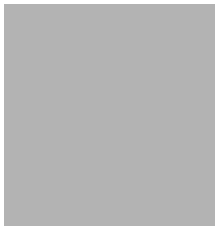
LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (POMFTH00010017) on TOWN HIGHWAY 1 (FAS 166), crossing MILL BROOK, POMFRET, VERMONT

U.S. Geological Survey
Open-File Report 97-2



Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
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FEDERAL HIGHWAY ADMINISTRATION

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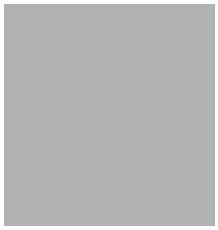

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VERMONT AGENCY OF TRANSPORTATION
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Pembroke, New Hampshire

1997

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	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 17 (POMFTH00010017) ON TOWN HIGHWAY 1 (FAS166), CROSSING MILL BROOK, POMFRET, VERMONT

By **Erick M. Boehmler and Robert E. Hammond**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure POMFTH00010017 on Town Highway 1 crossing Mill Brook, Pomfret, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 8.11-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture.

In the study area, Mill Brook has a sinuous channel with a slope of approximately 0.009 ft/ft, an average channel top width of 30 ft and an average channel depth of 3 ft. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 71.9 mm (0.236 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 25, 1996, indicated that the reach was stable.

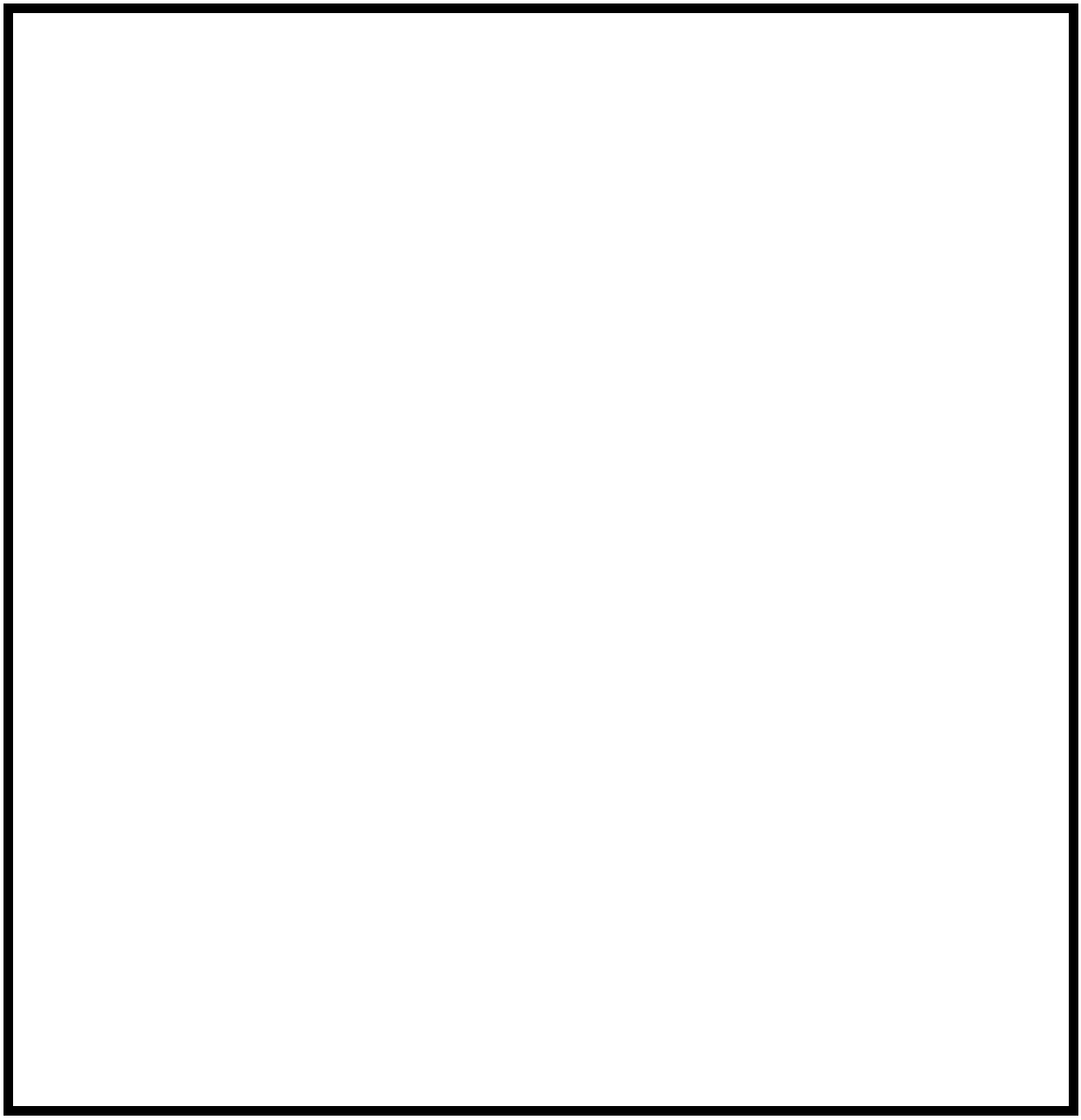
The Town Highway 1 crossing of Mill Brook is a 54-ft-long, two-lane bridge consisting of one 52-foot steel-beam span (Vermont Agency of Transportation, written communication, August 23, 1994). The bridge is supported by vertical, concrete abutments with spill-through embankments. The channel is skewed approximately 15 degrees to the opening and the opening-skew-to-roadway is 15 degrees.

The scour protection measures at the site were type-3 stone riprap (less than 48 inches diameter) on the spill-through embankments of each abutment and type-2 stone fill (less than 24 inches diameter) on the banks downstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 3.6 to 7.1 ft. The worst-case abutment scour also 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.

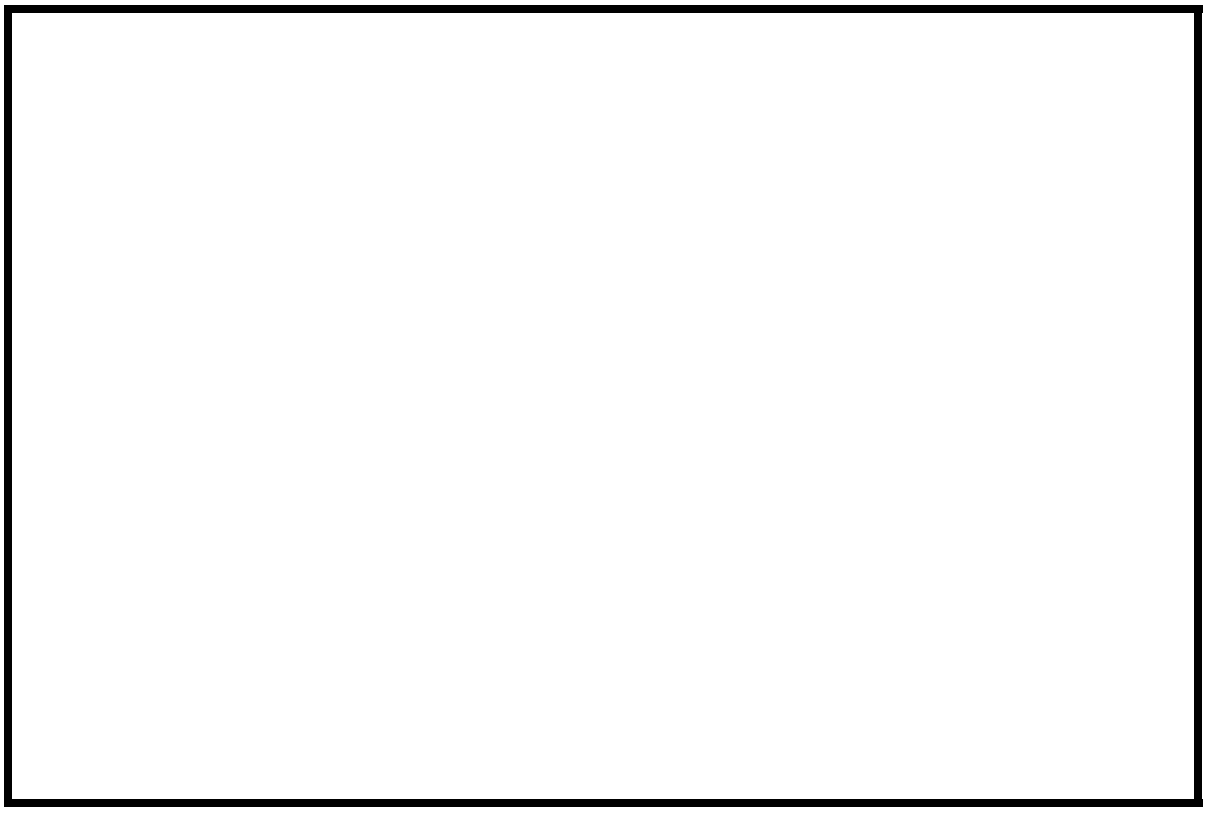


Quechee, VT. Quadrangle, 1:24,000, 1959
Photorevised 1988

NORTH

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

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



LEVEL II SUMMARY

Structure Number POMFTH00010017 ***Stream*** Mill Brook

County Windsor ***Road*** TH 1 ***District*** 4

Description of Bridge

Bridge length 54 ***ft*** ***Bridge width*** 27.3 ***ft*** ***Max span length*** 52 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 7/25/96

Description of stone fill Type-3 stone riprap on each spill-through embankment and Type-2 stone fill on the banks downstream.

Brief description of piers/abutments Abutment walls are concrete with sloping spill-through embankments in front of each abutment wall.

Is bridge skewed to flood flow according to Y ***survey?*** ***Angle*** Y 15

There is a sharp channel bend in the upstream reach which impacts the left bank. The left bank material is bedrock in the range of the impact.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/25/96	0	0
Level II	7/25/96	0	0

Potential for debris Moderate. There is some debris in the channel, particularly upstream, and significant vegetation cover on locally unstable banks.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on 7/25/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow overbanks and moderately sloping valley walls on both sides.

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

Date of inspection 7/25/96

DS left: Steep channel bank to a narrow overbank.

DS right: Steep channel bank to a narrow overbank

US left: Steep channel bank and valley wall.

US right: Moderately sloping bank to a narrow overbank.

Description of the Channel

Average top width 30 ft ***Average depth*** 3 ft

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

Incised upstream and sinuous but stable with semi-alluvial channel boundaries.

7/25/96

Vegetative co Dense trees and brush cover.

DS left: Brush and some trees.

DS right: Trees

US left: Grass and brush with some trees.

US right: Grass and brush with some trees.

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

None evident on 7/25/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 8.11 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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 1,670 ***ft³/s*** ***Q500*** 2,450 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957; and Talbot, 1887). The median of the 100- and 500-year discharges from each empirical discharge frequency curve was selected for the hydraulic analyses at this site.

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 Subtract 303.4 feet from the USGS survey to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled "X" in exposed bedrock about 45 feet upstream on left bank side of the channel (elev. 491.22 ft, arbitrary survey datum). RM2 is the center point of a chiseled "X" in exposed bedrock 20 feet left of left abutment and 10 feet upstream of the upstream side of TH1 (elev. 500.41 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-48	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APTEM	74	1	Approach section as surveyed (Used as a template)
APPRO	79	2	Modelled Approach section (Templated from APTEM)

[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 0.037 to 0.054, and overbank "n" values were 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 0.0087 ft/ft which was estimated from surveyed channel thalweg points downstream of the EXITX section.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0102 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.1 *ft*
Average low steel elevation 495.6 *ft*

100-year discharge 1,670 *ft³/s*
Water-surface elevation in bridge opening 495.6 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 247 *ft²*
Average velocity in bridge opening 6.8 *ft/s*
Maximum WSPRO tube velocity at bridge 9.9 *ft/s*

Water-surface elevation at Approach section with bridge 496.7
Water-surface elevation at Approach section without bridge 495.3
Amount of backwater caused by bridge 1.4 *ft*

500-year discharge 2,450 *ft³/s*
Water-surface elevation in bridge opening 495.7 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 248 *ft²*
Average velocity in bridge opening 9.9 *ft/s*
Maximum WSPRO tube velocity at bridge 12.4 *ft/s*

Water-surface elevation at Approach section with bridge 499.2
Water-surface elevation at Approach section without bridge 496.4
Amount of backwater caused by bridge 2.8

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

Water-surface elevation at Approach section with bridge --
Water-surface elevation at Approach section without bridge --
Amount of backwater caused by bridge -- *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 100- and 500-year discharges resulted in unsubmerged 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). Therefore, contraction scour depths were computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for each event also were computed and included in appendix F.

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

Scour at the right abutment for the 100- and 500-year discharges was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depths were applied for the entire spill-through embankment area below the elevation at the toe of each embankment, as shown in figure 8.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.9	--
Depth to armoring	0.4	6.2	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour	5.5	7.1	--
Left abutment	3.6	6.7	--
Right abutment	--	--	--
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	0.8	1.7	--
Left abutment	0.8	1.7	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

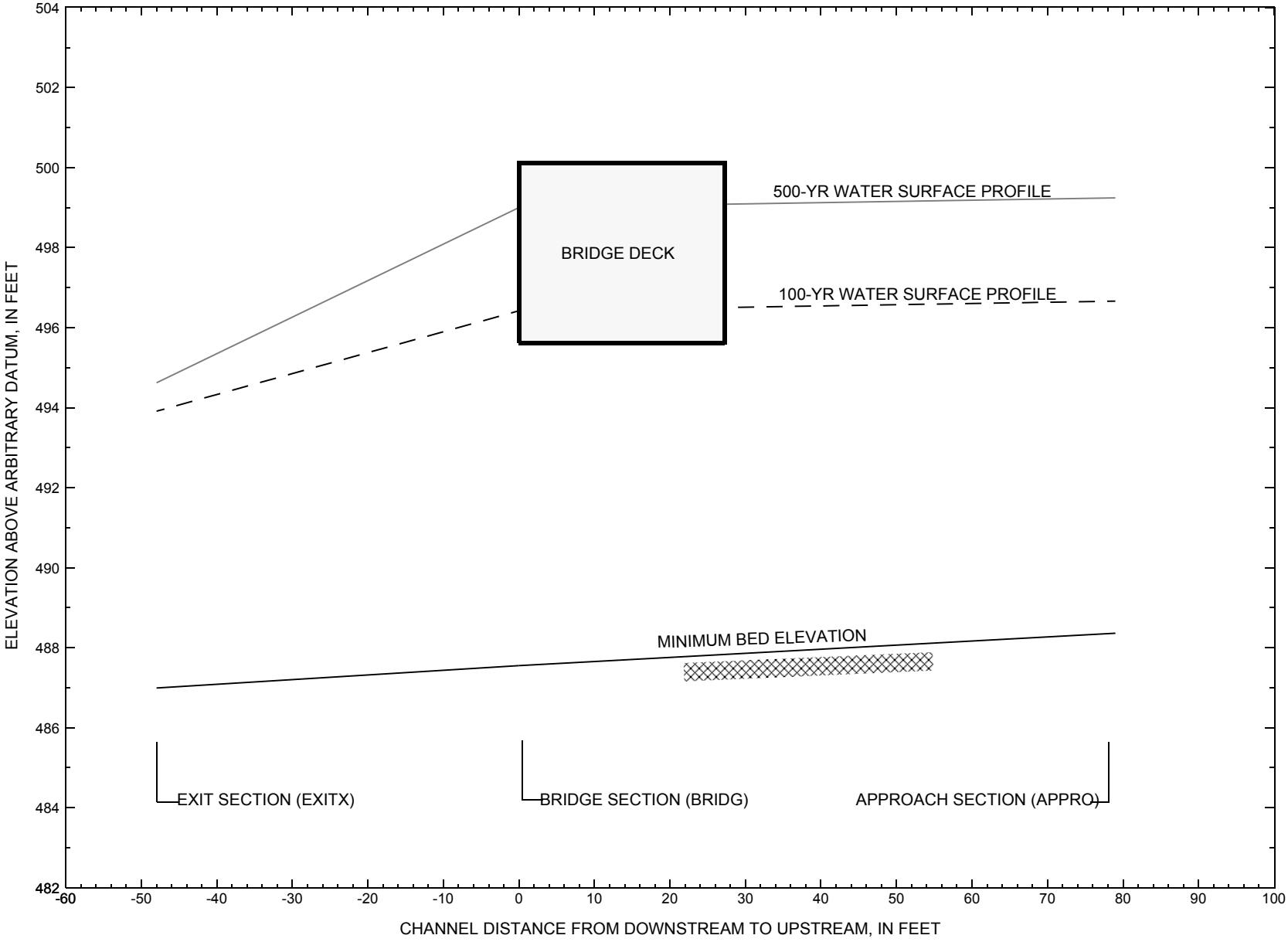


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure POMFTH00010017 on Town Highway 1, crossing Mill Brook, Pomfret, Vermont.

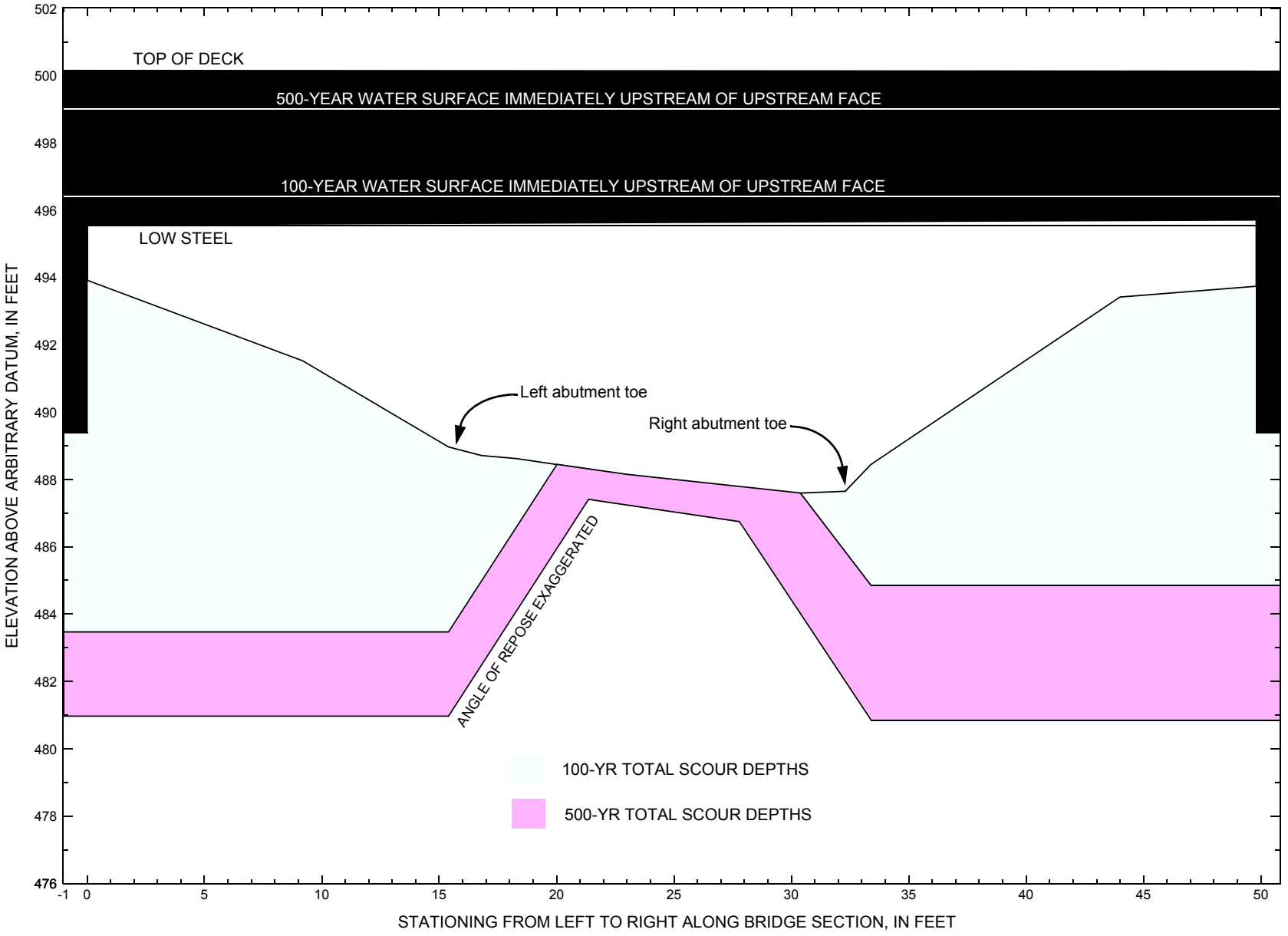


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure POMFTH00010017 on Town Highway 1, crossing Mill Brook, Pomfret, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure POMFTH00010017 on Town Highway 1, crossing Mill Brook, Pomfret, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed bridge seat elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,670 cubic-feet per second											
Left abutment	0.0	191.8	495.5	489.4	493.9	--	--	--	--	--	-5.9
Left abutment toe	15.4	--	--	--	489.0	0.0	5.5	--	5.5	483.5	--
Right abutment toe	33.4	--	--	--	488.4	0.0	3.6	--	3.6	484.8	--
Right abutment	49.8	192.1	495.7	489.4	493.7	--	--	--	--	--	-4.6

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 POMFTH00010017 on Town Highway 1, crossing Mill Brook, Pomfret, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed bridge seat elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,450 cubic-feet per second											
Left abutment	0.0	191.8	495.5	489.4	493.9	--	--	--	--	--	-8.4
Left abutment toe	15.4	--	--	--	489.0	0.9	7.1	--	8.0	481.0	--
Right abutment toe	33.4	--	--	--	488.4	0.9	6.7	--	7.6	480.8	--
Right abutment	49.8	192.1	495.7	489.4	493.7	--	--	--	--	--	-8.6

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File pomf017.wsp
T2        Hydraulic analysis for structure POMFTH00010017   Date: 17-OCT-96
T3        Town Highway 1 (FAS 166) over Mill Brook, Pomfret, VT              EMB
*
J1         *  *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1670.0   2450.0
SK          0.0087   0.0087
*
XS   EXITX    -48
GR         -121.3, 508.49   -115.1, 504.58   -104.9, 499.27    -96.6, 499.22
GR          -66.6, 499.28    -55.1, 498.36    -37.5, 493.51    -11.1, 492.47
GR           15.0, 491.70     19.0, 488.99     19.6, 487.97     20.0, 486.99
GR           23.2, 487.15     32.0, 487.20     34.7, 487.46     35.6, 487.86
GR           39.6, 488.74     40.7, 490.96     49.1, 492.02    106.9, 493.64
GR          154.8, 501.32    266.0, 505.60    400.9, 507.80    425.7, 510.59
*
N           0.050        0.054        0.050
SA                 15.0         40.7
*
XS   FULLV      0  * * *   0.0085
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    495.62      15.0
GR           0.0, 495.54      0.0, 493.92      9.2, 491.52     15.4, 488.97
GR          16.8, 488.71     18.3, 488.62     23.0, 488.15     28.7, 487.55
GR          32.3, 487.65     33.4, 488.45     44.0, 493.42     49.8, 493.74
GR          49.8, 495.69      0.0, 495.54
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      30.7     1.5     500.1
N           0.037
*
*         Although a type 1 bridge opening with wingwalls was indicated in
*         field notes, the opening was modeled as a type 3.
*                   BRTYPE  BRWDTH       WWANGL    WWWID
*         CD           1      33.3 * *     89.1      0.0
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      27.3     1
GR         -121.3, 508.49   -115.1, 504.58   -104.9, 499.25    -96.6, 499.27
GR          -66.6, 499.28    -30.9, 499.94     -1.9, 500.15      0.0, 500.15
GR            0.0, 500.75     49.9, 500.68     49.9, 500.13     52.0, 500.06
GR           74.0, 499.94    122.0, 500.93    253.9, 504.69    657.4, 520.30
GR          725.9, 525.27
*
XT   APTEM     74
GR         -27.7, 508.97     -8.6, 503.56      0.0, 495.96      0.9, 493.39
GR           2.5, 492.30     10.5, 490.04     12.8, 488.31     17.0, 489.02
GR          24.0, 489.43     25.0, 490.08     34.1, 493.69    216.5, 498.79
GR          242.8, 504.78    591.0, 516.14
*
AS   APPRO     79  *  *  *  0.0102
GT
N           0.043        0.050
SA                 34.1
*
HP 1 BRIDG 495.62 1 495.62
HP 2 BRIDG 495.62 * * 1670
HP 1 APPRO 496.66 1 496.66
HP 2 APPRO 496.66 * * 1670
*
HP 1 BRIDG 495.69 1 495.69
HP 2 BRIDG 495.69 * * 2450
HP 1 APPRO 499.24 1 499.24
HP 2 APPRO 499.24 * * 2450
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File pomf017.wsp
        Hydraulic analysis for structure POMFTH00010017   Date: 17-OCT-96
        Town Highway 1 (FAS 166) over Mill Brook, Pomfret, VT              EMB
           *** RUN DATE & TIME: 10-17-96  14:09

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      247     21181     22     80                        4653
   495.62           247     21181     22     80  1.00      0     50     4653

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.62     0.0    49.8   247.1   21181.    1670.   6.76

X STA.          0.0        8.8       12.8       15.4       17.6       19.5
  A(I)             23.8       18.0       15.6       14.0       13.2
  V(I)             3.51       4.64       5.35       5.95       6.32

X STA.         19.5       21.4       23.1       24.8       26.4       27.6
  A(I)             12.9       12.4       12.2       11.7        9.3
  V(I)             6.48       6.72       6.85       7.14       9.01

X STA.         27.6       28.7       29.8       30.9       32.0       33.2
  A(I)              8.6        8.7        8.4        8.5        9.0
  V(I)             9.70       9.64       9.91       9.79       9.26

X STA.         33.2       34.6       36.2       38.3       41.5       49.8
  A(I)              9.4        9.8       10.9       12.5       18.3
  V(I)             8.90       8.56       7.69       6.66       4.57

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      79.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      204     21184     35     39                        2791
             2      152      5841    104    104                        1045
   496.66           356     27025    139    144  1.53      0    138     2612

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      79.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.66    -0.7   138.5   355.9   27025.    1670.   4.69

X STA.         -0.7        5.5        8.2       10.3       12.2       13.6
  A(I)             22.0       15.1       13.4       13.0       11.7
  V(I)             3.80       5.52       6.25       6.44       7.15

X STA.         13.6       14.9       16.3       17.8       19.2       20.7
  A(I)             10.9       10.9       10.8       11.0       10.8
  V(I)             7.64       7.69       7.70       7.62       7.71

X STA.         20.7       22.2       23.7       25.5       27.7       30.7
  A(I)             11.0       10.9       12.2       12.9       14.9
  V(I)             7.59       7.69       6.82       6.48       5.61

X STA.         30.7       36.9       47.0       59.9       77.7      138.5
  A(I)             20.3       27.2       30.6       34.7       51.6
  V(I)             4.11       3.07       2.73       2.40       1.62
```

WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW       QCR
             1      248     18034      0    102                           0
   495.69           248     18034      0    102  1.00      0     50         0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.69     0.0    49.8   247.9   18034.    2450.   9.88

X STA.          0.0        8.0       11.6       14.1       16.0       17.7
  A(I)             20.7       15.0       13.2       12.0       11.2
  V(I)             5.91       8.17       9.27      10.22      10.92

X STA.         17.7       19.3       20.8       22.2       23.7       25.0
  A(I)             10.9       10.4       10.3       10.2       10.0
  V(I)            11.29      11.82      11.93      12.06      12.20

X STA.         25.0       26.3       27.7       28.9       30.2       31.6
  A(I)              9.8       10.0       10.0       10.2       10.3
  V(I)            12.44      12.22      12.29      12.06      11.88

X STA.         31.6       33.0       34.8       37.1       40.5       49.8
  A(I)             11.2       11.8       13.4       15.3       22.1
  V(I)            10.96      10.37       9.13       8.02       5.54

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      79.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW       QCR
             1      297     37367     38     43                          4730
             2      538     32775    184    184                          5222
   499.24           835     70142    222    227  1.44     -3    218       7663

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      79.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.24    -3.7   218.3   835.4   70142.    2450.   2.93

X STA.         -3.7        6.0        9.6       12.5       14.8       17.1
  A(I)             46.0       29.9       28.6       24.3       23.7
  V(I)             2.66       4.10       4.28       5.04       5.16

X STA.         17.1       19.4       21.8       24.2       27.0       30.7
  A(I)             23.6       23.6       23.1       25.4       27.8
  V(I)             5.20       5.18       5.29       4.83       4.41

X STA.         30.7       36.7       44.7       53.4       62.9       73.9
  A(I)             35.3       42.4       44.1       46.2       49.8
  V(I)             3.47       2.89       2.78       2.65       2.46

X STA.         73.9       86.0      100.8      119.1      145.0      218.3
  A(I)             51.0       56.8       61.8       71.5      100.4
  V(I)             2.40       2.16       1.98       1.71       1.22
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File pomf017.wsp
       Hydraulic analysis for structure POMFTH00010017   Date: 17-OCT-96
       Town Highway 1 (FAS 166) over Mill Brook, Pomfret, VT              EMB
          *** RUN DATE & TIME: 10-17-96  14:09

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

EXITX:XS   ******    -38      306  0.69 *****  494.60  493.71    1670  493.91
       -47 ******    109    17895  1.50 ***** *******    0.82    5.45

FULLV:FV       48    -38      312  0.66  0.41  495.02 *******    1670  494.35
         0     48    109    18271  1.49  0.00    0.01    0.79    5.36
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.42     494.60     495.32

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.85     516.19    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.85     516.19     495.32

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                   WSBEG,WSEND,CRWS =   495.32     516.19     495.32

APPRO:AS       79      0      202  1.39 *****  496.72  495.32    1670  495.32
        79     79     91    15417  1.32 ***** *******    1.12    8.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===230 REJECTED FLOW CLASS 1 SOLUTION.
              WS1,WSSD,WS3 =   495.32       0.00     493.81
                     CRWS =   495.32   ********     493.81
                     YMAX =   516.19   ********     495.69

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   501.78         1.      1669.

 ===280 REJECTED FLOW CLASS 4 SOLUTION.

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

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

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

BRIDG:BR       48      0      247  0.70 *****  496.32  493.79    1663  495.62
         0 ******     50    21181  1.00 ***** *******    0.53    6.73

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   2.  0.430  0.000  495.62 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.         <<<<<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       48      0      357  0.52  0.24  497.19  495.32    1670  496.66
        79     49    139    27075  1.53  0.00    0.00    0.64    4.68

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
    ****** ****** ******** ****** ******   496.47

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.   -39.   109.   1670.   17895.     306.    5.45  493.91
   FULLV:FV       0.   -39.   109.   1670.   18271.     312.    5.36  494.35
   BRIDG:BR       0.     0.    50.   1663.   21181.     247.    6.73  495.62
   RDWAY:RG      15.**************      0.******************    1.00********
   APPRO:AS      79.    -1.   139.   1670.   27075.     357.    4.68  496.66

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

WSPRO OUTPUT FILE (continued)

```
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#     YMIN     YMAX     HF     HO  VHD       EGL     WSEL
   EXITX:XS     493.71     0.82   486.99   510.59************  0.69   494.60   493.91
   FULLV:FV   ********     0.79   487.40   511.00   0.41   0.00  0.66   495.02   494.35
   BRIDG:BR     493.79     0.53   487.55   495.69************  0.70   496.32   495.62
   RDWAY:RG   ****************   499.25   525.27************  0.04   500.79********
   APPRO:AS     495.32     0.64   488.36   516.19   0.24   0.00  0.52   497.19   496.66

         U.S. Geological Survey WSPRO Input File pomf017.wsp
         Hydraulic analysis for structure POMFTH00010017   Date: 17-OCT-96
         Town Highway 1 (FAS 166) over Mill Brook, Pomfret, VT              EMB
            *** RUN DATE & TIME: 10-17-96  14:09

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

EXITX:XS    ******    -41       414  0.74 *****  495.36  494.28    2450  494.62
       -47 ******    113     26262  1.35 ***** *******    0.74    5.91

FULLV:FV        48    -41       418  0.72  0.41  495.78 *******    2450  495.06
         0      48    113     26601  1.35  0.00    0.01    0.73    5.86
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.56     516.19    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.56     516.19     496.41

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   496.41     516.19     496.41

APPRO:AS        79       0       323  1.35 *****  497.76  496.41    2450  496.41
        79      79     130     24456  1.51 ***** *******    1.04    7.60
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.78     496.54     497.00     495.62

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

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

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

BRIDG:BR        48       0       248  1.51 *****  497.20  494.78    2445  495.69
         0 ******      50     18034  1.00 ***** *******    0.78    9.86

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        3. ****   2.  0.499  0.000  495.62 ****** ****** ******

    XSID:CODE     SRD   FLEN     HF    VHD      EGL      ERR       Q    WSEL
   RDWAY:RG       15.         <<<<<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        48      -3       835  0.19  0.24  499.43  496.41    2450  499.24
         79     50    218     70041  1.44  0.48    0.00    0.32    2.94

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.17

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD     LEW     REW        Q         K      AREA      VEL     WSEL
   EXITX:XS     -48.    -42.    113.    2450.    26262.      414.     5.91   494.62
   FULLV:FV       0.    -42.    113.    2450.    26601.      418.     5.86   495.06
   BRIDG:BR       0.      0.     50.    2445.    18034.      248.     9.86   495.69
   RDWAY:RG      15.**************       0.        0.        0.     1.00********
   APPRO:AS      79.     -4.    218.    2450.    70041.      835.     2.94   499.24

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

WSPRO OUTPUT FILE (continued)

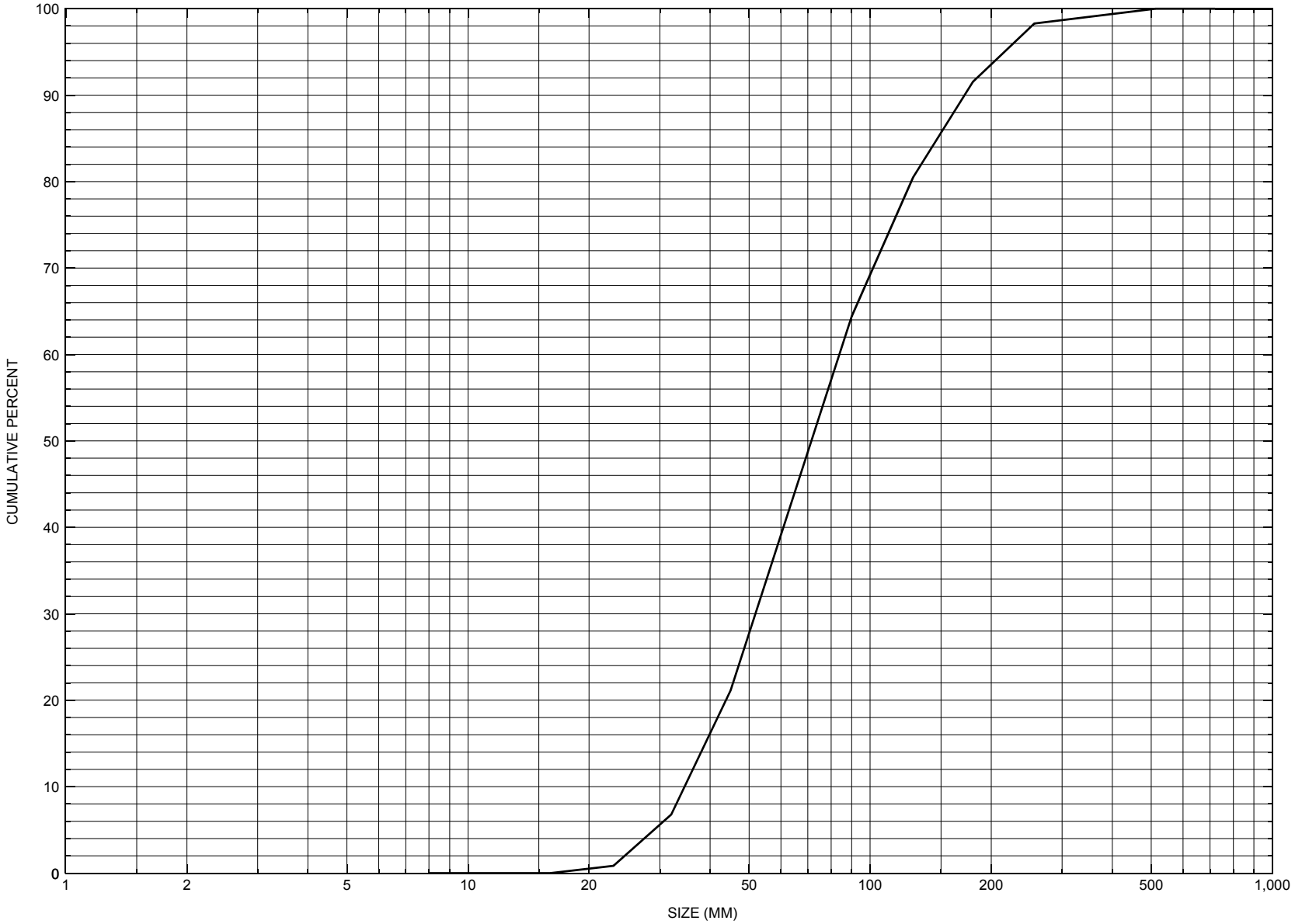
```
SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS      FR#     YMIN     YMAX     HF     HO  VHD       EGL     WSEL
  EXITX:XS     494.28     0.74   486.99   510.59************  0.74   495.36   494.62
  FULLV:FV   ********     0.73   487.40   511.00   0.41   0.00  0.72   495.78   495.06
  BRIDG:BR     494.78     0.78   487.55   495.69************  1.51   497.20   495.69
  RDWAY:RG   **********  499.25   525.27************  0.18   499.44********
  APPRO:AS     496.41     0.32   488.36   516.19   0.24   0.48  0.19   499.43   499.24
 ER

NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure POMFTH00010017, in Pomfret, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number POMFTH00010017

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 23 / 94

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 56350

Mile marker *(I - 11; nnn.nnn)* 007860

Waterway *(I - 6)* MILL BROOK

Road Name *(I - 7):* -

Route Number TH01

Vicinity *(I - 9)* 3.3 MI W JCT. VT.14

Topographic Map Quechee

Hydrologic Unit Code: 01080106

Latitude *(I - 16; nnnn.n)* 43435

Longitude *(i - 17; nnnnn.n)* 72280

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20016600171413

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

Maximum span length *(I - 48; nnnn)* 0052

Year built *(I - 27; YYYY)* 1948

Structure length *(I - 49; nnnnnn)* 000054

Average daily traffic, ADT *(I - 29; nnnnnn)* 000460

Deck Width *(I - 52; nn.n)* 273

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

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

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

Waterway adequacy *(I - 71; n)* 8

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

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)* 007.0

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

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

Comments:

This bridge is on the federal aid system, route 166. Structural inspection report of 5/5/94 indicates sub-structure has a vertical crack in left abutment at BM#2. Minor cracking on the back- and wingwalls. Heavy stone fill (rip rap) is noted at the abutments. No scour is noted and only minor embankment ero-sion. Channel alignment is straight through the bridge crossing. Status of drift/vegetation and riprap are not addressed on report.

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} (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. : U 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:

-
-
-
-
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **8.11** mi^2 Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **715** ft Headwater elevation **1964** ft

Main channel length **5.22** mi

10% channel length elevation **760** ft 85% channel length elevation **1240** ft

Main channel slope *(S)* **122.68** ft / mi

Watershed Precipitation Data

Average site precipitation _____ in Average headwater precipitation _____ in

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

Average seasonal snowfall *(Sn)* _____ ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* 06 / 1947

Project Number SA 25-1944 Minimum channel bed elevation: 184.0

Low superstructure elevation: USLAB 191.83 DSLAB 191.85 USRAB 192.15 DSRAB 192.13

Benchmark location description:
BM#2 in a 14 inch elm in area of downstream left wingwall near top of the left bank of the channel, elevation 187.32.

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

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 186.0

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
Riprap sloping abutment indicated as constructed at a 1.5 to 1 slope in front of abutment backwalls.

Cross-sectional Data

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

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

Comments: **Cross sections were available for the upstream and downstream face of the bridge, but elevations were not retrieved properly. Therefore, they were omitted.**

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

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

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

Comments:

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 8/12/96
Computerized by: EW Date: 8/12/96
Reviewd by: EMB Date: 12/9/96

Structure Number POMFTH00010017

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R Hammond Date *(MM/DD/YY)* 07 / 25 / 1996

2. Highway District Number 04
County Windsor (027)
Waterway *(I - 6)* Mill Brook
Route Number TH01
Mile marker 007860
Town Pomfret (56350)
Road Name Pomfret Road
Hydrologic Unit Code: 01080106

3. Descriptive comments:
Located 3.3 miles west from the intersection of VT 14 and TH 1. Also located 0.7 miles downstream of North Pomfret.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 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 2 UB 2 DS 2 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 54 *(feet)* Span length 52 *(feet)* Bridge width 27.3 *(feet)*

Road approach to bridge:

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

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

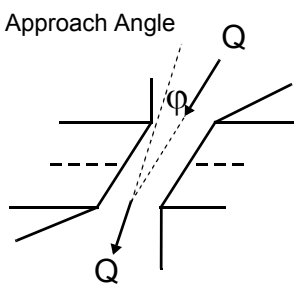
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

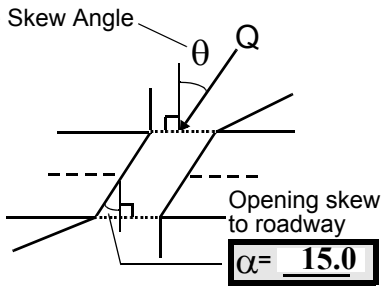
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: 5 16. Bridge skew: 15





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 90 feet US *(US, UB, DS)* to 64 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**

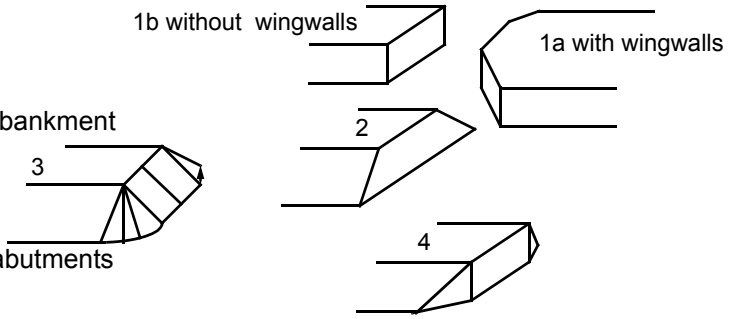
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7: Measured length (from outside of abutment to outside of abutment) is 54.2 feet. Clear span (from inside of abutment to inside of abutment) is 24.1 feet. The bridge width from each inside curbs is 24.1 feet, and the width from each outside curbs is 27.0 feet.

Recent (within at least the last month) flows upstream of the bridge have existed over the right bank and onto the flood plain. The water depth on the flood plain was approximately 0.5 feet.

17: Right angle change in stream channel, 90 degrees with respect to the bridge.

C. Upstream Channel Assessment

	21. Bank height (BF)		22. Bank angle (BF)		26. % Veg. cover (BF)		27. Bank material (BF)		28. Bank erosion (BF)	
20. SRD	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
45.0	**2.5**			**3.5**	***3**	***3**	**6**	**23**	**0**	**2**

23. Bank width **70.0** 24. Channel width **20.0** 25. Thalweg depth **34.0** 29. Bed Material **435**

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.):

26: * 0% vegetation cover from upstream bridge face to approach cross section. From approach cross section to at least two bridge lengths upstream, the vegetation cover is 100% on both banks.
28: Bedrock is exposed on the left bank.
30: Some boulders on top of bedrock on LB.

Bend in upstream section of reach is 83 feet US of upstream bridge face.
During recent bank full flows, several trees have fallen down which has blocked main channel at 180 feet US. In addition, a two feet in height channel bar has developed as a result of the upstream blockage.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **15** 35. Mid-bar width: **8**

36. Point bar extent: **20** feet **US** *(US, UB)* to **25** feet **DS** *(US, UB, DS)* positioned **0** %LB to **40** %RB

37. Material: **43**

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

Additional point bar exists on right bank 75 feet US to 62 feet US where bend exists in stream. A channel bar is also present in the center of the stream from approximately 300 feet US to 180 feet US.

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

41. Mid-bank distance: **25** 42. Cut bank extent: **40** feet **US** *(US, UB)* to **5** 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.):

In addition, roots are exposed on left bank above bedrock from 60 feet US to 35 feet US.

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **60**

47. Scour dimensions: Length **40** Width **7** Depth : **2.25** Position **20** %LB to **60** %RB

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

Average water depth is 0.75 feet. Channel scour extends from 80 feet US to 40 feet US.

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
24.0		**2.0**		**2**	**7**	**7**	-

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

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

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

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

432

55: Boulder protection extends up banks to about 2.5 feet to 2 feet below low cord.

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

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

70. Debris and Ice Comments:

1

68: Compared to channel upstream, bridge opening is rather wide. Therefore, capture efficiency is low.

69: Also, the ice blockage potential will be low.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**0**	**0**	-	-	**90.0**
RABUT	**1**	**0**	**90**			**0**	**0**	**48.0**

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.):

-

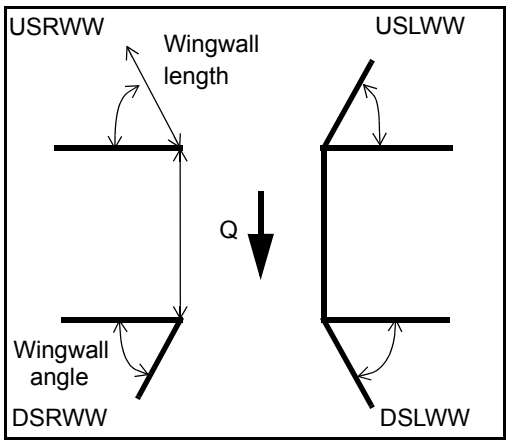
-

1

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**48.0**	
USRWW:	-		-		-	**1.0**	
DSLWW:	-		-		-	**30.5**	
DSRWW:	-		-		-	**30.5**	

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



82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	-	-	-	-	**1**	**1**
Condition	-	-	-	-	-	-	**1**	**1**
Extent	-	-	-	**0**	**0**	**3**	**3**	-

*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*

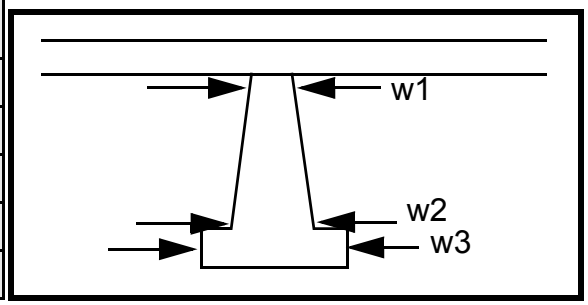
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

-
-
-
-
-
-
-
-
-
-

E. Downstream Channel Assessment

100.

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

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

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

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

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

3
2
5
5
0
0
432
2
2
1
1
Bank protection on both banks extends from downstream bridge face to 60 feet DS. The banks are protected with boulders and concrete blocks. Additional protection exists on the right bank 200 feet DS where a sharp

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

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

105. Drop structure comments (eg. downstream scour depth):
in the channel is present.
Bank material is bank protection. There is no bank erosion from bridge face to 60 feet DS. Moderate fluvial erosion exists from 60 feet DS to 200 feet DS on both banks; banks have exposed roots and undermining. Mass wasting is evident beyond this area.

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 **N** %LB to **-** %RB

Material: **NO**

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

DROP STRUCTURE

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

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

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

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

-
-
-
-

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

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

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

er to US Assessment for side bar which extends downstream of bridge.

N

-

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

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

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

Confluence comments (eg. confluence name):

T BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

__1__- Constructed
__2__- Stable
__3__- Aggraded
__4__- Degraded
__5__- Laterally unstable
__6__- Vertically and laterally unstable

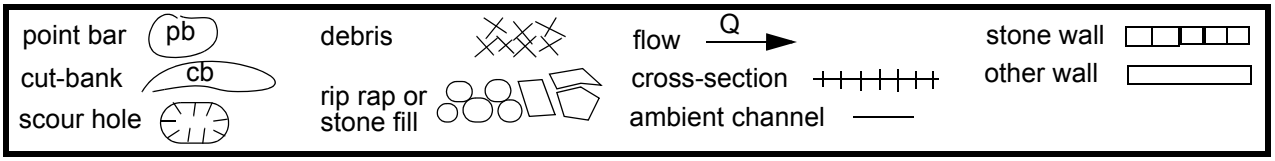
108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N
-
-
-
-
-
-
NO CHANNEL SCOUR

Local scour behind boulders.

N

109. G. Plan View Sketch



APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: POMFTH00010017 Town: Pomfret
Road Number: TH 1 County: Windsor
Stream: Mill Brook

Initials EMB Date: 11/15/96 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	1670	2450	0
Main Channel Area, ft2	204	297	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	152	538	0
Top width main channel, ft	35	38	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	104	184	0
D50 of channel, ft	0.236	0.236	0
D50 left overbank, ft	--	--	0
D50 right overbank, ft	--	--	0
y1, average depth, MC, ft	5.8	7.8	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	1.5	2.9	ERR
Total conveyance, approach	27025	70142	0
Conveyance, main channel	21184	37367	0
Conveyance, LOB	0	0	0
Conveyance, ROB	5841	32775	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1309.1	1305.2	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	360.9	1144.8	ERR
Vm, mean velocity MC, ft/s	6.4	4.4	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	2.4	2.1	ERR
Vc-m, crit. velocity, MC, ft/s	9.3	9.8	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	N/A
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	N/A

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	204	297	0
Main channel width, ft	35	38	0
y1, main channel depth, ft	5.83	7.82	ERR
Bridge Section			
(Q) total discharge, cfs	1670	2450	0
(Q) discharge thru bridge, cfs	1670	2450	
Main channel conveyance	21181	18034	
Total conveyance	21181	18034	
Q2, bridge MC discharge,cfs	1670	2450	ERR
Main channel area, ft2	247	248	0
Main channel width (skewed), ft	48.1	48.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	48.1	48.1	0
y_bridge (avg. depth at br.), ft	5.14	5.15	ERR
Dm, median (1.25*D50), ft	0.295	0.295	0
y2, depth in contraction,ft	3.67	5.10	ERR
ys, scour depth (y2-ybridge), ft	-1.47	-0.06	N/A
Comparison of Chang and Laursen results (for unsubmerged orifice flow)			
y2, from Laursen's equation, ft	3.669165	5.096104	0
Full valley WSEL, ft	494.35	495.06	0
Full valley depth, ft	3.867214	4.593846	N/A
Ys, depth of scour (y2-yfullv), ft	-0.19805	0.502258	0
ARMORING			
D90	0.5618	0.5618	0
D95	0.7058	0.7058	0
Critical grain size,Dc, ft	0.2072	0.4425	ERR
Decimal-percent coarser than Dc	0.58	0.176	
Depth to armoring,ft	0.45	6.21	ERR

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1670	2450	0
Q, thru bridge, cfs	1670	2450	0
Total Conveyance, bridge	21181	18034	0
Main channel(MC) conveyance, bridge	21181	18034	0
Q, thru bridge MC, cfs	1670	2450	ERR
Vc, critical velocity, ft/s	9.29	9.76	N/A
Vc, critical velocity, m/s	2.83	2.97	N/A
Main channel width (skewed), ft	48.1	48.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	48.1	48.1	0.0
qbr, unit discharge, ft^2/s	34.7	50.9	ERR
qbr, unit discharge, m^2/s	3.2	4.7	N/A
Area of full opening, ft^2	247.1	247.9	0.0
Hb, depth of full opening, ft	5.14	5.15	ERR
Hb, depth of full opening, m	1.57	1.57	N/A
Fr, Froude number, bridge MC	0.53	0.78	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
Elevation of Low Steel, ft	495.62	495.62	0
Elevation of Bed, ft	490.48	490.47	N/A
Elevation of Approach, ft	496.66	499.24	0
Friction loss, approach, ft	0.24	0.24	0
Elevation of WS immediately US, ft	496.42	499.00	0.00
ya, depth immediately US, ft	5.94	8.53	N/A
ya, depth immediately US, m	1.81	2.60	N/A
Mean elevation of deck, ft	500.14	500.14	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.96	0.86	ERR
Ys, depth of scour, ft	-1.26	0.94	0.00

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	1670	2450	0	1670	2450	0
a', abut.length blocking flow, ft	2.4	5.4	0	88.7	168.5	0
Ae, area of blocked flow ft2	8.5	25.6	0	110.3	455.8	0
Qe, discharge blocked abut.,cfs	32.3	68.2	0	232.4	908.2	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.80	2.66	ERR	2.11	1.99	ERR
ya, depth of f/p flow, ft	3.54	4.74	ERR	1.24	2.71	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	75	75	75	105	105	105
K2	0.98	0.98	0.98	1.02	1.02	1.02
Fr, froude number f/p flow	0.356	0.216	ERR	0.333	0.213	ERR
ys, scour depth, ft	5.49	7.14	N/A	6.32	10.64	N/A

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)	2.4	5.4	0	88.7	168.5	0
y1 (depth f/p flow, ft)	3.54	4.74	ERR	1.24	2.71	ERR
a'/y1	0.68	1.14	ERR	71.33	62.29	ERR
Skew correction (p. 49, fig. 16)	0.95	0.95	0.00	1.03	1.03	0.00
Froude no. f/p flow	0.36	0.22	N/A	0.33	0.21	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	6.48	12.17	ERR
vertical w/ ww's	ERR	ERR	ERR	5.31	9.98	ERR
spill-through	ERR	ERR	ERR	3.56	6.70	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.53	0.78	0	0.53	0.78	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.14	5.15	0.00	5.14	5.15	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (spillthrough abut.)	0.78	1.69	0.00	0.78	1.69	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR