LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (DORSTH00100029) on TOWN HIGHWAY 10, crossing the METTAWEE RIVER, DORSET, VERMONT

Open-File Report 97-774

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

U.S. Department of the Interior
USGS
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LEVEL II SCOUR ANALYSIS FOR BRIDGE 29 (DORSTH00100029) on TOWN HIGHWAY 10, crossing the METTAWEE RIVER, DORSET, VERMONT

By EMILY C. WILD

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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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 29 (DORSTH00100029) ON TOWN HIGHWAY 10, CROSSING THE METTAWEE RIVER, DORSET, VERMONT

***By* Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure DORSTH00100029 on Town Highway 10 crossing the Mettawee River, Dorset, 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 Taconic section of the New England physiographic province in southwestern Vermont. The 9.5-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the upstream left overbank and the upstream and downstream right overbanks. The downstream left overbank is pasture and brushland.

In the study area, the Mettawee River has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 66 ft and an average bank height of 8 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 79.0 mm (0.259 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 5, 1996, indicated that the reach was stable.

The Town Highway 10 crossing of the Mettawee River is a 26-ft-long, two-lane bridge consisting of a 24-ft steel-stringer span (Vermont Agency of Transportation, written communication, September 28, 1995). The opening length of the structure parallel to the bridge face is 24.1 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 45 degrees to the opening while the opening-skew-to-roadway is zero degrees.

At the upstream end of the right abutment, there is a scour hole 1.0 ft deeper than the mean thalweg depth. Scour counter-measures at the site include type-1 stone fill (less than 12 inches diameter) along the downstream right wingwall. Type-2 stone fill (less than 36 inches diameter) is present along the downstream left and right banks. Type-3 stone fill (less than 48 inches diameter) is present along the upstream left bank and sparsely in front of the right abutment. A concrete wall (old abutment) extends along the upstream right bank. 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 all modelled flows ranged from 0.4 to 1.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 10.5 to 10.8 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 11.4 to 11.9 ft. The worst-case right abutment scour occurred at the 100-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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 DORSTH00100029 ***Stream*** Mettawee River

County Bennington ***Road*** TH10 ***District*** 1

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 22.2 ***ft*** ***Max span length*** 24 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? No and Yes ***Date of inspection*** 8/05/96

Description of stone fill Type-1 stone fill along the downstream right wingwall. Type-2 stone fill is present along the downstream left and right banks. Type-3 stone fill is present along the upstream left bank and along the right abutment.

Abutments and wingwalls are concrete. There is a one foot deep scour hole in front of the upstream end of the right abutment.

Is bridge skewed to flood flow according to Y ***survey?*** Yes ***Angle*** 45

There is a moderate channel bend in the upstream reach. The scour hole has developed in the location where the bend impacts the upstream right wingwall.

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	8/05/96	0	0
Level II	8/05/96	0	0

Potential for debris Moderate. Debris is present along the upstream and downstream tops of banks.

Describe any features near or at the bridge that may affect flow (include observation date) An old channel restraint was noted, during the site visit on August 5, 1996, extending from the end of the upstream right wingwall to approximately 41 feet upstream from the upstream bridge face along the right bank.

Description of the Geomorphic Setting

General topography The channel is located within a narrow flood plain with moderately sloped valley walls on both sides.

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

Date of inspection 8/05/96

DS left: Narrow flood plain.

DS right: Steep channel bank to a narrow flood plain.

US left: Narrow flood plain.

US right: Narrow flood plain.

Description of the Channel

Average top width 66 ft ***Average depth*** 8 ft

Predominant bed material Cobbles, Gravel ***Bank material*** Cobbles, Gravel

Sinuous but stable with non-alluvial channel boundaries and a narrow flood plain.

8/05/96

Vegetative co Field of tall grass with some brush and a few trees on overbank.

DS left: Brush and trees with TH 10 (Dorset Hollow Road) along immediate bank.

DS right: Trees and brush.

US left: Trees and brush.

US right: Yes

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

No obstructions were observed in the channel during the August 5, 1996 site visit.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.5 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description Mettawee River near Pawlet, VT

USGS gage number 04280350

Gage drainage area 70.2 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 2,580 ***ft³/s*** ***Q500*** 3,750 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(9.5/9.9)exp 0.67] with bridge number 31 in Dorset. Bridge number 31 crosses the Mettawee River downstream of this site and has flood frequency estimates available from the VTAOT database. The drainage area above bridge number 31 is 9.9 square miles. These values are within a range defined by several empirical flood frequency curves (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 To obtain the Vermont AOT datum at this bridge site, subtract 1.6 feet from USGS survey.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the upstream right wingwall (elev. 499.86 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the downstream left wingwall (elev. 499.91 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	-24	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	11	1	Road Grade section
APTEM	52	1	Approach section as surveyed (Used as a template)
APPRO	82	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 and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel “n” values for the reach ranged from 0.050 to 0.055, and overbank “n” values ranged from 0.045 to 0.080.

Critical depth at the exit section (EXITX) was assumed as the starting water surface. Normal depth was computed by use of the slope-conveyance method outlined in the user’s manual for WSPRO (Shearman, 1990) and resulted in a supercritical solution, but within 0.2 feet of critical depth. The slope used was 0.0223 ft/ft which was calculated from thalweg slopes surveyed downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0168 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 provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.6 ***ft***
Average low steel elevation 498.4 ***ft***

100-year discharge 2,580 ***ft³/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Road overtopping? Y ***Discharge over road*** 530 ***ft³/s***
Area of flow in bridge opening 189 ***ft²***
Average velocity in bridge opening 10.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.3 ***ft/s***

Water-surface elevation at Approach section with bridge 501.8
Water-surface elevation at Approach section without bridge 497.4
Amount of backwater caused by bridge 4.4 ***ft***

500-year discharge 3,750 ***ft³/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Road overtopping? Y ***Discharge over road*** 1560 ***ft³/s***
Area of flow in bridge opening 189 ***ft²***
Average velocity in bridge opening 11.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 16.4 ***ft/s***

Water-surface elevation at Approach section with bridge 502.7
Water-surface elevation at Approach section without bridge 498.8
Amount of backwater caused by bridge 3.9 ***ft***

Incipient overtopping discharge 1,780 ***ft³/s***
Water-surface elevation in bridge opening 498.4 ***ft***
Area of flow in bridge opening 190 ***ft²***
Average velocity in bridge opening 9.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***ft/s***

Water-surface elevation at Approach section with bridge 500.6
Water-surface elevation at Approach section without bridge 496.4
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 100-year and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, the modeled 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 these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146).

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and 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 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	1.5	1.9	0.4
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	10.5	10.8	10.6
Right abutment	11.9	11.5	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	2.5	2.7	2.3
Right abutment	2.5	2.7	2.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

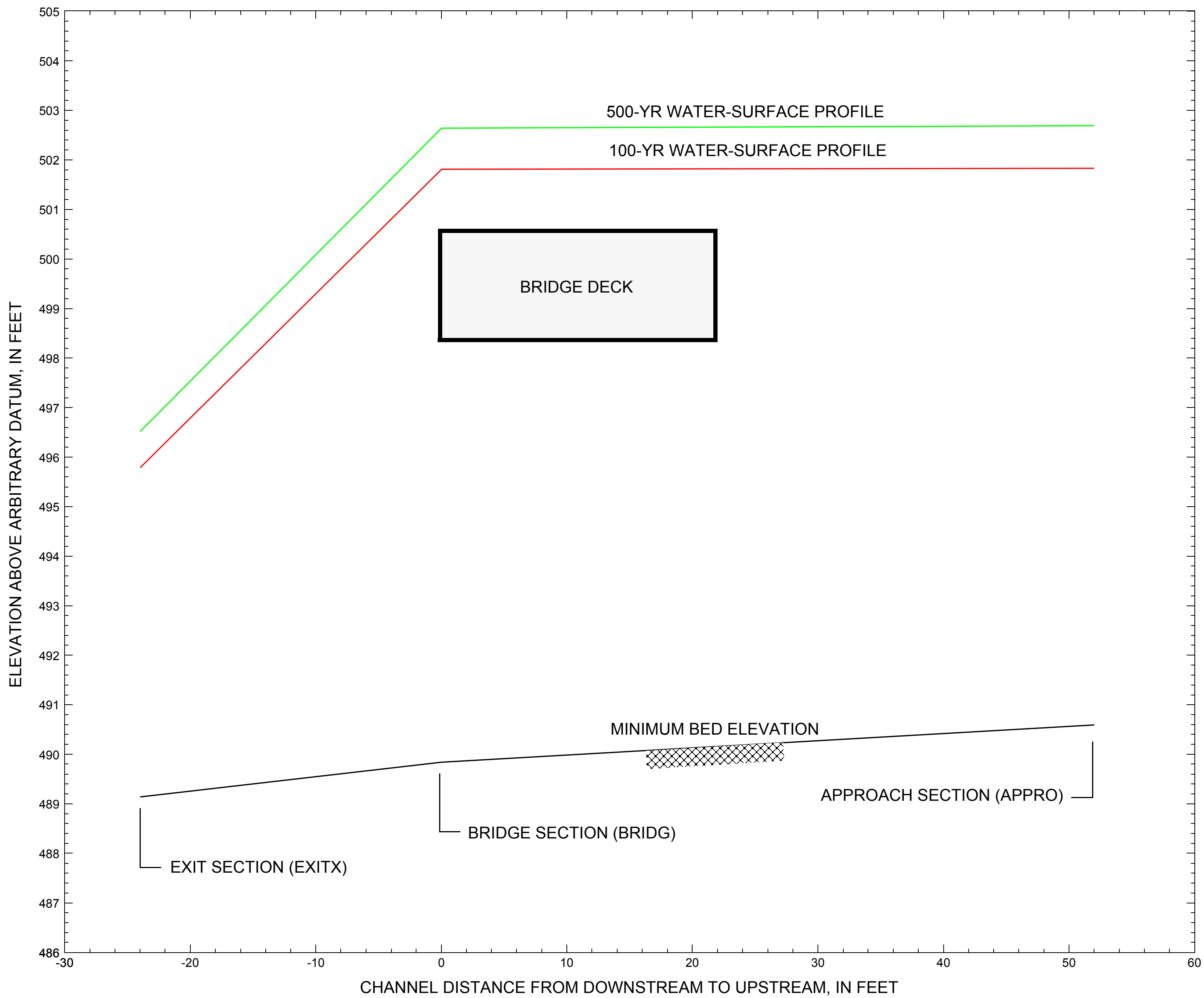

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure DORSTH00100029 on Town Highway 10, crossing the Mettawee River, Dorset, Vermont.

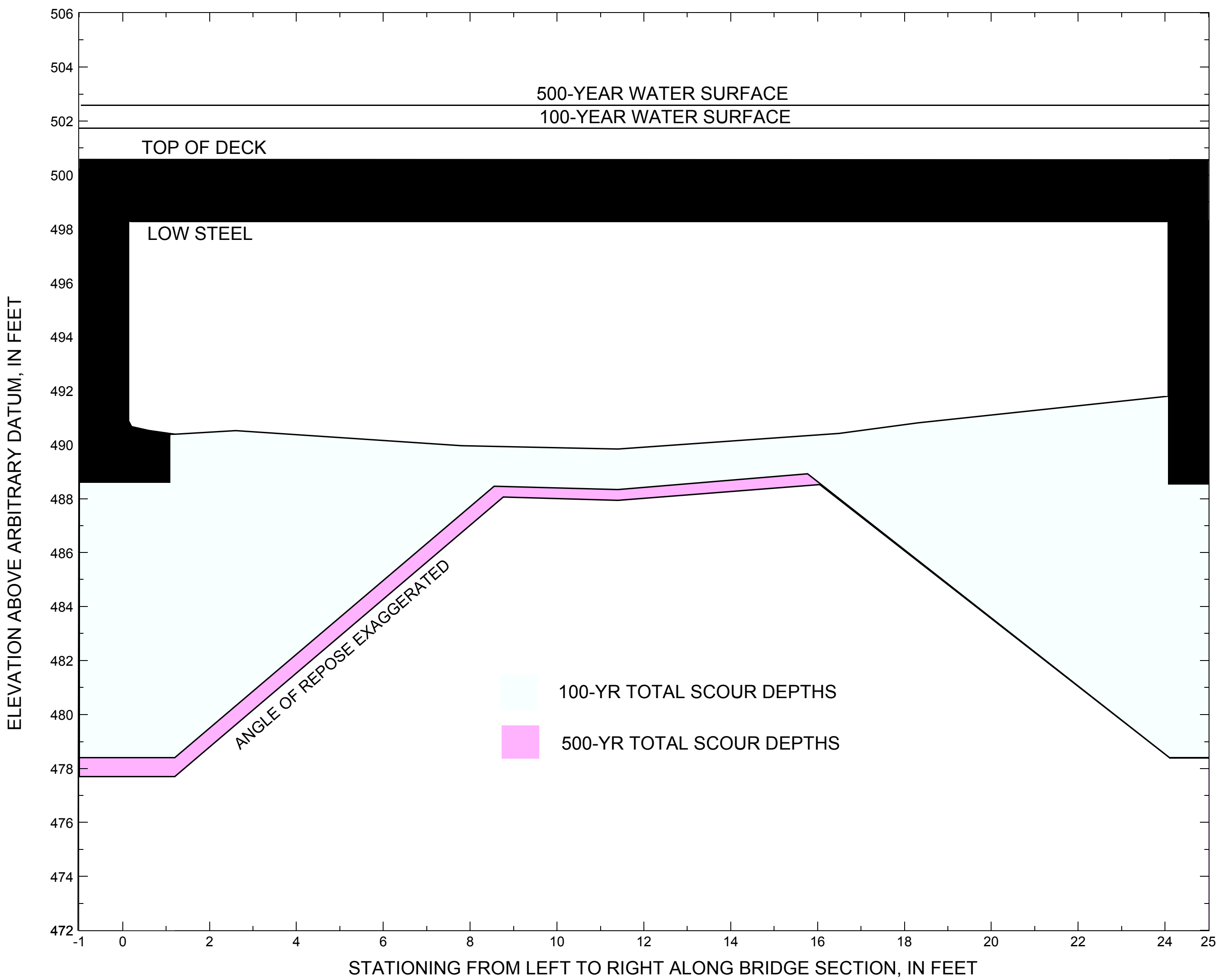

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure DORSTH00100029 on Town Highway 10, crossing the Mettawee River, Dorset, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure DORSTH00100029 on Town Highway 10, crossing the Mettawee River, Dorset, Vermont.

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

Description	Station[1]	VTAOT average 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 2,530 cubic-feet per second											
Left abutment	0.0	496.7	498.4	488.6	490.4	1.5	10.5	--	12.0	478.4	-10
Right abutment	24.1	496.7	498.3	488.6	491.8	1.5	11.9	--	13.4	478.4	-10

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 DORSTH00100029 on Town Highway 10, crossing the Mettawee River, Dorset, Vermont.

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

Description	Station[1]	VTAOT average 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 3,750 cubic-feet per second											
Left abutment	0.0	496.7	498.4	488.6	490.4	1.9	10.8	--	12.7	477.7	-11
Right abutment	24.1	496.7	498.3	488.6	491.8	1.9	11.5	--	13.4	478.4	-10

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

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U.S. Geological Survey, 1967, Dorset, 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 (continued)

```
T1        U.S. Geological Survey WSPRO Input File dors029.wsp
T2        Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
T3        Town Highway 10, Mettawee River, Dorset, Vermont         ECW
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2580.0   3750.0   1780.0
SK          0.0223   0.0223   0.0223
*
XS   EXITX    -24           0.
GR         -125.7, 503.81   -100.6, 497.97    -74.1, 494.06     -4.5, 493.73
GR            0.0, 490.09      1.1, 490.05      2.6, 489.70     11.0, 489.14
GR           17.9, 489.51     20.3, 489.86     25.2, 492.68     28.0, 496.03
GR           33.7, 498.71     83.8, 500.97    128.3, 501.91    133.4, 501.83
GR          167.7, 509.07
*
N           0.045        0.055        0.060
SA                  -4.5         33.7
*
*
XS   FULLV      0  * * *   0.0187
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.36       0.0
GR            0.0, 498.42      0.1, 490.99      0.1, 490.67      0.6, 490.53
GR            1.2, 490.39      2.6, 490.52      7.8, 489.96     11.4, 489.84
GR           16.5, 490.42     18.3, 490.81     24.1, 491.80     24.1, 498.30
GR            0.0, 498.42
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      29.1 * *     43.9      6.9
N           0.050
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     11      22.2     1
GR         -237.8, 510.07    -72.0, 501.46      0.0, 500.57     24.7, 500.56
GR           48.2, 501.01     88.6, 502.13    122.0, 502.17
*
XT   APTEM     82
GR         -188.2, 506.89   -152.8, 505.02    -24.8, 500.13    -10.8, 497.27
GR            0.0, 492.11      5.1, 491.39     14.6, 491.93     18.0, 491.67
GR           22.9, 491.09     23.7, 492.15     29.5, 495.23     62.1, 502.40
GR          106.7, 504.55    117.9, 504.44    133.7, 510.71
*
AS   APPRO     52 * * *  0.0168
GT
N           0.070        0.056        0.080
SA                 -24.8         62.1
*
HP 1 BRIDG 498.36 1 498.36
HP 2 BRIDG 498.36 * * 2043
HP 1 BRIDG 496.57 1 496.57
HP 2 RDWAY 501.81 * * 528
HP 1 APPRO 501.83 1 501.83
HP 2 APPRO 501.83 * * 2580
*
HP 1 BRIDG 498.36 1 498.36
HP 2 BRIDG 498.36 * * 2190
HP 1 BRIDG 496.97 1 496.97
HP 2 RDWAY 502.64 * * 1559
HP 1 APPRO 502.69 1 502.69
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File dors029.wsp
        Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
        Town Highway 10, Mettawee River, Dorset, Vermont         ECW
           *** RUN DATE & TIME: 07-31-97  09:45

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      189     13606     12     50                         4254
   498.36           189     13606     12     50  1.00      0     24     4254

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.36     0.0    24.1   189.2   13606.    2043.  10.80

X STA.         0.0         2.2         3.4         4.4         5.3         6.2
  A(I)            16.7         9.5         8.2         7.5         7.3
  V(I)            6.11       10.74       12.45       13.71       13.96

X STA.         6.2         7.1         7.9         8.7         9.5        10.3
  A(I)             6.9         7.0         6.7         6.8         6.9
  V(I)           14.89       14.56       15.32       14.92       14.87

X STA.        10.3        11.1        12.0        13.1        14.3        15.5
  A(I)             7.0         7.0         9.5         9.7         9.8
  V(I)           14.56       14.56       10.78       10.54       10.40

X STA.        15.5        16.8        18.1        19.7        21.4        24.1
  A(I)            10.2        10.6        11.4        12.4        18.1
  V(I)            9.98        9.63        8.97        8.27        5.63
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      146     11353     24     35                         2050
   496.57           146     11353     24     35  1.00      0     24     2050

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.81   -78.7    77.1   124.8    3280.     528.   4.23

X STA.       -78.7       -53.5       -42.3       -34.0       -27.0       -21.0
  A(I)             9.7         7.3         6.4         6.1         5.6
  V(I)            2.71        3.62        4.15        4.36        4.68

X STA.       -21.0       -15.7       -11.0        -6.7        -2.4         1.9
  A(I)             5.3         5.1         4.9         5.1         5.3
  V(I)            4.94        5.17        5.40        5.22        5.01

X STA.         1.9         6.1        10.3        14.5        18.7        22.9
  A(I)             5.2         5.2         5.3         5.2         5.2
  V(I)            5.08        5.07        5.01        5.04        5.06

X STA.        22.9        27.1        31.8        38.3        47.4        77.1
  A(I)             5.2         5.4         6.9         8.2        12.2
  V(I)            5.04        4.88        3.83        3.23        2.17
    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       64      1443     58     58                          379
             2      552     49087     87     90                         7903
   501.83           615     50530    144    148  1.14    -81     62     6746

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.83   -82.5    61.8   615.3   50530.    2580.   4.19

X STA.       -82.5       -17.8        -9.4        -4.9        -1.8         0.7
  A(I)            84.1        37.8        30.5        27.0        25.0
  V(I)            1.53        3.42        4.23        4.78        5.15

X STA.         0.7         2.9         5.0         7.0         9.0        11.1
  A(I)            23.0        22.1        22.0        22.3        22.0
  V(I)            5.62        5.84        5.87        5.80        5.86

X STA.        11.1        13.2        15.4        17.6        19.7        21.9
  A(I)            22.3        22.8        22.9        23.2        24.2
  V(I)            5.78        5.66        5.62        5.56        5.33

X STA.        21.9        24.6        27.8        32.5        39.2        61.8
  A(I)            28.0        28.9        33.0        38.2        56.0
  V(I)            4.61        4.46        3.91        3.38        2.30
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      U.S. Geological Survey WSPRO Input File dors029.wsp
      Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
      Town Highway 10, Mettawee River, Dorset, Vermont         ECW
         *** RUN DATE & TIME: 07-31-97  09:45

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

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           1      189     13606    12     50                          4254
 498.36           189     13606    12     50  1.00      0     24      4254

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.36     0.0    24.1   189.2   13606.    2190.  11.57

X STA.        0.0        2.2        3.4        4.4        5.3        6.2
  A(I)            16.7        9.5        8.2        7.5        7.3
  V(I)            6.55      11.52      13.35      14.70      14.97

X STA.        6.2        7.1        7.9        8.7        9.5       10.3
  A(I)             6.9        7.0        6.7        6.8        6.9
  V(I)           15.96      15.61      16.42      15.99      15.94

X STA.       10.3       11.1       12.0       13.1       14.3       15.5
  A(I)             7.0        7.0        9.5        9.7        9.8
  V(I)           15.61      15.61      11.55      11.30      11.15

X STA.       15.5       16.8       18.1       19.7       21.4       24.1
  A(I)            10.2       10.6       11.4       12.4       18.1
  V(I)           10.70      10.33       9.62       8.86       6.03

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

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           1      156     12436    24     36                          2255
 496.97           156     12436    24     36  1.00      0     24      2255

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

       WSEL     LEW     REW    AREA        K        Q    VEL
     502.64   -94.7   122.0   284.8   10375.    1559.   5.47

X STA.      -94.7      -66.2      -55.3      -45.9      -37.9      -30.5
  A(I)            20.5       14.4       13.5       12.5       12.1
  V(I)            3.81       5.40       5.79       6.23       6.45

X STA.      -30.5      -23.9      -17.6      -11.9       -6.7       -1.1
  A(I)            11.6       11.3       10.7       10.3       11.3
  V(I)            6.73       6.90       7.25       7.57       6.88

X STA.       -1.1        4.6       10.3       15.9       21.5       27.3
  A(I)            11.8       11.8       11.5       11.7       11.9
  V(I)            6.61       6.60       6.75       6.64       6.54

X STA.       27.3       33.5       42.3       53.4       70.1      122.0
  A(I)            12.2       16.1       18.0       20.9       30.6
  V(I)            6.36       4.84       4.33       3.73       2.55

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

   WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
           1      123      3474    80     80                           863
           2      626     60523    87     91                          9545
           3        7        66    16     16                            23
 502.69           756     64063   184    187  1.23   -104     79      7836

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

       WSEL     LEW     REW    AREA        K        Q    VEL
     502.69  -105.0    78.6   755.9   64063.    3750.   4.96

X STA.     -105.0      -27.2      -14.1       -7.7       -3.7       -0.7
  A(I)           115.7       51.6       39.3       33.3       30.2
  V(I)            1.62       3.63       4.77       5.63       6.20

X STA.       -0.7        1.8        4.2        6.4        8.6       10.9
  A(I)            28.1       26.7       25.8       26.2       25.9
  V(I)            6.68       7.02       7.27       7.16       7.24

X STA.       10.9       13.2       15.5       17.9       20.3       22.6
  A(I)            26.7       26.5       27.1       27.4       28.6
  V(I)            7.02       7.09       6.93       6.85       6.56

X STA.       22.6       25.7       29.5       34.7       42.1       78.6
  A(I)            32.9       34.7       38.6       43.9       66.6
  V(I)            5.70       5.40       4.86       4.27       2.82
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     U.S. Geological Survey WSPRO Input File dors029.wsp
     Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
     Town Highway 10, Mettawee River, Dorset, Vermont         ECW
        *** RUN DATE & TIME: 07-31-97  09:45

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      190     11826      0     63                            0
498.42           190     11826      0     63  1.00      0     24        0


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

      WSEL     LEW     REW    AREA        K        Q    VEL
    498.42     0.0    24.1   189.6   11826.    1780.   9.39

X STA.        0.0         2.2         3.5         4.6         5.7         6.7
  A(I)            16.7        10.4         9.1         9.0         8.4
  V(I)            5.32        8.52        9.78        9.85       10.55

X STA.        6.7         7.7         8.7         9.7        10.6        11.5
  A(I)             8.3         8.1         8.1         8.0         8.0
  V(I)           10.73       10.94       11.05       11.14       11.11

X STA.       11.5        12.5        13.4        14.4        15.5        16.5
  A(I)             8.0         7.9         8.2         8.5         8.4
  V(I)           11.11       11.26       10.90       10.52       10.61

X STA.       16.5        17.6        18.8        20.2        21.7        24.1
  A(I)             8.7         9.0         9.9        10.6        16.1
  V(I)           10.20        9.86        9.01        8.36        5.51

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      133      9930     24     34                         1783
496.03           133      9930     24     34  1.00      0     24     1783

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1       13       177     26     26                           53
          2      451     36618     81     85                         6035
500.63           464     36795    107    111  1.04    -50     56     5360


 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      52.

      WSEL     LEW     REW    AREA        K        Q    VEL
    500.63   -51.1    56.3   464.3   36795.    1780.   3.83

X STA.      -51.1       -10.3        -5.1        -1.9         0.5         2.6
  A(I)            49.4        27.8        23.4        20.5        19.3
  V(I)            1.80        3.20        3.81        4.34        4.60

X STA.        2.6         4.5         6.3         8.1        10.0        11.9
  A(I)            18.3        17.9        17.5        17.7        17.5
  V(I)            4.85        4.97        5.09        5.03        5.09

X STA.       11.9        13.8        15.7        17.7        19.6        21.6
  A(I)            17.6        18.1        18.2        18.4        19.2
  V(I)            5.05        4.93        4.88        4.83        4.63

X STA.       21.6        23.7        26.4        30.5        36.2        56.3
  A(I)            20.8        22.6        26.5        28.8        44.7
  V(I)            4.27        3.95        3.36        3.09        1.99
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       U.S. Geological Survey WSPRO Input File dors029.wsp
       Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
       Town Highway 10, Mettawee River, Dorset, Vermont         ECW
          *** RUN DATE & TIME: 07-31-97  09:45

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   495.50     495.79

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

EXITX:XS   ******    -85      314  1.21 *****  497.00  495.79    2580  495.79
       -23 ******     28    20024  1.15 ***** *******    0.94    8.22

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.97     496.18     496.24
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.29     509.52    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.29     509.52     496.24
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   496.24     509.52     496.24

FULLV:FV       24    -85      314  1.21 *****  497.45  496.24    2580  496.24
         0     24     28    20024  1.15 ***** *******    0.94    8.22
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.17     496.88     497.43
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.74     510.21    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.74     510.21     497.43
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   497.43     510.21     497.43

APPRO:AS       52    -13      226  2.02 *****  499.45  497.43    2580  497.43
        52     52     42    14805  1.00 ***** *******    1.00   11.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   502.01       0.00     497.59     500.56
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   503.64         0.      2580.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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       24      0      189  1.81 *****  500.17  496.57    2043  498.36
         0 ******     24    13606  1.00 ***** *******    0.68   10.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.491  0.000  498.36 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR      Q    WSEL
   RDWAY:RG      11.    30.  0.08  0.31  502.07    0.00    528.  501.81

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    305.    90.   -79.    11.   1.2   0.8   4.8   4.2   1.1   3.1
   RT:    224.    66.    11.    77.   1.3   0.8   4.9   4.3   1.0   3.2

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

APPRO:AS       23    -82      615  0.31  0.18  502.14  497.43    2580  501.83
        52     24     62    50537  1.14  0.00    0.00    0.38    4.19

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW     REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -24.   -86.     28.   2580.   20024.     314.    8.22  495.79
   FULLV:FV       0.   -86.     28.   2580.   20024.     314.    8.22  496.24
   BRIDG:BR       0.     0.     24.   2043.   13606.     189.   10.80  498.36
   RDWAY:RG      11.*******    305.    528.******************    1.00  501.81
   APPRO:AS      52.   -83.     62.   2580.   50537.     615.    4.19  501.83

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.79    0.94  489.14  509.07************  1.21  497.00  495.79
   FULLV:FV    496.24    0.94  489.59  509.52************  1.21  497.45  496.24
   BRIDG:BR    496.57    0.68  489.84  498.42************  1.81  500.17  498.36
   RDWAY:RG  ****************  500.56  510.07  0.08******  0.31  502.07  501.81
   APPRO:AS    497.43    0.38  490.59  510.21  0.18  0.00  0.31  502.14  501.83
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File dors029.wsp
       Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
       Town Highway 10, Mettawee River, Dorset, Vermont         ECW
          *** RUN DATE & TIME: 07-31-97  09:45

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                            WSI,CRWS =   496.28     496.52

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

EXITX:XS   ******    -90     399  1.49 *****  498.01  496.52    3750  496.52
       -23 ******     29   27885  1.08 ***** *******    0.94    9.40

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95     496.96     496.97
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.02     509.52    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.02     509.52     496.97

FULLV:FV       24    -90     399  1.49  0.43  498.46  496.97    3750  496.97
         0     24     29   27885  1.08  0.00    0.01    0.94    9.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.53     497.24     498.79
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.47     510.21    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.47     510.21     498.79
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                WSBEG,WSEND,CRWS =   498.79     510.21     498.79

APPRO:AS       52    -20     311  2.26 *****  501.05  498.79    3750  498.79
        52     52     48   21973  1.00 ***** *******    1.00   12.06
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   506.63       0.00     498.35     500.56
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   504.22         0.      3750.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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       24      0     189  2.08 *****  500.44  496.84    2190  498.36
         0 ******     24   13606  1.00 ***** *******    0.73   11.57

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.496  0.000  498.36 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF    VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    30.  0.10  0.47  503.06    0.00   1559.  502.64

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    847.   106.   -95.    12.   2.1   1.5   6.4   5.5   1.9   3.1
   RT:    713.   110.    12.   122.   2.1   1.2   6.1   5.5   1.6   3.2

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

APPRO:AS       23   -104     755  0.47  0.24  503.16  498.79    3750  502.69
        52     24     79   64004  1.23  0.00    0.00    0.48    4.97

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

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -24.   -91.    29.   3750.   27885.     399.    9.40  496.52
   FULLV:FV       0.   -91.    29.   3750.   27885.     399.    9.40  496.97
   BRIDG:BR       0.     0.    24.   2190.   13606.     189.   11.57  498.36
   RDWAY:RG      11.*******   847.   1559.******************    1.00  502.64
   APPRO:AS      52.  -105.    79.   3750.   64004.     755.    4.97  502.69

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.52    0.94  489.14  509.07************  1.49  498.01  496.52
   FULLV:FV    496.97    0.94  489.59  509.52  0.43  0.00  1.49  498.46  496.97
   BRIDG:BR    496.84    0.73  489.84  498.42************  2.08  500.44  498.36
   RDWAY:RG  ***************  500.56  510.07  0.10******  0.47  503.06  502.64
   APPRO:AS    498.79    0.48  490.59  510.21  0.24  0.00  0.47  503.16  502.69
```
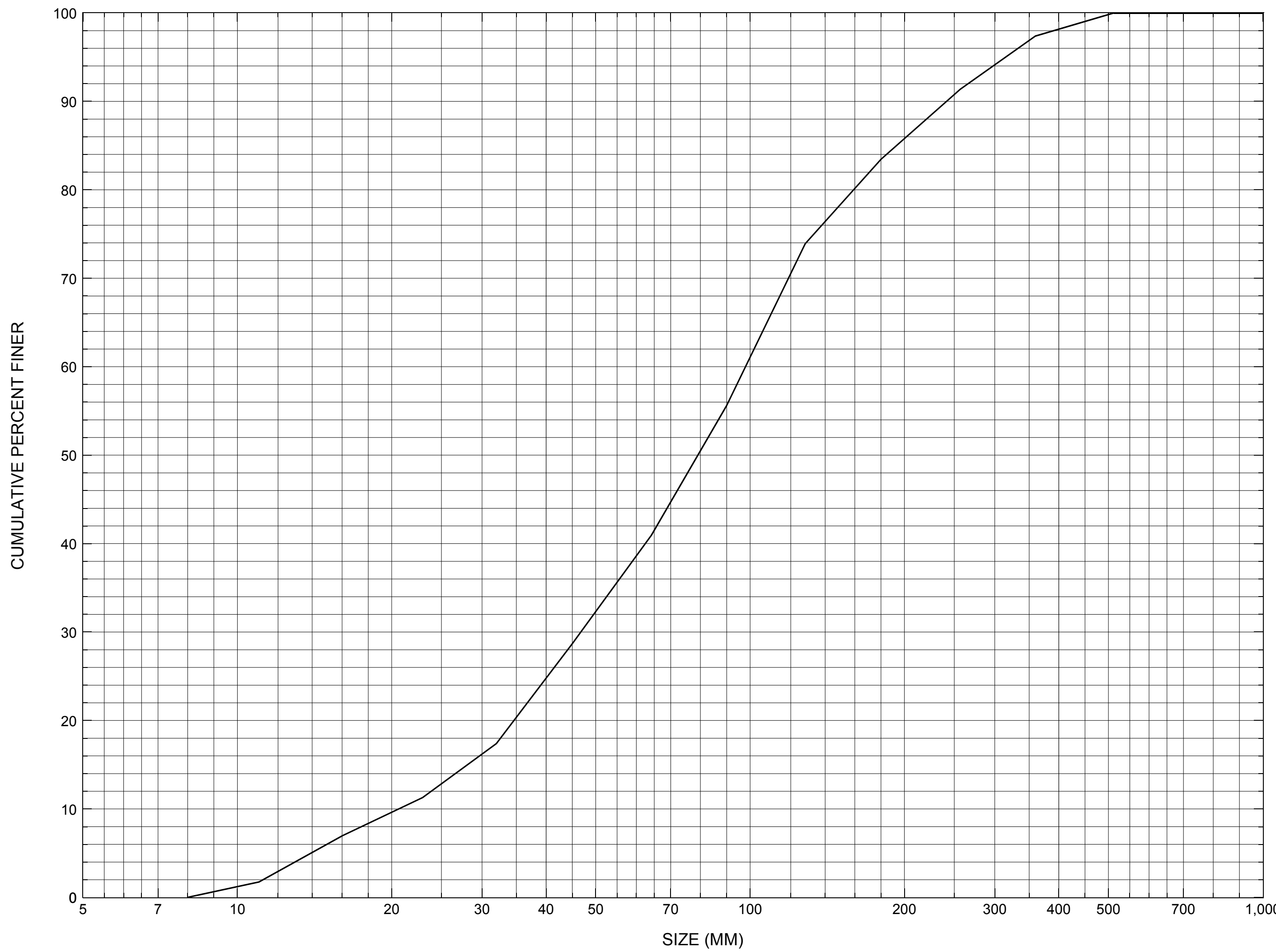

```
        U.S. Geological Survey WSPRO Input File dors029.wsp
        Hydraulic analysis for structure DORSTH00100029   Date: 15-JUL-97
        Town Highway 10, Mettawee River, Dorset, Vermont         ECW
           *** RUN DATE & TIME: 07-31-97  09:45

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                             WSI,CRWS =   494.85     495.18

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

EXITX:XS   ******    -81      246  1.00 *****  496.18  495.18    1780  495.18
       -23 ******     27    14473  1.23 ***** *******    0.94    7.24

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.03     495.51     495.63

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.68     509.52    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.68     509.52     495.63

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   495.63     509.52     495.63

FULLV:FV       24    -81      246  1.00 *****  496.63  495.63    1780  495.63
         0     24     27    14473  1.23 ***** *******    0.94    7.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.95     496.38     496.22

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.13     510.21    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.13     510.21     496.22

APPRO:AS       52     -9      173  1.65  1.08  498.03  496.22    1780  496.38
        52     52     37    10567  1.00  0.32    0.00    0.95   10.29
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   496.03     499.38     499.65     498.36

 ===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       24      0      190  1.37 *****  499.79  496.03    1777  498.42
         0 ******     24    11826  1.00 ***** *******    0.59    9.38

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.467  0.000  498.36 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.        <<<<<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       23    -50      464  0.24  0.17  500.87  496.22    1780  500.63
        52     23     56    36769  1.04  0.94    0.00    0.33    3.84

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   500.56

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -24.   -82.    27.   1780.   14473.     246.    7.24  495.18
   FULLV:FV       0.   -82.    27.   1780.   14473.     246.    7.24  495.63
   BRIDG:BR       0.     0.    24.   1777.   11826.     190.    9.38  498.42
   RDWAY:RG      11.**************      0.       0.       0.    1.00********
   APPRO:AS      52.   -51.    56.   1780.   36769.     464.    3.84  500.63

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.18    0.94  489.14  509.07************  1.00  496.18  495.18
   FULLV:FV    495.63    0.94  489.59  509.52************  1.00  496.63  495.63
   BRIDG:BR    496.03    0.59  489.84  498.42************  1.37  499.79  498.42
   RDWAY:RG  ****************  500.56  510.07************  0.24  500.80********
   APPRO:AS    496.22    0.33  490.59  510.21  0.17  0.94  0.24  500.87  500.63
  ER

NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure DORSTH00100029, in Dorset, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number DORSTH00100029

General Location Descriptive

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

Date *(MM/DD/YY)* 09 / 28 / 95

Highway District Number *(I - 2; nn)* 01

County *(FIPS county code; I - 3; nnn)* 003

Town *(FIPS place code; I - 4; nnnnn)* 17725

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

Waterway *(I - 6)* METTAWEE RIVER

Road Name *(I - 7)*: Lower Hollow Road

Route Number C3010

Vicinity *(I - 9)* @ JCT W CL 3 TH7

Topographic Map Dorset

Hydrologic Unit Code: 02010001

Latitude *(I - 16; nnnn.n)* 43156

Longitude *(i - 17; nnnnn.n)* 73050

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10020300290203

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

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

Year built *(I - 27; YYYY)* 1953

Structure length *(I - 49; nnnnnn)* 000026

Average daily traffic, ADT *(I - 29; nnnnnn)* 000250

Deck Width *(I - 52; nn.n)* 222

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

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)* 302

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 20.42

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

Vertical clearance from streambed (*nnn.n ft*) 8

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

Waterway of full opening (*nnn.n ft^2*) 164

Comments:

According to the structural inspection report dated 9/12/94, the structure (deck) is asphalt filled wrinkled tin. The abutments, wingwalls and backwalls are concrete. They have a few minor cracks and spalls, overall. A few boulders are present in front of the right abutment and around the ends of the wingwalls on both abutments, with boulders showing along the upstream and downstream channel embankments. There are also a few small areas of erosion from past flooding. The channel flows in at a 45 degree angle. Minor gravel bars and debris accumulation were noted.

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: -

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*): - Frequency: -

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

Are there other structures nearby? (*Yes, No, Unknown*): - *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)* 9.49 mi^2

Lake/pond/swamp area 0 mi^2

Watershed storage *(ST)* 0 %

Bridge site elevation 1010 ft

Headwater elevation 3760 ft

Main channel length 5.42 mi

10% channel length elevation 1060 ft

85% channel length elevation 2570 ft

Main channel slope *(S)* 371.46 ft / mi

Watershed Precipitation Data

Average site precipitation __________ in

Average headwater precipitation __________ in

Maximum 2yr-24hr precipitation event *(I24,2)* _________ in

Average seasonal snowfall *(Sn)* __________ ft

Bridge Plan Data

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

Project Number **-** Minimum channel bed elevation: **-**

Low superstructure elevation: USLAB **496.73** DSLAB **496.73** USRAB **496.73** DSRAB **496.73**

Benchmark location description:

BM #1, S.I.R. 30" M elev. 500'; 100' to right of river, on upstream side of town road next to driveway to field.

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

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

If 1: Footing Thickness **2** Footing bottom elevation: **487**

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

Briefly describe material at foundation bottom elevation or around piles:

Comments:

The average low superstructure elevation is 496.73', this is taken from the bridge plan.
The minimum channel bed elevation is 490'.

Cross-sectional Data

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

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

Comments: **A cross section dated 10/22/92 was included with the town bridge inspection report. It is of the upstream bridge face and is parallel to the clear span. It has been converted to this reports elevation coordinate by the low chord elevations.**

Station	0	10	15	20.42	-	-	-	-	-	-	-
Feature	LAB	-	-	RAB	-	-	-	-	-	-	-
Low chord elevation	498.43	498.37	498.33	498.30	-	-	-	-	-	-	-
Bed elevation	490.76	489.79	490.83	491.80	-	-	-	-	-	-	-
Low chord-bed	7.67	8.58	7.50	6.50	-	-	-	-	-	-	-
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: **RB** Date: **1/21/97**

Computerized by: **RB** Date: **1/22/97**

Reviewd by: **EW** Date: **8/4/97**

Structure Number **DORSTH00100029**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **WILD** Date *(MM/DD/YY)* **08** / **05** / 19**96**

2. Highway District Number **01** Mile marker **000000**

County **BENNINGTON (003)** Town **DORSET (17725)**

Waterway *(I - 6)* **METTAWEE RIVER** Road Name **LOWER HOLLOW ROAD**

Route Number **C3010** Hydrologic Unit Code: **02010001**

3. Descriptive comments:

Located at the junction between CL3 and Town Highway 7.
Old bridge abutments exist upstream of this bridge.

B. Bridge Deck Observations

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

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

7. Bridge length **26** *(feet)* Span length **24** *(feet)* Bridge width **22.2** *(feet)*

Road approach to bridge:

8. LB **2** RB **2** *(**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 **--** US right **--**

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

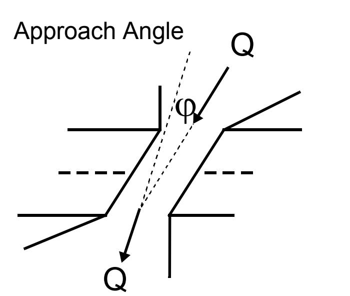
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

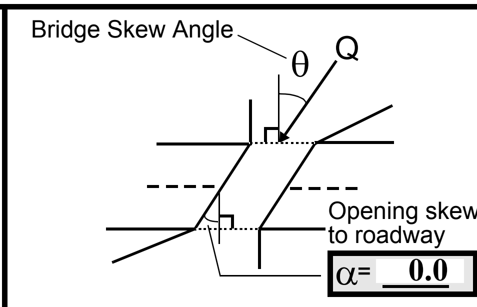
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **15** 16. Bridge skew: **45**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **1**

Range? **60** feet **US** *(US, UB, DS)* to **8** feet **US**

Channel impact zone 2: Exist? **N** *(Y or N)*

Where? **-** *(LB, RB)* Severity **-**

Range? **-** feet **-** *(US, UB, DS)* to **-** feet **-**

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

18. Bridge Type: **1a**

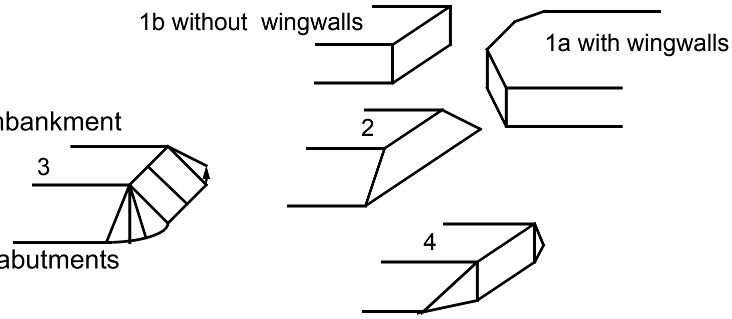
1a- Vertical abutments with wingwalls

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.)

4. The left bank downstream has trees and shrubs along the bank then an unmowed lawn and a home with many big trees surrounding the lot. The right bank downstream also has trees along the bank and then a small area of grass on the corner of the road intersection.
7. Values are from the Vermont AOT. Measured bridge length is 28 ft, bridge span is 24.7 ft, and the bridge width is 22.4 ft.
13. The banks are slumped where road wash has occurred.
18. The downstream right, upstream left and downstream left wingwalls go below low chord and are type 4. The upstream right wingwall is type 1a.

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
56.5	7.5			10.0	3	3	432	4326	1	1

23. Bank width **10.0** 24. Channel width **5.0** 25. Thalweg depth **94.0** 29. Bed Material **435**

30 .Bank protection type: LB **3** RB **5** 31. Bank protection condition: LB **1** RB **1**

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

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

30. The left bank protection extends from 18 ft upstream to 42 ft upstream. The protection is stacked boulders. From 8 ft upstream to 18 ft upstream the boulder protection has failed and road wash exists in this area. The right bank protection extends from 6 ft upstream to 41 ft upstream. It is a concrete wall which extends from the bedrock at the upstream end to the end of the upstream right wingwall. The downstream end of the wall has some stacked boulders within it. There are also placed flat stones along the right bank from 90 ft upstream to 50 ft upstream.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **24** 35. Mid-bar width: **5.5**

36. Point bar extent: **32** feet **US** (US, UB) to **2** feet **US** (US, UB, DS) positioned **0** %LB to **50** %RB

37. Material: **32**

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

An additional point bar extends from 112 ft upstream to 50 ft upstream and is comprised of gravel, sand and boulder materials. It exists from 0% left bank to 30% right bank where the mid-bar distance is 75 ft upstream and the width is 7.5 ft.

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

41. Mid-bank distance: **43** 42. Cut bank extent: **50** feet **US** (US, UB) to **41** 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 bank has eroded back about 10 ft between the two sections of protection described in #32.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **39**

47. Scour dimensions: Length **9** Width **4.5** Depth : **1.2** Position **60** %LB to **100** %RB

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

Assumed thalweg depth is 1 ft. Local scour is also occurring around boulders which have failed as protection and have dropped into the channel at the end of the upstream left wingwall.

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) 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
23.5		0.5		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.):

435

-

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

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

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

70. Debris and Ice Comments:

2

66. Debris has accumulated at the high water mark on the top of the banks upstream and can also be seen at the top of banks downstream.

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	2	0	0.2	90.0
RABUT	1	45	90			2	0	24.0

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.):

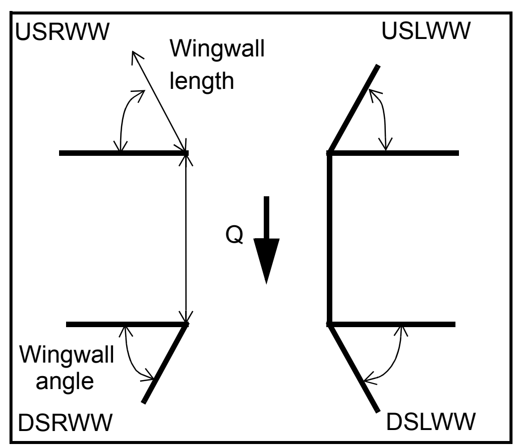
0
0
1

74. Footing is exposed 0.2 ft on the upstream left wingwall corner with the left abutment for approximately 0.5 ft (width).
There is channel scour from 5 ft upstream to 3 ft under the bridge. Mid-scour distance is at the upstream bridge face. The scour is 3 ft wide and 1 ft deep assuming a thalweg of 0.5 ft under the bridge.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						24.0	
USRWW:	Y		1		0	0.5	
DSLWW:	-		-		Y	22.5	
DSRWW:	1		0		-	22.5	

*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	-	0	Y	-	-	-	-	1
Condition	Y	-	1	-	-	-	-	1
Extent	1	-	0	0	0	0	3	-

*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*

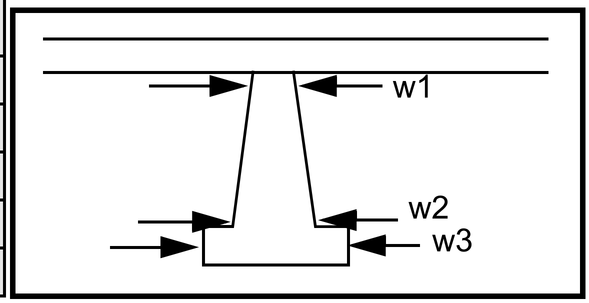
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
0
-
-
1
1
1

Piers:

84. Are there piers? **Th** *(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**	**10.0**	**45.0**
Pier 2	**9.5**	**7.5**	**9.0**	**45.0**	**45.0**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



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

Bank width (BF) -   Channel width -   Thalweg depth -   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.):
-
-
NO PIERS

2
3
435

101. Is a drop structure present? **43** *(Y or N, if N type ctrl-n ds)*   102. Distance: - feet

103. Drop: - feet   104. Structure material: **5** *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
1
1
453
2
2
2

106. Point/Side bar present? **2** (Y or N. if N type ctrl-n pb) Mid-bar distance: **The** Mid-bar width: **left**

Point bar extent: **bank** feet **pro** (US, UB, DS) to **tec-** feet **tio** (US, UB, DS) positioned **n** %LB to **ext** %RB

Material: **en**

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

ds from 32 ft downstream to 146 ft downstream. The right bank protection extends from 0 ft downstream to 148 ft downstream.

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

Cut bank extent: _____ 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.):

N

Is channel scour present? **-** (Y or if N type ctrl-n cs) Mid-scour distance: **NO**

Scour dimensions: Length **DRO** Width **P** Depth: **STR** Positioned **UC** %LB to **TU** %RB

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

RE

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

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

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

Confluence comments (eg. confluence name):

-

-

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)*:

-

NO POINT BARS

N

-

-

-

-

-

-

-

109. G. Plan View Sketch

- N

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: DORSTH00100029 Town: DORSET
Road Number: TH 10 County: BENNINGTON
Stream: METTAWEE RIVER

Initials ECW Date: 7/31/97 Checked: RLB

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	2580	3750	1780
Main Channel Area, ft2	552	626	451
Left overbank area, ft2	64	123	13
Right overbank area, ft2	0	7	0
Top width main channel, ft	87	87	81
Top width L overbank, ft	58	80	26
Top width R overbank, ft	0	16	0
D50 of channel, ft	0.259	0.259	0.259
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.3	7.2	5.6
y1, average depth, LOB, ft	1.1	1.5	0.5
y1, average depth, ROB, ft	ERR	0.4	ERR
Total conveyance, approach	50530	64063	36795
Conveyance, main channel	49087	60523	36618
Conveyance, LOB	1443	3474	177
Conveyance, ROB	0	66	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	2506.3	3542.8	1771.4
Ql, discharge, LOB, cfs	73.7	203.4	8.6
Qr, discharge, ROB, cfs	0.0	3.9	0.0
Vm, mean velocity MC, ft/s	4.5	5.7	3.9
Vl, mean velocity, LOB, ft/s	1.2	1.7	0.7
Vr, mean velocity, ROB, ft/s	ERR	0.6	ERR
Vc-m, crit. velocity, MC, ft/s	9.7	9.9	9.5
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	2580	3750	1780
(Q) discharge thru bridge, cfs	2043	2190	1780
Main channel conveyance	13606	13606	11826
Total conveyance	13606	13606	11826
Q2, bridge MC discharge,cfs	2043	2190	1780
Main channel area, ft2	189	189	190
Main channel width (normal), ft	24.1	24.1	24.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.1	24.1	24.1
y_bridge (avg. depth at br.), ft	7.84	7.84	7.88
Dm, median (1.25*D50), ft	0.32375	0.32375	0.32375
y2, depth in contraction,ft	7.68	8.15	6.82
ys, scour depth (y2-ybridge), ft	-0.16	0.31	-1.06

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	2043	2190	1780
Main channel area (DS), ft2	146	156	133
Main channel width (normal), ft	24.1	24.1	24.1
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	24.1	24.1	24.1
D90, ft	0.7920	0.7920	0.7920
D95, ft	1.0330	1.0330	1.0330
Dc, critical grain size, ft	0.9594	0.9381	0.9148
Pc, Decimal percent coarser than Dc	0.063	0.067	0.072
Depth to armoring, ft	42.81	39.19	35.53

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	2580	3750	1780
Q, thru bridge MC, cfs	2043	2190	1780
Vc, critical velocity, ft/s	9.72	9.93	9.51
Va, velocity MC approach, ft/s	4.54	5.66	3.93
Main channel width (normal), ft	24.1	24.1	24.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.1	24.1	24.1
qbr, unit discharge, ft2/s	84.8	90.9	73.9
Area of full opening, ft2	189.0	189.0	190.0
Hb, depth of full opening, ft	7.84	7.84	7.88
Fr, Froude number, bridge MC	0.68	0.73	0.59
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	146	156	133
**Hb, depth at downstream face, ft	6.06	6.47	5.52
**Fr, Froude number at DS face	1.00	0.97	1.00
**Cf, for downstream face (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	498.36	498.36	498.36
Elevation of Bed, ft	490.52	490.52	490.48
Elevation of Approach, ft	501.83	502.69	500.63
Friction loss, approach, ft	0.18	0.24	0.17
Elevation of WS immediately US, ft	501.65	502.45	500.46
ya, depth immediately US, ft	11.13	11.93	9.98
Mean elevation of deck, ft	500.565	500.565	500.565
w, depth of overflow, ft (>=0)	1.09	1.88	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.94	0.94
**Cc, for downstream face (<=1.0)	0.855541	0.88179	ERR
Ys, scour w/Chang equation, ft	1.45	1.91	0.36
Ys, scour w/Umbrell equation, ft	-0.56	0.60	-1.43

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

**Ys, scour w/Chang equation, ft	4.13	3.91	ERR

**Ys, scour w/Umbrell equation, ft	1.23	1.97	0.94

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	7.68	8.15	6.82
WSEL at downstream face, ft	496.57	496.97	496.03
Depth at downstream face, ft	6.06	6.47	5.52
Ys, depth of scour (Laursen), ft	1.62	1.68	1.31

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	2580	3750	1780	2580	3750	1780
a’, abut.length blocking flow, ft	82.5	105	51.1	37.7	54.5	32.2
Ae, area of blocked flow ft2	138.9	147.5	116.8	131.2	122	119.3
Qe, discharge blocked abut.,cfs	--	--	337.5	--	--	342.8
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.08	3.56	2.89	3.35	4.22	2.87
ya, depth of f/p flow, ft	1.68	1.40	2.29	3.48	2.24	3.70
--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	0.351	0.386	0.337	0.285	0.387	0.263
ys, scour depth, ft	10.50	10.76	10.62	11.87	11.45	11.44

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)	82.5	105	51.1	37.7	54.5	32.2
y1 (depth f/p flow, ft)	1.68	1.40	2.29	3.48	2.24	3.70
a'/y1	49.00	74.75	22.36	10.83	24.35	8.69
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.35	0.39	0.34	0.29	0.39	0.26
Ys w/ corr. factor K1/0.55:						
vertical	8.67	7.46	ERR	ERR	ERR	ERR
vertical w/ ww's	7.11	6.12	ERR	ERR	ERR	ERR
spill-through	4.77	4.10	ERR	ERR	ERR	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	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	0.97	1	1	0.97	1
y, depth of flow in bridge, ft	6.06	6.47	5.52	6.06	6.47	5.52
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.53	2.68	2.31	2.53	2.68	2.31