LEVEL II SCOUR ANALYSIS FOR BRIDGE 144 (ROCHVT01000144) on STATE ROUTE 100, crossing the WHITE RIVER, ROCHESTER, VERMONT

U.S. Geological Survey
Open-File Report 97-7

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

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Slope	
foot per mile (ft/mi)	0.1894	meter per kilometer (m/km)
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
	Velocity and Flow	
foot per second (ft/s)	0.3048	meter per second (m/s)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 144 (ROCHVT01000144) ON STATE ROUTE 100, CROSSING THE WHITE RIVER, ROCHESTER, VERMONT

By Erick M. Boehmler and Emily C. Wild

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ROCHVT01000144 on State Route 100 crossing the White River, Rochester, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 68.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture with forest on the valley walls.

In the study area, the White River has a meandering channel with a slope of approximately 0.003 ft/ft, an average channel top width of 119 ft and an average channel depth of 4 ft. The predominant channel bed material is gravel and cobbles with a median grain size (D_{50}) of 72.5 mm (0.238 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 22, 1996, indicated that the reach was laterally unstable due to a cut-bank present on the upstream left bank and wide point bars upstream and downstream in the vicinity of this site.

The State Route 100 crossing of the White River is a 103-ft-long, two-lane bridge consisting of one 101-foot steel-beam span (Vermont Agency of Transportation, written communication, March 8, 1995). The bridge is supported by vertical, concrete abutment walls with spill-through embankments in front of each abutment wall and no wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 5 degrees.

The scour protection measures at the site are type-2 stone fill (less than 36 inches diameter) on the upstream left bank, both abutment spill-through embankments, and the downstream banks. There also is type-1 stone fill (less than 12 inches diameter) on the upstream right bank. The stone fill is continuous on both sides of the river in the vicinity of the bridge. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

There was no computed contraction scour for the modelled flows. Abutment scour ranged from 6.9 to 10.9 ft. The worst-case abutment scour occurred at the incipient overtopping discharge, which was less than the 100-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Hancock, VT. Quadrangle, 1:24,000, 1970
Photographs, 1962 and 1965.

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 ROCHVT01000144 ***Stream*** White River

County Windsor ***Road*** VT 100 ***District*** 4

Description of Bridge

Bridge length 103 ***ft*** ***Bridge width*** 41.2 ***ft*** ***Max span length*** 101 ***ft***

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

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 7/22/96

Description of stone fill Type-2 protects the spill-through embankments of each abutment, the upstream left bank, and the downstream banks. The upstream right bank is protected with type-1 stone fill.

Brief description of piers/abutments Abutments are vertical concrete walls with sloping spill-through embankments in front of each wall.

Is bridge located on a bend in channel? Y ***If so, describe (mild, moderate, severe)***

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

There is a moderate channel bend in the upstream reach. A scour hole has developed along the left bank upstream.

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	7/22/96	0	0
Level II	7/22/96	0	0

Potential for debris Moderate. There is some debris caught on boulders upstream and downstream. Some trees are present on laterally unstable banks.

Describe any features near or at the bridge that may affect flow (include observation date) A scour hole has developed at the confluence of Marshs Brook with the White River 85 feet upstream noted on 7/22/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow, irregular flood plains and moderately sloping valley walls on both sides.

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

Date of inspection 7/22/96

DS left: Slightly sloping channel bank to a narrow flood plain.

DS right: Slightly sloping channel bank to a narrow flood plain.

US left: Steep channel bank to a narrow overbank.

US right: Moderately sloping channel bank to a narrow flood plain.

Description of the Channel

Average top width 119 ft ***Average depth*** 4 ft

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

Perennial and meandering with alluvial channel boundaries and wide point bars.

7/22/96

Vegetative co Young trees, shrubs and brush

DS left: Young trees, shrubs and brush

DS right: Short bushes, shrubs, brush and a few trees

US left: Short bushes, shrubs, brush and a few trees.

US right:

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

On 7/22/96 a cut bank was noted on the upstream left bank and several wide, partially vegetated point bars were evident both upstream and downstream of this site.

None evident on 7/22/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 68.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization:*** -

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

USGS gage description White River at West Hartford, VT

USGS gage number 01144000

Gage drainage area 690 ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 14,100 ***ft³/s*** ***Q500*** 20,800 ***ft³/s***

The 100- and 500-year discharges shown above are based on a drainage area relationship [Qs = Qf (As/Af)exp(0.67)] applying the 100- and 500-year discharges published for the upstream town line of Rochester on the White River (65 sq. mi.) in the Flood Insurance Study for the town (FEMA, 1991). These discharges were selected for the hydraulic analyses due to their central tendency with discharges computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957a&b; Talbot, 1887) and those available from the VTAOT database (written communication, VTAOT, May, 1995).

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

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

Datum tie between USGS survey and VTAOT plans Add 362.7 feet to the USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM2 is the center point of a chiseled "X" on top of the downstream concrete curb, three feet from the right end (elev. 497.26 ft, arbitrary survey datum). RM3 is a VTAOT brass tablet survey mark on top of the upstream concrete curb, ten feet from the left end (elev. 500.22 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-107	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	20	1	Road Grade section
APPRO	139	2	Modelled Approach section (Templated from APTEM)
APTEM	149	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.050, and overbank "n" values ranged from 0.035 to 0.045.

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 0.00268 ft/ft which was estimated from topographic maps (U.S. Geological Survey, 1970 a&b).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0112 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 498.1 *ft*
Average low steel elevation 493.2 *ft*

100-year discharge 14,100 *ft³/s*
Water-surface elevation in bridge opening 489.6 *ft*
Road overtopping? Yes *Discharge over road* 6890 *ft³/s*
Area of flow in bridge opening 813 *ft²*
Average velocity in bridge opening 8.9 *ft/s*
Maximum WSPRO tube velocity at bridge 10.3 *ft/s*

Water-surface elevation at Approach section with bridge 491.8
Water-surface elevation at Approach section without bridge 489.9
Amount of backwater caused by bridge 1.9 *ft*

500-year discharge 20,800 *ft³/s*
Water-surface elevation in bridge opening 490.7 *ft*
Road overtopping? Yes *Discharge over road* 12,200 *ft³/s*
Area of flow in bridge opening 916 *ft²*
Average velocity in bridge opening 9.4 *ft/s*
Maximum WSPRO tube velocity at bridge 10.9 */s*

Water-surface elevation at Approach section with bridge 493.2
Water-surface elevation at Approach section without bridge 490.7
Amount of backwater caused by bridge 2.5

Incipient overtopping discharge 3,750 *ft³/s*
Water-surface elevation in bridge opening 486.6 *ft*
Area of flow in bridge opening 539 *ft²*
Average velocity in bridge opening 7.0 *ft/s*
Maximum WSPRO tube velocity at bridge 8.1 *ft/s*

Water-surface elevation at Approach section with bridge 487.8
Water-surface elevation at Approach section without bridge 487.6
Amount of backwater caused by bridge 0.2 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour. In this case, there was no contraction scour computed for any of the modeled discharges.

Abutment scour for the 100- and 500-year discharges was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE 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.

For the incipient over-topping discharge model, abutment scour was computed by use of the Froehlich abutment-scour equation (Richardson and others, 1995, p. 48, equation 28). The variables used by the Froehlich abutment-scour equation are defined the same as those defined for the HIRE abutment-scour equation.

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the variables for the abutment scour equations applied were computed including the width of the spill-through embankments. The total scour depths were applied for the entire spill-through embankment below the elevation at the toe of each embankment, as shown in figure 8.

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	0.0	0.0	0.0
Depth to armoring	1.0	1.4	0.3
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	6.9	9.5	10.0
Right abutment	8.8	10.7	10.9
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	2.4	2.5	1.1
Right abutment	2.4	2.5	1.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

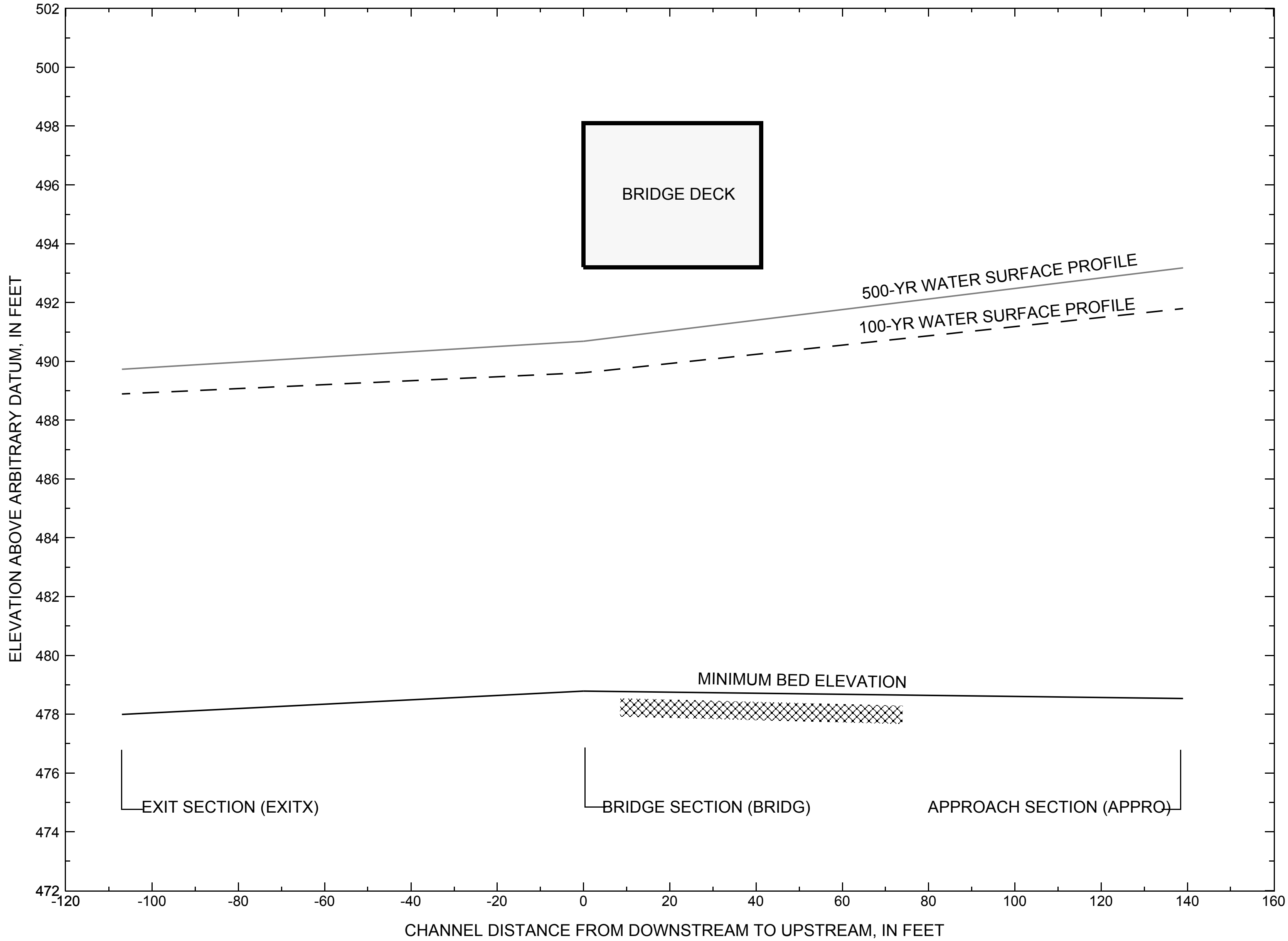

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ROCHVT01000144 on State Route 100, crossing White River, Rochester, Vermont.

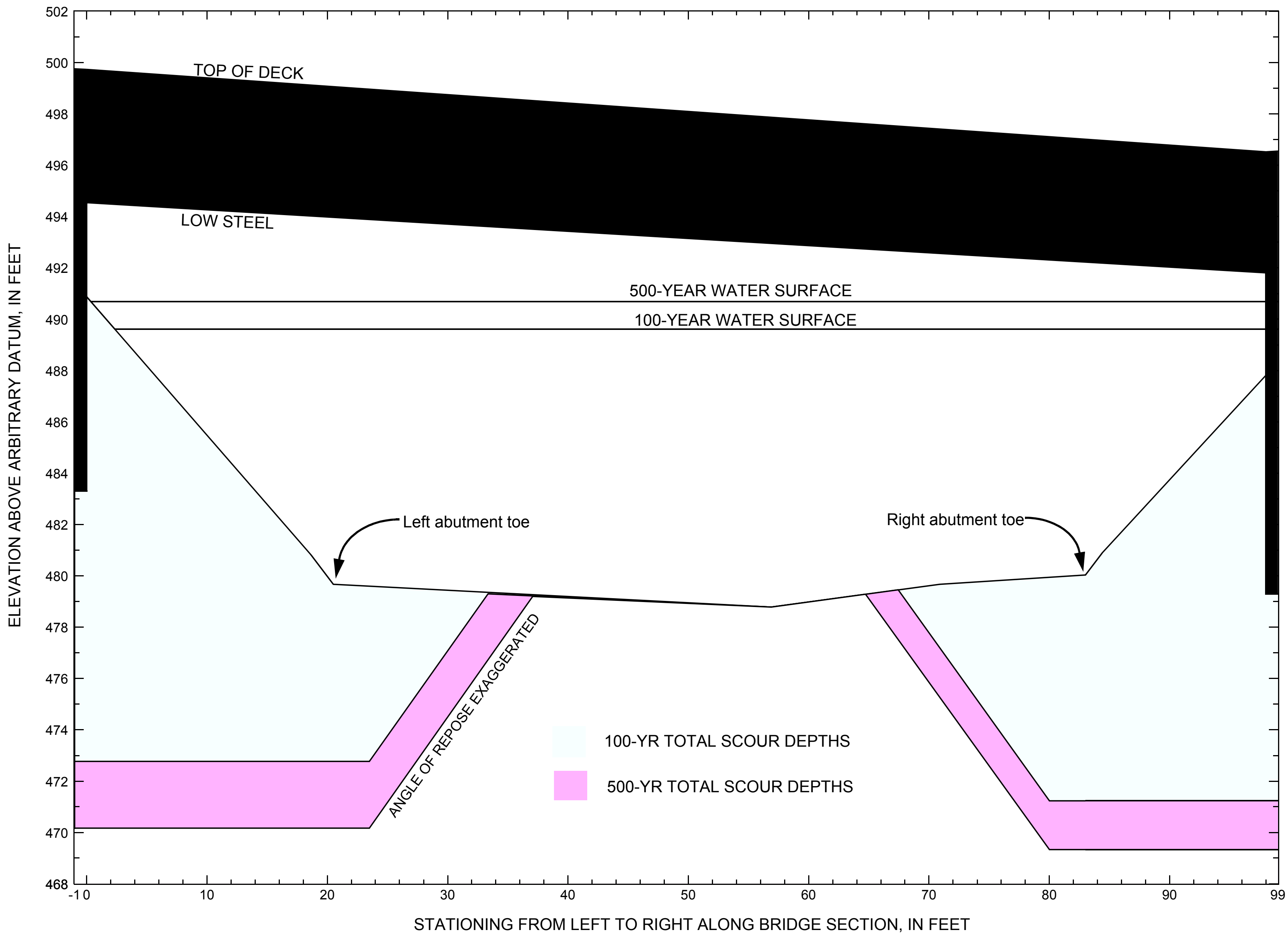

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ROCHVT01000144 on State Route 100, crossing the White River, Rochester, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ROCHVT01000144 on State Route 100, crossing the White River, Rochester, Vermont.

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

Description	Station[1]	VTAOT Bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 14,100 cubic-feet per second											
Left abutment	0.0	856.9	494.3	483.3	490.9	--	--	--	--	--	-10.5
Left abutment toe	20.5	--	--	--	479.7	0.0	6.9	--	6.9	472.8	--
Right abutment toe	83.0	--	--	--	480.0	0.0	8.8	--	8.8	471.2	--
Right abutment	98.0	854.3	491.5	479.3	487.8	--	--	--	--	--	-8.1

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 ROCHVT01000144 on State Route 100, crossing the White River, Rochester, Vermont.

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

Description	Station[1]	VTAOT Bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 20,800 cubic-feet per second											
Left abutment	0.0	856.9	494.3	483.3	490.9	--	--	--	--	--	-13.1
Left abutment toe	20.5	--	--	--	479.7	0.0	9.5	--	9.5	470.2	--
Right abutment toe	83.0	--	--	--	480.0	0.0	10.7	--	10.7	469.3	--
Right abutment	98.0	854.3	491.5	479.3	487.8	--	--	--	--	--	-10.0

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

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U.S. Geological Survey, 1970b, Rochester, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial Photographs, 1962 and 1965; Photorevised, 1988, Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File roch144.wsp
T2        Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
T3        State Route 100 Crossing the White River, Rochester, VT            EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           14100.0, 20800.0, 3750.0
SK          0.00268, 0.00268, 0.00268
*
XS   EXITX   -107
GR         -761.0, 512.25   -693.2, 505.66   -572.9, 506.36   -424.0, 503.90
GR         -374.9, 488.80    -97.0, 486.25    -15.1, 486.01    -11.8, 487.24
GR            0.0, 483.45      8.6, 483.34     18.5, 480.82     31.1, 479.73
GR           38.1, 478.38     53.4, 477.99     64.1, 478.22     73.4, 478.53
GR           82.1, 480.83     93.1, 483.49    112.0, 483.18    121.4, 487.11
GR          137.3, 486.20    696.2, 486.33    752.6, 494.17
*
N           0.035        0.050        0.035
SA                 -11.8        121.4
*
*
XS   FULLV      0  * * *   0.0074
*
*            SRD     LSEL    XSSKEW
BR   BRIDG     0    493.18       5.0
GR            0.0, 494.54      0.0, 490.88     18.6, 480.84     20.5, 479.67
GR           38.1, 479.17     56.9, 478.78     70.9, 479.67     83.0, 480.03
GR           84.4, 480.89     98.0, 487.81     98.0, 491.81      0.0, 494.54
*
*         No embankment slope points surveyed. EMBSS was estimated using
*         average spill-through embankment slope angle plus 10 degrees
*         based on discussion with field personnel, EW 10/24/96.
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      40.2     1.3     498.1
N           0.040
*
*
*            SRD    EMBWID   IPAVE
XR   RDWAY     20      41.2     1
GR         -349.3, 507.45    -11.7, 499.73    -11.6, 500.47      0.0, 500.18
GR           99.7, 497.36    111.9, 497.07    112.0, 496.52    431.3, 488.63
GR          660.9, 487.63    817.8, 494.29    955.8, 498.64
*
XT   APTEM    149
GR         -518.3, 511.77   -450.1, 502.31   -336.5, 500.71   -245.2, 496.64
GR         -203.4, 503.38   -180.6, 503.25   -128.1, 491.70    -38.4, 488.55
GR          -11.7, 490.02     -1.6, 482.23      0.0, 481.85      3.2, 480.48
GR            4.8, 481.86      9.0, 482.14     15.3, 481.80     25.8, 481.64
GR           43.3, 478.99     53.3, 478.64     66.6, 479.96     84.1, 481.52
GR           94.2, 481.90     98.8, 483.61    101.3, 484.10    113.6, 481.94
GR          116.7, 483.44    144.7, 484.17    239.5, 487.88    920.7, 486.59
GR          945.2, 487.92    979.8, 497.01
*
AS   APPRO    139 *  *  *  0.0112
GT
N           0.045        0.050        0.040
```

```
SA                   -11.7        101.3
*
HP 1 BRIDG 489.61 1 489.61
HP 2 BRIDG 489.61 * * 7214
HP 2 RDWAY 491.16 * * 6886
HP 1 APPRO 491.79 1 491.79
HP 2 APPRO 491.79 * * 14100
*
*
HP 1 BRIDG 490.68 1 490.68
HP 2 BRIDG 490.68 * * 8570
HP 2 RDWAY 492.32 * * 12230
HP 1 APPRO 493.18 1 493.18
HP 2 APPRO 493.18 * * 20800
*
HP 1 BRIDG 486.64 1 486.64
HP 2 BRIDG 486.64 * * 3750
HP 1 APPRO 487.83 1 487.83
HP 2 APPRO 487.83 * * 3750
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File roch144.wsp
      Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
      State Route 100 Crossing the White River, Rochester, VT            EMB
         *** RUN DATE & TIME: 12-02-96  14:01

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      813    121169     95    102                          13476
 489.61           813    121169     95    102  1.00      2     98    13476

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     489.61     2.4    98.0   813.0  121169.    7214.   8.87

X STA.         2.4       18.5       23.1       27.1       30.9       34.6
  A(I)             70.0       44.9       40.1       38.7       37.9
  V(I)             5.15       8.04       9.00       9.33       9.51

X STA.        34.6       38.1       41.6       44.9       48.2       51.5
  A(I)             36.2       36.0       35.1       34.9       35.1
  V(I)             9.96      10.01      10.28      10.33      10.27

X STA.        51.5       54.8       58.0       61.3       64.8       68.3
  A(I)             34.9       35.1       35.0       35.4       36.0
  V(I)            10.34      10.29      10.31      10.18      10.02

X STA.        68.3       72.2       76.0       80.2       84.9       98.0
  A(I)             38.5       37.5       41.3       43.8       66.7
  V(I)             9.37       9.63       8.74       8.23       5.41

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      20.

       WSEL     LEW     REW    AREA        K        Q    VEL
     491.16   328.9   744.1   972.0   72947.    6886.   7.08

X STA.       328.9      412.9      437.7      458.0      476.4      493.5
  A(I)             87.1       58.6       52.9       49.5       47.3
  V(I)             3.95       5.87       6.51       6.95       7.28

X STA.       493.5      509.8      525.1      540.1      554.3      567.7
  A(I)             46.0       44.7       44.5       43.2       41.4
  V(I)             7.48       7.70       7.74       7.97       8.32

X STA.       567.7      581.0      593.8      606.1      618.4      630.7
  A(I)             41.8       41.2       40.2       40.7       41.5
  V(I)             8.24       8.35       8.57       8.45       8.30

X STA.       630.7      642.4      654.6      667.4      684.8      744.1
  A(I)             39.9       42.5       44.4       50.1       74.5
  V(I)             8.62       8.11       7.76       6.87       4.62

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      229     11866    117    117                           1820
           2     1198    168237    113    117                          22147
           3     4245    458310    859    860                          53544
 491.79          5673    638413   1089   1095  1.07   -128    960    70857

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

       WSEL     LEW     REW    AREA        K        Q    VEL
     491.79  -129.0   960.4  5672.7  638413.   14100.   2.49

X STA.      -129.0       10.6       32.9       49.9       65.8       84.8
  A(I)            412.4      230.9      212.0      202.8      211.3
  V(I)             1.71       3.05       3.33       3.48       3.34

X STA.        84.8      110.4      135.8      167.2      212.7      296.5
  A(I)            236.6      216.8      233.7      271.0      354.4
  V(I)             2.98       3.25       3.02       2.60       1.99

X STA.       296.5      378.1      452.3      523.1      589.5      653.7
  A(I)            343.1      323.3      318.1      306.8      304.6
  V(I)             2.05       2.18       2.22       2.30       2.31

X STA.       653.7      715.9      773.7      832.3      887.7      960.4
  A(I)            302.9      287.7      298.2      288.1      318.0
  V(I)             2.33       2.45       2.36       2.45       2.22
```

WSPRO OUTPUT FILE (continued)

```
     U.S. Geological Survey WSPRO Input File roch144.wsp
     Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
     State Route 100 Crossing the White River, Rochester, VT            EMB
        *** RUN DATE & TIME: 12-02-96  14:01

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      916    144690     97    105                          15953
490.68           916    144690     97    105  1.00      0     98    15953

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    490.68     0.4    98.0   916.0  144690.    8570.   9.36

X STA.        0.4       17.6       22.6       26.7       30.6       34.3
  A(I)           79.5       52.8       45.1       43.5       42.7
  V(I)           5.39       8.11       9.49       9.84      10.05

X STA.       34.3       37.9       41.4       44.8       48.2       51.6
  A(I)           40.7       40.5       39.4       39.2       39.4
  V(I)          10.53      10.58      10.88      10.94      10.87

X STA.       51.6       54.9       58.2       61.6       65.1       68.7
  A(I)           39.2       39.3       39.3       39.8       40.5
  V(I)          10.93      10.89      10.91      10.75      10.58

X STA.       68.7       72.5       76.5       80.7       85.7       98.0
  A(I)           42.3       43.4       45.3       50.3       73.8
  V(I)          10.13       9.87       9.46       8.52       5.81

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      20.

      WSEL     LEW     REW    AREA        K        Q    VEL
    492.32   282.0   771.4  1496.6  134206.   12230.   8.17

X STA.      282.0      387.6      418.8      441.0      461.1      479.8
  A(I)          138.0       93.2       80.2       76.0       72.2
  V(I)           4.43       6.56       7.63       8.04       8.47

X STA.      479.8      497.5      514.1      530.2      546.0      560.9
  A(I)           69.9       66.5       65.7       65.7       62.7
  V(I)           8.75       9.19       9.31       9.30       9.75

X STA.      560.9      575.6      589.8      604.0      617.7      631.5
  A(I)           63.0       62.0       62.4       61.6       62.6
  V(I)           9.70       9.86       9.80       9.93       9.77

X STA.      631.5      645.4      659.2      674.8      696.6      771.4
  A(I)           63.7       64.4       69.0       79.1      118.9
  V(I)           9.60       9.50       8.87       7.73       5.14

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      397     28548    124    124                           4034
          2     1356    206569    113    117                          26641
          3     5443    690605    864    866                          77499
493.18          7195    925723   1101   1107  1.05   -134    966   101940

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

      WSEL     LEW     REW    AREA        K        Q    VEL
    493.18  -135.3   965.6  7195.0  925723.   20800.   2.89

X STA.     -135.3        5.8       32.1       52.2       72.6       98.0
  A(I)          556.5      305.9      278.6      281.4      298.4
  V(I)           1.87       3.40       3.73       3.70       3.49

X STA.       98.0      126.7      158.8      200.6      269.6      343.1
  A(I)          288.1      293.3      323.7      404.1      407.1
  V(I)           3.61       3.55       3.21       2.57       2.55

X STA.      343.1      413.4      479.5      543.8      605.2      665.7
  A(I)          399.1      383.4      381.0      371.4      372.7
  V(I)           2.61       2.71       2.73       2.80       2.79

X STA.      665.7      723.6      780.0      835.8      890.3      965.6
  A(I)          363.7      359.4      362.1      359.3      405.9
  V(I)           2.86       2.89       2.87       2.89       2.56
```

```
       U.S. Geological Survey WSPRO Input File roch144.wsp
       Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
       State Route 100 Crossing the White River, Rochester, VT            EMB
          *** RUN DATE & TIME: 12-02-96  14:01

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      540     65839     88     91                          7602
  486.64           540     65839     88     91  1.00      8     96     7602

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      486.64     7.9    95.7   539.5   65839.    3750.   6.95

X STA.        7.9       20.5       24.7       28.4       32.0       35.4
  A(I)            43.4       29.3       26.4       25.6       25.2
  V(I)            4.32       6.40       7.09       7.32       7.45

X STA.       35.4       38.6       41.8       45.0       48.0       51.1
  A(I)            23.7       24.2       23.6       23.5       23.7
  V(I)            7.93       7.76       7.95       7.98       7.91

X STA.       51.1       54.1       57.1       60.2       63.4       66.7
  A(I)            23.2       23.4       23.4       24.1       24.5
  V(I)            8.07       8.01       8.00       7.78       7.65

X STA.       66.7       70.3       74.1       78.1       82.6       95.7
  A(I)            25.5       26.0       27.2       30.3       43.3
  V(I)            7.35       7.21       6.90       6.18       4.33

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            2      754     79216    110    114                         11181
            3      873     33232    844    845                          5037
  487.83          1627    112448    954    958  1.72     -8    945     9195

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     139.

        WSEL     LEW     REW    AREA        K        Q    VEL
      487.83    -9.0   945.3  1626.6  112448.    3750.   2.31

X STA.       -9.0        6.9       16.9       26.2       34.0       40.2
  A(I)            75.7       59.7       57.9       54.6       49.6
  V(I)            2.48       3.14       3.24       3.44       3.78

X STA.       40.2       45.5       50.6       55.5       60.7       66.4
  A(I)            46.9       46.0       45.5       45.7       47.1
  V(I)            4.00       4.07       4.12       4.10       3.98

X STA.       66.4       72.8       80.0       88.5       99.6      115.9
  A(I)            49.3       51.5       54.7       62.7       79.6
  V(I)            3.80       3.64       3.43       2.99       2.35

X STA.      115.9      138.4      171.1      682.9      825.1      945.3
  A(I)            95.4      110.3      309.3      147.4      137.4
  V(I)            1.97       1.70       0.61       1.27       1.36
```

```
        U.S. Geological Survey WSPRO Input File roch144.wsp
        Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
        State Route 100 Crossing the White River, Rochester, VT            EMB
           *** RUN DATE & TIME: 12-02-96  14:01

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

EXITX:XS   ******   -374     3140  0.36 *****  489.25  487.90   14100  488.89
      -106 ******    715   272220  1.16 ***** *******    0.50    4.49

FULLV:FV      107   -327     2588  0.56  0.38  489.73 *******   14100  489.16
         0    107    711   207921  1.22  0.10    0.00    0.67    5.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  1.56

APPRO:AS      139    -78     3615  0.28  0.41  490.13 *******   14100  489.85
       139    139    953   323680  1.17  0.00    0.00    0.40    3.90
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   496.89       0.00     489.90     487.63

 ===260 ATTEMPTING FLOW CLASS 4 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      107      2      813  1.76  0.47  491.37  486.40    7214  489.61
         0    107     98   121172  1.44  1.66    0.00    0.64    8.87

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   4.  0.834 ******  493.18 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      20.    98.  0.05  0.10  491.86    0.00   6886.  491.16

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:   6886.   415.   329.   744.   3.5   2.3   8.2   7.1   3.0   3.1

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

APPRO:AS       99   -128     5676  0.10  0.35  491.90  488.47   14100  491.79
       139    189    960   639003  1.07  0.17    0.02    0.20    2.48

       M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
      0.908  0.849   95994.   109.   205. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS    -107.  -375.   715.  14100.  272220.    3140.    4.49  488.89
   FULLV:FV       0.  -328.   711.  14100.  207921.    2588.    5.45  489.16
   BRIDG:BR       0.     2.    98.   7214.  121172.     813.    8.87  489.61
   RDWAY:RG      20.*******     0.   6886.       0.*********    1.00  491.16
   APPRO:AS     139.  -129.   960.  14100.  639003.    5676.    2.48  491.79

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     109.   205.   95994.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     487.90    0.50  477.99  512.25************  0.36  489.25  488.89
   FULLV:FV   ********    0.67  478.78  513.04  0.38  0.10  0.56  489.73  489.16
   BRIDG:BR     486.40    0.64  478.78  494.54  0.47  1.66  1.76  491.37  489.61
   RDWAY:RG   ****************  487.63  507.45  0.05******  0.10  491.86  491.16
   APPRO:AS     488.47    0.20  478.53  511.66  0.35  0.17  0.10  491.90  491.79
```

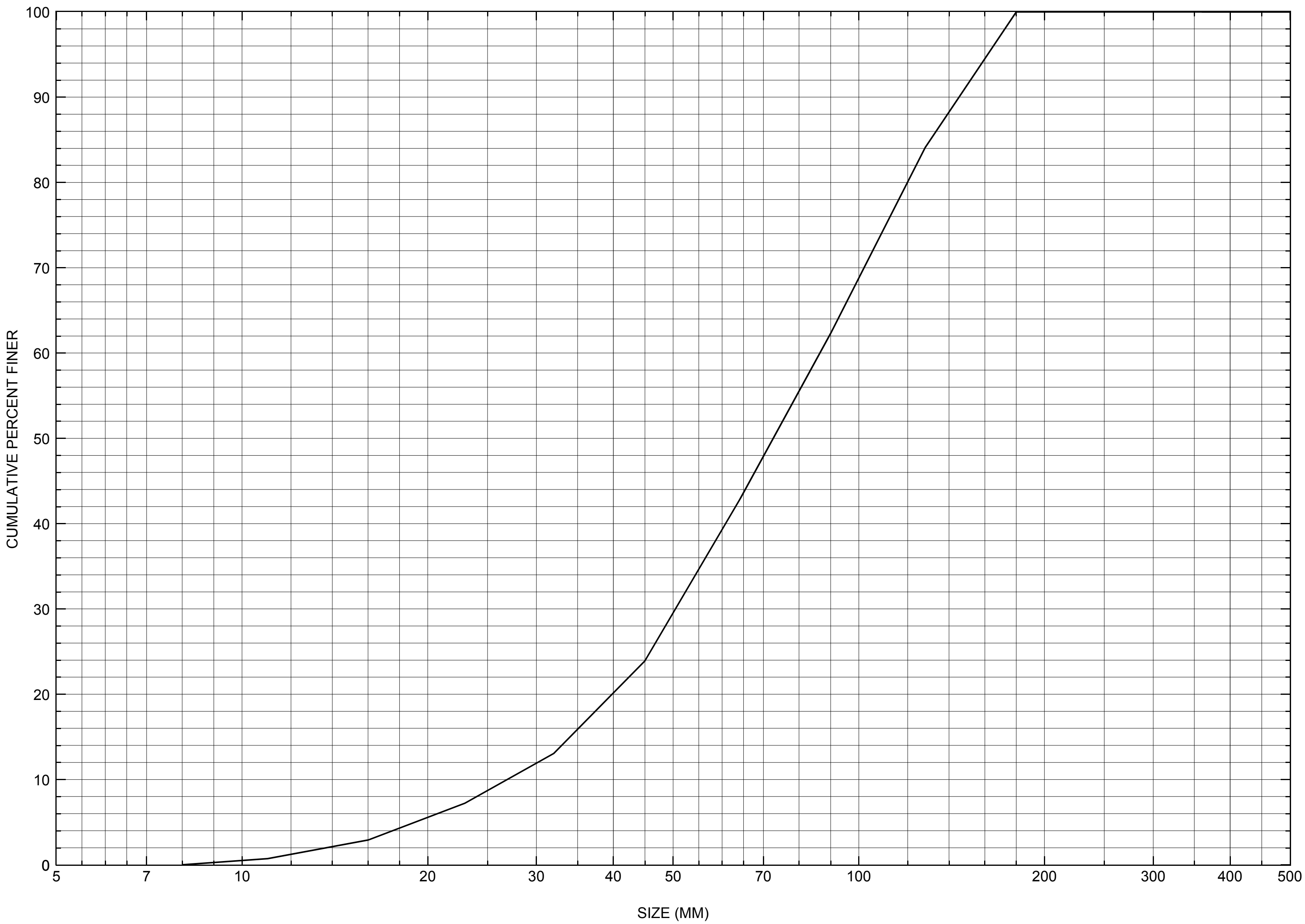
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File roch144.wsp
        Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
        State Route 100 Crossing the White River, Rochester, VT            EMB
           *** RUN DATE & TIME: 12-02-96  14:01

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

EXITX:XS   ******   -377     4058  0.44 *****  490.16  488.47   20800  489.73
      -106 ******    721   401588  1.07 ***** *******    0.49    5.13

FULLV:FV      107   -375     3471  0.63  0.36  490.61 *******   20800  489.98
         0    107    717   316078  1.12  0.09   -0.02    0.63    5.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      139   -101     4452  0.38  0.43  491.03 *******   20800  490.65
       139    139    956   441497  1.11  0.00    0.00    0.42    4.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.66       0.00     492.11     487.63

 ===260 ATTEMPTING FLOW CLASS 4 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      107      0      916  1.95  0.65  492.63  487.21    8570  490.68
         0    107     98   144716  1.43  1.82    0.02    0.64    9.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   4.  0.836 ******  493.18 ****** ****** ******

    XSID:CODE     SRD   FLEN     HF    VHD      EGL      ERR       Q    WSEL
   RDWAY:RG      20.    98.  0.05  0.14  493.25    0.00  12230.  492.32

             Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0. ****** ****** ****** ***** ***** ***** ***** ***** *****
   RT:  12230.   489.   282.   771.   4.7   3.1   9.4   8.2   4.0   3.1

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

APPRO:AS       99   -134     7200  0.14  0.52  493.32  489.02   20800  493.18
       139    196    966   926740  1.05  0.16    0.01    0.20    2.89

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.909  0.905   87919.   157.   255. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -107.  -378.   721.  20800.  401588.    4058.    5.13  489.73
   FULLV:FV       0.  -376.   717.  20800.  316078.    3471.    5.99  489.98
   BRIDG:BR       0.     0.    98.   8570.  144716.     916.    9.35  490.68
   RDWAY:RG      20.*******     0.  12230.       0.*********    1.00  492.32
   APPRO:AS     139.  -135.   966.  20800.  926740.    7200.    2.89  493.18

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     157.   255.   87919.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    488.47    0.49  477.99  512.25************  0.44   490.16  489.73
   FULLV:FV  ********    0.63  478.78  513.04  0.36  0.09  0.63   490.61  489.98
   BRIDG:BR    487.21    0.64  478.78  494.54  0.65  1.82  1.95   492.63  490.68
   RDWAY:RG  ****************  487.63  507.45  0.05******  0.14   493.25  492.32
   APPRO:AS    489.02    0.20  478.53  511.66  0.52  0.16  0.14   493.32  493.18
```

```
        U.S. Geological Survey WSPRO Input File roch144.wsp
        Hydraulic analysis for structure ROCHVT01000144   Date: 23-OCT-96
        State Route 100 Crossing the White River, Rochester, VT            EMB
           *** RUN DATE & TIME: 12-02-96  14:01

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

EXITX:XS   ******   -144     1013  0.32 *****  487.01  483.88    3750  486.69
      -106 ******    699    72433  1.48 ***** *******    0.72    3.70

FULLV:FV      107    -70      651  0.52  0.37  487.49 *******    3750  486.96
         0    107    119    56179  1.01  0.10    0.00    0.54    5.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.81

APPRO:AS      139     -8     1457  0.18  0.34  487.82 *******    3750  487.65
       139    139    942   101595  1.71  0.00   -0.01    0.46    2.57
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   487.83       0.00     486.64     487.63

 ===260 ATTEMPTING FLOW CLASS 4 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      107      8      539  0.90  0.32  487.54  484.03    3750  486.64
         0    107     96    65790  1.20  0.21    0.00    0.54    6.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   4.  0.912 ******  493.18 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      20.        <<<<<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       99     -8     1629  0.14  0.26  487.97  484.30    3750  487.83
       139    137    945   112597  1.72  0.17    0.01    0.41    2.30

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.906  0.375   70028.    20.   108. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS    -107.  -145.   699.   3750.   72433.    1013.    3.70  486.69
   FULLV:FV       0.   -71.   119.   3750.   56179.     651.    5.76  486.96
   BRIDG:BR       0.     8.    96.   3750.   65790.     539.    6.95  486.64
   RDWAY:RG      20.**************      0.       0.       0.    1.00********
   APPRO:AS     139.    -9.   945.   3750.  112597.    1629.    2.30  487.83

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      20.   108.   70028.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    483.88    0.72  477.99  512.25************  0.32  487.01  486.69
   FULLV:FV  ********    0.54  478.78  513.04  0.37  0.10  0.52  487.49  486.96
   BRIDG:BR    484.03    0.54  478.78  494.54  0.32  0.21  0.90  487.54  486.64
   RDWAY:RG  ****************  487.63  507.45  0.11******  0.14  487.85********
   APPRO:AS    484.30    0.41  478.53  511.66  0.26  0.17  0.14  487.97  487.83
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect in the channel approach of structure ROCHVT01000144, in Rochester, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ROCHVT01000144

General Location Descriptive

Data collected by *(First Initial, Full last name)* L. MEDALIE

Date *(MM/DD/YY)* 03 / 08 / 95

Highway District Number *(I - 2; nn)* 04

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 60100

Mile marker *(I - 11; nnn.nnn)* 007230

Waterway *(I - 6)* White River

Road Name *(I - 7):* -

Route Number VT100

Vicinity *(I - 9)* 2.6 MI N JCT. VT.73

Topographic Map Hancock

Hydrologic Unit Code:

Latitude *(I - 16; nnnn.n)* 43539

Longitude *(i - 17; nnnnn.n)* 72493

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20001301441415

Maintenance responsibility *(I - 21; nn)* 01

Maximum span length *(I - 48; nnnn)* 0101

Year built *(I - 27; YYYY)* 1983

Structure length *(I - 49; nnnnnn)* 000103

Average daily traffic, ADT *(I - 29; nnnnnn)* 001990

Deck Width *(I - 52; nn.n)* 412

Year of ADT *(I - 30; YY)* 92

Channel & Protection *(I - 61; n)* 7

Opening skew to Roadway *(I - 34; nn)* 05

Waterway adequacy *(I - 71; n)* 8

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

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

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 97.5

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

Vertical clearance from streambed (*nnn.n ft*) 18.7

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

Waterway of full opening (*nnn.n ft*^{2}) 1820

Comments:

The structural inspection report of 9/30/93 indicates the structure is a single span, steel stringer type bridge. The left abutment wall has some cracking with leakage reported. The wingwalls of the left abutment are in good condition, with the exception of some minor cracking noted. Both abutments are protected with stone fill. The channel takes a moderate turn into the structure, and currently flows along the right abutment side, predominantly. There is a sand and stone point bar deposited on the left abutment side of channel. The footings are not exposed and no apparent settlement has occurred. Minor channel scour along right abutment is reported.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: **68.85**

Terrain character: **Rolling hills to mountainous**

Stream character & type: **Tributary of the Connecticut River; type-meandering.**

Streambed material: **Sand-gravel**

Discharge Data *(cfs)*: $Q_{2.33}$ **2800** Q_{10} **6500** Q_{25} **10200**
Q_{50} **13000** Q_{100} **15500** Q_{500} **-**

Record flood date *(MM / DD / YY)*: **-** / **-** / **27** Water surface elevation *(ft)*: **856.0**

Estimated Discharge *(cfs)*: **-** Velocity at Q **50** *(ft/s)*: **5.7**

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: **Stage is not affected by downstream conditions**

Watershed storage area (*in percent*): **1** %

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

Water Surface Elevation Estimates for Existing Structure:

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	**848.6**	**851.9**	**854.1**	**855.2**	**856.3**
Velocity (*ft / sec*)	**5.2**	**7.3**	**9.2**	**10.4**	**11.8**

Long term stream bed changes: -

Is the roadway overtopped below the Q_{100}? (*Yes, No, Unknown*): **Y** Frequency: **Q5**

Relief Elevation (*ft*): **850.0** Discharge over roadway at Q_{100} (*ft^3/ sec*):

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

Upstream distance (*miles*): **1.7** Town: **Hancock** Year Built: **-**

Highway No. : **TH-1** Structure No. : **10** Structure Type: **-**

Clear span (*ft*): **86** Clear Height (*ft*): **8** Full Waterway (*ft^2*): **688**

Downstream distance (*miles*): **1.0** Town: **-** Year Built: **-**
Highway No. : **TH-18** Structure No. : **29** Structure Type: **-**
Clear span (*ft*): **58** Clear Height (*ft*): **18** Full Waterway (ft^2): **1044**

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **68.91** mi^2 Lake and pond area **0.04** mi^2
Watershed storage *(ST)* **0.1** %
Bridge site elevation **840** ft Headwater elevation **3780** ft
Main channel length **12.4** mi
10% channel length elevation **860** ft 85% channel length elevation **1760** ft
Main channel slope *(S)* **96.77** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in
Maximum 2yr-24hr precipitation event *(I24,2)* ______ in
Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* 03 / 1982

Project Number BRF 013-4(6)S Minimum channel bed elevation: 840.5

Low superstructure elevation: USLAB 856.85 DSLAB 856.94 USRAB 853.95 DSRAB 854.34

Benchmark location description:

Chiseled square on top of the upstream end of the upstream left wingwall on the old bridge which crossed just upstream, elevation 853.95. This may no longer exist.

Reference Point (*MSL, Arbitrary, Other*): MSL Datum (*NAD27, NAD83, Other*): NGVD1929

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 842.0*

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

If 3: Footing bottom elevation: -

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 2

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

Briefly describe material at foundation bottom elevation or around piles:

Sandy gravel

Comments:

***The right abutment has a proposed bottom elevation as shown above. However, the bottom of footing elevation proposed on the left abutment is 4 feet higher at 846.0. This is also shown in the copy of the boring data in the folder. The abutments appear to be the flow through type in the plans.**

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **09/27/96**
Computerized by: **RB** Date: **09/27/96**
Reviewd by: **EMB** Date: **12/2/96**

Structure Number **ROCHVT01000144**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **WILD** Date *(MM/DD/YY)* **07** / **22** / 19**96**

2. Highway District Number **04** Mile marker **007230**

County **Windsor (027)** Town **Rochester (60100)**

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

Route Number **VT100** Hydrologic Unit Code: **01080105**

3. Descriptive comments:

Located 2.6 miles north of junction with VT 73. This is a single span, steel stringer type bridge. Plaque on the bridge stamped with project number '013-4(6)S' and dated 1983.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** Overall **4**
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*

5. Ambient water surface... US **2** UB **2** DS **2** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **103** *(feet)* Span length **101** *(feet)* Bridge width **41.2** *(feet)*

Road approach to bridge:

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

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

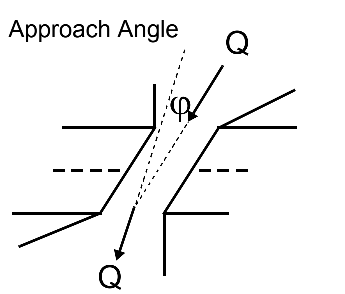
10. Embankment slope (*run / rise in feet / foot*):
US left **1.3:1** US right **1.3:1**

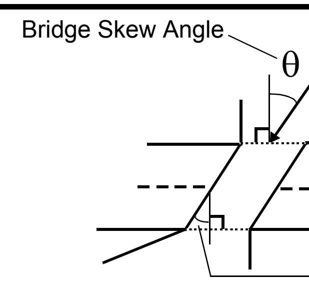
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **5** 16. Bridge skew: **10**





α= **5.0**

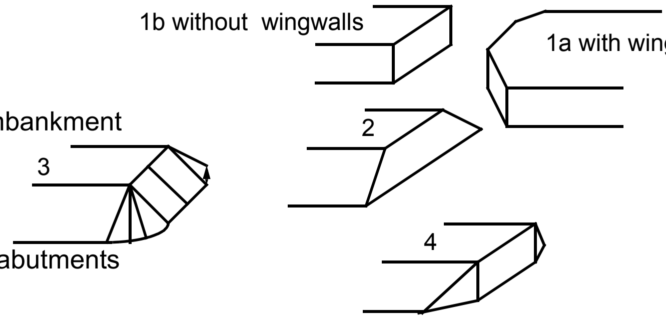
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **250** feet **US** *(US, UB, DS)* to **47** feet **US**

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

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

18. Bridge Type: 3

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face
3- Spill through abutments
4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



19. Bridge Deck Comments (surface cover variations, measured bridge and span lengths, bridge type variations, approach overflow width, etc.)

7. Values are from the VT AOT files. Measured bridge dimensions are the same.
10. Embankment slopes were not surveyed and could not be computed. However, both were estimated for hydraulic analysis based on discussion with the personnel in the field at this site. The slope on each side was estimated at 1.3:1.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
110.0	8.0			1.5	2	2	324	324	1	1

23. Bank width 30.0 24. Channel width 25.0 25. Thalweg depth 132.0 29. Bed Material 432

30 .Bank protection type: LB 2 RB 1 31. Bank protection condition: LB 1 RB 1

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

32. Comments (bank material variation, minor inflows, protection extent, etc.):

30. The right bank protection extends from 0 ft. US to 24 ft. US. The left bank protection is from 87 ft. US to 0 ft. US and extends an additional 20 ft. along the left bank of the confluence from where it enters the White River.
The river is locally anabranched. From 335 ft. US to 124 ft. US there is a channel bar positioned from 30% LB to 50% RB. It is comprised of gravel and cobbles and is vegetated with grass and small bushes.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 86 35. Mid-bar width: 19.5

36. Point bar extent: 194 feet US (US, UB) to 45 feet US (US, UB, DS) positioned 80 %LB to 95 %RB

37. Material: 324

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

On the left side of this point bar at mid-bar distance is where the confluence enters into the White River. The point bar is more vegetated on the US end and grades from fine to coarse moving from right to left. An additional bar is from 90 ft. US to 65 ft. US. It is comprised of cobble and is vegetated with grass. It is positioned from 25% LB to 40% RB and the mid-bar distance is at 87 ft. US.

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

41. Mid-bank distance: 108 42. Cut bank extent: 161 feet US (US, UB) to 95 feet US (US, UB, DS)

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

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

-

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 60

47. Scour dimensions: Length 33 Width 14 Depth : 0.5 Position 45 %LB to 55 %RB

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

Scour depth assumes a thalweg depth of 3 ft.

49. Are there major confluences? Y (Y or if N type ctrl-n mc) 50. How many? 1

51. Confluence 1: Distance 87 52. Enters on LB (LB or RB) 53. Type 1 (**1**- perennial; **2**- ephemeral)

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

54. Confluence comments (eg. confluence name):

The tributary is Marshs brook.

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
117.5		3.0		2	7	7	-

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

*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*

*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*

64. Comments (bank material variation, minor inflows, protection extent, etc.):

324

Bank material in front of the even abutments is dumped type 2 stone.

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

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

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

70. Debris and Ice Comments:

1

66. There is also debris accumulated DS and in the US confluence.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	27	0	0	-	-	90.0
RABUT	1	0	28			0	0	98.5

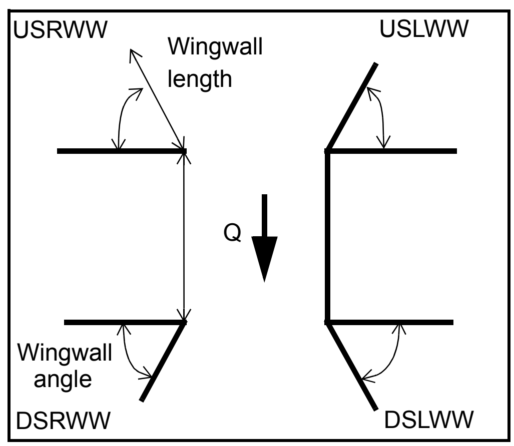
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						65.8	
USRWW:	N		-		-	2.0	
DSLWW:	-		-		N	40.0	
DSRWW:	-		-		-	40.0	



Wingwall materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	2	2	-

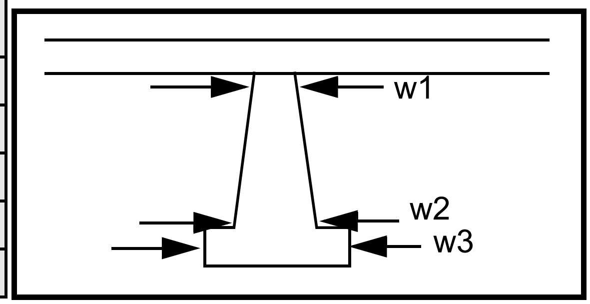
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? _-____ *(Y or if N type ctrl-n pr)*

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	N	-	-	-	
98. Exposure depth	-	-	-	-	

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

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-	-	NO	PIE	RS		

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

Bank protection type (Qmax): LB _____ RB _____ Bank protection condition: LB _____ RB _____

SRD - Section ref. dist. to US face *% Vegetation (Veg) cover: **1**- 0 to 25%; **2**- 26 to 50%; **3**- 51 to 75%; **4**- 76 to 100%*
*Bed and bank Material: **0**- organics; **1**- silt / clay, < 1/16mm; **2**- sand, 1/16 - 2mm; **3**- gravel, 2 - 64mm; **4**- cobble, 64 - 256mm; **5**- boulder, > 256mm; **6**- bedrock; **7**- manmade*
*Bank Erosion: **0**- not evident; **1**- light fluvial; **2**- moderate fluvial; **3**- heavy fluvial / mass wasting*
*Bank protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

Comments (eg. bank material variation, minor inflows, protection extent, etc.):

1
1
324
234
1
1
4352
2
2
1
1
The left and the right bank protection is an extension of the abutment protection. On the left bank it extends from 0 ft. DS to 30 ft. DS and on the right bank it is from 0 ft. DS to 22 ft. DS.

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

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

105. Drop structure comments (eg. downstream scour depth):

106. Point/Side bar present? _____ *(Y or N. if N type ctrl-n pb)* Mid-bar distance: ______ Mid-bar width: ______

Point bar extent: ______ feet ____ *(US, UB, DS)* to **N** feet **-** *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

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

STRUCTURE

Is a cut-bank present? _____ *(Y or if N type ctrl-n cb)* Where? _____ *(LB or RB)* Mid-bank distance: **Y**

Cut bank extent: **334** feet **163** *(US, UB, DS)* to **220** feet **DS** *(US, UB, DS)*

Bank damage: **435** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
15
85
43

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

Scour dimensions: Length **chan** Width **nel** Depth: **bar** Positioned **wh** %LB to **ere** %RB

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

the stream is anabranched. On either side of the bar it is vegetated with small clumps of brush and grass.

N

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

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

Confluence 2: Distance **-** Enters on **-** *(LB or RB)* Type **NO** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

CUT BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

1- *Constructed*
2- *Stable*
3- *Aggraded*
4- *Degraded*
5- *Laterally unstable*
6- *Vertically and laterally unstable*

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N
-
-
-
-
-
-
NO CHANNEL SCOUR

N

109. G. Plan View Sketch

-

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ROCHVT01000144 Town: Rochester
Road Number: VT 100 County: Windsor
Stream: White River

Initials EMB Date: 12/2/96 Checked: SAO 12/3/96

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	14100	20800	3750
Main Channel Area, ft2	1198	1356	754
Left overbank area, ft2	229	397	0
Right overbank area, ft2	4245	5443	873
Top width main channel, ft	113	113	110
Top width L overbank, ft	117	124	0
Top width R overbank, ft	859	864	844
D50 of channel, ft	0.2382	0.2382	0.2382
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	10.6	12.0	6.9
y1, average depth, LOB, ft	2.0	3.2	ERR
y1, average depth, ROB, ft	4.9	6.3	1.0
Total conveyance, approach	638413	925723	112448
Conveyance, main channel	168237	206569	79216
Conveyance, LOB	11866	28548	0
Conveyance, ROB	458310	690605	33232
Percent discrepancy, conveyance	0.0000	0.0001	0.0000
Qm, discharge, MC, cfs	3715.7	4641.4	2641.8
Ql, discharge, LOB, cfs	262.1	641.4	0.0
Qr, discharge, ROB, cfs	10122.2	15517.2	1108.2
Vm, mean velocity MC, ft/s	3.1	3.4	3.5
Vl, mean velocity, LOB, ft/s	1.1	1.6	ERR
Vr, mean velocity, ROB, ft/s	2.4	2.9	1.3
Vc-m, crit. velocity, MC, ft/s	10.3	10.5	9.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1198	1356	754
Main channel width, ft	113	113	110
y1, main channel depth, ft	10.60	12.00	6.85
Bridge Section			
(Q) total discharge, cfs	14100	20800	3750
(Q) discharge thru bridge, cfs	7214	8570	3750
Main channel conveyance	121169	144690	65839
Total conveyance	121169	144690	65839
Q2, bridge MC discharge,cfs	7214	8570	3750
Main channel area, ft2	813	916	540
Main channel width (skewed), ft	75.3	82.3	74.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	75.3	82.3	74.6
y_bridge (avg. depth at br.), ft	10.80	11.13	7.23
Dm, median (1.25*D50), ft	0.29775	0.29775	0.29775
y2, depth in contraction,ft	8.73	9.38	5.03
ys, scour depth (y2-ybridge), ft	-2.06	-1.75	-2.21
ARMORING			
D90	0.4768	0.4768	0.4768
D95	0.5307	0.5307	0.5307
Critical grain size,Dc, ft	0.2513	0.2764	0.1788
Decimal-percent coarser than Dc	0.42	0.38	0.625
Depth to armoring,ft	1.04	1.35	0.32

Abutment Scour

Froehlich's Abutment Scour
Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1
(Richardson and others, 1995, p. 48, eq. 28)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	14100	20800	3750	14100	20800	3750
a', abut.length blocking flow, ft	140.9	146.2	23.6	873.2	872.4	856.1
Ae, area of blocked flow ft2	425.9	615.8	121.7	3409	4034.1	938.2
Qe, discharge blocked abut.,cfs	746.1	1241.7	331.9	--	--	1300.7
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.75	2.02	2.73	2.40	2.86	1.39
ya, depth of f/p flow, ft	3.02	4.21	5.16	3.90	4.62	1.10
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.178	0.173	0.212	0.189	0.200	0.233
ys, scour depth, ft	9.93	12.56	9.99	21.84	25.06	10.90

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	140.9	146.2	23.6	873.2	872.4	856.1
y1 (depth f/p flow, ft)	3.02	4.21	5.16	3.90	4.62	1.10
a'/y1	46.61	34.71	4.58	223.67	188.66	781.18
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.18	0.17	0.21	0.19	0.20	0.23
Ys w/ corr. factor K1/0.55:						
vertical	12.55	17.35	ERR	16.06	19.38	4.83
vertical w/ ww's	10.29	14.22	ERR	13.17	15.89	3.96
spill-through	6.90	9.54	ERR	8.83	10.66	2.66

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.64	0.64	0.54	0.64	0.64	0.54
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	10.80	11.13	7.23	10.80	11.13	7.23
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (spillthrough abut.)	2.39	2.46	1.14	2.39	2.46	1.14
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR