LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (WOLCTH00150005) on TOWN HIGHWAY 15, crossing the WILD BRANCH LAMOILLE RIVER, WOLCOTT, VERMONT

Open-File Report 97-808

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 EMILY C. WILD

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Pembroke, New Hampshire

1997

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (WOLCTH00150005) ON TOWN HIGHWAY 15, CROSSING THE WILD BRANCH LAMOILLE RIVER, WOLCOTT, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure WOLCTH00150005 on Town Highway 15 crossing the Wild Branch Lamoille River, Wolcott, 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.

During the August 1995 and July 1997 flood events, the left roadway was overtopped. Although there was loss of stone fill along the right abutment, the structure withstood both events.

The site is in the Green Mountain section of the New England physiographic province in north-central Vermont. The 38.3-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture upstream and downstream of the bridge, while the immediate banks have dense woody vegetation.

In the study area, the Wild Branch Lamoille River has an incised, sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 98 ft and an average bank height of 5 ft. The channel bed material ranges from gravel to bedrock with a median grain size (D_{50}) of 89.1 mm (0.292 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 17, 1996, indicated that the reach was stable.

The Town Highway 15 crossing of the Wild Branch Lamoille River is a 46-ft-long, two-lane bridge consisting of a 43-foot prestressed concrete box-beam span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 42 ft. 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 ft deeper than the mean thalweg depth was observed near the bridge along the left side of the channel during the Level I assessment. Scour countermeasures at the site consists of type-1 stone fill (less than 12 inches diameter) along the upstream left bank and along the left and right downstream banks, type-2 stone fill (less than 36 inches diameter) along the downstream left and right wingwalls, type-3 stone fill (less than 48 inches diameter) along the upstream left wingwall and the right abutment, and type-4 stone fill (less than 60 inches diameter) along the upstream right wingwall and the left abutment. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was determined and analyzed as another potential worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows was zero ft. Left abutment scour ranged from 7.9 to 23.3 ft. The worst-case left abutment scour occurred at the 500-year discharge. Right abutment scour ranged from 21.5 to 22.8 ft. The worst-case right abutment scour occurred at the incipient roadway-overtopping discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

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

NORTH

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

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

LEVEL II SUMMARY

Structure Number WOLCTH00150005 ***Stream*** Wild Branch Lamoille River

County Lamoille ***Road*** TH15 ***District*** 6

Description of Bridge

Bridge length 46 ***ft*** ***Bridge width*** 16.4 ***ft*** ***Max span length*** 43 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/17/96

Description of stone fill Type-2, along the downstream left and right wingwalls. Type-3, along the upstream left wingwall and the right abutment. Type-4, along the upstream right wingwall and the left abutment.

Abutments and wingwalls are concrete. The left abutment footing is exposed 2 feet, and the downstream left wingwall footing is exposed 1 foot.

Yes

10 Yes

Is bridge skewed to flood flow according to There ***survey?*** ***Angle***

is a mild channel bend in the upstream reach.

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	7/17/96	0	0
Level II	7/17/96	0	0

Potential for debris Moderate. There is some debris caught within the brush along the banks, and some trees have fallen into the channel, within the upstream reach.

Describe any features near or at the bridge that may affect flow (include observation date) None, 7/17/96.

Description of the Geomorphic Setting

General topography The channel is located within a narrow, irregular flood plain with moderately sloped valley walls on both sides.

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

Date of inspection 7/17/96

DS left: Steep channel bank to a narrow flood plain.

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

US left: Narrow flood plain.

US right: Narrow flood plain.

Description of the Channel

Average top width 98 ***ft*** ***Average depth*** 5 ***ft***

Predominant bed material Gravel / Bedrock ***Bank material*** Sand/ Gravel

Sinuous but stable with semi-alluvial channel boundaries and a narrow flood plain.

7/17/96

Vegetative co Pasture.

DS left: Pasture with some trees and brush.

DS right: Pasture.

US left: Pasture.

US right: Pasture.

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

The assessment of 7/17/96 noted no obstructions.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 38.3 ***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***:

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 6,210 ***ft³/s*** ***Q500*** 9,030 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(38.3/39.5)exp 0.67] with discharge values for the Wild Branch Lamoille River in the Flood Insurance Study for the Town of Wolcott, at the confluence with the Lamoille River (Federal Emergency Management Agency, 1982).

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

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

Datum tie between USGS survey and VTAOT plans To obtain VTAOT datum, subtract 0.9 feet from USGS survey.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 499.73 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment (elev. 500.10 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	-49	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	76	1	Approach section

[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 0.055, and overbank "n" values ranged from 0.040 to 0.055.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0062 ft/ft, which was estimated from the 100-year water surface slope downstream of the bridge in the Flood Insurance Study for Wolcott, VT (Federal Emergency Management Agency, 1982).

The approach section (APPRO) was surveyed 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.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.1 *ft*
Average low steel elevation 497.7 *ft*

100-year discharge 6,210 *ft^3/s*
Water-surface elevation in bridge opening 494.1 *ft*
Road overtopping? Y *Discharge over road* 843 *ft^3/s*
Area of flow in bridge opening 448 *ft^2*
Average velocity in bridge opening 12.0 *ft/s*
Maximum WSPRO tube velocity at bridge 15.6 *ft/s*

Water-surface elevation at Approach section with bridge 497.5
Water-surface elevation at Approach section without bridge 495.5
Amount of backwater caused by bridge 2.0 *ft*

500-year discharge 9,030 *ft^3/s*
Water-surface elevation in bridge opening 495.9 *ft*
Road overtopping? Y *Discharge over road* 3,460 *ft^3/s*
Area of flow in bridge opening 523 *ft^2*
Average velocity in bridge opening 10.7 *ft/s*
Maximum WSPRO tube velocity at bridge 13.9 */s*

Water-surface elevation at Approach section with bridge 498.7
Water-surface elevation at Approach section without bridge 496.3
Amount of backwater caused by bridge 2.4 *ft*

Incipient overtopping discharge 3,900 *ft^3/s*
Water-surface elevation in bridge opening 496.2 *ft*
Area of flow in bridge opening 538 *ft^2*
Average velocity in bridge opening 7.3 *ft/s*
Maximum WSPRO tube velocity at bridge 9.4 *ft/s*

Water-surface elevation at Approach section with bridge 497.4
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 0.2 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

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

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

Because the influence of scour processes on the extensive stone-fill abutment protection is uncertain, the scour depth at the vertical wall of the right abutment is unknown. Therefore, the computed total scour depth was applied to the elevation at the toe of the stone fill in front of the right abutment and is shown in Tables 1 and 2 and Figure 8.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	0.0
Depth to armoring	7.6	2.7	0.2
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	19.7	23.3	7.9
Right abutment	21.9	21.5	22.8
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	3.4	2.9	1.2
Right abutment	3.4	2.9	1.2
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

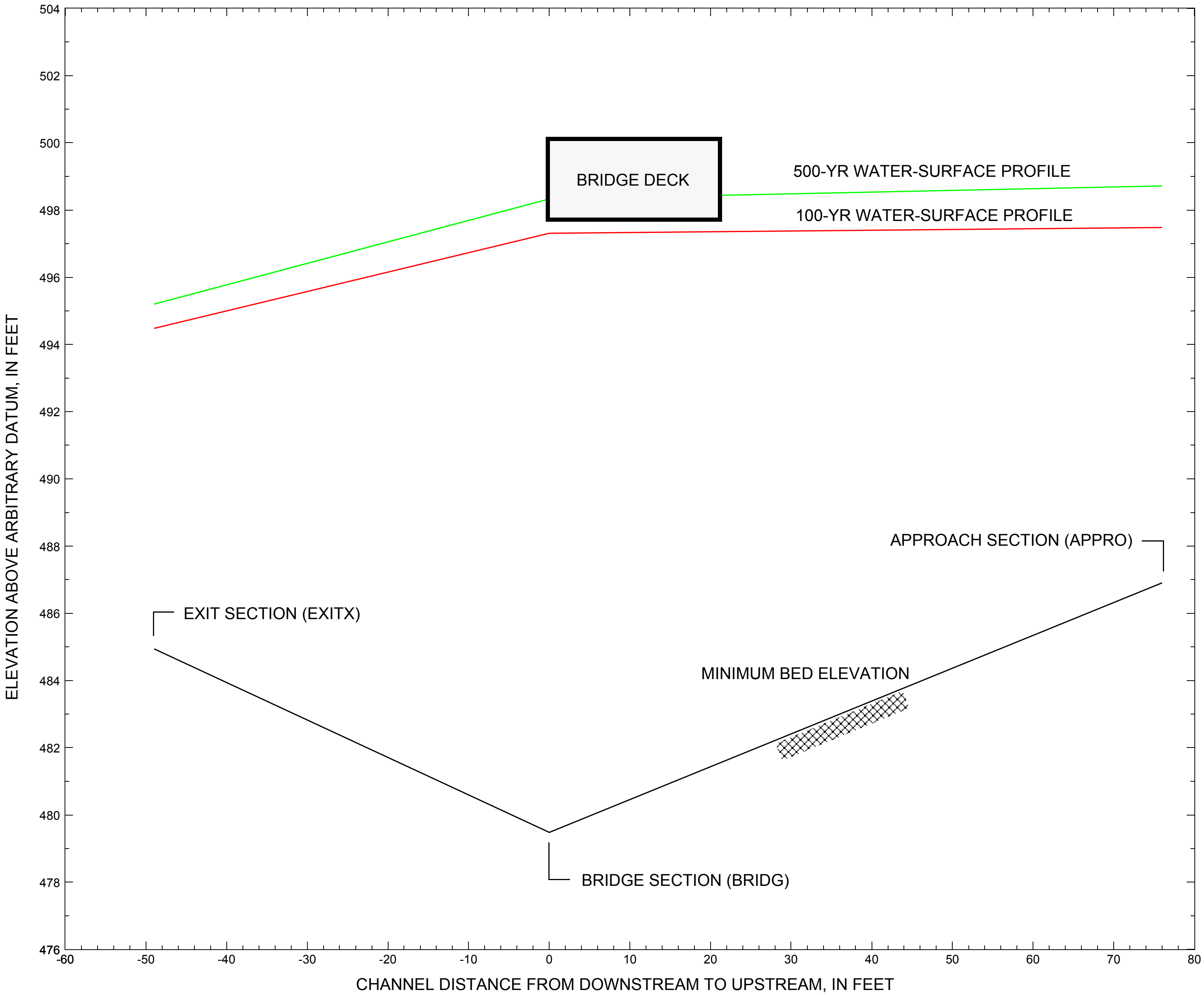

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure WOLCTH00150005 on Town Highway 15, crossing Wild Branch Lamoille River, Wolcott, Vermont.

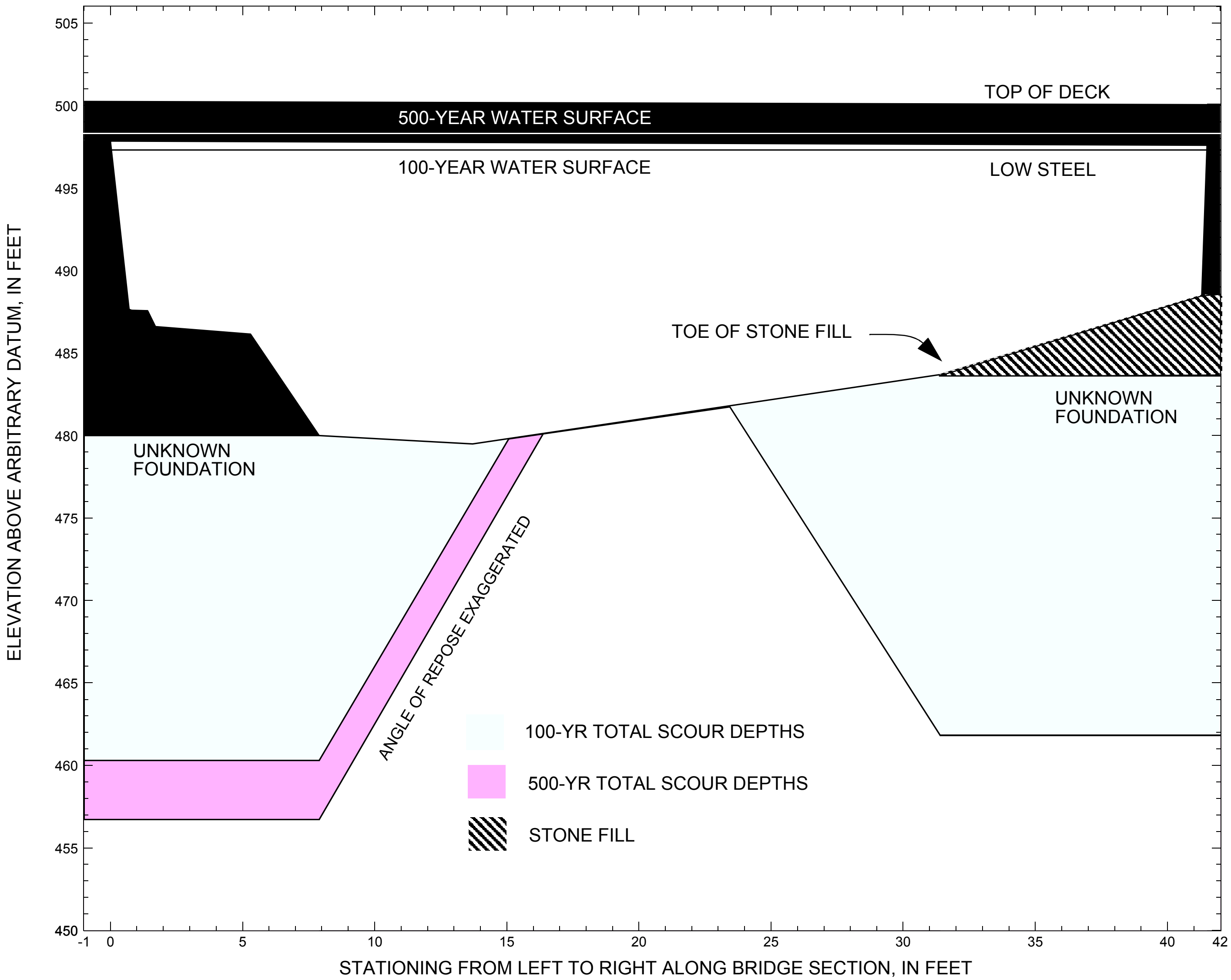

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure WOLCTH00150005 on Town Highway 15, crossing Wild Branch Lamoille River, Wolcott, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure WOLCTH00150005 on Town Highway 15, crossing Wild Branch Lamoille River, Wolcott, 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 6,210 cubic-feet per second											
Left abutment	0.0	497.0	497.8	--	480.0	0.0	19.7	--	19.7	460.3	--
Toe of Right Stone Fill	31.4	--	--	--	483.7	0.0	21.9		21.9	461.8	--
Right abutment	41.5	497.7	497.6	--	488.5	--	--	--	--	--	--

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 WOLCTH00150005 on Town Highway 15, crossing Wild Branch Lamoille River, Wolcott, 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 9,030 cubic-feet per second											
Left abutment	0.0	497.0	497.8	--	480.0	0.0	23.3	--	23.3	456.7	--
Toe of Right Stone Fill	31.4	--	--	--	483.7	0.0	21.5	--	21.5	462.2	--
Right abutment	41.5	497.7	497.6	--	488.5	--	--	--	--	--	--

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

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U.S. Geological Survey, 1986, Wolcott, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File wolc005.wsp
T2        Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
T3        Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont by ECW
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          6210.0   9030.0  3900
SK         0.0062   0.0062  0.0062
WS         494.48   495.20  496.12
*
XS   EXITX    -49
GR         -863.2, 502.13   -838.0, 492.57   -688.4, 491.89   -179.0, 495.94
GR          -21.6, 495.92     -7.6, 488.70      0.0, 487.46      7.8, 485.24
GR           11.8, 484.94     17.6, 486.43     22.2, 485.28     24.5, 485.38
GR           29.2, 487.32     30.5, 486.04     31.8, 487.41     37.8, 489.61
GR           43.6, 490.15     54.4, 490.51     63.4, 498.15    137.0, 497.19
GR          153.9, 497.57    191.6, 501.14    224.5, 503.44    312.4, 503.54
GR          376.0, 505.20    389.6, 509.38    410.9, 508.58    426.4, 510.45
GR          461.1, 522.21
N          0.040        0.055        0.055
SA                -21.6         63.4
*
XS   FULLV      0  * * *   0.015
*
BR   BRIDG     0    497.72
GR            0.0, 497.85      0.7, 487.58      0.7, 487.65      1.4, 487.56
GR            1.7, 486.60      5.3, 486.14      7.9, 479.99     13.7, 479.48
GR           22.7, 481.55     28.8, 483.08     31.4, 483.69     41.3, 488.48
GR           41.5, 497.60      0.0, 497.85
N           0.050
CD           4      20.7     7.46    500.1     39.2
*
XR   RDWAY     10      16.4     2
GR         -825.8, 508.79   -523.4, 496.08   -298.2, 496.86   -169.6, 497.70
GR          -98.7, 498.74    -35.0, 499.90      0.0, 500.24     41.7, 500.05
GR          108.7, 500.41    204.7, 501.46    273.8, 503.37    341.3, 506.68
GR          376.5, 509.21    398.4, 508.14    430.9, 508.68    462.6, 518.65
*
AS   APPRO     76
GR         -807.0, 507.41   -774.3, 497.20   -649.0, 494.09   -504.4, 494.52
GR                          -197.6, 496.74    -31.7, 497.37      0.0, 494.48
GR            6.0, 493.20     15.5, 489.96     19.2, 488.78     20.2, 487.72
GR           26.8, 487.19     30.8, 487.19     43.9, 486.91     50.6, 487.23
GR           52.0, 488.49     65.7, 489.82     70.1, 490.23     83.4, 491.22
GR          108.4, 493.43    141.4, 497.54    297.6, 500.71    372.3, 503.23
GR          396.2, 509.06    419.1, 508.22    441.7, 507.24    486.7, 519.14
*
N          0.045        0.055        0.050
SA                  0.0        108.4
*
*      The incipient roadway-overtopping discharge value was modeled assuming
*          the top of the left bank is the maximum possible water-surface elevation.
*
HP 1 BRIDG 494.05 1 494.05
HP 2 BRIDG 494.05 * * 5367
HP 2 RDWAY 497.31 * * 843
HP 1 APPRO 497.48 1 497.48
HP 2 APPRO 497.48 * * 6210
*
HP 1 BRIDG 495.87 1 495.87
HP 2 BRIDG 495.87 * * 5567
HP 2 RDWAY 498.33 * * 3463
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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      U.S. Geological Survey WSPRO Input File wolc005.wsp
      Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
      Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont by ECW
         *** RUN DATE & TIME: 09-12-97  13:05
  CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      448     51404     41     59                         8375
 494.05           448     51404     41     59  1.00      0     41     8375


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

       WSEL     LEW     REW    AREA        K        Q    VEL
     494.05     0.3    41.4   447.6   51404.    5367.  11.99

X STA.        0.3        6.2        8.7       10.2       11.7       13.0
  A(I)           43.9       31.2       22.4       20.3       19.0
  V(I)           6.11       8.60      11.96      13.22      14.13

X STA.       13.0       14.2       15.5       16.7       18.0       19.3
  A(I)           18.3       17.8       17.6       17.6       17.2
  V(I)          14.64      15.03      15.26      15.23      15.56

X STA.       19.3       20.7       22.1       23.5       25.1       26.7
  A(I)           17.8       17.9       18.0       18.7       18.8
  V(I)          15.09      14.99      14.92      14.33      14.26

X STA.       26.7       28.4       30.4       32.6       35.5       41.4
  A(I)           20.1       21.1       22.9       26.4       40.4
  V(I)          13.33      12.73      11.70      10.15       6.65

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.31  -552.7  -229.3   222.7    6468.     843.   3.79

X STA.     -552.7     -527.5     -519.8     -512.6     -505.6     -498.4
  A(I)           13.3        9.2        8.6        8.3        8.4
  V(I)           3.18       4.61       4.89       5.10       5.02

X STA.     -498.4     -490.9     -482.9     -474.7     -466.0     -456.7
  A(I)            8.5        8.8        8.8        9.1        9.4
  V(I)           4.98       4.76       4.79       4.62       4.47

X STA.     -456.7     -446.9     -436.1     -424.6     -412.1     -397.8
  A(I)            9.6       10.2       10.5       10.9       11.7
  V(I)           4.39       4.14       4.03       3.88       3.61

X STA.     -397.8     -382.1     -363.5     -342.0     -312.8     -229.3
  A(I)           12.1       13.1       13.7       16.1       22.4
  V(I)           3.49       3.21       3.07       2.62       1.88

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     1377     66824    775    775                        10409
           2      810     82810    108    110                        12561
           3       66      3125     33     33                          532
 497.48          2252    152759    916    919  1.47   -774    141    16550

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.48  -775.2   140.9  2252.3  152759.    6210.   2.76

X STA.     -775.2     -668.0     -631.7     -596.0     -559.9     -522.5
  A(I)          170.2      118.1      117.2      114.8      114.8
  V(I)           1.82       2.63       2.65       2.70       2.70

X STA.     -522.5     -480.1     -428.3     -354.7        8.6       20.4
  A(I)          123.9      134.5      157.7      359.7       84.4
  V(I)           2.51       2.31       1.97       0.86       3.68

X STA.       20.4       26.8       32.9       38.9       44.8       51.0
  A(I)           65.0       62.7       61.6       62.2       64.5
  V(I)           4.77       4.95       5.04       4.99       4.81

X STA.       51.0       59.2       68.6       80.0       95.2      140.9
  A(I)           71.6       73.8       79.2       89.4      126.8
  V(I)           4.34       4.20       3.92       3.47       2.45
```

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       U.S. Geological Survey WSPRO Input File wolc005.wsp
       Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
       Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont by ECW
          *** RUN DATE & TIME: 09-12-97  13:05
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      523     63961     41     63                        10547
  495.87           523     63961     41     63  1.00      0     41    10547

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      495.87     0.1    41.5   522.7   63961.    5567.  10.65

X STA.         0.1        5.9        8.5       10.2       11.7       13.0
  A(I)            51.3       36.8       26.3       24.3       22.1
  V(I)            5.43       7.56      10.60      11.44      12.60

X STA.        13.0       14.4       15.6       16.9       18.2       19.6
  A(I)            21.7       20.6       20.4       20.5       20.1
  V(I)           12.82      13.48      13.66      13.60      13.87

X STA.        19.6       20.9       22.4       23.8       25.4       27.0
  A(I)            20.5       20.7       20.8       21.7       21.9
  V(I)           13.60      13.47      13.37      12.80      12.69

X STA.        27.0       28.8       30.8       33.0       35.8       41.5
  A(I)            23.0       24.7       26.2       30.7       48.4
  V(I)           12.11      11.26      10.62       9.08       5.75

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      10.

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.33  -576.9  -126.7   627.7   29172.    3463.   5.52

X STA.      -576.9     -532.7     -519.5     -507.8     -496.1     -484.5
  A(I)            41.1       27.9       25.9       25.4       24.8
  V(I)            4.21       6.20       6.68       6.80       6.97

X STA.      -484.5     -472.3     -460.0     -447.1     -433.8     -419.7
  A(I)            25.4       25.3       25.9       26.0       27.0
  V(I)            6.81       6.85       6.69       6.65       6.41

X STA.      -419.7     -404.9     -389.1     -372.5     -354.8     -335.8
  A(I)            27.6       28.6       29.1       30.1       31.1
  V(I)            6.26       6.06       5.94       5.75       5.57

X STA.      -335.8     -314.3     -291.3     -263.1     -225.1     -126.7
  A(I)            33.5       34.2       37.5       42.4       58.6
  V(I)            5.18       5.06       4.62       4.08       2.96

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1     2340    161251    779    780                        23015
            2      944    106962    108    110                        15815
            3      141      5613     91     91                          996
  498.72          3426    273826    979    981  1.23   -778    200    32831

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.72  -779.2   199.5  3425.6  273826.    9030.   2.64

X STA.      -779.2     -687.8     -647.1     -611.8     -577.1     -540.0
  A(I)           228.0      169.9      161.3      154.8      161.8
  V(I)            1.98       2.66       2.80       2.92       2.79

X STA.      -540.0     -501.1     -458.8     -410.3     -350.3     -270.7
  A(I)           165.3      170.2      179.2      198.1      222.7
  V(I)            2.73       2.65       2.52       2.28       2.03

X STA.      -270.7     -130.9        8.9       22.7       31.8       40.6
  A(I)           287.7      288.0      122.7      104.9      102.7
  V(I)            1.57       1.57       3.68       4.30       4.40

X STA.        40.6       49.4       60.7       74.9       93.0      199.5
  A(I)           102.5      114.6      123.6      134.5      233.0
  V(I)            4.40       3.94       3.65       3.36       1.94
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        U.S. Geological Survey WSPRO Input File wolc005.incip.wsp
        Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
        Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont  ECW
           *** RUN DATE & TIME: 09-12-97  11:35
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      538     66588     41     64                        11009
   496.24           538     66588     41     64  1.00      0     41    11009

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.24     0.1    41.5   537.9   66588.    3900.   7.25

X STA.         0.1        5.9        8.5       10.2       11.6       13.1
  A(I)            53.4       38.0       27.0       24.4       23.3
  V(I)            3.65       5.14       7.23       8.00       8.36

X STA.        13.1       14.4       15.7       17.0       18.3       19.6
  A(I)            21.9       21.6       20.9       20.7       20.9
  V(I)            8.92       9.01       9.32       9.43       9.31

X STA.        19.6       21.0       22.4       23.9       25.4       27.1
  A(I)            20.8       21.0       21.9       21.9       22.5
  V(I)            9.38       9.29       8.91       8.89       8.68

X STA.        27.1       28.9       30.8       33.0       35.8       41.5
  A(I)            24.2       24.8       27.7       30.9       50.3
  V(I)            8.07       7.86       7.04       6.32       3.88

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       46      2175     32     32                          312
             2      808     69499    108    111                        12513
             3       62      2904     32     32                          496
   497.37           916     74577    172    175  1.06    -31    140    11641

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      76.

         WSEL     LEW     REW    AREA        K        Q    VEL
       497.37   -31.7   140.0   915.9   74577.    3900.   4.26

X STA.       -31.7        8.1       16.2       21.4       25.3       29.0
  A(I)            76.3       50.8       45.3       39.0       37.1
  V(I)            2.56       3.84       4.31       5.00       5.26

X STA.        29.0       32.6       36.1       39.6       43.1       46.6
  A(I)            37.1       35.8       36.3       36.1       36.2
  V(I)            5.25       5.45       5.37       5.39       5.39

X STA.        46.6       50.1       54.6       59.6       64.9       70.9
  A(I)            36.6       40.6       41.7       41.7       44.9
  V(I)            5.33       4.80       4.68       4.68       4.35

X STA.        70.9       76.6       83.5       92.7      105.0      140.0
  A(I)            44.9       47.7       52.7       59.0       76.3
  V(I)            4.34       4.08       3.70       3.31       2.56
```

```
        U.S. Geological Survey WSPRO Input File wolc005.wsp
        Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
        Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont by ECW
           *** RUN DATE & TIME: 09-12-97  13:05

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

EXITX:XS   ******   -842     1232  0.48 *****  494.96  493.93    6210  494.48
       -48 ******     59    78835  1.22 ***** *******    0.66    5.04

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.92     494.71     494.66
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   493.98     522.95    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   493.98     522.95     494.66
FULLV:FV       49   -841      966  0.83  0.41  495.54  494.66    6210  494.71
         0     49     58    58953  1.29  0.17    0.00    0.92    6.43
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>
 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.08     495.46     495.48
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   494.21     519.14    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   494.21     519.14     495.48
 ===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 =   495.48     519.14     495.48

APPRO:AS       76   -704      887  1.08 *****  496.56  495.48    6210  495.48
        76     76    125    57694  1.42 ***** *******    1.07    7.00
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.73       0.00     493.10     496.08
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

 XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
       SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL
BRIDG:BR       49      0      448  2.73  0.42  496.78  491.24    5367  494.05
         0     49     41    51412  1.22  1.40   -0.01    0.71   11.99

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   4.  0.904 ******  497.72 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.    60.  0.10  0.17  497.55    0.00    843.  497.31

             Q    WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    843.   323.  -553.  -230.   1.2   0.7   4.2   3.8   0.9   2.9
   RT:      0.   133.    19.   153.   0.8   0.5   5.4  10.0   1.5   2.9

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

APPRO:AS       55   -774     2250  0.17  0.43  497.65  495.48    6210  497.48
        76     99    141   152544  1.47  0.44    0.00    0.38    2.76

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.950  0.672   50145.    21.    62. ********

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.
    XSID:CODE     SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS      -49.  -843.    59.   6210.   78835.    1232.    5.04  494.48
   FULLV:FV        0.  -842.    58.   6210.   58953.     966.    6.43  494.71
   BRIDG:BR        0.     0.    41.   5367.   51412.     448.   11.99  494.05
   RDWAY:RG       10.*******   843.    843.*********      0.    2.00  497.31
   APPRO:AS       76.  -775.   141.   6210.  152544.    2250.    2.76  497.48

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      21.    62.   50145.
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    493.93    0.66  484.94  522.21************  0.48  494.96  494.48
   FULLV:FV    494.66    0.92  485.67  522.95  0.41  0.17  0.83  495.54  494.71
   BRIDG:BR    491.24    0.71  479.48  497.85  0.42  1.40  2.73  496.78  494.05
   RDWAY:RG  ****************  496.08  518.65  0.10******  0.17  497.55  497.31
   APPRO:AS    495.48    0.38  486.91  519.14  0.43  0.44  0.17  497.65  497.48
```

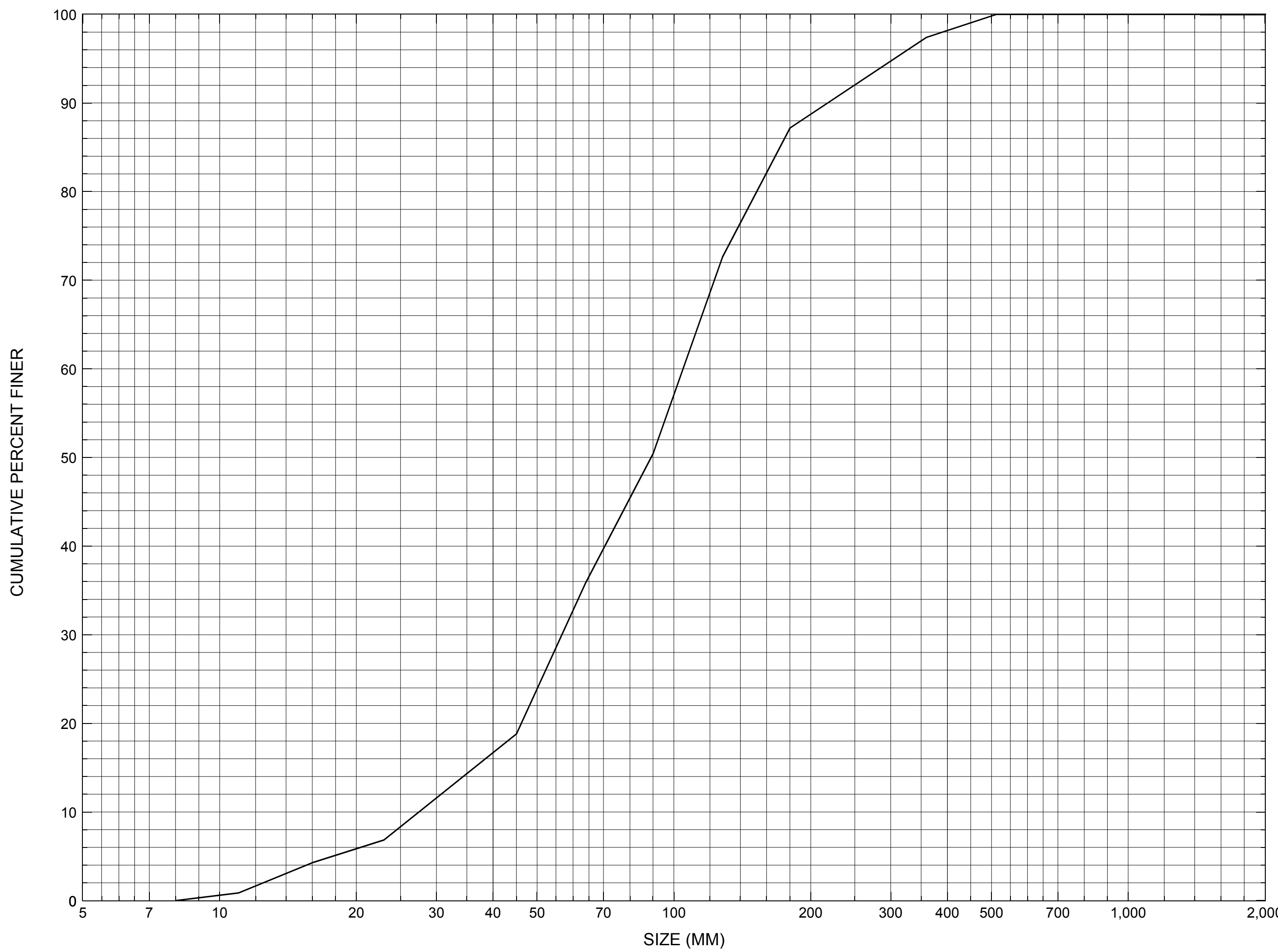
WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File wolc005.wsp
        Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
        Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont by ECW
           *** RUN DATE & TIME: 09-12-97  13:05
  XSID:CODE   SRDL    LEW     AREA   VHD    HF     EGL    CRWS       Q    WSEL
        SRD   FLEN    REW        K  ALPH    HO     ERR     FR#     VEL

 EXITX:XS   ******   -844     1665  0.52 *****  495.72  494.51    9030  495.20
       -48 ******     60   114680  1.14 ***** *******    0.64    5.42

  ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.84     495.44     495.24
  ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.70     522.95    0.50
  ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.70     522.95     495.24

 FULLV:FV       49   -843     1354  0.83  0.39  496.25  495.24    9030  495.43
          0     49     59    88539  1.19  0.15   -0.01    0.85    6.67
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.12     496.09     496.29
  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   494.93     519.14    0.50
  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   494.93     519.14     496.29
  ===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 =   496.29     519.14     496.29

 APPRO:AS       76   -737     1333  1.06 *****  497.35  496.29    9030  496.29
         76     76    131    86975  1.49 ***** *******    1.00    6.77
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   503.47       0.00     494.62     496.08
  ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
  ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   495.87     498.33     498.72     497.72
  ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
  ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.07     498.79     499.10
  ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

 BRIDG:BR       49      0      523  2.36  0.38  498.23  491.45    5567  495.87
          0     49     41    63964  1.34  2.14    0.00    0.61   10.65

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        4. ****   4.  0.865 ******  497.72 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      10.    60.  0.07  0.13  498.78    0.00   3463.  498.33

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
    LT:   3463.   450.  -577.  -126.   2.3   1.4   6.2   5.5   1.8   3.1
    RT:      0.   202.    20.   221.   1.9   1.3   7.1   9.1   2.4   3.0

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

 APPRO:AS       55   -778     3422  0.13  0.38  498.85  496.29    9030  498.72
         76    119    199   273414  1.23  0.24    0.00    0.28    2.64

        M(G)   M(K)        KQ   XLKQ   XRKQ    OTEL
       0.952  0.778   60663.     15.    56. ********
                           <<<<<END OF BRIDGE COMPUTATIONS>>>>>
   FIRST USER DEFINED TABLE.
     XSID:CODE     SRD    LEW     REW       Q        K     AREA     VEL    WSEL
    EXITX:XS     -49.  -845.     60.   9030.  114680.    1665.    5.42  495.20
    FULLV:FV       0.  -844.     59.   9030.   88539.    1354.    6.67  495.43
    BRIDG:BR       0.     0.     41.   5567.   63964.     523.   10.65  495.87
    RDWAY:RG      10.*******  3463.   3463.*********       0.    2.00  498.33
    APPRO:AS      76.  -779.    199.   9030.  273414.    3422.    2.64  498.72

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      15.    56.   60663.

  SECOND USER DEFINED TABLE.
     XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
    EXITX:XS     494.51    0.64  484.94  522.21************  0.52  495.72  495.20
    FULLV:FV     495.24    0.85  485.67  522.95  0.39  0.15  0.83  496.25  495.43
    BRIDG:BR     491.45    0.61  479.48  497.85  0.38  2.14  2.36  498.23  495.87
    RDWAY:RG  ****************  496.08  518.65  0.07******  0.13  498.78  498.33
    APPRO:AS     496.29    0.28  486.91  519.14  0.38  0.24  0.13  498.85  498.72
```

```
       U.S. Geological Survey WSPRO Input File wolc005.incip.wsp
       Hydraulic analysis for structure WOLCTH00150005   Date: 13-MAY-97
       Town Highway 15, Wild Branch Lamoille River, Wolcott, Vermont  ECW
          *** RUN DATE & TIME: 09-12-97  11:35

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

EXITX:XS   ******   -178      630  0.64 *****  496.76  492.54    3900  496.12
       -48 ******     61    49484  1.08 ***** *******    0.70    6.19

FULLV:FV       49    -20      563  0.75  0.34  497.15 *******    3900  496.40
         0     49     60    44544  1.00  0.05    0.00    0.46    6.93
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.60

APPRO:AS       76    -29      886  0.32  0.36  497.51 *******    3900  497.19
        76     76    139    71144  1.06  0.00    0.00    0.35    4.40
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       49      0      538  0.94  0.38  497.18  489.67    3900  496.24
         0     49     41    66563  1.15  0.04    0.00    0.38    7.25

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   1.  0.931 ******  497.72 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<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       55    -31      916  0.30  0.35  497.67  493.22    3900  497.37
        76     67    140    74551  1.06  0.14    0.00    0.34    4.26

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.754  0.473   39280.    27.    68.   497.21

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -49.  -179.    61.   3900.   49484.     630.    6.19  496.12
   FULLV:FV       0.   -21.    60.   3900.   44544.     563.    6.93  496.40
   BRIDG:BR       0.     0.    41.   3900.   66563.     538.    7.25  496.24
   RDWAY:RG      10.**************      0.******************    2.00********
   APPRO:AS      76.   -32.   140.   3900.   74551.     916.    4.26  497.37

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      27.    68.   39280.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     492.54    0.70  484.94  522.21************  0.64  496.76  496.12
   FULLV:FV   ********    0.46  485.68  522.95  0.34  0.05  0.75  497.15  496.40
   BRIDG:BR     489.67    0.38  479.48  497.85  0.38  0.04  0.94  497.18  496.24
   RDWAY:RG   ****************  499.90  518.65**********************************
   APPRO:AS     493.22    0.34  486.91  519.14  0.35  0.14  0.30  497.67  497.37
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure WOLCTH00150005, in Wolcott, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number WOLCTH00150005

General Location Descriptive

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

Date *(MM/DD/YY)* 10 / 13 / 95

Highway District Number *(I - 2; nn)* 06

County *(FIPS county code; I - 3; nnn)* 015

Town *(FIPS place code; I - 4; nnnnn)* 85375

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

Waterway *(I - 6)* WILD BR.LAMOILLE R.

Road Name *(I - 7):* -

Route Number C3015

Vicinity *(I - 9)* 0.05 MI TO JCT W CL2 TH1

Topographic Map Wolcott

Hydrologic Unit Code: 2010005

Latitude *(I - 16; nnnn.n)* 44343

Longitude *(i - 17; nnnnn.n)* 72287

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10081000050810

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

Maximum span length *(I - 48; nnnn)* 0043

Year built *(I - 27; YYYY)* 1967

Structure length *(I - 49; nnnnnn)* 000046

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

Deck Width *(I - 52; nn.n)* 164

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

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

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

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

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

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

Structure type *(I - 43; nnn)* 505

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 41.6

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

Vertical clearance from streambed (*nnn.n ft*) 9.3

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

Waterway of full opening (*nnn.n* ft^2) 386

Comments:

According to the structural inspection report dated 6/27/95, deck of structure is a prestressed concrete box beam. The concrete abutments and wings have minor fine cracks and small leaks overall. There are several fine random vertical or diagonal cracks, including one at the left end of the RABUT, and also in the right wing of the LABUT. The tops of both abuts have recently been repaired. The RABUT appears to be resting on ledge. Boulder riprap has been placed in front of the abutments and wingwalls. There is ledge showing in the channel in front of the abutment, extending DS. A large, coarse gravel bar is present in the US channel along the LABUT. Boulders, coarse gravel, and some erosion show along US and DS channel embankments.

Bridge Hydrologic Data

Is there hydrologic data available? N___ *if No, type ctrl-n h* VTAOT Drainage area *(mi^2)*: ________

Terrain character: ____

Stream character & type:

Streambed material: ____

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

Q_{50} ______________ Q_{100} ______________ Q_{500} ______________

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

Estimated Discharge *(cfs)*: __________ Velocity at Q ____ *(ft/s)*: _________

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes:

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

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

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

Upstream distance (*miles*): ____________ Town: ____________________ Year Built: ______

Highway No. : _________________ Structure No. : ______ Structure Type: ______________________

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

Downstream distance (*miles*): ___________ Town: ____________________ Year Built: ______

Highway No. : _________________ Structure No. : ______ Structure Type: ______________________

Clear span (*ft*): _____ Clear Height (*ft*): ______ Full Waterway (ft^2): _______

Comments:

Notes in file at AOT from 5/24/91 show undermined footings along both abutments and up to 4 feet of scour along the Labut.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **38.25** mi^2

Lake/pond/swamp area **0.391** mi^2

Watershed storage *(ST)* **1.02** %

Bridge site elevation **719** ft

Headwater elevation **2617** ft

Main channel length **13.782** mi

10% channel length elevation **738** ft

85% channel length elevation **1446.48** ft

Main channel slope *(S)* **68.54** 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)*: **6** / **1995**

Project Number **TF6647** Minimum channel bed elevation: **-**

Low superstructure elevation: USLAB **496.97** DSLAB **496.97** USRAB **496.65** DSRAB **496.65**

Benchmark location description:
BM#1 assumed elev. = 500'; spike in elm stump about 25 feet bankward of Labut, towards US side, very close to guard rail.

Reference Point (*MSL, Arbitrary, Other*): **Arbitrary** Datum (*NAD27, NAD83, Other*): **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 DRILL BORING INFORMATION

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

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 elevations are from the survey log done for this report on 7/17/96. The low cord to bed length data is from the sketch attached to a bridge inspection report dated 6/26/95. The sketch was done on 10/15/93.**

Station	**0**	**13.6**	**19.6**	**30.6**	**41.6**	-	-	-	-	-	-
Feature	**LAB**				**RAB**	-	-	-	-	-	-
Low chord elevation	**497.8**	**497.7**	**497.7**	**497.6**	**497.6**	-	-	-	-	-	-
Bed elevation	**490.9**	**485.3**	**486.4**	**486.9**	**491.0**	-	-	-	-	-	-
Low chord to bed	**6.9**	**12.4**	**11.3**	**10.7**	**6.6**	-	-	-	-	-	-

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: **09/13/96**
Computerized by: **RB** Date: **09/13/96**
Reviewd by: **EW** Date: **11/03/97**

Structure Number **WOLCTH00150005**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. WILD** Date *(MM/DD/YY)* **07** / **17** / 19**96**
2. Highway District Number **06** Mile marker **00000**
   County **Lamoille (015)** Town **WOLCOTT(85375)**
   Waterway *(I - 6)* **WILD BRANCH LAMOILLE R.** Road Name **-**
   Route Number **C3015** Hydrologic Unit Code: **2010005**
3. Descriptive comments:

Located 0.05 miles from the junction with CL2TH1. Bridge deck is a prestressed concrete beam.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **4** RBDS **4** Overall **4**
*(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 **46** *(feet)* Span length **43** *(feet)* Bridge width **16.4** *(feet)*

Road approach to bridge:

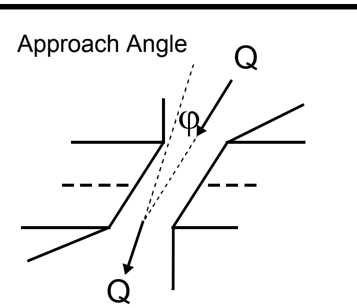
8. LB **0** RB **0** *(**0** even, **1**- lower, **2**- higher)*
9. LB **2** RB **2** *(**1**- Paved, **2**- Not paved)*
10. Embankment slope (*run / rise in feet / foot*):
    US left **--** US right **--**

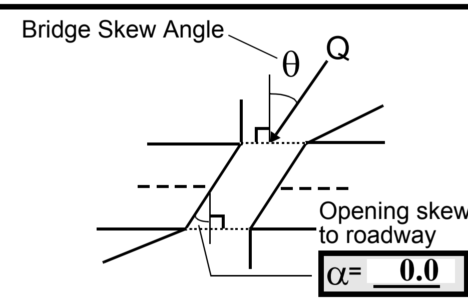
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	1
RBUS	1	1	2	1
RBDS	0	-	2	1
LBDS	1	1	2	2

*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: **5** 16. Bridge skew: **10**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
    Where? **RB** *(LB, RB)* Severity **1**
    Range? **125** feet **US** *(US, UB, DS)* to **80** feet **US**
    Channel impact zone 2: Exist? **Y** *(Y or N)*
    Where? **LB** *(LB, RB)* Severity **1**
    Range? **70** feet **US** *(US, UB, DS)* to **8** feet **UB**

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

18. Bridge Type: **4/1a**

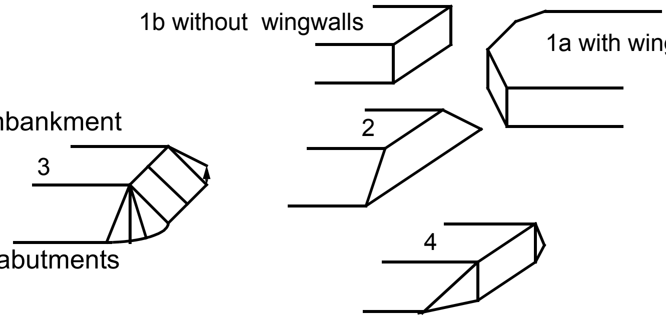
1a- Vertical abutments with wingwalls

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 VT AOT. Measured bridge length is 46 feet, bridge span is 43 feet, and bridge width is 16.4 feet.

18. The USLWW and DSLWW both go below low chord.

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
60.5	**4.5**			**2.0**	**2**	**2**	**134**	**341**	**1**	**1**

23. Bank width **15.0**   24. Channel width **5.0**   25. Thalweg depth **108.5**   29. Bed Material **3425**

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

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

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

30. The left bank protection extends from 37 ft. US to the end of the US left wingwall.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **52** 35. Mid-bar width: **16**

36. Point bar extent: **78** feet **US** (US, UB) to **23** feet **US** (US, UB, DS) positioned **85** %LB to **100** %RB

37. Material: **340**

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

37. The point bar is completely vegetated with grass.
An additional point bar comprised of gravel, cobble and small clumps of grass is on the left bank from 250 ft. US to 73 ft. US. Mid bar distance is at 95 ft. US where the width is 25 ft.

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: **49** 42. Cut bank extent: **70** feet **US** (US, UB) to **37** 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.):

An additional cut-bank is on the right bank from 100 ft. US to 85 ft. US, with mid bank at 90 ft. US. The bank has been eroded.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **5UB**

47. Scour dimensions: Length **19** Width **7** Depth : **2** Position **30** %LB to **50** %RB

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

47. Scour depth assumes a thalweg of 2.5 ft.
There is also local scour behind boulders.

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):

A minor confluence enters on the right bank from 22 ft. US to 14 ft. US, adjacent to the USRWW protection, and runs parallel to C3015.

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
68.0		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.):

324
-

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? **1** ___ (*Y or N*) Ice Blockage Potential **N** ____ (*1- Low; 2- Moderate; 3- High*)

70. Debris and Ice Comments:

1

65. Debris has accumulated in the channel from 90 ft. US to 50 ft. US where a tree has fallen into the chan nel. There is also debris caught in the trees on the right bank 4 ft. above the top of bank.

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		10	90	2	2	0	2	90.0
RABUT	1	0	90			2	0	41.5

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

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

0

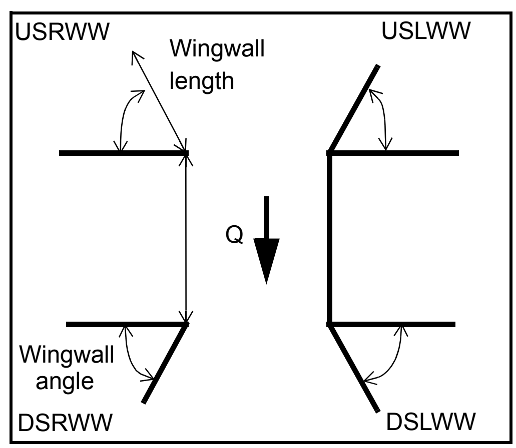
0

1

76. The footing is exposed 1 foot and the underlying subfooting is additionally exposed 1 foot. There is extensive protection in front of the left abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						41.5	
USRWW:	Y		1		0	6.0	
DSLWW:	-		-		Y	21.0	
DSRWW:	1		0		-	20.5	



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

82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	2	Y	-	1	1	1	1
Condition	Y	0	1	-	1	1	1	1
Extent	1	1	0	3	4	4	3	-

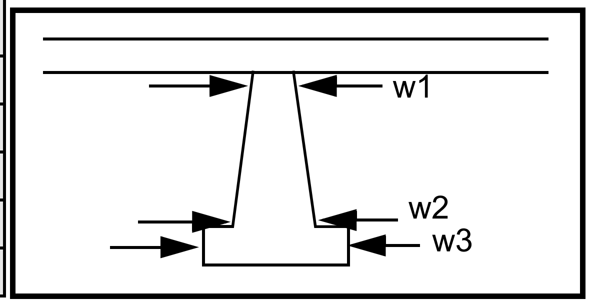
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **80.** *(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				**60.0**	**12.0**	**15.0**
Pier 2				**33.0**	**25.0**	**13.0**
Pier 3		**6.0**	**-**	**70.0**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**The**	**of the**	**the left**		*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**DSL**	**wing**	**abut**	**N**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**WW**	**wall.**	**ment**	**-**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**foot-**	**It is**	**.**	**-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**ing is**	**also**		**-**	*Y- yes; N- no*
91. Attack ∠ (BF)	**expo**	**exte**		**-**	
92. Pushed	**sed 1**	**nsive**		**-**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**foot**	**ly**		**-**	
95. Cross-members	**at**	**pro-**		**-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**the**	**tecte**		**-**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**US**	**d**		**-**	
98. Exposure depth	**end**	**like**		**-**	

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 **2** (US, UB, DS) to **2** feet **342** *(US, UB, DS)* positioned **342** %LB to **1** %RB

Material: **1**

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

6354
1
1
1

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

Cut bank extent: **in** feet **the** *(US, UB, DS)* to **chan** feet **nel** *(US, UB, DS)*

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

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

ends on the right side from 0 ft. UB to 65 ft. DS.
The right bank protection extends from the end of the wingwall to 21 ft. DS.
The left bank protection extends from the end of the wingwall, 16 ft. DS, to 52 ft. DS.
The channel flow is straight after the water exits the DS bridge face.

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)*:

Y
82
21
22.6
DS
107
DS
0
42
234

109. G. Plan View Sketch

\- T

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: WOLCTH00150005 Town: WOLCOTT
Road Number: TH 15 County: LAMOILLE
Stream: WILD BRANCH LAMOILLE RIVER

Initials ECW Date: 9/12/97 Checked: SAO

Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)
Vc=11.21*y1^0.1667*D50^0.33 with Ss=2.65
(Richardson and others, 1995, p. 28, eq. 16)

Approach Section Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	6210	9030	3900
Main Channel Area, ft2	810	944	808
Left overbank area, ft2	1377	2340	46
Right overbank area, ft2	66	141	62
Top width main channel, ft	108	108	108
Top width L overbank, ft	775	779	32
Top width R overbank, ft	33	91	32
D50 of channel, ft	0.292	0.292	0.292
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.5	8.7	7.5
y1, average depth, LOB, ft	1.8	3.0	1.4
y1, average depth, ROB, ft	2.0	1.5	1.9
Total conveyance, approach	152759	273826	74577
Conveyance, main channel	82810	106962	69499
Conveyance, LOB	66824	161251	2175
Conveyance, ROB	3125	5613	2904
Percent discrepancy, conveyance	0.0000	0.0000	-0.0013
Qm, discharge, MC, cfs	3366.4	3527.3	3634.4
Ql, discharge, LOB, cfs	2716.5	5317.6	113.7
Qr, discharge, ROB, cfs	127.0	185.1	151.9
Vm, mean velocity MC, ft/s	4.2	3.7	4.5
Vl, mean velocity, LOB, ft/s	2.0	2.3	2.5
Vr, mean velocity, ROB, ft/s	1.9	1.3	2.4
Vc-m, crit. velocity, MC, ft/s	10.4	10.7	10.4
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	6210	9030	3900
(Q) discharge thru bridge, cfs	5367	5567	3900
Main channel conveyance	51404	63961	66588
Total conveyance	51404	63961	66588
Q2, bridge MC discharge,cfs	5367	5567	3900
Main channel area, ft2	448	523	538
Main channel width (normal), ft	41.1	41.4	41.4
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	41.1	41.4	41.4
y_bridge (avg. depth at br.), ft	10.90	12.63	13.00
Dm, median (1.25*D50), ft	0.365	0.365	0.365
y2, depth in contraction,ft	10.75	11.02	8.12
ys, scour depth (y2-ybridge), ft	-0.15	-1.61	-4.87

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	5367	5567	3900
Main channel area (DS), ft2	448	523	538
Main channel width (normal), ft	41.1	41.4	41.4
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	41.1	41.4	41.4
D90, ft	0.7168	0.7168	0.7168
D95, ft	1.0045	1.0045	1.0045
Dc, critical grain size, ft	0.5305	0.3962	0.1818
Pc, Decimal percent coarser than Dc	0.174	0.310	0.711
Depth to armoring, ft	7.56	2.65	0.22

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	6210	9030	3900	6210	9030	3900
a', abut.length blocking flow, ft	775.5	779.3	31.8	99.5	158	98.5
Ae, area of blocked flow ft2	1179.98	1741.17	61	541.1	697.7	538.8
Qe, discharge blocked abut.,cfs	--	--	155.8	2041.9	2211.3	2234.1
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.99	2.28	2.55	3.77	3.17	4.15
ya, depth of f/p flow, ft	1.52	2.23	1.92	5.44	4.42	5.47
--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	0.260	0.230	0.325	0.285	0.266	0.312
ys, scour depth, ft	19.69	23.27	7.94	21.87	21.47	22.83

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)	775.5	779.3	31.8	99.5	158	98.5
y1 (depth f/p flow, ft)	1.52	2.23	1.92	5.44	4.42	5.47
a'/y1	509.67	348.79	16.58	18.30	35.78	18.01
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.26	0.23	0.32	0.29	0.27	0.31
Ys w/ corr. factor K1/0.55:						
vertical	7.09	10.00	ERR	ERR	20.74	ERR
vertical w/ ww's	5.82	8.20	ERR	ERR	17.01	ERR
spill-through	3.90	5.50	ERR	ERR	11.41	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.71	0.61	0.38	0.71	0.61	0.38
y, depth of flow in bridge, ft	10.90	12.63	13.00	10.90	12.63	13.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	3.40	2.91	1.16	3.40	2.91	1.16
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR