LEVEL II SCOUR ANALYSIS FOR BRIDGE 64 (STOWTH00340064) on TOWN HIGHWAY 34, crossing RANCH BROOK, STOWE, VERMONT

Open-File Report 98-081

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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

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By MICHELLE M. SERRA AND MICHAEL A. IVANOFF

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1998

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

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 64 (STOWTH00340064) ON TOWN HIGHWAY 34, CROSSING RANCH BROOK, STOWE, VERMONT

By **Michelle M. Serra and Michael A. Ivanoff**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure STOWTH00340064 on Town Highway 34 crossing Ranch Brook, Stowe, 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 (Federal Highway Administration, 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 north-central Vermont. The 6.41-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest except for the upstream left bank area, which is shrubs and brush.

In the study area, Ranch Brook has an incised, straight channel with a slope of approximately 0.03 ft/ft, an average channel top width of 44 ft and an average bank height of 7 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 119 mm (0.389 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 9, 1996, indicated that the reach was degraded. There are cut-banks noted on both banks upstream of the bridge and the abutment footings are exposed.

The Town Highway 34 crossing of Ranch Brook is a 28-ft-long, one-lane bridge consisting of one 26-foot steel-beam span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 25.9 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is 0 degrees.

A scour hole 1 ft deeper than the mean thalweg depth was observed along the downstream end of the left abutment during the Level I assessment. Also, there was exposed footing on the left abutment and all four wingwalls. The right abutment footing has been undermined. Concrete-filled bags were observed in front of the left abutment footing. All of the wingwalls were protected by type-3 stone fill (less than 48 inches diameter). Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.2 to 0.7 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.9 to 11.9 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 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.

Mount Mansfield, VT. Quadrangle, 1:24,000, 1948, photorevised 1980; and
Bolton Mountain, VT. Quadrangle, 1:24,000, 1948, photoinspected 1983

NORTH

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

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

LEVEL II SUMMARY

Structure Number STOWTH00340064 ***Stream*** Ranch Brook

County Lamoille ***Road*** TH34 ***District*** 6

Description of Bridge

Bridge length 28 ***ft*** ***Bridge width*** 16 ***ft*** ***Max span length*** 26 ***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*** 7/9/96

Description of stone fill Type-3, along the left and right wingwalls, both upstream and downstream.

.

Abutments and wingwalls are concrete. There is a one foot deep scour hole along the downstream end of the left abutment.

Is bridge skewed to flood flow according to Yes ***Level I survey?*** Yes ***Angle*** 15

There is a moderate channel bend through the bridge. A scour hole has developed on the bend where the flow impacts the left abutment.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	7/9/96	0	0
Level II	7/9/96	0	0

Potential for debris Moderate. The banks are eroded upstream and there are a few trees leaning into the channel.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 7/9/96.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with little to no flood plains and steep or moderately sloping valley walls on both sides.

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

Date of inspection 7/9/96

DS left: Steep channel bank to a moderately sloping overbank

DS right: Steep, low channel bank to a mildly sloping overbank

US left: Steep channel bank to a moderately sloping overbank

US right: Steep channel bank to a mildly sloping overbank

Description of the Channel

Average top width 44 *ft* ***Average depth*** 7 *ft*

Predominant bed material Boulders / Gravel ***Bank material*** Boulders/Gravel

Perennial, straight and degraded with non-alluvial channel boundaries.

Vegetative co 7/9/96

DS left: Trees

DS right: Trees

US left: Shrub and brushland

US right: Trees and brush

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

There are cut-banks on both banks upstream of the bridge and one on the left bank downstream of the bridge. The banks appear oversteepened in many places, particularly upstream, as of 7/9/96.

Describe any obstructions in channel and date of observation.

There is a pile of large boulders that extend across the stream 25 ft downstream of the bridge as of 7/9/96.

Hydrology

Drainage area 6.41 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/Green Mountain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None as of 7/9/96

Is there a USGS gage on the stream of interest? No

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 1,400 ***ft³/s*** ***Q500*** 2,100 ***ft³/s***

The 100- and 500-year discharges are based on flood frequency curves developed from several empirical methods, extrapolated to the 500-year event (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). The 100- and 500-year discharges from the New England Hills and Lowlands equation (Potter, 1957a) were the median values from the range of curves and were selected for this hydraulic analysis.

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 right abutment at the downstream end (elev. 499.81 ft, arbitrary survey datum). RM2 is a chiseled X on top of the left abutment at the upstream end (elev. 500.56 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	-46	1	Exit section
FULLV	0	1	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	50	2	Modelled Approach section (Templated from APTEM)
APTEM	77	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.045 to 0.065, and overbank "n" values ranged from 0.046 to 0.075.

Critical depth at the exit section (EXITX) was assumed as the starting water surface for the 500-year discharge. Normal depth was computed below critical depth approximately 0.2 ft by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). Normal depth at the exit section was assumed as the starting water surface for the 100-year discharge. The slope used was 0.0320 ft/ft, which was estimated from the appropriate topographic maps (U.S. Geological Survey, 1948a&b).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.024 ft/ft) to establish the modelled approach section (APPRO) one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. Analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.9 ***ft***
Average low steel elevation 499.3 ***ft***

100-year discharge 1,400 ***ft^3/s***
Water-surface elevation in bridge opening 492.5 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft^3/s***
Area of flow in bridge opening 116 ***ft^2***
Average velocity in bridge opening 12.1 ***ft/s***
Maximum WSPRO tube velocity at bridge 15.5 ***ft/s***

Water-surface elevation at Approach section with bridge 496.0
Water-surface elevation at Approach section without bridge 493.2
Amount of backwater caused by bridge 2.8 ***ft***

500-year discharge 2,100 ***ft^3/s***
Water-surface elevation in bridge opening 493.9 ***ft***
Road overtopping? No ***Discharge over road*** - ***ft^3/s***
Area of flow in bridge opening 152 ***ft^2***
Average velocity in bridge opening 13.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 17.9 ***ft/s***

Water-surface elevation at Approach section with bridge 498.1
Water-surface elevation at Approach section without bridge 494.2
Amount of backwater caused by bridge 3.9 ***ft***

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 - ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis for the 100- and 500- year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

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

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.2 0.7	--	14.8
Depth to armoring	22.3	--	--
Left overbank	--	--	--
Right overbank	--	--	7.9 8.2

Local scour:			
Abutment scour	-- 8.2	11.9	--
Left abutment	---	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	1.9	2.5	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.9	2.5	--
Left abutment	--	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1			
Pier 2			

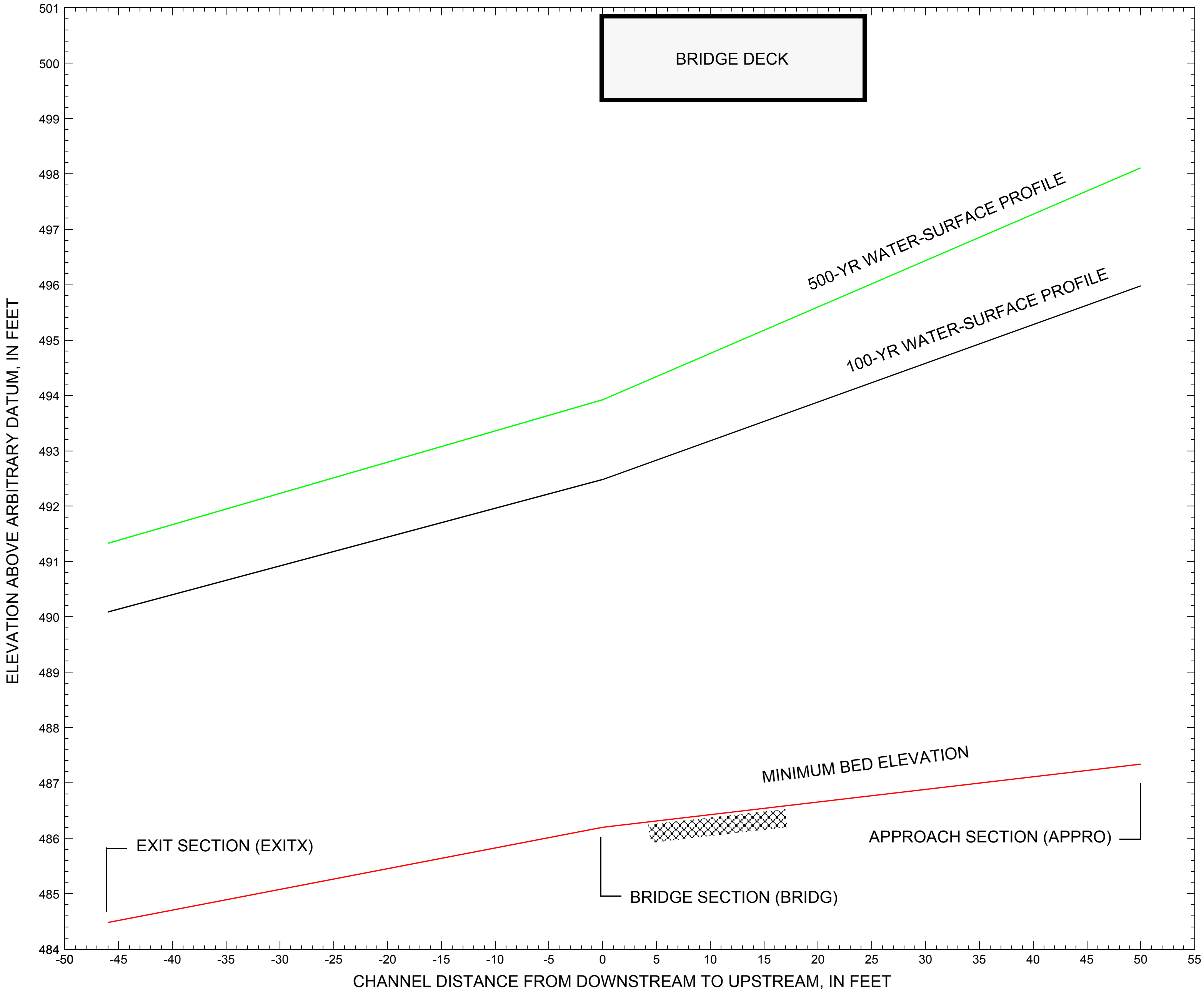

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure STOWTH00340064 on Town Highway 34, crossing Ranch Brook, Stowe, Vermont.

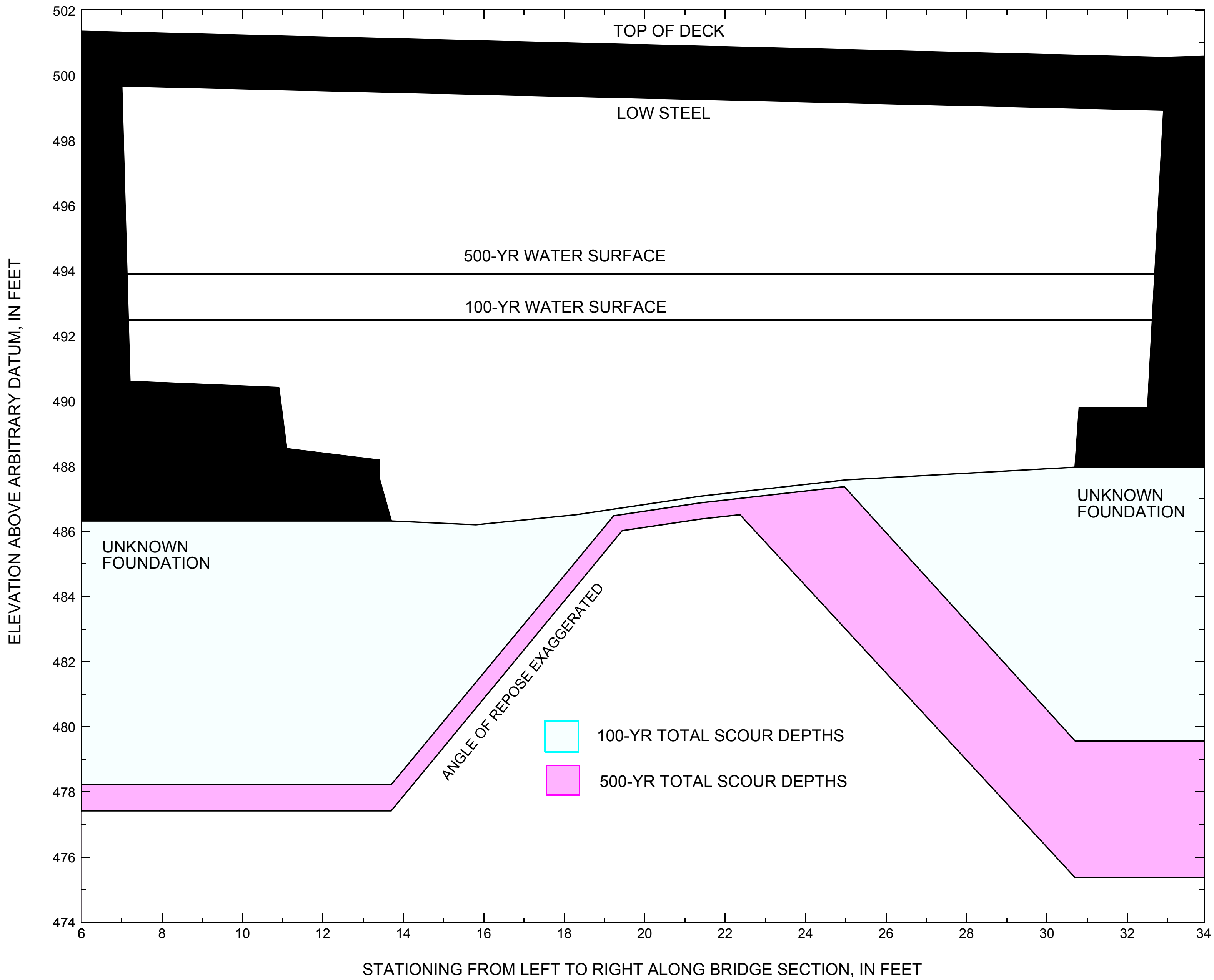

Figure 8. Scour elevations for the 100- and 500-yr discharges at structure STOWTH00340064 on Town Highway 34, crossing Ranch Brook, Stowe, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-yr discharge at structure STOWTH00340064 on Town Highway 34, crossing Ranch Brook, Stowe, 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 1,400 cubic-feet per second											
Left abutment	7.0	--	499.7	--	486.3	0.2	7.9	--	8.1	478.2	--
Right abutment	32.9	--	498.9	--	488.0	0.2	8.2	--	8.4	479.6	--

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-yr discharge at structure STOWTH00340064 on Town Highway 34, crossing Ranch Brook, Stowe, 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 2,100 cubic-feet per second											
Left abutment	7.0	--	499.7	--	486.3	0.7	8.2	--	8.9	477.4	--
Right abutment	32.9	--	498.9	--	488.0	0.7	11.9	--	12.6	475.4	--

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, 1948b, Mount Mansfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photorevised 1980, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File stow064.wsp
T2        Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
T3        Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1400.0   2100.0
SK          0.0320   0.0320
*
XS   EXITX    -46           0.
GR          -58.9, 503.25    -58.5, 504.97    -48.4, 502.34    -34.4, 498.37
GR          -15.3, 494.79      0.0, 494.08      7.9, 489.27     15.5, 485.97
GR           19.9, 485.03     26.8, 484.48     31.0, 484.63     32.3, 485.93
GR           42.7, 487.07     46.1, 490.50     78.0, 490.63
GR          141.1, 492.87    159.2, 496.98    181.4, 502.46    187.2, 508.63
* GR     63.5, 493.76
N           0.060        0.065        0.075
SA                 0.0         46.1
*
*
XS   FULLV      0  * * *   0.0330
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    499.31       0.0
GR            7.0, 499.68      7.2, 490.61     10.9, 490.42     11.1, 488.54
GR           13.4, 488.19     13.4, 487.62     13.7, 486.32     15.8, 486.20
GR           18.3, 486.51     21.4, 487.08     25.0, 487.58     30.8, 487.97
GR           30.8, 489.80     32.5, 489.80     32.9, 498.94      7.0, 499.68
*
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      57.7 * *     80.4      5.0
N           0.045
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     12      16.0     2
GR         -152.4, 514.36    -71.1, 507.48    -51.4, 503.60    -26.8, 501.46
GR            0.0, 501.33     25.9, 500.56     47.4, 500.01     82.5, 500.18
GR          108.3, 501.55    148.6, 505.28
*
*
*
*           EXPECTED SRD =   50 AT ONE BR. LENGTH BUT COMPUTED SRD =   77
*
XT   APTEM     77           0.
GR          -58.1, 511.57    -33.7, 498.78    -22.8, 498.78    -10.5, 498.77
GR            0.0, 497.80      2.7, 493.26      5.0, 492.16     10.4, 489.26
GR           13.1, 488.87     18.9, 488.00     22.7, 488.57     26.6, 489.27
GR           34.6, 490.87     39.2, 493.74     42.5, 495.90     65.2, 497.18
GR           83.6, 497.57    100.8, 498.54    113.5, 501.64
*
AS   APPRO     50  * * *  0.0243
GT
N           0.046        0.065        0.053
SA                   0.0         42.5
*
HP 1 BRIDG  492.48 1 492.48
HP 2 BRIDG  492.48 * * 1400
HP 1 APPRO  495.98 1 495.98
HP 2 APPRO  495.98 * * 1400
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File stow064.wsp
        Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
        Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
           *** RUN DATE & TIME: 07-14-97  16:02
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      116      8464     25     35                          1397
   492.48           116      8464     25     35  1.00      7     33      1397

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.48     7.2    32.6   115.6    8464.    1400.  12.11

X STA.         7.2       11.9       13.8       14.7       15.6       16.4
  A(I)            11.2        8.3        6.0        5.3        5.0
  V(I)            6.26       8.42      11.74      13.33      13.92

X STA.        16.4       17.1       17.9       18.7       19.5       20.3
  A(I)             4.7        4.7        4.6        4.5        4.5
  V(I)           15.01      14.80      15.29      15.53      15.43

X STA.        20.3       21.1       22.0       22.8       23.8       24.8
  A(I)             4.5        4.7        4.7        4.8        4.9
  V(I)           15.42      14.88      14.99      14.60      14.22

X STA.        24.8       25.8       26.9       28.1       29.5       32.6
  A(I)             5.1        5.2        5.8        6.4       10.7
  V(I)           13.81      13.39      12.06      11.01       6.53

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      253     17898     42     47                          3525
             3        5        69     13     13                            17
   495.98           258     17967     55     60  1.03      1     56      3124

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

         WSEL     LEW     REW    AREA        K        Q    VEL
       495.98     0.7    55.6   257.5   17967.    1400.   5.44

X STA.         0.7        6.9        9.4       11.1       12.7       14.1
  A(I)            21.7       15.3       12.8       11.9       11.3
  V(I)            3.23       4.57       5.45       5.90       6.17

X STA.        14.1       15.5       16.8       18.0       19.2       20.4
  A(I)            11.0       10.4       10.6       10.3       10.2
  V(I)            6.34       6.72       6.63       6.81       6.88

X STA.        20.4       21.7       23.0       24.4       25.8       27.3
  A(I)            10.4       10.5       10.9       10.8       11.5
  V(I)            6.74       6.69       6.44       6.47       6.08

X STA.        27.3       29.0       30.8       33.0       35.7       55.6
  A(I)            11.8       12.2       13.6       15.3       24.9
  V(I)            5.93       5.72       5.15       4.56       2.81
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File stow064.wsp
       Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
       Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
          *** RUN DATE & TIME: 07-14-97  16:02

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      152     12720     26     38                          2110
  493.92           152     12720     26     38  1.00      7     33      2110

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      493.92     7.1    32.7   152.3   12720.    2100.  13.79

X STA.        7.1       11.3       12.9       14.4       15.3       16.1
  A(I)           14.8        8.8        9.9        7.0        6.5
  V(I)           7.11      11.88      10.58      15.02      16.10

X STA.       16.1       17.0       17.8       18.6       19.4       20.2
  A(I)            6.3        6.0        6.0        6.0        5.9
  V(I)          16.61      17.44      17.58      17.50      17.87

X STA.       20.2       21.1       21.9       22.9       23.8       24.8
  A(I)            6.0        6.0        6.1        6.2        6.5
  V(I)          17.59      17.42      17.21      17.02      16.24

X STA.       24.8       25.9       27.0       28.2       29.6       32.7
  A(I)            6.7        6.9        7.5        8.7       14.5
  V(I)          15.68      15.16      14.02      12.05       7.24

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1        5       100     10     11                            20
            2      343     29192     43     48                          5525
            3       88      3246     59     59                           613
  498.11           436     32539    112    118  1.19     -9    102      4469

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      50.

        WSEL     LEW     REW    AREA        K        Q    VEL
      498.11   -10.5   101.7   436.3   32539.    2100.   4.81

X STA.      -10.5        6.2        9.0       11.1       13.0       14.7
  A(I)           36.1       22.2       19.9       18.0       17.2
  V(I)           2.91       4.73       5.29       5.85       6.09

X STA.       14.7       16.3       17.8       19.3       20.8       22.4
  A(I)           16.6       15.9       15.9       15.9       16.0
  V(I)           6.33       6.62       6.59       6.61       6.55

X STA.       22.4       23.9       25.6       27.4       29.3       31.3
  A(I)           16.0       16.5       16.8       17.3       17.8
  V(I)           6.56       6.35       6.24       6.05       5.91

X STA.       31.3       33.6       36.5       42.4       57.1      101.7
  A(I)           19.0       21.6       28.9       36.0       52.7
  V(I)           5.52       4.85       3.64       2.92       1.99
```

```
       U.S. Geological Survey WSPRO Input File stow064.wsp
       Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
       Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
          *** RUN DATE & TIME: 07-14-97  16:02

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

EXITX:XS   ******      7      148  1.40 *****  491.49  489.68    1400  490.09
       -45 ******     46     7825  1.00 ***** *******    0.86    9.48

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.87     491.57     491.20

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   489.59     510.15    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   489.59     510.15     491.20

FULLV:FV       46      7      146  1.43  1.49  493.00  491.20    1400  491.57
         0     46     46     7711  1.00  0.01    0.00    0.87    9.57
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.89     493.19     492.89

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   491.07     510.91    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   491.07     510.91     492.89

APPRO:AS       50      2      142  1.50  1.66  494.71  492.89    1400  493.21
        50     50     39     7657  1.00  0.04    0.02    0.88    9.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                 SECID "BRIDG"     Q,CRWS =    1400.     492.48

            <<<<<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       46      7      116  2.28 *****  494.76  492.48    1400  492.48
         0     46     33     8469  1.00 ***** *******    1.00   12.11

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.        <<<<<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       -8      1      257  0.47  0.11  496.45  492.89    1400  495.98
        50      9     56    17957  1.03  1.58   -0.01    0.45    5.44

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.315  0.083   16507.     7.    32.   495.77

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

   FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -46.     7.    46.   1400.    7825.     148.    9.48  490.09
   FULLV:FV       0.     7.    46.   1400.    7711.     146.    9.57  491.57
   BRIDG:BR       0.     7.    33.   1400.    8469.     116.   12.11  492.48
   RDWAY:RG      12.**************       0.*****************    2.00********
   APPRO:AS      50.     1.    56.   1400.   17957.     257.    5.44  495.98

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      7.    32.   16507.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    489.68    0.86  484.48  508.63************  1.40  491.49  490.09
   FULLV:FV    491.20    0.87  486.00  510.15  1.49  0.01  1.43  493.00  491.57
   BRIDG:BR    492.48    1.00  486.20  499.68************  2.28  494.76  492.48
   RDWAY:RG  ***************  500.01  514.36********************************
   APPRO:AS    492.89    0.45  487.34  510.91  0.11  1.58  0.47  496.45  495.98
```

```
        U.S. Geological Survey WSPRO Input File stow064.wsp
        Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
        Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
           *** RUN DATE & TIME: 07-14-97  16:02

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                           WSI,CRWS =   491.14     491.33

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

EXITX:XS   ******      5      229  1.57 *****  492.91  491.33    2100  491.33
       -45 ******     98    12625  1.21 ***** *******    1.13    9.16

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.23     492.60     492.85

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   490.83     510.15    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   490.83     510.15     492.85

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   492.85     510.15     492.85

FULLV:FV       46      5      229  1.57 *****  494.42  492.85    2100  492.85
         0     46     98    12625  1.21 ***** *******    1.13    9.16
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.96     494.19     494.05

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   492.35     510.91    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   492.35     510.91     494.05

APPRO:AS       50      2      180  2.12  1.62  496.32  494.05    2100  494.20
        50     50     41    10782  1.00  0.27    0.00    0.96   11.67
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =   2100.     493.92

            <<<<<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       46      7      152  2.96 *****  496.88  493.92    2100  493.92
         0     46     33    12709  1.00 ***** *******    1.00   13.80

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  499.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.        <<<<<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       -8     -9      437  0.43  0.09  498.54  494.05    2100  498.11
        50      8    102    32569  1.19  1.58   -0.01    0.47    4.81

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.349  0.230   25152.     7.    32.   497.97

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -46.     5.    98.   2100.   12625.     229.    9.16  491.33
   FULLV:FV       0.     5.    98.   2100.   12625.     229.    9.16  492.85
   BRIDG:BR       0.     7.    33.   2100.   12709.     152.   13.80  493.92
   RDWAY:RG      12.**************       0.*****************    2.00********
   APPRO:AS      50.   -10.   102.   2100.   32569.     437.    4.81  498.11

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       7.    32.   25152.
```

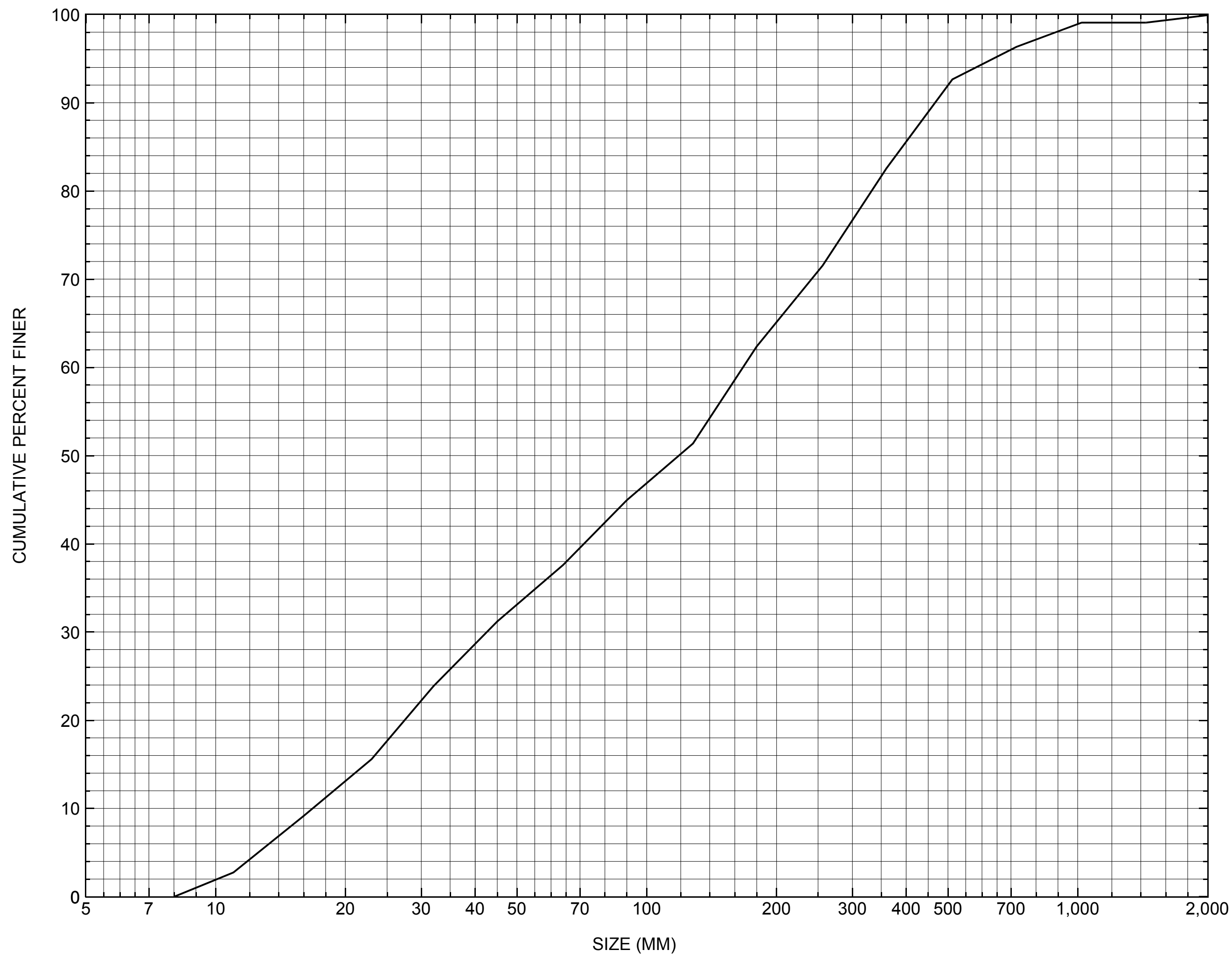
```
U.S. Geological Survey WSPRO Input File stow064.wsp
Hydraulic analysis for structure STOWTH00340064   Date: 11-JUL-97
Hydraulic analysis of bridge 64 in Stowe over Ranch Brook
   *** RUN DATE & TIME: 07-14-97  16:02
```

SECOND USER DEFINED TABLE.

```
  XSID:CODE    CRWS     FR#    YMIN    YMAX     HF     HO  VHD      EGL    WSEL
 EXITX:XS    491.33    1.13  484.48  508.63************  1.57  492.91  491.33
 FULLV:FV    492.85    1.13  486.00  510.15************  1.57  494.42  492.85
 BRIDG:BR    493.92    1.00  486.20  499.68************  2.96  496.88  493.92
 RDWAY:RG  ****************  500.01  514.36***********************************
 APPRO:AS    494.05    0.47  487.34  510.91  0.09  1.58  0.43  498.54  498.11
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure STOWTH00340064, in Stowe, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number STOWTH00340064

General Location Descriptive

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

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

Highway District Number (I - 2; nn) 06

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

Town (FIPS place code; I - 4; nnnnn) 70525

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

Waterway (I - 6) RANCH BROOK

Road Name (I - 7): -

Route Number C3034

Vicinity (I - 9) 0.02 MI TO JCT W VT108

Topographic Map Mount Mansfield

Hydrologic Unit Code: -

Latitude (I - 16; nnnn.n) 44302

Longitude (i - 17; nnnnn.n) 72455

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10080800640808

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0026

Year built (I - 27; YYYY) 1976

Structure length (I - 49; nnnnnn) 000028

Average daily traffic, ADT (I - 29; nnnnnn) 000040

Deck Width (I - 52; nn.n) 160

Year of ADT (I - 30; YY) 93

Channel & Protection (I - 61; n) 5

Opening skew to Roadway (I - 34; nn) 0

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) P

Underwater Inspection Frequency (I - 92B; XYY) No

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) -

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

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

Comments:

According to the structural inspection report dated 6/20/95, the deck of this structure consists of wood planks with large painted logs along each edge. Both abutments and their wingwalls have several fine vertical cracks and small leaks. Undermining problems have been noted, but not on this latest inspection. A double footing is noted on the LABUT. Channel scour problems in the past have been corrected for now. On the embankments are large boulders with signs of erosion. Mostly boulder and gravel bars are noted. Minor debris noted.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

Downstream distance (*miles*): - Town: - Year Built: -
Highway No. : - Structure No. : - Structure Type: -
Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 6.41 mi^2 Lake/pond/swamp area 0 mi^2
Watershed storage *(ST)* 0 %
Bridge site elevation 955 ft Headwater elevation 3849 ft
Main channel length 3.79 mi
10% channel length elevation 1020 ft 85% channel length elevation 3140 ft
Main channel slope *(S)* 995 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? No *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? No *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION AVAILABLE

Comments:

NO PLANS ARE AVAILABLE

Cross-sectional Data

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

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

Comments: **This cross section is the upstream face. The low chord elevation is from the survey log done for this report on 7/9/96. The low chord to bed length data are from the sketch attached to a bridge inspection report dated 8/16/93.**

Station	0	6	12	16	26	-	-	-	-	-	-
Feature	LAB	-	-	-	RAB	-	-	-	-	-	-
Low chord elevation	499.7	499.5	499.3	499.2	498.9	-	-	-	-	-	-
Bed elevation	490.6	486.8	486.9	488.0	489.8	-	-	-	-	-	-
Low chord to bed	9.1	12.7	12.4	11.2	9.1	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/23/96
Computerized by: RB Date: 10/24/96
Reviewd by: MS Date: 12/31/97

Structure Number STOWTH00340064

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. IVANOFF Date *(MM/DD/YY)* 7 / 9 / 1996

2. Highway District Number 06 Mile marker 0000

County LAMOILLE (015) Town STOWE (70525)

Waterway *(I - 6)* RANCH BROOK Road Name -

Route Number TH34 Hydrologic Unit Code: 02010003

3. Descriptive comments:

This bridge is located 0.02 miles from the junction of Town Highway 34 with VT 108.

B. Bridge Deck Observations

4. Surface cover... LBUS 5 RBUS 6 LBDS 6 RBDS 6 Overall 6
(2b us,ds,lb,rb: 1- Urban; 2- Suburban; 3- Row crops; 4- Pasture; 5- Shrub- and brushland; 6- Forest; 7- Wetland)

5. Ambient water surface... US 2 UB 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 28 *(feet)* Span length 26 *(feet)* Bridge width 16 *(feet)*

Road approach to bridge:

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

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

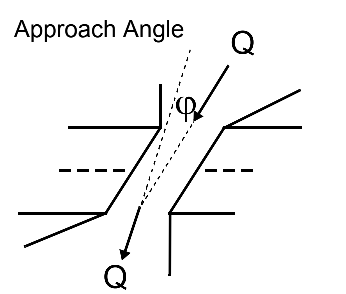
10. Embankment slope (*run / rise in feet / foot*):
US left 0.0:1 US right 0.0:1

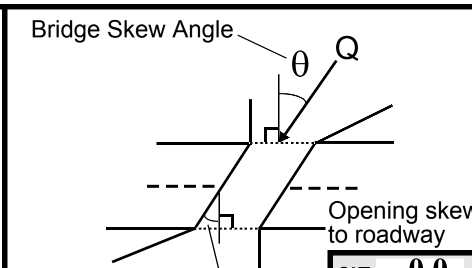
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	0	0
RBDS	0	-	0	0
LBDS	0	-	3	2

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

Channel approach to bridge (BF):

15. Angle of approach: 5 16. Bridge skew: 15





α= 0.0

17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 2
Range? 30 feet US *(US, UB, DS)* to 15 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**

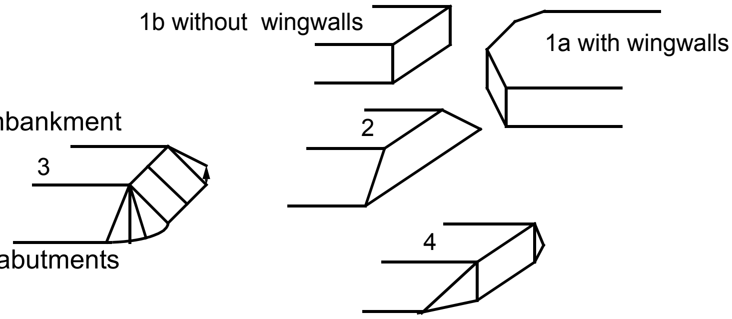
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. The US right bank has pasture and brush between a grove of trees. There is a gravel road along the left bank US. Also along the left high bank is VT 108.
7. The bridge dimension values on the previous page are from the VT AOT files. Measured bridge dimensions at the time of this assessment are the same.

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
61.5	**8.5**			**5.0**	**3**	**4**	**534**	**534**	**2**	**2**

23. Bank width **35.0**   24. Channel width **30.0**   25. Thalweg depth **41.5**   29. Bed Material **534**

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 bed and bank material consists of boulders, cobbles, and gravel.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **5UB** 35. Mid-bar width: **8**

36. Point bar extent: **40** feet **US** (US, UB) to **25** feet **DS** (US, UB, DS) positioned **60** %LB to **100** %RB

37. Material: **324**

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

This side bar extends from the US end of the US right wingwall to the DS end of the DS right wingwall.

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

41. Mid-bank distance: **200** 42. Cut bank extent: **100** feet **US** (US, UB) to **300** 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 also a cut bank on the right bank in this range. Both US banks are eroded, but not due to meanders.

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

NO CHANNEL SCOUR

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) 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
24.0		1.5		2	7	7	0

58. Bank width (BF) **-** 59. Channel width (Amb) **-** 60. Thalweg depth (Amb) **90.0** 63. Bed Material **0**

*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.):

435

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

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

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

70. Debris and Ice Comments:

2

The banks are eroded US with a lot of foliage. There are a few trees leaning into the channel.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**10**	**90**	**2**	**2**	**1**	**4.4**	**90.0**
RABUT	**1**	**0**	**90**			**2**	**3**	**26.0**

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.):

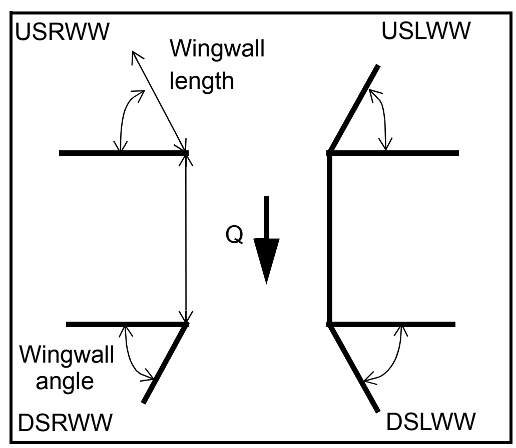
0
2
1

The left abutment footing and subfooting are exposed. Concrete-filled bags have been placed in front of the subfooting. The right abutment is undermined for 2 ft. from the US end, at the junction with the wingwall. It is undermined 0.3 ft. and can be penetrated 0.3 ft. horizontally underneath the footing.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**26.0**	
USRWW:	**Y**		**1**		**2**	**1.0**	
DSLWW:	**0.3**		**3.5**		**Y**	**23.5**	
DSRWW:	**1**		**2**		**0**	**24.5**	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	**2.0**	**2**	**Y**	**0**	**1**	**3**	**-**	**-**
Condition	**Y**	**0.8**	**1**	**1.5**	**2**	**2**	**-**	**-**
Extent	**1**	**4.0**	**2**	**3**	**3**	**0**	**0**	**-**

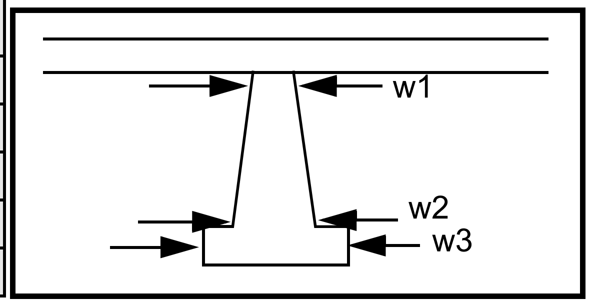
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
3
3
3
3
2
3

Piers:

84. Are there piers? **On** (*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				**90.0**	**38.0**	**70.0**
Pier 2				**31.0**	**70.0**	**30.5**
Pier 3			-	**70.0**	**15.0**	-
Pier 4	-	-	-	-	-	-



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

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

4

101. Is a drop structure present? 4 *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

103. Drop: - feet 104. Structure material: 534 *(**1**- steel sheet pile; **2**- wood pile; **3**- concrete; **4**- other)*

105. Drop structure comments (eg. downstream scour depth):
534
1
1
534
0
0

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

Point bar extent: vege- feet tati (US, UB, DS) to on feet on (US, UB, DS) positioned the %LB to left %RB

Material: ba

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

nk begins 45 ft. DS of the bridge. The bed and bank material consists of boulders, cobbles and gravel. A local resident commented that a dam crossed the stream about 200 ft. DS. When it blew out 20 years ago the stream bed dropped below the footings, exposing them and later undermining the left abutment. This was remedied with concrete filled sand bags along the entire base of the US left wingwall and left abutment.

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.):

N
-

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

Scour dimensions: Length of Width large Depth: boul Positioned der %LB to s %RB

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

extends across the stream 25 ft. DS of the bridge.

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

Confluence 1: Distance Y Enters on 200 (LB or RB) Type 40 (**1**- perennial; **2**- ephemeral)

Confluence 2: Distance 50 Enters on DS (LB or RB) Type 300 (**1**- perennial; **2**- ephemeral)

Confluence comments (eg. confluence name):

DS
50

F. Geomorphic Channel Assessment

107. Stage of reach evolution 100

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)*:

534

This is a side bar.

Y

LB

150

110

DS

200

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: STOWTH00340064   Town: Stowe
Road Number: TH34   County: Lamoille
Stream: Ranch Brook

Initials MMS   Date: 08/14/97 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	1400	2100	0
Main Channel Area, ft2	253	343	0
Left overbank area, ft2	0	5	0
Right overbank area, ft2	5	88	0
Top width main channel, ft	42	43	0
Top width L overbank, ft	0	10	0
Top width R overbank, ft	13	59	0
D50 of channel, ft	0.389	0.389	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.0	8.0	ERR
y1, average depth, LOB, ft	ERR	0.5	ERR
y1, average depth, ROB, ft	0.4	1.5	ERR
Total conveyance, approach	17967	32539	0
Conveyance, main channel	17898	29192	0
Conveyance, LOB	0	100	0
Conveyance, ROB	69	3246	0
Percent discrepancy, conveyance	0.0000	0.0031	ERR
Qm, discharge, MC, cfs	1394.6	1884.0	ERR
Ql, discharge, LOB, cfs	0.0	6.5	ERR
Qr, discharge, ROB, cfs	5.4	209.5	ERR
Vm, mean velocity MC, ft/s	5.5	5.5	ERR
Vl, mean velocity, LOB, ft/s	ERR	1.3	ERR
Vr, mean velocity, ROB, ft/s	1.1	2.4	ERR
Vc-m, crit. velocity, MC, ft/s	11.0	11.6	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1400	2100	0
(Q) discharge thru bridge, cfs	1400	2100	0
Main channel conveyance	8464	12720	0
Total conveyance	8464	12720	0
Q2, bridge MC discharge,cfs	1400	2100	ERR
Main channel area, ft2	116	152	0
Main channel width (normal), ft	25.4	25.6	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.4	25.6	0
y_bridge (avg. depth at br.), ft	4.57	5.94	ERR
Dm, median (1.25*D50), ft	0.48625	0.48625	0
y2, depth in contraction,ft	4.73	6.65	ERR
ys, scour depth (y2-ybridge), ft	0.16	0.71	N/A

Armoring

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

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1400	2100	N/A
Main channel area (DS), ft2	116	152	0
Main channel width (normal), ft	25.4	25.6	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.4	25.6	0.0
D90, ft	1.5308	1.5308	0.0000
D95, ft	2.0876	2.0876	0.0000
Dc, critical grain size, ft	1.1358	1.2930	ERR
Pc, Decimal percent coarser than Dc	0.187	0.148	0.000
Depth to armoring, ft	14.81	22.33	ERR

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1400	2100	0	1400	2100	0
a', abut.length blocking flow, ft	6.5	17.6	0	23	69	0
Ae, area of blocked flow ft2	23.54	43.24	0	42.67	146.63	0
Qe, discharge blocked abut.,cfs	78.4	138.75	0	152.73	461.09	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.33	3.21	ERR	3.58	3.14	ERR
ya, depth of f/p flow, ft	3.62	2.46	ERR	1.86	2.13	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.308	0.361	ERR	0.463	0.380	ERR
ys, scour depth, ft	7.85	8.18	N/A	8.23	11.92	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)	6.5	17.6	0	23	69	0
y1 (depth f/p flow, ft)	3.62	2.46	ERR	1.86	2.13	ERR
a'/y1	1.79	7.16	ERR	12.40	32.47	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.31	0.36	N/A	0.46	0.38	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	11.23	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	9.21	ERR

spill-through	ERR	ERR	ERR	ERR	6.18	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.57	5.94	0.00	4.57	5.94	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.91	2.48	ERR	1.91	2.48	ERR