LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (POULTH00040005) on TOWN HIGHWAY 4, crossing the POULTNEY RIVER, POULTNEY, VERMONT

Open-File Report 98-381

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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By MICHAEL A. IVANOFF AND ERICK M. BOEHMLER

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (POULTH00040005) ON TOWN HIGHWAY 4, CROSSING THE POULTNEY RIVER, POULTNEY, VERMONT

By **Michael A. Ivanoff 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 POULTH00040005 on Town Highway 4 crossing the Poultney River, Poultney, 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 (FHWA, 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 straddles the Taconic section of the New England and the Champlain section of the St. Lawrence Valley physiographic provinces in west-central Vermont. The 49.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream of the bridge and on the downstream right overbank, with dense woody vegetation on the immediate banks. The left bank downstream of the bridge has row crops beyond a strip of trees and brush.

In the study area, the Poultney River has a meandering channel with a slope of approximately 0.0021 ft/ft, an average channel top width of 203 ft and an average bank height of 9 ft. The channel bed material ranges from sand to cobble with a median grain size (D_{50}) of 36.6 mm (0.120 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 19, 1995, indicated that the reach was laterally unstable with heavy fluvial erosion on the upstream left and downstream right banks.

The Town Highway 4 crossing of the Poultney River is an 84-ft-long, two-lane bridge consisting of one 80-foot steel thru-truss (pony) span (Vermont Agency of Transportation, written communication, March 22, 1995). The opening length of the structure parallel to the bridge face is 81.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 2.5 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. The only scour protection measure at the site was type-3 stone fill (less than 48 inches diameter) along the upstream left wingwall, left abutment, downstream left wingwall, and the upstream left bank. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.4 to 2.3 ft. The worst-case contraction scour occurred at the incipient roadway-overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 4.3 to 10.1 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Poultney, VT. Quadrangle, 1:24,000, 1964
Photorevised 1972

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 POULTH00040005 ***Stream*** Poultney River

County Rutland ***Road*** TH 4 ***District*** 3

Description of Bridge

Bridge length 84.0 ***ft*** ***Bridge width*** 21.4 ***ft*** ***Max span length*** 80.0 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 9/19/95

Description of stone fill Type-3, along the upstream left wingwall, the left abutment, and the downstream left wingwall.

Abutments and wingwalls are concrete. There is a 2.5 ft deep scour hole in front of the left abutment.

Yes 10

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

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

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	9/19/95	0	0
Level II	9/19/95	0	0

Potential for debris High. Several trees along the banks are leaning over the upstream channel.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 9/19/95.

Description of the Geomorphic Setting

General topography The channel is located within a low relief valley with a wide and flat to slightly irregular flood plain.

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

Date of inspection 9/19/95

DS left: Moderately sloped channel bank to a wide flood plain

DS right: Steep channel slope to a wide flood plain

US left: Steep channel slope to a wide flood plain

US right: Moderately sloped channel bank to a wide flood plain

Description of the Channel

Average top width 203 *ft* ***Average depth*** 9 *ft*

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

Perennial, meandering channel with alluvial channel boundariesand wide point bars.

Vegetative co[ver] 9/19/95

DS left: Trees and brush with row crops on the flood plain

DS right: Trees and brush with pasture on the flood plain

US left: Trees and brush with pasture on the flood plain

US right: Trees and brush with pasture on the flood plain

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

There is heavy fluvial erosion along the upstream left and downstream right banks.

Describe any obstructions in channel and date of observation. None as of 9/19/95.

Hydrology

Drainage area 49.2 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Taconic	90
St. Lawrence Valley/ Champlain	10

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

Is there a USGS gage on the stream of interest? Yes

USGS gage description Poultney River below Fair Haven, VT

USGS gage number 04280000

Gage drainage area 187 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 6,700 ***ft³/s*** ***Q500*** 9,350 ***ft³/s***

The 100-year discharge is from the flood frequency estimates available from the VTAOT database for this site (written communication, May 1995). The values were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

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. Subtract 90.3 ft from the USGS arbitrary survey datum to obtain National Geodetic Verticle Datum 1929.

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" on top of the downstream curb above the right abutment (elev. 501.16 ft, arbitrary survey datum). RM2 is a chiseled "X" on top of the upstream curb above the left abutment (elev. 501.01 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	-47	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	105	1	Approach section

[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. Although flow approaches this site at an angle greater than the opening-skew-to-roadway, flow was assumed to align with the abutments and no skew was applied to the bridge section for the model. 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 0.060, and overbank "n" values ranged from 0.050 to 0.070.

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 0.0021 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1964).

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

For the incipient-overtopping discharge, WSPRO assumed critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles, it was determined that the water surface profile passed through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge was a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.2 ***ft***
Average low steel elevation 496.5 ***ft***

100-year discharge 6,700 ***ft³/s***
Water-surface elevation in bridge opening 496.6 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,410 ***ft³/s***
Area of flow in bridge opening 642 ***ft²***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.9 ***ft/s***

Water-surface elevation at Approach section with bridge 498.3
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 3.3 ***ft***

500-year discharge 9,350 ***ft³/s***
Water-surface elevation in bridge opening 496.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 3,540 ***ft³/s***
Area of flow in bridge opening 641 ***ft²***
Average velocity in bridge opening 9.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.4 ***/s***

Water-surface elevation at Approach section with bridge 498.8
Water-surface elevation at Approach section without bridge 496.8
Amount of backwater caused by bridge 2.0 ***ft***

Incipient overtopping discharge 4,710 ***ft³/s***
Water-surface elevation in bridge opening 493.2 ***ft***
Area of flow in bridge opening 377 ***ft²***
Average velocity in bridge opening 12.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 21.6 ***ft/s***

Water-surface elevation at Approach section with bridge 497.0
Water-surface elevation at Approach section without bridge 494.1
Amount of backwater caused by bridge 2.9 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the incipient roadway-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 100-year 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). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and Davis, 1995, p. 145-146).

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

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

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

Scour Results

Contraction scour:	100-year discharge	500-year discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.4	2.0	2.3
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	9.5	10.1	9.0
Right abutment	6.8	7.7	4.3
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	500-year discharge (D50 in feet)	Incipient overtopping discharge
Abutments:			
Left abutment	2.2	2.3	2.0
Right abutment	2.2	2.3	2.0
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

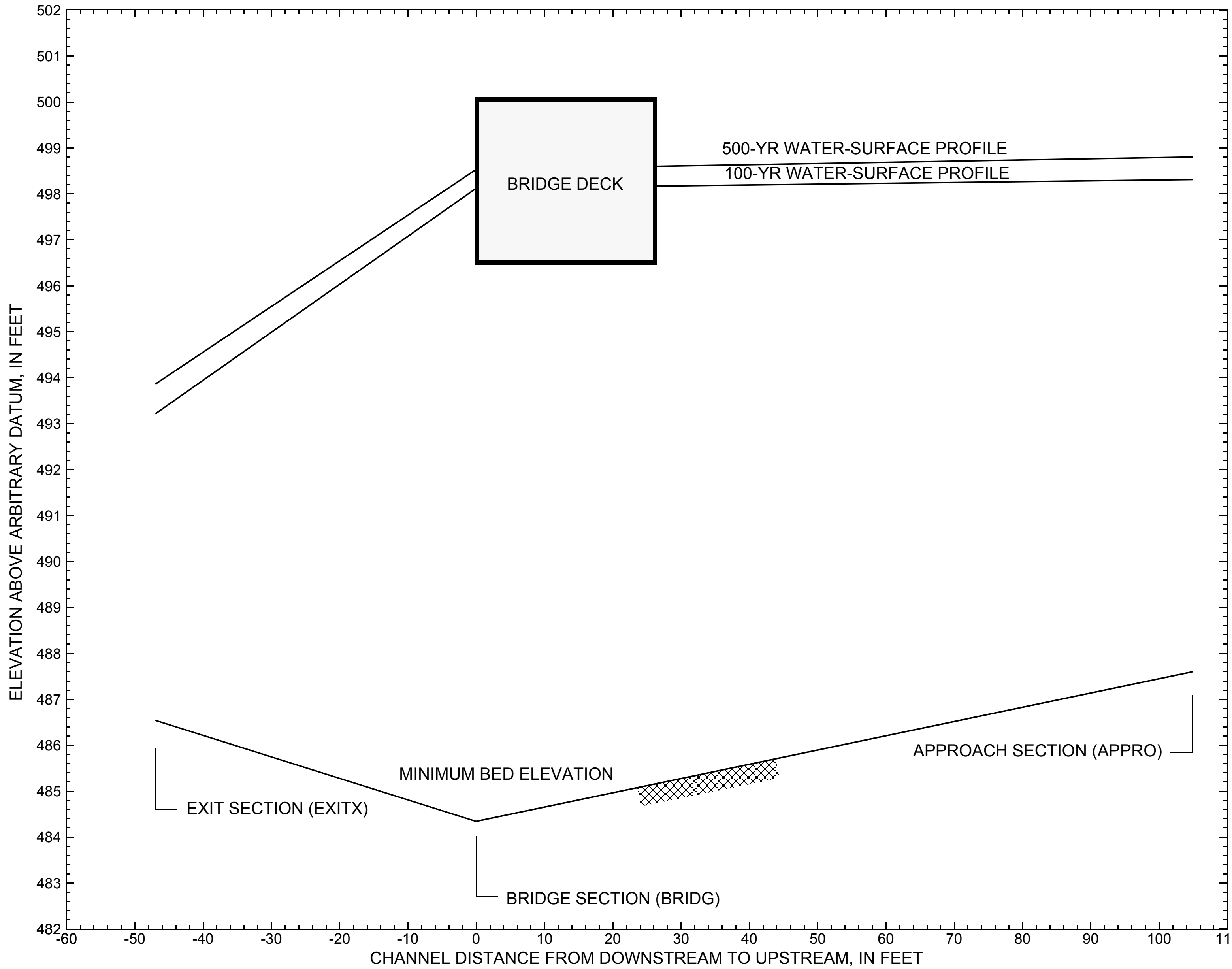

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure POULTH00040005 on Town Highway 4, crossing the Poultney River, Poultney, Vermont.

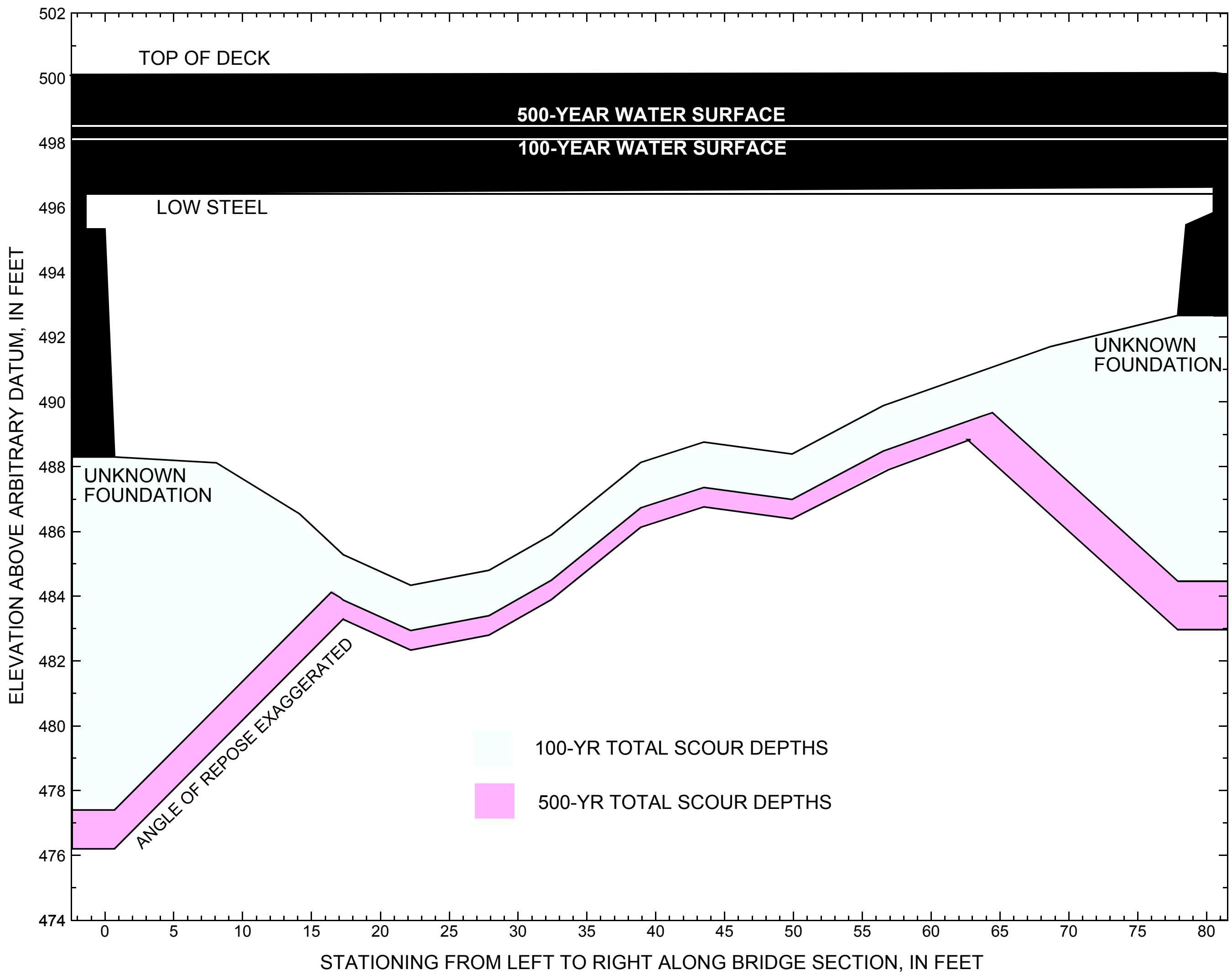

Figure 8. Scour elevations for the 100- and 500-year discharges at structure POULTH00040005 on Town Highway 4, crossing the Poultney River, Poultney, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure POULTH00040005 on Town Highway 4, crossing the Poultney River, Poultney, 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-year discharge is 6,700 cubic-feet per second											
Left abutment	-1.4	--	496.4	--	488.3	1.4	9.5	--	10.9	477.4	--
Right abutment	80.5	--	496.6	--	492.7	1.4	6.8	--	8.2	484.5	--

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure POULTH00040005 on Town Highway 4, crossing the Poultney River, Poultney, 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-year discharge is 9,350 cubic-feet per second											
Left abutment	-1.4	--	496.4	--	488.3	2.0	10.1	--	12.1	476.2	--
Right abutment	80.5	--	496.6	--	492.7	2.0	7.7	--	9.7	483.0	--

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, 1948, Thorn Hill, New York-Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File poul005.wsp
T2        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
T3        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
*              * * This file was generated by AWISPP v2.5 * *
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            6700.0  9350.0    4710
SK          0.0021  0.0021     0.0021
*
XS   EXITX    -47
GR         -275.8, 497.39   -137.8, 496.03   -101.7, 497.96    -79.7, 497.41
GR          -26.7, 494.45    -21.6, 491.40      0.0, 489.94     32.5, 489.05
GR           35.4, 487.52     42.0, 486.54     47.3, 487.03     52.8, 486.98
GR           55.8, 487.54     60.0, 489.23     61.5, 492.40     80.4, 496.67
GR          130.7, 495.98    742.8, 493.22    868.7, 490.05    929.1, 491.21
GR         1131.0, 491.03   1760.0, 490.27   1776.9, 494.98
N           0.070        0.060        0.050
SA                 -101.7        80.4
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.52       0.0
GR           -1.4, 496.42     -1.4, 495.33      0.0, 495.34      0.7, 488.30
GR            8.1, 488.12     14.1, 486.55     17.3, 485.28     22.2, 484.34
GR           27.9, 484.80     32.4, 485.89     38.9, 488.13     43.5, 488.76
GR           49.9, 488.39     56.5, 489.88     68.7, 491.71     77.9, 492.67
GR           78.5, 495.47     80.5, 495.84     80.5, 496.61     -1.4, 496.42
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD           4      26.2      2.1    500.4     45.5
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      21.4     1
GR         -495.8, 499.47   -367.3, 497.64   -270.9, 498.65   -201.7, 498.17
GR          -85.8, 499.41     -0.3, 500.32      0.0, 501.02
GR           83.0, 501.12     83.3, 500.23    133.8, 500.28
GR          343.1, 498.52    572.9, 497.99   1068.9, 497.16   1282.7, 498.05
GR         1534.1, 506.33
*
*  Flow remains within the approach channel at the incipient roadway-overtopping discharge
AS   APPRO    105
GR         -206.7, 499.63    -26.7, 498.15      0.0, 492.37
GR           11.6, 488.74     19.9, 488.56     25.3, 488.13     29.8, 487.60
GR           34.3, 487.63     38.4, 488.09     47.3, 488.07     58.3, 490.85
GR           76.8, 490.95     98.3, 492.11    197.5, 495.90    252.4, 495.90
GR          562.9, 496.15   1153.2, 496.05   1326.6, 497.80   1518.1, 503.46
N           0.060        0.055        0.050
SA                 -26.7         197.5
*
HP 1 BRIDG   496.61 1 496.61
HP 2 BRIDG   496.61 * * 5401
HP 1 BRIDG   493.64 1 493.64
HP 2 RDWAY   498.12 * * 1408
HP 1 APPRO   498.31 1 498.31
HP 2 APPRO   498.31 * * 6700
*
HP 1 BRIDG   496.52 1 496.52
HP 2 BRIDG   496.52 * * 5764
HP 1 BRIDG   493.97 1 493.97
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File poul005.wsp
      Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
      Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
         *** RUN DATE & TIME: 02-09-98  13:36
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     642.  56755.     0.   176.                            0.
 496.61          642.  56755.     0.   176.  1.00    -1.    81.      0.

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     496.61    -1.4    80.5   642.3   56755.    5401.   8.41

X STA.        -1.4        6.8       10.2       13.3       16.0       18.4
  A(I)            55.1       28.9       28.1       27.7       26.2
  V(I)            4.90       9.35       9.60       9.76      10.30

X STA.        18.4       20.6       22.7       24.8       27.1       29.2
  A(I)            25.4       25.8       25.4       26.5       24.4
  V(I)           10.62      10.46      10.62      10.20      11.08

X STA.        29.2       31.2       33.6       36.4       39.7       43.6
  A(I)            22.7       26.0       27.1       28.7       30.7
  V(I)           11.90      10.39       9.98       9.40       8.80

X STA.        43.6       47.4       51.2       55.7       61.6       80.5
  A(I)            30.4       30.5       32.8       37.9       82.0
  V(I)            8.88       8.84       8.24       7.12       3.29

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

   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     414.  44255.    78.    85.                         5409.
 493.64          414.  44255.    78.    85.  1.00     0.    78.   5409.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.12  -401.0  1284.8   403.2    7369.    1408.   3.49

X STA.      -401.0      774.3      814.3      847.1      875.2      900.4
  A(I)            82.9       20.0       18.4       17.2       16.5
  V(I)            0.85       3.52       3.82       4.10       4.26

X STA.       900.4      923.0      943.7      963.6      981.8      996.8
  A(I)            15.8       15.2       15.3       14.5       12.4
  V(I)            4.47       4.62       4.61       4.86       5.66

X STA.       996.8     1012.9     1031.0     1047.7     1064.0     1079.9
  A(I)            13.7       16.0       15.2       15.3       15.0
  V(I)            5.15       4.39       4.63       4.61       4.69

X STA.      1079.9     1097.2     1116.3     1139.1     1167.8     1284.8
  A(I)            15.1       15.4       16.3       17.5       35.6
  V(I)            4.65       4.58       4.32       4.03       1.98

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     105.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1       2.       7.    19.    19.                           2.
           2    1342.  119203.   224.   226.                        18624.
           3    2391.  116309.  1146.  1146.                        19594.
 498.31         3734.  235519.  1390.  1392.  1.30   -46.  1344.  30483.

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     105.

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.31   -46.2  1343.9  3734.2  235519.    6700.   1.79

X STA.       -46.2       11.8       22.7       32.6       42.7       54.0
  A(I)           175.3      105.6      102.8      105.1      110.1
  V(I)            1.91       3.17       3.26       3.19       3.04

X STA.        54.0       69.8       87.5      109.3      138.3      180.5
  A(I)           120.0      127.5      135.9      151.1      163.4
  V(I)            2.79       2.63       2.46       2.22       2.05

X STA.       180.5      276.9      373.3      474.3      580.5      690.0
  A(I)           237.6      226.6      229.4      232.7      237.8
  V(I)            1.41       1.48       1.46       1.44       1.41

X STA.       690.0      795.7      903.0     1006.2     1107.6     1343.9
  A(I)           231.6      236.8      229.8      227.5      347.5
  V(I)            1.45       1.41       1.46       1.47       0.96
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        U.S. Geological Survey WSPRO Input File poul005.wsp
        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
           *** RUN DATE & TIME: 02-09-98  13:36
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1      641.   66745.    39.   137.                         14769.
   496.52           641.   66745.    39.   137.  1.00    -1.     81.  14769.

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

         WSEL     LEW     REW    AREA         K        Q    VEL
       496.52    -1.4    80.5   640.5   66745.    5764.   9.00

X STA.        -1.4         9.3        13.0        16.1        18.7        21.0
  A(I)            75.4        34.0        31.0        29.0        27.7
  V(I)            3.82        8.47        9.30        9.95       10.39

X STA.        21.0        23.3        25.6        28.0        30.5        33.1
  A(I)            27.4        27.6        27.7        28.5        28.7
  V(I)           10.54       10.46       10.41       10.11       10.05

X STA.        33.1        36.3        40.1        43.8        47.1        50.2
  A(I)            30.7        33.7        29.3        25.8        25.3
  V(I)            9.39        8.55        9.84       11.19       11.40

X STA.        50.2        53.6        57.4        61.9        67.2        80.5
  A(I)            25.8        26.1        27.7        28.9        50.5
  V(I)           11.19       11.06       10.40        9.96        5.70

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1      439.   48683.    78.    86.                          5918.
   493.97           439.   48683.    78.    86.  1.00     0.     78.   5918.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA         K        Q    VEL
       498.53  -429.8  1297.3   819.1   19374.    3540.   4.32

X STA.      -429.8       647.6       707.4       756.0       797.2       832.9
  A(I)           189.2        42.8        39.2        36.2        33.8
  V(I)            0.94        4.14        4.52        4.88        5.24

X STA.       832.9       865.3       894.6       922.8       948.5       966.7
  A(I)            32.5        30.9        31.0        29.5        21.5
  V(I)            5.45        5.73        5.71        6.00        8.22

X STA.       966.7       987.4      1013.2      1037.6      1060.3      1083.0
  A(I)            25.2        32.4        31.6        30.3        30.6
  V(I)            7.02        5.46        5.60        5.84        5.78

X STA.      1083.0      1107.8      1135.4      1167.6      1208.2      1297.3
  A(I)            31.2        31.9        33.0        35.5        50.8
  V(I)            5.67        5.56        5.36        4.99        3.48

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     105.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1       26.     302.    79.    79.                            83.
             2     1452.  135910.   224.   226.                         20958.
             3     2957.  164130.  1163.  1163.                         26752.
   498.80          4434.  300341.  1466.  1468.  1.23  -106.   1360.  39424.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     105.

         WSEL     LEW     REW    AREA         K        Q    VEL
       498.80  -105.8  1360.4  4433.9  300341.    9350.   2.11

X STA.      -105.8        12.4        24.9        36.2        48.4        64.5
  A(I)           224.3       127.5       125.2       131.3       140.1
  V(I)            2.08        3.67        3.73        3.56        3.34

X STA.        64.5        84.1       107.4       139.3       191.0       277.3
  A(I)           152.3       160.4       182.5       214.0       250.6
  V(I)            3.07        2.91        2.56        2.18        1.87

X STA.       277.3       365.0       458.4       553.3       653.2       751.3
  A(I)           249.6       258.9       255.8       265.4       262.4
  V(I)            1.87        1.81        1.83        1.76        1.78

X STA.       751.3       847.1       943.3      1038.5      1132.0      1360.4
  A(I)           257.5       260.5       259.0       256.0       400.4
  V(I)            1.82        1.79        1.80        1.83        1.17
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File poul005.wsp
        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
           *** RUN DATE & TIME: 02-09-98  13:28

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     377.   38212.    78.    84.                         4712.
   493.17          377.   38212.    78.    84.  1.00     0.    78.   4712.



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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.17     0.2    78.0   377.1   38212.    4710.  12.49

X STA.         0.2        6.8       10.2       12.9       15.3       17.3
  A(I)           31.3       17.7       15.9       16.0       14.9
  V(I)           7.53      13.30      14.85      14.70      15.76

X STA.        17.3       19.1       20.8       22.5       24.2       25.7
  A(I)           14.9       14.5       14.6       14.8       12.9
  V(I)          15.82      16.24      16.13      15.88      18.26

X STA.        25.7       27.0       28.6       30.3       32.1       34.2
  A(I)           10.9       13.4       13.4       14.1       14.7
  V(I)          21.55      17.59      17.57      16.76      16.03

X STA.        34.2       36.7       40.1       44.3       48.6       78.0
  A(I)           15.5       17.7       19.4       19.7       70.9
  V(I)          15.17      13.29      12.14      11.98       3.32


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     105.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
             2    1044.   79848.   219.   220.                        12951.
             3     908.   24595.  1047.  1047.                         4796.
   496.97         1952.  104443.  1266.  1267.  1.62   -21.  1244.  10804.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     105.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.97   -21.2  1244.4  1952.1  104443.    4710.   2.41

X STA.       -21.2        8.6       15.3       21.5       27.5       33.1
  A(I)          100.0       54.2       51.9       52.8       51.7
  V(I)           2.35       4.34       4.54       4.46       4.56

X STA.        33.1       39.0       45.1       51.9       61.0       68.1
  A(I)           53.8       54.7       58.0       60.8       43.1
  V(I)           4.38       4.31       4.06       3.88       5.47

X STA.        68.1       74.1       84.1       96.5      112.4      135.6
  A(I)           36.2       58.7       65.7       73.7       90.0
  V(I)           6.50       4.02       3.58       3.20       2.62

X STA.       135.6      311.5      500.9      743.6      959.5     1244.4
  A(I)          259.9      179.1      203.4      187.6      217.0
  V(I)           0.91       1.31       1.16       1.26       1.09
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        U.S. Geological Survey WSPRO Input File poul005.wsp
        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
           *** RUN DATE & TIME: 02-09-98  13:36

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

EXITX:XS   ******   -25.    2741.  0.09 *****  493.30  491.82   6700.  493.21
      -47. ******  1771.  146067.  1.01 ***** *******    0.28    2.44

FULLV:FV      47.   -25.    2864.  0.09  0.09  493.40 *******   6700.  493.31
        0.    47.  1771.  155097.  1.01  0.00    0.01    0.26    2.34
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.81     503.46    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.81     503.46     495.03

 ===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 =   495.03     503.46     495.03

APPRO:AS     105.   -12.     638.  1.72 *****  496.74  495.03   6700.  495.03
      105.   105.   175.   38989.  1.00 ***** *******    1.00   10.50
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.35       0.00     494.47     497.16

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   493.80     497.91     498.21     496.52

 ===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      47.    -1.     642.  1.10 *****  497.71  493.64   5401.  496.61
        0. ******    81.   56755.  1.00 ***** *******    0.53    8.41

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.445  0.000  496.52 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG      13.    84.  0.07  0.07  498.31    0.02   1408.  498.12

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     67.    79.  -401.  -322.   0.5   0.2   3.0   3.6   0.4   3.0
   RT:   1342.   766.   519.  1285.   1.0   0.5   3.8   3.5   0.7   3.1

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

APPRO:AS      79.   -46.    3733.  0.07  0.22  498.37  495.03   6700.  498.31
      105.    83.  1344.  235421.  1.30  0.46    0.02    0.22    1.79

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -47.   -25.  1771.   6700.  146067.    2741.    2.44  493.21
   FULLV:FV       0.   -25.  1771.   6700.  155097.    2864.    2.34  493.31
   BRIDG:BR       0.    -1.    81.   5401.   56755.     642.    8.41  496.61
   RDWAY:RG      13.*******    67.   1408.******************    1.00  498.12
   APPRO:AS     105.   -46.  1344.   6700.  235421.    3733.    1.79  498.31

  SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.82    0.28  486.54  497.96************  0.09  493.30  493.21
   FULLV:FV  ********    0.26  486.54  497.96  0.09  0.00  0.09  493.40  493.31
   BRIDG:BR    493.64    0.53  484.34  496.61************  1.10  497.71  496.61
   RDWAY:RG  ****************  497.16  506.33  0.07******  0.07  498.31  498.12
   APPRO:AS    495.03    0.22  487.60  503.46  0.22  0.46  0.07  498.37  498.31
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File poul005.wsp
        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
           *** RUN DATE & TIME: 02-09-98  13:36

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

EXITX:XS   ******   -26.    3519.  0.11 *****  493.97  492.07   9350.  493.86
      -47. ******  1773.  203993.  1.00 ***** *******    0.28    2.66

FULLV:FV      47.   -26.    3656.  0.10  0.09  494.07 *******   9350.  493.97
        0.    47.  1773.  214629.  1.00  0.00    0.01    0.27    2.56
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   493.47     503.46    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   493.47     503.46     496.83

 ===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 =   496.83     503.46     496.83

APPRO:AS     105.   -21.    1781.  0.70 *****  497.54  496.83   9350.  496.83
      105.   105.  1231.   94940.  1.64 ***** *******    0.99    5.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.98       0.00     496.07     497.16

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                   WS,QBO,QRD =   499.63         0.      9350.

 ===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      47.    -1.     641.  1.26 *****  497.78  493.87   5764.  496.52
        0. ******    81.   66745.  1.00 ***** *******    0.57    9.00

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.461  0.000  496.52 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    84.  0.08  0.09  498.80    0.00   3540.  498.53

               Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    349.   232.  -430.  -168.   0.9   0.3   3.6   4.3   0.6   3.1
   RT:   3192.   955.   342.  1297.   1.4   0.8   4.8   4.3   1.0   3.1

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

APPRO:AS      79.  -105.    4430.  0.09  0.36  498.88  496.83   9350.  498.80
      105.   125.  1360.  299947.  1.23  0.00    0.00    0.24    2.11

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -47.   -26.  1773.   9350.  203993.    3519.    2.66  493.86
   FULLV:FV       0.   -26.  1773.   9350.  214629.    3656.    2.56  493.97
   BRIDG:BR       0.    -1.    81.   5764.   66745.     641.    9.00  496.52
   RDWAY:RG      13.*******   349.   3540.******************    1.00  498.53
   APPRO:AS     105.  -105.  1360.   9350.  299947.    4430.    2.11  498.80

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    492.07    0.28  486.54  497.96************  0.11  493.97  493.86
   FULLV:FV  ********    0.27  486.54  497.96  0.09  0.00  0.10  494.07  493.97
   BRIDG:BR    493.87    0.57  484.34  496.61************  1.26  497.78  496.52
   RDWAY:RG  ****************  497.16  506.33  0.08******  0.09  498.80  498.53
   APPRO:AS    496.83    0.24  487.60  503.46  0.36  0.00  0.09  498.88  498.80
```

```
        U.S. Geological Survey WSPRO Input File poul005.wsp
        Hydraulic analysis for structure POULTH00040005   Date: 22-JAN-98
        Bridge 5 on Granville St.(TH4) over Poultney River Poultney, VT  MAI
           *** RUN DATE & TIME: 02-09-98  13:28

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

 EXITX:XS   ******   -24.    2194.  0.07 *****  492.78  491.61   4710.  492.71
       -47. ******  1769.  102722.  1.02 ***** *******    0.27    2.15

 FULLV:FV      47.   -24.    2312.  0.07  0.09  492.88 *******   4710.  492.82
         0.    47.  1769.  111567.  1.01  0.00    0.01    0.25    2.04
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   492.32     503.46    0.50

  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   492.32     503.46     494.11

  ===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 =   494.11     503.46     494.11

 APPRO:AS     105.    -8.     479.  1.50 *****  495.61  494.11   4710.  494.11
       105.   105.   151.   26983.  1.00 ***** *******    1.00    9.83
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    4710.     493.17

             <<<<<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      47.     0.     377.  2.98 *****  496.16  493.17   4710.  493.17
         0.    47.    78.   38265.  1.23 ***** *******    1.11   12.48

      TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   1.  0.901 ******  496.52 ****** ****** ******

     XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      13.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRO:AS      79.   -21.    1953.  0.15  0.46  497.12  494.11   4710.  496.97
       105.    82.  1244.  104498.  1.62  0.51    0.01    0.44    2.41

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.510  0.422   59822.    12.    89.   496.80

    FIRST USER DEFINED TABLE.

     XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS      -47.    -24.  1769.   4710.  102722.    2194.    2.15  492.71
    FULLV:FV        0.    -24.  1769.   4710.  111567.    2312.    2.04  492.82
    BRIDG:BR        0.     0.    78.    4710.   38265.     377.   12.48  493.17
    RDWAY:RG       13.**************      0.******************     1.00********
    APPRO:AS      105.    -21.  1244.   4710.  104498.    1953.    2.41  496.97

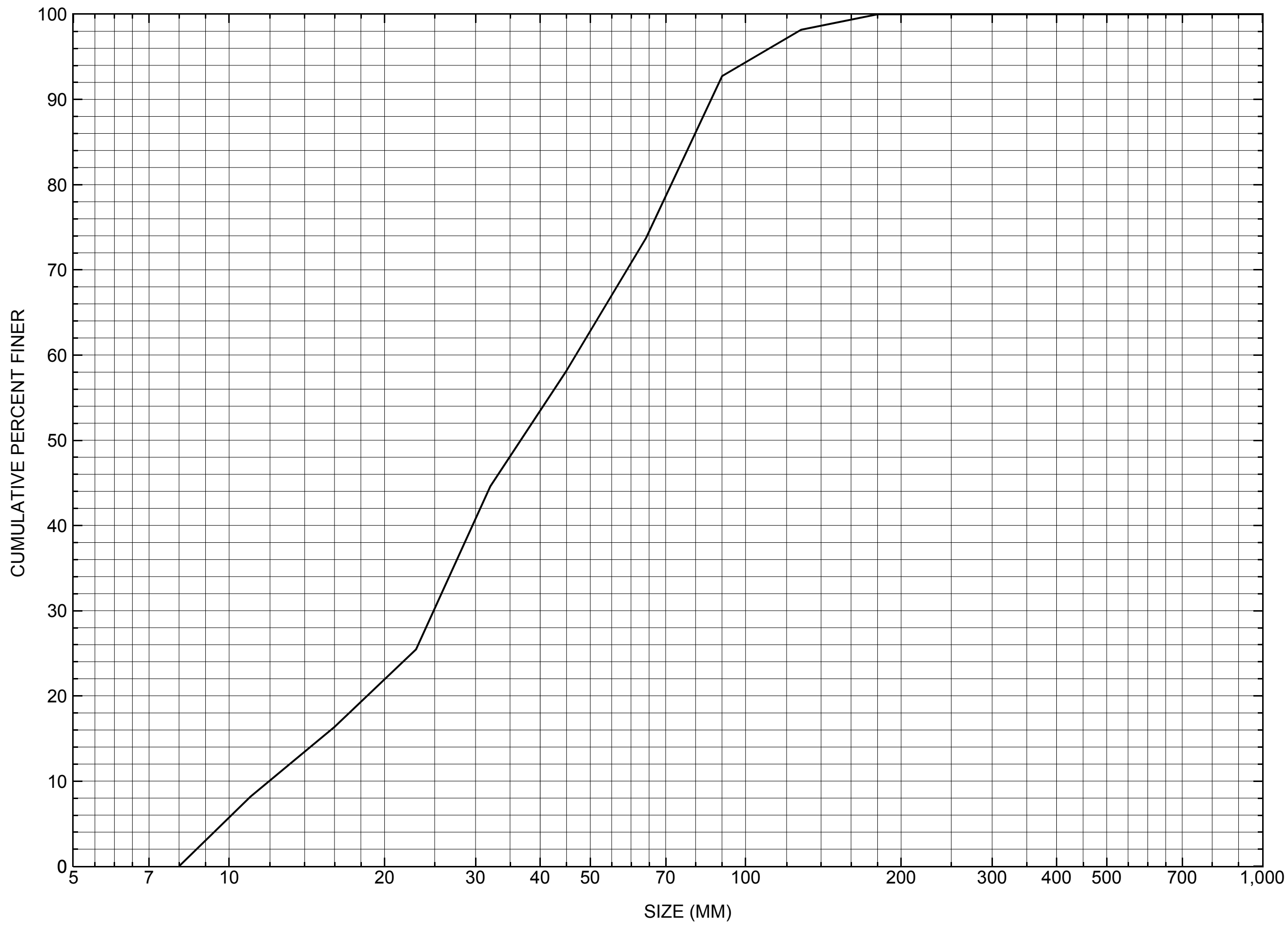
     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      12.    89.   59822.

  SECOND USER DEFINED TABLE.

     XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXITX:XS    491.61    0.27  486.54  497.96************  0.07  492.78  492.71
    FULLV:FV  ********    0.25  486.54  497.96  0.09  0.00  0.07  492.88  492.82
    BRIDG:BR    493.17    1.11  484.34  496.61************  2.98  496.16  493.17
    RDWAY:RG  ****************  497.16  506.33**********************************
    APPRO:AS    494.11    0.44  487.60  503.46  0.46  0.51  0.15  497.12  496.97
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure POULTH00040005, in Poultney, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number POULTH00040005

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 22 / 95

Highway District Number *(I - 2; nn)* 03

County *(FIPS county code; I - 3; nnn)* 021

Town *(FIPS place code; I - 4; nnnnn)* 56875

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

Waterway *(I - 6)* Poultney River

Road Name *(I - 7)*: -

Route Number TH004

Vicinity *(I - 9)* 0.6 MI TO JCT C2 TH 3

Topographic Map Poultney

Hydrologic Unit Code: 02010001

Latitude *(I - 16; nnnn.n)* 43307

Longitude *(i - 17; nnnnn.n)* 73146

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10111700051117

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

Maximum span length *(I - 48; nnnn)* 0080

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

Structure length *(I - 49; nnnnnn)* 000084

Average daily traffic, ADT *(I - 29; nnnnnn)* 001200

Deck Width *(I - 52; nn.n)* 214

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)* A

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

Structure type *(I - 43; nnn)* 310

Year Reconstructed *(I - 106)* 1976

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

Clear span (*nnn.n ft*) 080.0

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) 660.0

Comments:

The structural inspection report of 7/6/94 indicates the structure is a steel thru-truss (pony) type bridge with a concrete deck. The abutment walls and wingwalls are concrete and have scales and some spalls reported overall. The wingwalls in particular are noted as having numerous cracks with extensive spalling. The wingwalls of the left abutment had some concrete break-up. The streambed is reported as composed primarily of gravel. There is a large gravel point bar noted just upstream from the structure on the right bank side, which extends under the bridge creating a sharp channel bend just upstream from the crossing. A deep scour hole has developed according to the report along the right **(Continued, page 33)**

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **48.1**

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ **1600** Q_{10} **3400** Q_{25} **4600**

Q_{50} **5700** Q_{100} **6700** 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*)	**402.7**	**405.0**	**406.4**	**408.0**	**408.6**
Velocity (*ft / sec*)	-	-	-	-	-

Long term stream bed changes: -

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

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

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

Upstream distance (*miles*): **0.4** Town: **Poultney** Year Built: -

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

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

Downstream distance (*miles*): **1.3** Town: **Poultney/Hampton, NY** Year Built: **-**

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

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

Comments:

abutment side of the channel under the bridge. Debris was reported as a problem due to random logs and branches which are present just downstream from the bridge. There are several large sections of cut bedrock used as stone fill in front of the left abutment and its wingwalls. The foundation type is recorded as unknown for this bridge. Hence, the abutment footings are noted as not seen, and undermining and settling noted as none apparent on the report.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **49.19** mi^2 Lake/pond/swamp area **0.26** mi^2

Watershed storage *(ST)* **0.528** %

Bridge site elevation **410** ft Headwater elevation **2565** ft

Main channel length **12.72** mi

10% channel length elevation **440** ft 85% channel length elevation **900** ft

Main channel slope *(S)* **48.21** ft / mi

Watershed Precipitation Data

Average site precipitation **-** in Average headwater precipitation **-** in

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

Average seasonal snowfall *(Sn)* **-** ft

Bridge Plan Data

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

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS

Cross-sectional Data

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

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

Comments: **FEMA, Flood Insurance Study for Poultney, VT.**
This cross section is taken from a HEC-2 input file. All measurements are in feet.

Station	1479	1485	1505	1515	1560	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	407	407	407	407	407	-	-	-	-	-	-
Bed elevation	399.5	397.6	397.6	399.5	403	-	-	-	-	-	-
Low chord to bed	7.5	9.4	9.4	7.5	4	-	-	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -
-

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **CG** Date: **02/15/96**
Computerized by: **CG** Date: **02/15/96**
Reviewd by: **MAI** Date: **02/13/98**

Structure Number **POULTH00040005**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. Boehmler** Date *(MM/DD/YY)* **9** / **19** / 19**95**

2. Highway District Number **03** Mile marker **0**

County **Rutland (021)** Town **Poultney (56875)**

Waterway *(I - 6)* **Poultney River** Road Name **-**

Route Number **TH 04** Hydrologic Unit Code: **02010001**

3. Descriptive comments:

This site is located 0.6 miles from the junction with Town Highway 3.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **4** LBDS **3** 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 **84.0** *(feet)* Span length **80.0** *(feet)* Bridge width **21.4** *(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)*

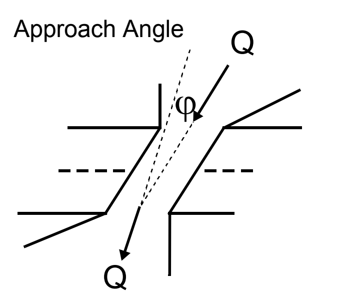
10. Embankment slope (*run / rise in feet / foot*):
US left **1.7:1** US right **2.4:1**

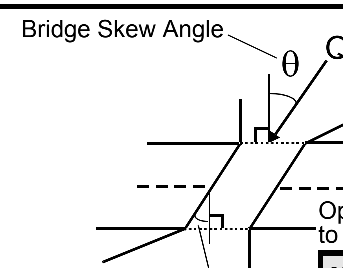
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	1	1	2
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: **15** 16. Bridge skew: **10**





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **3**
Range? **115** feet **US** *(US, UB, DS)* to **0** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **5** feet **DS** *(US, UB, DS)* to **45** feet **DS**

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

18. Bridge Type: 4

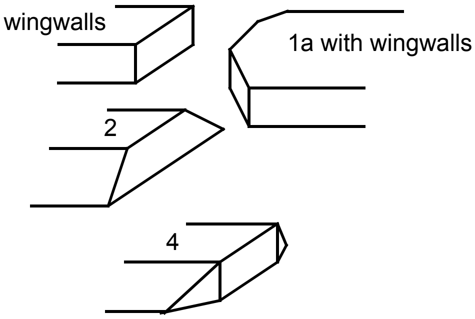
1a- Vertical abutments with wingwalls

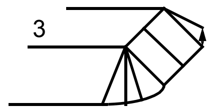
1b- Vertical abutments without wingwalls

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.)

7. The measured bridge dimensions were the same as the historical values.
4. The surface cover on the upstream left bank is mostly sumac trees with lots of brush for a strip about 50 ft wide from the upstream left bank to the left overbank area. Then the coverage becomes pasture. The upstream right bank is pasture with a similar strip of trees and brush in between the pasture and the right bank. The downstream left bank area has a 30 ft wide strip of trees along the left bank and then row crops. The downstream right bank is pasture with a 50 ft wide strip of sumac trees, hardwoods and brush between the right bank and the pasture.
5. The water surface is generally pooled except for a small area of riffle at the downstream bridge face to 15 ft downstream.

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
79.0	10.0			8.0	2	2	324	324	3	0

23. Bank width 10.0   24. Channel width 5.0   25. Thalweg depth 224.5   29. Bed Material 324

30 .Bank protection type: LB 3 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.):

The upstream channel is a series of pools and riffles, each being about 75 ft to 100 ft long. The channel meanders and has a few large point bars and cut banks. The left bank is protected from 60 ft upstream to 10 ft upstream where the protection becomes wingwall protection.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 125 35. Mid-bar width: 42.0

36. Point bar extent: 215 feet US (US, UB) to 5 feet DS (US, UB, DS) positioned 30 %LB to 100 %RB

37. Material: 32

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

The point bar is composed of primarily gravel and sand. The bar is so high that it makes it difficult to determine where the point bar starts and the right bank ends. The point bar level on top is nearly the same height as the left bank and may be considered a bank. The bar is partially vegetated with brush mostly on its upstream and downstream ends. This vegetation makes up 20% of the bar area.

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: 200 feet US (US, UB) to 40 feet US (US, UB, DS)

43. Bank damage: 23 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)

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

The cut bank failure is mainly slip failure in the range of 200 ft to 110 ft upstream. Then it is more severe block failure in the range of 110 ft to 75 ft upstream. The range of 60 ft to 40 ft upstream is where the erosion type is unclear as this range is composed of road fill which may have filled in some of the cut area. The erosion is influencing the left bank road approach embankment fill.

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

47. Scour dimensions: Length 33.0 Width 20.0 Depth : 1.5 Position 5 %LB to 20 %RB

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

Trees which have fallen into the channel from the cut bank have deflected the flow into the bed, created turbulence, and caused heavier erosion of the bed. These erosional processes are probably due to a sharp channel bend. This area is a severe impact zone.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB 2 RB ___ (**1**- natural bank; **2**- abutment; **3**- artificial levee)

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
13.5		0.5		1	7	32	-

58. Bank width (BF) - 59. Channel width - 60. Thalweg depth 90.0 63. Bed Material 1

*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.):

324

The left abutment protrudes into the channel. The channel passes under the structure at an angle and the abutments are not aligned with the channel trend.

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

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

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

70. Debris and Ice Comments:

2

There are frequent bends in the channel with cut banks and many trees and brush on the banks. Trees are falling into the channel on the left bank upstream and are in the channel at several locations on the left bank downstream and upstream of the scour hole. The bends in the channel and point bars are likely to collect debris and ice.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**-**	**90**	**2**	**1**	**2.5**	**0**	**90.0**
RABUT	**1**	**10**	**90**			**0**	**0**	**79.0**

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.):

0

0

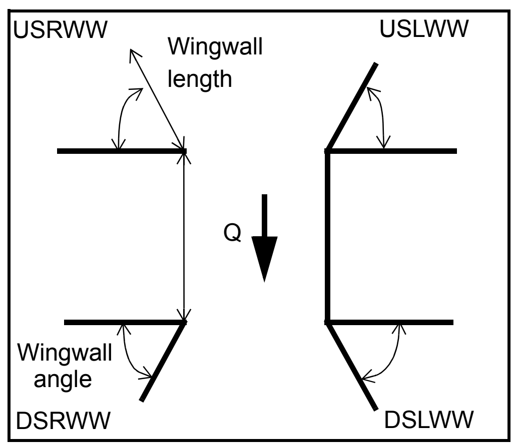
1

A scour hole is present along the left abutment side of the channel under the bridge. The scour hole is 70 ft long beginning 50 ft upstream to 20 ft under bridge (~0 ft downstream); it is 24 ft wide at the deepest point which is at the upstream face. A stone fill slope protects the left abutment and the left bank road approach embankment. This stone fill slope protrudes into the channel about 18 ft.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**79.0**	
USRWW:	**Y**		**1**		**1**	**4.0**	
DSLWW:	**1.0’**		**0**		**Y**	**26.5**	
DSRWW:	**1**		**0**		**0**	**26.0**	

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

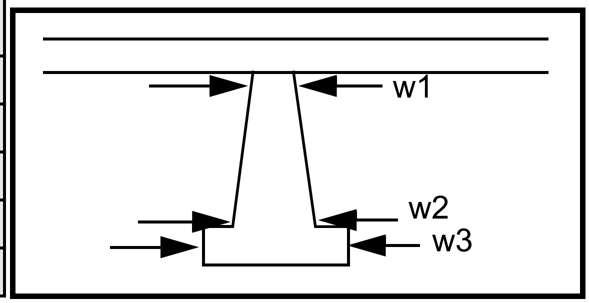
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
0
-
-
3
1
1
0
-
-

Piers:

84. Are there piers? **Th** *(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				**45.0**	**15.0**	**45.0**
Pier 2				**11.0**	**40.0**	**10.0**
Pier 3		**7.0**	**-**	**45.0**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e**	**a few**	**right**	**which**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**dow**	**slabs**	**wing**	**has**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**nstre**	**of**	**wall**	**been**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**am**	**stone**	**is**	**piled**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**right**	**fill at**	**pro-**	**up**	*Y- yes; N- no*
91. Attack ∠ (BF)	**wing**	**the**	**tecte**	**(bac**	
92. Pushed	**wall**	**chan**	**d**	**k**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**is**	**nel**	**with**	**fill)**	
95. Cross-members	**pro-**	**edge.**	**only**	**arou**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**tecte**	**The**	**bank**	**nd**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**d**	**upst**	**mate**	**the**	
98. Exposure depth	**with**	**ream**	**rial**	**wall.**	

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

The upstream and downstream left wingwalls are protected with stone fill.

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? N____ *(Y or if N type ctrl-n cb)* Where? O____ *(LB or RB)* Mid-bank distance: PIE__

Cut bank extent: RS___ 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? _____ *(Y or if N type ctrl-n cs)* Mid-scour distance: 2_____

Scour dimensions: Length 3____ Width 324___ Depth: 324__ Positioned 0___ %LB to 3___ %RB

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

324
0
0
-

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

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

Confluence 2: Distance com-_ Enters on posi_ *(LB or RB)* Type te in_ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

nature with the more cohesive soil layer on top and the less cohesive alluvial material below. The alluvial material slopes at a smaller angle (angle of repose for this material). This slope is from just below the soil

F. Geomorphic Channel Assessment

107. Stage of reach evolution ma__

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)*:

terial to the channel. This is also evident upstream on the left bank cut bank. The downstream channel bends moderately. The downstream channel is pooled from 15 ft downstream of the bridge to greater than 300 ft downstream where the next riffle begins. The channel begins to bend right again with a cut bank on the left and another vegetated, high point bar along the right bank. Then the river flows into New York State.

109. G. Plan View Sketch

- N

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:	POULTH00040005	Town:	Poultney
Road Number:	TH 4	County:	Rutland
Stream:	Poultney River		

Initials MAI Date: 02/09/98 Checked: ECW

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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	6700	9350	4710
Main Channel Area, ft2	1342	1452	1044
Left overbank area, ft2	2	26	0
Right overbank area, ft2	2391	2957	908
Top width main channel, ft	224	224	219
Top width L overbank, ft	19	79	0
Top width R overbank, ft	1146	1163	1047
D50 of channel, ft	0.1203	0.1203	0.1203
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.0	6.5	4.8
y1, average depth, LOB, ft	0.1	0.3	ERR
y1, average depth, ROB, ft	2.1	2.5	0.9
Total conveyance, approach	235519	300341	104443
Conveyance, main channel	119203	135910	79848
Conveyance, LOB	7	302	0
Conveyance, ROB	116309	164130	24595
Percent discrepancy, conveyance	0.0000	-0.0003	0.0000
Qm, discharge, MC, cfs	3391.1	4231.1	3600.9
Ql, discharge, LOB, cfs	0.2	9.4	0.0
Qr, discharge, ROB, cfs	3308.7	5109.6	1109.1
Vm, mean velocity MC, ft/s	2.5	2.9	3.4
Vl, mean velocity, LOB, ft/s	0.1	0.4	ERR
Vr, mean velocity, ROB, ft/s	1.4	1.7	1.2
Vc-m, crit. velocity, MC, ft/s	7.5	7.6	7.2
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	6700	9350	4710
(Q) discharge thru bridge, cfs	5401	5764	4710
Main channel conveyance	56755	66745	38212
Total conveyance	56755	66745	38212
Q2, bridge MC discharge,cfs	5401	5764	4710
Main channel area, ft2	642	641	377
Main channel width (normal), ft	81.9	81.9	77.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	81.9	81.9	77.8
y_bridge (avg. depth at br.), ft	7.84	7.83	4.85
Dm, median (1.25*D50), ft	0.150375	0.150375	0.150375
y2, depth in contraction,ft	7.71	8.15	7.16
ys, scour depth (y2-ybridge), ft	-0.13	0.32	**2.32**

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 Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	6700	9350	4710
Q, thru bridge MC, cfs	5401	5764	4710
Vc, critical velocity, ft/s	7.46	7.56	7.18
Va, velocity MC approach, ft/s	2.53	2.91	3.45
Main channel width (normal), ft	81.9	81.9	77.8
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	81.9	81.9	77.8
qbr, unit discharge, ft2/s	65.9	70.4	60.5
Area of full opening, ft2	642.0	641.0	377.0
Hb, depth of full opening, ft	7.84	7.83	4.85
Fr, Froude number, bridge MC	0.53	0.57	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	414	439	N/A
**Hb, depth at downstream face, ft	5.05	5.36	N/A
**Fr, Froude number at DS face	1.02	1.00	ERR
**Cf, for downstream face (<=1.0)	1.00	1.00	N/A

Elevation of Low Steel, ft	496.52	496.52	496.52
Elevation of Bed, ft	488.68	488.69	491.67
Elevation of Approach, ft	498.31	498.8	0
Friction loss, approach, ft	0.22	0.36	0
Elevation of WS immediately US, ft	498.09	498.44	0.00
ya, depth immediately US, ft	9.41	9.75	-491.67
Mean elevation of deck, ft	501.07	501.07	501.07
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.96	0.95	ERR
**Cc, for downstream face (<=1.0)	0.79	0.79	ERR
Ys, scour w/Chang equation, ft	**1.42**	**2.02**	N/A
Ys, scour w/Umbrell equation, ft	-2.44	-1.78	N/A

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

**Ys, scour w/Chang equation, ft	6.14	6.43	N/A
**Ys, scour w/Umbrell equation, ft	0.34	0.69	ERR

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	7.71	8.15	7.16
WSEL at downstream face, ft	493.64	493.97	--
Depth at downstream face, ft	5.05	5.36	N/A
Ys, depth of scour (Laursen), ft	2.65	2.79	N/A

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	5401	5764	4710
Main channel area (DS), ft2	414	439	377
Main channel width (normal), ft	81.9	81.9	77.8
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	81.9	81.9	77.8
D90, ft	0.2812	0.2812	0.2812
D95, ft	0.3420	0.3420	0.3420
Dc, critical grain size, ft	0.5907	0.5856	0.5504
Pc, Decimal percent coarser than Dc	0.000	0.0449	0.376
Depth to armoring, ft	**N/A**	**N/A**	**N/A**

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 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	6700	9350	4710	6700	9350	4710

a’, abut.length blocking flow, ft	44.8	104.4	21.4	1263	1280	1166
Ae, area of blocked flow ft2	132.24	179.78	71.81	2569	2831	1312
Qe, discharge blocked abut.,cfs	--	--	169.12	--	--	2028

(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)

Ve, (Qe/Ae), ft/s	1.91	2.08	2.36	1.53	1.86	1.55
ya, depth of f/p flow, ft	2.95	1.72	3.36	2.03	2.21	1.13

--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	0.196	0.267	0.227	0.176	0.197	0.257
ys, scour depth, ft	**9.50**	**10.09**	**8.96**	22.88	25.77	19.22

HIRE equation (a’/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55

(Richardson and Davis, 1995, p. 49, eq. 29)

a’(abut length blocked, ft)	44.8	104.4	21.4	1263	1280	1166
y1 (depth f/p flow, ft)	2.95	1.72	3.36	2.03	2.21	1.13
a’/y1	15.18	60.63	6.38	620.93	578.74	1036.25
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.20	0.27	0.23	0.18	0.20	0.26
Ys w/ corr. factor K1/0.55:						
vertical	ERR	8.10	ERR	8.34	9.41	5.23
vertical w/ ww’s	ERR	6.64	ERR	**6.84**	**7.72**	**4.28**
spill-through	ERR	4.46	ERR	4.59	5.18	2.87

Abutment riprap Sizing

Isbash Relationship

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

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	0.98	1	1	0.98	1
y, depth of flow in bridge, ft	5.23	5.55	4.85	5.23	5.55	4.85
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.)	**2.19**	**2.31**	**2.03**	**2.19**	**2.31**	**2.03**