LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (BRIGVT01140027) on STATE HIGHWAY 114, crossing PHERRINS RIVER, BRIGHTON, VERMONT

U.S. Geological Survey
Open-File Report 97-207

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 27 (BRIGVT01140027) on STATE HIGHWAY 114, crossing PHERRINS RIVER, BRIGHTON, VERMONT

By ERICK M. BOEHMLER

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
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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 27 (BRIGVT01140027) ON STATE HIGHWAY 114, CROSSING PHERRINS RIVER, BRIGHTON, VERMONT

By **Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRIGVT01140027 on state highway 114 crossing the Pherrins River, Brighton, 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 assessment is included in Appendix E of this report. A Level I assessment provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from VTAOT files, was compiled prior to conducting Level I and Level II analyses and is provided in Appendix D.

The site is in the White Mountain section of the New England physiographic province of northeastern Vermont in the town of Brighton. The 19.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the overall surface cover is forest except for the upstream right bank side which is shrub and brush covered and the downstream left bank side which has grass and row crops on the overbank and shrubs on the immediate bank.

In the study area, the Pherrins River has a sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 40 ft and an average channel depth of 3 ft. The predominant channel bed material is gravel (D_{50} is 54.6 mm or 0.179 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 5, 1995, indicated that the reach was laterally unstable.

The state highway 114 crossing of the Pherrins River is a 28-ft-long, two-lane bridge consisting of one 24-foot concrete span (Vermont Agency of Transportation, written communication, August 5, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately five degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the left abutment wall during the Level I assessment. The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) on the banks upstream, each wingwall, and

the left bank downstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D
and E.

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

Contraction scour for all modelled flows ranged from 1.0 to 3.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 12.7 to 16.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 BRIGVT01140027 ***Stream*** Pherrins River

County Essex ***Road*** VT 114 ***District*** 09

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 34.0 ***ft*** ***Max span length*** 24 ***ft***

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

Abutment type Vertical concrete ***Embankment type*** Sloping

Stone fill on abutment? No ***Date of inspection*** 7/5/95

Description of stone fill Type-2, on each wingwall, the banks upstream, and the left bank downstream.

Abutments and wingwalls are concrete. There is a 1.5 ft deep scour hole in front of the left abutment.

Y 5

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

There is a moderate channel bend in the upstream reach. The scour hole has developed in the location where the bend impacts the upstream end of the left abutment.

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	7/5/95	0	0
Level II	7/5/95	--	--

Potential for debris Low.

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

None evident on 7/5/95.

Description of the Geomorphic Setting

General topography The channel is located in a narrow, moderate relief valley setting with a narrow, flat to slightly irregular flood plain and steep valley walls on both sides.

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

Date of inspection 7/5/95

DS left: Gradually sloping bank to a narrow, flat flood plain

DS right: Steep bank with a narrow, irregular flood plain.

US left: Moderately sloping bank and narrow flood plain

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

Description of the Channel

Average top width 40 ft ***Average depth*** 3 ft

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

Sinuous and narrow with semi-alluvial channel boundaries.

7/5/95

Vegetative co Shrubs with grass and row crops on the overbank.

DS left: Shrubs and brush with a few scattered trees.

DS right: Shrubs, brush and grass.

US left: Shrubs and brush with a few trees on the overbank.

US right: N

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

There is a cut-bank evident on the upstream left bank. Cut-bank development is noted as impeded by stone fill on the left bank downstream. The stone fill evident on the left bank downstream restrains the channel in its current narrow and straight configuration.

The assessment of 7/5/95 noted a larger boulder fraction of the bed material downstream. It is unclear whether the boulders are native or a product of the stone fill lining the left side of the channel downstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 19.4 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province / Section	***Percent of drainage area***
New England/ White Mountain	100

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

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

USGS gage description

USGS gage number

Gage drainage area ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,480 ***ft³/s*** ***Q500*** 3,550 ***ft³/s***

The 100- and 500-year discharges were selected based on the range of results from several empirical equations (Benson, 1964; FHWA, 1983; Johnson and Tasker, 1974; Potter, 1957; and Talbot, 1887) and frequency estimates 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 None

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled "X" on top of the DS end of the right abutment (elev. 500.68 ft, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of the US end of the left abutment (elev. 499.73 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	-26	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APTEM	55	1	Approach section as surveyed (Used as a template)
APPR1	60	2	Modelled Approach section (Templated from APTEM)

[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, 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 0.050, and overbank "n" values ranged from 0.035 to 0.060.

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 0.01 ft/ft which was estimated from surveyed thalweg points downstream of the site.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0318 ft/ft) to establish the modelled approach section (APPR1), 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.

For the 100-year discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 502.0 ***ft***
Average low steel elevation 498.0 ***ft***

100-year discharge 2,480 ***ft^3/s***
Water-surface elevation in bridge opening 493.5 ***ft***
Road overtopping? N ***Discharge over road*** 0 ***ft^3/s***
Area of flow in bridge opening 167 ***ft^2***
Average velocity in bridge opening 14.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 18.8 ***ft/s***

Water-surface elevation at Approach section with bridge 497.9
Water-surface elevation at Approach section without bridge 495.7
Amount of backwater caused by bridge 2.2 ***ft***

500-year discharge 3,550 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Y ***Discharge over road*** 275 ***ft^3/s***
Area of flow in bridge opening 275 ***ft^2***
Average velocity in bridge opening 11.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.5 ***ft/s***

Water-surface elevation at Approach section with bridge 501.7
Water-surface elevation at Approach section without bridge 496.8
Amount of backwater caused by bridge 4.9

Incipient overtopping discharge 2,750 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Area of flow in bridge opening 275 ***ft^2***
Average velocity in bridge opening 10.0 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.3 ***ft/s***

Water-surface elevation at Approach section with bridge 500.2
Water-surface elevation at Approach section without bridge 496.0
Amount of backwater caused by bridge 4.2 ***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 for the 100-year discharge was computed by use of the Laursen's 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. The 500-year and incipient roadway overtopping discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 500-year and incipient roadway overtopping events was computed by use of the Chang equation (Richardson and others, 1995, P. 145-146). The results of Laursen's clear-water contraction scour for the 500-year and incipient roadway otertopping events were also computed and can be found in appendix F. In this case, the 500-year discharge model resulted in the worst case contraction scour with a scour depth of 3.4 ft. The armoring depths computed suggest that streambed armoring will not limit the depth of contraction scour.

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

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	3.2	3.4	1.0
Depth to armoring	N/A	13.6	3.2
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	14.9	16.7	16.3
Right abutment	12.7	16.4	14.4
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	2.9	2.7	1.9
Right abutment	2.9	2.7	1.9
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

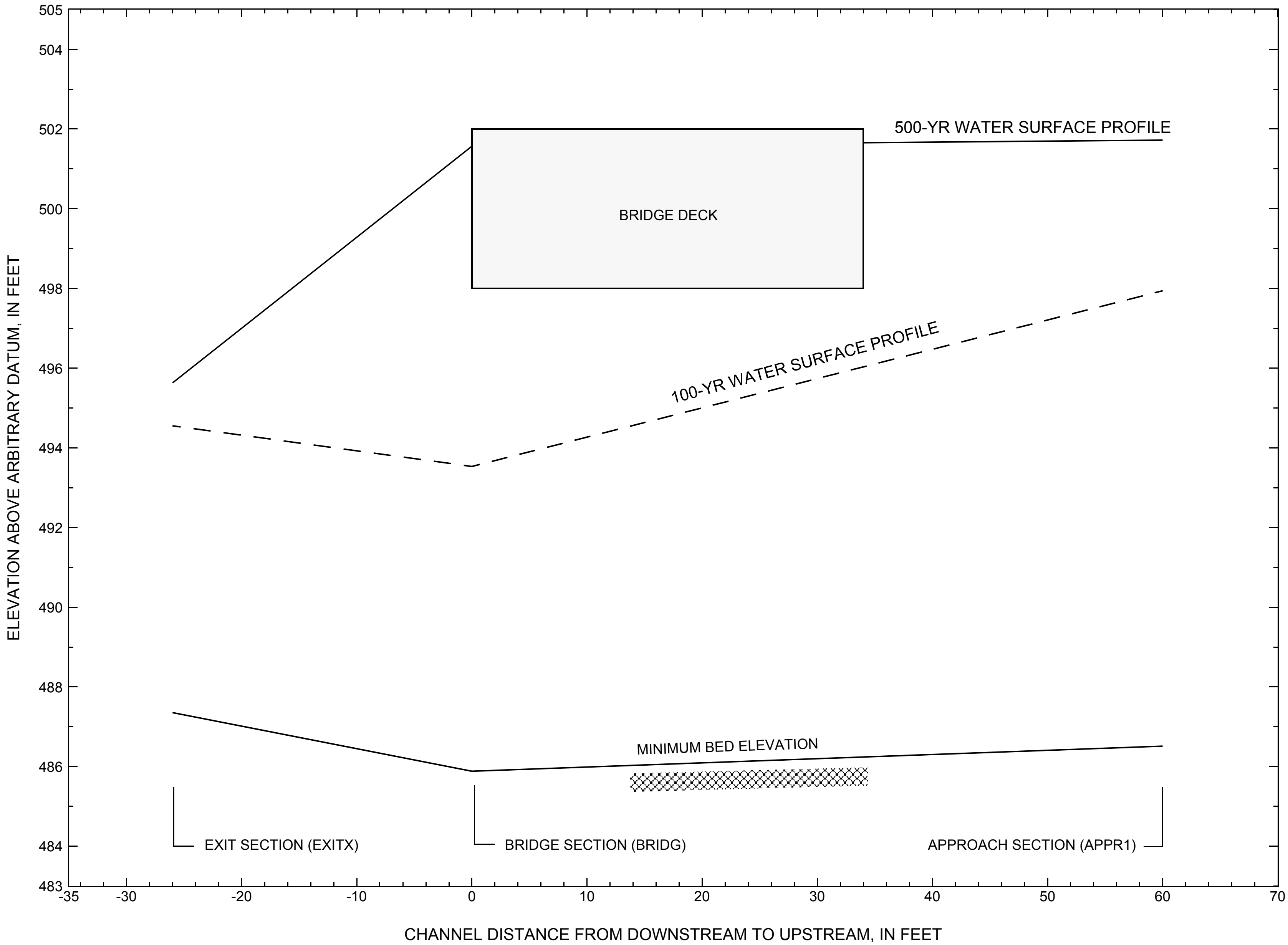

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BRIGVT01140027 on state highway 114, crossing the Pherrins River, Brighton, Vermont.

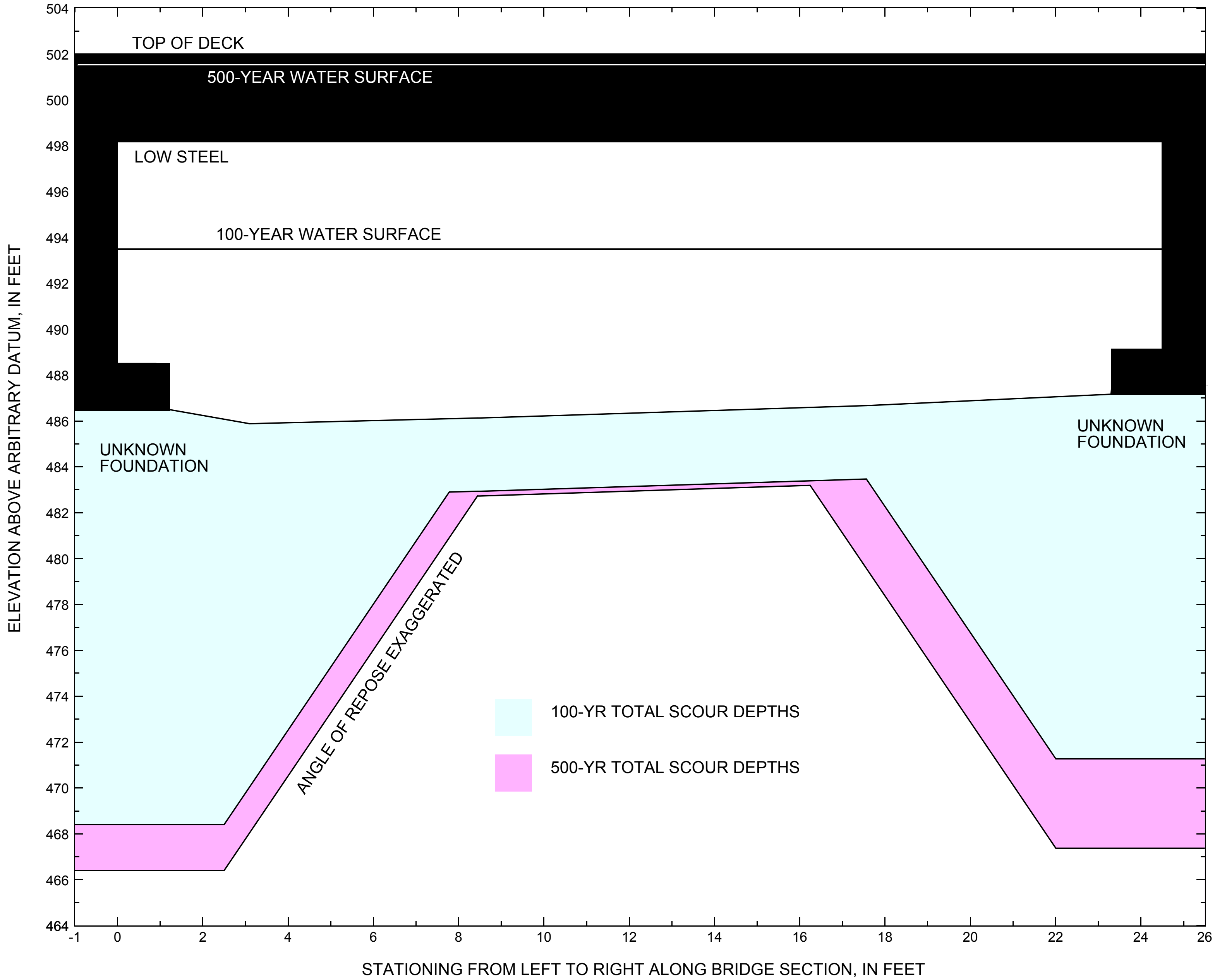

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BRIGVT01140027 on state highway 114, crossing the Pherrins River, Brighton, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRIGVT01140027 on State Highway 114, crossing the Pherrins River, Brighton, 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 2,480 cubic-feet per second											
Left abutment	0.0	--	498.0	--	486.5	3.2	14.9	--	18.1	468.4	--
Right abutment	24.5	--	498.0	--	487.2	3.2	12.7	--	15.9	471.3	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure BRIGVT01140027 on State Highway 114, crossing the Pherrins River, Brighton, 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 3,550 cubic-feet per second											
Left abutment	0.0	--	498.0	--	486.5	3.4	16.7	--	20.1	466.4	--
Right abutment	24.5	--	498.0	--	487.2	3.4	16.4	--	19.8	467.4	--

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

SELECTED REFERENCES

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

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

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

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

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

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

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

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 p.

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

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

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

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

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

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

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

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

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

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

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

U.S. Geological Survey, 1988, Island Pond, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps; Aerial photography, 1983; Contour interval, 20 feet; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File brig027.wsp
T2        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
T3        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
Q           2480.0,   3550.0,   2750.0
SK          0.0100,   0.0100,   0.0100
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
XS   EXITX    -26           0.
GR         -114.3, 499.70    -98.1, 497.49    -12.4, 494.02     -7.3, 491.10
GR            0.0, 488.41      4.4, 487.58     11.2, 487.35     16.6, 487.62
GR           23.6, 488.31     28.8, 488.54     31.1, 491.10     48.9, 494.10
GR           69.2, 496.04     96.0, 499.86    105.1, 501.41    126.1, 501.16
GR          246.1, 505.29    258.9, 510.35
*
N           0.035        0.050        0.040
SA                  -12.4         31.1
*
*
XS   FULLV      0  * * *   0.0000
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    497.99       0.0
GR            0.0, 497.99      0.3, 488.44      0.9, 488.55      1.2, 486.50
GR            3.1, 485.88      8.5, 486.13     17.4, 486.66     23.3, 487.17
GR           23.4, 489.11     24.2, 489.12     24.5, 497.99      0.0, 497.99
*
*        BRTYPE  BRWDTH    EMBSS   EMBELV   WWANGL
CD            4     35.6      2.8    499.8     44.8
N           0.040
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     18       34.0     1
GR         -277.4, 503.63    -81.3, 500.27    -73.7, 500.27    -73.6, 501.69
GR            0.0, 501.93     24.3, 502.10     64.8, 502.42     64.8, 501.09
GR          129.8, 502.19    199.6, 504.87    352.6, 514.54    376.2, 518.80
*
XT   APTEM     55
GR          -87.2, 507.37    -56.5, 496.00    -10.8, 491.18     -7.5, 488.64
GR            0.0, 487.74      3.9, 486.56     11.4, 486.35     18.5, 487.44
GR           25.0, 488.57     31.4, 492.38     82.0, 497.16    120.5, 500.02
GR          181.3, 502.82    243.0, 506.33
*
AS   APPR1     60  *  *  *  0.0318
GT
N           0.060        0.045        0.035
SA                 -10.8         31.4
*
HP 1 BRIDG   493.53 1 493.53
HP 2 BRIDG   493.53 * * 2480
HP 1 APPR1   497.94 1 497.94
HP 2 APPR1   497.94 * * 2480
*
HP 1 BRIDG   497.99 1 497.99
HP 2 BRIDG   497.99 * * 3243
HP 2 RDWAY   501.57 * *  275
HP 1 APPR1   501.72 1 501.72
HP 2 APPR1   501.72 * * 3550
*
HP 1 BRIDG   497.99 1 497.99
HP 2 BRIDG   497.99 * * 2750
HP 1 APPR1   500.23 1 500.23
HP 2 APPR1   500.23 * * 2750
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     167.  16893.    24.    37.                        2483.
   493.53          167.  16893.    24.    37.  1.00     0.    24.   2483.

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

         WSEL     LEW     REW    AREA       K        Q    VEL
       493.53     0.1    24.3   166.7   16893.    2480.  14.87

 X STA.        0.1        2.8        4.0        5.1        6.1        7.1
  A(I)            16.5        9.6        8.2        7.8        7.1
  V(I)            7.50      12.98      15.18      16.00      17.34

 X STA.        7.1        8.0        8.9        9.8       10.8       11.7
  A(I)             7.0        6.8        6.8        6.7        6.6
  V(I)           17.83      18.28      18.27      18.63      18.77

 X STA.       11.7       12.6       13.5       14.5       15.5       16.5
  A(I)             6.7        6.7        6.9        6.9        7.1
  V(I)           18.50      18.64      17.94      17.90      17.41

 X STA.       16.5       17.6       18.7       20.0       21.5       24.3
  A(I)             7.3        7.9        8.3        9.8       16.1
  V(I)           16.92      15.69      14.99      12.61       7.68

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     196.  11910.    51.    51.                        2188.
             2     412.  60104.    42.    45.                        7302.
             3     155.  12527.    59.    59.                        1425.
   497.94          763.  84542.   152.   155.  1.35   -61.    90.   8343.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

         WSEL     LEW     REW    AREA       K        Q    VEL
       497.94   -61.3    90.4   762.7   84542.    2480.   3.25

 X STA.      -61.3      -30.3      -18.1       -9.6       -5.9       -2.8
  A(I)            87.4       63.1       53.6       32.9       29.5
  V(I)            1.42       1.96       2.31       3.77       4.21

 X STA.       -2.8        0.1        2.8        5.1        7.4        9.7
  A(I)            27.8       28.3       26.5       25.6       25.8
  V(I)            4.45       4.38       4.68       4.84       4.81

 X STA.        9.7       11.9       14.3       16.8       19.4       22.4
  A(I)            25.9       26.2       27.0       27.3       29.6
  V(I)            4.79       4.74       4.59       4.54       4.19

 X STA.       22.4       25.7       31.2       39.0       50.0       90.4
  A(I)            30.3       39.8       39.3       45.9       70.8
  V(I)            4.09       3.12       3.15       2.70       1.75
```

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        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     275.   25416.     0.    71.                           0.
   497.99          275.   25416.     0.    71.  1.00     0.    25.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.99     0.0    24.5   275.4   25416.    3243.  11.78

X STA.         0.0        2.5        3.9        5.0        6.0        7.0
  A(I)            26.1       15.8       13.6       12.3       12.0
  V(I)            6.22      10.26      11.95      13.23      13.47

X STA.         7.0        8.0        9.0       10.0       10.9       11.9
  A(I)            11.7       11.6       11.4       11.3       11.2
  V(I)           13.82      13.93      14.17      14.41      14.48

X STA.        11.9       12.8       13.8       14.8       15.8       16.9
  A(I)            11.4       11.4       11.4       11.5       12.1
  V(I)           14.20      14.27      14.17      14.07      13.43

X STA.        16.9       18.0       19.1       20.4       21.8       24.5
  A(I)            12.5       12.7       13.6       15.8       25.9
  V(I)           13.01      12.73      11.88      10.27       6.26

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      18.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.57  -157.2    93.2    66.1    2084.     275.   4.16

X STA.      -157.2     -128.6     -120.0     -114.1     -109.1     -105.1
  A(I)             7.0        4.8        4.1        3.9        3.5
  V(I)            1.97       2.84       3.36       3.57       3.97

X STA.      -105.1     -101.6      -98.4      -95.7      -93.0      -90.7
  A(I)             3.2        3.1        2.9        2.8        2.7
  V(I)            4.27       4.45       4.78       4.91       5.18

X STA.       -90.7      -88.5      -86.4      -84.5      -82.7      -81.0
  A(I)             2.5        2.4        2.4        2.3        2.2
  V(I)            5.45       5.62       5.82       6.06       6.12

X STA.       -81.0      -79.3      -77.6      -75.9      -74.0       93.2
  A(I)             2.2        2.2        2.2        2.5        7.2
  V(I)            6.26       6.28       6.33       5.41       1.90

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     406.   35307.    61.    62.                        5958.
             2     571.  103713.    42.    45.                       11932.
             3     484.   51339.   123.   123.                        5454.
   501.72         1461.  190359.   225.   229.  1.32   -72.   154.  18378.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.72   -71.5   154.0  1461.2  190359.    3550.   2.43

X STA.       -71.5      -40.7      -27.5      -17.2       -8.9       -4.6
  A(I)           142.6      105.1       94.0       85.4       55.5
  V(I)            1.25       1.69       1.89       2.08       3.20

X STA.        -4.6       -0.8        2.8        6.0        9.2       12.3
  A(I)            51.7       50.6       47.8       47.7       47.9
  V(I)            3.43       3.51       3.71       3.72       3.71

X STA.        12.3       15.6       19.1       22.9       27.3       34.1
  A(I)            48.4       49.8       51.8       56.6       67.2
  V(I)            3.66       3.57       3.42       3.14       2.64

X STA.        34.1       41.7       50.7       62.4       79.8      154.0
  A(I)            64.9       70.0       79.9       94.5      150.0
  V(I)            2.74       2.54       2.22       1.88       1.18
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        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     275.   25416.     0.    71.                          0.
   497.99          275.   25416.     0.    71.  1.00     0.    25.      0.

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.99     0.0    24.5   275.4   25416.    2750.   9.99

X STA.         0.0        2.5        3.9        5.0        6.0        7.0
  A(I)            26.1       15.8       13.6       12.3       12.0
  V(I)            5.27       8.70      10.13      11.22      11.42

X STA.         7.0        8.0        9.0       10.0       10.9       11.9
  A(I)            11.7       11.6       11.4       11.3       11.2
  V(I)           11.72      11.81      12.02      12.22      12.28

X STA.        11.9       12.8       13.8       14.8       15.8       16.9
  A(I)            11.4       11.4       11.4       11.5       12.1
  V(I)           12.04      12.10      12.02      11.93      11.39

X STA.        16.9       18.0       19.1       20.4       21.8       24.5
  A(I)            12.5       12.7       13.6       15.8       25.9
  V(I)           11.03      10.80      10.08       8.71       5.31

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     319.   24718.    57.    58.                       4285.
             2     509.   85399.    42.    45.                      10018.
             3     325.   32482.    90.    91.                       3505.
   500.23         1152.  142600.   189.   193.  1.32   -67.   122.  14054.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      60.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.23   -67.5   121.6  1152.4  142600.    2750.   2.39

X STA.       -67.5      -37.4      -24.5      -14.7       -7.8       -4.1
  A(I)           119.5       87.3       77.6       63.7       43.1
  V(I)            1.15       1.58       1.77       2.16       3.19

X STA.        -4.1       -0.7        2.6        5.6        8.4       11.2
  A(I)            41.8       41.5       39.5       38.2       38.4
  V(I)            3.29       3.31       3.48       3.60       3.58

X STA.        11.2       14.0       17.0       20.3       23.8       28.4
  A(I)            38.3       39.4       41.3       42.0       49.3
  V(I)            3.59       3.49       3.33       3.27       2.79

X STA.        28.4       35.1       43.0       53.2       67.3      121.6
  A(I)            53.8       55.5       62.2       69.6      110.2
  V(I)            2.55       2.48       2.21       1.97       1.25

  EX
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

EXITX:XS   ******   -26.     289.  1.25 *****  495.80  493.56   2480.  494.55
      -26. ******    54.   24777.  1.09 ***** *******    0.83    8.59

FULLV:FV      26.   -38.     333.  0.98  0.22  496.03 *******   2480.  495.05
        0.    26.    59.   29294.  1.13  0.00    0.01    0.75    7.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          "APPR1"     KRATIO =  1.56

APPR1:AS      60.   -52.     460.  0.60  0.28  496.30 *******   2480.  495.70
       60.    60.    65.   45656.  1.34  0.00   -0.01    0.55    5.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                 SECID "BRIDG"     Q,CRWS =    2480.     493.53

            <<<<<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      26.     0.     167.  3.64 *****  497.17  493.53   2480.  493.53
        0.    26.    24.   16884.  1.06 ***** *******    1.03   14.88

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.972 ******  497.99 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS      24.   -61.     763.  0.22  0.11  498.16  493.12   2480.  497.94
       60.    26.    90.   84594.  1.35  0.88    0.00    0.30    3.25

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.792  0.506   41714.    -3.    22.   497.92

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K      AREA     VEL    WSEL
   EXITX:XS     -26.   -26.    54.   2480.   24777.      289.    8.59  494.55
   FULLV:FV       0.   -38.    59.   2480.   29294.      333.    7.46  495.05
   BRIDG:BR       0.     0.    24.   2480.   16884.      167.   14.88  493.53
   RDWAY:RG      18.**************      0.*****************    1.00********
   APPR1:AS      60.   -61.    90.   2480.   84594.      763.    3.25  497.94

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS      -3.    22.   41714.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    493.56    0.83  487.35  510.35************  1.25  495.80  494.55
   FULLV:FV  ********    0.75  487.35  510.35  0.22  0.00  0.98  496.03  495.05
   BRIDG:BR    493.53    1.03  485.88  497.99************  3.64  497.17  493.53
   RDWAY:RG  ****************  500.27  518.80**********************************
   APPR1:AS    493.12    0.30  486.51  507.53  0.11  0.88  0.22  498.16  497.94
```

WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

EXITX:XS   ******   -52.     394.  1.48 *****  497.11  495.07   3550.  495.63
      -26. ******    65.   35483.  1.17 ***** *******    0.94    9.02

FULLV:FV      26.   -68.     474.  1.05  0.21  497.30 *******   3550.  496.25
        0.    26.    71.   43847.  1.20  0.00   -0.02    0.78    7.49
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPR1"     KRATIO =  1.45

APPR1:AS      60.   -58.     606.  0.73  0.27  497.57 *******   3550.  496.84
       60.    60.    77.   63500.  1.36  0.00   -0.01    0.57    5.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   500.86       0.00     495.40     500.27

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.34     500.67     500.77     497.99

 ===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      26.     0.     275.  2.16 *****  500.15  494.88   3243.  497.99
        0. ******    25.   25416.  1.00 ***** *******    0.62   11.78

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.479 ******  497.99 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      18.    26.  0.01  0.12  501.83   -0.01    275.  501.57

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    245.    83.  -157.   -74.   1.3   0.7   4.5   4.1   1.0   3.1
   RT:     30.    28.    65.    93.   0.5   0.2   3.2   4.4   0.5   3.0

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

APPR1:AS      24.   -72.    1460.  0.12  0.07  501.84  494.60   3550.  501.72
       60.    27.   154.  190221.  1.32  0.80   -0.01    0.19    2.43

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
           *** RUN DATE & TIME: 08-08-96  14:02

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.   -52.    65.   3550.   35483.     394.    9.02  495.63
   FULLV:FV       0.   -68.    71.   3550.   43847.     474.    7.49  496.25
   BRIDG:BR       0.     0.    25.   3243.   25416.     275.   11.78  497.99
   RDWAY:RG      18.*******   245.    275.*********       0.    1.00  501.57
   APPR1:AS      60.   -72.   154.   3550.  190221.    1460.    2.43  501.72

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.07    0.94  487.35  510.35************  1.48  497.11  495.63
   FULLV:FV  ********    0.78  487.35  510.35  0.21  0.00  1.05  497.30  496.25
   BRIDG:BR    494.88    0.62  485.88  497.99************  2.16  500.15  497.99
   RDWAY:RG  ****************  500.27  518.80  0.01******  0.12  501.83  501.57
   APPR1:AS    494.60    0.19  486.51  507.53  0.07  0.80  0.12  501.84  501.72
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        U.S. Geological Survey WSPRO Input File brig027.wsp
        Hydraulic analysis for structure BRIGVT01140027   Date: 22-APR-96
        State Highway 114 Bridge Crossing Pherrins River, Brighton, VT     EMB
           *** RUN DATE & TIME: 08-08-96  14:02

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

 EXITX:XS   ******   -33.     315.  1.32 *****  496.18  493.90   2750.  494.86
       -26. ******    57.   27482.  1.11 ***** *******    0.87    8.74

 FULLV:FV      26.   -46.     364.  1.02  0.22  496.39 *******   2750.  495.36
         0.    26.    62.   32492.  1.15  0.00   -0.02    0.78    7.55
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPR1"     KRATIO =  1.54

 APPR1:AS      60.   -55.     499.  0.64  0.28  496.66 *******   2750.  496.02
        60.    60.    68.   50167.  1.35  0.00   -0.01    0.56    5.51
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.03     498.59     498.70     497.99

  ===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      26.     0.     275.  1.55 *****  499.54  494.03   2750.  497.99
         0. ******    25.   25416.  1.00 ***** *******    0.53    9.99

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   2.  0.443 ******  497.99 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
    RDWAY:RG      18.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPR1:AS      24.   -67.    1152.  0.12  0.06  500.34  493.54   2750.  500.23
        60.    27.   122.  142479.  1.32  0.84    0.00    0.20    2.39

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      ****** ****** ******** ****** ******   500.22

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

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
    EXITX:XS     -26.   -33.    57.   2750.   27482.     315.    8.74  494.86
    FULLV:FV       0.   -46.    62.   2750.   32492.     364.    7.55  495.36
    BRIDG:BR       0.     0.    25.   2750.   25416.     275.    9.99  497.99
    RDWAY:RG      18.**************      0.*********       0.    1.00********
    APPR1:AS      60.   -67.   122.   2750.  142479.    1152.    2.39  500.23

     XSID:CODE   XLKQ   XRKQ       KQ
    APPR1:AS  ***********************

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    493.90    0.87  487.35  510.35************  1.32  496.18  494.86
    FULLV:FV  ********    0.78  487.35  510.35  0.22  0.00  1.02  496.39  495.36
    BRIDG:BR    494.03    0.53  485.88  497.99************  1.55  499.54  497.99
    RDWAY:RG  ****************  500.27  518.80************  0.11  500.48********
    APPR1:AS    493.54    0.20  486.51  507.53  0.06  0.84  0.12  500.34  500.23
   ER

1  NORMAL  END  OF  WSPRO  EXECUTION.
```
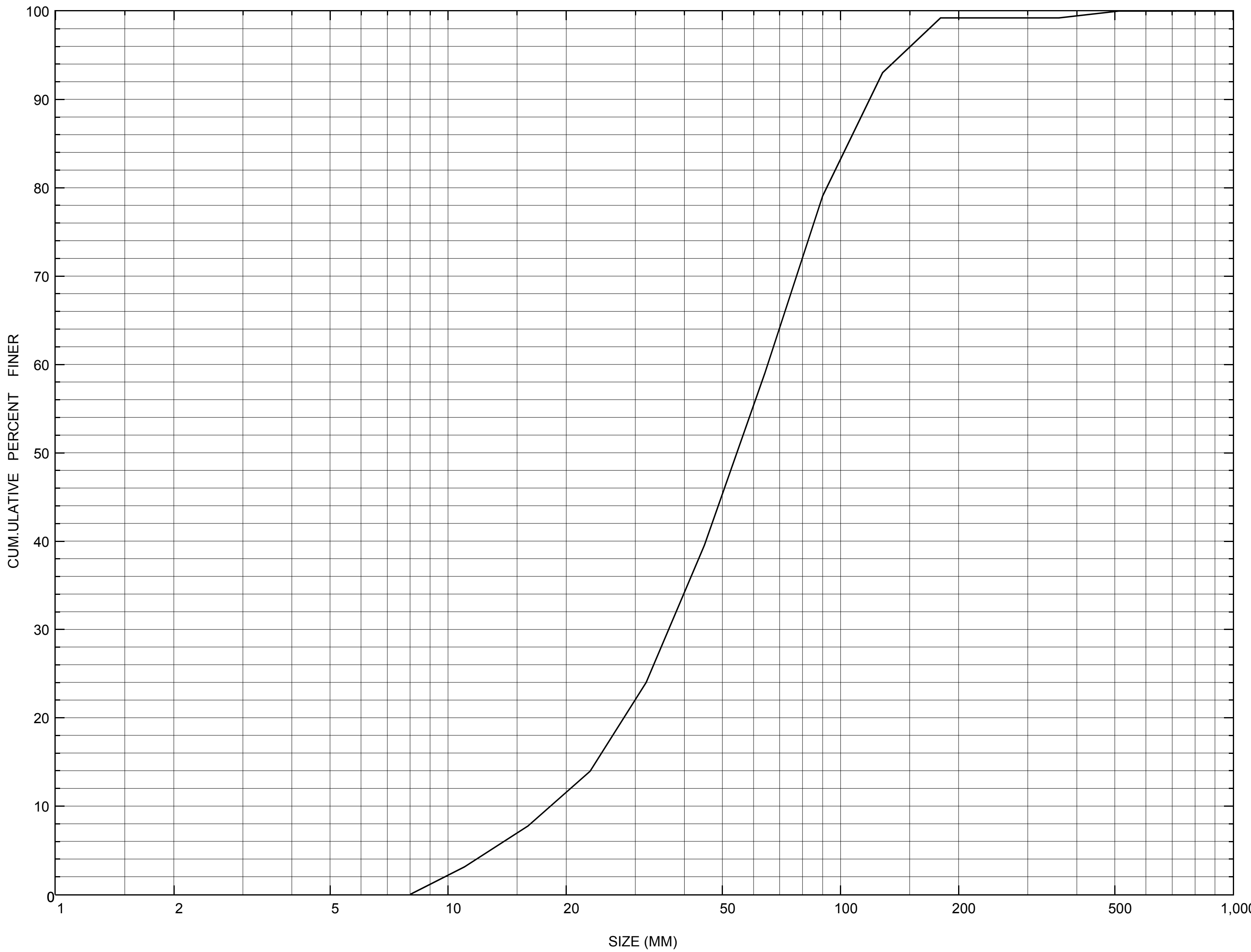

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for one pebble count transect at the approach cross-section for structure BRIGVT01140027, in Brighton, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BRIGVT01140027

General Location Descriptive

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

Date *(MM/DD/YY)* 08 / 05 / 94

Highway District Number *(I - 2; nn)* 09

County *(FIPS county code; I - 3; nnn)* 009

Town *(FIPS place code; I - 4; nnnnn)* 08725

Mile marker *(I - 11; nnn.nnn)* 005700

Waterway *(I - 6)* PHERRINS RIVER

Road Name *(I - 7)*: -

Route Number VT114

Vicinity *(I - 9)* 1.2 MI N JCT. VT.105 E

Topographic Map Island.Pond

Hydrologic Unit Code: 01110000

Latitude *(I - 16; nnnn.n)* 44495

Longitude *(i - 17; nnnnn.n)* 71539

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20032100270504

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

Maximum span length *(I - 48; nnnn)* 0024

Year built *(I - 27; YYYY)* 1926

Structure length *(I - 49; nnnnnn)* 000028

Average daily traffic, ADT *(I - 29; nnnnnn)* 001170

Deck Width *(I - 52; nn.n)* 340

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

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

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

Waterway adequacy *(I - 71; n)* 6

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

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

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

Year Reconstructed *(I - 106)* 1971

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 010.0

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

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

Comments:

The structural inspection report of 10/20/93 indicates the current bridge is a concrete slab type structure. Both abutments have minor concrete spalling, cracking, and staining reported. The wingwall concrete, however, appears in newer condition. Minor left abutment undermining is noted at the upstream end with little or no settlement. Channel scour is indicated as located mainly at the upstream end of the left abutment. The report indicated there was no embankment erosion or debris accumulation. Additional comments noted that the channel makes a moderate bend into the bridge crossing and that stone fill (riprap) was needed at the upstream end of the left abutment.

Bridge Hydrologic Data

Is there hydrologic data available? N *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: -

Terrain character: -

Stream character & type: -

Streambed material: COARSE SAND, GRAVEL, AND BOULDERS

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -
Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **19.35** mi^2 Lake and pond area **0.42** mi^2

Watershed storage *(ST)* **2.1** %

Bridge site elevation **1228** ft Headwater elevation **2789** ft

Main channel length **8.96** mi

10% channel length elevation **1240** ft 85% channel length elevation **1880** ft

Main channel slope *(S)* **95.25** 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? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number -

Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB

Benchmark location description:

-

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO 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: **MAI** Date: **10/25/95**
Computerized by: **MAI** Date: **10/26/96**
Reviewd by: **EMB** Date: **7/15/96**

Structure Number **BRIGVT01140027**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. Boehmler** Date *(MM/DD/YY)* **07** / **05** / 19**95**

2. Highway District Number **09** Mile marker **005700**

County **Essex (009)** Town **Brighton (08725)**

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

Route Number **VT 114** Hydrologic Unit Code: **01110000**

3. Descriptive comments:

Located 1.2 miles north of the intersection of State route 114 with State route 105.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **5** LBDS **3** RBDS **6** Overall **6**
*(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 **1** UB **1** DS **2** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **28.0** *(feet)* Span length **24.0** *(feet)* Bridge width **34.0** *(feet)*

Road approach to bridge:

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

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

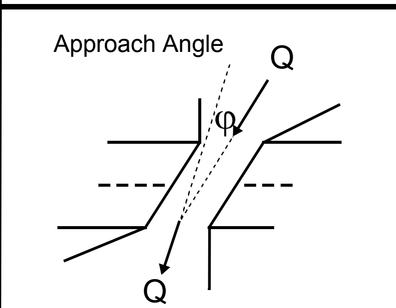
10. Embankment slope (*run / rise in feet / foot*):
US left **2.6:1** US right **3.0:1**

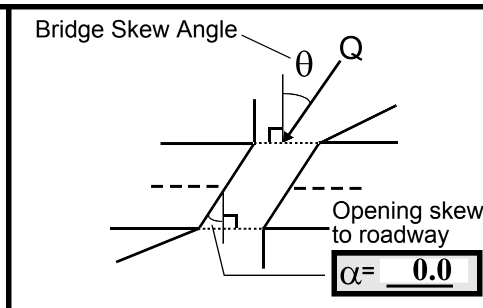
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	0	-	2	1
RBDS	0	-	0	0
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **30** feet **US** *(US, UB, DS)* to **0** feet **DS**

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

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

18. Level II Bridge Type: **4**

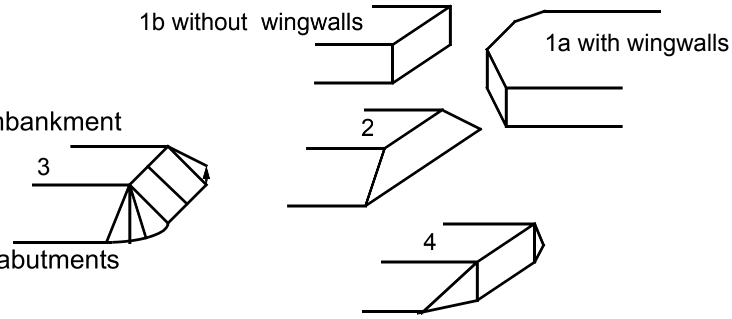
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls perpendicular to abut. face

3- Spill through abutments

4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.



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

The bridge dimensions measured the same as historical values. Small roadway gullies have developed along the side of both US wingwalls. Storm drainage US is carried along the base of the road embankments entering the stream US of the wingwalls.

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
22.4	**2.5**			**4.0**	**2**	**2**	**253**	**23**	**2**	**1**

23. Bank width **35.0** 24. Channel width **30.0** 25. Thalweg depth **42.0** 29. Bed Material **345**

30 .Bank protection type: LB **2** RB **2** 31. Bank protection condition: LB **2** 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.):

The left bank protection extends from 10 to 30 feet US beginning along the wingwall. The right bank protection extends from 10 to 175 feet US beginning along the wingwall.

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

36. Point bar extent: - feet - (US, UB) to - feet - (US, UB, DS) positioned - %LB to - %RB

37. Material: -

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

There is a small mid-channel sand and gravel bar from 95 to 58 feet US positioned 40% left to 50% right bank and 6 feet wide at 85 feet 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: 40 42. Cut bank extent: 105 feet US (US, UB) to 25 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.):

The heaviest cutting is evident from 30 to 50 feet US with roots exposed and possibly some minor block and/or slip failure. The remaining range of the cut consist of minor erosion.

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

47. Scour dimensions: Length - Width - Depth : - Position - %LB to - %RB

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
32.5		2.0		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.):

342

Material at the surface along the right abutment is sand with cobbles and a few boulders below, as evident along the left abutment. Some granitic bedrock is visible on the left bank side of the channel just US of the US left wingwall.

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

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

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

70. Debris and Ice Comments:

1

There is a bend in the channel that may increase capture of debris and ice on the left bank just upstream of the US left wingwall.

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		10	90	2	2	1.5	1.5	90.0
RABUT	1	0	90			2	2	0.0

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

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

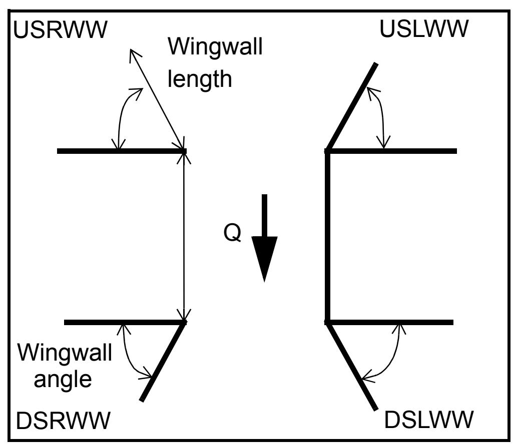
0
1.5
1

The left abutment footing is exposed for it entire length. The right abutment footing is exposed at the US end for 11 feet. The rest of the right abutment footing is detectable by probing below the sand and gravel bed material.

The left abutment footing is exposed 2 feet from the US face to 11 feet under the bridge where the top of footing steps down 1 foot. The lower footing is exposed 1.5 to 1.0 feet US to DS, respectively. There was no undermining detected. Ambient thalweg depth ranges from 0.5 to 2.0 feet, 1.25 average. A scour hole runs 27 feet beginning near the US bridge face, about 13 feet wide and 1.5 feet deep mainly along the left abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	The		right		abut	0.0	
USRWW:	ment		expo		sure	2.5	
DSLWW:	is 2		to		1.5	35.5	
DSRWW:	feet		deep		from	35.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	the	to	und	brid	ecti		2	Y
Condition	US	11	er	ge,	vely.	Y	0.5	1
Extent	end	feet	the	resp		1	2.0	2

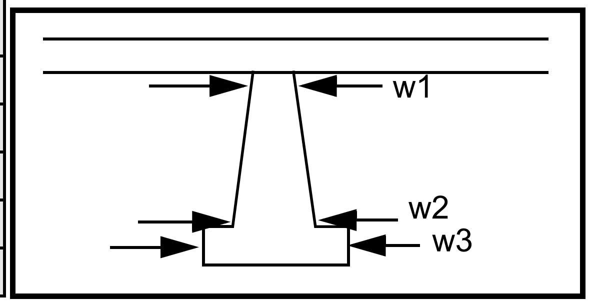
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
0
1.5
Y
1
2
0
2.0
Y
1
2
0

Piers:

84. Are there piers? **2.5** *(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				**45.0**	**20.0**	**45.0**
Pier 2				**20.5**	**45.0**	**19.5**
Pier 3			**-**	**50.0**	**19.0**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



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

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

road fill present around the end of the wingwall. The top of the US left wingwall footing sits 0.3 feet higher than the left abutment footing. The exposure is 2.0 feet at the corner with the abutment then gradually covered with stone fill to its US end. The US right wingwall footing is exposed from 0 feet to 2 feet from its US end to where it meets the left abutment. Exposure of the footing is 0.5 feet for 8 feet from the right abutment. Undermining is evident on the DS right wingwall from the DS bridge face to 2 feet along the wall. A pole penetrated up to 1 foot under the footing. The remaining footing is exposed 2 to 0.5 feet from 2 to 10 feet respectively along the wall from the DS bridge face. The DS left wingwall has two footings. The upstream end of the first footing sits below the water surface with only the top surface exposed for 2 feet from the end of left abutment. The second downstream section of the footing begins 5 feet along the wall exposed 2.0 feet and then gradually covered by stone fill to the end.

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
-	-			-	N	-	-	-	-	-

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.):

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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 - feet - (US, UB, DS) positioned - %LB to - %RB

Material: -

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

-
-
-
-

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

Cut bank extent: RS feet ____ (US, UB, DS) to _____ feet ____ (US, UB, DS)

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 2

Scour dimensions: Length 2 Width 235 Depth: 234 Positioned 1 %LB to 1 %RB

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

354
2
0
1

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

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

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

Confluence comments (eg. confluence name):

the bed surface DS than US. The DS channel is more narrow than US possibly due to the channel straighten-ing and stone fill along the left bank. A small storm drainage ditch flows into the stream on the right bank 75

F. Geomorphic Channel Assessment

107. Stage of reach evolution fee

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)*:

t DS. The left bank protection extends from the end of the left wingwall to 140 feet DS.

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:	BRIGVT01140027	Town:	Brighton
Road Number:	VT 114	County:	Essex
Stream:	Pherrins River		

Initials EMB   Date: 5/3/96   Checked: JDA   5/13/96

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	2480	3550	2750
Main Channel Area, ft2	412	571	509
Left overbank area, ft2	196	406	319
Right overbank area, ft2	155	484	325
Top width main channel, ft	42.2	42.2	42.2
Top width L overbank, ft	50.5	60.7	56.7
Top width R overbank, ft	59	122.6	90.2
D50 of channel, ft	0.1786	0.1786	0.1786
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	9.8	13.5	12.1
y1, average depth, LOB, ft	3.9	6.7	5.6
y1, average depth, ROB, ft	2.6	3.9	3.6
Total conveyance, approach	84542	190359	142600
Conveyance, main channel	60104	103713	85399
Conveyance, LOB	11910	35307	24718
Conveyance, ROB	12527	51339	32482
Percent discrepancy, conveyance	0.0012	0.0000	0.0007
Qm, discharge, MC, cfs	1763.1	1934.1	1646.9
Ql, discharge, LOB, cfs	349.4	658.4	476.7
Qr, discharge, ROB, cfs	367.5	957.4	626.4
Vm, mean velocity MC, ft/s	4.3	3.4	3.2
Vl, mean velocity, LOB, ft/s	1.8	1.6	1.5
Vr, mean velocity, ROB, ft/s	2.4	2.0	1.9
Vc-m, crit. velocity, MC, ft/s	9.2	9.7	9.6
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

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

Main Channel	0	0	0

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	412	571	509
Main channel width, ft	42.2	42.2	42.2
y1, main channel depth, ft	9.76	13.53	12.06
Bridge Section			
(Q) total discharge, cfs	2480	3550	2750
(Q) discharge thru bridge, cfs	2480	3243	2750
Main channel conveyance	16893	25416	25416
Total conveyance	16893	25416	25416
Q2, bridge MC discharge,cfs	2480	3243	2750
Main channel area, ft2	167	275	275
Main channel width (skewed), ft	24.2	24.5	24.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.2	24.5	24.5
y_bridge (avg. depth at br.), ft	6.89	11.24	11.24
Dm, median (1.25*D50), ft	0.22325	0.22325	0.22325
y2, depth in contraction,ft	10.05	12.51	10.86
ys, scour depth (y2-ybridge), ft	3.16	1.27	-0.38
ys, scour depth (y2-y1), ft	0.28	-1.02	-1.20
ys, scour depth (y2-yfullv), ft	N/A	3.01	2.25
ARMORING			
D90	0.38909	0.38909	0.38909
D95	0.46816	0.46816	0.46816
Critical grain size,Dc, ft	0.7726	0.4067	0.2924
Decimal-percent coarser than Dc	N/A	0.0825	0.2151
Depth to armoring,ft	ERR	13.57	3.20

PRESSURE FLOW SCOUR COMPUTATION

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	0	3243	2750
Vc, critical velocity, ft/s	0	9.7	9.6
Vc, critical velocity, m/s	0	2.956416	2.925937
Main channel width (skewed), ft	0	24.5	24.5
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	0	24.5	24.5
qbr, unit discharge, ft^2/s	ERR	132.3673	112.2449
qbr, unit discharge, m^2/s	N/A	12.29613	10.42687
Area of full opening, ft^2	0	275.4	275.4
Hb, depth of full opening, ft	ERR	11.24082	11.24082
Hb, depth of full opening, m	N/A	3.426034	3.426034
Fr, Froude number MC	1	0.62	0.53
Cf, Fr correction factor (<=1.0)	1.5	1	1
Elevation of Low Steel, ft	0	497.99	497.99
Elevation of Bed, ft	N/A	486.7492	486.7492
Elevation of approach WS, ft	0	501.72	500.23
HF, bridge to approach, ft	0	0.07	0.06
Elevation of WS immediately US, ft	0	501.65	500.17
ya, depth immediately US, ft	N/A	14.90082	13.42082
ya, depth immediately US, m	N/A	4.630459	4.170546
Mean elev. of deck, ft	0	502.01	502.01
w, depth of overflow, ft (>=0)	0	0	0
Cc, vert contrac correction (<=1.0)	ERR	0.929419	0.956603
Ys, depth of scour (chang), ft	N/A	3.441606	0.981784

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	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	2480	3550	2750	2480	3550	2750
a', abut.length blocking flow, ft	61.3	71.5	67.5	65.9	129.5	97.1
Ae, area of blocked flow ft2	293.34	483.45	441.8	206.82	559.56	393.1
Qe, discharge blocked abut.,cfs	739.72	--	854.17	541.09	--	804.08
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve manually)						
Ve, (Qe/Ae), ft/s	2.52	2.02	1.93	2.62	2.09	2.05
ya, depth of f/p flow, ft	4.79	6.76	6.55	3.14	4.32	4.05
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.203	0.129	0.133	0.260	0.177	0.179
ys, scour depth, ft	14.87	16.71	16.26	12.65	16.40	14.40

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)	61.3	71.5	67.5	65.9	129.5	97.1
y1 (depth f/p flow, ft)	4.79	6.76	6.55	3.14	4.32	4.05
a'/y1	12.81	10.57	10.31	21.00	29.97	23.98
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.20	0.13	0.13	0.26	0.18	0.18
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	17.75	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	14.56	ERR
spill-through	ERR	ERR	ERR	ERR	9.76	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	1	0.62	0.53	1	0.62	0.53
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	6.89	11.2	11.2	6.89	11.2	11.2
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	2.66	1.94	ERR	2.66	1.94
Fr>0.8 (vertical abut.)	2.88	ERR	ERR	2.88	ERR	ERR