LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (MANCTH00060008) on TOWN HIGHWAY 6, crossing BOURN BROOK, MANCHESTER, VERMONT

Open-File Report 97-813

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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By RONDA L. BURNS and ROBERT E. HAMMOND

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (MANCTH00060008) ON TOWN HIGHWAY 6, CROSSING BOURN BROOK, MANCHESTER, VERMONT

By **Ronda L. Burns and Robert E. Hammond**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MANCTH00060008 on Town Highway 6 crossing Bourn Brook, Manchester, 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 15.5-mi^2 drainage area is in a predominantly rural and forested basin. The bridge site is located within a suburban setting in the Town of Manchester with houses and lawns on the overbanks.

In the study area, Bourn Brook has an incised, straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 61 ft and an average bank height of 7 ft. The channel bed material ranges from sand to cobbles with a median grain size (D_{50}) of 87.2 mm (0.286 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 6, 1996, indicated that the reach was stable.

The Town Highway 6 crossing of Bourn Brook is a 44-ft-long, two-lane bridge consisting of one 41-foot concrete T-beam span (Vermont Agency of Transportation, written communication, September 28, 1995). The opening length of the structure parallel to the bridge face is 40.0 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately zero degrees to the opening while the opening-skew-to-roadway is 15 degrees.

A scour hole 3.5 ft deeper than the mean thalweg depth was observed along the upstream right wingwall and right abutment during the Level I assessment. The scour countermeasures at the site were stone walls in front of the upstream left wingwall and bank, along the upstream right bank extending from the end of the upstream right wingwall, and in front of the downstream right wingwall and 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 was 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 was zero ft. The left abutment scour ranged from 3.6 to 9.2 ft. The worst-case left abutment scour occurred at the 500-year discharge. The right abutment scour ranged from 9.8 to 12.6 ft. The worst case right abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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

NORTH

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

LEVEL II SUMMARY

Structure Number MANCTH00060008 ***Stream*** Bourn Brook

County Bennington ***Road*** TH 6 ***District*** 1

Description of Bridge

Bridge length 44 ***ft*** ***Bridge width*** 23.7 ***ft*** ***Max span length*** 41 ***ft***

Alignment of bridge to road (on curve or straight) Curve, right/Straight, left

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

Stone fill on abutment? No ***Date of inspection*** 8/6/96

Description of stone fill There are stone walls in front of the upstream left wingwall and downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a 3.5 foot deep scour hole in front of the upstream right wingwall and along the right abutment.

No

Is bridge skewed to flood flow according to survey? Yes ***Angle*** 0

There is a moderate channel bend through the bridge. The scour hole has developed in the location where the flow impacts the upstream right wingwall and right abutment.

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/6/96	0	0
Level II	8/6/96	0	0

Potential for debris Low. There is very little vegetative cover in the vicinity of the bridge.

Describe any features near or at the bridge that may affect flow (include observation date) There is a point bar along the left abutment as of 8/6/96.

Description of the Geomorphic Setting

General topography The channel is located in a low relief valley with a wide flood plain.

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

Date of inspection 8/6/96

DS left: Steep channel bank to a wide flood plain

DS right: Steep channel bank to a moderately sloped overbank

US left: Steep channel bank to a wide flood plain

US right: Steep channel bank to a moderately sloped overbank

Description of the Channel

Average top width 61 ***ft*** ***Average depth*** 7 ***ft***

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

Straight and stable with semi-alluvial channel boundaries and channelized near the bridge.

8/6/96

Vegetative co Shrubs with lawn on the overbank

DS left: Stone wall with lawn on the overbank

DS right: Trees with lawn on the overbank

US left: Trees with lawn on the overbank

US right:

Do banks appear stable? Yes

date of observation.

None as of 8/6/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 15.5 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Rural

Is drainage area considered rural or urban? ***Describe any significant***
There are houses on all the overbanks except the upstream right overbank.
urbanization:

No

--

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

USGS gage description
--

USGS gage number
No

Gage drainage area ***mi²***
-

Is there a lake/p

-

2,930

Calculated Discharges

4,850 The

Q100 ***ft³/s*** ***Q500*** ***ft³/s***

100-year discharge is from flood frequency estimates at the confluence of Bourn Brook with the Batten Kill. Estimates were available from the Flood Insurance Study for the town of Manchester (Federal Emergency Management Agency, 1985) which were extended graphically to the 500-year discharge. The values used were within a range defined by flood frequency curves developed from several empirical methods (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 a chiseled "X" on top of the right end of the upstream curb (elev. 497.47 ft, arbitrary survey datum). RM2 is a chiseled "X" on top of the left end of the downstream curb (elev. 496.20 ft, arbitrary survey datum). RM3 is a nail 3 ft above the ground in a telephone pole located at the upstream right corner of the intersection of TH 6 and TH 27 (elev. 504.46 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	-63	3	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	13	3	Road Grade section
APPR1	61	2	Modelled Approach section (Templated from APTEM)
APTEM	74	3	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.

[2] Cross-section development: (1) survey at SRD, (2) shift of survey data to SRD, (3) modification of survey data, (4) composite bridge section, (5) other.

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.050, and the overbank "n" value was 0.055.

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 0.0093 ft/ft which was estimated from the 100-year discharge water surface profile downstream of this site (Federal Emergency Management Agency, 1985).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0189 ft/ft) to establish the modelled approach section (APPR1), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

At this site, the elevation of the left overbank area, including the road approach, is lower than the bridge and the left bank. For the 100-year and 500-year discharge, WSPRO provides a solution in which the channel is less than bank-full and a disproportionate quantity of the flow is modeled as weir flow over the roadway in the left overbank area. Therefore, modifications to the exit, approach, and roadway cross-sections were made to achieve a reasonable division of flow between the channel (through the bridge) and the left overbank (over the roadway). These modifications yielded water surface elevations just above the bank full elevations at the exit and approach.

Bridge Hydraulics Summary

Average bridge embankment elevation 495.9 *ft*
Average low steel elevation 493.0 *ft*

100-year discharge 2,930 *ft^3/s*
Water-surface elevation in bridge opening 491.4 *ft*
Road overtopping? Yes *Discharge over road* 1,570 *ft^3/s*
Area of flow in bridge opening 206 *ft^2*
Average velocity in bridge opening 6.6 *ft/s*
Maximum WSPRO tube velocity at bridge 8.2 *ft/s*

Water-surface elevation at Approach section with bridge 492.5
Water-surface elevation at Approach section without bridge 491.7
Amount of backwater caused by bridge 0.8 *ft*

500-year discharge 4,850 *ft^3/s*
Water-surface elevation in bridge opening 491.5 *ft*
Road overtopping? Yes *Discharge over road* 3,358 *ft^3/s*
Area of flow in bridge opening 211 *ft^2*
Average velocity in bridge opening 7.1 *ft/s*
Maximum WSPRO tube velocity at bridge 8.9 *ft/s*

Water-surface elevation at Approach section with bridge 493.1
Water-surface elevation at Approach section without bridge 492.5
Amount of backwater caused by bridge 0.6 *ft*

Incipient overtopping discharge 1,360 *ft^3/s*
Water-surface elevation in bridge opening 491.3 *ft*
Area of flow in bridge opening 202 *ft^2*
Average velocity in bridge opening 6.7 *ft/s*
Maximum WSPRO tube velocity at bridge 8.5 *ft/s*

Water-surface elevation at Approach section with bridge 491.7
Water-surface elevation at Approach section without bridge 491.9
Amount of backwater caused by bridge N/A *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year, 500-year, and incipient roadway-overtopping discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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	0.0	0.0	0.0
Depth to armoring	0.3	0.5	0.3
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.3	9.2	3.6
Right abutment	10.7	12.6	9.8
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	0.8	1.0	0.9
Right abutment	0.8	1.0	0.9
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

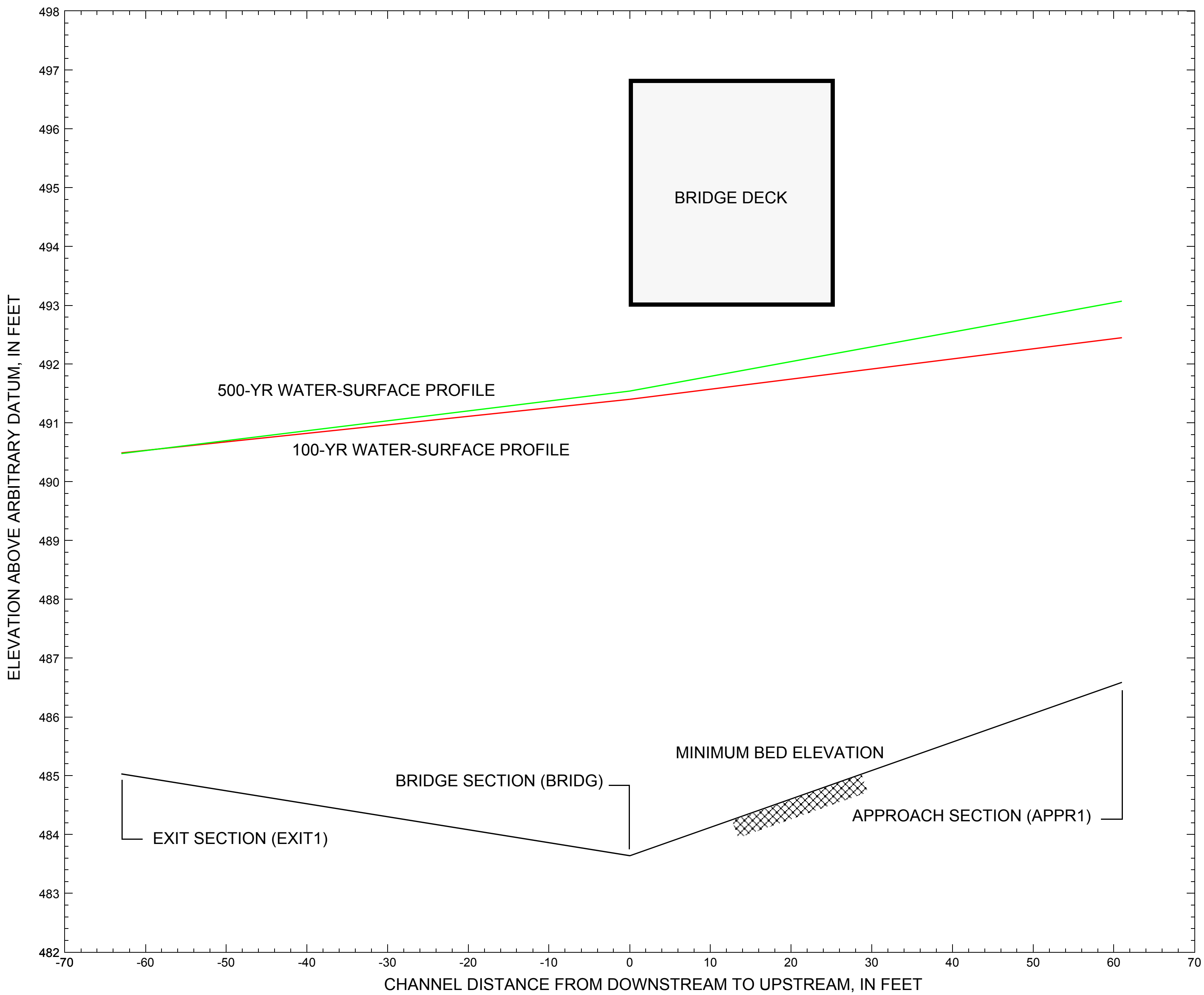

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure MANCTH00060008 on Town Highway 6, crossing Bourn Brook, Manchester, Vermont.

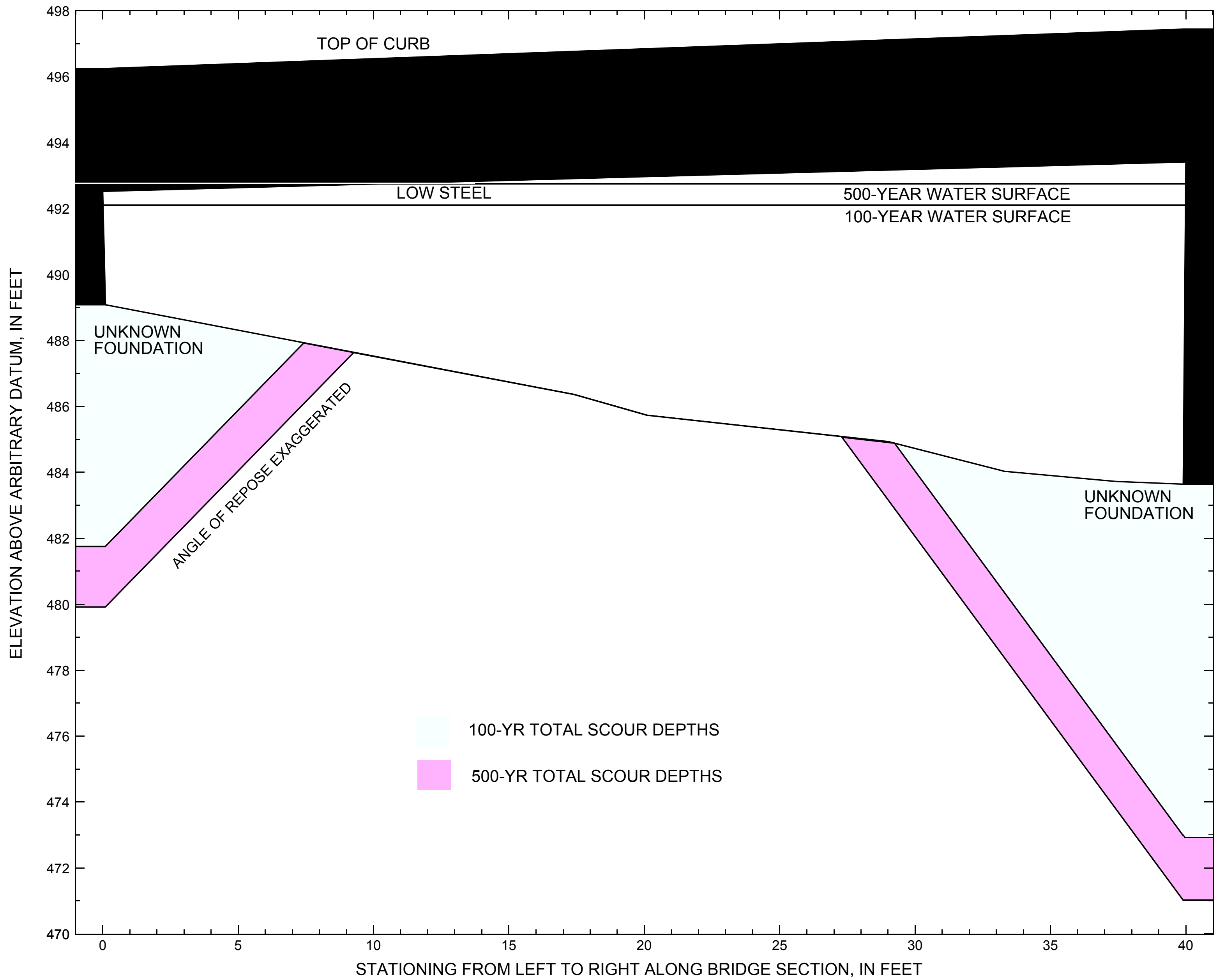

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure MANCTH00060008 on Town Highway 6, crossing Bourn Brook, Manchester, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MANCTH00060008 on Town Highway 6, crossing Bourn Brook, Manchester, 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 2,930 cubic-feet per second											
Left abutment	0.0	--	492.5	--	489.1	0.0	7.3	--	7.3	481.8	--
Right abutment	40.0	--	493.4	--	483.6	0.0	10.7	--	10.7	472.9	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure MANCTH00060008 on Town Highway 6, crossing Bourn Brook, Manchester, 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 4,850 cubic-feet per second											
Left abutment	0.0	--	492.5	--	489.1	0.0	9.2	--	9.2	479.9	--
Right abutment	40.0	--	493.4	--	483.6	0.0	12.6	--	12.6	471.0	--

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

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U.S. Geological Survey, 1968, Manchester, 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 manc008.wsp
T2        Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
T3        TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2930.0   4850.0   1360.0
SK          0.0093   0.0093   0.0093
*
XS   EXIT1    -63           0.
GR        -750.0, 500.00   -750.0, 488.89   -208.4, 488.89   -139.6, 488.93
GR         -51.8, 490.25     -8.7, 490.48      0.0, 486.11
GR           0.9, 485.58      1.4, 485.03     11.4, 485.37     15.5, 485.66
GR          18.9, 485.89     25.9, 485.68     32.1, 486.14     32.1, 486.36
GR          33.2, 491.82     43.0, 493.59     86.7, 495.35    222.8, 497.06
GR         346.6, 502.49
*
*    For the 100-year discharge model, the left flood plain was only extended
*    to station -400.0. For the incipient road-overtopping model, a vertical wall
*    was placed at the top of the left bank at station -8.7.
*
N           0.055        0.045
SA                  -8.7
*
XS   FULLV      0  * * *   0.0108
*
*           SRD     LSEL    XSSKEW
BR   BRIDG     0    492.96      15.0
GR           0.0, 492.52      0.0, 489.08     17.4, 486.36
GR          20.1, 485.73     29.0, 484.93     33.3, 484.03     37.4, 483.72
GR          40.0, 483.64     40.0, 493.41      0.0, 492.52
*
*        BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      35.9 * *     58.5      6.6
N           0.040
*
*           SRD    EMBWID   IPAVE
XR   RDWAY     13      23.7     1
GR        -236.0, 500.00   -236.0, 489.52   -187.5, 489.52    -96.7, 490.47
GR         -47.9, 492.06     -1.6, 495.07     -1.3, 496.20      0.0, 496.24
GR          40.7, 497.44     41.9, 497.45     42.2, 496.73    110.3, 498.42
GR         196.6, 499.79    461.3, 501.99    685.3, 508.50
*
*    For the 100-year discharge model, the left flood plain was only extended
*    to station -197.0. For the incipient road-overtopping model, a vertical wall
*    was placed at the top of the left abutment at station 0.0.
*
XT   APTEM     74           0.
GR        -201.0, 510.00   -201.0, 489.10   -170.7, 489.10    -55.5, 491.81
GR           0.0, 491.98      6.8, 488.76      9.5, 487.91
GR          14.5, 487.21     19.7, 486.91     27.9, 487.24     35.7, 486.87
GR          38.9, 486.84     42.9, 487.69     69.4, 498.82     96.4, 500.55
GR         113.2, 499.76    145.9, 499.88    381.2, 498.99    550.2, 503.75
*
*    For the 100-year discharge model, the left flood plain was only extended
*    to station -197.0. For the incipient road-overtopping model, a vertical wall
*    was placed at the top of the left bank at station 0.0.
*
AS   APPR1     61  * * *  0.0189
```

```
GT
N           0.055        0.050
SA                   0.0
*
HP 1 BRIDG  491.40 1 491.40
HP 2 BRIDG  491.40 * * 1360
HP 2 RDWAY  492.10 * * 1570
HP 1 APPR1  492.45 1 492.45
HP 2 APPR1  492.45 * * 2930
*
HP 1 BRIDG  491.54 1 491.54
HP 2 BRIDG  491.54 * * 1492
HP 2 RDWAY  492.75 * * 3358
HP 1 APPR1  493.07 1 493.07
HP 2 APPR1  493.07 * * 4850
*
HP 1 BRIDG  491.29 1 491.29
HP 2 BRIDG  491.29 * * 1360
HP 1 APPR1  491.74 1 491.74
HP 2 APPR1  491.74 * * 1360
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File manc008.wsp
      Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
      TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
         *** RUN DATE & TIME: 10-08-97  12:26

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      206     19934     39     49                          2698
 491.40           206     19934     39     49  1.00      0     40     2698

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     491.40     0.0    40.0   205.9   19934.    1360.   6.60

X STA.         0.0        6.4       10.0       13.0       15.4       17.6
  A(I)            17.5       12.6       11.7       10.7       10.3
  V(I)            3.88       5.40       5.82       6.37       6.62

X STA.        17.6       19.5       21.1       22.7       24.2       25.7
  A(I)             9.8        9.0        9.0        8.5        8.7
  V(I)            6.97       7.52       7.52       7.96       7.79

X STA.        25.7       27.1       28.4       29.8       31.1       32.3
  A(I)             8.4        8.3        8.4        8.4        8.4
  V(I)            8.10       8.19       8.07       8.14       8.09

X STA.        32.3       33.5       34.7       36.0       37.5       40.0
  A(I)             8.3        8.9        9.4       10.9       18.7
  V(I)            8.15       7.68       7.26       6.26       3.63

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

       WSEL     LEW     REW    AREA        K        Q    VEL
     492.10  -197.0   -47.3   256.4    9829.    1570.   6.12

X STA.      -197.0     -192.0     -188.1     -184.3     -180.3     -176.1
  A(I)            12.9       10.0        9.9       10.2       10.3
  V(I)            6.10       7.83       7.96       7.71       7.61

X STA.      -176.1     -171.9     -167.4     -162.8     -158.1     -153.0
  A(I)            10.3       10.6       10.9       10.9       11.4
  V(I)            7.59       7.42       7.23       7.19       6.91

X STA.      -153.0     -147.7     -142.0     -136.1     -129.7     -122.9
  A(I)            11.6       12.1       12.3       12.8       13.2
  V(I)            6.74       6.51       6.37       6.14       5.94

X STA.      -122.9     -115.6     -107.4      -98.2      -86.5      -47.3
  A(I)            13.6       14.6       15.6       17.4       25.8
  V(I)            5.76       5.37       5.04       4.52       3.04

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      397     16962    197    201                          3200
           2      243     19061     55     57                          2901
 492.45           640     36023    252    257  1.30   -196     55     5079

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

       WSEL     LEW     REW    AREA        K        Q    VEL
     492.45  -197.0    54.8   640.0   36023.    2930.   4.58

X STA.      -197.0     -187.4     -179.0     -170.9     -162.1     -152.5
  A(I)            34.6       30.3       29.0       30.6       31.7
  V(I)            4.23       4.84       5.06       4.78       4.62

X STA.      -152.5     -140.8     -127.1     -109.1      -77.9        8.5
  A(I)            35.2       37.4       42.5       55.6       93.0
  V(I)            4.16       3.91       3.45       2.63       1.58

X STA.         8.5       13.0       16.7       20.2       23.6       27.2
  A(I)            22.3       20.5       19.9       19.6       20.0
  V(I)            6.57       7.15       7.36       7.48       7.34

X STA.        27.2       30.9       34.5       38.1       42.1       54.8
  A(I)            20.3       20.2       20.9       22.8       33.7
  V(I)            7.21       7.25       7.02       6.44       4.35
```

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        U.S. Geological Survey WSPRO Input File manc008.wsp
        Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
        TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
           *** RUN DATE & TIME: 10-08-97  13:31
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      211     20736     39     49                         2805
   491.54           211     20736     39     49  1.00      0     40     2805

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.54     0.0    40.0   211.3   20736.    1492.   7.06

X STA.         0.0        6.2        9.8       12.8       15.2       17.4
  A(I)            17.6       13.0       12.0       11.0       10.5
  V(I)            4.24       5.73       6.20       6.79       7.07

X STA.        17.4       19.3       21.0       22.6       24.1       25.5
  A(I)            10.0        9.3        9.3        8.9        8.8
  V(I)            7.48       8.05       8.04       8.39       8.47

X STA.        25.5       27.0       28.3       29.7       30.9       32.2
  A(I)             8.7        8.6        8.7        8.4        8.6
  V(I)            8.61       8.71       8.59       8.87       8.67

X STA.        32.2       33.4       34.7       36.0       37.5       40.0
  A(I)             8.8        9.1        9.6       11.2       19.3
  V(I)            8.48       8.19       7.74       6.68       3.87

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.75  -236.0   -37.3   482.9   23393.    3358.   6.95

X STA.      -236.0     -228.3     -222.0     -215.6     -209.5     -203.3
  A(I)            24.7       20.4       20.7       19.8       20.1
  V(I)            6.79       8.24       8.10       8.46       8.37

X STA.      -203.3     -196.9     -190.6     -184.2     -177.7     -170.7
  A(I)            20.5       20.5       20.5       20.7       21.5
  V(I)            8.17       8.19       8.19       8.12       7.80

X STA.      -170.7     -163.5     -155.8     -147.7     -139.0     -129.7
  A(I)            21.8       22.6       23.1       24.0       24.8
  V(I)            7.70       7.42       7.27       7.00       6.77

X STA.      -129.7     -119.8     -109.2      -97.2      -81.1      -37.3
  A(I)            25.6       26.1       28.3       32.7       44.5
  V(I)            6.56       6.44       5.93       5.13       3.78

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      536     27549    201    205                         4969
             2      277     23340     56     58                         3493
   493.07           813     50888    257    264  1.20   -200     56     7508

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.07  -201.0    56.3   813.5   50888.    4850.   5.96

X STA.      -201.0     -190.3     -181.4     -172.6     -163.5     -153.4
  A(I)            45.3       37.5       37.1       37.7       39.5
  V(I)            5.36       6.47       6.54       6.43       6.14

X STA.      -153.4     -142.2     -129.1     -113.2      -92.3      -56.3
  A(I)            41.2       44.4       48.6       54.7       70.2
  V(I)            5.89       5.46       4.99       4.43       3.46

X STA.       -56.3        5.1       11.5       16.0       20.1       24.2
  A(I)            93.0       31.3       27.0       26.4       25.8
  V(I)            2.61       7.74       8.99       9.20       9.41

X STA.        24.2       28.5       32.8       37.2       41.8       56.3
  A(I)            26.4       26.5       28.0       28.9       44.1
  V(I)            9.17       9.17       8.65       8.40       5.50
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        U.S. Geological Survey WSPRO Input File manc008.io.wsp
        Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
        TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
           *** RUN DATE & TIME: 11-04-97  07:29

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      202     19311     39     49                         2615
   491.29           202     19311     39     49  1.00      0     40     2615

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.29     0.0    40.0   201.7   19311.    1360.   6.74

X STA.         0.0        6.5       10.2       13.2       15.6       17.7
  A(I)            16.9       12.8       11.4       10.4       10.0
  V(I)            4.02       5.30       5.97       6.52       6.77

X STA.        17.7       19.6       21.3       22.9       24.4       25.8
  A(I)             9.6        8.9        8.8        8.5        8.4
  V(I)            7.11       7.68       7.68       8.01       8.08

X STA.        25.8       27.2       28.6       29.9       31.1       32.4
  A(I)             8.2        8.1        8.3        8.0        8.2
  V(I)            8.26       8.35       8.21       8.46       8.27

X STA.        32.4       33.6       34.8       36.0       37.5       40.0
  A(I)             8.4        8.4        9.2       10.6       18.3
  V(I)            8.08       8.09       7.42       6.41       3.71

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      205     14633     53     55                         2278
   491.74           205     14633     53     55  1.00      0     53     2278

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPR1;  SRD =      61.

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.74     0.0    53.1   204.6   14633.    1360.   6.65

X STA.         0.0        8.5       11.3       13.6       15.6       17.5
  A(I)            16.9       11.5       10.4        9.6        9.4
  V(I)            4.02       5.89       6.54       7.08       7.27

X STA.        17.5       19.4       21.1       22.9       24.7       26.5
  A(I)             9.1        8.7        8.9        8.8        8.9
  V(I)            7.46       7.78       7.68       7.73       7.61

X STA.        26.5       28.4       30.2       32.0       33.8       35.6
  A(I)             8.8        8.9        8.9        8.8        9.0
  V(I)            7.68       7.62       7.66       7.73       7.59

X STA.        35.6       37.3       39.2       41.3       44.0       53.1
  A(I)             9.1        9.7       10.1       11.5       17.6
  V(I)            7.47       7.01       6.73       5.94       3.87
```

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        U.S. Geological Survey WSPRO Input File manc008.wsp
        Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
        TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
           *** RUN DATE & TIME: 10-08-97  12:26

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

EXIT1:XS   ******   -399      679  0.53 *****  491.02  490.27    2930  490.49
       -62 ******     33    30374  1.82 ***** *******    0.82    4.31

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.88     491.09     490.95
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   489.99     503.17    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   489.99     503.17     490.95

FULLV:FV       63   -399      648  0.58  0.62  491.68  490.95    2930  491.10
         0     63     33    28833  1.84  0.03    0.02    0.87    4.52
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPR1":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    1.01     491.73     491.50
 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   490.60     509.75    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   490.60     509.75     491.50

APPR1:AS       61   -196      458  0.94  0.80  492.66  491.50    2930  491.72
        61     61     53    22708  1.48  0.18    0.00    1.01    6.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
         WS1,WSSD,WS3,RGMIN =   495.30       0.00     491.71     489.52
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                  FLOW,Q =    4      1135.
            WS1,WSSD,WS3 =   492.24       0.00     491.47
 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                  ITER,QRD =    5      1795.
            WS,WSMIN,WSMAX =   492.68     492.05     493.31

            <<<<<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       63      0      206  0.68  0.81  492.08  489.45    1360  491.40
         0     63     40    19945  1.00  0.25    0.00    0.50    6.60

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  492.96 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
  RDWAY:RG      13.    37.  0.25  0.43  492.62    0.00   1570.  492.10

           Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:   1570.   150.  -197.   -47.   2.6   1.7   7.0   6.1   2.2   3.1
  RT:      0.    66.    26.    92.   1.2   0.6   7.0  16.8   2.3   3.0

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

APPR1:AS       25   -196      640  0.42  0.63  492.87  491.50    2930  492.45
        61     58     55    35983  1.30  0.17    0.00    0.58    4.58

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.840  0.671    11851.   -10.    30. ********

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

  FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
  EXIT1:XS     -63.  -400.    33.   2930.   30374.     679.    4.31  490.49
  FULLV:FV       0.  -400.    33.   2930.   28833.     648.    4.52  491.10
  BRIDG:BR       0.     0.    40.   1360.   19945.     206.    6.60  491.40
  RDWAY:RG      13.******* 1570.   1570.*********       0.    1.00  492.10
  APPR1:AS      61.  -197.    55.   2930.   35983.     640.    4.58  492.45

   XSID:CODE   XLKQ   XRKQ       KQ
  APPR1:AS     -10.    30.   11851.
```

WSPRO OUTPUT FILE (continued)

```
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    490.27    0.82  485.03  502.49************  0.53  491.02  490.49
   FULLV:FV    490.95    0.87  485.71  503.17  0.62  0.03  0.58  491.68  491.10
   BRIDG:BR    489.45    0.50  483.64  493.41  0.81  0.25  0.68  492.08  491.40
   RDWAY:RG  ****************  489.52  508.50  0.25******  0.43  492.62  492.10
   APPR1:AS    491.50    0.58  486.59  509.75  0.63  0.17  0.42  492.87  492.45

        U.S. Geological Survey WSPRO Input File manc008.wsp
        Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
        TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
           *** RUN DATE & TIME: 10-08-97  13:31

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

EXIT1:XS   ******   -749     1230  0.39 *****  490.87  490.25    4850  490.48
       -62 ******     33    50284  1.61 ***** *******    0.70    3.94

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    3.77     490.11     490.93

FULLV:FV       63   -749     1178  0.43  0.62  491.53  490.93    4850  491.09
         0     63     33    47588  1.64  0.02    0.02    0.75    4.12
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===110 WSEL NOT FOUND AT SECID "APPR1":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   490.59     509.75    0.50
 ===115 WSEL NOT FOUND AT SECID "APPR1":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   490.59     509.75     492.46
 ===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 "APPR1"
                  WSBEG,WSEND,CRWS =   492.46     509.75     492.46

APPR1:AS       61   -200      658  1.09 *****  493.55  492.46    4850  492.46
        61     61     55    37090  1.29 ***** *******    0.92    7.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   499.90       0.00     492.86     489.52
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                   FLOW,Q =    4      1164.
             WS1,WSSD,WS3 =   493.28       0.00     492.14
 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                   ITER,QRD =    4      3686.
             WS,WSMIN,WSMAX =   493.31     492.05     494.58
 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                   FLOW,Q =    4      1384.
             WS1,WSSD,WS3 =   493.03       0.00     491.69
 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                   ITER,QRD =    7      3466.
             WS,WSMIN,WSMAX =   493.16     493.00     493.31

           <<<<<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       63      0      211  0.78  1.32  492.32  489.67    1492  491.54
         0     63     40    20733  1.00  0.12    0.00    0.53    7.06

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  1.000 ******  492.96 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    37.  0.34  0.66  493.40    0.00   3358.  492.75

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3358.   199.  -236.   -37.   3.2   2.4   8.2   6.9   3.1   3.1
   RT:      0.    67.    26.    93.   1.3   0.7   7.0  16.6   2.4   3.0

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

APPR1:AS       25   -200      813  0.66  1.22  493.73  492.46    4850  493.07
        61     59     56    50833  1.20  0.19   -0.02    0.65    5.97

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.844  0.814    9513.   -19.    21. ********

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

```
  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -63.  -750.    33.   4850.   50284.    1230.    3.94  490.48
   FULLV:FV       0.  -750.    33.   4850.   47588.    1178.    4.12  491.09
   BRIDG:BR       0.     0.    40.   1492.   20733.     211.    7.06  491.54
   RDWAY:RG      13.******* 3358.   3358.*********       0.    1.00  492.75
   APPR1:AS      61.  -201.    56.   4850.   50833.     813.    5.97  493.07

    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS     -19.    21.    9513.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    490.25    0.70  485.03  502.49************  0.39  490.87  490.48
   FULLV:FV    490.93    0.75  485.71  503.17  0.62  0.02  0.43  491.53  491.09
   BRIDG:BR    489.67    0.53  483.64  493.41  1.32  0.12  0.78  492.32  491.54
   RDWAY:RG   ****************  489.52  508.50  0.34******  0.66  493.40  492.75
   APPR1:AS    492.46    0.65  486.59  509.75  1.22  0.19  0.66  493.73  493.07

       U.S. Geological Survey WSPRO Input File manc008.io.wsp
       Hydraulic analysis for structure MANCTH00060008   Date: 17-JUL-97
       TH 6 CROSSING BOURN BROOK IN MANCHESTER, VT           RLB
          *** RUN DATE & TIME: 11-04-97  07:29

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

EXIT1:XS   ******     -8      176  0.93 *****  491.36  489.33    1360  490.43
       -62 ******     33    14091  1.00 ***** *******    0.66    7.75

FULLV:FV       63     -7      172  0.97  0.60  491.99 *******    1360  491.02
         0     63     33    13686  1.00  0.02    0.01    0.68    7.90
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPR1:AS       61      0      212  0.64  0.54  492.52 *******    1360  491.87
        61     61     53    15405  1.00  0.00   -0.01    0.57    6.42
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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       63      0      202  0.71  0.63  492.00  489.45    1360  491.29
         0     63     40    19312  1.00  0.02    0.01    0.52    6.74

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  492.96 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPR1:AS       25      0      205  0.69  0.25  492.43  490.45    1360  491.74
        61     26     53    14633  1.00  0.18    0.00    0.60    6.65

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.252  0.098   13207.     0.    40.   491.42

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -63.    -9.    33.   1360.   14091.     176.    7.75  490.43
   FULLV:FV       0.    -8.    33.   1360.   13686.     172.    7.90  491.02
   BRIDG:BR       0.     0.    40.   1360.   19312.     202.    6.74  491.29
   RDWAY:RG      13.**************      0.*****************    1.00********
   APPR1:AS      61.     0.    53.   1360.   14633.     205.    6.65  491.74

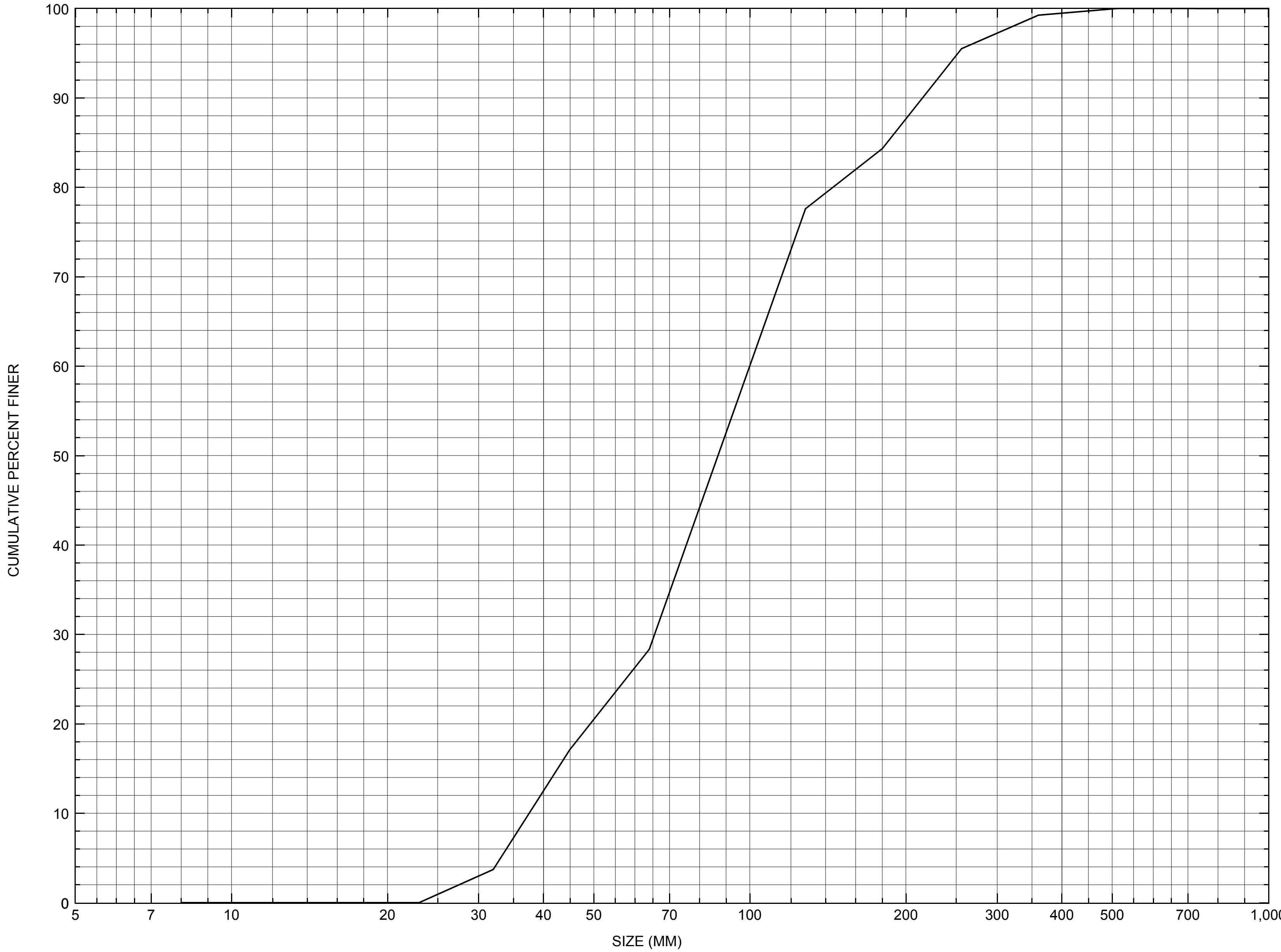
    XSID:CODE   XLKQ   XRKQ       KQ
   APPR1:AS       0.    40.   13207.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    489.33    0.66  485.03  502.49************  0.93  491.36  490.43
   FULLV:FV   ********    0.68  485.71  503.17  0.60  0.02  0.97  491.99  491.02
   BRIDG:BR    489.45    0.52  483.64  493.41  0.63  0.02  0.71  492.00  491.29
   RDWAY:RG   ****************  496.24  508.50**********************************
   APPR1:AS    490.45    0.60  486.59  503.50  0.25  0.18  0.69  492.43  491.74
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MANCTH00060008, in Manchester, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number MANCTH00060008

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)* 42700

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

Waterway *(I - 6)* BOURN BROOK

Road Name *(I - 7):* -

Route Number C2006

Vicinity *(I - 9)* AT JCT TH6 & TH27

Topographic Map Manchester

Hydrologic Unit Code: 2020003

Latitude *(I - 16; nnnn.n)* 43101

Longitude *(i - 17; nnnnn.n)* 73029

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10020600080206

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

Maximum span length *(I - 48; nnnn)* 0041

Year built *(I - 27; YYYY)* 1929

Structure length *(I - 49; nnnnnn)* 000044

Average daily traffic, ADT *(I - 29; nnnnnn)* 000960

Deck Width *(I - 52; nn.n)* 237

Year of ADT *(I - 30; YY)* 91

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

Opening skew to Roadway *(I - 34; nn)* 15

Waterway adequacy *(I - 71; n)* 5

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

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

Structure type *(I - 43; nnn)* 104

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 39.83

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

Vertical clearance from streambed (*nnn.n ft*) 6.25

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

Waterway of full opening (*nnn.n* ft^2) 250

Comments:

According to structural inspection report dated 9/12/94, the structure is a concrete T-beam with an asphalt overlay. The upstream left wingwall is grouted laid-up stone. Both wingwalls on the RABUT have grouted stone retaining wall extensions. The upstream end and wingwall of the RABUT have alligator cracks and leaks overall, with some surface spalling along the bottom of the abutment. The LABUT has alligator cracks and leaks at the downstream end. A coarse gravel bar in front of the LABUT blocks half the channel flow, and directs it toward the upstream end and wingwall of the RABUT. The channel is scoured at least 3 ft in that area. Boulders are showing along the US and DS channel embankments.

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*): U Frequency: -

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

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

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

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

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

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

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

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **15.46** mi^2 Lake/pond/swamp area **0.153** mi^2

Watershed storage *(ST)* **0.99** %

Bridge site elevation **700** ft Headwater elevation **3280.84** ft

Main channel length **6.916** mi

10% channel length elevation **750** ft 85% channel length elevation **2480** ft

Main channel slope *(S)* **333.52** 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:

NO BENCKMARK INFORMATION

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

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

No plans were available.

Cross-sectional Data

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

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

Comments: **This cross section dated 7-31-92 was attached to a town bridge inspection report. The elevations are in feet. It has been converted to this reports elevation coordinates by the low chord points.**

Station	0	27.5	32.25	39.83	-	-	-	-	-	-	-
Feature	LAB	-	-	RAB	-	-	-	-	-	-	-
Low chord elevation	492.52	493.13	493.24	493.41	-	-	-	-	-	-	-
Bed elevation	489.27	486.13	484.99	482.58	-	-	-	-	-	-	-
Low chord to bed	3.25	7	8.25	10.83	-	-	-	-	-	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **10/7/96**

Computerized by: **EW** Date: **10/7/96**

Reviewd by: **RB** Date: **11/12/97**

Structure Number **MANCTH00060008**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. HAMMOND** Date *(MM/DD/YY)* **08** / **06** / 19**96**

2. Highway District Number **01**

Mile marker **000000**

County **BENNINGTON (003)**

Town **MANCHESTER (42700)**

Waterway *(I - 6)* **BOURN BROOK**

Road Name **RICHVILLE ROAD**

Route Number **C2006**

Hydrologic Unit Code: **02020003**

3. Descriptive comments:

Located at the junction of TH6 and TH27 (East Manchester Street).

B. Bridge Deck Observations

4. Surface cover... LBUS **2** RBUS **2** LBDS **2** RBDS **2** Overall **2**
*(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 **44** *(feet)* Span length **41** *(feet)* Bridge width **23.7** *(feet)*

Road approach to bridge:

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

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

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

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

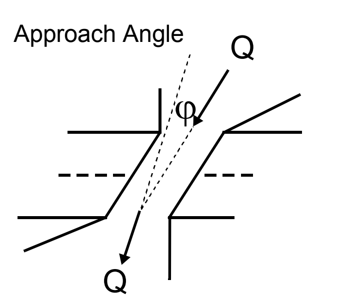
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

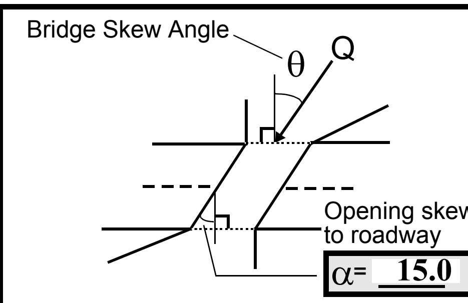
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: **20**

16. Bridge skew: **0**





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

Where? **RB** *(LB, RB)* Severity **2**

Range? **20** feet **US** *(US, UB, DS)* to **10** feet **DS**

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

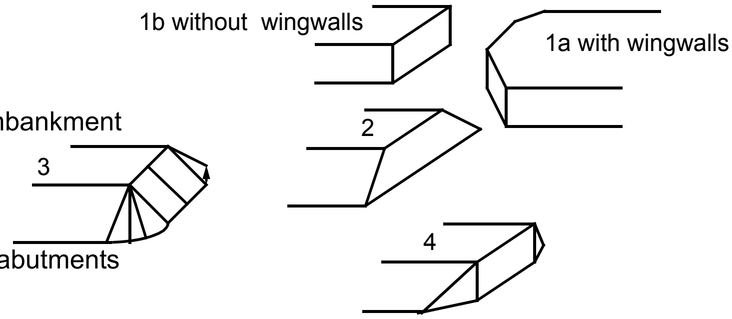
Where? **-** *(LB, RB)* Severity **-**

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

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

18. 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.)

#7: Bridge dimensions are from the VTAOT files. Measured bridge span = 41 feet; bridge length = 44 feet; and bridge width = 24.8 feet.

The owner of a house on the downstream right bank said the water has flowed over the upstream left bank, flooding the area along the left bank. The water then flows southwest towards the Batten Kill.

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
52.5	**4.0**			**11.0**	**1**	**1**	**7**	**432**	**1**	**2**

23. Bank width **15.0** 24. Channel width **25.0** 25. Thalweg depth **70.0** 29. Bed Material **34**

30 .Bank protection type: LB **5** 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.):

#28: Light fluvial erosion along the left bank extends from 70 feet upstream to 36 feet upstream.

#30: The left bank protection is a stone and mortar wall from 36 feet upstream to the upstream bridge face. The right bank protection is a stone and mortar wall from 25 feet upstream to the end of the upstream right wingwall.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 0 US 35. Mid-bar width: 25
36. Point bar extent: 45 feet US (US, UB) to 40 feet DS (US, UB, DS) positioned 0 %LB to 70 %RB
37. Material: 43
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):
-

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: 120 42. Cut bank extent: 155 feet US (US, UB) to 85 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.):
There are tree roots exposed. Some small trees are completely undermined and some larger trees (diameter 6 inches) are partially undermined.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 0 US
47. Scour dimensions: Length 77 Width 15 Depth : 4 Position 70 %LB to 100 %RB
48. Scour comments (eg. additional scour areas, local scouring process, etc.):
The scour hole extends from 12 feet upstream to 40 feet downstream. Average thalweg is between 0.3 feet to 0.5 feet.

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
36.0		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.):
342
#63: The bed material grades from sand along the left abutment to gravel and cobbles along the right abutment.

The scour hole upstream extends under the bridge along the right abutment.

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

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

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

70. Debris and Ice Comments:

1

-

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**	**1**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**20**	**90**			**2**	**2**	**35.5**

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

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

3.5

0.5

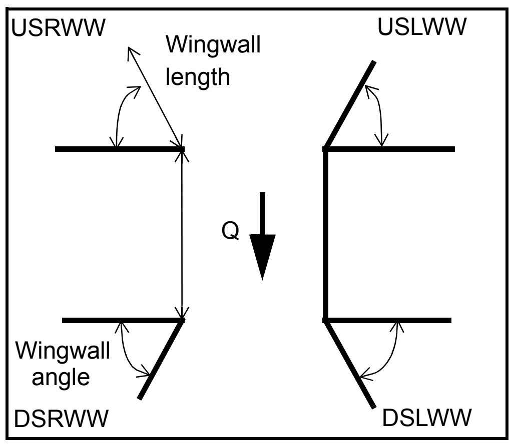
1

#76: The right abutment footing is exposed 0.5 feet. There is no undermining of the abutment evident.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**35.5**	
USRWW:	**Y**		**1**		**0**	**2.5**	
DSLWW:	**-**		**-**		**Y**	**25.5**	
DSRWW:	**1**		**1**		**3.0**	**26.0**	

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**	**0**	**Y**	**-**	**1**	**-**	**-**	**-**
Condition	**Y**	**-**	**1**	**-**	**1**	**-**	**-**	**-**
Extent	**1**	**-**	**0**	**5**	**0**	**0**	**0**	**-**

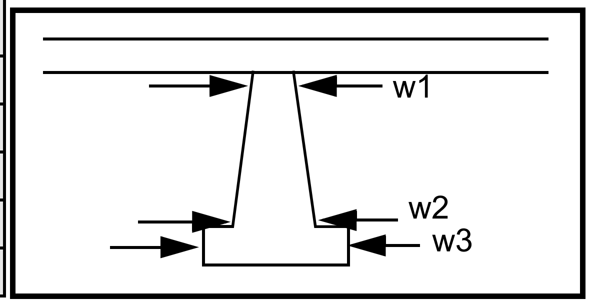
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
5
1
1

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		**9.5**		**65.0**	**50.0**	**15.0**
Pier 2		**8.5**	**6.5**	**45.0**	**80.0**	-
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
-	-			-	-	NO	PIE	RS		

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.):

1
1
3
7
1
0
342
0
5
-
1
The right bank rock wall extends from the downstream bridge face to 100 feet downstream.

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

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

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

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

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

Material: **OP**

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

STRUCTURE

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

Cut bank extent: **150** feet **25** *(US, UB, DS)* to **40** feet **DS** *(US, UB, DS)*

Bank damage: **235** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
50
100
342

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

Scour dimensions: Length **thal-** Width **weg** Depth: **runs** Positioned **alo** %LB to **ng** %RB

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

the left bank, then shifts to the right side of the channel 235 feet downstream.

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

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

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

Confluence comments (eg. confluence name):

NO CUT BANKS

F. Geomorphic Channel Assessment

107. Stage of reach evolution **A**

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)*:

stump with a diameter of 4 feet has exposed roots and is partially undermined on the left bank.

N
-
-
-
-
-
-
NO CHANNEL SCOUR

*** Refer to upstream channel assessment for downstream scour.**

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: MANCTH00060008 Town: MANCHESTER
Road Number: TH 6 County: BENNINGTON
Stream: BOURN BROOK

Initials RLB Date: 10/8/97 Checked: EMB

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	2930	4850	1360
Main Channel Area, ft2	243	277	205
Left overbank area, ft2	397	536	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	55	56	53
Top width L overbank, ft	197	201	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.286	0.286	0.286
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.4	4.9	3.9
y1, average depth, LOB, ft	2.0	2.7	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	36023	50888	14633
Conveyance, main channel	19061	23340	14633
Conveyance, LOB	16962	27549	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	-0.0020	0.0000
Qm, discharge, MC, cfs	1550.4	2224.5	1360.0
Ql, discharge, LOB, cfs	1379.6	2625.6	0.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	6.4	8.0	6.6
Vl, mean velocity, LOB, ft/s	3.5	4.9	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.5	9.6	9.3
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	2930	4850	1360
(Q) discharge thru bridge, cfs	1360	1492	1360
Main channel conveyance	19934	20736	19311
Total conveyance	19934	20736	19311
Q2, bridge MC discharge,cfs	1360	1492	1360
Main channel area, ft2	206	211	202
Main channel width (normal), ft	38.6	38.6	38.6
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	38.6	38.6	38.6
y_bridge (avg. depth at br.), ft	5.34	5.47	5.23
Dm, median (1.25*D50), ft	0.3575	0.3575	0.3575
y2, depth in contraction,ft	3.52	3.81	3.52
ys, scour depth (y2-ybridge), ft	-1.82	-1.66	-1.72

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	1360	1492	1360
Main channel area (DS), ft2	206	211	202
Main channel width (normal), ft	38.6	38.6	38.6
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	38.6	38.6	38.6
D90, ft	0.7059	0.7059	0.7059
D95, ft	0.8262	0.8262	0.8262
Dc, critical grain size, ft	0.2147	0.2437	0.2252
Pc, Decimal percent coarser than Dc	0.701	0.612	0.667
Depth to armoring, ft	0.27	0.46	0.34

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	Left Abutment 500 yr Q	Left Abutment Other Q	Right Abutment 100 yr Q	Right Abutment 500 yr Q	Right Abutment Other Q
(Qt), total discharge, cfs	2930	4850	1360	2930	4850	1360
a', abut.length blocking flow, ft	56.2	56.2	0.7	15.5	17	13.8
Ae, area of blocked flow ft2	55.09	66.64	1.39	49.66	59.81	38.72
Qe, discharge blocked abut.,cfs	--	--	5.6	249.05	374.29	200.76
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.53	4.88	4.02	5.02	6.26	5.19
ya, depth of f/p flow, ft	0.98	1.19	1.99	3.20	3.52	2.81
--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	105	105	105	75	75	75
K2	1.02	1.02	1.02	0.98	0.98	0.98
Fr, froude number f/p flow	0.431	0.525	0.503	0.494	0.588	0.546
ys, scour depth, ft	7.33	9.17	3.57	10.66	12.62	9.80

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)	56.2	56.2	0.7	15.5	17	13.8
y1 (depth f/p flow, ft)	0.98	1.19	1.99	3.20	3.52	2.81
a'/y1	57.33	47.40	0.35	4.84	4.83	4.92
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.43	0.53	0.50	0.49	0.59	0.55
Ys w/ corr. factor K1/0.55:						
vertical	5.58	7.20	ERR	ERR	ERR	ERR
vertical w/ ww's	4.57	5.91	ERR	ERR	ERR	ERR
spill-through	3.07	3.96	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	0.5	0.53	0.52	0.5	0.53	0.52
y, depth of flow in bridge, ft	5.34	5.47	5.23	5.34	5.47	5.23
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.83	0.95	0.87	0.83	0.95	0.87
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR