LEVEL II SCOUR ANALYSIS FOR BRIDGE 57 (NEWFTH00690057) on TOWN HIGHWAY 69, crossing HUNTER BROOK, NEWFANE, VERMONT

Open-File Report 98-193

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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LEVEL II SCOUR ANALYSIS FOR BRIDGE 57 (NEWFTH00690057) on TOWN HIGHWAY 69, crossing HUNTER BROOK, NEWFANE, VERMONT

By RONDA L. BURNS

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Pembroke, New Hampshire

1998

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

U.S. GEOLOGICAL SURVEY
Thomas J. Casadevall, Acting Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 57 (NEWFTH00690057) ON TOWN HIGHWAY 69, CROSSING HUNTER BROOK, NEWFANE, VERMONT

By **Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NEWFTH00690057 on Town Highway 69 crossing Hunter Brook, Newfane, 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 New England Upland section of the New England physiographic province in southeastern Vermont. The 4.67-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 on the downstream left bank, where there is a house with a lawn.

In the study area, Hunter Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 58 ft and an average bank height of 11 ft. The channel bed material ranges from sand to boulders with a median grain size (D_{50}) of 79.2 mm (0.260 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 13, 1996, indicated that the reach was laterally unstable. There is a cut-bank upstream and point bars are upstream and downstream of the bridge.

The Town Highway 69 crossing of Hunter Brook is a 40-ft-long, one-lane bridge consisting of one 36-foot steel-beam span (Vermont Agency of Transportation, written communication, April 6, 1995). The opening length of the structure parallel to the bridge face is 35.8 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 zero degrees.

The tops of the footings on the left and right abutments and upstream right wingwall were observed during the Level I assessment. The downstream left wingwall footing was also exposed 1 ft. The scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the downstream right bank and type-2 stone fill (less than 36 inches diameter) along the upstream right bank, upstream left wingwall, downstream right wingwall, and the upstream end of the upstream right wingwall. There was also a wall along the downstream left bank constructed of concrete blocks. 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 computed for all modelled flows was zero ft. Abutment scour ranged from 4.9 to 7.3 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. 46). 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.

West Dover, VT. Quadrangle, 1:24,000, 1986

NORTH

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

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

LEVEL II SUMMARY

Structure Number NEWFTH00690057 ***Stream*** Hunter Brook

County Windham ***Road*** TH 69 ***District*** 2

Description of Bridge

Bridge length 40 ***ft*** ***Bridge width*** 14.5 ***ft*** ***Max span length*** 36 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 8/13/96

Description of stone fill Type-2, along the upstream left wingwall and downstream right wingwall and at the upstream end of the upstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. The tops of the footings on the left and right abutments and the upstream right wingwall are visible and the downstream left wingwall footing is exposed 1 ft.

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

There is a mild channel bend in the upstream reach. The cut-bank has developed in the location where the flow impacts the upstream right bank.

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	8/13/96	0	0
Level II	8/13/96	0	0

Potential for debris Moderate. The banks are heavily vegetated.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 8/13/96.

Description of the Geomorphic Setting

General topography The channel is located within a high relief valley with steep valley walls.

8/13/96

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

Date of inspection Vertical

DS left: concrete block wall to a mildly sloped overbank

DS right: Steep valley wall

US left: Steep channel bank to a moderately sloped overbank

US right: Steep valley wall

Description of the Channel

Average top width 58 *ft* ***Average depth*** 11 *ft*

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

Sinuous and laterally unstable with non-alluvial channel boundaries and wide point bars.

8/13/96

Vegetative co Short grass

DS left: Trees and brush

DS right: Trees and brush

US left: Trees and brush

US right: No

Do banks appear stable? There is a cut-bank on the upstream right bank and point bars are ***If not, describe location and type of instability and date of observation.*** located upstream and downstream. There is also a large landslide approximately 400 ft upstream.

There are two small dams across the channel upstream that are constructed from the available bed material as

Describe any obstructions in channel and date of observation.

observed on 8/13/96. These dams create pools during low flow conditions.

Hydrology

Drainage area 4.67 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: -

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi***^{2}

Is there a lake/p - No

Calculated Discharges

Q100 1,470 ***ft***^{3}***/s*** ***Q500*** 2,100 ***ft***^{3}***/s***

The 100- and 500-year discharges are based on a drainage area relationship [(4.67/4.6)exp 0.67] with bridge number 45 in Newfane. Bridge number 45 crosses Hunter Brook upstream of this site and has flood frequency estimates available from the VTAOT database (Vermont Agency of Transportation, written communication, May 1995). The drainage area above bridge number 45 is 4.6 square miles. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 499.93 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment (elev. 499.87 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	-39	1	Exit section
BRIDG	0	1	Downstream bridge face section
USBRG	19	1	Upstream bridge face section
APPRO	55	2	Modelled Approach section (Templated from APTEM)
APTEM	67	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 0.060 to 0.075.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0258 ft/ft, which was estimated from surveyed thalweg points downstream of the bridge.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0294 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 provides a consistent method for determining scour variables.

For all modelled flows, the bridge was not a significant constriction in the channel. The WSPRO bridge routines failed to find a solution which balanced the total discharge and energy at the APPRO section with the sum of the discharges and energy over the roadway and through the bridge opening. Therefore, the bridge sections at the upstream and downstream faces were modelled as open channel sections. This allowed the model to evaluate flow conditions through the bridge and at the approach section as unconstricted.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.9 *ft*
Average low steel elevation 497.7 *ft*

100-year discharge 1,470 *ft^3/s*
Water-surface elevation in bridge opening 490.9 *ft*
Road overtopping? No *Discharge over road* - *ft^3/s*
Area of flow in bridge opening 146 *ft^2*
Average velocity in bridge opening 10.1 *ft/s*
Maximum WSPRO tube velocity at bridge 12.2 *ft/s*

Water-surface elevation at Approach section with bridge -
Water-surface elevation at Approach section without bridge -
Amount of backwater caused by bridge N/A *ft*

500-year discharge 2,100 *ft^3/s*
Water-surface elevation in bridge opening 492.3 *ft*
Road overtopping? No *Discharge over road* - *ft^3/s*
Area of flow in bridge opening 193 *ft^2*
Average velocity in bridge opening 10.9 *ft/s*
Maximum WSPRO tube velocity at bridge 13.3 *ft/s*

Water-surface elevation at Approach section with bridge -
Water-surface elevation at Approach section without bridge -
Amount of backwater caused by bridge N/A *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 analyses 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 was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17). The flow conditions evaluated at the downstream bridge face were used for the scour analysis.

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-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	8.2	9.3	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	5.9	7.3	--
Right abutment	4.9	6.5	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.7	2.2	--
Right abutment	1.7	2.2	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

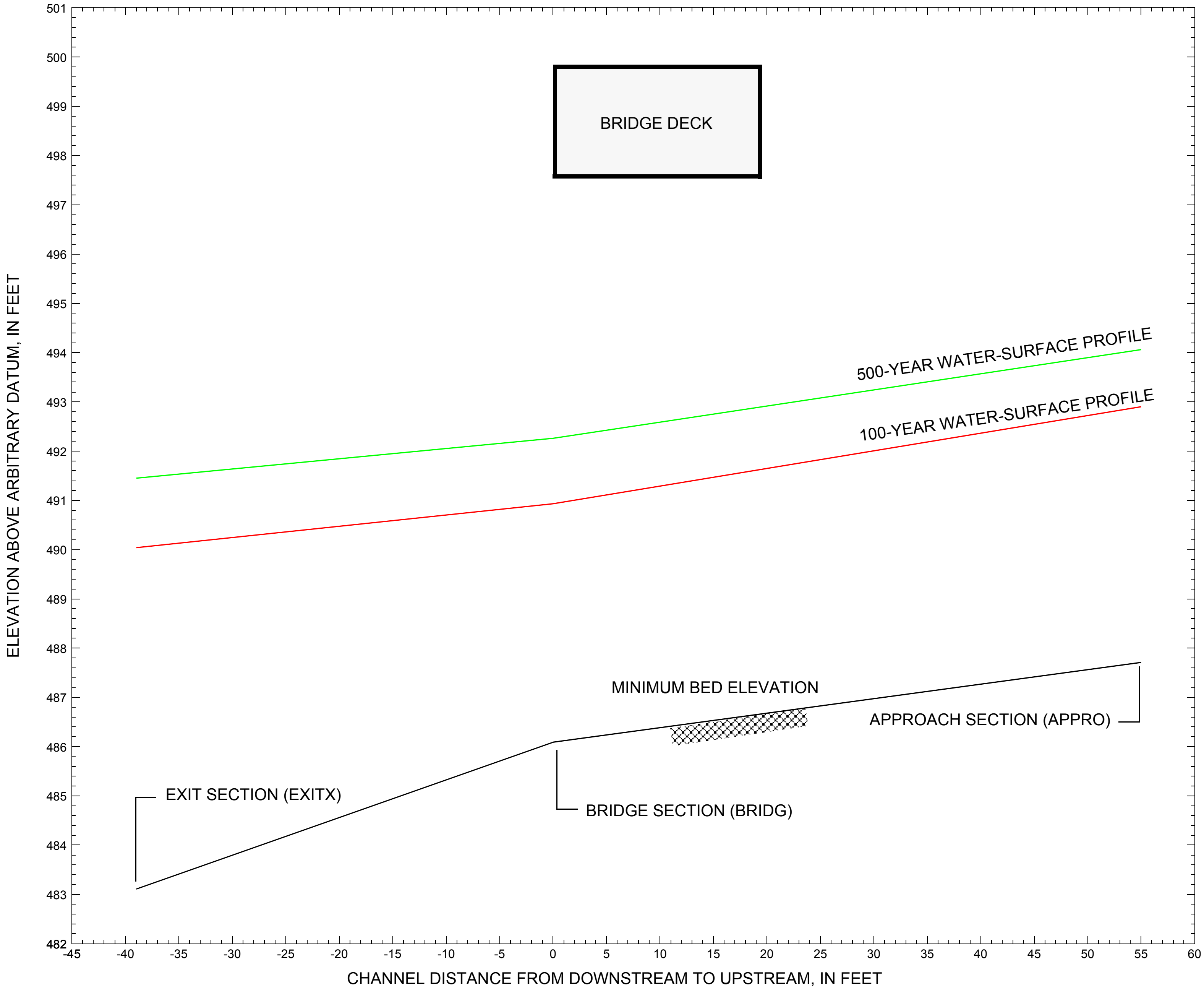

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure NEWFTH00690057 on Town Highway 69, crossing Hunter Brook, Newfane, Vermont.

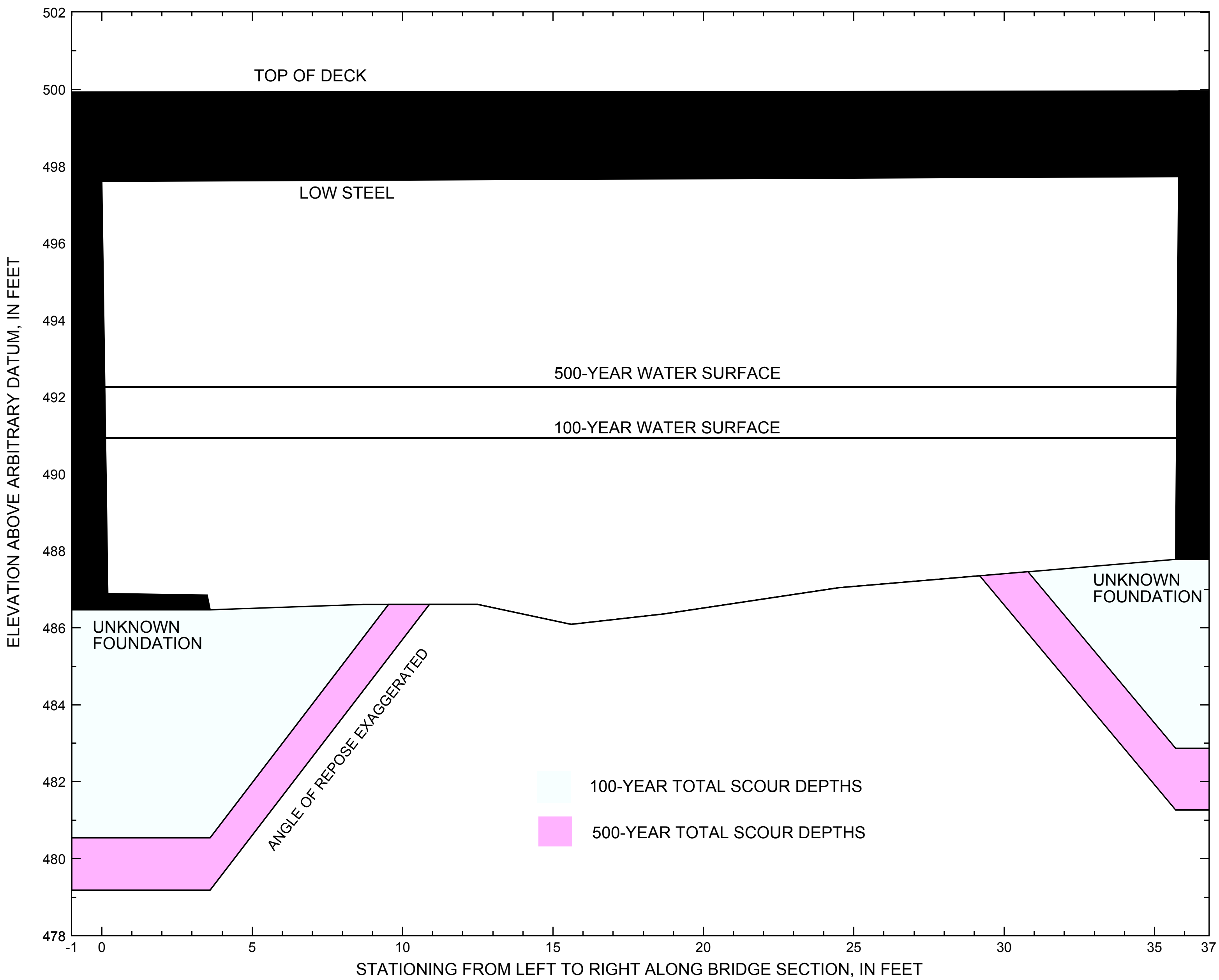

Figure 8. Scour elevations for the 100- and 500-year discharges at structure NEWFTH00690057 on Town Highway 69, crossing Hunter Brook, Newfane, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NEWFTH00690057 on Town Highway 69, crossing Hunter Brook, Newfane, 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/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-year discharge is 1,470 cubic-feet per second											
Left abutment	0.0	--	497.6	--	486.5	0.0	5.9	--	5.9	480.6	--
Right abutment	35.8	--	497.7	--	487.8	0.0	4.9	--	4.9	482.9	--

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 NEWFTH00690057 on Town Highway 69, crossing Hunter Brook, Newfane, 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/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-year discharge is 2,100 cubic-feet per second											
Left abutment	0.0	--	497.6	--	486.5	0.0	7.3	--	7.3	479.2	--
Right abutment	35.8	--	497.7	--	487.8	0.0	6.5	--	6.5	481.3	--

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

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

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File newf057.wsp
T2        Hydraulic analysis for structure NEWFTH00690057   Date: 05-JAN-98
T3        TH 69 CROSSING HUNTER BROOK IN NEWFANE, VERMONT          RLB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1470.0   2100.0
SK          0.0258   0.0258
*
XS   EXITX    -39          0.
GR         -131.8, 501.46    -72.4, 498.20     -1.6, 496.05      0.0, 484.53
GR            1.4, 484.33      3.1, 484.08      6.8, 483.68      9.8, 483.11
GR           13.2, 483.57     21.0, 484.37     25.9, 485.62     46.6, 497.39
GR           66.8, 495.73     88.5, 499.66
*
N           0.075
*
XS   BRIDG     0           0.0
GR         -193.9, 516.70   -170.3, 505.57   -108.6, 503.11   -100.3, 498.12
GR          -77.0, 497.32    -52.0, 499.94     -0.1, 499.93
GR            0.0, 497.61      0.2, 486.89      3.5, 486.85      3.6, 486.47
GR            8.7, 486.61     12.5, 486.61     15.6, 486.09     18.7, 486.36
GR           24.5, 487.04     35.7, 487.78     35.8, 497.73
GR           36.2, 499.95     85.6, 500.26    150.1, 505.74    166.4, 516.96
*
N           0.060
*
XS   USBRG     19           0.0
GR         -193.9, 516.70   -170.3, 505.57   -108.6, 503.11   -100.3, 498.12
GR          -77.0, 497.32    -52.0, 499.94     -0.1, 499.93      0.0, 497.61
GR            0.1, 488.41      5.0, 487.68     11.0, 486.99     16.2, 487.16
GR           24.1, 487.02     30.0, 487.72     35.8, 487.65     36.0, 487.98
GR           36.1, 497.73     36.2, 499.95     85.6, 500.26    150.1, 505.74
GR          166.4, 516.96
*
N           0.060
*
XT   APTEM     67          0.
GR         -117.1, 506.84    -87.1, 501.66    -31.5, 501.79    -19.2, 500.34
GR            0.0, 490.45      8.3, 489.68     14.5, 488.64     18.4, 488.06
GR           21.3, 488.30     25.5, 489.30     28.0, 489.74     35.0, 490.93
GR           48.9, 502.83     65.2, 505.88     77.0, 510.59
*
XS   APPRO     55   * * *  0.0294
GT
N           0.070
*
HP 1 BRIDG  490.93 1 490.93
HP 2 BRIDG  490.93 * * 1470
HP 1 APPRO  492.90 1 492.90
HP 2 APPRO  492.90 * * 1470
*
HP 1 BRIDG  492.26 1 492.26
HP 2 BRIDG  492.26 * * 2100
HP 1 APPRO  494.06 1 494.06
HP 2 APPRO  494.06 * * 2100
*
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File newf057.wsp
        Hydraulic analysis for structure NEWFTH00690057   Date: 05-JAN-98
        TH 69 CROSSING HUNTER BROOK IN NEWFANE, VERMONT          RLB
           *** RUN DATE & TIME: 02-09-98  16:00

    CROSS-SECTION PROPERTIES:  ISEQ =  2;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     146.    8137.    36.    43.                        1670.
   490.93          146.    8137.    36.    43.  1.00     0.    36.   1670.

    VELOCITY DISTRIBUTION:  ISEQ =  2;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       490.93     0.1    35.7   145.6    8137.    1470.  10.10

X STA.        0.1        4.0        5.4        6.8        8.2        9.7
  A(I)            15.7        6.1        6.4        6.2        6.2
  V(I)            4.68      12.03      11.56      11.94      11.82

X STA.        9.7       11.1       12.6       14.0       15.3       16.6
  A(I)             6.3        6.4        6.3        6.2        6.1
  V(I)           11.64      11.54      11.75      11.93      12.01

X STA.       16.6       17.9       19.2       20.6       22.1       23.7
  A(I)             6.0        6.1        6.3        6.3        6.4
  V(I)           12.15      12.08      11.71      11.60      11.40

X STA.       23.7       25.4       27.2       29.1       31.1       35.7
  A(I)             6.7        6.7        7.0        7.0       15.2
  V(I)           10.94      10.94      10.57      10.53       4.82

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     145.    6713.    43.    45.                        1507.
   492.90          145.    6713.    43.    45.  1.00    -5.    38.   1507.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.90    -5.4    37.7   144.9    6713.    1470.  10.14

X STA.       -5.4        3.1        5.3        7.4        9.3       11.0
  A(I)            16.7        7.2        7.1        6.8        6.5
  V(I)            4.40      10.20      10.34      10.79      11.37

X STA.       11.0       12.5       13.8       15.1       16.4       17.5
  A(I)             6.1        6.1        5.9        5.9        5.7
  V(I)           11.98      12.13      12.36      12.48      12.81

X STA.       17.5       18.6       19.8       20.9       22.1       23.4
  A(I)             5.8        5.8        5.8        5.9        5.9
  V(I)           12.66      12.69      12.78      12.46      12.37

X STA.       23.4       24.9       26.5       28.4       30.6       37.7
  A(I)             6.3        6.3        6.7        7.3       15.0
  V(I)           11.72      11.60      10.91      10.02       4.91
```

```
        U.S. Geological Survey WSPRO Input File newf057.wsp
        Hydraulic analysis for structure NEWFTH00690057   Date: 05-JAN-98
        TH 69 CROSSING HUNTER BROOK IN NEWFANE, VERMONT          RLB
           *** RUN DATE & TIME: 02-09-98  16:00

    CROSS-SECTION PROPERTIES:  ISEQ =  2;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     193.  12506.    36.    46.                        2548.
   492.26          193.  12506.    36.    46.  1.00     0.    36.   2548.

    VELOCITY DISTRIBUTION:  ISEQ =  2;  SECID = BRIDG;  SRD =       0.

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.26     0.1    35.7   193.0   12506.    2100.  10.88

X STA.         0.1        4.4        5.8        7.2        8.6       10.0
  A(I)            23.1        7.9        8.2        8.0        8.1
  V(I)            4.54      13.28      12.74      13.13      12.96

X STA.        10.0       11.5       12.9       14.3       15.6       16.9
  A(I)             8.2        8.0        8.1        8.0        8.1
  V(I)           12.75      13.20      12.94      13.05      12.94

X STA.        16.9       18.3       19.6       21.1       22.5       24.1
  A(I)             8.0        8.0        8.1        8.2        8.4
  V(I)           13.19      13.06      13.02      12.76      12.50

X STA.        24.1       25.7       27.4       29.2       31.0       35.7
  A(I)             8.4        8.8        8.5        8.8       22.0
  V(I)           12.54      11.99      12.30      11.97       4.77

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = APPRO;  SRD =      55.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     197.  10544.    47.    49.                        2295.
   494.06          197.  10544.    47.    49.  1.00    -8.    39.   2295.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.06    -7.7    39.1   197.1   10544.    2100.  10.66

X STA.        -7.7        2.2        4.4        6.4        8.4       10.1
  A(I)            24.1        9.3        9.0        9.1        8.6
  V(I)            4.36      11.24      11.63      11.50      12.26

X STA.        10.1       11.7       13.3       14.7       16.0       17.3
  A(I)             8.5        8.3        8.1        7.9        7.9
  V(I)           12.42      12.65      12.96      13.33      13.31

X STA.        17.3       18.6       19.8       21.1       22.5       23.9
  A(I)             7.9        7.9        7.9        7.9        8.1
  V(I)           13.22      13.21      13.28      13.24      12.90

X STA.        23.9       25.5       27.2       29.2       31.4       39.1
  A(I)             8.5        8.6        9.0        9.7       20.6
  V(I)           12.41      12.16      11.64      10.85       5.09
```

```
        U.S. Geological Survey WSPRO Input File newf057.wsp
        Hydraulic analysis for structure NEWFTH00690057   Date: 05-JAN-98
        TH 69 CROSSING HUNTER BROOK IN NEWFANE, VERMONT          RLB
           *** RUN DATE & TIME: 02-09-98  16:00

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

EXITX:XS   ******    -1.     175.  1.10 *****  491.14  488.66   1470.  490.04
      -39. ******    34.    9152.  1.00 ***** *******    0.66    8.42

 ===125 FR# EXCEEDS FNTEST AT SECID "BRIDG":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.88     490.93     490.60
 ===110 WSEL NOT FOUND AT SECID "BRIDG":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   489.54     516.96    0.50
 ===115 WSEL NOT FOUND AT SECID "BRIDG":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   489.54     516.96     490.60

BRIDG:XS      39.     0.     146.  1.59  1.13  492.52  490.60   1470.  490.93
        0.    39.    36.    8132.  1.00  0.24    0.00    0.88   10.10

 ===125 FR# EXCEEDS FNTEST AT SECID "USBRG":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.84     491.61     491.14
 ===110 WSEL NOT FOUND AT SECID "USBRG":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   490.43     516.96    0.50
 ===115 WSEL NOT FOUND AT SECID "USBRG":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   490.43     516.96     491.14

USBRG:XS      19.     0.     152.  1.45  0.58  493.09  491.14   1470.  491.64
       19.    19.    36.    8756.  1.00  0.00    0.00    0.83    9.66

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.98     492.89     492.84
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   491.14     510.24    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   491.14     510.24     492.84

APPRO:XS      36.    -5.     145.  1.60  1.32  494.50  492.84   1470.  492.90
       55.    36.    38.    6717.  1.00  0.07    0.01    0.98   10.14
```

FIRST USER DEFINED TABLE.

XSID:CODE	SRD	LEW	REW	Q	K	AREA	VEL	WSEL
EXITX:XS	-39.	-1.	34.	1470.	9152.	175.	8.42	490.04
BRIDG:XS	0.	0.	36.	1470.	8132.	146.	10.10	490.93
USBRG:XS	19.	0.	36.	1470.	8756.	152.	9.66	491.64
APPRO:XS	55.	-5.	38.	1470.	6717.	145.	10.14	492.90

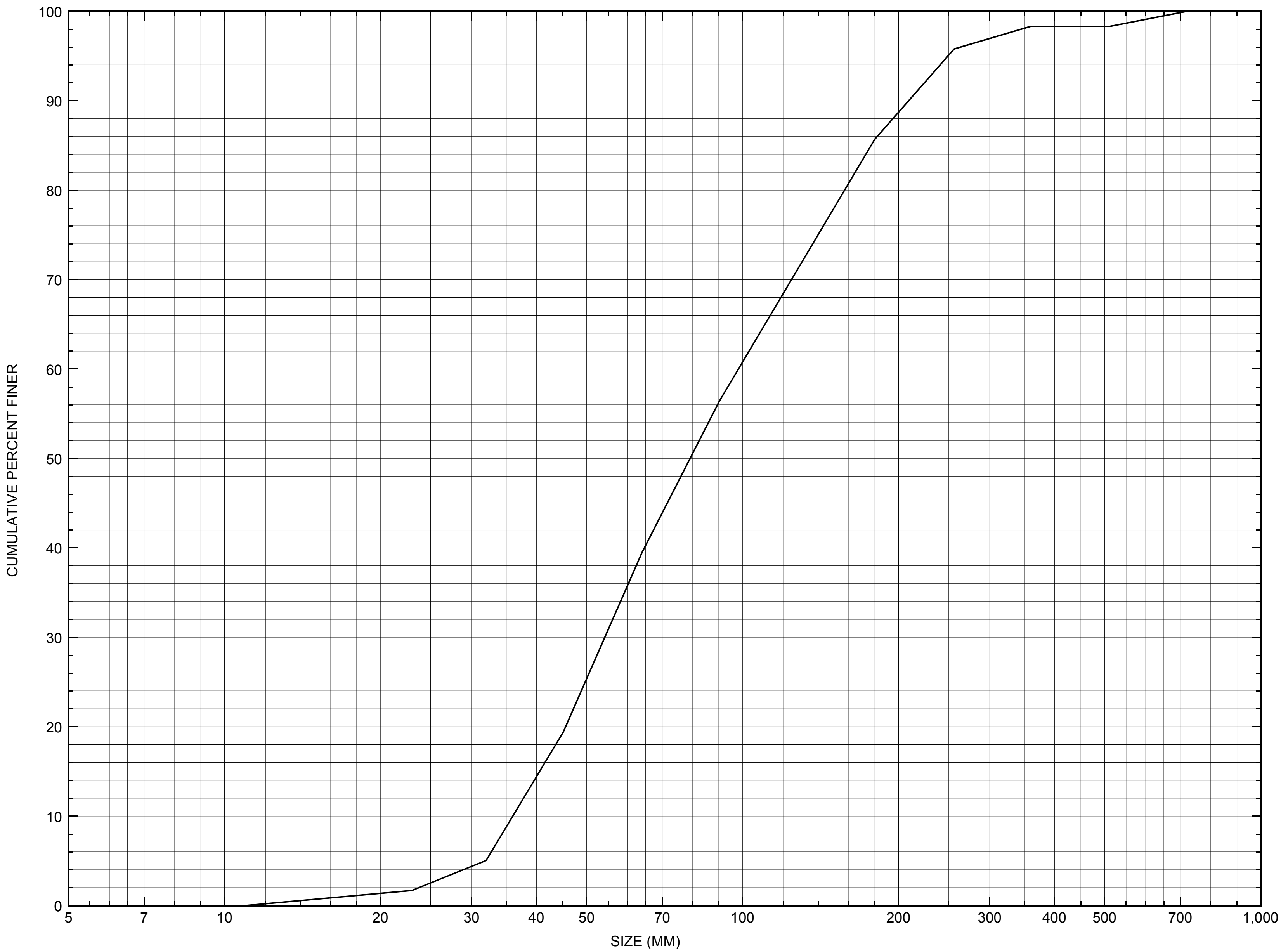
SECOND USER DEFINED TABLE.

XSID:CODE	CRWS	FR#	YMIN	YMAX	HF	HO	VHD	EGL	WSEL
EXITX:XS	488.66	0.66	483.11	501.46	*****	*******	1.10	491.14	490.04
BRIDG:XS	490.60	0.88	486.09	516.96	1.13	0.24	1.59	492.52	490.93
USBRG:XS	491.14	0.83	486.99	516.96	0.58	0.00	1.45	493.09	491.64
APPRO:XS	492.84	0.98	487.71	510.24	1.32	0.07	1.60	494.50	492.90

```
        U.S. Geological Survey WSPRO Input File newf057.wsp
        Hydraulic analysis for structure NEWFTH00690057   Date: 05-JAN-98
        TH 69 CROSSING HUNTER BROOK IN NEWFANE, VERMONT          RLB
           *** RUN DATE & TIME: 02-09-98  16:00

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

EXITX:XS   ******    -1.     225.  1.35 *****  492.80  489.82   2100.  491.45
      -39. ******    36.   13069.  1.00 ***** *******    0.67    9.33

 ===125 FR# EXCEEDS FNTEST AT SECID "BRIDG":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.83     492.25     491.61
 ===110 WSEL NOT FOUND AT SECID "BRIDG":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   490.95     516.96    0.50
 ===115 WSEL NOT FOUND AT SECID "BRIDG":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   490.95     516.96     491.61

BRIDG:XS      39.     0.     193.  1.85  1.05  494.10  491.61   2100.  492.26
        0.    39.    36.   12489.  1.00  0.25    0.00    0.83   10.89

 ===125 FR# EXCEEDS FNTEST AT SECID "USBRG":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.82     492.81     492.15
 ===110 WSEL NOT FOUND AT SECID "USBRG":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   491.76     516.96    0.50
 ===115 WSEL NOT FOUND AT SECID "USBRG":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   491.76     516.96     492.15

USBRG:XS      19.     0.     196.  1.79  0.52  494.64  492.15   2100.  492.85
       19.    19.    36.   12837.  1.00  0.00    0.02    0.81   10.74

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
            FNTEST,FR#,WSEL,CRWS =  0.80    0.91     494.07     493.80
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                 WSLIM1,WSLIM2,DELTAY =   492.35     510.24    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                 WSLIM1,WSLIM2,CRWS =   492.35     510.24     493.80

APPRO:XS      36.    -8.     197.  1.77  1.17  495.83  493.80   2100.  494.06
       55.    36.    39.   10535.  1.00  0.00    0.01    0.92   10.66

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -39.    -1.    36.   2100.   13069.     225.    9.33  491.45
   BRIDG:XS       0.     0.    36.   2100.   12489.     193.   10.89  492.26
   USBRG:XS      19.     0.    36.   2100.   12837.     196.   10.74  492.85
   APPRO:XS      55.    -8.    39.   2100.   10535.     197.   10.66  494.06

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    489.82    0.67  483.11  501.46************  1.35  492.80  491.45
   BRIDG:XS    491.61    0.83  486.09  516.96  1.05  0.25  1.85  494.10  492.26
   USBRG:XS    492.15    0.81  486.99  516.96  0.52  0.00  1.79  494.64  492.85
   APPRO:XS    493.80    0.92  487.71  510.24  1.17  0.00  1.77  495.83  494.06
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NEWFTH00690057, in Newfane, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NEWFTH00690057

General Location Descriptive

Data collected by *(First Initial, Full last name)* M. IVANOFF

Date *(MM/DD/YY)* 04 / 06 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 025

Town *(FIPS place code; I - 4; nnnnn)* 48400

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

Waterway *(I - 6)* HUNTER BROOK

Road Name *(I - 7):* -

Route Number TH069

Vicinity *(I - 9)* 0.05 MI TO JCT W C3 TH32

Topographic Map West Dover

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 42567

Longitude *(i - 17; nnnnn.n)* 72452

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10131200571312

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

Maximum span length *(I - 48; nnnn)* 0036

Year built *(I - 27; YYYY)* 1977

Structure length *(I - 49; nnnnnn)* 000040

Average daily traffic, ADT *(I - 29; nnnnnn)* 000025

Deck Width *(I - 52; nn.n)* 145

Year of ADT *(I - 30; YY)* 90

Channel & Protection *(I - 61; n)* 6

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

Waterway adequacy *(I - 71; n)* 7

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 010.5

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

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

Comments:

The structural inspection report of 07/27/94 indicates the structure is a steel beam type bridge with a bare concrete deck. Both concrete abutment walls and the wingwalls have some hairline vertical shrinkage cracks reported in a few random locations. There is a steel pipe handrail connected along the upstream left wingwall. The footing is slightly in view at the upstream end of the right abutment and the downstream end of the left abutment. The streambed consists of stone and boulders with some gravel deposits. The waterway makes a moderate turn through the structure and flows into the Rock River roughly 200 feet downstream. Off the downstream end of the left abutment, there is a laid up **(Continued, page 31)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

Comments:

concrete block retaining wall, behind which there is a home. Channel scour is localized from turbulent flashy floods noted. Bank erosion is heavy about 400 feet upstream. The stone fill consists of stone and boulder material.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **4.67** mi^2 Lake/pond/swamp area **0.01** mi^2

Watershed storage *(ST)* **0.2** %

Bridge site elevation **1043** ft Headwater elevation **2382** ft

Main channel length **3.63** mi

10% channel length elevation **984** ft 85% channel length elevation **1772** ft

Main channel slope *(S)* **289.20** 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? N *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: - / -

Project Number - Minimum channel bed elevation: -

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

Benchmark location description:

NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness - Footing bottom elevation: -

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

If 3: Footing bottom elevation: -

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

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

Briefly describe material at foundation bottom elevation or around piles:

NO FOUNDATION MATERIAL INFORMATION

Comments:

NO PLANS

Cross-sectional Data

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

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

Comments: The station and elevation measurements are in feet. This cross section was attached to the 07/27/94 bridge inspection report. The low chord elevations match the survey elevations used for this report.

Station	0	18	27.5	36	-	-	-	-	-	-	-
Feature	LAB	-	-	RAB	-	-	-	-	-	-	-
Low chord elevation	497.67	497.67	497.67	497.67	-	-	-	-	-	-	-
Bed elevation	490.17	486.17	487.67	487.17	-	-	-	-	-	-	-
Low chord to bed	7.5	11.5	10	10.5	-	-	-	-	-	-	-

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: **JRD** Date: **5/9/97**

Computerized by: **JRD** Date: **5/9/97**

Reviewd by: **RLB** Date: **2/10/97**

Structure Number **NEWFTH00690057**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **Boehmler** Date *(MM/DD/YY)* **08** / **13** / 19**96**

2. Highway District Number **2** Mile marker **000000**

County **Windham (025)** Town **Newfane (48400)**

Waterway *(I - 6)* **Hunter Brook** Road Name **-**

Route Number **TH069** Hydrologic Unit Code: **01080107**

3. Descriptive comments:

This site is located 0.05 miles from the junction of TH069 with C3 TH32.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **2** 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 **1** 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 **40** *(feet)* Span length **36** *(feet)* Bridge width **14.5** *(feet)*

Road approach to bridge:

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

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

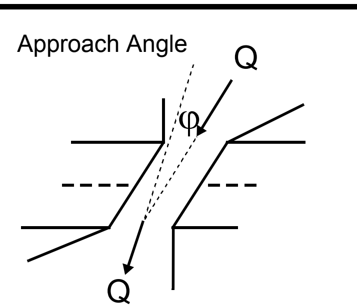
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

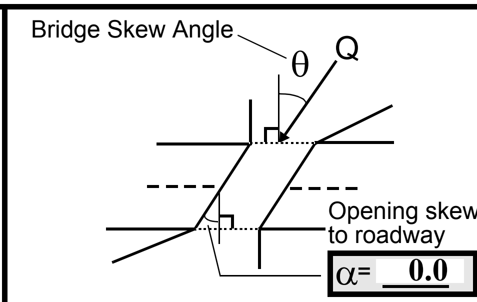
	Protection			
	11.Type	12.Cond.	13.Erosion	14.Severity
LBUS	0	-	0	0
RBUS	0	-	2	1
RBDS	0	-	2	1
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: **20** 16. Bridge skew: **15**





17. Channel impact zone 1: Exist? **y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **80** feet **US** *(US, UB, DS)* to **35** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **0** feet **US** *(US, UB, DS)* to **45** feet **DS**

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

18. Bridge Type: **1a**

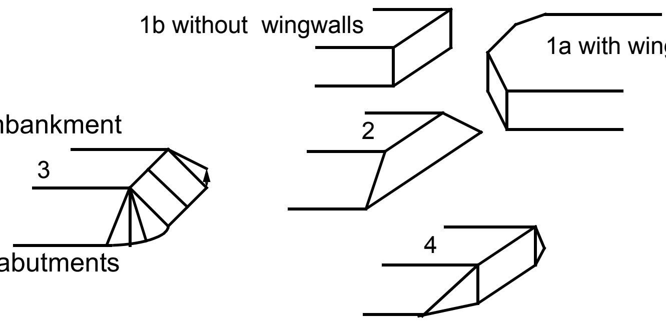
1a- Vertical abutments with wingwalls

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 surface cover is predominantly forest except for the house and lawn on the downstream left bank.

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
53.0	**10.0**			**12.0**	**4**	**4**	**324**	**325**	**1**	**2**

23. Bank width **25.0** 24. Channel width **40.0** 25. Thalweg depth **68.0** 29. Bed Material **324**

30 .Bank protection type: LB **0** RB **2** 31. Bank protection condition: LB **-** RB **2**

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. The bed material has a high percentage of fine gravel and coarse sand between the larger gravel, cobbles, and boulders.
30. The right bank protection extends from 100 feet upstream to 0 feet upstream. It doubles as wing wall protection from 25 feet upstream to 0 feet upstream.
31. The protection is slumped along with the bank material. This is most severe at the cut bank.
The channel material is larger and the stream bed is steeper upstream of 175 feet. The channel also increases in slope downstream of 35 feet upstream.
There are two small dams across the channel, constructed from the bed material and located at 25 feet and 35 feet upstream. They create pools which have a maximum depth of 2.5 feet. The bed material in the pools is loose sand and gravel.

33. Point/Side bar present? Y (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: 90 35. Mid-bar width: 15
36. Point bar extent: 125 feet US (US, UB) to 35 feet US (US, UB, DS) positioned 0 %LB to 40 %RB
37. Material: 342
38. Point or side bar comments (Circle Point or Side; Note additional bars, material variation, status, etc.):
This point bar consists of sand and gravel material on top of coarse gravel and cobble sized material.

39. Is a cut-bank present? Y (Y or if N type ctrl-n cb) 40. Where? RB (LB or RB)
41. Mid-bank distance: 70 42. Cut bank extent: 100 feet US (US, UB) to 40 feet US (US, UB, DS)
43. Bank damage: 2 (**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)
44. Cut bank comments (eg. additional cut banks, protection condition, etc.):
The bank material has slipped leaving a near vertical escarpment on the upper 1/3 of the cut bank at 70 feet US, despite the type-2 stone fill.

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
35.0		1.5		2	7	7	-

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

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

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

64. Comments (bank material variation, minor inflows, protection extent, etc.):
453
The channel steepens half-way under the bridge.

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 upstream point bar and boulders at the upstream face have potential to catch ice and debris. The lateral instability and slumping on the RB will cause trees to fall into the brook. Trees have already fallen into the brook at the landslide 400 feet upstream.

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	0	2	0	0	90.0
RABUT	1	-	90			2	2	35.5

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

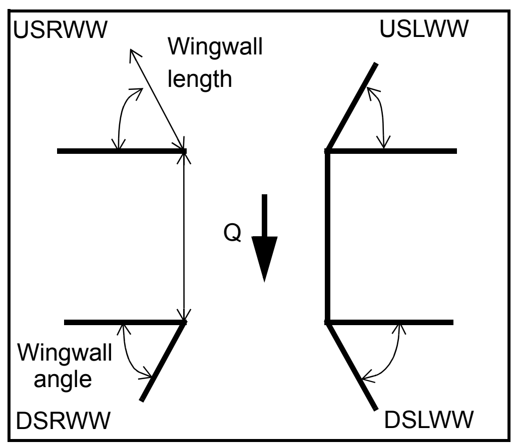
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0
1

74. The right abutment footing is exposed from the upstream face to 12 feet under the bridge, the footing top is flush with the bed material. The left abutment footing is exposed from 4 feet under the bridge to its downstream end, continuing along the downstream left wingwall. The abutment portion of the footing is flush with the stream bed.

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						35.5	
USRWW:	Y		1		0	1.0	
DSLWW:	0		0		Y	19.5	
DSRWW:	1		2		0	18.5	



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

82. Bank / Bridge Protection:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	0	2	Y	0	1	1	-	-
Condition	Y	0	1	0	1	2	-	-
Extent	1	1.0	0	2	2	0	0	-

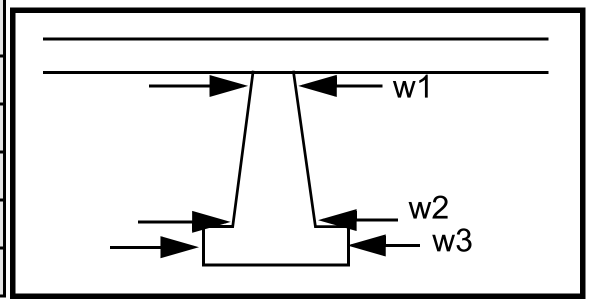
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
0
-
-
2
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1				45.0	13.5	40.0
Pier 2				24.0	90.0	14.0
Pier 3			-	60.0	12.0	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	e	but is	nds 4	length	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	upst	lowe	feet	of	**1**- Solid pier, **2**- column, **3**- bent
88. Material	ream	r	upst	the	**1**- Wood; **2**- concrete; **3**- metal; **4**- stone
89. Shape	right	than	ream	dow	**1**- Round; **2**- Square; **3**- Pointed
90. Inclined?	wing	the	from	nstre	Y- yes; N- no
91. Attack ∠ (BF)	wall	chan	the	am	
92. Pushed	foot-	nel	right	left	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	ing	bed.	abut	wing	
95. Cross-members	top	The	ment	wall	**0**- none; **1**- laterals; **2**- diagonals; **3**- both
96. Scour Condition	is	expo	. The	is	**0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed
97. Scour depth	expo	sure	entir	expo	
98. Exposure depth	sed,	exte	e	sed,	

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

to a depth of 1 foot. The depth increases in the downstream direction.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

-
-
-
-
-
-
-
-
-
-
-
-
-
-
-

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

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

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

-
-
-
-
-
-

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

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

Material: -

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

-
-
-
-

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

Cut bank extent: **RS** 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.):

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: **1**

Scour dimensions: Length **3** Width **7** Depth: **345** Positioned **0** %LB to **0** %RB

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

453
5
1
1

Are there major confluences? **1** (Y or if N type ctrl-n mc) How many? **The**

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

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

Confluence comments (eg. confluence name):

steep. The channel drops 3 feet abruptly at the confluence into the Rock River.
The left bank material and protection is made up of 3 feet by 3 feet concrete blocks, stacked 4 to 5 high.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Th**

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)*:

e right bank protection is stone fill, extending from the downstream end of the downstream right wingwall to 90 feet downstream, where it intersects the Rock River right bank.

109. G. Plan View Sketch

- N

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: NEWFTH00690057 Town: NEWFANE
Road Number: TH 69 County: WINDHAM
Stream: HUNTER BROOK

Initials RLB Date: 1/26/98 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	1470	2100	0
Main Channel Area, ft2	145	197	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	43	47	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2598	0.2598	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	3.4	4.2	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	6713	10544	0
Conveyance, main channel	6713	10544	0
Conveyance, LOB	0	0	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1470.0	2100.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	10.1	10.7	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	8.8	9.1	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	1	1	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)

Characteristic	Approach 100 yr	Approach 500 yr	Approach Other Q	Bridge 100 yr	Bridge 500 yr	Bridge Other Q
Q1, discharge, cfs	1470	2100	0	1470	2100	0
Total conveyance	6713	10544	0	8137	12506	0
Main channel conveyance	6713	10544	0	8137	12506	0
Main channel discharge	1470	2100	ERR	1470	2100	ERR
Area - main channel, ft2	145	197	0	146	193	0
(W1) channel width, ft	43	47	0	35.6	35.6	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	43	47	0	35.6	35.6	0
D50, ft	0.2598	0.2598	0.2598			
w, fall velocity, ft/s (p. 32)	4.1705	4.1705	0			
y, ave. depth flow, ft	3.37	4.19	N/A	4.10	5.42	ERR
S1, slope EGL	0.036	0.0315	0			
P, wetted perimeter, MC, ft	45	49	0			
R, hydraulic Radius, ft	3.222	4.020	ERR			
V*, shear velocity, ft/s	1.933	2.019	N/A			
V*/w	0.463	0.484	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	0.59	0.59	0			
y2,depth in contraction, ft	3.77	4.94	ERR			
ys, scour depth, ft (y2-y_bridge)	-0.33	-0.48	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	1470	2100	N/A
Main channel area (DS), ft2	146	193	0
Main channel width (normal), ft	35.6	35.6	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	35.6	35.6	0.0
D90, ft	0.6859	0.6859	0.0000
D95, ft	0.8168	0.8168	0.0000
Dc, critical grain size, ft	0.5553	0.5718	ERR
Pc, Decimal percent coarser than Dc	0.169	0.156	0.000

Depth to armoring, ft	8.19	9.28	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	1470	2100	0	1470	2100	0
a', abut.length blocking flow, ft	5.5	7.8	0	2	3.4	0
Ae, area of blocked flow ft2	10.81	18.99	0	4.23	9.1	0
Qe, discharge blocked abut.,cfs	47.56	82.73	0	20.7	46.36	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.40	4.36	ERR	4.89	5.09	ERR
ya, depth of f/p flow, ft	1.97	2.43	ERR	2.12	2.68	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	0.553	0.492	ERR	0.593	0.549	ERR
ys, scour depth, ft	5.93	7.29	N/A	4.91	6.51	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)	5.5	7.8	0	2	3.4	0
y1 (depth f/p flow, ft)	1.97	2.43	ERR	2.12	2.68	ERR
a'/y1	2.80	3.20	ERR	0.95	1.27	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.55	0.49	N/A	0.59	0.55	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.88	0.83	0	0.88	0.83	0
y, depth of flow in bridge, ft	4.10	5.42	0.00	4.10	5.42	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.)	1.65	2.15	ERR	1.65	2.15	ERR