LEVEL II SCOUR ANALYSIS FOR BRIDGE 35 (BRIDTH00050035) on TOWN HIGHWAY 5, crossing the NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

U.S. Geological Survey
Open-File Report 96-305

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 35 (BRIDTH00050035) on TOWN HIGHWAY 5, crossing the NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

By SCOTT A. OLSON and JOSEPH D. AYOTTE

U.S. Geological Survey
Open-File Report 96-305

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275

Copies of this report may be purchased from:

U.S. Geological Survey
Earth Science Information Center
Open-File Reports Section
Box 25286, MS 517
Federal Center
Denver, CO 80225

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 35 (BRIDTH00050035) ON TOWN HIGHWAY 5, CROSSING THE NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

By **Scott A. Olson and Joseph D. Ayotte**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRIDTH00050035 on town highway 5 crossing the North Branch Ottauquechee River, Bridgewater, 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). A Level I study is included in Appendix E of this report. A Level I study provides a qualitative geomorphic characterization of the study site. Information on the bridge available from 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 Green Mountain physiographic division of central Vermont. The 6.70-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, surface cover is predominately forest. Town Highway 5 runs parallel to the upstream left and downstream right banks.

In the study area, the North Branch Ottauquechee River has an incised, sinuous channel with a slope of approximately 0.015 ft/ft, an average channel top width of 33 ft and an average channel depth of 3 ft. The predominant channel bed materials are gravel and cobble (D_{50} is 74.8 mm or 0.245 ft). The geomorphic assessment at the time of the Level I and Level II site visit on November 2, 1994, indicated that the reach was stable.

The town highway 5 crossing of the North Branch Ottauquechee River is a 30-ft-long, one-lane bridge consisting of one 24-foot steel-beam span with a timber deck (Vermont Agency of Transportation, written communication, August 25, 1994). The bridge is supported by a timber cribwork abutment on the right and stone wall abutment on the left. A scour hole 3 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. The channel is skewed approximately 30 degrees to the opening while the opening-skew-to-roadway is 25 degrees. 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, 1993). 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 0.7 to 0.8 ft. The worst-case contraction scour occurred at the incipient-roadway-overtopping discharge and at the 100-year discharge. Abutment scour ranged from 8.0 to 15.1 ft. with the worst-case abutment scour occurring 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, 1993, p. 48). Many factors, including historical performance during flood events, the geomorphic assessment, scour protection measures, and the results of the hydraulic analyses, must be considered to properly assess the validity of abutment scour results. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein, based on the consideration of additional contributing factors and experienced engineering judgement.

Delectable Mountain, 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 BRIDTH00050035 *Stream* N. Br. Ottauquechee River

County Windsor *Road* TH005 *District* 04

Description of Bridge

Bridge length 30 *ft* *Bridge width* 13.2 *ft* *Max span length* 24 *ft*

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

Abutment type Vertical *Embankment type* Sloping

Stone fill on abutment? No *Date of inspection* 11/02/94

Description of stone fill Type-2 (less than 36 inches diameter), at the road embankments and the upstream banks near the bridge.

Brief description of piers/abutments Left abutment is stone. Right abutment is timber cribbing filled with stone. There is a three foot deep scour hole along the left abutment.

Is bridge skewed to flood flow according to Y *survey?* Y *Angle* 30

There is a severe channel bend at the entrance of the bridge opening. A scour hole has developed in the location where the bend impacts the left 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	11/02/94	0	0
Level II	11/02/94	--	--

Potential for debris Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) November 2, 1994--Flow severely impacts the left abutment.

Description of the Geomorphic Setting

General topography The channel is located in a narrow incised upland valley.

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

Date of inspection 11/02/95

DS left: Narrow terrace to steep valley wall

DS right: Steep valley wall

US left: Steep valley wall

US right: Narrow terrace to steep valley wall

Description of the Channel

Average top width 33 ft ***Average depth*** 3 ft

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

Sinuous but stable

with non-alluvial channel boundaries and no flood plains.

11/02/94

Vegetative co Forested except for gravel road running parallel to bank.

DS left: Forested

DS right: Forested except for gravel road running parallel to bank.

US left: Forested

US right:

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

November 2, 1994--

None.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.70 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	***Percent of drainage area***
Green Mountain	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 ***mi***^{2}

No

Is there a lake/p --

Calculated Discharges

Q100 1,790 ***ft***^{3}***/s***

Q500 2,530 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(6.70/5.00)exp 0.7] with bridge number 33 in Bridgewater. Bridge number 33 crosses the North Branch Ottauquechee River upstream of this site and has flood frequency estimates for the 100 year event available from the VTAOT database (VTAOT, written communication, May, 1995). The 500-year event at bridge 33 was estimated by multiplying the 100-year discharge by 1.7 (Richardson and others, 1993). The drainage area above bridge number 33 is 5.0 square miles.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled square on top of an exposed abutment stone at the downstream end of the left abutment. (elev. 97.16 ft, arbitrary datum). RM2 is a chiseled square on top of a bedrock exposure fifty feet downstream of the bridge and on the left bank (elev. 94.32 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-27	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	36	2	Modelled Approach section (Templated from APTEM)
APTEM	57	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 analysis reported herein reflects 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, Jr. and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.050, and the overbank "n" value (the gravel road) was 0.030.

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 0.015 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 (0.03 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.

Water overtopped the structure in both the 100- and 500-year models. The incipient-overtopping discharge was 830 cfs. For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for the incipient-overtopping discharge at this bridge site. Analyzing both the supercritical and subcritical models, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satifactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 100.4 *ft*
Average low steel elevation 98.7 *ft*

100-year discharge 1,790 *ft³/s*
Water-surface elevation in bridge opening 99.0 *ft*
Road overtopping? Y *Discharge over road* 649 *ft³/s*
Area of flow in bridge opening 112 *ft²*
Average velocity in bridge opening 10.4 *ft/s*
Maximum WSPRO tube velocity at bridge 12.5 *ft/s*

Water-surface elevation at Approach section with bridge 101.4
Water-surface elevation at Approach section without bridge 99.9
Amount of backwater caused by bridge 1.5 *ft*

500-year discharge 2,530 *ft³/s*
Water-surface elevation in bridge opening 99.1 *ft*
Road overtopping? Y *Discharge over road* 1,410 *ft³/s*
Area of flow in bridge opening 112 *ft²*
Average velocity in bridge opening 10.3 *ft/s*
Maximum WSPRO tube velocity at bridge 12.7 *ft/s*

Water-surface elevation at Approach section with bridge 102.3
Water-surface elevation at Approach section without bridge 101.2
Amount of backwater caused by bridge 1.1

Incipient overtopping discharge 830 *ft³/s*
Water-surface elevation in bridge opening 96.4 *ft*
Area of flow in bridge opening 71.9 *ft²*
Average velocity in bridge opening 11.6 *ft/s*
Maximum WSPRO tube velocity at bridge 14.6 *ft/s*

Water-surface elevation at Approach section with bridge 98.9
Water-surface elevation at Approach section without bridge 97.7
Amount of backwater caused by bridge 1.2 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1993). 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 and 500-year discharges where orifice flow occurred 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, 1993, p. 35, equation 18) for the 100-year and 500-year dicharges were also computed and can be found in appendix F. Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18) for the incipient road-overflow model. For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, the 100-year discharge model and the incipient road-overflow model resulted in the worst case contraction scour with scour depths of 0.8 ft. However, neither discharges were the worst case total scour.

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 1993, p. 49, equation 24). The Froehlich equation gives "excessively conservative estimates of scour depths" (Richardson and others, 1993, p. 48). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.8	0.7	0.8
Depth to armoring	8.9	8.8	19.1
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	12.6	12.9	10.9
Right abutment	13.1	15.1	8.0
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Rock Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.4	2.4	1.8
Right abutment	2.4	2.4	1.8
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

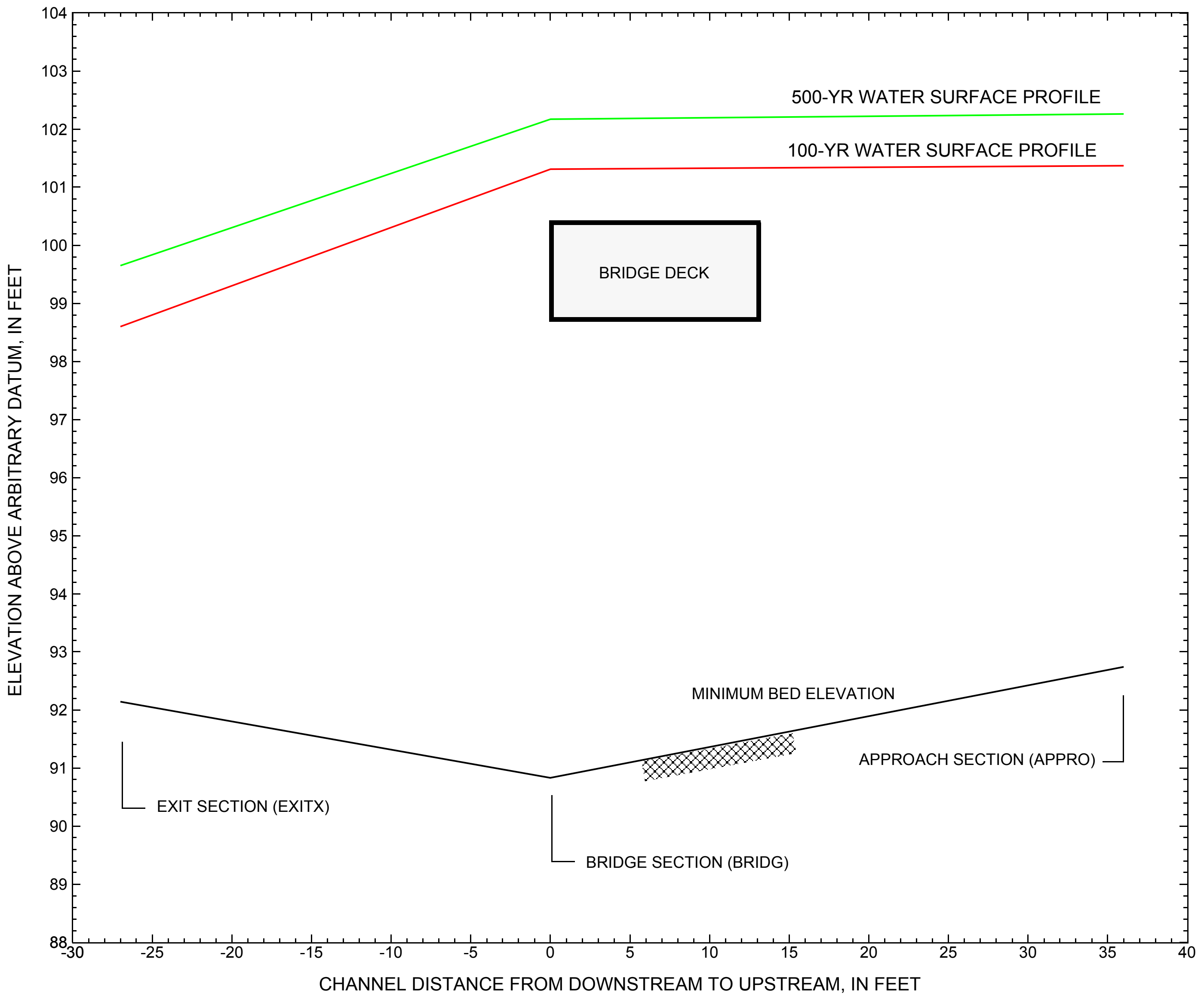


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIDTH00050035 on town highway 5, crossing the North Branch Ottauquechee River, Bridgewater, Vermont.

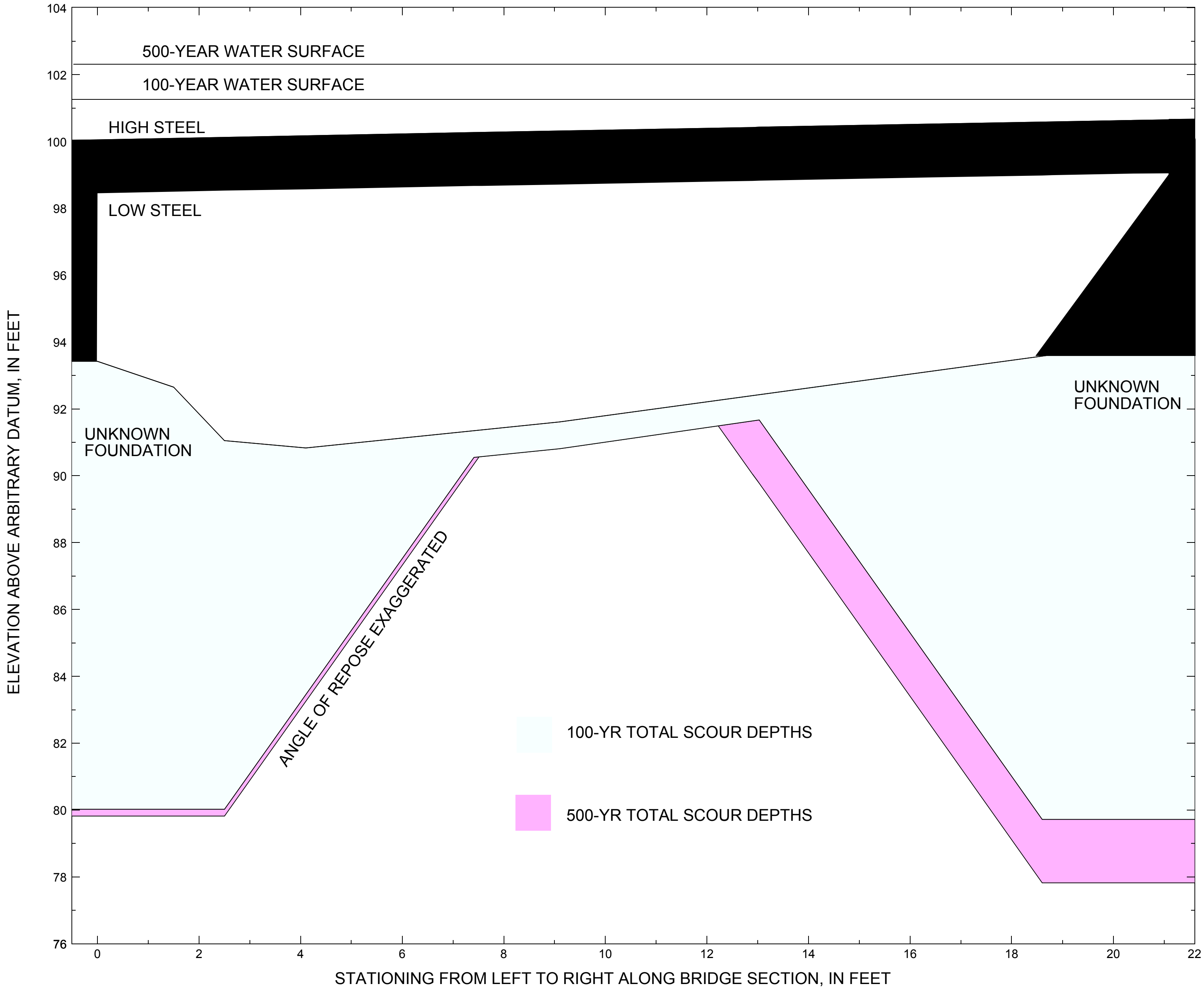


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00050035 on town highway 5, crossing the North Branch Ottauquechee River, Bridgewater, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRIDTH00050035 on Town Highway 5, crossing the North Branch Ottauquechee River, Bridgewater, 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 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 1,790 cubic-feet per second											
Left abutment	0.0	--	98.30	--	93.4	0.8	12.6	--	13.4	80.0	--
Right abutment	21.1	--	99.09	--	93.6	0.8	13.1	--	13.9	79.7	--

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 BRIDTH00050035 on Town Highway 5, crossing the North Branch Ottauquechee River, Bridgewater, 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 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 2,530 cubic-feet per second											
Left abutment	0.0	--	98.30	--	93.4	0.7	12.9	--	13.6	79.8	--
Right abutment	21.1	--	99.09	--	93.6	0.7	15.1	--	15.8	77.8	--

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.

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 Emergency Management Agency, 1980, Flood Insurance Study, Town of Bridgewater, Windsor County, Vermont: Washington, D.C., January 1980.

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.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 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., Richardson, J.R., Chang, F., 1991, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 195 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.

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., Harrison, L.J., Richardson, J.R., and Davis, S.R., 1993, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 131 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.

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, Delectable Mountain, 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 brid035.wsp
T2        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
T3        HYDRAULIC ANALYSIS OF BRID035      SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          1790 2530 830
SK         0.0150 0.0150 0.0150
*
XS   EXITX  -27
GR          -49.3, 110.50    -39.8,  99.14    -25.5,  99.12     -9.1,  98.96
GR           -6.4,  96.73      0.0,  93.26      5.8,  92.14     11.9,  92.98
GR           17.7,  93.06     24.2,  93.25     28.4,  95.52     42.4, 108.01
N            0.030        0.050
SA                  -9.1
*
XS   FULLV    0 * * * 0.015
*
BR   BRIDG    0 98.7 30
GR            0.0,  98.30      0.0,  93.42      1.5,  92.65      2.5,  91.05
GR            4.1,  90.83      9.1,  91.61     12.9,  92.44     16.6,  93.18
GR           18.8,  93.62     20.4,  97.37     21.1,  99.09      0.0,  98.30
N            0.045
CD           1 17.8
*
XR   RDWAY    9 13.2 2
GR          -53.9, 110.50    -44.4,  99.14    -26.4,  99.45      0.0, 100.06
GR           25.7, 100.79     69.2, 100.91     69.2, 110.93
BP           0
*
XT   APTEM    57
GR          -25.6, 111.63     -7.4,  96.52     -2.0,  94.46     -1.8,  93.67
GR            5.7,  93.36      9.6,  93.65     14.2,  93.86     20.0,  94.33
GR           24.1,  97.10     28.3,  98.47     35.3,  99.76     48.9, 101.11
GR           63.0, 100.73     71.0, 107.14
*
AS   APPRO    36
GT            -0.62
N            0.050        0.030
SA                   35.3
BP            0
*
HP 1 BRIDG    99.03 1 99.03
HP 2 BRIDG    99.03 * * 1159
HP 2 RDWAY    101.31 * * 649
HP 1 APPRO    101.37 1 101.37
HP 2 APPRO    101.37 * * 1790
*
HP 1 BRIDG    99.09 1 99.09
HP 2 BRIDG    99.09 * * 1158
HP 2 RDWAY    102.17 * * 1408
HP 1 APPRO    102.26 1 102.26
HP 2 APPRO    102.26 * * 2530
*
HP 1 BRIDG    96.43 1 96.43
HP 2 BRIDG    96.43 * * 830
HP 1 APPRO    98.87 1 98.87
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
        HYDRAULIC ANALYSIS OF BRID035      SAO
           *** RUN DATE & TIME: 09-26-95  09:14
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     112.    6776.     1.    45.                       5751.
    99.03          112.    6776.     1.    45.  1.00     0.    21.   5751.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
        99.03     0.0    21.1   112.0    6776.    1159.  10.35
X STA.         0.0         2.1         3.1         4.0         4.7         5.5
  A(I)             10.1         6.5         5.4         5.2         4.8
  V(I)             5.76        8.94       10.64       11.25       12.09

X STA.         5.5         6.2         7.0         7.7         8.5         9.2
  A(I)              4.8         4.8         4.6         4.7         4.6
  V(I)            12.06       12.14       12.49       12.35       12.51

X STA.         9.2        10.0        10.8        11.7        12.6        13.5
  A(I)              4.7         4.8         4.8         5.0         5.1
  V(I)            12.22       12.10       12.00       11.67       11.36

X STA.        13.5        14.5        15.5        16.7        17.9        21.1
  A(I)              5.2         5.3         5.9         6.1         9.5
  V(I)            11.04       10.83        9.89        9.47        6.12

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA        K        Q    VEL
       101.31   -46.2    69.2   122.0    6134.     649.   5.32
X STA.       -46.2       -42.8       -40.9       -39.1       -37.2       -35.2
  A(I)              5.5         4.0         3.8         3.9         3.9
  V(I)             5.94        8.04        8.49        8.30        8.26

X STA.       -35.2       -33.3       -31.2       -29.1       -27.0       -24.8
  A(I)              3.9         4.0         4.0         4.1         4.1
  V(I)             8.30        8.05        8.18        7.98        7.91

X STA.       -24.8       -22.4       -20.0       -17.4       -14.6       -11.6
  A(I)              4.2         4.3         4.4         4.5         4.6
  V(I)             7.78        7.54        7.42        7.20        7.01

X STA.       -11.6        -7.6        -0.3         9.6        29.6        69.2
  A(I)              5.9         9.7        11.1        14.0        18.0
  V(I)             5.47        3.33        2.92        2.31        1.80

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     299.   27996.    49.    53.                       4169.
             2      37.    2145.    29.    30.                        238.
   101.37          336.   30141.    79.    83.  1.04   -14.    65.   3857.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
         WSEL     LEW     REW    AREA        K        Q    VEL
       101.37   -14.0    64.6   335.8   30141.    1790.   5.33
X STA.       -14.0        -5.8        -3.0        -0.8         0.9         2.5
  A(I)             27.1        18.3        17.2        14.7        13.7
  V(I)             3.30        4.88        5.21        6.10        6.52

X STA.         2.5         4.1         5.7         7.2         8.7        10.3
  A(I)             13.5        13.4        13.1        13.1        13.3
  V(I)             6.61        6.69        6.81        6.85        6.73

X STA.        10.3        11.9        13.6        15.2        17.0        18.8
  A(I)             13.3        13.2        13.7        13.9        14.6
  V(I)             6.71        6.78        6.54        6.45        6.14

X STA.        18.8        21.0        24.1        29.6        40.0        64.6
  A(I)             16.0        18.6        22.1        25.2        27.9
  V(I)             5.61        4.82        4.06        3.55        3.21
```

WSPRO OUTPUT FILE (continued)

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
        HYDRAULIC ANALYSIS OF BRID035      SAO
           *** RUN DATE & TIME: 09-26-95  09:14
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     112.   6639.     0.    47.                           0.
    99.09          112.   6639.     0.    47.  1.00     0.    21.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
        99.09     0.0    21.1   112.0    6639.    1158.  10.34
X STA.         0.0        2.1        3.1        3.9        4.7        5.4
  A(I)             9.9        6.5        5.2        5.1        4.8
  V(I)            5.87       8.87      11.19      11.43      11.99

X STA.         5.4        6.1        6.9        7.6        8.3        9.1
  A(I)             4.6        4.7        4.6        4.6        4.6
  V(I)           12.54      12.31      12.66      12.52      12.67

X STA.         9.1        9.9       10.7       11.5       12.4       13.3
  A(I)             4.7        4.8        4.8        4.9        5.1
  V(I)           12.28      12.15      12.04      11.72      11.40

X STA.        13.3       14.3       15.3       16.5       17.8       21.1
  A(I)             5.2        5.5        5.9        6.5       10.1
  V(I)           11.08      10.57       9.88       8.90       5.75

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA        K        Q    VEL
       102.17   -46.9    69.2   221.6   14001.    1408.   6.35
X STA.       -46.9      -42.3      -39.9      -37.4      -34.9      -32.4
  A(I)            10.1        7.4        7.2        7.1        7.1
  V(I)            6.99       9.57       9.77       9.90       9.85

X STA.       -32.4      -29.9      -27.3      -24.6      -21.8      -18.9
  A(I)             7.1        7.1        7.3        7.3        7.6
  V(I)            9.88       9.89       9.62       9.58       9.23

X STA.       -18.9      -15.9      -12.7       -9.3       -3.0        4.2
  A(I)             7.5        7.8        7.9       14.2       15.1
  V(I)            9.36       9.05       8.88       4.95       4.67

X STA.         4.2       12.9       23.9       38.2       52.7       69.2
  A(I)            16.2       17.5       19.5       19.3       21.2
  V(I)            4.34       4.02       3.61       3.65       3.32

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     343.  34664.    50.    55.                        5077.
             2      64.   5100.    30.    31.                         524.
   102.26          407.  39765.    81.    86.  1.02   -15.    66.   5134.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
         WSEL     LEW     REW    AREA        K        Q    VEL
       102.26   -15.1    65.7   406.7   39765.    2530.   6.22
X STA.       -15.1       -6.0       -3.0       -0.6        1.3        3.1
  A(I)            33.5       22.4       20.9       18.2       17.0
  V(I)            3.77       5.64       6.05       6.97       7.45

X STA.         3.1        4.9        6.6        8.3       10.1       11.9
  A(I)            16.8       16.0       16.2       16.4       16.2
  V(I)            7.55       7.91       7.79       7.71       7.79

X STA.        11.9       13.7       15.5       17.4       19.4       21.8
  A(I)            16.3       16.6       16.9       17.4       19.2
  V(I)            7.76       7.60       7.50       7.25       6.60

X STA.        21.8       25.5       31.4       39.4       50.5       65.7
  A(I)            23.1       26.3       25.4       24.3       27.6
  V(I)            5.49       4.81       4.99       5.20       4.59
```

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
        HYDRAULIC ANALYSIS OF BRID035      SAO
           *** RUN DATE & TIME: 09-26-95  09:14
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      72.   4975.    17.    24.                          831.
    96.43           72.   4975.    17.    24.  1.00     0.    20.    831.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
        96.43     0.0    20.0    71.9    4975.     830.  11.55
X STA.         0.0         2.2        3.1        3.9        4.5        5.2
  A(I)            7.0        4.3        3.4        3.2        3.0
  V(I)            5.92       9.54      12.12      12.80      13.82

X STA.         5.2         5.8        6.4        7.1        7.7        8.4
  A(I)            2.9        2.9        2.9        2.8        2.9
  V(I)           14.14      14.20      14.40      14.57      14.41

X STA.         8.4         9.1        9.8       10.5       11.3       12.2
  A(I)            2.9        3.0        3.0        3.1        3.2
  V(I)           14.54      14.03      13.81      13.40      13.05

X STA.        12.2        13.2       14.2       15.4       16.9       20.0
  A(I)            3.4        3.5        3.8        4.2        6.4
  V(I)           12.17      11.90      10.95       9.80       6.52

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     179.  12848.    45.    48.                         2035.
    98.87          179.  12848.    45.    48.  1.00   -11.    34.   2035.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      36.
         WSEL     LEW     REW    AREA        K        Q    VEL
        98.87   -11.0    33.8   179.3   12848.     830.   4.63
X STA.       -11.0        -4.9       -2.6       -0.9        0.5        1.7
  A(I)           14.1       10.1        9.2        7.9        7.5
  V(I)            2.95       4.12       4.51       5.28       5.51

X STA.         1.7         3.0        4.1        5.3        6.5        7.7
  A(I)            7.4        7.1        7.2        7.1        7.2
  V(I)            5.63       5.83       5.74       5.88       5.77

X STA.         7.7         8.9       10.1       11.4       12.8       14.2
  A(I)            7.1        7.4        7.5        7.6        8.1
  V(I)            5.85       5.57       5.55       5.44       5.14

X STA.        14.2        15.7       17.3       19.1       21.5       33.8
  A(I)            8.2        9.0        9.5       11.5       18.6
  V(I)            5.08       4.60       4.38       3.59       2.23
```

WSPRO OUTPUT FILE (continued)

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
        HYDRAULIC ANALYSIS OF BRID035      SAO
           *** RUN DATE & TIME: 09-26-95  09:14

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

EXITX:XS   ******    -9.     187.  1.43 *****  100.02   97.84   1790.   98.60
      -27. ******    32.   14608.  1.00 ***** *******    0.79    9.58

FULLV:FV      27.    -9.     188.  1.41  0.40  100.44 *******   1790.   99.03
        0.    27.    32.   14732.  1.00  0.00    0.01    0.78    9.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      36.   -12.     230.  0.95  0.43  100.85 *******   1790.   99.89
       36.    36.    43.   18354.  1.01  0.00   -0.02    0.68    7.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    99.03      98.70

            <<<<<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      27.     0.     112.  1.67 *****  100.69   97.50   1159.   99.03
        0. ******    21.    6782.  1.00 ***** *******    0.79   10.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000   98.70 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    23.  0.08  0.46  101.75    0.01    649.  101.31

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    483.    55.   -46.     9.   2.2   1.6   6.4   5.4   2.1   3.0
   RT:    165.    60.     9.    69.   1.0   0.5   4.2   5.1   1.0   2.8

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

APPRO:AS      18.   -14.     336.  0.46  0.20  101.83   98.45   1790.  101.37
       36.    19.    65.   30120.  1.04  0.00    0.01    0.46    5.33

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

                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -27.    -9.    32.   1790.   14608.     187.    9.58   98.60
   FULLV:FV       0.    -9.    32.   1790.   14732.     188.    9.52   99.03
   BRIDG:BR       0.     0.    21.   1159.    6782.     112.   10.35   99.03
   RDWAY:RG       9.*******   483.    649.*********       0.    2.00  101.31
   APPRO:AS      36.   -14.    65.   1790.   30120.     336.    5.33  101.37

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS     97.84    0.79   92.14  110.50************  1.43  100.02   98.60
   FULLV:FV  ********    0.78   92.54  110.90  0.40  0.00  1.41  100.44   99.03
   BRIDG:BR     97.50    0.79   90.83   99.09************  1.67  100.69   99.03
   RDWAY:RG  ****************   99.14  110.93  0.08******  0.46  101.75  101.31
   APPRO:AS     98.45    0.46   92.74  111.01  0.20  0.00  0.46  101.83  101.37
```

WSPRO OUTPUT FILE (continued)

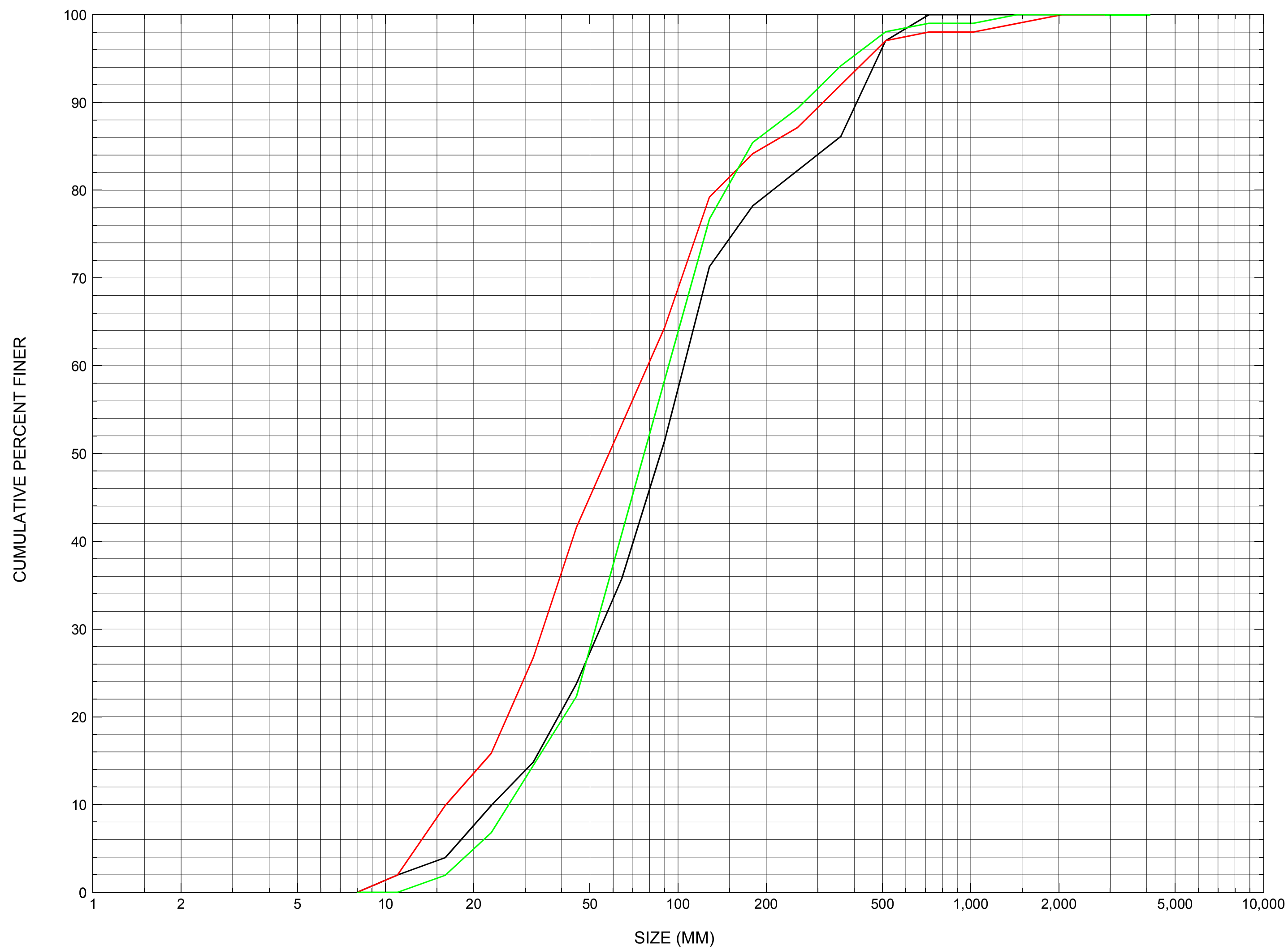
```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
        CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
        HYDRAULIC ANALYSIS OF BRID035      SAO
           *** RUN DATE & TIME: 09-26-95  09:14

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

EXITX:XS   ******   -40.     248.  1.73 *****  101.37   99.62   2530.   99.65
      -27. ******    33.   20648.  1.07 ***** *******    1.01   10.21

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.97     100.15     100.03

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =    99.15     110.90    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =    99.15     110.90     100.03

FULLV:FV      27.   -40.     246.  1.75  0.41  101.78  100.03   2530.  100.03
        0.    27.    33.   20459.  1.07  0.01   -0.02    1.02   10.29
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      36.   -14.     318.  1.03  0.40  102.18 *******   2530.  101.15
       36.    36.    64.   27997.  1.05  0.00    0.00    0.71    7.95
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   100.03      98.70

            <<<<<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      27.     0.     112.  1.66 *****  100.75   97.50   1158.   99.09
        0. ******    21.    6639.  1.00 ***** *******    0.79   10.34

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    6.  0.800  0.000   98.70 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    23.  0.09  0.61  102.78    0.01   1408.  102.17

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    901.    56.   -47.     9.   3.0   2.5   7.9   6.6   3.1   3.0
   RT:    507.    60.     9.    69.   1.9   1.4   6.3   6.0   2.0   3.0

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

APPRO:AS      18.   -15.     406.  0.61  0.25  102.87   99.61   2530.  102.26
       36.    20.    66.   39725.  1.02  0.00    0.01    0.49    6.23

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -27.   -40.    33.   2530.   20648.     248.   10.21   99.65
   FULLV:FV       0.   -40.    33.   2530.   20459.     246.   10.29  100.03
   BRIDG:BR       0.     0.    21.   1158.    6639.     112.   10.34   99.09
   RDWAY:RG       9.*******   901.   1408.******************    2.00  102.17
   APPRO:AS      36.   -15.    66.   2530.   39725.     406.    6.23  102.26

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

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS     99.62    1.01   92.14  110.50************  1.73  101.37   99.65
   FULLV:FV    100.03    1.02   92.54  110.90  0.41  0.01  1.75  101.78  100.03
   BRIDG:BR     97.50    0.79   90.83   99.09************  1.66  100.75   99.09
   RDWAY:RG  ****************   99.14  110.93  0.09******  0.61  102.78  102.17
   APPRO:AS     99.61    0.49   92.74  111.01  0.25  0.00  0.61  102.87  102.26
```

WSPRO OUTPUT FILE (continued)

```
       U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid035.wsp
       CREATED ON 26-SEP-95 FOR BRIDGE BRIDTH00050035 USING FILE brid035.dca
       HYDRAULIC ANALYSIS OF BRID035      SAO
          *** RUN DATE & TIME: 09-26-95  09:14

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

EXITX:XS   ******    -6.     111.  0.87 *****   97.48   96.01    830.   96.61
      -27. ******    30.    6775.  1.00 ***** *******    0.75    7.48

FULLV:FV      27.    -6.     112.  0.86  0.40   97.89 *******    830.   97.03
        0.    27.    30.    6840.  1.00  0.00    0.01    0.74    7.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      36.   -10.     131.  0.63  0.42   98.31 *******    830.   97.68
       36.    36.    28.    8561.  1.00  0.00   -0.01    0.60    6.35
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =      830.      96.43

            <<<<<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      27.     0.      72.  2.08 *****   98.50   96.43    830.   96.43
        0.    27.    20.    4973.  1.00 ***** *******    1.00   11.55

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******   98.70 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      18.   -11.     179.  0.33  0.21   99.20   96.46    830.   98.87
       36.    19.    34.   12849.  1.00  0.50    0.02    0.41    4.63

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.457  0.134   11068.    -1.    19.    98.77

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -27.    -6.    30.    830.    6775.     111.    7.48   96.61
   FULLV:FV       0.    -6.    30.    830.    6840.     112.    7.43   97.03
   BRIDG:BR       0.     0.    20.    830.    4973.      72.   11.55   96.43
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      36.   -11.    34.    830.   12849.     179.    4.63   98.87

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    19.   11068.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL     WSEL
   EXITX:XS     96.01    0.75   92.14  110.50************  0.87    97.48    96.61
   FULLV:FV  ********    0.74   92.54  110.90  0.40  0.00  0.86    97.89    97.03
   BRIDG:BR     96.43    1.00   90.83   99.09************  2.08    98.50    96.43
   RDWAY:RG  ****************   99.14  110.93*********************************
   APPRO:AS     96.46    0.41   92.74  111.01  0.21  0.50  0.33    99.20    98.87
```

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 BRIDTH00050035, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM