LEVEL II SCOUR ANALYSIS FOR BRIDGE 12 (FFIETH00030012) on TOWN HIGHWAY 3, crossing the FAIRFIELD RIVER, FAIRFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-108

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

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By Erick M. Boehmler and James R. Degnan

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Pembroke, New Hampshire

1996

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, 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	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 12 (FFIETH00030012) ON TOWN HIGHWAY 3, CROSSING THE FAIRFIELD RIVER, FAIRFIELD, VERMONT

By Erick M. Boehmler and James R. Degnan

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FFIETH00030012 on Town Highway 3 crossing the Fairfield River, 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 north-western Vermont. The 7.34-mi^2 drainage area is in a predominantly rural basin with forest on the valley walls and pasture/row crops on the valley bottom. In the vicinity of the study site, the surface cover is row crops with a few trees on the immediate banks.

In the study area, the Fairfield River has a meandering channel with a slope of approximately 0.005 ft/ft, an average channel top width of 37 ft and an average channel depth of 6 ft. The predominant channel bed materials are sand and gravel with a median grain size (D_{50}) of 32.5 mm (0.107 ft). The geomorphic assessment at the time of the Level I and Level II site visit on June 16, 1995, indicated that the reach was stable.

The Town Highway 3 crossing of the Fairfield River is a 24-ft-long, one-lane bridge consisting of one 20-foot concrete span (Vermont Agency of Transportation, written communication, March 8, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 40 degrees to the opening. Although bridge records show an opening-skew-to-roadway of 45 degrees, the skew measured from surveyed points was 30 degrees.

At the time of the level I assessment, the left abutment had been undermined and settled into a scour hole at the upstream end. The right abutment footing was exposed but not undermined. The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) on the downstream right bank, and type-2 stone fill (less than 36 inches diameter) along the entire base of the upstream right wingwall, the upstream banks, and downstream left bank. The type-2 stone fill on the left bank downstream changes to type-1 about 55 feet downstream of the bridge. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 1.6 to 3.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 3.2 to 4.0 ft. at the left abutment and 9.7 to 11.7 feet at the right abutment. The worst-case left abutment scour occurred at the incipient over-topping discharge, which was less than the 100-year discharge. The worst-case right 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
Aerial photography, 1981; Contour interval, 6 meters

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 FFIETH00030012 ***Stream*** Fairfield River

County Franklin ***Road*** TH 3 ***District*** 8

Description of Bridge

Bridge length 24 ***ft*** ***Bridge width*** 20.1 ***ft*** ***Max span length*** 20 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 6/16/95

Description of stone fill Type-2 was present along the entire length of the upstream left wingwall, the upstream banks, and the downstream left bank. Type-1 was present on the right bank downstream.

Brief description of piers/abutments Abutments and wingwalls are concrete. The left abutment had been undermined at the upstream end and settled into the scour hole.

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

There is a severe channel bend (about 90 degrees) immediately upstream of the bridge. A scour hole is present where the flow impacts the right bank upstream.

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	6/16/95	0	0
Level II	6/16/95	0	0

Potential for debris Moderate. There are some young trees on the banks of this meandering channel.

Describe any features near or at the bridge that may affect flow (include observation date) None evident on 6/16/95.

Description of the Geomorphic Setting

General topography The channel is located in a low relief valley setting with wide, flat to slightly irregular flood plains and moderately sloping valley walls on both sides.

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

Date of inspection 6/16/95

DS left: Steep channel bank to flood plain.

DS right: Steep channel bank to flood plain

US left: Steep channel bank and TH 3 roadway embankment.

US right: Steep channel bank to flood plain.

Description of the Channel

Average top width 37 *ft* ***Average depth*** 6 *ft*

Predominant bed material Gravel ***Bank material*** Sand

Perennial and meandering with alluvial channel boundaries.

6/16/95

Vegetative co

Grass on flood plain.

DS left: Grass on flood plain.

DS right: Trees and shrubs.

US left: Grass with a few trees.

US right:

Do banks appear stable? Y

date of observation.

None evident on 6/16/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 7.34 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p - No

Calculated Discharges

Q100 1,140 ***ft³/s*** ***Q500*** 1,700 ***ft³/s***

The 100- and 500-year discharges are based on discharge frequency curves computed by use of several empirical equations (Benson, 1962; FHWA, 1983; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957a&b; and Talbot, 1887). The median of the 100- and 500-year discharges computed from the empirical equations were selected for the hydraulic analyses at this site.

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 the center point of a chiseled "X" on top of the concrete curb at the downstream left corner of the bridge deck (elev. 502.20 ft, arbitrary survey datum). RM2 is the center point of an engraved "X" on top of the first wooden, cable-guard-rail post from the right abutment on the upstream side of the roadway (elev. 503.11 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	-26	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	41	2	Modelled Approach section (Templated from APTEM)
APTEM	52	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 0.030 to 0.045, and overbank "n" values ranged from 0.040 to 0.060.

There is another bridge site (FFIETH00010014) located about 1700 feet downstream of this site. Backwater was suspected to influence the starting water surface at this site. Therefore, a model of the reach between the two sites was developed. Results of this model indicate that backwater does not affect the starting water surface at this site. Hence, 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 0.00483 ft/ft, which was estimated from the surveyed thalweg points of the EXITX section at this site and the approach section of FFIETH00010014.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0163 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 approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 500.6 *ft*
Average low steel elevation 498.8 *ft*

100-year discharge 1,140 *ft*^{3}*/s*
Water-surface elevation in bridge opening 499.4 *ft*
Road overtopping? Yes *Discharge over road* 29 *ft*^{3}*/s*
Area of flow in bridge opening 126 *ft*^{2}
Average velocity in bridge opening 8.8 *ft/s*
Maximum WSPRO tube velocity at bridge 11.0 *ft/s*

Water-surface elevation at Approach section with bridge 500.9
Water-surface elevation at Approach section without bridge 497.5
Amount of backwater caused by bridge 3.4 *ft*

500-year discharge 1,700 *ft*^{3}*/s*
Water-surface elevation in bridge opening 499.4 *ft*
Road overtopping? Yes *Discharge over road* 483 *ft*^{3}*/s*
Area of flow in bridge opening 126 *ft*^{2}
Average velocity in bridge opening 9.7 *ft/s*
Maximum WSPRO tube velocity at bridge 12.1 *ft/s*

Water-surface elevation at Approach section with bridge 501.6
Water-surface elevation at Approach section without bridge 498.4
Amount of backwater caused by bridge 3.2

Incipient overtopping discharge 1,060 *ft*^{3}*/s*
Water-surface elevation in bridge opening 499.1 *ft*
Area of flow in bridge opening 126 *ft*^{2}
Average velocity in bridge opening 8.4 *ft/s*
Maximum WSPRO tube velocity at bridge 10.3 *ft/s*

Water-surface elevation at Approach section with bridge 500.6
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 3.3 *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 results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, all discharges modeled resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Therefore, contraction scour depths were computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The results of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) for each event also were computed and included in appendix F. The depths to armoring computed suggest that streambed armoring will not impede contraction scour.

Abutment scour was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. Variables for the HIRE 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	2.0	3.0	1.6
Depth to armoring	5.6	8.5	4.1
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	3.6	3.2	4.0
Right abutment	10.2	11.7	9.7
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	1.8	2.1	1.6
Right abutment	1.8	2.1	1.6
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

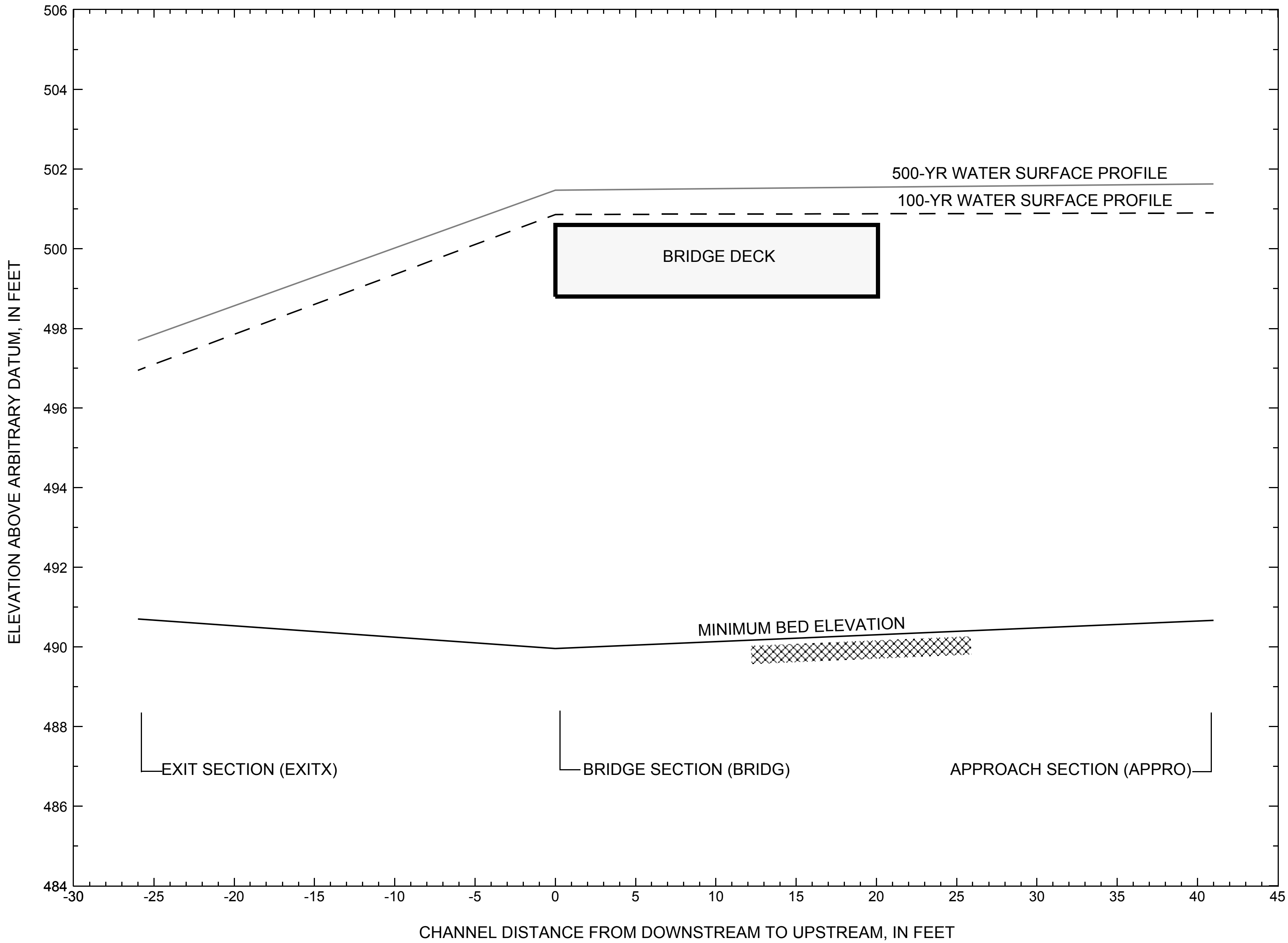

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure FFIETH00030012 on Town Highway 3, crossing the Fairfield River, Fairfield, Vermont.

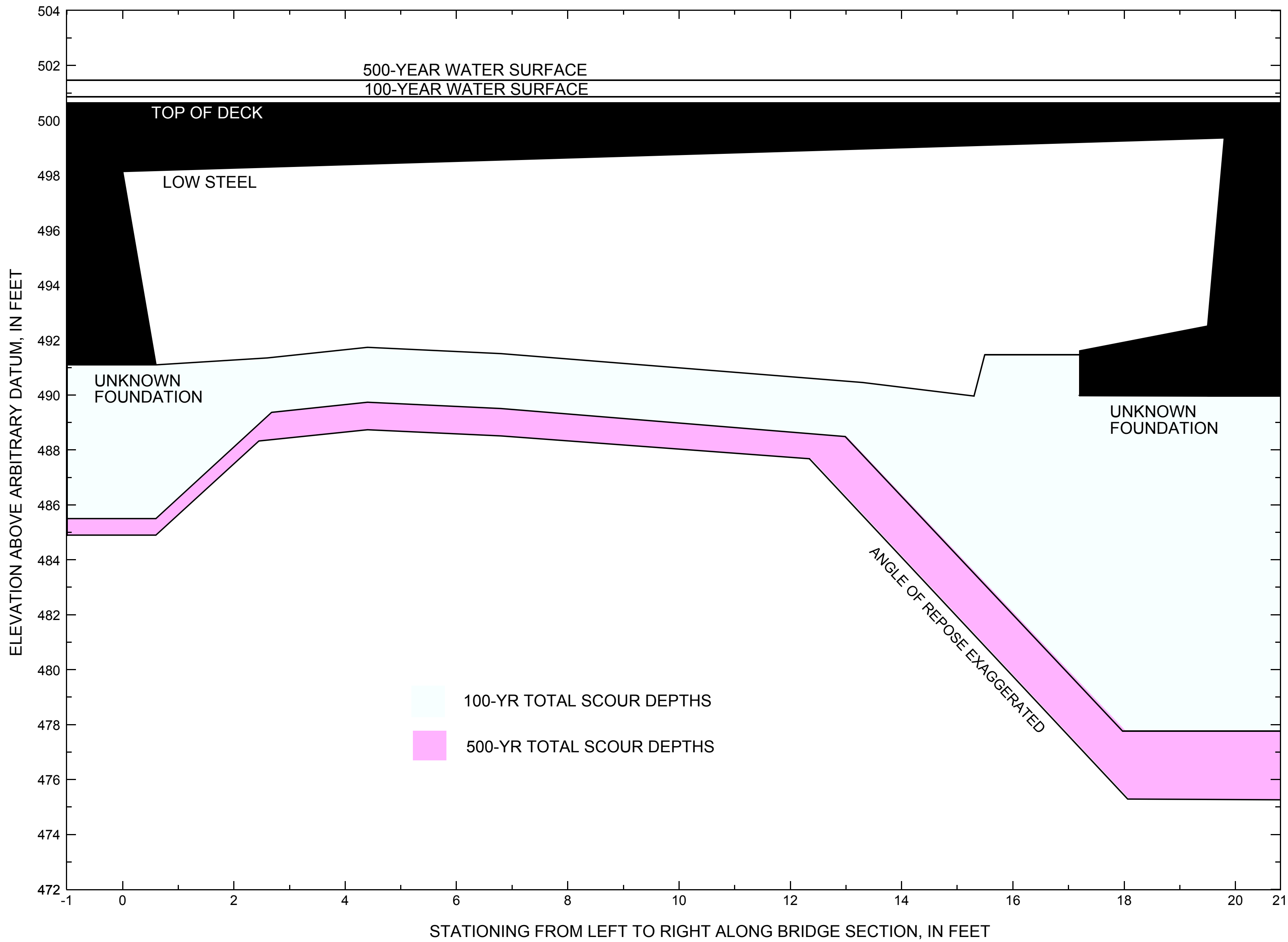

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure FFIETH00030012 on Town Highway 3, crossing the Fairfield River, Fairfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FFIETH00030012 on Town Highway 3, crossing the Fairfield River, 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 1,140 cubic-feet per second											
Left abutment	0.0	--	498.1	--	491.1	2.0	3.6	--	5.6	485.5	--
Right abutment	19.8	--	499.4	--	490.0	2.0	10.2	--	12.2	477.8	--

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 FFIETH00030012 on Town Highway 3, crossing the Fairfield River, 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 1,700 cubic-feet per second											
Left abutment	0.0	--	498.1	--	491.1	3.0	3.2	--	6.2	484.9	--
Right abutment	19.8	--	499.4	--	490.0	3.0	11.7	--	14.7	475.3	--

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, Fairfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Arial photography, 1981; Contour interval, 6 meters; Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO input file ffie012.wsp
T2        Created on 17-JAN-96 for bridge FFIETH00030012 using file ffie012.dca
T3        Hydraulic analysis for TH 3 over Fairfield River, Fairfield, VT   EMB
*
J1         *  *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          1140.0   1700.0   1060.0
SK         0.00483  0.00483  0.00483
*
XS   EXITX    -26
*
GR         -278.8, 503.62   -178.8, 499.93    -89.2, 497.54    -38.3, 497.03
GR           -9.3, 497.35      0.0, 491.34      2.4, 491.22      4.2, 491.03
GR            7.1, 490.70     14.3, 491.23     18.5, 491.48     31.4, 498.17
GR          100.8, 496.32    139.4, 496.14    155.8, 496.23    189.2, 496.23
GR          203.8, 497.73    248.3, 498.91    275.9, 499.90    286.6, 503.64
*
*           149.6, 493.73 removed
*
N           0.060        0.040        0.060
SA                   -9.3         31.4
*
XS   FULLV      0  * * *  0.0049
*
BR   BRIDG   0     498.8      30.0
*
GR             0.0, 498.14      0.4, 491.74      0.6, 491.10      2.6, 491.35
GR             4.4, 491.74      6.8, 491.51      8.9, 491.15     13.3, 490.46
GR            15.3, 489.96     15.6, 491.55     15.8, 491.74     17.2, 491.61
GR            19.5, 492.51     19.8, 499.36      0.0, 498.14
*
CD         4     23.8      3.9    500.3     82.9
N           0.030
*
XR   RDWAY     12      20.1   2
*
GR         -253.5, 505.83   -142.2, 502.73    -61.0, 501.45     -0.2, 500.63
GR             0.0, 500.96     19.5, 502.32     19.6, 500.63     67.3, 500.75
GR          167.2, 500.77    257.5, 502.12    313.0, 502.91
*
XT   APTEM     52
*
GR         -241.1, 505.77   -126.2, 502.46    -90.2, 501.66    -12.1, 500.06
GR           -6.9, 497.80      0.0, 492.44      3.3, 491.65      5.9, 490.94
GR            7.9, 490.96     10.8, 490.85     12.9, 491.69     20.1, 496.47
GR           53.9, 496.62    202.8, 497.10    254.8, 497.17    320.1, 498.06
GR          340.0, 503.29
*
*           239.6, 495.99 removed
*
AS   APPRO     41 * * * 0.0163
GT
N           0.060        0.045        0.040
SA                  -12.1         20.1
*
HP 1 BRIDG   499.36 1 499.36
```

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HP 2 BRIDG   499.36 * * 1112
HP 2 RDWAY   500.86 * *   29
HP 1 APPRO   500.90 1 500.90
HP 2 APPRO   500.90 * * 1140
*



HP 1 BRIDG   499.36 1 499.36
HP 2 BRIDG   499.36 * * 1218
HP 2 RDWAY   501.47 * *  483
HP 1 APPRO   501.63 1 501.63
HP 2 APPRO   501.63 * * 1700
*
HP 1 BRIDG   499.13 1 499.13
HP 2 BRIDG   499.13 * * 1060
HP 1 APPRO   500.60 1 500.60
HP 2 APPRO   500.60 * * 1060
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO input file ffie012.wsp
        Created on 17-JAN-96 for bridge FFIETH00030012 using file ffie012.dca
        Hydraulic analysis for TH 3 over Fairfield River, Fairfield, VT   EMB
           *** RUN DATE & TIME: 11-14-96  11:38

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

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      126     11713     0     49                      5822795
   499.36           126     11713     0     49  1.00      0     20  5822795

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.36     0.0    19.8   126.2   11713.    1112.   8.81

 X STA.        0.0        2.1        3.3        4.4        5.4        6.4
   A(I)            11.4        7.1        6.4        5.9        5.9
   V(I)            4.89       7.83       8.62       9.46       9.48

 X STA.        6.4        7.3        8.1        9.0        9.8       10.5
   A(I)             5.5        5.4        5.4        5.2        5.1
   V(I)           10.03      10.29      10.30      10.74      10.84

 X STA.       10.5       11.2       12.0       12.7       13.4       14.1
   A(I)             5.1        5.0        5.1        5.3        5.3
   V(I)           10.89      11.01      10.89      10.52      10.59

 X STA.       14.1       14.8       15.7       16.7       17.8       19.8
   A(I)             5.4        7.0        6.3        6.8       11.6
   V(I)           10.28       7.95       8.89       8.14       4.81

HP table output for the roadway overflow is ommitted due to incorrect computations.
Area of roadway overflow left and right of the bridge for purposes of computing the
area blocked by the roadway embankments for abutment scour was done manually...

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1       25       402    50     50                          103
             2      228     25756    32     36                         3450
             3     1230    114394   311    312                        13872
   500.90          1484    140552   393    398  1.04    -61    332    16000

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.90   -61.9   331.6  1483.8  140552.    1140.   0.77

 X STA.      -61.9        2.5        8.0       13.1       24.4       39.4
   A(I)           100.3       54.4       50.4       68.4       68.3
   V(I)            0.57       1.05       1.13       0.83       0.83

 X STA.       39.4       54.9       70.7       87.0      103.4      120.3
   A(I)            69.5       70.2       71.2       70.9       72.3
   V(I)            0.82       0.81       0.80       0.80       0.79

 X STA.      120.3      137.7      155.1      173.4      191.8      211.0
   A(I)            73.5       72.5       74.9       74.6       76.3
   V(I)            0.78       0.79       0.76       0.76       0.75

 X STA.      211.0      230.3      250.1      270.6      294.4      331.6
   A(I)            76.5       77.7       78.7       84.1       99.3
   V(I)            0.75       0.73       0.72       0.68       0.57
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WSPRO OUTPUT FILE (continued)

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      126     11713      0     49                      5822795
   499.36           126     11713      0     49  1.00      0     20  5822795

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.36     0.0    19.8   126.2   11713.    1218.   9.65

X STA.         0.0        2.1        3.3        4.4        5.4        6.4
  A(I)            11.4        7.1        6.4        5.9        5.9
  V(I)            5.35       8.58       9.44      10.36      10.39

X STA.         6.4        7.3        8.1        9.0        9.8       10.5
  A(I)             5.5        5.4        5.4        5.2        5.1
  V(I)           10.99      11.27      11.28      11.76      11.87

X STA.        10.5       11.2       12.0       12.7       13.4       14.1
  A(I)             5.1        5.0        5.1        5.3        5.3
  V(I)           11.93      12.06      11.93      11.52      11.60

X STA.        14.1       14.8       15.7       16.7       17.8       19.8
  A(I)             5.4        7.0        6.3        6.8       11.6
  V(I)           11.26       8.71       9.74       8.91       5.27

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      12.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.47   -62.3   214.0   152.7    2852.     483.   3.16

X STA.       -62.3      -18.5       -7.2       -1.4       24.1       29.6
  A(I)            13.1        7.5        4.5        6.8        4.5
  V(I)            1.85       3.20       5.36       3.56       5.33

X STA.        29.6       37.0       45.6       54.7       64.3       74.5
  A(I)             5.9        6.8        6.9        7.1        7.4
  V(I)            4.07       3.55       3.50       3.39       3.27

X STA.        74.5       84.7       94.9      105.2      115.6      126.3
  A(I)             7.3        7.3        7.3        7.4        7.6
  V(I)            3.31       3.32       3.29       3.26       3.18

X STA.       126.3      137.1      148.3      159.6      172.6      214.0
  A(I)             7.6        7.9        7.9        8.9       12.8
  V(I)            3.18       3.05       3.04       2.71       1.88

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       75      1702     85     85                          397
             2      252     30326     32     36                         3996
             3     1459    151016    314    315                        17831
   501.63          1785    183044    431    436  1.07    -96    334    19921

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.63   -96.9   334.4  1785.0  183044.    1700.   0.95

X STA.       -96.9        1.9        8.2       14.3       27.7       42.9
  A(I)           154.2       65.8       64.6       82.5       80.1
  V(I)            0.55       1.29       1.32       1.03       1.06

X STA.        42.9       59.0       75.0       91.4      108.0      125.0
  A(I)            83.4       82.3       83.7       83.5       85.2
  V(I)            1.02       1.03       1.02       1.02       1.00

X STA.       125.0      142.3      160.1      177.9      196.2      215.3
  A(I)            85.2       86.9       85.5       87.4       89.6
  V(I)            1.00       0.98       0.99       0.97       0.95

X STA.       215.3      234.5      253.6      273.9      296.8      334.4
  A(I)            90.0       88.8       92.0       96.3      118.0
  V(I)            0.94       0.96       0.92       0.88       0.72
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    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      126     12236      3     46                         4459
   499.13           126     12236      3     46  1.00      0     20     4459

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.13     0.0    19.8   125.8   12236.    1060.   8.43

X STA.         0.0         2.2         3.4         4.6         5.6         6.6
  A(I)            11.8         7.3         6.8         6.2         6.0
  V(I)            4.49        7.24        7.77        8.52        8.78

X STA.         6.6         7.5         8.5         9.3        10.1        10.9
  A(I)             5.7         5.8         5.4         5.4         5.2
  V(I)            9.27        9.21        9.82        9.74       10.14

X STA.        10.9        11.6        12.3        13.0        13.7        14.4
  A(I)             5.2         5.1         5.2         5.2         5.2
  V(I)           10.21       10.33       10.21       10.28       10.26

X STA.        14.4        15.1        16.1        16.9        17.9        19.8
  A(I)             5.3         7.1         5.2         6.0        10.6
  V(I)           10.06        7.42       10.16        8.86        4.99

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       13       159     35     35                           43
             2      219     23966     32     36                         3233
             3     1137    100561    310    311                        12348
   500.60          1368    124685    378    382  1.04    -46    330    14505

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.60   -47.2   330.4  1368.2  124685.    1060.   0.77

X STA.       -47.2         2.7         7.9        12.6        22.0        37.0
  A(I)            84.7        49.4        46.0        59.4        63.8
  V(I)            0.63        1.07        1.15        0.89        0.83

X STA.        37.0        52.4        68.2        84.0       100.8       117.6
  A(I)            64.9        65.4        64.7        67.8        66.9
  V(I)            0.82        0.81        0.82        0.78        0.79

X STA.       117.6       134.8       152.6       170.9       189.4       208.5
  A(I)            67.5        68.6        69.7        69.4        70.8
  V(I)            0.79        0.77        0.76        0.76        0.75

X STA.       208.5       228.5       247.8       269.1       293.0       330.4
  A(I)            72.8        70.1        75.5        78.0        92.6
  V(I)            0.73        0.76        0.70        0.68        0.57
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -8      236  0.60 *****  497.55  495.47    1140  496.95
       -25 ******    196    16398  1.65 ***** *******    0.89    4.84

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.89     497.09     495.60

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.45     503.77    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.45     503.77     495.60

FULLV:FV       26     -8      239  0.59  0.12  497.69  495.60    1140  497.10
         0     26    196    16592  1.67  0.00    0.01    0.88    4.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.82     497.50     497.40

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.60     505.59    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.60     505.59     497.40

APPRO:AS       41     -6      330  0.35  0.19  497.87  497.40    1140  497.52
        41     41    294    16991  1.86  0.00   -0.01    0.79    3.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   496.52     499.49     499.54     498.80

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<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       26      0      126  1.21 *****  500.57  496.44    1112  499.36
         0 ******     20    11713  1.00 ***** *******    0.62    8.82

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.479  0.000  498.80 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    21.  0.00  0.01  500.90    0.00     29.  500.86

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     3.    17.   -17.     0.   0.2   0.1   1.5   1.4   0.2   2.6
   RT:    26.   154.    20.   173.   0.2   0.1   1.6   1.5   0.2   2.6

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

APPRO:AS       17    -61     1482  0.01  0.02  500.91  497.40    1140  500.90
        41     28    332   140312  1.04  0.39    0.00    0.07    0.77

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.    -9.   196.   1140.   16398.     236.    4.84  496.95
   FULLV:FV       0.    -9.   196.   1140.   16592.     239.    4.76  497.10
   BRIDG:BR       0.     0.    20.   1112.   11713.     126.    8.82  499.36
   RDWAY:RG      12.*******     3.     29.*****************    2.00  500.86
   APPRO:AS      41.   -62.   332.   1140.  140312.    1482.    0.77  500.90

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS  **********************
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WSPRO OUTPUT FILE (continued)

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 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    495.47    0.89  490.70  503.64************  0.60  497.55  496.95
   FULLV:FV    495.60    0.88  490.83  503.77  0.12  0.00  0.59  497.69  497.10
   BRIDG:BR    496.44    0.62  489.96  499.36************  1.21  500.57  499.36
   RDWAY:RG  ****************  500.63  505.83  0.00******  0.01  500.90  500.86
   APPRO:AS    497.40    0.07  490.67  505.59  0.02  0.39  0.01  500.91  500.90

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

EXITX:XS   ******    -94      404  0.60 *****  498.30  497.28    1700  497.70
       -25 ******    204    24444  2.19 ***** *******    0.91    4.21

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.89     497.86     497.41

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.20     503.77    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.20     503.77     497.41

FULLV:FV       26    -95      410  0.59  0.12  498.44  497.41    1700  497.85
         0     26    204    24757  2.20  0.00    0.01    0.90    4.14
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  1.49

APPRO:AS       41     -8      616  0.15  0.13  498.56 *******    1700  498.41
        41     41    322    36976  1.31  0.00    0.00    0.41    2.76
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.89       0.00     498.12     500.63

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.68     501.16     501.23     498.80

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<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       26      0      126  1.45 *****  500.81  496.76    1218  499.36
         0 ******     20    11713  1.00 ***** *******    0.67    9.65

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   5.  0.492  0.000  498.80 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    21.  0.00  0.02  501.64    0.00    483.  501.47

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     82.    70.   -62.     7.   0.8   0.4   3.1   2.9   0.6   2.7
   RT:    401.   194.    20.   214.   0.8   0.6   3.8   3.2   0.8   2.8

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

APPRO:AS       17    -96     1783  0.02  0.04  501.64  497.74    1700  501.63
        41     37    334   182735  1.07  0.35    0.00    0.09    0.95

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ****** ********

                      <<<<<END OF BRIDGE COMPUTATIONS>>>>>
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  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.   -95.   204.   1700.   24444.     404.    4.21  497.70
   FULLV:FV       0.   -96.   204.   1700.   24757.     410.    4.14  497.85
   BRIDG:BR       0.     0.    20.   1218.   11713.     126.    9.65  499.36
   RDWAY:RG      12.*******    82.    483.******************    2.00  501.47
   APPRO:AS      41.   -97.   334.   1700.  182735.    1783.    0.95  501.63

    XSID:CODE   XLKQ   XRKQ      KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    497.28    0.91  490.70  503.64************  0.60  498.30  497.70
   FULLV:FV    497.41    0.90  490.83  503.77  0.12  0.00  0.59  498.44  497.85
   BRIDG:BR    496.76    0.67  489.96  499.36************  1.45  500.81  499.36
   RDWAY:RG  ***************  500.63  505.83  0.00******  0.02  501.64  501.47
   APPRO:AS    497.74    0.09  490.67  505.59  0.04  0.35  0.02  501.64  501.63

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

EXITX:XS   ******     -7      213  0.60 *****  497.40  495.30    1060  496.80
       -25 ******    195    15249  1.56 ***** *******    0.92    4.98

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.91     496.94     495.43

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.30     503.77    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.30     503.77     495.43

FULLV:FV       26     -7      214  0.60  0.13  497.53  495.43    1060  496.93
         0     26    195    15279  1.56  0.00    0.00    0.91    4.96
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.31     497.14     497.34

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.43     505.59    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.43     505.59     497.34

 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "APPRO"
                  WSBEG,WSEND,CRWS =   497.34     505.59     497.34

APPRO:AS       41     -6      276  0.45 *****  497.79  497.34    1060  497.34
        41     41    280    14187  1.96 ***** *******    0.97    3.84
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   496.28     499.13     499.18     498.80

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

            <<<<<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       26      0      126  1.10 *****  500.23  496.26    1058  499.13
         0 ******     20    12237  1.00 ***** *******    0.59    8.41

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       4. ****   2.  0.470  0.000  498.80 ****** ****** ******

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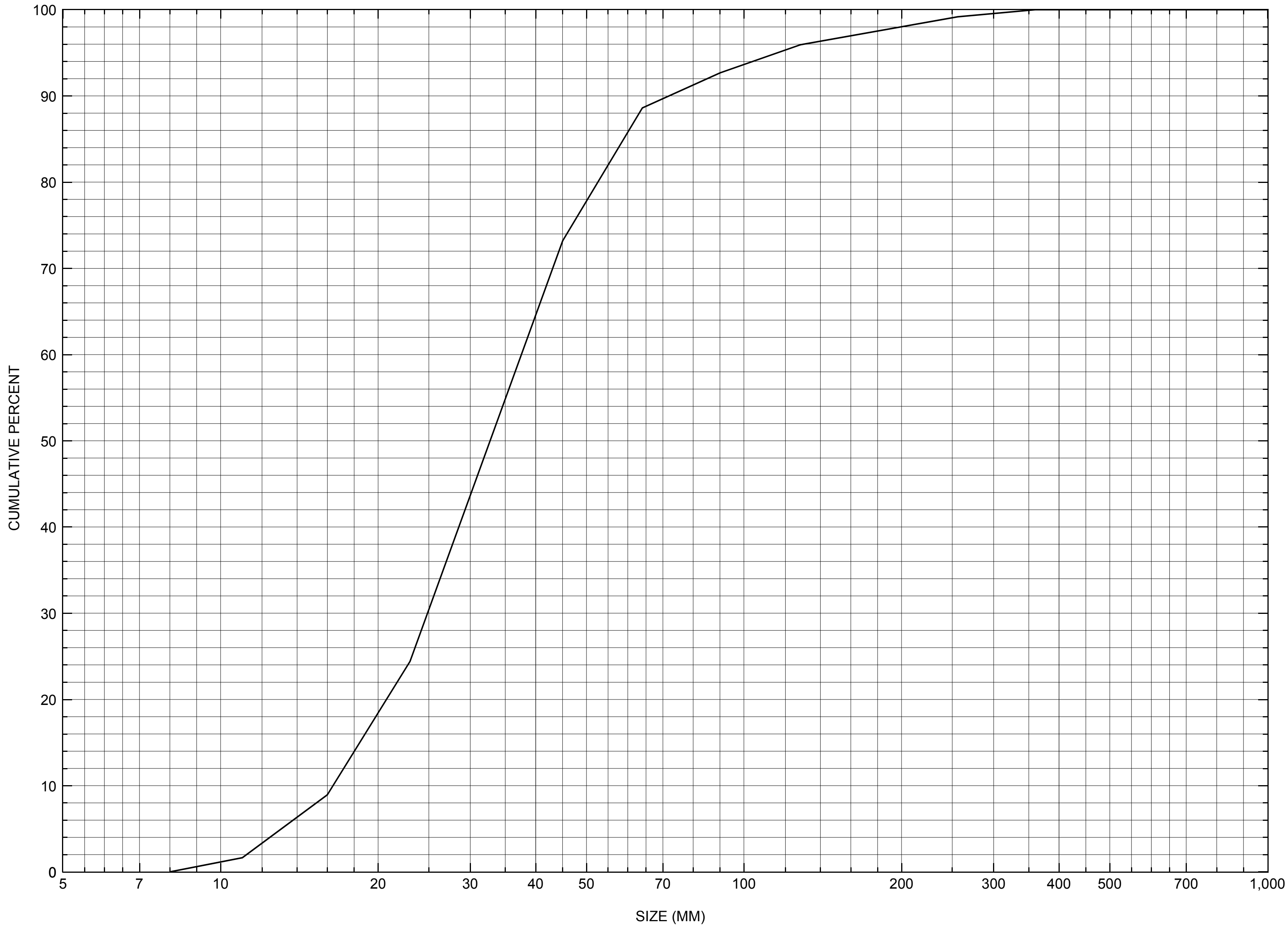

WSPRO OUTPUT FILE (continued)

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

APPRO:AS       17    -46     1370  0.01  0.02  500.61  497.34    1060  500.60
        41     26    330   124880  1.04  0.40    0.00    0.07    0.77

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   500.60
                   <<<<<END OF BRIDGE COMPUTATIONS>>>>>

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K     AREA     VEL    WSEL
   EXITX:XS     -26.    -8.   195.   1060.   15249.     213.    4.98  496.80
   FULLV:FV       0.    -8.   195.   1060.   15279.     214.    4.96  496.93
   BRIDG:BR       0.     0.    20.   1058.   12237.     126.    8.41  499.13
   RDWAY:RG      12.**************      0.*****************    2.00********
   APPRO:AS      41.   -47.   330.   1060.  124880.    1370.    0.77  500.60

    XSID:CODE   XLKQ   XRKQ      KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO   VHD      EGL    WSEL
   EXITX:XS    495.30    0.92  490.70  503.64************  0.60  497.40  496.80
   FULLV:FV    495.43    0.91  490.83  503.77  0.13  0.00  0.60  497.53  496.93
   BRIDG:BR    496.26    0.59  489.96  499.36************  1.10  500.23  499.13
   RDWAY:RG  ***************  500.63  505.83************  0.01  500.72********
   APPRO:AS    497.34    0.07  490.67  505.59  0.02  0.40  0.01  500.61  500.60
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for one pebble count transect in the channel approach of structure FFIETH00030012, in Fairfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FFIETH00030012

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)* Fairfield River (Soule Brook)

Road Name *(I - 7):* -

Route Number TH003

Vicinity *(I - 9)* 0.2 MI TO JCT C2 TH 1

Topographic Map Fairfield

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44459

Longitude *(i - 17; nnnnn.n)* 72578

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10060500120605

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

Maximum span length *(I - 48; nnnn)* 0020

Year built *(I - 27; YYYY)* 1940

Structure length *(I - 49; nnnnnn)* 000024

Average daily traffic, ADT *(I - 29; nnnnnn)* 000190

Deck Width *(I - 52; nn.n)* 201

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

Channel & Protection *(I - 61; n)* 4

Opening skew to Roadway *(I - 34; nn)* 45

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

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

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

Structure type *(I - 43; nnn)* 101

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 20.6

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

Vertical clearance from streambed (*nnn.n ft*) 8.0

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

Waterway of full opening (*nnn.n ft^2*) 164.7

Comments:

The structural inspection report of 8/22/94 indicates the structure is a concrete slab type bridge. The abutments and wingwalls are concrete. The abutment footings on both walls are exposed. That on the right abutment side is undermined for about 10 feet upstream and downstream of the roadway centerline. The undermining is about 4.5 feet deep and penetration is between 3 and 4 feet under the wall. Both abutment walls have alligator cracking and spalling, particularly at both ends upstream and downstream. The downstream right wingwall has broken away from the abutment wall at the corner where the two meet. This wingwall has also broken free from its footing. The left abutment is reported **(Continued, page 35)**

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:

to have settled as much as 0.75 feet on the upstream end and up to nearly 0.5 feet at the downstream end. The footing has broken away from the abutment wall along the bottom of the wall. Some riprap protection is noted on the banks up- and downstream along with some erosion from previous flooding. The channel flows into the upstream face of the bridge at nearly a 90 degree angle. The settling of the left abutment is detectable on the road surface as the deck dropped below the roadway level.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **7.34** mi^2 Lake and pond area **0.03** mi^2

Watershed storage *(ST)* **0.4** %

Bridge site elevation **600** ft Headwater elevation **1920** ft

Main channel length **4.44** mi

10% channel length elevation **610** ft 85% channel length elevation **1140** ft

Main channel slope *(S)* **159.16** 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? N *If no, type ctrl-n xs*

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **MI** Date: **1/29/96**
Computerized by: **MI** Date: **1/29/96**
Reviewd by: **EB** Date: **10/3/96**

Structure Number **FFIETH00030012**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **J** . **Degnan** Date *(MM/DD/YY)* **6/** / **16/** / 19**95**

2. Highway District Number **08** Mile marker **000000**

County **Franklin (011)** Town **Fairfield (25225)**

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

Route Number **TH003** Hydrologic Unit Code: **02010007**

3. Descriptive comments:
Bridge is located about 0.2 miles from the intersection of TH03 with TH01. The structure is a steel reinforced concrete slab type bridge. This assessment was assisted by E. Boehmler

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **3** LBDS **3** RBDS **4** Overall **3**
*(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 **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 **24.0** *(feet)* Span length **20.0** *(feet)* Bridge width **20.1** *(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)*

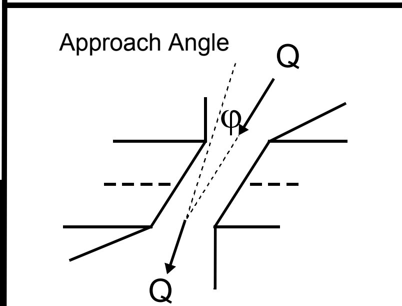
10. Embankment slope (*run / rise in feet / foot*):
US left **1.4:1** US right **6.4:1**

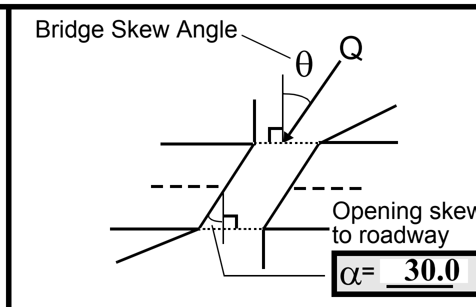
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	5	3	3	3
RBUS	0	-	2	1
RBDS	0	-	2	3
LBDS	0	-	2	2

*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: **70** 16. Bridge skew: **40**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **3**
Range? **5** feet **US** *(US, UB, DS)* to **20** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **115** feet **US** *(US, UB, DS)* to **90** feet **US**

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

18. Bridge Type: **1a,4**

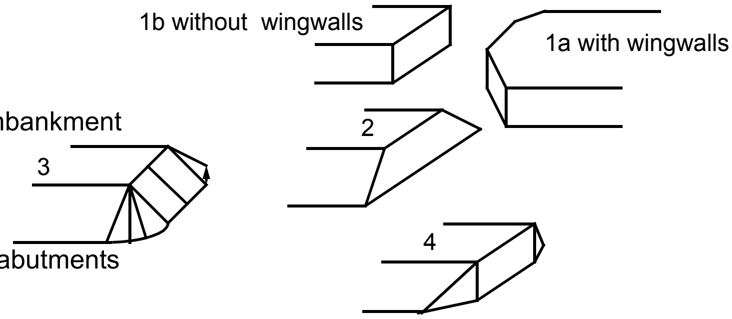
1a- Vertical abutments with wingwalls

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.)

The measured deck width was 19.8 feet. The remaining bridge measurements matched the historical values. The left bank upstream coverage includes the gravel roadway surface. Roadwash gullies are developing on the upstream side of the left bank road approach embankment. This area is also impacted severely by the channel. There is no clearly visible protection on the roadway fill here except at the base. The embankment is well vegetated with shrubs but few trees. The downstream wingwalls extend parallel to the abutment walls while the upstream wingwalls are angled.

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
28.5	7.5			5.0	2	1	7	2	2	2

23. Bank width **30.0** 24. Channel width **35.0** 25. Thalweg depth **32.0** 29. Bed Material **324**

30 .Bank protection type: LB **2** RB **2** 31. Bank protection condition: LB **3** 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.):

Type 2 stone fill is evident on the left bank from 115 feet upstream to the upstream left wingwall. Some has fallen completely off the embankment and is now in the center of the channel. The bed material is fine to medium gravel with sand and a few cobbles. The left bank material is mostly gravel fill that forms the roadway embankment. The end of the upstream left bank stone fill is about 35 feet upstream where a stone and concrete block wall protects the bank down to the upstream left wingwall near 15 feet upstream. The right bank stone fill protection extends from the right abutment wall to about 45 feet upstream; the last 10 feet is mainly protecting the upstream right wingwall.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **15** 35. Mid-bar width: **7.0**

36. Point bar extent: **25** feet **US** (US, UB) to **7** feet **DS** (US, UB, DS) positioned **0** %LB to **40** %RB

37. Material: **32**

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

This point bar is not vegetated and is composed of mainly fine to medium gravel with some medium to coarse sand. The mid-bar distance is 15 feet under the bridge. An additional point bar is present from 130 feet upstream to 86 feet upstream on the right bank across from where the channel impacts the road approach embankment. The bar is about 7 feet wide.

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.):

A severe impact is present on the right bank upstream, but a cut bank has not developed due to the stone fill present protecting the right bank. The left bank impact upstream is also protected at least at the base of the roadway embankment. The roadway embankment appears oversteepened though especially in the area of 115 feet to 90 feet upstream, but with vegetation coverage does not appear cut by the stream.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **3**

47. Scour dimensions: Length **37** Width **4** Depth : **1.0** Position **60** %LB to **100** %RB

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

The scour has developed mainly along the toe of the stone fill on the right bank. Some areas of the stone fill appears slightly slumped into the scour hole.

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
13.0		0.5		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.):

32

The gravel and sand point bar material extending under the bridge is very loose. The rangepole easily penetrates the streambed down about one foot below the surface near mid-channel under the bridge and up to 3.5 feet easily near the upstream end of the left abutment where the footing has settled. The bed material at the surface is different from that encountered upstream. The bed material appears to be the same as the fill used for the roadway. Under this, the material is more compact as the rangepole only penetrates a couple tenths of a foot at the most, which is more like the material found upstream and beyond 200 feet downstream.

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? **2**___ *(Y or N)* Ice Blockage Potential **N**____ *(1- Low; 2- Moderate; 3- High)*

70. Debris and Ice Comments:

2

The stone fill on the right bank at the bend upstream constricts the channel and the bend is severe enough that ice and debris are likely to build-up at this bend.

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		**-**	**90**	**2**	**5**	**0.5**	**2.0**	**90.0**
RABUT	**1**	**10**	**90**			**2**	**2**	**17.0**

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

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

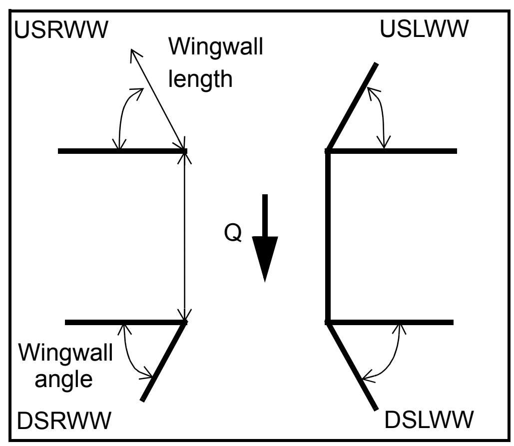
1.0
2.0
1

The left abutment wall and its footing have settled into a scour hole which subsequently filled in with road fill material making a scour depth difficult to measure. The left abutment appears to have rotated with the upstream end having sunk at least one foot below the other corners of the bridge and some twisting evident in the deck. The exposure depth was taken from that part of the footing still visible at the surface at the down-stream end of the left abutment. The footing has completely broken away from the abutment wall and settled resting at an angle greater than 90 degrees from the abutment wall. Because the footing has broken away, the exposure depth given is a minimum value. There is a 0.5 foot vertical gap between the left abutment wall and

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**its**		**foot-**		**ing**	**17.0**	
USRWW:	**with**		**2.5**		**feet**	**1.0**	
DSLWW:	**pen-**		**etra-**		**tion**	**24.0**	
DSRWW:	**befo**		**re**		**reac**	**23.5**	

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	**hing**	**mat**	**nd**	**.**	**orit**	**stre**	**atta**	**the**
Condition	**the**	**erial**	**the**	**The**	**y of**	**amfl**	**ck is**	**righ**
Extent	**fill**	**behi**	**wall**	**maj**	**the**	**ow**	**on**	**t**

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.):

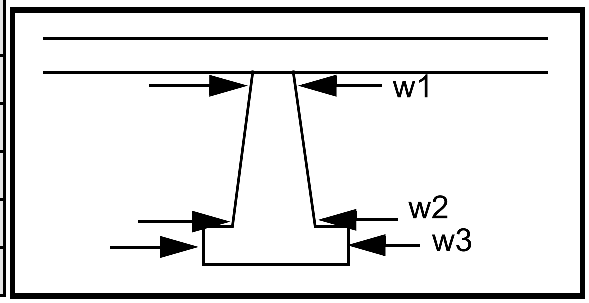
abutment. Its footing is exposed between 1.5 and 2 feet but has not been undermined. The right abutment protection extends only 4 feet under the bridge from the upstream face.

Y
1
6
-
-
Y
1
5
-

Piers:

84. Are there piers? __-__ *(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				**55.0**	**10.0**	**110.0**
Pier 2			**7.5**	**12.5**	**120.0**	**60.0**
Pier 3	**7.0**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**Y**	**-**	**-**	**nstre**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**1**	**2**	**-**	**am**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**5**	**1**	**-**	**left**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**0.5**	**1**	**-**	**wing**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**1.5**	**0**	**0**	**wall**	*Y- yes; N- no*
91. Attack ∠ (BF)	**Y**	**-**	**-**	**foot-**	
92. Pushed	**1**	**-**	**-**	**ing**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**2**	**0**	**0**	**has**	
95. Cross-members	**0**	**-**	**-**	**bro-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**1.5**	**-**	**-**	**ken**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**0**	**-**	**The**	**away**	
98. Exposure depth	**-**	**-**	**dow**	**from**	

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

the wingwall. The wingwall is in-tact and is elevated above its footing by 0.5 feet from the rotation of the abutment wall. The upstream left wingwall has settled in a scour hole which subsequently refilled with sediment. The top portion of this wingwall has broken away from the rest of the wingwall and rotated about 1.5 feet toward the stream. The upstream right wingwall footing has been buried in the stone fill protection. Four large concrete blocks are set in the streambed along the right side of the scour hole and the base of the wingwall footing.

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
-	-			-		N	-	-	-	-

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? - (Y or if N type ctrl-n cb) Where? - (LB or RB) Mid-bank distance: NO

Cut bank extent: PIE feet RS. (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: ____

Scour dimensions: Length 1 Width 1 Depth: 7 Positioned 7 %LB to 2 %RB

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

0
32
2
1

Are there major confluences? 2 (Y or if N type ctrl-n mc) How many? 1

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

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

Confluence comments (eg. confluence name):

tion has slumped and partially eroded in places. The banks are unvegetated downstream. The type 2 stone fill on the left bank downstream extends from the bridge to about 55 feet downstream where type 1 stone fill pro-

F. Geomorphic Channel Assessment

107. Stage of reach evolution tec

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)*:

tion continues on left bank to about 185 feet. The stone fill on the right bank extends from the bridge to about 155 feet downstream. There is a slight impact zone on the left bank extending from 40 to 70 feet downstream. The bank material on both banks is covered with stone fill to about 185 feet downstream where the native bank material resurfaces. The bank material beyond 185 feet is mostly medium to fine sand and some silt, which is more like that found upstream on the 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: FFIETH00030012   Town: Fairfield
Road Number: TH 3   County: Franklin
Stream: Fairfield River

Initials EMB   Date: 11/14/96 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	1140	1700	1060
Main Channel Area, ft2	228	252	219
Left overbank area, ft2	25	75	13
Right overbank area, ft2	1230	1459	1137
Top width main channel, ft	32	32	32
Top width L overbank, ft	50	85	35
Top width R overbank, ft	311	314	310
D50 of channel, ft	0.107	0.107	0.107
D50 left overbank, ft	0	0	0
D50 right overbank, ft	0	0	0
y1, average depth, MC, ft	7.1	7.9	6.8
y1, average depth, LOB, ft	0.5	0.9	0.4
y1, average depth, ROB, ft	4.0	4.6	3.7
Total conveyance, approach	140552	183044	124685
Conveyance, main channel	25756	30326	23966
Conveyance, LOB	402	1702	159
Conveyance, ROB	114394	151016	100561
Percent discrepancy, conveyance	0.0000	0.0000	-0.0008
Qm, discharge, MC, cfs	208.9	281.6	203.7
Ql, discharge, LOB, cfs	3.3	15.8	1.4
Qr, discharge, ROB, cfs	927.8	1402.5	854.9
Vm, mean velocity MC, ft/s	0.9	1.1	0.9
Vl, mean velocity, LOB, ft/s	0.1	0.2	0.1
Vr, mean velocity, ROB, ft/s	0.8	1.0	0.8
Vc-m, crit. velocity, MC, ft/s	7.4	7.5	7.3
Vc-l, crit. velocity, LOB, ft/s	0.0	0.0	0.0
Vc-r, crit. velocity, ROB, ft/s	0.0	0.0	0.0

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?

Main Channel	0	0	0

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	228	252	219
Main channel width, ft	32	32	32
y1, main channel depth, ft	7.13	7.88	6.84

Bridge Section			
(Q) total discharge, cfs	1140	1700	1060
(Q) discharge thru bridge, cfs	1112	1218	1060
Main channel conveyance	11713	11713	12236
Total conveyance	11713	11713	12236
Q2, bridge MC discharge,cfs	1112	1218	1060
Main channel area, ft2	126	126	126
Main channel width (skewed), ft	17.1	17.1	17.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	17.1	17.1	17.1
y_bridge (avg. depth at br.), ft	7.38	7.38	7.36
Dm, median (1.25*D50), ft	0.13375	0.13375	0.13375
y2, depth in contraction,ft	7.88	8.52	7.56
ys, scour depth (y2-ybridge), ft	0.50	1.14	0.20

Comparison of Chang and Laursen results (for unsubmerged orifice flow)			
y2, from Laursen's equation, ft	7.876287	8.515597	7.559514
Full valley WSEL, ft	497.1	497.85	496.93
Full valley depth, ft	5.680117	6.430117	5.486725
Ys, depth of scour (y2-yfullv), ft	2.19617	2.08548	2.072789

ARMORING			
D90	0.2358	0.2358	0.2358
D95	0.3795	0.3795	0.3795
Critical grain size,Dc, ft	0.2216	0.2659	0.2029
Decimal-percent coarser than Dc	0.107	0.0857	0.129
Depth to armoring,ft	5.55	8.51	4.11

Pressure Flow Scour (contraction scour for orifice flow conditions)

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

	Q100	Q500	OtherQ
Q, total, cfs	1140	1700	1060
Q, thru bridge, cfs	1112	1218	1060
Total Conveyance, bridge	11713	11713	12236
Main channel(MC) conveyance, bridge	11713	11713	12236
Q, thru bridge MC, cfs	1112	1218	1060
Vc, critical velocity, ft/s	7.38	7.51	7.33
Vc, critical velocity, m/s	2.25	2.29	2.23
Main channel width (skewed), ft	17.1	17.1	17.1
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	17.1	17.1	17.1
qbr, unit discharge, ft^2/s	65.0	71.2	62.0
qbr, unit discharge, m^2/s	6.0	6.6	5.8
Area of full opening, ft^2	126.2	126.2	125.8
Hb, depth of full opening, ft	7.38	7.38	7.36
Hb, depth of full opening, m	2.25	2.25	2.24
Fr, Froude number, bridge MC	0.62	0.67	0.59
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	498.8	498.8	498.8
Elevation of Bed, ft	491.42	491.42	491.44
Elevation of Approach, ft	500.9	501.63	500.6
Friction loss, approach, ft	0.02	0.04	0.02
Elevation of WS immediately US, ft	500.88	501.59	500.58
ya, depth immediately US, ft	9.46	10.17	9.14
ya, depth immediately US, m	2.88	3.10	2.78
Mean elevation of deck, ft	501.64	501.64	501.64
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.94	0.92	0.95
Ys, depth of scour, ft	2.01	2.95	1.57

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	1140	1700	1060	1140	1700	1060
a', abut.length blocking flow, ft	64.5	99.5	49.8	311.8	314.6	310.6
Ae, area of blocked flow ft2	99.31	135.69	84.5	1220	1343.7	1142.4
Qe, discharge blocked abut.,cfs	--	--	52.9	--	--	860.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	0.57	0.58	0.63	0.76	0.96	0.75
ya, depth of f/p flow, ft	1.54	1.36	1.70	3.91	4.27	3.68
--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	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.081	0.081	0.085	0.067	0.078	0.069
ys, scour depth, ft	4.46	4.65	4.54	13.46	15.33	13.07

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)	64.5	99.5	49.8	311.8	314.6	310.6
y1 (depth f/p flow, ft)	1.54	1.36	1.70	3.91	4.27	3.68
a'/y1	41.89	72.96	29.35	79.69	73.66	84.45
Skew correction (p. 49, fig. 16)	0.90	0.90	0.90	1.07	1.07	1.07
Froude no. f/p flow	0.08	0.08	0.08	0.07	0.08	0.07
Ys w/ corr. factor K1/0.55:						
vertical	4.40	3.89	4.92	12.48	14.32	11.86
vertical w/ ww's	3.60	3.19	4.03	10.23	11.74	9.72
spill-through	2.42	2.14	2.70	6.86	7.88	6.52

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.62	0.67	0.59	0.62	0.67	0.59
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	7.38	7.38	7.36	7.38	7.38	7.36
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.75	2.05	1.58	1.75	2.05	1.58
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR