LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (SHEFTH00380017) on TOWN HIGHWAY 38, crossing MILLER RUN, SHEFFIELD, VERMONT

Open-File Report 97-782

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

U.S. Department of the Interior
U.S. Geological Survey

USGS
science for a changing world

LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (SHEFTH00380017) on TOWN HIGHWAY 38, crossing MILLER RUN, SHEFFIELD, VERMONT

By LORA K. STRIKER AND JAMES R. DEGNAN

U.S. Geological Survey
Open-File Report 97-782

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

Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
Mark Schaefer, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

Copies of this report may be purchased from:

U.S. Geological Survey
Branch of Information Services
Open-File Reports Unit
Box 25286
Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	MC	main channel
D_{50}	median diameter of bed material	RAB	right abutment
DS	downstream	RABUT	face of right abutment
elev.	elevation	RB	right bank
f/p	flood plain	ROB	right overbank
ft^2	square feet	RWW	right wingwall
ft/ft	feet per foot	TH	town highway
JCT	junction	UB	under bridge
LAB	left abutment	US	upstream
LABUT	face of left abutment	USGS	United States Geological Survey
LB	left bank	VTAOT	Vermont Agency of Transportation
LOB	left overbank	WSPRO	water-surface profile model

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (SHEFTH00380017) ON TOWN HIGHWAY 38, CROSSING MILLER RUN, SHEFFIELD, VERMONT

By **Lora K. Striker and James R. Degnan**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SHEFTH00380017 on Town Highway 38 crossing Miller Run, Sheffield, 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 White Mountain section of the New England physiographic province in northeastern Vermont. The 24.2-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture along the right bank while the immediate banks are covered by trees, shrubs, and brush. The surface cover along the left bank is grass and Route 122 with shrubs and brush along the immediate banks.

In the study area, Miller Run has a sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 52 ft and an average bank height of 3 ft. The channel bed material ranges from sand to bedrock with a median grain size (D_{50}) of 80.5 mm (0.264 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 1, 1995, indicated that the reach was stable.

The Town Highway 38 crossing of Miller Run is a 52-ft-long, one-lane bridge consisting of one 48-foot steel I-beam span with a wooden deck (Vermont Agency of Transportation, written communication, March 28, 1995). The opening length of the structure parallel to the bridge face is 42.4 ft. The bridge is supported by vertical, concrete abutments with wingwalls on the upstream end. The channel is skewed approximately 30 degrees to the opening while the computed opening-skew-to-roadway is 5 degrees.

A scour hole 3.0 ft deeper than the mean thalweg depth was observed under the bridge during the Level I assessment. The only scour protection measure at the site was type-4 stone fill (less than 60 inches diameter) at the upstream end of the upstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. 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 modelled flows ranged from 0.0 to 2.4 ft. Abutment scour ranged from 6.1 to 7.9 ft at the left abutment and 11.4 to 17.4 ft at the right abutment. The worst-case contraction and 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.

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.

Lydonville, VT. Quadrangle, 1:24,000, 1986

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 SHEFTH00380017 ***Stream*** Miller Run

County Caledonia ***Road*** TH 38 ***District*** 7

Description of Bridge

Bridge length 52 ***ft*** ***Bridge width*** 15.7 ***ft*** ***Max span length*** 48 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 08/01/95

Description of stone fill Type-4, along the upstream end of the USLWW. There is a three foot deep scour hole in the center of the channel under the bridge and a 0.5 ft deep scour hole at the center of the LABUT as well as at the DS half of the RABUT.

Brief description of piers/abutments The LABUT and its’ wingwalls are concrete faced “laid-up” stone with a concrete backwall and footing. The RABUT and its’ wingwalls are grouted “laid-up” stone with a concrete backwall, kneewall, and footing.

Y 30

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

There is a mild channel bend in the upstream reach. A scour hole has developed in the location where the bend impacts the downstream RABUT.

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	08/01/95	0	0
Level II	08/01/95	0	0

Potential for debris Low. There is debris caught 40 ft US, just DS of a localized scour on the RB. However, the channel is laterally stable with no cut-banks.

Describe any features near or at the bridge that may affect flow (include observation date) None, 08/01/95. There is a point bar along the US right bank that directs flow to the left side of the channel during low flows.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley setting with a flat to slightly irregular flood plain.

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

Date of inspection 08/01/95

DS left: Steeply sloping channel bank to moderately sloping overbank and Rte. 122

DS right: Steeply sloping channel bank to narrow terrace with pasture beyond

US left: Moderately sloping channel bank and overbank to Rte. 122

US right: Steeply sloping channel bank to wide pasture on overbank

Description of the Channel

Average top width 52 ft ***Average depth*** 3 ft

Predominant bed material Sand to Bedrock ***Bank material*** Cobble to Silt

Sinuous but stable with semi-alluvial boundaries and a narrow flood plain that widens US and DS of site.

08/01/95

Vegetative co Grass and Rte. 122 with shrubs and brush along banks

DS left: Pasture with trees, shrubs, and brush along banks

DS right: Grass and Rte. 122 with shrubs and brush along banks

US left: Pasture with trees, shrubs, and brush along banks

US right: Y

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

None, 08/01/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 24.2 ***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? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 3,860 ***ft³/s*** ***Q500*** 5,300 ***ft³/s***

The 100-year discharge is based on flood frequency estimates computed by use of the FHWA empirical method and extended to the 500-year discharge (Federal Highway Administration, 1983). These values were selected due to the central tendency of the discharge frequency curve with others which were developed from empirical relationships and extended to the 500-year discharge (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is center point of chiseled “X” on top of the upstream end of the LABUT (elev. 500.74 ft, arbitrary survey datum). RM2 is an engraved “X” on top of the first wooden deck plank at the DS Right corner of the bridge (elev. 505.25 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-42	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	60	2	Modelled Approach section (Templated from APTEM)
APTEM	74	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 0.055, and overbank "n" values ranged from 0.045 to 0.065.

Normal depth at the exit section (EXIT1) 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 0.0082 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1986).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0111 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 location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 504.7 ***ft***
Average low steel elevation 501.8 ***ft***

100-year discharge 3,860 ***ft^3/s***
Water-surface elevation in bridge opening 502.3 ***ft***
Road overtopping? Y ***Discharge over road*** 530 ***ft^3/s***
Area of flow in bridge opening 315 ***ft^2***
Average velocity in bridge opening 10.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.1 ***ft/s***

Water-surface elevation at Approach section with bridge 505.4
Water-surface elevation at Approach section without bridge 502.3
Amount of backwater caused by bridge 3.1 ***ft***

500-year discharge 5,300 ***ft^3/s***
Water-surface elevation in bridge opening 502.0 ***ft***
Road overtopping? Y ***Discharge over road*** 1,301 ***ft^3/s***
Area of flow in bridge opening 313 ***ft^2***
Average velocity in bridge opening 12.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 18.2 ***ft/s***

Water-surface elevation at Approach section with bridge 506.0
Water-surface elevation at Approach section without bridge 503.3
Amount of backwater caused by bridge 2.7 ***ft***

Incipient overtopping discharge 2,810 ***ft^3/s***
Water-surface elevation in bridge opening 502.3 ***ft***
Area of flow in bridge opening 315 ***ft^2***
Average velocity in bridge opening 8.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.2 ***ft/s***

Water-surface elevation at Approach section with bridge 503.9
Water-surface elevation at Approach section without bridge 501.3
Amount of backwater caused by bridge 2.6 ***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. However, bedrock may limit the depth of contraction scour.

At this site, the 500-year discharge resulted in submerged orifice flow while, the 100-year and the 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 all discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8. The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was computed by use of the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

Abutment scour 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.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.8	2.4	0.0
Depth to armoring	12.8	23.5	11.4
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	6.8	7.9	6.1
Right abutment	15.1	17.4	11.4
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	2.6	2.9	2.4
Right abutment	2.6	2.9	2.4
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

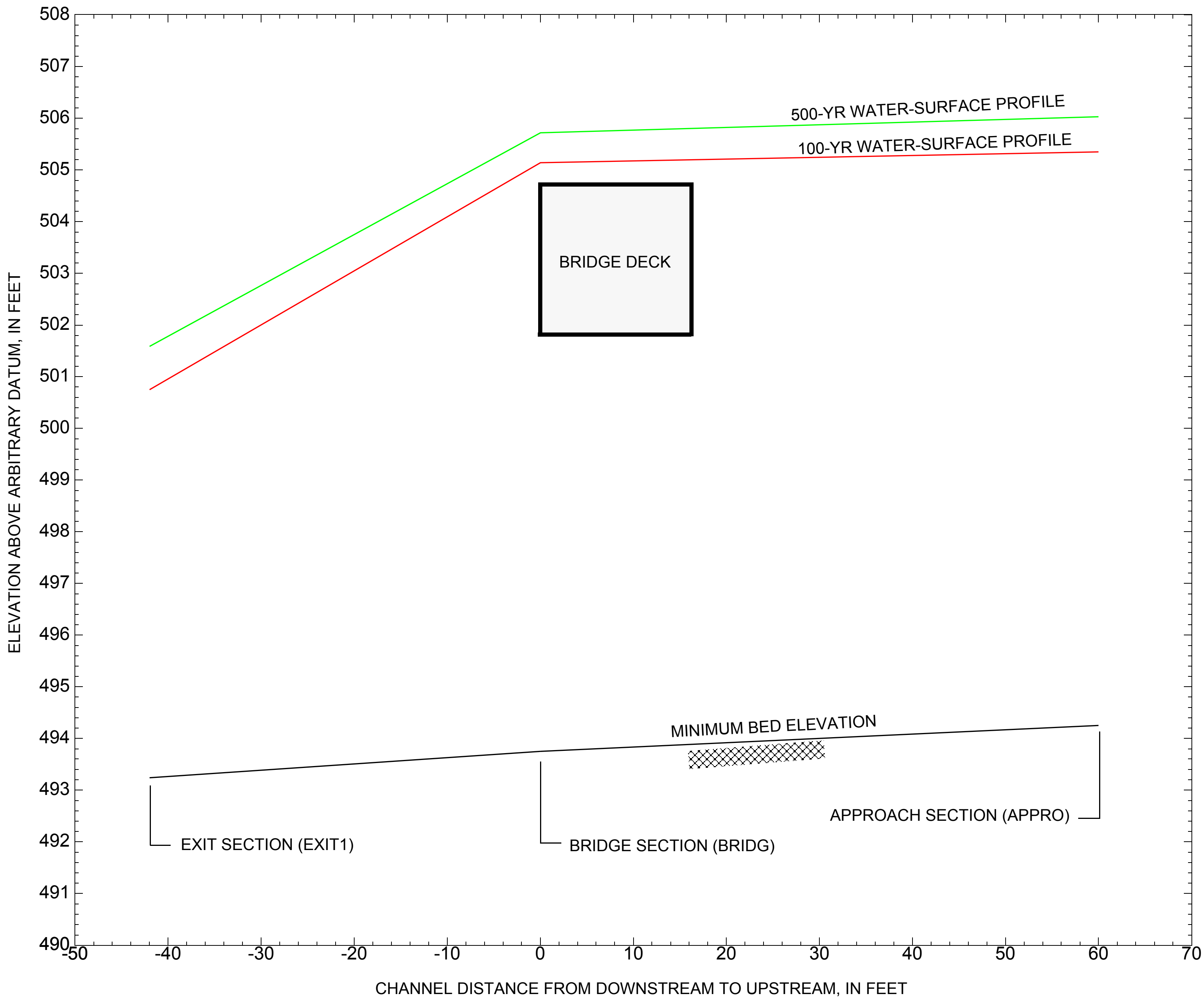


Figure 7. Water-surface profiles for the 100-year and 500-year discharges at structure SHEFTH00380017 on Town Highway 38, crossing Miller Run, Sheffield, Vermont.

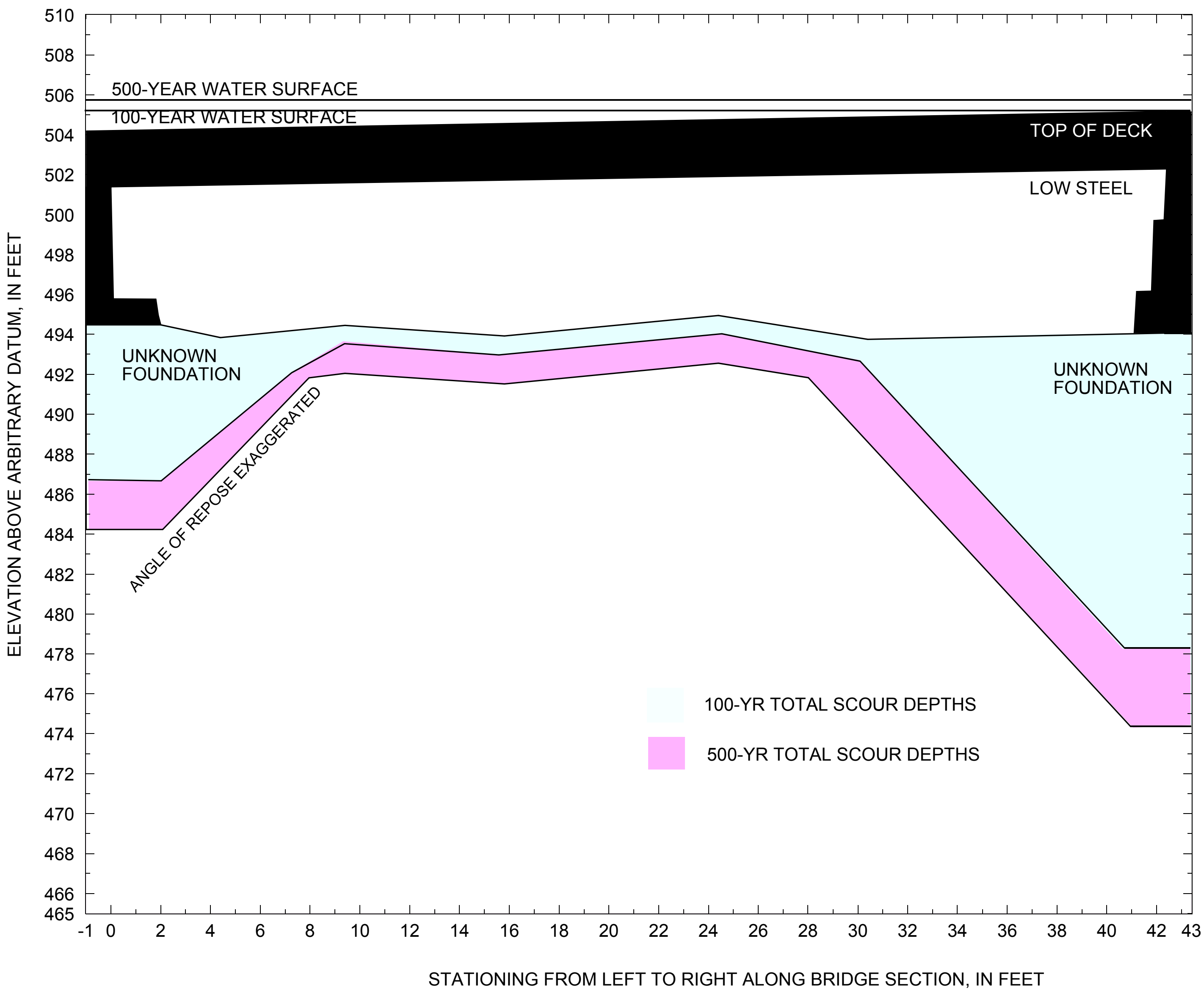


Figure 8. Scour elevations for the 100-year and 500-year discharges at structure SHEFTH00380017 on Town Highway 38, crossing Miller Run, Sheffield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SHEFTH00380017 on Town Highway 38, crossing Miller Run, Sheffield, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 3,860 cubic-feet per second											
Left abutment	0.0	--	501.4	--	494.5	0.8	6.8	--	7.6	486.9	--
Right abutment	42.4	--	502.3	--	494.1	0.8	15.1	--	15.9	478.2	--

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 SHEFTH00380017 on Town Highway 38, crossing Miller Run, Sheffield, 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/pile 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 5,300 cubic-feet per second											
Left abutment	0.0	--	501.4	--	494.5	2.4	7.9	--	10.3	484.2	--
Right abutment	42.4	--	502.3	--	494.1	2.4	17.4	--	19.8	474.3	--

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.

Federal Highway Administration, 1993, Stream Stability and Scour at Highway Bridges: Participant Workbook: Federal Highway Administration Report FHWA-HI-91-011.

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

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

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

Richardson, E.V., 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, 1986, Lydonville, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File shef017.wsp
T2        Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
T3        TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3860.0   5300.0   2810.0
SK          0.0082   0.0082   0.0082
*
XS   EXIT1    -42           0.
GR         -160.2, 517.72   -138.9, 514.14   -125.8, 506.57   -116.1, 504.02
GR         -109.6, 504.99    -98.4, 505.60    -83.7, 504.81    -77.0, 501.64
GR          -67.7, 500.13     -9.0, 497.88      0.0, 496.96      3.9, 495.05
GR            5.1, 494.86      8.1, 494.08     13.4, 493.39     17.4, 493.93
GR           19.6, 493.46     27.9, 493.24     35.9, 493.94     39.1, 494.88
GR           42.9, 495.88     49.8, 499.06     83.8, 499.08     88.7, 498.86
GR           98.9, 500.01    103.5, 503.05    108.9, 506.69    127.6, 507.49
GR          217.9, 508.44    251.0, 510.46    286.4, 517.92    314.2, 521.93
GR          352.9, 523.03
*
N           0.045        0.045        0.065
SA                   0.0         49.8
*
*
XS   FULLV      0  * * *   0.0082
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    501.84       5.0
GR            0.0, 501.39      0.1, 495.77      1.8, 495.76      1.9, 494.95
GR            2.0, 494.48      4.4, 493.84      9.4, 494.45     15.8, 493.92
GR           24.4, 494.95     30.4, 493.75     36.2, 493.97
GR           41.1, 494.06     41.2, 496.14     41.8, 496.16     41.8, 499.70
GR           42.3, 499.73     42.4, 502.29      0.0, 501.39
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      23.7 * *     49.5      5.3
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      9      15.7     2
GR         -462.8, 549.38   -402.0, 536.11   -376.0, 523.79   -213.1, 516.43
GR         -139.4, 505.34   -112.0, 504.83    -88.1, 504.40    -66.6, 503.85
GR            0.0, 504.20     42.3, 505.15     59.0, 505.40     96.9, 505.32
GR          182.6, 507.48    279.6, 513.83    349.0, 521.42    385.8, 522.38
*
*
*
XT   APTEM     74           0.
GR         -356.5, 532.62   -321.8, 520.57   -287.9, 517.96   -199.0, 509.28
GR         -198.9, 509.28   -182.7, 505.48   -104.6, 501.41   -101.9, 501.48
GR          -99.0, 503.68    -96.4, 504.10    -85.2, 504.33    -74.5, 504.14
GR          -71.8, 503.64    -65.7, 502.22    -10.9, 500.20      0.0, 497.89
GR            3.6, 495.85      5.7, 495.33     12.4, 494.41     20.8, 494.66
GR           22.7, 494.99     30.1, 495.23     35.2, 495.09     39.7, 495.51
GR           43.6, 498.02     52.1, 499.56     77.5, 499.40     87.7, 500.55
GR          140.4, 500.78    198.8, 499.89    252.4, 501.66    272.2, 501.77
GR          317.4, 509.92    358.8, 520.86
*
AS   APPRO     60 * * * 0.0111
GT
N           0.060        0.055        0.045
SA                 -10.9         43.6
*
HP 1 BRIDG   502.29 1 502.29
HP 2 BRIDG   502.29 * * 3333
HP 1 BRIDG   501.16 1 501.16
HP 2 RDWAY   505.14 * *  530
HP 1 APPRO   505.35 1 505.35
HP 2 APPRO   505.35 * * 3860
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
U.S. Geological Survey WSPRO Input File shef017.wsp
Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
   *** RUN DATE & TIME: 10-03-97  10:50
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      315     25338      0     99                            0
   502.29           315     25338      0     99  1.00      0     42        0

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

         WSEL     LEW     REW    AREA         K        Q    VEL
       502.29     0.0    42.4   315.2   25338.    3333.  10.57

X STA.         0.0         3.8         6.0         8.1        10.3        12.3
  A(I)            24.4        16.4        15.5        15.4        14.9
  V(I)            6.84       10.14       10.79       10.83       11.19

X STA.        12.3        14.3        16.1        17.9        19.9        21.9
  A(I)            14.6        14.2        14.1        14.6        14.3
  V(I)           11.43       11.73       11.78       11.38       11.68

X STA.        21.9        24.0        26.1        28.0        29.7        31.4
  A(I)            14.8        14.8        14.3        14.1        13.8
  V(I)           11.23       11.23       11.65       11.79       12.06

X STA.        31.4        33.1        34.9        36.7        38.7        42.4
  A(I)            14.1        14.2        15.2        16.1        25.3
  V(I)           11.79       11.77       10.98       10.34        6.59

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      286     31757     42     56                         4236
   501.16           286     31757     42     56  1.00      0     42     4236

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA         K        Q    VEL
       505.14  -128.7    41.9   130.9    3735.     530.   4.05

X STA.      -128.7       -92.0       -81.1       -74.0       -68.6       -64.1
  A(I)            12.4         8.5         7.2         6.4         5.8
  V(I)            2.13        3.12        3.70        4.17        4.59

X STA.       -64.1       -59.6       -55.1       -50.7       -46.2       -41.7
  A(I)             5.7         5.6         5.4         5.4         5.3
  V(I)            4.69        4.75        4.92        4.90        5.00

X STA.       -41.7       -37.0       -32.1       -27.3       -22.1       -16.7
  A(I)             5.4         5.4         5.3         5.6         5.6
  V(I)            4.92        4.88        5.01        4.77        4.75

X STA.       -16.7       -11.3        -5.5         0.8         9.9        41.9
  A(I)             5.5         5.7         6.0         7.4        11.5
  V(I)            4.79        4.65        4.42        3.57        2.31

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      468     22566    172    173                         4383
             2      516     61239     55     56                         9002
             3     1191    111664    249    250                        14769
   505.35          2175    195469    476    479  1.20   -182    293    24069

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

         WSEL     LEW     REW    AREA         K        Q    VEL
       505.35  -182.8   292.9  2174.7  195469.    3860.   1.77

X STA.      -182.8       -61.5       -20.4         0.6         9.2        16.2
  A(I)           246.8       172.4       123.9        83.9        77.0
  V(I)            0.78        1.12        1.56        2.30        2.51

X STA.        16.2        23.1        30.5        38.0        48.6        63.6
  A(I)            74.2        77.3        77.5        86.3        90.7
  V(I)            2.60        2.50        2.49        2.24        2.13

X STA.        63.6        78.8        98.2       119.6       141.5       162.3
  A(I)            91.5       100.5       104.1       104.4       101.9
  V(I)            2.11        1.92        1.85        1.85        1.89

X STA.       162.3       181.6       199.7       219.1       244.6       292.9
  A(I)           100.8        99.2       102.3       115.1       144.9
  V(I)            1.92        1.95        1.89        1.68        1.33
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File shef017.wsp
        Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
        TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
           *** RUN DATE & TIME: 10-03-97  10:50
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      313     27974     15     84                         8104
   501.97           313     27974     15     84  1.00      0     42     8104

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.97     0.0    42.4   312.8   27974.    4002.  12.79

X STA.         0.0        4.1        6.5        8.9       11.3       13.5
  A(I)            26.5       18.0       17.5       17.2       16.6
  V(I)            7.55      11.11      11.46      11.65      12.08

X STA.        13.5       15.6       17.7       19.9       22.2       24.6
  A(I)            15.8       16.2       16.1       16.6       17.1
  V(I)           12.63      12.37      12.45      12.04      11.68

X STA.        24.6       27.0       28.6       30.0       31.3       32.7
  A(I)            17.1       12.4       11.0       11.2       11.1
  V(I)           11.69      16.14      18.16      17.92      18.10

X STA.        32.7       34.1       35.5       37.1       38.8       42.4
  A(I)            11.0       11.6       12.4       14.1       23.2
  V(I)           18.11      17.21      16.10      14.15       8.61

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       9.

         WSEL     LEW     REW    AREA        K        Q    VEL
       505.72  -141.9   112.8   259.9    9513.    1301.   5.01

X STA.      -141.9     -109.5      -94.7      -84.1      -76.1      -69.4
  A(I)            20.2       15.8       13.8       12.2       11.4
  V(I)            3.22       4.11       4.73       5.34       5.70

X STA.       -69.4      -63.6      -58.0      -52.1      -46.4      -40.6
  A(I)            10.8       10.2       10.6       10.3       10.1
  V(I)            6.00       6.35       6.14       6.32       6.43

X STA.       -40.6      -34.5      -28.4      -22.0      -15.6       -8.9
  A(I)            10.4       10.3       10.5       10.4       10.6
  V(I)            6.23       6.34       6.18       6.24       6.15

X STA.        -8.9       -2.0        6.0       16.5       32.5      112.8
  A(I)            10.7       11.8       13.3       15.5       30.9
  V(I)            6.06       5.52       4.90       4.20       2.10

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      586     32441    175    176                         6088
             2      553     68747     55     56                         9990
             3     1362    138206    253    254                        17923
   506.03          2500    239395    482    486  1.18   -185    297    29754

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       506.03  -185.7   296.7  2500.4  239395.    5300.   2.12

X STA.      -185.7      -91.2      -32.1       -5.2        6.8       14.7
  A(I)           254.9      212.3      156.3      108.2       90.9
  V(I)            1.04       1.25       1.70       2.45       2.92

X STA.        14.7       22.4       30.3       38.6       50.7       66.3
  A(I)            88.6       87.5       91.3      102.3      104.2
  V(I)            2.99       3.03       2.90       2.59       2.54

X STA.        66.3       81.9      101.8      123.2      144.5      165.0
  A(I)           104.0      114.1      117.8      116.4      114.9
  V(I)            2.55       2.32       2.25       2.28       2.31

X STA.       165.0      184.3      202.4      222.5      248.1      296.7
  A(I)           114.7      112.0      117.7      130.1      162.4
  V(I)            2.31       2.37       2.25       2.04       1.63
```

```
      U.S. Geological Survey WSPRO Input File shef017.wsp
      Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
      TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
         *** RUN DATE & TIME: 10-03-97  10:50
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      315     25338      0     99                            0
 502.29           315     25338      0     99  1.00      0     42        0

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     502.29     0.0    42.4   315.2   25338.    2810.   8.92

X STA.         0.0        3.8        6.0        8.1       10.3       12.3
  A(I)             24.4       16.4       15.5       15.4       14.9
  V(I)             5.77       8.55       9.09       9.13       9.44

X STA.        12.3       14.3       16.1       17.9       19.9       21.9
  A(I)             14.6       14.2       14.1       14.6       14.3
  V(I)             9.64       9.89       9.93       9.60       9.85

X STA.        21.9       24.0       26.1       28.0       29.7       31.4
  A(I)             14.8       14.8       14.3       14.1       13.8
  V(I)             9.47       9.47       9.82       9.94      10.16

X STA.        31.4       33.1       34.9       36.7       38.7       42.4
  A(I)             14.1       14.2       15.2       16.1       25.3
  V(I)             9.94       9.92       9.26       8.72       5.55

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      253     26344     42     54                         3521
 500.37           253     26344     42     54  1.00      0     42     3521

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      60.
   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      241      9388    122    123                         1925
           2      436     46316     55     56                         7002
           3      833     62910    241    242                         8780
 503.89          1510    118614    417    420  1.22   -154    285    14736

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     503.89  -155.2   284.8  1509.9  118614.    2810.   1.86

X STA.      -155.2      -31.5       -3.3        5.9       11.6       17.0
  A(I)            169.6      106.5       64.7       52.4       50.7
  V(I)             0.83       1.32       2.17       2.68       2.77

X STA.        17.0       22.4       28.1       33.9       40.0       50.4
  A(I)             51.5       51.0       50.9       53.3       63.2
  V(I)             2.73       2.75       2.76       2.63       2.22

X STA.        50.4       65.3       80.1      101.1      124.9      149.8
  A(I)             67.3       68.1       76.1       80.8       82.3
  V(I)             2.09       2.06       1.85       1.74       1.71

X STA.       149.8      171.5      190.7      209.3      234.5      284.8
  A(I)             77.8       74.5       75.0       85.4      108.6
  V(I)             1.81       1.89       1.87       1.65       1.29
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File shef017.wsp
        Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
        TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
           *** RUN DATE & TIME: 10-03-97  10:50

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

EXIT1:XS   ******    -71      520  1.25 *****  501.99  500.56    3860  500.75
       -41 ******    100    42626  1.45 ***** *******    0.91    7.42

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.88     501.15     500.91

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   500.25     523.37    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   500.25     523.37     500.91

FULLV:FV       42    -71      526  1.22  0.34  502.34  500.91    3860  501.12
         0     42    100    43176  1.45  0.00    0.01    0.89    7.34
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       60   -124      887  0.40  0.36  502.70 *******    3860  502.30
        60     60    276    57652  1.37  0.00    0.00    0.58    4.35
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   504.45       0.00     500.76     503.85

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   500.70     504.18     504.37     501.84

 ===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       42      0      315  1.74 *****  504.03  500.16    3333  502.29
         0 ******     42    25338  1.00 ***** *******    0.68   10.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.493  0.000  501.84 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    44.  0.02  0.06  505.40    0.00    530.  505.14

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    511.   149.  -129.    21.   1.3   0.8   4.7   4.1   1.1   3.0
   RT:     19.    21.    21.    42.   0.5   0.2   2.8   3.9   0.5   2.7

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

APPRO:AS       36   -182     2177  0.06  0.13  505.41  501.47    3860  505.35
        60     50    293   195718  1.20  0.42    0.00    0.16    1.77

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXIT1:XS     -42.   -72.   100.   3860.   42626.     520.    7.42  500.75
   FULLV:FV       0.   -72.   100.   3860.   43176.     526.    7.34  501.12
   BRIDG:BR       0.     0.    42.   3333.   25338.     315.   10.57  502.29
   RDWAY:RG       9.*******   511.    530.*********       0.    2.00  505.14
   APPRO:AS      60.  -183.   293.   3860.  195718.    2177.    1.77  505.35


 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS     500.56    0.91  493.24  523.03************  1.25  501.99  500.75
   FULLV:FV     500.91    0.89  493.58  523.37  0.34  0.00  1.22  502.34  501.12
   BRIDG:BR     500.16    0.68  493.75  502.29************  1.74  504.03  502.29
   RDWAY:RG   ****************  503.85  549.38  0.02******  0.06  505.40  505.14
   APPRO:AS     501.47    0.16  494.25  532.46  0.13  0.42  0.06  505.41  505.35
```

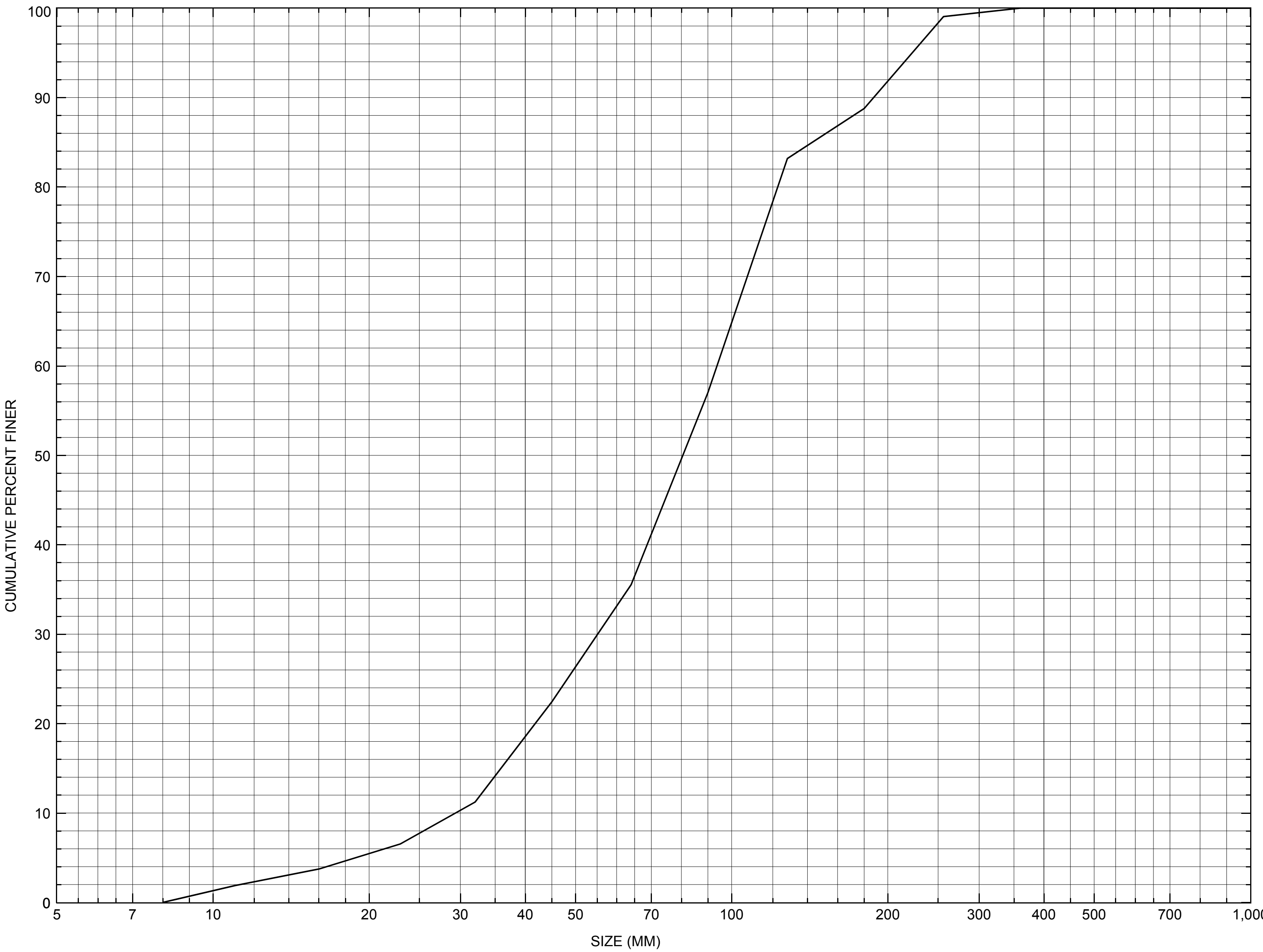
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File shef017.wsp
        Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
        TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
           *** RUN DATE & TIME: 10-03-97  10:50

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

EXIT1:XS   ******    -76      667  1.39 *****  502.98  501.29    5300  501.59
       -41 ******    101    58475  1.42 ***** *******    0.86    7.94

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.84     501.99     501.64

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   501.09     523.37    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   501.09     523.37     501.64

FULLV:FV       42    -76      673  1.37  0.34  503.33  501.64    5300  501.97
         0     42    101    59130  1.42  0.00    0.01    0.85    7.88
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  1.57

APPRO:AS       60   -142     1262  0.34  0.31  503.62 *******    5300  503.28
        60     60    281    92606  1.26  0.00   -0.02    0.47    4.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                      WS3N,LSEL =   501.97     501.84

            <<<<<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       42      0      313  2.55 *****  504.51  500.91    4002  501.97
         0 ******     42    28011  1.00 ***** *******    0.83   12.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  501.84 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.    44.  0.02  0.08  506.09    0.00   1301.  505.72

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   1122.   167.  -142.    25.   1.9   1.3   5.9   5.1   1.7   3.0
   RT:    179.    88.    25.   113.   1.0   0.4   3.8   4.8   0.8   2.8

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

APPRO:AS       36   -185     2501  0.08  0.17  506.11  502.04    5300  506.03
        60     54    297   239479  1.18  0.42    0.00    0.18    2.12


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -42.   -77.   101.   5300.   58475.     667.    7.94  501.59
   FULLV:FV       0.   -77.   101.   5300.   59130.     673.    7.88  501.97
   BRIDG:BR       0.     0.    42.   4002.   28011.     313.   12.80  501.97
   RDWAY:RG       9.******* 1122.   1301.******************    2.00  505.72
   APPRO:AS      60.  -186.   297.   5300.  239479.    2501.    2.12  506.03


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXIT1:XS    501.29    0.86  493.24  523.03************  1.39  502.98  501.59
   FULLV:FV    501.64    0.85  493.58  523.37  0.34  0.00  1.37  503.33  501.97
   BRIDG:BR    500.91    0.83  493.75  502.29************  2.55  504.51  501.97
   RDWAY:RG  ****************  503.85  549.38  0.02******  0.08  506.09  505.72
   APPRO:AS    502.04    0.18  494.25  532.46  0.17  0.42  0.08  506.11  506.03
```

```
        U.S. Geological Survey WSPRO Input File shef017.wsp
        Hydraulic analysis for structure SHEFTH00380017   Date: 18-JUN-97
        TH 38 CROSSING MILLER RUN, SHEFFIELD, VT
           *** RUN DATE & TIME: 10-03-97  10:50

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

EXIT1:XS   ******    -63      394  1.13 *****  501.13  499.67    2810  500.00
       -41 ******     99    31017  1.43 ***** *******    0.97    7.13

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.96     500.37     500.02

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.50     523.37    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.50     523.37     500.02

FULLV:FV       42    -64      399  1.11  0.34  501.48  500.02    2810  500.37
         0     42     99    31402  1.43  0.00    0.01    0.95    7.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       60   -105      561  0.57  0.45  501.91 *******    2810  501.34
        60     60    247    33751  1.46  0.00   -0.01    0.78    5.01
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   499.51     502.38     502.64     501.84

 ===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       42      0      315  1.24 *****  503.53  499.51    2810  502.29
         0 ******     42    25338  1.00 ***** *******    0.58    8.92

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.465  0.000  501.84 ****** ****** ******

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

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

APPRO:AS       36   -154     1509  0.07  0.12  503.95  501.00    2810  503.89
        60     46    285   118550  1.22  0.43    0.00    0.19    1.86

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   503.86

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K      AREA     VEL    WSEL
   EXIT1:XS    -42.   -64.    99.   2810.   31017.     394.    7.13  500.00
   FULLV:FV      0.   -65.    99.   2810.   31402.     399.    7.05  500.37
   BRIDG:BR      0.     0.    42.   2810.   25338.     315.    8.92  502.29
   RDWAY:RG      9.**************      0.       0.       0.    2.00********
   APPRO:AS     60.  -155.   285.   2810.  118550.    1509.    1.86  503.89


 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    499.67    0.97  493.24  523.03************  1.13  501.13  500.00
   FULLV:FV    500.02    0.95  493.58  523.37  0.34  0.00  1.11  501.48  500.37
   BRIDG:BR    499.51    0.58  493.75  502.29************  1.24  503.53  502.29
   RDWAY:RG  ****************  503.85  549.38************  0.07  503.93********
   APPRO:AS    501.00    0.19  494.25  532.46  0.12  0.43  0.07  503.95  503.89
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SHEFTH00380017, in Sheffield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SHEFTH00380017

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 28 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 005

Town *(FIPS place code; I - 4; nnnnn)* 64075

Mile marker *(I - 11; nnn.nnn)* 000000

Waterway *(I - 6)* MILLER RUN

Road Name *(I - 7):* -

Route Number TH038

Vicinity *(I - 9)* 0.05 MI JCT TH 38 +VT122

Topographic Map Lyndonville

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44358

Longitude *(i - 17; nnnnn.n)* 72064

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10031200170312

Maintenance responsibility *(I - 21; nn)* 03

Maximum span length *(I - 48; nnnn)* 0048

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000052

Average daily traffic, ADT *(I - 29; nnnnnn)* 000010

Deck Width *(I - 52; nn.n)* 157

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

Channel & Protection *(I - 61; n)* 5

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

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

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

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

Structure type *(I - 43; nnn)* 303

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 042.4

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

Vertical clearance from streambed (*nnn.n ft*) 008.4

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

Waterway of full opening (*nnn.n ft^2*) 356.0

Comments:

The structural inspection of 10/31/94 indicates that the structure is a steel I-beam type bridge with a creosote treated wooden deck. The left abutment and its' wingwalls are concrete faced "laid-up" stone with a concrete backwall and footing. The right abutment and its' wingwalls are grouted "laid-up" stone with a concrete backwall, kneewall, and footing. Both abutment walls have a concrete subfooting, which was constructed to prevent further undermining. However, now the right abutment footing is undermined, reportedly, for nearly its entire length. There are small undermined areas reported along the left abutment footing as well **(Continued, page 33).**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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)* : - Debris *(Heavy, Moderate, 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} (*ft^3/ sec*): -

Are there other structures nearby? (*Yes, No, Unknown*): Y *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 (*ft^2*): -

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

Comments:

A few boulders are noted on the stream banks up- and downstream. There is no report on channel scour, bank erosion, point bar, or debris accumulation at this site.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **24.17** mi^2 Lake/pond/swamp area **0.15** mi^2
Watershed storage *(ST)* **0.6** %
Bridge site elevation **854** ft Headwater elevation **2720** ft
Main channel length **7.37** mi
10% channel length elevation **886** ft 85% channel length elevation **1595** ft
Main channel slope *(S)* **128.27** 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:
There is no benchmark information available.

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:
There is no foundation material information available.

Comments:
There are no bridge plans available.

Cross-sectional Data

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

Source (*FEMA, VTAOT, Other*)? **VT AOT**

Comments: **There is cross-section at the upstream face. The low chord to bed length data is from a sketch attached to the VTAOT bridge inspection report dated 10/31/94.**

Station	0	3.0	9.4	24.8	33.1	42.3	-	-	-	-	-
Feature	RAB	-	-	-	-	LAB	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	3.0	7.3	6.9	6.7	6.7	5.7	-	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

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

Comments: -

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-
Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord-bed	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: EW Date: 03/19/96
Computerized by: EW Date: 03/19/96
Reviewd by: LKS Date: 08/06/97

Structure Number SHEFTH00380017

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* J. DEGNAN Date *(MM/DD/YY)* 08 / 01 / 1995

2. Highway District Number 07 Mile marker -

County Caledonia (005) Town Sheffield (64075)

Waterway *(I - 6)* Miller Run Road Name -

Route Number TH038 Hydrologic Unit Code: 01080102

3. Descriptive comments:

The bridge is a wooden deck bridge with a steel I-beam frame. The LABUT is concrete faced "laid-up" stone while the RABUT is grouted "laid-up" stone with a concrete kneewall.

B. Bridge Deck Observations

4. Surface cover... LBUS 5 RBUS 4 LBDS 5 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 1 DS 1 *(**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 52 *(feet)* Span length 48 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

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

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

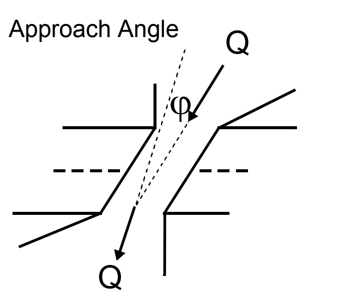
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

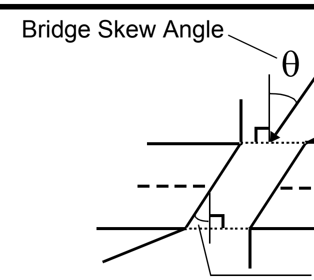
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	2	2	2	1
RBUS	2	2	2	2
RBDS	5	1	2	2
LBDS	2	2	2	1

*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: 30





α= 5.0

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 US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 0 feet US *(US, UB, DS)* to 5 feet DS

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

18. Bridge Type: **1a/1b**

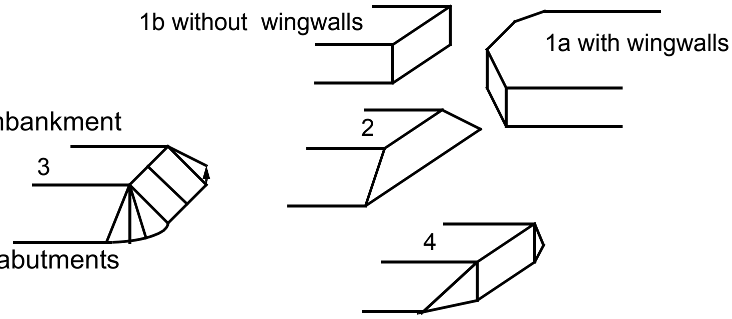
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel 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: VT AOT (USGS Field measured values): bridge length- 52 ft (52 ft), span length- 48 ft (48 ft), deck width- 15.7 ft (16 ft).

18: There are no wingwalls downstream of the bridge.

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
59.0	**4.5**			**2.5**	**1**	**3**	**4321**	**4321**	**1**	**1**

23. Bank width **15.0**   24. Channel width **30.0**   25. Thalweg depth **54.5**   29. Bed Material **432**

30 .Bank protection type: LB **0** RB **0**   31. 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*

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

-

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 55 35. Mid-bar width: 18

36. Point bar extent: 40 feet US (US, UB) to 70 feet US (US, UB, DS) positioned 80 %LB to 100 %RB

37. Material: 324

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

-

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

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

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

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

There are no cut-banks upstream at this site.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 5

47. Scour dimensions: Length 77 Width 27 Depth : 3 Position 0 %LB to 80 %RB

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

-

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):

There are no major confluences upstream at this site.

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
36.5		1.0		2	7	7	-

58. Bank width (BF) - 59. Channel width - 60. Thalweg depth 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.):

26

There is a bedrock outcrop across the channel at the DS bridge face

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 1____ (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

There is debris 40 feet US on the RB.

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	90	2	3	0.5	1.5	90.0
RABUT	1	30	90			2	3	42.0

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.):

0.5

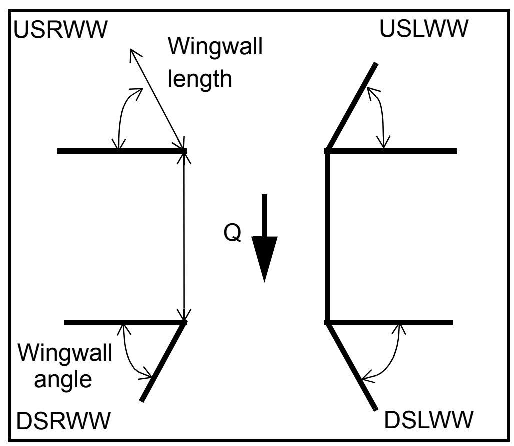
1.5

1

Undermining has occurred along the center of the right abutment and along the upstream half of the left abutment.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						42.0	
USRWW:	Y		1		2	1.0	
DSLWW:	0		1		Y	21.5	
DSRWW:	1		1		0	14.0	



*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	0.3	-	N	-	1	-	-	-
Condition	N	-	-	-	2	-	-	-
Extent	-	-	-	4	0	0	0	-

*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*

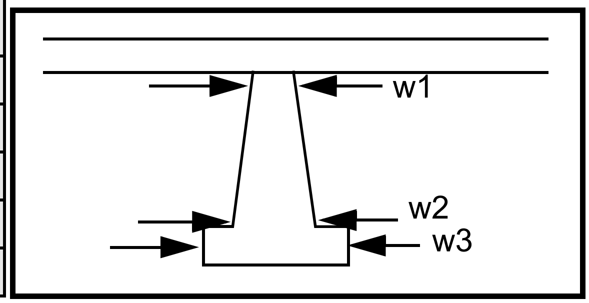
*Protection extent: **1**- entire base length; **2**- US end; **3**- DS end; **4**- other*

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				10.0	10.5	85.0
Pier 2		-	-	10.0	-	-
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
-	-			-	-	The	re	are	no	pier

Bank width (BF) -   Channel width -   Thalweg depth -   Bed Material s.

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
3
1234
1234
1
1
2634
0
0
-

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

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

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

e downstream banks are mostly silt and sand to one bridge length downstream. Beyond one bridge length downstream, the banks are composed primarily of cobble.

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: **N**

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

-

There is no drop structure at this site.

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

Cut bank extent: **Y** feet **15** *(US, UB, DS)* to **5** feet **6** *(US, UB, DS)*

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

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

22
DS
5
15

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned **N** %LB to **-** %RB

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

-
-
-
-

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

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

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

Confluence comments (eg. confluence name):

ks downstream at this site.

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
-
-
-
-
-
-
There is no channel scour downstream at this site.

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:	SHEFTH00380017	Town:	SHEFFIELD
Road Number:	TH 38	County:	CALEDONIA
Stream:	MILLER RUN		

Initials LKS Date: 07/14/97 Checked: RF

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	3860	5300	2810
Main Channel Area, ft2	516	553	436
Left overbank area, ft2	468	586	241
Right overbank area, ft2	1191	1362	833
Top width main channel, ft	55	55	55
Top width L overbank, ft	172	175	122
Top width R overbank, ft	249	253	241
D50 of channel, ft	0.2642	0.2642	0.2642
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.4	10.1	7.9
y1, average depth, LOB, ft	2.7	3.3	2.0
y1, average depth, ROB, ft	4.8	5.4	3.5
Total conveyance, approach	195469	239395	118614
Conveyance, main channel	61239	68747	46316
Conveyance, LOB	22566	32441	9388
Conveyance, ROB	111664	138206	62910
Percent discrepancy, conveyance	0.0000	0.0004	0.0000
Qm, discharge, MC, cfs	1209.3	1522.0	1097.2
Ql, discharge, LOB, cfs	445.6	718.2	222.4
Qr, discharge, ROB, cfs	2205.1	3059.8	1490.4
Vm, mean velocity MC, ft/s	2.3	2.8	2.5
Vl, mean velocity, LOB, ft/s	1.0	1.2	0.9
Vr, mean velocity, ROB, ft/s	1.9	2.2	1.8
Vc-m, crit. velocity, MC, ft/s	10.4	10.6	10.2
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
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

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)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3860	5300	2810
(Q) discharge thru bridge, cfs	3333	4002	2810
Main channel conveyance	25338	27974	25338
Total conveyance	25338	27974	25338
Q2, bridge MC discharge,cfs	3333	4002	2810
Main channel area, ft2	315	313	315
Main channel width (normal), ft	42.2	42.2	42.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	42.2	42.2	42.2
y_bridge (avg. depth at br.), ft	7.47	7.41	7.47
Dm, median (1.25*D50), ft	0.33025	0.33025	0.33025
y2, depth in contraction,ft	7.19	8.41	6.21
ys, scour depth (y2-ybridge), ft	-0.28	0.99	-1.26

Armoring
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	3333	4002	2810
Main channel area (DS), ft2	286	312.8	253
Main channel width (normal), ft	42.2	42.2	42.2
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	42.2	42.2	42.2
D90, ft	0.6156	0.6156	0.6156
D95, ft	0.7307	0.7307	0.7307
Dc, critical grain size, ft	0.5703	0.6630	0.5449
Pc, Decimal percent coarser than Dc	0.118	0.078	0.125
Depth to armoring, ft	12.79	23.51	11.44

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1) Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	3860	5300	2810
Q, thru bridge MC, cfs	3333	4002	2810
Vc, critical velocity, ft/s	10.45	10.57	10.16
Va, velocity MC approach, ft/s	2.34	2.75	2.52
Main channel width (normal), ft	42.2	42.2	42.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	42.2	42.2	42.2
qbr, unit discharge, ft2/s	79.0	94.8	66.6
Area of full opening, ft2	315.2	312.8	315.2
Hb, depth of full opening, ft	7.47	7.41	7.47
Fr, Froude number, bridge MC	0.68	0.83	0.58
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	286	N/A	253
**Hb, depth at downstream face, ft	6.78	N/A	6.00
**Fr, Froude number at DS face	0.79	ERR	0.80
**Cf, for downstream face (<=1.0)	1.00	N/A	1.00
Elevation of Low Steel, ft	501.84	501.84	501.84
Elevation of Bed, ft	494.37	494.43	494.37
Elevation of Approach, ft	505.35	506.03	503.89
Friction loss, approach, ft	0.13	0.17	0.12
Elevation of WS immediately US, ft	505.22	505.86	503.77
ya, depth immediately US, ft	10.85	11.43	9.40
Mean elevation of deck, ft	504.68	504.68	504.68
w, depth of overflow, ft (>=0)	0.54	1.18	0.00
Cc, vert contrac correction (<=1.0)	0.92	0.92	0.94
**Cc, for downstream face (<=1.0)	0.888691	ERR	0.878232
Ys, scour w/Chang equation, ft	0.76	2.37	-0.52
Ys, scour w/Umbrell equation, ft	-2.76	-2.17	-3.00

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	1.73	N/A	1.47

**Ys, scour w/Umbrell equation, ft	-2.07	N/A	-1.53

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	7.19	8.41	6.21
WSEL at downstream face, ft	501.16	--	500.37
Depth at downstream face, ft	6.78	N/A	6.00
Ys, depth of scour (Laursen), ft	0.41	N/A	0.21

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)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	3860	5300	2810	3860	5300	2810
a', abut.length blocking flow, ft	182.9	185.8	155.3	250.6	254.4	242.5
Ae, area of blocked flow ft2	428.62	479.89	300	1206.69	1352.19	845.1
Qe, discharge blocked abut.,cfs	--	--	332.9	--	--	1514.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.06	1.36	1.11	1.85	2.25	1.79
ya, depth of f/p flow, ft	2.34	2.58	1.93	4.82	5.32	3.48
--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	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	0.109	0.126	0.141	0.149	0.170	0.169
ys, scour depth, ft	9.74	11.19	9.15	20.05	22.90	16.99

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)	182.9	185.8	155.3	250.6	254.4	242.5
y1 (depth f/p flow, ft)	2.34	2.58	1.93	4.82	5.32	3.48
a'/y1	78.05	71.94	80.39	52.04	47.86	69.58
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.11	0.13	0.14	0.15	0.17	0.17
Ys w/ corr. factor K1/0.55:						
vertical	8.29	9.59	7.44	18.37	21.17	13.86
vertical w/ ww's	6.80	7.86	6.10	15.06	17.36	11.37
spill-through	4.56	5.27	4.09	10.10	11.65	7.62

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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.79	0.83	0.8	0.79	0.83	0.8
y, depth of flow in bridge, ft	6.78	7.41	6.00	6.78	7.41	6.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.62	ERR	2.37	2.62	ERR	2.37
Fr>0.8 (vertical abut.)	ERR	2.94	ERR	ERR	2.94	ERR