LEVEL II SCOUR ANALYSIS FOR BRIDGE 2 (WHITTH00020002) on TOWN HIGHWAY 2, crossing the SOUTH BRANCH DEERFIELD RIVER, WHITINGHAM, VERMONT

Open-File Report 98-008

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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By RONDA L. BURNS and ROBERT H. FLYNN

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Pembroke, New Hampshire

1998

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

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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 2 (WHITTH00020002) ON TOWN HIGHWAY 2, CROSSING THE SOUTH BRANCH DEERFIELD RIVER, WHITINGHAM, VERMONT

By **Ronda L. Burns and Robert H. Flynn**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WHITTH00020002 on Town Highway 2 crossing the South Branch Deerfield River, Whitingham, 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 southern Vermont. The 6.81-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, the South Branch Deerfield River enters the Sherman Reservoir. The right bank downstream is forested and there is a recreation area on the left bank downstream.

In the study area, the South Branch Deerfield River has an incised, sinuous channel with a slope of approximately 0.04 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 boulder with a median grain size (D_{50}) of 73.7 mm (0.242 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 30, 1996, indicated that the reach was stable. The downstream channel, however, is affected by backwater from Sherman Reservoir.

The Town Highway 2 crossing of the South Branch Deerfield River is a 59-ft-long, two-lane bridge consisting of one 57-foot steel-beam span (Vermont Agency of Transportation, written communication, December 14, 1995). The opening length of the structure parallel to the bridge face is 56.4 ft at the top and 24.1 ft at the bottom. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 2.0 to 3.0 ft deeper than the mean thalweg depth was observed under the bridge and up to 4.0 ft deeper than the mean thalweg depth along the right bank downstream during the Level I assessment. The scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) along the downstream left and right banks and downstream left road approach. There was type-2 stone fill (less than 36 inches diameter) at the downstream end of the downstream right wingwall and type-3 stone fill (less than 48 inches diameter) at the upstream end of the upstream left wingwall and along the entire base length of the upstream right wingwall. The upstream left and right banks were protected with type-4 stone fill (less than 60 inches diameter). 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 Davis, 1995) for the 100- and 500-year discharges. 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 2.3 to 3.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 13.4 to 17.7 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 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 Davis, 1995, p. 46). 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 WHITTH00020002 ***Stream*** South Branch Deerfield River

County Windham ***Road*** TH 2 ***District*** 1

Description of Bridge

Bridge length 59 ***ft*** ***Bridge width*** 31 ***ft*** ***Max span length*** 57 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/30/96

Description of stone fill Type-2, at the downstream end of the downstream right wingwall. Type-3, at the upstream end of the upstream left wingwall and along the entire base length of the upstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a two to three foot deep scour hole under the bridge extending from the left to the right abutment and continuing along the downstream right bank where it is four feet deep.

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

There is a mild channel bend in the upstream reach. There is a cut bank where the stream impacts the upstream right bank.

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	7/30/96	0	0
Level II	7/30/96	0	0

Potential for debris Moderate. The banks are well vegetated with trees and some roots are exposed.

Describe any features near or at the bridge that may affect flow (include observation date) When the new bridge was constructed, the old abutments were left in place and protrude into the channel as of 7/30/96.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow flood plain.

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

Date of inspection 7/30/96

DS left: Steep channel bank to a moderately sloped overbank

DS right: Steep channel bank to a moderately sloped overbank

US left: Steep valley wall

US right: Steep valley wall

Description of the Channel

Average top width 43 ***ft*** ***Average depth*** 6 ***ft***

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

Sinuous and stable upstream but vertically unstable downstream with semi-alluvial channel boundaries.

7/30/96

Vegetative co Few trees with a gravel parking lot on the overbank

DS left: Trees and brush

DS right: Trees

US left: Trees

US right:

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

However, the downstream channel is affected by backwater from the Sherman Reservoir.

Describe any obstructions in channel and date of observation. None as of 7/30/96.

Hydrology

Drainage area 6.81 ***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 2,400 ***ft³/s*** ***Q500*** 3,300 ***ft³/s***

The 100-year discharge is from flood frequency estimates available from the VTAOT database and was extended graphically to the 500-year discharge. The drainage are given in the VTAOT database is 6.7 square miles while the computed drainage area was 6.8 square miles. 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 Subtract 2.5 ft from the VTAOT plans' datum to obtain the USGS arbitrary survey datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont survey mark on top of the bridge curb 21 ft from the downstream right end of the curb (elev. 500.43 ft, arbitrary survey datum). RM2 is a chiseled X on top of the bridge curb at the upstream left end of the curb (elev. 500.88 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	-73	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APPRO	86	2	Modelled Approach section (Templated from APTEM)
APTEM	91	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.

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 0.035 to 0.060, and the overbank "n" value was 0.070.

Backwater from the Deerfield River at Sherman Reservoir affects the water surface at this site even during low flow conditions. However, due to the difference in drainage areas at the reservoir, the depth of backwater from the Deerfield River during flooding on the South Branch Deerfield River is assumed to be negligible. Richardson and Davis (1995, p.26) recommend use of the "lowest reasonable downstream water surface elevation" as the starting water surface elevation for the hydraulic modeling of the site. Therefore, the starting water surface used was the water surface surveyed at the exit section (EXITX) on July 30, 1996. This water surface was significantly below the critical water surface based on the computation of minimum specific energy at the exit section (EXITX) outlined in the user's manual for WSPRO (Sherman, 1990). Consequently, the critical water surface was assumed as the starting water surface for all modelled discharges.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0412 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

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 500.6 ***ft***
Average low steel elevation 495.7 ***ft***

100-year discharge 2,400 ***ft³/s***
Water-surface elevation in bridge opening 485.5 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft³/s***
Area of flow in bridge opening 162 ***ft²***
Average velocity in bridge opening 14.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 19.0 ***ft/s***

Water-surface elevation at Approach section with bridge 489.5
Water-surface elevation at Approach section without bridge 487.5
Amount of backwater caused by bridge 2.0 ***ft***

500-year discharge 3,300 ***ft³/s***
Water-surface elevation in bridge opening 487.1 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft³/s***
Area of flow in bridge opening 201 ***ft²***
Average velocity in bridge opening 16.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 21.3 ***ft/s***

Water-surface elevation at Approach section with bridge 492.0
Water-surface elevation at Approach section without bridge 488.5
Amount of backwater caused by bridge 3.5 ***ft***

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 - ***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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in Tables 1 and 2 and the scour depths are shown graphically 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 Davis, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Abutment scour was computed by use of the Froehlich equation (Richardson and Davis, 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	2.3	3.5	--
Depth to armoring	41.9	49.5	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	14.2	17.7	--
Right abutment	13.4	16.4	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	2.9	3.5	--
Right abutment	2.9	3.5	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

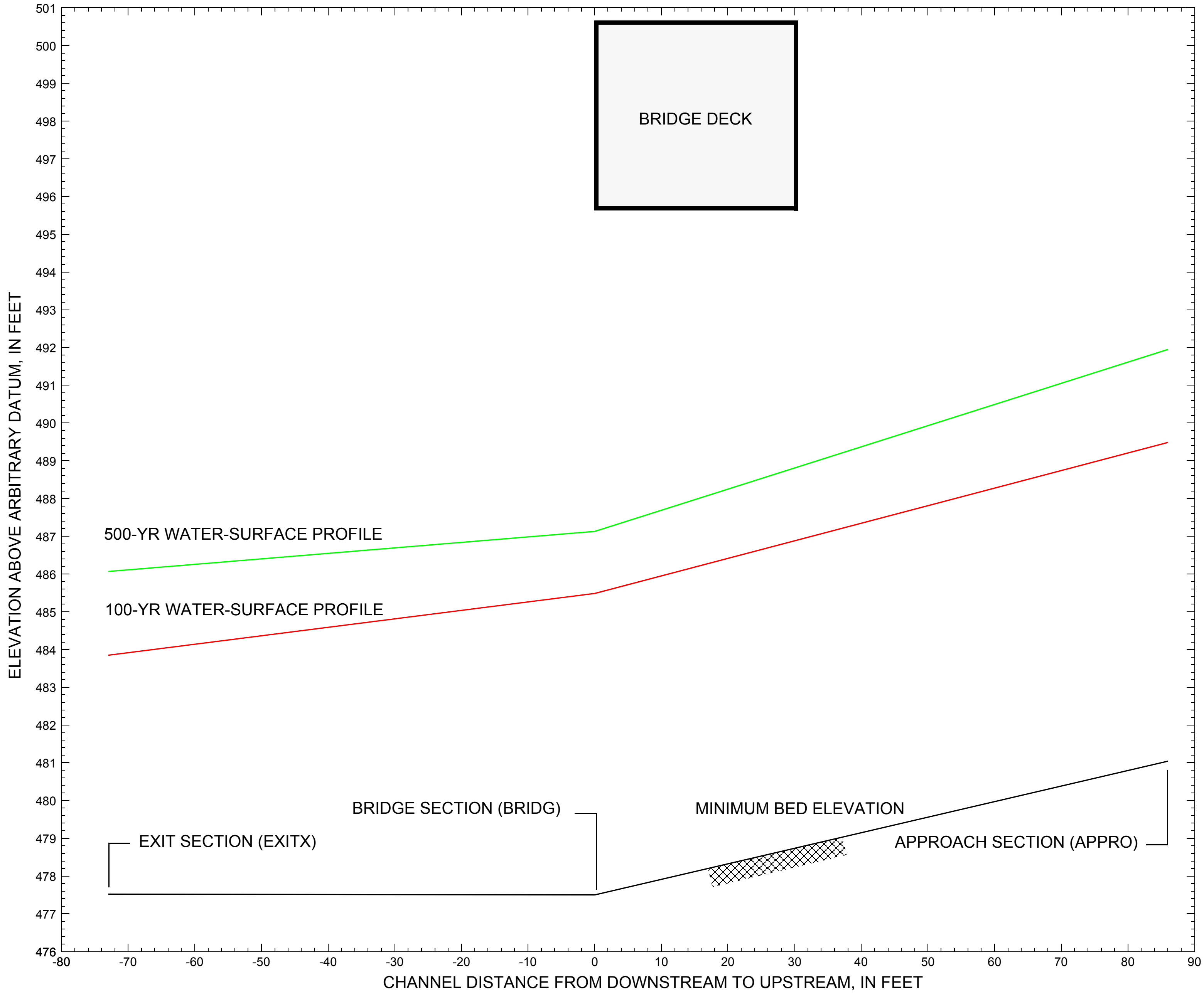

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure WHITTH00020002 on Town Highway 2, crossing the South Branch Deerfield River, Whitingham, Vermont.

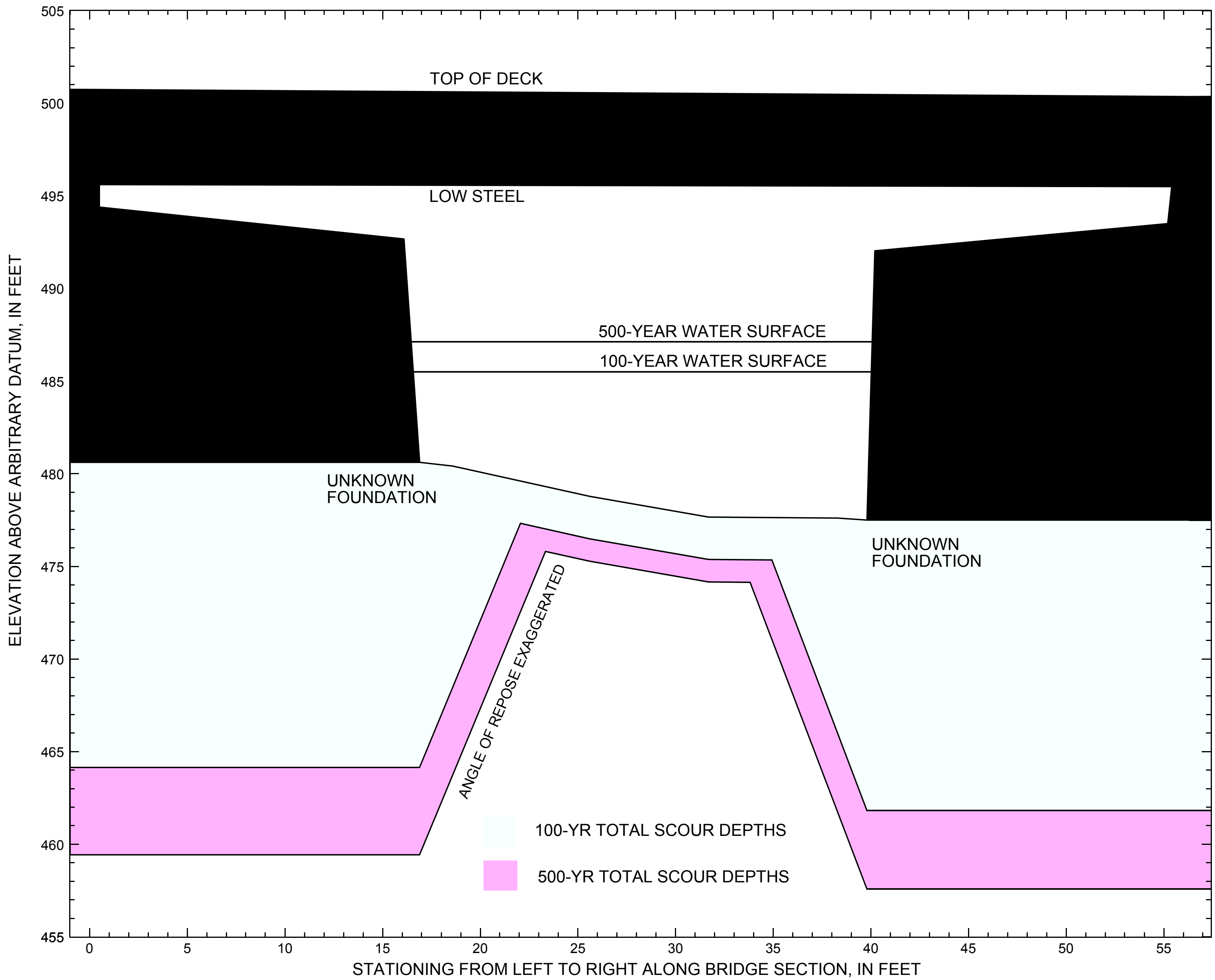

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure WHITTH00020002 on Town Highway 2, crossing South Branch Deerfield River, Whitingham, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WHITTH00020002 on Town Highway 2, crossing the South Branch Deerfield River, Whitingham, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 2,400 cubic-feet per second											
Left abutment	0.0	498.1	495.9	--	480.6	2.3	14.2	--	16.5	464.1	--
Right abutment	56.4	497.9	495.5	--	477.5	2.3	13.4	--	15.7	461.8	--

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 WHITTH00020002 on Town Highway 2, crossing the South Branch Deerfield River, Whitingham, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 3,300 cubic-feet per second											
Left abutment	0.0	498.1	495.9	--	480.6	3.5	17.7	--	21.2	459.4	--
Right abutment	56.4	497.9	495.5	--	477.5	3.5	16.4	--	19.9	457.6	--

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

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APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File whit002.wsp
T2        Hydraulic analysis for structure WHITTH00020002   Date: 20-NOV-97
T3        TH 2 CROSSING THE SOUTH BRANCH DEERFIELD RIVER IN WHITINGHAM, VT   RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2400.0   3300.0
WS          481.05   481.05
*
XS   EXITX    -73           0.
GR         -299.7, 527.29   -282.1, 512.82   -228.5, 508.06   -159.6, 499.23
GR          -94.8, 494.55    -28.5, 492.18      0.0, 486.68      9.0, 481.03
GR            9.5, 477.52     17.8, 478.94     27.4, 479.66     36.7, 478.78
GR           46.2, 477.67     46.4, 481.07     48.7, 486.79     85.3, 485.16
GR          118.9, 486.20    152.7, 507.13    158.5, 498.50    208.5, 496.59
GR          232.9, 512.08
*
N           0.050
*
XS   FULLV      0  * * *   0.0000
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    495.68       0.0
GR            0.0, 495.87      0.5, 495.61      0.5, 494.39     16.1, 492.68
GR           16.7, 481.64     16.9, 480.62     18.6, 480.42     25.6, 478.78
GR           31.7, 477.66     38.3, 477.61     39.8, 477.50     40.2, 480.05
GR           40.2, 492.04     55.2, 493.50     55.4, 495.24     56.3, 495.25
GR           56.4, 495.50      0.0, 495.87
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      41.1 * *     34.7     17.5
N           0.035
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     15      31.0      1
GR         -265.4, 515.71   -239.6, 510.26   -164.5, 505.31    -47.0, 500.39
GR          -28.2, 499.84    -28.1, 500.74      0.0, 500.59     22.9, 500.54
GR           64.6, 500.36     64.8, 499.30     79.0, 499.07
GR          112.9, 497.55    138.9, 511.73
*
XT   APTEM     91           0.
GR         -198.4, 514.98   -181.1, 508.98   -139.3, 506.53   -111.5, 504.31
GR          -50.6, 499.09    -35.7, 489.98      0.0, 484.70      8.6, 482.95
GR           13.5, 482.41     16.9, 481.43     25.4, 481.43     34.7, 481.25
GR           40.2, 482.64     44.2, 486.71     60.9, 486.23    101.7, 520.75
*
AS   APPRO     86  * * *  0.0412
GT
N           0.070        0.060        0.070
SA                   0.0         44.2
*
HP 1 BRIDG  485.49 1 485.49
HP 2 BRIDG  485.49 * * 2400
HP 1 APPRO  489.49 1 489.49
HP 2 APPRO  489.49 * * 2400
*
HP 1 BRIDG  487.13 1 487.13
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File whit002.wsp
       Hydraulic analysis for structure WHITTH00020002   Date: 20-NOV-97
       TH 2 CROSSING THE SOUTH BRANCH DEERFIELD RIVER IN WHITINGHAM, VT   RLB
          *** RUN DATE & TIME: 12-01-97  15:45

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      162     18703     24     36                         2397
  485.49           162     18703     24     36  1.00     16     40     2397

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

        WSEL     LEW     REW    AREA       K        Q    VEL
      485.49    16.5    40.2   161.7   18703.    2400.  14.84

X STA.        16.5        19.6        21.3        22.7        23.9        25.1
  A(I)             15.0         9.2         8.2         7.7         7.4
  V(I)             8.00       13.01       14.61       15.49       16.18

X STA.        25.1        26.1        27.1        28.0        29.0        29.8
  A(I)              6.9         6.8         6.6         6.6         6.5
  V(I)            17.29       17.72       18.18       18.31       18.48

X STA.        29.8        30.7        31.5        32.3        33.1        34.0
  A(I)              6.3         6.5         6.4         6.5         6.6
  V(I)            18.97       18.59       18.77       18.45       18.08

X STA.        34.0        34.9        35.8        36.9        38.0        40.2
  A(I)              7.0         7.4         8.2         9.1        16.9
  V(I)            17.21       16.32       14.61       13.24        7.12

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      86.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1       84      3283     34     34                          757
            2      322     29081     44     46                         4932
            3       61      2555     21     22                          592
  489.49           467     34919     99    103  1.27    -33     65     5128

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      86.

        WSEL     LEW     REW    AREA       K        Q    VEL
      489.49   -33.8    65.0   467.3   34919.    2400.   5.14

X STA.       -33.8        -7.0         0.6         4.7         8.1        11.0
  A(I)             53.2        34.4        22.7        21.0        20.1
  V(I)             2.26        3.49        5.28        5.72        5.98

X STA.        11.0        13.7        16.1        18.3        20.4        22.5
  A(I)             19.3        18.5        17.7        17.6        17.6
  V(I)             6.22        6.48        6.79        6.83        6.83

X STA.        22.5        24.6        26.7        28.8        30.9        33.0
  A(I)             17.3        17.3        17.6        17.6        17.6
  V(I)             6.93        6.92        6.81        6.83        6.83

X STA.        33.0        35.2        37.6        40.6        50.1        65.0
  A(I)             18.4        19.4        21.7        35.4        43.0
  V(I)             6.53        6.19        5.53        3.39        2.79
```

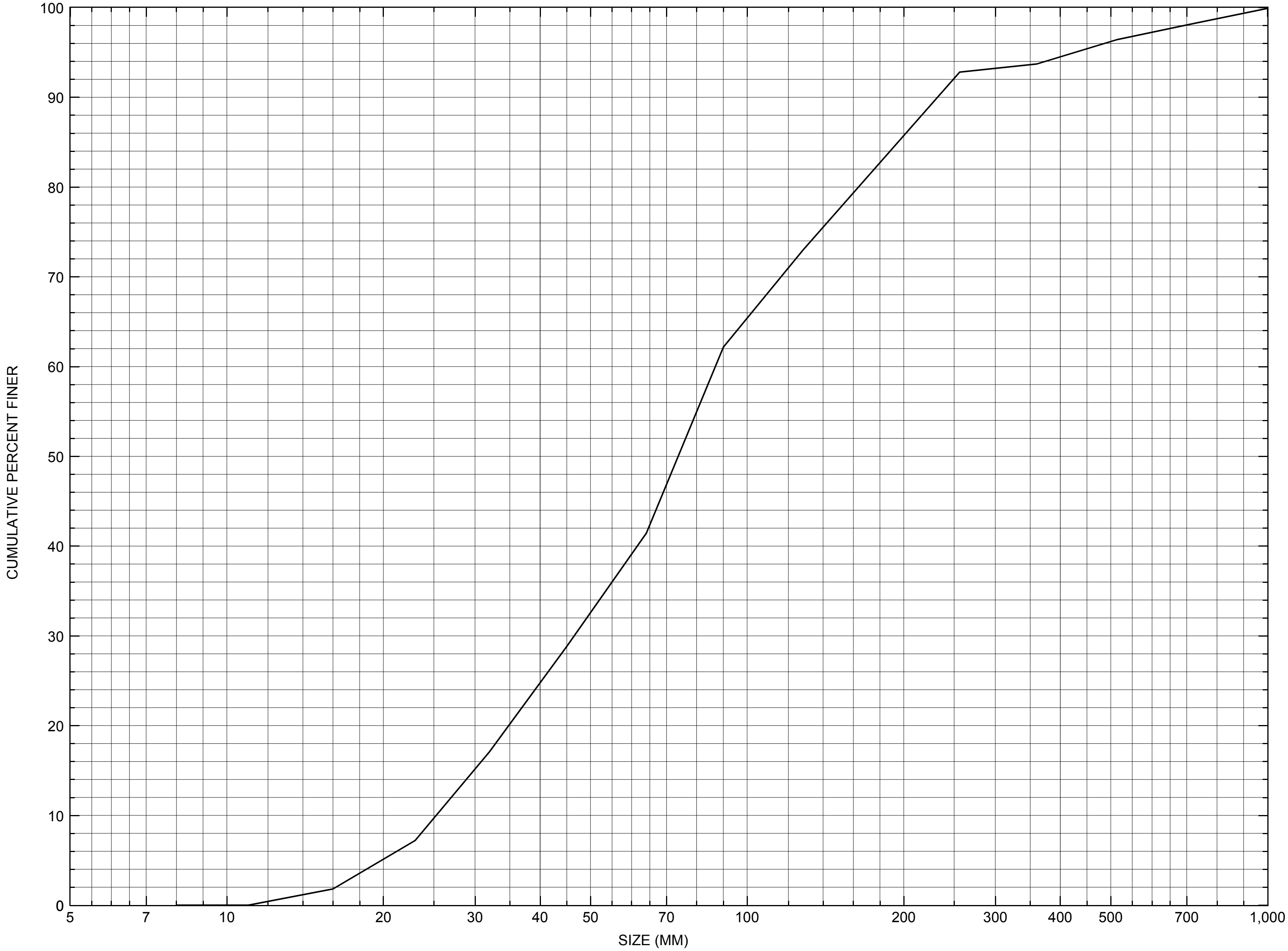
```
        U.S. Geological Survey WSPRO Input File whit002.wsp
        Hydraulic analysis for structure WHITTH00020002   Date: 20-NOV-97
        TH 2 CROSSING THE SOUTH BRANCH DEERFIELD RIVER IN WHITINGHAM, VT   RLB
           *** RUN DATE & TIME: 12-01-97  15:45

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      201     25290     24     39                           3307
   487.13           201     25290     24     39  1.00     16     40     3307

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       487.13    16.4    40.2   200.7   25290.    3300.  16.44

X STA.        16.4        19.5        21.1        22.5        23.7        24.8
  A(I)            19.2        11.7        10.2         9.3         8.7
  V(I)            8.62       14.14       16.12       17.69       18.93

X STA.        24.8        25.8        26.8        27.7        28.6        29.5
  A(I)             8.5         8.3         8.0         7.9         7.8
  V(I)           19.37       19.93       20.55       20.79       21.07

X STA.        29.5        30.3        31.2        32.0        32.8        33.7
  A(I)             7.8         7.9         7.8         8.0         8.1
  V(I)           21.27       20.92       21.09       20.68       20.27

X STA.        33.7        34.6        35.6        36.6        37.9        40.2
  A(I)             8.8         9.1        10.1        11.9        21.6
  V(I)           18.78       18.21       16.31       13.88        7.66

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      86.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      176      9997     39     40                           2111
             2      431     47228     44     46                           7630
             3      116      6684     24     26                           1451
   491.95           722     63909    107    113  1.24    -38     68     9540

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      86.

         WSEL     LEW     REW    AREA        K        Q    VEL
       491.95   -39.3    67.9   722.2   63909.    3300.   4.57

X STA.       -39.3       -16.5        -7.4        -0.8         3.7         7.3
  A(I)            72.7        52.2        45.3        34.8        30.7
  V(I)            2.27        3.16        3.64        4.74        5.38

X STA.         7.3        10.6        13.5        16.3        18.9        21.3
  A(I)            30.3        28.1        28.5        27.2        26.4
  V(I)            5.44        5.86        5.79        6.07        6.25

X STA.        21.3        23.9        26.4        28.8        31.3        33.8
  A(I)            27.0        27.0        26.5        27.0        27.0
  V(I)            6.11        6.11        6.23        6.11        6.11

X STA.        33.8        36.4        39.4        45.1        53.7        67.9
  A(I)            27.9        29.9        43.0        48.1        62.6
  V(I)            5.92        5.52        3.83        3.43        2.64
```

```
        U.S. Geological Survey WSPRO Input File whit002.wsp
        Hydraulic analysis for structure WHITTH00020002   Date: 20-NOV-97
        TH 2 CROSSING THE SOUTH BRANCH DEERFIELD RIVER IN WHITINGHAM, VT   RLB
           *** RUN DATE & TIME: 12-01-97  15:45

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   481.05     483.85

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

EXITX:XS   ******      5      198  2.29 *****  486.14  483.85    2400  483.85
       -72 ******     48    14325  1.00 ***** *******    1.00   12.13

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.72

FULLV:FV       73      0      396  0.57  1.19  487.33 *******    2400  486.76
         0     73    120    24633  1.00  0.00    0.00    0.59    6.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.88     487.48     486.96
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   486.26     520.54    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   486.26     520.54     486.96

APPRO:AS       86    -19      283  1.34  1.11  488.80  486.96    2400  487.46
        86     86     63    18198  1.20  0.38   -0.01    0.88    8.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    2400.      485.49

            <<<<<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       73     16      162  3.42 *****  488.91  485.49    2400  485.49
         0     73     40    18716  1.00 ***** *******    1.00   14.83

     TYPE PPCD FLOW       C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<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       45    -33      467  0.52  0.42  490.01  486.96    2400  489.49
        86     47     65    34894  1.27  0.68    0.01    0.47    5.14

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.712  0.457   18909.    10.    34.   489.23

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -73.     5.    48.   2400.   14325.     198.   12.13  483.85
   FULLV:FV       0.     0.   120.   2400.   24633.     396.    6.05  486.76
   BRIDG:BR       0.    16.    40.   2400.   18716.     162.   14.83  485.49
   RDWAY:RG      15.**************      0.*****************    1.00********
   APPRO:AS      86.   -34.    65.   2400.   34894.     467.    5.14  489.49

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      10.    34.   18909.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    483.85    1.00  477.52  527.29************  2.29  486.14  483.85
   FULLV:FV  ********    0.59  477.52  527.29  1.19  0.00  0.57  487.33  486.76
   BRIDG:BR    485.49    1.00  477.50  495.87************  3.42  488.91  485.49
   RDWAY:RG  ****************  497.55  515.71**********************************
   APPRO:AS    486.96    0.47  481.04  520.54  0.42  0.68  0.52  490.01  489.49
```

```
U.S. Geological Survey WSPRO Input File whit002.wsp
Hydraulic analysis for structure WHITTH00020002   Date: 20-NOV-97
TH 2 CROSSING THE SOUTH BRANCH DEERFIELD RIVER IN WHITINGHAM, VT   RLB
   *** RUN DATE & TIME: 12-01-97  15:45

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   481.05     486.07

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

EXITX:XS   ******      1      321  1.65 *****  487.71  486.07    3300  486.07
       -72 ******    115    19689  1.00 ***** *******    1.00   10.29

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  2.17

FULLV:FV       73     -7      569  0.52  0.95  488.66 *******    3300  488.14
         0     73    122    42716  1.00  0.00    0.00    0.49    5.80
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.86     488.48     487.93
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   487.64     520.54    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   487.64     520.54     487.93
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.61

APPRO:AS       86    -26      372  1.52  0.85  490.01  487.93    3300  488.49
        86     86     64    25893  1.24  0.50    0.00    0.86    8.86
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =    3300.     487.13

            <<<<<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       73     16      201  4.21 *****  491.34  487.13    3300  487.13
         0     73     40    25284  1.00 ***** *******    1.00   16.45

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  495.68 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      15.        <<<<<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       45    -38      722  0.40  0.32  492.35  487.93    3300  491.95
        86     48     68    63923  1.24  0.70    0.01    0.35    4.57

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.737  0.536   29566.    10.    34.   491.80

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

  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -73.     1.   115.   3300.   19689.     321.   10.29  486.07
   FULLV:FV       0.    -8.   122.   3300.   42716.     569.    5.80  488.14
   BRIDG:BR       0.    16.    40.   3300.   25284.     201.   16.45  487.13
   RDWAY:RG      15.**************      0.******************    1.00********
   APPRO:AS      86.   -39.    68.   3300.   63923.     722.    4.57  491.95

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      10.    34.   29566.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    486.07    1.00  477.52  527.29************  1.65  487.71  486.07
   FULLV:FV  ********    0.49  477.52  527.29  0.95  0.00  0.52  488.66  488.14
   BRIDG:BR    487.13    1.00  477.50  495.87************  4.21  491.34  487.13
   RDWAY:RG  ****************  497.55  515.71**********************************
   APPRO:AS    487.93    0.35  481.04  520.54  0.32  0.70  0.40  492.35  491.95
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count at the approach cross-section for structure WHITTH00020002, in Whitingham, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WHITTH00020002

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 14 / 95

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

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 83950

Mile marker *(I - 11; nnn.nnn)* 000380

Waterway *(I - 6)* S BR DEERFIELD RIVER

Road Name *(I - 7):* -

Route Number TR2ML

Vicinity *(I - 9)* 2.6 MI S JCT. VT.100

Topographic Map Rowe

Hydrologic Unit Code: 1080203

Latitude *(I - 16; nnnn.n)* 42447

Longitude *(i - 17; nnnnn.n)* 72558

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20010500021321

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

Maximum span length *(I - 48; nnnn)* 0057

Year built *(I - 27; YYYY)* 1978

Structure length *(I - 49; nnnnnn)* 000059

Average daily traffic, ADT *(I - 29; nnnnnn)* 000463

Deck Width *(I - 52; nn.n)* 310

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

Channel & Protection *(I - 61; n)* 8

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)* 302

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 23

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

Vertical clearance from streambed (*nnn.n ft*) 14

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

Waterway of full opening (*nnn.n* ft^2) 322

Comments:

According to the structural inspection report dated 5/5/94, this structure is a single span rolled beam bridge. The curtain wall at the LABUT is in good condition, except for some breakouts at some of the bearing blockouts. The LABUT bridge seat, stem, and wingwalls are also in good condition. The stem of the RABUT has some minor staining of the weathering steel. The RABUT bridge seat area, the fixed radius plate bearing devices, the curtain wall, and wingwalls are in good condition. Old abutments from a previous structure were capped and left in place to serve as retaining walls for the fill in front of the new abutments. The channel is straight through the structure.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 6.7

Terrain character: -

Stream character & type: -

-

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} 1200 Q_{25} 1600

Q_{50} 2000 Q_{100} 2400 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*): **Rapidly**

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: **Memo of 5/4/77 in hydraulics file states, "this is a steep mountain stream susceptible to sudden summer storms of high intensity. Much debris could be carried to the site."**
Another memo in the hydraulics file describes a field trip to the site on 4/1/77: "The bridge seemed to be in outlet control. Talking with the power company, on 4/1 the water elevation was 1108.36 ft (USGS). This elevation is 1 ft above the dam. The water elevation at maximum can be 2 ft higher. There was a large scour hole at the inlet. The stream itself is steep and fast moving. Large boulders and trees have been washed out. Side slope erosion is 10-15 ft high on both sides of the channel."

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*)	**492.7**	**493.6**	**494.3**	**495**	**-**
Velocity (*ft / sec*)	-	-	**14.5**	-	-

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:

According to the hydraulic study dated 5/4/77, outlet velocity at Q25 = 14.5 feet per second and tailwater elevation at Q25 = 488 ft.
Corresponding USGS highwater elevations at Q10, 25, 50 and 100 are: 1112.8 ft, 1113.7 ft, 1114.4 ft, and 1115.1 ft.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.81** mi^2 Lake/pond/swamp area **0.014** mi^2

Watershed storage *(ST)* **0.21** %

Bridge site elevation **1119** ft Headwater elevation **2737** ft

Main channel length **5.98** mi

10% channel length elevation **1280** ft 85% channel length elevation **2320** ft

Main channel slope *(S)* **231.88** 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)*: 12 / 1977

Project Number -

Minimum channel bed elevation: 485

Low superstructure elevation: USLAB 498.05 DSLAB 498.13 USRAB 497.03 DSRAB 497.91

Benchmark location description:

B.M. #1, Assumed elev. 500 ft (elev. 1120.1 ft USGS); 8 in. yellow birch on DS right bank, approx. 100 ft from bridge. B.M. #2, S.I.T. Assumed elev. 501.90 ft (elev. 1122.0 ft USGS); 3-12 in. WB on DS left bank, approx. 40 ft from bridge. B.M. #2A, S.I.T. Elev. 492.93 ft; 12 in. maple on DS left bank, approx. 20 ft from road approach and 20 ft from bank.

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

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

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

If 1: Footing Thickness 1.5 Footing bottom elevation: 492

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 DRILL BORING INFORMATION

Comments:

The low superstructure elevations are bridge seat elevations from the bridge plans.

Cross-sectional Data

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

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

Comments: -

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

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/28/96
Computerized by: RB Date: 10/30/96
Reviewd by: RB Date: 12/5/97

Structure Number WHITTH00020002

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* R. FLYNN Date *(MM/DD/YY)* 07 / 30 / 1996
2. Highway District Number 01 Mile marker 000380
County WINDHAM (025) Town WHITINGHAM (83950)
Waterway *(I - 6)* S. BR. DEERFIELD RIVER Road Name TH02
Route Number TR2ML Hydrologic Unit Code: 1080203
3. Descriptive comments:
Located 2.6 miles south of the junction with VT 100.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 5 RBDS 6 Overall 6
*(2b us,ds,lb,rb: **1**- Urban; **2**- Suburban; **3**- Row crops; **4**- Pasture; **5**- Shrub- and brushland; **6**- Forest; **7**- Wetland)*
5. Ambient water surface... US 2 UB 1 DS 1 *(**1**- pool; **2**- riffle)*
6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*
7. Bridge length 59 *(feet)* Span length 57 *(feet)* Bridge width 31 *(feet)*

Road approach to bridge:

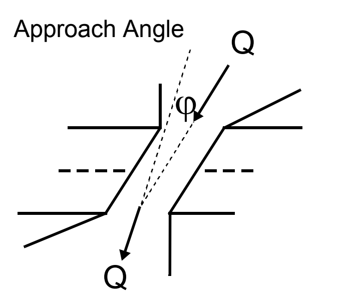
8. LB 2 RB 1 *(**0** even, **1**- lower, **2**- higher)*
9. LB 1 RB 1 *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

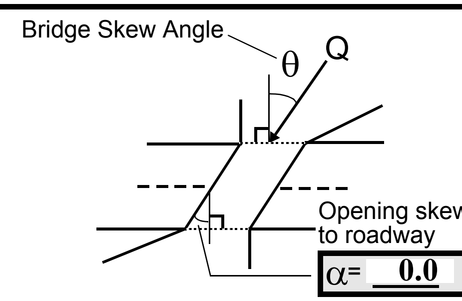
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	-	-
RBUS	0	-	-	-
RBDS	0	-	-	-
LBDS	1	1	2	1

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

Channel approach to bridge (BF):

15. Angle of approach: 25 16. Bridge skew: 10





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 2
Range? 20 feet US *(US, UB, DS)* to 80 feet US
Channel impact zone 2: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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

18. Bridge Type: **1a**

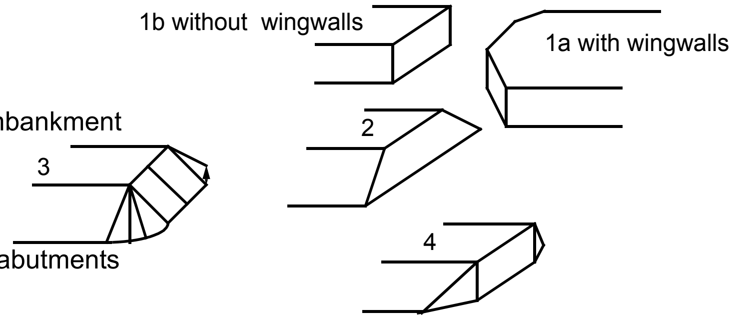
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Values are from the VTAOT files. The measured bridge length is 59 ft, span length is 57 ft and the bridge width is 31.4 ft.

4. On the left bank DS is a recreation and picnic area.

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
62.5	**1.5**			**4.0**	**3**	**3**	**540**	**540**	**0**	**2**

23. Bank width **10.0** 24. Channel width **40.0** 25. Thalweg depth **44.5** 29. Bed Material **245**

30 .Bank protection type: LB **4** RB **4** 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.):

29. The stream bed is predominantly cobble US with large boulders on both banks.

30. Bank protection is mostly type-4 with some smaller stone fill. It extends 200 ft US on both banks.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 40 35. Mid-bar width: 15

36. Point bar extent: 24 feet US (US, UB) to 54 feet US (US, UB, DS) positioned 0 %LB to 60 %RB

37. Material: 425

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

-

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

41. Mid-bank distance: 60 42. Cut bank extent: 41 feet US (US, UB) to 80 feet US (US, UB, DS)

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

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

Roots are exposed from 40 ft to 70 ft US and the bank is undermined from 40 ft to 50 ft US.

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
31.5		1.5		2	7	7	-

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

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

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

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

425

-

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? 2___ *(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		**-**	**90**	**2**	**1**	**2**	**-**	**90.0**
RABUT	**1**	**10**	**90**			**2**	**1**	**56.0**

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.):

2.5-3

-

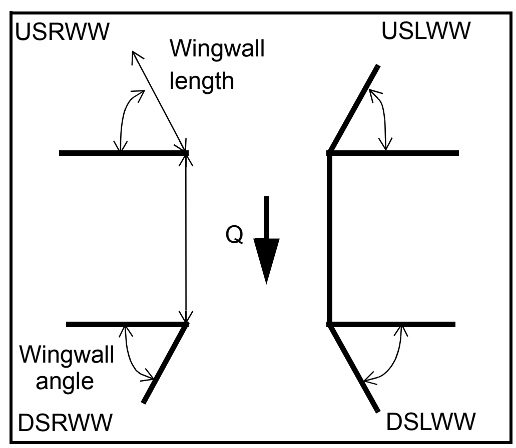
1

The abutment assessment refers to the old, lower abutments in the stream. There is a 2 ft build up of sand along the left abutment. The left abutment is undermined slightly at the US left corner where there is also a small scour hole. The scour hole is 2 ft deep and 6 ft long and extends to the center right of the channel. There are 2 sets of abutments on either side. A lower abutment extends from the banks up 15 ft and then set back from both of these is a smaller abutment which carries the I beams for the bridge. The lower abutments are the old abutments left behind to act as retaining walls for the upper abutments according to the historical form. Between the upper and lower abutments, there is placed cobbles and grass. The right and left abut-

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**ment**		**s are**		**con-**	**56.0**	
USRWW:	**crete**		**with**		**the**	**3.0**	
DSLWW:	**exce**		**ption**		**of**	**36.0**	
DSRWW:	**the**		**DS**		**end**	**24.5**	

*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	**of**	**abut**	**whi**	**ft**	**15 ft**	**tion**	**tare**	**.**
Condition	**the**	**men**	**ch is**	**long**	**high**	**of**	**d**	
Extent	**left**	**t**	**a 9**	**by**	**sec-**	**mor**	**rock**	**Y**

*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*

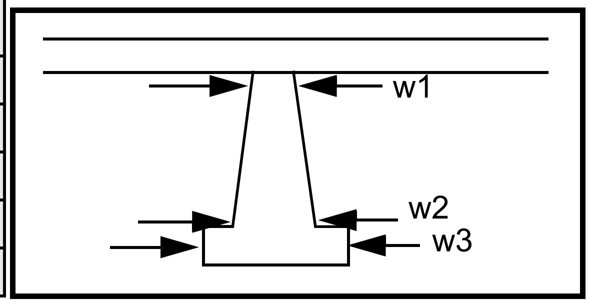
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

1
1
1
-
Y
1
0
-
-
Y
1

Piers:

84. Are there piers? **0** (*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				**20.0**	**25.5**	**45.0**
Pier 2				**16.5**	**175.0**	**22.5**
Pier 3			**-**	**45.0**	**38.5**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



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

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

E. Downstream Channel Assessment

100.

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

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

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

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

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

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 ____ *(US, UB, DS)* to ______ feet ____ *(US, UB, DS)* positioned ____ %LB to _____ %RB

Material: **2**

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

3
045
045
2

Is a cut-bank present? **2** *(Y or if N type ctrl-n cb)* Where? **425** *(LB or RB)* Mid-bank distance: **1**

Cut bank extent: **1** feet **1** *(US, UB, DS)* to **1** feet **Ex** *(US, UB, DS)*

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

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

ed roots and undermining of the bank is apparent on the left and right banks. Bank protection begins at the wingwalls and extends to 83 ft DS on the right and to 200 ft DS on the left bank. DS of the bridge the South Branch of the Deerfield River enters into the Sherman Reservoir.

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.):

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

Confluence 1: Distance **NO** Enters on **DR** *(LB or RB)* Type **OP** *(**1**- perennial; **2**- ephemeral)*

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

Confluence comments (eg. confluence name):

RE

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
-
-
-
-
-
-
-
-
-

109. G. Plan View Sketch

\- N

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: WHITTH00020002   Town: WHITINGHAM
Road Number: TH 2   County: WINDHAM
Stream: SOUTH BRANCH DEERFIELD RIVER

Initials RLB   Date: 12/1/97   Checked: MAI

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	2400	3300	0
Main Channel Area, ft2	322	431	0
Left overbank area, ft2	84	176	0
Right overbank area, ft2	61	116	0
Top width main channel, ft	44	44	0
Top width L overbank, ft	34	39	0
Top width R overbank, ft	21	24	0
D50 of channel, ft	0.2417	0.2417	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.3	9.8	ERR
y1, average depth, LOB, ft	2.5	4.5	ERR
y1, average depth, ROB, ft	2.9	4.8	ERR
Total conveyance, approach	34919	63909	0
Conveyance, main channel	29081	47228	0
Conveyance, LOB	3283	9997	0
Conveyance, ROB	2555	6684	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1998.8	2438.7	ERR
Ql, discharge, LOB, cfs	225.6	516.2	ERR
Qr, discharge, ROB, cfs	175.6	345.1	ERR
Vm, mean velocity MC, ft/s	6.2	5.7	ERR
Vl, mean velocity, LOB, ft/s	2.7	2.9	ERR
Vr, mean velocity, ROB, ft/s	2.9	3.0	ERR
Vc-m, crit. velocity, MC, ft/s	9.7	10.2	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	2400	3300	0
(Q) discharge thru bridge, cfs	2400	3300	0
Main channel conveyance	18703	25290	0
Total conveyance	18703	25290	0
Q2, bridge MC discharge,cfs	2400	3300	ERR
Main channel area, ft2	162	201	0
Main channel width (normal), ft	23.7	23.8	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.7	23.8	0
y_bridge (avg. depth at br.), ft	6.84	8.45	ERR
Dm, median (1.25*D50), ft	0.302125	0.302125	0
y2, depth in contraction,ft	9.12	11.94	ERR
ys, scour depth (y2-ybridge), ft	2.29	3.50	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	2400	3300	N/A
Main channel area (DS), ft2	162	201	0
Main channel width (normal), ft	23.7	23.8	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	23.7	23.8	0.0
D90, ft	0.7605	0.7605	0.0000
D95, ft	1.4003	1.4003	0.0000
Dc, critical grain size, ft	1.0029	1.1280	ERR
Pc, Decimal percent coarser than Dc	0.067	0.064	0.000
Depth to armoring, ft	41.90	49.49	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	2400	3300	0	2400	3300	0
a', abut.length blocking flow, ft	45.3	50.7	0	29.8	32.7	0
Ae, area of blocked flow ft2	154.97	273.75	0	119.5	196.48	0
Qe, discharge blocked abut.,cfs	622.22	1035.52	0	480	736.15	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.02	3.78	ERR	4.02	3.75	ERR
ya, depth of f/p flow, ft	3.42	5.40	ERR	4.01	6.01	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.383	0.287	ERR	0.353	0.269	ERR
ys, scour depth, ft	14.18	17.69	N/A	13.39	16.42	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

	Left 100 yr Q	500 yr Q	Other Q	Right 100 yr Q	500 yr Q	Other Q
a'(abut length blocked, ft)	45.3	50.7	0	29.8	32.7	0
y1 (depth f/p flow, ft)	3.42	5.40	ERR	4.01	6.01	ERR
a'/y1	13.24	9.39	ERR	7.43	5.44	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.38	0.29	N/A	0.35	0.27	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)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	6.84	8.45	0.00	6.84	8.45	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.)	2.86	3.53	ERR	2.86	3.53	ERR