LEVEL II SCOUR ANALYSIS FOR BRIDGE 50 (FFIETH00490050) on TOWN HIGHWAY 49, crossing BLACK CREEK, FAIRFIELD, VERMONT

Open-File Report 98-418

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

LEVEL II SCOUR ANALYSIS FOR BRIDGE 50 (FFIETH00490050) on TOWN HIGHWAY 49, crossing BLACK CREEK, FAIRFIELD, VERMONT

By SCOTT A. OLSON and LAURA MEDALIE

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Pembroke, New Hampshire

1998

U.S. DEPARTMENT OF THE INTERIOR
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Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 50 (FFIETH00490050) ON TOWN HIGHWAY 49, CROSSING BLACK CREEK, FAIRFIELD, VERMONT

By **Scott A. Olson and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure FFIETH00490050 on Town Highway 49 crossing Black Creek, 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in northwestern Vermont. The 35.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is lawn except the downstream left overbank, which is brush and some trees.

In the study area, Black Creek has an incised, sinuous channel with an average channel top width of 66 ft and an average bank height of 6 ft. Approximately 235 ft downstream of the bridge is an old mill dam, which backs water up through the bridge. The channel bed material ranges from silt to boulders with bedrock outcrops. The median grain size (D_{50}) is 0.079 mm (0.00026 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 12, 1995, indicated that the reach was stable.

The Town Highway 49 crossing of Black Creek is a 70-ft-long, one-lane covered bridge consisting of one 59-foot wooden span (Vermont Agency of Transportation, written communication, March 09, 1995). The opening length of the structure parallel to the bridge face is 58.6 ft. The bridge is supported by vertical, stone abutments. The right abutment is partially faced with concrete. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is 0 degrees. The bridge has been closed to traffic since January 1987.

Approximately 1 ft of scour deeper than the mean thalweg depth was observed along the upstream end of the right abutment during the Level I assessment. Scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) sparsely distributed along the downstream left wingwall, type-2 stone fill (less than 36 inches diameter) located at the upstream end of the upstream left wingwall and sporadically along the right abutment, and a wooden retaining wall located along the downstream right bank. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.4 to 3.1 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.9 to 11.1 ft at the left abutment and 12.6 to 16.6 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”. Bedrock was observed at the right abutment and may limit the amount of scour that will occur at this site. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and Davis, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Bakersfield, 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 FFIETH00490050 ***Stream*** Black Creek

County Franklin ***Road*** TH 49 ***District*** 8

Description of Bridge

Bridge length 70 ***ft*** ***Bridge width*** 13.1 ***ft*** ***Max span length*** 59 ***ft***

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

Abutment type Vertical, stone ***Embankment type*** Sloping. Wall on RBUS

Stone fill on abutment? Yes ***Date of inspection*** 7/12/95

Description of stone fill Type-2, sporadically along the right abutment.

Abutments are stone. The upstream half of the right abutment has been faced with concrete. Much of the exposed stone have deep gaps between stones. On the left abutment most of the gaps have been filled with concrete.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 10

There is a moderate channel bend in the downstream reach.

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	7/12/95	0	0
Level II	7/12/95	0	0

Potential for debris Low.

Describe any features near or at the bridge that may affect flow (include observation date)

There is a dam 235 ft downstream of the bridge, which backs water up through the structure.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley. There are bedrock falls both upstream and downstream of the bridge.

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

Date of inspection 7/12/95

DS left: Moderately sloping bank and irregular overbank.

DS right: Channel boundary is bedrock with a mildly sloping overbank.

US left: Mildly sloping bank and overbank.

US right: Mildly sloping bank and overbank.

Description of the Channel

Average top width 66 ***ft*** ***Average depth*** 6 ***ft***

Predominant bed material Silt with boulders ***Bank material*** Sand with boulders

Sinuous but stable with semi-alluvial to non-alluvial channel boundaries and a narrow flood plain.

7/12/95

Vegetative co Brush with trees.

DS left: Lawn.

DS right: Lawn with a narrow strip of brush on the immediate bank.

US left: Lawn.

US right: Yes

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

None. July 12, 1995.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 35.1 ***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 3,310 ***ft³/s*** ***Q500*** 4,750 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(35.1/46.7)exp 0.67] with flood frequency estimates available from the VAOT database (written communication, May 1995) for bridge number 9 in Fairfield. Bridge number 9 crosses Black Creek downstream of this site and has a drainage area of 46.7 square miles. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve was extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the upstream end of the right abutment (elev. 499.91 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment (elev. 498.17 ft, arbitrary survey datum). RM4 is a chiseled X on a bedrock outcrop, 3 ft from the right side of the dam (elev. 495.74 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
DAM	-235	1	Section across dam
EXITX	-89	1	Exit Section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	9	1	Road Grade section
APPRO	77	2	Modelled Approach section (Templated from APTEM)
APTEM	109	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 0.025 to 0.038, and overbank "n" values ranged from 0.035 to 0.075.

Critical depth at the dam section (DAM) was assumed as the starting water surface. Critical depth was allowed because it was determined that normal depth immediately downstream of the dam did not submerge the dam. Normal depth was computed in a section surveyed downstream of the dam by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.00056 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1986).

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

Bridge Hydraulics Summary

Average bridge embankment elevation 500.2 ***ft***
Average low steel elevation 498.1 ***ft***

100-year discharge 3,310 ***ft^3/s***
Water-surface elevation in bridge opening 497.3 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 698 ***ft^2***
Average velocity in bridge opening 4.7 ***ft/s***
Maximum WSPRO tube velocity at bridge 5.9 ***ft/s***

Water-surface elevation at Approach section with bridge 497.6
Water-surface elevation at Approach section without bridge 497.6
Amount of backwater caused by bridge 0.0 ***ft***

500-year discharge 4,750 ***ft^3/s***
Water-surface elevation in bridge opening 498.6 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft^3/s***
Area of flow in bridge opening 732 ***ft^2***
Average velocity in bridge opening 6.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.7 ***/s***

Water-surface elevation at Approach section with bridge 499.4
Water-surface elevation at Approach section without bridge 499.0
Amount of backwater caused by bridge 0.4 ***ft***

Incipient overtopping discharge -- ***ft^3/s***
Water-surface elevation in bridge opening -- ***ft***
Area of flow in bridge opening -- ***ft^2***
Average velocity in bridge opening -- ***ft/s***
Maximum WSPRO tube velocity at bridge -- ***ft/s***

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the Laursen live-bed contraction scour equation (Richardson and Davis, 1995, p. 30, equation 17). At this site, the 500-year discharge resulted in submerged orifice flow. Typically, 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). The result of Chang's contraction scour equation (Richardson and others, 1995, p. 145-146) for this event was also computed and can be found in appendix F. Because the Chang equation for pressure flow scour was derived solely with data for clear-water scour, it is not currently understood how well it would predict in live-bed conditions. Therefore, although pressure flow conditions exist for the 500-year discharge, the reported scour depths were computed using Laursen's live-bed contraction scour equation.

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

Scour Results

Contraction scour:	*100-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
	(Scour depths in feet)		
Main channel			
Live-bed scour	0.4	3.1	--
Clear-water scour	--	--	--
Depth to armoring	N/A	N/A	--
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.9	11.1	--
Right abutment	12.6–	16.6–	---
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	0.5	0.8	--
Right abutment	0.5	0.8	--
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

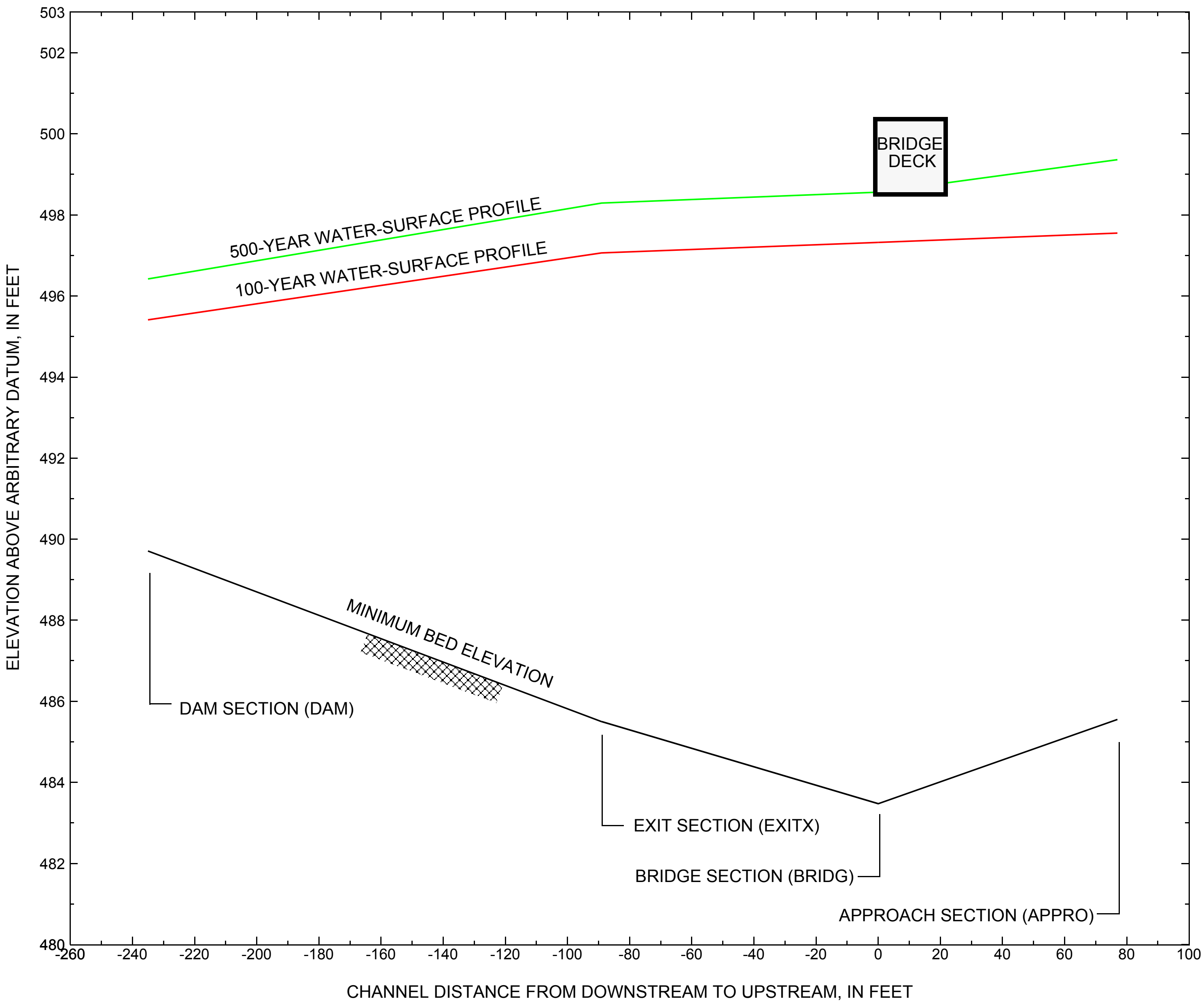


Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure FFIETH00490050 on Town Highway 49, crossing Black Creek, Fairfield, Vermont.

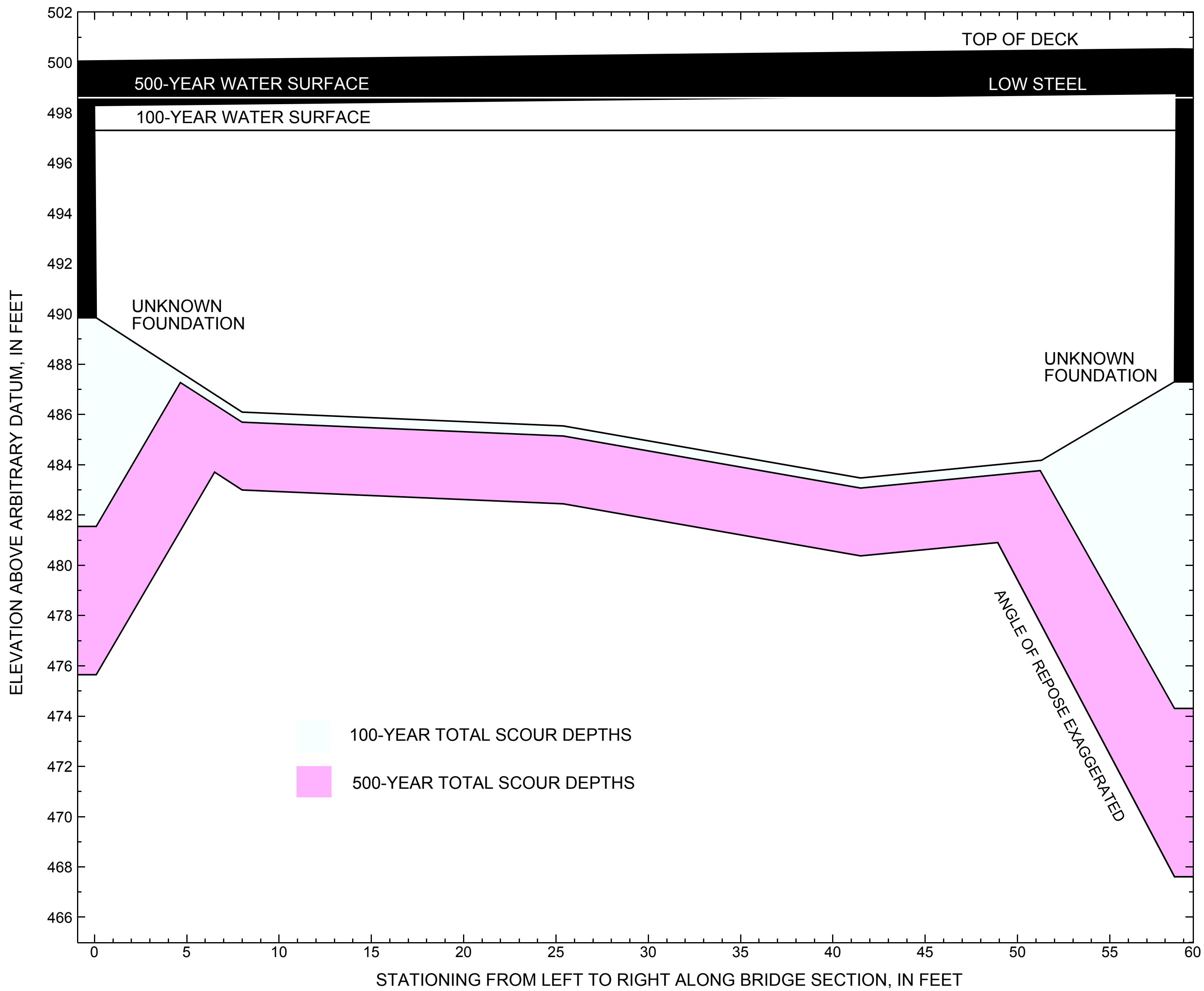


Figure 8. Scour elevations for the 100- and 500-year discharges at structure FFIETH00490050 on Town Highway 49, crossing Black Creek, Fairfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure FFIETH00490050 on Town Highway 49, crossing Black Creek, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-year discharge is 3,310 cubic-feet per second											
Left abutment	0.0	--	498.3	--	489.8	0.4	7.9	--	8.3	481.5	--
Right abutment	58.6	--	498.8	--	487.3	0.4	12.6	--	13.0	474.3	--

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 FFIETH00490050 on Town Highway 49, crossing Black Creek, 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/pile elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 4,750 cubic-feet per second											
Left abutment	0.0	--	498.3	--	489.8	3.1	11.1	--	14.2	475.6	--
Right abutment	58.6	--	498.8	--	487.3	3.1	16.6	--	19.7	467.6	--

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

SELECTED REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 213 p.

Benson, M. A., 1962, Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Brown, S.A. and Clyde, E.S., 1989, Design of riprap revetment: Federal Highway Administration Hydraulic Engineering Circular No. 11, Publication FHWA-IP-89-016, 156 p.

Federal Highway Administration, 1983, Runoff estimates for small watersheds and development of sound design: Federal Highway Administration Report FHWA-RD-77-158.

Federal Highway Administration, 1993, Stream Stability and Scour at Highway Bridges: Participant Workbook: Federal Highway Administration Report FHWA-HI-91-011.

Froehlich, D.C., 1989, Local scour at bridge abutments *in* Ports, M.A., ed., Hydraulic Engineering--Proceedings of the 1989 National Conference on Hydraulic Engineering: New York, American Society of Civil Engineers, p. 13-18.

Hayes, D.C.,1993, Site selection and collection of bridge-scour data in Delaware, Maryland, and Virginia: U.S. Geological Survey Water-Resources Investigation Report 93-4017, 23 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 p.

Johnson, C.G. and Tasker, G.D.,1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Chang, F., 1995, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Laursen, E.M., 1960, Scour at bridge crossings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 86, no. HY2, p. 39-53.

Potter, W. D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine woods area, Bureau of Public Roads

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

Richardson, E.V. and Davis, S.R., 1995, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Richardson, E.V., Simons, D.B., and Julien, P.Y., 1990, Highways in the river environment: Federal Highway Administration Publication FHWA-HI-90-016.

Ritter, D.F., 1984, Process Geomorphology: W.C. Brown Co., Debuque, Iowa, 603 p.

Shearman, J.O., 1990, User's manual for WSPRO--a computer model for water surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 187 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model; research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

Talbot, A.N., 1887, The determination of water-way for bridges and culverts.

U.S. Geological Survey, 1986, Bakersfield, 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 ffie050.wsp
T2        Hydraulic analysis for structure FFIETH00490050   Date: 29-SEP-97
T3        HYDRAULIC ANALYSIS OF BRIDGE 50 IN FAIRFIELD OVER BLACK CREEK
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3310.0   4750.0
SK          -1       -1
*
*           SK is coded as -1 to force critical depth over dam. Analysis
*           of normal depth downstream of the dam indicated that the
*           dam would NOT be submerged. The dam is modelled as a cross
*           section with critical depth.
*
XS   DAM     -235
GR         -145.0, 511.83   -100.2, 495.30    -81.8, 492.50    -81.1, 489.71
GR          -80.0, 490.77    -72.4, 492.02    -59.1, 497.15    -38.9, 496.24
GR          -27.9, 497.09     -6.4, 496.83     -5.5, 498.95     -0.2, 499.10
GR            0.0, 497.20      0.8, 491.67     14.4, 491.37     24.1, 491.61
GR           74.1, 492.02     74.4, 495.16     89.5, 496.50     99.2, 497.73
GR          111.7, 504.55
N            0.075      0.045    0.065        0.025          0.040
SA                -81.8    -59.1         -0.2            74.4
*
XS   EXITX    -89
GR         -145.0, 511.83   -133.7, 496.58   -101.3, 496.62    -98.9, 492.00
GR          -90.8, 491.85    -82.9, 491.91    -81.3, 492.27    -78.6, 493.04
GR          -66.3, 494.56    -54.4, 494.92    -46.3, 496.21    -36.9, 497.24
GR          -25.7, 498.27    -20.8, 499.89    -10.3, 500.07     -3.5, 496.00
GR            0.0, 491.52      4.0, 488.87     10.8, 487.20     18.7, 485.50
GR           29.7, 486.59     38.0, 488.77     38.2, 491.51     38.8, 493.13
GR           42.8, 495.30     50.3, 496.60     65.6, 499.34
N             0.050       0.040       0.050        0.037       0.035
SA                 -101.3       -78.6      -10.3      42.8
*
XS   FULLV      0  * * *   0.0000
*
BR   BRIDG     0 498.53
GR            0.0, 498.29      0.0, 489.84      8.0, 486.09     25.4, 485.54
GR           41.5, 483.47     51.3, 484.17     58.6, 487.30     58.6, 498.77
GR           28.8, 497.26      0.0, 498.29
N             0.035
CD           1 21 * * 15 7
*
XR   RDWAY     9 13
GR         -145.0, 511.83   -106.4, 500.71    -75.9, 499.81    -10.7, 499.78
GR            0.0, 500.06      0.0, 510.00     58.9, 510.00     58.9, 500.40
GR           80.6, 500.08    124.7, 499.36    157.4, 499.52    190.1, 500.67
GR          198.5, 506.21
*
XT   APTEM    109
GR         -106.9, 507.85    -65.1, 499.87    -44.8, 498.16    -18.4, 495.67
GR           -4.5, 493.40      0.0, 491.56     12.2, 486.66     24.8, 485.62
GR           35.0, 485.55     47.6, 485.61     67.9, 491.50     74.1, 494.20
GR           79.8, 495.06    155.6, 499.14
*
AS   APPRO    77
GT             0
N           0.035        0.038        0.040
SA                  -4.5         74.1
*
HP 1 BRIDG   497.32 1 497.32
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
      U.S. Geological Survey WSPRO Input File ffie050.wsp
      Hydraulic analysis for structure FFIETH00490050   Date: 29-SEP-97
      HYDRAULIC ANALYSIS OF BRIDGE 50 IN FAIRFIELD OVER BLACK CREEK

  CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      0.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1     698.  125342.    56.    81.                       14020.
 497.32          698.  125342.    56.    81.  1.00     0.    59.  14020.

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =      0.
      WSEL     LEW     REW    AREA        K        Q    VEL
    497.32     0.0    58.6   698.1  125342.    3310.   4.74
X STA.        0.0        6.6        10.1        13.2        16.0        18.7
  A(I)           59.4       39.2        34.6        32.7        31.0
  V(I)           2.79       4.22        4.79        5.07        5.34

X STA.       18.7       21.4        24.0        26.5        30.1        32.4
  A(I)           31.1       30.2        30.3        43.4        28.7
  V(I)           5.33       5.48        5.46        3.82        5.76

X STA.       32.4       34.7        36.9        39.0        41.0        43.1
  A(I)           29.1       28.8        28.2        28.1        28.9
  V(I)           5.69       5.74        5.87        5.90        5.73

X STA.       43.1       45.3        47.6        50.1        53.1        58.6
  A(I)           30.4       30.5        33.2        38.7        61.9
  V(I)           5.45       5.43        4.99        4.28        2.67

  CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =     77.
   WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
           1      61.    3789.    34.    34.                         461.
           2     754.  130494.    79.    81.                       13256.
           3      74.    3502.    52.    52.                         504.
 497.55          889.  137785.   164.   168.  1.19   -38.   126.  10766.

  VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =     77.
      WSEL     LEW     REW    AREA        K        Q    VEL
    497.55   -38.3   126.1   889.0  137785.    3310.   3.72
X STA.      -38.3        0.8         7.4        11.7        15.2        18.4
  A(I)           88.5       50.4        41.7        38.9        36.6
  V(I)           1.87       3.29        3.97        4.25        4.52

X STA.       18.4       21.6        24.6        27.5        30.4        33.3
  A(I)           36.1       35.5        34.8        34.5        34.5
  V(I)           4.59       4.66        4.75        4.80        4.79

X STA.       33.3       36.2        39.0        42.0        45.0        48.0
  A(I)           34.6       34.6        35.0        36.1        35.6
  V(I)           4.78       4.78        4.73        4.58        4.64

X STA.       48.0       51.4        55.3        60.2        67.3       126.1
  A(I)           38.5       40.7        43.5        52.1       106.8
  V(I)           4.30       4.06        3.81        3.17        1.55
```

```
         U.S. Geological Survey WSPRO Input File ffie050.wsp
         Hydraulic analysis for structure FFIETH00490050   Date: 29-SEP-97
         HYDRAULIC ANALYSIS OF BRIDGE 50 IN FAIRFIELD OVER BLACK CREEK

     CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     732.   96348.     4.   134.                       55159.
    498.56          732.   96348.     4.   134.  1.00     0.    59.  55159.

     VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =       0.
          WSEL     LEW     REW    AREA        K        Q    VEL
        498.56     0.0    58.6   731.6   96348.    4750.   6.49
 X STA.        0.0        6.0        9.5       12.7       15.8       18.9
   A(I)           58.2       41.0       38.7       36.2       36.5
   V(I)           4.08       5.79       6.14       6.56       6.51

 X STA.       18.9       21.8       24.8       27.8       30.6       33.2
   A(I)           35.4       35.4       35.3       34.5       33.7
   V(I)           6.72       6.71       6.72       6.88       7.06

 X STA.       33.2       35.8       38.1       40.4       42.6       44.7
   A(I)           33.0       32.1       32.1       31.5       31.0
   V(I)           7.19       7.41       7.39       7.54       7.66

 X STA.       44.7       47.0       49.3       51.6       54.3       58.6
   A(I)           32.4       32.2       33.7       37.0       51.8
   V(I)           7.34       7.38       7.04       6.43       4.58

     CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =      77.
      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     140.   11146.    55.    55.                        1275.
              2     896.  174051.    79.    81.                       17178.
              3     198.   13316.    82.    82.                        1755.
    499.36         1235.  198513.   215.   218.  1.30   -59.   156.  14716.

     VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =      77.
          WSEL     LEW     REW    AREA        K        Q    VEL
        499.36   -59.0   155.6  1234.8  198513.    4750.   3.85
 X STA.      -59.0       -6.4        3.7        9.2       13.3       17.0
   A(I)          129.0       73.3       57.6       50.9       47.7
   V(I)           1.84       3.24       4.12       4.67       4.97

 X STA.       17.0       20.6       24.0       27.3       30.6       33.9
   A(I)           47.0       46.4       45.5       45.1       45.1
   V(I)           5.05       5.12       5.22       5.27       5.26

 X STA.       33.9       37.1       40.4       43.7       47.1       50.7
   A(I)           45.2       45.2       45.6       46.2       48.3
   V(I)           5.26       5.26       5.20       5.14       4.91

 X STA.       50.7       54.9       60.0       66.6       82.4      155.6
   A(I)           51.3       55.6       61.2       88.3      160.4
   V(I)           4.63       4.27       3.88       2.69       1.48
```

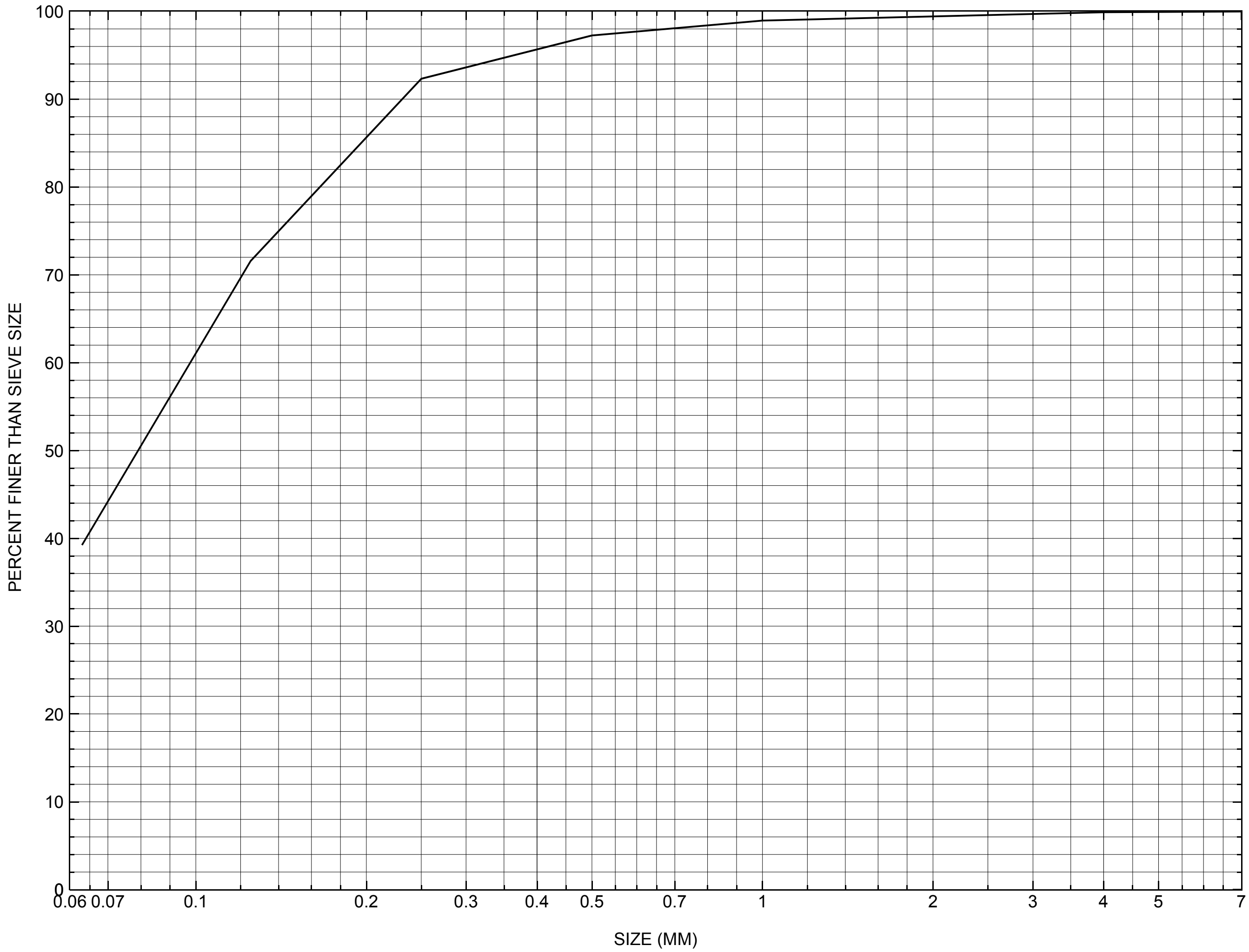
```
        U.S. Geological Survey WSPRO Input File ffie050.wsp
        Hydraulic analysis for structure FFIETH00490050   Date: 29-SEP-97
        HYDRAULIC ANALYSIS OF BRIDGE 50 IN FAIRFIELD OVER BLACK CREEK

 ===010 WSI BELOW YMIN AT SECID "DAM  ":  USED WSI = CRWS.
                        YMIN,WSI,CRWS =     489.7   ********     495.41

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

DAM  :XS   ******  -100.     355.  1.71 *****  497.12  495.41   3310.  495.41
     -235. ******    77.   40668.  1.26 ***** *******    1.05    9.34

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXITX"     KRATIO =  1.84

EXITX:XS     146.  -134.     617.  0.58  0.52  497.64 *******   3310.  497.06
      -89.   146.    53.   75017.  1.30  0.00    0.00    0.54    5.36

FULLV:FV      89.  -134.     652.  0.53  0.16  497.82 *******   3310.  497.29
        0.    89.    54.   79270.  1.32  0.00    0.01    0.51    5.07
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.77

APPRO:AS      77.    -39.     905.  0.25  0.08  497.89 *******   3310.  497.64
       77.    77.   128.  140510.  1.19  0.00    0.00    0.30    3.66
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

            <<<<<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      89.      0.     698.  0.44  0.11  497.75  490.04   3310.  497.32
        0.    89.    59.  125448.  1.24  0.00    0.00    0.26    4.74

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.897 ******  498.53 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD      EGL      ERR       Q    WSEL
   RDWAY:RG       9.         <<<<<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      56.    -38.     889.  0.26  0.04  497.81  491.38   3310.  497.55
       77.    58.   126.  137764.  1.19  0.01    0.00    0.31    3.72

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.649  0.127  120423.     1.    60.   497.51

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW     REW       Q         K      AREA     VEL    WSEL
   DAM  :XS    -235.  -100.     77.    3310.    40668.     355.    9.34  495.41
   EXITX:XS     -89.  -134.     53.    3310.    75017.     617.    5.36  497.06
   FULLV:FV       0.  -134.     54.    3310.    79270.     652.    5.07  497.29
   BRIDG:BR       0.     0.     59.    3310.   125448.     698.    4.74  497.32
   RDWAY:RG       9.**************       0.******************    1.00********
   APPRO:AS      77.    -38.    126.    3310.   137764.     889.    3.72  497.55

 SECOND USER DEFINED TABLE.
    XSID:CODE     CRWS     FR#    YMIN     YMAX     HF     HO   VHD      EGL     WSEL
   DAM  :XS     495.41    1.05  489.71   511.83************  1.71   497.12   495.41
   EXITX:XS   ********    0.54  485.50   511.83   0.52   0.00  0.58   497.64   497.06
   FULLV:FV   ********    0.51  485.50   511.83   0.16   0.00  0.53   497.82   497.29
   BRIDG:BR     490.04    0.26  483.47   498.77   0.11   0.00  0.44   497.75   497.32
   RDWAY:RG   ****************  499.36   511.83**********************************
   APPRO:AS     491.38    0.31  485.55   507.85   0.04   0.01  0.26   497.81   497.55
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File ffie050.wsp
        Hydraulic analysis for structure FFIETH00490050   Date: 29-SEP-97
        HYDRAULIC ANALYSIS OF BRIDGE 50 IN FAIRFIELD OVER BLACK CREEK

 ===010 WSI BELOW YMIN AT SECID "DAM  ":  USED WSI = CRWS.
                        YMIN,WSI,CRWS =    489.7   ********     496.42

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

DAM  :XS   ******  -103.     478.  2.07 *****  498.49  496.42   4750.  496.42
     -235. ******    89.   61434.  1.35 ***** *******    1.09    9.93

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "EXITX"     KRATIO =  1.64

EXITX:XS     146.  -135.     819.  0.72  0.53  499.01 *******   4750.  498.29
      -89.   146.    60.  100580.  1.38  0.00   -0.01    0.56    5.80

FULLV:FV      89.  -135.     868.  0.64  0.19  499.21 *******   4750.  498.56
        0.    89.    61.  107334.  1.38  0.00    0.01    0.52    5.47
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "APPRO"     KRATIO =  1.70

APPRO:AS      77.   -54.    1148.  0.34  0.09  499.29 *******   4750.  498.95
       77.    77.   152.  182915.  1.29  0.00    0.00    0.35    4.14
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.56     498.53

            <<<<<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      89.     0.     732.  0.66 *****  499.22  491.32   4765.  498.56
        0. ******    59.   96324.  1.00 ***** *******    0.33    6.51

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800 ******  498.53 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       9.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

===140 AT SECID "APPRO":  END OF CROSS SECTION EXTENDED VERTICALLY.
                             WSEL,YLT,YRT =   499.36      507.9      499.1

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

APPRO:AS      56.   -59.    1235.  0.30  0.07  499.66  492.65   4750.  499.36
       77.    58.   156.  198545.  1.30  0.01    0.00    0.32    3.85

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******    499.32

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

  FIRST USER DEFINED TABLE.
    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   DAM  :XS    -235.  -103.    89.   4750.   61434.     478.    9.93  496.42
   EXITX:XS     -89.  -135.    60.   4750.  100580.     819.    5.80  498.29
   FULLV:FV       0.  -135.    61.   4750.  107334.     868.    5.47  498.56
   BRIDG:BR       0.     0.    59.   4765.   96324.     732.    6.51  498.56
   RDWAY:RG       9.**************      0.       0.       0.    1.00********
   APPRO:AS      77.    -59.   156.   4750.  198545.    1235.    3.85  499.36

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   DAM  :XS    496.42    1.09  489.71  511.83************  2.07  498.49  496.42
   EXITX:XS  ********    0.56  485.50  511.83  0.53  0.00  0.72  499.01  498.29
   FULLV:FV  ********    0.52  485.50  511.83  0.19  0.00  0.64  499.21  498.56
   BRIDG:BR    491.32    0.33  483.47  498.77************  0.66  499.22  498.56
   RDWAY:RG  ****************  499.36  511.83************  0.30  499.62********
   APPRO:AS    492.65    0.32  485.55  507.85  0.07  0.01  0.30  499.66  499.36
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a bed sample taken from the channel approach of structure FFIETH00490050, in Fairfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number FFIETH00490050

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 09 / 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)* BLACK CREEK

Road Name *(I - 7):* -

Route Number TH049

Vicinity *(I - 9)* 0.05 MI TO JCT VT 36

Topographic Map Bakersfield

Hydrologic Unit Code: 02010007

Latitude *(I - 16; nnnn.n)* 44472

Longitude *(i - 17; nnnnn.n)* 72518

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10060500500605

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

Maximum span length *(I - 48; nnnn)* 0059

Year built *(I - 27; YYYY)* 1865

Structure length *(I - 49; nnnnnn)* 000070

Average daily traffic, ADT *(I - 29; nnnnnn)* 000000

Deck Width *(I - 52; nn.n)* 131

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

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

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

Waterway adequacy *(I - 71; n)* 0

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

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

Structure type *(I - 43; nnn)* 710

Year Reconstructed *(I - 106)* 1967

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

Clear span (*nnn.n ft*) -

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

Vertical clearance from streambed (*nnn.n ft*) 5.7

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

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

Comments:

The structural inspection report of 8/29/94 indicates the structure is a wooden, modified, queen post, thru-truss covered bridge. The structure is old and deteriorated and currently closed to vehicular traffic with earth embankment barricades piled at each end. Being closed, a full assessment of the substructure was not performed and evidently has not been performed since at least 1988. It was recommended to be closed via office memo. of 1/12/1987.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (*ft²*): -

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

Comments:

-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 35.15 mi^2 Lake/pond/swamp area 0.18 mi^2

Watershed storage *(ST)* 0.5 %

Bridge site elevation 374 ft Headwater elevation 1440 ft

Main channel length 15.3 mi

10% channel length elevation 394 ft 85% channel length elevation 720 ft

Main channel slope *(S)* 28.4 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 chord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low chord to bed	-	-	-	-	-	-	-	-	-	-	-

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

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

Comments: **NO CROSS SECTION INFORMATION**

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **3/7/96**

Computerized by: **RB** Date: **3/7/96**

Reviewd by: **SAO** Date: **6/1/98**

Structure Number **FFIETH00490050**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L. MEDALIE** Date *(MM/DD/YY)* **7** / **12** / 19**95**

2. Highway District Number **08** Mile marker **000**

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

Waterway *(I - 6)* **BLACK CREEK** Road Name **-**

Route Number **TH049** Hydrologic Unit Code: **02010007**

3. Descriptive comments:

Located 0.05 miles south along Town Highway 49 from its junction with Vermont State Highway 36.

B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **4** LBDS **5** 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 **1** UB **1** DS **1** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **70** *(feet)* Span length **59** *(feet)* Bridge width **13.1** *(feet)*

Road approach to bridge:

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

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

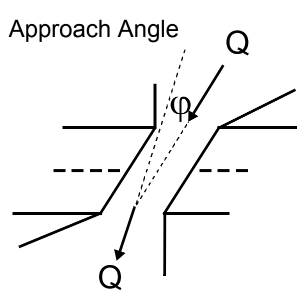
10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

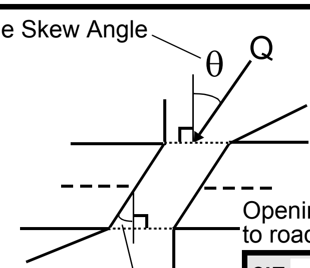
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	2	1	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **15** 16. Bridge skew: **10**





Opening skew to roadway
α= **0.0**

17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **40** feet **DS** *(US, UB, DS)* to **140** feet **DS**

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

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

18. Bridge Type: **1a**

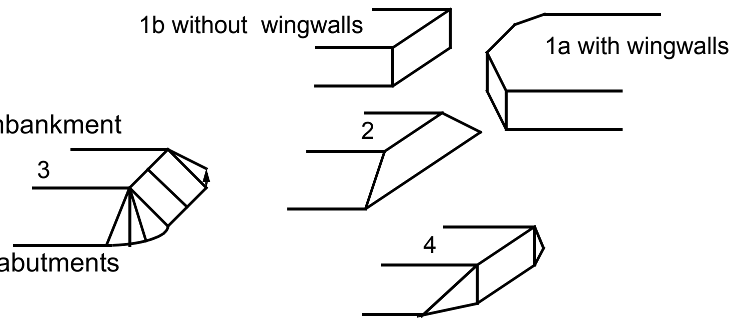
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

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

3- Spill through abutments

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



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

4. Some trees on the downstream left overbank. There are row crops 200 feet downstream on the left overbank. On the left bank upstream, there is a 20 foot strip of brush adjacent to the channel. The upstream right bank is lawn with a house within 1 bridge length then brush and trees.
7. Values are from the VAOT files. Measured span length is 63 feet, bridge length is 72 feet, and the bridge width is 16 feet.
8. The left bank road approach is level with the bridge for 25 ft then increases in elevation.
11. The upstream right road approach protection consists of a 25 ft long stone wall. The downstream right road approach is protected by the wingwall.
18. This is a type 1a bridge except on the upstream right which is type 1b.

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
93.5	2.0			2.5	1	1	2	2	0	0

23. Bank width **20.0** 24. Channel width **25.0** 25. Thalweg depth **78.5** 29. Bed Material **1**

30 .Bank protection type: LB **0** RB **1** 31. Bank protection condition: LB **-** 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 has some type 2 protection, but is mostly type 1.
500 ft US is a large bedrock control and waterfall into calm water.
250 ft US is a bedrock outcrop on the right bank behind which is a cutbank due to an eddy vortex.

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

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

37. Material: -

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? 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
68.0		6.0		2	7	7	-

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

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

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

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

1

63. Some stones are in the channel.

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

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		**15**	**90**	**2**	**2**	**0**	**0.25**	**90.0**
RABUT	**2**	**-**	**90**			**2**	**3**	**58.5**

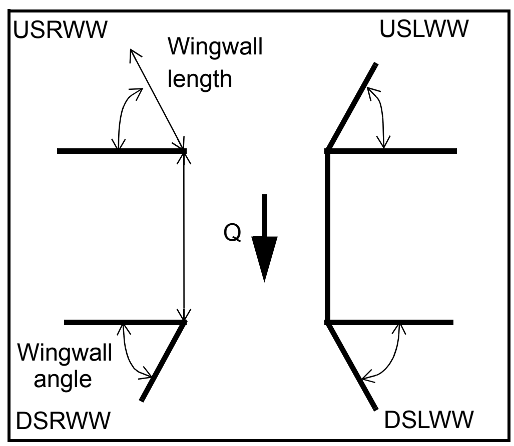
Pushed: LB or RB *Toe Location (Loc.): **0**- even, **1**- set back, **2**- protrudes*
*Scour cond.: **0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**-undermined footing; **4**- piling exposed; **5**- settled; **6**- failed*
Materials: **1**- Concrete; **2**- Stone masonry or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

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

1
1
1,2
74. The upstream end of the right abutment is undermined 1 ft.
77. The upstream end of the right abutment is stone faced with concrete. The downstream end of the right abutment is composed of piled stones. The gaps between stones are as much as 2 feet deep.
76. A footing (or more stone) on the left abutment was detected when poking with the range pole, but the footing is not exposed along the length of the abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**58.5**	
USRWW:	**Y**		**2**		**0**	**6.0**	
DSLWW:	**-**		**-**		**N**	**18.0**	
DSRWW:	**-**		**-**		**-**	**17.0**	



*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	**-**	**2**	**Y**	**1**	**1**	**-**	**-**	**1**
Condition	**Y**	**-**	**1**	**-**	**2**	**-**	**-**	**4**
Extent	**1**	**0.5**	**1**	**2**	**-**	**0**	**2**	**-**

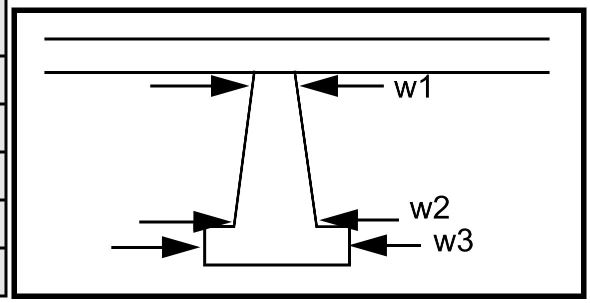
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
1
1
4
0
-
-

Piers:

84. Are there piers? **80.** *(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			-	30.0	15.5	-
Pier 2				90.0	37.5	30.0
Pier 3		-	-	27.5	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	The	on a	is	There	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	dow	bed-	erod	are	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	nstre	rock	ed/	crac	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	am	expo	spall	ks in	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	right	sure.	ed	the	*Y- yes; N- no*
91. Attack ∠ (BF)	wing	The	up to	con-	
92. Pushed	wall	bot-	1	crete	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	is	tom	foot	up to	
95. Cross-members	con-	of	abov	6 in	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	crete	the	e the	wide.	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	and	con-	bed-	On	
98. Exposure depth	sits	crete	rock.	the	

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

downstream left wingwall, there are also some cracks and the top of the footing is exposed. There are 1 ft lateral gaps between stones of the wingwall.

82. The protection for the downstream left wingwall and the right abutment is a few sporadic stones that cover the footing of the wingwall and extend the entire length of the abutment.

N

E. Downstream Channel Assessment

100.

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

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

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

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

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

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

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

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

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

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

Material: -

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

-
-
-
-

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

Cut bank extent: RS feet ____ (US, UB, DS) to _____ feet ____ (US, UB, DS)

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 2

Scour dimensions: Length 1 Width 542 Depth: 6 Positioned 1 %LB to 0 %RB

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

541
1
5
1

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

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

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

Confluence comments (eg. confluence name):

a wingwall for 40 ft, then a spillway opening for 20 ft, and then protection for 100 ft. The right bank is composed of a wingwall for 30 ft, then bedrock for 50 ft, followed by a wooden

F. Geomorphic Channel Assessment

107. Stage of reach evolution ret

- **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)*:

aining wall for 50 ft.

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: FFIETH00490050 Town: FAIRFIELD
Road Number: TH49 County: FRANKLIN
Stream: BLACK CREEK

Initials SAO Date: 10/29/97 Checked: RF

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	3310	4750	0
Main Channel Area, ft2	754	896	0
Left overbank area, ft2	61	140	0
Right overbank area, ft2	74	198	0
Top width main channel, ft	79	79	0
Top width L overbank, ft	34	55	0
Top width R overbank, ft	52	82	0
D50 of channel, ft	0.00026	0.00026	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.5	11.3	ERR
y1, average depth, LOB, ft	1.8	2.5	ERR
y1, average depth, ROB, ft	1.4	2.4	ERR
Total conveyance, approach	137785	198513	0
Conveyance, main channel	130494	174051	0
Conveyance, LOB	3789	11146	0
Conveyance, ROB	3502	13316	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	3134.8	4164.7	ERR
Ql, discharge, LOB, cfs	91.0	266.7	ERR
Qr, discharge, ROB, cfs	84.1	318.6	ERR
Vm, mean velocity MC, ft/s	4.2	4.6	ERR
Vl, mean velocity, LOB, ft/s	1.5	1.9	ERR
Vr, mean velocity, ROB, ft/s	1.1	1.6	ERR
Vc-m, crit. velocity, MC, ft/s	1.0	1.1	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Live-Bed Contraction Scour

Laursen's Live Bed Contraction Scour

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

ys=y2-y_bridge

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

Characteristic	Approach 100 yr	Approach 500 yr	Approach Other Q	Bridge 100 yr	Bridge 500 yr	Bridge Other Q
Q1, discharge, cfs	3310	4750	0	3310	4750	0
Total conveyance	137785	198513	0	125342	96348	0
Main channel conveyance	130494	174051	0	125342	96348	0
Main channel discharge	3135	4165	ERR	3310	4750	ERR
Area - main channel, ft2	754	896	0	698	732	0
(W1) channel width, ft	79	79	0	58.6	58.6	0
(Wp) cumulative pier width, ft	0	0	0	0	0	0
W1, adjusted bottom width(ft)	79	79	0	58.6	58.6	0
D50, ft	0.00026	0.00026	0.00026			
w, fall velocity, ft/s (p. 32)	0.015	0.015	0			
y, ave. depth flow, ft	9.54	11.34	N/A	11.91	12.49	ERR
S1, slope EGL	0.00091	0.001	0			
P, wetted perimeter, MC, ft	81	81	0			
R, hydraulic Radius, ft	9.309	11.062	ERR			
V*, shear velocity, ft/s	0.522	0.597	N/A			
V*/w	34.818	39.788	ERR			
Bed transport coeff., k1, (0.59 if V*/w<0.5; 0.64 if .5<V*/w<2; 0.69 if V*/w>2.0 p. 33)						
k1	0.69	0.69	0			
y2,depth in contraction, ft	12.29	15.60	ERR			
ys, scour depth, ft (y2-y_bridge)	**0.38**	**3.11**	N/A			

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation Hb+Ys=Cq*qbr/Vc

Cq=1/Cf*Cc Cf=1.5*Fr^0.43 (<=1) Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)

Umbrell pressure flow equation

(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031

(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	3310	4750	0
Q, thru bridge MC, cfs	3310	4750	N/A
Vc, critical velocity, ft/s	1.04	1.07	N/A
Va, velocity MC approach, ft/s	4.16	4.65	N/A
Main channel width (normal), ft	58.6	58.6	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	58.6	58.6	0.0
qbr, unit discharge, ft2/s	56.5	81.1	ERR
Area of full opening, ft2	698.0	732.0	0.0
Hb, depth of full opening, ft	11.91	12.49	ERR
Fr, Froude number, bridge MC	0	0.33	0

Cf, Fr correction factor (<=1.0)	0.00	0.93	0.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	ERR
**Fr, Froude number at DS face	ERR	ERR	ERR
**Cf, for downstream face (<=1.0)	N/A	N/A	N/A
Elevation of Low Steel, ft	0	498.53	0
Elevation of Bed, ft	N/A	486.04	N/A
Elevation of Approach, ft	0	499.36	0
Friction loss, approach, ft	0	0.07	0
Elevation of WS immediately US, ft	0.00	499.29	0.00
ya, depth immediately US, ft	N/A	13.25	N/A
Mean elevation of deck, ft	0	510	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	ERR	0.99	ERR
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	N/A	69.86	N/A
Ys, scour w/Umbrell equation, ft	N/A	22.88	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	3310	4750	N/A
Main channel area (DS), ft2	698	732	0
Main channel width (normal), ft	58.6	58.6	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	58.6	58.6	0.0
D90, ft	0.0008	0.0008	0.0000
D95, ft	0.0012	0.0012	0.0000
Dc, critical grain size, ft	0.0154	0.0285	ERR
Pc, Decimal percent coarser than Dc	0.000	0.000	0.000
Depth to armoring, ft	N/A	N/A	ERR

Abutment Scour

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

	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	3310	4750	0	3310	4750	0
a', abut.length blocking flow, ft	38.3	59	0	67.5	97	0
Ae, area of blocked flow ft2	86.7	175	0	173	325	0
Qe, discharge blocked abut.,cfs	162	388	0	385	778	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.87	2.22	ERR	2.23	2.39	ERR

ya, depth of f/p flow, ft	2.26	2.97	ERR	2.56	3.35	ERR

--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)

K1	0.82	0.82	0.82	1	1	1

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.219	0.227	ERR	0.245	0.230	ERR
ys, scour depth, ft	7.89	11.05	N/A	12.63	16.56	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)	38.3	59	0	67.5	97	0
y1 (depth f/p flow, ft)	2.26	2.97	ERR	2.56	3.35	ERR
a'/y1	16.92	19.89	ERR	26.34	28.95	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.22	0.23	N/A	0.24	0.23	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	11.72	15.01	ERR
vertical w/ ww's	ERR	ERR	ERR	9.61	12.31	ERR
spill-through	ERR	ERR	ERR	6.44	8.26	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.26	0.33	0	0.26	0.33	0
y, depth of flow in bridge, ft	11.91	12.49	0.00	11.91	12.49	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.50	0.84	0.00	0.50	0.84	0.00
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR