LEVEL II SCOUR ANALYSIS FOR BRIDGE 7 (CHARTH00010007) on TOWN HIGHWAY 1, crossing MAD BROOK, CHARLESTON, VERMONT

U.S. Geological Survey
Open-File Report 97-213

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

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By Erick M. Boehmler and Matthew A. Weber

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

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

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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 7 (CHARTH00010007) ON TOWN HIGHWAY 1, CROSSING MAD BROOK, CHARLESTON, VERMONT

By **Erick M. Boehmler and Matthew A. Weber**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure CHARTH00010007 on town highway 1 crossing Mad Brook, Charleston, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the White Mountain section of the New England physiographic province in north-central Vermont in the town of Charleston. The 6.59-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture except for the upstream left bank, which is forest. The stream banks are tree covered upstream and on the downstream left bank side.

In the study area, Mad Brook has an incised, sinuous channel with a slope of approximately 0.01 ft/ft, an average channel top width of 41 ft and an average channel depth of 5 ft. The predominant channel bed materials range from gravel to boulders with a median grain size (D_{50}) of 105 mm (0.344 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 28, 1994, indicated that the reach was stable.

The town highway 1 crossing of Mad Brook is a 27-ft-long, two-lane bridge consisting of one 25-foot concrete T-beam span (Vermont Agency of Transportation, written communication, August 4, 1994). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening. The opening-skew-to-roadway computed from surveyed data is 5 degrees, but historical bridge records indicate this angle is closer to 10 degrees.

There was scour evident during the Level I assessment due to the presence of two subfootings at the base of each abutment wall. Although the subfootings may have been constructed at the same time as the abutment walls, the subfootings may have been constructed at a later time in response to streambed degradation under the bridge. The right abutment was noted as undermined during the Level I assessment. Scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the upstream right and downstream road embankments and type-2 stone fill on each wingwall and the downstream left bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.3 ft. The worst-case contraction scour occurred at the incipient overtopping discharge, which was less than the 100-year discharge. Abutment scour ranged from 6.2 to 9.4 ft. The worst-case abutment scour for the right abutment was 9.4 feet at the 100-year discharge. The worst-case abutment scour for the left abutment was 8.6 feet at the incipient overtopping 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 CHARTH00010007 ***Stream*** Mad Brook

County Orleans ***Road*** TH 1 ***District*** 9

Description of Bridge

Bridge length 27 ***ft*** ***Bridge width*** 23.5 ***ft*** ***Max span length*** 25 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 10/28/94

Description of stone fill No stone fill on abutments. Type-1 was noted on the upstream right and both downstream road embankments. Type-2 was noted on each wingwall and the left bank downstream.

Brief description of piers/abutments Abutments and wingwalls are concrete. There are two-step footings exposed at the toe of each abutment wall. The subfootings were undermined at the downstream end of the right abutment.

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

--

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	10/28/94	0	0
Level II	7/24/95	0	0

Potential for debris Low. The reach upstream is straight and laterally stable with old growth trees on both banks.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on 10/28/94 or 7/24/95.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting. The gradient is steeper upstream than downstream and wider flood plains exist downstream.

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

Date of inspection 10/28/94

DS left: Steep channel bank to a narrow flood plain and a steep valley wall.

DS right: Moderately sloped bank to a narrow flood plain.

US left: Steep channel bank to a narrow flood plain and a steep valley wall.

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

Description of the Channel

Average top width 41 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel to Boulders ***Bank material*** Cobbles

Straight and perennial but flashy with semi-alluvial channel boundaries.

10/28/94

Vegetative co Pasture with trees along the immediate bank.

DS left: Pasture with trees and brush along the immediate bank.

DS right: Trees.

US left: Grass and brush with trees along the immediate bank.

US right: Y

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

The assessment of 10/28/94 noted many large boulders scattered in the channel upstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.59 ***mi^2***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

Is there a USGS gage on the stream of interest? No

USGS gage description

USGS gage number

Gage drainage area ***mi^2***

Is there a lake/p _ No

Calculated Discharges

Q100 1,300 ***ft^3/s*** ***Q500*** 1,780 ***ft^3/s***

The 100- and 500-year discharges noted above are the same as those applied for bridge number 19 over Mad Brook in Charleston. The watershed area above this site and bridge 19 practically are the same. The 100- and 500-year discharges at bridge 19 were based on a range determined from several empirical relationships (Benson, 1962; FHWA, 1983; Johnson and Tasker, 1974; Johnson and Laraway, unpublished draft, 1971; Potter, 1957; and Talbot, 1887). The values from the FHWA method were seleted due to the central tendency of the relationship with the others.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled “X” on top of the concrete bridge deck near the upstream left corner (elev. 501.51 ft, arbitrary survey datum). RM2 is the center point of a chiseled “X” on top of the concrete bridge deck near the downstream right corner (elev. 500.97ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXIT1	-22	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APTEM	47	1	Approach section as surveyed (Used as a template)
APPRO	50	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 0.055 to 0.065, and overbank "n" values ranged from 0.045 to 0.085.

Downstream of this site, Mad Brook enters the Clyde River valley. However, the elevation at the location where Mad Brook enters the Clyde River is more than 20 feet below the channel elevation downstream of this site (below EXIT1) according to the topographic map (U.S. Geological Survey, 1988). Therefore, it was assumed there was no backwater from the Clyde River.

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 0.0145 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1988).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0262 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the bridge as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the incipient-overtopping discharge, a vertical wall was inserted at the top of the right bank upstream. This was necessary to prevent WSPRO from computing flow on the right overbank area due to high banks adjacent to the channel. WSPRO assumes critical depth at the bridge section for the incipient-overtopping discharge. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.5 ***ft***
Average low steel elevation 498.9 ***ft***

100-year discharge 1,300 ***ft^3/s***
Water-surface elevation in bridge opening 499.1 ***ft***
Road overtopping? Y ***Discharge over road*** 66 ***ft^3/s***
Area of flow in bridge opening 184 ***ft^2***
Average velocity in bridge opening 6.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 8.4 ***ft/s***

Water-surface elevation at Approach section with bridge 499.9 ***ft***
Water-surface elevation at Approach section without bridge 496.9 ***ft***
Amount of backwater caused by bridge 3.0 ***ft***

500-year discharge 1,780 ***ft^3/s***
Water-surface elevation in bridge opening 498.9 ***ft***
Road overtopping? Y ***Discharge over road*** 335 ***ft^3/s***
Area of flow in bridge opening 183 ***ft^2***
Average velocity in bridge opening 7.9 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.0 ***ft/s***

Water-surface elevation at Approach section with bridge 500.3 ***ft***
Water-surface elevation at Approach section without bridge 497.6 ***ft***
Amount of backwater caused by bridge 2.7 ***ft***

Incipient overtopping discharge 1,270 ***ft^3/s***
Water-surface elevation in bridge opening 495.7 ***ft***
Area of flow in bridge opening 107 ***ft^2***
Average velocity in bridge opening 11.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 14.6 ***ft/s***

Water-surface elevation at Approach section with bridge 499.3 ***ft***
Water-surface elevation at Approach section without bridge 496.8 ***ft***
Amount of backwater caused by bridge 2.5 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for the incipient road overtopping discharge. The 100- and 500-year 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). Therefore, contraction scour for the 100- and 500-year discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). In this case, the incipient road-overflow model resulted in the worst case contraction scour with a scour depth of 0.3 ft. However, it was not the worst case total 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.

The length to depth ratio of the embankment blocking flow exceeded 25 for the right abutment at the 100-year discharge and both abutments at the 500-year discharge. Although the HIRE equation (Richardson and others, 1993, p. 50, equation 25) generally is applicable when this ratio exceeds 25, the results from the HIRE equation were not used. Hydraulic Engineering Circular 18 recommends that the HIRE equation be used only when field conditions at the bridge site are similar to those for which the HIRE equation was derived (Richardson and others, 1993). Since the equation was developed from Army Corp. of Engineers' data obtained for spurs dikes in the Mississippi River, the HIRE equation was not adopted for the narrow, incised, upland valley at this site.

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	0.3
Depth to armoring	0.6	1.5	21.0
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
Abutment scour			
Left abutment	8.0	7.3	8.6
Right abutment	9.4	8.9	6.2
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	0.9	1.2	1.8
Right abutment	0.9	1.2	1.8
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

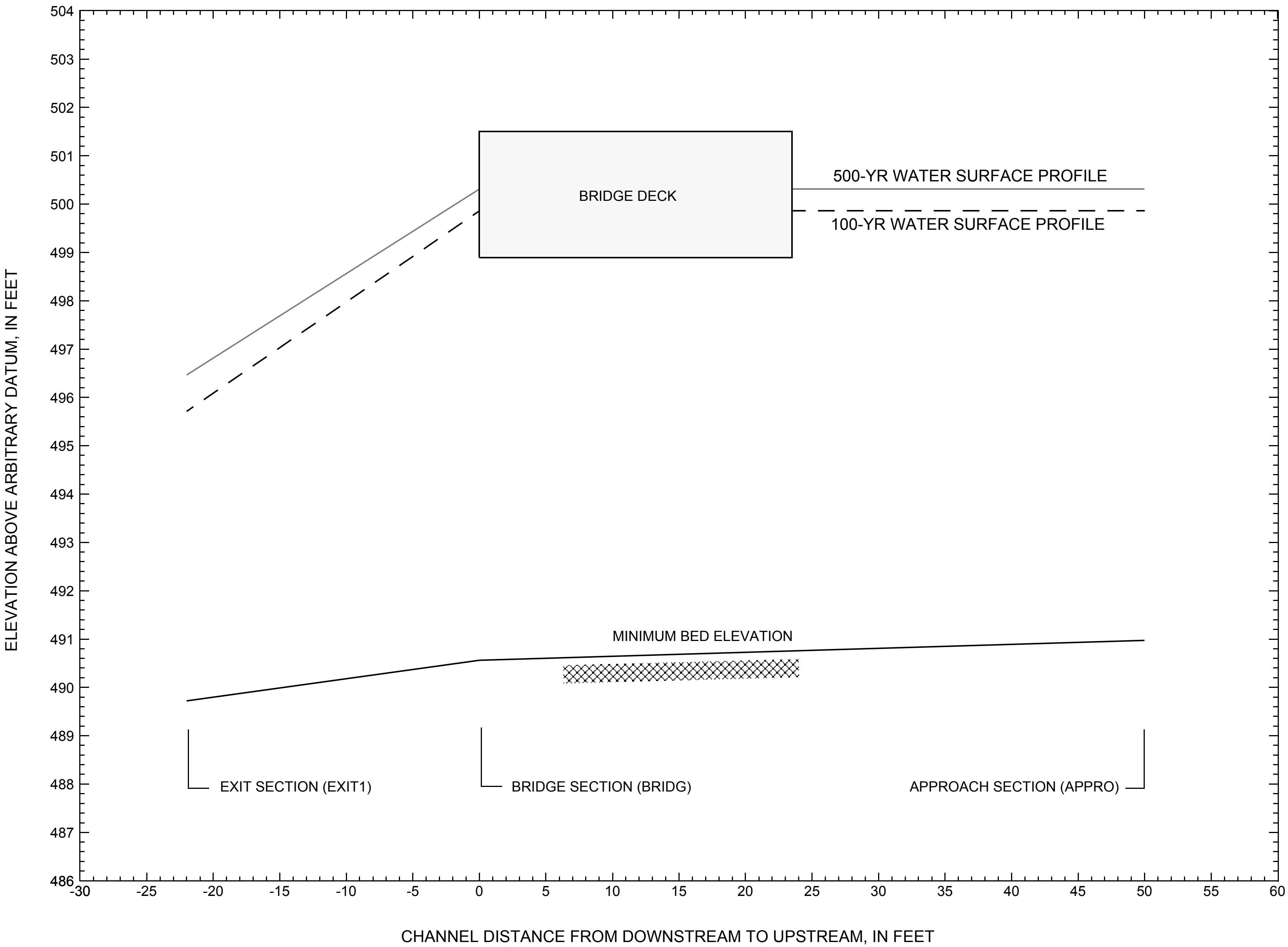

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure CHARTH00010007 on town highway 1, crossing Mad Brook, Charleston, Vermont.

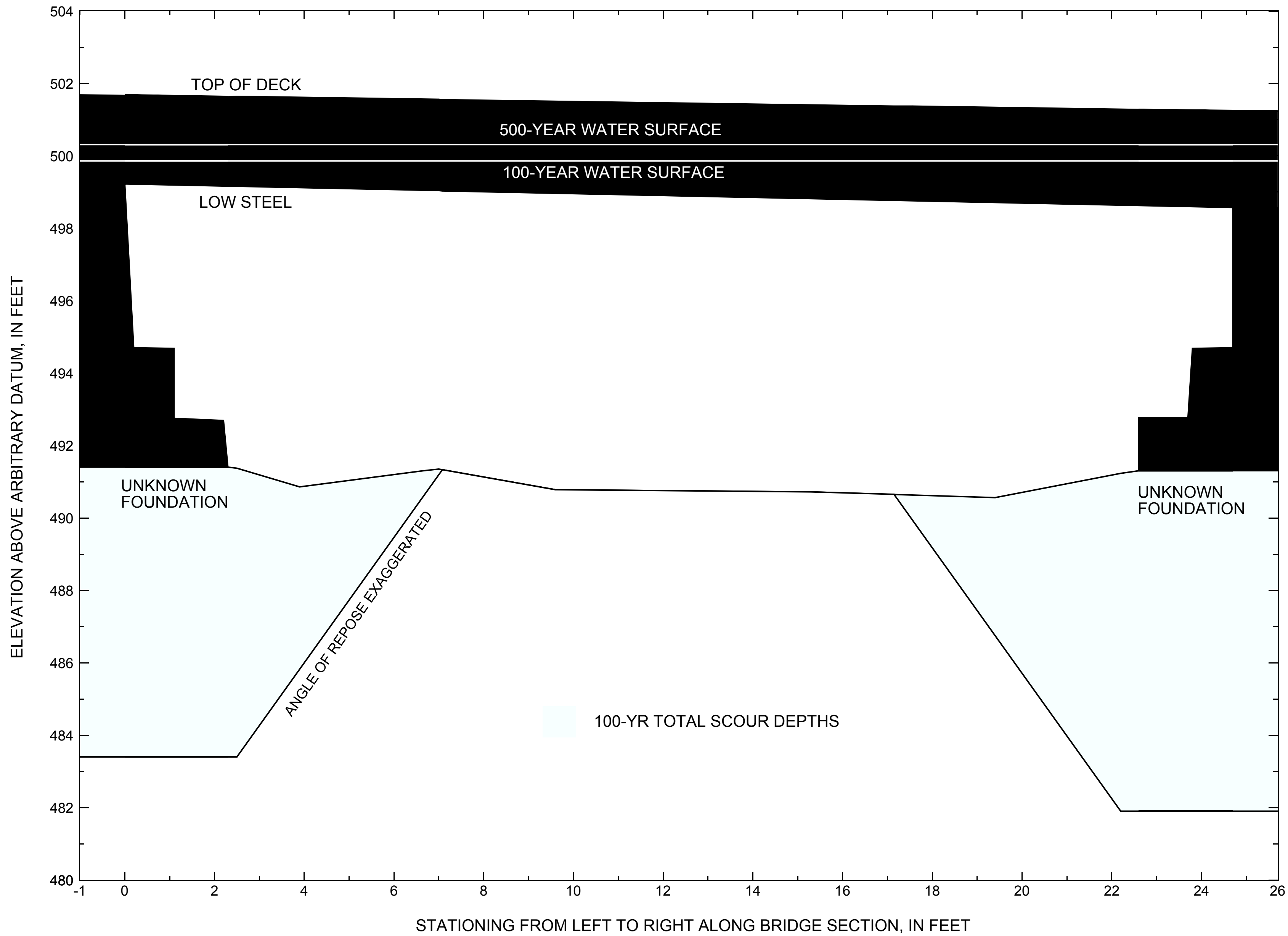

Figure 8. Scour elevations for the 100-year discharge at structure CHARTH00010007 on town highway 1, crossing Mad Brook, Charleston, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure CHARTH00010007 on Town Highway 1, crossing Mad Brook, Charleston, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,300 cubic-feet per second											
Left abutment	0.0	--	499.2	--	491.4	0.0	8.0	--	8.0	483.4	--
Right abutment	24.7	--	498.6	--	491.3	0.0	9.4	--	9.4	481.9	--

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 CHARTH00010007 on Town Highway 1, crossing Mad Brook, Charleston, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 1,780 cubic-feet per second											
Left abutment	0.0	--	499.2	--	491.4	0.0	7.3	--	7.3	484.1	--
Right abutment	24.7	--	498.6	--	491.3	0.0	8.9	--	8.9	482.4	--

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

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File char007.wsp
T2        Hydraulic analysis for structure CHARTH00010007   Date: 18-JUL-96
T3        Town Highway 1 Crossing of Mad Brook, Charleston, VT              EMB
*
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           1300.0,  1780.0,   1270.0
SK          0.0145,  0.0145,   0.0145
*
XS   EXIT1    -22
GR         -187.1, 508.58   -113.4, 497.23    -54.9, 496.43    -37.0, 496.79
GR          -26.3, 495.79    -17.4, 497.54     -5.0, 493.92      0.0, 490.86
GR            1.3, 489.72      7.3, 489.83     14.1, 490.22     17.1, 490.86
GR           23.3, 491.94     27.4, 494.52     50.9, 495.35     60.0, 500.61
GR          113.4, 499.66    225.0, 499.70    299.3, 500.38
*           Exit brought into roadway. Replaced: 148.8, 494.37 and
*           255.1, 497.92 with roadway elevations at STA 60.0 and higher
*
N           0.060        0.055        0.045
SA                 -17.4         27.4
*
XS   FULLV      0  * * *   0.0157
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.89       5.0
GR            0.0, 499.22      0.2, 494.70      1.1, 494.68      1.1, 492.75
GR            2.2, 492.69      2.3, 491.44      3.9, 490.86      7.0, 491.35
GR            9.6, 490.78     15.3, 490.72     19.4, 490.56     22.6, 491.33
GR           22.6, 492.77     23.7, 492.76     23.8, 494.68     24.7, 494.70
GR           24.7, 498.57      0.0, 499.22
*
*        BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      28.9 * *     41       4.0
N           0.060
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      23.5     1
GR         -181.3, 508.68    -99.4, 503.23      0.0, 501.68     24.8, 501.24
GR          113.4, 499.66    225.0, 499.70    299.3, 500.38
*
*           Notice: For the incipient overtopping model run, a vertical wall
*                   was inserted at station 54.1 of the approach section
*                   below to prevent WSPRO modeling flow on the right overbank.
*                   Flow on the right overbank is not likely at this discharge.
*
XT   APTEM     47
GR          -87.3, 505.94    -77.8, 501.08    -38.1, 500.13    -13.2, 501.23
GR           -3.7, 495.31      0.0, 492.58      3.2, 491.94      7.9, 490.99
GR           10.4, 490.89     13.7, 491.34     16.9, 491.32     18.8, 491.95
GR           22.0, 492.59     27.7, 495.94     35.1, 498.27     54.1, 499.97
GR          109.5, 498.20    112.5, 499.11    147.9, 498.45    172.9, 497.90
GR          173.2, 505.00
*
AS   APPRO     50  *  *  *  0.0262
GT
N           0.085        0.065        0.045
SA                 -13.2         35.1
*
HP 1 BRIDG  499.09 1 499.09
HP 2 BRIDG  499.09 * * 1230
HP 2 RDWAY  499.86 * *   66
HP 1 APPRO  499.86 1 499.86
HP 2 APPRO  499.86 * * 1300
*
HP 1 BRIDG  498.89 1 498.89
HP 2 BRIDG  498.89 * * 1441
HP 2 RDWAY  500.31 * *  335
HP 1 APPRO  500.31 1 500.31
HP 2 APPRO  500.31 * * 1780
*
HP 1 BRIDG  495.74 1 495.74
HP 2 BRIDG  495.74 * * 1270
HP 1 APPRO  499.29 1 499.29
HP 2 APPRO  499.29 * * 1270
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

```
         U.S. Geological Survey WSPRO Input File char007.wsp
         Hydraulic analysis for structure CHARTH00010007   Date: 18-JUL-96
         Town Highway 1 Crossing of Mad Brook, Charleston, VT              EMB
            *** RUN DATE & TIME: 10-29-96  12:57

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      184      9777      5     59                         6402
    499.09           184      9777      5     59  1.00      0     25     6402
1
   HP 2 BRIDG  499.09 * * 1230

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.09     0.0    24.7   184.3    9777.    1230.   6.67

 X STA.        0.0        2.7        3.8        4.7        5.7        6.8
   A(I)           15.3        8.8        7.4        7.9        8.2
   V(I)           4.01       7.01       8.36       7.74       7.55

 X STA.        6.8        7.8        8.9        9.9       10.8       11.8
   A(I)            8.2        8.1        8.0        8.0        8.0
   V(I)           7.49       7.58       7.66       7.71       7.72

 X STA.       11.8       12.8       13.8       14.8       15.8       16.9
   A(I)            8.1        8.1        8.1        8.4        8.3
   V(I)           7.62       7.63       7.56       7.32       7.39

 X STA.       16.9       18.0       19.1       20.3       21.7       24.7
   A(I)            8.7        9.0        9.5       11.0       17.2
   V(I)           7.03       6.86       6.45       5.60       3.58

Notice: HP table computations for roadway overflow at the Q100 discharge
        modeled were not acceptable. Hence they were omitted from this listing
        of the model output.

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              2      269     19024     46     50                         3698
              3      131      4316    130    132                          746
    499.86           400     23340    176    182  1.26    -10    173     3058

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

          WSEL     LEW     REW    AREA        K        Q    VEL
        499.86   -10.9   173.0   400.3   23340.    1300.   3.25

 X STA.      -10.9       -1.3        1.3        3.4        5.3        7.0
   A(I)           28.9       18.4       16.4       14.8       14.2
   V(I)           2.25       3.54       3.97       4.38       4.58

 X STA.        7.0        8.5       10.1       11.5       13.1       14.6
   A(I)           13.6       13.5       13.0       13.5       13.2
   V(I)           4.77       4.80       5.01       4.83       4.93

 X STA.       14.6       16.2       17.9       19.8       21.8       24.6
   A(I)           13.5       13.8       14.8       14.9       18.2
   V(I)           4.80       4.71       4.39       4.35       3.58

 X STA.       24.6       30.0      100.0      134.1      157.5      173.0
   A(I)           22.7       50.2       35.8       30.4       26.4
   V(I)           2.86       1.29       1.82       2.14       2.46
```

WSPRO OUTPUT FILE (continued)

```
      U.S. Geological Survey WSPRO Input File char007.wsp
      Hydraulic analysis for structure CHARTH00010007   Date: 18-JUL-96
      Town Highway 1 Crossing of Mad Brook, Charleston, VT              EMB
         *** RUN DATE & TIME: 10-29-96  12:57

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      183     10574     12     51                         3962
 498.89           183     10574     12     51  1.00      0     25     3962

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.89     0.0    24.7   182.5   10574.    1441.   7.89

X STA.        0.0        2.9        4.1        5.1        6.0        6.9
  A(I)            16.0        9.4        7.8        7.3        7.0
  V(I)            4.51       7.70       9.19       9.81      10.31

X STA.        6.9        7.8        8.7        9.5       10.3       11.1
  A(I)             6.7        6.7        6.7        6.5        6.5
  V(I)           10.70      10.83      10.69      11.04      11.03

X STA.       11.1       12.0       12.9       14.0       15.1       16.3
  A(I)             6.7        7.6        8.9        9.1        9.4
  V(I)           10.72       9.45       8.11       7.95       7.64

X STA.       16.3       17.5       18.7       20.0       21.5       24.7
  A(I)             9.6        9.5       10.6       11.6       18.8
  V(I)            7.48       7.56       6.80       6.21       3.84

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     500.31    77.0   291.7   102.5    2072.     335.   3.27

X STA.       77.0      106.3      115.2      122.4      129.4      136.4
  A(I)             7.7        5.3        4.7        4.5        4.5
  V(I)            2.18       3.16       3.59       3.69       3.73

X STA.      136.4      143.3      150.2      157.0      164.0      171.0
  A(I)             4.4        4.4        4.3        4.4        4.4
  V(I)            3.79       3.79       3.86       3.79       3.80

X STA.      171.0      178.1      185.2      192.4      199.9      207.6
  A(I)             4.5        4.5        4.5        4.6        4.8
  V(I)            3.74       3.76       3.73       3.62       3.51

X STA.      207.6      215.4      223.7      233.1      246.4      291.7
  A(I)             4.8        5.0        5.5        6.3        9.4
  V(I)            3.49       3.32       3.06       2.66       1.79

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1        0         1      7      7                            0
           2      290     21300     47     51                         4104
           3      192      7851    138    140                         1288
 500.31           483     29152    191    198  1.20    -41    173     3969

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

       WSEL     LEW     REW    AREA        K        Q    VEL
     500.31   -42.3   173.0   482.7   29152.    1780.   3.69

X STA.      -42.3       -1.2        1.7        4.0        6.0        7.9
  A(I)            34.0       22.3       18.9       17.7       17.1
  V(I)            2.61       3.99       4.72       5.03       5.22

X STA.        7.9        9.6       11.4       13.1       14.9       16.8
  A(I)            16.0       16.0       16.1       16.1       16.1
  V(I)            5.56       5.56       5.54       5.52       5.52

X STA.       16.8       18.7       20.9       23.5       27.9       42.6
  A(I)            16.8       17.8       19.2       24.0       34.6
  V(I)            5.30       4.99       4.65       3.70       2.57

X STA.       42.6       99.5      121.1      144.0      159.6      173.0
  A(I)            53.7       33.8       34.2       29.2       29.2
  V(I)            1.66       2.63       2.61       3.05       3.04
```

```
        U.S. Geological Survey WSPRO Input File char007.wsp
        Hydraulic analysis for structure CHARTH00010007   Date: 18-JUL-96
        Town Highway 1 Crossing of Mad Brook, Charleston, VT              EMB
           *** RUN DATE & TIME: 10-29-96  12:57

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      107      5826     24     33                         1274
   495.74           107      5826     24     33  1.00      0     25     1274

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.74     0.2    24.7   107.2    5826.    1270.  11.84

X STA.        0.2        3.5        4.8        5.9        7.1        8.2
  A(I)           10.3        6.0        5.3        5.2        4.8
  V(I)           6.19      10.54      11.96      12.23      13.35

X STA.        8.2        9.2       10.1       11.0       11.9       12.7
  A(I)            4.7        4.5        4.4        4.4        4.4
  V(I)          13.41      14.03      14.41      14.56      14.53

X STA.       12.7       13.6       14.5       15.4       16.3       17.2
  A(I)            4.3        4.3        4.4        4.5        4.5
  V(I)          14.64      14.62      14.42      14.17      14.01

X STA.       17.2       18.1       19.0       20.1       21.3       24.7
  A(I)            4.7        4.9        5.3        6.0       10.4
  V(I)          13.62      12.93      12.09      10.58       6.12

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      248     14793     56     59                         2978
   499.29           248     14793     56     59  1.00     -9     46     2978

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.29   -10.0    45.6   248.3   14793.    1270.   5.11

X STA.      -10.0       -1.9        0.3        1.9        3.4        4.7
  A(I)           20.2       13.5       11.0       10.7       10.0
  V(I)           3.14       4.70       5.78       5.96       6.35

X STA.        4.7        6.0        7.2        8.3        9.4       10.6
  A(I)            9.6        9.4        9.3        9.3        9.4
  V(I)           6.59       6.77       6.81       6.82       6.79

X STA.       10.6       11.7       12.9       14.2       15.5       16.9
  A(I)            9.5        9.6       10.1       10.3       10.9
  V(I)           6.68       6.60       6.30       6.15       5.83

X STA.       16.9       18.4       20.2       22.3       25.5       45.6
  A(I)           11.7       12.7       14.3       17.7       29.2
  V(I)           5.42       5.02       4.45       3.59       2.17
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File char007.wsp
        Hydraulic analysis for structure CHARTH00010007   Date: 18-JUL-96
        Town Highway 1 Crossing of Mad Brook, Charleston, VT              EMB
           *** RUN DATE & TIME: 10-29-96  12:57

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

EXIT1:XS   ******    -10      174  0.95 *****  496.66  494.98    1300  495.71
       -21 ******     52    10789  1.09 ***** *******    0.82    7.46

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     496.02     495.32

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.21     508.93    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.21     508.93     495.32

FULLV:FV       22    -10      172  0.97  0.32  496.99  495.32    1300  496.03
         0     22     51    10646  1.09  0.01    0.00    0.84    7.54
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     496.89     496.26

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.53     506.02    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.53     506.02     496.26

APPRO:AS       50     -5      143  1.28  1.02  498.17  496.26    1300  496.89
        50     50     30     7769  1.00  0.16    0.00    0.81    9.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.81     499.09     499.42     498.89

 ===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       22      0      184  0.69 *****  499.78  495.64    1230  499.09
         0 ******     25     9775  1.00 ***** *******    0.43    6.67

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.381  0.000  498.89 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    27.  0.08  0.21  499.99    0.00     66.  499.86

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    34.   -21.    13.   0.6   0.3   4.0   7.2   0.7   3.1
   RT:     66.   141.   102.   243.   0.2   0.2   2.4   2.8   0.3   3.0

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

APPRO:AS       21    -10      401  0.21  0.15  500.07  496.26    1300  499.86
        50     22    173    23391  1.26  1.38    0.00    0.42    3.24

       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
   EXIT1:XS     -22.   -11.    52.   1300.   10789.     174.    7.46  495.71
   FULLV:FV       0.   -11.    51.   1300.   10646.     172.    7.54  496.03
   BRIDG:BR       0.     0.    25.   1230.    9775.     184.    6.67  499.09
   RDWAY:RG      13.*******     0.     66.       0.*********    1.00  499.86
   APPRO:AS      50.   -11.   173.   1300.   23391.     401.    3.24  499.86

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

```
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    494.98    0.82  489.72  508.58************  0.95  496.66  495.71
   FULLV:FV    495.32    0.84  490.07  508.93  0.32  0.01  0.97  496.99  496.03
   BRIDG:BR    495.64    0.43  490.56  499.22************  0.69  499.78  499.09
   RDWAY:RG  ****************  499.66  508.68  0.08******  0.21  499.99  499.86
   APPRO:AS    496.26    0.42  490.97  506.02  0.15  1.38  0.21  500.07  499.86

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

EXIT1:XS   ******    -56      226  1.06 *****  497.52  496.00    1780  496.46
       -21 ******     53    14780  1.10 ***** *******    0.87    7.87

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.86     496.76     496.35

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   495.96     508.93    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   495.96     508.93     496.35

FULLV:FV       22    -54      224  1.07  0.32  497.86  496.35    1780  496.78
         0     22     53    14653  1.10  0.01    0.01    0.86    7.94
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.90     497.57     497.21

 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.28     506.02    0.50

 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.28     506.02     497.21

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             “APPRO”     KRATIO =  0.66

APPRO:AS       50     -6      169  1.72  1.12  499.29  497.21    1780  497.57
        50     50     33     9693  1.00  0.32    0.00    0.90   10.52
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.03       0.00     496.84     499.66

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   501.60         0.      1780.

 ===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       22      0      183  0.97 *****  499.86  496.13    1441  498.89
         0 ******     25    10574  1.00 ***** *******    0.51    7.89

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.432  0.000  498.89 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    27.  0.10  0.25  500.47    0.00    335.  500.31

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    35.   -22.    13.   0.6   0.3   4.0   7.2   0.7   3.1
   RT:    335.   215.    77.   292.   0.7   0.5   3.7   3.3   0.6   3.1

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

APPRO:AS       21    -41      483  0.25  0.18  500.56  497.21    1780  500.31
        50     22    173    29154  1.20  0.00    0.00    0.45    3.69


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

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

WSPRO OUTPUT FILE (continued)

```
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -22.   -57.    53.   1780.   14780.     226.    7.87  496.46
   FULLV:FV       0.   -55.    53.   1780.   14653.     224.    7.94  496.78
   BRIDG:BR       0.     0.    25.   1441.   10574.     183.    7.89  498.89
   RDWAY:RG      13.*******     0.    335.       0.       0.    1.00  500.31
   APPRO:AS      50.   -42.   173.   1780.   29154.     483.    3.69  500.31

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    496.00    0.87  489.72  508.58************  1.06  497.52  496.46
   FULLV:FV    496.35    0.86  490.07  508.93  0.32  0.01  1.07  497.86  496.78
   BRIDG:BR    496.13    0.51  490.56  499.22************  0.97  499.86  498.89
   RDWAY:RG  ***************  499.66  508.68  0.10******  0.25  500.47  500.31
   APPRO:AS    497.21    0.45  490.97  506.02  0.18  0.00  0.25  500.56  500.31

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

EXIT1:XS   ******    -10      171  0.94 *****  496.60  494.86    1270  495.66
       -21 ******     51    10540  1.09 ***** *******    0.83    7.43

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.84     495.97     495.21

 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.16     508.93    0.50

 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.16     508.93     495.21

FULLV:FV       22    -10      169  0.96  0.32  496.93  495.21    1270  495.97
         0     22     51    10398  1.09  0.01    0.00    0.84    7.52
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.80     496.84     496.20

 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   495.47     506.02    0.50

 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   495.47     506.02     496.20

APPRO:AS       50     -5      141  1.26  1.02  498.09  496.20    1270  496.84
        50     50     30     7638  1.00  0.15    0.00    0.80    8.99
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID “BRIDG”     Q,CRWS =    1270.     495.74

           <<<<<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       22      0      107  2.18 *****  497.92  495.74    1270  495.74
         0     22     25     5830  1.00 ***** *******    1.00   11.84

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.89 ****** ****** ******

    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

APPRO:AS       21     -9      248  0.41  0.40  499.70  496.20    1270  499.29
        50     22     46    14790  1.00  1.37    0.00    0.43    5.12

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.324  0.000   15695.    -2.    23.   499.09

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

FIRST USER DEFINED TABLE.

XSID:CODE	SRD	LEW	REW	Q	K	AREA	VEL	WSEL
EXIT1:XS	-22.	-11.	51.	1270.	10540.	171.	7.43	495.66
FULLV:FV	0.	-11.	51.	1270.	10398.	169.	7.52	495.97
BRIDG:BR	0.	0.	25.	1270.	5830.	107.	11.84	495.74
RDWAY:RG	13.**************			0.******************			1.00********	
APPRO:AS	50.	-10.	46.	1270.	14790.	248.	5.12	499.29

XSID:CODE	XLKQ	XRKQ	KQ
APPRO:AS	-2.	23.	15695.

SECOND USER DEFINED TABLE.

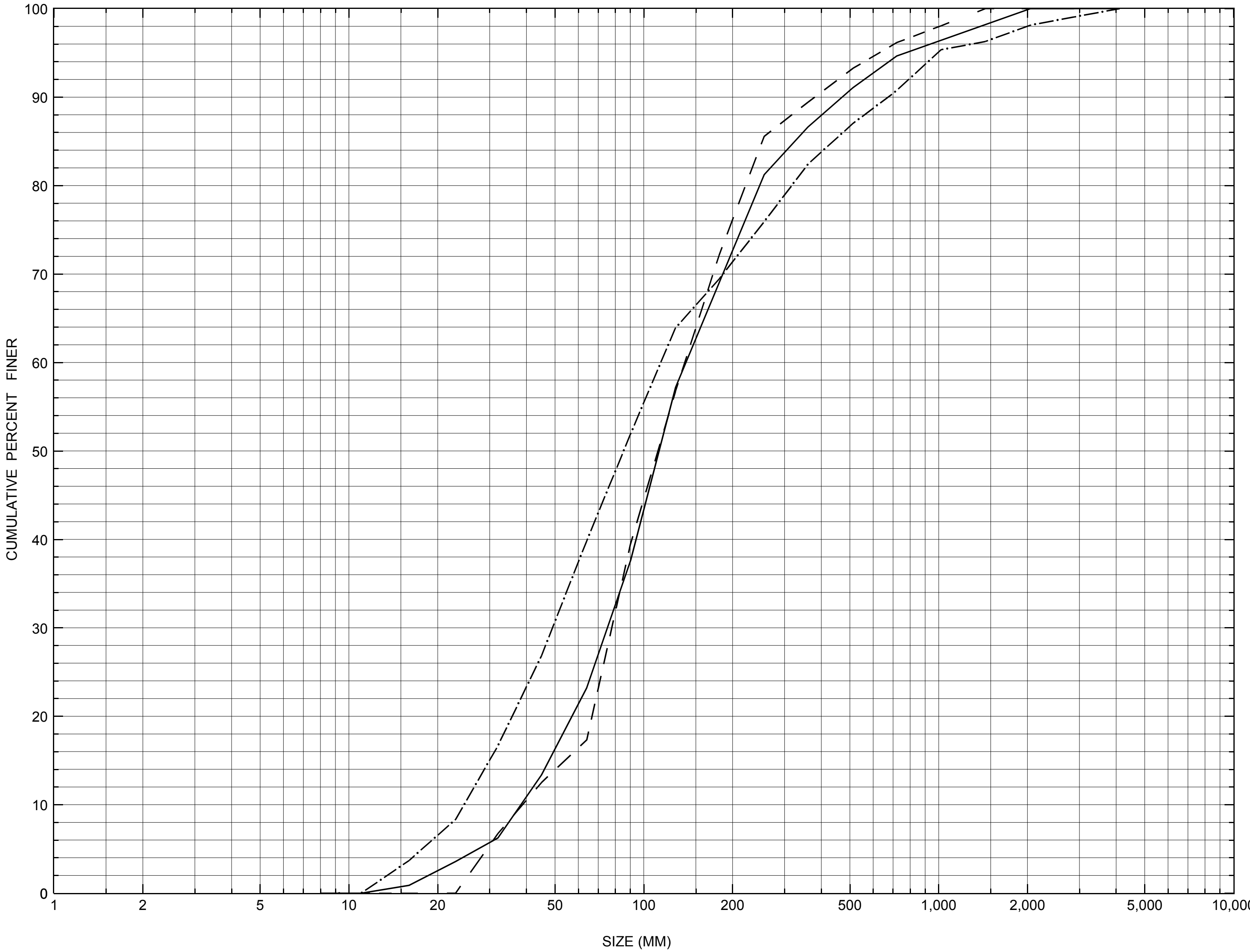
XSID:CODE	CRWS	FR#	YMIN	YMAX	HF	HO	VHD	EGL	WSEL
EXIT1:XS	494.86	0.83	489.72	508.58************			0.94	496.60	495.66
FULLV:FV	495.21	0.84	490.07	508.93	0.32	0.01	0.96	496.93	495.97
BRIDG:BR	495.74	1.00	490.56	499.22************			2.18	497.92	495.74
RDWAY:RG	****************		499.66	508.68**********************************					
APPRO:AS	496.20	0.43	490.97	506.02	0.40	1.37	0.41	499.70	499.29

ER

NORMAL END OF WSPRO EXECUTION.

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distributions for three pebble count transects at the approach cross-section for structure CHARTH00010007, in Charleston, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number CHARTH00010007

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. WEBER

Date *(MM/DD/YY)* 08 / 04 / 94

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

County *(FIPS county code; I - 3; nnn)* 019

Town *(FIPS place code; I - 4; nnnnn)* 13150

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

Waterway *(I - 6)* Mad Brook

Road Name *(I - 7)*: -

Route Number TH001

Vicinity *(I - 9)* 0.1 MI TO JCT W CL3 TH39

Topographic Map Island.Pond

Hydrologic Unit Code: 01110000

Latitude *(I - 16; nnnn.n)* 44490

Longitude *(i - 17; nnnnn.n)* 71583

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10100400071004

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

Maximum span length *(I - 48; nnnn)* 0025

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

Structure length *(I - 49; nnnnnn)* 000027

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

Deck Width *(I - 52; nn.n)* 235

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

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

Opening skew to Roadway *(I - 34; nn)* 10

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

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*) -

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

Vertical clearance from streambed (*nnn.n ft*) 007.7

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

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

Comments:

The structural inspection report of 6/17/94 indicates the structure is a concrete T-beam type bridge. Some deep concrete spalling is noted on the wingwalls. The report notes a possibility that the left abutment has settled. There was no channel scour noted on the report of 6/17/94. However, a previous report on 9/17/92 indicated heavy channel scour. The report of 6/17/94 indicated that riprap is needed along the new sub-footings. No point bars 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: Stones, gravel, boulders

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

Relief Elevation (*ft*): - Discharge over roadway at Q_{100} (*ft^3/ 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 (*ft^2*): -

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

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

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

Comments:

The water surface velocity at the time of the June 14, 1994 inspection was about 2 feet/second.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.59** mi^2

Lake and pond area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **1196** ft

Headwater elevation **3300** ft

Main channel length **4.37** mi

10% channel length elevation **1270** ft

85% channel length elevation **2320** ft

Main channel slope *(S)* **320.59** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in

Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:
-

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **2/13/96**
Computerized by: **RB** Date: **2/23/96**
Reviewd by: **EB** Date: **10/30/96**

Structure Number **CHARTH00010007**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **M**. **WEBER** Date *(MM/DD/YY)* **10** / **28** / 19**94**

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

County **Orleans (019)** Town **Charleston (13150)**

Waterway *(I - 6)* **Mad Brook** Road Name **-**

Route Number **TH 1** Hydrologic Unit Code: **01110000**

3. Descriptive comments:

This structure is a concrete T-beam type bridge located about 0.1 mile from the intersection of TH 1 with TH 39.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **5** LBDS **4** RBDS **4** Overall **5**
*(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 **27** *(feet)* Span length **25** *(feet)* Bridge width **23.5** *(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)*

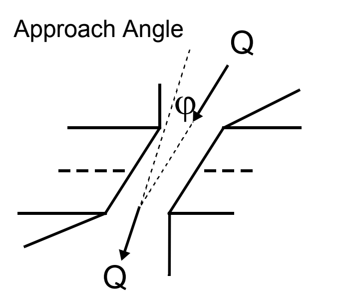
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

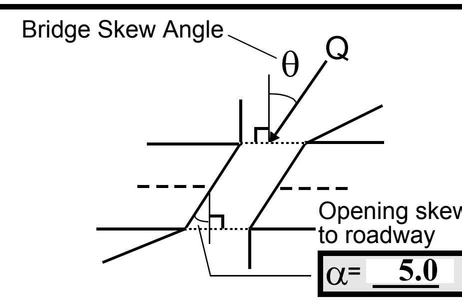
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	1	1	0	0
RBDS	1	1	2	1
LBDS	1	2	0	0

*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: **0** 16. Bridge skew: **10**





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

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

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

18. Level II Bridge Type: **1A/4**

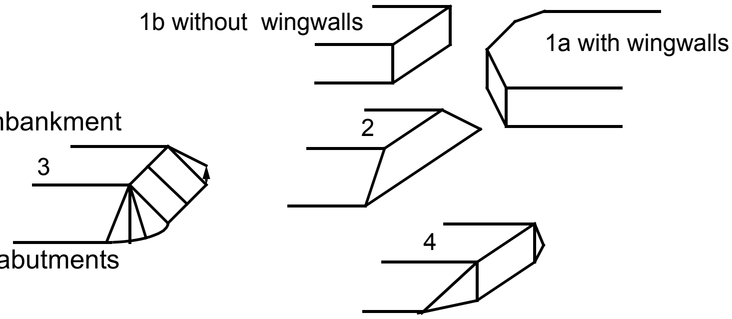
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

The bridge dimensions shown are from the VTAOT files. Field measurements of the bridge dimensions are 28.0 feet for the bridge length, 25.0 feet for the span length, and 23.5 feet for the roadway width.
Surface cover on the left bank upstream consists of mostly brush with trees on the bank. The upstream right bank surface cover is small trees and shrubs on the bank with tall grass and a gravel driveway on the overbank area. Surface cover downstream consists of mainly shrubs and brush near the bridge and pasture elsewhere.
The protection indicated on the upstream right and downstream left road embankments is located around the ends of the wingwalls. There is some protection around the end of the downstream right wingwall, which is covered by sand up to 1.5 feet thick. The class of this protection is approximated. A small hole has developed in the sand / protection, which is about 1 foot in diameter, 3 feet deep, and looks like it may have developed from road wash.

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
21.0	**8.5**			**5.5**	**2**	**2**	**4**	**4**	**1**	**0**

23. Bank width **35.0** 24. Channel width **25.0** 25. Thalweg depth **48.5** 29. Bed Material **5**

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

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

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

There is a waterfall type channel feature located over a bedrock outcrop about 275 feet upstream. The water falls approximately 10 feet as it proceeds over the falls.
27. The bank material is composed primarily of cobbles with a few boulders embedded in sand.
29. The bed material is boulder size mostly, with some cobbles embedded in sand and gravel.
28. There is some undercutting of the shrubs and trees on the left bank.

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

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

37. Material: -

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

NO POINT BARS

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

41. Mid-bank distance: 52 42. Cut bank extent: 18 feet US (US, UB) to 82 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 is light bank cutting present with tree and shrub root systems exposed but holding material and preventing more extensive erosion. The old left abutment stonework extends 17 feet upstream probably preventing the cut bank from extending to the bridge. While there is some bank cutting here, there is no significant bend in the channel and hence no impact zone.

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

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

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) 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
22.0		1.0		2	7	7	-

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

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

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

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

5

The bed material here is boulders mostly, embedded in sand and gravel with some cobbles.

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

The channel reach is straight and steep upstream, which probably prevents extensive ice formation and blockage. There are no extensive cut banks and the channel is stable. Therefore, the potential for debris production is low, even though there is a high tree cover percentage on the banks.

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		**-**	**90**	**2**	**2**	**0.0**	**4.0**	**90.0**
RABUT	**1**	**5**	**90**			**2**	**3**	**24.5**

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.):

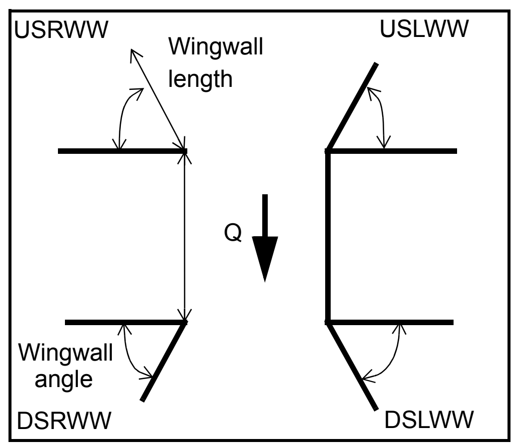
0.0
4.0
1

Both abutments have 2 newer subfootings each, which hide the original scour conditions and scour depths. The lower subfootings appear poured with minimal excavation. There is some minimal undermining (less than 2 inches) visible at the downstream end of the right abutment and at 6 feet under the bridge on the left abutment from the upstream face. The top of the upper footings are about 4 feet above the bed level at the thalweg under the bridge while that of the lower are about 2 feet above the bed level. Some old slab stonework protects the upstream left wingwall. The old stonework may be the construction material for the abutments of the original structure that were since refaced with concrete. The deck concrete appears in newer condition

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**than**	____	**the**	____	**abut**	**24.5**	____
USRWW:	**ment**	____	**con-**	____	**crete**	**0.5**	____
DSLWW:	**.**	____	**Ther**	____	**e is a**	**25.0**	____
DSRWW:	**ver-**	____	**tical**	____	**crac**	**25.5**	____

*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	**k in**	**abut**	**wall**	**abo**	**feet**	**the**	**fro**	**upst**
Condition	**the**	**men**	**loca**	**ut**	**und**	**brid**	**m**	**rea**
Extent	**left**	**t**	**ted**	**16**	**er**	**ge**	**the**	**m**

*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.):

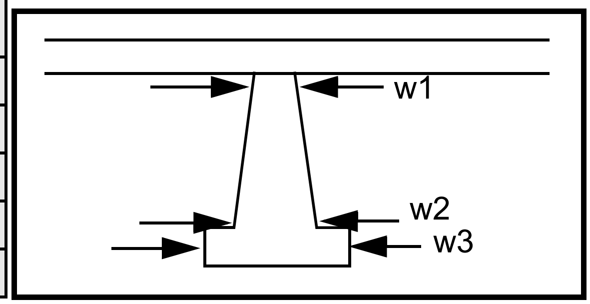
face. The crack is about one eighth of an inch wide and does not include the subfootings.

Y
1
0
-
-
Y
1
2
0.0
4.0

Piers:

84. Are there piers? **Y** (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		**4.5**	**6.0**	**35.0**	**45.0**	**50.0**
Pier 2	**3.5**	**6.0**	**-**	**30.0**	**-**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**1**	**2**	**-**	**t**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**2**	**1**	**-**	**unde**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**0.0**	**1**	**-**	**rmin**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**4.0**	**0**	**2**	**ing**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**Y**	**-**	**1**	**of a**	*Y- yes; N- no*
91. Attack ∠ (BF)	**1**	**-**	**1**	**few**	
92. Pushed	**2**	**0**	**2**	**inch**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**0.0**	**-**	**1**	**es or**	
95. Cross-members	**4.0**	**-**	**1**	**less**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**2**	**-**	**Som**	**is**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**1**	**-**	**e**	**reco**	
98. Exposure depth	**1**	**-**	**sligh**	**gniz-**	

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

able where the downstream right wingwall and right abutment meet. Like the abutments, the upstream and downstream right wingwalls have two subfootings that are two feet thick each. The subfootings possibly have masked the original scour conditions and depths. Only the upper subfooting on the downstream left wingwall is visible at the surface. The upstream left wingwall appears to have no subfootings and the concrete from the left abutment subfootings is molded around some very large native boulder material where the concrete ends at the upstream end of the left abutment. Protection on the upstream left wingwall consists of one, class 4 boulder, the old left abutment stonework, and a few native boulders. Concrete appears to have been poured over the old abutment walls. The concrete is spalling at all of the wingwalls except the upstream left wingwall.

E. Downstream Channel Assessment

100.

SRD	Bank height (BF) LB	Bank height (BF) RB	Bank angle (BF) LB	Bank angle (BF) RB	% Veg. cover (BF) LB	% Veg. cover (BF) RB	Bank material (BF) LB	Bank material (BF) RB	Bank erosion (BF) LB	Bank erosion (BF) RB
-	-			-		N	-	-	-	-

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

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

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

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

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

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

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

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

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

Material: -

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

-
-
-
-

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

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

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

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

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

Scour dimensions: Length 2 Width 1 Depth: 4 Positioned 4 %LB to 0 %RB

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

0
4
2
0

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

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

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

Confluence comments (eg. confluence name):

tion consists of class 1 and 2 native (field) stone piled about 1 to 2 feet high in a wall type fashion extending to at least 300 feet downstream. There is a large sand deposit along the right bank from 15 to 46 feet down-

F. Geomorphic Channel Assessment

107. Stage of reach evolution str

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)*:

eam. The bank material is composed of mainly cobbles with sand and gravel. The bed material is composed also of mainly cobbles with a few boulders embedded in sand and gravel. The cobble material on the right bank does not appear placed for protection of the bank. However, if it was placed, it is now slumped and eroded and is not nearly as extensive as the protection clearly present on the left bank.

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: CHARTH00010007   Town: CHARLESTON
Road Number: TH 1   County: ORLEANS
Stream: MAD BROOK

Initials EMB   Date: 8/22/96   Checked:

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	1300	1780	1270
Main Channel Area, ft2	269	290	248
Left overbank area, ft2	0	0	0
Right overbank area, ft2	131	192	0
Top width main channel, ft	46	47	56
Top width L overbank, ft	0	7	0
Top width R overbank, ft	130	138	0
D50 of channel, ft	0.344	0.344	0.344
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	5.8	6.2	4.4
y1, average depth, LOB, ft	ERR	0.0	ERR
y1, average depth, ROB, ft	1.0	1.4	ERR
Total conveyance, approach	23340	29152	14793
Conveyance, main channel	19024	21300	14793
Conveyance, LOB	0	1	0
Conveyance, ROB	4316	7851	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	1059.6	1300.6	1270.0
Ql, discharge, LOB, cfs	0.0	0.1	0.0
Qr, discharge, ROB, cfs	240.4	479.4	0.0
Vm, mean velocity MC, ft/s	3.9	4.5	5.1
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	1.8	2.5	ERR
Vc-m, crit. velocity, MC, ft/s	10.5	10.6	10.1
Vc-l, crit. velocity, LOB, ft/s	N/A	0.0	N/A
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	N/A

Results

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

ARMORING			
D90	1.622	1.622	1.622
D95	2.736	2.736	2.736
Critical grain size,Dc, ft	0.2762	0.3885	1.1556
Decimal-percent coarser than Dc	0.602	0.444	0.142
Depth to armoring,ft	0.55	1.46	20.95

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	269	290	248
Main channel width, ft	46	47	56
y1, main channel depth, ft	5.85	6.17	4.43

Bridge Section			
(Q) total discharge, cfs	1300	1780	1270
(Q) discharge thru bridge, cfs	1230	1441	1270
Main channel conveyance	9777	10574	5826
Total conveyance	9777	10574	5826
Q2, bridge MC discharge,cfs	1230	1441	1270
Main channel area, ft2	184	183	107
Main channel width (skewed), ft	24.6	24.6	24.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	24.6	24.6	24.4
y_bridge (avg. depth at br.), ft	7.49	7.42	4.39
Dm, median (1.25*D50), ft	0.43	0.43	0.43
y2, depth in contraction,ft	4.50	5.16	4.66
ys, scour depth (y2-ybridge), ft	-2.99	-2.26	0.27
ys, scour depth (y2-yfullv), ft	-0.13	-0.15	N/A

Pressure Flow Scour (contraction scour for orifice flow condtions)

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

	Q100	Q500	OtherQ
Q thru bridge main chan, cfs	1230	1441	0
Vc, critical velocity, ft/s	10.5	10.6	0
Vc, critical velocity, m/s	3.200244	3.230722	0
Main channel width (skewed), ft	24.6	24.6	0
Cum. width of piers, ft	0	0	0
W, adjusted width, ft	24.6	24.6	0
qbr, unit discharge, ft^2/s	50	58.57724	ERR
qbr, unit discharge, m^2/s	4.644699	5.441472	N/A
Area of full opening, ft^2	184.3	182.5	0
Hb, depth of full opening, ft	7.49187	7.418699	ERR
Hb, depth of full opening, m	2.283411	2.261109	N/A
Fr, Froude number MC	0.43	0.51	1
Cf, Fr correction factor (<=1.0)	1	1	1.5
Elevation of Low Steel, ft	498.89	498.89	0
Elevation of Bed, ft	491.3981	491.4713	N/A
Elevation of approach WS, ft	499.86	500.31	0
HF, bridge to approach, ft	0.15	0.18	0
Elevation of WS immediately US, ft	499.71	500.13	0
ya, depth immediately US, ft	8.31187	8.658699	N/A
ya, depth immediately US, m	2.58293	2.690708	N/A
Mean elev. of deck, ft	501.46	501.46	0
w, depth of overflow, ft (>=0)	0	0	0
Cc, vert contrac correction (<=1.0)	0.974755	0.962276	ERR
Ys, depth of scour (chang), ft	-2.60664	-1.67591	N/A
y2, from Laursen equation, ft	4.5	5.16	0
Full valley WSEL, ft	496.03	496.78	0
Full valley depth (approx), ft	4.63187	5.308699	N/A
ys, depth of scour (FULLV), ft	-0.13187	-0.1487	N/A

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	1300	1780	1270	1300	1780	1270
a', abut.length blocking flow, ft	11	42.4	10.3	148.3	148.3	20.9
Ae, area of blocked flow ft2	38.8	44	33.7	154.9	129.7	33.6
Qe, discharge blocked abut.,cfs	100	128.9	127	--	--	79.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.58	2.93	3.77	1.96	2.58	2.36
ya, depth of f/p flow, ft	3.53	1.04	3.27	1.04	0.87	1.61
--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	85	85	85	95	95	95
K2	0.99	0.99	0.99	1.01	1.01	1.01
Fr, froude number f/p flow	0.242	0.507	0.367	0.328	0.363	0.328
ys, scour depth, ft	8.00	7.28	8.64	9.40	8.91	6.21

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)	11	42.4	10.3	148.3	148.3	20.9
y1 (depth f/p flow, ft)	3.53	1.04	3.27	1.04	0.87	1.61
a'/y1	3.12	40.86	3.15	141.98	169.57	13.00
Skew correction (p. 49, fig. 16)	0.98	0.98	0.98	1.01	1.01	1.01
Froude no. f/p flow	0.24	0.51	0.37	0.33	0.36	0.33
Ys w/ corr. factor K1/0.55:						
vertical	ERR	5.91	ERR	5.31	4.60	ERR
vertical w/ ww's	ERR	4.85	ERR	4.35	3.77	ERR
spill-through	ERR	3.25	ERR	2.92	2.53	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.43	0.51	1	0.43	0.51	1
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	7.5	7.4	4.4	7.5	7.4	4.4
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.86	1.19	ERR	0.86	1.19	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.84	ERR	ERR	1.84