LEVEL II SCOUR ANALYSIS FOR BRIDGE 1 (BLOOTH00020001) on TOWN HIGHWAY 2, crossing MILL BROOK, BLOOMFIELD, VERMONT

U.S. Geological Survey
Open-File Report 96-408

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

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By JOSEPH D. AYOTTE and LAURA MEDALIE

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Pembroke, New Hampshire

1996

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 1 (BLOOTH00020001) ON TOWN HIGHWAY 2, CROSSING MILL BROOK, BLOOMFIELD, VERMONT

By **Joseph D. Ayotte and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BLOOTH00020001 on town highway 2 crossing Mill Brook, Bloomfield, 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 White Mountain section of the New England Upland physiographic province of north-east Vermont in the town of Bloomfield. The 4.85-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the banks have dense woody vegetation coverage.

In the study area, Mill Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 28 ft and an average channel depth of 4 ft. The predominant channel bed materials are gravel and cobbles (D_{50} is 57.3 mm or 0.188 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 6, 1995, indicated that the reach was stable.

The town highway 2 crossing of Mill Brook is a 26-ft-long, one-lane bridge consisting of one 24-foot concrete span (Vermont Agency of Transportation, written commun., August 4, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 10 degrees.

No scour was observed along the channel or at the bridge during the Level I assessment. Type-2 stone fill (less than 24 inches diameter) was noted as present along all wingwalls. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term aggradation or degradation; 2) contraction scour (due to reduction in flow area caused by a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute scour depths for contraction and local scour and a summary of the results follows.

Contraction scour for all modelled flows ranged from 0 to 1.0 feet and the worst-case contraction scour occurred at the incipient overtopping discharge. Abutment scour ranged from 7.3 to 10.1 feet and 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.

Tinkerville, NH-VT. Quadrangle, 1:24,000, 1988

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 BLOOTH00020001 ***Stream*** Mill Brook

County Essex ***Road*** TH 2 ***District*** 09

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 17.1 ***ft*** ***Max span length*** 24 ***ft***

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

Abutment type Vertical ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 7/6/95

Description of stone fill Type-2, around all four wingwalls, in good condition.

Brief description of piers/abutments Abutments and wingwalls are concrete.

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

There is a mild channel bend in the downstream reach.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/6/95	0	0
Level II	7/6/95	--	--

Potential for debris Moderate.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 7/6/95, but channel contains many large boulders

Description of the Geomorphic Setting

General topography The channel is located within a narrow valley with steep valley walls on both sides.

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

Date of inspection 7/6/95

DS left: Narrow overbank to steep valley wall

DS right: Narrow overbank to steep valley wall

US left: Narrow overbank to steep valley wall

US right: Narrow overbank to steep valley wall

Description of the Channel

Average top width 28 ***ft*** ***Average depth*** 4.0 ***ft***

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

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

7/6/95

Vegetative co Forest

DS left: Forest

DS right: Forest

US left: Forest

US right:

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

The assessment of 7/6/95 noted large boulders in the channel.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.85 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: --

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 1,030 ***ft³/s*** ***Q500*** 1,420 ***ft³/s***

The 100- and 500-year discharges are based on the median value of several empirical methods (Potter, 1957a&b; Johnson and Tasker, 1974; FHWA, 1983; Talbot, 1887; Richardson and others, 1993).

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

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

Datum tie between USGS survey and VTAOT plans --

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the US end of the left abutment and wingwall joint (elev. 1288.51 ft, arbitrary datum). RM2 is the center of VTAOT brass disk on DS right abutment (elev. 1287.96 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[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 analysis reported herein reflects 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 0.055 to 0.059, and overbank "n" values ranged from 0.050 to 0.080.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the User's manual for WSPRO (Shearman, 1990). The slope used was 0.032 ft/ft which was determined from cross-section thalweg points between the EXITX and the BRIDG sections.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.033 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 approach also provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. Further analysis, in which the water surface is shown to pass through critical depth in the bridge, suggests the critical depth assumption at the bridge section is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 1288.4 ***ft***
Average low steel elevation 1286.8 ***ft***

100-year discharge 1,030 ***ft³/s***
Water-surface elevation in bridge opening 1286.8 ***ft***
Road overtopping? Y ***Discharge over road*** 52 ***ft³/s***
Area of flow in bridge opening 148 ***ft²***
Average velocity in bridge opening 6.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.2 ***ft/s***

Water-surface elevation at Approach section with bridge 1287.7
Water-surface elevation at Approach section without bridge 1285.2
Amount of backwater caused by bridge 2.5 ***ft***

500-year discharge 1,420 ***ft³/s***
Water-surface elevation in bridge opening 1286.8 ***ft***
Road overtopping? Y ***Discharge over road*** 219 ***ft³/s***
Area of flow in bridge opening 148 ***ft²***
Average velocity in bridge opening 8.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***ft/s***

Water-surface elevation at Approach section with bridge 1288.3
Water-surface elevation at Approach section without bridge 1286.4
Amount of backwater caused by bridge 1.9

Incipient overtopping discharge 960 ***ft³/s***
Water-surface elevation in bridge opening 1283.5 ***ft***
Area of flow in bridge opening 83 ***ft²***
Average velocity in bridge opening 11.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.8 ***ft/s***

Water-surface elevation at Approach section with bridge 1286.9
Water-surface elevation at Approach section without bridge 1284.9
Amount of backwater caused by bridge 2.0 ***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 was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 100-year and 500-year discharges, where there was orifice flow at the bridge. 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). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) were also computed for the 100-year and 500-year discharges and can be found in appendix F. Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient road-overflow discharge. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the incipient road-overflow model resulted in the worst case contraction scour with a scour depth of 1.0 ft. However, it was not the worst case total scour.

Abutment scour for all modelled discharges was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). The Froehlich equation gives "excessively conservative estimates of scour depths" (Richardson and others, 1995, p. 47). 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	0.3	1.0
Depth to armoring	0.7	1.9	19.1
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	8.3	10.1	7.3
Right abutment	8.0	9.0	7.4
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	0.9	1.4	1.7
Right abutment	0.9	1.4	1.7
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

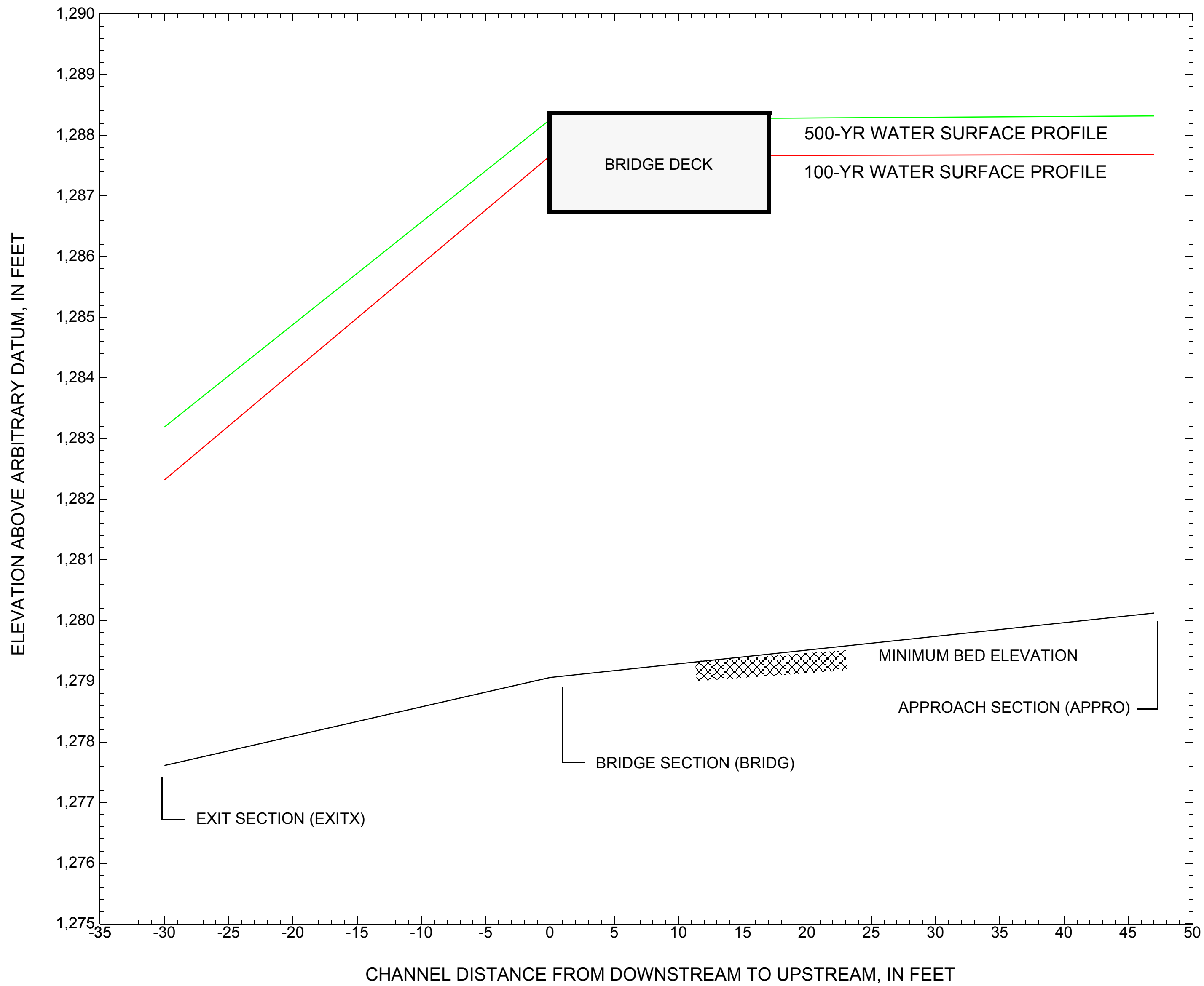

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BLOOTH00020001 on town highway 2, crossing Mill Brook, Bloomfield, Vermont.

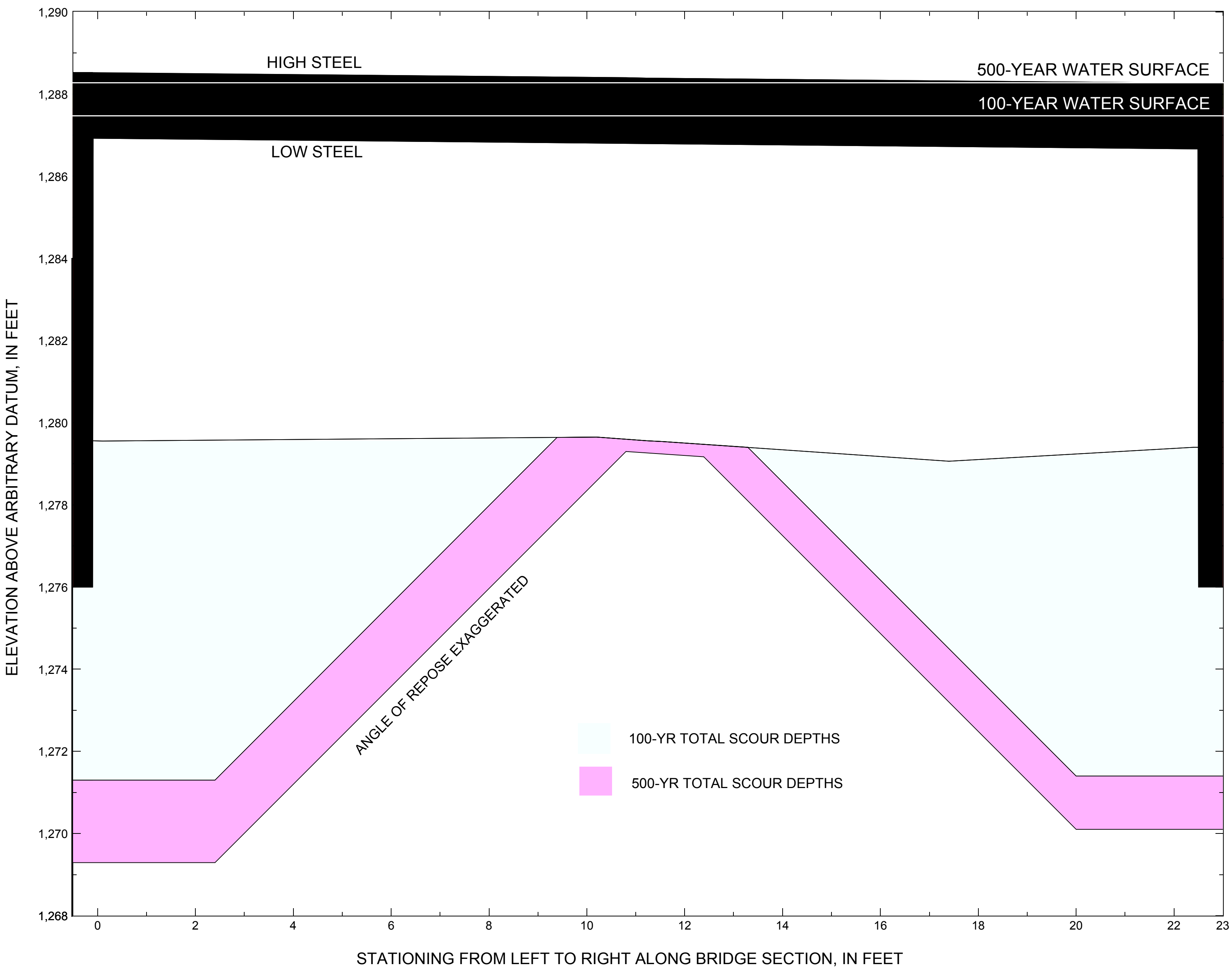

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00340026 on town highway 34, crossing Ottauquechee River, Bridgewater, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BLOOTH00020001 on Town Highway 2, crossing Mill Brook, Bloomfield, 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 8,030 cubic-feet per second											
Left abutment	0.0	1286.93	1286.93	1276	1279.6	0.0	8.3	--	8.3	1271.3	-5
Right abutment	22.5	1286.60	1286.60	1276	1279.4	0.0	8.0	--	8.0	1271.4	-5

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 BLOOTH00020001 on Town Highway 2, crossing Mill Brook, Bloomfield, 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 11,600 cubic-feet per second											
Left abutment	0.0	1286.93	1286.93	1276	1279.6	0.3	10.1	--	10.4	1269.2	-7
Right abutment	22.5	1286.60	1286.60	1276	1279.4	0.3	9.0	--	9.3	1270.1	-6

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File bloo001.wsp
T2        Hydraulic analysis for structure BLOOTH00020001   Date: 09-APR-96
T3        Bloomfield br 1, Mill Brook crossing town highway 2       JDA
Q           1030.0   1420.0   960
SK          0.0320   0.0320   0.0320
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -30           0.
GR         -114.4,1294.12   -104.8,1286.22    -83.5,1286.55    -49.3,1287.40
GR          -19.6,1287.63    -12.5,1288.07     -3.9,1283.62      0.0,1278.84
GR            1.0,1278.61      4.1,1277.99      8.4,1278.39     12.4,1278.06
GR           17.4,1277.61     19.8,1277.91     20.2,1278.40     23.9,1281.79
GR           31.6,1286.28     58.7,1285.97     96.4,1286.23    122.1,1285.91
GR          139.5,1288.33
*
N           0.080        0.055        0.050
SA                 -12.5         31.6
*
*
XS   FULLV       0  * * *   0.0320
*
*             SRD     LSEL    XSSKEW
BR   BRIDG      0   1286.76      25.0
GR            0.0,1286.93      0.1,1279.80      0.1,1279.55      5.3,1279.56
GR           10.2,1279.65     17.4,1279.06     22.4,1279.36     22.4,1279.66
GR           22.5,1286.60      0.0,1286.93
*
*         BRTYPE  BRWDTH      WWANGL    WWWID
CD             1      31.9  * *   55       9.8
N           0.055
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      17.1     2
GR         -132.4,1299.23   -120.2,1292.62    -40.5,1289.39      0.0,1288.63
GR           22.6,1288.15     60.0,1287.36     79.8,1286.82    102.8,1288.95
*
*
XT   APTEM      51
GR         -164.3,1298.66   -143.8,1294.92    -35.7,1289.20    -22.3,1287.12
GR          -11.4,1285.38     -4.0,1284.60      1.6,1281.88      4.0,1281.56
GR           12.2,1280.74     15.1,1280.56     18.8,1280.25     21.0,1280.62
GR           21.6,1280.85     24.5,1284.30     29.9,1286.25     37.0,1291.26
*
AS   APPRO      47 * * 0.033
GT
N           0.075        0.059
SA                 -35.7
*
HP 1 BRIDG 1286.76 1 1286.76
HP 2 BRIDG 1286.76 * * 977
```

```
HP 2 RDWAY 1287.66 * * 52
HP 1 APPRO 1287.68 1 1287.68
HP 2 APPRO 1287.68 * * 1030
*
*
*
*

HP 1 BRIDG 1286.76 1 1286.76
HP 2 BRIDG 1286.76 * * 1205
HP 2 RDWAY 1288.26 * * 219
HP 1 APPRO 1288.32 1 1288.32
HP 2 APPRO 1288.32 * * 1420
*
HP 1 BRIDG 1283.54 1 1283.54
HP 2 BRIDG 1283.54 * * 960
HP 1 APPRO 1286.86 1 1286.86
HP 2 APPRO 1286.86 * * 960
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

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

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     148.    8933.    11.    45.                       3156.
 1286.76          148.    8933.    11.    45.  1.00     0.    23.   3156.
   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

        WSEL     LEW     REW    AREA        K        Q    VEL
     1286.76     0.0    22.5   148.1    8933.     977.   6.60

X STA.        0.0        2.1        3.2        4.2        5.1        6.0
  A(I)            13.2        7.7        6.4        5.9        5.7
  V(I)            3.70       6.37       7.66       8.23       8.61

X STA.        6.0        6.9        7.7        8.5        9.4       10.2
  A(I)             5.5        5.4        5.3        5.4        5.4
  V(I)            8.82       9.01       9.17       8.98       9.00

X STA.       10.2       11.0       12.0       13.1       14.2       15.4
  A(I)             5.5        6.3        7.4        7.4        7.5
  V(I)            8.87       7.74       6.57       6.61       6.54

X STA.       15.4       16.5       17.6       18.9       20.2       22.5
  A(I)             7.7        8.0        8.3        9.0       15.0
  V(I)            6.35       6.10       5.86       5.45       3.26

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1287.66    45.8    88.9    17.2     278.      52.   3.02

X STA.       45.8       59.2       63.1       65.7       67.8       69.4
  A(I)             1.9        1.3        1.1        1.0        0.9
  V(I)            1.37       2.00       2.35       2.65       2.93

X STA.       69.4       70.9       72.2       73.3       74.4       75.3
  A(I)             0.9        0.8        0.8        0.7        0.7
  V(I)            3.04       3.38       3.42       3.68       3.76

X STA.       75.3       76.3       77.1       77.9       78.7       79.5
  A(I)             0.7        0.6        0.6        0.6        0.6
  V(I)            3.90       4.02       4.16       4.13       4.09

X STA.       79.5       80.2       81.1       82.2       83.7       88.9
  A(I)             0.6        0.7        0.7        0.8        1.2
  V(I)            4.11       3.90       3.64       3.16       2.09

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            2     233.   14213.    59.    62.                       2637.
 1287.68          233.   14213.    59.    62.  1.00   -27.    32.   2637.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1287.68   -26.7    32.1   233.3   14213.    1030.   4.41

X STA.      -26.7       -8.8       -3.1        0.2        2.3        4.1
  A(I)            25.1       17.2       14.6       12.3       10.9
  V(I)            2.05       2.99       3.52       4.18       4.71

X STA.        4.1        5.8        7.3        8.8       10.1       11.4
  A(I)            10.5       10.1        9.6        9.4        9.0
  V(I)            4.89       5.11       5.34       5.50       5.74

X STA.       11.4       12.7       13.9       15.1       16.3       17.5
  A(I)             8.9        8.7        8.8        8.8        8.8
  V(I)            5.78       5.90       5.88       5.84       5.84

X STA.       17.5       18.7       20.0       21.4       23.7       32.1
  A(I)             9.0        9.5       10.1       13.4       18.5
  V(I)            5.73       5.43       5.08       3.85       2.78
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   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     148.    8933.    11.    45.                       3156.
  1286.76         148.    8933.    11.    45.  1.00     0.    23.   3156.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1286.76     0.0    22.5   148.1    8933.    1205.   8.14

X STA.         0.0        2.1        3.2        4.2        5.1        6.0
  A(I)            13.2        7.7        6.4        5.9        5.7
  V(I)            4.57       7.86       9.44      10.15      10.62

X STA.         6.0        6.9        7.7        8.5        9.4       10.2
  A(I)             5.5        5.4        5.3        5.4        5.4
  V(I)           10.87      11.11      11.31      11.07      11.10

X STA.        10.2       11.0       12.0       13.1       14.2       15.4
  A(I)             5.5        6.3        7.4        7.4        7.5
  V(I)           10.93       9.55       8.10       8.15       8.07

X STA.        15.4       16.5       17.6       18.9       20.2       22.5
  A(I)             7.7        8.0        8.3        9.0       15.0
  V(I)            7.83       7.53       7.22       6.72       4.03

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1288.26    17.4    95.3    53.5    1342.     219.   4.09

X STA.        17.4       40.1       46.7       51.4       55.2       58.6
  A(I)             5.5        3.6        3.1        2.9        2.8
  V(I)            2.01       3.02       3.49       3.76       3.92

X STA.        58.6       61.5       64.0       66.3       68.4       70.3
  A(I)             2.6        2.5        2.3        2.3        2.2
  V(I)            4.15       4.43       4.70       4.77       4.99

X STA.        70.3       72.1       73.7       75.3       76.8       78.3
  A(I)             2.1        2.1        2.0        2.1        2.0
  V(I)            5.11       5.24       5.39       5.33       5.39

X STA.        78.3       79.7       81.3       83.3       86.0       95.3
  A(I)             2.0        2.2        2.3        2.7        4.0
  V(I)            5.35       4.99       4.70       3.99       2.73

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            2     273.   17445.    64.    68.                       3196.
  1288.32         273.   17445.    64.    68.  1.00   -31.    33.   3196.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1288.32   -30.9    33.0   272.6   17445.    1420.   5.21

X STA.       -30.9      -11.6       -5.7       -1.5        1.1        3.1
  A(I)            29.1       19.5       17.7       15.0       13.3
  V(I)            2.44       3.64       4.01       4.72       5.36

X STA.         3.1        4.9        6.6        8.1        9.6       11.0
  A(I)            12.3       11.6       11.3       10.9       10.5
  V(I)            5.79       6.14       6.30       6.49       6.78

X STA.        11.0       12.4       13.7       15.0       16.3       17.5
  A(I)            10.4       10.2       10.2       10.3       10.3
  V(I)            6.85       6.97       6.96       6.91       6.91

X STA.        17.5       18.8       20.2       21.7       24.4       33.0
  A(I)            10.5       11.0       11.7       16.0       20.9
  V(I)            6.79       6.44       6.05       4.44       3.39
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    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      83.    4629.    20.    28.                        959.
  1283.54           83.    4629.    20.    28.  1.00     0.    22.    959.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1283.54     0.0    22.5    83.4    4629.     960.  11.51

X STA.         0.0        2.2        3.4        4.6        5.7        6.7
  A(I)              7.5        4.6        4.1        4.0        3.8
  V(I)             6.36      10.36      11.61      12.08      12.69

X STA.         6.7        7.8        8.8        9.8       10.9       11.8
  A(I)              3.7        3.7        3.6        3.7        3.5
  V(I)            13.03      13.14      13.38      13.12      13.70

X STA.        11.8       12.8       13.7       14.6       15.5       16.4
  A(I)              3.5        3.5        3.5        3.5        3.6
  V(I)            13.61      13.78      13.64      13.76      13.49

X STA.        16.4       17.3       18.3       19.3       20.5       22.5
  A(I)              3.6        3.8        4.1        4.6        7.5
  V(I)            13.21      12.77      11.81      10.35       6.36

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     188.   10676.    52.    56.                       2016.
  1286.86          188.   10676.    52.    56.  1.00   -21.    31.   2016.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1286.86   -21.5    30.9   187.7   10676.     960.   5.11

X STA.       -21.5       -5.0       -0.5        1.9        3.7        5.3
  A(I)             20.5       13.7       11.1        9.5        9.0
  V(I)             2.34       3.51       4.32       5.03       5.32

X STA.         5.3        6.8        8.2        9.5       10.8       12.0
  A(I)              8.5        7.9        7.8        7.5        7.4
  V(I)             5.68       6.11       6.14       6.42       6.49

X STA.        12.0       13.1       14.2       15.3       16.4       17.5
  A(I)              7.1        7.2        7.1        7.0        7.3
  V(I)             6.77       6.69       6.78       6.87       6.59

X STA.        17.5       18.6       19.8       21.0       22.9       30.9
  A(I)              7.3        7.7        8.3       10.4       15.6
  V(I)             6.60       6.22       5.81       4.63       3.07
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+++ BEGINNING PROFILE CALCULATIONS --   3
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -3.      99.  1.70 ***** 1284.02 1282.26   1030. 1282.32
      -30. ******    25.    5754.  1.00 ***** *******    0.98   10.45

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.97    1283.30    1283.22

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1281.82    1295.08    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1281.82    1295.08    1283.22

FULLV:FV      30.    -3.     100.  1.66  0.95 1284.98 1283.22   1030. 1283.31
        0.    30.    25.    5838.  1.00  0.00    0.01    0.96   10.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95    1285.21    1285.06

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1282.81    1298.53    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1282.81    1298.53    1285.06

APPRO:AS      47.   -11.     112.  1.32  1.55 1286.52 1285.06   1030. 1285.20
       47.    47.    27.    5522.  1.00  0.01   -0.02    0.95    9.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =  1287.15       0.00    1283.75    1286.82

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =  1289.81         0.      1030.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

 ===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      30.     0.     148.  0.68 ***** 1287.44 1283.60    977. 1286.76
        0. ******    23.    8933.  1.00 ***** *******    0.45    6.60
     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.393  0.000 1286.76 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    30.  0.16  0.30 1287.83    0.00     52. 1287.66

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    47.   -35.    12.   0.9   0.4   4.2   5.9   0.9   2.9
   RT:     52.    43.    46.    89.   0.8   0.4   3.2   3.0   0.6   2.8

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

APPRO:AS      15.   -27.     233.  0.30  0.13 1287.98 1285.06   1030. 1287.68
       47.    16.    32.   14211.  1.00  0.00    0.00    0.39    4.41

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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WSPRO OUTPUT FILE (continued)

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  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -30.    -3.    25.   1030.    5754.      99.   10.45 1282.32
   FULLV:FV       0.    -3.    25.   1030.    5838.     100.   10.35 1283.31
   BRIDG:BR       0.     0.    23.    977.    8933.     148.    6.60 1286.76
   RDWAY:RG       9.*******     0.     52.       0.*********    2.00 1287.66
   APPRO:AS      47.   -27.    32.   1030.   14211.     233.    4.41 1287.68

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  ***********************
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS   1282.26    0.98 1277.61 1294.12************  1.70 1284.02 1282.32
   FULLV:FV   1283.22    0.96 1278.57 1295.08  0.95  0.00  1.66 1284.98 1283.31
   BRIDG:BR   1283.60    0.45 1279.06 1286.93************  0.68 1287.44 1286.76
   RDWAY:RG  *************** 1286.82 1299.23  0.16******  0.30 1287.83 1287.66
   APPRO:AS   1285.06    0.39 1280.12 1298.53  0.13  0.00  0.30 1287.98 1287.68
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -4.     124.  2.05 ***** 1285.24 1283.17   1420. 1283.19
      -30. ******    26.    7933.  1.00 ***** *******    0.99   11.47

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.98    1284.19    1284.13

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1282.69    1295.08    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1282.69    1295.08    1284.13

FULLV:FV      30.    -4.     123.  2.07  0.97 1286.20 1284.13   1420. 1284.13
        0.    30.    26.    7875.  1.00  0.01   -0.02    1.00   11.53
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.83    1286.42    1285.89

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1283.63    1298.53    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1283.63    1298.53    1285.89

APPRO:AS      47.   -19.     164.  1.16  1.35 1287.56 1285.89   1420. 1286.39
       47.    47.    30.    8945.  1.00  0.03   -0.02    0.83    8.65
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =  1288.73       0.00    1284.77    1286.82

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =  1290.17         0.      1420.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

 ===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      30.     0.     148.  1.03 ***** 1287.79 1284.23   1205. 1286.76
        0. ******    23.    8933.  1.00 ***** *******    0.56    8.13

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.449  0.000 1286.76 ****** ****** ******
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   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG       9.    30.  0.20  0.42 1288.55    0.00    219. 1288.26

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:      0.     4.     7.    12.   0.1   0.0   2.4  13.3   0.4   2.6
  RT:    219.    73.    23.    95.   1.4   0.7   4.4   4.1   1.0   2.9

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

APPRO:AS      15.   -31.     273.  0.42  0.17 1288.74 1285.89   1420. 1288.32
       47.    16.    33.   17465.  1.00  0.00    0.00    0.44    5.20

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
  EXITX:XS     -30.    -4.    26.   1420.    7933.     124.   11.47 1283.19
  FULLV:FV       0.    -4.    26.   1420.    7875.     123.   11.53 1284.13
  BRIDG:BR       0.     0.    23.   1205.    8933.     148.    8.13 1286.76
  RDWAY:RG       9.*******     0.    219.       0.*********    2.00 1288.26
  APPRO:AS      47.   -31.    33.   1420.   17465.     273.    5.20 1288.32

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

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXITX:XS   1283.17    0.99 1277.61 1294.12************  2.05 1285.24 1283.19
  FULLV:FV   1284.13    1.00 1278.57 1295.08  0.97  0.01  2.07 1286.20 1284.13
  BRIDG:BR   1284.23    0.56 1279.06 1286.93************  1.03 1287.79 1286.76
  RDWAY:RG   *************** 1286.82 1299.23  0.20******  0.42 1288.55 1288.26
  APPRO:AS   1285.89    0.44 1280.12 1298.53  0.17  0.00  0.42 1288.74 1288.32
 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

EXITX:XS   ******    -3.      94.  1.63 ***** 1283.77 1282.08    960. 1282.14
      -30. ******    25.    5364.  1.00 ***** *******    0.97   10.24

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.96    1283.13    1283.04

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1281.64    1295.08    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1281.64    1295.08    1283.04

FULLV:FV      30.    -3.      95.  1.60  0.95 1284.73 1283.04    960. 1283.14
        0.    30.    25.    5442.  1.00  0.00    0.02    0.96   10.13
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.96    1284.95    1284.83

 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =  1282.64    1298.53    0.50

 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =  1282.64    1298.53    1284.83

APPRO:AS      47.    -8.     102.  1.37  1.58 1286.31 1284.83    960. 1284.94
       47.    47.    27.    5040.  1.00  0.01   -0.01    0.97    9.37
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =  1286.86       0.00    1283.54    1286.82

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID “BRIDG”     Q,CRWS =     960.     1283.54
            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>
```
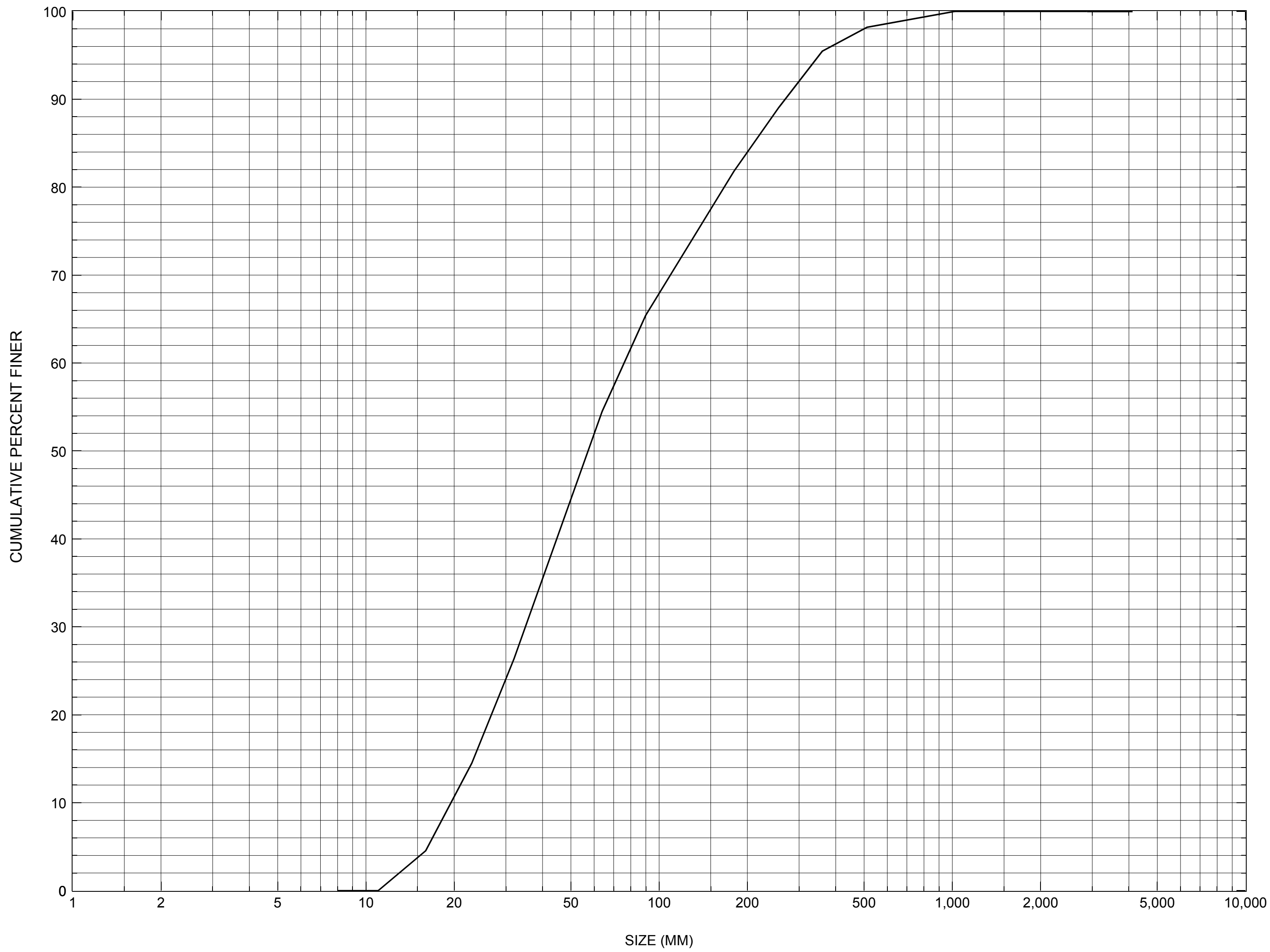

```
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 BRIDG:BR      30.     0.      83.  2.06 ***** 1285.60 1283.54    960. 1283.54
         0.    30.    22.    4632.  1.00 ***** *******    1.00   11.51

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   4.  1.000 ****** 1286.76 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG       9.        <<<<<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      15.   -21.     188.  0.41  0.29 1287.27 1284.83    960. 1286.86
        47.    16.    31.   10684.  1.00  1.37   -0.02    0.48    5.11

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.362  0.002   10734.     1.    24. ********
                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -30.    -3.    25.    960.    5364.      94.   10.24 1282.14
    FULLV:FV       0.    -3.    25.    960.    5442.      95.   10.13 1283.14
    BRIDG:BR       0.     0.    22.    960.    4632.      83.   11.51 1283.54
    RDWAY:RG       9.**************      0.       0.       0.    2.00********
    APPRO:AS      47.   -21.    31.    960.   10684.     188.    5.11 1286.86

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS       1.    24.   10734.
  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS   1282.08    0.97 1277.61 1294.12************  1.63 1283.77 1282.14
    FULLV:FV   1283.04    0.96 1278.57 1295.08  0.95  0.00  1.60 1284.73 1283.14
    BRIDG:BR   1283.54    1.00 1279.06 1286.93************  2.06 1285.60 1283.54
    RDWAY:RG   **************** 1286.82 1299.23  0.24******  0.41 1287.03********
    APPRO:AS   1284.83    0.48 1280.12 1298.53  0.29  1.37  0.41 1287.27 1286.86
      END OF FILE ON PRIMARY INPUT UNIT  55


1  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count transect at the approach cross-section for structure BRIDTH00340026, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BLOOTH00020001

General Location Descriptive

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

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

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

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 06325

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

Waterway *(I - 6)* MILL BROOK

Road Name *(I - 7):* -

Route Number TH002

Vicinity *(I - 9)* 1.38 MI TO JCT W VT102

Topographic Map Tinkerville, NH

Hydrologic Unit Code: 01080101

Latitude *(I - 16; nnnn.n)* 44478

Longitude *(i - 17; nnnnn.n)* 71365

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10050300010503

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

Maximum span length *(I - 48; nnnn)* 0024

Year built *(I - 27; YYYY)* 1988

Structure length *(I - 49; nnnnnn)* 000026

Average daily traffic, ADT *(I - 29; nnnnnn)* 000020

Deck Width *(I - 52; nn.n)* 171

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

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 25

Waterway adequacy *(I - 71; n)* 7

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 019.6

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

Vertical clearance from streambed (*nnn.n ft*) 006.0

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

Waterway of full opening (*nnn.n* ft^2) 120.0

Comments:
-

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **4.81**

Terrain character: **Hilly, wooded, no permanent population**

Stream character & type: -

Streambed material: **Boulders**

Discharge Data *(cfs)*: $Q_{2.33}$ **300** Q_{10} **675** Q_{25} **900**
Q_{50} **1100** Q_{100} **1300** Q_{500} -

Record flood date *(MM / DD / YY)*: - / - / - Water surface elevation *(ft)*: -

Estimated Discharge *(cfs)*: - Velocity at Q - *(ft/s)*: -

Ice conditions *(Heavy, Moderate, Light)* : **Light** Debris *(Heavy, Moderate, Light)*: **Heavy**

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*)

<u>Water Surface Elevation Estimates for Existing Structure:</u>

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	-	**1286.6**	**1288.0**	**1288.5**	**1289.1**
Velocity (*ft / sec*)	-	-	**14.5**	-	-

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*): **Y** *If No or Unknown, type ctrl-n os*

Upstream distance (*miles*): **0.75** Town: - Year Built: -

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

Downstream distance (*miles*): **-** Town: **Bloomfield** Year Built: **1973**
Highway No. : **TH 2** Structure No. : **B 2** Structure Type: **Concrete slab bridge**
Clear span (*ft*): **18** Clear Height (*ft*): **7** Full Waterway (ft^2): **126**

Comments:
Ice problems noted with bridge 2 downstream. Field notes do not indicate ice problems at this site.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.85** mi^2 Lake and pond area **0** mi^2
Watershed storage *(ST)* **0** %
Bridge site elevation **1280** ft Headwater elevation **2448** ft
Main channel length **4.15** mi
10% channel length elevation **1400** ft 85% channel length elevation **2060** ft
Main channel slope *(S)* **212.09** ft / mi

Watershed Precipitation Data

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

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **10** / **1987**

Project Number **TH 3623** Minimum channel bed elevation: **1278.5**

Low superstructure elevation: USLAB **1286.93** DSLAB **1287.07** USRAB **1286.60** DSRAB **1286.45**

Benchmark location description:

Top of concrete deck at landward edge of left abutment and downstream face of bridge guard rail, elevation 1288.93.

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

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

If 1: Footing Thickness **2.0** Footing bottom elevation: **1276.0**

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

If 3: Footing bottom elevation: **-**

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

Cross-sectional Data

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

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

Comments: **To be retrieved when deemed necessary.**

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

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

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

Comments:

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: MAI Date: 10/23/95
Computerized by: MAI Date: 10/23/95
Reviewd by: JDA Date: 4/26/96

Structure Number BLOOTH00020001

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 7 / 6 / 1995
2. Highway District Number 04 Mile marker 0
   County Essex (009) Town Bloomfield (06325)
   Waterway *(I - 6)* Mill Brook Road Name -
   Route Number TH 2 Hydrologic Unit Code: 01080101
3. Descriptive comments:

1.38 miles to the junction with VT 102.

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 2 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 26.0 *(feet)* Span length 24.0 *(feet)* Bridge width 17.1 *(feet)*

Road approach to bridge:

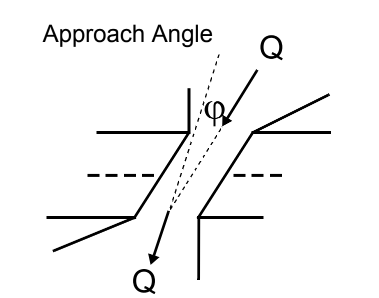
8. LB 2 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
    US left 0.0:1 US right 0.0:1

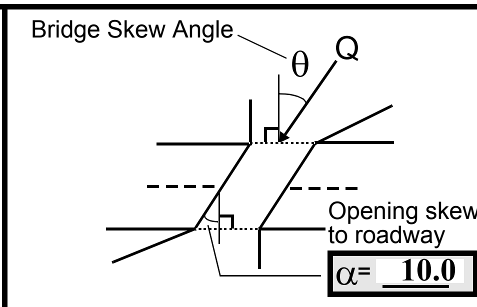
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	1	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	1	1	0	0

*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: 25 16. Bridge skew: 30





17. Channel impact zone 1: Exist? Y *(Y or N)*
    Where? RB *(LB, RB)* Severity 2
    Range? 26 feet US *(US, UB, DS)* to 120 feet US
    Channel impact zone 2: Exist? N *(Y or N)*
    Where? - *(LB, RB)* Severity -
    Range? - feet - *(US, UB, DS)* to - feet -

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

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

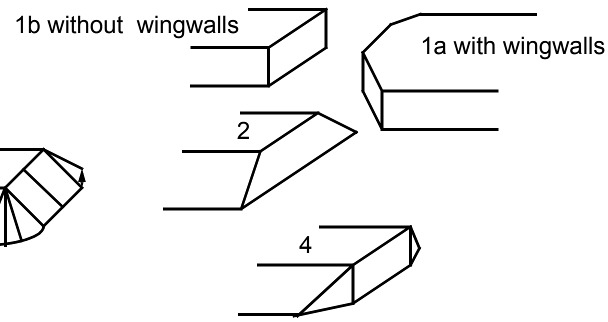
1a- Vertical abutments with wingwalls

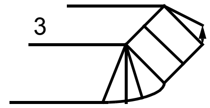
1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





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

4. The predominant surface cover is forest, but since this is a relatively new bridge it is still clear of trees within one bridge length in all directions.
8. The right road approach goes down after about 60 feet and follows the stream valley.
11. The left bank upstream protection may be native stones.
17. Impact zone 1 becomes severe 100 feet US and slight under the bridge and DS as the meander angle decreases.
18. The wingwall ends are not lower than the low chords.

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
34.9	**2.5**			**3.5**	**1**	**2**	**4352**	**4352**	**1**	**2**

23. Bank width **25.0** 24. Channel width **50.0** 25. Thalweg depth **28.5** 29. Bed Material **4352**

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 protection is placed, extending 23 feet from the bridge upstream. The material could be native, but has been dumped.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **55** 35. Mid-bar width: **15**

36. Point bar extent: **14** feet **US** (US, UB) to **104** feet **US** (US, UB, DS) positioned **0** %LB to **55** %RB

37. Material: **43**

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

Point bar consisting of cobbles, gravel, boulders, and sand.

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

41. Mid-bank distance: **100** 42. Cut bank extent: **26** feet **US** (US, UB) to **120** 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.):

43. More severe erosion in local spots with tree roots offering stability.
The cut bank ends where the right bank protection begins.

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

49. Are there major confluences? **N** (Y or if N type ctrl-n mc) 50. How many? **-**

51. Confluence 1: Distance **-** 52. Enters on **-** (LB or RB) 53. Type **-** (*1*- perennial; *2*- ephemeral)

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES
There is a minor confluence entering the right bank at 120 feet US.

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
20.0		0.5		2	7	7	-

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

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

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

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

432
63. Bed material consist of cobble, gravel, and sand.

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

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

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

70. Debris and Ice Comments:

1

The bridge opening is narrower than the top of bank width.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	0	-	-	90.0
RABUT	1	10	90			2	0	23.0

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

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

-

-

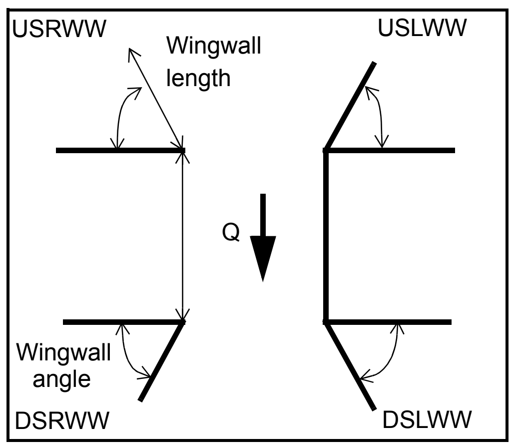
1

This is a new bridge in good condition. The channel under the bridge has a shallower slope than the US and DS sections.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						23.0	
USRWW:	Y		1		0	0.5	
DSLWW:	-		-		Y	24.5	
DSRWW:	1		0		-	25.0	

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	-	0	Y	-	1	1	-	-
Condition	Y	-	1	-	1	1	-	-
Extent	1	-	0	2	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

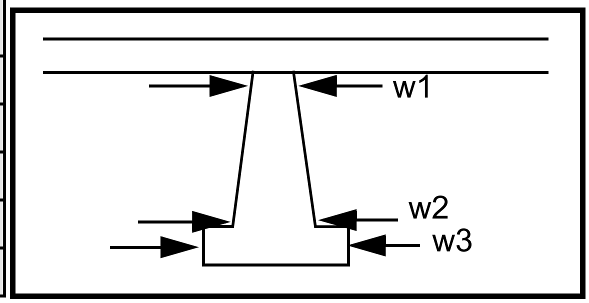
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
3
2
1
1

Piers:

84. Are there piers? __--__ *(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				**20.0**	**20.5**	**90.0**
Pier 2	**8.0**	**9.5**		**65.0**	**20.0**	**13.5**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	NO	PIE	RS		

Bank width (BF) - Channel width (Amb) - Thalweg depth (Amb) - 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.):

1
1
4352
4352
0
0
4352
2
2
1
1
Left bank protection extends 38 feet DS from the bridge.
Right bank protection extends 65 feet DS from the bridge.

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 **N** feet **-** *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

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

STRUCTURE

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

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.):

-
-
-
-

Is channel scour present? **NO** *(Y or if N type ctrl-n cs)* Mid-scour distance: **POIN**

Scour dimensions: Length **T** Width **BAR** Depth: **S** Positioned ____ %LB to ____ %RB

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

N
-
-

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 **NO** Enters on **CU** *(LB or RB)* Type **T** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

BANKS

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 CHANNEL SCOUR

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: BLOOTH00020001 Town: Bloomfield
Road Number: TH2 County: Essex
Stream: Mill Brook

Initials JDA Date: 4/16/96 Checked: SAO Date: 4/23/96

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1030	1420	960
Main Channel Area, ft2	233	273	188
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	59	64	52
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.188089	0.188089	0.188089
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	3.9	4.3	3.6
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	14213	17445	10676
Conveyance, main channel	14213	17445	10676
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0	0	0
Qm, discharge, MC, cfs	1030	1420	960
Ql, discharge, LOB, cfs	0	0	0
Qr, discharge, ROB, cfs	0	0	0
Vm, mean velocity MC, ft/s	4.4	5.2	5.1
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	8.1	8.2	8.0
Vc-l, crit. velocity, LOB, ft/s	N/A	N/A	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	N/A	N/A

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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	233	273	188
Main channel width, ft	59	64	52
y1, main channel depth, ft	3.949153	4.265625	3.615385

Bridge Section			
(Q) total discharge, cfs	1030	1420	960
(Q) discharge thru bridge, cfs	977	1205	960
Main channel conveyance	8933	8933	4629
Total conveyance	8933	8933	4629
Q2, bridge MC discharge,cfs	977	1205	960
Main channel area, ft2	148	148	83
Main channel width (skewed), ft	20.4	20.4	20.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	20.4	20.4	20.4
y_bridge (avg. depth at br.), ft	7.259804	7.259804	4.088235
Dm, median (1.25*D50), ft	0.235111	0.235111	0.235111
y2, depth in contraction,ft	5.157756	6.173623	5.080735
ys, scour depth (y2-ybridge), ft	-2.10	-1.09	0.99
ys, scour depth (y2-y1), ft	1.21	1.91	1.47
ys, scour depth (y2-yfullv), ft	1.35	1.55	N/A

ARMORING			
D90	0.882	0.882	0.882
D95	1.153	1.153	1.153
Critical grain size,Dc, ft	0.206515	0.314149	0.820157
Decimal-percent coarser than Dc	0.4614	0.3311	0.114
Depth to armoring,ft	0.723204	1.903964	19.12262

PRESSURE FLOW SCOUR COMPUTATION

Structure Number: BLOO001 Town: Bloomfield
Road Number: County:
Stream:
Initial: SAO Date: 10/10/96 Checked:
Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	977	1205	0
Vc, critical velocity, ft/s	8.1	8.2	0
Vc, critical velocity, m/s	2.46876	2.499238	0
Main channel width (skewed), ft	20.4	20.4	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	20.4	20.4	0
qbr, unit discharge, ft^2/s	47.89216	59.06863	ERR
qbr, unit discharge, m^2/s	4.448893	5.48712	N/A
Area of full opening, ft^2	148	148	0
Hb, depth of full opening, ft	7.254902	7.254902	ERR
Hb, depth of full opening, m	2.211186	2.211186	N/A
Fr, Froude number MC	0.45	0.56	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	1286.76	1286.76	0
Elevation of Bed, ft	1279.505	1279.505	N/A
Elevation of approach WS, ft	1287.68	1288.32	0
HF, bridge to approach, ft	0.13	0.17	0
Elevation of WS immediately US, ft	1287.55	1288.15	0
ya, depth immediately US, ft	8.044902	8.644902	N/A
ya, depth immediately US, m	2.49997	2.686421	N/A
Mean elev. of deck, ft	1288.39	1288.39	0
w, depth of overflow, ft (>=0)	0	0	0
Cc, vert contrac correction (<=1.0)	0.974879	0.957096	ERR
Ys, depth of scour (chang), ft	-1.18993	0.2715	N/A

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	1030	1420	960	1030	1420	960
a', abut.length blocking flow, ft	27.85	31.95	22.55	10.65	11.55	9.45
Ae, area of blocked flow ft2	61.88	81.01	41.37	31.61	36.05	23.54
Qe, discharge blocked abut.,cfs	175.35	282.63	127	101.88	--	84.63
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						3.6
Ve, (Qe/Ae), ft/s	2.83371	3.488829	3.069857	3.223031	3.96	3.595157
ya, depth of f/p flow, ft	2.22	2.54	1.83	2.97	3.12	2.49
--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	65	65	65	115	115	115
K2	0.958577	0.958577	0.958577	1.032379	1.032379	1.032379
Fr, froude number f/p flow	0.34	0.39	0.40	0.33	0.38	0.40
ys, scour depth, ft	8.26	10.06	7.34	7.99	8.96	7.36

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)	27.85	31.95	22.55	10.65	11.55	9.45
y1 (depth f/p flow, ft)	2.22	2.54	1.83	2.97	3.12	2.49
a'/y1	12.53	12.60	12.29	3.59	3.70	3.79
Froude no. f/p flow	0.34	0.39	0.40	0.33	0.38	0.40
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	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)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.45	0.56	1			
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	7.25	7.25	4.07			
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.91	1.41	ERR	0.91	1.41	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.70	ERR	ERR	1.70