LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (BRIDTH00360029) on TOWN HIGHWAY 36, crossing the NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

U.S. Geological Survey
Open-File Report 96-245

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (BRIDTH00360029) on TOWN HIGHWAY 36, crossing the NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

By SCOTT A. OLSON and MICHAEL A. IVANOFF

U.S. Geological Survey
Open-File Report 96-245

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 29 (BRIDTH00360029) ON TOWN HIGHWAY 36, CROSSING THE NORTH BRANCH OTTAUQUECHEE RIVER, BRIDGEWATER, VERMONT

By Scott A. Olson and Michael A. Ivanoff

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRIDTH00360029 on town highway 36 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 in the town of Bridgewater. The 27.1-mi^2 drainage area is a predominantly rural basin. In the vicinity of the study site, the left and right banks are covered by pasture and (or) fields with the immediate stream banks covered by woody vegetation. The left bank of North Branch Ottauquechee River is adjacent to Bridgewater town highway 001.

In the study area, the North Branch Ottauquechee River has a sinuous channel with a slope of approximately 0.008 ft/ft, an average channel top width of 73 ft and an average bank height of 6 ft. The predominant channel bed materials are gravel and cobble with a median grain size (D_{50}) of 61.0 mm (0.200 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 26, 1994, indicated that the reach was stable.

The town highway 36 crossing of the North Branch Ottauquechee River is a 46-ft-long, one-lane bridge consisting of one 43-foot steel-beam span (Vermont Agency of Transportation, written communication, August 25, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. Type-2 (less than 36 inches) stone fill protects the upstream and downstream wingwalls. Sparse type-2 stone fill was also observed along the right abutment. The channel approach to the bridge is not skewed, however, the measured opening skew-to-roadway is five 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 1.4 to 2.8 ft. The worst-case contraction scour occurred at the incipient overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 7.3 to 13.2 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, 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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

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 BRIDTH00360029 ***Stream*** North Br. Ottauquechee River

County Windsor ***Road*** TH036 ***District*** 04

Description of Bridge

Bridge length 46 ***ft*** ***Bridge width*** 14.0 ***ft*** ***Max span length*** 43 ***ft***

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

Abutment type vertical ***Embankment type*** sloping

Stone fill on abutment? yes ***Date of inspection*** 10/26/94

Description of stone fill Sparse type-2 on right abutment, none on left. Upstream and downstream wingwalls are also protected by type-2 stone fill.

Abutments are vertical and concrete. Two vertical feet of footing are exposed on both abutments.

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

There is a mild channel bend upstream of the bridge.

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	10/26/94	0	0
Level II	10/26/94	0	0

Potential for debris Moderate, due to much of the headwaters being heavily forested.

Describe any features near or at the bridge that may affect flow (include observation date) There is a small stone wall across the channel constructed of streambed materials 35 feet downstream of the bridge. It is causing about a foot of backwater through the bridge at ambient conditions on October 26, 1994.

Description of the Geomorphic Setting

General topography The bridge crosses a high gradient upland stream with flood plains in a moderate relief valley.

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

Date of inspection 10/26/94

DS left: narrow flood plain to steep valley wall

DS right: narrow flood plain to steep valley wall

US left: narrow flood plain to steep valley wall

US right: relatively wide flood plain

Description of the Channel

Average top width 73 ***ft*** ***Average depth*** 6 ***ft***

Predominant bed material gravel and cobbles ***Bank material*** cobbles

slightly sinuous, probably incised with flood plains.

10/26/94

Vegetative co field grasses with some woody vegetation on immediate banks

DS left: field grasses with some woody vegetation on immediate banks

DS right: field grasses with some woody vegetation on immediate banks

US left: field grasses with some woody vegetation on immediate banks

US right:

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

Describe any obstructions in channel and date of observation. There is a small stone wall across the channel constructed of streambed materials 35 feet downstream of the bridge. It is causing about a foot of backwater through the bridge at ambient conditions on October 26, 1994.

Hydrology

Drainage area 27.1 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province	*Percent of drainage area*
Green Mountain Prov.	100

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

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

USGS gage description

USGS gage number

Gage drainage area ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 4,860 ***ft³/s*** ***Q500*** 6,590 ***ft³/s***

Discharges are based on an area relationship [(27.1/26.6) to the 0.7 power] with discharges determined for Bridgewater bridge 049. Bridge 049 has a drainage area of 26.6 square miles and is on the same river. The discharges at bridge 049 were graphically extrapolated from an estimated probability curve from a previous analysis (VTAOT, written communication, May 1995). The discharges determined for bridge 029 by this method compared well with discharges computed from various empirical equations (Potter, 1957a&b; Johnson and Tasker, 1974; FHWA, 1983; Talbot, 1887; FEMA, 1980).

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 Not Applicable.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on the top of the downstream end of the left abutment (elev. 999.63 ft, arbitrary datum). RM2 is a chiseled X on the top of the upstream end of the right abutment (elev. 999.50 ft, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-46	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	7	1	Road Grade section
APPRO	55	2	Modelled Approach section (Templated from SURVA)
SURVA	68	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 0.037 to 0.045, and overbank "n" values ranged from 0.030 to 0.048.

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 0.0083 ft/ft which was measured from water surface profiles in the flood insurance study for the Town of Bridgewater (Federal Emergency Management Agency, 1980).

The surveyed approach section (SURVA) was moved along the approach channel slope (0.028 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.

In the incipient overtopping model (3,760 cfs), WSPRO assumes critical depth at the bridge section. Further analysis, in which the water surface is shown to pass through critical depth in the bridge, suggests the critical depth assumption at the bridge section is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 999.5 *ft*
Average low steel elevation 997.1 *ft*

100-year discharge 4,860 *ft³/s*
Water-surface elevation in bridge opening 997.2 *ft*
Road overtopping? Y *Discharge over road* 856 *ft³/s*
Area of flow in bridge opening 376 *ft²*
Average velocity in bridge opening 10.6 *ft/s*
Maximum WSPRO tube velocity at bridge 12.3 *ft/s*

Water-surface elevation at Approach section with bridge 1000.1
Water-surface elevation at Approach section without bridge 996.1
Amount of backwater caused by bridge 4.0 *ft*

500-year discharge 6,590 *ft³/s*
Water-surface elevation in bridge opening 997.2 *ft*
Road overtopping? Y *Discharge over road* 2,215 *ft³/s*
Area of flow in bridge opening 376 *ft²*
Average velocity in bridge opening 11.7 *ft/s*
Maximum WSPRO tube velocity at bridge 13.5 *ft/s*

Water-surface elevation at Approach section with bridge 1001.1
Water-surface elevation at Approach section without bridge 996.8
Amount of backwater caused by bridge 4.3

Incipient overtopping discharge 3,760 *ft³/s*
Water-surface elevation in bridge opening 994.3 *ft*
Area of flow in bridge opening 261 *ft²*
Average velocity in bridge opening 14.4 *ft/s*
Maximum WSPRO tube velocity at bridge 17.3 *ft/s*

Water-surface elevation at Approach section with bridge 997.3
Water-surface elevation at Approach section without bridge 995.6
Amount of backwater caused by bridge 1.7 *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.

The 100-year and 500-year discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Therefore, contraction scour for these two discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Contraction scour was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1993, p. 35, equation 18) for the incipient road-overflow discharge. 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. The results of Laursen's clear-water contraction scour for the 100-year and 500-year events were also computed and can be found in appendix F.

Abutment scour was computed using the HIRE equation (Richardson and others, 1993, p 50) in all cases except the right abutment scour at incipient overtopping. This is because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The Froehlich equation (Richardson and others, 1993, p. 49, eq. 24) was used to compute abutment scour for the right abutment at incipient overtopping. Variables for each 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	1.4	2.2	2.8
Depth to armoring	5.1	9.3	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	12.6	13.2	8.1
Right abutment	7.3	10.0	10.9
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	2.2	2.7	2.6
Right abutment	2.2	2.7	2.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

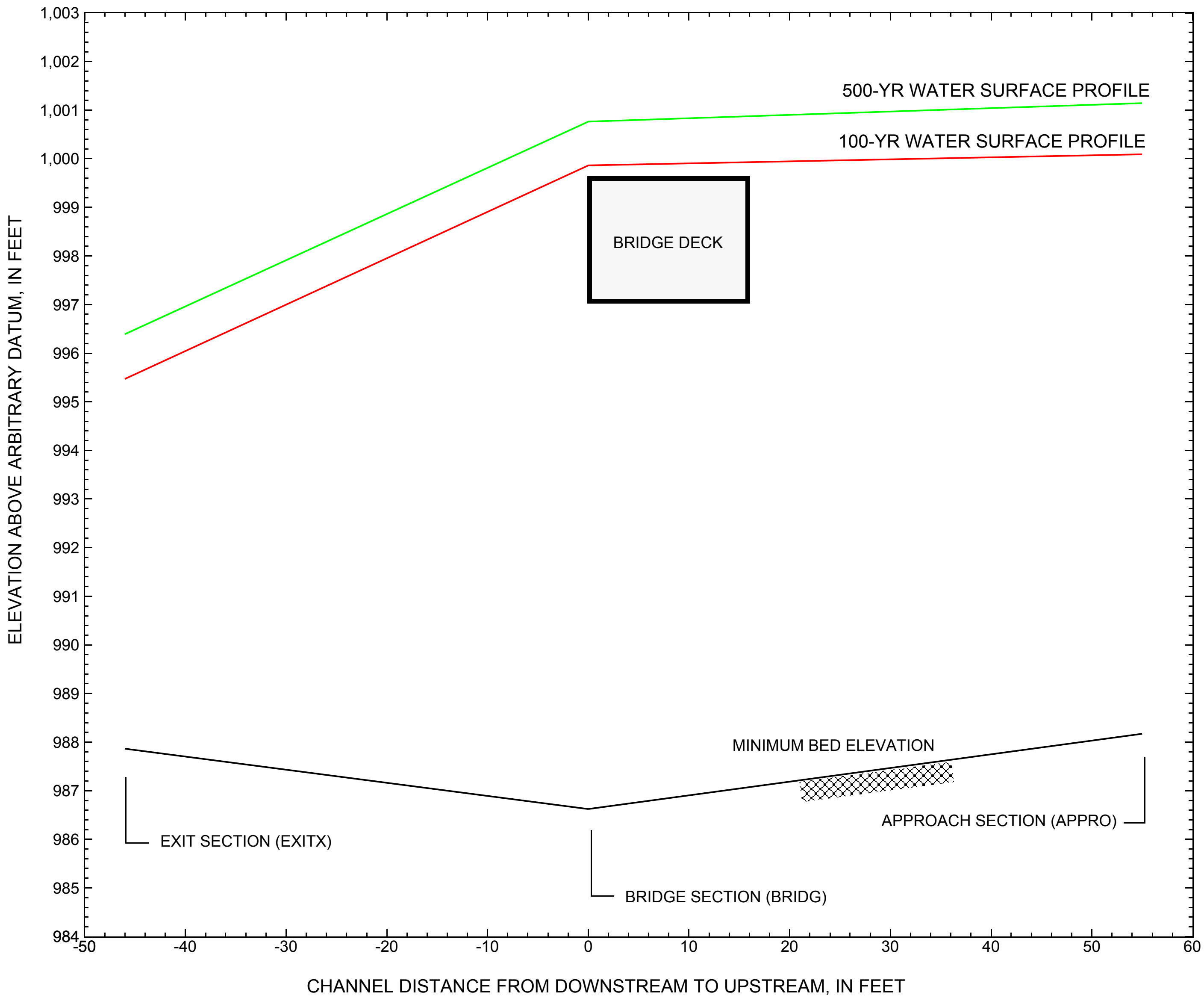


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIDTH00360029 on town highway 36, crossing the North Branch Ottauquechee River, Bridgewater, Vermont.

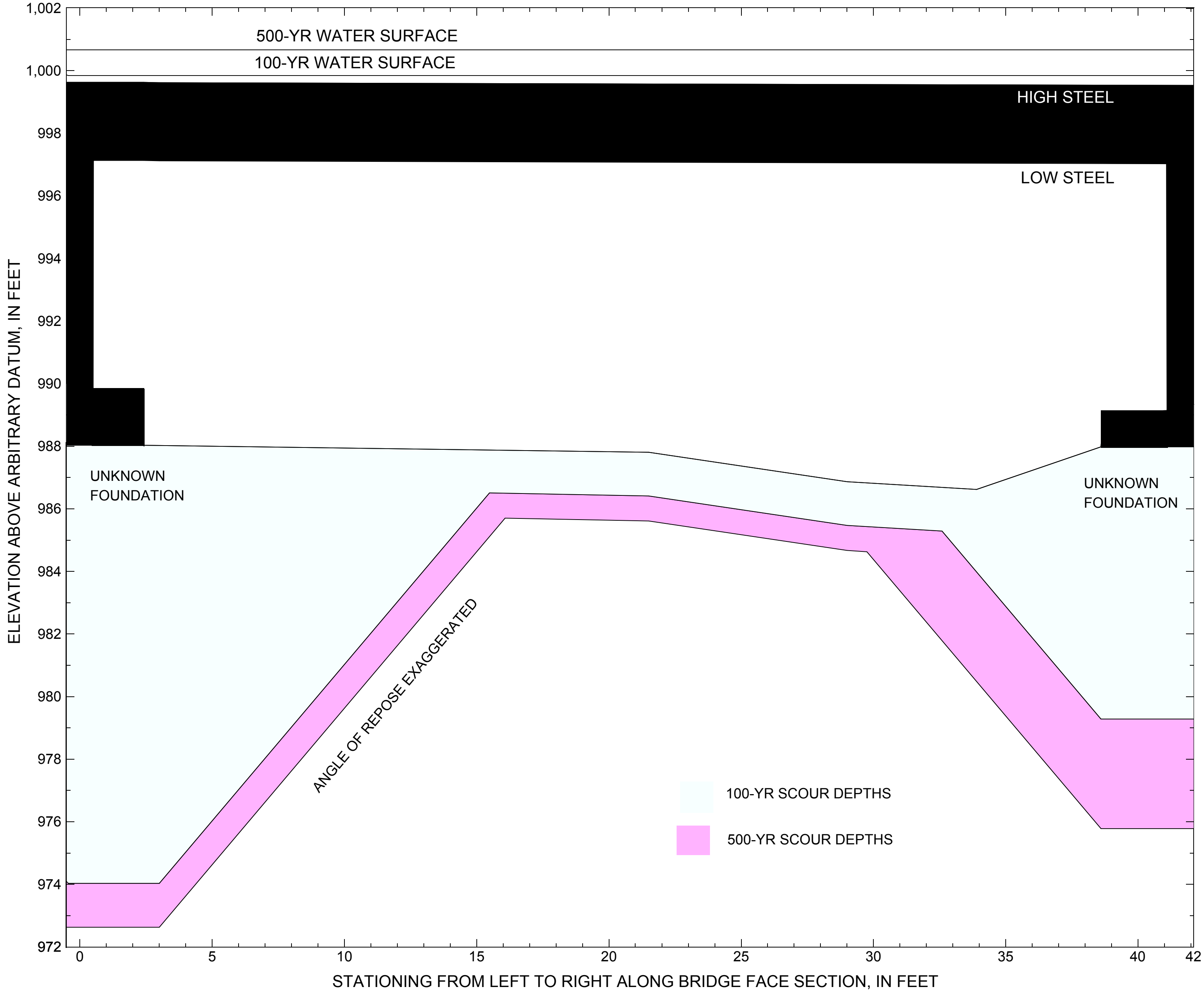


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00360029 on town highway 36, crossing the North Branch Ottauquechee River, Bridgewater, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRIDTH00360029 on Town Highway 36, 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 4,860 cubic-feet per second											
Left abutment	0.0	--	997.18	--	988.0	1.4	12.6	--	14.0	974.0	--
Right abutment	41.6	--	996.94	--	988.0	1.4	7.3	--	8.7	979.3	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BRIDTH00360029 on Town Highway 36, 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 6,590 cubic-feet per second											
Left abutment	0.0	--	997.18	--	988.0	2.2	13.2	--	15.4	972.6	-
Right abutment	41.6	--	996.94	--	988.0	2.2	10.0	--	12.2	975.8	--

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

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.

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., 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.

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, Plymouth, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid029.wsp
T2        CREATED ON 30-AUG-95 FOR BRIDGE BRIDTH00360029 USING FILE brid029.dca
T3        HYDRAULIC ANALYSIS OF BRID029    SAO
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          4860 6590 3760
SK         0.0083 0.0083 0.0083
*
XS   EXITX    -46
GR         -126.1,1001.99   -116.1, 996.71   -109.4, 997.24    -80.4, 997.44
GR          -70.5, 993.65    -14.8, 993.98     -8.5, 991.38     -3.6, 989.71
GR            0.0, 988.90     10.8, 988.37     27.9, 987.86     38.7, 988.16
GR           48.5, 989.19     59.3, 996.04    156.7, 998.45    176.7, 998.50
GR          200.0,1004.00
N         0.032        0.045        0.048
SA                 -15.         59.3
*
XS   FULLV   0 * * * 0.0069
*
BR   BRIDG   0 997.1 5.0
GR            0.0, 997.18      1.0, 989.84      2.3, 989.81      2.4, 989.36
GR            2.4, 988.03     12.7, 987.95     21.5, 987.81     29.0, 986.87
GR           33.9, 986.62     38.6, 987.98     38.7, 989.08     40.6, 989.15
GR           40.6, 989.40     41.6, 996.94      0.0, 997.18
N            0.037
CD            1 22.9 * * 47.5 6.2
*
XR   RDWAY   7 14.0 2
GR         -125.9,1006.68   -108.5, 997.30    -76.6, 998.46      0.0, 999.68
GR           42.2, 999.48    159.0,1001.47    215.8,1005.16    258.2,1009.68
BP           0
*
*             BRAIL
*             0.0, 999.71      0.2,1002.86     42.2, 999.51     42.3,1002.72
*
XT   SURVA     68
GR         -107.6,1001.34   -102.0, 997.13    -57.7, 998.37    -22.8, 995.68
GR          -15.1, 993.63     -7.6, 990.66      0.0, 989.74     18.9, 988.97
GR           29.7, 988.54     35.6, 988.89     40.9, 989.62     55.6, 998.20
GR          173.9,1000.23    219.8,1004.63    241.8,1009.92
*
AS   APPRO     55
GT            -0.37
N            0.032        0.045        0.030
SA                 -23.         55.6
BP            0
*
HP 1 BRIDG    997.18 1 997.18
HP 2 BRIDG    997.18 * * 3995
HP 2 RDWAY    999.86 * * 856
HP 1 APPRO    1000.09 1 1000.09
HP 2 APPRO    1000.09 * * 4860
HP 1 BRIDG    997.18 1 997.18
HP 2 BRIDG    997.18 * * 4386
HP 2 RDWAY    1000.76 * * 2215
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
           U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid029.wsp
       CREATED ON 30-AUG-95 FOR BRIDGE BRIDTH00360029 USING FILE brid029.dca
       HYDRAULIC ANALYSIS OF BRID029    SAO
          *** RUN DATE & TIME: 08-30-95  10:46
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     376.  36770.     0.    99.                           0.
  997.18          376.  36770.     0.    99.  1.00     0.    42.      0.

   VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
        WSEL     LEW     REW    AREA        K        Q    VEL
      997.18     0.0    41.6   375.6   36770.    3995.  10.64

X STA.        0.0        4.2        6.5        8.6       10.5       12.5
  A(I)            30.7       20.5       19.0       17.8       17.6
  V(I)            6.50       9.73      10.53      11.22      11.38

X STA.       12.5       14.3       16.2       18.1       19.9       21.7
  A(I)            17.2       17.4       16.9       16.7       16.8
  V(I)           11.61      11.46      11.82      11.94      11.91

X STA.       21.7       23.5       25.3       26.9       28.6       30.2
  A(I)            16.7       16.6       16.2       16.5       16.4
  V(I)           11.94      12.05      12.32      12.10      12.18

X STA.       30.2       31.8       33.5       35.3       37.3       41.6
  A(I)            16.5       16.9       18.3       19.9       31.0
  V(I)           12.14      11.79      10.93      10.02       6.44

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       7.
        WSEL     LEW     REW    AREA        K        Q    VEL
      999.86  -113.2    64.5   145.8    7111.     856.   5.87

X STA.     -113.2     -108.2     -106.3     -104.4     -102.6     -100.5
  A(I)             6.8        4.7        4.6        4.5        4.8
  V(I)            6.29       9.05       9.26       9.51       8.91

X STA.     -100.5      -98.3      -96.0      -93.5      -90.7      -87.7
  A(I)             4.8        5.0        5.2        5.4        5.6
  V(I)            8.98       8.60       8.24       7.94       7.64

X STA.      -87.7      -84.3      -80.3      -75.7      -70.2      -64.2
  A(I)             6.1        6.3        6.7        7.3        7.6
  V(I)            7.06       6.75       6.40       5.83       5.63

X STA.      -64.2      -57.2      -48.9      -38.0      -21.1       64.5
  A(I)             7.9        8.6        9.5       11.0       23.4
  V(I)            5.40       5.00       4.51       3.89       1.83

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
    WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     246.  23380.    83.    85.                        2402.
            2     747. 108039.    79.    82.                       13074.
            3     148.   8379.   121.   121.                         926.
 1000.09         1141. 139798.   283.   287.  1.19  -106.   176.  11928.

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
        WSEL     LEW     REW    AREA        K        Q    VEL
     1000.09  -106.4   176.3  1141.2  139798.    4860.   4.26

X STA.     -106.4      -78.5      -44.9      -27.3      -15.1       -8.2
  A(I)            78.0       82.4       66.1       65.6       56.3
  V(I)            3.12       2.95       3.68       3.70       4.31

X STA.       -8.2       -3.4        0.9        5.0        9.0       12.8
  A(I)            47.7       45.7       44.6       43.9       43.1
  V(I)            5.09       5.32       5.45       5.54       5.63

X STA.       12.8       16.7       20.4       24.0       27.7       31.3
  A(I)            43.1       42.4       42.6       42.9       42.7
  V(I)            5.63       5.73       5.70       5.66       5.69

X STA.       31.3       35.0       39.1       44.4       63.9      176.3
  A(I)            43.6       46.6       54.1       80.4      129.3
  V(I)            5.58       5.21       4.49       3.02       1.88
```

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid029.wsp
        CREATED ON 30-AUG-95 FOR BRIDGE BRIDTH00360029 USING FILE brid029.dca
        HYDRAULIC ANALYSIS OF BRID029    SAO
           *** RUN DATE & TIME: 08-30-95  10:46
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1     376.   36770.     0.    99.                           0.
   997.18          376.   36770.     0.    99.  1.00     0.    42.       0.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       997.18     0.0    41.6   375.6   36770.    4386.  11.68

X STA.         0.0         4.2         6.5         8.6        10.5        12.5
  A(I)            30.7        20.5        19.0        17.8        17.6
  V(I)            7.14       10.68       11.56       12.32       12.49

X STA.        12.5        14.3        16.2        18.1        19.9        21.7
  A(I)            17.2        17.4        16.9        16.7        16.8
  V(I)           12.75       12.58       12.98       13.11       13.08

X STA.        21.7        23.5        25.3        26.9        28.6        30.2
  A(I)            16.7        16.6        16.2        16.5        16.4
  V(I)           13.11       13.23       13.53       13.29       13.38

X STA.        30.2        31.8        33.5        35.3        37.3        41.6
  A(I)            16.5        16.9        18.3        19.9        31.0
  V(I)           13.32       12.95       12.00       11.00        7.07

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       7.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1000.76  -114.9   117.3   330.3   20282.    2215.   6.71

X STA.      -114.9      -107.4      -104.2      -101.0       -97.6       -94.0
  A(I)            15.0        10.6        10.4        10.6        10.7
  V(I)            7.37       10.47       10.61       10.42       10.35

X STA.       -94.0       -90.1       -85.9       -81.1       -75.9       -69.9
  A(I)            11.3        11.3        12.1        12.5        13.4
  V(I)            9.78        9.77        9.14        8.86        8.27

X STA.       -69.9       -63.6       -56.7       -49.0       -40.5       -30.7
  A(I)            13.5        14.1        14.7        15.2        16.1
  V(I)            8.20        7.85        7.51        7.27        6.86

X STA.       -30.7       -18.7         1.3        26.1        47.1       117.3
  A(I)            17.7        24.4        28.3        26.1        42.0
  V(I)            6.26        4.53        3.91        4.24        2.64

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW     REW     QCR
             1     335.   38465.    85.    86.                        3777.
             2     830.  128650.    79.    82.                       15299.
             3     280.   22997.   132.   132.                        2318.
  1001.14         1445.  190112.   295.   300.  1.14  -108.   187.  16989.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
         WSEL     LEW     REW    AREA        K        Q    VEL
      1001.14  -107.6   187.3  1444.5  190112.    6590.   4.56

X STA.      -107.6       -83.0       -58.2       -37.0       -23.6       -12.4
  A(I)            90.7        87.0        83.2        70.1        80.4
  V(I)            3.63        3.79        3.96        4.70        4.10

X STA.       -12.4        -5.9        -0.7         4.1         8.7        13.3
  A(I)            66.3        58.7        56.9        55.2        56.1
  V(I)            4.97        5.62        5.79        5.97        5.88

X STA.        13.3        17.6        22.0        26.3        30.4        34.8
  A(I)            54.1        54.9        54.3        53.6        55.9
  V(I)            6.09        6.00        6.06        6.15        5.89

X STA.        34.8        39.5        45.8        68.1       105.7       187.3
  A(I)            58.4        68.7       100.2       104.1       135.8
  V(I)            5.64        4.80        3.29        3.16        2.43
```

```
         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid029.wsp
        CREATED ON 30-AUG-95 FOR BRIDGE BRIDTH00360029 USING FILE brid029.dca
        HYDRAULIC ANALYSIS OF BRID029    SAO
           *** RUN DATE & TIME: 08-30-95  10:46
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     261.   30878.    41.    52.                        3761.
   994.28          261.   30878.    41.    52.  1.00     0.    41.   3761.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       994.28     0.4    41.2   261.5   30878.    3760.  14.38

X STA.        0.4         4.8         7.2         9.3        11.3        13.2
  A(I)             22.8        14.5        13.3        12.8        11.9
  V(I)             8.24       12.97       14.08       14.71       15.81

X STA.       13.2        15.1        16.9        18.7        20.5        22.3
  A(I)             12.1        11.6        11.5        11.6        11.3
  V(I)            15.49       16.24       16.38       16.24       16.63

X STA.       22.3        24.0        25.6        27.2        28.7        30.2
  A(I)             11.4        11.1        11.1        10.9        10.9
  V(I)            16.45       16.98       16.96       17.27       17.19

X STA.       30.2        31.7        33.3        34.9        37.0        41.2
  A(I)             11.6        11.7        12.2        14.5        22.6
  V(I)            16.25       16.12       15.36       12.94        8.30

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      33.    1172.    48.    48.                         153.
             2     531.   61684.    78.    81.                        7881.
   997.34          564.   62856.   125.   129.  1.07  -103.    55.   6571.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
         WSEL     LEW     REW    AREA        K        Q    VEL
       997.34  -102.8    54.8   563.9   62856.    3760.   6.67

X STA.     -102.8       -13.9        -8.0        -4.0        -0.6         2.6
  A(I)             61.6        33.8        28.9        26.5        25.2
  V(I)             3.05        5.56        6.50        7.11        7.46

X STA.        2.6         5.6         8.6        11.5        14.2        17.0
  A(I)             24.7        24.5        24.1        23.3        23.6
  V(I)             7.62        7.67        7.80        8.06        7.95

X STA.       17.0        19.6        22.2        24.8        27.4        30.0
  A(I)             23.0        23.3        23.0        23.7        23.2
  V(I)             8.16        8.07        8.16        7.94        8.09

X STA.       30.0        32.6        35.4        38.5        42.2        54.8
  A(I)             23.9        25.1        26.1        30.2        46.0
  V(I)             7.87        7.49        7.20        6.22        4.09

        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid029.wsp
        CREATED ON 30-AUG-95 FOR BRIDGE BRIDTH00360029 USING FILE brid029.dca
        HYDRAULIC ANALYSIS OF BRID029    SAO
           *** RUN DATE & TIME: 08-30-95  10:46

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

EXITX:XS   ******   -75.     538.  1.37 *****  996.84  995.03   4860.  995.47
      -46. ******    58.   53343.  1.08 ***** *******    0.82    9.03

FULLV:FV      46.   -76.     563.  1.24  0.36  997.21 *******   4860.  995.97
        0.    46.    59.   56782.  1.07  0.00    0.02    0.77    8.64
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     996.13     995.34

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   995.47    1009.55    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   995.47    1009.55     995.34

APPRO:AS      55.   -34.     444.  1.89  0.50  998.03  995.34   4860.  996.14
       55.    55.    53.   45932.  1.01  0.32    0.00    0.86   10.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
```

```
 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   999.30       0.00     995.50     997.30

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   995.26     998.64     998.84     997.10

 ===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      46.     0.     376.  1.76 *****  998.94  994.55   3995.  997.18
        0. ******    42.   36770.  1.00 ***** *******    0.62   10.64

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.478  0.000  997.10 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       7.    41.  0.05  0.34 1000.38    0.00    856.  999.86

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    775.   135.  -113.    22.   2.6   1.0   5.7   5.7   1.5   3.1
   RT:     81.    43.    22.    65.   0.4   0.3   3.7   7.2   0.8   2.8

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

APPRO:AS      32.  -106.    1141.  0.34  0.13 1000.43  995.34   4860. 1000.09
       55.    34.   176.  139838.  1.19  0.34    0.00    0.41    4.26

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -46.   -75.    58.   4860.   53343.     538.    9.03  995.47
   FULLV:FV       0.   -76.    59.   4860.   56782.     563.    8.64  995.97
   BRIDG:BR       0.     0.    42.   3995.   36770.     376.   10.64  997.18
   RDWAY:RG       7.*******   775.    856.*********       0.    2.00  999.86
   APPRO:AS      55.  -106.   176.   4860.  139838.    1141.    4.26 1000.09

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    995.03    0.82  987.86 1004.00************  1.37  996.84  995.47
   FULLV:FV  ********    0.77  988.18 1004.32  0.36  0.00  1.24  997.21  995.97
   BRIDG:BR    994.55    0.62  986.62  997.18************  1.76  998.94  997.18
   RDWAY:RG  ****************  997.30 1009.68  0.05******  0.34 1000.38  999.86
   APPRO:AS    995.34    0.41  988.17 1009.55  0.13  0.34  0.34 1000.43 1000.09

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

EXITX:XS   ******   -78.     665.  1.60 *****  997.99  995.88   6590.  996.39
      -46. ******    73.   72293.  1.05 ***** *******    0.85    9.90

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     996.89     996.20

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   995.89    1004.32    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   995.89    1004.32     996.20

FULLV:FV      46.   -78.     686.  1.51  0.37  998.35  996.20   6590.  996.84
        0.    46.    79.   75434.  1.05  0.00   -0.01    0.83    9.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.03     996.78     996.74

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   996.34    1009.55    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   996.34    1009.55     996.74

APPRO:AS      55.  -102.     504.  2.74  0.58  999.54  996.74   6590.  996.81
       55.    55.    54.   54883.  1.03  0.61    0.00    1.03   13.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
```

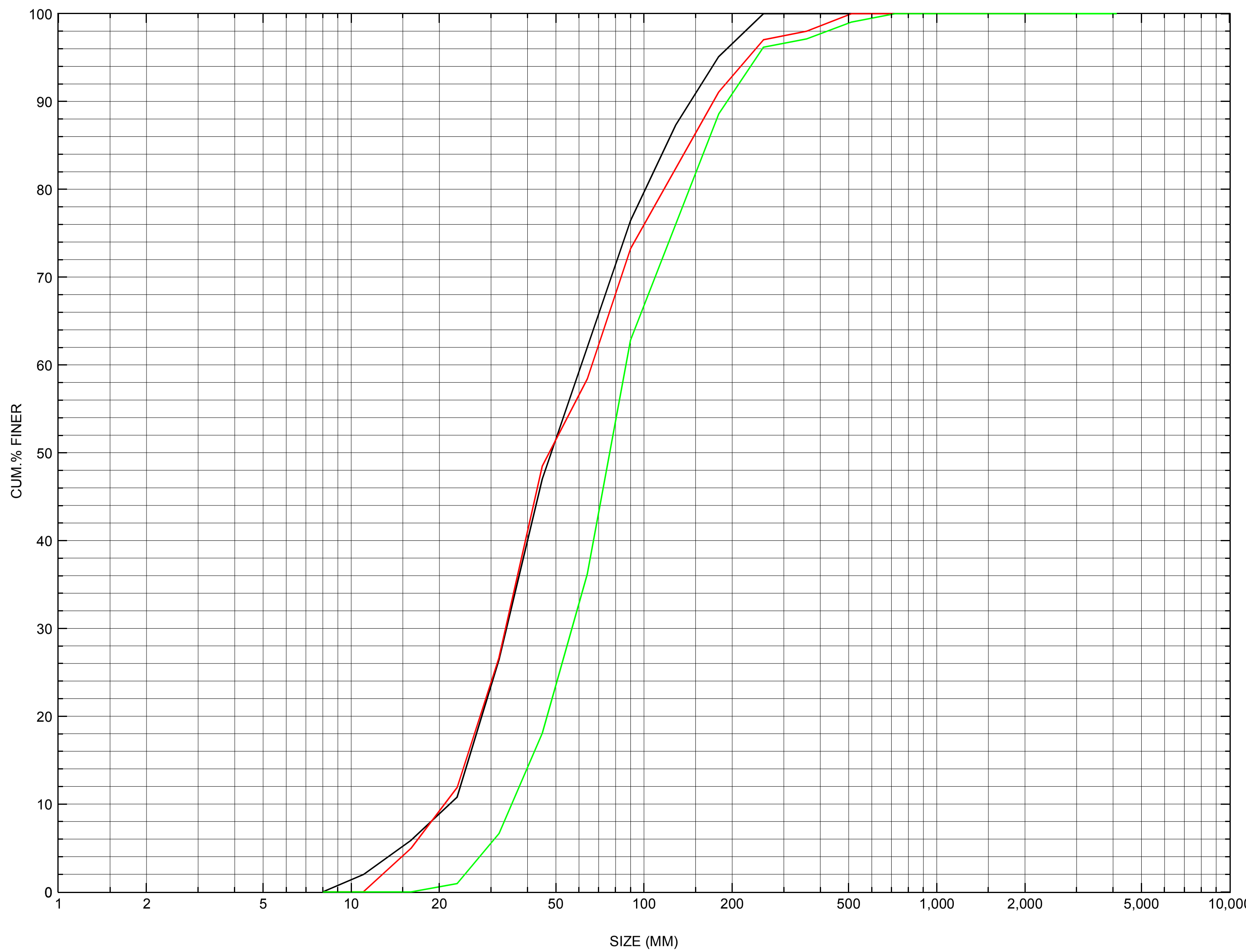
WSPRO OUTPUT FILE (continued)

```
===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =  1002.12       0.00     996.95     997.30

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   996.12     999.93    1000.13     997.10

 ===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      46.     0.     376.  2.12 *****  999.30  994.98   4386.  997.18
        0. ******    42.   36770.  1.00 ***** *******    0.69   11.68

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.492  0.000  997.10 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       7.    41.  0.05  0.37 1001.46    0.00   2215. 1000.76

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1717.   137.  -115.    22.   3.5   1.9   7.3   6.7   2.6   3.0
   RT:    498.    96.    22.   118.   1.3   0.8   5.3   6.8   1.5   2.9

===140 AT SECID “APPRO”:  END OF CROSS SECTION EXTENDED VERTICALLY.
                          WSEL,YLT,YRT =  1001.14     1001.0     1009.5

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

APPRO:AS      32.  -108.    1443.  0.37  0.15 1001.51  996.74   6590. 1001.14
       55.    34.   187.  189924.  1.14  0.34    0.00    0.39    4.57

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -46.   -78.    73.   6590.   72293.     665.    9.90  996.39
   FULLV:FV       0.   -78.    79.   6590.   75434.     686.    9.60  996.84
   BRIDG:BR       0.     0.    42.   4386.   36770.     376.   11.68  997.18
   RDWAY:RG       7.******* 1717.    2215.*********       0.    2.00 1000.76
   APPRO:AS      55.  -108.   187.   6590.  189924.    1443.    4.57 1001.14

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    995.88    0.85  987.86 1004.00************  1.60  997.99  996.39
   FULLV:FV    996.20    0.83  988.18 1004.32  0.37  0.00  1.51  998.35  996.84
   BRIDG:BR    994.98    0.69  986.62  997.18************  2.12  999.30  997.18
   RDWAY:RG  ****************  997.30 1009.68  0.05******  0.37 1001.46 1000.76
   APPRO:AS    996.74    0.39  988.17 1009.55  0.15  0.34  0.37 1001.51 1001.14

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

EXITX:XS   ******   -73.     444.  1.22 *****  995.98  994.23   3760.  994.76
      -46. ******    57.   41233.  1.10 ***** *******    0.85    8.46

FULLV:FV      46.   -74.     468.  1.10  0.36  996.36 *******   3760.  995.26
        0.    46.    58.   44147.  1.09  0.00    0.02    0.78    8.03
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      55.   -26.     395.  1.41  0.45  996.96 *******   3760.  995.55
       55.    55.    52.   38726.  1.00  0.16   -0.01    0.74    9.52
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   997.34       0.00     994.28     997.30

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID “BRIDG”     Q,CRWS =    3760.     994.28

            <<<<<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      46.     0.     261.  3.22 *****  997.50  994.28   3760.  994.28
        0.    46.    41.   30879.  1.00 ***** *******    1.00   14.38

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  997.10 ****** ****** ******
```

```
   XSID:CODE     SRD    FLEN     HF    VHD      EGL      ERR       Q    WSEL
  RDWAY:RG       7.        <<<<<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       32.  -103.     564.  0.74  0.24  998.08  994.41   3760.  997.34
       55.     33.    55.  62852.  1.07  0.34    0.01    0.57    6.67

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.470  0.226   48566.    -3.    38. ********

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

 FIRST USER DEFINED TABLE.

   XSID:CODE     SRD     LEW     REW       Q        K     AREA     VEL    WSEL
  EXITX:XS      -46.    -73.     57.   3760.   41233.     444.    8.46  994.76
  FULLV:FV        0.    -74.     58.   3760.   44147.     468.    8.03  995.26
  BRIDG:BR        0.      0.     41.   3760.   30879.     261.   14.38  994.28
  RDWAY:RG        7.**************       0.       0.       0.    2.00********
  APPRO:AS       55.   -103.     55.   3760.   62852.     564.    6.67  997.34

   XSID:CODE    XLKQ    XRKQ       KQ
  APPRO:AS       -3.     38.   48566.

 SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL     WSEL
  EXITX:XS     994.23    0.85  987.86 1004.00************  1.22  995.98  994.76
  FULLV:FV   ********    0.78  988.18 1004.32  0.36  0.00  1.10  996.36  995.26
  BRIDG:BR     994.28    1.00  986.62  997.18************  3.22  997.50  994.28
  RDWAY:RG   ****************  997.30 1009.68  0.15******  0.74  997.94********
  APPRO:AS     994.41    0.57  988.17 1009.55  0.24  0.34  0.74  998.08  997.34
```

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 BRIDTH00360029, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM