LEVEL II SCOUR ANALYSIS FOR BRIDGE 11 (HINETH00040011) on TOWN HIGHWAY 4 (FAS 199), crossing LEWIS CREEK, HINESBURG, VERMONT

U.S. Geological Survey
Open-File Report 97-106

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

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By MICHAEL A. IVANOFF AND RONDA L. BURNS

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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 11 (HINETH00040011) ON TOWN HIGHWAY 4 (FAS 199), CROSSING LEWIS CREEK, HINESBURG, VERMONT

By **Michael A. Ivanoff and Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure HINETH00040011 on Town Highway 4 crossing Lewis Creek, Hinesburg, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in northwestern Vermont. The 38.4-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture.

In the study area, Lewis Creek has an incised, straight channel with a slope of approximately 0.001 ft/ft, an average channel top width of 60 ft and an average channel depth of 7 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 47.0 mm (0.154 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 3, 1996, indicated that the reach was stable.

The Town Highway 4 crossing of Lewis Creek is an 84-foot-long, two-lane bridge consisting of one 82-foot steel-beam span (Vermont Agency of Transportation, written communication, December 15, 1995). The bridge is supported by vertical, concrete abutments with wingwalls and spill-through embankments at each abutment. The channel is skewed approximately 40 degrees to the opening while the opening-skew-to-roadway is 15 degrees.

The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) at the downstream left and right wingwalls and the downstream right bank. Scour protection also included type-3 stone fill (less than 48 inches diameter) at the left and right upstream wingwalls, both abutments, both upstream banks, and the left bank downstream. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 1.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 14.1 to 18.2 ft. Right abutment scour ranged from 9.9 to 13.4 ft. The worst-case abutment scour occurred at left abutment for the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Hinesburg, VT. Quadrangle, 1:24,000, 1948
Photorevised 1987

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 HINETH00040011 ***Stream*** Lewis Creek

County Chittenden ***Road*** TH4 ***District*** 5

Description of Bridge

Bridge length 84 ***ft*** ***Bridge width*** 31.6 ***ft*** ***Max span length*** 82 ***ft***

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

Abutment type Spill-through, stone fill ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 07/03/96

Description of stone fill Type-2, at the base of the left and right downstream wingwalls and downstream right bank. Type-3, on the spill-through slope of each abutment and upstream wingwall, both upstream banks, and left bank downstream.

Abutments are spill-through type with stone fill extending from the toe of the vertical, concrete part of the abutment located at the top of the bank.

Yes

Is bridge skewed to flood flow according to There ***survey?*** ***Angle*** 40 Yes

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	07/03/96	0	0
Level II	07/03/96	0	0

Potential for debris Low. There is some debris caught on the stone fill at the base of the abutments and the upstream right bank.

Describe any features near or at the bridge that may affect flow (include observation date) None, 07/03/96.

Description of the Geomorphic Setting

General topography The channel is located in a low relief valley with moderately sloping valley walls and a mild gradient bed slope.

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

Date of inspection 07/03/96

DS left: Moderately sloped valley wall

DS right: Moderately sloped channel bank to a narrow overbank

US left: Moderately sloped valley wall

US right: Moderately sloped channel bank to a narrow overbank

Description of the Channel

Average top width 60.0

Average depth 7.0

Predominant bed material Gravel to Boulders

Bank material Silt/sand

Straight and stable with semi-alluvial channel boundaries.

07/03/96

Vegetative co

Pasture

DS left: Pasture

DS right: Pasture

US left: Some brush and trees on immediate channel bank with pasture beyond

US right:

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

None 07/03/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 38.0 ***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 4,850 ***ft³/s*** ***Q500*** 7,200 ***ft³/s***

The 100- and 500-year discharges are the median values based on a comparison of empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Add 0.3 ft. to USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a State of Vermont survey mark, set in the top of the upstream end of the left abutment (elev. 498.74 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the right abutment (elev. 498.13 ft, arbitrary survey datum). RM3 is a chiseled X on top of the upstream end of the right abutment (elev. 497.50 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	-87	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	20	1	Road Grade section
APPRO	116	1	Approach section as surveyed

[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 0.040 to 0.046, and overbank "n" values ranged from 0.025 to 0.037.

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 0.001 ft/ft which was from surveyed thalweg points downstream of the exit section.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 499.0 ***ft***
Average low steel elevation 494.5 ***ft***

100-year discharge 4,850 ***ft^3/s***
Water-surface elevation in bridge opening 493.8 ***ft***
Road overtopping? No ***Discharge over road*** -- ***s***
Area of flow in bridge opening 662 ***ft^2***
Average velocity in bridge opening 7.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.5 ***ft/s***

Water-surface elevation at Approach section with bridge 494.5
Water-surface elevation at Approach section without bridge 494.2
Amount of backwater caused by bridge 0.3 ***t***

500-year discharge 7,200 ***ft^3/s***
Water-surface elevation in bridge opening 495.3 ***ft***
Road overtopping? No ***Discharge over road*** -- ***$^3/s$***
Area of flow in bridge opening 715 ***ft^2***
Average velocity in bridge opening 10.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.5 ***/s***

Water-surface elevation at Approach section with bridge 498.0
Water-surface elevation at Approach section without bridge 495.8
Amount of backwater caused by bridge 2.2

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year discharge was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for the 500-year discharge was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour for this event were also computed and can be found in appendix F.

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 spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depth computed at the toe of each abutment was applied to the entire area of the embankment, as shown in 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	1.8	--
Depth to armoring	0.5	4.2	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	14.1	18.2	--
Right abutment	9.9	13.4	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.2	2.1	--
Right abutment	1.2	2.1	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

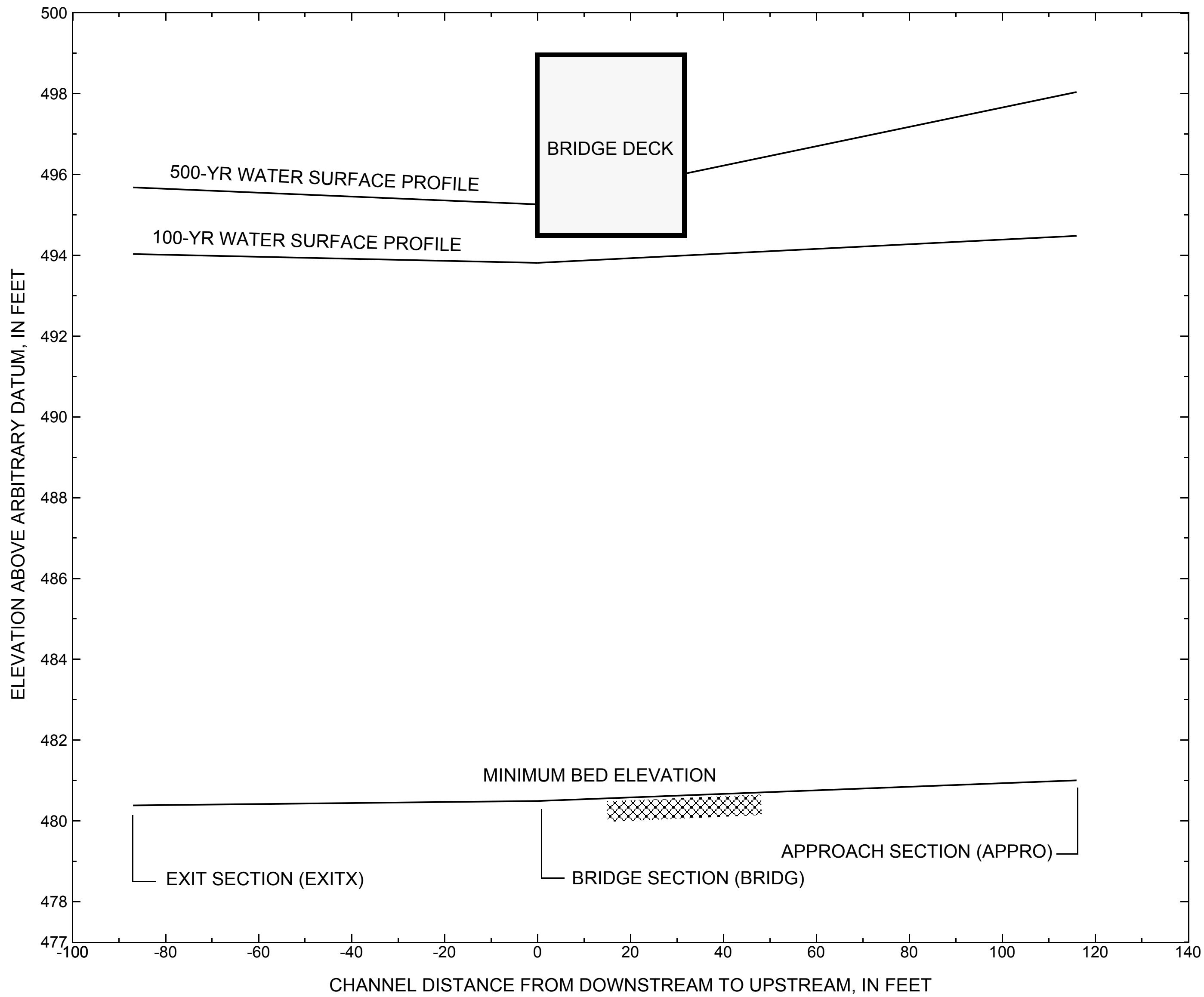

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure HINETH00040011 on Town Highway 4, crossing Lewis Creek, Hinesburg, Vermont.

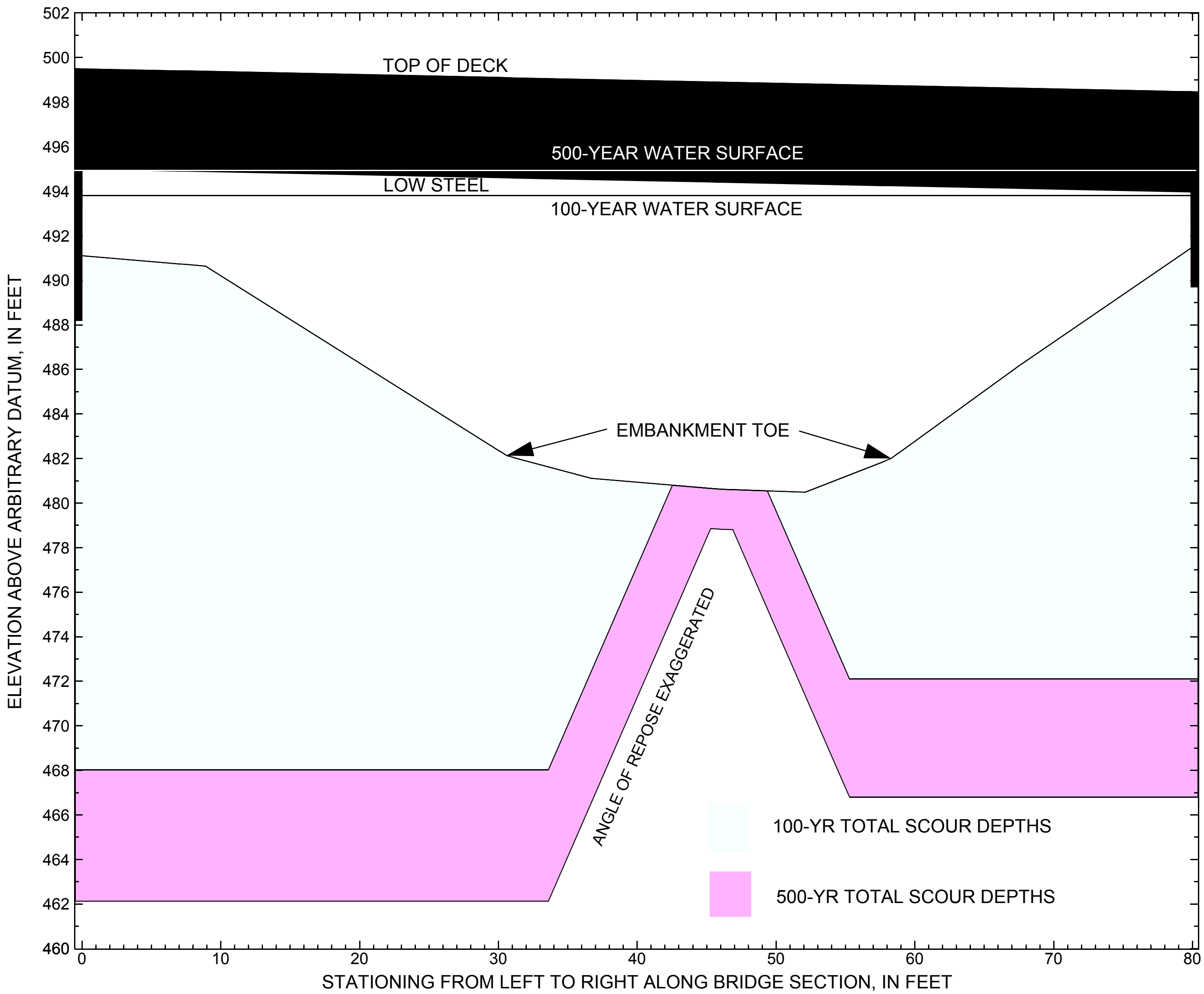

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure HINETH00040011 on Town Highway 4, crossing Lewis Creek, Hinesburg, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure HINETH00040011 on Town Highway 4, crossing Lewis Creek, Hinesburg, 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 4,850 cubic-feet per second											
Left abutment	0.0	--	495.3	488.2	491.1	--	--	--	--	--	-20.2
Left embankment toe	31.1	--	--	--	482.1	0.0	14.1	--	14.1	468.0	--
Right embankment toe	57.8	--	--	--	482.0	0.0	9.9	--	9.9	472.1	--
Right abutment	79.9	--	493.7	489.7	491.7	--	--	--	--	--	-17.6

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 HINETH00040011 on Town Highway 4, crossing Lewis Creek, Hinesburg, 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 7,200 cubic-feet per second											
Left abutment	0.0	--	495.3	488.2	491.1	--	--	--	--	--	-26.1
Left embankment toe	31.1	--	--	--	482.1	1.8	18.2	--	20.0	462.1	--
Right embankment toe	57.8	--	--	--	482.0	1.8	13.4	--	15.2	466.8	--
Right abutment	79.9	--	493.7	489.7	491.7	--	--	--	--	--	-22.9

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

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U.S. Geological Survey, 1948, Hinesburg, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1987, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File hine011.wsp
T2        Hydraulic analysis for structure HINETH00040011   Date: 29-OCT-96
T3        Bridge # 11 over Lewis Creek in Hinesburg, VT by MAI
*
J1         * * 0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           4850.0   7200.0
SK          0.0010   0.0010
*
XS   EXITX    -87
GR         -329.6, 524.30   -181.7, 504.89    -87.9, 493.05      0.0, 487.94
GR           12.7, 481.90     13.9, 481.36     19.4, 480.51     26.1, 480.43
GR           32.9, 480.38     38.3, 481.08     38.4, 481.95     40.7, 482.82
GR           43.3, 483.23     55.0, 487.95    154.4, 494.39    195.7, 498.42
GR          346.7, 502.81    665.2, 525.02
N           0.035        0.044        0.037
SA                   0.0          55.0
*
XS   FULLV      0  * * *  0.0022
*
*              SRD     LSEL    XSSKEW
BR   BRIDG      0    494.49      15.0
GR            0.0, 495.26      0.0, 491.13      8.9, 490.64     31.1, 482.13
GR           36.7, 481.11     45.8, 480.63     52.1, 480.49     57.8, 482.00
GR           67.5, 486.16     79.6, 491.66     79.9, 493.72      0.0, 495.26
*
*         BRTYPE  BRWDTH  EMBSS  EMBELV  WWANGL  WWWID
CD            1     46.9     *      *     64.5    9.3
N           0.040
*
*              SRD    EMBWID   IPAVE
XR   RDWAY     20      31.6     1
GR         -494.4, 535.73   -385.6, 525.37   -297.9, 517.25   -176.5, 507.80
GR          -77.1, 502.43      0.0, 499.75     80.0, 498.21    195.7, 498.42
GR          346.7, 502.81    665.2, 525.02
*
AS   APPRO    116
*
GR         -243.1, 517.17   -118.0, 506.67    -64.5, 503.45    -52.4, 502.07
GR          -16.0, 489.21     16.0, 487.57     26.7, 486.19     32.8, 483.39
GR           36.6, 482.52     38.9, 481.88     49.8, 481.73     57.8, 481.00
GR           62.5, 481.31     67.9, 481.61     69.1, 482.59     87.9, 495.53
GR          145.8, 498.17    360.0, 501.07    424.3, 506.64    555.2, 527.13
N           0.030        0.046        0.025
SA                  26.7          87.9
*
HP 1 BRIDG    493.81 1 493.81
HP 2 BRIDG    493.81 * * 4850
HP 1 APPRO    494.48 1 494.48
HP 2 APPRO    494.48 * * 4850
*
HP 1 BRIDG    495.26 1 495.26
HP 2 BRIDG    495.26 * * 7200
HP 1 APPRO    498.04 1 498.04
HP 2 APPRO    498.04 * * 7200
*
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File hine011.wsp
        Hydraulic analysis for structure HINETH00040011   Date: 29-OCT-96
        Bridge # 11 over Lewis Creek in Hinesburg, VT by MAI
           *** RUN DATE & TIME: 11-01-96  11:55
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      662     93208     73     90                        11349
   493.81           662     93208     73     90  1.00      0     80    11349

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

         WSEL     LEW     REW    AREA         K        Q    VEL
       493.81     0.0    79.9   662.4   93208.    4850.   7.32

X STA.         0.0       17.0       22.8       26.9       30.0       32.6
  A(I)            62.1       41.4       36.3       32.2       29.8
  V(I)            3.90       5.85       6.68       7.53       8.13

X STA.        32.6       35.0       37.2       39.4       41.5       43.5
  A(I)            28.1       27.1       26.7       25.7       25.9
  V(I)            8.64       8.94       9.08       9.43       9.35

X STA.        43.5       45.6       47.6       49.6       51.6       53.8
  A(I)            25.5       25.7       26.1       25.9       27.4
  V(I)            9.51       9.45       9.31       9.35       8.84

X STA.        53.8       56.2       58.8       62.2       66.8       79.9
  A(I)            28.7       30.8       34.5       40.0       62.4
  V(I)            8.45       7.87       7.04       6.06       3.89


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     116.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      316     48109     58     59                         4190
             2      625     91877     60     65                        11470
   494.48           940    139986    117    123  1.00    -30     86    15099

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     116.

         WSEL     LEW     REW    AREA         K        Q    VEL
       494.48   -30.9    86.4   940.2  139986.    4850.   5.16

X STA.       -30.9      -11.0       -2.7        4.8       11.4       17.4
  A(I)            66.3       47.9       45.9       42.8       41.1
  V(I)            3.66       5.06       5.28       5.67       5.90

X STA.        17.4       22.7       27.5       32.6       36.5       39.9
  A(I)            39.1       39.2       50.4       44.2       42.0
  V(I)            6.20       6.18       4.82       5.48       5.78

X STA.        39.9       43.1       46.3       49.6       52.9       56.0
  A(I)            40.9       41.1       41.7       41.9       41.6
  V(I)            5.93       5.91       5.82       5.79       5.83

X STA.        56.0       59.2       62.6       66.2       70.8       86.4
  A(I)            42.5       44.7       47.0       55.9       84.0
  V(I)            5.70       5.42       5.16       4.34       2.89
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File hine011.wsp
        Hydraulic analysis for structure HINETH00040011   Date: 29-OCT-96
        Bridge # 11 over Lewis Creek in Hinesburg, VT by MAI
           *** RUN DATE & TIME: 11-01-96  11:55
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      715     70991      0    164                            0
   495.26           715     70991      0    164  1.00      0     80        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.26     0.0    79.9   715.1   70991.    7200.  10.07

X STA.         0.0       13.7       20.3       24.7       28.2       31.0
  A(I)             61.5       47.0       39.8       37.0       32.9
  V(I)             5.85       7.66       9.04       9.74      10.93

X STA.        31.0       33.6       36.0       38.3       40.6       42.8
  A(I)             31.5       30.8       30.0       28.8       29.0
  V(I)            11.43      11.67      12.00      12.49      12.42

X STA.        42.8       44.9       47.1       49.3       51.5       53.8
  A(I)             28.7       28.9       29.2       29.0       29.9
  V(I)            12.53      12.48      12.32      12.41      12.03

X STA.        53.8       56.2       59.0       62.6       67.4       79.9
  A(I)             30.9       32.8       37.2       41.5       58.5
  V(I)            11.64      10.97       9.68       8.68       6.15


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     116.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      539    104907     68     69                         8620
             2      842    148213     61     66                        17716
             3       69      4787     55     55                          439
   498.04          1449    257908    184    191  1.05    -40    143    22500

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     116.

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.04   -41.0   142.9  1449.4  257908.    7200.   4.97

X STA.       -41.0      -16.5       -8.7       -1.6        4.7       10.7
  A(I)            105.8       70.6       66.0       62.1       59.5
  V(I)             3.40       5.10       5.45       5.80       6.05

X STA.        10.7       16.3       21.4       26.1       31.8       36.3
  A(I)             58.1       56.1       53.4       73.2       68.0
  V(I)             6.20       6.42       6.74       4.92       5.30

X STA.        36.3       40.4       44.4       48.3       52.3       56.2
  A(I)             65.1       64.2       63.9       65.3       64.7
  V(I)             5.53       5.61       5.64       5.51       5.56

X STA.        56.2       60.1       64.2       68.8       75.5      142.9
  A(I)             66.0       69.3       75.0       90.0      153.3
  V(I)             5.45       5.19       4.80       4.00       2.35
```

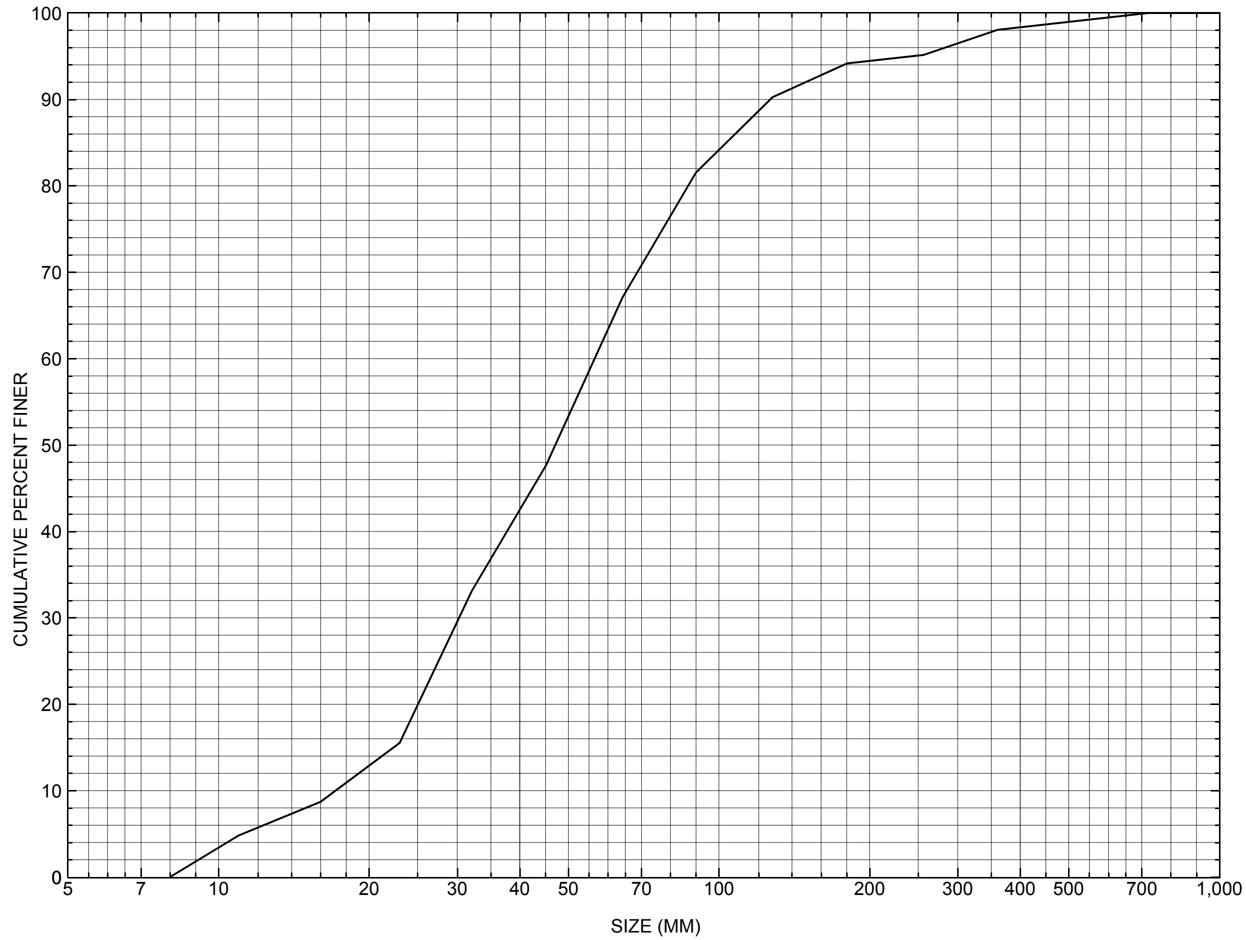
```
        U.S. Geological Survey WSPRO Input File hine011.wsp
        Hydraulic analysis for structure HINETH00040011   Date: 29-OCT-96
        Bridge # 11 over Lewis Creek in Hinesburg, VT by MAI
           *** RUN DATE & TIME: 11-01-96  11:55

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

EXITX:XS   ******    -95     1214  0.31 *****  494.34  489.77    4850  494.03
       -86 ******    149   153303  1.25 ***** *******    0.35    3.99

FULLV:FV       87    -94     1189  0.32  0.09  494.45 *******    4850  494.12
         0     87    147   149394  1.25  0.01    0.01    0.36    4.08
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      116    -29      907  0.44  0.14  494.64 *******    4850  494.20
       116    116     86   132800  1.00  0.06    0.00    0.34    5.34
         <<<<<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       87      0      662  0.83  0.14  494.64  489.59    4850  493.81
         0     87     80    93298  1.00  0.15    0.00    0.43    7.33

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  494.49 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      20.        <<<<<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       69    -30      940  0.41  0.13  494.90  489.75    4850  494.48
       116     72     86   140038  1.00  0.13    0.00    0.32    5.16

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.312  0.065  130902.    -1.    79.   494.38

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -87.   -96.   149.   4850.  153303.    1214.    3.99  494.03
   FULLV:FV       0.   -95.   147.   4850.  149394.    1189.    4.08  494.12
   BRIDG:BR       0.     0.    80.   4850.   93298.     662.    7.33  493.81
   RDWAY:RG      20.**************       0.******************    1.00********
   APPRO:AS     116.   -31.    86.   4850.  140038.     940.    5.16  494.48

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    79.  130902.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    489.77    0.35  480.38  525.02************  0.31  494.34  494.03
   FULLV:FV  ********    0.36  480.57  525.21  0.09  0.01  0.32  494.45  494.12
   BRIDG:BR    489.59    0.43  480.49  495.26  0.14  0.15  0.83  494.64  493.81
   RDWAY:RG ****************  498.21  535.73**********************************
   APPRO:AS    489.75    0.32  481.00  527.13  0.13  0.13  0.41  494.90  494.48
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File hine011.wsp
        Hydraulic analysis for structure HINETH00040011   Date: 29-OCT-96
        Bridge # 11 over Lewis Creek in Hinesburg, VT by MAI
           *** RUN DATE & TIME: 11-01-96  11:55

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

EXITX:XS   ******   -108     1645  0.35 *****  496.04  491.57    7200  495.68
       -86 ******    168   227659  1.19 ***** *******    0.35    4.38

FULLV:FV       87   -107     1617  0.37  0.09  496.14 *******    7200  495.77
         0     87    167   222539  1.19  0.01    0.01    0.35    4.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      116    -34     1096  0.67  0.15  496.45 *******    7200  495.77
       116    116     93   176061  1.01  0.15    0.00    0.40    6.57
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   495.77      494.49

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

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

BRIDG:BR       87      0      715  1.58 *****  496.84  491.69    7209  495.26
         0 ******     80    70991  1.00 ***** *******    0.59   10.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800 ******  494.49 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
   RDWAY:RG      20.        <<<<<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       69    -40     1449  0.40  0.20  498.44  491.06    7200  498.04
       116     72    143   257904  1.05  0.13    0.00    0.32    4.97


  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXITX:XS     -87.  -109.   168.   7200.  227659.    1645.    4.38  495.68
   FULLV:FV       0.  -108.   167.   7200.  222539.    1617.    4.45  495.77
   BRIDG:BR       0.     0.    80.   7209.   70991.     715.   10.08  495.26
   RDWAY:RG      20.**************      0.       0.       0.    1.00********
   APPRO:AS     116.   -41.   143.   7200.  257904.    1449.    4.97  498.04


 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN     YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.57    0.35  480.38  525.02************  0.35  496.04  495.68
   FULLV:FV  ********    0.35  480.57  525.21  0.09  0.01  0.37  496.14  495.77
   BRIDG:BR    491.69    0.59  480.49  495.26************  1.58  496.84  495.26
   RDWAY:RG  ****************  498.21  535.73************  0.39  498.55********
   APPRO:AS    491.06    0.32  481.00  527.13  0.20  0.13  0.40  498.44  498.04
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure HINETH00040011, in Hinesburg, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number HINETH000400011

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 15 / 95

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

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

Town *(FIPS place code; I - 4; nnnnn)* 33475

Mile marker *(I - 11; nnn.nnn)* 000290

Waterway *(I - 6)* LEWIS CREEK

Road Name *(I - 7)*: FAS 199

Route Number TR 04

Vicinity *(I - 9)* 3.1 MI SOUTH JCT. VT.116

Topographic Map Hinesburg

Hydrologic Unit Code: 2010002

Latitude *(I - 16; nnnn.n)* 44170

Longitude *(i - 17; nnnnn.n)* 73065

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20019900110407

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

Maximum span length *(I - 48; nnnn)* 0082

Year built *(I - 27; YYYY)* 1983

Structure length *(I - 49; nnnnnn)* 000084

Average daily traffic, ADT *(I - 29; nnnnnn)* 002880

Deck Width *(I - 52; nn.n)* 316

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

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

Opening skew to Roadway *(I - 34; nn)* 15

Waterway adequacy *(I - 71; n)* 8

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 82

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

Vertical clearance from streambed (*nnn.n ft*) 12

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

Waterway of full opening (*nnn.n ft*^{2}) 984

Comments:

The structure is a steel beam bridge with a concrete deck.

Bridge Hydrologic Data

Is there hydrologic data available? Y *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: 38.4

Terrain character: ______

Stream character & type:

Streambed material: ______

Discharge Data *(cfs)*: $Q_{2.33}$ 1150 Q_{10} 2700 Q_{25} 3600

Q_{50} 4600 Q_{100} 5600 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*)	489.2	492	493.2	494.4	495.4
Velocity (*ft / sec*)					

Long term stream bed changes:

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

Relief Elevation (*ft*): ______ Discharge over roadway at Q_{100} (*ft³/ 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 (*ft²*): ______

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

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

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

Comments:

Tailwater depth @ Q 25 = 8.7'; velocity @ Q 25 = 9.1 fps.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **38.41** mi^2 Lake and pond area **0.09** mi^2

Watershed storage *(ST)* **0.23** %

Bridge site elevation **340** ft Headwater elevation **2250** ft

Main channel length **19.26** mi

10% channel length elevation **420** ft 85% channel length elevation **1060** ft

Main channel slope *(S)* **44.31** 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)*: - / 1939

Project Number BHS 0199 (1) Minimum channel bed elevation: -

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

Benchmark location description:

BM #1, assumed elevation, 500 feet, at corner of left abutment and downstream wingwall.
BM #2, assumed elevation, 504.66 feet, on 24 inch elm, S.I.R., near upstream edge of road, 300 feet to north (right) of bridge.

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

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

If 1: Footing Thickness ____ Footing bottom elevation: 490

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? Y *If no, type ctrl-n bi* Number of borings taken: 2

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

Briefly describe material at foundation bottom elevation or around piles:

Bottom of the right abutment is in sandy silt, at 490 feet.
Bottom of the left abutment is in sandy gravel at 488.5 feet.

Comments:

Cross-sectional Data

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

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

Comments: **NO CROSS SECTIONAL INFORMATION**

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

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

Comments: -
-

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **EW** Date: **10/9/96**
Computerized by: **EW** Date: **10/11/96**
Reviewd by: **MAI** Date: **12/11/96**

Structure Number **HINETH00040011**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. BURNS** Date *(MM/DD/YY)* **07** / **03** / 19**96**

2. Highway District Number **05** Mile marker **000290**

County **CHITTENDEN (007)** Town **HINEBURG (33475)**

Waterway *(I - 6)* **LEWIS CREEK** Road Name **FAS 199**

Route Number **TH04** Hydrologic Unit Code: **2010002**

3. Descriptive comments:

Located 3.1 miles south of junction with VT 116.

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 **84** *(feet)* Span length **82** *(feet)* Bridge width **31.6** *(feet)*

Road approach to bridge:

8. LB **2** RB **2** *(**0** even, **1**- lower, **2**- higher)*

9. LB **1** RB **1** *(**1**- Paved, **2**- Not paved)*

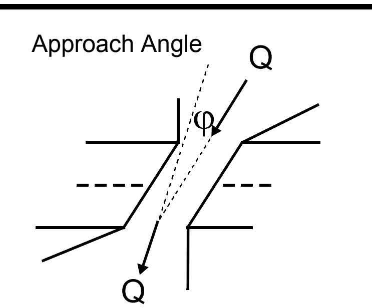
10. Embankment slope (*run / rise in feet / foot*):
US left **2.0:1** US right **4.9:1**

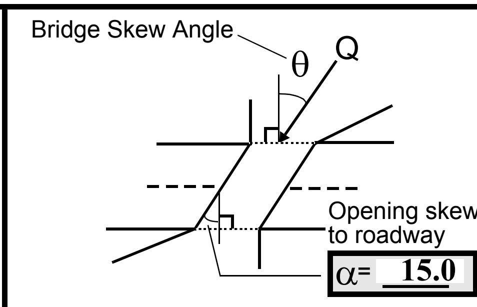
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	1	1	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **25** 16. Bridge skew: **40**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **25** feet **DS** *(US, UB, DS)* to **40** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **30** feet **US** *(US, UB, DS)* to **20** feet **US**

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

18. Bridge Type: 3

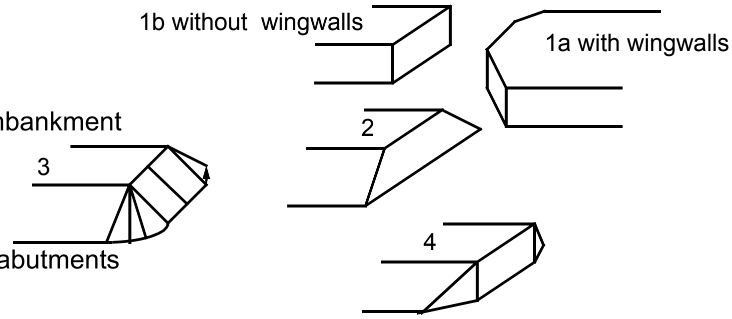
1a- Vertical abutments with wingwalls

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.)

#11: On the LBDS, there is a rock lined gully at the bottom of the road embankment. On the RBDS, the wingwall runs along the road embankment.

#18: There is stone fill placed in front of the abutments and wingwalls forming a spill through abutment.

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
80.0	3.0			14.0	1	1	21	21	1	1

23. Bank width 25.0 24. Channel width 30.0 25. Thalweg depth 65.5 29. Bed Material 432

30 .Bank protection type: LB 3 RB 3 31. Bank protection condition: LB 1 RB 1

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

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

#28: Both the left and right banks are scalloped with alternating clumps of grass and small cut-banks.

#30: The bank protection extends from the upstream bridge face to 64 feet upstream along the left bank, and 17 feet upstream along the right bank. The bank protection is in front of the wingwalls and could be considered part of the spill through.

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? Y (Y or if N type ctrl-n cb) 40. Where? RB (LB or RB)

41. Mid-bank distance: 32 42. Cut bank extent: 37 feet US (US, UB) to 26 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.):

There is another cut-bank on the upstream right bank from 120 feet upstream to 110 feet upstream, where the bank has been eroded.

A third cut-bank exists on the left bank from 193 feet upstream to 167 feet upstream. This cut-bank is also eroded.

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 114

47. Scour dimensions: Length 20 Width 4 Depth : 1 Position 60 %LB to 80 %RB

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

There is also some local scouring behind boulders in stream.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
35.5		1.5		2	5	5	-

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

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

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

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

543

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

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

There is some debris caught in the stone fill in front of the abutments and along the USRB.

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		**-**	**30**	**2**	**0**	**-**	**-**	**90.0**
RABUT	**21**	**5**	**35**			**2**	**0**	**77.0**

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

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

-

-

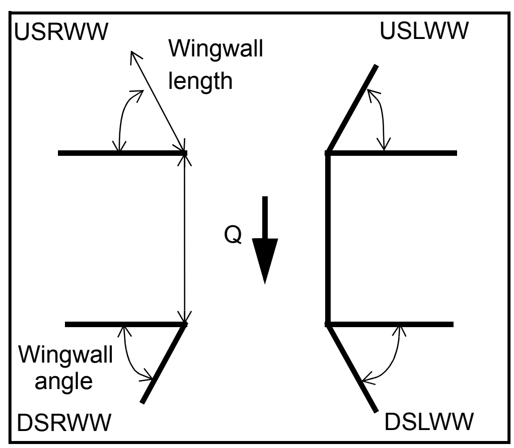
21

The abutments are concrete and at 90 degrees for about 4 feet on the LABUT and 2 feet on the RABUT. At the toe of the vertical abutments, stone fill covers the bank slope to the stream channel and acts like a spill through abutment as described in the table above.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**77.0**	
USRWW:	**Y**		**1**		**0**	**1.5**	
DSLWW:	**-**		**-**		**Y**	**38.5**	
DSRWW:	**1**		**0**		**-**	**39.5**	

*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	**-**	**0**	**Y**	**-**	**1**	**1**	**1**	**1**
Condition	**Y**	**-**	**1**	**-**	**1**	**1**	**1**	**1**
Extent	**1**	**-**	**0**	**3**	**3**	**3**	**3**	**-**

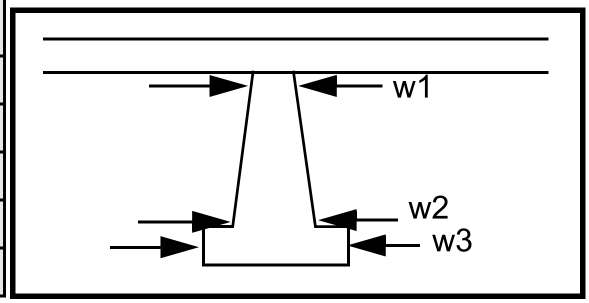
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length; **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? **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				**20.0**	**22.5**	**105.0**
Pier 2	**8.0**	**8.0**	**7.5**	**55.0**	**180.0**	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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: ____ *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

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

106. Point/Side bar present? 43 (Y or N. if N type ctrl-n pb) Mid-bar distance: 2 Mid-bar width: 3

Point bar extent: 2 feet 1 (US, UB, DS) to 1 feet Ba (US, UB, DS) positioned nk %LB to pro %RB

Material: tec

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

tion on the left bank is in front of the wingwall and is part of the spill through abutments. Wingwall protection which goes from the bridge face to 10 feet downstream. Then, there is type 3 protection from 24 feet downstream to 80 feet downstream on the left bank.

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

Cut bank extent: t feet ba (US, UB, DS) to nk feet pro (US, UB, DS)

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

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

tion is from the bridge face to 47 feet downstream and is in front of the wingwall.

Like the upstream banks, both downstream banks are scalloped with alternating grass clumps and cut-banks.

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

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

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

N

-

NO DROP STRUCTURE

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

Confluence 1: Distance ____ Enters on ____ (LB or RB) Type N (**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)*:

-

-

-

NO POINT BARS

Y

RB

58

47

DS

68

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:	HINETH00040011	Town:	Hinesburg
Road Number:	TH 4	County:	Chittenden
Stream:	Lewis Creek		

Initials MAI   Date: 11/1/96 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	4850	7200	0
Main Channel Area, ft2	625	842	0
Left overbank area, ft2	316	539	0
Right overbank area, ft2	0	69	0
Top width main channel, ft	60	61	0
Top width L overbank, ft	58	68	0
Top width R overbank, ft	0	55	0
D50 of channel, ft	0.1543	0.1543	0
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	10.4	13.8	ERR
y1, average depth, LOB, ft	5.4	7.9	ERR
y1, average depth, ROB, ft	ERR	1.3	ERR
Total conveyance, approach	139986	257908	0
Conveyance, main channel	91877	148213	0
Conveyance, LOB	48109	104907	0
Conveyance, ROB	0	4787	0
Percent discrepancy, conveyance	0.0000	0.0004	ERR
Qm, discharge, MC, cfs	3183.2	4137.7	ERR
Ql, discharge, LOB, cfs	1666.8	2928.7	ERR
Qr, discharge, ROB, cfs	0.0	133.6	ERR
Vm, mean velocity MC, ft/s	5.1	4.9	ERR
Vl, mean velocity, LOB, ft/s	5.3	5.4	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.9	ERR
Vc-m, crit. velocity, MC, ft/s	8.9	9.3	N/A
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	N/A
Vc-r, crit. velocity, ROB, ft/s	N/A	0.0	N/A

Results

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

ARMORING		
D90	0.415	0.415
D95	0.7967	0.7967

Critical grain size,Dc, ft	0.1556	0.2928	ERR
Decimal-percent coarser than Dc	0.495	0.188	
Depth to armoring,ft	0.48	3.79	ERR

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	625	842	0
Main channel width, ft	60	61	0
y1, main channel depth, ft	10.42	13.80	ERR

Bridge Section			
(Q) total discharge, cfs	4850	7200	0
(Q) discharge thru bridge, cfs	4850	7200	
Main channel conveyance	93208	70991	
Total conveyance	93208	70991	
Q2, bridge MC discharge,cfs	4850	7200	ERR
Main channel area, ft2	662	715	0
Main channel width (skewed), ft	53.9	64.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	53.9	64.1	0
y_bridge (avg. depth at br.), ft	12.29	11.16	ERR
Dm, median (1.25*D50), ft	0.193	0.193	0
y2, depth in contraction,ft	9.37	11.33	ERR
ys, scour depth (y2-ybridge), ft	-2.92	0.18	N/A

Pressure Flow Scour (contraction scour for orifice flow conditions

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

	Q100	Q500	OtherQ
Q, total, cfs		7200	0
Q, thru bridge, cfs		7200	0
Total Conveyance, bridge		70991	0
Main channel(MC) conveyance, bridge		70991	0
Q, thru bridge MC, cfs	ERR	7200	ERR
Vc, critical velocity, ft/s		9.31	N/A
Vc, critical velocity, m/s		2.84	N/A
Main channel width (skewed), ft		64.1	0.0
Cum. width of piers in MC, ft	0	0	0
W, adjusted width, ft	ERR	64.1	0.0
qbr, unit discharge, ft2/s	ERR	112.3	ERR
qbr, unit discharge, m2/s	N/A	10.4	N/A
Area of full opening, ft2		715.1	0
Hb, depth of full opening, ft	ERR	11.16	ERR
Hb, depth of full opening, m	N/A	3.40	N/A
Fr, Froude number, bridge MC	1	0.59	1

Cf, Fr correction factor (<=1.0)	1.50	1.00	1.50
Elevation of Low Steel, ft	0	494.49	0
Elevation of Bed, ft	N/A	483.33	N/A
Elevation of Approach, ft	0	498.04	0
Friction loss, approach, ft	0	0.2	0
Elevation of WS immediately US, ft	0.00	497.84	0.00
ya, depth immediately US, ft	N/A	14.51	N/A
ya, depth immediately US, m	N/A	4.42	N/A
Mean elevation of deck, ft	0	498.21	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	ERR	0.93	ERR
Ys, depth of scour, ft	N/A	1.75	N/A

Comparison of Chang and Laursen results (for unsubmerged orifice flow)

y2, from Laurse's equation, ft	0	12.53	0
Full valley WSEL, ft	0	495.77	0
Full valley depth, ft	N/A	12.436	N/A
Ys, depth of scour (y2-yfullv), ft	N/A	0.094	N/A

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	4850	7200	0	4850	7200	0
a', abut.length blocking flow, ft	47.8	56.1	0	15.9	79.9	0
Ae, area of blocked flow ft2	240.6	409.6	0	87.6	338.6	0
Qe, discharge blocked abut.,cfs	1192.3	2082.9	0	258.3	1185.4	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.96	5.09	ERR	2.95	3.50	ERR
ya, depth of f/p flow, ft	5.03	7.30	ERR	5.51	4.24	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0	0.55	0.55	0
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	75	75	0	105	105	0
K2	0.98	0.98	0.00	1.02	1.02	0.00
Fr, froude number f/p flow	0.389	0.332	ERR	0.221	0.300	ERR
ys, scour depth, ft	14.12	18.21	N/A	9.92	13.39	N/A

HIRE equation (a'/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55

(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	47.8	56.1	0	15.9	79.9	0
y1 (depth f/p flow, ft)	5.03	7.30	ERR	5.51	4.24	ERR
a'/y1	9.50	7.68	ERR	2.89	18.85	ERR
Skew correction (p. 49, fig. 16)	0.95	0.95	1.00	1.03	1.03	1.00
Froude no. f/p flow	0.39	0.33	N/A	0.22	0.30	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.43	0.59		0.43	0.59	
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	12.29	11.16		12.29	11.16	
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.40	2.40	0.00	1.40	2.40	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr<=0.8 (spillthrough abut.)	1.23	2.10	0.00	1.23	2.10	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR