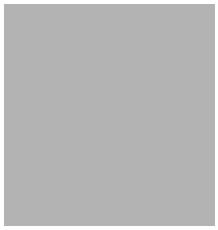
LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (BRIDTH00490027) on TOWN HIGHWAY 49, crossing BROAD BROOK, BRIDGEWATER, VERMONT

U.S. Geological Survey
Open-File Report 96-195

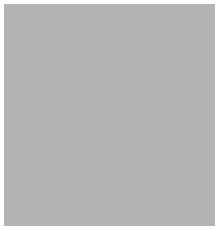


Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (BRIDTH00490027) on TOWN HIGHWAY 49, crossing BROAD BROOK, BRIDGEWATER, VERMONT

By SCOTT A. OLSON

U.S. Geological Survey
Open-File Report 96-195



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 03275-3718

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 27 (BRIDTH00490027) ON TOWN HIGHWAY 49, CROSSING BROAD BROOK, BRIDGEWATER, VERMONT

By **Scott A. Olson**

INTRODUCTION

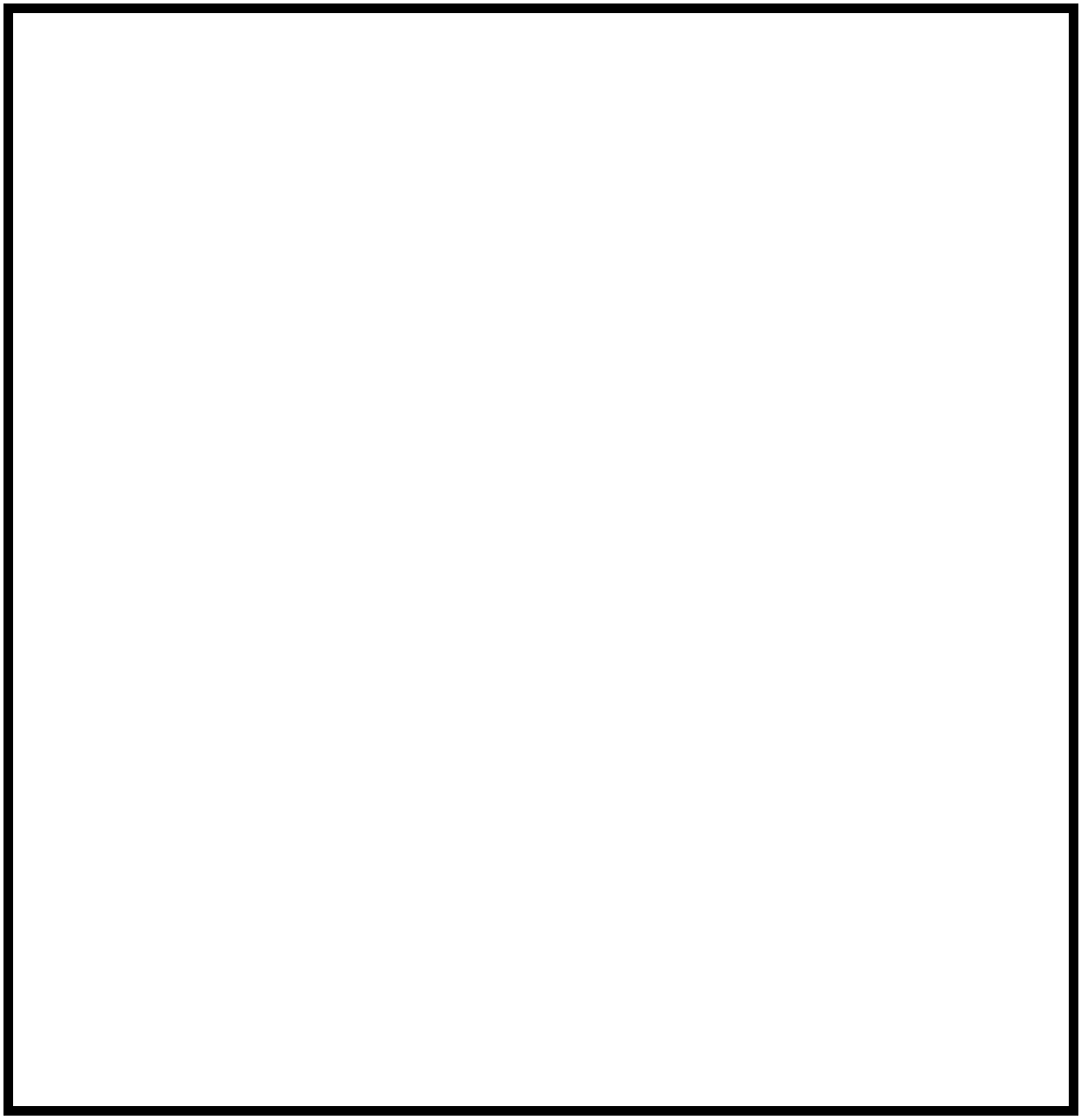
This report provides the results of a detailed Level II analysis of scour potential at structure BRIDTH00490027 on town highway 49 crossing Broad Brook, Bridgewater, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability 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 province of central Vermont in the town of Bridgewater. The 13.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the left and right banks are pasture with moderate tree cover on the immediate banks. Upstream of bridge 27, a gravel road runs parallel to the left bank.

In the study area, the Broad Brook has an incised channel with a slope of approximately 0.007 ft/ft, an average channel top width of 54 ft and an average channel depth of 4 ft. The predominant channel bed materials are gravel and cobble with a D_{50} (median diameter) of 77.9 mm or 0.256 ft. The geomorphic assessment at the time of the Level I and Level II site visit on November 9, 1994, indicated that the reach was stable.

The town highway 49 crossing of the Broad Brook is a 32-ft-long, one-lane bridge consisting of one 31-ft steel-beam span (Vermont Agency of Transportation, written commun., August 24, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The left abutment is noted as settled due to previous undermining. Type-2 (less than 3 ft diameter) stone fill protects the upstream left and right wingwalls, the downstream right wingwall, the right abutment, the upstream right road embankment, and the downstream left and right road embankments. Type-3 (less than 4 ft diameter) stone fill protects the downstream left wingwall, but it's condition was reported as slumping. The channel is skewed approximately 10 degrees to the opening; the opening-skew-to-roadway is also 10 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). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The scour analysis results are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

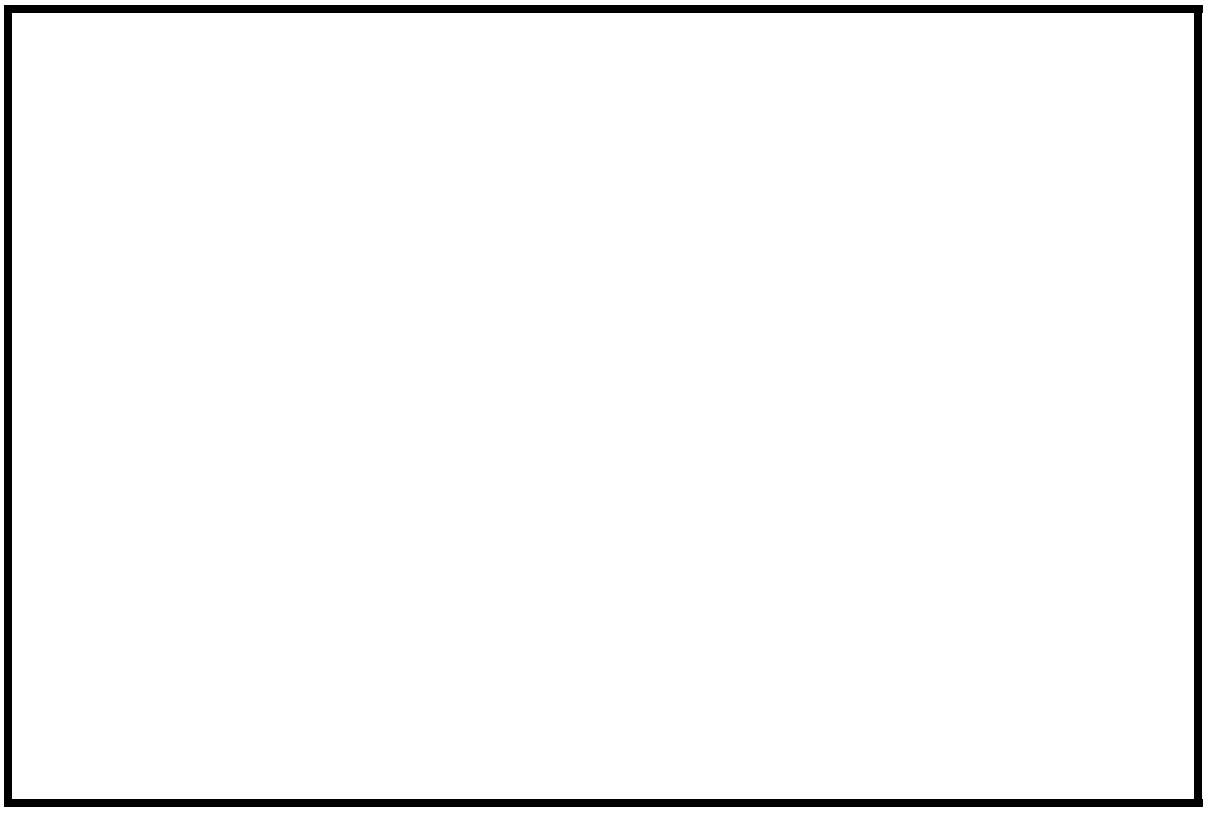


Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

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 BRIDTH00490027 *Stream* Broad Brook

County Windsor *Road* TH049 *District* 04

Description of Bridge

Bridge length 32 *ft* *Bridge width* 12 *ft* *Max span length* 31 *ft*

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

Abutment type vertical *Embankment type* none

Stone fill on abutment? yes, right *Date of inspection* 11/09/94

Description of stone fill Type-2, in good condition, on right abutment, US wingwalls, US right road approach, DS road approaches, and DS right wingwall. Type-3 on DS left wingwall in slumping condition.

Brief description of piers/abutments Abutments are vertical and concrete. The left abutment is noted as settled due to previous undermining.

Is bridge skewed to flood flow according to N *survey?* Y *Angle* 10

Opening skew to roadway is 10 degrees.

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	11/09/94	0	0
Level II	11/09/94	-	-

Potential for debris Low

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

Description of the Geomorphic Setting

General topography The bridge crosses a moderately steep upland probably incised channel.

11/09/94

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

Date of inspection Moderate flood

DS left: plain

DS right: Narrow flood plain with a moderately steep hillside

US left: Narrow flood plain with a moderately steep hillside

US right: Bank is at the foot of a moderate slope

Description of the Channel

Average top width 54 ***ft*** ***Average depth*** 4 ***ft***

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

Narrow, incised channel with only slight sinuosity.

11/09/94

Vegetative co Pasture with moderate tree cover at the immediate bank

DS left: Pasture with moderate tree cover at the immediate bank

DS right: Pasture with moderate tree cover at the immediate bank

US left: Pasture with brush at the immediate bank

US right: Y

Do banks appear stable? 11/09/94--Banks upstream and downstream of the bridge are experiencing only moderate to light fluvial erosion.

date of observation.

11/09/94--none.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 13.9 ***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. Area is mostly forested high-elevation headwater drainage.

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 3780 ***ft³/s*** ***Q500*** 4910 ***ft³/s***

The Q100 and Q500 discharges were determined from a drainage area relationship [(13.9/26.9) to the 0.7 power] with the discharge estimates at Bridgewater bridge 57. The discharges at bridge 57, which has a drainage area of 26.9 square miles, were taken from VTAOT files (VTAOT, written communication, May, 1995). The discharges compared well to values determined by several different empirical methods (Potter, 1957a&b; Johnson and Tasker, 1974; FHWA, 1983; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans No datum tie.

Description of reference marks used to determine USGS datum. RM1 is a chiseled 'X' at the upstream end of the left abutment (elev. 500.06 feet, arbitrary datum). RM2 is a chiseled 'X' in top of the downstream end of the downstream right wingwall (elev. 501.29 feet, arbitrary datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-34	1	Exit section
FULLV	0	2	Downstream full valley section (templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	7	1	Roadway section
APPRO	39	1	Approach section

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

Data and Assumptions Used in WSPRO Model

Hydraulic analyses of the reach were done by use of the Federal Highway Administration's WSPRO step-backwater computer program (Shearman and others, 1986, and Shearman, 1990). 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 0.040 to 0.045, and overbank "n" values ranged from 0.035 to 0.040.

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 0.0066 ft/ft which was determined from an analysis of the topographic map (U.S. Geological Survey, 1966) and surveyed thalweg and water-surface points downstream of the structure.

The modelled approach section (APPRO) was surveyed 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.

The modeled 100- and 500-year discharges overtop the bridge and roadway. For the 100-year discharge, 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 500.2 *ft*
Average low steel elevation 499.0 *ft*

100-year discharge 3780 ft^3/s
Water-surface elevation in bridge opening 499.5 *ft*
Road overtopping? Y *Discharge over road* 880 ft^3/s
Area of flow in bridge opening 271 ft^2
Average velocity in bridge opening 10.8 *ft/s*
Maximum WSPRO tube velocity at bridge 12.7 *ft/s*

Water-surface elevation at Approach section with bridge 502.0
Water-surface elevation at Approach section without bridge 498.2
Amount of backwater caused by bridge 3.8 *ft*

500-year discharge 4910 ft^3/s
Water-surface elevation in bridge opening 499.1 *ft*
Road overtopping? Y *Discharge over road* 1480 ft^3/s
Area of flow in bridge opening 268 ft^2
Average velocity in bridge opening 12.8 *ft/s*
Maximum WSPRO tube velocity at bridge 18.2 *ft/s*

Water-surface elevation at Approach section with bridge 502.6
Water-surface elevation at Approach section without bridge 499.3
Amount of backwater caused by bridge 3.3 *ft*

Incipient overtopping discharge 2590 ft^3/s
Water-surface elevation in bridge opening 495.9 *ft*
Area of flow in bridge opening 182 ft^2
Average velocity in bridge opening 14.2 *ft/s*
Maximum WSPRO tube velocity at bridge 17.2 *ft/s*

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 496.7
Amount of backwater caused by bridge 2.4 *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 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 events was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient road-overflow discharges.

Abutment scour for the right abutment at all modelled discharges and the left abutment at the incipient overtopping discharge 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 at the left abutment for the 100- and 500-year discharges was computed by use of the HIRE equation (Richardson and others, 1993, p. 50, equation 25) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.4	2.2	2.1
Depth to armoring	4.2	13.3	N/A
Left overbank	--	--	--
Right overbank			

Local scour:			
Abutment scour	7.6	7.7	13.1
Left abutment	16.4	17.8	15.0
Right abutment			
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:	2.3	3.2	2.6
Left abutment	2.3	3.2	2.6
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2			

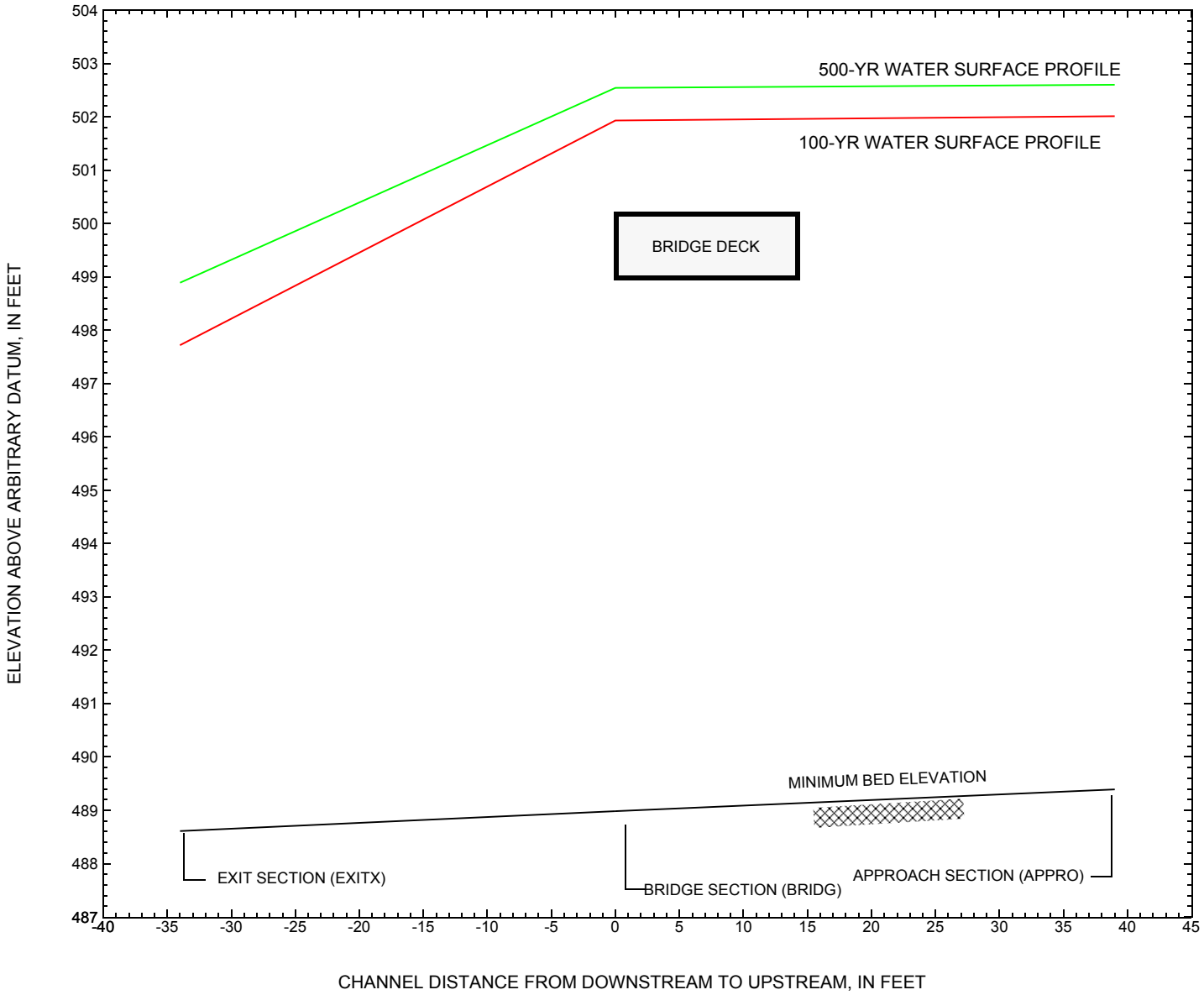


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIDTH00490027 on town highway 49, crossing Broad Brook, Bridgewater, Vermont.

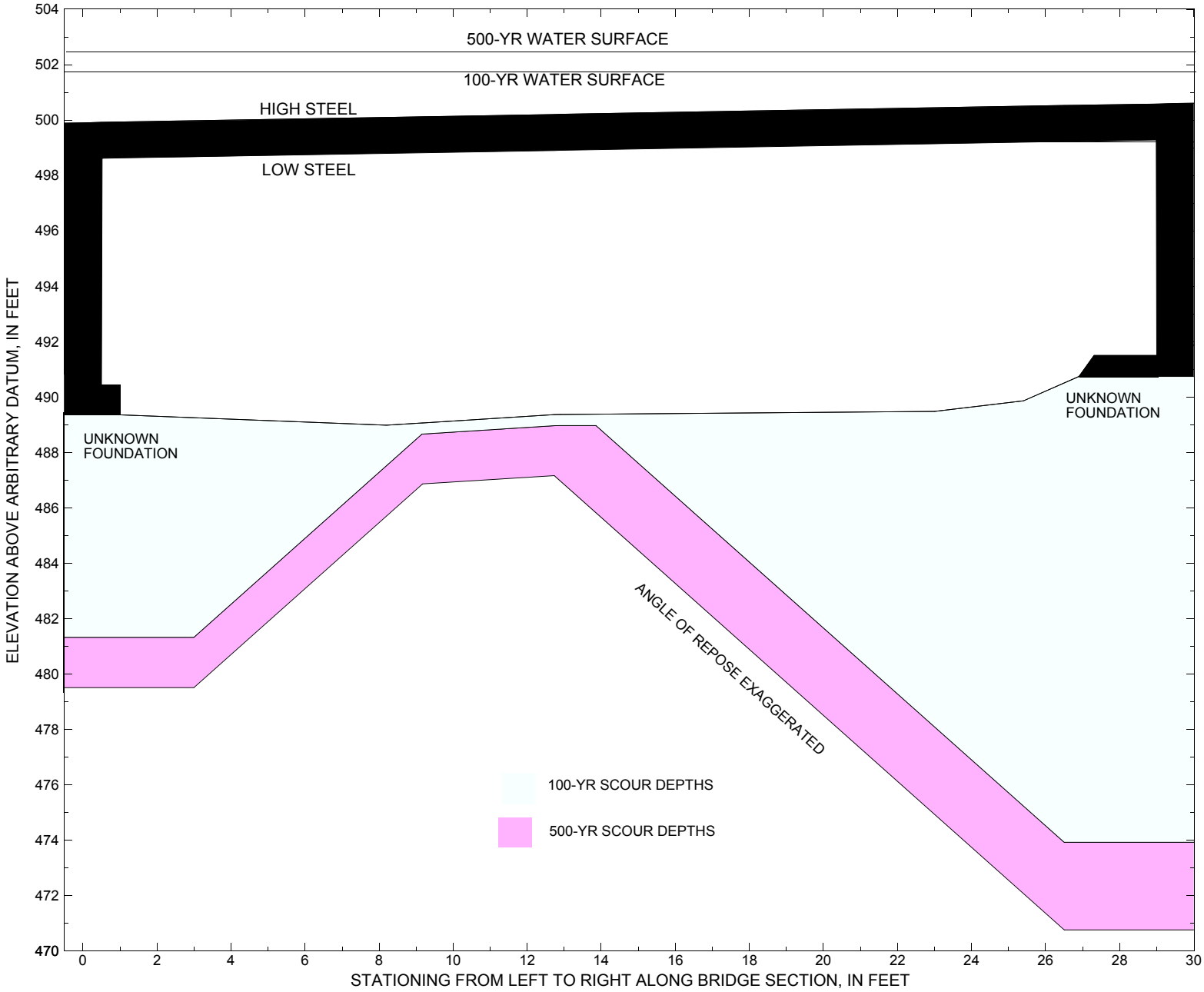


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIDTH00490027 on town highway 49, crossing Broad Brook, Bridgewater, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRIDTH00490027 on Town Highway 49, crossing Broad Brook, 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 3,780 cubic-feet per second											
Left abutment	0.0	--	498.45	--	489.4	0.4	7.6	--	8.0	481.4	--
Right abutment	29.5	--	499.46	--	490.7	0.4	16.4	--	16.8	473.9	--

[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 BRIDTH00490027 on Town Highway 49, crossing Broad Brook, 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 4,910 cubic-feet per second											
Left abutment	0.0	--	498.45	--	489.4	2.2	7.7	--	9.9	479.5	--
Right abutment	29.5	--	499.46	--	490.7	2.2	17.8	--	20.0	470.7	--

[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.

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 brid027.wsp
T2        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
T3        HYDRAULIC ANALYSIS OF BRID027    SAO
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3780 4910 2590
WS          497.7  499.0 496.3
SK          0.0066 0.0066 0.0066
*
XS   EXITX    -34
GR         -301.4, 520.38   -225.3, 509.84   -119.4, 501.86    -81.6, 498.79
GR          -22.0, 498.52    -14.9, 493.78     -7.6, 491.91      0.0, 490.27
GR            2.1, 489.88      7.8, 488.61     15.0, 488.93     19.0, 488.76
GR           26.8, 489.84     31.9, 490.71     36.5, 491.60     39.8, 493.72
GR           52.9, 499.36     78.5, 501.06    112.8, 500.77    136.5, 505.29
GR          225.0, 517.63
N            0.035    0.045     0.040
SA                -22       52.9
*
XS   FULLV   0 * * * 0.011
*
BR   BRIDG   0 499.0 10
GR            0.0, 498.45      0.3, 490.40      0.9, 490.42      0.9, 489.90
GR            1.0, 489.35      4.2, 489.20      8.2, 488.98     12.9, 489.37
GR           18.1, 489.38     23.0, 489.48     25.4, 489.86     26.9, 490.74
GR           27.3, 491.48     29.4, 491.48     29.5, 499.46      0.0, 498.45
N            0.040
CD           1 21.2 * * 57.5 3.8
*
XR   RDWAY   7 12.0 2
GR         -325.2, 513.84   -303.4, 509.56   -248.8, 510.37   -140.0, 509.00
GR          -39.6, 500.23      0.0, 499.67     29.9, 500.83     77.2, 502.85
GR          141.1, 506.70    238.2, 515.76
BP          0
*
AS   APPRO     39
GR         -333.2, 513.84   -312.2, 509.56   -259.9, 510.37   -146.3, 509.00
GR         -112.4, 506.26    -62.8, 501.48    -41.0, 499.56    -25.4, 499.93
GR          -12.9, 499.63     -8.3, 494.90     -4.7, 491.42     -2.8, 490.54
GR            0.0, 490.14      3.4, 489.64      8.1, 489.39     14.7, 489.80
GR           19.8, 490.17     24.8, 490.79     41.1, 492.58     45.6, 494.67
GR           57.7, 500.40    116.1, 504.50    212.2, 515.76
N           0.035        0.045        0.035
SA                -13.         57.7
BP           0
*
HP 1 BRIDG    499.46 1 499.46
HP 2 BRIDG    499.46 * * 2917
HP 2 RDWAY    501.93 * * 880
HP 1 APPRO    502.01 1 502.01
HP 2 APPRO    502.01 * * 3780
*
HP 1 BRIDG    499.08 1 499.08
HP 2 BRIDG    499.08 * * 3435
HP 2 RDWAY    502.54 * * 1482
HP 1 APPRO    502.60 1 502.60
HP 2 APPRO    502.60 * * 4910
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
        HYDRAULIC ANALYSIS OF BRID027    SAO
           *** RUN DATE & TIME: 08-29-95  09:52
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     271.   23608.     0.    75.                          0.
    499.46         271.   23608.     0.    75.  1.00     0.    30.      0.

     VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        499.46     0.0    29.5   270.6   23608.    2917.  10.78

X STA.          0.0         2.9         4.5         5.9         7.2         8.5
  A(I)             23.8        14.9        13.4        12.3        12.3
  V(I)             6.13        9.80       10.88       11.84       11.87

X STA.          8.5         9.8        11.0        12.2        13.5        14.7
  A(I)             12.0        11.7        11.7        11.5        11.6
  V(I)            12.15       12.46       12.44       12.65       12.62

X STA.         14.7        15.9        17.2        18.4        19.6        20.8
  A(I)             11.7        11.7        11.5        11.7        11.9
  V(I)            12.50       12.45       12.70       12.47       12.21

X STA.         20.8        22.1        23.4        24.8        26.5        29.5
  A(I)             12.2        12.4        13.5        15.2        23.6
  V(I)            11.93       11.75       10.80        9.62        6.18

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       7.
          WSEL     LEW     REW    AREA        K        Q    VEL
        501.93   -59.1    55.7   159.3    7223.     880.   5.52

X STA.        -59.1       -43.0       -38.4       -34.5       -31.0       -27.7
  A(I)             11.3         7.3         6.7         6.4         6.0
  V(I)             3.89        6.00        6.59        6.88        7.34

X STA.        -27.7       -24.6       -21.5       -18.0       -14.5       -11.2
  A(I)              6.0         5.9         7.1         7.0         7.0
  V(I)             7.34        7.50        6.24        6.28        6.33

X STA.        -11.2        -7.9        -4.7        -1.5         1.7         5.2
  A(I)              6.9         7.0         7.0         7.2         7.5
  V(I)             6.39        6.25        6.27        6.11        5.88

X STA.          5.2         9.4        14.1        20.1        28.5        55.7
  A(I)              8.3         8.6         9.6        11.0        15.7
  V(I)             5.33        5.14        4.60        3.99        2.80

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      39.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      97.    5988.    55.    55.                        728.
             2     669.   94106.    71.    76.                      11667.
             3      18.     679.    23.    23.                         94.
    502.01          784.  100774.   149.   155.  1.13   -68.    81.   9585.

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      39.
          WSEL     LEW     REW    AREA        K        Q    VEL
        502.01   -68.3    80.6   784.0  100774.    3780.   4.82

X STA.        -68.3       -18.3        -5.3        -1.8         1.1         3.7
  A(I)             84.6        60.5        38.3        34.2        31.7
  V(I)             2.24        3.12        4.94        5.53        5.97

X STA.          3.7         6.2         8.6        11.0        13.4        15.8
  A(I)             30.7        30.4        29.8        29.7        30.3
  V(I)             6.15        6.21        6.34        6.36        6.25

X STA.         15.8        18.4        21.0        23.7        26.6        29.7
  A(I)             30.4        30.8        32.0        32.0        33.5
  V(I)             6.23        6.14        5.90        5.91        5.65

X STA.         29.7        33.0        36.5        40.5        45.7        80.6
  A(I)             34.4        36.0        38.3        44.6        71.8
  V(I)             5.49        5.25        4.93        4.24        2.63
```

WSPRO OUTPUT FILE (continued)

```
       U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
        HYDRAULIC ANALYSIS OF BRID027    SAO
           *** RUN DATE & TIME: 08-29-95  09:52
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     269.   25972.    11.    64.                       7553.
   499.08          269.   25972.    11.    64.  1.00     0.    29.   7553.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.08     0.0    29.5   268.5   25972.    3435.  12.79

X STA.          0.0        3.1        4.8        6.4        7.9        9.3
  A(I)             25.8       16.0       14.9       14.1       13.2
  V(I)             6.67      10.75      11.53      12.21      12.97

X STA.          9.3       10.7       12.0       13.4       14.8       16.1
  A(I)             13.2       13.1       12.8       12.7       12.8
  V(I)            12.97      13.11      13.37      13.49      13.43

X STA.         16.1       17.4       18.7       19.7       20.7       21.7
  A(I)             12.5       11.8        9.5        9.5        9.7
  V(I)            13.73      14.56      18.04      18.16      17.70

X STA.         21.7       22.7       23.8       25.1       26.5       29.5
  A(I)              9.8       10.5       11.3       12.9       22.4
  V(I)            17.58      16.37      15.23      13.28       7.66

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       7.
         WSEL     LEW     REW    AREA        K        Q    VEL
       502.54   -66.0    69.9   235.8   12943.    1482.   6.28

X STA.       -66.0      -46.1      -40.4      -35.9      -31.9      -28.2
  A(I)             17.4       11.4       10.4        9.4        9.1
  V(I)             4.27       6.47       7.10       7.87       8.18

X STA.       -28.2      -24.6      -21.0      -17.0      -13.2       -9.3
  A(I)              9.0        9.1       10.5       10.2       10.4
  V(I)             8.21       8.12       7.09       7.27       7.12

X STA.        -9.3       -5.6       -2.0        1.7        5.6       10.0
  A(I)             10.2       10.4       10.3       10.8       11.3
  V(I)             7.26       7.13       7.21       6.83       6.58

X STA.        10.0       14.9       20.8       27.8       37.7       69.9
  A(I)             11.8       12.8       13.4       15.8       22.2
  V(I)             6.30       5.78       5.52       4.70       3.35

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      39.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     131.    9266.    61.    62.                       1090.
             2     710.  104094.    71.    76.                      12776.
             3      34.    1561.    31.    31.                        205.
   502.60          876.  114921.   163.   169.  1.16   -74.    89.  10707.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      39.

         WSEL     LEW     REW    AREA        K        Q    VEL
       502.60   -74.4    89.0   876.1  114921.    4910.   5.60
X STA.       -74.4      -28.7       -7.6       -3.1        0.0        2.8
  A(I)             87.4       74.5       47.2       37.5       35.5
  V(I)             2.81       3.30       5.20       6.55       6.91

X STA.         2.8        5.5        8.0       10.5       13.1       15.6
  A(I)             34.4       33.3       32.8       33.2       32.8
  V(I)             7.13       7.37       7.48       7.40       7.49

X STA.        15.6       18.3       21.0       23.9       26.9       30.1
  A(I)             33.7       34.2       34.4       35.8       36.1
  V(I)             7.28       7.17       7.14       6.85       6.79

X STA.        30.1       33.5       37.2       41.4       47.2       89.0
  A(I)             37.9       39.6       42.1       49.5       84.0
  V(I)             6.48       6.20       5.83       4.96       2.92
```

WSPRO OUTPUT FILE (continued)

```
        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
        HYDRAULIC ANALYSIS OF BRID027    SAO
           *** RUN DATE & TIME: 08-29-95  09:52
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     182.   18569.    29.    40.                       2598.
   495.91          182.   18569.    29.    40.  1.00     0.    29.   2598.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       495.91     0.1    29.5   182.3   18569.    2590.  14.21

X STA.          0.1         3.0         4.6         5.9         7.1         8.3
  A(I)             17.4        10.3         8.9         8.2         8.2
  V(I)             7.45       12.60       14.49       15.81       15.88

X STA.          8.3         9.4        10.6        11.7        12.9        14.1
  A(I)              7.6         7.8         7.5         7.6         7.5
  V(I)             16.95       16.69       17.19       17.04       17.17

X STA.         14.1        15.3        16.4        17.6        18.9        20.1
  A(I)              7.6         7.6         7.7         7.9         7.8
  V(I)             17.11       17.11       16.92       16.38       16.63

X STA.         20.1        21.4        22.7        24.2        25.9        29.5
  A(I)              8.1         8.5         9.1        10.2        16.8
  V(I)             15.90       15.15       14.22       12.70        7.70

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      39.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2     465.   53272.    67.    72.                       6943.
   499.11          465.   53272.    67.    72.  1.00   -12.    55.   6943.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      39.
         WSEL     LEW     REW    AREA        K        Q    VEL
       499.11   -12.4    55.0   465.5   53272.    2590.   5.56

X STA.        -12.4        -3.6        -0.8         1.6         3.8         5.9
  A(I)             38.6        24.5        21.9        20.5        20.0
  V(I)             3.36        5.29        5.90        6.31        6.47

X STA.          5.9         7.9         9.9        11.9        13.9        16.0
  A(I)             19.0        19.3        19.2        19.1        19.4
  V(I)             6.80        6.70        6.75        6.79        6.67

X STA.         16.0        18.2        20.4        22.7        25.2        27.9
  A(I)             19.5        19.8        20.5        20.8        21.8
  V(I)             6.64        6.55        6.31        6.22        5.94

X STA.         27.9        30.7        34.0        37.5        41.6        55.0
  A(I)             22.5        24.2        25.1        27.4        42.4
  V(I)             5.76        5.36        5.16        4.73        3.06

        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
        HYDRAULIC ANALYSIS OF BRID027    SAO
           *** RUN DATE & TIME: 08-29-95  09:52

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

EXITX:XS   ******   -21.     431.  1.20 *****  498.92  495.78   3780.  497.72
      -34. ******    49.   46486.  1.00 ***** *******    0.62    8.77

FULLV:FV      34.   -21.     420.  1.26  0.23  499.19 *******   3780.  497.93
```

WSPRO OUTPUT FILE (continued)

```
        0.    34.    49.   44734.  1.00  0.03    0.01    0.65    9.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      39.   -11.     403.  1.37  0.29  499.53 *******   3780.  498.16
       39.    39.    53.   43284.  1.00  0.05   -0.01    0.66    9.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.85       0.00     497.71     499.67

  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.20     500.81     500.94     499.00

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

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


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

 BRIDG:BR      34.     0.     271.  1.81 *****  501.27  496.42   2917.  499.46
         0. ******    30.   23608.  1.00 ***** *******    0.63   10.78

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   5.  0.478  0.000  499.00 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG       7.    27.  0.04  0.41  502.38    0.00    880.  501.93

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:     691.    73.   -59.    14.   2.3   1.7   6.6   5.6   2.1   3.0
    RT:     189.    41.    14.    56.   1.7   0.9   5.2   5.2   1.3   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.   -68.     784.  0.41  0.09  502.42  496.45   3780.  502.01
        39.    19.    81.  100810.  1.13  0.42    0.00    0.39    4.82

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
         CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
         HYDRAULIC ANALYSIS OF BRID027    SAO
            *** RUN DATE & TIME: 08-29-95  09:52
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -34.   -21.    49.   3780.   46486.     431.    8.77  497.72
    FULLV:FV       0.   -21.    49.   3780.   44734.     420.    9.01  497.93
    BRIDG:BR       0.     0.    30.   2917.   23608.     271.   10.78  499.46
    RDWAY:RG       7.******   691.    880.******************    2.00  501.93
    APPRO:AS      39.   -68.    81.   3780.  100810.     784.    4.82  502.01

  SECOND USER DEFINED TABLE.

     XSID:CODE     CRWS      FR#     YMIN     YMAX     HF     HO  VHD       EGL     WSEL
    EXITX:XS     495.78     0.62  488.61  520.38************  1.20  498.92  497.72
    FULLV:FV   ********     0.65  488.98  520.75  0.23  0.03  1.26  499.19  497.93
    BRIDG:BR     496.42     0.63  488.98  499.46************  1.81  501.27  499.46
    RDWAY:RG   ***************  499.67  515.76  0.04******  0.41  502.38  501.93
    APPRO:AS     496.45     0.39  489.39  515.76  0.09  0.42  0.41  502.42  502.01

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

WSPRO OUTPUT FILE (continued)

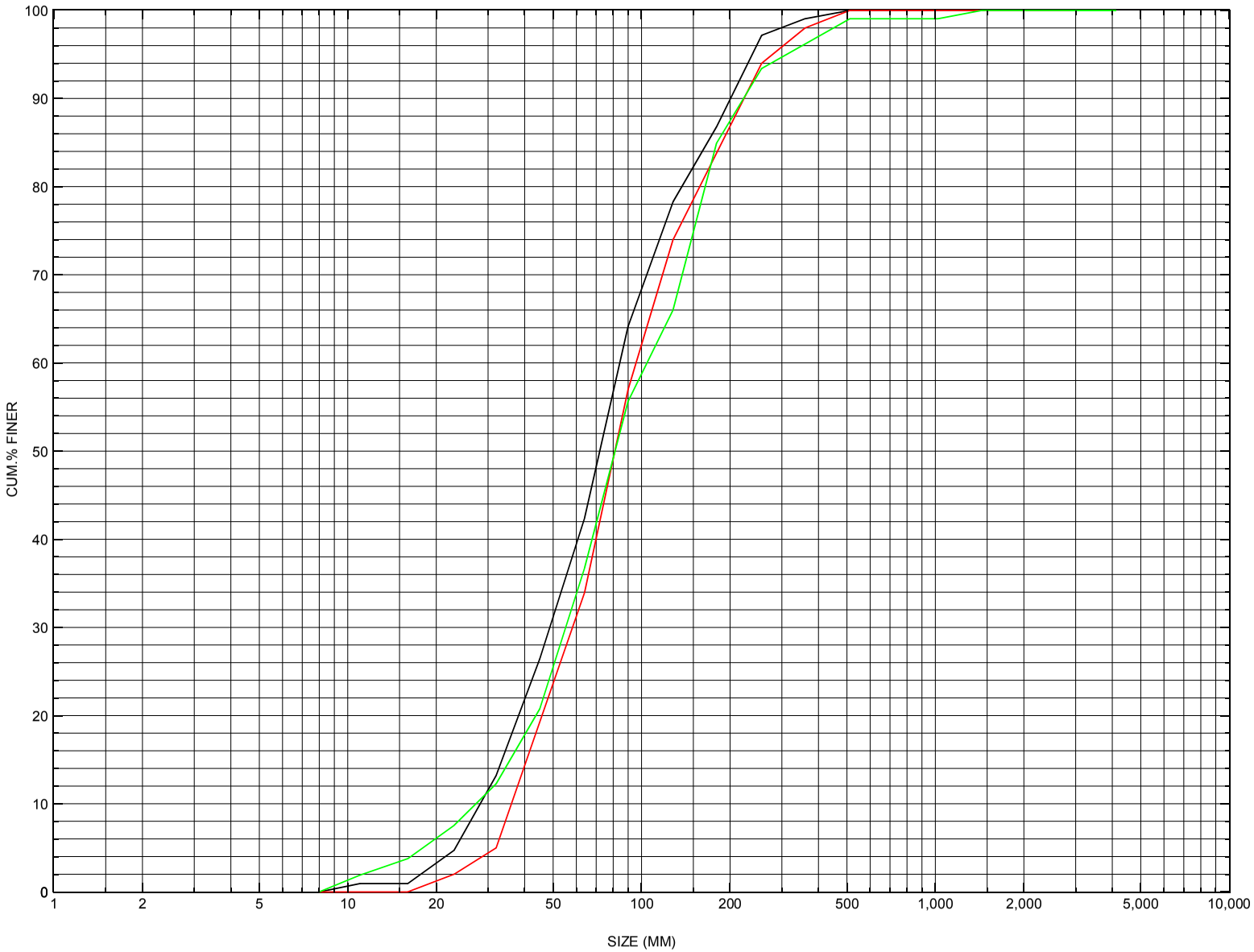
```
 EXITX:XS   ******   -83.     529.  1.40 *****  500.28  496.79   4910.  498.89
       -34. ******    52.   60381.  1.04 ***** *******    0.84    9.28

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
               FNTEST,FR#,WSEL,CRWS =  0.80    0.82     499.08     497.16

  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                    WSLIM1,WSLIM2,DELTAY =   498.39     520.75    0.50

  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                    WSLIM1,WSLIM2,CRWS =   498.39     520.75     497.16

 FULLV:FV      34.   -62.     505.  1.49  0.23  500.56  497.16   4910.  499.08
         0.    34.    51.   57803.  1.01  0.05    0.00    0.82    9.72
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 APPRO:AS      39.   -13.     477.  1.65  0.29  500.93 *******   4910.  499.28
        39.    39.    55.   55212.  1.00  0.08   -0.01    0.68   10.29
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>









  ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                          WS3N,LSEL =   499.08     499.00

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

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

 BRIDG:BR      34.     0.     268.  2.55 *****  501.62  497.20   3435.  499.08
         0. ******    29.   25993.  1.00 ***** *******    0.75   12.79

       TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
         1. ****   6.  0.800  0.000  499.00 ****** ****** ******

      XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
     RDWAY:RG       7.    27.  0.05  0.57  503.11    0.00   1482.  502.54

               Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
     LT:   1117.    82.   -66.    16.   2.9   2.1   7.6   6.4   2.7   3.1
     RT:    364.    54.    16.    70.   2.2   1.1   5.9   5.9   1.7   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.   -74.     875.  0.57  0.11  503.16  497.48   4910.  502.60
        39.    19.    89.  114813.  1.16  0.42    0.00    0.46    5.61

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

                       <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
  WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
  V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

          U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
          CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
          HYDRAULIC ANALYSIS OF BRID027    SAO
             *** RUN DATE & TIME: 08-29-95  09:52
    FIRST USER DEFINED TABLE.

      XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
     EXITX:XS     -34.   -83.    52.   4910.   60381.     529.    9.28  498.89
     FULLV:FV       0.   -62.    51.   4910.   57803.     505.    9.72  499.08
     BRIDG:BR       0.     0.    29.   3435.   25993.     268.   12.79  499.08
```

WSPRO OUTPUT FILE (continued)

```
   RDWAY:RG       7.*******  1117.   1482.******************    2.00  502.54
   APPRO:AS      39.   -74.    89.   4910.  114813.     875.    5.61  502.60

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.79    0.84  488.61  520.38************  1.40  500.28  498.89
   FULLV:FV    497.16    0.82  488.98  520.75  0.23  0.05  1.49  500.56  499.08
   BRIDG:BR    497.20    0.75  488.98  499.46************  2.55  501.62  499.08
   RDWAY:RG  ****************  499.67  515.76  0.05******  0.57  503.11  502.54
   APPRO:AS    497.48    0.46  489.39  515.76  0.11  0.42  0.57  503.16  502.60

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

EXITX:XS   ******   -19.     331.  0.95 *****  497.18  494.57   2590.  496.23
      -34. ******    46.   31878.  1.00 ***** *******    0.61    7.82

FULLV:FV      34.   -18.     321.  1.01  0.24  497.46 *******   2590.  496.44
        0.    34.    45.   30437.  1.00  0.03    0.01    0.63    8.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      39.   -10.     313.  1.07  0.29  497.78 *******   2590.  496.71
       39.    39.    50.   29981.  1.00  0.03    0.01    0.64    8.28
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    2590.     495.91

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

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

BRIDG:BR      34.     0.     182.  3.14 *****  499.05  495.91   2590.  495.91
        0.    34.    29.   18550.  1.00 ***** *******    1.00   14.22

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.00 ****** ****** ******



    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      18.   -12.     465.  0.48  0.13  499.59  495.21   2590.  499.11
       39.    19.    55.   53271.  1.00  0.41    0.00    0.37    5.56

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.510  0.289   37862.     1.    30.   499.05

                  <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. GEOLOGICAL SURVEY WSPRO INPUT FILE brid027.wsp
        CREATED ON 21-AUG-95 FOR BRIDGE BRIDTH00490027 USING FILE brid027.dca
        HYDRAULIC ANALYSIS OF BRID027    SAO
           *** RUN DATE & TIME: 08-29-95  09:52
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -34.   -19.    46.   2590.   31878.     331.    7.82  496.23
   FULLV:FV       0.   -18.    45.   2590.   30437.     321.    8.07  496.44
   BRIDG:BR       0.     0.    29.   2590.   18550.     182.   14.22  495.91
   RDWAY:RG       7.**************      0.******************    2.00********
   APPRO:AS      39.   -12.    55.   2590.   53271.     465.    5.56  499.11

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       1.    30.   37862.

 SECOND USER DEFINED TABLE.
```

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 BRIDTH00490027, in Bridgewater, Vermont.

APPENDIX D:

HISTORICAL DATA FORM