LEVEL II SCOUR ANALYSIS FOR BRIDGE 48 (FFIETH00300048) on TOWN HIGHWAY 30 crossing WANZER BROOK, FAIRFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-592

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

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By ROBERT H. FLYNN AND ERICK M. BOEHMLER

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Pembroke, New Hampshire

1997

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

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

In this report, the words “right” and “left” refer to directions that would be reported by an observer facing downstream.

Sea level: In this report, “sea level” refers to the National Geodetic Vertical Datum of 1929-- a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

In the appendices, the above abbreviations may be combined. For example, USLB would represent upstream left bank.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 48 (FFIETH00300048) ON TOWN HIGHWAY 30 CROSSING WANZER BROOK, FAIRFIELD, VERMONT

By **Robert H. Flynn and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FFIETH00300048 on Town Highway 30 crossing Wanzer Brook, Fairfield, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the Green Mountain section of the New England physiographic province in northwestern Vermont. The 6.78-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover upstream of the bridge and on the downstream right bank is primarily pasture. The downstream left bank is forested.

In the study area, Wanzer Brook has an incised, straight channel with a slope of approximately 0.03 ft/ft, an average channel top width of 65 ft and an average bank height of 5 ft. The channel bed material is cobble with a median grain size (D_{50}) of 111 mm (0.364 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 11, 1995, indicated that the reach was stable.

The Town Highway 30 crossing of Wanzer Brook is a 31-ft-long, two-lane bridge consisting of one 28-foot steel-beam span (Vermont Agency of Transportation, written communication, March 8, 1995). The opening length of the structure parallel to the bridge face is 26 ft.The bridge is supported by vertical stone wall abutments with concrete caps and “kneewall” footings. The channel is skewed approximately 25 degrees to the opening while the measured opening-skew-to-roadway is 20 degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the downstream left retaining wall (extended concrete footing) during the Level I assessment. It was also observed that the right abutment is undermined with a scour depth of 0.5 ft. The scour protection at the site was limited to four large boulders (type-4, less than 60 inches diameter) along the downstream right retaining wall. The channel under the bridge is a “corduroy” log mat floor composed of 13 logs which are parallel to the bridge face and extend from 5 ft under the bridge to the downstream bridge face. The most downstream log is approximately 0.3 to 0.4 ft higher than the other logs and controls flow at lower flows. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.3 to 0.6 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 14.1 to 16.0 ft at the left abutment and from 6.8 to 7.6 ft at the right abutment. 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 others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Fairfield, 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 FFIETH00300048 ***Stream*** Wanzer Brook

County Franklin ***Road*** TH30 ***District*** 8

Description of Bridge

Bridge length 31 ***ft*** ***Bridge width*** 19.2 ***ft*** ***Max span length*** 28 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 7/11/95

Description of stone fill Type-4 (less than 60 inches) along the base length of the downstream right retaining wall (extended footing) where there are four very large boulders.

Abutments and retaining walls (extended footings) are stone walls with concrete caps and concrete "kneewall" footings. The upstream end of the left abutment is concrete. The upstream end of the right abutment is concrete faced.

Y 25

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

There is a mild channel bend through the bridge and a moderate channel bend in both the upstream and downstream reaches.

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	7/11/95	0	0
Level II	7/11/95	0	0

Potential for debris Low. The upstream channel and banks are stable and there is no debris in the channel.

Describe any features near or at the bridge that may affect flow (include observation date) A point bar along the downstream right bank and a "corduroy" log mat floor in the channel under the bridge will affect flow at lower flows (observed on 7/11/95).

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley setting with steep valley walls on both sides.

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

Date of inspection 11/08/94

DS left: Steep channel bank

DS right: Steep channel bank

US left: Steep channel bank

US right: Steep channel bank

Description of the Channel

Average top width 65 *ft*   ***Average depth*** 5 *ft*

Predominant bed material Cobble/Gravel   ***Bank material*** Boulder/Cobble

Straight and stable with non-alluvial channel boundaries and little to no flood plain.

7/11/95

Vegetative co Trees.

DS left: Pasture and trees.

DS right: Pasture and trees.

US left: Pasture and trees.

US right:

Do banks appear stable? Y

date of observation.

The assessment of 7/11/95 noted a "corduroy" log mat floor in the channel under the bridge . The farthest most DS log sits higher than the others and controls flow at lower flows. The top of the log is 0.3 to 0.4 foot higher than the next log immediately upstream.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.78 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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 980 ***ft³/s*** ***Q500*** 1,350 ***ft³/s***

The 100- and 500-year discharges are based on the FHWA discharge frequency curve, which is approximately the median of the discharge frequency curves developed from empirical relationships (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887) and extended to the 500-year discharge.

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 in concrete at the top of the upstream right corner of the bridge deck (elev. 497.72 ft, arbitrary survey datum). RM2 is a chiseled X in concrete at the top of the downstream left corner of the bridge deck (elev. 498.02 ft, arbitrary survey datum). RM3 is a chisled X on top of a boulder, 100 ft upstream, on the left bank (elev. 494.88, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-35	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	50	1	Modelled Approach section (as surveyed)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. The channel "n" value for the reach was 0.060, and overbank "n" values ranged from 0.050 to 0.060.

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 0.026 ft/ft which was estimated from the topographic map (U.S. Geological Survey, 1986).

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

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

Bridge Hydraulics Summary

Average bridge embankment elevation 497.7 *ft*
Average low steel elevation 496.5 *ft*

100-year discharge 980 *ft³/s*
Water-surface elevation in bridge opening 488.5 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 81 *ft²*
Average velocity in bridge opening 12.1 *ft/s*
Maximum WSPRO tube velocity at bridge 15.6 *ft/s*

Water-surface elevation at Approach section with bridge 492.1
Water-surface elevation at Approach section without bridge 488.6
Amount of backwater caused by bridge 3.5 *ft*

500-year discharge 1,350 *ft³/s*
Water-surface elevation in bridge opening 489.7 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 103 *ft²*
Average velocity in bridge opening 13.2 *ft/s*
Maximum WSPRO tube velocity at bridge 17.1 */s*

Water-surface elevation at Approach section with bridge 493.7
Water-surface elevation at Approach section without bridge 489.4
Amount of backwater caused by bridge 4.3 *ft*

Incipient overtopping discharge - *ft³/s*
Water-surface elevation in bridge opening - *ft*
Area of flow in bridge opening - *ft²*
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 others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The bed material particle-size distribution was obtained from a pebble count in the channel approach of the bridge. At this site, the channel under the bridge is a “corduroy” log mat floor composed of 13 logs which are parallel to the bridge face and extend from 5 ft under the bridge to the downstream bridge face. Although these logs may serve as a countermeasure against scour under the bridge, this analysis assumed that they would not remain in place during a major flood event. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

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

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.3	0.6	--
Depth to armoring	22.1	27.8	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	14.1	16.0	--
Right abutment	6.8	7.6	--
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.9	2.2	--
Right abutment	1.9	2.2	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

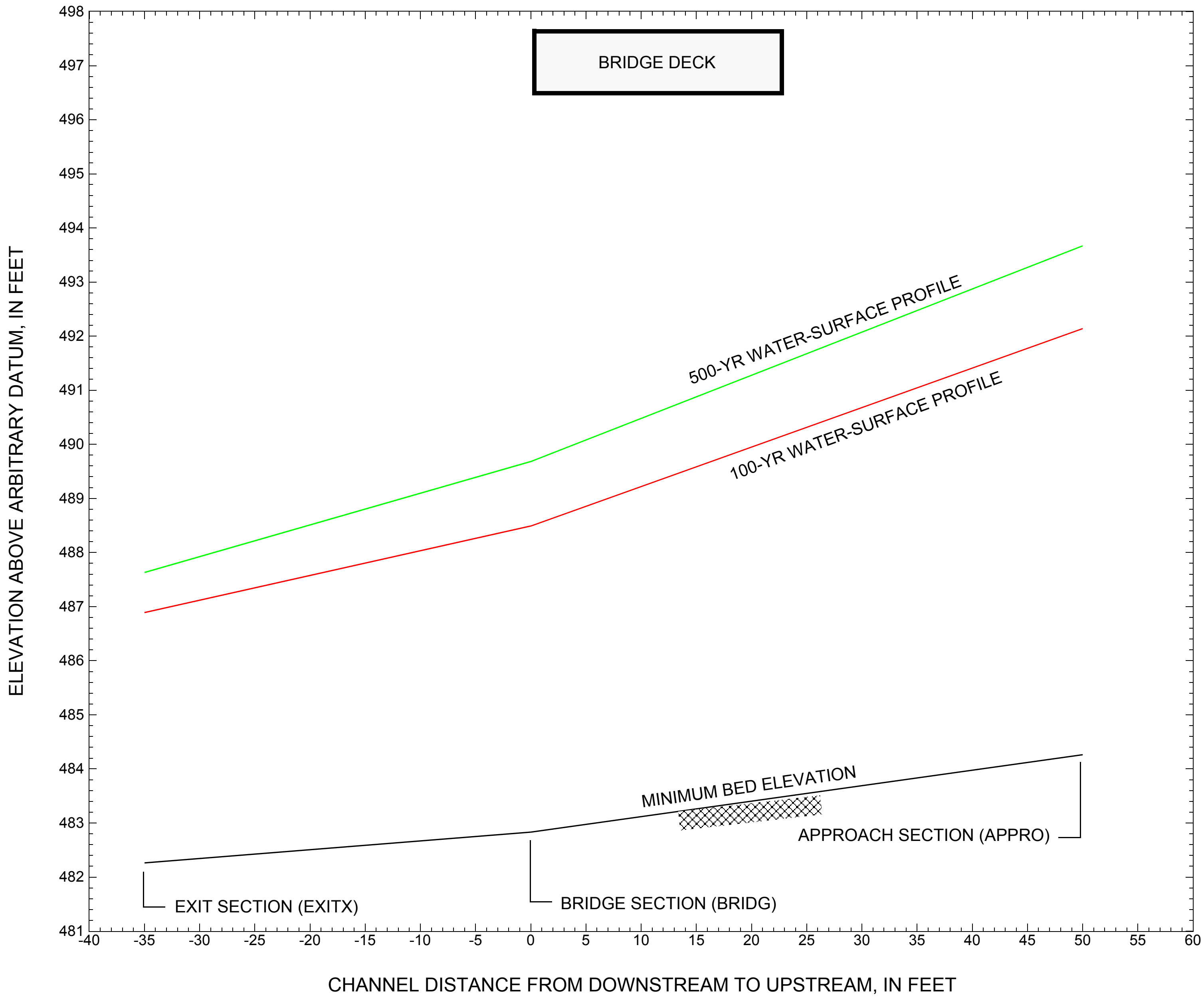

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FFIETH00300048 on Town Highway 30, crossing Wanzer Brook, Fairfield, Vermont.

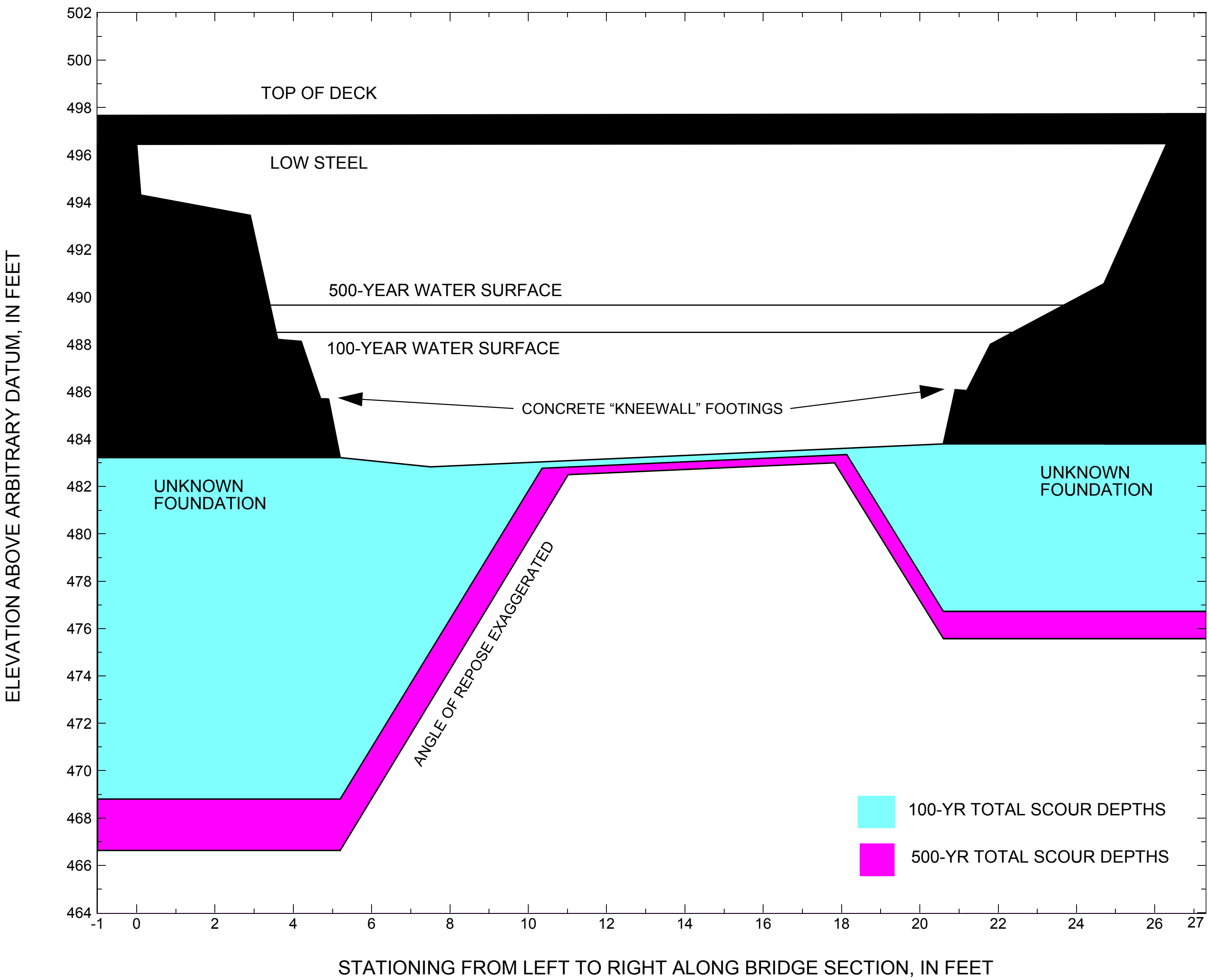

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure FFIETH00300048 on Town Highway 30, crossing Wanzer Brook, Fairfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FFIETH00300048 on Town Highway 30, crossing Wanzer Brook, Fairfield, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 980 cubic-feet per second											
Left abutment	5.2	--	496.5	--	483.2	0.3	14.1	--	14.4	468.8	--
Right abutment	20.6	--	496.5	--	483.8	0.3	6.8	--	7.1	476.7	--

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

2.Arbitrary datum for this study.

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure FFIETH00300048 on Town Highway 30, crossing Wanzer Brook, Fairfield, Vermont.

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

Description	Station[1]	VTAOT minimum low-chord elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 1,350 cubic-feet per second											
Left abutment	5.2	--	496.5	--	483.2	0.6	16.0	--	16.6	466.6	--
Right abutment	20.6	--	496.5	--	483.8	0.6	7.6	--	8.2	475.6	--

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, Fairfield, 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 ffie048.wsp
T2        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97
T3
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           980.0    1350.0
SK          0.026   0.026
*
XS   EXITX    -35           0.
GR          -81.4, 504.46    -19.4, 499.83     -7.2, 486.21      0.0, 483.16
GR            2.0, 482.26      7.9, 482.30     14.6, 483.10     22.2, 483.90
GR           28.9, 486.35     37.3, 493.90     48.4, 494.49    106.6, 502.04
*
N           0.060         0.060         0.060
SA                 -19.4         37.3
*
*
XS   FULLV       0  * * *
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.47      20.0
GR            0.0, 496.45      0.1, 494.31      2.9, 493.45      3.6, 488.21
GR            4.2, 488.13      4.7, 485.71      4.9, 485.70      5.2, 483.22
GR            7.5, 482.83     13.9, 483.30     20.6, 483.80     20.9, 486.09
GR           21.2, 486.05     21.8, 488.01     24.7, 490.56     26.3, 496.48
GR            0.0, 496.45
*
*         BRTYPE  BRWDTH
CD            1      23.0
N           0.060
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     12      19.2     2
GR         -133.9, 509.99    -57.2, 502.06     -4.6, 497.82
GR            0.0, 497.67     26.6, 497.74     33.8, 497.95
GR           76.3, 502.08    132.1, 509.07
*
*
AS   APPRO     50           0.
GR         -184.8, 510.72   -140.8, 501.11   -104.5, 497.08    -68.5, 493.73
GR          -44.8, 493.47    -32.5, 492.51    -16.4, 489.84      0.0, 484.40
GR            6.3, 484.50     12.5, 484.26     14.8, 484.30     17.2, 485.04
GR           28.5, 490.51     40.1, 498.11     97.6, 505.79
*
N           0.050         0.060        0.060
SA                -32.5        40.1
*
HP 1 BRIDG  488.49 1 488.49
HP 2 BRIDG  488.49 * * 980
HP 1 APPRO  492.14 1 492.14
HP 2 APPRO  492.14 * * 980
*
HP 1 BRIDG  489.68 1 489.68
HP 2 BRIDG  489.68 * * 1350
HP 1 APPRO  493.67 1 493.67
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1      81.   4282.    18.    26.                         980.
   488.49            81.   4282.    18.    26.  1.00     4.    22.    980.

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        488.49     3.6    22.3    80.7    4282.     980.  12.14

X STA.         3.6        6.3        7.3        8.0        8.7        9.4
  A(I)             8.3        4.8        3.9        3.7        3.4
  V(I)            5.89      10.20      12.42      13.11      14.25

X STA.         9.4       10.0       10.7       11.3       11.9       12.6
  A(I)             3.3        3.2        3.2        3.2        3.1
  V(I)           14.69      15.11      15.12      15.43      15.57

X STA.        12.6       13.2       13.8       14.5       15.2       15.9
  A(I)             3.2        3.2        3.3        3.3        3.4
  V(I)           15.27      15.41      14.85      14.84      14.46

X STA.        15.9       16.7       17.5       18.4       19.4       22.3
  A(I)             3.6        3.7        4.1        4.7        8.0
  V(I)           13.72      13.36      12.06      10.37       6.15


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

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              2     282.  18808.    61.    64.                        3437.
   492.14           282.  18808.    61.    64.  1.00   -30.    31.   3437.

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        492.14   -30.3    31.0   282.2   18808.     980.   3.47

X STA.       -30.3      -11.6       -7.4       -4.6       -2.4       -0.6
  A(I)            30.7       19.4       16.2       14.3       13.4
  V(I)            1.59       2.53       3.02       3.42       3.67

X STA.        -0.6        1.0        2.6        4.1        5.6        7.0
  A(I)            12.3       11.9       11.7       11.2       11.2
  V(I)            3.97       4.12       4.17       4.38       4.39

X STA.         7.0        8.4        9.9       11.2       12.6       14.0
  A(I)            10.9       11.0       10.8       10.8       11.2
  V(I)            4.50       4.47       4.55       4.54       4.38

X STA.        14.0       15.5       17.2       19.2       22.0       31.0
  A(I)            11.3       12.2       13.5       15.3       22.8
  V(I)            4.32       4.00       3.62       3.20       2.15
```

```
        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     103.    5940.    19.    29.                        1350.
    489.68          103.    5940.    19.    29.  1.00     3.    24.   1350.

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        489.68     3.4    23.7   102.6    5940.    1350.  13.16

X STA.         3.4        6.2        7.2        8.0        8.7        9.4
  A(I)             10.8        6.0        5.2        4.5        4.4
  V(I)             6.27      11.22      12.96      14.91      15.37

X STA.         9.4       10.0       10.7       11.3       12.0       12.6
  A(I)              4.2        4.0        4.0        4.0        3.9
  V(I)            16.25      16.69      16.68      17.00      17.13

X STA.        12.6       13.3       14.0       14.6       15.3       16.1
  A(I)              4.0        3.9        4.1        4.1        4.3
  V(I)            16.97      17.10      16.45      16.41      15.60

X STA.        16.1       16.8       17.6       18.5       19.6       23.7
  A(I)              4.4        4.7        5.1        6.2       10.7
  V(I)            15.43      14.27      13.16      10.96       6.32


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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
              1      10.     146.    31.    31.                          33.
              2     381.   29453.    66.    69.                        5195.
    493.67          391.   29599.    96.   100.  1.04   -63.    33.   4383.

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        493.67   -63.0    33.3   390.9   29599.    1350.   3.45

X STA.       -63.0      -18.5      -12.0       -8.3       -5.5       -3.1
  A(I)             42.8       27.4       22.1       19.9       18.5
  V(I)             1.58       2.46       3.06       3.40       3.65

X STA.        -3.1       -1.1        0.7        2.4        4.0        5.7
  A(I)             17.1       16.6       15.5       15.3       15.3
  V(I)             3.95       4.08       4.35       4.41       4.42

X STA.         5.7        7.3        9.0       10.6       12.2       13.8
  A(I)             15.0       15.1       14.9       15.2       15.5
  V(I)             4.50       4.47       4.54       4.44       4.34

X STA.        13.8       15.5       17.5       19.8       23.2       33.3
  A(I)             15.8       17.1       18.8       21.9       31.3
  V(I)             4.28       3.96       3.59       3.08       2.16
```

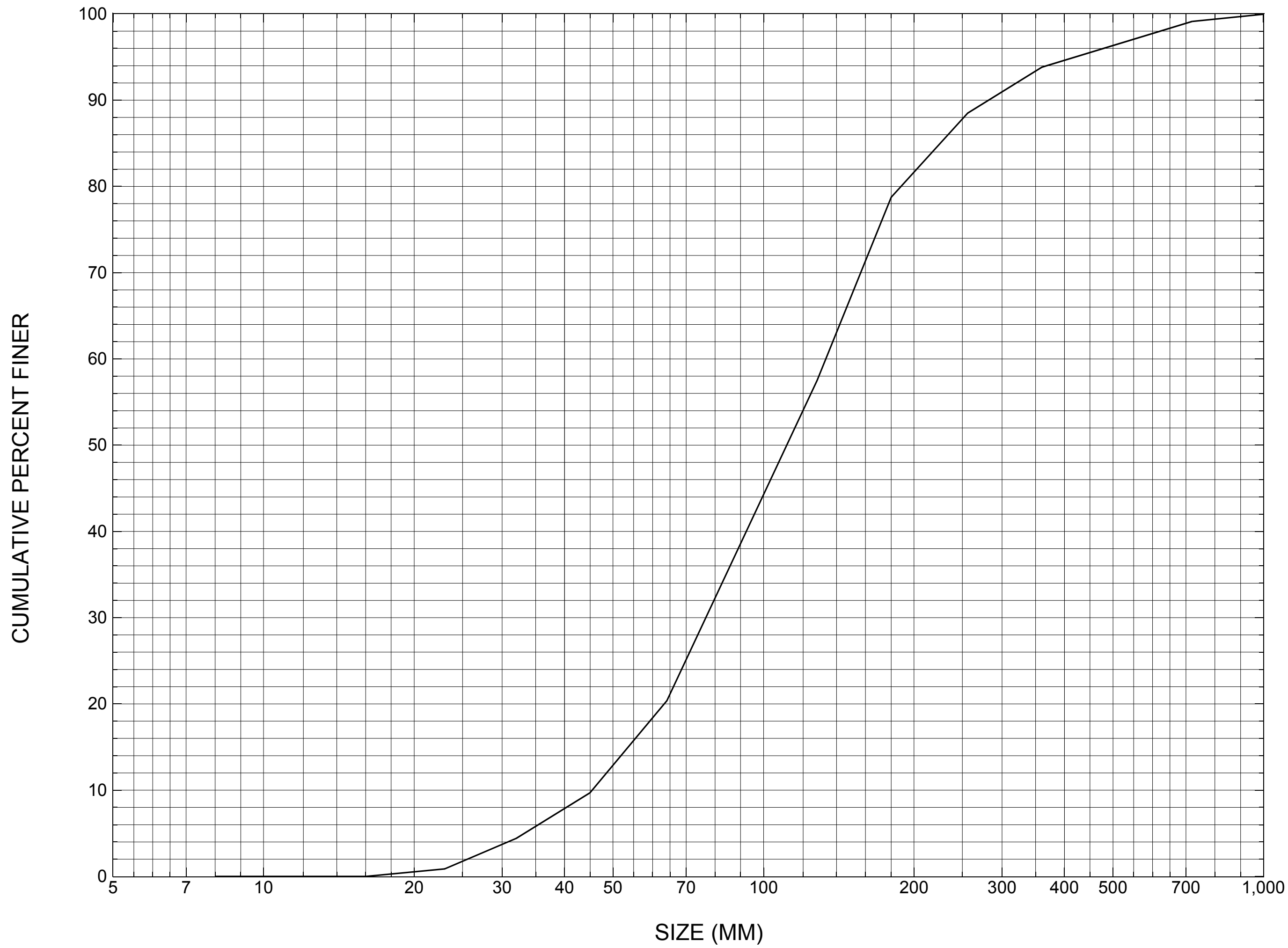
```
        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04

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

EXITX:XS   ******    -8.     118.  1.08 *****  487.97  486.49    980.  486.89
      -35. ******    30.    6077.  1.00 ***** *******    0.83    8.33

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                               "FULLV"     KRATIO =  1.56

FULLV:FV      35.    -9.     158.  0.60  0.58  488.55 *******    980.  487.95
        0.    35.    31.    9476.  1.00  0.00   -0.01    0.55    6.20
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.92     488.55     488.37
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   487.45     510.72    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   487.45     510.72     488.37
 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                               "APPRO"     KRATIO =  0.58

APPRO:AS      50.   -13.     110.  1.24  0.93  489.80  488.37    980.  488.55
       50.    50.    24.    5459.  1.00  0.32    0.00    0.92    8.94
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                   SECID "BRIDG"     Q,CRWS =     980.     488.49

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

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

BRIDG:BR      35.     4.      81.  2.29 *****  490.78  488.49    980.  488.49
        0.    35.    22.    4283.  1.00 ***** *******    1.00   12.13

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.47 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS      27.   -30.     282.  0.19  0.34  492.33  488.37    980.  492.14
       50.    29.    31.   18802.  1.00  1.20    0.00    0.29    3.47

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.525  0.263   13850.    -1.    17.  492.06

                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
1
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS
```

```
        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -35.    -8.    30.    980.    6077.     118.    8.33  486.89
   FULLV:FV       0.    -9.    31.    980.    9476.     158.    6.20  487.95
   BRIDG:BR       0.     4.    22.    980.    4283.      81.   12.13  488.49
   RDWAY:RG      12.**************      0.*****************    2.00********
   APPRO:AS      50.   -30.    31.    980.   18802.     282.    3.47  492.14

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -1.    17.   13850.
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04
 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    486.49    0.83  482.26  504.46************  1.08  487.97  486.89
   FULLV:FV  ********    0.55  482.26  504.46  0.58  0.00  0.60  488.55  487.95
   BRIDG:BR    488.49    1.00  482.83  496.48************  2.29  490.78  488.49
   RDWAY:RG  ****************  497.67  509.99**********************************
   APPRO:AS    488.37    0.29  484.26  510.72  0.34  1.20  0.19  492.33  492.14
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File ffie048.wsp
        Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

           *** RUN DATE & TIME: 06-09-97  08:04

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

 EXITX:XS   ******    -8.     145.  1.34 *****  488.97  487.19   1350.  487.63
      -35. ******    30.    8371.  1.00 ***** *******    0.84    9.28

  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "FULLV"     KRATIO =  1.51

 FULLV:FV      35.   -10.     192.  0.77  0.60  489.56 *******   1350.  488.79
        0.     35.    32.   12612.  1.00  0.00   -0.01    0.57    7.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.90     489.39     489.12
  ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   488.29     510.72    0.50
  ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   488.29     510.72     489.12
  ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  0.62
```

```
 APPRO:AS      50.   -15.     142.  1.40  0.92  490.79  489.12   1350.  489.39
        50.    50.    26.    7839.  1.00  0.31    0.00    0.90    9.48
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

  ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                    SECID "BRIDG"     Q,CRWS =    1350.     489.68

             <<<<<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      35.     3.     103.  2.69 *****  492.37  489.68   1350.  489.68
         0.    35.    24.    5942.  1.00 ***** *******    1.00   13.16

      TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
        1. ****   1.  1.000 ******  496.47 ****** ****** ******

     XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
    RDWAY:RG      12.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

 APPRO:AS      27.   -63.     390.  0.19  0.30  493.86  489.12   1350.  493.67
        50.    29.    33.   29562.  1.04  1.19    0.00    0.31    3.46

        M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
       0.535  0.324   19954.    -2.    18.   493.60

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

         U.S. Geological Survey WSPRO Input File ffie048.wsp
         Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97
            *** RUN DATE & TIME: 06-09-97  08:04
   FIRST USER DEFINED TABLE.

     XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
    EXITX:XS     -35.    -8.    30.   1350.    8371.     145.    9.28  487.63
    FULLV:FV       0.   -10.    32.   1350.   12612.     192.    7.04  488.79
    BRIDG:BR       0.     3.    24.   1350.    5942.     103.   13.16  489.68
    RDWAY:RG      12.**************      0.******************    2.00********
    APPRO:AS      50.   -63.    33.   1350.   29562.     390.    3.46  493.67

     XSID:CODE   XLKQ   XRKQ       KQ
    APPRO:AS      -2.    18.   19954.
1
 WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
 V090192           MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

         U.S. Geological Survey WSPRO Input File ffie048.wsp
         Hydraulic analysis for structure FFIETH00300048   Date: 02-MAY-97

  SECOND USER DEFINED TABLE.

     XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
    EXITX:XS    487.19    0.84  482.26  504.46************  1.34  488.97  487.63
    FULLV:FV  ********    0.57  482.26  504.46  0.60  0.00  0.77  489.56  488.79
    BRIDG:BR    489.68    1.00  482.83  496.48************  2.69  492.37  489.68
    RDWAY:RG  ****************  497.67  509.99**********************************
    APPRO:AS    489.12    0.31  484.26  510.72  0.30  1.19  0.19  493.86  493.67
   ER
NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure FFIETH00300048, in Fairfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FFIETH00300048

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 08 / 95

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

County *(FIPS county code; I - 3; nnn)* 011

Town *(FIPS place code; I - 4; nnnnn)* 25225

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

Waterway *(I - 6)* WANZER BROOK

Road Name *(I - 7):* -

Route Number TH030

Vicinity *(I - 9)* 0.3 MI TO JCT C2 TH 2

Topographic Map Fairfield

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44498

Longitude *(i - 17; nnnnn.n)* 72546

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10060500480605

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

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

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000031

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

Deck Width *(I - 52; nn.n)* 192

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

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

Opening skew to Roadway *(I - 34; nn)* 30

Waterway adequacy *(I - 71; n)* 6

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*) 23.9

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

Vertical clearance from streambed (*nnn.n ft*) 12.2

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

Waterway of full opening (*nnn.n* ft^2) 291.8

Comments:

The structural inspection report of 8/22/94 indicates that the structure is a steel stringer type bridge. The abutments are stone walls with concrete caps and concrete "kneewall" footings. The left abutment has a concrete upstream end. The upstream end of the right abutment is concrete faced. Both abutments have retaining walls (extended footings) at both ends which are stone walls that are at least partially concrete faced. A few cracks are noted on the concrete caps and kneewalls of each abutment. Some movement has occurred in the boulders making up the retaining walls, which has resulted in cracks in the concrete facing. The abutment walls are sitting on a "corduroy" log mat floor in the channel **(Continued, page 32)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

Are there other structures nearby? (*Yes, No, Unknown*): 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:

under the bridge. Where the logs are exposed, there are signs of deterioration and rotten sections with some splitting. Some boulders are noted as exposed in the bank material up- and downstream. The banks are showing signs of erosion from previous flooding.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.78** mi^2 Lake/pond/swamp area **0.02** mi^2
Watershed storage *(ST)* **0.3** %
Bridge site elevation **472** ft Headwater elevation **1139** ft
Main channel length **4.37** mi
10% channel length elevation **522** ft 85% channel length elevation **827** ft
Main channel slope *(S)* **93.05** 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: **This cross-section is at the upstream face. The low chord elevations are from the survey log done for this report on 7/14/95. The low chord to bed length data is from the sketch attached to a bridge inspection report, dated 8/22/94. The sketch was done on 7/16/92.**

Station	**0**	**5.2**	**10.5**	**26.3**	-	-	-	-	-	-	-
Feature	**LAB**	-	-	**RAB**	-	-	-	-	-	-	-
Low cord elevation	**496.5**	**496.5**	**496.5**	**496.5**	-	-	-	-	-	-	-
Bed elevation	-	**483.7**	**483.7**	-	-	-	-	-	-	-	-
Low cord to bed length	-	**12.8**	**12.8**	-	-	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **3/11/96**
Computerized by: **RB** Date: **3/11/96**
Reviewd by: **RF** Date: **6/12/97**

Structure Number **FFIETH00300048**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. BOEHMELR** Date *(MM/DD/YY)* **7** / **11** / 19**95**

2. Highway District Number **08** Mile marker **0000**

County **011** Town **FAIRFIELD (25225)**

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

Route Number **TH030** Hydrologic Unit Code: **02010007**

3. Descriptive comments:

Located 0.3 miles from the intersection of TH30 and TH02.

B. Bridge Deck Observations

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

5. Ambient water surface... US **2** UB **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 **31** *(feet)* Span length **28** *(feet)* Bridge width **19.2** *(feet)*

Road approach to bridge:

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

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

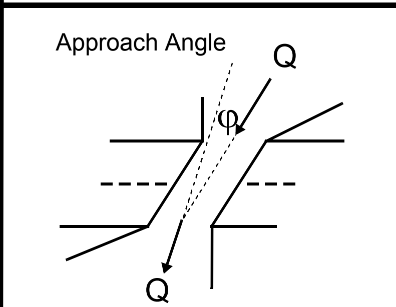
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

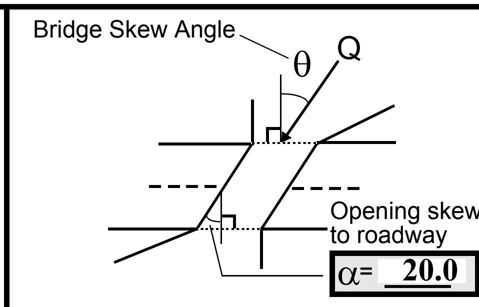
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	0	-	2	2
RBDS	0	-	0	0
LBDS	0	-	2	2

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

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **25** feet **US** *(US, UB, DS)* to **0** feet **US**

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**

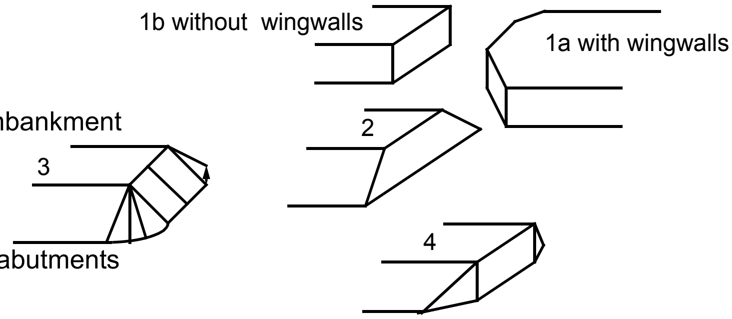
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

7. Values are from the VT AOT files. Measured bridge dimensions are the same as the historical values.
4. The US right bank has trees on the immediate bank then pasture beyond. The US left bank is all pasture. The DS left bank is forest exclusively, and the DS right bank has trees on the bank but then pasture above.
13. The roadway, left and right of the bridge, has a steep slope above the bridge. The roadway erosion is concentrated mainly on the US right bank corner and the DS left corner.
18. The bridge is 1b, but there are extended concrete footings with stones on top acting as a retaining wall/ pseudo wingwall structure.

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
0.0	5.5			5.5	1	2	543	453	0	1

23. Bank width **20.0** 24. Channel width **25.0** 25. Thalweg depth **73.0** 29. Bed Material **435**

30 .Bank protection type: LB **4** RB **3** 31. Bank protection condition: LB **1** RB **1**

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

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

30. The right bank protection extends from 0 feet US to 46 feet US. The left bank protection extends from 0 feet US to 55 feet US. From roughly 25 feet US to the bridge, on both banks, the protection changes from stone fill to dry masonry retaining walls/pseudo wingwalls. On the US right wall, the bottom 2 feet (at the base) is concrete and above this is approximately 5 feet of stone slabs. The US left wall is constructed similarly except, stone slabs make up only the top 3 feet of the wall.
The channel flow, as of 7/11/95, is only interstitial, except for a few small stagnant pools, the channel is dry upstream.

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 BETWEEN THE APPROACH AND EXIT CROSS-SECTIONS.
There is a point bar on the upstream left bank with a mid-bar width of 30 feet and mid-bar distance of 150 feet.

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? **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)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
17.0		**-**		**2**	**7**	**7**	**-**

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

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

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

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

7

Except for some small gaps, the bed material under the bridge is covered by a set of 13 logs. The gaps are filled with mainly medium to fine grained gravel. The first upstream 5 feet under the bridge is not covered by logs and here the material is much like that found US. The logs all extend below the exposed abutment footings on both sides. At least 2 logs are rotten and split. At one log, only the half under the right abutment remains, the other half may have eroded away. The farthest most DS log sits higher than the others and controls flow as water is pooled in channel under the bridge. The top of the log is 0.3 to 0.4 foot higher than the next log immediately upstream.

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 1____ *(1- Low; 2- Moderate; 3- High)*

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

70. Debris and Ice Comments:

1

Even though the banks are well vegetated, debris potential is low, and the likelihood of capture is low due to the high gradient and fairly stable banks.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		10	90	2	2	0	5.0	90.0
RABUT	1	-	90			2	3	25.5

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

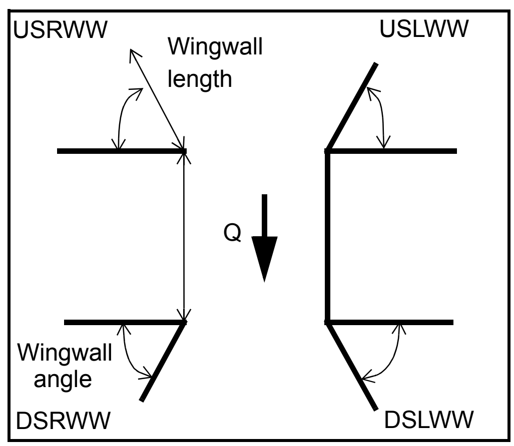
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0.5
5.0
1

The lower 5 feet on each abutment is concrete, while the next higher section is a 6.5 foot combination of dry masonry stone wall and concrete from 6 feet under the bridge to the DS end of the abutment. On top of the stone is a 2 foot concrete bridge seat.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						25.5	
USRWW:	N		-		-	0.5	
DSLWW:	-		-		N	24.0	
DSRWW:	-		-		-	22.0	



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	-	-	-	-	-
Condition	N	-	-	-	-	-	-	-
Extent	-	-	-	0	0	0	0	-

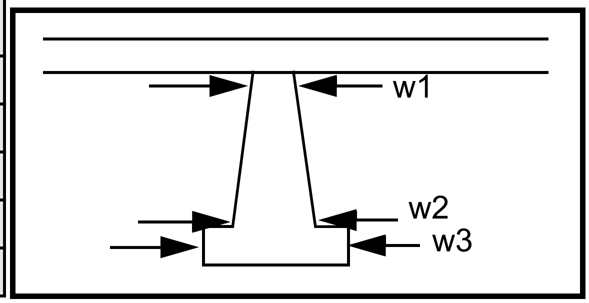
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

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

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



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	ere is	extend	where	inches)	LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP
87. Type	no	ed	there	alon	1- Solid pier, 2- column, 3- bent
88. Material	pro-	foot-	are 4	g the	1- Wood; 2- concrete; 3- metal; 4- stone
89. Shape	tec-	ing	very	entir	1- Round; 2- Square; 3- Pointed
90. Inclined?	tion	(reta	large	e	Y- yes; N- no
91. Attack ∠ (BF)	exce	ining	boul-	base	
92. Pushed	pt	wall	ders	lengt	LB or RB
93. Length (feet)	-	-	-	-	
94. # of piles	for	/	(type	h.	
95. Cross-members	on	pseu	-4,	The	0- none; 1- laterals; 2- diagonals; 3- both
96. Scour Condition	the	do	less	retai	0- not evident; 1- evident (comment); 2- footing exposed; 3- piling exposed; 4- undermined footing; 5- settled; 6- failed
97. Scour depth	DS	wing	than	ning	
98. Exposure depth	right	wall)	60	walls	

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

/pseudo wingwalls all have a concrete footing. Stacked on top of the concrete are size 3 stone slabs overlapping each other. The US and DS left retaining walls are undermined. Penetration under the US left retaining wall is up to 1.5 feet and the footing concrete is cracked vertically in 3 places. The DS left retaining wall is undermined vertically nearly 1.0 foot and has two wide vertical cracks.

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 (Amb) - Thalweg depth (Amb) - Bed Material -

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

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

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

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: 4______

Scour dimensions: Length 4_____ Width 543___ Depth: 543__ Positioned 0___ %LB to 0___ %RB

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

435
5
5
1

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

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

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

Confluence comments (eg. confluence name):

under the bridge and DS. The level would need to be 0.5 feet or higher to go over the control point DS. The area just DS of the bridge is scoured out.

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 protection on the left and right banks are dry masonry retaining walls/pseudo wingwall structures. They extend about 15 feet DS. The DS left wall has a 2 foot concrete footing and is topped with 5 feet of stone slabs. The DS right wall has a 4 foot thick footing and a 3 foot portion of stone slabs.

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: FFIETH00300048 Town: Fairfield
Road Number: TH3 County: Franklin
Stream: Wanzer Brook
Initials RHF Date: 6/9/97 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	980	1350	0
Main Channel Area, ft2	282	381	0
Left overbank area, ft2	0	10	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	61	66	0
Top width L overbank, ft	0	31	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.364	0.364	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	4.6	5.8	ERR
y1, average depth, LOB, ft	ERR	0.3	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	18808	29599	0
Conveyance, main channel	18808	29453	0
Conveyance, LOB	0	146	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	980.0	1343.3	ERR
Ql, discharge, LOB, cfs	0.0	6.7	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	3.5	3.5	ERR
Vl, mean velocity, LOB, ft/s	ERR	0.7	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.3	10.7	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

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	980	1350	N/A
Main channel area (DS), ft2	80.7	102.6	0

Main channel width (normal), ft	17.6	19.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	17.6	19.1	0.0
D90, ft	0.9251	0.9251	0.0000
D95, ft	1.3840	1.3840	0.0000
Dc, critical grain size, ft	0.8833	0.9615	ERR
Pc, Decimal percent coarser than Dc	0.107	0.094	0.000
Depth to armoring, ft	22.07	27.81	ERR

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	980	1350	0
(Q) discharge thru bridge, cfs	980	1350	0
Main channel conveyance	4282	5940	0
Total conveyance	4282	5940	0
Q2, bridge MC discharge,cfs	980	1350	ERR
Main channel area, ft2	81	103	0
Main channel width (normal), ft	17.6	19.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	17.6	19.1	0
y_bridge (avg. depth at br.), ft	4.59	5.37	ERR
Dm, median (1.25*D50), ft	0.455	0.455	0
y2, depth in contraction,ft	4.86	5.96	ERR
ys, scour depth (y2-ybridge), ft	0.27	0.59	N/A

Abutment Scour

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

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	980	1350	0	980	1350	0
a', abut.length blocking flow, ft	34.5	67	0	9.3	10.2	0
Ae, area of blocked flow ft2	130.65	195.2	0	24.44	31.94	0
Qe, discharge blocked abut.,cfs	395.27	607.5	0	54.25	69.49	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve a						
Ve, (Qe/Ae), ft/s	3.03	3.11	ERR	2.22	2.18	ERR
ya, depth of f/p flow, ft	3.79	2.91	ERR	2.63	3.13	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	110	110	110	70	70	70
K2	1.03	1.03	1.03	0.97	0.97	0.97
Fr, froude number f/p flow	0.274	0.321	ERR	0.241	0.217	ERR

ys, scour depth, ft	14.14	15.99	N/A	6.80	7.63	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)	34.5	67	0	9.3	10.2	0
y1 (depth f/p flow, ft)	3.79	2.91	ERR	2.63	3.13	ERR
a'/y1	9.11	23.00	ERR	3.54	3.26	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.27	0.32	N/A	0.24	0.22	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)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.59	5.37	0.00	4.59	5.37	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.)	1.92	2.25	ERR	1.92	2.25	ERR
Fr<=0.8 (spillthrough abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (spillthrough abut.)	1.70	1.99	ERR	1.70	1.99	ERR