LEVEL II SCOUR ANALYSIS FOR BRIDGE 7H (HUNTTH0001007H) on TOWN HIGHWAY 1, crossing COBB BROOK, HUNTINGTON, VERMONT

U.S. Geological Survey
Open-File Report 97-339

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

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By EMILY C. WILD

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic

LEVEL II SCOUR ANALYSIS FOR BRIDGE 7H (HUNTTH0001007H) ON TOWN HIGHWAY 1, CROSSING COBB BROOK, HUNTINGTON, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HUNTTH001007H on Town Highway 1 crossing the Cobb Brook, Huntington, Vermont (figures 1–10). 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.

In August 1976, Hurricane Belle caused flooding at this site which resulted in road and bridge damage (figures 7-8). This was approximately a 25-year flood event (U.S. Department of Housing and Urban Development, 1978).

The site is in the Green Mountain section of the New England physiographic province in central Vermont. The 4.20-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest upstream of the bridge . Downstream of the bridge is brushland and pasture.

In the study area, the Cobb Brook has an incised, straight channel with a slope of approximately 0.03 ft/ft, an average channel top width of 43 ft and an average bank height of 6 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 65.5 mm (0.215 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 24, 1996, indicated that the reach was stable.

The Town Highway 1 crossing of the Cobb Brook is a 23-ft-long, two-lane bridge consisting of one 20-foot concrete slab span (Vermont Agency of Transportation, written communication, June 21, 1996). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 2.8 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. Protection measures at the site include type-1 stone fill (less than 12 inches diameter) at the downstream right wingwall, type-2 stone fill (less than 36 inches diameter) at the upstream right wingwall and the downstream end of the downstream left wingwall, and type-3 stone fill (less than 48 inches diameter) at the upstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). 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 0.2 to 1.3 ft. The worst-case contraction scour occurred at the incipient-overtopping discharge. Abutment scour ranged from 4.0 to 8.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 10. 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.

Figure 3. Structure BRIDTH00340026 viewed from upstream (November 8, 1994).

Figure 5. Upstream channel viewed from structure BRIDTH00340026 (November 8, 1994).

Figure 7. Downstream channel viewed after August 1976 flood which destroyed bridge (U.S. Department of Housing and Urban Development, 1978).

Figure 8. Left road approach viewed from right road approach after August 1976 flood (U.S. Department of Housing and Urban Development, 1978).

LEVEL II SUMMARY

Structure Number HUNTTH0001007H ***Stream*** Cobb Brook

County Chittenden ***Road*** TH1 ***District*** 5

Description of Bridge

Bridge length 23 ***ft*** ***Bridge width*** 31.3 ***ft*** ***Max span length*** 20 ***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*** 06/24/96

Description of stone fill Type-1, around the downstream right wingwall. Type-2, around the upstream right wingwall and around the down-stream end of the downstream left wingwall. Type-3, around the upstream left wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a scour hole approximately 3 feet deep that extends 25 feet along the left abutment.

Y 15

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

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

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	06/24/96	0	0
Level II	06/24/96	0	0

Potential for debris Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

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

Description of the Geomorphic Setting

General topography The channel is located within a 400 foot-wide, slightly irregular flood plain of the Huntington River with moderate valley walls on both sides.

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

Date of inspection 06/24/96

DS left: Flood plain

DS right: Flood plain

US left: Flood plain

US right: Flood plain

Description of the Channel

Average top width 43 ***ft*** ***Average depth*** 5.9 ***ft***

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

Straight and stable with alluvial channel boundaries and a wide flood plain.

06/24/96

Vegetative co Brush, trees and pasture.

DS left: Brush and trees

DS right: Brush and trees

US left: Brush and trees

US right:

Do banks appear stable? N

If not, describe location and type of instability and date of observation. The assessment of 6/24/96 noted moderate fluvial erosion along the upstream and downstream left banks. The upstream left cut-bank damage is slip failure. The downstream left cut-bank damage has been eroded.

None. 6/24/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 4.20 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/ No

Calculated Discharges

Q100 1200 ***ft³/s*** ***Q500*** 2200 ***ft³/s***

The 100- and 500-year discharges are from the Flood Insurance Study of the Town of Huntington (U.S. Department of Housing and Urban Development, 1978). The 100-year discharge is equivalent to discharge found in Vermont Agency of Transportation database (written communication, VTAOT, May 1995).

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

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

Datum tie between USGS survey and VTAOT plans To obtain VTAOT datum, add 0.7 feet to USGS survey.

Description of reference marks used to determine USGS datum. RM1 is a VTAOT brass tablet on top of the upstream end of the left abutment (elev. 499.90 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 499.77 ft, arbitrary survey datum). RM3 is a spike in post no. 5163, located 20 feet left of left abutment and 12 feet downstream of bridge (elev. 494.88 ft, arbitrary survey datum).

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-25	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	18	1	Road Grade section
APPRO	55	2	Modelled Approach section (Templated from APTEM)
APTEM	60	1	Approach section as surveyed (Used as a template)

[1] For location of cross-sections see plan-view sketch included with Level I field form, Appendix E. For more detail on how cross-sections were developed see WSPRO input file.

[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 9.

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.050 to 0.055, and overbank "n" values ranged from 0.065 to 0.080.

Critical depth at the exit section (EXITX) was assumed as the starting water surface. Normal depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990) which resulted in a supercritical solution, but within 0.8 feet of critical depth. The slope used was 0.0307 ft/ft which was calculated from thalweg slopes surveyed downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0375 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This approach also provides a consistent method for determining scour variables.

For the 100-year and incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.9 *ft*
Average low steel elevation 498.2 *ft*

100-year discharge 1200 *ft^3/s*
Water-surface elevation in bridge opening 494.0 *ft*
Road overtopping? N *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 96 *ft^2*
Average velocity in bridge opening 12.5 *ft/s*
Maximum WSPRO tube velocity at bridge 15.5 *ft/s*

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 3.0 *ft*

500-year discharge 2200 *ft^3/s*
Water-surface elevation in bridge opening 498.2 *ft*
Road overtopping? Y *Discharge over road* 480 *ft^3/s*
Area of flow in bridge opening 180 *ft^2*
Average velocity in bridge opening 9.4 *ft/s*
Maximum WSPRO tube velocity at bridge 11.5 *ft/s*

Water-surface elevation at Approach section with bridge 500.3
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 3.1

Incipient overtopping discharge 1250 *ft^3/s*
Water-surface elevation in bridge opening 494.1 *ft*
Area of flow in bridge opening 99 *ft^2*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 16.0 *ft/s*

Water-surface elevation at Approach section with bridge 498.2
Water-surface elevation at Approach section without bridge 495.0
Amount of backwater caused by bridge 3.1 *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 10.

Contraction scour for the 100-year and incipient overtopping discharges were computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge 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 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour equation were also computed for the 500-year discharge and can be found in appendix F.

Abutment scour was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	1.2	0.2	1.3
Depth to armoring	29.6 2.7	29.9	--
Left overbank	--	--	--
Right overbank	--	--	4.0 8.7

Local scour:			
Abutment scour	4.2	4.6	8.7
Left abutment	5.2	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	2.0	1.7
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	2.1	2.0	1.7
Left abutment	2.1	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

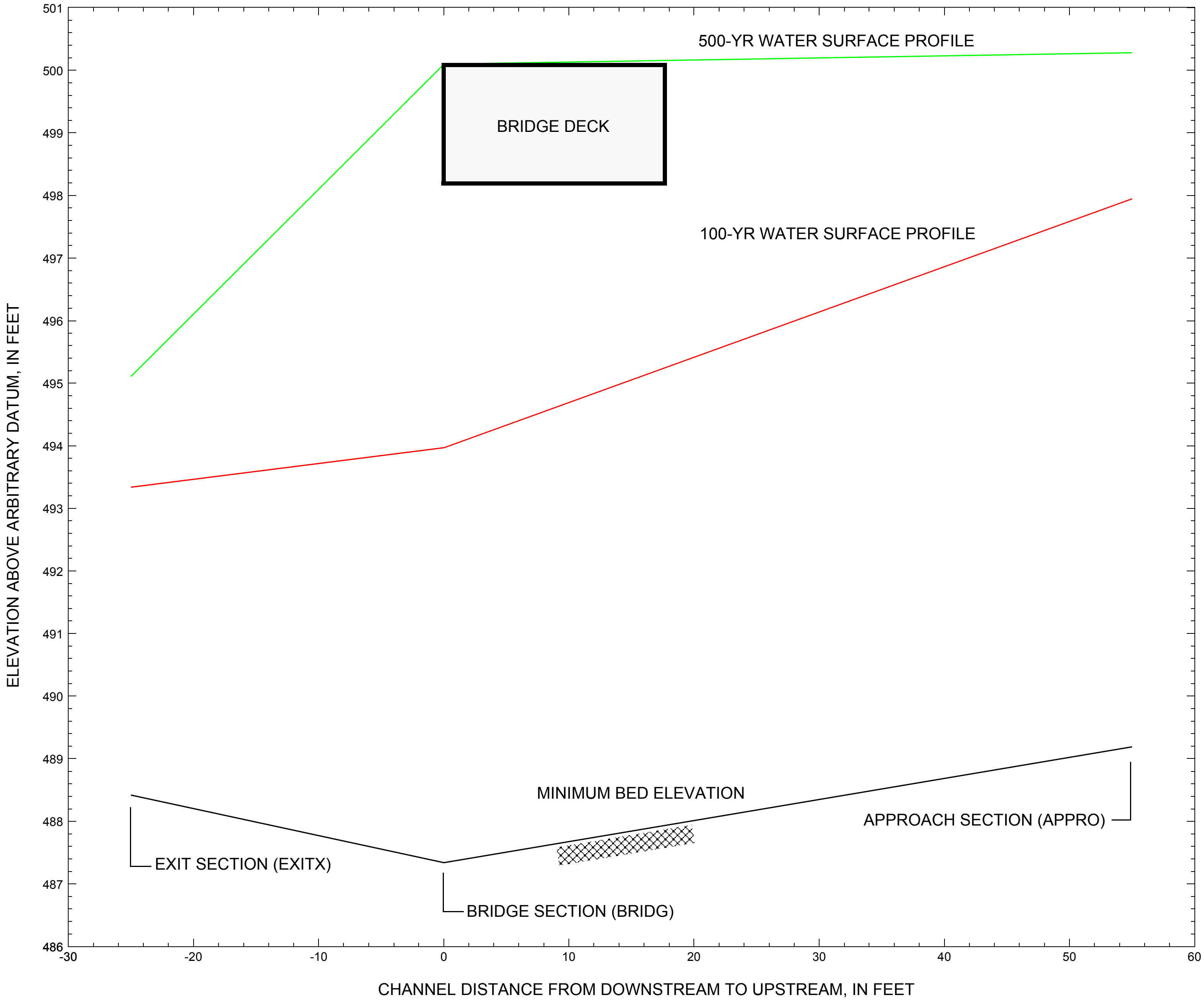

Figure 9. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH0001007H on Town Highway 34, crossing Cobb Book, Huntington, Vermont.

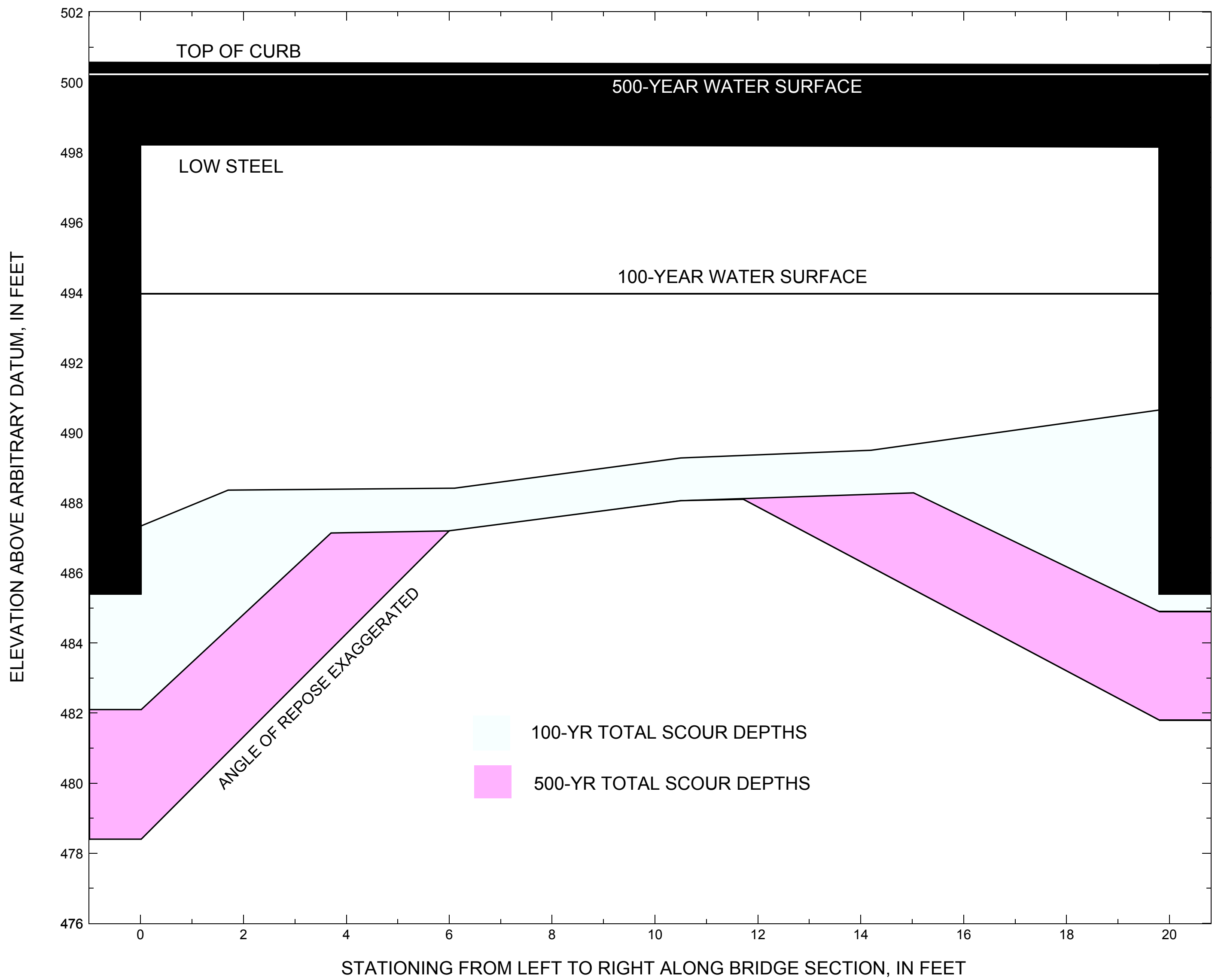

Figure 10. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH0001007H on Town Highway 1, crossing Cobb Brook, Huntington Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH0001007H on Town Highway 1, crossing Cobb Brook, Huntington, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat 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 1200 cubic-feet per second											
Left abutment	0.0	498.3	498.2	485.3	487.3	1.2	4.0	--	5.2	482.1	-3.2
Right abutment	20.0	498.2	498.1	485.3	490.7	1.2	4.6	--	5.8	484.9	-0.4

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 HUNTTH0001007H on Town Highway 1, crossing Cobb Brook, Huntington, 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 2200 cubic-feet per second											
Left abutment	0.0	498.3	498.2	485.3	487.3	0.2	8.7	--	8.9	478.4	-6.9
Right abutment	20.0	498.2	498.1	485.3	490.7	0.2	8.7	--	8.9	481.8	-3.5

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, 1948, Huntington, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File hunt07h.wsp
T2        Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
T3        TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1200.0   2200.0   1250.0
SK          0.0307   0.0307   0.0307
*
XS   EXITX      -25
GR         -194.7, 500.70   -159.2, 498.27   -132.4, 494.68    -64.2, 494.17
GR          -28.1, 494.41     -7.6, 494.57     -6.2, 492.85      0.0, 489.27
GR            5.0, 488.61      8.7, 488.42     14.4, 489.03     19.1, 489.15
GR           24.3, 491.01     29.2, 492.04     35.0, 493.19     63.8, 493.19
GR          132.4, 496.80    209.6, 495.67    255.2, 496.33    257.0, 498.92
*
N           0.065        0.055        0.065
SA                   -7.6         35.4
*
XS   FULLV      0  * * *   0.0110
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.18       0.0
GR            0.0, 498.22      0.0  487.34      1.7, 488.36      6.1, 488.42
GR           10.5, 489.28     14.2, 489.50     19.8, 490.65     20.0, 498.13
GR            0.0, 498.22
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      43.2 * *     42.2      8.6
N           0.050
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     18      31.3     1
GR         -361.5, 505.27   -326.4, 503.74   -204.3, 501.70    -93.7, 500.72
GR           -1.3, 500.02     -1.1, 500.56      0.0, 500.57     20.1, 500.50
GR           21.2, 500.49     21.3, 499.87     58.9, 499.89    158.4, 499.42
GR          236.3, 499.00    247.2, 502.57
*
*
XT   APTEM     60
GR         -257.1, 504.77   -210.2, 498.76   -148.3, 497.83    -98.1, 497.69
GR          -34.7, 496.36     -9.0, 495.88     -4.1, 493.21      0.0, 489.91
GR            4.1, 489.49      9.8, 489.38     13.4, 489.61     17.1, 490.15
GR           23.4, 493.31     33.3, 496.64     67.5, 496.67     98.7, 496.47
GR          156.0, 496.71    205.2, 496.99    238.4, 497.65    238.5, 502.53
*
AS   APPRO     55  *  *  *  0.0375
GT
N           0.080        0.055        0.080
SA                    -9.0         33.3
*
HP 1 BRIDG     493.97 1 493.97
HP 2 BRIDG     493.97 * * 1200
HP 1 APPRO     497.95 1 497.95
HP 2 APPRO     497.95 * * 1200
*
HP 1 BRIDG     498.22 1 498.22
HP 2 BRIDG     498.22 * * 1685
HP 2 RDWAY     500.10 * * 480
HP 1 APPRO     500.28 1 500.28
HP 2 APPRO     500.28 * * 2200
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APPENDIX B:

WSPRO OUTPUT FILE

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V042094            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File hunt07h.wsp
        Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
        TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
           *** RUN DATE & TIME: 01-31-97  10:12
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       96      6221    20     30                         1204
   493.97            96      6221    20     30  1.00      0     20     1204


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       493.97     0.0    19.9    96.4    6221.    1200.  12.45

X STA.         0.0        1.6        2.7        3.5        4.3        5.1
  A(I)            10.1        5.8        4.9        4.4        4.2
  V(I)            5.96      10.43      12.22      13.58      14.23

X STA.         5.1        5.8        6.5        7.2        8.0        8.7
  A(I)             4.0        3.9        3.9        3.9        3.9
  V(I)           15.15      15.27      15.23      15.52      15.48

X STA.         8.7        9.5       10.4       11.2       12.1       13.0
  A(I)             3.9        4.0        4.0        4.1        4.1
  V(I)           15.38      14.92      15.08      14.50      14.57

X STA.        13.0       13.9       15.0       16.1       17.5       19.9
  A(I)             4.2        4.5        4.8        5.4        8.4
  V(I)           14.20      13.30      12.40      11.15       7.18


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      144      2516   160    160                          780
             2      262     22817    42     46                         3702
             3      279      6361   205    206                         1844
   497.95           685     31694   407    411  2.61   -168    238     3122


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.95  -168.8   238.4   685.4   31694.    1200.   1.75

X STA.      -168.8      -28.0       -5.2       -1.3        1.0        2.9
  A(I)           105.0       52.1       22.1       18.2       15.8
  V(I)            0.57       1.15       2.71       3.29       3.79

X STA.         2.9        4.6        6.4        8.1        9.8       11.5
  A(I)            15.0       15.0       14.9       14.8       14.7
  V(I)            4.01       3.99       4.03       4.06       4.07

X STA.        11.5       13.2       15.1       17.1       19.6       23.4
  A(I)            15.3       15.5       16.6       18.3       21.8
  V(I)            3.91       3.87       3.62       3.29       2.75

X STA.        23.4       34.2       77.7      117.4      162.2      238.4
  A(I)            32.8       64.6       64.1       66.9       81.8
  V(I)            1.83       0.93       0.94       0.90       0.73
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        U.S. Geological Survey WSPRO Input File hunt07h.wsp
        Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
        TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
           *** RUN DATE & TIME: 01-31-97  10:12  HP 1 BRIDG     498.22 1 498.22
 CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      180     11355      0     59                            0
   498.22           180     11355      0     59  1.00      0     20        0


    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.22     0.0    20.0   180.3   11355.    1685.   9.35

X STA.         0.0         1.7         2.8         3.7         4.5         5.3
  A(I)            18.0        10.1         9.0         8.3         8.0
  V(I)            4.69        8.32        9.39       10.10       10.58

X STA.         5.3         6.1         6.9         7.7         8.5         9.3
  A(I)             7.5         7.6         7.4         7.3         7.4
  V(I)           11.26       11.03       11.39       11.49       11.33

X STA.         9.3        10.1        10.9        11.8        12.6        13.5
  A(I)             7.5         7.4         7.6         7.7         7.7
  V(I)           11.26       11.45       11.02       10.97       10.90

X STA.        13.5        14.5        15.5        16.5        17.8        20.0
  A(I)             8.1         8.4         9.0        10.2        16.0
  V(I)           10.38        9.98        9.41        8.26        5.27


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      18.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.10   -11.9   239.7   124.2    1973.     480.   3.87

X STA.       -11.9        73.0       102.1       121.2       135.5       147.7
  A(I)            12.1        10.0         8.8         7.7         7.3
  V(I)            1.98        2.39        2.74        3.10        3.28

X STA.       147.7       158.1       167.1       175.3       182.6       189.3
  A(I)             6.8         6.3         6.1         5.8         5.5
  V(I)            3.53        3.79        3.94        4.13        4.33

X STA.       189.3       195.5       201.3       206.6       211.7       216.5
  A(I)             5.4         5.2         4.9         4.8         4.7
  V(I)            4.48        4.60        4.92        4.96        5.13

X STA.       216.5       221.0       225.3       229.4       233.4       239.7
  A(I)             4.6         4.3         4.4         4.2         5.1
  V(I)            5.20        5.54        5.50        5.65        4.75


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      612     22903    215    215                         5862
             2      361     38842     42     46                         5976
             3      757     33347    205    208                         8247
   500.28          1729     95092    462    468  1.90   -223    238    13760


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.28  -223.5   238.5  1729.2   95092.    2200.   1.27

X STA.      -223.5      -142.0       -92.1       -55.8       -27.6        -6.6
  A(I)           162.6       136.2       119.4       111.7        94.4
  V(I)            0.68        0.81        0.92        0.98        1.17

X STA.        -6.6        -0.1         3.5         6.9        10.3        13.7
  A(I)            51.8        39.3        37.4        37.2        36.8
  V(I)            2.12        2.80        2.94        2.96        2.99

X STA.        13.7        17.4        22.6        33.6        61.0        88.4
  A(I)            39.5        45.6        61.8       104.3       105.7
  V(I)            2.78        2.41        1.78        1.05        1.04

X STA.        88.4       114.4       141.3       169.3       199.8       238.5
  A(I)           103.0       104.3       105.0       109.8       123.4
  V(I)            1.07        1.05        1.05        1.00        0.89
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        U.S. Geological Survey WSPRO Input File hunt07h.wsp
        Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
        TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
           *** RUN DATE & TIME: 01-31-97  10:12

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       99      6465     20     31                         1253
   494.10            99      6465     20     31  1.00      0     20     1253


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      494.10     0.0    19.9    99.0    6465.    1250.  12.63

X STA.        0.0         1.7         2.7         3.6         4.4         5.1
  A(I)            10.5         5.9         4.9         4.7         4.3
  V(I)            5.94       10.62       12.79       13.42       14.49

X STA.        5.1         5.8         6.6         7.3         8.0         8.8
  A(I)             4.1         4.0         4.0         4.0         3.9
  V(I)           15.42       15.56       15.52       15.56       16.00

X STA.        8.8         9.6        10.4        11.3        12.1        13.0
  A(I)             4.0         4.1         4.1         4.2         4.2
  V(I)           15.60       15.13       15.26       14.96       14.82

X STA.       13.0        14.0        15.0        16.1        17.5        19.9
  A(I)             4.3         4.6         5.0         5.5         8.6
  V(I)           14.43       13.51       12.58       11.29        7.25


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      181      3463    174    174                         1048
             2      271     24183     42     46                         3901
             3      324      8162    205    206                         2310
   498.17           777     35808    422    426  2.61   -182    238     3703


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
        WSEL     LEW     REW    AREA        K        Q    VEL
      498.17  -183.4   238.4   776.6   35808.    1250.   1.61

X STA.     -183.4       -40.0        -8.0        -2.1         0.5         2.6
  A(I)           113.5        70.6        27.4        20.4        18.0
  V(I)            0.55        0.88        2.28        3.06        3.47

X STA.        2.6         4.5         6.4         8.2        10.0        11.9
  A(I)            16.7        16.8        16.6        16.2        16.6
  V(I)            3.75        3.73        3.76        3.85        3.76

X STA.       11.9        13.8        15.9        18.1        21.3        26.6
  A(I)            16.8        17.4        18.7        21.8        26.0
  V(I)            3.72        3.59        3.35        2.87        2.40

X STA.       26.6        55.6        94.1       128.9       171.2       238.4
  A(I)            57.2        67.4        63.6        70.6        84.3
  V(I)            1.09        0.93        0.98        0.89        0.74
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       U.S. Geological Survey WSPRO Input File hunt07h.wsp
       Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
       TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
          *** RUN DATE & TIME: 01-31-97  10:12

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   493.21     493.34

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

EXITX:XS   ******     -6      135  1.31 *****  494.64  493.34    1200  493.34
       -24 ******     67     7326  1.06 ***** *******    1.19    8.91

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.80     494.37     493.61

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.84     500.98    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.84     500.98     493.61

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.49

FULLV:FV       25     -6      195  0.72  0.45  495.08  493.61    1200  494.36
         0     25     81    10935  1.23  0.00   -0.01    0.81    6.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       55     -7      140  1.15  0.82  496.11 *******    1200  494.96
        55     55     29     8801  1.00  0.21    0.00    0.78    8.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    1200.     493.97

            <<<<<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       25      0       96  2.41 *****  496.38  493.97    1200  493.97
         0     25     20     6223  1.00 ***** *******    1.00   12.45

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.18 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL

   RDWAY:RG      18.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       12   -168      686  0.12  0.09  498.08  494.23    1200  497.95
        55     12    238    31709  2.61  1.61    0.00    0.38    1.75

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.455  0.422   18287.     0.    20.   497.92
                        <<<<<END OF BRIDGE COMPUTATIONS>>>>>


  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -25.    -7.    67.   1200.    7326.     135.    8.91  493.34
   FULLV:FV      0.    -7.    81.   1200.   10935.     195.    6.16  494.36
   BRIDG:BR      0.     0.    20.   1200.    6223.      96.   12.45  493.97
   RDWAY:RG     18.**************      0.******************    1.00********
   APPRO:AS     55.  -169.   238.   1200.   31709.     686.    1.75  497.95

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      0.    20.   18287.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD     EGL    WSEL
   EXITX:XS    493.34    1.19  488.42  500.70************  1.31  494.64  493.34
   FULLV:FV    493.61    0.81  488.70  500.98  0.45  0.00  0.72  495.08  494.36
   BRIDG:BR    493.97    1.00  487.34  498.22************  2.41  496.38  493.97
   RDWAY:RG  ****************  499.00  505.27**********************************
   APPRO:AS    494.23    0.38  489.19  504.58  0.09  1.61  0.12  498.08  497.95
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WSPRO OUTPUT FILE (continued)

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       U.S. Geological Survey WSPRO Input File hunt07h.wsp
       Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
       TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
          *** RUN DATE & TIME: 01-31-97  10:12

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   494.35     495.11

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
EXITX:XS   ******   -135      386  0.89 *****  496.00  495.11    2200  495.11
       -24 ******    100    19477  1.75 ***** *******    1.04    5.70
 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.91     495.56     495.39
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.61     500.98    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.61     500.98     495.39

FULLV:FV       25   -135      411  0.79  0.30  496.28  495.39    2200  495.49
         0     25    102    20741  1.76  0.00   -0.02    0.96    5.36
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.14     495.68     497.19
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.99     504.58    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.99     504.58     497.19
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   497.19     504.58     497.19

APPRO:AS       55    -82      412  0.96 *****  498.15  497.19    2200  497.19
        55     55    225    20984  2.15 ***** *******    1.20    5.34
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   501.74       0.00     496.37     499.00
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   495.41     500.15     500.24     498.18
 ===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       25      0      180  1.36 *****  499.58  495.19    1685  498.22
         0 ******     20    11355  1.00 ***** *******    0.55    9.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.454 ******  498.18 ****** ****** ******

   XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
  RDWAY:RG      18.    24.  0.01  0.05  500.32   -0.02    480.  500.10

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
  LT:      4.    10.   -11.    -1.   0.1   0.0   2.3  10.2   0.3   3.0
  RT:    476.   218.    21.   240.   1.1   0.6   4.2   3.9   0.8   3.2

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

APPRO:AS       12   -223     1730  0.05  0.07  500.33  497.19    2200  500.28
        55     19    238    95121  1.90  1.66   -0.02    0.16    1.27
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

   XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
  EXITX:XS     -25.  -136.   100.   2200.   19477.     386.    5.70  495.11
  FULLV:FV       0.  -136.   102.   2200.   20741.     411.    5.36  495.49
  BRIDG:BR       0.     0.    20.   1685.   11355.     180.    9.35  498.22
  RDWAY:RG      18.*******     4.    480.       0.*********    1.00  500.10
  APPRO:AS      55.  -224.   238.   2200.   95121.    1730.    1.27  500.28
   XSID:CODE   XLKQ   XRKQ       KQ
  APPRO:AS  ***********************
 SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
  EXITX:XS     495.11    1.04  488.42  500.70************  0.89  496.00  495.11
  FULLV:FV     495.39    0.96  488.70  500.98  0.30  0.00  0.79  496.28  495.49
  BRIDG:BR     495.19    0.55  487.34  498.22************  1.36  499.58  498.22
  RDWAY:RG  ****************  499.00  505.27  0.01******  0.05  500.32  500.10
  APPRO:AS     497.19    0.16  489.19  504.58  0.07  1.66  0.05  500.33  500.28
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       U.S. Geological Survey WSPRO Input File hunt07h.wsp
       Hydraulic analysis for structure HUNTTH0001007H   Date: 28-OCT-96
       TOWN HIGHWAY 1, COBB BROOK, HUNTINGTON, VERMONT    ECW
          *** RUN DATE & TIME: 01-31-97  10:12

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   493.29     493.48

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

EXITX:XS   ******     -6      145  1.26 *****  494.75  493.48    1250  493.48
       -24 ******     69     7940  1.10 ***** *******    1.15    8.60

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.81     494.44     493.76

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.98     500.98    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.98     500.98     493.76

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.43

FULLV:FV       25     -6      201  0.74  0.43  495.17  493.76    1250  494.43
         0     25     82    11354  1.24  0.00   -0.01    0.81    6.21
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       55     -7      142  1.20  0.84  496.24 *******    1250  495.04
        55     55     29     9025  1.00  0.23    0.00    0.79    8.79
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    1250.     494.10

            <<<<<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       25      0       99  2.48 *****  496.58  494.10    1250  494.10
         0     25     20     6471  1.00 ***** *******    1.00   12.62

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  498.18 ****** ****** ******

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

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

APPRO:AS       12   -182      776  0.11  0.08  498.27  494.34    1250  498.17
        55     12    238    35769  2.61  1.61    0.02    0.34    1.61

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.461  0.462   19028.     0.    20.   498.14
                    <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -25.    -7.    69.   1250.    7940.     145.    8.60  493.48
   FULLV:FV       0.    -7.    82.   1250.   11354.     201.    6.21  494.43
   BRIDG:BR       0.     0.    20.   1250.    6471.      99.   12.62  494.10
   RDWAY:RG      18.**************       0.*****************    1.00********
   APPRO:AS      55.  -183.   238.   1250.   35769.     776.    1.61  498.17

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       0.    20.   19028.

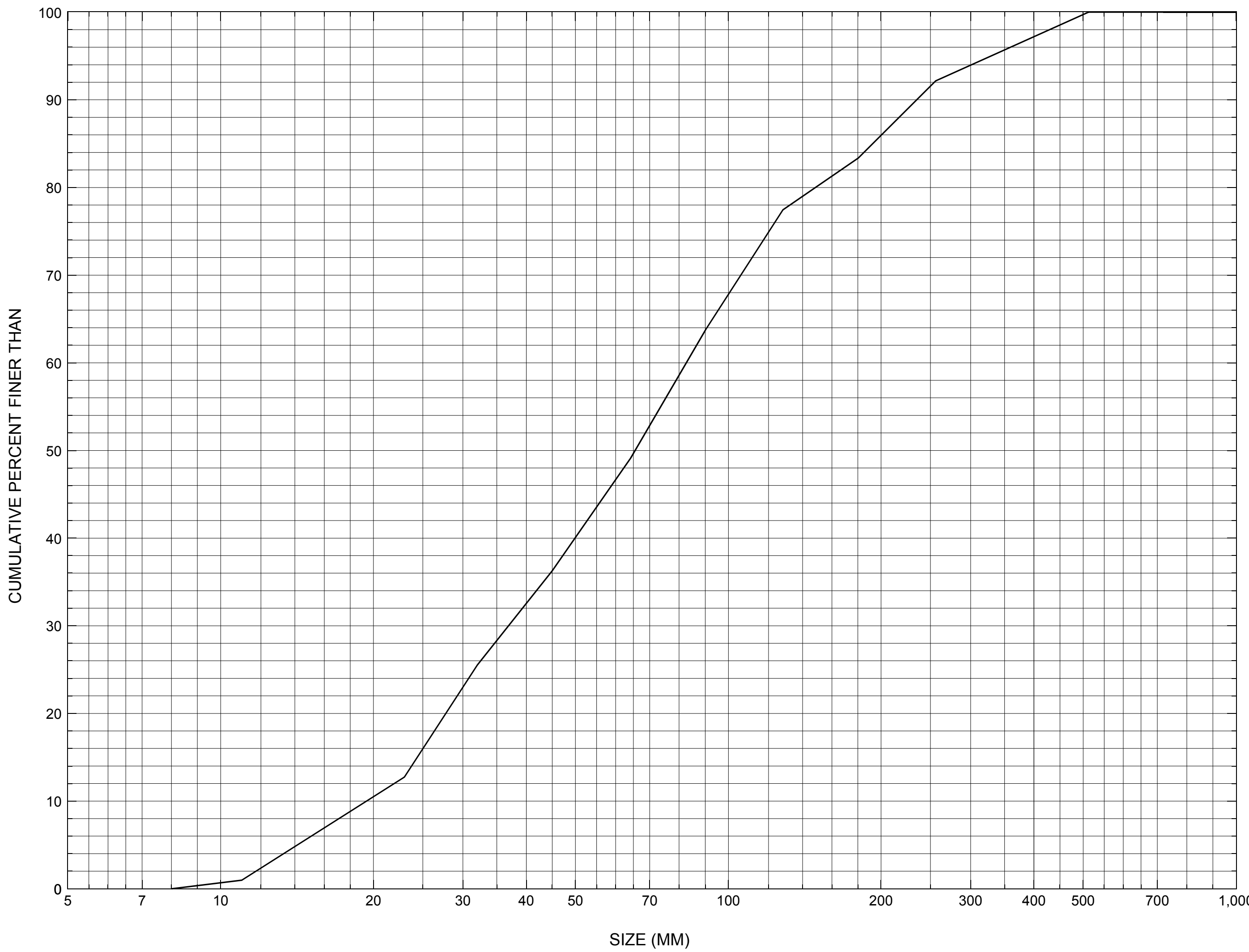
 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    493.48    1.15  488.42  500.70************  1.26  494.75  493.48
   FULLV:FV    493.76    0.81  488.70  500.98  0.43  0.00  0.74  495.17  494.43
   BRIDG:BR    494.10    1.00  487.34  498.22************  2.48  496.58  494.10
   RDWAY:RG  ***************  499.00  505.27**********************************
   APPRO:AS    494.34    0.34  489.19  504.58  0.08  1.61  0.11  498.27  498.17
  ER

  NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure HUNTTH0001007H, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH0001007H

General Location Descriptive

Data collected by *(First Initial, Full last name)* R. BURNS

Date *(MM/DD/YY)* 06 / 21 / 96

Highway District Number *(I - 2; nn)* 05

County *(FIPS county code; I - 3; nnn)* 007

Town *(FIPS place code; I - 4; nnnnn)* 34600

Mile marker *(I - 11; nnn.nnn)* 002970

Waterway *(I - 6)* COBB BROOK

Road Name *(I - 7):* FAS 211

Route Number TR 01

Vicinity *(I - 9)* 4.4 MI N JCT. VT.17

Topographic Map Huntington

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44163

Longitude *(i - 17; nnnnn.n)* 72576

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 200211007H0408

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

Maximum span length *(I - 48; nnnn)* 0020

Year built *(I - 27; YYYY)* 1976

Structure length *(I - 49; nnnnnn)* 000023

Average daily traffic, ADT *(I - 29; nnnnnn)* 000660

Deck Width *(I - 52; nn.n)* 313

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

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

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

Waterway adequacy *(I - 71; n)* 7

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 22.5

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

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

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

Waterway of full opening (*nnn.n* ft^2) 180

Comments:

According to the structural inspection report dated 7/12/94, the structure is a concrete slab bridge. The stems of both abutments are in good condition except for minor cracking at the fascia lines and light scaling at the bottom of the stem of the Labut. The footing of the Labut is slightly exposed but not undermined. The channel takes a slight turn into and is straight leaving the structure. Flow in the channel is currently along the Labut side. There is a sand and silt buildup along the Rabut side. The wingwalls are protected with heavy stone fill. There is minor channel scour noted along the Labut and at mid-channel.

Bridge Hydrologic Data

Is there hydrologic data available? __Y__ *if No, type ctrl-n h* VTAOT Drainage area (*mi²*): __4.17__

Terrain character: ____

Stream character & type:

Streambed material: ____

Discharge Data (*cfs*): $Q_{2.33}$ __300__ Q_{10} __650__ Q_{25} __900__

Q_{50} __1050__ Q_{100} __1200__ 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*)

<u>Water Surface Elevation Estimates for Existing Structure:</u>

Peak discharge frequency	$Q_{2.33}$	Q_{10}	Q_{25}	Q_{50}	Q_{100}
Water surface elevation (*ft*)	**494**	**495.9**	**497.1**	**497.8**	**498.4**
Velocity (*ft / sec*)					

Long term stream bed changes:

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

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

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

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

Highway No. : ____ Structure No. : ____ Structure Type: ____

Clear span (*ft*): ____ Clear Height (*ft*): ____ Full Waterway (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:

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.20** mi^2 Lake and pond area **0.01** mi^2

Watershed storage *(ST)* **0.24** %

Bridge site elevation **760** ft Headwater elevation **3160** ft

Main channel length **4.12** mi

10% channel length elevation **890** ft 85% channel length elevation **2680** ft

Main channel slope *(S)* **579.29** ft / mi

Watershed Precipitation Data

Average site precipitation __________ in Average headwater precipitation __________ in

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

Average seasonal snowfall *(Sn)* _________ ft

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **4** / **1976**

Project Number ________________

Minimum channel bed elevation: **490**

Low superstructure elevation: USLAB **498.34** DSLAB **498.34** USRAB **498.24** DSRAB **498.24**

Benchmark location description:

BM #1, 14.5' Lt. Sta 19+67, spike in pole #163 elev. 500', next to DS edge of road, 20' up left bank.
BM #2, 35' Lt. Sta 22+94, S.I.T. 15" M elev. 501.01' 30' Ds of road, 280' up right bank.

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

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

If 1: Footing Thickness **1.5** Footing bottom elevation: **486**

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

If 3: Footing bottom elevation: ____

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

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

Briefly describe material at foundation bottom elevation or around piles:

Comments:

The low superstructure elevations are the bridge seat elevations from the bridge plans.
The elevation of the top wing wall- abutment corner is 500.60 on the left abutment US and DS, and 500.50 on the right abutment US and DS.

Cross-sectional Data

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

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

Comments: **NO CROSS SECTIONAL 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: -
-

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: 10/29/96
Computerized by: EW Date: 10/29/96
Reviewd by: EW Date: 03/18/97

Structure Number HUNTTH0001007H

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. WILD Date *(MM/DD/YY)* 06 / 24 / 1996
2. Highway District Number 05 Mile marker 002970
   County WASHINGTON 007 Town HUNTINGTON 34600
   Waterway *(I - 6)* COBB BROOK Road Name FAS 211
   Route Number TH 1 Hydrologic Unit Code: 02010003
3. Descriptive comments:
LOCATED 4.4 MILES NORTH OF JUNCTION WITH VERMONT 17.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 4 RBDS 5 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 1 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 23 *(feet)* Span length 20 *(feet)* Bridge width 31.3 *(feet)*

Road approach to bridge:

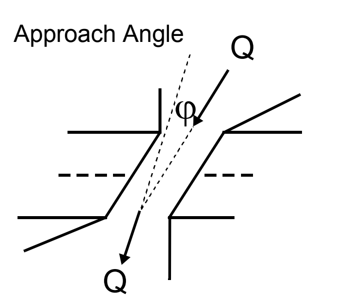
8. LB 0 RB 0 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
    US left -- US right --

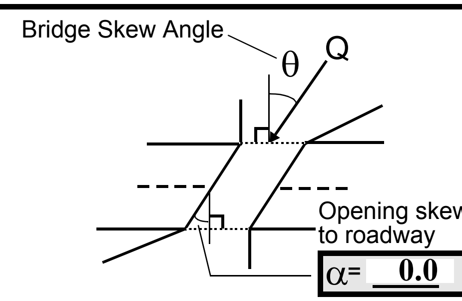
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	3	1	3	0
RBUS	2	1	2	0
RBDS	1	1	0	-
LBDS	2	2	3	1

*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: 15 16. Bridge skew: 15





17. Channel impact zone 1: Exist? Y *(Y or N)*
    Where? LB *(LB, RB)* Severity 1
    Range? 134 feet US *(US, UB, DS)* to 30 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**

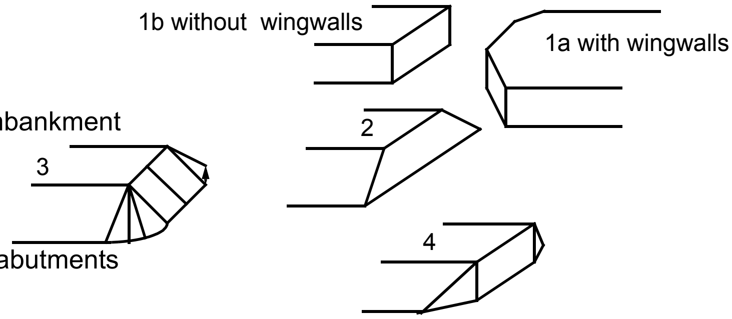
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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.)

4: Along the upstream right and left banks, the surface cover is grass for one bridge length, with forest beyond. The downstream left bank surface cover is a house, brush, and pasture. Right bank downstream surface cover is brushland with some trees.

18: Though abutments slope below low cord (type 4), for modeling purposes the bridge type is a 1a.

C. Upstream Channel Assessment

20. SRD	21. Bank height (BF) LB	21. Bank height (BF) RB	22. Bank angle (BF) LB	22. Bank angle (BF) RB	26. % Veg. cover (BF) LB	26. % Veg. cover (BF) RB	27. Bank material (BF) LB	27. Bank material (BF) RB	28. Bank erosion (BF) LB	28. Bank erosion (BF) RB
24.5	**5.5**			**7.5**	**2**	**2**	**432**	**243**	**2**	**1**

23. Bank width **40.0** 24. Channel width **25.0** 25. Thalweg depth **42.0** 29. Bed Material **4325**

30 .Bank protection type: LB **2** RB **1** 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.):

26: At 54 feet upstream and further upstream, banks are mostly trees (76% to 100% vegetation cover). From 54 feet upstream to upstream bridge face, the percent vegetation is much lower because the banks are covered with brush, high grass and some trees.

28: Base of trees lean into channel about a foot, then they are vertical. Brush along channel banks, from 52 feet upstream to upstream bridge face, are growing in a downstream direction.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance **10.8 UB** 35. Mid-bar width: **11.6**

36. Point bar extent: **8** feet **US** (US, UB) to **18** feet **DS** (US, UB, DS) positioned **50** %LB to **100** %RB

37. Material: **23**

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

The section of the point bar under bridge is finely-grained material (silt and sand) from the middle of the channel to the right abutment. From downstream bridge face to 18 feet downstream, the point bar is comprised of grass and brush, in addition to sand and gravel. A side bar extends from 57 feet US to 43 feet US, clumps of grass overlie cobbles. It is positioned 0%LB to 20%RB. It is 4 feet wide at 46.6 feet US.

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

41. Mid-bank distance: **30** 42. Cut bank extent: **37** feet **US** (US, UB) to **19** feet **US** (US, UB, DS)

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

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

Brush/ root systems are the only objects on failed bank, adjacent to channel.

Left bank is eroded from 134 feet upstream to 37 feet upstream.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **21 UB**

47. Scour dimensions: Length **32.5** Width **5.5** Depth : **3.3** Position **0** %LB to **40** %RB

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

Scour depth 3.3 feet assumes 0.5 thalweg, (total water depth 3.8 feet).
Scour hole extends from 7 feet under bridge (from upstream bridge face) to 8 feet downstream.

Local scour is also present upstream behind boulders in stream.

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
17.0		0.5		2	7	7	-

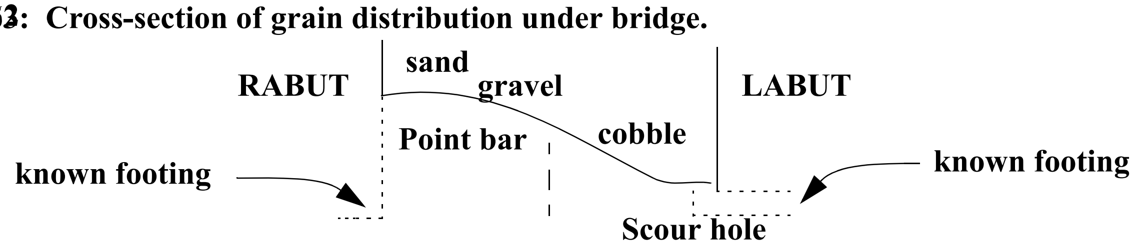
58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **90.0** 63. Bed Material **-**

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.):

463: Cross-section of grain distribution under bridge.



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 **2**____ (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		**20**	**90**	**2**	**2**	**2.8**	**0.2**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**0**	**20.0**

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

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

-

-

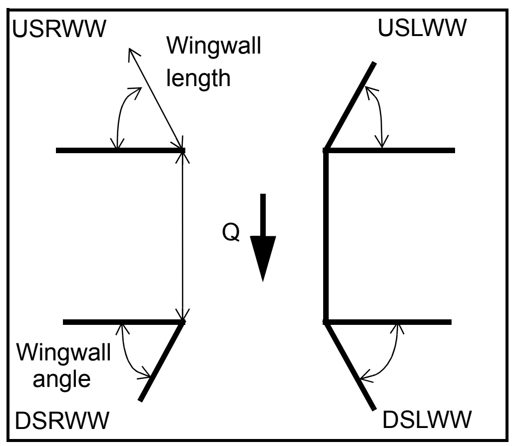
1

LABUT footing is exposed but not undermined.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**20.0**	
USRWW:	**Y**		**1**		**0**	**1.0**	
DSLWW:	**-**		**-**		**Y**	**35.5**	
DSRWW:	**1**		**0**		**-**	**35.5**	

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



82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**-**	**2**	**Y**	**-**	**1**	**1**	**-**	**-**
Condition	**Y**	**2**	**1**	**-**	**1**	**1**	**-**	**-**
Extent	**1**	**0.1**	**0**	**3**	**2**	**0**	**0**	**-**

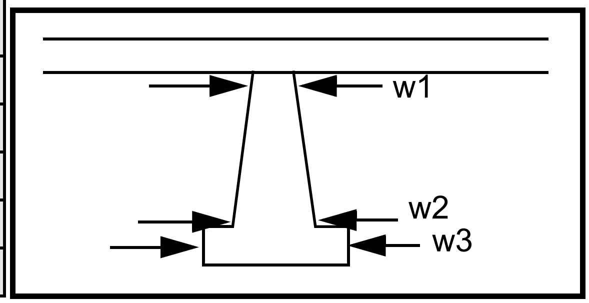
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
2
2
3
1
1
1

Piers:

84. Are there piers? **DS** *(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				**40.0**	**11.5**	**45.0**
Pier 2				**12.0**	**50.0**	**12.0**
Pier 3			**-**	**45.0**	**12.0**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**LW**	**USL**	**trud**		*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**W**	**WW**	**es**	**N**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**only**	**/**	**into**	**-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**upst**	**USR**	**chan**	**-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**ream**	**WW**	**nel.**	**-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**end**	**/**		**-**	
92. Pushed	**of**	**DSL**		**-**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**foot-**	**WW**		**-**	
95. Cross-members	**ing is**	**pro-**		**-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**expo**	**tec-**		**-**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**sed.**	**tion**		**-**	
98. Exposure depth		**pro-**		**-**	

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

E. Downstream Channel Assessment

100.

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

Bank width (BF) - Channel width (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):

NO PIERS

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

Point bar extent: ______ feet **1** ____ *(US, UB, DS)* to **2** ______ feet **432** *(US, UB, DS)* positioned **324** %LB to **2** ____ %RB

Material: **1** ____

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

4325
1
0
2

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

Cut bank extent: **d left** feet **ba** *(US, UB, DS)* to **nk** feet **pro** *(US, UB, DS)*

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

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

tion extends from end of wingwall to 20 feet downstream. The top of the left bank is moderately eroded.

Channel is rather straight downstream of bridge.

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

Scour dimensions: Length ______ Width ______ Depth: _____ Positioned ____ %LB to ____ %RB

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

N

Are there major confluences? **-** ____ *(Y or if N type ctrl-n mc)* How many? **NO**

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

1- *Constructed*
2- *Stable*
3- *Aggraded*
4- *Degraded*
5- *Laterally unstable*
6- *Vertically and laterally unstable*

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

N
-
-
-
-
-
-
-
-
-
NO POINT BARS

109. G. Plan View Sketch

point bar (pb)	debris	flow (Q)	stone wall
cut-bank (cb)	rip rap or stone fill	cross-section	other wall
scour hole		ambient channel	

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: HUNTTH0001007H   Town: HUNTINGTON
Road Number: TH001   County: WASHINGTON
Stream: COBB BROOK

Initials ECW   Date: 2/10/97 Checked: SAO

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	1200	2200	1250
Main Channel Area, ft2	262	361	271
Left overbank area, ft2	144	612	181
Right overbank area, ft2	279	757	324
Top width main channel, ft	42	42	42
Top width L overbank, ft	160	215	174
Top width R overbank, ft	205	205	205
D50 of channel, ft	0.215	0.215	0.215
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.2	8.6	6.5
y1, average depth, LOB, ft	0.9	2.8	1.0
y1, average depth, ROB, ft	1.4	3.7	1.6
Total conveyance, approach	31694	95092	35808
Conveyance, main channel	22817	38842	24183
Conveyance, LOB	2516	22903	3463
Conveyance, ROB	6361	33347	8162
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	863.9	898.6	844.2
Ql, discharge, LOB, cfs	95.3	529.9	120.9
Qr, discharge, ROB, cfs	240.8	771.5	284.9
Vm, mean velocity MC, ft/s	3.3	2.5	3.1
Vl, mean velocity, LOB, ft/s	0.7	0.9	0.7
Vr, mean velocity, ROB, ft/s	0.9	1.0	0.9
Vc-m, crit. velocity, MC, ft/s	9.1	9.6	9.2
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Main Channel	0	0	0

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	262	361	271
Main channel width, ft	42	42	42
y1, main channel depth, ft	6.24	8.60	6.45
Bridge Section			
(Q) total discharge, cfs	1200	2200	1250
(Q) discharge thru bridge, cfs	1200	1685	1250
Main channel conveyance	6221	11355	6465
Total conveyance	6221	11355	6465
Q2, bridge MC discharge,cfs	1200	1685	1250
Main channel area, ft2	96	180	99
Main channel width (skewed), ft	19.9	20.0	19.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	19.9	20	19.9
y_bridge (avg. depth at br.), ft	4.82	9.02	4.97
Dm, median (1.25*D50), ft	0.26875	0.26875	0.26875
y2, depth in contraction,ft	6.05	8.06	6.26
ys, scour depth (y2-ybridge), ft	1.22	-0.96	1.29
ARMORING			
D90	0.771	0.771	0.771
D95	1.075	1.075	1.075
Critical grain size,Dc, ft	0.8381	0.3579	0.8431
Decimal-percent coarser than Dc	0.0784	0.2878	0.078
Depth to armoring,ft	29.56	2.66	29.90

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1200	2200	1250
Q, thru bridge, cfs	0	1685	0
Total Conveyance, bridge	0	11355	0
Main channel(MC) conveyance, bridge	0	11355	0
Q, thru bridge MC, cfs	ERR	1685	ERR
Vc, critical velocity, ft/s	0.00	9.61	0.00
Vc, critical velocity, m/s	0.00	2.93	0.00
Main channel width (skewed), ft	0.0	20.0	0.0

W, adjusted width, ft	0.0	20.0	0.0
qbr, unit discharge, ft2/s	ERR	84.3	ERR
qbr, unit discharge, m2/s	N/A	7.8	N/A
Area of full opening, ft2	0.0	180.3	0.0
Hb, depth of full opening, ft	ERR	9.02	ERR
Hb, depth of full opening, m	N/A	2.75	N/A
Fr, Froude number, bridge MC	1	0.55	1
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	0	498.18	0
Elevation of Bed, ft	N/A	489.17	N/A
Elevation of Approach, ft	0	500.28	0
Friction loss, approach, ft	0	0.07	0
Elevation of WS immediately US, ft	0.00	500.21	0.00
ya, depth immediately US, ft	N/A	11.05	N/A
ya, depth immediately US, m	N/A	3.37	N/A
Mean elevation of deck, ft	500.53	500.53	500.53
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	ERR	0.95	ERR
Ys, depth of scour, ft	N/A	0.21	N/A
Comparison of Chang and Laursen results (for unsubmerged orifice flow)			
y2, from Laursen's equation, ft	6.04835	8.056192	6.263729
Full valley WSEL, ft	494.36	495.49	494.43
Full valley depth, ft	N/A	6.325	N/A
Ys, depth of scour (y2-yfullv), ft	N/A	1.731192	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	1200	2200	1250	1200	2200	1250
a', abut.length blocking flow, ft	168.8	223.5	183.4	218.4	218.5	218.4
Ae, area of blocked flow ft2	189.49	675.5	227.98	329.71	718	377.96
Qe, discharge blocked abut.,cfs	213.91	--	237.98	353.68	--	400.39
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.13	0.98	1.04	1.07	1.11	1.06
ya, depth of f/p flow, ft	1.12	3.02	1.24	1.51	3.29	1.73
--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	0.188	0.099	0.165	0.154	0.100	0.142
ys, scour depth, ft	7.76	11.95	7.98	8.95	12.20	9.39

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)	168.8	223.5	183.4	218.4	218.5	218.4
y1 (depth f/p flow, ft)	1.12	3.02	1.24	1.51	3.29	1.73
a'/y1	150.37	73.95	147.54	144.67	66.49	126.20
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.19	0.10	0.16	0.15	0.10	0.14
Ys w/ corr. factor K1/0.55:						
vertical	4.86	10.60	5.15	5.62	10.62	6.28
vertical w/ ww's	3.98	8.69	4.23	4.61	8.71	5.15
spill-through	2.67	5.83	2.83	3.09	5.84	3.45

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	1	0.55	1	1	0.55	1
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	4.82	9.02	4.97	4.82	9.02	4.97
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	1.69	ERR	ERR	1.69	ERR
Fr>0.8 (vertical abut.)	2.02	ERR	2.08	2.02	ERR	2.08