LEVEL II SCOUR ANALYSIS FOR BRIDGE 6 (ALBUTH00150006) on TOWN HIGHWAY 15, crossing MUD CREEK, ALBURG, VERMONT

U.S. Geological Survey
Open-File Report 97-397

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

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By SCOTT A. OLSON

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
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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 6 (ALBUTH00150006) ON TOWN HIGHWAY 15, CROSSING MUD CREEK, ALBURG, VERMONT

By **Scott A. Olson**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ALBUTH00150006 on Town Highway 15 crossing Mud Creek, Alburg, 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 Champlain section of the St. Lawrence Valley physiographic province in northwestern Vermont. The 2.90-mi^2 drainage area is in a predominantly rural and forested basin. However, nearly a third of the drainage, including the location of the study site, is wetland.

In the study area, Mud Creek has an sinuous channel through wetland with a slope of approximately 0.0002 ft/ft, an average channel top width of 42 ft and an average bank height of 2 ft. The channel bed material ranges from clay to sand with an estimated median grain size (D_{50}) of 0.047 mm (0.00015 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 26, 1995, indicated that the reach was stable.

The Town Highway 15 crossing of Mud Creek is a 30-ft-long, one-lane bridge consisting of one 28-foot steel-beam span (Vermont Agency of Transportation, written communication, March 7, 1995). The opening length of the structure parallel to the bridge face is 26.7 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed zero degrees to the opening and the opening-skew-to-roadway is also zero degrees.

Channel scour, approximately 2 ft deeper than the mean thalweg depth, was observed in the middle of the channel extending from 5 to 35 ft upstream of the bridge. The only scour countermeasure observed at this site was some small stone, possibly type-1 stone fill (less than 12 inches diameter), partially covering the channel bed under the bridge. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 6.2 to 7.2 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 2.0 to 2.4 ft and 2.1 to 2.6 ft on the left and right abutments respectively. 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.

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.

Rouses Point, VT-NY. Quadrangle, 1:24,000, 1966

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 ALBUTH00150006 ***Stream*** Mud Creek

County Grand Isle ***Road*** TH15 ***District*** 8

Description of Bridge

Bridge length 30 ***ft*** ***Bridge width*** 17.1 ***ft*** ***Max span length*** 28 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 6/26/95

Description of stone fill Type-1, partially covering the channel bed under the bridge.

Brief description of piers/abutments Abutments and wingwalls are concrete and rest on logs. The logs are acting as a footing.

Is bridge located on a bend in channel? N ***If so, describe (mild, moderate, severe)*** -

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

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	6/26/95	50	20
Level II	6/26/95	50	20

Potential for debris High.

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

There is a lot of debris under the bridge, including hub caps, mailboxes, a cow carcass, etc. In addition to the debris, there is a wire fence crossing at least half of the channel at the downstream face of the bridge.

Description of the Geomorphic Setting

General topography The channel is located within a 1500 foot-wide wetland.

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

Date of inspection 6/26/95

DS left: Wetland.

DS right: Wetland.

US left: Wetland

US right: Wetland.

Description of the Channel

Average top width 42 ***ft*** ***Average depth*** 2 ***ft***

Predominant bed material Silt / clay ***Bank material*** Silt / clay

Sinuous, swampy channel through a wetland.

6/26/95

Vegetative co Swamp grasses and brush.

DS left: Swamp grasses and brush.

DS right: Swamp grasses and brush.

US left: Swamp grasses and brush.

US right: Y

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

June 26, 1995. Debris--

see page 7.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 2.90 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
St. Lawrence Valley/Champlain	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 Yes

Nearly a third of the drainage is wetland.

Calculated Discharges

Q100 220 ***ft³/s*** ***Q500*** 300 ***ft³/s***

The 100- and 500-year discharges are the median of several empirical methods for estimating flood frequencies at ungaged sites (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 500.13 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 499.76 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	-33	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	45	2	Modelled Approach section (Templated from APTEM)
APTEM	56	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). Channel "n" values for the reach ranged from 0.035 to 0.055, and overbank "n" values ranged from 0.050 to 0.095.

Although the Flood Insurance Study for the Town of Alburg (Federal Emergency Management Agency, 1980) indicates that the 100-year water-surface elevation of Lake Champlain will reach this bridge, simultaneous peaks from both Mud Creek and Lake Champlain are unlikely. Thus, 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 0.00020 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1966).

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

There was a 2.5 ft diameter concrete culvert behind the right abutment and at least two 1.5 ft diameter culverts under the roadway 269 and 709 feet left of the left abutment. The culverts were not included in the hydraulic analysis.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.2 *ft*
Average low steel elevation 498.8 *ft*

100-year discharge 220 *ft³/s*
Water-surface elevation in bridge opening 497.2 *ft*
Road overtopping? Y *Discharge over road* 9 *ft³/s*
Area of flow in bridge opening 42.1 *ft²*
Average velocity in bridge opening 5.0 *ft/s*
Maximum WSPRO tube velocity at bridge 6.6 *ft/s*

Water-surface elevation at Approach section with bridge 498.3
Water-surface elevation at Approach section without bridge 497.2
Amount of backwater caused by bridge 1.1 *ft*

500-year discharge 300 *ft³/s*
Water-surface elevation in bridge opening 497.5 *ft*
Road overtopping? Y *Discharge over road* 71 *ft³/s*
Area of flow in bridge opening 47.6 *ft²*
Average velocity in bridge opening 4.8 *ft/s*
Maximum WSPRO tube velocity at bridge 6.2 */s*

Water-surface elevation at Approach section with bridge 498.4
Water-surface elevation at Approach section without bridge 497.4
Amount of backwater caused by bridge 1.0 *ft*

Incipient overtopping discharge 190 *ft³/s*
Water-surface elevation in bridge opening 497.1 *ft*
Area of flow in bridge opening 39.4 *ft²*
Average velocity in bridge opening 4.8 *ft/s*
Maximum WSPRO tube velocity at bridge 6.3 *ft/s*

Water-surface elevation at Approach section with bridge 498.2
Water-surface elevation at Approach section without bridge 497.1
Amount of backwater caused by bridge 1.1 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). Variables for the Laursen equation include the discharge through the bridge, the width of the bridge opening, the depth in the bridge, and the median grain size of the bed material.

Field observations during the Level I data collection indicated that the bed material was silt and clay with some fine sand and covered with organics. When the bed sample from this site was sieved, 66.7 percent of the sample passed through the smallest available sieve size, 0.063 mm. Therefore, it was necessary to estimate the median grain size by interpolating between the 0.063 mm sieve and zero. The result was 0.047 mm, which is in the coarse silt range. The 0.047 mm grain size was used as the D_{50} in the scour analysis. Increasing the D_{50} from 0.047 mm to 0.063 mm decreased contraction scour by less than 10 percent.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	6.8	7.2	6.2
Depth to armoring	N/A	N/A	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour			
Left abutment	2.2	2.4	2.0
Right abutment	2.3	2.6	2.1
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	0.6	0.7	0.6
Right abutment	0.6	0.7	0.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

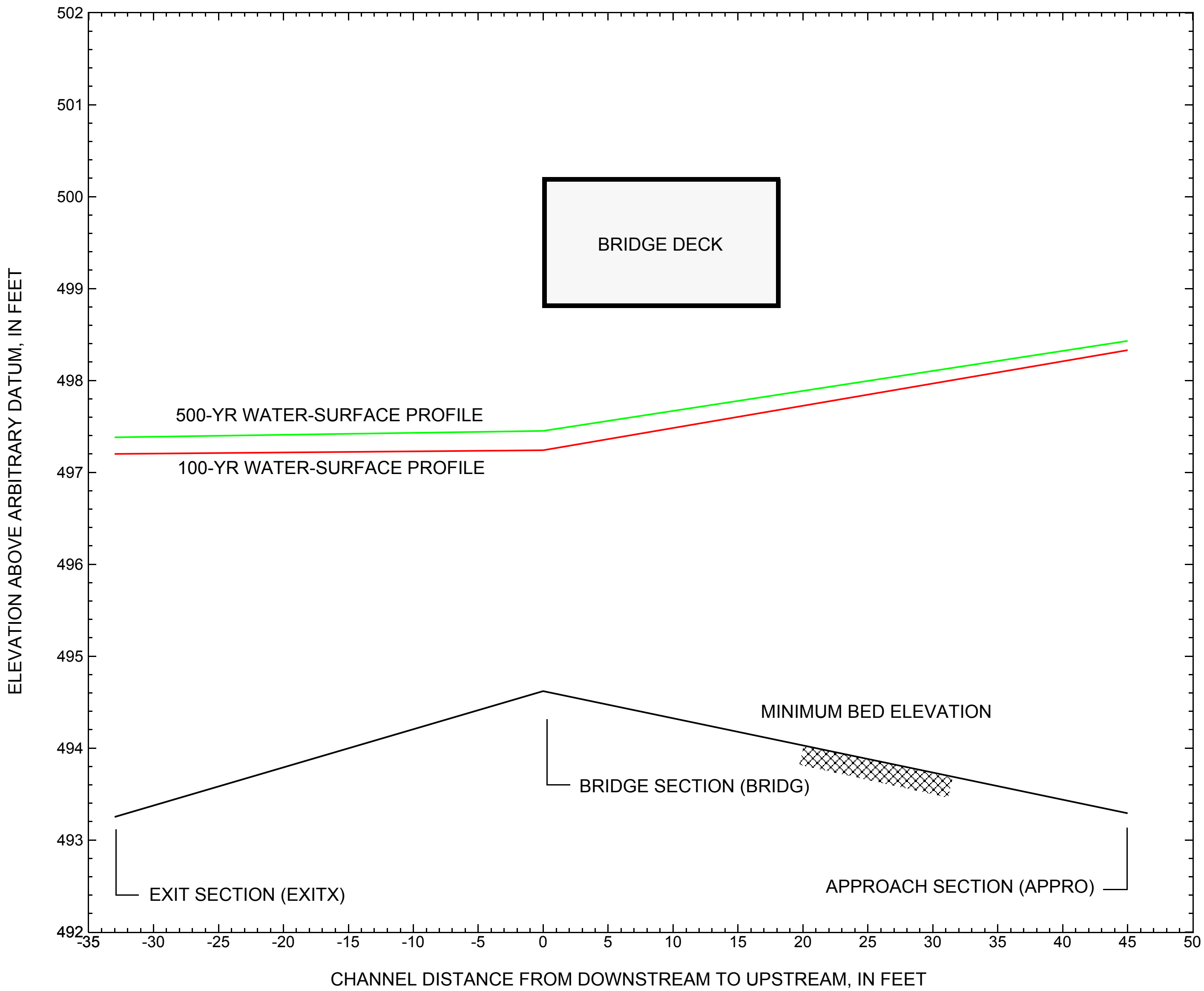

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ALBUTH00150006 on Town Highway 15, crossing Mud Creek, Alburg, Vermont.

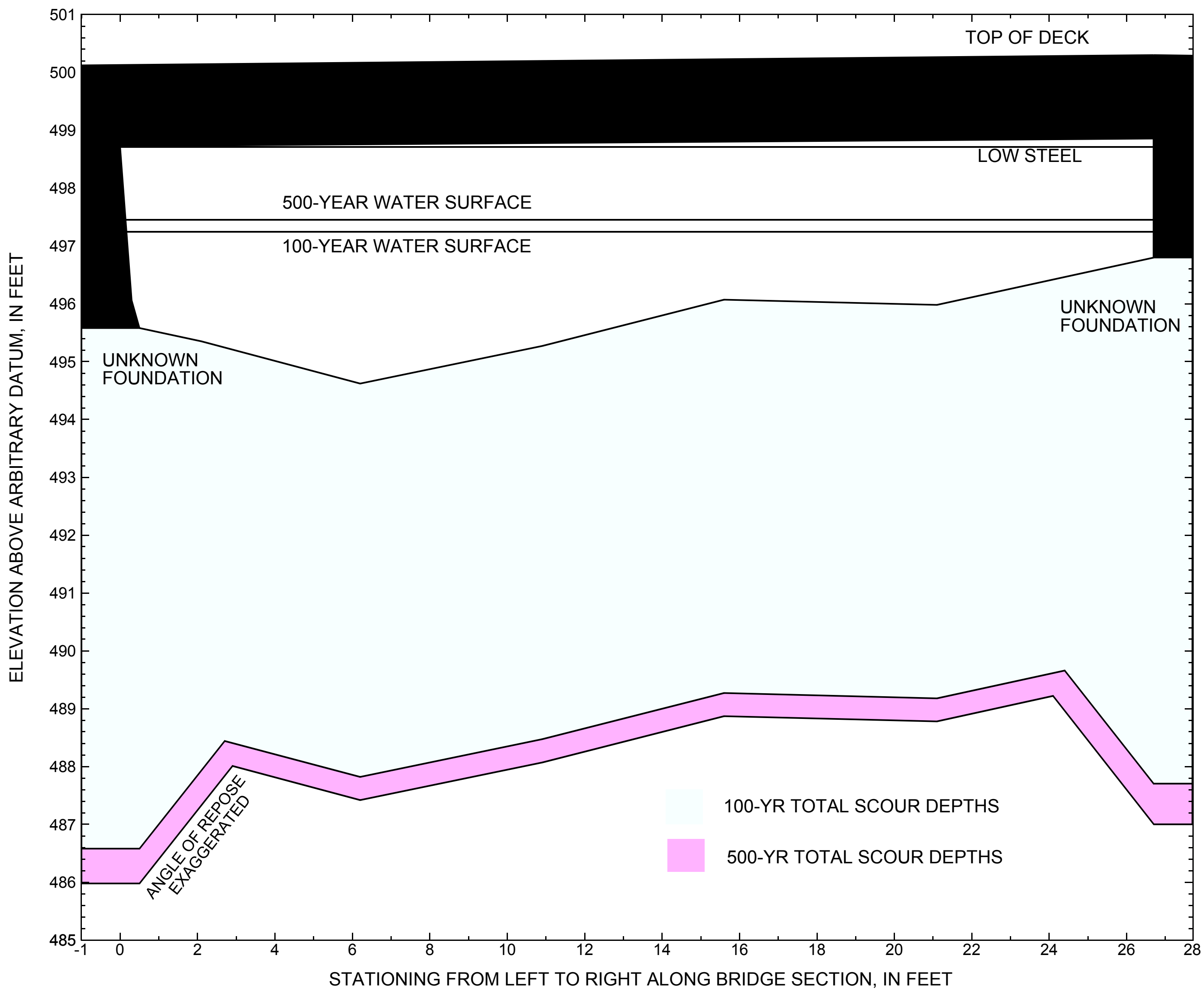

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ALBUTH00150006 on Town Highway 15, crossing Mud Creek, Alburg, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ALBUTH00150006 on Town Highway 15, crossing Mud Creek, Alburg, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 220 cubic-feet per second											
Left abutment	0.0	--	498.7	--	495.6	6.8	2.2	--	9.0	486.6	--
Right abutment	26.7	--	498.8	--	496.8	6.8	2.3	--	9.1	487.7	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure ALBUTH00150006 on Town Highway 15, crossing Mud Creek, Alburg, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 300 cubic-feet per second											
Left abutment	0.0	--	498.7	--	495.6	7.2	2.4	--	9.6	486.0	--
Right abutment	26.7	--	498.8	--	496.8	7.2	2.6	--	9.8	487.0	--

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 albu006.wsp
T2        Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
T3        Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           220     300     190
SK          0.00020 0.00020 0.00020
*
XS   EXITX    -33
GR        -1400.0, 502.00  -1400.0, 496.65   -111.7, 496.66    -79.0, 496.47
GR          -16.2, 500.10     -8.1, 496.66     -3.7, 495.23      0.0, 493.38
GR            8.8, 493.25     12.5, 493.84     22.2, 494.30     26.6, 495.11
GR           31.8, 498.08     60.0, 496.95     95.1, 497.36    139.5, 497.77
GR          197.5, 500.41    365.3, 501.18
N          0.095        0.040        0.050
SA                  -8.1         31.8
*
XS   FULLV      0
*
BR   BRIDG     0 498.78
GR            0.0, 498.71      0.3, 496.06      0.5, 495.58      2.1, 495.35
GR            6.2, 494.62     10.9, 495.27     15.6, 496.07     21.1, 495.98
GR           26.7, 496.80     26.7, 498.84      0.0, 498.71
N           0.055
CD          1 24.5 * * 90 0.0
*
XR   RDWAY      9 17 2
GR        -1400.0, 502.00  -1400.0, 498.79   -825.9, 498.35   -708.7, 498.26
GR         -577.9, 498.22   -269.2, 498.52   -124.9, 498.68      0.0, 500.13
GR           26.7, 500.30    130.5, 499.09    271.3, 500.42    365.3, 501.18
*
XT   APTEM     56
GR        -1400.0, 502.00  -1400.0, 496.65   -135.8, 496.65   -106.7, 496.67
GR          -58.1, 496.23     -9.1, 495.88     -3.1, 495.31      0.0, 494.53
GR            2.7, 493.54     11.9, 493.41     18.8, 493.69     24.5, 493.29
GR           28.2, 495.36     33.7, 496.36     44.7, 497.11     65.3, 497.17
GR           88.2, 496.71    128.9, 497.14    149.5, 498.94    365.3, 501.18
*
AS   APPRO     45
GT             0
N          0.095        0.035        0.055
SA                  -3.1         28.2
*
HP 1 BRIDG    497.24 1 497.24
HP 2 BRIDG    497.24 * * 211
HP 2 RDWAY    498.29 * * 9
HP 1 APPRO    498.33 1 498.33
HP 2 APPRO    498.33 * * 220
*
HP 1 BRIDG    497.45 1 497.45
HP 2 BRIDG    497.45 * * 229
HP 2 RDWAY    498.40 * * 71
HP 1 APPRO    498.43 1 498.43
HP 2 APPRO    498.43 * * 300
*
HP 1 BRIDG    497.14 1 497.14
HP 2 BRIDG    497.14 * * 190
HP 1 APPRO    498.18 1 498.18
HP 2 APPRO    498.18 * * 190
*
EX
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File albu006.wsp
       Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
       Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      42.    1473.    27.    29.                         300.
   497.24           42.    1473.    27.    29.  1.00     0.    27.    300.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.24     0.2    26.7    42.1    1473.     211.   5.02
X STA.         0.2         2.0         3.0         3.9         4.6         5.3
  A(I)             2.9         2.0         1.9         1.7         1.7
  V(I)            3.61        5.31        5.62        6.23        6.21

X STA.         5.3         6.0         6.6         7.2         7.9         8.6
  A(I)             1.6         1.6         1.6         1.7         1.7
  V(I)            6.46        6.60        6.50        6.33        6.20

X STA.         8.6         9.4        10.3        11.2        12.4        13.7
  A(I)             1.7         1.9         1.9         2.0         2.2
  V(I)            6.09        5.67        5.53        5.16        4.86

X STA.        13.7        15.6        17.8        19.9        22.1        26.7
  A(I)             2.5         2.6         2.6         2.7         3.6
  V(I)            4.15        4.14        4.08        3.91        2.96

    CROSS-SECTION PROPERTIES:  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA
       498.29   -747.8  -505.9    9.7

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2392.   53642.  1397.  1399.                       17758.
             2     142.   16322.    31.    32.                        1720.
             3     153.    5016.   114.   114.                        1002.
   498.33         2687.   74980.  1543.  1545.  4.24 -1400.   143.   9776.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.33 -1400.0   142.5  2686.7   74980.     220.   0.08
X STA.     -1400.0     -1297.5     -1198.3     -1097.4      -995.2      -896.1
  A(I)           172.2       166.6       169.6       171.6       166.6
  V(I)            0.06        0.07        0.06        0.06        0.07

X STA.      -896.1      -793.4      -692.7      -593.6      -492.2      -390.7
  A(I)           172.4       169.1       166.5       170.4       170.4
  V(I)            0.06        0.07        0.07        0.06        0.06

X STA.      -390.7      -290.6      -190.5       -89.2       -19.6         3.5
  A(I)           168.2       168.2       170.9       147.1        67.7
  V(I)            0.07        0.07        0.06        0.07        0.16

X STA.         3.5         9.8        16.1        22.8        46.7       142.5
  A(I)            30.3        30.9        31.6        57.0       119.2
  V(I)            0.36        0.36        0.35        0.19        0.09
```

```
        U.S. Geological Survey WSPRO Input File albu006.wsp
        Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
        Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1      48.    1795.   27.    29.                         362.
   497.45           48.    1795.   27.    29.  1.00     0.    27.    362.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.45     0.1    26.7    47.6    1795.     229.   4.81
X STA.         0.1         2.0         3.1         3.9         4.8         5.5
  A(I)             3.4         2.3         2.1         2.0         1.9
  V(I)            3.40        4.91        5.50        5.62        6.05

X STA.         5.5         6.2         6.8         7.5         8.2         9.0
  A(I)             1.9         1.8         1.9         1.9         2.0
  V(I)            6.10        6.20        6.14        5.99        5.86

X STA.         9.0         9.9        10.8        11.8        13.1        14.6
  A(I)             2.0         2.1         2.2         2.4         2.6
  V(I)            5.67        5.45        5.26        4.85        4.48

X STA.        14.6        16.5        18.5        20.4        22.6        26.7
  A(I)             2.8         2.8         2.8         2.9         3.9
  V(I)            4.15        4.05        4.14        3.88        2.90

    CROSS-SECTION PROPERTIES:  SECID = RDWAY;  SRD =       9.
         WSEL     LEW     REW    AREA
       498.40  -891.1  -392.7    55.6

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1    2531.   58963.  1397.  1399.                      19337.
             2     145.   16925.    31.    32.                       1777.
             3     164.    5622.   115.   116.                       1112.
   498.43         2841.   81510.  1544.  1546.  4.00 -1400.   144.  10942.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.43 -1400.0   143.7  2841.0   81510.     300.   0.11
X STA.     -1400.0     -1299.0     -1201.2     -1101.7     -1001.0     -903.2
  A(I)           179.9       174.0       177.1       179.2       174.0
  V(I)            0.08        0.09        0.08        0.08        0.09

X STA.      -903.2      -802.0      -702.8      -602.8      -503.9     -405.1
  A(I)           180.1       176.7       178.0       176.0       176.0
  V(I)            0.08        0.08        0.08        0.09        0.09

X STA.      -405.1      -305.2      -205.3      -104.3       -29.4        2.4
  A(I)           177.8       177.8       179.5       157.9        88.6
  V(I)            0.08        0.08        0.08        0.09        0.17

X STA.         2.4         9.3        15.8        22.9        49.4      143.7
  A(I)            33.9        32.7        34.5        62.0       125.4
  V(I)            0.44        0.46        0.44        0.24        0.12
```

```
        U.S. Geological Survey WSPRO Input File albu006.wsp
        Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
        Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      39.   1328.    27.    28.                          273.
   497.14           39.   1328.    27.    28.  1.00     0.    27.    273.

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K        Q    VEL
       497.14     0.2    26.7    39.4    1328.     190.   4.82
X STA.        0.2         1.9         2.9         3.8         4.5         5.2
  A(I)            2.7         1.9         1.7         1.6         1.6
  V(I)           3.54        5.06        5.50        5.95        6.09

X STA.        5.2         5.8         6.4         7.1         7.7         8.4
  A(I)            1.5         1.5         1.5         1.5         1.6
  V(I)           6.33        6.31        6.30        6.14        6.00

X STA.        8.4         9.2        10.0        10.9        12.0        13.3
  A(I)            1.6         1.7         1.8         1.9         2.0
  V(I)           5.88        5.47        5.32        5.04        4.66

X STA.       13.3        15.1        17.4        19.5        21.8        26.7
  A(I)            2.3         2.5         2.4         2.6         3.4
  V(I)           4.10        3.77        3.92        3.63        2.81

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1    2182.  46044.  1397.  1398.                        15477.
             2     138.  15434.    31.    32.                         1636.
             3     136.   4161.   113.   113.                          846.
   498.18         2455.  65639.  1541.  1543.  4.66 -1400.   141.   8144.

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      45.
         WSEL     LEW     REW    AREA        K        Q    VEL
       498.18 -1400.0   140.8  2455.4   65639.     190.   0.08
X STA.    -1400.0    -1295.2    -1193.7    -1090.5     -986.0     -884.6
  A(I)          160.4       155.2       158.0       159.8       155.2
  V(I)           0.06        0.06        0.06        0.06        0.06

X STA.     -884.6     -779.6     -676.7     -575.3     -471.5     -367.8
  A(I)          160.6       157.5       155.1       158.8       158.8
  V(I)           0.06        0.06        0.06        0.06        0.06

X STA.     -367.8     -264.4     -161.0      -63.6       -3.9        4.9
  A(I)          158.2       158.2       156.3       128.0        33.5
  V(I)           0.06        0.06        0.06        0.07        0.28

X STA.        4.9        10.6        16.6        22.7        41.5       140.8
  A(I)           27.0        28.2        28.0        47.9       110.9
  V(I)           0.35        0.34        0.34        0.20        0.09
```

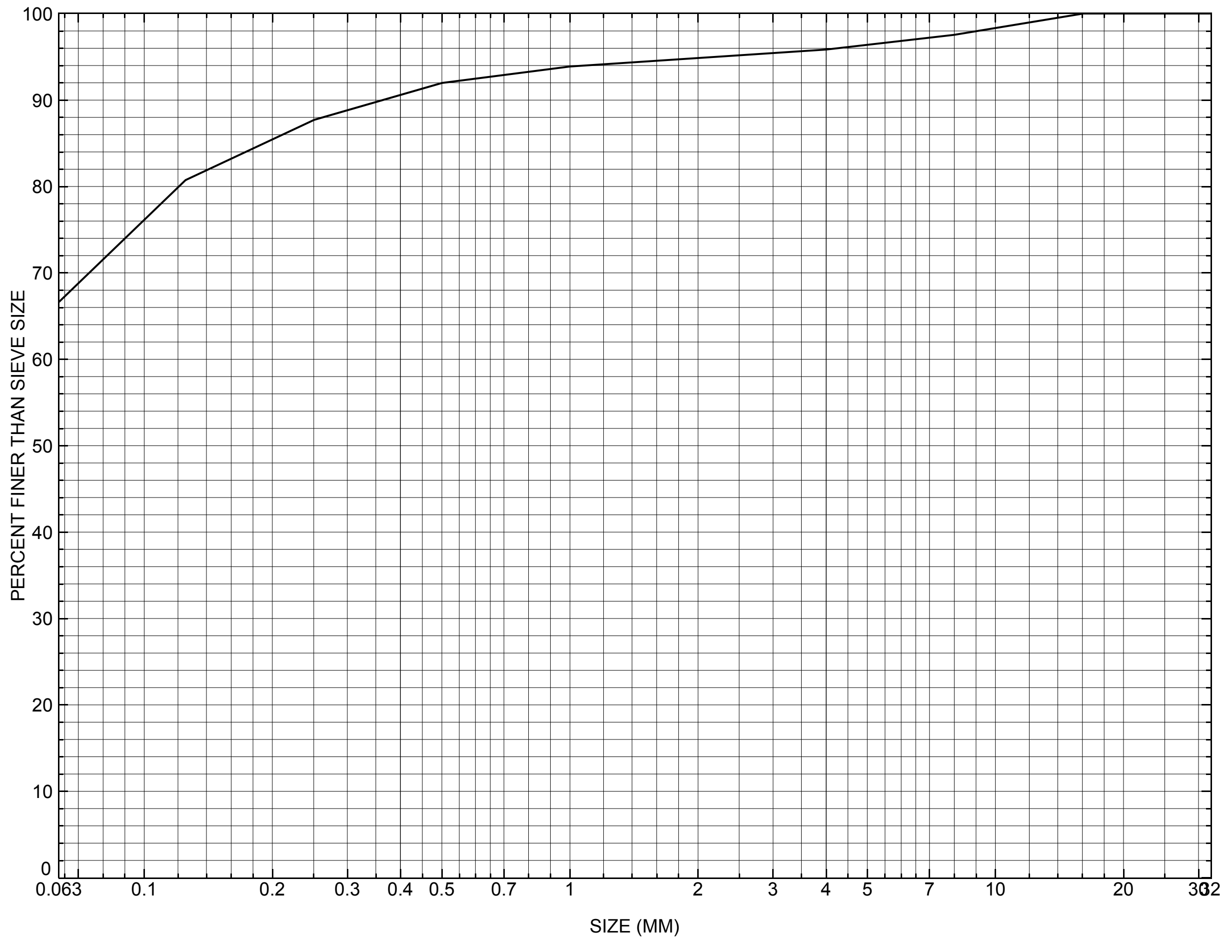
```
       U.S. Geological Survey WSPRO Input File albu006.wsp
       Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
       Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

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

EXITX:XS   ****** -1400.     837.  0.01 *****  497.21  495.09    220.  497.20
      -33. ******    81.   15555.  8.07 ***** *******    0.17    0.26

FULLV:FV      33. -1400.     829.  0.01  0.01  497.20 *******    220.  497.19
        0.    33.    81.   15383.  8.12  0.00   -0.01    0.17    0.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      45. -1400.     933.  0.01  0.01  497.20 *******    220.  497.19
       45.    45.   129.   19019. 11.54  0.00   -0.01    0.18    0.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   498.42       0.00     497.22     498.22

 ===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      33.     0.      42.  0.55  0.07  497.79  496.91    211.  497.24
        0.    33.    27.    1480.  1.40  0.52    0.00    0.83    5.01

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.845 ******  498.78 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG        9.    28.  0.00  0.00  498.31    0.00      9.  498.29

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    9.   251.  -753.  -502.   0.1   0.0   0.9   0.8   0.1   2.6
   RT:    0.   135.    70.   205.   0.7   0.4   3.3   4.2   0.7   2.7

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

APPRO:AS      21. -1400.    2684.  0.00  0.04  498.33  494.89    220.  498.33
       45.    91.   142.   74866.  4.24  0.50    0.00    0.02    0.08

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.983  0.832   12538.    -7.    20. ********

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

  FIRST USER DEFINED TABLE.
    XSID:CODE     SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS      -33. -1400.    81.    220.   15555.     837.    0.26  497.20
   FULLV:FV        0. -1400.    81.    220.   15383.     829.    0.27  497.19
   BRIDG:BR        0.     0.    27.    211.    1480.      42.    5.01  497.24
   RDWAY:RG        9.*******     9.      9.*********       0.    2.00  498.29
   APPRO:AS       45. -1400.   142.    220.   74866.    2684.    0.08  498.33

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -7.    20.   12538.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    495.09    0.17  493.25  502.00************  0.01  497.21  497.20
   FULLV:FV  ********    0.17  493.25  502.00  0.01  0.00  0.01  497.20  497.19
   BRIDG:BR    496.91    0.83  494.62  498.84  0.07  0.52  0.55  497.79  497.24
   RDWAY:RG  ****************  498.22  502.00  0.00******  0.00  498.31  498.29
   APPRO:AS    494.89    0.02  493.29  502.00  0.04  0.50  0.00  498.33  498.33
```

```
        U.S. Geological Survey WSPRO Input File albu006.wsp
        Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
        Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

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

EXITX:XS   ****** -1400.    1098.  0.01 *****  497.39  495.37    300.  497.38
      -33. ******    97.   21198.  6.63 ***** *******    0.14    0.27

FULLV:FV      33. -1400.    1093.  0.01  0.01  497.39 *******    300.  497.38
        0.    33.    97.   21087.  6.65  0.00   -0.01    0.14    0.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      45. -1400.    1221.  0.01  0.01  497.39 *******    300.  497.38
       45.    45.   132.   25651.  9.60  0.00   -0.01    0.15    0.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   499.01       0.00     497.41     498.22

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                   QRD,QRDMAX,RATIO =      71.        52.    1.37

            <<<<<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      33.     0.      48.  0.53  0.06  497.98  496.97    229.  497.45
        0.    33.    27.    1799.  1.48  0.53    0.00    0.77    4.80

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.821 ******  498.78 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q   WSEL
   RDWAY:RG       9.    28.  0.00  0.00  498.44    0.00     71.  498.40

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     71.   510.  -897.  -388.   0.2   0.1   1.5   1.3   0.1   2.6
   RT:      0.   135.    70.   205.   0.7   0.4   3.3   4.2   0.7   2.7

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

APPRO:AS      21. -1400.    2846.  0.00  0.05  498.43  495.20    300.  498.43
       45.   102.   144.   81719.  3.99  0.40    0.02    0.03    0.11

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.983  0.979    1721.   -49.   -23. ********

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -33. -1400.    97.    300.   21198.    1098.    0.27  497.38
   FULLV:FV       0. -1400.    97.    300.   21087.    1093.    0.27  497.38
   BRIDG:BR       0.     0.    27.    229.    1799.      48.    4.80  497.45
   RDWAY:RG       9.*******    71.     71.*********       0.    2.00  498.40
   APPRO:AS      45. -1400.   144.    300.   81719.    2846.    0.11  498.43

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     -49.   -23.    1721.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    495.37    0.14  493.25  502.00************  0.01  497.39  497.38
   FULLV:FV  ********    0.14  493.25  502.00  0.01  0.00  0.01  497.39  497.38
   BRIDG:BR    496.97    0.77  494.62  498.84  0.06  0.53  0.53  497.98  497.45
   RDWAY:RG  ****************  498.22  502.00  0.00******  0.00  498.44  498.40
   APPRO:AS    495.20    0.03  493.29  502.00  0.05  0.40  0.00  498.43  498.43
```

```
        U.S. Geological Survey WSPRO Input File albu006.wsp
        Hydraulic analysis for structure ALBUTH00150006   Date: 21-MAY-97
        Hydraulic analysis of bridge 6 over Mud Creek in Alburg, VT

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

EXITX:XS   ****** -1400.     726.  0.01 *****  497.13  494.96    190.  497.12
      -33. ******    74.   13432.  8.66 ***** *******    0.19    0.26

FULLV:FV      33. -1400.     722.  0.01  0.01  497.12 *******    190.  497.11
        0.    33.    74.   13358.  8.68  0.00   -0.01    0.19    0.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      45. -1400.     823.  0.01  0.01  497.13 *******    190.  497.12
       45.    45.   127.   16846. 12.07  0.00   -0.01    0.19    0.23
         <<<<<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      33.     0.      39.  0.51  0.07  497.65  496.83    190.  497.14
        0.    33.    27.    1332.  1.40  0.46    0.00    0.82    4.81

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.844 ******  498.78 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      21. -1400.    2459.  0.00  0.04  498.18  494.78    190.  498.18
       45.    86.   141.   65776.  4.66  0.50    0.00    0.02    0.08

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.983  0.803   12926.    -4.    22.  498.18

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -33. -1400.    74.    190.   13432.     726.    0.26  497.12
   FULLV:FV       0. -1400.    74.    190.   13358.     722.    0.26  497.11
   BRIDG:BR       0.     0.    27.    190.    1332.      39.    4.81  497.14
   RDWAY:RG       9.**************      0.******************    2.00********
   APPRO:AS      45. -1400.   141.    190.   65776.    2459.    0.08  498.18

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -4.    22.   12926.

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS      FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS    494.96     0.19  493.25  502.00************  0.01  497.13  497.12
   FULLV:FV  ********     0.19  493.25  502.00  0.01  0.00  0.01  497.12  497.11
   BRIDG:BR    496.83     0.82  494.62  498.84  0.07  0.46  0.51  497.65  497.14
   RDWAY:RG  ****************  498.22  502.00**********************************
   APPRO:AS    494.78     0.02  493.29  502.00  0.04  0.50  0.00  498.18  498.18
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ALBUTH00150006, in Alburg, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ALBUTH00150006

General Location Descriptive

Data collected by *(First Initial, Full last name)* E. BOEHMLER

Date *(MM/DD/YY)* 03 / 07 / 95

Highway District Number *(I - 2; nn)* 08

County *(FIPS county code; I - 3; nnn)* 013

Town *(FIPS place code; I - 4; nnnnn)* 00700

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

Waterway *(I - 6)* MUD CREEK

Road Name *(I - 7)*: -

Route Number TH015

Vicinity *(I - 9)* 0.9 MI TO JCT W CL3 TH10

Topographic Map Rouses.Point

Hydrologic Unit Code: 02010005

Latitude *(I - 16; nnnn.n)* 45000

Longitude *(i - 17; nnnnn.n)* 73161

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10070100060701

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

Maximum span length *(I - 48; nnnn)* 0028

Year built *(I - 27; YYYY)* 1936

Structure length *(I - 49; nnnnnn)* 000030

Average daily traffic, ADT *(I - 29; nnnnnn)* 000100

Deck Width *(I - 52; nn.n)* 171

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

Channel & Protection *(I - 61; n)* 3

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

Waterway adequacy *(I - 71; n)* 5

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

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*) 25.1

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

Vertical clearance from streambed (*nnn.n ft*) 3.7

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

Waterway of full opening (*nnn.n* ft^2) 92.9

Comments:

The structural inspection report of 5/10/93 indicates the structure is a steel stringer type bridge with a concrete deck. The abutments and wingwalls are concrete. The left abutment has a vertical crack just downstream from the roadway centerline with 1 to 1.5 inches of movement indicated along the crack. The left abutment also has a diagonal crack just upstream of the roadway centerline. The right abutment is cracked at both the upstream and downstream ends. Accessibility under the bridge is limited by a 1.5 foot clearance from the water surface due to a beaver dam located at the downstream face of the bridge. There is a concrete overflow pipe behind the right abutment. The water is stagnant and **(Continued, page 34)**

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*): U 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:

very murky. No riprap protection was noticeable. Some settlement was noted as possible. No scour was visible. Roadway embankments were noted as showing some erosion.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **2.90** mi^2

Lake/pond/swamp area **1.05** mi^2

Watershed storage *(ST)* **36.2** %

Bridge site elevation **100** ft

Headwater elevation **140** ft

Main channel length **1.76** mi

10% channel length elevation **100** ft

85% channel length elevation **120** ft

Main channel slope *(S)* **15.15** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in

Average headwater precipitation ______ in

Maximum 2yr-24hr precipitation event *(I24,2)* **2.09** in

Average seasonal snowfall *(Sn)* **7.0** ft

Bridge Plan Data

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

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness _______ Footing bottom elevation: ______

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

If 3: Footing bottom elevation: ______

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

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

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

Comments:
NO PLANS.

Cross-sectional Data

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

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

Comments: NO CROSS SECTION INFORMATION

-

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

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

Source (*FEMA, VTAOT, Other*)? NO

Comments: CROSS SECTION INFORMATION

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **3/18/96**
Computerized by: **RB** Date: **3/25/96**
Reviewd by: **SAO** Date: **6/6/97**

Structure Number **ALBUTH00150006**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. BOEHMLER** Date *(MM/DD/YY)* **6** / **26** / 19**95**

2. Highway District Number **08** Mile marker **000**

County **GRAND ISLE (013)** Town **ALBURG 00700**

Waterway *(I - 6)* **MUD CREEK** Road Name **-**

Route Number **TH015** Hydrologic Unit Code: **02010005**

3. Descriptive comments:

Located 0.9 mile from the intersection of TH 10 and TH 15.

B. Bridge Deck Observations

4. Surface cover... LBUS **7** RBUS **7** LBDS **7** RBDS **7** Overall **7**
*(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 **1** 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 **30** *(feet)* Span length **28.6** *(feet)* Bridge width **17.1** *(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)*

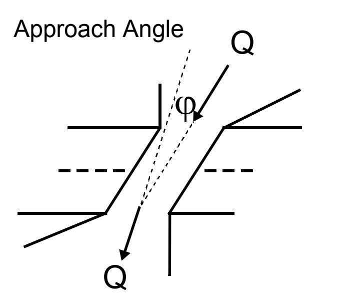
10. Embankment slope (*run / rise in feet / foot*):
US left **1.8:1** US right **2.5:1**

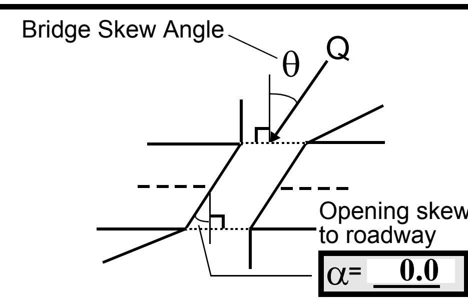
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	2	2
RBUS	0	-	2	1
RBDS	0	-	0	0
LBDS	0	-	2	1

*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: **5** 16. Bridge skew: **0**





α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **70** feet **DS** *(US, UB, DS)* to **100** feet **DS**

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

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

18. Bridge Type: **1a/2**

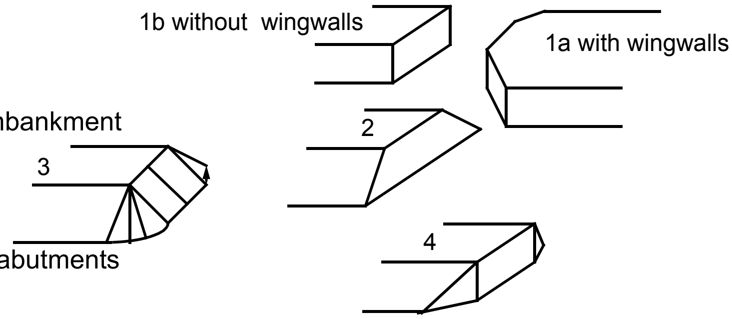
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. Wetlands are all around the bridge area. Some areas in the wetlands are higher ground with a few trees but vegetation is mostly swamp grasses and small shrubs.

18. The wingwalls are at 90 degrees and sloping for the top 2 feet.

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
38.5	**0.5**			**1.0**	**1**	**1**	**120**	**120**	**0**	**0**

23. Bank width **5.0** 24. Channel width **10.0** 25. Thalweg depth **43.0** 29. Bed Material **012**

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

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

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

The channel US is pooled from debris and fill blockage under the bridge. The channel is filling in with branches and trees which are currently covering the bottom. Three small channels drain the wetland US and converge about 150 feet US and flow into a large pooled area. There is a small area where a hole has developed just US of the bridge.

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

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

37. Material: -

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 20

47. Scour dimensions: Length 30 Width 30 Depth : 2 Position 10 %LB to 90 %RB

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

-

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
31.5		2.0		2	7	7	-

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

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

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

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

210

A chicken wire fence is stretched across two road sign posts and goes at least half way across the span under the bridge from the right abutment. The main part of the flow is along the left abutment, but there is debris here also. Debris accounts for about 15-20% of the under bridge area. In addition to natural debris, there are hub caps, mail boxes, cow carcasses, antique metal milk jugs and more. The fence is across both the US and DS bridge faces. The bed material under the bridge is more sandy and partly covered by class 1 stone fill.

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

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

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

70. Debris and Ice Comments:

3

The fence across the US and DS faces will continue to block debris.
The beaver dam mentioned in the historical form no longer exists.

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		0	90	2	2	0	1	90.0
RABUT	1	-	90			2	2	26.5

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

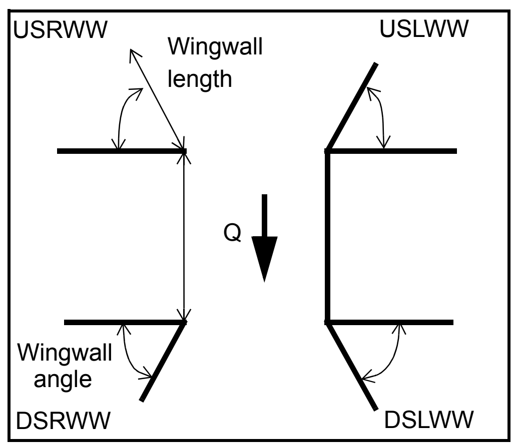
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
1
1
The footings on both abutments are logs which are exposed.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						26.5	
USRWW:	Y		1		2	0.5	
DSLWW:	0		1		Y	18.5	
DSRWW:	1		2		0	18.5	

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	1	2	Y	0	-	-	-	-
Condition	Y	0	1	1	-	-	-	-
Extent	1	1	2	0	0	0	0	-

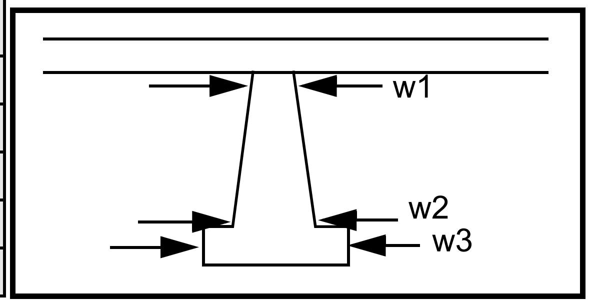
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**6.0**	**6.0**	**90.0**	**90.0**	**90.0**
Pier 2	**6.0**	**6.0**	-	**90.0**	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

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

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

Comments (eg. bank material variation, minor inflows, protection extent, etc.):
-
-
-
-
-
-
NO PIERS

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

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

105. Drop structure comments (eg. downstream scour depth):
1
120
120
0
2
012

106. Point/Side bar present? 0 (Y or N. if N type ctrl-n pb) Mid-bar distance: 0 Mid-bar width: -

Point bar extent: - feet Th (US, UB, DS) to e bed feet is (US, UB, DS) positioned cov %LB to ere %RB

Material: d

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

mostly with organic material with silt and clay and a little fine sand underneath. There is a very low gradient and little bed erosion.

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

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

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

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

Y

Is channel scour present? 4 (Y or if N type ctrl-n cs) Mid-scour distance: A log

Scour dimensions: Length span Width s the Depth: cha Positioned nne %LB to l at %RB

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

the DS face from the left abutment to mid span where in disappears below fill under the bridge for the right half of the span.

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

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

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

Confluence comments (eg. confluence name):

-

-

F. Geomorphic Channel Assessment

107. Stage of reach evolution -

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

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

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NO POINT BARS

Y
RB
25
10
DS
42
DS
1

109. G. Plan View Sketch

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ALBUTH00150006 Town: ALBURG
Road Number: TH15 County: GRAND ISLE
Stream: MUD CREEK

Initials SAO Date: 6/3/97 Checked: EMB

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	220	300	190
Main Channel Area, ft2	142	145	138
Left overbank area, ft2	2392	2531	2182
Right overbank area, ft2	153	164	136
Top width main channel, ft	31	31	31
Top width L overbank, ft	1397	1397	1397
Top width R overbank, ft	114	115	113
D50 of channel, ft	0.000155	0.000155	0.000155
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.6	4.7	4.5
y1, average depth, LOB, ft	1.7	1.8	1.6
y1, average depth, ROB, ft	1.3	1.4	1.2
Total conveyance, approach	74980	81510	65639
Conveyance, main channel	16322	16925	15434
Conveyance, LOB	53642	58963	46044
Conveyance, ROB	5016	5622	4161
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	47.9	62.3	44.7
Ql, discharge, LOB, cfs	157.4	217.0	133.3
Qr, discharge, ROB, cfs	14.7	20.7	12.0
Vm, mean velocity MC, ft/s	0.3	0.4	0.3
Vl, mean velocity, LOB, ft/s	0.1	0.1	0.1
Vr, mean velocity, ROB, ft/s	0.1	0.1	0.1
Vc-m, crit. velocity, MC, ft/s	0.8	0.8	0.8
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	220	300	190
(Q) discharge thru bridge, cfs	211	229	190
Main channel conveyance	1473	1795	1328
Total conveyance	1473	1795	1328
Q2, bridge MC discharge,cfs	211	229	190
Main channel area, ft2	42.1	47.6	39.4
Main channel width (normal), ft	26.5	26.6	26.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	26.5	26.6	26.5
y_bridge (avg. depth at br.), ft	1.59	1.79	1.49
Dm, median (1.25*D50), ft	0.000194	0.000194	0.000194
y2, depth in contraction,ft	8.43	9.01	7.70
ys, scour depth (y2-ybridge), ft	6.84	7.22	6.22

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	211	229	190	
Main channel area (DS), ft2	42.1	47.6	39.4	
Main channel width (normal), ft	26.5	26.6	26.5	
Cum. width of piers, ft	0.0	0.0	0.0	
Adj. main channel width, ft	26.5	26.6	26.5	
D90, ft	0.00119	0.00119	0.00119	
D95, ft	0.00686	0.00686	0.00686	
Dc, critical grain size, ft	0.0270	0.0242	0.0253	
Pc, Decimal percent coarser than Dc	0.000	0.000	0.000	<===???
Depth to armoring, ft	ERR	ERR	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)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	220	300	190	220	300	190
a', abut.length blocking flow, ft	1399.8	1399.9	1399.8	115.8	117	114.1
Ae, area of blocked flow ft2	2398.1	2490.6	2195.7	166.9	178.5	148.6
Qe, discharge blocked abut.,cfs	--	--	137.4	20.2	27.9	17
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.07	0.09	0.06	0.12	0.16	0.11
ya, depth of f/p flow, ft	1.71	1.78	1.57	1.44	1.53	1.30
--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	0.009	0.011	0.009	0.018	0.022	0.018
ys, scour depth, ft	4.96	5.60	4.59	2.95	3.33	2.72

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)	1399.8	1399.9	1399.8	115.8	117	114.1
y1 (depth f/p flow, ft)	1.71	1.78	1.57	1.44	1.53	1.30
a'/y1	817.08	786.85	892.40	80.35	76.69	87.61
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.01	0.01	0.01	0.02	0.02	0.02
Ys w/ corr. factor K1/0.55:						
vertical	2.64	2.96	2.39	2.77	3.16	2.50
vertical w/ ww's	2.17	2.43	1.96	2.27	2.59	2.05
spill-through	1.45	1.63	1.32	1.52	1.74	1.38

Abutment riprap Sizing

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

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.83	0.77	0.82	0.83	0.77	0.82
y, depth of flow in bridge, ft	1.59	1.79	1.49	1.59	1.79	1.49
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	0.66	ERR	ERR	0.66	ERR
Fr>0.8 (vertical abut.)	0.63	ERR	0.59	0.63	ERR	0.59