LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (HUNTTH00220032) on TOWN HIGHWAY 22, crossing BRUSH BROOK, HUNTINGTON, VERMONT

U.S. Geological Survey
Open-File Report 97-651

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

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By RONDA L. BURNS

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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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 32 (HUNTTH00220032) ON TOWN HIGHWAY 22, CROSSING BRUSH BROOK, HUNTINGTON, VERMONT

By **Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HUNTTH00220032 on Town Highway 22 crossing Brush Brook, Huntington, 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 Green Mountain section of the New England physiographic province in central Vermont. The 5.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except on the downstream right overbank which is pasture.

In the study area, Brush Brook has an incised, straight channel with a slope of approximately 0.05 ft/ft, an average channel top width of 58 ft and an average bank height of 6 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 127 mm (0.416 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 25, 1996, indicated that the reach was stable.

The Town Highway 22 crossing of Brush Brook is a 36-ft-long, one-lane bridge consisting of one 34-foot steel-beam span and a timber deck (Vermont Agency of Transportation, written communication, December 12, 1995). The opening length of the structure parallel to the bridge face is 35.7 ft. The bridge is supported by vertical, concrete abutments with wingwalls on the left. The channel is skewed approximately 50 degrees to the opening while the measured opening-skew-to-roadway is 15 degrees.

A scour hole 1.0 ft deeper than the mean thalweg depth was observed along the left abutment and downstream left wingwall during the Level I assessment. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the upstream right bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). 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 0.2 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 6.4 to 10.2 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 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 HUNTTH00220032 ***Stream*** Brush Brook

County Chittenden ***Road*** TH 22 ***District*** 5

Description of Bridge

Bridge length 36 ***ft*** ***Bridge width*** 16.2 ***ft*** ***Max span length*** 34 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 06/25/97

Description of stone fill Type-2, along the right bank upstream near the bridge.

Abutments and wingwalls are concrete. Only the left abutment has wingwalls. There is a one foot deep scour hole in front of the left abutment and downstream left wingwall.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 50

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

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	06/25/97	0	0
Level II	06/26/97	0	0

Potential for debris Moderate. There are fallen trees in the channel upstream and downstream as well as many logs and branches caught in between the large boulders.

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

None. 06/25/97

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with steep valley walls on both sides.

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

Date of inspection 06/25/97

DS left: Steep valley wall

DS right: Low channel bank to a narrow plain and steep bank

US left: Steep valley wall

US right: Steep channel bank to a moderately sloped overbank

Description of the Channel

Average top width 58 ***ft*** ***Average depth*** 6 ***ft***

Predominant bed material Boulders/Cobbles ***Bank material*** Boulders/Cobbles

Straight and stable with semi-alluvial channel boundaries.

06/25/97

Vegetative co Trees and brush

DS left: Short grass and a few trees

DS right: Trees and brush

US left: Trees and brush

US right: Yes

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

There is a bedrock outcrop across the channel downstream that diverts the flow to the right. There is also a 3 ft. stone dam across the channel downstream of the bedrock.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 5.7 ***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/p No

Calculated Discharges

Q100 1,610 ***ft³/s*** ***Q500*** 2,110 ***ft³/s***

The discharges are interpolated between flood frequency estimates for drainage areas of 9.19 square miles at bridge 12 and 5.01 square miles at bridge 31 in Huntington. The estimates are available from the VTAOT database (Vermont Agency of Transportation, written communication, May 1995) and were graphically extrapolated to the 500-year event. The values used were within a range defined by flood frequency curves developed from several empirical methods. (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887)

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the upstream left wingwall (elev. 498.29 ft, arbitrary survey datum). RM2 is a chiseled X in bedrock on the right bank 55 ft. downstream (elev. 489.78 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-35	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APTEM	52	1	Approach section as surveyed (Used as a template)
APPRO	55	2	Modelled Approach section (Templated from APTEM)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.050 to 0.070, and overbank "n" values ranged from 0.040 to 0.075.

Critical depth at the exit section (EXITX) was assumed for each discharge as the starting water surface. Normal depth was computed below critical depth approximately 0.3 ft for each discharge by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0547 ft/ft, which was estimated from surveyed points downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0454 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it was 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 499.7 *ft*
Average low steel elevation 497.6 *ft*

100-year discharge 1,610 *ft³/s*
Water-surface elevation in bridge opening 493.0 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 140 *ft²*
Average velocity in bridge opening 11.5 *ft/s*
Maximum WSPRO tube velocity at bridge 14.2 *ft/s*

Water-surface elevation at Approach section with bridge 495.4
Water-surface elevation at Approach section without bridge 494.4
Amount of backwater caused by bridge 1.0 *t*

500-year discharge 2,110 *ft³/s*
Water-surface elevation in bridge opening 493.9 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 167 *ft²*
Average velocity in bridge opening 12.6 *ft/s*
Maximum WSPRO tube velocity at bridge 15.4 */s*

Water-surface elevation at Approach section with bridge 496.4
Water-surface elevation at Approach section without bridge 495.1
Amount of backwater caused by bridge 1.3 *t*

Incipient overtopping discharge - *ft³/s*
Water-surface elevation in bridge opening - *ft*
Area of flow in bridge opening - *ft²*
Average velocity in bridge opening - *ft/s*
Maximum WSPRO tube velocity at bridge - *ft/s*

Water-surface elevation at Approach section with bridge -
Water-surface elevation at Approach section without bridge -
Amount of backwater caused by bridge - *t*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

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

Abutment scour was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.2	--
Depth to armoring	18.1	22.3	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	8.5	10.2	--
Right abutment	6.4	7.8	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

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

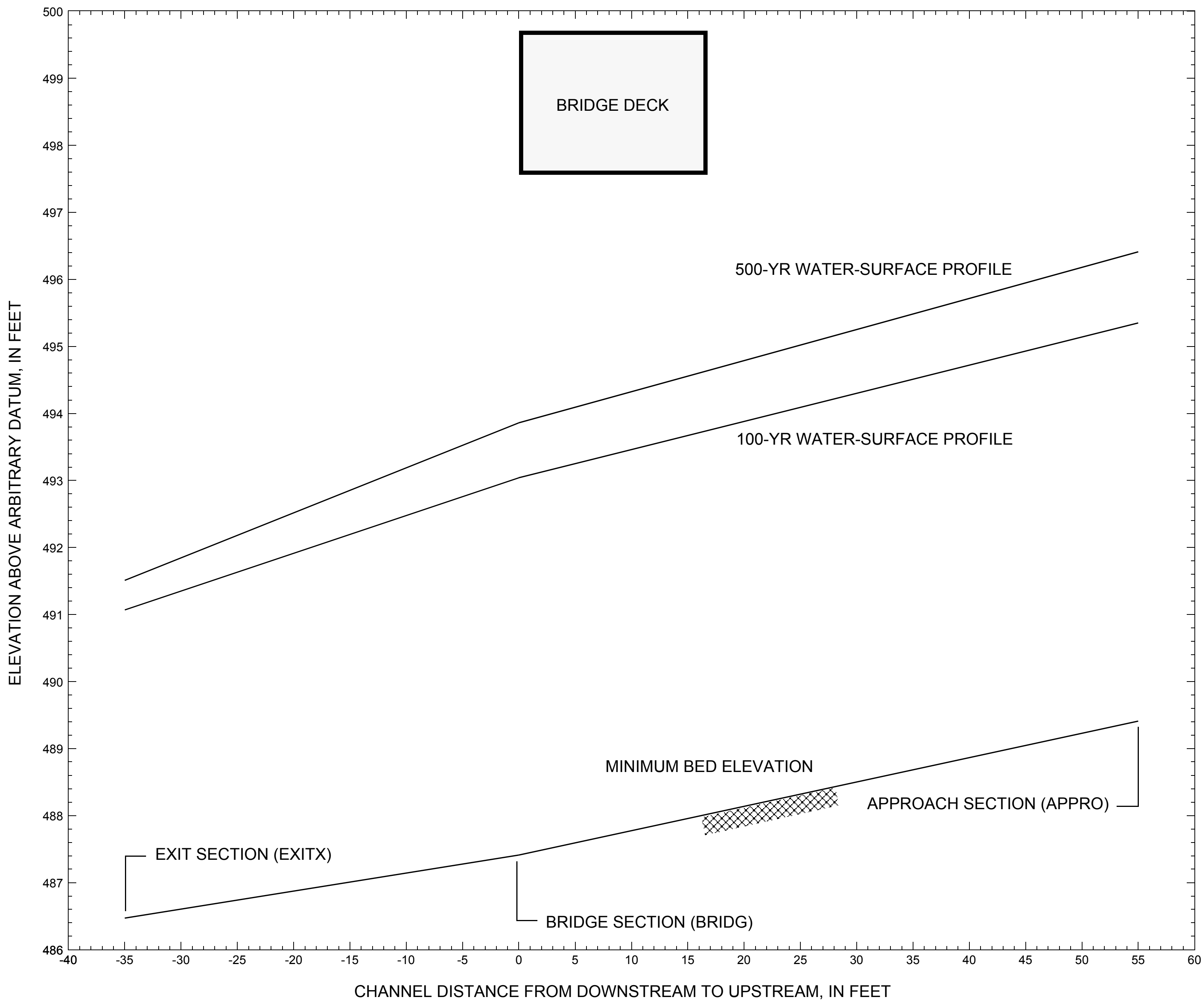

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HUNTTH00220032 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

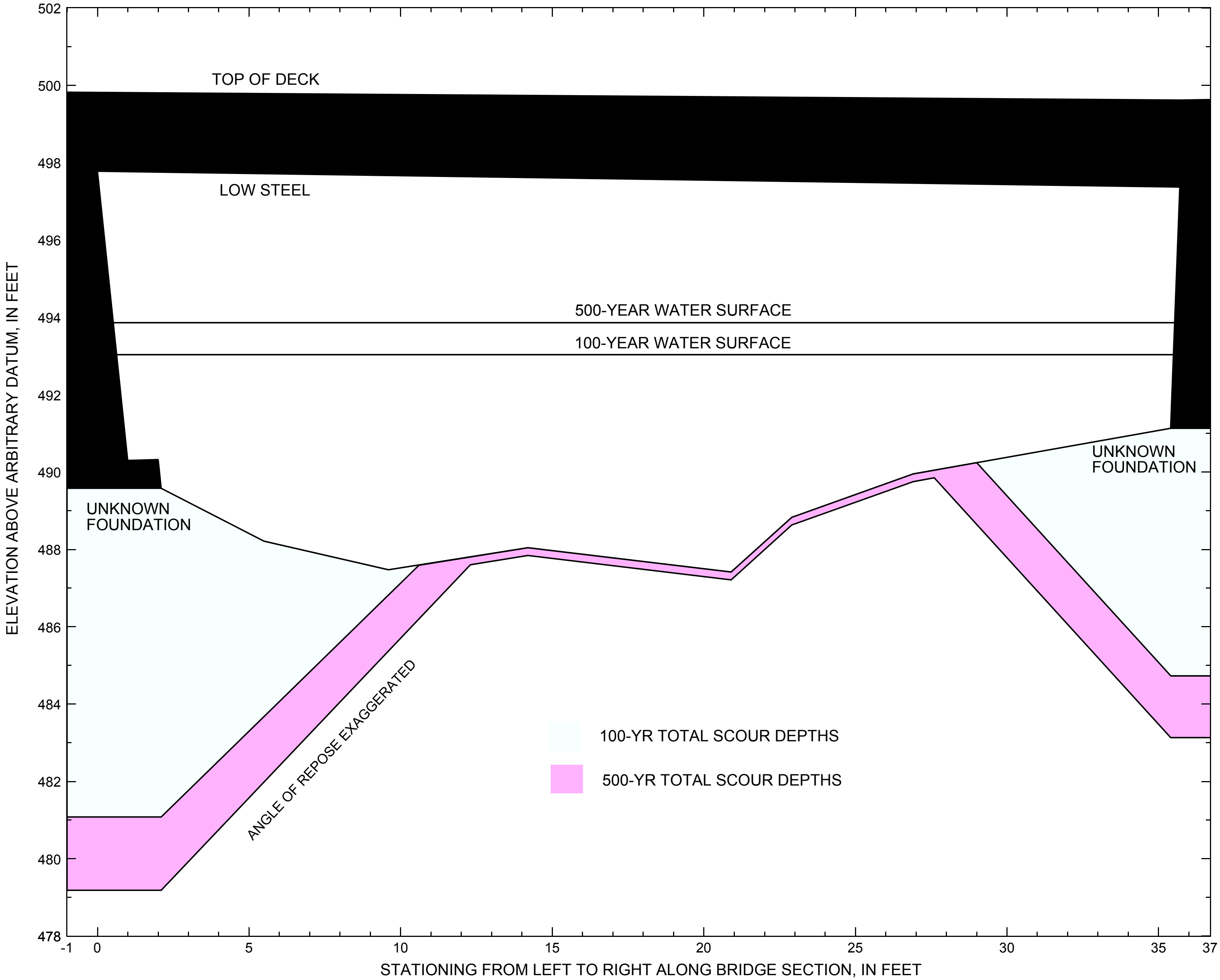

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HUNTTH00220032 on Town Highway 22, crossing Brush Brook, Huntington, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HUNTTH00220032 on Town Highway 22, crossing Brush 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,610 cubic-feet per second											
Left abutment	0.0	--	497.8	--	489.6	0.0	8.5	--	8.5	481.1	--
Right abutment	35.7	--	497.4	--	491.1	0.0	6.4	--	6.4	484.7	--

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 HUNTTH00220032 on Town Highway 22, crossing Brush 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 2,110 cubic-feet per second											
Left abutment	0.0	--	497.8	--	489.6	0.2	10.2	--	10.4	479.2	--
Right abutment	35.7	--	497.4	--	491.1	0.2	7.8	--	8.0	483.1	--

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, Photorevised 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File hunt032.wsp
T2        Hydraulic analysis for structure HUNTTH00220032   Date: 04-JUN-97
T3        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT                    RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1610.0   2110.0
SK          0.0547   0.0547
*
XS   EXITX    -35           0.
GR          -96.9, 522.05    -74.1, 502.02    -45.0, 500.69    -29.4, 498.73
GR          -15.9, 490.11      0.0, 487.60      4.5, 486.47      9.6, 486.84
GR           17.4, 486.47     27.8, 487.64     35.9, 490.28     61.1, 490.13
GR           72.7, 496.91    156.7, 499.43    193.9, 515.71
*
N           0.070        0.040
SA                  35.9
*
*
XS   FULLV      0  * * *   0.0198
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.57      15.0
GR            0.0, 497.78      1.0, 490.30      2.0, 490.32      2.1, 489.58
GR            5.5, 488.21      9.6, 487.47     14.2, 488.04     20.9, 487.41
GR           22.9, 488.83     26.9, 489.95     35.4, 491.13     35.7, 497.37
GR            0.0, 497.78
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      21.2 * *     25.0     10.1
N           0.050
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      16.2     2
GR          -60.2, 518.08    -29.9, 500.83    -17.3, 500.01      0.0, 499.81
GR           39.6, 499.62     96.0, 500.18    128.9, 502.33    140.0, 505.86
GR          206.5, 506.65    322.4, 511.15
*
*
XT   APTEM     52           0.
GR          -43.0, 518.42    -19.7, 505.22     -7.4, 499.13     -5.0, 492.85
GR            7.0, 490.43     12.4, 489.87     15.2, 489.27     21.8, 489.49
GR           25.1, 489.46     29.9, 490.25     33.5, 491.77     40.4, 498.10
GR           63.7, 499.89     96.0, 500.18    128.9, 502.33    140.0, 505.86
GR          206.5, 506.65    322.4, 511.15
*
AS   APPRO    55  *  *  *  0.0454
GT
N           0.060        0.075
SA                  40.4
*
HP 1 BRIDG   493.04 1 493.04
HP 2 BRIDG   493.04 * * 1610
HP 1 APPRO   495.35 1 495.35
HP 2 APPRO   495.35 * * 1610
*
```

APPENDIX B:

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File hunt032.wsp
        Hydraulic analysis for structure HUNTTH00220032   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT                    RLB
           *** RUN DATE & TIME: 06-23-97  16:37

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      140      9639     34     40                          1615
   493.04           140      9639     34     40  1.00      1     35      1615

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.04     0.6    35.5   139.7    9639.    1610.  11.52

X STA.         0.6        4.3        6.0        7.3        8.5        9.7
  A(I)             11.6        7.6        6.6        6.2        5.9
  V(I)             6.97      10.57      12.16      12.89      13.57

X STA.         9.7       10.7       11.9       13.0       14.2       15.4
  A(I)              5.7        5.8        5.7        5.9        5.8
  V(I)            14.16      13.84      14.18      13.74      13.80

X STA.        15.4       16.5       17.7       18.8       19.9       21.0
  A(I)              5.8        5.9        5.9        5.8        6.1
  V(I)            13.97      13.68      13.73      13.83      13.22

X STA.        21.0       22.5       24.4       26.8       30.0       35.5
  A(I)              7.0        7.5        8.0        8.9       12.0
  V(I)            11.50      10.75      10.01       9.04       6.69

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      192     12198     43     47                          2296
   495.35           192     12198     43     47  1.00     -5     37      2296

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.35    -5.9    37.3   191.9   12198.    1610.   8.39

X STA.        -5.9        0.0        3.2        5.7        7.7        9.6
  A(I)             15.5       11.9       10.4        9.7        9.1
  V(I)             5.19       6.78       7.72       8.30       8.86

X STA.         9.6       11.3       12.9       14.4       15.8       17.1
  A(I)              8.8        8.7        8.3        8.0        8.0
  V(I)             9.15       9.20       9.71      10.03      10.01

X STA.        17.1       18.5       19.9       21.3       22.7       24.2
  A(I)              8.0        8.0        8.0        8.2        8.3
  V(I)            10.01      10.09      10.05       9.78       9.64

X STA.        24.2       25.6       27.2       29.0       31.1       37.3
  A(I)              8.4        8.7        9.5       10.3       15.8
  V(I)             9.62       9.25       8.47       7.79       5.08
```

```
        U.S. Geological Survey WSPRO Input File hunt032.wsp
        Hydraulic analysis for structure HUNTTH00220032   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT                    RLB
           *** RUN DATE & TIME: 06-23-97  16:37

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      167     12677     34     41                         2113
   493.86           167     12677     34     41  1.00      1     36     2113

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.86     0.5    35.5   167.4   12677.    2110.  12.61

X STA.         0.5        4.2        6.0        7.4        8.6        9.8
  A(I)            14.2        9.3        8.0        7.3        7.3
  V(I)            7.40      11.34      13.16      14.39      14.43

X STA.         9.8       11.0       12.1       13.3       14.5       15.8
  A(I)             6.9        6.9        6.9        6.9        7.0
  V(I)           15.28      15.28      15.25      15.24      15.12

X STA.        15.8       16.9       18.1       19.3       20.4       21.7
  A(I)             6.8        7.0        6.9        7.2        7.6
  V(I)           15.42      15.14      15.23      14.73      13.97

X STA.        21.7       23.3       25.3       27.7       30.6       35.5
  A(I)             8.5        8.6        9.5       10.1       14.4
  V(I)           12.37      12.21      11.15      10.49       7.32

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      238     16880     45     50                         3124
   496.41           238     16880     45     50  1.00     -5     38     3124

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.41    -6.3    38.4   238.4   16880.    2110.   8.85

X STA.        -6.3       -0.5        2.5        5.0        7.1        9.0
  A(I)            19.6       13.8       12.8       12.1       11.1
  V(I)            5.37       7.62       8.23       8.72       9.47

X STA.         9.0       10.7       12.4       14.0       15.5       16.9
  A(I)            10.8       10.6       10.3       10.1        9.9
  V(I)            9.76       9.93      10.22      10.40      10.61

X STA.        16.9       18.3       19.8       21.2       22.7       24.2
  A(I)             9.8       10.1        9.9       10.0       10.6
  V(I)           10.75      10.50      10.61      10.53       9.99

X STA.        24.2       25.8       27.5       29.4       31.7       38.4
  A(I)            10.4       11.1       11.9       13.3       19.9
  V(I)           10.17       9.48       8.85       7.94       5.29
```

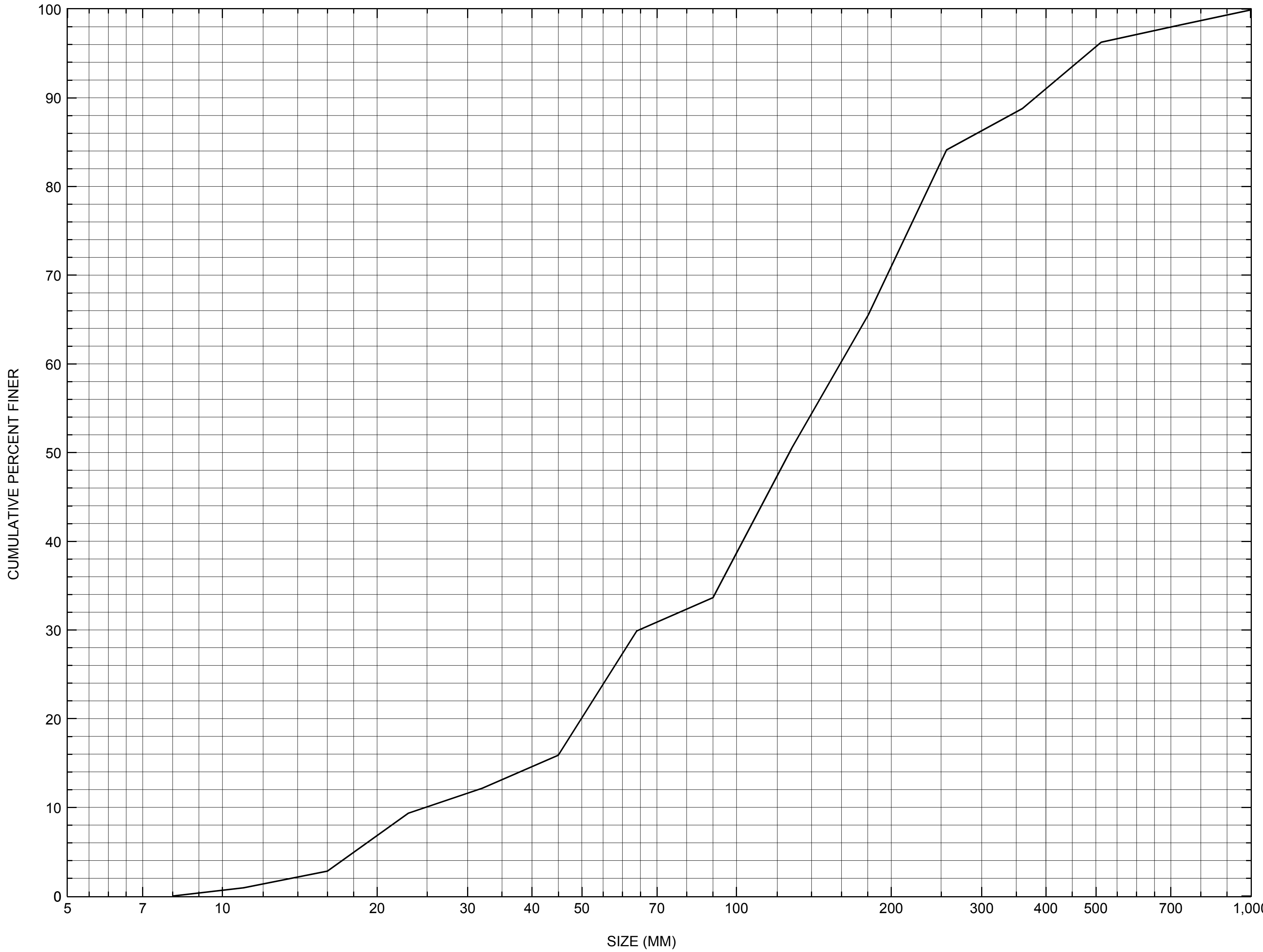
```
        U.S. Geological Survey WSPRO Input File hunt032.wsp
        Hydraulic analysis for structure HUNTTH00220032   Date: 04-JUN-97
        TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT                    RLB
           *** RUN DATE & TIME: 06-23-97  16:37

 ===015 WSI IN WRONG FLOW REGIME AT SECID “EXITX”:  USED WSI = CRWS.
                          WSI,CRWS =   490.75     491.07

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

EXITX:XS   ******    -16      192  1.12 *****  492.18  491.07    1610  491.07
       -34 ******     63     8449  1.02 ***** *******    0.96    8.38

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                          “FULLV”     KRATIO =  1.44

FULLV:FV       35    -17      243  0.68  0.89  493.07 *******    1610  492.39
         0     35     64    12126  1.00  0.00    0.00    0.68    6.63
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     1.61      493.32     494.36
 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   491.89      518.56    0.50
 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   491.89      518.56     494.36
 ===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 =   494.36      518.56     494.36

APPRO:AS       55     -5      150  1.80 *****  496.16  494.36    1610  494.36
        55     55     36     8370  1.00 ***** *******    1.00   10.76
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID “BRIDG”     Q,CRWS =    1610.      493.04

            <<<<<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       35      1      140  2.06 *****  495.10  493.04    1610  493.04
         0     35     35     9645  1.00 ***** *******    1.00   11.52

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.57 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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       34     -5      192  1.09  0.75  496.45  494.36    1610  495.35
        55     34     37    12202  1.00  0.59   -0.01    0.70    8.39

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.167  0.077   11288.     3.    38.   494.68

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -35.   -17.    63.   1610.    8449.     192.    8.38  491.07
   FULLV:FV       0.   -18.    64.   1610.   12126.     243.    6.63  492.39
   BRIDG:BR       0.     1.    35.   1610.    9645.     140.   11.52  493.04
   RDWAY:RG       8.**************      0.******************     2.00********
   APPRO:AS      55.    -6.    37.   1610.   12202.     192.    8.39  495.35

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.    38.   11288.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.07    0.96  486.47  522.05************  1.12  492.18  491.07
   FULLV:FV  ********    0.68  487.16  522.74  0.89  0.00  0.68  493.07  492.39
   BRIDG:BR    493.04    1.00  487.41  497.78************  2.06  495.10  493.04
   RDWAY:RG ****************  499.62  518.08**********************************
   APPRO:AS    494.36    0.70  489.41  518.56  0.75  0.59  1.09  496.45  495.35
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File hunt032.wsp
       Hydraulic analysis for structure HUNTTH00220032   Date: 04-JUN-97
       TH 22 CROSSING BRUSH BROOK IN HUNTINGTON, VT                    RLB
          *** RUN DATE & TIME: 06-23-97  16:37

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   491.17     491.51

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

EXITX:XS   ******    -17      228  1.34 *****  492.85  491.51    2110  491.51
       -34 ******     63    10985  1.01 ***** *******    0.98    9.25

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

FULLV:FV       35    -18      286  0.85  0.90  493.75 *******    2110  492.91
         0     35     65    15705  1.00  0.00    0.00    0.70    7.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    3.40     492.52     495.08
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.41     518.56    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.41     518.56     495.08
 ===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 =   495.08     518.56     495.08

APPRO:AS       55     -5      180  2.13 *****  497.21  495.08    2110  495.08
        55     55     37    11121  1.00 ***** *******    1.00   11.69
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =   2110.     493.86

            <<<<<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       35      1      167  2.48 *****  496.33  493.86    2110  493.86
         0     35     36    12658  1.00 ***** *******    1.00   12.62

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.57 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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       34     -5      239  1.22  0.71  497.63  495.08    2110  496.41
        55     34     38    16895  1.00  0.59   -0.01    0.68    8.84

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.185  0.058   15955.     2.    37.   495.81

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS     -35.   -18.    63.   2110.   10985.     228.    9.25  491.51
   FULLV:FV       0.   -19.    65.   2110.   15705.     286.    7.37  492.91
   BRIDG:BR       0.     1.    36.   2110.   12658.     167.   12.62  493.86
   RDWAY:RG       8.**************       0.******************    2.00********
   APPRO:AS      55.    -6.    38.   2110.   16895.     239.    8.84  496.41

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       2.    37.   15955.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.51    0.98  486.47  522.05************  1.34  492.85  491.51
   FULLV:FV  ********    0.70  487.16  522.74  0.90  0.00  0.85  493.75  492.91
   BRIDG:BR    493.86    1.00  487.41  497.78************  2.48  496.33  493.86
   RDWAY:RG ****************  499.62  518.08**********************************
   APPRO:AS    495.08    0.68  489.41  518.56  0.71  0.59  1.22  497.63  496.41
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure HUNTTH00220032, in Huntington, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HUNTTH00220032

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 12 / 95

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)* 000000

Waterway *(I - 6)* BRUSH BROOK

Road Name *(I - 7):* -

Route Number C3022

Vicinity *(I - 9)* 0.7 MI TO JCT W CL3 TH21

Topographic Map Huntington

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44177

Longitude *(i - 17; nnnnn.n)* 72563

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040800320408

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

Maximum span length *(I - 48; nnnn)* 0034

Year built *(I - 27; YYYY)* 1925

Structure length *(I - 49; nnnnnn)* 000036

Average daily traffic, ADT *(I - 29; nnnnnn)* 000050

Deck Width *(I - 52; nn.n)* 162

Year of ADT *(I - 30; YY)* 93

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)* P

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

Structure type *(I - 43; nnn)* 302

Year Reconstructed *(I - 106)* 1976

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*) 9.16

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

Waterway of full opening (*nnn.n ft²*) -

Comments:

According to the structural inspection report dated 7-17-95, the structure is a steel stringer bridge with a wooden deck. There is a concrete footing exposed on the LABUT and its wingwalls. The LABUT has a few fine cracks, small leaks, and minor spalls overall, with small voids along the bottom of the footing at the DS end. The RABUT has a few fine cracks and small leaks overall, with spalls along the top of the wall. The spalling extends in 6-10 in. under beams 3,4, and 5. A 3-4 ft triangular section at the top of the US right wingwall has broken away and slid out 4-5 in. A 3-5 ft section at the bottom US end of the RABUT is undermined up to 15 in. horizontally and 3-4 in. vertically. Additional **(continued on p. 31)**

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: **Boulders with some gravel**

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

Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

undermining may be present but is covered with boulders and gravel. A course gravel bar in front of the RABUT blocks 1/3 of the channel flow. Numerous large boulders and possibly bedrock are in the US and DS channel. There is also debris in the channel. The US channel flow approaches the structure at nearly a 45 degree angle.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **5.66** mi^2 Lake/pond/swamp area **0** mi^2

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

Bridge site elevation **940** ft Headwater elevation **4290** ft

Main channel length **3.45** mi

10% channel length elevation **1020** ft 85% channel length elevation **2840** ft

Main channel slope *(S)* **699.27** ft / mi

Watershed Precipitation Data

Average site precipitation - in Average headwater precipitation - in

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

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

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

Project Number -

Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION AVAILABLE

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

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION AVAILABLE

Comments:

-

Cross-sectional Data

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

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

Comments: **This cross-section is the upstream face. The low cord elevation is from the survey log done for this report on 06/25/96. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 07/17/95. The sketch was done on 11/03/93.**

Station	0	12	19	27	34	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low cord elevation	497.8	-	-	-	497.4	-	-	-	-	-	-
Bed elevation	490.4	-	-	-	490.5	-	-	-	-	-	-
Low cord to bed length	7.4	9.7	9.8	10.3	6.9	-	-	-	-	-	-

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: EW Date: 07/09/96
Computerized by: EW Date: 07/09/96
Reviewd by: RB Date: 06/26/97

Structure Number HUNTTH00220032

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. BURNS Date *(MM/DD/YY)* 06 / 25 / 1996
2. Highway District Number 05 Mile marker 000000
County 007 CHITTENDEN Town 34600 HUNTINGTON
Waterway *(I - 6)* BRUSH BROOK Road Name -
Route Number C3022 Hydrologic Unit Code: 02010003
3. Descriptive comments:
Located 0.7 miles from the junction with TH21.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 6 RBDS 4 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 2 DS 2 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 36 *(feet)* Span length 34 *(feet)* Bridge width 16.2 *(feet)*

Road approach to bridge:

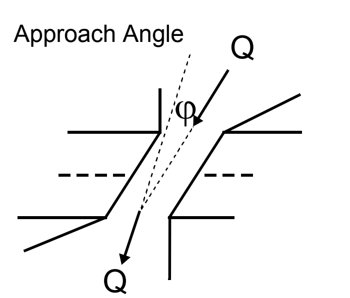
8. LB 2 RB 2 *(**0** even, **1**- lower, **2**- higher)*
9. LB 2 RB 2 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

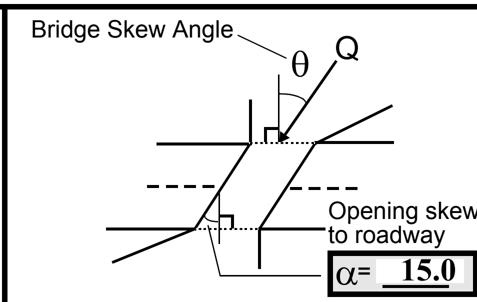
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	1	1	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*
*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: 40 16. Bridge skew: 50



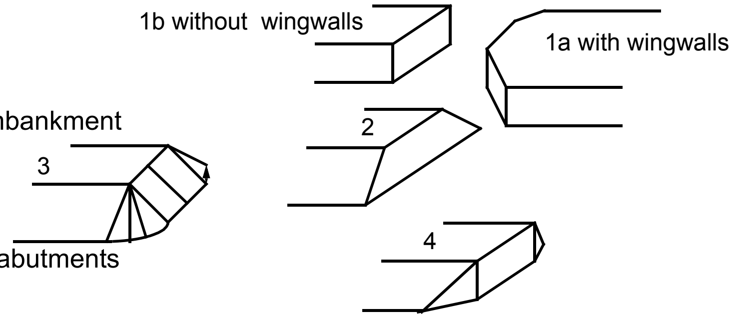


17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 14 feet US *(US, UB, DS)* to 7 feet US
Channel impact zone 2: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 37 feet DS *(US, UB, DS)* to 47 feet DS

*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: The RBDS surface cover is a lawn. Beyond two bridge lengths the surface cover is forest.
#7: Values are from the VT AOT database. Measured bridge length = 38 feet; bridge span = 36 feet; bridge width = 16.2 feet.
#11: USRB road protection is small stone above the USRB type-2 protection.
#18: Only the left abutment has wingwalls.

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
34.5	**6.5**			**6.5**	**4**	**4**	**543**	**543**	**2**	**1**

23. Bank width **70.0** 24. Channel width **40.0** 25. Thalweg depth **48.0** 29. Bed Material **543**

30 .Bank protection type: LB **0** RB **2** 31. Bank protection condition: LB **-** RB **1**

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

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

#30: RB protection is piled native stones extending from 10 feet US to 0 feet US.

A land slide occurred on the left bank from 150 feet US to 100 feet US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **36** 35. Mid-bar width: **14**

36. Point bar extent: **56** feet **US** (US, UB) to **23** feet **US** (US, UB, DS) positioned **0** %LB to **25** %RB

37. Material: **5432**

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

This point bar is beneath the cut-bank and DS of a large boulder. The material grades from gravel US, behind the boulder, to cobble material at the DS end. Sand is present along the bottom of the bank.

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: **43** 42. Cut bank extent: **56** feet **US** (US, UB) to **23** 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.):

Two large trees have fallen into the stream and many roots have been exposed.

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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
38.5		**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.):

543

There are big pieces of concrete under the bridge and in the channel at the US bridge face.

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

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

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

70. Debris and Ice Comments:

2

Trees have fallen into the channel both US and DS of the bridge. Many logs and branches have been caught in the large boulders.

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		40	90	2	2	1 ft.	4 ft.	90.0
RABUT	1	-	90			2	0	34.5

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.):

-

-

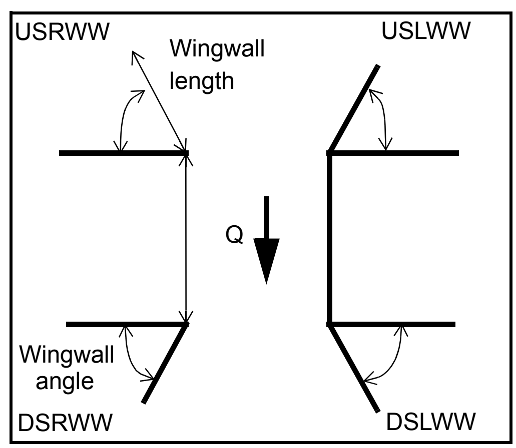
1

The left abutment footing is two feet thick (vertically) and rests upon two feet of boulders. There is little penetration between the boulders. At the US end of the LABUT, concrete has been poured over the stone to the top of the wingwall footing. Only the top of the upstream left wingwall footing is visible.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						34.5	
USRWW:	Y		1		2	1.0	
DSLWW:	0		0		N	17.0	
DSRWW:	-		-		-	16.5	

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	-	3	N	-	-	-	-	-
Condition	Y	1.5	-	-	-	-	-	-
Extent	1	3.5	-	0	-	0	0	-

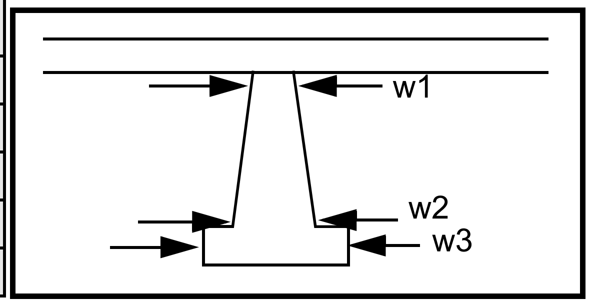
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **Th** *(Y or if N type ctrl-n pr)*

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1			**-**	**50.0**	**11.0**	**-**
Pier 2		**9.0**	**-**	**10.0**	**-**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e**	**also**	**betwee**	**under-**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**DSL**	**has**	**n the**	**mine**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**boul-**	**DSL**	**d**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**foot-**	**ders**	**WW**	**with**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**ing is**	**bene**	**and**	**2**	*Y- yes; N- no*
91. Attack ∠ (BF)	**two**	**ath**	**the**	**feet**	
92. Pushed	**feet**	**it.**	**left**	**of**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**thick**	**At**	**abut**	**pen-**	
95. Cross-members	**ver-**	**the**	**ment**	**etra-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**ticall**	**inter**	**, the**	**tion.**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**y**	**sec-**	**foot-**		
98. Exposure depth	**and**	**tion**	**ing is**		

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

N
-
-

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):
-
-
-
-
-
-

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.):

-
-
NO PIERS

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

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

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

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

3
2
543
543

Is channel scour present? **2** (Y or if N type ctrl-n cs) Mid-scour distance: **1**

Scour dimensions: Length **54** Width **0** Depth: **0** Positioned - %LB to - %RB

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

Bed, right bank and left bank materials become bedrock at 60 feet DS. The bedrock extends to 80 feet DS. A stone dam was built at 92 feet DS from the bridge. It extends across the channel to form a swimming hole.

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

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

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

Confluence comments (eg. confluence name):

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 DROP STRUCTURE

Y

13

12

0

US

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: HUNTTH00220032		Town:	HUNTINGTON
Road Number:	TH 22	County:	WINDSOR
Stream: BRUSH BROOK			

Initials RLB Date: 06/12/97 Checked: EB

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	1610	2110	0
Main Channel Area, ft2	192	238	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	43	45	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.4159	0.4159	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.5	5.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	12198	16880	0
Conveyance, main channel	12198	16880	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1610.0	2110.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	8.4	8.9	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.7	11.0	N/A
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	N/A
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1610	2110	0
(Q) discharge thru bridge, cfs	1610	2110	0
Main channel conveyance	9639	12677	0
Total conveyance	9639	12677	0
Q2, bridge MC discharge,cfs	1610	2110	ERR
Main channel area, ft2	140	167	0
Main channel width (normal), ft	33.7	33.8	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	33.7	33.8	0
y_bridge (avg. depth at br.), ft	4.15	4.94	ERR
Dm, median (1.25*D50), ft	0.519875	0.519875	0
y2, depth in contraction,ft	4.10	5.16	ERR
ys, scour depth (y2-ybridge), ft	-0.05	0.22	N/A

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

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1610	2110	N/A
Main channel area (DS), ft2	140	167	0
Main channel width (normal), ft	33.7	33.8	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	33.7	33.8	0.0
D90, ft	1.2507	1.2507	0.0000
D95, ft	1.5829	1.5829	0.0000
Dc, critical grain size, ft	0.9724	1.0712	ERR
Pc, Decimal percent coarser than Dc	0.139	0.126	0.000
Depth to armoring, ft	18.07	22.29	ERR

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1610	2110	0	1610	2110	0
a', abut.length blocking flow, ft	7.1	7.4	0	2.4	3.5	0
Ae, area of blocked flow ft2	20	27	0	6.1	10.4	0
Qe, discharge blocked abut.,cfs	110.7	161.8	0	31.2	55.1	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	5.54	5.99	ERR	5.11	5.30	ERR
ya, depth of f/p flow, ft	2.82	3.65	ERR	2.54	2.97	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	1	1	1
--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	0.581	0.553	ERR	0.565	0.542	ERR
ys, scour depth, ft	8.53	10.19	N/A	6.42	7.83	N/A

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)	7.1	7.4	0	2.4	3.5	0
y1 (depth f/p flow, ft)	2.82	3.65	ERR	2.54	2.97	ERR
a'/y1	2.52	2.03	ERR	0.94	1.18	ERR
Skew correction (p. 49, fig. 16)	1.03	1.03	1.03	0.95	0.95	0.95
Froude no. f/p flow	0.58	0.55	N/A	0.57	0.54	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship

D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)

(Richardson and others, 1995, p112, eq. 81,82)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.15	4.94	0.00	4.15	4.94	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.74	2.07	ERR	1.74	2.07	ERR