LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (NEWFTH00010008) on TOWN HIGHWAY 1, crossing WARDSBORO BROOK, NEWFANE, VERMONT

Open-File Report 98-90

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior
U.S. Geological Survey

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (NEWFTH00010008) on TOWN HIGHWAY 1, crossing WARDSBORO BROOK, NEWFANE, VERMONT

By EMILY C. WILD and JAMES R. DEGNAN

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (NEWFTH00010008) ON TOWN HIGHWAY 1, CROSSING WARDSBORO BROOK, NEWFANE, VERMONT

By **Emily C. Wild and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWFTH00010008 on Town Highway 1 crossing Wardsboro Brook, Newfane, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (Federal Highway Administration, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in southestern Vermont. The 6.91-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the upstream right overbank and downstream left and right overbanks. The surface cover on the upstream left overbank is pasture.

In the study area, Wardsboro Brook has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 63 ft and an average bank height of 9 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 95.4 mm (0.313 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 21, 1996, indicated that the reach was stable.

The Town Highway 1 crossing of the Wardsboro Brook is a 32-ft-long, two-lane bridge consisting of a 26-foot concrete tee-beam span (Vermont Agency of Transportation, written communication, April 6, 1995). The opening length of the structure parallel to the bridge face is 26.7 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 45 degrees to the computed opening while the opening-skew-to-roadway is 45 degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. Scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the upstream right bank, and type-2 stone fill (less than 36 inches diameter) along the upstream left bank and the upstream ends of the upstream left and right wingwalls. A stone wall extends along the downstream right bank from the end of the downstream right wingwall. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.1 to 3.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 11.1 to 12.9 ft. Right abutment scour ranged from 4.3 to 4.8 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number NEWFTH00010008 ***Stream*** Wardsboro Brook

County Windham ***Road*** TH1 ***District*** 2

Description of Bridge

Bridge length 32 ***ft*** ***Bridge width*** 23.3 ***ft*** ***Max span length*** 26 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 8/21/96

Description of stone fill Type-2, along the upstream ends of the upstream left and right wingwalls.

Abutments and wingwalls are concrete. There was a one foot deep scour hole in front of the right abutment.

Is bridge skewed to flood flow according to No ***survey?*** Yes ***Angle*** 45

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	8/21/96	0	0
Level II	8/21/96	0	0

Potential for debris High. There was some debris accumulation within the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) No features that may affect flow were observed during the 8/21/96 inspection.

Description of the Geomorphic Setting

General topography The channel is located within a narrow irregular flood plain with steep valley walls.

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

Date of inspection 8/21/96

DS left: Moderately sloped overbank

DS right: Steep valley wall

US left: Steep valley wall

US right: Steep valley wall

Description of the Channel

Average top width 63 ***ft*** ***Average depth*** 9 ***ft***

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

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

8/21/96

Vegetative co Trees and brush

DS left: Trees and brush

DS right: Pasture and trees

US left: Trees and brush

US right:

Do banks appear stable? Yes

date of observation.

No obstructions were noted during the assessment of 8/21/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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 1,690 ***ft³/s*** ***Q500*** 2,350 ***ft³/s***

The 100- and 500-year discharges are the median values taken from empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). The 500-year discharge was extrapolated.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the downstream right wingwall (elev. 498.32 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream left wingwall (elev. 498.93 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	-35	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	17	1	Road Grade section
APPRO	53	2	Modelled Approach section (Templated from APTEM)
APTEM	71	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.073, and overbank "n" values ranged from 0.038 to 0.050.

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 0.0240 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1984a).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0285 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 498.7 *ft*
Average low steel elevation 495.1 *ft*

100-year discharge 1,690 *ft³/s*
Water-surface elevation in bridge opening 495.1 *ft*
Road overtopping? Yes *Discharge over road* 400 *ft³/s*
Area of flow in bridge opening 120 *ft²*
Average velocity in bridge opening 10.8 *ft/s*
Maximum WSPRO tube velocity at bridge 13.6 *ft/s*

Water-surface elevation at Approach section with bridge 499.9
Water-surface elevation at Approach section without bridge 495.7
Amount of backwater caused by bridge 4.2 *ft*

500-year discharge 2,350 *ft³/s*
Water-surface elevation in bridge opening 495.1 *ft*
Road overtopping? Yes *Discharge over road* 712 *ft³/s*
Area of flow in bridge opening 120 *ft²*
Average velocity in bridge opening 13.7 *ft/s*
Maximum WSPRO tube velocity at bridge 17.3 *ft/s*

Water-surface elevation at Approach section with bridge 500.3
Water-surface elevation at Approach section without bridge 496.6
Amount of backwater caused by bridge 3.7 *ft*

Incipient overtopping discharge 1,120 *ft³/s*
Water-surface elevation in bridge opening 495.1 *ft*
Area of flow in bridge opening 120 *ft²*
Average velocity in bridge opening 9.4 *ft/s*
Maximum WSPRO tube velocity at bridge 11.9 *ft/s*

Water-surface elevation at Approach section with bridge 498.2
Water-surface elevation at Approach section without bridge 494.7
Amount of backwater caused by bridge 3.5 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

At this site, 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 Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). 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. The additional contraction scour computations are presented in appendix F.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.5	3.9	0.1
Depth to armoring	7.1	N/A	10.7
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.6	12.9	11.1
Right abutment	4.7	4.8	4.3
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	2.3	2.7	2.1
Right abutment	2.3	2.7	2.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

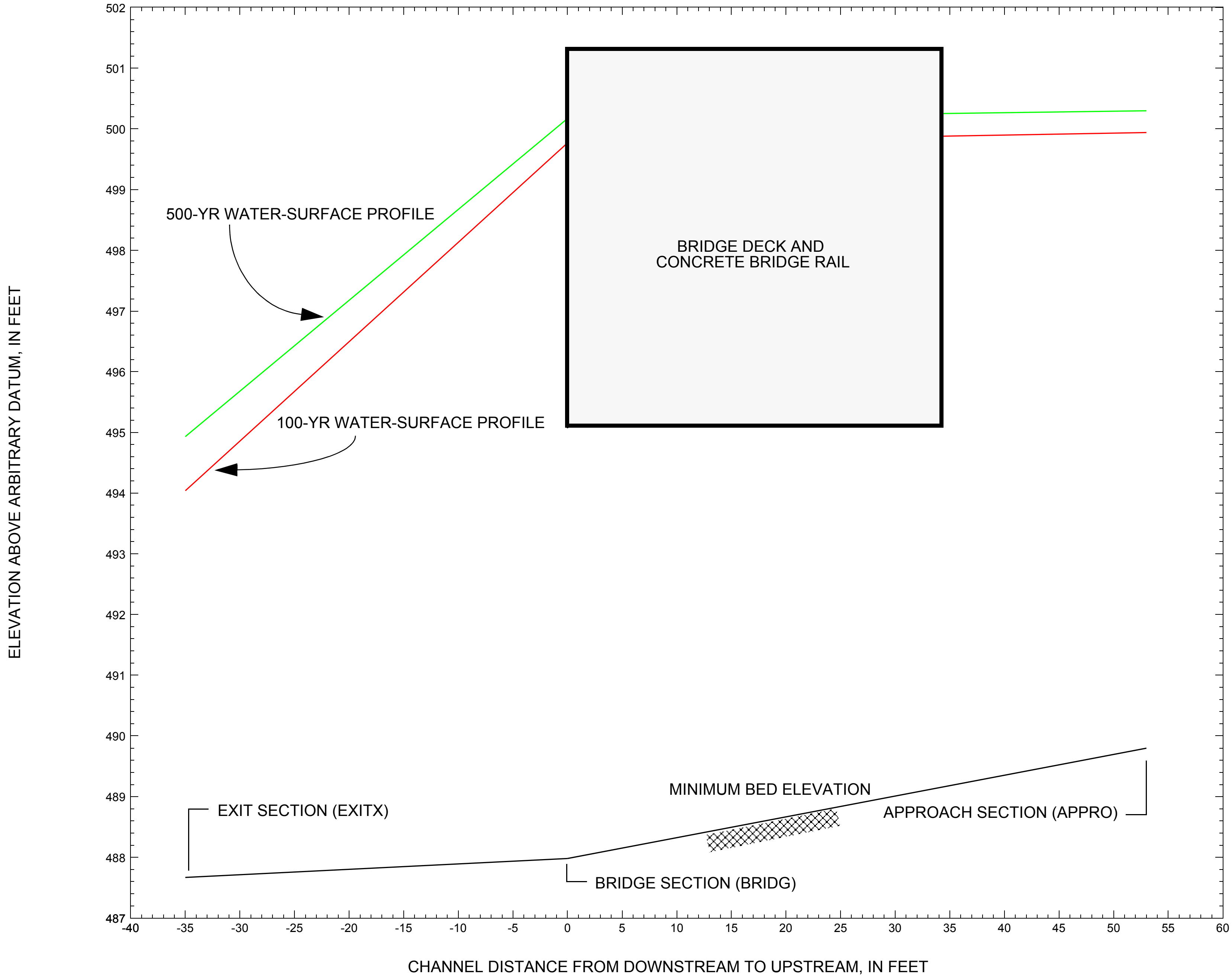

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NEWFTH00010008 on Town Highway 1, crossing Wardsboro Brook, Newfane, Vermont.

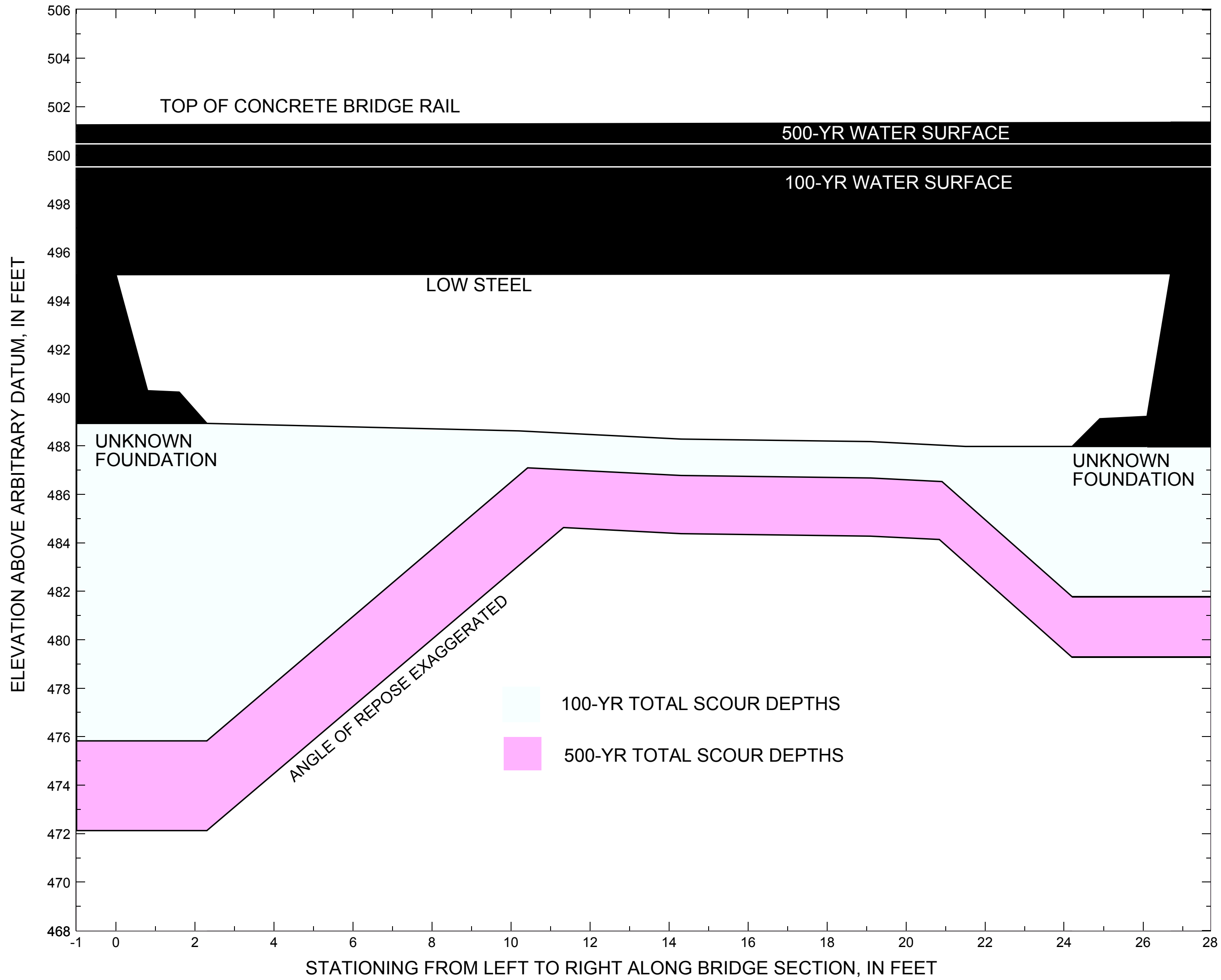

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure NEWFTH00010008 on Town Highway 1, crossing Wardsboro Brook, Newfane, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure NEWFTH00010008 on Town Highway 1, crossing Wardsboro Brook, Newfane, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr discharge is 1,690 cubic-feet per second											
Left abutment	0.0	--	495.1	--	488.9	1.5	11.6	--	13.1	475.8	--
Right abutment	26.7	--	495.1	--	488.0	1.5	4.7	--	6.2	481.8	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-yr discharge at structure NEWFTH00010008 on Town Highway 1, crossing Wardsboro Brook, Newfane, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr discharge is 2,350 cubic-feet per second											
Left abutment	0.0	--	495.1	--	488.9	3.9	12.9	--	16.8	472.1	--
Right abutment	26.7	--	495.1	--	488.0	3.9	4.8	--	8.7	479.3	--

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, 1984a, Newfane, Vermont 7.5 by 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

U.S. Geological Survey, 1984b, Townshend, Vermont 7.5 by 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File newf008.wsp
T2        Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
T3        Town Highway 1, Wardsboro Brook, Newfane, Vermont          ECW
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1690.0   2350.0   1120.0
SK          0.0240   0.0240   0.0240
*
XS   EXITX    -35           0.
GR          -74.5, 506.98    -60.8, 496.73     -5.6, 494.50      0.0, 492.76
GR           27.6, 488.51     30.8, 488.33     34.2, 487.67     38.7, 488.16
GR           41.4, 488.60     43.7, 490.10     52.3, 491.24     53.9, 496.87
GR           97.5, 498.04
*
N           0.040        0.073        0.050
SA                   0.0          53.9
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.09      45.0
GR            0.0, 495.07      0.8, 490.28      1.6, 490.22      2.3, 488.93
GR           10.2, 488.62     14.3, 488.28     19.1, 488.18     21.5, 487.98
GR           24.2, 487.98     24.6, 488.63     24.9, 489.12     26.1, 489.22
GR           26.7, 495.11      0.0, 495.07
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      39.7 * *     41.6     13.9
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     17      23.3     1
GR        -361.0, 507.30   -203.2, 503.83    -95.7, 501.38    -35.4, 500.54
GR           -2.6, 499.32     -2.6, 501.18      0.0, 501.25     28.1, 501.35
GR           29.6, 501.24     29.7, 498.08     41.1, 499.16     91.5, 498.64
GR          122.4, 499.38    163.7, 501.40    230.8, 518.08
*
XT   APTEM     71           0.0
GR        -370.0, 507.30   -212.2, 503.83   -104.7, 501.38    -44.4, 500.54
GR          -18.0, 499.78     -9.0, 495.82     -1.0, 490.71      2.7, 490.31
GR            7.0, 490.33     13.1, 490.57     24.1, 491.37     32.4, 495.51
GR           41.7, 501.79     54.0, 503.36     84.8, 504.02    141.4, 503.34
GR          189.5, 510.45    203.0, 517.45
*
AS   APPRO     53 * * * 0.0285
GT
N           0.040        0.073        0.038
SA                 -18.0         54.0
*
HP 1 BRIDG 495.11 1 495.11
HP 2 BRIDG 495.11 * * 1289
HP 1 BRIDG 494.97 1 494.97
HP 2 RDWAY 499.77 * * 400
HP 1 APPRO 499.94 1 499.94
HP 2 APPRO 499.94 * * 1690
*
HP 1 BRIDG 495.11 1 495.11
HP 2 BRIDG 495.11 * * 1637
HP 2 RDWAY 500.17 * * 712
HP 1 APPRO 500.30 1 500.30
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File newf008.wsp
      Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
      Town Highway 1, Wardsboro Brook, Newfane, Vermont           ECW
         *** RUN DATE & TIME: 01-06-98  14:51
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     120.    8058.     0.    49.                          0.
 495.11          120.    8058.     0.    49.  1.00     0.    27.      0.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.11     0.0    26.7   119.6    8058.    1289.  10.78

X STA.        0.0        4.1        5.3        6.4        7.6        8.7
  A(I)            14.8        5.2        5.0        5.1        5.1
  V(I)            4.35      12.49      12.77      12.64      12.72

X STA.        8.7        9.8       10.9       12.0       13.0       14.1
  A(I)             5.0        5.1        5.0        5.0        5.1
  V(I)           12.91      12.66      12.91      12.88      12.71

X STA.       14.1       15.1       16.2       17.2       18.2       19.2
  A(I)             5.0        5.0        4.9        5.0        4.9
  V(I)           12.92      12.88      13.14      12.89      13.24

X STA.       19.2       20.2       21.2       22.1       23.1       26.7
  A(I)             4.9        4.8        4.7        4.8       15.3
  V(I)           13.06      13.37      13.64      13.55       4.22

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     117.   10837.    19.    30.                       1661.
 494.97          117.   10837.    19.    30.  1.00     0.    27.   1661.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.77   -14.7   130.4    84.8    1964.     400.   4.72

X STA.      -14.7       31.7       35.0       40.9       50.6       56.9
  A(I)             6.0        4.3        5.4        6.4        4.7
  V(I)            3.32       4.63       3.68       3.13       4.29

X STA.       56.9       61.7       66.2       70.1       74.0       77.5
  A(I)             3.8        3.7        3.5        3.6        3.4
  V(I)            5.20       5.35       5.66       5.61       5.92

X STA.       77.5       80.8       83.9       86.9       89.8       92.5
  A(I)             3.3        3.2        3.2        3.2        3.1
  V(I)            6.05       6.24       6.22       6.33       6.47

X STA.       92.5       95.5       98.8      102.8      107.4      130.4
  A(I)             3.2        3.3        3.6        3.8       10.1
  V(I)            6.33       6.03       5.58       5.31       1.99

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1       8.     142.    23.    23.                         26.
           2     403.   28513.    58.    63.                       6051.
 499.94          411.   28655.    81.    86.  1.02   -41.    40.   5192.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.94   -41.4    39.7   411.2   28655.    1690.   4.11

X STA.      -41.4       -4.2       -2.0       -0.2        1.4        2.9
  A(I)            61.2       18.8       16.9       15.9       15.7
  V(I)            1.38       4.48       5.01       5.31       5.38

X STA.        2.9        4.5        6.1        7.7        9.3       10.9
  A(I)            15.7       16.2       15.9       16.2       16.1
  V(I)            5.37       5.22       5.31       5.21       5.25

X STA.       10.9       12.5       14.2       15.9       17.6       19.3
  A(I)            16.4       16.3       16.3       16.6       16.2
  V(I)            5.15       5.19       5.19       5.09       5.21

X STA.       19.3       21.0       22.8       24.6       26.9       39.7
  A(I)            16.3       16.3       16.6       18.6       53.0
  V(I)            5.17       5.17       5.10       4.55       1.60
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       U.S. Geological Survey WSPRO Input File newf008.wsp
       Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
       Town Highway 1, Wardsboro Brook, Newfane, Vermont          ECW
          *** RUN DATE & TIME: 01-06-98  14:51
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     120.    8058.     0.    49.                           0.
  495.11          120.    8058.     0.    49.  1.00     0.    27.      0.

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.11     0.0    26.7   119.6    8058.    1637.  13.69

X STA.         0.0         4.1         5.3         6.4         7.6         8.7
  A(I)             14.8         5.2         5.0         5.1         5.1
  V(I)             5.53       15.87       16.22       16.05       16.16

X STA.         8.7         9.8        10.9        12.0        13.0        14.1
  A(I)              5.0         5.1         5.0         5.0         5.1
  V(I)            16.39       16.07       16.39       16.36       16.15

X STA.        14.1        15.1        16.2        17.2        18.2        19.2
  A(I)              5.0         5.0         4.9         5.0         4.9
  V(I)            16.41       16.35       16.69       16.37       16.81

X STA.        19.2        20.2        21.2        22.1        23.1        26.7
  A(I)              4.9         4.8         4.7         4.8        15.3
  V(I)            16.58       16.98       17.33       17.21        5.36

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.17   -25.5   138.6   133.7    3846.     712.   5.33

X STA.       -25.5        -3.1        33.8        39.0        47.6        54.9
  A(I)              9.3         8.2         7.6         9.1         8.2
  V(I)             3.82        4.35        4.68        3.92        4.36

X STA.        54.9        59.9        64.4        68.8        73.0        76.9
  A(I)              5.9         5.6         5.6         5.5         5.3
  V(I)             6.07        6.34        6.41        6.51        6.72

X STA.        76.9        80.4        84.0        87.4        90.7        94.0
  A(I)              5.0         5.1         5.1         4.9         4.9
  V(I)             7.16        6.98        6.97        7.30        7.22

X STA.        94.0        97.5       101.6       106.1       111.6       138.6
  A(I)              5.1         5.4         5.6         6.0        16.4
  V(I)             7.02        6.57        6.30        5.89        2.18

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1      20.     424.    46.    46.                          74.
            2     424.   30804.    58.    63.                        6497.
  500.30          444.   31228.   104.   109.  1.05   -64.    40.    5069.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.30   -64.0    40.3   444.2   31228.    2350.   5.29

X STA.       -64.0        -5.4        -2.8        -0.8         0.8         2.5
  A(I)             69.3        21.4        18.6        16.9        17.1
  V(I)             1.70        5.48        6.32        6.94        6.86

X STA.         2.5         4.1         5.7         7.3         9.0        10.7
  A(I)             16.7        17.0        17.0        17.4        17.3
  V(I)             7.02        6.93        6.90        6.77        6.81

X STA.        10.7        12.3        14.0        15.7        17.4        19.2
  A(I)             17.3        17.2        17.2        17.2        17.5
  V(I)             6.77        6.82        6.82        6.82        6.72

X STA.        19.2        21.0        22.8        24.7        27.0        40.3
  A(I)             17.3        17.3        17.6        19.7        57.1
  V(I)             6.79        6.78        6.69        5.97        2.06
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       U.S. Geological Survey WSPRO Input File newf008.wsp
       Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
       Town Highway 1, Wardsboro Brook, Newfane, Vermont           ECW
          *** RUN DATE & TIME: 01-06-98  14:51
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     120.    8058.     0.    49.                          0.
   495.11          120.    8058.     0.    49.  1.00     0.    27.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.11     0.0    26.7   119.6    8058.    1120.   9.36

X STA.        0.0        4.1        5.3        6.4        7.6        8.7
  A(I)            14.8        5.2        5.0        5.1        5.1
  V(I)            3.78      10.86      11.10      10.98      11.06

X STA.        8.7        9.8       10.9       12.0       13.0       14.1
  A(I)             5.0        5.1        5.0        5.0        5.1
  V(I)           11.22      11.00      11.22      11.19      11.05

X STA.       14.1       15.1       16.2       17.2       18.2       19.2
  A(I)             5.0        5.0        4.9        5.0        4.9
  V(I)           11.23      11.19      11.42      11.20      11.50

X STA.       19.2       20.2       21.2       22.1       23.1       26.7
  A(I)             4.9        4.8        4.7        4.8       15.3
  V(I)           11.35      11.61      11.85      11.77       3.67

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      99.    8489.    19.    28.                       1286.
   493.97           99.    8489.    19.    28.  1.00     0.    27.   1286.

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     308.   19374.    53.    57.                       4221.
   498.23          308.   19374.    53.    57.  1.00   -16.    37.   4221.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      53.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.23   -15.6    37.2   308.1   19374.    1120.   3.64

X STA.      -15.6       -2.1       -0.5        1.0        2.5        3.9
  A(I)            44.9       13.0       11.9       12.3       12.1
  V(I)            1.25       4.32       4.71       4.57       4.65

X STA.        3.9        5.3        6.7        8.2        9.7       11.2
  A(I)            12.0       12.0       12.2       12.4       12.4
  V(I)            4.67       4.68       4.58       4.50       4.53

X STA.       11.2       12.7       14.2       15.8       17.4       19.0
  A(I)            12.6       12.5       12.4       12.7       12.4
  V(I)            4.45       4.49       4.50       4.42       4.53

X STA.       19.0       20.6       22.3       24.0       26.0       37.2
  A(I)            12.8       12.5       12.7       14.0       38.6
  V(I)            4.38       4.49       4.43       3.99       1.45
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       U.S. Geological Survey WSPRO Input File newf008.wsp
       Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
       Town Highway 1, Wardsboro Brook, Newfane, Vermont           ECW
          *** RUN DATE & TIME: 01-06-98  14:51

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

EXITX:XS   ******    -4.     219.  0.93 *****  494.97  493.12   1690.  494.04
      -35. ******    53.   10899.  1.01 ***** *******    0.70    7.73

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.41

FULLV:FV      35.   -17.     276.  0.60  0.60  495.57 *******   1690.  494.97
        0.    35.    53.   15361.  1.03  0.00    0.00    0.55    6.13
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.62

APPRO:AS      53.   -10.     184.  1.31  1.04  496.96 *******   1690.  495.65
       53.    53.    33.    9492.  1.00  0.35    0.00    0.78    9.17
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.92       0.00     495.05     498.08

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.02     498.70     498.87     495.09

 ===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      35.     0.     120.  1.81 *****  496.92  493.98   1289.  495.11
        0. ******    27.    8058.  1.00 ***** *******    0.90   10.78

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.500  0.000  495.09 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    30.  0.10  0.27  500.11    0.00    400.  499.77

            Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     16.    12.   -15.    -3.   0.5   0.2   3.4   5.7   0.6   3.0
   RT:    384.   101.    30.   130.   1.7   0.8   5.0   4.7   1.2   3.1

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

APPRO:AS      13.   -42.     412.  0.27  0.14  500.21  494.92   1690.  499.94
       53.    15.    40.   28680.  1.02  0.93    0.00    0.33    4.11

       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     -35.    -4.    53.   1690.   10899.     219.    7.73  494.04
   FULLV:FV       0.   -17.    53.   1690.   15361.     276.    6.13  494.97
   BRIDG:BR       0.     0.    27.   1289.    8058.     120.   10.78  495.11
   RDWAY:RG      17.*******    16.    400.       0.*********    1.00  499.77
   APPRO:AS      53.   -42.    40.   1690.   28680.     412.    4.11  499.94

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    493.12    0.70  487.67  506.98************  0.93  494.97  494.04
   FULLV:FV  ********    0.55  487.67  506.98  0.60  0.00  0.60  495.57  494.97
   BRIDG:BR    493.98    0.90  487.98  495.11************  1.81  496.92  495.11
   RDWAY:RG  ***************  498.08  518.08  0.10******  0.27  500.11  499.77
   APPRO:AS    494.92    0.33  489.80  516.94  0.14  0.93  0.27  500.21  499.94
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        U.S. Geological Survey WSPRO Input File newf008.wsp
        Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
        Town Highway 1, Wardsboro Brook, Newfane, Vermont           ECW
           *** RUN DATE & TIME: 01-06-98  14:51

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

EXITX:XS   ******   -16.     273.  1.18 *****  496.11  493.94   2350.  494.93
      -35. ******    53.   15166.  1.03 ***** *******    0.78    8.60

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.44

FULLV:FV      35.   -42.     361.  0.70  0.58  496.68 *******   2350.  495.99
        0.    35.    54.   21815.  1.05  0.00   -0.01    0.61    6.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80     0.84     496.55     495.92

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.49     516.94    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.49     516.94     495.92

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.57

APPRO:AS      53.   -12.     225.  1.70  1.07  498.25  495.92   2350.  496.55
       53.    53.    35.   12532.  1.00  0.50    0.00    0.84   10.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   495.99     495.09

            <<<<<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      35.     0.     120.  2.91 *****  498.02  494.91   1637.  495.11
        0. ******    27.    8058.  1.00 ***** *******    1.14   13.69

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  495.09 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    30.  0.17  0.46  500.59    0.00    712.  500.17

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     54.    23.   -26.    -3.   0.9   0.4   4.2   5.5   0.8   3.0
   RT:    657.   109.    30.   139.   2.1   1.1   5.8   5.3   1.6   3.1

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

APPRO:AS      13.   -64.     445.  0.46  0.23  500.76  495.92   2350.  500.30
       53.    14.    40.   31254.  1.05  0.93    0.00    0.46    5.29

       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     -35.   -16.    53.   2350.   15166.     273.    8.60  494.93
   FULLV:FV       0.   -42.    54.   2350.   21815.     361.    6.52  495.99
   BRIDG:BR       0.     0.    27.   1637.    8058.     120.   13.69  495.11
   RDWAY:RG      17.*******    54.    712.       0.       0.    1.00  500.17
   APPRO:AS      53.   -64.    40.   2350.   31254.     445.    5.29  500.30

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     493.94    0.78  487.67  506.98************  1.18  496.11  494.93
   FULLV:FV   ********    0.61  487.67  506.98  0.58  0.00  0.70  496.68  495.99
   BRIDG:BR     494.91    1.14  487.98  495.11************  2.91  498.02  495.11
   RDWAY:RG   ***************  498.08  518.08  0.17******  0.46  500.59  500.17
   APPRO:AS     495.92    0.46  489.80  516.94  0.23  0.93  0.46  500.76  500.30
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        U.S. Geological Survey WSPRO Input File newf008.wsp
        Hydraulic analysis for structure NEWFTH00010008   Date: 02-JAN-98
        Town Highway 1, Wardsboro Brook, Newfane, Vermont           ECW
           *** RUN DATE & TIME: 01-06-98  14:51

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

EXITX:XS   ******    -1.     169.  0.69 *****  493.82  492.28   1120.  493.14
      -35. ******    53.    7223.  1.00 ***** *******    0.66    6.64

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "FULLV"     KRATIO =  1.47

FULLV:FV      35.    -4.     215.  0.43  0.57  494.40 *******  1120.  493.97
        0.    35.    53.   10602.  1.01  0.00    0.00    0.47    5.21
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  0.62

APPRO:AS      53.    -8.     143.  0.95  0.95  495.61 *******  1120.  494.66
       53.    53.    32.    6619.  1.00  0.26    0.00    0.73    7.83
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   493.50     496.44     496.63     495.09

 ===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      35.     0.     120.  1.36 *****  496.47  493.50   1120.  495.11
        0. ******    27.    8058.  1.00 ***** *******    0.78    9.36

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.499  0.000  495.09 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG      17.        <<<<<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      13.   -16.     308.  0.21  0.12  498.43  493.86   1120.  498.23
       53.    14.    37.   19357.  1.00  0.90    0.00    0.27    3.64

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   498.13

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -35.    -1.    53.   1120.    7223.     169.    6.64  493.14
   FULLV:FV       0.    -4.    53.   1120.   10602.     215.    5.21  493.97
   BRIDG:BR       0.     0.    27.   1120.    8058.     120.    9.36  495.11
   RDWAY:RG      17.**************      0.       0.       0.    1.00********
   APPRO:AS      53.   -16.    37.   1120.   19357.     308.    3.64  498.23

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD     EGL    WSEL
   EXITX:XS    492.28    0.66  487.67  506.98************  0.69  493.82  493.14
   FULLV:FV  ********    0.47  487.67  506.98  0.57  0.00  0.43  494.40  493.97
   BRIDG:BR    493.50    0.78  487.98  495.11************  1.36  496.47  495.11
   RDWAY:RG  ****************  498.08  518.08************  0.21  498.33********
   APPRO:AS    493.86    0.27  489.80  516.94  0.12  0.90  0.21  498.43  498.23
  ER

NORMAL  END  OF  WSPRO  EXECUTION.
```
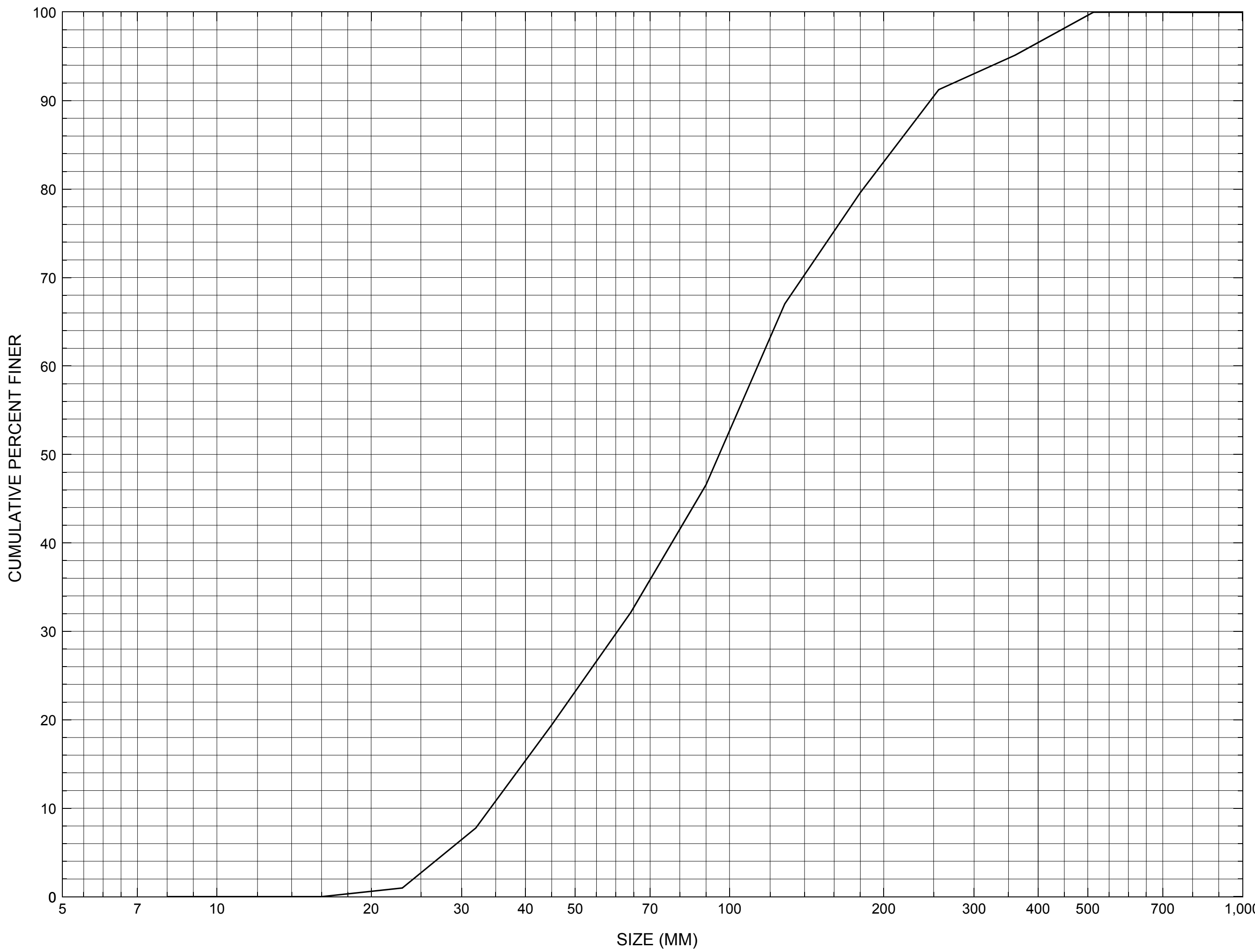

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWFTH00010008, in Newfane, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWFTH00010008

General Location Descriptive

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

Date *(MM/DD/YY)* 04 / 06 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 48400

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

Waterway *(I - 6)* WARDSBORO BROOK

Road Name *(I - 7):* -

Route Number TH001

Vicinity *(I - 9)* 0.15 MI TO JCT W C3 TH12

Topographic Map Newfane

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 42598

Longitude *(i - 17; nnnnn.n)* 72408

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10131200081312

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

Maximum span length *(I - 48; nnnn)* 0026

Year built *(I - 27; YYYY)* 1926

Structure length *(I - 49; nnnnnn)* 000032

Average daily traffic, ADT *(I - 29; nnnnnn)* 000540

Deck Width *(I - 52; nn.n)* 233

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

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

Opening skew to Roadway *(I - 34; nn)* 15

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*) -

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) -

Comments:

The structural inspection report of 07/26/94 indicates the structure is a concrete T-beam type bridge with an asphalt road surface. Both abutments have newer concrete subfootings along them. The waterway consists of stone and gravel, with some random boulders. Across the channel, along the upstream bridge face, there is a home-made stone and plastic dam roughly 2 feet high. There are a few minor voids beneath the subfooting of the right abutment near the upstream end. The downstream right wingwall has some concrete patching along the front face. Stone fill protection consists of some small stone along with a few large boulders.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -

Q_{50} - Q_{100} - Q_{500} -

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

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

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

The stage increases to maximum highwater elevation (*Rapidly, Not rapidly*): -

The stream response is (*Flashy, Not flashy*): -

Describe any significant site conditions upstream or downstream that may influence the stream's stage: -

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

Downstream distance (*miles*): - Town: - Year Built: -
Highway No. : - Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.91** mi^2 Lake/pond/swamp area **0.10** mi^2
Watershed storage *(ST)* **1.5** %
Bridge site elevation **886** ft Headwater elevation **1870** ft
Main channel length **5.64** mi
10% channel length elevation **1319** ft 85% channel length elevation **1575** ft
Main channel slope *(S)* **60.52** ft / mi

Watershed Precipitation Data

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

Bridge Plan Data

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

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

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

If 1: Footing Thickness ______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS

Cross-sectional Data

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

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

Comments: **The stations and elevations are in feet. The elevation coordinate has been made to match the coordinate system set up in this report, using the low chord point as a line-up.**

Station	0	1.17	1.18	13	24.83	24.84	26	-	-	-	-
Feature	LAB	-	-	-	-	-	-	-	-	-	-
Low chord elevation	495.1	495.1	495.1	495.1	495.1	495.1	495.1	-	-	-	-
Bed elevation	490.2	490.2	489.1	488.8	488.1	489.9	489.9	-	-	-	-
Low chord to bed	4.9	4.9	6	6.3	7	5.2	5.2	-	-	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **MS** Date: **6/18/97**
Computerized by: **MS** Date: **6/23/97**
Reviewd by: **EW** Date: **1/14/98**

Structure Number **NEWFTH00010008**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J** . **DEGNAN** Date *(MM/DD/YY)* **08** / **21** / 19**96**

2. Highway District Number **02** Mile marker **000000**

County **WINDHAM (025)** Town **NEWFANE (48400)**

Waterway *(I - 6)* **WARDSBORO BROOK** Road Name **-**

Route Number **TH001** Hydrologic Unit Code: **01080107**

3. Descriptive comments:

This concrete T-beam type bridge is located 0.15 miles from junction with Town Highway 12.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** 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 **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 **32** *(feet)* Span length **26** *(feet)* Bridge width **23.3** *(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)*

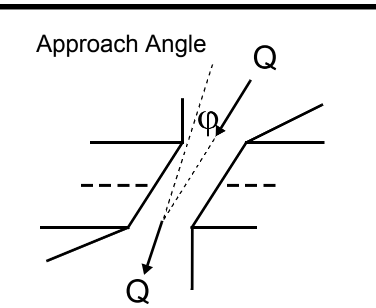
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

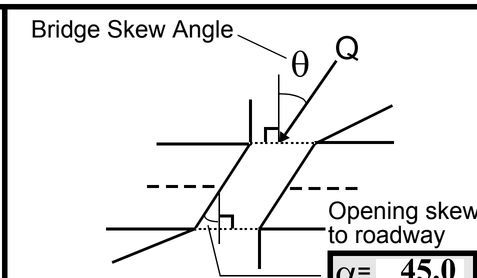
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	5	1	2	1
LBDS	5	1	0	0

*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: **10** 16. Bridge skew: **45**





α= **45.0**

17. Channel impact zone 1: Exist? **y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **60** feet **US** *(US, UB, DS)* to **13** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **0** feet **US** *(US, UB, DS)* to **5** feet **DS**

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

18. Bridge Type: **1a**

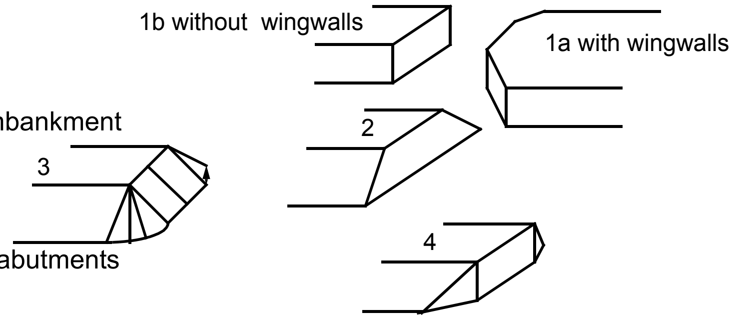
1a- Vertical abutments with wingwalls

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.)

4. The US right bank and DS left bank surface cover both include a house and lawn, but the forest is the dominant surface cover.
18. The DS left wingwall is a type 4 wingwall.

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
37.5	**9.0**			**12.0**	**2**	**3**	**453**	**432**	**2**	**1**

23. Bank width **25.0** 24. Channel width **20.0** 25. Thalweg depth **72.0** 29. Bed Material **453**

30 .Bank protection type: LB **2** RB **1** 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.):

All measurements are referenced to the mid-point of the bridge face.
The right bank protection extends from 15 ft US to 0 ft US and consists of stone fill.
The left bank protection extends from 40 ft US to 20 ft US and also consists of stone fill.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **92** 35. Mid-bar width: **15**

36. Point bar extent: **180** feet **US** (US, UB) to **0** feet **US** (US, UB, DS) positioned **60** %LB to **100** %RB

37. Material: **432**

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

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: **165** 42. Cut bank extent: **230** feet **US** (US, UB) to **100** 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? **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

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
25.0		0.5		2	7	7	-

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

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

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

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

432

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

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

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

70. Debris and Ice Comments:

3

This bridge constricts the natural channel and is not aligned with flow. The debris potential is high because the vertical clearance between the bridge and stream bed is low. Ice scarring is present along both banks on tree trunks.

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	85	2	3	0	1	90.0
RABUT	1	5	85			2	3	19.0

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.):

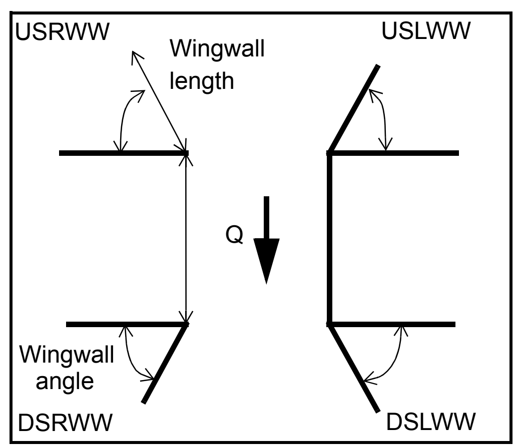
1
2
1

There is a 3 ft of horizontal penetration and a 0.3 ft of vertical penetration along the US end of the left abutment footing. There is also a bar along the left abutment footing. The thalweg runs along the right abutment footing. The right abutment footing has been patched up.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						19.0	
USRWW:	Y		1		2	0.5	
DSLWW:	0		1		Y	35.0	
DSRWW:	1		2		0.5	34.0	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	2	2	Y	0.5	1	1	-	-
Condition	Y	0	1	1	2	2	-	-
Extent	1	1	2	2	2	0	0	-

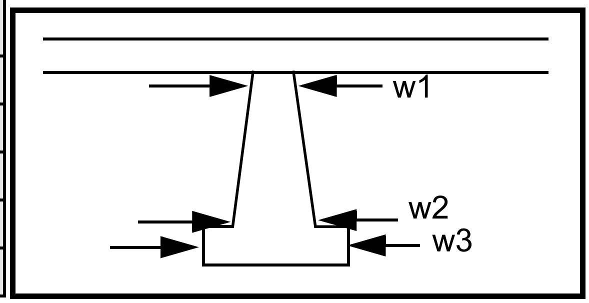
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

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	0.0			26.5	80.0	10.0
Pier 2		7.0	9.5	130.0	15.0	-
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 - 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.):

1
2
453
432
1
1
435
0
5
-
1
The right bank protection extends from the DS end of the DS right wingwall to 70 ft DS. It also serves as road approach protection.

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: **Y**

Cut bank extent: **0** feet **8** *(US, UB, DS)* to **0** feet **US** *(US, UB, DS)*

Bank damage: **15** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
0
40
345

Is channel scour present? **Th** *(Y or if N type ctrl-n cs)* Mid-scour distance: **ere is**

Scour dimensions: Length **a** Width **point** Depth: **bar** Positioned **ext** %LB to **end** %RB

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

ing from 20 ft DS to 100 ft DS. Its mid-bar distance is 80 ft DS and the width is 10 ft. The material is boulders, cobbles and gravel. The point bar is along the right bank.

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

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

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

Confluence comments (eg. confluence name):

NO CUT 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)*:

Y
50
10
5
1.5
0
50
The scour depth is based on a 0.5 ft thalweg. The scour hole is located DS of a large boulder, approximately 6 ft wide.

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: NEWFTH00010008 Town: NEWFANE
Road Number: TH 1 County: WINDHAM
Stream: WARDSBORO BROOK

Initials ECW Date: 1-6-98 Checked: LKS

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	1690	2350	1120
Main Channel Area, ft2	403	424	308
Left overbank area, ft2	8	20	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	58	58	53
Top width L overbank, ft	23	46	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3131	0.3131	0.3131
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.9	7.3	5.8
y1, average depth, LOB, ft	0.3	0.4	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	28655	31228	19374
Conveyance, main channel	28513	30804	19374
Conveyance, LOB	142	424	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1681.6	2318.1	1120.0
Ql, discharge, LOB, cfs	8.4	31.9	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	4.2	5.5	3.6
Vl, mean velocity, LOB, ft/s	1.0	1.6	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.5	10.6	10.2
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

y2 = (Q2^2/(131*Dm^(2/3)*W2^2))^(3/7)   Converted to English Units
ys=y2-y_bridge
(Richardson and others, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1690	2350	1120
(Q) discharge thru bridge, cfs	1289	1637	1120
Main channel conveyance	8058	8058	8058
Total conveyance	8058	8058	8058
Q2, bridge MC discharge,cfs	1289	1637	1120
Main channel area, ft2	120	120	120
Main channel width (normal), ft	18.9	18.9	18.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	18.9	18.9	18.9
y_bridge (avg. depth at br.), ft	6.35	6.35	6.35
Dm, median (1.25*D50), ft	0.391375	0.391375	0.391375
y2, depth in contraction,ft	6.04	7.41	5.35
ys, scour depth (y2-ybridge), ft	-0.31	1.06	-1.00

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	1289	1637	1120
Main channel area (DS), ft2	117	120	99
Main channel width (normal), ft	18.9	18.9	18.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	18.9	18.9	18.9
D90, ft	0.8085	0.8085	0.8085
D95, ft	1.1661	1.1661	1.1661
Dc, critical grain size, ft	0.5945	0.9014	0.6756
Pc, Decimal percent coarser than Dc	0.202	0.079	0.159
Depth to armoring, ft	7.06	N/A	10.69

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	1690	2350	1120
Q, thru bridge MC, cfs	1289	1637	1120
Vc, critical velocity, ft/s	10.52	10.60	10.21
Va, velocity MC approach, ft/s	4.17	5.47	3.64
Main channel width (normal), ft	18.9	18.9	18.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	18.9	18.9	18.9
qbr, unit discharge, ft2/s	68.2	86.6	59.3
Area of full opening, ft2	120.0	120.0	120.0
Hb, depth of full opening, ft	6.35	6.35	6.35
Fr, Froude number, bridge MC	0.9	1.14	0.78
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	117	N/A	99
**Hb, depth at downstream face, ft	6.19	N/A	5.24
**Fr, Froude number at DS face	0.78	ERR	0.87
**Cf, for downstream face (<=1.0)	1.00	N/A	1.00
Elevation of Low Steel, ft	495.09	495.09	495.09
Elevation of Bed, ft	488.74	488.74	488.74
Elevation of Approach, ft	499.94	500.3	498.23
Friction loss, approach, ft	0.14	0.23	0.12
Elevation of WS immediately US, ft	499.80	500.07	498.11
ya, depth immediately US, ft	11.06	11.33	9.37
Mean elevation of deck, ft	501.3	501.3	501.3
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.83	0.80	0.90
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	1.49	3.90	0.11
Ys, scour w/Umbrell equation, ft	0.63	2.02	-0.81

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

**Ys, scour w/Chang equation, ft	ERR	N/A	ERR

**Ys, scour w/Umbrell equation, ft	0.79	N/A	0.30

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	6.04	7.41	5.35
WSEL at downstream face, ft	494.97	--	493.97
Depth at downstream face, ft	6.19	N/A	5.24
Ys, depth of scour (Laursen), ft	-0.15	N/A	0.11

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	1690	2350	1120	1690	2350	1120
a', abut.length blocking flow, ft	45.3	67.9	19.5	16.9	17.5	14.4
Ae, area of blocked flow ft2	136.41	147.92	94.2	78.95	83.84	61.56
Qe, discharge blocked abut.,cfs	--	--	280	--	--	151.53
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.44	4.37	2.97	2.87	3.73	2.46
ya, depth of f/p flow, ft	3.01	2.18	4.83	4.67	4.79	4.28
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0	0	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	45	45	45	135	135	135
K2	0.91	0.91	0.91	1.05	1.05	1.05
Fr, froude number f/p flow	0.347	0.505	0.238	0.222	0.283	0.210
ys, scour depth, ft	11.63	12.90	11.07	4.67	4.79	4.28

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)	45.3	67.9	19.5	16.9	17.5	14.4
y1 (depth f/p flow, ft)	3.01	2.18	4.83	4.67	4.79	4.28
a'/y1	15.04	31.17	4.04	3.62	3.65	3.37
Skew correction (p. 49, fig. 16)	0.80	0.80	0.80	1.10	1.10	1.10
Froude no. f/p flow	0.35	0.51	0.24	0.22	0.28	0.21
Ys w/ corr. factor K1/0.55:						
vertical	ERR	10.12	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	8.30	ERR	ERR	ERR	ERR
spill-through	ERR	5.56	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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.78	1	0.87	0.78	1	0.87
y, depth of flow in bridge, ft	6.19	6.35	5.24	6.19	6.35	5.24
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	2.33	ERR	ERR	2.33	ERR	ERR
Fr>0.8 (vertical abut.)	ERR	2.66	2.11	ERR	2.66	2.11