LEVEL II SCOUR ANALYSIS FOR BRIDGE 13 (POMFTH00020013) on TOWN HIGHWAY 2, crossing BARNARD BROOK, POMFRET, VERMONT

U.S. Geological Survey
Open-File Report 96-583

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

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By MICHAEL A. IVANOFF

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
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CONTENTS

FIGURES

TABLES

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 13 (POMFTH00020013) ON TOWN HIGHWAY 2, CROSSING BARNARD BROOK, POMFRET, VERMONT

***By* Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure POMFTH00020013 on town highway 2 crossing Barnard 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 study 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 can be found in Appendix D.

The site is in the New England Upland section of the New England physiographic province of east-central Vermont in the town of Pomfret. The 7.98-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is primarily field grasses with some brush on the immediate banks.

In the study area, Barnard Brook has an incised, sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 32 ft and an average channel depth of 4 ft. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 51.0 mm (0.167 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 15, 1994, indicated that the reach was stable.

The town highway 2 crossing of Barnard Brook is a 23-ft-long, two-lane bridge consisting of one 20-foot concrete span (Vermont Agency of Transportation, written communication, August 22, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

Scour, 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-2 stone fill (less than 36 inches diameter) along the base and upstream of the upstream left wingwall. 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 1.5 ft. The worst-case contraction scour occurred at the 100-year discharge. Abutment scour ranged from 7.2 to 12.6 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Woodstock North, VT. Quadrangle, 1:24,000, 1966

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 POMFTH00020013 ***Stream*** Barnard Brook

County Windsor ***Road*** TH2 ***District*** 4

Description of Bridge

Bridge length 23 ***ft*** ***Bridge width*** 31.3 ***ft*** ***Max span length*** 20 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 9/15/94

Description of stone fill Type-2, along the base and upstream of the upstream left wingwall.

Abutments and wingwalls are concrete. There is a 2.5 ft scour hole along left abutment.

Brief description of piers/abutments

Y

30

Y There is

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

severe channel bend in the channel approach to the bridge. Scour has occurred in the location where the bend impacts the upstream left wingwall and abutment.

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	9/15/94	0	0
Level II	9/15/94	--	--

Potential for debris Low. Minor debris consisting of a couple small logs exist in the upstream channel on 9/15/94.

Describe any features near or at the bridge that may affect flow (include observation date)

The severe channel bend concentrates most of the flow along the left abutment and may set up an eddy current at the right abutment. September 15, 1994.

Description of the Geomorphic Setting

General topography The stream is in a moderate relief, upland valley setting with irregular floodplains and steep valley walls.

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

Date of inspection 9/15/94

DS left: Flood plain to steep valley wall.

DS right: Flood plain to steep valley wall.

US left: Steep channel bank to high terrace and steep valley wall.

US right: Moderately sloping bank and flood plain.

Description of the Channel

Average top width 32 ***ft*** ***Average depth*** 4 ***ft***

Predominant bed material gravel/cobble ***Bank material*** gravel

Small, sinuous, incised channel with non-alluvial channel boundaries.

9/15/94

Vegetative co Field grasses with gravel roadway on overbank.

DS left: Field grasses and some brush on immediate bank. Overbank is forested.

DS right: Field grasses with some brush on immediate banks.

US left: Field grasses with paved roadway on the overbank.

US right: Y

Do banks appear stable? 9/15/94 ***If not, describe location and type of instability and date of observation.***

None. September 15, 1994.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 7.98 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,600 ***ft³/s*** ***Q500*** 2,200 ***ft³/s***

The 100- and 500-year discharges were determined from a graphical extrapolation of available flood frequency estimates for this site in the VTAOT database (VTAOT, written communication, May, 1995). The values used were within a range defined by several empirical methods for estimating flood discharges of a given frequency (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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 Add one foot to the USGS field survey datum to obtain the VTAOT plans' datum to the nearest foot.

Description of reference marks used to determine USGS datum. RM1 is the center of a chiseled X on top of the downstream end of the left abutment (elev. 501.62 ft, arbitrary survey datum). RM2 is the center of a chiseled X on top of the upstream end of the right abutment (elev. 501.80 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	-34	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	17	1	Road Grade section
APPRO	54	2	Modelled Approach section (Templated from APTEM)
APTEM	114	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. The channel "n" value for the reach was 0.040. Overbank "n" values ranged from 0.035 to 0.080.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0063 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1966).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.014 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.

Both the 100- and 500-year discharges overtopped the roadway. The incipient road overtopping discharge is 760 cfs.

Bridge Hydraulics Summary

Average bridge embankment elevation 502.2 ***ft***
Average low steel elevation 500.3 ***ft***

100-year discharge 1,600 ***ft^3/s***
Water-surface elevation in bridge opening 500.3 ***ft***
Road overtopping? Y ***Discharge over road*** 519 ***s***
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 9.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.8 ***ft/s***

Water-surface elevation at Approach section with bridge 502.6
Water-surface elevation at Approach section without bridge 500.9
Amount of backwater caused by bridge 1.7 ***t***

500-year discharge 2,200 ***ft^3/s***
Water-surface elevation in bridge opening 500.3 ***ft***
Road overtopping? Y ***Discharge over road*** 1170
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 9.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.2 ***/s***

Water-surface elevation at Approach section with bridge 503.2
Water-surface elevation at Approach section without bridge 501.6
Amount of backwater caused by bridge 1.6

Incipient overtopping discharge 760 ***ft^3/s***
Water-surface elevation in bridge opening 500.3 ***ft***
Area of flow in bridge opening 113 ***ft^2***
Average velocity in bridge opening 6.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.1 ***ft/s***

Water-surface elevation at Approach section with bridge 501.2
Water-surface elevation at Approach section without bridge 499.4
Amount of backwater caused by bridge 1.8 ***t***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

Contraction scour was computed by use of the Chang pressure-flow scour equation (Richardson and others, 1995, p. 145-146) for the 100-year, 500-year and incipient overtopping discharges. For all of the modelled discharges, there was orifice flow at the bridge. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) were also computed for the 100-year and 500-year discharges and can be found in appendix F.

In this case, the 100-year model resulted in the worst case contraction scour with a scour depth of 1.5 ft. It was also the worst case total scour. The depths to armoring indicate that armoring will not limit the amount of contraction scour.

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

The length to depth ratio of the embankment blocking flow exceeded 25 for the 100- and 500-year discharges at the right abutment. Although the HIRE equation (Richardson and others, 1993, p. 50, equation 25) generally is applicable when this ratio exceeds 25, the results from the HIRE equation were not used. Hydraulic Engineering Circular 18 recommends that the field conditions should be similar to those from which the HIRE equation was derived (Richardson and others, 1993). Since the equation was developed from Army Corp. of Engineers' data obtained for spurs dikes in the Mississippi River, the HIRE equation was not adopted for the narrow, incised, upland valley at this site.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.5	1.1	0.0
Depth to armoring	10.4	7.4	0.4
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	9.1	9.2	7.2
Right abutment	12.1	12.6	10.0
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	1.9	1.7	0.9
Right abutment	1.9	1.7	0.9
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

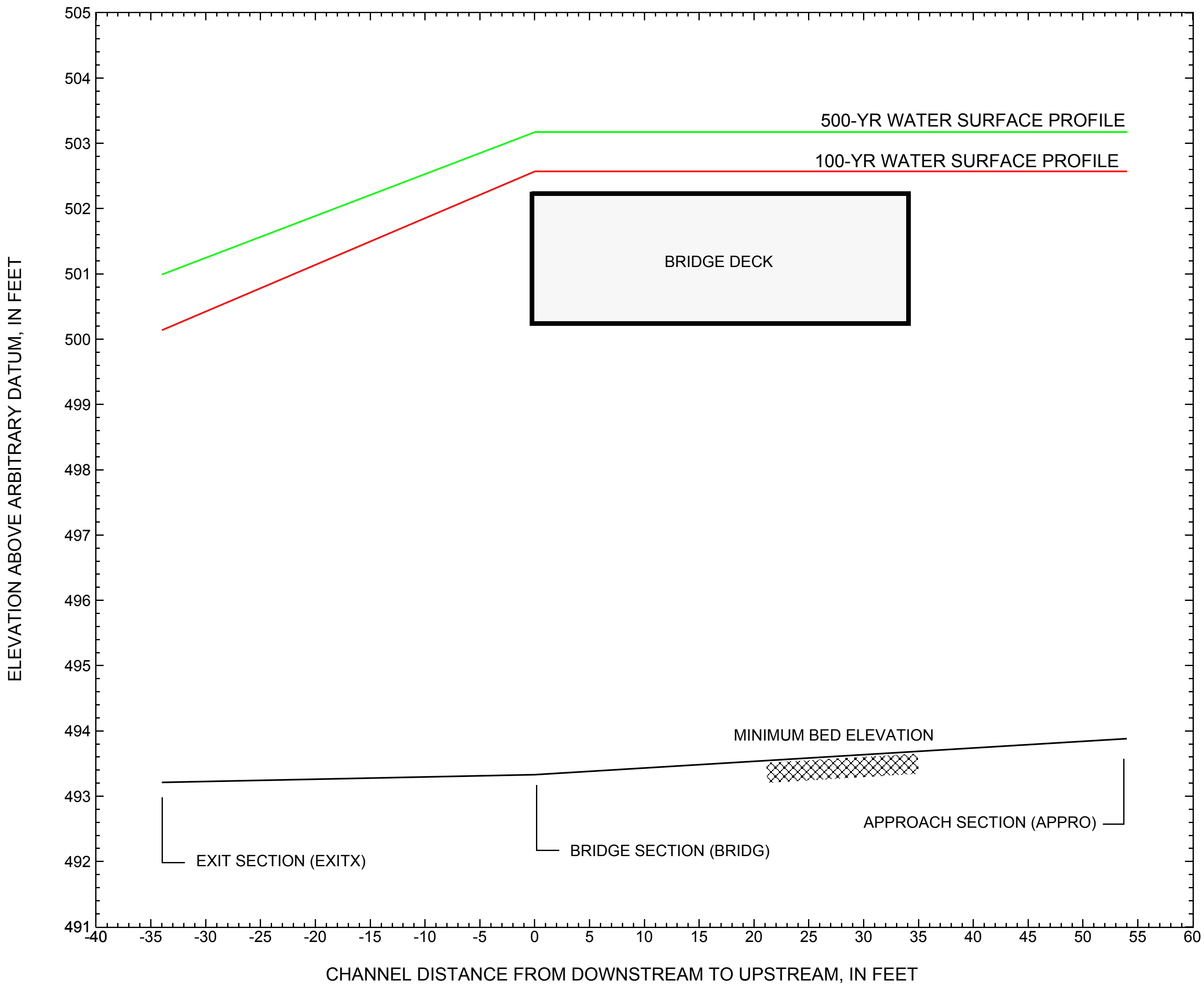

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure POMFTH00020013 on town highway 2, crossing Barnard Brook, Pomfret, Vermont.

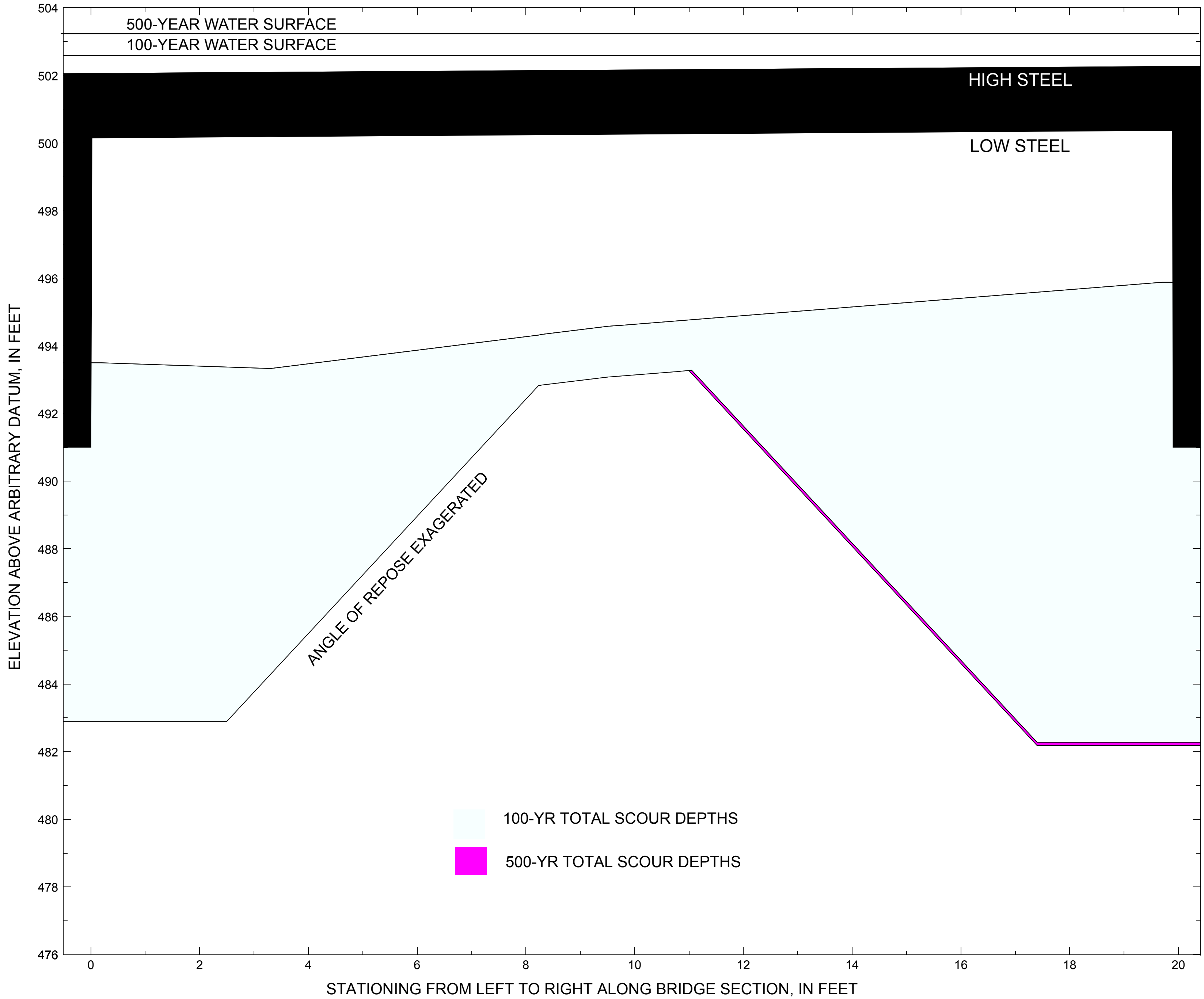

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure POMFTH00020013 on town highway 2, crossing Barnard Brook, Pomfret, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure POMFTH00020013 on Town Highway 2, crossing Barnard Brook, Pomfret, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,600 cubic-feet per second											
Left abutment	0.0	500.70	500.17	490	493.5	1.5	9.1	--	10.6	482.9	-7
Right abutment	19.9	500.94	500.33	490	495.9	1.5	12.1	--	13.6	482.3	-8

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure POMFTH00020013 on Town Highway 2, crossing Barnard Brook, Pomfret, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,200 cubic-feet per second											
Left abutment	0.0	500.70	500.17	490	493.5	1.1	9.2	--	10.3	483.2	-7
Right abutment	19.9	500.94	500.33	490	495.9	1.1	12.6	--	13.7	482.2	-8

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

SELECTED REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 213 p.

Benson, M. A., 1962, Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Brown, S.A. and Clyde, E.S., 1989, Design of riprap revetment: Federal Highway Administration Hydraulic Engineering Circular No. 11, Publication FHWA-IP-89-016, 156 p.

Federal Highway Administration, 1983, Runoff estimates for small watersheds and development of sound design: Federal Highway Administration Report FHWA-RD-77-158

Froehlich, D.C., 1989, Local scour at bridge abutments *in* Ports, M.A., ed., Hydraulic Engineering--Proceedings of the 1989 National Conference on Hydraulic Engineering: New York, American Society of Civil Engineers, p. 13-18.

Hayes, D.C.,1993, Site selection and collection of bridge-scour data in Delaware, Maryland, and Virginia: U.S. Geological Survey Water-Resources Investigation Report 93-4017, 23 p.

Johnson, C.G. and Tasker, G.D.,1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Chang, F., 1995, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Laursen, E.M., 1960, Scour at bridge crossings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 86, no. HY2, p. 39-53.

Potter, W. D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine woods area, Bureau of Public Roads

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

Richardson, E.V. and Davis, S.R., 1995, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Richardson, E.V., Simons, D.B., and Julien, P.Y., 1990, Highways in the river environment: Federal Highway Administration Publication FHWA-HI-90-016.

Ritter, D.F., 1984, Process Geomorphology: W.C. Brown Co., Debuque, Iowa, 603 p.

Shearman, J.O., 1990, User's manual for WSPRO--a computer model for water surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 187 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model; research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

Talbot, A.N., 1887, The determination of water-way for bridges and culverts.

U.S. Department of Transportation, 1993, Stream stability and scour at highway bridges, Participant Workbook: Federal Highway Administration Publication FHWA HI-91-011.

U.S. Geological Survey, 1966, Woodstock North, 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 pomf013.wsp
T2        Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
T3        Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
Q           1600.0   2200.0  760.0
SK          0.0063   0.0063  0.0063
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -34
GR         -119.3, 501.30    -97.9, 500.50    -79.8, 501.22    -58.3, 500.64
GR          -14.1, 497.20     -6.0, 496.88      0.0, 494.22      1.2, 493.36
GR            3.0, 493.21     10.9, 494.14     13.3, 494.72     14.8, 495.94
GR           21.6, 498.22     57.7, 499.54     99.1, 501.10    109.5, 504.75
N           0.035        0.040        0.080
SA                  -6.0         14.8
*
XS   FULLV      0  * * *   0.0034
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     0    500.25       0.0
GR            0.0, 500.17      0.2, 493.50      3.3, 493.33      9.5, 494.58
GR           19.7, 495.88     19.9, 500.33      0.0, 500.17
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      42.3 * *     58.4      4.9
N           0.040
*
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     17      31.3     1
GR          -88.1, 501.30    -47.9, 501.22    -29.8, 501.50      0.0, 502.05
GR           20.4, 502.27     23.7, 502.30     60.6, 502.67    123.3, 503.58
GR          202.1, 505.89
*
XT   ATEMP    114
GR          -22.0, 506.10    -15.8, 503.35     0.0, 495.73      0.3, 495.30
GR            4.4, 494.72     12.9, 495.61    12.9, 495.61     26.2, 497.66
GR           32.9, 498.93     43.5, 499.00    49.9, 502.29     56.6, 502.98
GR           93.1, 503.6     171.9, 505.9
*
AS   APPRO   54 * * * 0.014
GT
N           0.035        0.040        0.035
SA                 -15.8         26.2
*
HP 1 BRIDG   500.33 1 500.33
HP 2 BRIDG   500.33 * * 1107
HP 2 RDWAY   502.57 * * 519
HP 1 APPRO   502.57 1 502.57
HP 2 APPRO   502.57 * * 1600
*
HP 1 BRIDG   500.33 1 500.33
HP 2 BRIDG   500.33 * * 1051
HP 2 RDWAY   503.17 * * 1168
HP 1 APPRO   503.17 1 503.17
HP 2 APPRO   503.17 * * 2200
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File pomf013.wsp
       Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
       Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
          *** RUN DATE & TIME: 05-28-96  11:34
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     113.    7129.     0.    51.                          0.
  500.33          113.    7129.     0.    51.  1.00     0.    20.      0.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      500.33     0.0    19.9   112.5    7129.    1107.   9.84
X STA.        0.0        1.6        2.4        3.2        3.9        4.7
  A(I)            9.8        5.9        5.3        4.9        4.9
  V(I)           5.65       9.41      10.35      11.24      11.35

X STA.        4.7        5.4        6.1        6.9        7.7        8.5
  A(I)            4.7        4.8        4.7        4.7        4.9
  V(I)          11.79      11.49      11.73      11.69      11.27

X STA.        8.5        9.3       10.2       11.1       12.1       13.1
  A(I)            4.8        5.0        5.0        5.2        5.3
  V(I)          11.45      11.03      11.07      10.74      10.41

X STA.       13.1       14.1       15.2       16.4       17.8       19.9
  A(I)            5.5        5.6        5.8        6.4        9.3
  V(I)          10.10       9.90       9.58       8.68       5.96

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.
        WSEL     LEW     REW    AREA        K        Q    VEL
      502.57   -88.1    50.6   111.2    4662.     519.   4.67
X STA.      -88.1      -83.7      -80.0      -76.5      -72.9      -69.4
  A(I)            5.6        4.8        4.5        4.7        4.6
  V(I)           4.66       5.44       5.75       5.50       5.68

X STA.      -69.4      -65.8      -62.4      -58.9      -55.4      -52.0
  A(I)            4.6        4.6        4.6        4.6        4.6
  V(I)           5.61       5.69       5.62       5.65       5.63

X STA.      -52.0      -48.6      -45.1      -41.3      -37.3      -32.8
  A(I)            4.6        4.7        4.8        4.9        5.2
  V(I)           5.66       5.54       5.41       5.30       5.01

X STA.      -32.8      -27.7      -21.8      -14.4       -3.9       50.6
  A(I)            5.5        5.8        6.3        7.2       15.1
  V(I)           4.70       4.50       4.14       3.58       1.72

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1       0.       0.     0.     0.                          0.
            2     258.   31181.    42.    44.                       3632.
            3     110.    7256.    56.    57.                        874.
  502.57          368.   38436.    98.   101.  1.16   -16.    82.   3758.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
        WSEL     LEW     REW    AREA        K        Q    VEL
      502.57   -15.9    81.9   367.9   38436.    1600.   4.35
X STA.      -15.9       -4.7       -1.4        0.9        2.8        4.4
  A(I)           30.3       20.3       17.8       15.5       14.4
  V(I)           2.64       3.94       4.50       5.17       5.54

X STA.        4.4        6.1        7.7        9.4       11.1       12.8
  A(I)           14.0       14.1       13.6       13.5       13.6
  V(I)           5.71       5.66       5.87       5.95       5.89

X STA.       12.8       14.6       16.5       18.5       20.6       23.0
  A(I)           13.8       14.1       14.2       14.5       15.1
  V(I)           5.81       5.67       5.62       5.50       5.29

X STA.       23.0       25.6       28.9       33.7       39.5       81.9
  A(I)           15.7       18.6       22.7       26.1       46.0
  V(I)           5.09       4.31       3.53       3.07       1.74
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       U.S. Geological Survey WSPRO Input File pomf013.wsp
       Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
       Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
          *** RUN DATE & TIME: 05-28-96  11:34
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     113.    7129.     0.    51.                          0.
   500.33          113.    7129.     0.    51.  1.00     0.    20.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.33     0.0    19.9   112.5    7129.    1051.   9.34
X STA.         0.0         1.6         2.4         3.2         3.9         4.7
  A(I)             9.8         5.9         5.3         4.9         4.9
  V(I)            5.37        8.94        9.83       10.68       10.78

X STA.         4.7         5.4         6.1         6.9         7.7         8.5
  A(I)             4.7         4.8         4.7         4.7         4.9
  V(I)           11.20       10.91       11.14       11.10       10.70

X STA.         8.5         9.3        10.2        11.1        12.1        13.1
  A(I)             4.8         5.0         5.0         5.2         5.3
  V(I)           10.87       10.47       10.51       10.20        9.89

X STA.        13.1        14.1        15.2        16.4        17.8        19.9
  A(I)             5.5         5.6         5.8         6.4         9.3
  V(I)            9.59        9.40        9.09        8.24        5.65

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      17.
         WSEL     LEW     REW    AREA        K        Q    VEL
       503.17   -88.1    95.1   208.5   10177.    1168.   5.60
X STA.       -88.1       -82.9       -78.7       -74.5       -70.4       -66.2
  A(I)             9.8         7.8         7.9         7.8         8.0
  V(I)            5.94        7.45        7.35        7.50        7.34

X STA.       -66.2       -62.2       -58.2       -54.2       -50.2       -46.2
  A(I)             7.7         7.7         7.8         7.8         7.8
  V(I)            7.61        7.54        7.45        7.51        7.51

X STA.       -46.2       -42.0       -37.6       -32.8       -27.7       -22.1
  A(I)             7.8         8.0         8.4         8.6         8.9
  V(I)            7.46        7.26        6.95        6.81        6.55

X STA.       -22.1       -15.8        -8.4         1.7        14.5        95.1
  A(I)             9.2         9.9        11.9        13.2        42.3
  V(I)            6.32        5.89        4.89        4.42        1.38

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1       0.       9.     1.     2.                          2.
             2     283.   36417.    42.    44.                       4176.
             3     152.    9737.    81.    82.                       1178.
   503.17          436.   46163.   124.   128.  1.24   -17.   107.   4157.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
         WSEL     LEW     REW    AREA        K        Q    VEL
       503.17   -17.3   107.1   435.5   46163.    2200.   5.05
X STA.       -17.3        -5.5        -2.0         0.5         2.5         4.3
  A(I)            32.8        22.6        20.3        17.5        16.4
  V(I)            3.36        4.86        5.42        6.28        6.72

X STA.         4.3         6.0         7.7         9.5        11.3        13.2
  A(I)            15.9        15.6        15.7        15.5        15.6
  V(I)            6.90        7.06        7.01        7.11        7.05

X STA.        13.2        15.1        17.1        19.2        21.5        24.1
  A(I)            15.7        16.1        16.2        16.6        17.6
  V(I)            7.01        6.84        6.78        6.63        6.24

X STA.        24.1        27.0        31.1        36.6        43.3       107.1
  A(I)            18.8        23.6        28.1        33.7        61.1
  V(I)            5.84        4.66        3.91        3.26        1.80
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       U.S. Geological Survey WSPRO Input File pomf013.wsp
       Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
       Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
          *** RUN DATE & TIME: 05-28-96  11:34
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     113.    7129.     0.    51.                           0.
  500.33          113.    7129.     0.    51.  1.00     0.    20.      0.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      500.33     0.0    19.9   112.5    7129.     760.   6.75
X STA.        0.0        1.6        2.4        3.2        3.9        4.7
  A(I)            9.8        5.9        5.3        4.9        4.9
  V(I)           3.88       6.46       7.11       7.72       7.79

X STA.        4.7        5.4        6.1        6.9        7.7        8.5
  A(I)            4.7        4.8        4.7        4.7        4.9
  V(I)           8.10       7.89       8.05       8.03       7.74

X STA.        8.5        9.3       10.2       11.1       12.1       13.1
  A(I)            4.8        5.0        5.0        5.2        5.3
  V(I)           7.86       7.57       7.60       7.37       7.15

X STA.       13.1       14.1       15.2       16.4       17.8       19.9
  A(I)            5.5        5.6        5.8        6.4        9.3
  V(I)           6.94       6.80       6.58       5.96       4.09

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            2     202.   21724.    39.    41.                        2600.
            3      66.    5570.    23.    24.                         638.
  501.19          268.   27294.    62.    65.  1.03   -13.    49.   3113.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      54.
        WSEL     LEW     REW    AREA        K        Q    VEL
      501.19   -13.1    49.4   268.4   27294.     760.   2.83
X STA.      -13.1       -3.3       -0.4        1.7        3.4        5.0
  A(I)           23.0       15.8       13.6       12.1       11.4
  V(I)           1.65       2.40       2.80       3.13       3.33

X STA.        5.0        6.5        8.1        9.7       11.3       13.0
  A(I)           11.2       10.9       10.7       10.9       11.0
  V(I)           3.38       3.47       3.55       3.48       3.46

X STA.       13.0       14.8       16.7       18.7       21.0       23.5
  A(I)           11.1       11.3       11.7       12.0       12.7
  V(I)           3.41       3.35       3.25       3.17       2.99

X STA.       23.5       26.4       29.8       34.5       39.7       49.4
  A(I)           13.4       13.4       15.5       16.0       20.4
  V(I)           2.83       2.83       2.45       2.37       1.86
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        U.S. Geological Survey WSPRO Input File pomf013.wsp
        Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
        Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
           *** RUN DATE & TIME: 05-28-96  11:34

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

EXITX:XS   ******   -52.     271.  0.97 *****  501.11  499.86   1600.  500.14
      -34. ******    74.   20144.  1.78 ***** *******    0.95    5.90

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     500.51     499.97

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.64     504.87    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.64     504.87     499.97

FULLV:FV      34.   -55.     299.  0.81  0.19  501.28  499.97   1600.  500.47
        0.    34.    79.   22265.  1.83  0.00   -0.02    0.85    5.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      54.   -12.     249.  0.66  0.25  501.54 *******   1600.  500.88
       54.    54.    49.   24503.  1.03  0.00    0.00    0.57    6.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   500.47     500.25

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =     519.       451.    1.15

            <<<<<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      34.     0.     113.  1.51 *****  501.84  499.17   1107.  500.33
        0. ******    20.    7129.  1.00 ***** *******    0.73    9.84

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  500.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    23.  0.04  0.34  502.87    0.02    519.  502.57

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    472.    97.   -88.     8.   1.3   1.1   5.4   4.6   1.4   3.1
   RT:     47.    42.     8.    50.   0.4   0.2   3.3   5.3   0.5   3.1

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

APPRO:AS      12.   -16.     368.  0.34  0.09  502.91  499.52   1600.  502.57
       54.    13.    82.   38404.  1.16  0.00    0.02    0.43    4.35

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -34.   -52.    74.   1600.   20144.     271.    5.90  500.14
   FULLV:FV       0.   -55.    79.   1600.   22265.     299.    5.35  500.47
   BRIDG:BR       0.     0.    20.   1107.    7129.     113.    9.84  500.33
   RDWAY:RG      17.*******   472.    519.*********      0.    1.00  502.57
   APPRO:AS      54.   -16.    82.   1600.   38404.     368.    4.35  502.57

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    499.86    0.95  493.21  504.75************  0.97  501.11  500.14
   FULLV:FV    499.97    0.85  493.33  504.87  0.19  0.00  0.81  501.28  500.47
   BRIDG:BR    499.17    0.73  493.33  500.33************  1.51  501.84  500.33
   RDWAY:RG  ****************  501.22  505.89  0.04******  0.34  502.87  502.57
   APPRO:AS    499.52    0.43  493.88  505.26  0.09  0.00  0.34  502.91  502.57
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        U.S. Geological Survey WSPRO Input File pomf013.wsp
        Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
        Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
           *** RUN DATE & TIME: 05-28-96  11:34

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

EXITX:XS   ******  -111.     399.  1.04 *****  502.03  500.50   2200.  500.99
      -34. ******    96.   27705.  2.20 ***** *******    1.00    5.51

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     501.49     500.61

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   500.49     504.87    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   500.49     504.87     500.61

 ===140 AT SECID "FULLV":  END OF CROSS SECTION EXTENDED VERTICALLY.
                            WSEL,YLT,YRT =   501.44     501.42     504.87

FULLV:FV      34.  -119.     469.  0.77  0.18  502.21  500.61   2200.  501.44
        0.    34.   100.   32314.  2.25  0.00    0.00    0.85    4.69
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      54.   -14.     297.  0.88  0.26  502.51 *******   2200.  501.63
       54.    54.    52.   31246.  1.03  0.06   -0.01    0.62    7.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   501.44     500.25

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =    1168.       886.    1.32

            <<<<<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      34.     0.     113.  1.36 *****  501.69  499.00   1051.  500.33
        0. ******    20.    7129.  1.00 ***** *******    0.69    9.34

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  500.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.    23.  0.05  0.49  503.61    0.01   1168.  503.17

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    899.    97.   -88.     8.   2.0   1.7   6.7   5.6   2.1   3.1
   RT:    269.    87.     8.    95.   1.0   0.6   4.7   5.6   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      12.    -17.     436.  0.49  0.11  503.66  500.28   2200.  503.17
       54.    14.   107.   46164.  1.24  0.00    0.01    0.53    5.05

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -34.  -111.    96.   2200.   27705.     399.    5.51  500.99
   FULLV:FV       0.  -119.   100.   2200.   32314.     469.    4.69  501.44
   BRIDG:BR       0.     0.    20.   1051.    7129.     113.    9.34  500.33
   RDWAY:RG      17.*******   899.   1168.******************    1.00  503.17
   APPRO:AS      54.   -17.   107.   2200.   46164.     436.    5.05  503.17

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS    500.50     1.00  493.21  504.75************  1.04  502.03  500.99
   FULLV:FV    500.61     0.85  493.33  504.87  0.18  0.00  0.77  502.21  501.44
   BRIDG:BR    499.00     0.69  493.33  500.33************  1.36  501.69  500.33
   RDWAY:RG   ***************  501.22  505.89  0.05******  0.49  503.61  503.17
   APPRO:AS    500.28     0.53  493.88  505.26  0.11  0.00  0.49  503.66  503.17
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        U.S. Geological Survey WSPRO Input File pomf013.wsp
        Hydraulic analysis for structure POMFTH00020013   Date: 03-MAY-96
        Hydraulic Analysis for Pomfret bridge 13 over Barnard Brook by MAI
           *** RUN DATE & TIME: 05-28-96  11:34

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

EXITX:XS   ******   -33.     128.  0.76 *****  499.41  498.11    760.  498.64
      -34. ******    33.    9571.  1.39 ***** *******    0.89    5.95

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     498.97     498.22

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.14     504.87    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.14     504.87     498.22

FULLV:FV      34.   -35.     140.  0.65  0.19  499.60  498.22    760.  498.94
        0.    34.    38.   10526.  1.44  0.00    0.00    0.83    5.41
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      54.    -9.     165.  0.35  0.22  499.79 *******    760.  499.44
       54.    54.    46.   13664.  1.07  0.00   -0.02    0.49    4.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   498.43     500.55     500.61     500.25

 ===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      34.     0.     113.  0.71 *****  501.04  498.14    760.  500.33
        0. ******    20.    7129.  1.00 ***** *******    0.50    6.75

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.429  0.000  500.25 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      17.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      12.   -13.     268.  0.13  0.04  501.32  497.94    760.  501.19
       54.    13.    49.   27289.  1.03  0.76    0.00    0.24    2.83

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   501.17
                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>

   FIRST USER DEFINED TABLE.
     XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
    EXITX:XS     -34.   -33.    33.    760.    9571.     128.    5.95  498.64
    FULLV:FV       0.   -35.    38.    760.   10526.     140.    5.41  498.94
    BRIDG:BR       0.     0.    20.    760.    7129.     113.    6.75  500.33
    RDWAY:RG      17.**************      0.*********       0.    1.00********
    APPRO:AS      54.   -13.    49.    760.   27289.     268.    2.83  501.19

   SECOND USER DEFINED TABLE.
     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    498.11    0.89  493.21  504.75************  0.76  499.41  498.64
    FULLV:FV    498.22    0.83  493.33  504.87  0.19  0.00  0.65  499.60  498.94
    BRIDG:BR    498.14    0.50  493.33  500.33************  0.71  501.04  500.33
    RDWAY:RG  ****************  501.22  505.89************  0.11  501.60********
    APPRO:AS    497.94    0.24  493.88  505.26  0.04  0.76  0.13  501.32  501.19
```
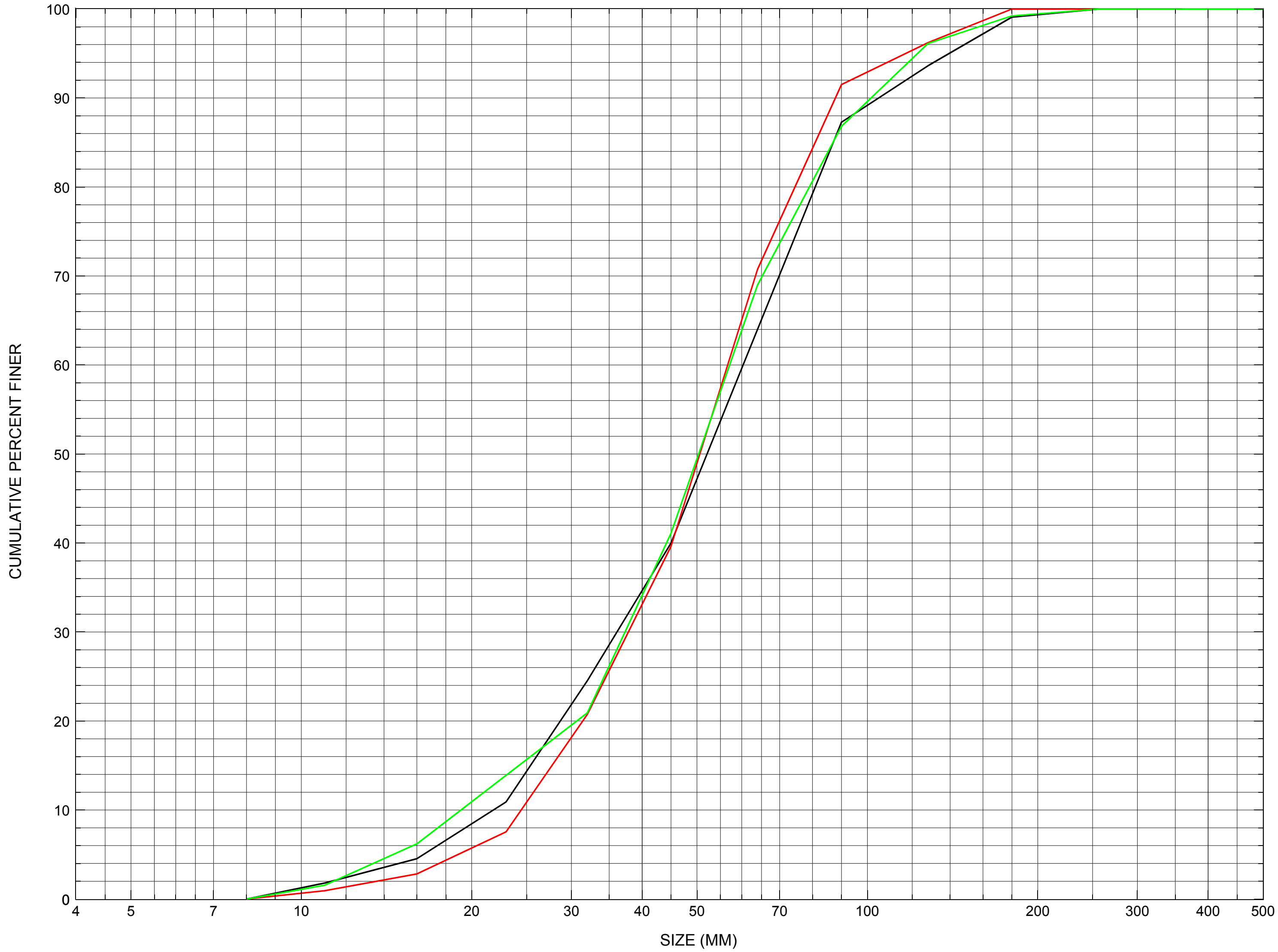

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure POMFTH00020013, in Pomfret, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number POMFTH00020013

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 22 / 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)* 000000

Waterway *(I - 6)* BARNARD BROOK

Road Name *(I - 7):* -

Route Number TH002

Vicinity *(I - 9)* 0.5 MI JCT TH 2 + TH 1

Topographic Map Woodstock.North

Hydrologic Unit Code: 01080106

Latitude *(I - 16; nnnn.n)* 43402

Longitude *(i - 17; nnnnn.n)* 72328

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10141300131413

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

Maximum span length *(I - 48; nnnn)* 0020

Year built *(I - 27; YYYY)* 1972

Structure length *(I - 49; nnnnnn)* 000023

Average daily traffic, ADT *(I - 29; nnnnnn)* 000300

Deck Width *(I - 52; nn.n)* 313

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 6

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

Waterway adequacy *(I - 71; n)* 5

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 005.0

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

Waterway of full opening (*nnn.n ft²*) -

Comments:

Structural inspection report of 6/22/94 indicates abutment concrete walls look new. Footings are not visible at the surface. The inspection indicated no channel scour or road embankment erosion. A mid-channel sand bar is noted along the right abutment. The channel is noted as making a sharp bend into the bridge crossing. Stone fill was present and in good condition.

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: **Mud and gravel**

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **7.98** mi^2

Lake and pond area **0.03** mi^2

Watershed storage *(ST)* **0.4** %

Bridge site elevation **750** ft

Headwater elevation **1623** ft

Main channel length **5.12** mi

10% channel length elevation **780** ft

85% channel length elevation **1310** ft

Main channel slope *(S)* **138.03** 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)*: 03 / 1972

Project Number SAB 7116 Minimum channel bed elevation: 495.0

Low superstructure elevation: USLAB 500.7 DSLAB 500.7 USRAB 500.94 DSRAB 500.94

Benchmark location description:
BM#1, spike in a tree at the top of the downstream left wingwall and left abutment wall junction, stationing 8+50, 20 feet left, elevation 500.00 feet.

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 1.5 Footing bottom elevation: 491.00

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

If 3: Footing bottom elevation: ______

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

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

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

Comments:

Cross-sectional Data

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

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

Comments: **Upstream bridge face: 1 + 10 along the center base line 4 feet behind the left abutment Footings: top at 492, bottom at 491; protruding 2 ft from the abutment walls.**

Station	4.0	14.0	24.0								
Feature	LCL	chan	LCR								
Low cord elevation	500.5		500.5								
Bed elevation	495.0	495.0	495.0								
Low cord to bed length	5.5		5.5								

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

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

Comments: **Downstream bridge face: 0 + 80 along the center base line.**

Station	4.0	14.0	24.0								
Feature	LCL	chan	LCR								
Low cord elevation	500.5		500.5								
Bed elevation	495.0	495.0	495.0								
Low cord to bed length	5.5		5.5								

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: EMB Date: 2/14/95
Computerized by: EMB Date: 2/14/95
Reviewd by: SAO Date: 6/27/96

Structure Number POMFTH00020013

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. WEBER Date *(MM/DD/YY)* 09 / 15 / 1994

2. Highway District Number 04 Mile marker -

County WINDSOR Town POMFRET

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

Route Number TH02 Hydrologic Unit Code: 01080106

3. Descriptive comments:

House and barn nearby on upstream left bank. Log debris on upstream left bank and branches and sticks in riffle upstream.

B. Bridge Deck Observations

4. Surface cover... LBUS 4 RBUS 4 LBDS 4 RBDS 6 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 1 DS 2 *(**1**- pool; **2**- riffle)*

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

7. Bridge length 23 *(feet)* Span length 20 *(feet)* Bridge width 31.3 *(feet)*

Road approach to bridge:

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

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

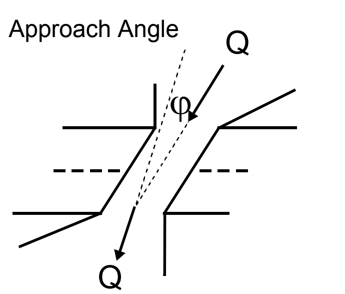
10. Embankment slope (*run / rise in feet / foot*):
US left -:1 US right 2.6:1

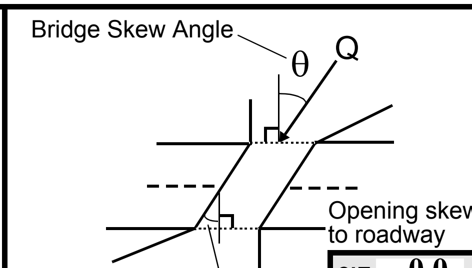
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	2	1
RBDS	0	-	0	0
LBDS	0	-	0	0

*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: 35 16. Bridge skew: 30





α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 3
Range? 10 feet UB *(US, UB, DS)* to 50 feet US

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

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

18. Level II Bridge Type: **1a/4**

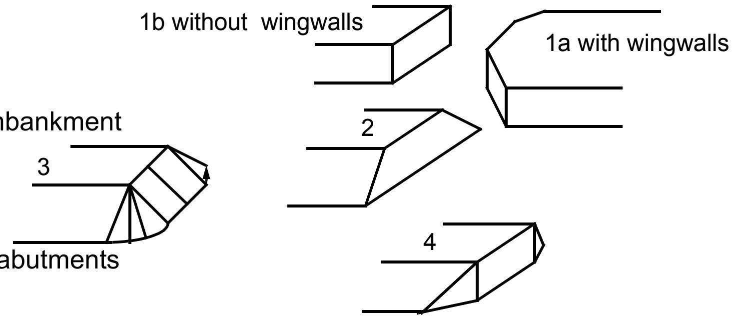
1a- Vertical abutments with wingwalls

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.)

Gravel driveway on downstream left overbank. Paved road along upstream right bank. Approach channel makes a severe bend into the bridge opening. Upstream left does not have an actual roadway embankment.

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
115.0	8.0			2.0	1	1	3	3	1	0

23. Bank width **25.0** 24. Channel width **10.0** 25. Thalweg depth **42.0** 29. Bed Material **4**

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.):

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **0** 35. Mid-bar width: **8**

36. Point bar extent: **21** feet **US** *(US, UB)* to **17** feet **DS** *(US, UB, DS)* positioned **50** %LB to **100** %RB

37. Material: **2**

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

Mid-bar distance coincides with the downstream bridge face. Point bar extends from 21 feet upstream of the bridge to 17 feet downstream of the bridge. Bridge is 32 feet wide, thus total length of point bar is 70 ft.

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

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

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

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

No cut banks

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **0**

47. Scour dimensions: Length **40** Width **5** Depth : **20** Position **0** %LB to **5** %RB

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

Scour is 2.5 feet deep in the deepest part of the hole along the left abutment. Deepest scour is at 11 feet under bridge from the upstream bridge face.

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 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
13.0		1.0		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.):

4

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

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

70. Debris and Ice Comments:

1

There are some small logs/branches in the upstream channel.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		30	90	2	1	2		90.0
RABUT	1	-	90			0	0	20.0

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.):

-

-

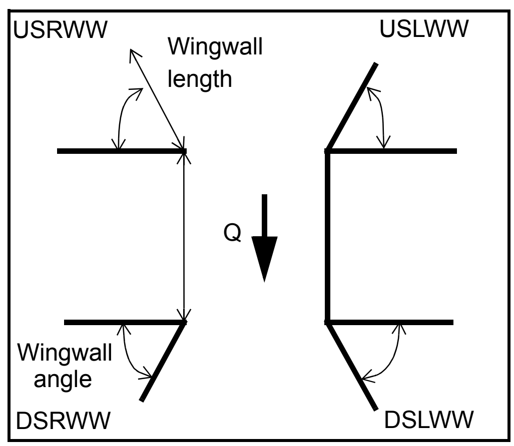
1

Abutments constrict the channel slightly. There is scour along the left abutment where the flow impacts the upstream left wingwall and left abutment.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						9.0	
USRWW:	Y		1		1	0.5	
DSLWW:	1		0		Y	34.0	
DSRWW:	1		0		-	34.5	

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

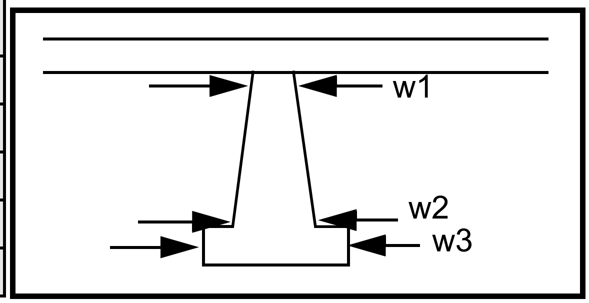
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? **Mo** *(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				**75.0**	**10.0**	**45.0**
Pier 2	**9.5**	**9.5**		**45.0**	**45.0**	**10.0**
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4
86. Location (BF)	**stly**		-	-
87. Type	**type-**		-	-
88. Material	**2,**		-	-
89. Shape	**some**		-	-
90. Inclined?	**type-**		-	-
91. Attack ∠ (BF)	**3**		-	-
92. Pushed	**stone**	**N**	-	-
93. Length (feet)	-	-	-	-
94. # of piles	**-fill.**	-	-	-
95. Cross-members		-	-	-
96. Scour Condition		-	-	-
97. Scour depth		-	-	-
98. Exposure depth		-	-	-

LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP

***1**- Solid pier, **2**- column, **3**- bent*

***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*

***1**- Round; **2**- Square; **3**- Pointed*

Y- yes; N- no

LB or RB

***0**- none; **1**- laterals; **2**- diagonals; **3**- both*

***0**- not evident; **1**- evident (comment);*
***2**- footing exposed; **3**- piling exposed;*
***4**- undermined footing; **5**- settled; **6**- failed*

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
-	-			-		-	-	-	-	

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

Bank protection type (Qmax): LB - RB - Bank protection condition: LB No RB pier

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.):
s

1
3
3
3
1

101. Is a drop structure present? 1 *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

105. Drop structure comments (eg. downstream scour depth):
0
0
-
-
Some erosion along the bottoms of each bank.

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.):

N

Is a cut-bank present? - *(Y or if N type ctrl-n cb)* Where? **No** *(LB or RB)* Mid-bank distance: **drop**

Cut bank extent: **struc** feet **tur** *(US, UB, DS)* to **e** 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.):

N

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

Scour dimensions: Length - Width - Depth: - Positioned - %LB to - %RB

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

-

-

No point bars

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

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

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

Confluence comments (eg. confluence name):

-

-

F. Geomorphic Channel Assessment

107. Stage of reach evolution **No**

- ***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)*:

cut banks

N
-
-
-
-
-
-
No channel scour

N
-
-
-
-
-
-
-
No major confluences

2
Overall stream is stable. Meanders are fairly well incised and banks are vegetated with larger woody growth beyond two bridge lengths from the bridge site. Lateral instability may be a concern at the bridge since the structure is located on a sharp bend. Flood flows would likely overtop the bridge and probably cut off the large downstream meander bend before re-entering the main channel.

Geomorphic factors affecting stream stability:
Small stream

109. G. Plan View Sketch

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: POMFTH00020013 Town: Pomfret
Road Number: TH 2 County: Windsor
Stream: Barnard Brook

Initials MAI Date: 05/21/96 Checked: JDA

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	1600	2200	760
Main Channel Area, ft2	258	283	202
Left overbank area, ft2	0	0	0
Right overbank area, ft2	110	152	66
Top width main channel, ft	42	42	39
Top width L overbank, ft	0	1	0
Top width R overbank, ft	56	81	23
D50 of channel, ft	0.167	0.167	0.167
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	6.1	6.7	5.2
y1, average depth, LOB, ft	ERR	0.0	ERR
y1, average depth, ROB, ft	2.0	1.9	2.9
Total conveyance, approach	38436	46163	27294
Conveyance, main channel	31181	36417	21724
Conveyance, LOB	0	9	0
Conveyance, ROB	7256	9737	5570
Percent discrepancy, conveyance	-0.0026	0.0000	0.0000
Qm, discharge, MC, cfs	1298.0	1735.5	604.9
Ql, discharge, LOB, cfs	0.0	0.4	0.0
Qr, discharge, ROB, cfs	302.1	464.0	155.1
Vm, mean velocity MC, ft/s	5.0	6.1	3.0
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	2.7	3.1	2.3
Vc-m, crit. velocity, MC, ft/s	8.4	8.5	8.1
Vc-l, crit. velocity, LOB, ft/s	N/A	0.0	N/A
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

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

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	258	283	202
Main channel width, ft	42	42	39
y1, main channel depth, ft	6.14	6.74	5.18

Bridge Section			
(Q) total discharge, cfs	1600	2200	760
(Q) discharge thru bridge, cfs	1107	1051	760
Main channel conveyance	7129	7129	7129
Total conveyance	7129	7129	7129
Q2, bridge MC discharge,cfs	1107	1051	760
Main channel area, ft2	113	113	113
Main channel width (skewed), ft	19.9	19.9	19.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.9	19.9	19.9
y_bridge (avg. depth at br.), ft	5.65	5.65	5.65
Dm, median (1.25*D50), ft	0.20875	0.20875	0.20875
y2, depth in contraction,ft	6.07	5.80	4.39
ys, scour depth (y2-ybridge), ft	0.41	0.15	-1.26

ARMORING			
D90	0.32	0.32	0.32
D95	0.412	0.412	0.412
Critical grain size,Dc, ft	0.3383	0.3049	0.1594
Decimal-percent coarser than Dc	0.089	0.11	0.537
Depth to armoring,ft	10.39	7.40	0.41

PRESSURE FLOW SCOUR COMPUTATION

```
 Structure Number: POMFTH00020013            Town:    Pomfret
 Road Number:      TH 2                      County:  Windsor
 Stream:           Barnard Brook
 Initial:  EMB      Date:    10/10/96 Checked:
 Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	1107	1051	760
Vc, critical velocity, ft/s	8.4	8.5	8.1
Vc, critical velocity, m/s	2.560195	2.590674	2.46876
Main channel width (skewed), ft	19.9	19.9	19.9
Cum. width of piers, ft	0	0	0

W, adjusted width, ft	19.9	19.9	19.9
qbr, unit discharge, ft^2/s	55.62814	52.81407	38.19095
qbr, unit discharge, m^2/s	5.167519	4.906109	3.54771
Area of full opening, ft^2	112.5	112.5	112.5
Hb, depth of full opening, ft	5.653266	5.653266	5.653266
Hb, depth of full opening, m	1.723031	1.723031	1.723031
Fr, Froude number MC	0.73	0.69	0.5
Cf, Fr correction factor (<=1.0)	1	1	1
Elevation of Low Steel, ft	500.25	500.25	500.25
Elevation of Bed, ft	494.5967	494.5967	494.5967
Elevation of approach WS, ft	502.57	503.17	501.19
HF, bridge to approach, ft	0.09	0.11	0.04
Elevation of WS immediately US, ft	502.48	503.06	501.15
ya, depth immediately US, ft	7.883266	8.463266	6.553266
ya, depth immediately US, m	2.449741	2.629977	2.036441
Mean elev. of deck, ft	502.16	502.16	502.16
w, depth of overflow, ft (>=0)	0.32	0.9	0
Cc, vert contrac correction (<=1.0)	0.926917	0.926917	0.963972
Ys, depth of scour (chang), ft	1.491273	1.05005	-0.76212

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	1600	2200	760	1600	2200	760
a', abut.length blocking flow, ft	15.9	17.3	13.1	62	87.2	29.5
Ae, area of blocked flow ft2	51.87	49.65	41.4	140.52	154.98	97.14
Qe, discharge blocked abut.,cfs	--	--	83.24	--	--	246.17
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	3.40	4.30	2.01	3.40	3.79	2.53
ya, depth of f/p flow, ft	3.26	2.87	3.16	2.27	1.78	3.29
--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	0.305	0.372	0.199	0.386	0.447	0.246
ys, scour depth, ft	9.08	9.20	7.21	12.06	12.57	9.98

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)	15.9	17.3	13.1	62	87.2	29.5
y1 (depth f/p flow, ft)	3.26	2.87	3.16	2.27	1.78	3.29
a'/y1	4.87	6.03	4.15	27.36	49.06	8.96
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.31	0.37	0.20	0.39	0.45	0.25
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	12.04	9.91	ERR
vertical w/ ww's	ERR	ERR	ERR	9.87	8.13	ERR
spill-through	ERR	ERR	ERR	6.62	5.45	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	0.73	0.69	0.5	0.73	0.69	0.5
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	5.65	5.65	5.65	5.65	5.65	5.65
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.86	1.66	0.87	1.86	1.66	0.87
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR