LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (FERRTH00190032) on TOWN HIGHWAY 19, crossing the SOUTH SLANG LITTLE OTTER CREEK, FERRISBURGH, VERMONT

Open-File Report 98-025

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

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U.S. Geological Survey

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By MICHAEL A. IVANOFF AND EMILY C. WILD

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Pembroke, New Hampshire

1998

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

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 32 (FERRTH00190032) ON TOWN HIGHWAY 19, CROSSING THE SOUTH SLANG LITTLE OTTER CREEK, FERRISBURGH, VERMONT

By **Michael A. Ivanoff and Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FERRTH00190032 on Town Highway 19 crossing the South Slang Little Otter Creek (Hawkins Slang Brook), Ferrisburg, 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Champlain section of the St. Lawrence Valley physiographic province in west-central Vermont. The 8.00-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of wetlands upstream and downstream of the bridge with trees and pasture on the wide flood plains.

In the study area, the South Slang Little Otter Creek has a meandering channel with essentially no channel slope, an average channel top width of 932 ft and an average bank height of 6 ft. The channel bed material ranges from clay to sand. Sieve analysis indicates that greater than 50% of the sample is coarse silt and clay and thus a medium grain size by use of sieve analysis was indeterminate. The median grain size was assumed to be a course silt with a size (D50) of 0.061mm (0.0002 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 2, 1996, indicated that the reach was stable.

The Town Highway 19 crossing of the South Slang Little Otter Creek is a 45-ft-long, two-lane bridge consisting of one 42-foot concrete box-beam span (Vermont Agency of Transportation, written communication, December 11, 1995). The opening length of the structure parallel to the bridge face is 41.8 ft. The bridge is supported by vertical, concrete abutments. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 3.5 ft deeper than the mean thalweg depth was observed in the upstream channel. Also a scour hole 2.0 ft deeper than the mean thalweg depth was observed along the right abutment during the Level I assessment. The scour protection measures at the site are type-1 stone fill (less than 12 inches diameter) around the left and right abutments, along the upstream and downstream road embankments, and across the entire upstream and downstream bridge face. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. 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 14.0 to 20.2 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 3.2 to 8.3 ft. The worst-case abutment scour occurred at the 500-year discharge. The predicted scour is well above the pile bottom elevations. 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.

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.

Westport, NY.-VT. Quadrangle, 1:25,000, 1980

NORTH

Figure 1. Location of study area on USGS 1:25,000 scale map.

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

LEVEL II SUMMARY

Structure Number FERRTH00190032 ***Stream*** South Slang Little Otter Creek

County Addison ***Road*** TH 19 ***District*** 5

Description of Bridge

Bridge length 45.0 ***ft*** ***Bridge width*** 24.8 ***ft*** ***Max span length*** 42.0 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 7/2/96

Description of stone fill Type-1, around the left and right abutments and across the upstream and downstream bridge faces.

Abutments are concrete. There is a two foot deep scour hole in front of the right abutment exposing the footing.

Yes 5

Is bridge skewed to flood flow according to No ***survey?*** ***Angle***

The channel meanders through a wetland in the upstream reach. A scour hole has developed upstream of the bridge and through the constriction.

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	7/2/96	0	0
Level II	7/2/96	0	0

Potential for debris Moderate. There is some debris caught on the upstream and downstream road embankments.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 7/2/96.

Description of the Geomorphic Setting

General topography The channel is located within a wide low relief valley with flat to slightly irregular, wide flood plain.

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

Date of inspection 7/2/96

DS left: Wide flood plain.

DS right: Slightly sloped channel bank to a wide flood plain.

US left: Slightly sloped channel bank to a wide flood plain.

US right: Slightly sloped channel bank to a wide flood plain.

Description of the Channel

Average top width 932 *ft* ***Average depth*** 6 *ft*

Predominant bed material Silt / Sand ***Bank material*** Silt / Sand

Meandering but stable with alluvial channel boundaries and a wide flood plain.

7/2/96

Vegetative co Trees and brush with pasture on the flood plain.

DS left: Trees and brush with pasture on the flood plain.

DS right: Trees and brush with pasture on the flood plain.

US left: Trees and brush with pasture on the flood plain.

US right: Yes

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

None 7/2/96.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 8.00 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
St. Lawrence Valley / Champlain	100

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 770 ***ft³/s*** ***Q500*** 1,200 ***ft³/s***

The 100- and 500-year discharges are based on the empirical method documented in "Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B" (Benson, 1962). The Benson results were chosen due to their central tendency among the results from several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Subtract 400.3 ft from the USGS arbitrary survey datum to obtain the datum used in the VTAOT plans.

Description of reference marks used to determine USGS datum. RM1 is a VT Highway Dept. brass tablet on top of the downstream end of the right abutment (elev. 500.52 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the left abutment (elev. 500.09 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	-59	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	15	1	Road Grade section
APPRO	72	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.030 to 0.040, and overbank "n" values ranged from 0.058 to 0.069.

The starting water surface was the minimum stage of Lake Champlain during the period of record for the gage (04294500) at Burlington, VT. The flow at all stages is influenced by backwater from Lake Champlain. This starting water surface was assumed for all analysis in order to obtain the maximum scour estimate, as recommended by Richardson and Davis, 1995, p. 26.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 501.4 ***ft***
Average low steel elevation 498.1 ***ft***

100-year discharge 770 ***ft^3/s***
Water-surface elevation in bridge opening 493.8 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 91 ***ft^2***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.5 ***ft/s***

Water-surface elevation at Approach section with bridge 495.3
Water-surface elevation at Approach section without bridge 493.0
Amount of backwater caused by bridge 2.3 ***ft***

500-year discharge 1,200 ***ft^3/s***
Water-surface elevation in bridge opening 494.6 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 123 ***ft^2***
Average velocity in bridge opening 9.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.8 ***ft/s***

Water-surface elevation at Approach section with bridge 496.6
Water-surface elevation at Approach section without bridge 494.4
Amount of backwater caused by bridge 2.2 ***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 100-year and 500-year discharges scour analysis are presented in tables 1 and 2 and the scour depths are presented graphically in figure 8.

The channel bed material ranges from clay to sand. Sieve analysis indicates that greater than 50% of the sample is coarse silt and clay and thus a medium grain size by use of sieve analysis was indeterminate. The median grain size was assumed to be a course silt with a size (D50) of 0.061mm (0.0002 ft). The coarse silt bed material size was determined from the Sediment Grade Scale in Hydraulic Engineering Circular 20 (Table 1, Lagasse and others, 1995).

Contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). The stone fill placed at the upstream and downstream bridge faces may offer some protection of the bed material. The bottom of footing elevation is at 488.3 ft with piles extending 70 ft below the footing to an elevation of 418 ft. Calculated scour depths are below the bottom of footing but above the pile depth indicated on the VTAOT plans.

Abutment scour was computed by use of the HIRE equation (Richardson and Davis, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour 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	14.0	20.7	--
Depth to armoring	N/A	N/A	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	3.2	5.6	--
Right abutment	6.6	8.3	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:			
Left abutment	0.9	1.2	--
Right abutment	0.9	1.2	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

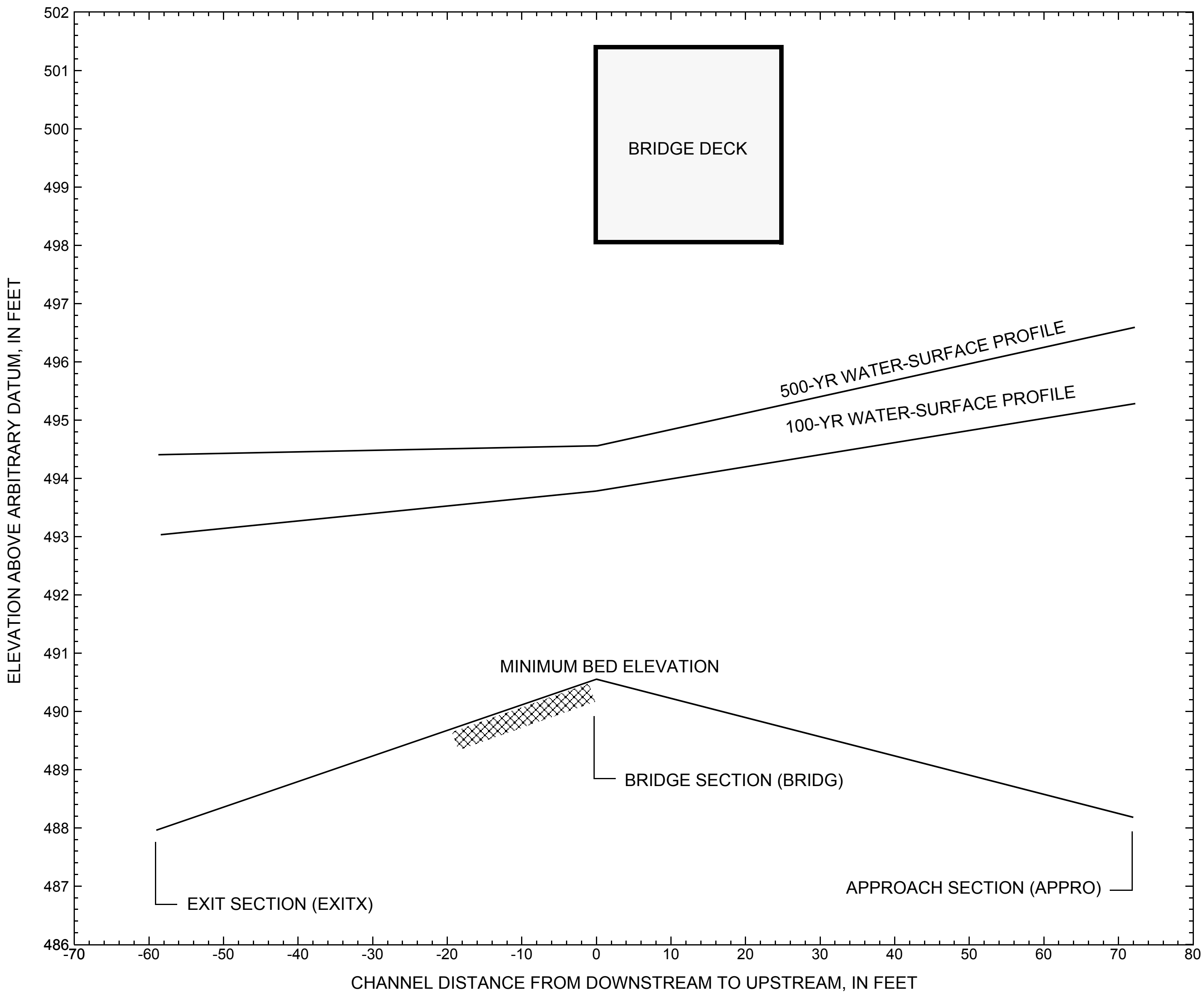

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FERRTH00190032 on Town Highway 19, crossing the South Slang Little Otter Creek, Ferrisburg, Vermont.

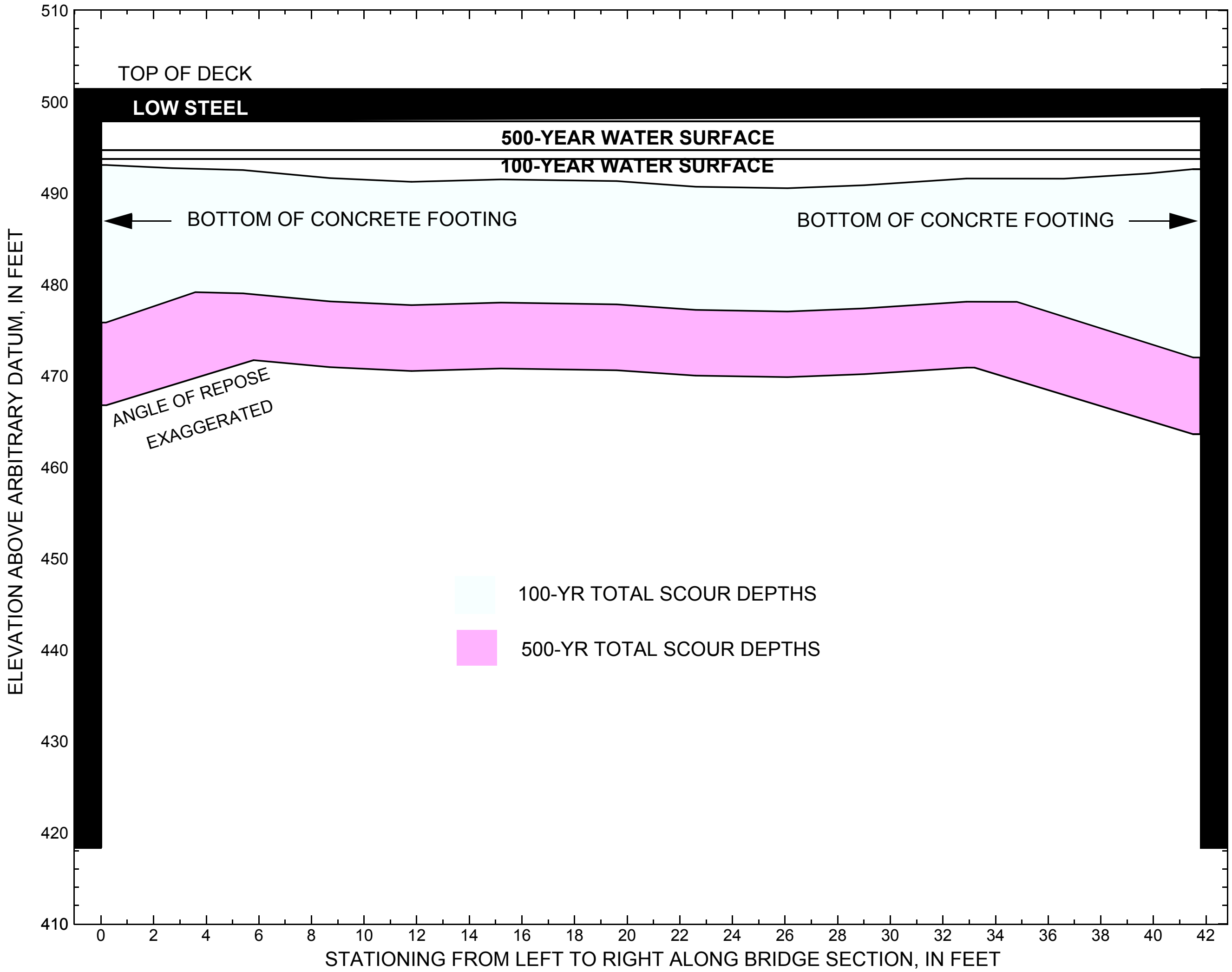

Figure 8. Scour elevations for the 100-year and 500-year discharges at structure FERRTH00190032 on Town Highway 19, crossing the South Slang Little Otter Creek, Ferrisburg, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FERRTH00190032 on Town Highway 19, crossing the South Slang Little Otter Creek, Ferrisburg, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 770 cubic-feet per second											
Left abutment	0.0	--	497.9	418	493.1	14.0	3.2	--	17.2	475.9	58
Right abutment	41.8	--	498.3	418	492.6	14.0	6.6	--	20.6	472.0	54

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 FERRTH00190032 on Town Highway 19, crossing the South Slang Little Otter Creek, Ferrisburg, Vermont.

[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 1,200 cubic-feet per second											
Left abutment	0.0	--	497.9	418	493.1	20.7	5.6	--	26.3	466.8	48
Right abutment	41.8	--	498.3	418	492.6	20.7	8.3	--	29.0	463.6	45

1.Measured along the face of the most constricting side of the bridge.

2.Arbitrary datum for this study.

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dU.S. Geological Survey, 1980, Westport, Vermont 7.5 X 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File ferr032.wsp
T2        Hydraulic analysis for structure FERRTH00190032   Date: 27-OCT-97
T3        Br 32 on Hawkins Rd over South Slang Little Otter Crk Ferrisburg, VT
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q            770.0   1200.0
WS           493.0    493.0
*
XS   EXITX    -59           0.
GR         -712.4, 499.52   -632.5, 499.07   -562.2, 499.16   -492.8, 499.13
GR         -485.4, 497.84   -483.9, 496.38   -472.0, 494.54   -430.9, 491.61
GR         -387.6, 492.66   -313.8, 492.39   -211.4, 491.14   -147.0, 491.46
GR          -91.1, 491.36    -46.6, 492.18    -17.8, 491.21      0.0, 489.12
GR           10.0, 488.14     29.0, 487.96     41.4, 489.14     56.6, 491.90
GR           76.6, 492.85    106.6, 493.05    197.0, 495.23    241.7, 496.16
GR          248.8, 497.75    281.5, 499.82    296.0, 501.61    370.5, 503.50
GR          558.3, 507.72
N           0.065        0.040        0.065
SA                -492.8        296.0
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG      0    498.08       0.0
GR            0.0, 497.86      0.0, 497.79      0.2, 493.07      2.7, 492.73
GR            5.4, 492.53      8.7, 491.65     11.8, 491.24     15.2, 491.51
GR           19.6, 491.32     22.6, 490.72     26.1, 490.55     29.0, 490.88
GR           32.9, 491.61     36.6, 491.59     39.8, 492.16     41.5, 492.62
GR           41.8, 497.84     41.8, 498.30      0.0, 497.86
*
*         BRTYPE  BRWDTH
CD           1      30.1
N           0.030
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     15      24.8     1
GR        -1758.0, 510.73  -1473.0, 504.01   -828.4, 502.83   -715.8, 502.29
GR         -682.6, 502.16   -476.3, 501.43   -364.2, 500.67   -255.2, 500.39
GR         -132.3, 500.22    -46.3, 500.45      0.0, 501.41     41.6, 501.35
GR          130.1, 501.01    229.4, 502.07    305.2, 502.28    369.1, 503.41
GR          459.1, 505.64
*
AS   APPRO     72           0.
GR        -1237.4, 500.83   -730.1, 500.85   -727.9, 498.26   -644.9, 496.27
GR         -596.7, 495.98   -530.9, 495.83   -461.3, 494.81   -384.7, 495.10
GR         -284.1, 494.88   -163.6, 494.14   -116.6, 493.52    -87.0, 492.95
GR          -63.6, 492.49    -39.7, 492.11    -16.1, 490.99      0.0, 489.58
GR           14.3, 488.21     31.0, 488.18     48.8, 489.99     84.3, 491.89
GR          119.8, 493.15    154.2, 493.97    237.9, 494.28    283.2, 496.36
GR          314.0, 496.95    324.9, 497.84    331.2, 498.52    345.1, 501.01
N           0.065        0.058        0.040        0.069
SA                -730.1       -530.9        345.1
*
HP 1 BRIDG 493.77 1 493.77
HP 2 BRIDG 493.77 * * 770
HP 1 APPRO 495.26 1 495.26
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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U.S. Geological Survey WSPRO Input File ferr032.wsp
Hydraulic analysis for structure FERRTH00190032   Date: 27-OCT-97
Bridge 32 on Hawkins Road over South Slang Little Otter Creek Ferrisburgh, VT MAI
   *** RUN DATE & TIME: 01-20-98  11:44

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

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          1      91.    7371.    41.    44.                          765.
493.77           91.    7371.    41.    44.  1.00     0.    42.    765.


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

     WSEL     LEW     REW    AREA        K        Q    VEL
   493.77     0.2    41.6    90.9    7371.     770.   8.47

X STA.         0.2         8.7        10.7        12.3        14.0        15.9
  A(I)            10.9         4.4         4.1         4.1         4.2
  V(I)            3.54        8.72        9.44        9.37        9.09

X STA.        15.9        17.7        19.4        21.0        22.3        23.5
  A(I)             4.3         4.1         4.0         3.8         3.6
  V(I)            8.98        9.36        9.65       10.14       10.74

X STA.        23.5        24.7        25.9        27.0        28.2        29.6
  A(I)             3.7         3.8         3.7         3.7         3.8
  V(I)           10.43       10.24       10.49       10.33       10.02

X STA.        29.6        31.1        32.9        35.0        37.0        41.6
  A(I)             4.0         4.3         4.5         4.3         7.6
  V(I)            9.64        8.98        8.61        8.86        5.04

CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

  WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
          3     1306.   70338.   751.   752.                        9774.
495.26          1306.   70338.   751.   752.  1.00  -492.   259.   9774.


VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

     WSEL     LEW     REW    AREA        K        Q    VEL
   495.26  -492.0   259.2  1306.3   70338.     770.   0.59

X STA.      -492.0       -28.5       -18.4       -10.0        -3.0         3.1
  A(I)           443.5        39.3        37.4        35.8        35.1
  V(I)            0.09        0.98        1.03        1.08        1.10

X STA.         3.1         8.8        14.0        19.0        24.1        27.3
  A(I)            35.4        35.3        35.2        35.8        23.0
  V(I)            1.09        1.09        1.09        1.08        1.68

X STA.        27.3        32.2        39.3        47.3        56.3        66.4
  A(I)            34.4        47.0        46.3        46.4        46.3
  V(I)            1.12        0.82        0.83        0.83        0.83

X STA.        66.4        78.1        92.7       111.4       142.4       259.2
  A(I)            47.0        48.8        51.3        60.6       122.4
  V(I)            0.82        0.79        0.75        0.64        0.31
```

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        U.S. Geological Survey WSPRO Input File ferr032.wsp
        Hydraulic analysis for structure FERRTH00190032   Date: 27-OCT-97
        Bridge 32 on Hawkins Road over South Slang Little Otter Creek Ferrisburg, VT MAI
           *** RUN DATE & TIME: 12-16-97  11:14
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     123.   11953.    41.    45.                         1206.
   494.55          123.   11953.    41.    45.  1.00     0.    42.   1206.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.55     0.1    41.6   123.2   11953.    1200.   9.74

 X STA.         0.1        7.2        9.4       11.3       12.9       14.7
   A(I)            13.4        6.2        5.8        5.4        5.7
   V(I)            4.48       9.73      10.38      11.14      10.53

 X STA.        14.7       16.6       18.4       20.1       21.6       23.0
   A(I)             5.7        5.6        5.6        5.3        5.1
   V(I)           10.45      10.79      10.75      11.24      11.79

 X STA.        23.0       24.3       25.6       26.9       28.2       29.6
   A(I)             5.1        5.2        5.1        5.2        5.2
   V(I)           11.80      11.61      11.81      11.55      11.64

 X STA.        29.6       31.3       33.1       35.1       37.1       41.6
   A(I)             5.5        5.7        5.9        5.8       10.9
   V(I)           10.92      10.48      10.23      10.26       5.51


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             2      76.    1370.   129.   129.                          331.
             3    2408.  182530.   829.   829.                        23285.
   496.64         2484.  183900.   958.   959.  1.04  -660.   298.  22238.


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      72.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.64  -660.3   297.8  2483.6  183900.    1200.   0.48

 X STA.      -660.3     -326.8     -201.7     -138.2      -99.7      -72.3
   A(I)           389.8      239.0      158.6      119.8      101.8
   V(I)            0.15       0.25       0.38       0.50       0.59

 X STA.       -72.3      -49.5      -29.7      -14.4       -1.5        6.7
   A(I)            95.6       91.0       82.5       81.7       60.1
   V(I)            0.63       0.66       0.73       0.73       1.00

 X STA.         6.7       16.0       26.5       36.9       48.9       63.3
   A(I)            75.5       88.9       86.0       87.3       89.9
   V(I)            0.79       0.68       0.70       0.69       0.67

 X STA.        63.3       79.9      101.3      130.3      175.0      297.8
   A(I)            90.0       97.2      105.8      125.4      217.6
   V(I)            0.67       0.62       0.57       0.48       0.28
```

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        U.S. Geological Survey WSPRO Input File ferr032.wsp
        Hydraulic analysis for structure FERRTH00190032   Date: 27-OCT-97
        Bridge 32 on Hawkins Road over South Slang Little Otter Crk Ferrisburgh, VT MAI
           *** RUN DATE & TIME: 01-20-98  11:44

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

 EXITX:XS   ******  -450.     798.  0.01 *****  493.01  490.53    770.  493.00
       -59. ******    99.   38131.  1.00 ***** *******    0.14    0.96

 FULLV:FV      59.  -451.     813.  0.01  0.02  493.04 *******    770.  493.03
         0.    59.   103.   39107.  1.00  0.00    0.00    0.14    0.95
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  0.61

 APPRO:AS      72.   -92.     411.  0.05  0.05  493.10 *******    770.  493.05
        72.    72.   117.   23971.  1.00  0.02    0.00    0.24    1.87
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     770.     493.77

             <<<<<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      59.     0.      91.  1.11 *****  494.89  493.77    770.  493.77
         0.    59.    42.    7395.  1.00 ***** *******    1.00    8.45

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  498.08 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR      Q    WSEL
    RDWAY:RG      15.         <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRO:AS      42.  -492.    1304.  0.01  0.05  495.26  490.75    770.  495.26
        72.    45.   259.   70176.  1.00  0.33   -0.02    0.08    0.59

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.804  0.484   36769.     1.    42.   495.25

   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL   WSEL
    EXITX:XS     -59.  -450.    99.    770.   38131.     798.    0.96  493.00
    FULLV:FV       0.  -451.   103.    770.   39107.     813.    0.95  493.03
    BRIDG:BR       0.     0.    42.    770.    7395.      91.    8.45  493.77
    RDWAY:RG      15.**************      0.******************    1.00********
    APPRO:AS      72.  -492.   259.    770.   70176.    1304.    0.59  495.26

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS       1.    42.   36769.

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    490.53    0.14  487.96  507.72************  0.01  493.01  493.00
    FULLV:FV  ********    0.14  487.96  507.72  0.02  0.00  0.01  493.04  493.03
    BRIDG:BR    493.77    1.00  490.55  498.30************  1.11  494.89  493.77
    RDWAY:RG  ****************  500.22  510.73**********************************
    APPRO:AS    490.75    0.08  488.18  501.01  0.05  0.33  0.01  495.26  495.26
```

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        U.S. Geological Survey WSPRO Input File ferr032.wsp
        Hydraulic analysis for structure FERRTH00190032   Date: 27-OCT-97
        Bridge 32 on Hawkins Road over South Slang Little Otter Creek Ferrisburg, VT MAI
           *** RUN DATE & TIME: 12-16-97  11:14

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

EXITX:XS   ******  -470.    1630.  0.01 *****  494.41  491.64   1200.  494.40
      -59. ******   163.  113992.  1.00 ***** *******    0.08    0.74

FULLV:FV      59.  -470.    1634.  0.01  0.01  494.42 *******   1200.  494.41
        0.    59.   163.  114474.  1.00  0.00    0.00    0.08    0.73
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "APPRO"     KRATIO =  0.39

APPRO:AS      72.  -208.     814.  0.03  0.02  494.45 *******   1200.  494.41
       72.    72.   241.   45048.  1.00  0.01    0.00    0.19    1.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =     1200.     494.55

            <<<<<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      59.     0.     123.  1.76 *****  496.31  494.55   1200.  494.55
        0.    59.    42.   11950.  1.19 ***** *******    1.09    9.74

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.916 ******  498.08 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      15.       <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      42.  -660.    2484.  0.00  0.03  496.64  491.36   1200.  496.64
       72.    51.   298.  183983.  1.04  0.30    0.00    0.05    0.48

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.908  0.729   49726.    -2.    39.   496.64

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -59.  -470.   163.   1200.  113992.    1630.    0.74  494.40
   FULLV:FV       0.  -470.   163.   1200.  114474.    1634.    0.73  494.41
   BRIDG:BR       0.     0.    42.   1200.   11950.     123.    9.74  494.55
   RDWAY:RG      15.**************      0.*****************    1.00********
   APPRO:AS      72.  -660.   298.   1200.  183983.    2484.    0.48  496.64

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -2.    39.   49726.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    491.64    0.08  487.96  507.72************  0.01  494.41  494.40
   FULLV:FV  ********    0.08  487.96  507.72  0.01  0.00  0.01  494.42  494.41
   BRIDG:BR    494.55    1.09  490.55  498.30************  1.76  496.31  494.55
   RDWAY:RG  ****************  500.22  510.73**********************************
   APPRO:AS    491.36    0.05  488.18  501.01  0.03  0.30  0.00  496.64  496.64
```

APPENDIX C:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FERRTH00190032

General Location Descriptive

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

Date *(MM/DD/YY)* 12 / 11 / 95

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

County *(FIPS county code; I - 3; nnn)* 001

Town *(FIPS place code; I - 4; nnnnn)* 26275

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

Waterway *(I - 6)* Hawkins Slang Brook

Road Name *(I - 7)*: Hawkins Road

Route Number TH 19

Vicinity *(I - 9)* 1.9 miles to jct. with TH5

Topographic Map Westport

Hydrologic Unit Code: 02010002

Latitude *(I - 16; nnnn.n)* 44133

Longitude *(i - 17; nnnnn.n)* 73164

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10010500320105

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

Maximum span length *(I - 48; nnnn)* 0042

Year built *(I - 27; YYYY)* 1966

Structure length *(I - 49; nnnnnn)* 000045

Average daily traffic, ADT *(I - 29; nnnnnn)* 000150

Deck Width *(I - 52; nn.n)* 248

Year of ADT *(I - 30; YY)* 92

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

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

Waterway adequacy *(I - 71; n)* 4

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

Underwater Inspection Frequency *(I - 92B; XYY)* Y48

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 40

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

Vertical clearance from streambed (*nnn.n ft*) 7.5

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

Waterway of full opening (*nnn.n* ft^2) 300

Comments:

According to the structural inspection report dated 9/28/94, the structure consists of 6 concrete box beams with a concrete overlay. The abutments are concrete. The abutments have overall light to heavy scaling. Portions of the substructure stem and footings are inaccessible due to the depth of the water. There was approximately 2 ft of freeboard at the time of the inspection. The channel is very wide through this locations, with large areas of marshland. There is stone fill along the front of the abutments. Contraction scour through the channel is noted. There is poor hydraulic adequacy because of the low height.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: **Silt to sand.**

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: **On the cross-section sketch of the DS bridge face dated 10-15-92, a beaver dam is noted against the left abutment.**

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

According to the underwater bridge inspection report dated 7/7/93, the bottom is silt-sand and the water is dark with poor visibility and weeds.

Also, the top of the footing is exposed on the right abutment.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **8.02** mi^2 Lake/pond/swamp area **0.048** mi^2

Watershed storage *(ST)* **0.06** %

Bridge site elevation **98** ft Headwater elevation **290** ft

Main channel length **7.35** mi

10% channel length elevation **98** ft 85% channel length elevation **189** ft

Main channel slope *(S)* **16.51** 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):* - / 1966

Project Number -

Minimum channel bed elevation: 90.5

Low superstructure elevation: USLAB 99.8 DSLAB 99.8 USRAB 100.21 DSRAB 100.21

Benchmark location description:

The low superstructure elevations are the top of the abutment corner elevations from the bridge plans. BM #1 (spike in root or trunk) elevation 100 ft (assumed), in a 36 in elm, 200 ft from the right side of the bridge at the DS end.

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

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

If 1: Footing Thickness 3 Footing bottom elevation: 88.0

If 2: Pile Type: 1 (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: 70*

If 3: Footing bottom elevation: -

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 3

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

Briefly describe material at foundation bottom elevation or around piles:

The B-10 boring near center of channel shows that refusal on rock is reached at about 125' below bottom of the stream bed. Clay constitutes most of the material above rock.

Comments:

***The plans indicate estimated length, 70 ft each pile. Office memo in folder contains note that "local resident says that abutments are on 90 ft piles. There was ledge at 132 ft."**

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 at the downstream face. The low chord data is from the survey log done for this report on 7/2/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 9/28/94. The sketch was done on 10/15/92.**

Station	0	16.1	24.6	40.8	-	-	-	-	-	-	-
Feature	RAB	-	-	LAB	-	-	-	-	-	-	-
Low chord elevation	498.3	498.1	498.1	497.9	-	-	-	-	-	-	-
Bed elevation	492.5	491.1	491.4	493.1	-	-	-	-	-	-	-
Low chord to bed	5.8	7.0	6.7	4.8	-	-	-	-	-	-	-

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 D:

LEVEL I DATA FORM

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

Qa/Qc Check by: RB Date: 10/25/96
Computerized by: RB Date: 10/28/96
Reviewd by: MAI Date: 10/30/97

Structure Number FERRTH00190032

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. Wild Date *(MM/DD/YY)* 07 / 02 / 1996

2. Highway District Number 05 Mile marker -

County Addison (001) Town Ferrisburg (26275)

Waterway *(I - 6)* South Slang Little Otter Creek Road Name Hawkins Road

Route Number TH019 Hydrologic Unit Code: 02010002

3. Descriptive comments:

The site is located 1.9 miles from the junction with Town Highway 5.

B. Bridge Deck Observations

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

5. Ambient water surface... US 1 UB 1 DS 1 *(**1**- pool; **2**- riffle)*

6. Bridge structure type 1 *(**1**- single span; **2**- multiple span; **3**- single arch; **4**- multiple arch; **5**- cylindrical culvert; **6**- box culvert; or **7**- other)*

7. Bridge length 45 *(feet)* Span length 42 *(feet)* Bridge width 24.8 *(feet)*

Road approach to bridge:

8. LB 0 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 -- US right --

	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	1	1	0	-
RBUS	1	1	0	-
RBDS	1	1	3	1
LBDS	1	1	3	1

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

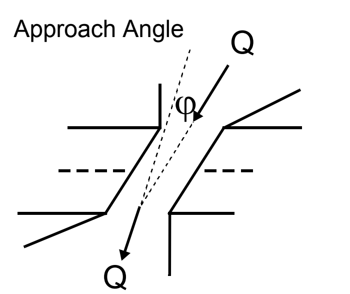
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

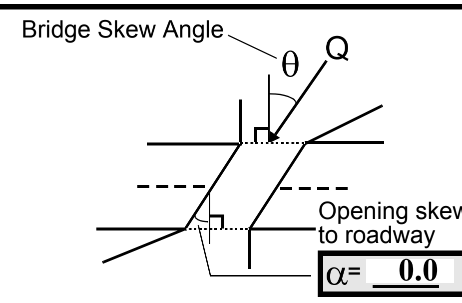
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

15. Angle of approach: 0 16. Bridge skew: 5





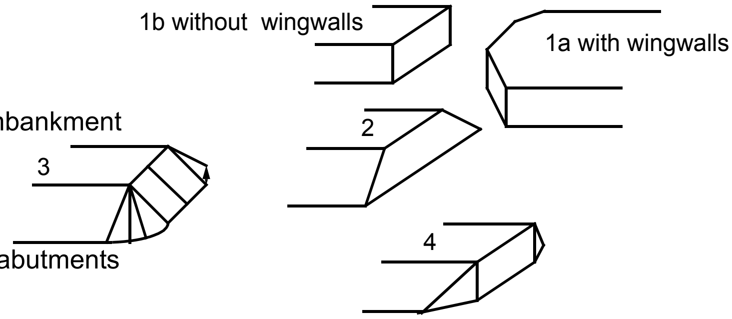
17. Channel impact zone 1: Exist? N *(Y or N)*
Where? - *(LB, RB)* Severity -
Range? - feet - *(US, UB, DS)* to - feet -

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: **1b**

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 main channel thalweg upstream and downstream meanders through a wetland. (see sketch)
13. There is no roadwash and the channel is protected with stone fill along the road embankments. However, at the bridge there is erosion of the material along the downstream road embankment. Debris has filled in the void behind the DS right road embankment. The sand has been washed away undermining 0.4 ft under the pavement near the DS left road embankment.

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
71.5	2.5			3.0	2	2	10	10	1	1

23. Bank width **45.0**   24. Channel width **10.0**   25. Thalweg depth **1075.0**   29. Bed Material **017**

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.):

29. Stone fill extends to 28 ft US and across the US bridge face in the channel.

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

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

37. Material: **-**

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? **Y** *(Y or if N type ctrl-n cs)* 46. Mid-scour distance: **62**

47. Scour dimensions: Length **57** Width **40** Depth : **3.5** Position **40** %LB to **47** %RB

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

The total depth is 9.5 ft. The thalweg is assumed to be 6 ft.

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
1058.5		10.0		2	7	7	-

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

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

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

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

173

63. The bed material is clay and stone fill extending across the entire bridge face on the US end. Silt, clay, and gravel exists DS to the edge of the abutments where the abutment side walls begin then there is slumped stone fill from the corners to 10 ft DS.

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 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

66. The debris is in the form of large trees accumulating on the US and DS edges of the road.

67. There is moderate debris potential due to vegetation along the marsh banks and in the marsh itself.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	0	0	0	90.0
RABUT	1	5	90			2	2	42.0

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

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

2

.5

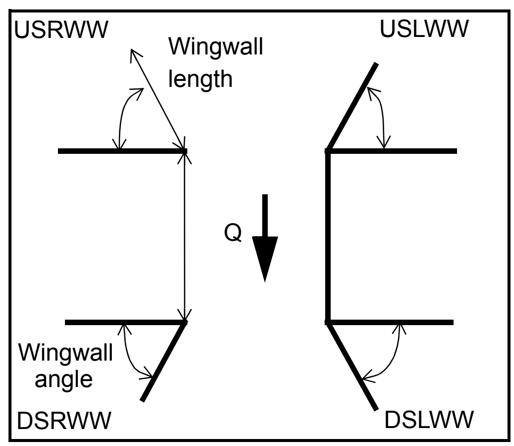
1

74. The scour is on the right side from the US bridge face to 17 ft US. The scour hole width is 9 ft and the depth is 2 ft at 7 ft US. The assumed thalweg depth is 6 ft.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						42.0	
USRWW:	N		-		-	7.0	
DSLWW:	-		-		N	29.5	
DSRWW:	-		-		-	30.0	

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	-	-	N	-	-	-	1	1
Condition	N	-	-	-	-	-	1	1
Extent	-	-	-	-	-	1	1	-

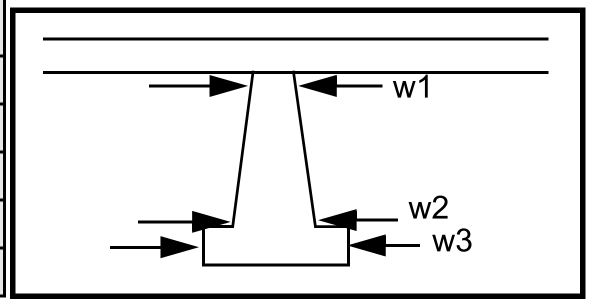
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



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

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

E. Downstream Channel Assessment

100.

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

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

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

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

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

101. Is a drop structure present? 2 *(Y or N, if N type ctrl-n ds)* 102. Distance: - feet

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

105. Drop structure comments (eg. downstream scour depth):
120
120
1
1
10
0

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

Point bar extent: Ther feet e is (US, UB, DS) to a feet lay (US, UB, DS) positioned er %LB to of %RB

Material: thi

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

ck muck on the bed. There is silt/ clay material in the channel bed near the bridge and just DS of the bridge.

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? NO (Y or if N type ctrl-n cs) Mid-scour distance: DRO

Scour dimensions: Length P Width STR Depth: UC Positioned TU %LB to RE %RB

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

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

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

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

Confluence comments (eg. confluence name):

-

-

F. Geomorphic Channel Assessment

107. Stage of reach evolution -

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

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

NO POINT BARS

N
-
-
-
-
-
-
-
NO CUT BANKS

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 E:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number:	FERRTH00190032	Town:	Ferrisburgh
Road Number:	TH 19	County:	Addison
Stream:	South Slang Little Otter Creek		

Initials MAI Date: 10/28/97 Checked: SAO

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

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

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	770	1200	0
Main Channel Area, ft2	1306	2408	0
Left overbank area, ft2	0	76	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	751	829	0
Top width L overbank, ft	0	129	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.0002	0.0002	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	1.7	2.9	ERR
y1, average depth, LOB, ft	ERR	0.6	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	70338	183900	0
Conveyance, main channel	70338	182530	0
Conveyance, LOB	0	1370	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	770.0	1191.1	ERR
Ql, discharge, LOB, cfs	0.0	8.9	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	0.6	0.5	ERR
Vl, mean velocity, LOB, ft/s	ERR	0.1	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	0.7	0.8	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

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour

y2/y1 = (Q2/Q1)^(6/7)*(W1/W2)^(k1)

ys=y2-y_bridge

(Richardson and others, 1995, p. 30, eq. 17 and 18)

	Approach			Bridge		
Characteristic	100 yr	500 yr	Other Q	100 yr	500 yr	Other Q
Q1, discharge, cfs	770	1200	0	770	1200	0
Total conveyance	70338	183900	0	7371	11953	0
Main channel conveyance	70338	182530	0	7371	11953	0
Main channel discharge	770	1191	ERR	770	1200	ERR
Area - main channel, ft2	1306	2408	0	90.9	123.2	0
(W1) channel width, ft	751	829	0	41.4	41.5	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	751	829	0	41.4	41.5	0
D50, ft	0.0002	0.0002	0.0002			
w, fall velocity, ft/s (p. 32)	0.01418	0.01418	0			
y, ave. depth flow, ft	1.74	2.90	N/A	2.20	2.97	ERR
S1, slope EGL	0.00083	0.00194	0			
P, wetted perimeter, MC, ft	752	829	0			
R, hydraulic Radius, ft	1.737	2.905	ERR			
V*, shear velocity, ft/s	0.215	0.426	N/A			
V*/w	15.193	30.040	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.69	0.69	0			
y2,depth in contraction, ft	12.85	23.08	ERR			
ys, scour depth, ft (y2-y_bridge)	**10.65**	**20.11**	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	770	1200	0
(Q) discharge thru bridge, cfs	770	1200	0
Main channel conveyance	7371	11953	0
Total conveyance	7371	11953	0
Q2, bridge MC discharge,cfs	770	1200	ERR
Main channel area, ft2	91	123	0
Main channel width (normal), ft	41.4	41.5	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	41.4	41.5	0
y_bridge (avg. depth at br.), ft	2.20	2.96	ERR
Dm, median (1.25*D50), ft	0.00025	0.00025	0
y2, depth in contraction,ft	16.21	23.67	ERR
ys, scour depth (y2-ybridge), ft	**14.02**	**20.70**	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	770	1200	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)

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	770	1200	0	770	1200	0
a', abut.length blocking flow, ft	492.2	660.4	0	217.6	256.2	0
Ae, area of blocked flow ft2	574.41	1371.53	0	455.79	779.01	0
Qe, discharge blocked abut.,cfs	174.2	551.71	0	296.93	396.5	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.30	0.40	ERR	0.65	0.51	ERR
ya, depth of f/p flow, ft	1.17	2.08	ERR	2.09	3.04	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--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	0.049	0.049	ERR	0.079	0.051	ERR
ys, scour depth, ft	6.86	11.02	N/A	9.56	10.64	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)	492.2	660.4	0	217.6	256.2	0
y1 (depth f/p flow, ft)	1.17	2.08	ERR	2.09	3.04	ERR
a'/y1	421.76	317.99	ERR	103.89	84.26	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.05	0.05	N/A	0.08	0.05	N/A
Ys w/ corr. factor K1/0.55:						
vertical	**3.15**	**5.59**	ERR	**6.60**	**8.31**	ERR
vertical w/ ww's	2.58	4.58	ERR	5.41	6.81	ERR
spill-through	1.73	3.07	ERR	3.63	4.57	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	2.20	2.96	0.00	2.20	2.96	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.)	0.92	1.24	ERR	0.92	1.24	ERR