^3/s***
Area of flow in bridge opening 535 ***ft^2***
Average velocity in bridge opening 3.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 4.6 ***/s***

Water-surface elevation at Approach section with bridge 499.7
Water-surface elevation at Approach section without bridge 499.5
Amount of backwater caused by bridge 0.2 ***ft***

Incipient overtopping discharge 2,210 ***ft^3/s***
Water-surface elevation in bridge opening 494.4 ***ft***
Area of flow in bridge opening 370 ***ft^2***
Average velocity in bridge opening 6.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.0 ***ft/s***

Water-surface elevation at Approach section with bridge 494.9
Water-surface elevation at Approach section without bridge 494.6
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 others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour for the 100-year and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 500-year discharge resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for this discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Field observations at the time of the Level I site inspection indicate type-2 stone fill on the channel bed under the bridge. The presence of stone fill will impact the actual scour depths.

For the discharges resulting in orifice flow, estimates of contraction scour were also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, since the velocity of flow in the main channel was less than a foot per second below the velocity necessary for motion of the bed material, the results of the Laursen live-bed contraction scour equation are also presented in Appendix F for all modelled discharges.

Abutment scour 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 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	4.4	4.0
Depth to armoring	0.1	0.1	2.6
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.4	14.3	7.5
Right abutment	13.7	16.3	12.2
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	0.6	0.3	0.8
Right abutment	0.6	0.3	0.8
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

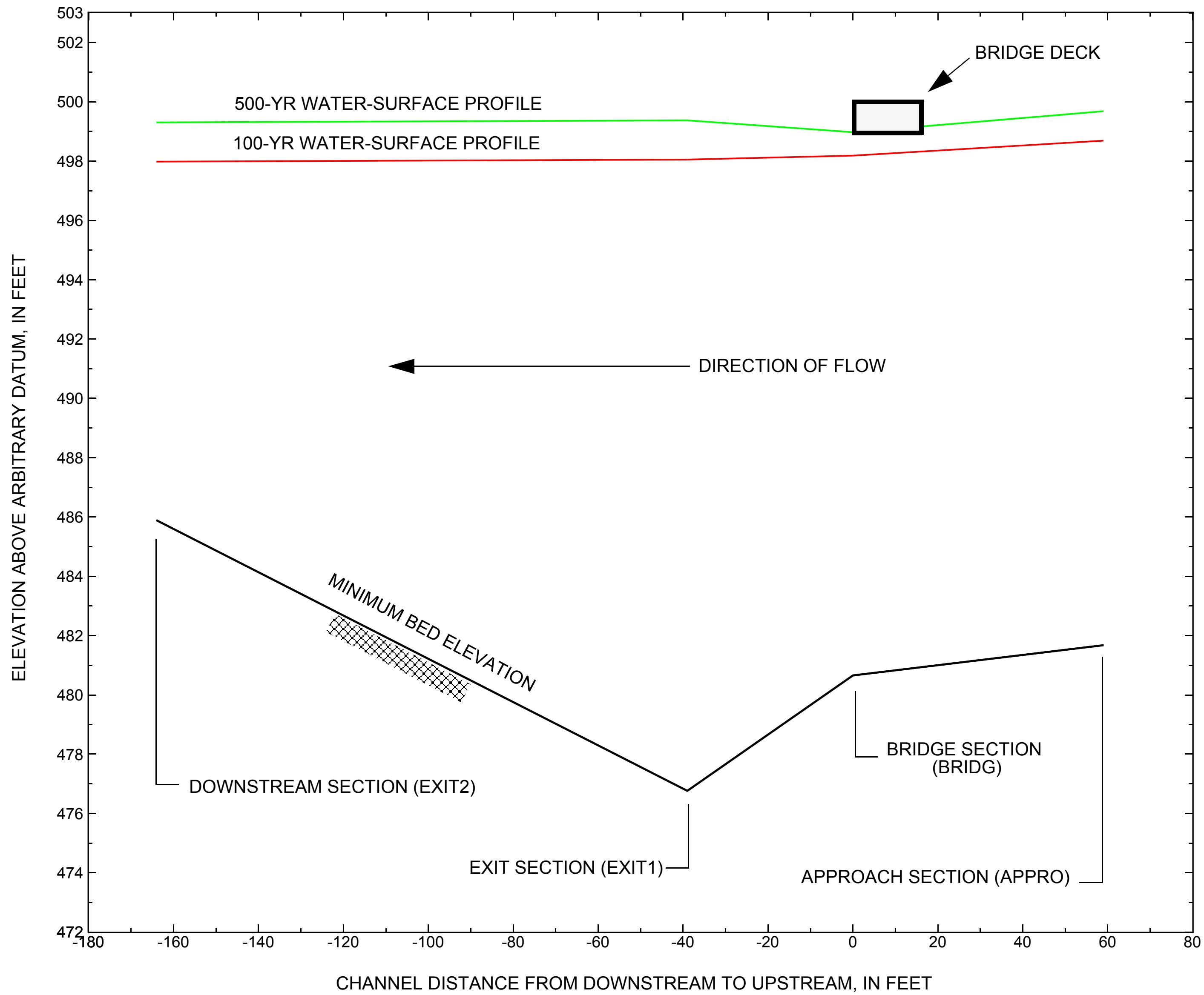

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FFIETH00290049 on Town Highway 29, crossing Black Creek, Fairfield, Vermont.

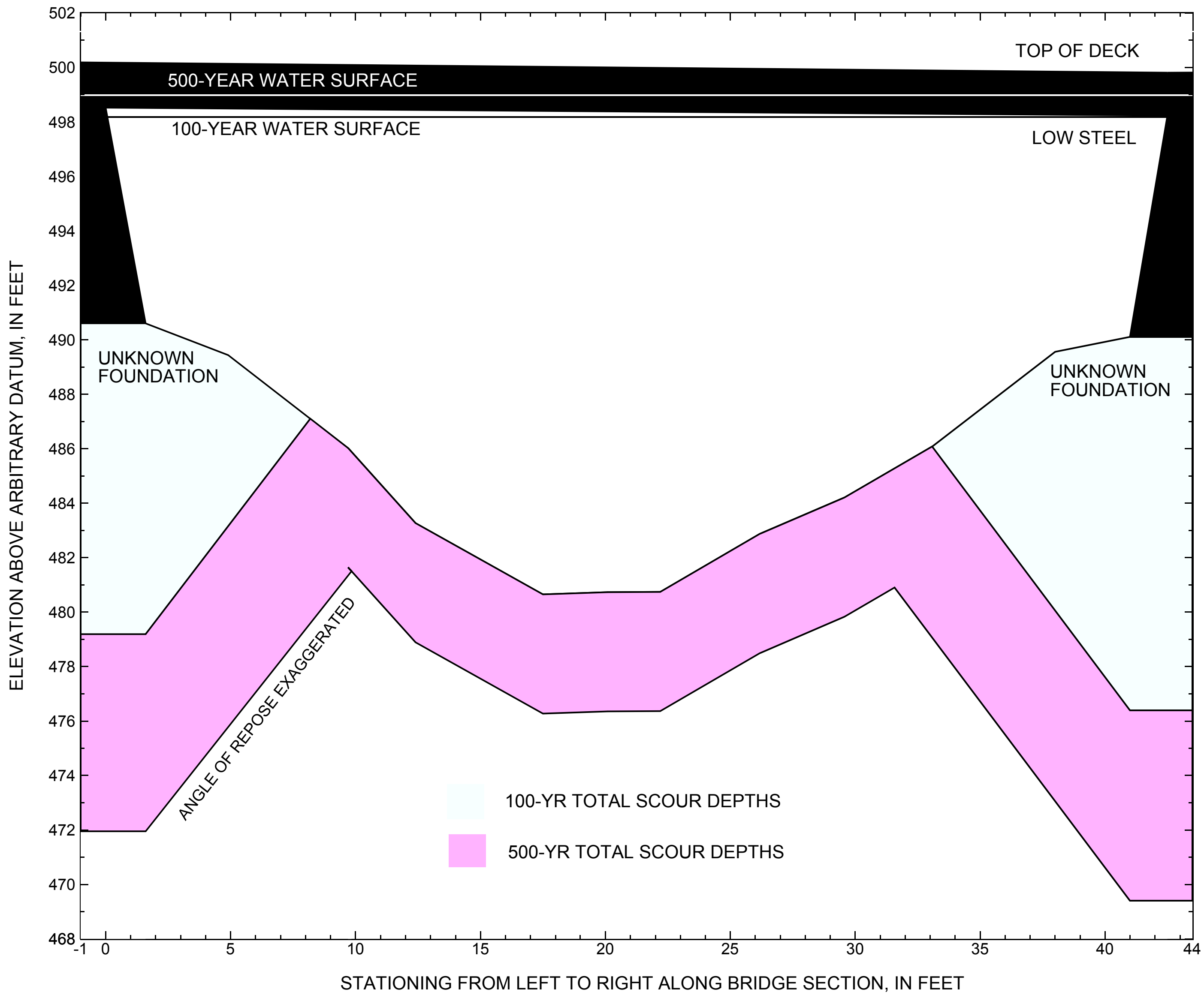

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure FFIETH00290049 on Town Highway 29, crossing Black Creek, Fairfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FFIETH00290049 on Town Highway 29, crossing Black Creek, Fairfield, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 7,860 cubic-feet per second											
Left abutment	0.0	--	498.5	--	490.6	0.0	11.4	--	11.4	479.2	--
Right abutment	42.5	--	498.2	--	490.1	0.0	13.7	--	13.7	476.4	--

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 FFIETH00290049 on Town Highway 29, crossing Black Creek, Fairfield, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 11,000 cubic-feet per second											
Left abutment	0.0	--	498.5	--	490.6	4.4	14.3	--	18.7	471.9	--
Right abutment	42.5	--	498.2	--	490.1	4.4	16.3	--	20.7	469.4	--

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

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U.S. Geological Survey, 1986, Fairfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ffie049.wsp
T2        Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
T3        BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           7860  11000 2210
SK          0.00053  0.00053 0.00053
*
XS   EXIT2    -164
GR         -205.3, 512.95   -165.8, 494.79   -136.8, 492.18   -109.8, 492.44
GR          -66.6, 495.05    -14.8, 496.00      0.0, 487.37      4.4, 486.01
GR           36.9, 486.14     42.7, 486.07     50.5, 485.89     55.2, 486.07
GR           78.1, 494.98     93.3, 494.69    208.3, 494.60    328.5, 493.96
GR          475.1, 494.49    492.0, 497.52    513.2, 498.77    589.1, 498.83
GR          695.3, 501.46    796.5, 508.49
N           0.035        0.035        0.048
SA                 -14.8        78.1
*
XS   EXIT1     -39
GR         -205.3, 512.95   -165.8, 494.79   -136.8, 492.18   -109.8, 492.44
GR          -66.6, 495.05    -14.8, 496.00      0.0, 486.08      2.5, 484.35
GR            6.7, 479.95     20.7, 476.76     31.2, 476.94     55.2, 486.07
GR           78.1, 494.98     93.3, 494.69    208.3, 494.60    328.5, 493.96
GR          475.1, 494.49    492.0, 497.52    513.2, 498.77    589.1, 498.83
GR          695.3, 501.46    796.5, 508.49
N           0.035        0.035        0.048
SA                 -14.8         78.1
*
XS   FULLV      0
*
BR   BRIDG     0    498.38       0.0
GR            0.0, 498.52      1.6, 490.60      4.9, 489.44      9.7, 486.02
GR           12.4, 483.27     17.5, 480.65     20.1, 480.73     22.2, 480.74
GR           26.2, 482.88     29.6, 484.22     33.1, 486.09     38.0, 489.55
GR           41.0, 490.10     42.5, 498.23      0.0, 498.52
N            0.035
CD           1      16.6
*
XR   RDWAY      8      14.0     2
GR         -231.3, 514.10   -215.7, 512.08   -204.3, 508.38   -195.8, 507.42
GR         -163.9, 503.50   -116.6, 499.53    -89.1, 498.27    -57.1, 497.83
GR          -29.4, 498.87     -2.8, 500.21      0.0, 500.17     41.0, 499.80
GR           43.8, 499.65     60.9, 499.14     94.5, 497.23    133.8, 496.17
GR          179.0, 495.60    259.6, 495.99    325.4, 496.01    398.1, 494.92
GR          431.7, 494.92    513.2, 498.77    589.1, 498.83    695.3, 501.46
GR          796.5, 508.49
*
XT   APTEM     80
GR         -194.9, 510.87   -163.9, 507.30    -92.2, 497.84    -36.7, 494.81
GR           -5.6, 493.79      0.0, 486.02      3.7, 483.58      9.7, 482.16
GR           15.2, 481.68     21.2, 482.08     32.0, 482.80     35.7, 483.11
GR           42.0, 483.13     48.5, 486.00     51.8, 488.11     57.9, 492.89
GR           68.2, 494.87     94.7, 496.35    125.1, 496.52    204.5, 493.72
GR          270.7, 490.70    325.5, 491.30    543.9, 492.75    593.0, 493.00
GR          593.0, 499.21    695.3, 501.46    796.5, 508.49
*
AS   APPRO     59 * * * 0.0005
GT             * * 125.1     <====section ended at 125.1 for incipient road-overflow
*                                model only.
N           0.035        0.032        0.040
SA                  -5.6         68.2
```

```
*
HP 1 BRIDG    498.18 1 498.18
HP 2 BRIDG    498.18 * * 1911
HP 2 RDWAY    498.12 * * 5949
HP 1 APPRO    498.69 1 498.69
HP 2 APPRO    498.69 * * 7860
*
HP 1 BRIDG    498.52 1 498.52
HP 2 BRIDG    498.52 * * 1930
HP 2 RDWAY    498.97 * * 9146
HP 1 APPRO    499.68 1 499.68
HP 2 APPRO    499.68 * * 11000
*
HP 1 BRIDG     494.41 1 494.41
HP 2 BRIDG     494.41 * * 2210
HP 1 APPRO     494.91 1 494.91
HP 2 APPRO     494.91 * * 2210
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
         U.S. Geological Survey WSPRO Input File ffie049.wsp
         Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
         BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO

     CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
              1     527.   94607.   42.    61.                        10538.
    498.18          527.   94607.   42.    61.  1.00     0.    42.  10538.

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        498.18     0.1    42.5   526.9   94607.    1911.   3.63
 X STA.         0.1         6.6         9.6        11.8        13.5        15.0
   A(I)            48.6        33.4        29.2        25.1        23.0
   V(I)            1.97        2.86        3.27        3.81        4.15

 X STA.        15.0        16.3        17.5        18.7        19.8        20.9
   A(I)            22.5        21.2        20.0        19.7        19.7
   V(I)            4.25        4.51        4.78        4.84        4.85

 X STA.        20.9        22.1        23.3        24.6        26.0        27.4
   A(I)            20.0        20.3        21.6        21.6        22.6
   V(I)            4.78        4.70        4.43        4.42        4.22

 X STA.        27.4        29.0        30.9        33.1        36.0        42.5
   A(I)            22.9        25.6        27.6        32.6        49.6
   V(I)            4.18        3.73        3.46        2.93        1.92

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =       8.
          WSEL     LEW     REW    AREA        K        Q    VEL
        498.12   -78.2   499.4   903.8   46397.    5949.   6.58
 X STA.       -78.2       135.7       159.8       178.3       195.7       213.7
   A(I)            70.8        51.3        44.2        43.1        43.2
   V(I)            4.20        5.80        6.73        6.90        6.88

 X STA.       213.7       233.1       252.8       274.5       295.9       317.2
   A(I)            44.7        43.6        46.2        45.4        45.2
   V(I)            6.65        6.83        6.44        6.55        6.57

 X STA.       317.2       338.0       355.3       370.2       383.3       395.6
   A(I)            45.1        41.9        39.7        37.9        37.6
   V(I)            6.60        7.11        7.49        7.85        7.92

 X STA.       395.6       407.1       419.1       431.1       446.8       499.4
   A(I)            37.0        38.2        38.4        44.8        65.5
   V(I)            8.03        7.79        7.74        6.64        4.54

     CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      59.
      WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
              1     272.   23562.   93.    93.                         2631.
              2     951.  227195.   74.    82.                        19369.
              3    3031.  360698.  525.   531.                        41328.
    498.69         4253.  611456.  692.   706.  1.44   -99.   593.  49792.

     VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      59.
          WSEL     LEW     REW    AREA        K        Q    VEL
        498.69   -98.7   593.0  4253.1  611456.    7860.   1.85
 X STA.       -98.7         0.1         8.7        15.4        21.7        28.2
   A(I)           322.5       128.7       111.7       105.2       106.9
   V(I)            1.22        3.05        3.52        3.74        3.68

 X STA.        28.2        34.9        42.1        53.2       195.1       244.4
   A(I)           107.6       111.6       142.4       475.8       280.4
   V(I)            3.65        3.52        2.76        0.83        1.40

 X STA.       244.4       275.1       304.0       334.1       365.2       397.5
   A(I)           229.8       224.8       225.2       225.5       227.0
   V(I)            1.71        1.75        1.75        1.74        1.73

 X STA.       397.5       431.1       466.6       505.4       546.7       593.0
   A(I)           228.4       234.2       245.4       250.8       269.4
   V(I)            1.72        1.68        1.60        1.57        1.46
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WSPRO OUTPUT FILE (continued)

```
     U.S. Geological Survey WSPRO Input File ffie049.wsp
     Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
     BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO

 CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      0.
  WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1    535.  68029.     0.   104.                            0.
498.52         535.  68029.     0.   104.  1.00     0.    43.       0.

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =      0.
      WSEL     LEW     REW    AREA        K        Q    VEL
    498.52     0.0    42.5   535.2   68029.    1930.   3.61
X STA.       0.0        6.2        9.1       11.3       13.1       14.6
 A(I)           46.6       32.1       28.6       26.7       24.1
 V(I)           2.07       3.01       3.38       3.62       4.01

X STA.      14.6       16.0       17.3       18.5       19.7       20.9
 A(I)           22.7       22.4       21.3       21.0       21.0
 V(I)           4.25       4.31       4.53       4.59       4.60

X STA.      20.9       22.0       23.3       24.6       26.0       27.6
 A(I)           21.0       21.3       22.6       22.6       23.6
 V(I)           4.60       4.53       4.27       4.27       4.08

X STA.      27.6       29.3       31.2       33.4       36.4       42.5
 A(I)           24.4       26.1       27.8       33.2       46.1
 V(I)           3.95       3.70       3.47       2.91       2.09

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      8.
      WSEL     LEW     REW    AREA        K        Q    VEL
    498.97  -104.4   594.8  1336.1   74411.    9146.   6.85
X STA.    -104.4      107.7      135.2      156.0      173.9      190.6
 A(I)          104.0       67.7       61.5       57.2       55.7
 V(I)           4.40       6.75       7.44       7.99       8.21

X STA.     190.6      207.6      225.4      244.0      263.7      283.4
 A(I)           55.8       56.6       57.6       59.3       58.7
 V(I)           8.20       8.08       7.94       7.71       7.79

X STA.     283.4      303.7      324.0      343.1      360.6      376.6
 A(I)           60.2       60.1       58.9       58.7       57.8
 V(I)           7.59       7.61       7.76       7.79       7.91

X STA.     376.6      391.8      407.3      423.8      444.6      594.8
 A(I)           58.6       62.4       66.6       80.2      138.3
 V(I)           7.81       7.32       6.86       5.70       3.31

 CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =     59.
  WSEL  SA#    AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1    367.   37033.   101.   101.                         3984.
          2   1024.  257028.    74.    82.                        21643.
          3   3555.  457920.   547.   553.                        51454.
499.68        4947.  751981.   721.   736.  1.39  -106.   615.  62345.

 VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =     59.
      WSEL     LEW     REW    AREA        K        Q    VEL
    499.68  -106.2   614.8  4946.8  751981.   11000.   2.22
X STA.    -106.2       -4.5        7.9       15.2       22.3       29.5
 A(I)          374.6      173.2      128.6      125.4      125.6
 V(I)           1.47       3.18       4.28       4.39       4.38

X STA.      29.5       37.2       45.5       85.2      195.9      240.9
 A(I)          128.2      135.7      274.1      446.1      297.7
 V(I)           4.29       4.05       2.01       1.23       1.85

X STA.     240.9      272.3      300.9      330.1      361.1      393.2
 A(I)          261.8      251.8      248.8      255.8      258.5
 V(I)           2.10       2.18       2.21       2.15       2.13

X STA.     393.2      426.6      462.0      499.3      538.9      614.8
 A(I)          261.2      269.1      274.9      281.2      374.7
 V(I)           2.11       2.04       2.00       1.96       1.47
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      U.S. Geological Survey WSPRO Input File ffie049.wsp
      Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
      BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO

   CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     370.   57355.    41.    53.                       6303.
  494.41          370.   57355.    41.    53.  1.00     1.    42.   6303.

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      494.41     0.8    41.8   369.7  57355.    2210.   5.98
X STA.        0.8        7.9       10.7       12.7       14.2       15.5
  A(I)            33.9       23.2       20.6       17.1       16.5
  V(I)            3.26       4.77       5.35       6.46       6.69

X STA.       15.5       16.7       17.8       18.8       19.8       20.9
  A(I)            15.8       14.5       14.2       14.0       14.0
  V(I)            6.98       7.60       7.78       7.89       7.90

X STA.       20.9       21.9       22.9       24.1       25.3       26.7
  A(I)            13.9       14.6       14.7       15.6       16.0
  V(I)            7.97       7.56       7.50       7.09       6.91

X STA.       26.7       28.3       30.0       32.1       34.9       41.8
  A(I)            16.9       17.7       19.8       22.9       33.8
  V(I)            6.54       6.23       5.57       4.83       3.27

   CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      59.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      19.     578.    33.    33.                         84.
            2     672.  127366.    74.    82.                      11505.
            3       0.       0.     1.     1.                          0.
  494.91          691.  127945.   108.   116.  1.04   -39.    69.   9720.

   VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      59.
        WSEL     LEW     REW    AREA        K        Q    VEL
      494.91   -38.7    69.1   691.4  127945.   2210.   3.20
X STA.      -38.7        2.3        5.5        8.1       10.4       12.6
  A(I)            69.2       36.4       31.3       29.4       27.9
  V(I)            1.60       3.03       3.53       3.76       3.96

X STA.       12.6       14.7       16.7       18.8       20.9       23.0
  A(I)            27.7       26.5       27.0       27.3       27.0
  V(I)            3.99       4.17       4.10       4.05       4.09

X STA.       23.0       25.2       27.4       29.7       32.2       34.7
  A(I)            28.0       27.7       28.7       29.8       30.2
  V(I)            3.94       3.99       3.85       3.71       3.66

X STA.       34.7       37.4       40.2       43.4       47.7       69.1
  A(I)            32.0       33.4       37.2       43.4       71.3
  V(I)            3.46       3.31       2.97       2.55       1.55
```

WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File ffie049.wsp
       Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
       BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO

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

EXIT2:XS   ******  -173.    2983.  0.18 *****  498.16  495.20   7860.  497.98
     -164. ******   500.  341315.  1.69 ***** *******    0.29    2.64

EXIT1:XS     125.  -173.    3376.  0.16  0.05  498.21 *******   7860.  498.05
      -39.   125.   501.  462045.  1.90  0.00    0.00    0.25    2.33

FULLV:FV      39.  -173.    3387.  0.16  0.01  498.22 *******   7860.  498.07
        0.    39.   501.  463971.  1.90  0.00    0.00    0.25    2.32
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      59.    -95.    3873.  0.10  0.01  498.24 *******   7860.  498.14
       59.    59.   593.  533944.  1.51  0.00    0.00    0.18    2.03
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   503.71       0.00     496.83     494.92
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   498.19     498.58     498.69     498.38
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                       YU/Z,WSIU,WS = 1.02     498.64     498.70
 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.
 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =    5949.      5140.    1.16

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

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

BRIDG:BR      39.     0.     527.  0.46  0.05  498.65  488.76   1911.  498.18
        0.    39.    42.   94660.  2.27  0.39    0.00    0.27    3.62

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.664 ******  498.38 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    45.  0.01  0.08  498.76    0.00   5949.  498.12

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     55.    29.   -78.   -49.   0.3   0.1   3.7  13.3   0.8   2.8
   RT:   5895.   420.    79.   499.   3.2   2.1   7.6   6.6   2.8   3.0

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

APPRO:AS      42.    -99.    4252.  0.08  0.11  498.76  493.68   7860.  498.69
       59.   104.   593.  611164.  1.44  0.01    0.00    0.16    1.85

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.938  0.939   37296.   220.   263. ********

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT2:XS    -164.  -173.   500.   7860.  341315.    2983.    2.64  497.98
   EXIT1:XS     -39.  -173.   501.   7860.  462045.    3376.    2.33  498.05
   FULLV:FV       0.  -173.   501.   7860.  463971.    3387.    2.32  498.07
   BRIDG:BR       0.     0.    42.   1911.   94660.     527.    3.62  498.18
   RDWAY:RG       8.*******    55.   5949.       0.       0.    2.00  498.12
   APPRO:AS      59.    -99.   593.   7860.  611164.    4252.    1.85  498.69

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     220.   263.   37296.

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS      FR#    YMIN     YMAX     HF     HO  VHD      EGL    WSEL
   EXIT2:XS    495.20     0.29  485.89  512.95************  0.18  498.16  497.98
   EXIT1:XS  ********     0.25  476.76  512.95  0.05  0.00  0.16  498.21  498.05
   FULLV:FV  ********     0.25  476.76  512.95  0.01  0.00  0.16  498.22  498.07
   BRIDG:BR    488.76     0.27  480.65  498.52  0.05  0.39  0.46  498.65  498.18
   RDWAY:RG  ****************  494.92  514.10  0.01******  0.08  498.76  498.12
   APPRO:AS    493.68     0.16  481.67  510.86  0.11  0.01  0.08  498.76  498.69
```
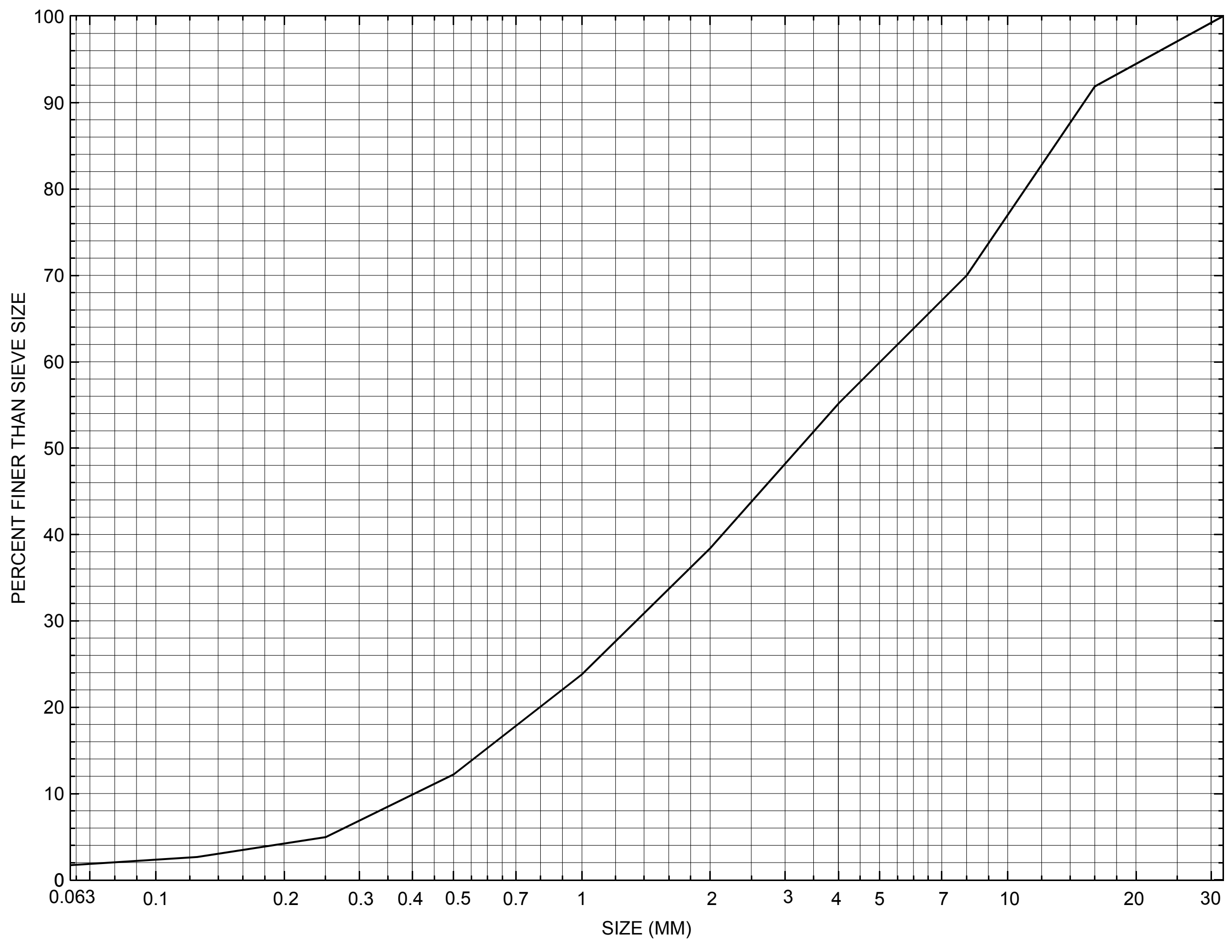

```
        U.S. Geological Survey WSPRO Input File ffie049.wsp
        Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
        BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO
           *** RUN DATE & TIME: 05-19-97  11:01

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

EXIT2:XS   ******  -176.    3932.  0.20 *****  499.51  496.12  11000.  499.30
     -164. ******   608.  477709.  1.67 ***** *******    0.28    2.80

EXIT1:XS     125.  -176.    4332.  0.19  0.05  499.56 *******  11000.  499.37
      -39.   125.   611.  607142.  1.90  0.00    0.00    0.26    2.54

FULLV:FV      39.  -176.    4347.  0.19  0.01  499.58 *******  11000.  499.39
        0.    39.   612.  609763.  1.90  0.00    0.01    0.26    2.53
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      59.  -105.    4805.  0.11  0.02  499.60 *******  11000.  499.48
       59.    59.   606.  724964.  1.39  0.00    0.00    0.18    2.29
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =    499.39     498.38

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =     9146.      7909.    1.16

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

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

BRIDG:BR      39.     0.     535.  0.20 *****  498.72  488.80   1930.  498.52
        0. ******    43.   68029.  1.00 ***** *******    0.18    3.61

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800 ******  498.38 ****** ****** ******

   XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG        8.    45.  0.01  0.11  499.78    0.01    9146.  498.97

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:    409.    77.  -104.   -27.   1.1   0.7   5.4   7.9   1.5   2.9
  RT:   8736.   531.    64.   595.   4.1   2.4   7.6   6.8   3.2   2.8

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

APPRO:AS      42.  -106.    4950.  0.11  0.08  499.79  494.43  11000.  499.68
       59.   102.   615.  752512.  1.39  0.01    0.01    0.18    2.22

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

  FIRST USER DEFINED TABLE.

   XSID:CODE     SRD    LEW    REW       Q        K      AREA     VEL    WSEL
  EXIT2:XS     -164.  -176.   608.  11000.  477709.    3932.    2.80  499.30
  EXIT1:XS      -39.  -176.   611.  11000.  607142.    4332.    2.54  499.37
  FULLV:FV        0.  -176.   612.  11000.  609763.    4347.    2.53  499.39
  BRIDG:BR        0.     0.    43.   1930.   68029.     535.    3.61  498.52
  RDWAY:RG        8.*******   409.   9146.******************    2.00  498.97
  APPRO:AS       59.  -106.   615.  11000.  752512.    4950.    2.22  499.68

 SECOND USER DEFINED TABLE.
   XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXIT2:XS     496.12    0.28  485.89  512.95************  0.20  499.51  499.30
  EXIT1:XS   ********    0.26  476.76  512.95  0.05  0.00  0.19  499.56  499.37
  FULLV:FV   ********    0.26  476.76  512.95  0.01  0.00  0.19  499.58  499.39
  BRIDG:BR     488.80    0.18  480.65  498.52************  0.20  498.72  498.52
  RDWAY:RG   ****************  494.92  514.10  0.01******  0.11  499.78  498.97
  APPRO:AS     494.43    0.18  481.67  510.86  0.08  0.01  0.11  499.79  499.68
```

```
        U.S. Geological Survey WSPRO Input File ffie049.wsp
        Hydraulic analysis for structure FFIETH00290049   Date: 09-MAY-97
        BRIDGE 49 OVER BLACK CREEK IN FAIRFIELD, VT    SAO
           *** RUN DATE & TIME: 05-19-97  11:03

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

EXIT2:XS   ******  -163.     792.  0.17 *****  494.67  489.68   2210.  494.50
     -164. ******   475.   95923.  1.38 ***** *******    0.42    2.79

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "EXIT1"     KRATIO =  2.02

EXIT1:XS     125.  -164.    1193.  0.07  0.03  494.70 *******   2210.  494.63
      -39.   125.   476.  193602.  1.36  0.00    0.00    0.24    1.85

FULLV:FV      39.  -164.    1198.  0.07  0.01  494.71 *******   2210.  494.64
        0.    39.   476.  193917.  1.36  0.00    0.00    0.25    1.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.63

APPRO:AS      59.   -31.     660.  0.18  0.01  494.78 *******   2210.  494.60
       59.    59.    67.  121884.  1.03  0.05    0.00    0.23    3.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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      39.     1.     370.  0.61  0.02  495.02  489.35   2210.  494.41
        0.    39.    42.   57381.  1.09  0.30    0.00    0.37    5.98

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.958 ******  498.38 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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      42.   -39.     691.  0.17  0.03  495.07  486.99   2210.  494.91
       59.    44.    69.  127840.  1.04  0.02    0.00    0.23    3.20

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.579  0.026  124468.     3.    44.   494.89

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT2:XS    -164.  -163.   475.   2210.   95923.     792.    2.79  494.50
   EXIT1:XS     -39.  -164.   476.   2210.  193602.    1193.    1.85  494.63
   FULLV:FV       0.  -164.   476.   2210.  193917.    1198.    1.85  494.64
   BRIDG:BR       0.     1.    42.   2210.   57381.     370.    5.98  494.41
   RDWAY:RG       8.**************       0.******************    2.00********
   APPRO:AS      59.    -39.    69.   2210.  127840.     691.    3.20  494.91

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    44.  124468.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT2:XS    489.68    0.42  485.89  512.95************  0.17  494.67  494.50
   EXIT1:XS   ********   0.24  476.76  512.95  0.03  0.00  0.07  494.70  494.63
   FULLV:FV   ********   0.25  476.76  512.95  0.01  0.00  0.07  494.71  494.64
   BRIDG:BR    489.35    0.37  480.65  498.52  0.02  0.30  0.61  495.02  494.41
   RDWAY:RG   ****************  494.92  514.10**********************************
   APPRO:AS    486.99    0.23  481.67  510.86  0.03  0.02  0.17  495.07  494.91
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a bed sample taken from the channel approach of structure FFIETH00290049, in Fairfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FFIETH00290049

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 08 / 95

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 011

Town *(FIPS place code; I - 4; nnnnn)* 25225

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

Waterway *(I - 6)* BLACK CREEK

Road Name *(I - 7):* -

Route Number TH029

Vicinity *(I - 9)* 0.7 MI TO JCT C2 TH1

Topographic Map Fairfield

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44499

Longitude *(i - 17; nnnnn.n)* 72557

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10060500490605

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

Maximum span length *(I - 48; nnnn)* 0045

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000048

Average daily traffic, ADT *(I - 29; nnnnnn)* 000100

Deck Width *(I - 52; nn.n)* 140

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

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

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

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

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

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

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

Year Reconstructed *(I - 106)* 1963

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

Clear span (*nnn.n ft*) 42.5

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

Vertical clearance from streambed (*nnn.n ft*) 12.8

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

Waterway of full opening (*nnn.n ft*^{2}) 544.0

Comments:

The structural inspection report of 8/22/94 indicates the structure is a steel pony thru-truss type bridge. The abutments are constructed of stone with concrete caps. The right abutment has a “kneewall” along the bottom of the stone wall. The left abutment has several medium sized voids where small stones have dropped out. A few boulders are in view around the ends of both abutments. There are some small areas of bank erosion noted up- and downstream of the bridge.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: -

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} (*ft³/ 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 (*ft²*): -

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **83.48** mi^2 Lake/pond/swamp area **0.31** mi^2

Watershed storage *(ST)* **0.4** %

Bridge site elevation **354** ft Headwater elevation **1440** ft

Main channel length **22.62** mi

10% channel length elevation **364** ft 85% channel length elevation **650** ft

Main channel slope *(S)* **16.85** 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:

NO BENCHMARK INFORMATION

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:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS

Cross-sectional Data

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

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

Comments: **This is the cross-section of the upstream face. The low cord elevation is from the survey log done for this report on 7/13/95. The station measurements are from the sketch attached to a bridge inspection report dated 8/22/94 and reflect the clear span measurement.**

Station	0	9.5	16.5	24.75	31.67	35.92	42.5	-	-	-	-
Feature	LAB	-	-	-	-	-	RAB	-	-	-	-
Low cord elevation	498.52	498.46	498.41	498.36	498.31	498.28	498.24	-	-	-	-
Bed elevation	490.44	486.79	480.91	480.78	484.73	486.78	488.57	-	-	-	-
Low cord to bed length	8.08	11.67	17.5	17.58	13.58	11.5	9.67	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

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

Comments:

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 3/8/96

Computerized by: RB Date: 3/8/96

Reviewd by: SAO Date: 6/5/97

Structure Number FFIETH00290049

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. HAMMOND Date *(MM/DD/YY)* 7 / 13 / 1995
2. Highway District Number 8 Mile marker 0

County FRANKLIN 011 Town FAIRFIELD 25225

Waterway *(I - 6)* BLACK CREEK Road Name -

Route Number TH029 Hydrologic Unit Code: 02010007

3. Descriptive comments:

The bridge is located 0.7 miles from Town Highway 49's junction with Town Highway 1.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 4 RBDS 3 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 1 UB 1 DS 1 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 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 48 *(feet)* Span length 45 *(feet)* Bridge width 14 *(feet)*

Road approach to bridge:

8. LB 1 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left 1.5:1 US right 3.0:1

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

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

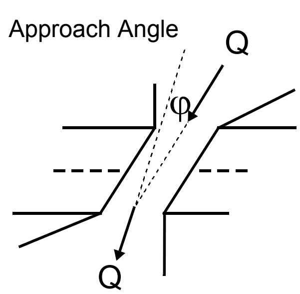
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

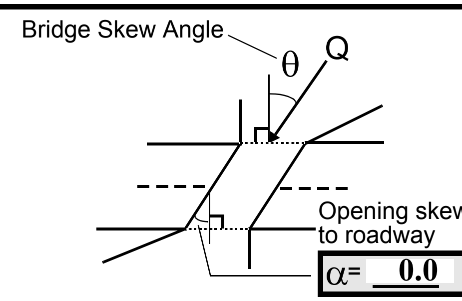
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: 30 16. Bridge skew: 30





α= 0.0

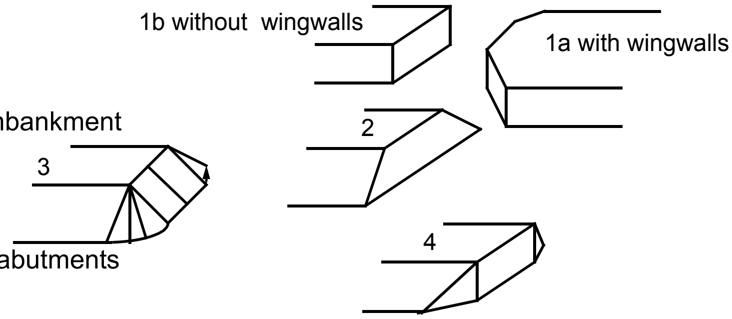
17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 60 feet US *(US, UB, DS)* to 10 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 20 feet US *(US, UB, DS)* to 0 feet US

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

18. Bridge Type: **1b**

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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. Values are from the VT AOT files. Measured bridge length is 48 feet, span length is 42 feet, and the bridge width is 14 feet.

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
64.5	**8.0**			**9.0**	**1**	**1**	**1**	**1**	**1**	**1**

23. Bank width **25.0** 24. Channel width **25.0** 25. Thalweg depth **76.5** 29. Bed Material **2**

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

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.):

30. The left and right bank have dumped stone protection, 12 inches to 4 feet in diameter, in good condition as a scour countermeasure. On the left bank the protection extends 60 feet US. On the right bank the protection extends 20 feet US.
28. The left and right banks are steep.

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

There is a gravel bar 1000 feet US with no vegetation.

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

The banks are steep and the bottom of the bank slopes are about 3 or 4 feet below the water surface.

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

47. Scour dimensions: Length >100 Width 30 Depth : 6 Position 20 %LB to 80 %RB

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

The scour hole continues through the bridge to about 125 feet DS.

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

There is a minor drainage on the right bank that drains the field.

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
48.5		4.0		2	54	54	0

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

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

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

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

4

63. The bed material under the bridge is stone fill.

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

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

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

70. Debris and Ice Comments:

2

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		-	90	2	0	-	-	90.0
RABUT	2	20	90			2	0	42.5

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.):

-

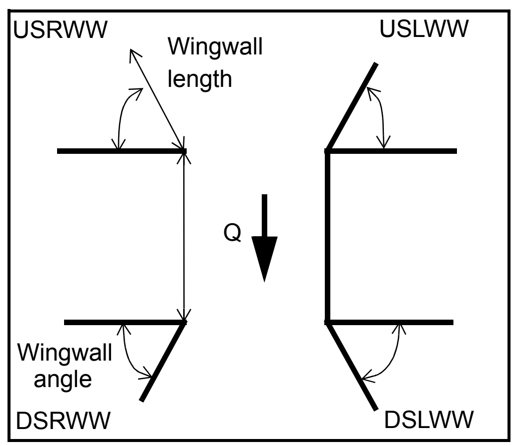
-

2

77. The abutments are dry stone masonry with concrete caps. There is a loose slope of rock from the abutment toes to the bottom of the channel.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						42.5	
USRWW:	N		-		-	5.5	
DSLWW:	-		-		N	16.0	
DSRWW:	-		-		-	17.0	



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

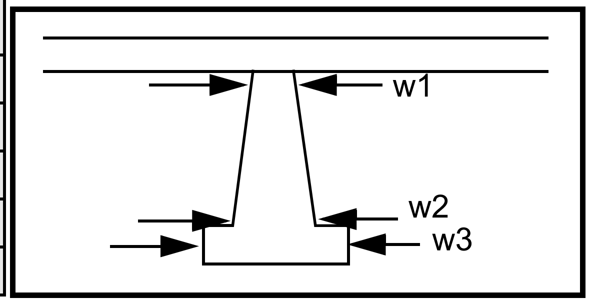
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? Th (Y or if N type ctrl-n pr)

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e abut-	, 45	of both	up to 5	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	ment	degr	the	feet,	1- Solid pier, 2- column, 3- bent
88. Material	pro-	ees.	right	to	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	tec-	No	and	pro-	1- Round; 2- Square; 3- Pointed
90. Inclined?	tion	ero-	left	tect	Y- yes; N- no
91. Attack ∠ (BF)	is	sion	bank	from	
92. Pushed	loose	is	s	strea	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	rock	appa	have	m	
95. Cross-members	piled	rent.	large	impa	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	on a	The	boul-	cts.	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	steep	US	ders,		
98. Exposure depth	slope	side	some		

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 ____ (US, UB, DS)

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

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

2
1
1
1

Is channel scour present? 1 (Y or if N type ctrl-n cs) Mid-scour distance: 1

Scour dimensions: Length 4 Width 2 Depth: 2 Positioned 1 %LB to 1 %RB

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

The right bank protection extends to more than 500 feet DS. The left bank protection extends 90 feet DS. Bank erosion may be due to ice.

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):

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)*:

N

-

NO DROP STRUCTURE

N

-

-

-

-

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: FFIETH00290049 Town: FAIRFIELD
Road Number: TH49 County: FRANKLIN
Stream: BLACK CREEK

Initials SAO Date: 5/19/97 Checked: LKS

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	7860	11000	2210
Main Channel Area, ft2	951	1024	672
Left overbank area, ft2	272	367	19
Right overbank area, ft2	3031	3555	0
Top width main channel, ft	74	74	74
Top width L overbank, ft	93	101	33
Top width R overbank, ft	525	547	1
D50 of channel, ft	0.0106	0.0106	0.0106
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	12.9	13.8	9.1
y1, average depth, LOB, ft	2.9	3.6	0.6
y1, average depth, ROB, ft	5.8	6.5	0.0
Total conveyance, approach	611456	751981	127945
Conveyance, main channel	227195	257028	127366
Conveyance, LOB	23562	37033	578
Conveyance, ROB	360698	457920	0
Percent discrepancy, conveyance	0.0002	0.0000	0.0008
Qm, discharge, MC, cfs	2920.5	3759.8	2200.0
Ql, discharge, LOB, cfs	302.9	541.7	10.0
Qr, discharge, ROB, cfs	4636.6	6698.5	0.0
Vm, mean velocity MC, ft/s	3.1	3.7	3.3
Vl, mean velocity, LOB, ft/s	1.1	1.5	0.5
Vr, mean velocity, ROB, ft/s	1.5	1.9	ERR
Vc-m, crit. velocity, MC, ft/s	3.8	3.8	3.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR
Results			
Main Channel	0	0	0

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour
y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)
ys=y2-y_bridge
(Richardson and others, 1995, p. 30, eq. 17 and 18)

Characteristic	Approach 100 yr	500 yr	Other Q	Bridge 100 yr	500 yr	Other Q
Q1, discharge, cfs	7860	11000	2210	1911	1930	2210
Total conveyance	611456	751981	127945	94607	68029	57355
Main channel conveyance	227195	257028	127366	94607	68029	57355
Main channel discharge	2920	3760	2200	1911	1930	2210
Area - main channel, ft2	951	1024	672	527	535	370
(W1) channel width, ft	74	74	74	42.4	42.5	41
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	74	74	74	42.4	42.5	41
D50, ft	0.0106	0.0106	0.0106			
w, fall velocity, ft/s (p. 32)	1.2	1.2	1.2			
y, ave. depth flow, ft	12.85	13.84	9.08	12.43	12.59	9.02
S1, slope EGL	0.00034	0.00034	0.0012			
P, wetted perimeter, MC, ft	82	82	82			
R, hydraulic Radius, ft	11.598	12.488	8.195			
V*, shear velocity, ft/s	0.356	0.370	0.563			
V*/w	0.297	0.308	0.469			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.59	0.59	0.59			
y2,depth in contraction, ft	12.41	10.84	12.92			
ys, scour depth, ft (y2-y_bridge)	-0.02	-1.75	3.89			

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	7860	11000	2210
(Q) discharge thru bridge, cfs	1911	1930	2210
Main channel conveyance	94607	68029	57355

Total conveyance	94607	68029	57355
Q2, bridge MC discharge,cfs	1911	1930	2210
Main channel area, ft2	527	535	370
Main channel width (normal), ft	42.4	42.5	41.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	42.4	42.5	41
y_bridge (avg. depth at br.), ft	12.43	12.59	9.02
Dm, median (1.25*D50), ft	0.01325	0.01325	0.01325
y2, depth in contraction,ft	11.14	11.21	12.98
ys, scour depth (y2-ybridge), ft	**-1.29**	-1.38	**3.96**

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	7860	11000	2210
Q, thru bridge MC, cfs	1911	1930	2210
Vc, critical velocity, ft/s	3.77	3.82	3.56
Va, velocity MC approach, ft/s	3.07	3.67	3.27
Main channel width (normal), ft	42.4	42.5	41.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	42.4	42.5	41.0
qbr, unit discharge, ft2/s	45.1	45.4	53.9
Area of full opening, ft2	527.0	535.0	370.0
Hb, depth of full opening, ft	12.43	12.59	9.02
Fr, Froude number, bridge MC	0	0.18	0
Cf, Fr correction factor (<=1.0)	0.00	0.72	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	0	498.38	0
Elevation of Bed, ft	-12.43	485.79	-9.02
Elevation of Approach, ft	0	499.68	0
Friction loss, approach, ft	0	0.08	0
Elevation of WS immediately US, ft	0.00	499.60	0.00
ya, depth immediately US, ft	12.43	13.81	9.02
Mean elevation of deck, ft	0.0	500.0	0.0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.98	1.00
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	N/A	**4.38**	N/A
Ys, scour w/Umbrell equation, ft	N/A	2.28	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]

Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1911	1930	2210
Main channel area (DS), ft2	527	535	370
Main channel width (normal), ft	42.4	42.5	41.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	42.4	42.5	41.0
D90, ft	0.0495	0.0495	0.0495
D95, ft	0.0685	0.0685	0.0685
Dc, critical grain size, ft	0.0206	0.0203	0.0606
Pc, Decimal percent coarser than Dc	0.352	0.355	0.065
Depth to armoring, ft	**0.11**	**0.11**	**2.62**

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	7860	11000	2210	7860	11000	2210
a', abut.length blocking flow, ft	98.8	106.2	39.5	82.6	82.6	26.6
Ae, area of blocked flow ft2	298.7	370.9	66.7	340.1	403.9	125.2
Qe, discharge blocked abut.,cfs	--	--	106.5	--	--	252.1
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.22	1.71	1.60	1.53	1.96	2.01
ya, depth of f/p flow, ft	3.02	3.49	1.69	4.12	4.89	4.71
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.119	0.149	0.217	0.126	0.143	0.164
ys, scour depth, ft	**11.41**	**14.27**	**7.54**	**13.71**	**16.32**	**12.16**

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)	98.8	106.2	39.5	82.6	82.6	26.6
y1 (depth f/p flow, ft)	3.02	3.49	1.69	4.12	4.89	4.71
a'/y1	32.68	30.41	23.39	20.06	16.89	5.65
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.12	0.15	0.22	0.13	0.14	0.16
Ys w/ corr. factor K1/0.55:						
vertical	10.89	13.55	ERR	ERR	ERR	ERR
vertical w/ ww's	8.93	11.11	ERR	ERR	ERR	ERR
spill-through	5.99	7.45	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship

D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)

(Richardson and others, 1995, p112, eq. 81,82)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.27	0.18	0.37	0.27	0.18	0.37
y, depth of flow in bridge, ft	12.43	12.59	9.02	12.43	12.59	9.02
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	**0.56**	**0.25**	**0.76**	**0.56**	**0.25**	**0.76**
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR