LEVEL II SCOUR ANALYSIS FOR BRIDGE 38 (TOPSTH00570038) on TOWN HIGHWAY 57, crossing WAITS RIVER, TOPSHAM, VERMONT

U.S. Geological Survey
Open-File Report 97-649

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

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By LORA K. STRIKER AND ERICK M. BOEHMLER

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1997

U.S. DEPARTMENT OF THE INTERIOR
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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 38 (TOPSTH00570038) ON TOWN HIGHWAY 57, CROSSING WAITS RIVER, TOPSHAM, VERMONT

By **Lora K. Striker and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure TOPSTH00570038 on Town Highway 57 crossing the Waits River, Topsham, 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 New England Upland section of the New England physiographic province in east central Vermont. The 37.3-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is predominantly pasture while the left bank upstream is suburban.

In the study area, the Waits River has a sinuous locally anabranched channel with a slope of approximately 0.01 ft/ft, an average channel top width of 76 ft and an average bank height of 6 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 57.2 mm (0.188 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 28, 1995, indicated that the reach was considered laterally unstable due to cut-banks upstream, mid-channel bars and lateral migration of the channel towards the left abutment.

The Town Highway 34 crossing of the Waits River is a 34-ft-long, one-lane bridge consisting of one 31-foot steel-beam span (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 30.4 ft. The bridge is supported by a vertical, stone abutment with concrete facing and wingwalls on the right and by a vertical, concrete abutment with wingwalls on the left. The channel is skewed approximately 0 degrees to the opening and the opening-skew-to-roadway is also zero degrees.

A scour hole 2.0 ft deeper than the mean thalweg depth was observed towards the left bank underneath the bridge. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the left bank upstream, in the upstream left wing wall area, along the left abutment, at the downstream end of the right abutment, and in the downstream left wing wall area. There is type-3 stone fill (less than 48 inches diameter) in the downstream right wing wall area. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.6 to 5.2 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 9.8 to 18.5 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and 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.

West Topsham, VT. Quadrangle, 1:24,000, 1981

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 TOPSTH00570038 ***Stream*** Waits River

County Orange ***Road*** TH57 ***District*** 7

Description of Bridge

Bridge length 34 ***ft*** ***Bridge width*** 16.0 ***ft*** ***Max span length*** 31 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 08/28/95

Description of stone fill Type-2, along the entire base length of the LABUT and downstream end of the RABUT, along the entire base of the upstream and downstream left wingwalls. Type-3 along entire base length of the DSRWW

Brief description of piers/abutments Abutments and wingwalls are concrete faced stone blocks on the right while the left abutment is concrete. There is a two foot deep scour hole near the left abutment.

Is bridge skewed to flood flow according to survey? N ***Angle*** 0

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

-

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	08/28/95	0	0
Level II	08/28/95	0	0

Potential for debris Moderate.

Describe any features near or at the bridge that may affect flow (include observation date) The left abutment intrusion into the channel is causing localized channel scour 2.0 ft in depth.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley, with narrow flood plains and little to no natural levees.

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

Date of inspection 08/28/95

DS left: Steep channel bank to moderately sloped overbank.

DS right: Moderately sloped bank to steep valley wall.

US left: Steep channel bank to narrow flood plain.

US right: Steep channel bank to moderately sloped overbank.

Description of the Channel

Average top width 76 ***ft*** ***Average depth*** 6 ***ft***

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

Sinuous and laterally unstable with semi-alluvial channel boundaries and a narrow flood plain.

08/28/95

Vegetative co

Tall grass and shrubs and pasture overbank

DS left: Trees and brush and pasture overbank

DS right: Trees and brush and suburban overbank

US left: Trees and brush and pasture overbank

US right:

N

Do banks appear stable? Lateral instability was seen upstream of the bridge due to cut banks and mid channel bars.

If not, describe location and type of instability and date of observation.

The assessment of 08/28/95 noted that the flow at the bridge site is influenced by fill along the left abutment and the left abutment intrusion into the channel.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 37.3 ***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***: There are a couple houses and a church on the left overbank, however the basin is rural.

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 4,760 ***ft³/s*** ***Q500*** 6,050 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(37.3/34.3)exp 0.7] with bridge number 16 in Topsham. Bridge number 16 crosses the Waits River upstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 16 is 34.3 square miles.

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 in concrete near the DSR corner of the wooden bridge deck (elev. 498.40 ft, arbitrary survey datum). RM2 is a chiseled X in concrete at the junction of the USLWW and the LABUT (elev. 496.81 ft, arbitrary survey datum). RM 3 is a chiseled X in concrete wingwall 4 ft downstream from the end of the US LWW (elev. 494.65 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	9	1	Road Grade section
APPRO	52	2	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 0.050, and overbank "n" values ranged from 0.060 to 0.065.

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 0.0106 ft/ft which was estimated from the 100-yr water surface slope elevation downstream of the site (Federal Emergency Management Agency, 1991).

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

Bridge Hydraulics Summary

Average bridge embankment elevation 500.0 ***ft***
Average low steel elevation 496.9 ***ft***

100-year discharge 4,760 ***ft³/s***
Water-surface elevation in bridge opening 497.0 ***ft***
Road overtopping? Y ***Discharge over road*** 1,400 ***ft³/s***
Area of flow in bridge opening 239 ***ft²***
Average velocity in bridge opening 14.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.3 ***ft/s***

Water-surface elevation at Approach section with bridge 502.0
Water-surface elevation at Approach section without bridge 497.5
Amount of backwater caused by bridge 4.5 ***ft***

500-year discharge 6,050 ***ft³/s***
Water-surface elevation in bridge opening 497.0 ***ft***
Road overtopping? Y ***Discharge over road*** 2,520 ***ft³/s***
Area of flow in bridge opening 239 ***ft²***
Average velocity in bridge opening 14.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.4 ***ft/s***

Water-surface elevation at Approach section with bridge 502.8
Water-surface elevation at Approach section without bridge 498.2
Amount of backwater caused by bridge 4.6 ***ft***

Incipient overtopping discharge 2,390 ***ft³/s***
Water-surface elevation in bridge opening 497.0 ***ft***
Area of flow in bridge opening 239 ***ft²***
Average velocity in bridge opening 10.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.2 ***ft/s***

Water-surface elevation at Approach section with bridge 499.5
Water-surface elevation at Approach section without bridge 495.4
Amount of backwater caused by bridge 4.1 ***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.

At this site, the incipient roadway-overtopping discharge resulted in unsubmerged orifice flow. The 100- and 500-yr discharges result 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 was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146).

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

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	5.2 5.1	1.6	N/A N/
Depth to armoring	A N/	A	--
Left overbank	--	--	--
Right overbank	--	--	12.4

Local scour:			
Abutment scour			
Left abutment	13.2	9.8	18.0
Right abutment	18.5–	17.1-	---
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	3.2

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	3.2	2.5	3.2
Right abutment	3.2	2.5	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--
	--	--	

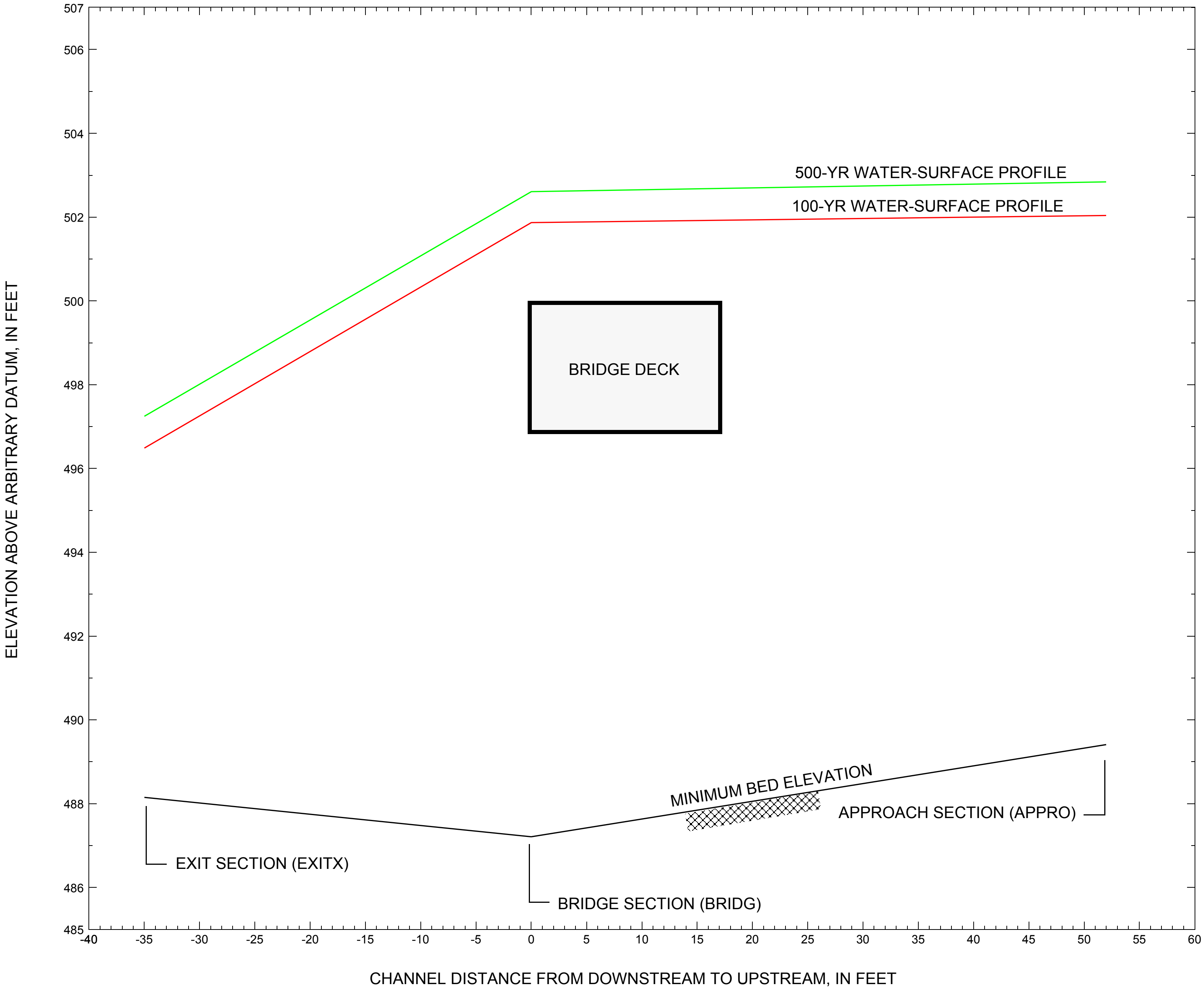

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure TOPSTH00570038 on Town Highway 57, crossing Waits River, Topsham, Vermont.

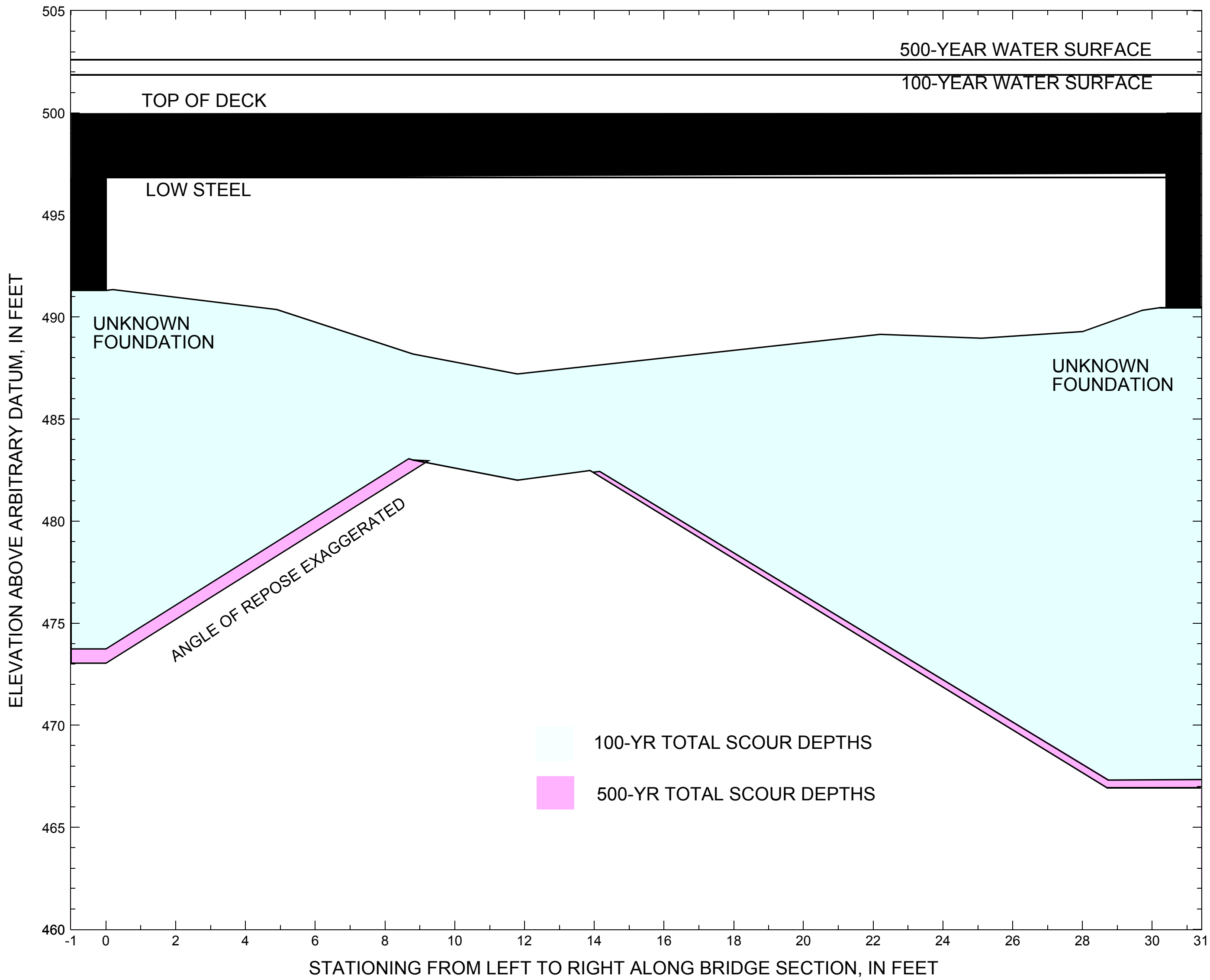

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure TOSTH00570038 on Town Highway 57, crossing Waits River, Topsham, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure TOPSTH00570038 on Town Highway 57, crossing Waits River, Topsham, 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 4,760 cubic-feet per second											
Left abutment	0.0	--	496.8	--	491.3	5.2	12.4	--	17.6	473.7	--
Right abutment	30.4	--	497.0	--	490.5	5.2	18.0	--	23.2	467.3	--

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 TOPSTH00570038 on Town Highway 57, crossing Waits River, Topsham, 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 6,050 cubic-feet per second											
Left abutment	0.0	--	496.8	--	491.3	5.1	13.2	--	18.3	473.0	--
Right abutment	30.4	--	497.0	--	490.5	5.1	18.5	--	23.6	466.9	--

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, 1981, West Topsham, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File tops038.wsp
T2        Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
T3        TH 57 crossing Waits River, left abutment concrete facing
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           4760.0   6050.0   2390.0
SK          0.0106   0.0106   0.0106
*
XS   EXITX    -35           0.
GR         -249.5, 513.98   -231.7, 509.52   -203.9, 509.29   -199.5, 507.74
GR         -106.7, 504.54    -92.6, 497.46    -86.2, 496.00    -80.3, 496.42
GR           -6.7, 493.44     -4.9, 492.00      0.0, 490.35      5.2, 489.30
GR           23.3, 488.15     27.8, 488.38     44.4, 490.32     47.7, 490.68
GR           49.6, 492.17     53.2, 494.24    126.0, 500.21    152.8, 500.98
GR          163.2, 504.96    192.9, 509.58    231.8, 514.48    240.5, 513.79
GR          281.4, 521.84    313.0, 525.66    330.6, 526.59
*
N          0.065   0.050  0.065
SA            -6.7      53.2
*
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.93       0.0
GR            0.0, 496.83      0.2, 491.34      4.9, 490.36      8.8, 488.19
GR           11.8, 487.21     17.8, 488.28     22.2, 489.15     25.1, 488.96
GR           28.0, 489.29     29.7, 490.32     30.2, 490.45     30.4, 497.02
GR            0.0, 496.83
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD          1      31.5 * *     55.2      9.1
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      16.0     1
GR         -329.7, 523.00   -245.3, 513.73   -148.9, 506.09    -41.1, 499.60
GR            0.5, 499.96     32.7, 499.97     99.9, 502.12    162.9, 505.39
GR          192.7, 507.28    279.3, 523.40    296.8, 526.18    319.2, 526.45
GR          347.6, 535.31
*
*
*
AS   APPRO     52           0.
GR          -85.8, 504.23    -67.6, 497.37    -66.4, 498.20    -56.1, 497.59
GR          -45.0, 498.29    -19.7, 497.91    -10.2, 495.64     -7.8, 494.08
GR            0.0, 490.87      3.1, 490.34      4.3, 489.68      6.8, 489.55
GR            7.5, 489.41     12.0, 489.47     14.9, 489.93     20.0, 489.80
GR           24.4, 489.80     29.5, 489.64     32.7, 489.98     38.2, 489.78
GR           42.7, 490.49     46.8, 490.55     50.9, 493.11     58.4, 494.86
GR           66.8, 498.82     72.1, 500.64    110.2, 501.46    216.0, 508.67
GR          274.8, 513.15
*
N          0.060   0.050   0.065
SA             -19.7       72.1
*
HP 1 BRIDG   497.02 1 497.02
HP 2 BRIDG   497.02 * * 3389
HP 1 BRIDG   497.34 1 497.34
HP 2 RDWAY   501.87 * * 1397
HP 1 APPRO   502.04 1 502.04
HP 2 APPRO   502.04 * * 4760
*
HP 1 BRIDG   497.02 1 497.02
HP 2 BRIDG   497.02 * * 3408
HP 2 RDWAY   502.61 * * 2522
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File tops038.wsp
        Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
        TH 57 crossing Waits River, left abutment concrete facing
           *** RUN DATE & TIME: 06-17-97  10:54
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      239     19527      0     74                            0
   497.02           239     19527      0     74  1.00      0     30        0

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K       Q    VEL
       497.02     0.0    30.4   239.3   19527.    3389.  14.16
 X STA.         0.0         3.5         5.6         7.4         8.8        10.0
  A(I)             19.8        13.9        13.0        11.4        11.1
  V(I)             8.57       12.23       13.02       14.83       15.31

 X STA.        10.0        11.1        12.2        13.2        14.3        15.4
  A(I)             10.4        10.3         9.8        10.2        10.0
  V(I)            16.34       16.48       17.29       16.61       16.95

 X STA.        15.4        16.5        17.7        18.9        20.2        21.5
  A(I)             10.1        10.2        10.6        10.6        10.8
  V(I)            16.80       16.65       15.99       15.99       15.64

 X STA.        21.5        23.0        24.4        25.9        27.5        30.4
  A(I)             11.1        11.4        11.8        13.0        19.9
  V(I)            15.22       14.84       14.40       13.02        8.53

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      239     19527      0     74                            0
   497.34           239     19527      0     74  1.00      0     30        0

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA        K       Q    VEL
       501.87   -78.8    92.1   247.5    8774.    1397.   5.64
 X STA.       -78.8       -51.4       -43.3       -37.5       -31.9       -26.2
  A(I)             22.5        15.3        13.0        12.6        12.2
  V(I)             3.10        4.56        5.38        5.56        5.72

 X STA.       -26.2       -20.4       -14.6        -8.5        -3.3         1.7
  A(I)             12.2        12.2        12.3        10.1         9.6
  V(I)             5.71        5.75        5.69        6.88        7.26

 X STA.         1.7         6.7        11.8        16.8        21.9        26.9
  A(I)              9.6         9.6         9.7         9.6         9.5
  V(I)             7.29        7.30        7.22        7.28        7.32

 X STA.        26.9        32.1        37.4        44.0        52.5        92.1
  A(I)              9.9         9.7        10.9        12.0        25.0
  V(I)             7.03        7.19        6.43        5.84        2.79

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      222     12973     60     61                         2416
             2      868    112518     92     96                        15142
             3       40       834     47     47                          212
   502.04          1130    126325    199    204  1.23    -79    119    13809

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.
         WSEL     LEW     REW    AREA        K       Q    VEL
       502.04   -80.0   118.7  1130.0  126325.    4760.   4.21
X STA.       -80.0       -47.3       -21.2        -7.7        -1.8         2.4
  A(I)            113.3       102.4        74.5        53.9        47.4
  V(I)             2.10        2.32        3.20        4.41        5.02

 X STA.         2.4         6.0         9.4        12.7        16.2        19.6
  A(I)             43.8        42.5        41.8        41.6        41.5
  V(I)             5.43        5.61        5.70        5.72        5.74

 X STA.        19.6        23.0        26.4        29.7        33.3        36.8
  A(I)             41.8        41.9        41.2        43.1        43.4
  V(I)             5.69        5.68        5.77        5.53        5.48

 X STA.        36.8        40.5        44.5        49.1        56.0       118.7
  A(I)             44.7        46.5        51.4        58.9       114.3
  V(I)             5.32        5.12        4.63        4.04        2.08
1
  *
  HP 1 BRIDG   497.02 1 497.02
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V042094           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File tops038.wsp
```

```
       Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
       TH 57 crossing Waits River, left abutment concrete facing
          *** RUN DATE & TIME: 06-17-97  10:54
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      239     19527      0     74                            0
  497.02           239     19527      0     74  1.00      0     30        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.02     0.0    30.4   239.3   19527.    3408.  14.24

 X STA.        0.0        3.5        5.6        7.4        8.8       10.0
   A(I)            19.8       13.9       13.0       11.4       11.1
   V(I)            8.61      12.30      13.10      14.92      15.39

 X STA.       10.0       11.1       12.2       13.2       14.3       15.4
   A(I)            10.4       10.3        9.8       10.2       10.0
   V(I)           16.43      16.58      17.38      16.70      17.05

 X STA.       15.4       16.5       17.7       18.9       20.2       21.5
   A(I)            10.1       10.2       10.6       10.6       10.8
   V(I)           16.89      16.74      16.08      16.08      15.72

 X STA.       21.5       23.0       24.4       25.9       27.5       30.4
   A(I)            11.1       11.4       11.8       13.0       19.9
   V(I)           15.30      14.93      14.49      13.09       8.58

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
        WSEL     LEW     REW    AREA        K        Q    VEL
      502.61   -91.1   109.3   385.6   16290.    2522.   6.54
 X STA.      -91.1      -56.8      -46.5      -39.1      -32.7      -26.0
   A(I)            35.5       24.4       21.3       19.2       19.4
   V(I)            3.55       5.16       5.93       6.58       6.51

 X STA.      -26.0      -19.6      -12.8       -6.2       -0.9        4.4
   A(I)            18.3       18.9       18.1       14.3       14.1
   V(I)            6.89       6.68       6.98       8.82       8.93

 X STA.        4.4        9.9       15.3       20.6       26.1       31.6
   A(I)            14.4       14.4       14.1       14.3       14.6
   V(I)            8.74       8.74       8.96       8.82       8.66

 X STA.       31.6       37.2       43.6       51.3       65.1      109.3
   A(I)            14.6       15.4       16.7       25.1       38.8
   V(I)            8.67       8.19       7.56       5.03       3.25

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.
    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      271     17668     62     64                         3204
            2      941    128830     92     96                        17105
            3       82      2365     58     58                          553
  502.84          1294    148863    213    218  1.26    -81    130    16118

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

        WSEL     LEW     REW    AREA        K        Q    VEL
      502.84   -82.1   130.5  1294.5  148863.    6050.   4.67

 X STA.      -82.1      -51.2      -28.1      -11.1       -3.7        1.1
   A(I)           121.6      108.6       92.3       64.5       54.3
   V(I)            2.49       2.78       3.28       4.69       5.58

 X STA.        1.1        5.0        8.6       12.1       15.7       19.3
   A(I)            50.4       47.5       47.0       47.0       46.6
   V(I)            6.00       6.37       6.44       6.44       6.49

 X STA.       19.3       22.9       26.4       30.1       33.8       37.5
   A(I)            46.6       46.7       47.6       48.5       48.0
   V(I)            6.49       6.48       6.35       6.24       6.31

 X STA.       37.5       41.4       45.7       50.9       58.6      130.5
   A(I)            49.9       53.6       58.5       67.8      147.6
   V(I)            6.06       5.64       5.17       4.46       2.05
```

```
        U.S. Geological Survey WSPRO Input File tops038.wsp
        Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
        TH 57 crossing Waits River, left abutment concrete facing
           *** RUN DATE & TIME: 06-17-97  10:54
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      239     19527      0     74                            0
   497.02           239     19527      0     74  1.00      0     30        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.02     0.0    30.4   239.3  19527.    2390.   9.99
X STA.         0.0        3.5        5.6        7.4        8.8       10.0
  A(I)            19.8       13.9       13.0       11.4       11.1
  V(I)            6.04       8.62       9.18      10.46      10.79

X STA.        10.0       11.1       12.2       13.2       14.3       15.4
  A(I)            10.4       10.3        9.8       10.2       10.0
  V(I)           11.52      11.62      12.19      11.71      11.95

X STA.        15.4       16.5       17.7       18.9       20.2       21.5
  A(I)            10.1       10.2       10.6       10.6       10.8
  V(I)           11.85      11.74      11.27      11.27      11.03

X STA.        21.5       23.0       24.4       25.9       27.5       30.4
  A(I)            11.1       11.4       11.8       13.0       19.9
  V(I)           10.73      10.47      10.16       9.18       6.02

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      181     18523     30     40                         2503
   494.99           181     18523     30     40  1.00      0     30     2503

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       75      2325     53     54                          506
             2      633     68246     88     92                         9615
   499.46           708     70572    142    146  1.14    -72     69     8430

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.46   -73.1    68.7   708.3  70572.    2390.   3.37

X STA.       -73.1      -10.8       -2.8        1.4        4.8        7.7
  A(I)            98.6       44.9       35.1       31.2       29.2
  V(I)            1.21       2.66       3.41       3.83       4.10

X STA.         7.7       10.5       13.4       16.2       19.1       21.9
  A(I)            27.8       28.4       27.6       27.3       27.5
  V(I)            4.30       4.21       4.32       4.38       4.35

X STA.        21.9       24.8       27.6       30.4       33.4       36.5
  A(I)            27.7       27.8       27.4       28.3       29.3
  V(I)            4.32       4.30       4.37       4.22       4.07

X STA.        36.5       39.5       42.9       46.6       51.9       68.7
  A(I)            29.0       31.7       32.7       39.1       57.6
  V(I)            4.11       3.77       3.65       3.06       2.07
```

```
       U.S. Geological Survey WSPRO Input File tops038.wsp
       Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
       TH 57 crossing Waits River, left abutment concrete facing
          *** RUN DATE & TIME: 06-17-97  10:54

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

EXITX:XS   ******    -87      552  1.64 *****  498.12  495.96    4760  496.49
       -34 ******     81    46223  1.41 ***** *******    1.00    8.63

FULLV:FV       35    -91      703  1.06  0.28  498.40 *******    4760  497.34
         0     35     91    60437  1.49  0.00    0.00    0.74    6.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       52    -67      465  1.63  0.45  499.13 *******    4760  497.50
        52     52     64    42988  1.00  0.28   -0.01    0.76   10.23
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   497.34     496.93

            <<<<<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      239  3.12 *****  500.14  496.33    3389  497.02
         0 ******     30    19527  1.00 ***** *******    0.89   14.16

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.93 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    36.  0.05  0.34  502.32    0.01   1397.  501.87

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    907.    94.   -79.    15.   2.3   1.7   6.8   5.7   2.1   3.1
   RT:    490.    77.    15.    92.   1.9   1.2   5.9   5.5   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       21    -79     1129  0.34  0.17  502.37  496.34    4760  502.04
        52     25    119   126194  1.23  0.00    0.01    0.35    4.22

       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.   -88.    81.   4760.   46223.      552.    8.63  496.49
   FULLV:FV      0.   -92.    91.   4760.   60437.      703.    6.77  497.34
   BRIDG:BR      0.     0.    30.   3389.   19527.      239.   14.16  497.02
   RDWAY:RG      9.*******   907.   1397.******************    1.00  501.87
   APPRO:AS     52.   -80.   119.   4760.  126194.     1129.    4.22  502.04

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    495.96    1.00  488.15  526.59************  1.64  498.12  496.49
   FULLV:FV  ********    0.74  488.15  526.59  0.28  0.00  1.06  498.40  497.34
   BRIDG:BR    496.33    0.89  487.21  497.02************  3.12  500.14  497.02
   RDWAY:RG  ****************  499.60  535.31  0.05******  0.34  502.32  501.87
   APPRO:AS    496.34    0.35  489.41  513.15  0.17  0.00  0.34  502.37  502.04
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File tops038.wsp
        Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
        TH 57 crossing Waits River, left abutment concrete facing
           *** RUN DATE & TIME: 06-17-97  10:54

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

EXITX:XS   ******    -91      686  1.79 *****  499.04  497.03    6050  497.25
       -34 ******     90    58756  1.48 ***** *******    0.97    8.83

FULLV:FV       35    -93      856  1.17  0.29  499.32 *******    6050  498.15
         0     35    101    76245  1.51  0.00    0.00    0.73    7.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.99     498.18     497.35

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   497.65     513.15    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   497.65     513.15     497.35

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  0.67

APPRO:AS       52    -69      533  2.07  0.49  500.26  497.35    6050  498.19
        52     52     65    51030  1.03  0.45    0.00    0.99   11.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.15     496.93

            <<<<<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      239  3.15 *****  500.17  496.37    3408  497.02
         0 ******     30    19527  1.00 ***** *******    0.90   14.24

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  496.93 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    36.  0.06  0.43  503.21   -0.02   2522.  502.61

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1541.   106.   -91.    15.   3.0   2.2   7.8   6.6   2.8   3.1
   RT:    981.    94.    15.   109.   2.6   1.6   7.0   6.4   2.2   3.1

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

APPRO:AS       21    -81     1294  0.43  0.20  503.27  497.35    6050  502.84
        52     25    130   148804  1.26  0.00   -0.02    0.38    4.68

       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.   -92.    90.   6050.   58756.     686.    8.83  497.25
   FULLV:FV       0.   -94.   101.   6050.   76245.     856.    7.07  498.15
   BRIDG:BR       0.     0.    30.   3408.   19527.     239.   14.24  497.02
   RDWAY:RG       9.******* 1541.   2522.*****************    1.00  502.61
   APPRO:AS      52.   -82.   130.   6050.  148804.    1294.    4.68  502.84

 SECOND USER DEFINED TABLE.

   XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    497.03    0.97  488.15  526.59************  1.79  499.04  497.25
   FULLV:FV  ********    0.73  488.15  526.59  0.29  0.00  1.17  499.32  498.15
   BRIDG:BR    496.37    0.90  487.21  497.02************  3.15  500.17  497.02
   RDWAY:RG  ****************  499.60  535.31  0.06******  0.43  503.21  502.61
   APPRO:AS    497.35    0.38  489.41  513.15  0.20  0.00  0.43  503.27  502.84
```

```
        U.S. Geological Survey WSPRO Input File tops038.wsp
        Hydraulic analysis for structure TOPSTH00570038   Date: 12-JUN-97
        TH 57 crossing Waits River, left abutment concrete facing
           *** RUN DATE & TIME: 06-17-97  10:54

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

 EXITX:XS   ******    -30      294  1.09 *****  495.53  493.36    2390  494.44
        -34 ******     56    23200  1.07 ***** *******    0.80    8.12

 FULLV:FV       35    -44      348  0.84  0.30  495.83 *******    2390  494.99
          0     35     62    28350  1.14  0.00    0.00    0.72    6.87
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS       52     -9      304  0.96  0.44  496.33 *******    2390  495.37
         52     52     59    23803  1.00  0.06    0.00    0.66    7.85
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
            WS3,WSIU,WS1,LSEL =   494.82     497.94     498.09     496.93

  ===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      239  1.49 *****  498.51  494.74    2344  497.02
          0 ******     30    19527  1.00 ***** *******    0.62    9.80

      TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   2.  0.476  0.000  496.93 ****** ****** ******

     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       21    -72      709  0.20  0.10  499.67  494.17    2390  499.46
         52     23     69    70646  1.14  0.57   -0.02    0.28    3.37

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      ****** ****** ******** ****** ******   499.42

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

   FIRST USER DEFINED TABLE.

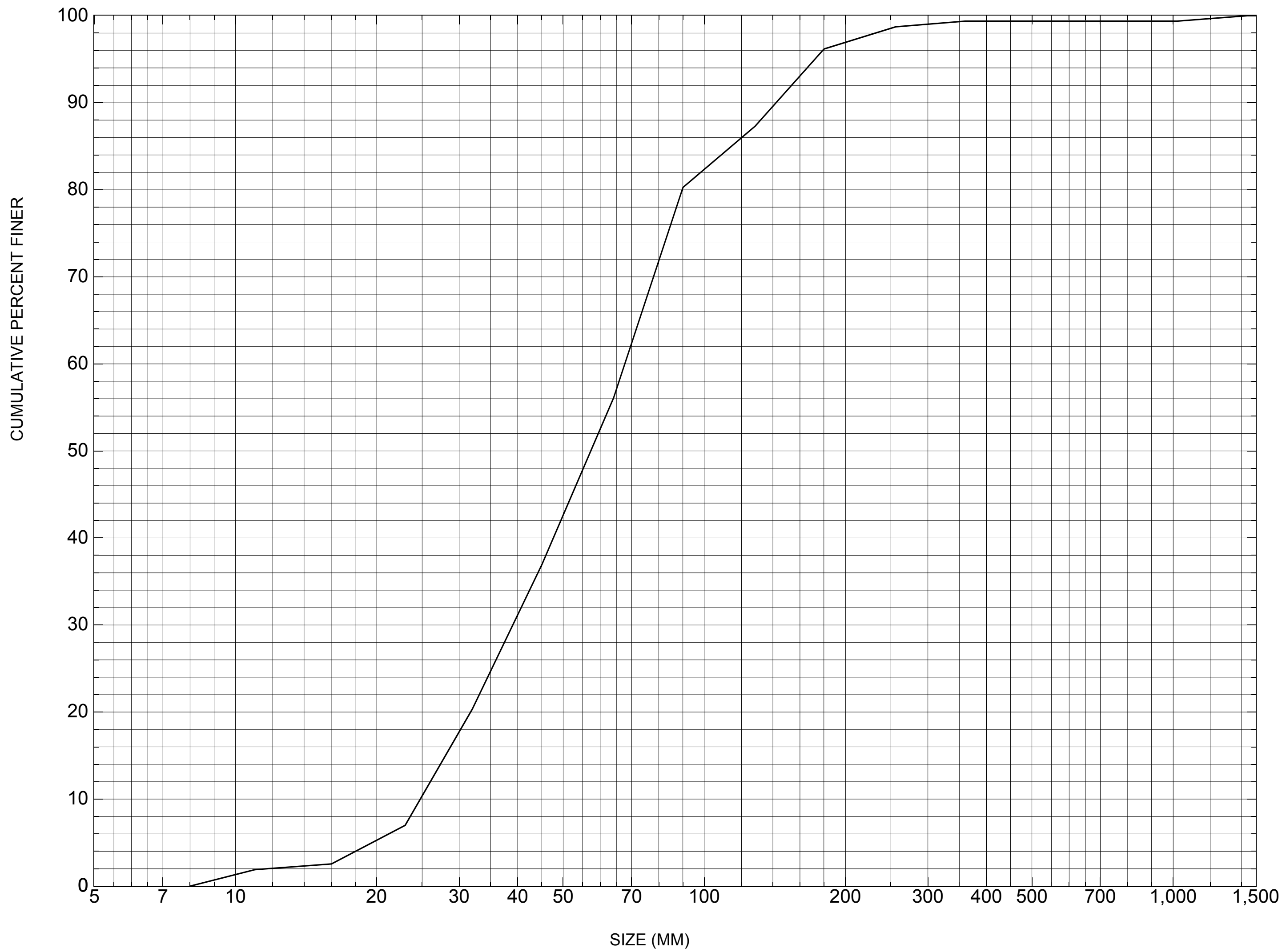
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS    -35.   -31.    56.   2390.   23200.     294.    8.12  494.44
    FULLV:FV      0.   -45.    62.   2390.   28350.     348.    6.87  494.99
    BRIDG:BR      0.     0.    30.   2344.   19527.     239.    9.80  497.02
    RDWAY:RG      9.**************       0.*********      0.    1.00********
    APPRO:AS     52.   -73.    69.   2390.   70646.     709.    3.37  499.46

   SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
    EXITX:XS    493.36    0.80  488.15  526.59************  1.09  495.53  494.44
    FULLV:FV   ********   0.72  488.15  526.59  0.30  0.00  0.84  495.83  494.99
    BRIDG:BR    494.74    0.62  487.21  497.02************  1.49  498.51  497.02
    RDWAY:RG   ****************  499.60  535.31************  0.17  500.11********
    APPRO:AS    494.17    0.28  489.41  513.15  0.10  0.57  0.20  499.67  499.46
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure TOPSTH00570038, in Topsham, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **TOPSTH00570038**

General Location Descriptive

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

Date *(MM/DD/YY)* **03** / **28** / **95**

Highway District Number *(I - 2; nn)* **07**

County *(FIPS county code; I - 3; nnn)* **017**

Town *(FIPS place code; I - 4; nnnnn)* **73075**

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

Waterway *(I - 6)* **WAITS RIVER**

Road Name *(I - 7)*: **-**

Route Number **TH057**

Vicinity *(I - 9)* **0.1 MI JCT TH 57 + VT 25**

Topographic Map **West Topsham**

Hydrologic Unit Code: **01080103**

Latitude *(I - 16; nnnn.n)* **44054**

Longitude *(i - 17; nnnnn.n)* **72170**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10091200380912**

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

Maximum span length *(I - 48; nnnn)* **0031**

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

Structure length *(I - 49; nnnnnn)* **000034**

Average daily traffic, ADT *(I - 29; nnnnnn)* **000200**

Deck Width *(I - 52; nn.n)* **160**

Year of ADT *(I - 30; YY)* **93**

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

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

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

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

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

Structure type *(I - 43; nnn)* **302**

Year Reconstructed *(I - 106)* **0000**

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

Clear span (*nnn.n ft*) **-**

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

Vertical clearance from streambed (*nnn.n ft*) **009.0**

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

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

Comments:

The structural inspection report of 8/30/93 indicates the structure is a steel stringer type bridge with a timber deck and an asphalt roadway surface. The right abutment and its wingwalls are "laid-up" granite stone blocks and slabs with stone chinking. Most of the stone chinking has broken and fallen out. The left abutment and its wingwalls are concrete or "laid-up" stone with concrete facing. The abutment face and wingwalls have alligator cracks and small leaks reported overall. There also is a concrete sub-footing constructed in front of the abutment wall and its upstream wingwall. The sub-footing is undermined for most of its length about 0.5 to 1 foot and penetration reaches 1 to 2 inches. **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: -

Terrain character: -

Stream character & type: -

Streambed material: -

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} (*ft^3/ sec*): -

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

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

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

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

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

Comments:

The channel reportedly scoured down to a point where the water is now 5 feet deep in front of the left abutment. The depths of water under the bridge are augmented by a "homemade" stone dam, which is present just downstream of the bridge. There is also a large metal pipeline, which stretches across the channel bottom just downstream. A few boulders are noted on the banks. The banks are reported showing signs of erosion from previous flooding. Point bar problems are noted as minor. The streambed consists of mainly sand and gravel.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **37.29** mi^2 Lake/pond/swamp area **0.25** mi^2
Watershed storage *(ST)* **0.7** %
Bridge site elevation **900** ft Headwater elevation **3123** ft
Main channel length **11.82** mi
10% channel length elevation **950** ft 85% channel length elevation **2070** ft
Main channel slope *(S)* **126.33** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

Maximum 2yr-24hr precipitation event *(I24,2)* ______ in

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:
There is no benchmark information available.

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

Foundation Type: 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:
There is no foundation material information available.

Comments:
There were no bridge plans available.

Cross-sectional Data

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

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

Comments: **This cross-section is of the upstream face. The low cord elevation is from the survey log done for this report on 08/28/95. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 08/30/93**

Station	0	3	13.4	21.4	30.4	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low cord elevation	496.8	496.8	496.9	496.9	497.0	-	-	-	-	-	-
Bed elevation	490.8	485.8	487.4	489.6	490.1	-	-	-	-	-	-
Low cord to bed length	6	11	9.5	7.3	6.9	-	-	-	-	-	-

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: EW Date: 03/25/96
Computerized by: EW Date: 04/11/96
Reviewd by: LKS Date: 06/24/97

Structure Number TOPSTH00570038

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 08 / 28 / 1995
2. Highway District Number 07 Mile marker -
County 017 Town TOPSHAM 73075
Waterway *(I - 6)* WAITS RIVER Road Name -
Route Number TH057 Hydrologic Unit Code: 01080103
3. Descriptive comments:
The bridge is a steel stringer bridge with a timber deck and an asphalt roadway surface. The abutments and wingwalls are laid up stone. The left abutment has concrete facing. The site is located 0.1 miles from the junction with VT 25.

B. Bridge Deck Observations

4. Surface cover... LBUS 2 RBUS 4 LBDS 4 RBDS 4 Overall 4
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 1 UB 1 DS 1 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 34 *(feet)* Span length 31 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

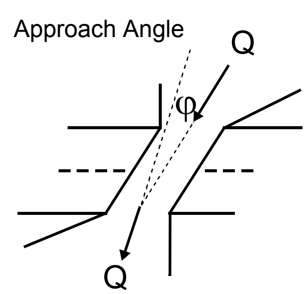
8. LB 0 RB 2 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

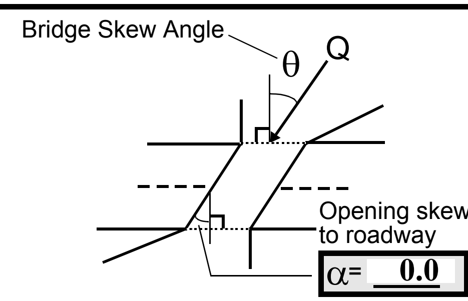
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	1
RBDS	0	-	2	1
LBDS	0	-	2	1

*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: 0 16. Bridge skew: 0





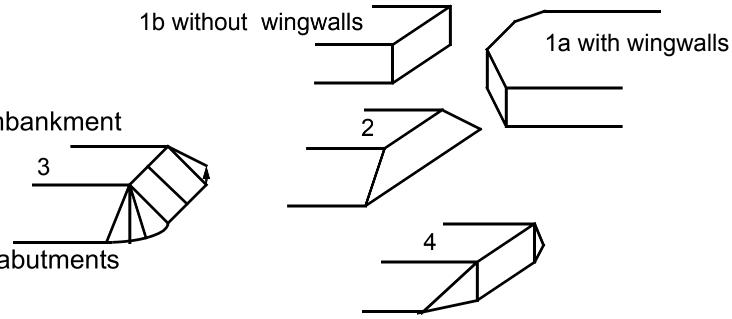
α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 45 feet US *(US, UB, DS)* to 0 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. 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.)

Since the last structural report, the bridge structure has been changed.
#4: LBUS - barn and a house with a small grass lawn backyard and a few trees along the LB
LBDS - all pasture
RBUS - lawn and house
RBDS - lawn and house; all forest DS
RBUS and RBDS have narrow strip of trees along immediate bank edges

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
36.5	7.0			10.0	2	2	234	324	1	1

23. Bank width **20.0** 24. Channel width **20.0** 25. Thalweg depth **91.5** 29. Bed Material **324**

30 .Bank protection type: LB **2** RB **0** 31. Bank protection condition: LB **1** RB **-**

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

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

At 200 feet US, the channel width is about three times wider and shallower than in areas closer to the bridge. The LB is protected from 45 feet US to 19 feet US, where concrete USLWW begins.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **45** 35. Mid-bar width: **15**

36. Point bar extent: **60** feet **US** (US, UB) to **35** feet **US** (US, UB, DS) positioned **10** %LB to **40** %RB

37. Material: **324**

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

A second mid-channel bar exists from 130 feet US to 85 feet US. It is 17 feet wide and extends from 15% LB to 40% RB.

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: **100** 42. Cut bank extent: **140** feet **US** (US, UB) to **70** 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.):

An additional cut-bank extends from 110 feet US to 40 feet US on RB. Both banks show some minor to moderate bank scalloping, particularly on RB where cut-banks overlap (where channel is widest).

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.):

There is no channel scour present at this site upstream.

49. Are there major confluences? **Y** (Y or if N type ctrl-n mc) 50. How many? **1**

51. Confluence 1: Distance **190** 52. Enters on **RB** (LB or RB) 53. Type **1** (**1**- perennial; **2**- ephemeral)

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

54. Confluence comments (eg. confluence name):

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
47.0		**1.0**		**2**	**7**	**7**	**-**

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

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

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

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

432

The bridge is very narrow compared to channel US and DS of bridge. The LABUT protrudes into the channel the greatest. Channel scouring is occurring UB along LABUT.

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:

2

Ice and debris may pile up on the stone fill in front of the USLWW where the channel makes a significant curve to flow around the abutment. There are some trees on a sinuous to meandering channel.

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		**10**	**90**	**2**	**1**	**1.5**	**0**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**30.5**

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

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

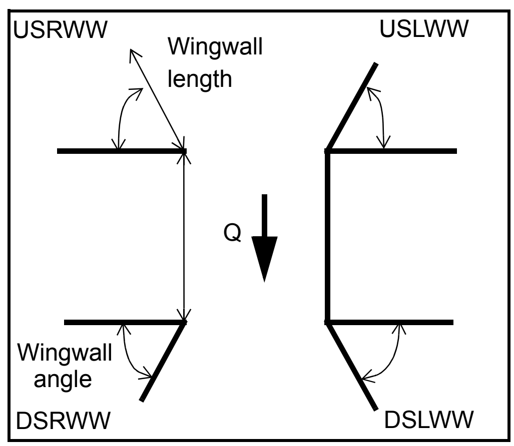
0
0
2

#77: The abutment wall is made of stone blocks. The blocks have been grouted recently, and new concrete has been constructed over the blocks from four feet up the wall to the bridge seat. The entire wall has been faced on the DSRWW.

The LABUT according to historical records was undermined with a sub-footing visible at the surface. This sub-footing is not visible at the surface due to coverage with type 2 stone fill. The stone fill slope projects into the channel between nine feet and twelve feet from the LABUT wall. The LABUT sub-footing is only currently visible at the DS end.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**30.5**	
USRWW:	**Y**		**1**		**1**	**3.0**	
DSLWW:	**0.5**		**0**		**Y**	**17.5**	
DSRWW:	**2**		**0**		**0**	**18.0**	



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**	**1**	**Y**	**0**	**1**	**-**	**1**	**1**
Condition	**Y**	**1.5**	**1**	**0**	**1**	**-**	**1**	**3**
Extent	**1**	**0**	**0**	**2**	**0**	**2**	**2**	**-**

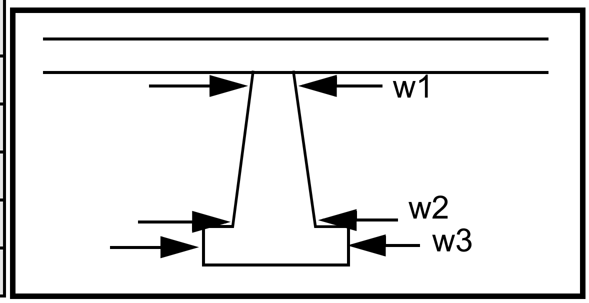
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
1
1
3
1
1

Piers:

84. Are there piers? Ne (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				60.0	19.0	50.0
Pier 2				14.0	15.0	11.5
Pier 3	5.0	-	-	7.0	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	w	left	fill in	the	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	stone	wing	the	gaps	**1**- Solid pier, **2**- column, **3**- bent
88. Material	fill is	walls	chan	betw	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	cur-	. The	nel	een	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	rentl	scou	at	the	Y- yes; N- no
91. Attack ∠ (BF)	y in	r is	these	stone	
92. Pushed	place	alon	loca-	fill	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	on	g the	tions	bloc	
95. Cross-members	the	toe	. On	ks	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	US	of	the	have	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	and	the	DSL	been	
98. Exposure depth	DS	stone	WW,	filled	

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

with sand, silt and organics (leaves and branches). This material is easily penetrated up to two feet with a range pole.

N

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width - Thalweg depth - Bed Material -

Bank protection type (Qmax): LB - RB - Bank protection condition: LB - RB -

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

101. Is a drop structure present? - *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: - *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):

-
-
-
-
-
-

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

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

Material: -_____

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

-
-
-
-

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

Cut bank extent: no____ feet pie____ *(US, UB, DS)* to rs at____ feet this____ *(US, UB, DS)*

Bank damage: site_____ *(**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? _____ *(Y or if N type ctrl-n cs)* Mid-scour distance: _______

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to 1____ %RB

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

1
231
213
1

Are there major confluences? 1____ *(Y or if N type ctrl-n mc)* How many? 342____

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

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

Confluence comments (eg. confluence name):

is the same width as the channel US. But, further downstream the channel narrows to the same width as exists at 250 feet US.

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

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: TOPSTH00570038 Town: TOPSHAM
Road Number: TH 57 County: ORANGE
Stream: WAITS RIVER

Initials LKS Date: 06/17/97 Checked: SAO

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	4760	6050	2390
Main Channel Area, ft2	868	941	633
Left overbank area, ft2	222	271	75
Right overbank area, ft2	40	82	0
Top width main channel, ft	92	92	88
Top width L overbank, ft	60	62	53
Top width R overbank, ft	47	58	0
D50 of channel, ft	0.1878	0.1878	0.1878
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.4	10.2	7.2
y1, average depth, LOB, ft	3.7	4.4	1.4
y1, average depth, ROB, ft	0.9	1.4	ERR
Total conveyance, approach	126325	148863	70572
Conveyance, main channel	112518	128830	68246
Conveyance, LOB	12973	17668	2325
Conveyance, ROB	834	2365	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0014
Qm, discharge, MC, cfs	4239.7	5235.8	2311.2
Ql, discharge, LOB, cfs	488.8	718.1	78.7
Qr, discharge, ROB, cfs	31.4	96.1	0.0
Vm, mean velocity MC, ft/s	4.9	5.6	3.7
Vl, mean velocity, LOB, ft/s	2.2	2.6	1.0
Vr, mean velocity, ROB, ft/s	0.8	1.2	ERR
Vc-m, crit. velocity, MC, ft/s	9.3	9.5	8.9
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	4760	6050	2390
(Q) discharge thru bridge, cfs	3389	3408	2390
Main channel conveyance	19527	19527	19527
Total conveyance	19527	19527	19527
Q2, bridge MC discharge,cfs	3389	3408	2390
Main channel area, ft2	239	239	239
Main channel width (normal), ft	30.4	30.4	30.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	30.4	30.4	30.4
y_bridge (avg. depth at br.), ft	7.87	7.87	7.87
Dm, median (1.25*D50), ft	0.23475	0.23475	0.23475
y2, depth in contraction,ft	10.65	10.70	7.89
ys, scour depth (y2-ybridge), ft	2.77	2.82	0.02

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	3389	3408	2390
Main channel area (DS), ft2	239	239	181
Main channel width (normal), ft	30.4	30.4	30.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	30.4	30.4	30.4
D90, ft	0.4663	0.4663	0.4663
D95, ft	0.5645	0.5645	0.5645
Dc, critical grain size, ft	0.7148	0.7228	0.6899
Pc, Decimal percent coarser than Dc	0.024	0.024	0.027
Depth to armoring, ft	N/A	N/A	N/A

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	4760	6050	2390
Q, thru bridge MC, cfs	3389	3408	2390
Vc, critical velocity, ft/s	9.33	9.46	8.92
Va, velocity MC approach, ft/s	4.88	5.56	3.65
Main channel width (normal), ft	30.4	30.4	30.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	30.4	30.4	30.4
qbr, unit discharge, ft2/s	111.5	112.1	78.6
Area of full opening, ft2	239.3	239.3	239.3
Hb, depth of full opening, ft	7.87	7.87	7.87
Fr, Froude number, bridge MC	0.89	0.9	0.62
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	--	--	181
**Hb, depth at downstream face, ft	ERR	ERR	5.95
**Fr, Froude number at DS face	ERR	ERR	0.95
**Cf, for downstream face (<=1.0)	N/A	N/A	1.00
Elevation of Low Steel, ft	496.93	496.93	496.93
Elevation of Bed, ft	489.06	489.06	489.06
Elevation of Approach, ft	502.04	502.84	499.46
Friction loss, approach, ft	0.17	0.2	0.1
Elevation of WS immediately US, ft	501.87	502.64	499.36
ya, depth immediately US, ft	12.81	13.58	10.30
Mean elevation of deck, ft	499.97	499.97	499.97
w, depth of overflow, ft (>=0)	1.90	2.67	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.92	0.93
**Cc, for downstream face (<=1.0)	ERR	ERR	0.832376
Ys, scour w/Chang equation, ft	5.16	5.05	1.58
Ys, scour w/Umbrell equation, ft	0.80	1.65	-1.25

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

**Ys, scour w/Chang equation, ft	N/A	N/A	4.64
**Ys, scour w/Umbrell equation, ft	N/A	N/A	0.67

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	10.65	10.70	7.89
WSEL at downstream face, ft	--	--	494.99
Depth at downstream face, ft	N/A	N/A	5.95
Ys, depth of scour (Laursen), ft	N/A	N/A	1.94

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	4760	6050	2390	4760	6050	2390
a', abut.length blocking flow, ft	80	82.1	73.1	88.3	100.1	38.3
Ae, area of blocked flow ft2	235.7	246.4	166.9	333.1	356.2	247.7
Qe, discharge blocked abut.,cfs	--------	---------	318.7	--------	---------	836.5
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.89	3.37	1.91	4.11	4.45	3.38
ya, depth of f/p flow, ft	2.95	3.00	2.28	3.77	3.56	6.47
--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	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.239	0.259	0.223	0.343	0.362	0.234
ys, scour depth, ft	12.42	13.17	9.83	17.96	18.52	17.13

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)	80	82.1	73.1	88.3	100.1	38.3
y1 (depth f/p flow, ft)	2.95	3.00	2.28	3.77	3.56	6.47
a'/y1	27.15	27.36	32.02	23.41	28.13	5.92

Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.24	0.26	0.22	0.34	0.36	0.23
Ys w/ corr. factor K1/0.55:						
vertical	13.36	13.98	10.12	ERR	18.51	ERR
vertical w/ ww's	10.96	11.46	8.29	ERR	15.18	ERR
spill-through	7.35	7.69	5.56	ERR	10.18	ERR

Abutment riprap Sizing

Isbash Relationship

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

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

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.89	0.9	0.95	0.89	0.9	0.95
y, depth of flow in bridge, ft	7.86	7.86	5.95	7.86	7.86	5.95

Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	3.18	3.19	2.45	3.18	3.19	2.45
Fr<=0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (spillthrough abut.)	2.81	2.82	2.17	2.81	2.82	2.17