LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (FAYSTH00010006) on TOWN HIGHWAY 1, crossing SHEPARD BROOK, FAYSTON, VERMONT

Open-File Report 97-755

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (FAYSTH00010006) on TOWN HIGHWAY 1, crossing SHEPARD BROOK, FAYSTON, VERMONT

By LORA K. STRIKER AND ROBERT H. FLYNN

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
Mark Schaefer, Acting Director

For additional information write to:

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (FAYSTH00010006) ON TOWN HIGHWAY 1, CROSSING SHEPARD BROOK, FAYSTON, VERMONT

By **Lora K. Striker and Robert H. Flynn**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FAYSTH00010006 on Town Highway 1 crossing Shepard Brook, Fayston, 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 central Vermont. The 16.6-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, Shepard Brook has an incised, sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 56 ft and an average bank height of 3 ft. The channel bed material ranges from sand to boulder with a median grain size (D_{50}) of 72.6 mm (0.238 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 2, 1996, indicated that the reach was stable.

The Town Highway 1 crossing of the Shepard Brook is a 42-ft-long, two-lane bridge consisting of one 40-foot concrete T-beam span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 39.6 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the calculated opening-skew-to-roadway is 30 degrees.

Scour, 2.0 ft deeper than the mean thalweg depth, was observed along the right abutment during the Level I assessment. The left abutment is undermined along the base of the footing. In addition, 1.5 ft of scour was observed along the left abutment during the Level I assessment. The only scour protection measure at the site was type-1 stone fill (less than 12 inches diameter) along the left bank upstream and type-2 stone fill (less than 36 inches diameter) along the upstream end of 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 others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.9 to 3.9 ft. The worst-case contraction scour occurred at the 500-year. Abutment scour ranged from 11.1 to 17.2 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 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.

Waitsfield, VT. Quadrangle, 1:24,000, 1970

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 FAYSTH00010006 ***Stream*** Shepard Brook

County Washington ***Road*** TH 1 ***District*** 6

Description of Bridge

Bridge length 42 ***ft*** ***Bridge width*** 21.5 ***ft*** ***Max span length*** 40 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Sloping; near vertical

Stone fill on abutment? No ***Date of inspection*** 07/02/96

Description of stone fill Type-2, around the upstream end of the upstream right wingwall in good condition.

Abutments and wingwalls are concrete. There is a 2.0 ft of scour on the RABUT and 1.5 ft of scour and undermining of the LABUT. In addition, there is 2.0 ft of scour in front of the USLWW and DSRWW.

Yes 15

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

There is a mild channel bend in the upstream reach. A scour hole has developed in the location where the bend impacts the upstream left wingwall.

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	07/02/96	0	0
Level II	07/02/96	0	0

Potential for debris Low. There was a few branches at the upstream right wingwall. Ice build up is evidenced by scarring of stream along the LB and RB DS.

Describe any features near or at the bridge that may affect flow (include observation date) None, 07/02/96.

Description of the Geomorphic Setting

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

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

Date of inspection 07/02/96

DS left: Steep channel to narrow flood plain

DS right: Moderately sloping channel bank to narrow flood plain

US left: Steep channel bank to moderately sloping overbank

US right: Steep channel bank to irregular overbank

Description of the Channel

Average top width 56 ft ***Average depth*** 3 ft

Predominant bed material Cobble/ Boulder ***Bank material*** Cobble/Boulder

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

07/02/96

Vegetative co Trees and grass

DS left: Trees and grass

DS right: Trees and grass

US left: Short grass with a few trees.

US right:

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

The assessment of 07/02/96 noted flow conditions are not influenced by any obstructions.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 16.6 ***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 3,900 ***ft***^{3}***/s*** ***Q500*** 5,880 ***ft***^{3}***/s***

The 100-year flood frequency discharge estimate was available from the VTAOT database. The drainage area from VTAOT was 16.5 mi^2 while the drainage area digitized by the USGS was 16.6 mi^2. The 500-year discharge was extrapolated. VTAOT discharges are within range of 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 RABUT (elev. 500.23 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the LABUT (elev. 500.04 ft, arbitrary survey datum). RM 3 is high point on boulder in lawn, 16 ft shoreward of the USRWW, 20 feet upstream of road (elev. 496.67 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	-48	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	68	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 0.047 to 0.055, and overbank "n" values ranged from 0.055 to 0.090.

Normal depth at the exit section (EXITX) was assumed as the starting water surface for the 100-year and incipient roadway overflow discharges. These depths were computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0133 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1970). Critical depth at the EXITX section was assumed as the starting water surface elevation for the 500-year discharge. The computed normal depth was within 0.2 ft of critical depth by use of the slope-conveyance method. Therefore, the critical water surface was assumed to be a satisfactory starting water surface for the 500-year discharge model.

The surveyed 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 500.7 ***ft***
Average low steel elevation 497.5 ***ft***

100-year discharge 3,900 ***ft^3/s***
Water-surface elevation in bridge opening 497.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 421 ***ft^3/s***
Area of flow in bridge opening 309 ***ft^2***
Average velocity in bridge opening 11.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.4 ***ft/s***

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 4.4 ***ft***

500-year discharge 5,880 ***ft^3/s***
Water-surface elevation in bridge opening 497.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,600 ***ft^3/s***
Area of flow in bridge opening 309 ***ft^2***
Average velocity in bridge opening 13.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 16.4 ***/s***

Water-surface elevation at Approach section with bridge 502.5
Water-surface elevation at Approach section without bridge 498.3
Amount of backwater caused by bridge 4.2 ***ft***

Incipient overtopping discharge 3,190 ***ft^3/s***
Water-surface elevation in bridge opening 497.5 ***ft***
Area of flow in bridge opening 309 ***ft^2***
Average velocity in bridge opening 10.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.3 ***ft/s***

Water-surface elevation at Approach section with bridge 500.4
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 3.7 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

The 100-year and incipient roadway-overtopping discharges resulted in unsubmerged orifice flow while 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 these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.7	3.9	0.9
Depth to armoring	10.3	19.2	12.4
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	12.5	14.0	11.1
Right abutment	15.6	17.2	15.3
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	2.9	3.6	3.0
Right abutment	2.9	3.6	3.0
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

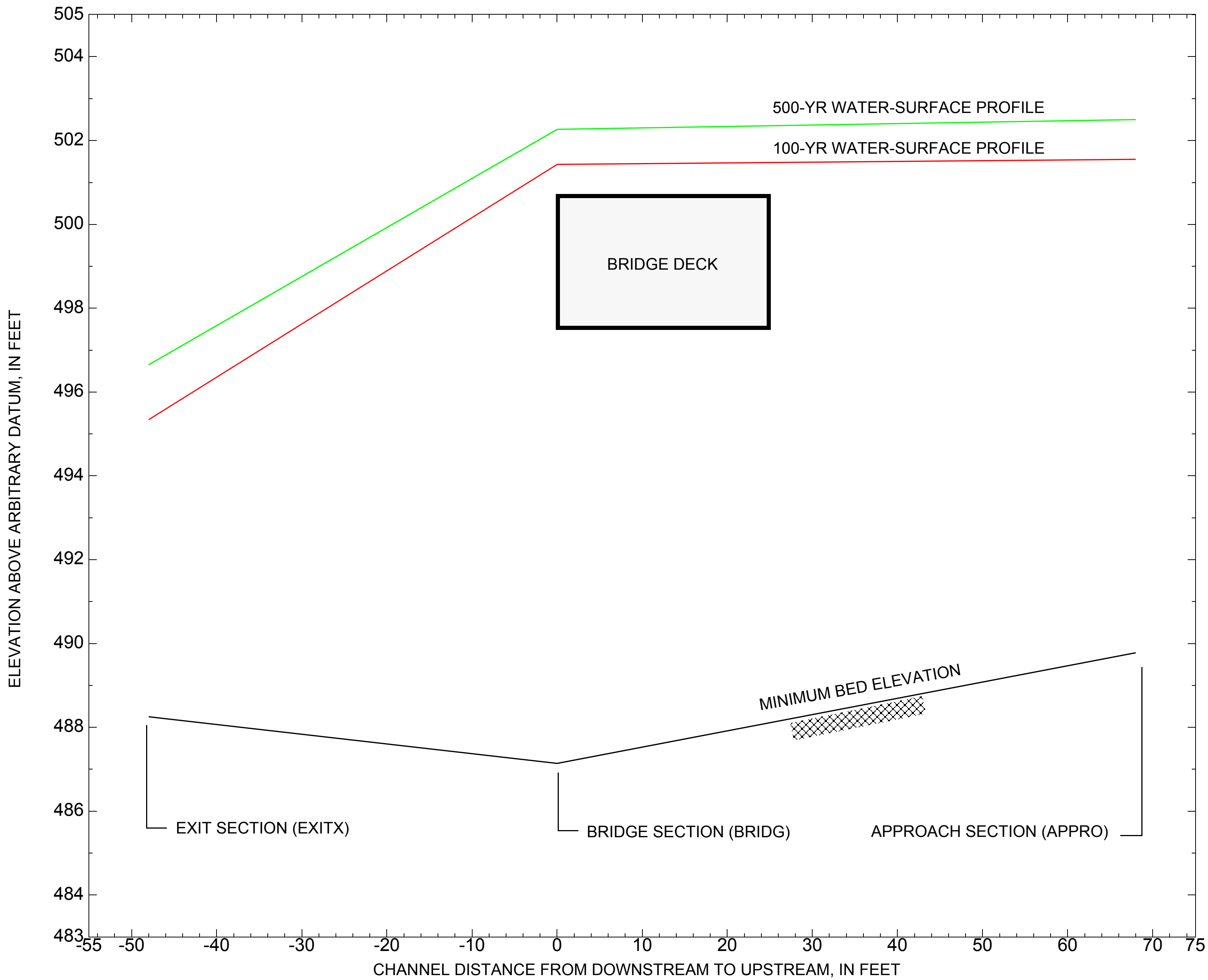

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FAYSTH00010006 on Town Highway 1, crossing Shepard Brook, Fayston, Vermont.

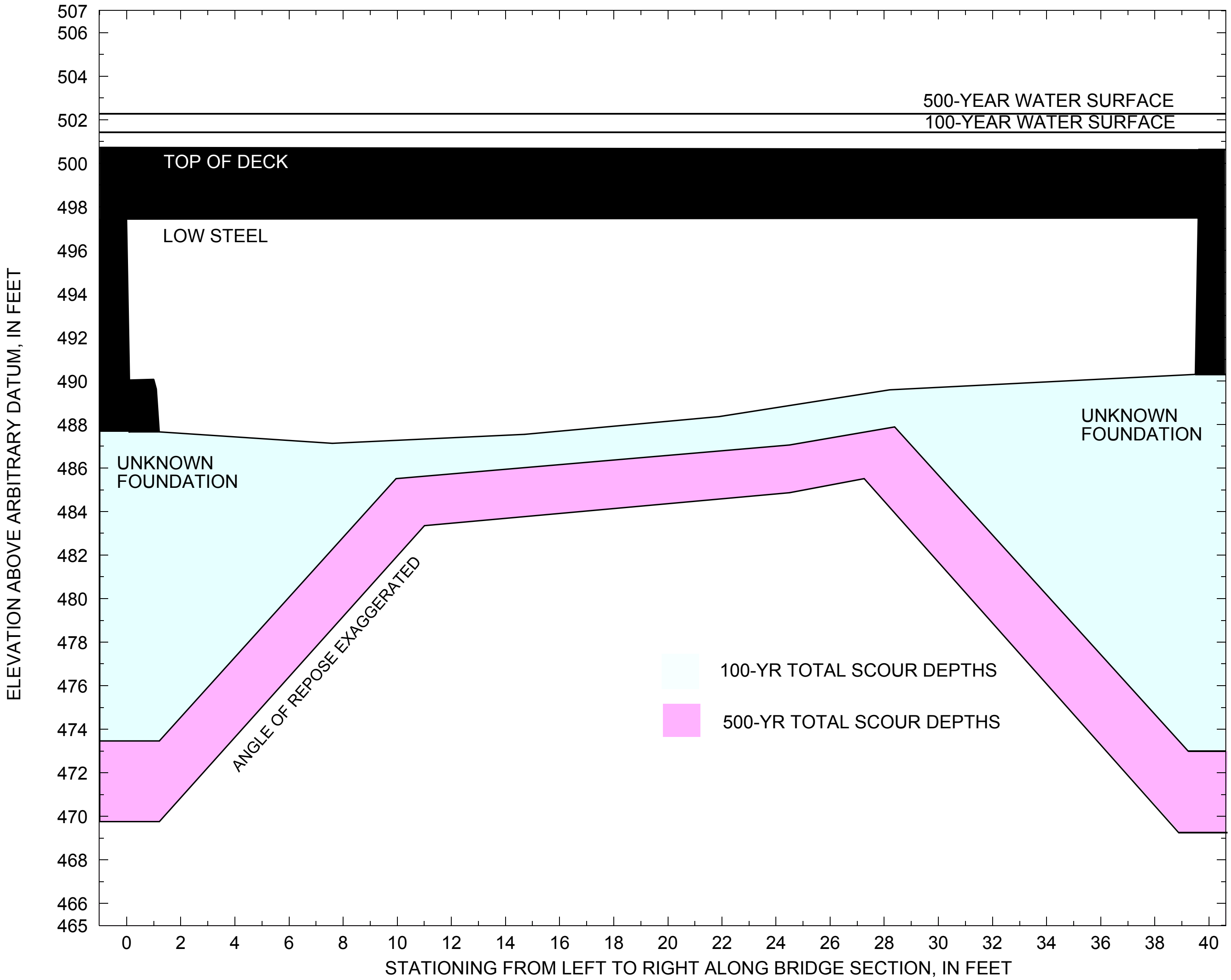

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure FAYSTH00010006 on Town Highway 1, crossing Shepard Brook, Fayston, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FAYSTH00010006 on Town Highway 1, crossing Shepard Brook, Fayston, 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 3.900 cubic-feet per second											
Left abutment	0.0	--	497.4	--	487.7	1.7	12.5	--	14.2	473.5	--
Right abutment	39.6	--	497.5	--	490.3	1.7	15.6	--	17.3	473.0	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure FAYSTH00010006 on Town Highway 1, crossing Shepard Brook, Fayston, 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 5,880 cubic-feet per second											
Left abutment	0.0	--	497.4	--	487.7	3.9	14.0	--	17.9	469.8	--
Right abutment	39.6	--	497.5	--	490.3	3.9	17.2	--	21.1	469.2	--

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, 1970, Waitsfield, 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 fays006.wsp
T2        Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
T3        The bridge is located 1.0 miles from junction of CL 3 and TH 9
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3900.0   5880.0  3190.0
SK          0.0133   0.0133  0.0133
*
XS   EXITX    -48          0.
GR         -201.5, 505.83   -129.7, 500.89   -117.5, 499.56   -104.7, 494.39
GR          -17.0, 494.50    -10.5, 490.11      0.0, 489.57      3.2, 489.19
GR           12.0, 488.58     19.8, 488.25     30.4, 488.69     35.0, 488.93
GR           37.8, 489.58     39.8, 492.04     63.1, 495.07    113.4, 495.10
GR          126.1, 501.10    144.8, 501.19
*
N           0.090        0.050        0.090
SA                  -17.0         39.8
*
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.46      30.0
GR            0.0, 497.44      0.1, 490.04      1.0, 490.07      1.1, 489.62
GR            1.2, 487.66      7.6, 487.14     14.7, 487.55     21.9, 487.67
GR           24.5, 488.36     28.2, 489.59     39.3, 490.26     39.6, 497.48
GR            0.0, 497.44
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      40.0 * *     53.9     11.1
N           0.047
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      21.5     1
GR         -339.1, 507.62   -210.6, 503.97    -85.0, 501.69     -5.8, 500.55
GR            0.0, 500.73     36.3, 500.62
GR           41.7, 500.77     77.0, 500.45    125.0, 501.48    165.5, 502.29
*
*
AS   APPRO     68          0.
GR         -211.2, 504.17   -140.3, 498.50    -11.9, 495.08    -10.8, 491.84
GR           -5.0, 490.91      0.0, 490.27      9.9, 489.78     19.2, 490.05
GR           23.0, 490.61     32.4, 491.91     41.9, 495.36     71.6, 496.53
GR          113.4, 495.13    126.1, 501.09    140.7, 501.82
*
N           0.070     0.055        0.055
SA                  -11.9    41.9
*
HP 1 BRIDG   497.48 1 497.48
HP 2 BRIDG   497.48 * * 3461
HP 1 BRIDG   496.69 1 496.69
HP 2 RDWAY   501.43 * *  421
HP 1 APPRO   501.55 1 501.55
HP 2 APPRO   501.55 * * 3900
*
HP 1 BRIDG   497.48 1 497.48
HP 2 BRIDG   497.48 * * 4246
HP 2 RDWAY   502.27 * * 1600
HP 1 APPRO   502.50 1 502.50
HP 2 APPRO   502.50 * * 5880
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File fays006.wsp
       Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
       The bridge is located 1.0 miles from junction of CL 3 and TH 9
          *** RUN DATE & TIME: 07-31-97  08:00
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      309     23032     0     86                            0
  497.48           309     23032     0     86  1.00      0     40        0

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA         K        Q    VEL
      497.48     0.0    39.6   308.7   23032.    3461.  11.21

X STA.         0.0         3.4         5.3         7.0         8.5        10.1
  A(I)             26.2        16.5        14.9        13.8        13.6
  V(I)             6.62       10.49       11.58       12.57       12.73

X STA.        10.1        11.6        13.1        14.6        16.1        17.7
  A(I)             13.3        13.3        12.9        13.2        13.1
  V(I)            13.01       13.06       13.38       13.15       13.18

X STA.        17.7        19.2        20.8        22.3        24.0        25.9
  A(I)             13.0        13.4        13.3        13.8        14.4
  V(I)            13.31       12.93       13.04       12.53       12.00

X STA.        25.9        28.0        30.3        32.8        35.5        39.6
  A(I)             15.4        15.4        16.5        17.7        25.1
  V(I)            11.24       11.26       10.50        9.78        6.88

   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      282     28504    34     50                         4599
  496.69           282     28504    34     50  1.00      0     40     4599

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.
        WSEL     LEW     REW    AREA         K        Q    VEL
      501.43   -66.9   122.7   114.2    1883.     421.   3.69

X STA.       -66.9       -24.6       -14.8       -10.2        -5.9        -1.5
  A(I)             12.9         6.7         3.6         3.6         3.6
  V(I)             1.64        3.14        5.79        5.86        5.82

X STA.        -1.5         4.1         9.6        14.8        20.0        24.8
  A(I)              3.9         4.0         3.9         3.9         3.7
  V(I)             5.34        5.30        5.45        5.43        5.66

X STA.        24.8        29.6        34.2        38.9        48.7        57.7
  A(I)              3.8         3.6         3.7         6.8         6.9
  V(I)             5.58        5.83        5.64        3.10        3.06

X STA.        57.7        65.7        72.8        80.1        89.8       122.7
  A(I)              6.7         6.5         7.0         7.8        11.6
  V(I)             3.14        3.25        3.00        2.70        1.82

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      669     35992   167    167                         7615
            2      560     69510    54     57                        10240
            3      451     34611    93     95                         5631
  501.55          1680    140113   314    318  1.42   -177    135    18539

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.

        WSEL     LEW     REW    AREA         K        Q    VEL
      501.55  -178.4   135.3  1680.3  140113.    3900.   2.32

X STA.      -178.4      -105.2       -73.9       -50.8       -30.9       -13.8
  A(I)            181.5       138.0       118.0       113.4       105.8
  V(I)             1.07        1.41        1.65        1.72        1.84

X STA.       -13.8        -5.5        -0.5         4.1         8.5        12.8
  A(I)             75.0        54.6        52.1        51.5        50.5
  V(I)             2.60        3.57        3.75        3.79        3.86

X STA.        12.8        17.3        21.8        26.9        32.6        41.1
  A(I)             51.5        52.1        54.3        57.2        68.3
  V(I)             3.79        3.74        3.59        3.41        2.86

X STA.        41.1        54.9        70.7        86.9       102.3       135.3
  A(I)             82.2        84.9        85.3        89.0       115.1
  V(I)             2.37        2.30        2.29        2.19        1.69
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        U.S. Geological Survey WSPRO Input File fays006.wsp
        Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
        The bridge is located 1.0 miles from junction of CL 3 and TH 9
           *** RUN DATE & TIME: 07-31-97  08:00

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      309     23032      0     86                             0
   497.48           309     23032      0     86  1.00      0     40        0

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.48     0.0    39.6   308.7   23032.    4246.  13.75

 X STA.        0.0        3.4        5.3        7.0        8.5       10.1
   A(I)            26.2       16.5       14.9       13.8       13.6
   V(I)            8.12      12.87      14.20      15.42      15.62

 X STA.       10.1       11.6       13.1       14.6       16.1       17.7
   A(I)            13.3       13.3       12.9       13.2       13.1
   V(I)           15.96      16.02      16.41      16.13      16.17

 X STA.       17.7       19.2       20.8       22.3       24.0       25.9
   A(I)            13.0       13.4       13.3       13.8       14.4
   V(I)           16.33      15.87      15.99      15.37      14.72

 X STA.       25.9       28.0       30.3       32.8       35.5       39.6
   A(I)            15.4       15.4       16.5       17.7       25.1
   V(I)           13.79      13.81      12.88      12.00       8.44

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.
         WSEL     LEW     REW    AREA        K        Q    VEL
       502.27  -117.0   164.5   313.0    7419.    1600.   5.11

 X STA.     -117.0      -54.2      -34.1      -19.7      -12.5       -7.1
   A(I)            34.0       23.5       20.3       11.4        8.8
   V(I)            2.35       3.40       3.94       7.01       9.05

 X STA.       -7.1       -1.8        4.2       10.2       15.9       21.6
   A(I)             9.0        9.2        9.3        9.0        9.1
   V(I)            8.90       8.70       8.56       8.87       8.77

 X STA.       21.6       27.2       32.7       38.2       48.1       58.9
   A(I)             9.1        9.0        8.9       15.3       17.4
   V(I)            8.75       8.93       8.97       5.23       4.61

 X STA.       58.9       68.9       78.8       90.3      107.0      164.5
   A(I)            17.0       17.6       19.1       22.6       33.3
   V(I)            4.71       4.56       4.18       3.54       2.40

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      833     49512    178    179                         10217
             2      611     80411     54     57                         11675
             3      544     45391     99    101                          7253
   502.50          1988    175314    331    336  1.38   -189    141     23517
1
    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
        WSEL     LEW     REW    AREA        K        Q    VEL
       502.50  -190.3   140.7  1988.4  175314.    5880.   2.96

 X STA.     -190.3     -114.3      -84.2      -60.1      -39.7      -22.2
   A(I)           212.8      153.7      140.2      130.4      120.7
   V(I)            1.38       1.91       2.10       2.25       2.44

 X STA.      -22.2       -8.4       -2.5        2.7        7.6       12.3
   A(I)           111.9       66.8       63.5       61.0       60.0
   V(I)            2.63       4.40       4.63       4.82       4.90

 X STA.       12.3       17.1       22.2       27.7       34.0       44.2
   A(I)            61.2       61.9       64.4       67.5       84.3
   V(I)            4.81       4.75       4.56       4.36       3.49

 X STA.       44.2       57.7       73.4       89.0      104.1      140.7
   A(I)            91.4       98.0       98.1      102.5      138.2
   V(I)            3.22       3.00       3.00       2.87       2.13
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        U.S. Geological Survey WSPRO Input File fays006.wsp
        Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
        The bridge is located 1.0 miles from junction of CL 3 and TH 9
           *** RUN DATE & TIME: 07-31-97  08:00

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      309     23032      0     86                            0
   497.48           309     23032      0     86  1.00      0     40        0

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.48     0.0    39.6   308.7   23032.    3190.  10.33

X STA.         0.0        3.4        5.3        7.0        8.5       10.1
  A(I)            26.2       16.5       14.9       13.8       13.6
  V(I)            6.10       9.67      10.67      11.59      11.73

X STA.        10.1       11.6       13.1       14.6       16.1       17.7
  A(I)            13.3       13.3       12.9       13.2       13.1
  V(I)           11.99      12.03      12.33      12.12      12.15

X STA.        17.7       19.2       20.8       22.3       24.0       25.9
  A(I)            13.0       13.4       13.3       13.8       14.4
  V(I)           12.27      11.92      12.02      11.55      11.06

X STA.        25.9       28.0       30.3       32.8       35.5       39.6
  A(I)            15.4       15.4       16.5       17.7       25.1
  V(I)           10.36      10.38       9.68       9.02       6.34

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      257     24914     34     48                         4004
   495.96           257     24914     34     48  1.00      0     40     4004

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      486     22432    152    152                         4930
             2      498     57179     54     57                         8590
             3      353     24905     83     84                         4136
   500.40          1337    104516    289    293  1.45   -163    125    13555

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      68.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.40  -164.1   124.6  1336.7  104516.    3190.   2.39

X STA.      -164.1      -89.0      -58.4      -35.8      -16.7       -6.7
  A(I)           155.3      112.3       99.1       94.0       69.9
  V(I)            1.03       1.42       1.61       1.70       2.28

X STA.        -6.7       -2.0        2.3        6.2       10.1       14.0
  A(I)            44.7       42.8       40.7       41.0       41.1
  V(I)            3.57       3.73       3.92       3.89       3.88

X STA.        14.0       17.9       22.0       26.6       31.8       39.0
  A(I)            41.2       41.5       44.6       45.9       53.5
  V(I)            3.88       3.84       3.57       3.47       2.98

X STA.        39.0       52.6       70.1       88.1      103.0      124.6
  A(I)            67.7       75.0       74.0       69.9       82.5
  V(I)            2.36       2.13       2.15       2.28       1.93
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       U.S. Geological Survey WSPRO Input File fays006.wsp
       Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
       The bridge is located 1.0 miles from junction of CL 3 and TH 9
          *** RUN DATE & TIME: 07-31-97  08:00

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******   -106      471  1.75 *****  497.09  495.05    3900  495.34
       -47 ******    114    33805  1.64 ***** *******    1.28    8.28

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.62

FULLV:FV       48   -109      773  0.78  0.40  497.47 *******    3900  496.69
         0     48    117    54611  1.96  0.00   -0.02    0.68    5.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     1.28     496.83     497.23

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.19     504.17    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.19     504.17     497.23

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   497.23      504.17     497.23

APPRO:AS       68    -92      516  1.35 *****  498.59  497.23    3900  497.23
        68     68    118    33720  1.52 ***** *******    1.05    7.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.56       0.00     495.84     500.45

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.84     500.38     500.56     497.46

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

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

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

BRIDG:BR       48      0      309  1.95 *****  499.43  495.27    3461  497.48
         0 ******     40    23032  1.00 ***** *******    0.71   11.21

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.495  0.000  497.46 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    47.  0.04  0.12  501.63    0.00    421.  501.43

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    161.    85.   -67.    18.   0.9   0.5   3.9   3.6   0.7   3.1
   RT:    260.   105.    18.   123.   1.0   0.7   4.3   3.7   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       28   -177     1680  0.12  0.14  501.67  497.23    3900  501.55
        68     32    135   140078  1.42  1.03    0.00    0.21    2.32

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.  -107.   114.   3900.   33805.     471.    8.28  495.34
   FULLV:FV       0.  -110.   117.   3900.   54611.     773.    5.04  496.69
   BRIDG:BR       0.     0.    40.   3461.   23032.     309.   11.21  497.48
   RDWAY:RG      13.*******   161.    421.       0.       0.    1.00  501.43
   APPRO:AS      68.  -178.   135.   3900.  140078.    1680.    2.32  501.55

  SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.05    1.28  488.25  505.83************  1.75  497.09  495.34
   FULLV:FV   ********   0.68  488.25  505.83  0.40  0.00  0.78  497.47  496.69
   BRIDG:BR    495.27    0.71  487.14  497.48************  1.95  499.43  497.48
   RDWAY:RG   ****************  500.45  507.62  0.04******  0.12  501.63  501.43
   APPRO:AS    497.23    0.21  489.78  504.17  0.14  1.03  0.12  501.67  501.55
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File fays006.wsp
        Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
        The bridge is located 1.0 miles from junction of CL 3 and TH 9
           *** RUN DATE & TIME: 07-31-97  08:00

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   496.48     496.65

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******   -109      765  1.80 *****  498.46  496.65    5880  496.65
       -47 ******    117    53926  1.96 ***** *******    1.03    7.69

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

FULLV:FV       48   -112     1046  0.97  0.39  498.85 *******    5880  497.88
         0     48    119    77958  1.98  0.00    0.00    0.66    5.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.03     498.19     498.25

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.38     504.17    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.38     504.17     498.25

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   498.25     504.17     498.25

APPRO:AS       68   -130      750  1.51 *****  499.75  498.25    5880  498.25
        68     68    120    50645  1.58 ***** *******    1.00    7.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   497.88     497.46

            <<<<<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       48      0      309  2.94 *****  500.42  496.26    4246  497.48
         0 ******     40    23032  1.00 ***** *******    0.87   13.75

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.46 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    47.  0.05  0.19  502.63   -0.01   1600.  502.27

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    694.   135.  -117.    18.   1.7   1.0   5.6   5.0   1.4   3.2
   RT:    906.   147.    18.   165.   1.8   1.2   5.9   5.2   1.6   3.2

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                          WSEL,YLT,YRT =   502.50      504.2      501.8

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
APPRO:AS       28   -189     1988  0.19  0.22  502.69  498.25    5880  502.50
        68     34    141   175268  1.38  1.03   -0.01    0.25    2.96

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

  FIRST USER DEFINED TABLE.
   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.  -110.   117.   5880.   53926.     765.    7.69  496.65
   FULLV:FV       0.  -113.   119.   5880.   77958.    1046.    5.62  497.88
   BRIDG:BR       0.     0.    40.   4246.   23032.     309.   13.75  497.48
   RDWAY:RG      13.*******   694.   1600.******************    1.00  502.27
   APPRO:AS      68.  -190.   141.   5880.  175268.    1988.    2.96  502.50

 SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS     FR#   YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    496.65    1.03  488.25  505.83************  1.80  498.46  496.65
   FULLV:FV   ********   0.66  488.25  505.83  0.39  0.00  0.97  498.85  497.88
   BRIDG:BR    496.26    0.87  487.14  497.48************  2.94  500.42  497.48
   RDWAY:RG   ****************  500.45  507.62  0.05******  0.19  502.63  502.27
   APPRO:AS    498.25    0.25  489.78  504.17  0.22  1.03  0.19  502.69  502.50
```
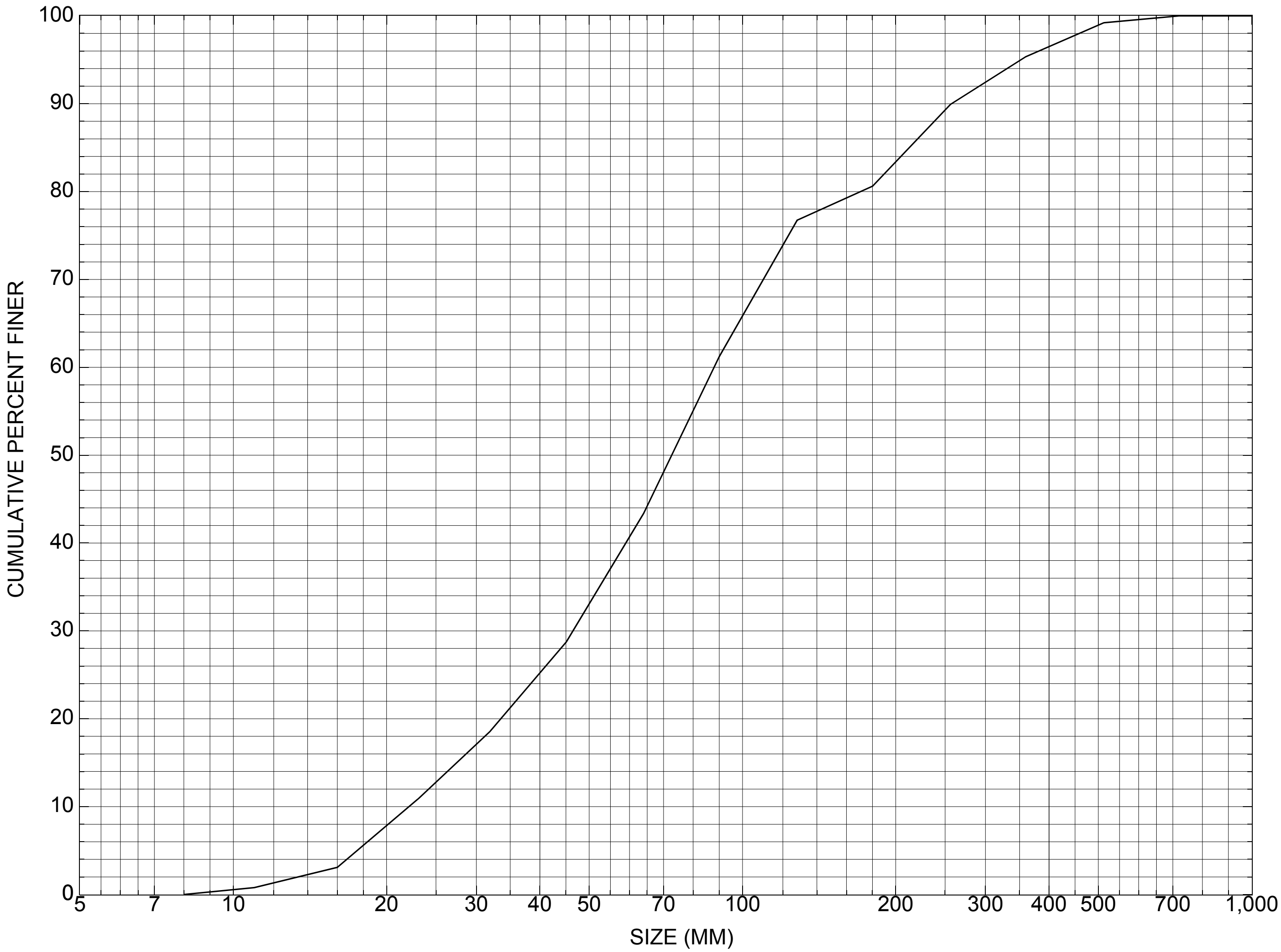

```
        U.S. Geological Survey WSPRO Input File fays006.wsp
        Hydraulic analysis for structure FAYSTH00010006   Date: 19-JUN-97
        The bridge is located 1.0 miles from junction of CL 3 and TH 9
           *** RUN DATE & TIME: 07-31-97  08:00

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******   -105      361  1.57 *****  496.34  494.08    3190  494.77
       -47 ******     61    27659  1.29 ***** *******    1.20    8.84

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.53

FULLV:FV       48   -108      607  0.80  0.42  496.75 *******    3190  495.96
         0     48    115    42435  1.86  0.00    0.00    0.77    5.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.37     496.11     496.74

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.46     504.17    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.46     504.17     496.74

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   496.74      504.17     496.74

APPRO:AS       68    -73      417  1.31 *****  498.05  496.74    3190  496.74
        68     68    117    27243  1.44 ***** *******    1.10    7.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.91     498.91     499.13     497.46

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

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

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
BRIDG:BR       48      0      309  1.60 *****  499.08  494.82    3132  497.48
         0 ******     40    23032  1.00 ***** *******    0.64   10.14

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.484  0.000  497.46 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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       28   -163     1335  0.13  0.13  500.52  496.74    3190  500.40
        68     31    125   104385  1.45  1.02   -0.02    0.24    2.39

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

  FIRST USER DEFINED TABLE.
   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.  -106.    61.   3190.   27659.     361.    8.84  494.77
   FULLV:FV       0.  -109.   115.   3190.   42435.     607.    5.25  495.96
   BRIDG:BR       0.     0.    40.   3132.   23032.     309.   10.14  497.48
   RDWAY:RG      13.**************       0.******************     1.00********
   APPRO:AS      68.  -164.   125.   3190.  104385.    1335.    2.39  500.40

  SECOND USER DEFINED TABLE.
   XSID:CODE    CRWS      FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    494.08     1.20  488.25  505.83************  1.57  496.34  494.77
   FULLV:FV  ********     0.77  488.25  505.83  0.42  0.00  0.80  496.75  495.96
   BRIDG:BR    494.82     0.64  487.14  497.48************  1.60  499.08  497.48
   RDWAY:RG  ****************  500.45  507.62************  0.11  500.89********
   APPRO:AS    496.74     0.24  489.78  504.17  0.13  1.02  0.13  500.52  500.40
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure FAYSTH00010006, in Fayston, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FAYSTH00010006

General Location Descriptive

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

Date *(MM/DD/YY)* 10 / 13 / 95

Highway District Number *(I - 2; nn)* 06

County *(FIPS county code; I - 3; nnn)* 023

Town *(FIPS place code; I - 4; nnnnn)* 25825

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

Waterway *(I - 6)* SHEPARD BROOK

Road Name *(I - 7)*: -

Route Number C2001

Vicinity *(I - 9)* 1.0 MI TO JCT W CL3 TH9

Topographic Map Waitsfield

Hydrologic Unit Code: 2010003

Latitude *(I - 16; nnnn.n)* 44139

Longitude *(i - 17; nnnnn.n)* 72480

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10120800061208

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

Maximum span length *(I - 48; nnnn)* 0040

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

Structure length *(I - 49; nnnnnn)* 000042

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

Deck Width *(I - 52; nn.n)* 215

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

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

Opening skew to Roadway *(I - 34; nn)* 33

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

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

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

Structure type *(I - 43; nnn)* 104

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 39.67

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

Vertical clearance from streambed (*nnn.n ft*) 9.11

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

Waterway of full opening (*nnn.n* ft^2) 361.3

Comments:

According to the structural inspection report dated 5/10/94, the structure is a concrete T-beam bridge. At the RABUT, there is a full-height 3/16" vertical crack below beam 1, scaling and some spalling along the bottom of the stem, a large diagonal crack at the top of the left corner, and heavy scaling on the footing. There is approx. 2-3' of local scour at the right corner of the RABUT. The LABUT has a 1/4" full-height vertical crack in its left corner, with moderate scaling and spalling along the bottom of the stem, heavy scaling along most of the footing, and heavy spalling and section loss at the RWW footing. There is section loss on the bottom stem of the RWW and a long horizontal crack in the LWW.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **16.5**

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} **1500** Q_{25} **2500**
Q_{50} **3200** Q_{100} **3900** 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:

Tailwater @ Q25 = 5.7'.
Outlet velocity @ Q 25 = 12.7 fps.
Headwater elevations are based on an invert elevation of 701 and the existing roadway grade.
Ordinary High water = 50 cfs; depth of flow = 2.0'
Ordinary Low water = 15 cfs; depth of flow = 1.5'

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*)	-	**707**	**709.6**	**711.5**	**712.8**
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): **Y** Frequency: **Q35**

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft³/ sec*): -

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

Upstream distance (*miles*): **1.2** Town: **Fayston** Year Built: **1900**

Highway No. : **C3010** Structure No. : **019** Structure Type: **302**

Clear span (*ft*): **25** Clear Height (*ft*): **9.14** Full Waterway (*ft²*): **228.5**

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)* 16.61 mi^2 Lake/pond/swamp area 0 mi^2
Watershed storage *(ST)* 0 %
Bridge site elevation 700 ft Headwater elevation 3688 ft
Main channel length 8.64 mi
10% channel length elevation 780 ft 85% channel length elevation 2190 ft
Main channel slope *(S)* 217.59 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:

There is no benchmark information available.

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

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

Foundation Type: - (*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? - *If no, type ctrl-n bi* Number of borings taken: -

Foundation Material Type: - (*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 the upstream face. The low chord elevations are from the survey log done for this report on 7/2/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 5/12/94. The sketch was done on 7/20/92.**

Station	0	1.4	10.4	19.7	29.1	39.7	-	-	-	-	-
Feature	LAB					RAB	-	-	-	-	-
Low chord elevation	497.4	497.4	497.4	497.5	497.5	497.5	-	-	-	-	-
Bed elevation	490.0	487.5	486.8	488.4	489.3	490.3	-	-	-	-	-
Low chord-bed length	7.4	9.9	10.6	9.1	8.2	7.2	-	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord - bed length	-	-	-	-	-	-	-	-	-	-	-

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

Comments:

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: LKS Date: 06/19/97
Computerized by: LKS Date: 06/19/97
Reviewd by: LKS Date: 07/31/97

Structure Number FAYSTH00010006

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. FLYNN Date *(MM/DD/YY)* 7 / 02 / 1996

2. Highway District Number 06 Mile marker -

County (023) WASHINGTON Town FAYSTON

Waterway *(I - 6)* SHEPARD BROOK Road Name N. FAYSTON ROAD

Route Number C2 001 Hydrologic Unit Code: 2010003

3. Descriptive comments:

The bridge is located 1.0 miles from the junction of CL 3 and TH 9.

B. Bridge Deck Observations

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

5. Ambient water surface... US 2 UB 1 DS 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 42 *(feet)* Span length 40 *(feet)* Bridge width 21.5 *(feet)*

Road approach to bridge:

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

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

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

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

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

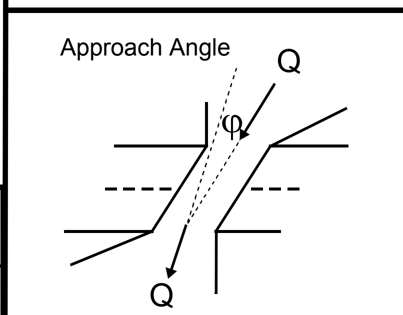
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

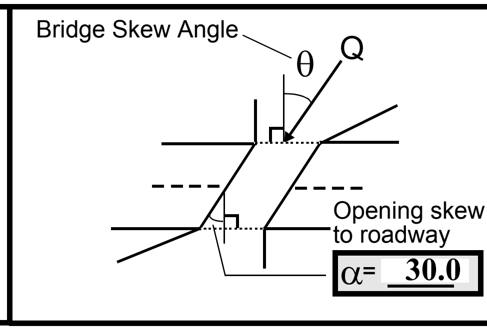
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 110 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 0 feet DS *(US, UB, DS)* to 90 feet DS

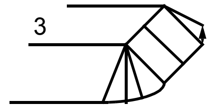
*Impact Severity: **0**- none to very slight; **1**- Slight; **2**- Moderate; **3**- Severe*

18. Bridge Type: **1a**

1a- Vertical abutments with wingwalls

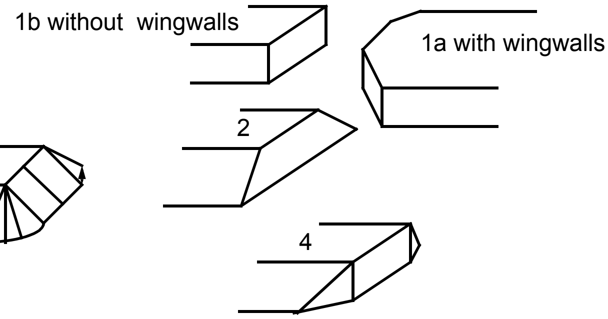
1b- Vertical abutments without wingwalls

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.)

18. The bridge type is best described as a 1a since the ends of the wingwalls are close to the elevation of the low chord.

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
46.0	**3.0**			**3.5**	**2**	**1**	**405**	**403**	**2**	**2**

23. Bank width **70.0**   24. Channel width **20.0**   25. Thalweg depth **54.0**   29. Bed Material **453**

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

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

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

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

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

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

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

30. LB: The bank protection is primarily < 12”; however, approximately 30 percent could be classified as < 36”.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **25** 35. Mid-bar width: **6**

36. Point bar extent: **55** feet **us** (US, UB) to **18** feet **ub** (US, UB, DS) positioned **90** %LB to **100** %RB

37. Material: **4523**

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

The side bar is primarily sand with some cobble and boulder (appx. 10%) from 15 ft US to 18 ft UB.

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: **90** 42. Cut bank extent: **130** feet **US** (US, UB) to **52** 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.):

-

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **7.5**

47. Scour dimensions: Length **15** Width **10** Depth : **2** Position **10** %LB to **50** %RB

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

The mid-scour distance is 7.5 ft US of the US bridge face. There is also scour at the US wingwall (see wingwall assessment). The mid-scour distance = 20 ft US, length = 10 ft, width = 8 ft, depth = 2.5 ft, the position is 50% LB to 70% RB.

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):

There are no major confluences upstream at this site.

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
43.0		1.0		2	7	7	-

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

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

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

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

4532

-

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

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

70. Debris and Ice Comments:

2

66. There are a few branches stuck at the upstream right wingwall.

69. Ice build up is evident from scarring of trees along the banks downstream.

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	3	1.5	2.0	90.0
RABUT	1	15	90			2	1	34.5

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

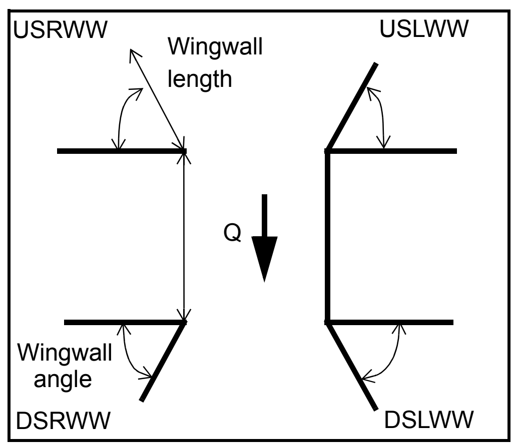
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

2
2.5
1

74. LABUT: The concrete of the footing is in poor condition and is undermined along the base as well as on tops where it meets the bottom of the abutment. RABUT: Scour is evident along the downstream 10 ft of abutment and extending downstream (see downstream assessment).

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						34.5	
USRWW:	Y		1		2	2.5	
DSLWW:	2.5		3		Y	25.0	
DSRWW:	1		0		-	25.5	



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

82. **Bank / Bridge Protection**:

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

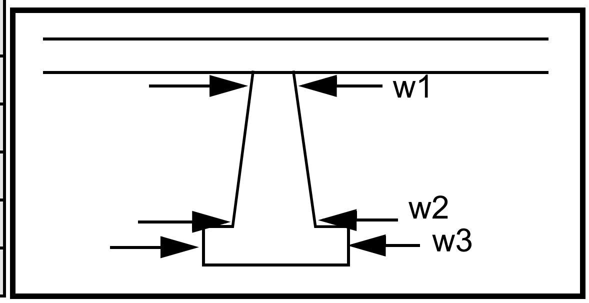
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? Co (*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				**30.0**	**21.5**	**80.0**
Pier 2				**20.0**	**120.0**	**14.5**
Pier 3			-	**35.0**	**13.5**	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ncrete**	**rating**	**ream**	**for 21**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**at**	**alon**	**left**	**ft**	*1- Solid pier, 2- column, 3- bent*
88. Material	**the**	**g the**	**wing**	**upst**	*1- Wood; 2- concrete; 3- metal; 4- stone*
89. Shape	**dow**	**base**	**wall**	**ream**	*1- Round; 2- Square; 3- Pointed*
90. Inclined?	**nstre**	**wher**	**is**	**, the**	*Y- yes; N- no*
91. Attack ∠ (BF)	**am**	**e it**	**one**	**wing**	
92. Pushed	**right**	**meet**	**large**	**wall**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**wing**	**s the**	**sec-**	**for**	
95. Cross-members	**wall**	**foot-**	**tion**	**16 ft**	*0- none; 1- laterals; 2- diagonals; 3- both*
96. Scour Condition	**is**	**ing.**	**of**	**then**	*0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed*
97. Scour depth	**dete-**	**The**	**con-**	**con-**	
98. Exposure depth	**rio-**	**upst**	**crete**	**sists**	

99. Pier comments (eg. undermined penetration, protection and protection extent, unusual scour processes, etc.):
of 2' x 2' x 4' concrete blocks.

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.):

-
-
-
-

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

Cut bank extent: no feet pie (US, UB, DS) to rs on feet this (US, UB, DS)

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

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

dge.

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

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

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

2
402
405
2

Are there major confluences? 2 (Y or if N type ctrl-n mc) How many? 4532

Confluence 1: Distance 0 Enters on 0 (LB or RB) Type - (**1**- perennial; **2**- ephemeral)

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

Confluence comments (eg. confluence name):

are cobbles in the banks on both sides of the channel but there is no bank protection, 07/02/96.

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

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: FAYSTH00010006 Town: NORTH FAYSTON
Road Number: TH 1 County: WASHINGTON
Stream: SHEPARD BROOK

Initials LKS Date: 07/08/97 Checked: SAO

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	3900	5880	3190
Main Channel Area, ft2	560	611	498
Left overbank area, ft2	669	833	486
Right overbank area, ft2	451	544	353
Top width main channel, ft	54	54	54
Top width L overbank, ft	167	178	152
Top width R overbank, ft	93	99	83
D50 of channel, ft	0.2382	0.2382	0.2382
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.4	11.3	9.2
y1, average depth, LOB, ft	4.0	4.7	3.2
y1, average depth, ROB, ft	4.8	5.5	4.3
Total conveyance, approach	140113	175314	104516
Conveyance, main channel	69510	80411	57179
Conveyance, LOB	35992	49512	22432
Conveyance, ROB	34611	45391	24905
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1934.8	2697.0	1745.2
Ql, discharge, LOB, cfs	1001.8	1660.6	684.7
Qr, discharge, ROB, cfs	963.4	1522.4	760.1
Vm, mean velocity MC, ft/s	3.5	4.4	3.5
Vl, mean velocity, LOB, ft/s	1.5	2.0	1.4
Vr, mean velocity, ROB, ft/s	2.1	2.8	2.2
Vc-m, crit. velocity, MC, ft/s	10.3	10.4	10.1
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	3900	5880	3190
(Q) discharge thru bridge, cfs	3461	4246	3190
Main channel conveyance	23032	23032	23032
Total conveyance	23032	23032	23032
Q2, bridge MC discharge,cfs	3461	4246	3190
Main channel area, ft2	309	309	309
Main channel width (normal), ft	34.3	34.3	34.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	34.3	34.3	34.3
y_bridge (avg. depth at br.), ft	9.00	9.00	9.00
Dm, median (1.25*D50), ft	0.29775	0.29775	0.29775
y2, depth in contraction,ft	9.13	10.88	8.52
ys, scour depth (y2-ybridge), ft	0.13	1.88	-0.48

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	3461	4246	3190
Main channel area (DS), ft2	282	308.7	257
Main channel width (normal), ft	34.3	34.3	34.3
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	34.3	34.3	34.3
D90, ft	0.8440	0.8440	0.8440
D95, ft	1.1555	1.1555	1.1555
Dc, critical grain size, ft	0.6653	0.8049	0.7077
Pc, Decimal percent coarser than Dc	0.162	0.112	0.146
Depth to armoring, ft	10.32	19.15	12.42

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	3900	5880	3190
Q, thru bridge MC, cfs	3461	4246	3190
Vc, critical velocity, ft/s	10.26	10.41	10.06
Va, velocity MC approach, ft/s	3.45	4.41	3.50
Main channel width (normal), ft	34.3	34.3	34.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	34.3	34.3	34.3
qbr, unit discharge, ft2/s	100.9	123.8	93.0
Area of full opening, ft2	308.7	308.7	308.7
Hb, depth of full opening, ft	9.00	9.00	9.00
Fr, Froude number, bridge MC	0.71	0.87	0.64
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	282	N/A	257
**Hb, depth at downstream face, ft	8.22	N/A	7.49
**Fr, Froude number at DS face	0.75	ERR	0.80
**Cf, for downstream face (<=1.0)	1.00	N/A	1.00
Elevation of Low Steel, ft	497.46	497.46	497.46
Elevation of Bed, ft	488.46	488.46	488.46
Elevation of Approach, ft	501.55	502.5	500.4
Friction loss, approach, ft	0.14	0.22	0.13
Elevation of WS immediately US, ft	501.41	502.28	500.27
ya, depth immediately US, ft	12.95	13.82	11.81
Mean elevation of deck, ft	500.68	500.68	500.68
w, depth of overflow, ft (>=0)	0.73	1.60	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.92	0.93
**Cc, for downstream face (<=1.0)	0.896206	ERR	0.876277
Ys, scour w/Chang equation, ft	1.66	3.88	0.91
Ys, scour w/Umbrell equation, ft	-1.85	-0.57	-2.11

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	2.75	N/A	3.05

**Ys, scour w/Umbrell equation, ft	-1.07	N/A	-0.60

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	9.13	10.88	8.52
WSEL at downstream face, ft	496.69	--	495.96
Depth at downstream face, ft	8.22	N/A	7.49
Ys, depth of scour (Laursen), ft	0.91	N/A	1.02

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	3900	5880	3190	3900	5880	3190
a', abut.length blocking flow, ft	181.05	192.95	166.75	98.35	103.75	87.65
Ae, area of blocked flow ft2	788.69	885.57	621.75	435.01	457.58	384.33
Qe, discharge blocked abut.,cfs	--	--	1130.81	--	--	842.91
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.82	2.35	1.82	2.18	2.85	2.19
ya, depth of f/p flow, ft	4.36	4.59	3.73	4.42	4.41	4.38
--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	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.151	0.182	0.166	0.173	0.211	0.185
ys, scour depth, ft	16.41	18.90	15.01	15.55	17.24	15.34

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)	181.05	192.95	166.75	98.35	103.75	87.65
y1 (depth f/p flow, ft)	4.36	4.59	3.73	4.42	4.41	4.38
a'/y1	41.56	42.04	44.72	22.24	23.52	19.99
Skew correction (p. 49, fig. 16)	0.90	0.90	0.90	1.00	1.00	1.00
Froude no. f/p flow	0.15	0.18	0.17	0.17	0.21	0.18
Ys w/ corr. factor K1/0.55:						
vertical	15.28	17.12	13.49	ERR	ERR	ERR
vertical w/ ww's	12.53	14.04	11.06	ERR	ERR	ERR
spill-through	8.40	9.42	7.42	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.75	0.87	0.8	0.75	0.87	0.8
y, depth of flow in bridge, ft	8.22	9.00	7.49	8.22	9.00	7.49
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.86	ERR	2.96	2.86	ERR	2.96
Fr>0.8 (vertical abut.)	ERR	3.62	ERR	ERR	3.62	ERR
Fr<=0.8 (spillthrough abut.)	2.49	ERR	2.59	2.49	ERR	2.59
Fr>0.8 (spillthrough abut.)	ERR	3.20	ERR	ERR	3.20	ERR