LEVEL II SCOUR ANALYSIS FOR BRIDGE 5 (BRNETH00020005) on TOWN HIGHWAY 2, crossing EAST PEACHAM BROOK, BARNET, VERMONT

Open-File Report 98-263

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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By MICHAEL A. IVANOFF AND LAURA MEDALIE

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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 5 (BRNETH00020005) ON TOWN HIGHWAY 2, CROSSING EAST PEACHAM BROOK, BARNET, VERMONT

By **Michael A. Ivanoff and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BRNETH00020005 on Town Highway 2 crossing East Peacham Brook, Barnet, 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 (Federal Highway Administration, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the New England Upland section of the New England physiographic province in east-central Vermont. The 15.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, East Peacham Brook has an incised, sinuous channel with a slope of approximately 0.004 ft/ft, an average channel top width of 60 ft and an average bank height of 4 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 63.5 mm (0.208 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 23, 1995, indicated that the reach was laterally unstable with moderate fluvial erosion along the banks and trees have fallen into the channel.

The Town Highway 2 crossing of East Peacham Brook is a 49-ft-long, two-lane bridge consisting of one 46-foot steel-beam span (Vermont Agency of Transportation, written communication, March 16, 1995). The opening length of the structure parallel to the bridge face is 44.5 ft. The bridge is supported by vertical, concrete abutments with spill-through embankments. The channel is skewed approximately zero degrees to the opening, and the opening-skew-to-roadway is also zero degrees.

The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) along the left and right abutments that form spill-through embankments. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge is determined and analyzed as another potential worst-case scour scenario. 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 0.5 to 2.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 11.6 to 12.4 ft. Right abutment scour ranged from 6.2 to 6.7 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and 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.

Barnet, VT. Quadrangle, 1:25,000, 1983

NORTH

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

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

LEVEL II SUMMARY

Structure Number BRNETH00020005 ***Stream*** East Peacham Brook

County Caledonia ***Road*** TH 2 ***District*** 7

Description of Bridge

Bridge length 49.0 ***ft*** ***Bridge width*** 26.0 ***ft*** ***Max span length*** 46.0 ***ft***

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

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

Stone fill on abutment? Yes ***Date of inspection*** 8/23/95

Description of stone fill Type-2, along the base of the left and right abutments extending around the upstream and downstream wingwall ends forming spill-through embankments.

Abutments are concrete. The stone blocks at the base of the abutments form spill-through slopes.

No

--

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

severe channel bend in the upstream and downstream reach over 200 ft from the bridge.

8/23/95

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*
	0	0	8/23/
Level I	95	0	0
Level II			

Potential for debris Moderate. There is some debris caught on the banks and trees leaning over the channel upstream.

None as of 8/23/95.

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

Description of the Geomorphic Setting

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

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

Date of inspection 8/23/95

DS left: Steep channel bank to a moderately sloped overbank.

DS right: Steep channel bank to a moderately sloped overbank.

US left: Steep channel bank to a moderately sloped overbank.

US right: Steep valley wall.

Description of the Channel

Average top width 60 ***ft*** ***Average depth*** 4 ***ft***

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

Sinuous but stable with semi-alluvial channel boundaries.

8/23/95

Vegetative co Trees and brush.

DS left: Trees and brush.

DS right: Trees and brush.

US left: Trees and brush.

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

There is moderate fluvial erosion along the banks and trees have fallen into the channel.

None 8/23/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 15.9 ***mi***^{2}

Percentage of drainage area in physiographic provinces: (approximate)

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

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

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

USGS gage description --

USGS gage number --

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

Is there a lake/p No

Calculated Discharges

Q100 2,330 ***ft***^{3}***/s*** ***Q500*** 2,940 ***ft***^{3}***/s***

The 100- and 500-year discharges were obtained from the median of several flood frequency curves based on 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 Subtract 695 ft from the USGS arbitrary survey datum to obtain the datum used within the VTAOT plans.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the left abutment (elev. 798.93 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right abutment (elev. 798.79 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	-31	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	13	1	Road Grade section
APPRO	72	1	Approach section

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. The channel "n" value for the reach was 0.055, and the overbank "n" value was 0.075.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0036 ft/ft, which was estimated from surveyed points downstream of the bridge.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 799.7 *ft*
Average low steel elevation 796.1 *ft*

100-year discharge 2,330 *ft³/s*
Water-surface elevation in bridge opening 796.2 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 254 *ft²*
Average velocity in bridge opening 9.0 *ft/s*
Maximum WSPRO tube velocity at bridge 11.1 *ft/s*

Water-surface elevation at Approach section with bridge 798.3
Water-surface elevation at Approach section without bridge 796.4
Amount of backwater caused by bridge 1.9 *ft*

500-year discharge 2,940 *ft³/s*
Water-surface elevation in bridge opening 796.2 *ft*
Road overtopping? Yes *Discharge over road* 136 *ft³/s*
Area of flow in bridge opening 254 *ft²*
Average velocity in bridge opening 11.1 *ft/s*
Maximum WSPRO tube velocity at bridge 13.4 */s*

Water-surface elevation at Approach section with bridge 800.1
Water-surface elevation at Approach section without bridge 797.1
Amount of backwater caused by bridge 3.0 *ft*

Incipient overtopping discharge 2,570 *ft³/s*
Water-surface elevation in bridge opening 796.2 *ft*
Area of flow in bridge opening 254 *ft²*
Average velocity in bridge opening 9.9 *ft/s*
Maximum WSPRO tube velocity at bridge 12.2 *ft/s*

Water-surface elevation at Approach section with bridge 799.0
Water-surface elevation at Approach section without bridge 796.7
Amount of backwater caused by bridge 2.3 *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 100-year and 500-year scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, the 100-year, 500-year, and incipient roadway-overtopping discharges resulted in submerged 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). Thus, contraction scour for these discharges (Figure 8 and Tables 1 and 2) was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). For comparison, estimates of contraction scour also were computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20) and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and are presented in appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, the total scour depth computed at the toe of each embankment was applied to the entire embankment, as shown in figure 8.

The length to depth ratio of the embankment blocking flow exceeded 25 for the left abutment. Although the HIRE equation (Richardson and others, 1993, p. 50, equation 25) is generally applicable when this ratio exceeds 25, the results from the HIRE equation were not used. Hydraulic Engineering Circular 18 recommends that the field conditions be similar to those from which the HIRE equation was derived (Richardson and others, 1993). Since the equation was developed from U. S. Army Corps of Engineers' data for spur dikes in the Mississippi River, the HIRE equation was determined to be non-applicable to the narrow, incised, upland valley at this site.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.5	2.4	1.4
Depth to armoring	2.5	9.0	4.5
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	11.6	12.4	12.2
Right abutment	6.2	6.7	6.5
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
		(D_{50} in feet)	
Abutments:			
Left abutment	1.9	2.8	2.3
Right abutment	1.9	2.8	2.3
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

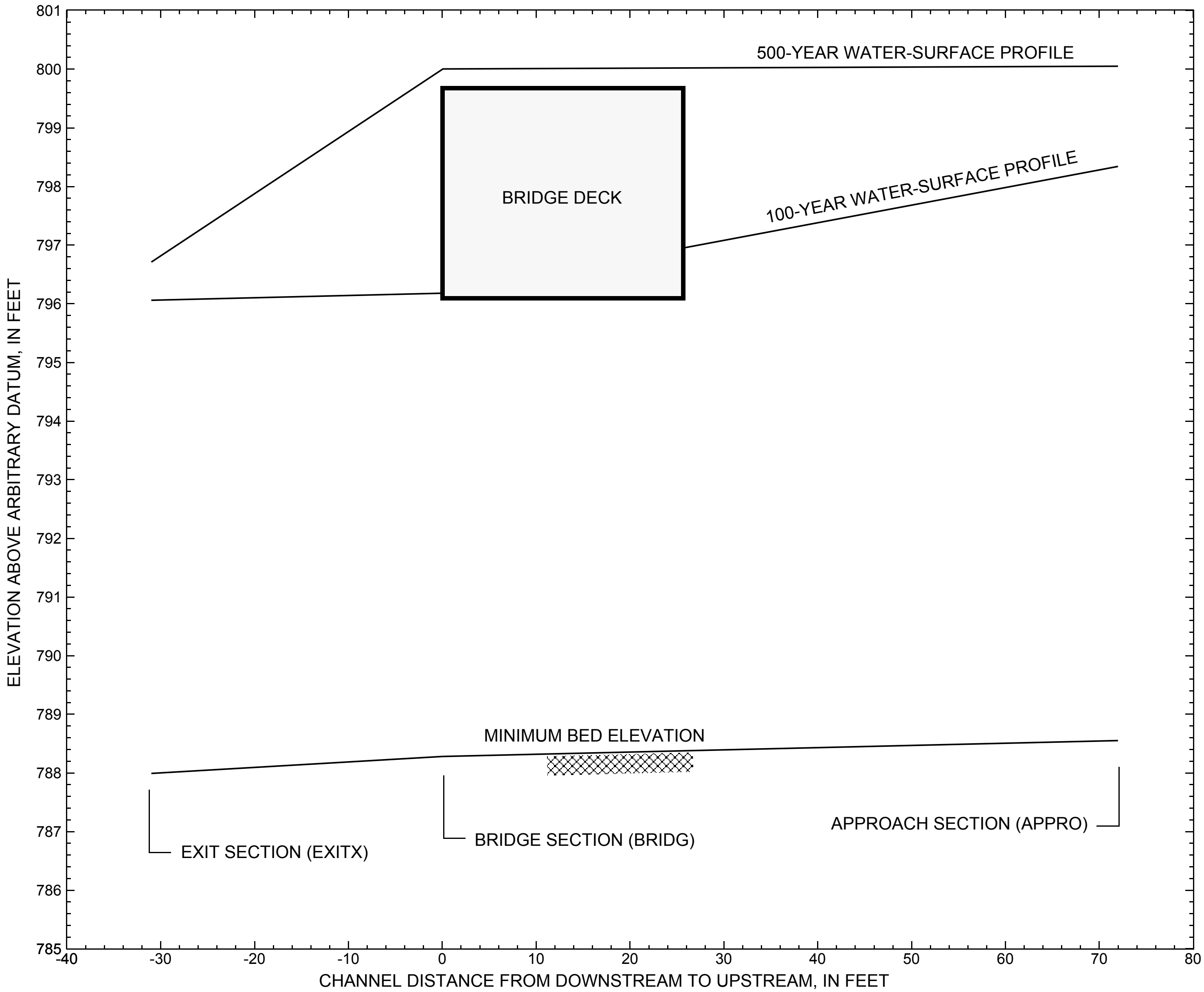

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BRNETH00020005 on Town Highway 2, crossing East Peacham Brook, Barnet, Vermont.

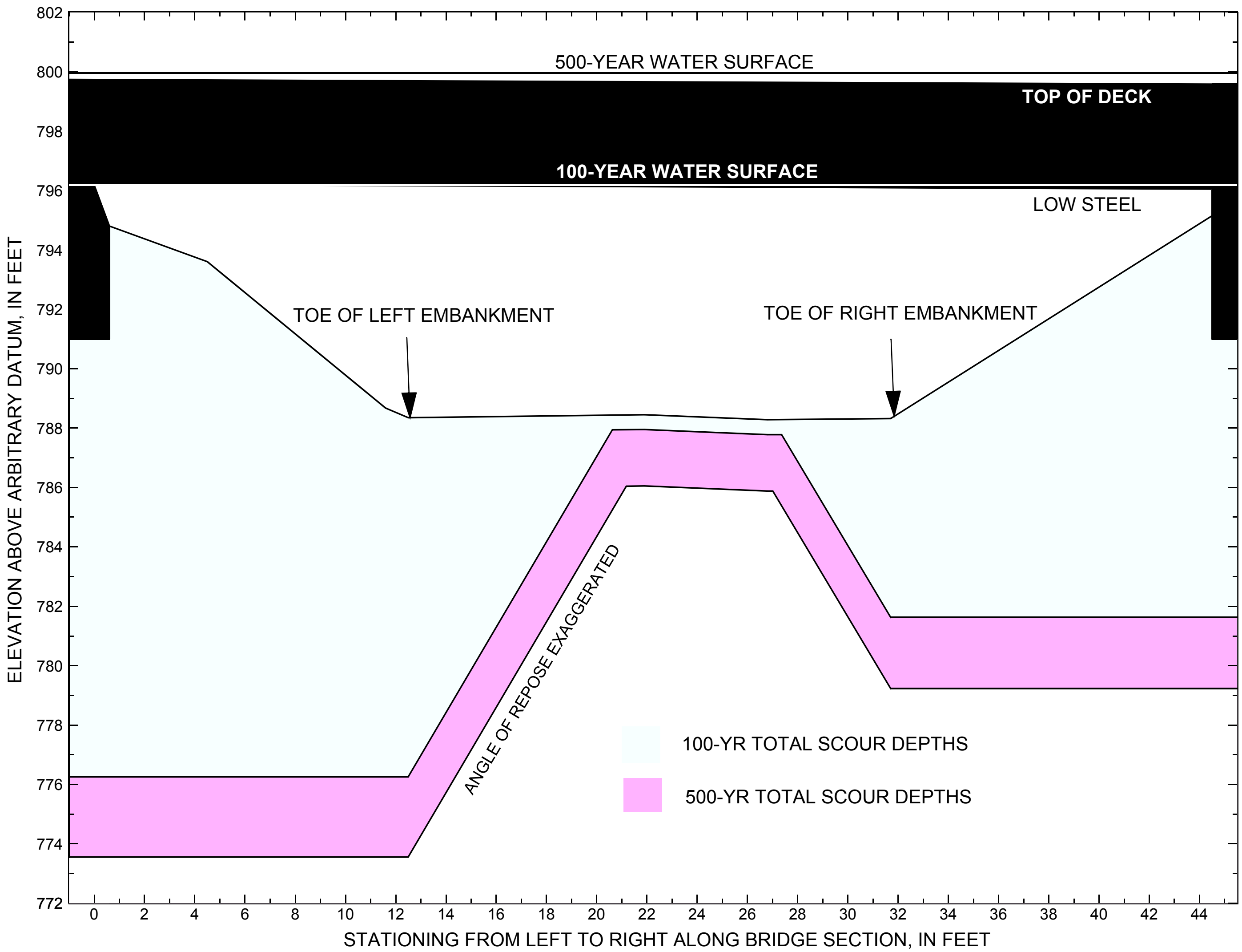

Figure 8. Scour elevations for the 100- and 500-year discharges at structure BRNETH00020005 on Town Highway 2, crossing East Peacham Brook, Barnet, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BRNETH00020005 on Town Highway 2, crossing East Peacham Brook, Barnet, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing 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 2,330 cubic-feet per second											
Left abutment	0.0	100.7	796.2	791.0	794.8	--	--	--	--	--	-14.7
Toe of left embankment	12.5	--	--	--	788.4	0.5	11.6	--	12.1	776.3	--
Toe of right embankment	31.7	--	--	--	788.3	0.5	6.2	--	6.7	781.6	--
Right abutment	44.5	100.5	796.0	791.0	795.2	--	--	--	--	--	-9.4

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 BRNETH00020005 on Town Highway 2, crossing East Peacham Brook, Barnet, Vermont.

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

Description	Station[1]	VTAOT minimum bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-year discharge is 2,940 cubic-feet per second											
Left abutment	0.0	100.7	796.2	791.0	794.8	--	--	--	--	--	-17.4
Toe of left embankment	12.5	--	--	--	788.4	2.4	12.4	--	14.8	773.6	--
Toe of right embankment	31.7	--	--	--	788.3	2.4	6.7	--	9.1	779.2	--
Right abutment	44.5	100.5	796.0	791.0	795.2	--	--	--	--	--	-11.8

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, 1983, Barnet, Vermont 7.5 X 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File brne005.wsp
T2        Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
T3        Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2330.0   2940.0  2570.0
SK          0.0036   0.0036  0.0036
*
XS   EXITX    -31
GR         -377.5, 808.26   -235.8, 801.83    -99.0, 797.94    -29.4, 792.28
GR            0.0, 791.81      5.8, 791.08     10.0, 788.57     13.7, 788.20
GR           24.6, 788.04     28.1, 788.34     33.7, 787.99     37.2, 788.69
GR           38.1, 790.29     44.5, 792.04     69.7, 794.74     88.8, 794.78
GR          123.7, 796.30    150.0, 797.38
*           229.8, 794.14    384.5, 793.38    610.6, 790.39    727.0, 795.08
N           0.075        0.055        0.075
SA                   0.0          69.7
*
XS   FULLV      0  * * *   0.0044
*
*             SRD     LSEL    XSSKEW
BR   BRIDG      0    796.10       0.0
GR            0.0, 796.18      0.6, 794.80      4.5, 793.60     11.6, 788.67
GR           12.5, 788.35     21.9, 788.45     26.8, 788.28     31.7, 788.32
GR           32.9, 788.95     44.5, 795.15     44.5, 796.02      0.0, 796.18
*
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD            3      25.8      1.5    799.7
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     13      26.0     2
GR         -459.1, 813.22   -357.3, 807.28   -237.5, 802.84   -114.7, 800.16
GR           -2.1, 799.30     -1.4, 799.72      0.0, 799.75     45.3, 799.61
GR           47.0, 799.63     47.4, 799.03     63.6, 802.29
*           540.7, 794.11    735.2, 795.72
*
*
AS   APPRO     72
GR         -467.3, 811.53   -401.1, 806.96   -322.5, 803.49   -125.1, 798.74
GR          -76.4, 794.65    -10.3, 793.76      0.0, 792.01      7.2, 789.73
GR           15.8, 789.36     20.6, 788.71     25.5, 788.55     30.4, 788.71
GR           33.9, 789.33     36.6, 789.82     39.1, 793.76     63.6, 802.29
*
N           0.075        0.055
SA                 -10.3
*
HP 1 BRIDG   796.18 1 796.18
HP 2 BRIDG   796.18 * * 2330
HP 1 APPRO   798.34 1 798.34
HP 2 APPRO   798.34 * * 2330
*
HP 1 BRIDG   796.18 1 796.18
HP 2 BRIDG   796.18 * * 2824
HP 2 RDWAY   799.96 * * 136
HP 1 APPRO   800.05 1 800.05
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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       U.S. Geological Survey WSPRO Input File brne005.wsp
       Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
       Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
          *** RUN DATE & TIME: 10-16-97  12:33
   CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     254.   13350.     0.    94.                            0.
  796.18          254.   13350.     0.    94.  1.00     0.    45.      0.


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      796.18     0.0    44.5   254.3   13350.    2330.   9.16

X STA.        0.0        8.3       10.8       12.5       14.0       15.5
  A(I)            22.7       15.1       12.9       11.8       11.3
  V(I)            5.14       7.72       9.01       9.84      10.32

X STA.       15.5       16.9       18.3       19.7       21.1       22.5
  A(I)            11.0       10.8       10.8       10.7       10.7
  V(I)           10.57      10.80      10.75      10.90      10.92

X STA.       22.5       23.9       25.2       26.6       28.0       29.4
  A(I)            10.5       10.6       10.8       10.9       10.9
  V(I)           11.09      11.02      10.84      10.67      10.65

X STA.       29.4       30.9       32.4       34.3       37.0       44.5
  A(I)            11.2       11.9       13.0       15.3       21.5
  V(I)           10.45       9.83       8.99       7.61       5.41


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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW     QCR
            1     354.   15339.   110.   110.                         3609.
            2     428.   40294.    63.    66.                         6358.
  798.34          783.   55633.   173.   176.  1.37  -120.    52.   8076.


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

        WSEL     LEW     REW    AREA        K        Q    VEL
      798.34  -120.3    52.3   782.6   55633.    2330.   2.98

X STA.     -120.3      -73.5      -56.6      -42.1      -28.7      -16.3
  A(I)            91.7       65.1       59.0       56.8       54.5
  V(I)            1.27       1.79       1.98       2.05       2.14

X STA.      -16.3       -6.7       -0.9        3.6        6.9        9.9
  A(I)            44.9       33.1       30.1       26.7       25.6
  V(I)            2.59       3.52       3.87       4.36       4.56

X STA.        9.9       12.7       15.5       18.3       20.9       23.5
  A(I)            25.2       24.8       25.2       24.9       25.3
  V(I)            4.62       4.71       4.63       4.67       4.61

X STA.       23.5       26.1       28.9       32.0       35.7       52.3
  A(I)            25.4       27.5       28.9       33.7       54.3
  V(I)            4.59       4.23       4.03       3.46       2.15
```

```
        U.S. Geological Survey WSPRO Input File brne005.wsp
        Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
        Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
           *** RUN DATE & TIME: 10-16-97  12:33
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     254.  13350.     0.    94.                            0.
   796.18          254.  13350.     0.    94.  1.00     0.    45.      0.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       796.18     0.0    44.5   254.3   13350.    2824.  11.11

X STA.         0.0        8.3       10.8       12.5       14.0       15.5
  A(I)            22.7       15.1       12.9       11.8       11.3
  V(I)            6.23       9.35      10.93      11.92      12.50

X STA.        15.5       16.9       18.3       19.7       21.1       22.5
  A(I)            11.0       10.8       10.8       10.7       10.7
  V(I)           12.81      13.09      13.03      13.21      13.24

X STA.        22.5       23.9       25.2       26.6       28.0       29.4
  A(I)            10.5       10.6       10.8       10.9       10.9
  V(I)           13.44      13.36      13.13      12.93      12.91

X STA.        29.4       30.9       32.4       34.3       37.0       44.5
  A(I)            11.2       11.9       13.0       15.3       21.5
  V(I)           12.66      11.91      10.89       9.23       6.56


    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      13.

         WSEL     LEW     REW    AREA        K        Q    VEL
       799.96   -88.5    52.0    44.8     466.     136.   3.03

X STA.       -88.5      -53.3      -42.7      -35.1      -29.3      -24.3
  A(I)             4.7        3.3        2.9        2.5        2.3
  V(I)            1.44       2.08       2.35       2.73       2.90

X STA.       -24.3      -20.0      -16.1      -12.7       -9.5       -6.6
  A(I)             2.2        2.1        1.9        1.9        1.8
  V(I)            3.07       3.26       3.51       3.60       3.81

X STA.        -6.6       -3.8        1.8       12.0       20.4       27.6
  A(I)             1.8        2.1        2.3        2.2        2.0
  V(I)            3.88       3.17       2.90       3.11       3.32

X STA.        27.6       33.9       39.7       44.9       48.0       52.0
  A(I)             1.9        1.9        1.8        1.5        1.6
  V(I)            3.52       3.63       3.81       4.55       4.21

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

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     585.  26579.   169.   169.                         6178.
             2     539.  56283.    67.    71.                         8654.
   800.05         1125.  82863.   237.   241.  1.48  -180.    57.  11419.


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       800.05  -179.5    57.2  1124.8   82863.    2940.   2.61

X STA.      -179.5      -84.7      -66.1      -51.5      -38.2      -26.1
  A(I)           157.0       98.6       82.2       77.4       72.2
  V(I)            0.94       1.49       1.79       1.90       2.03

X STA.       -26.1      -14.7       -6.5       -0.9        3.6        7.2
  A(I)            70.5       52.7       41.1       38.1       35.2
  V(I)            2.09       2.79       3.57       3.86       4.18

X STA.         7.2       10.4       13.6       16.7       19.8       22.8
  A(I)            33.4       33.8       33.5       33.7       33.9
  V(I)            4.41       4.35       4.39       4.36       4.34

X STA.        22.8       25.8       29.0       32.6       36.9       57.2
  A(I)            35.1       36.1       40.1       45.3       74.9
  V(I)            4.19       4.08       3.67       3.24       1.96
```

```
         U.S. Geological Survey WSPRO Input File brne005.wsp
         Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
         Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
            *** RUN DATE & TIME: 10-16-97  12:33
     CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     254.   13350.     0.    94.                          0.
    796.18          254.   13350.     0.    94.  1.00     0.    45.      0.


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

          WSEL     LEW     REW    AREA        K        Q    VEL
        796.18     0.0    44.5   254.3   13350.    2570.  10.11

 X STA.         0.0         8.3        10.8        12.5        14.0        15.5
   A(I)            22.7        15.1        12.9        11.8        11.3
   V(I)            5.67        8.51        9.94       10.85       11.38

 X STA.        15.5        16.9        18.3        19.7        21.1        22.5
   A(I)            11.0        10.8        10.8        10.7        10.7
   V(I)           11.66       11.92       11.86       12.03       12.05

 X STA.        22.5        23.9        25.2        26.6        28.0        29.4
   A(I)            10.5        10.6        10.8        10.9        10.9
   V(I)           12.23       12.16       11.95       11.77       11.75

 X STA.        29.4        30.9        32.4        34.3        37.0        44.5
   A(I)            11.2        11.9        13.0        15.3        21.5
   V(I)           11.52       10.84        9.91        8.40        5.97


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

      WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
              1     436.   19640.   127.   127.                       4574.
              2     473.   46517.    65.    68.                       7258.
    799.04          908.   66157.   192.   196.  1.40  -138.    54.   9489.


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

          WSEL     LEW     REW    AREA        K        Q    VEL
        799.04  -137.6    54.3   908.4   66157.    2570.   2.83

 X STA.      -137.6       -77.0       -60.3       -46.0       -32.8       -20.8
   A(I)           113.3        75.2        67.1        64.7        60.6
   V(I)            1.13        1.71        1.91        1.99        2.12

 X STA.       -20.8        -9.8        -3.4         1.6         5.4         8.6
   A(I)            57.6        37.4        34.6        31.5        29.4
   V(I)            2.23        3.44        3.72        4.08        4.37

 X STA.         8.6        11.7        14.6        17.5        20.4        23.1
   A(I)            28.6        28.1        28.4        28.7        28.8
   V(I)            4.49        4.57        4.53        4.48        4.47

 X STA.        23.1        26.0        28.9        32.1        36.1        54.3
   A(I)            29.7        30.5        32.9        38.4        62.9
   V(I)            4.32        4.21        3.90        3.35        2.04
```

```
        U.S. Geological Survey WSPRO Input File brne005.wsp
        Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
        Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
           *** RUN DATE & TIME: 10-16-97  12:33

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

EXITX:XS   ******   -76.     621.  0.30 *****  796.36  793.77   2330.  796.06
      -31. ******   118.   38824.  1.38 ***** *******    0.43    3.75

FULLV:FV      31.   -76.     619.  0.30  0.11  796.49 *******   2330.  796.19
        0.    31.   118.   38638.  1.38  0.00    0.01    0.44    3.77
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      72.   -97.     476.  0.52  0.33  796.92 *******   2330.  796.40
       72.    72.    47.   30313.  1.40  0.11   -0.01    0.56    4.89
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =    796.19      796.10

            <<<<<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      31.     0.     254.  1.27 *****  797.45  794.66   2297.  796.18
        0. ******    45.   13350.  1.00 ***** *******    0.67    9.03

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   3.  0.800  0.000  796.10 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      46.  -120.     783.  0.19  0.37  798.53  794.90   2330.  798.34
       72.    50.    52.   55679.  1.37  0.00   -0.01    0.29    2.98

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -31.   -76.   118.   2330.   38824.     621.    3.75  796.06
   FULLV:FV       0.   -76.   118.   2330.   38638.     619.    3.77  796.19
   BRIDG:BR       0.     0.    45.   2297.   13350.     254.    9.03  796.18
   RDWAY:RG      13.**************      0.       0.       0.    2.00********
   APPRO:AS      72.  -120.    52.   2330.   55679.     783.    2.98  798.34

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    793.77    0.43  787.99  808.26************  0.30  796.36  796.06
   FULLV:FV  ********    0.44  788.13  808.40  0.11  0.00  0.30  796.49  796.19
   BRIDG:BR    794.66    0.67  788.28  796.18************  1.27  797.45  796.18
   RDWAY:RG  ****************  799.03  813.22************  0.14  799.15********
   APPRO:AS    794.90    0.29  788.55  811.53  0.37  0.00  0.19  798.53  798.34
```

```
        U.S. Geological Survey WSPRO Input File brne005.wsp
        Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
        Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
           *** RUN DATE & TIME: 10-16-97  12:33

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

EXITX:XS   ******   -84.     753.  0.34 *****  797.05  794.31   2940.  796.71
      -31. ******   134.   48992.  1.44 ***** *******    0.44    3.90

FULLV:FV      31.   -84.     751.  0.34  0.11  797.17 *******   2940.  796.83
        0.    31.   133.   48788.  1.44  0.00    0.01    0.44    3.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      72.  -105.     572.  0.57  0.34  797.62 *******   2940.  797.05
       72.    72.    49.   37716.  1.39  0.12   -0.01    0.56    5.14
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =   796.83      796.10

            <<<<<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      31.     0.     254.  1.92 *****  798.10  795.38   2824.  796.18
        0. ******    45.   13350.  1.00 ***** *******    0.82   11.10

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   6.  0.800  0.000  796.10 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.    46.  0.06  0.16  800.15    0.01    136.  799.96

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    105.   111.   -88.    23.   0.7   0.3   2.8   3.0   0.5   2.7
   RT:     31.    30.    23.    52.   0.9   0.3   3.0   3.0   0.5   2.7

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

APPRO:AS      46.  -179.    1124.  0.16  0.38  800.20  795.49   2940.  800.05
       72.    51.    57.   82782.  1.48  0.00    0.01    0.26    2.62


  FIRST USER DEFINED TABLE.

    XSID:CODE     SRD    LEW    REW       Q         K      AREA     VEL    WSEL
   EXITX:XS      -31.   -84.   134.   2940.   48992.      753.    3.90  796.71
   FULLV:FV        0.   -84.   133.   2940.   48788.      751.    3.92  796.83
   BRIDG:BR        0.     0.    45.   2824.   13350.      254.   11.10  796.18
   RDWAY:RG       13.*******   105.    136.******************    2.00  799.96
   APPRO:AS       72.  -179.    57.   2940.   82782.     1124.    2.62  800.05

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    794.31    0.44  787.99  808.26************  0.34  797.05  796.71
   FULLV:FV  ********    0.44  788.13  808.40  0.11  0.00  0.34  797.17  796.83
   BRIDG:BR    795.38    0.82  788.28  796.18************  1.92  798.10  796.18
   RDWAY:RG  ****************  799.03  813.22  0.06******  0.16  800.15  799.96
   APPRO:AS    795.49    0.26  788.55  811.53  0.38  0.00  0.16  800.20  800.05
```

```
        U.S. Geological Survey WSPRO Input File brne005.wsp
        Hydraulic analysis for structure BRNETH00020005   Date: 16-SEP-97
        Bridge 5 on Town Highway 2 over East Peacham Brook Barnet, VT by MAI
           *** RUN DATE & TIME: 10-16-97  12:33

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

EXITX:XS   ******   -79.     674.  0.32 *****  796.64  793.99   2570.  796.33
      -31. ******   124.   42823.  1.40 ***** *******    0.44    3.82

FULLV:FV      31.   -79.     671.  0.32  0.11  796.77 *******   2570.  796.45
        0.    31.   124.   42630.  1.40  0.00    0.01    0.44    3.83
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      72.  -100.     515.  0.54  0.34  797.21 *******   2570.  796.67
       72.    72.    47.   33238.  1.40  0.11   -0.01    0.56    4.99
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                         WS3N,LSEL =   796.45      796.10

            <<<<<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      31.     0.     254.  1.53 *****  797.71  794.99   2522.  796.18
        0. ******    45.   13350.  1.00 ***** *******    0.73    9.92

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3. ****   3.  0.800  0.000  796.10 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      13.        <<<<<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      46.  -138.     909.  0.17  0.38  799.22  795.15   2570.  799.04
       72.    51.    54.   66183.  1.40  0.00   -0.02    0.27    2.83

  FIRST USER DEFINED TABLE.

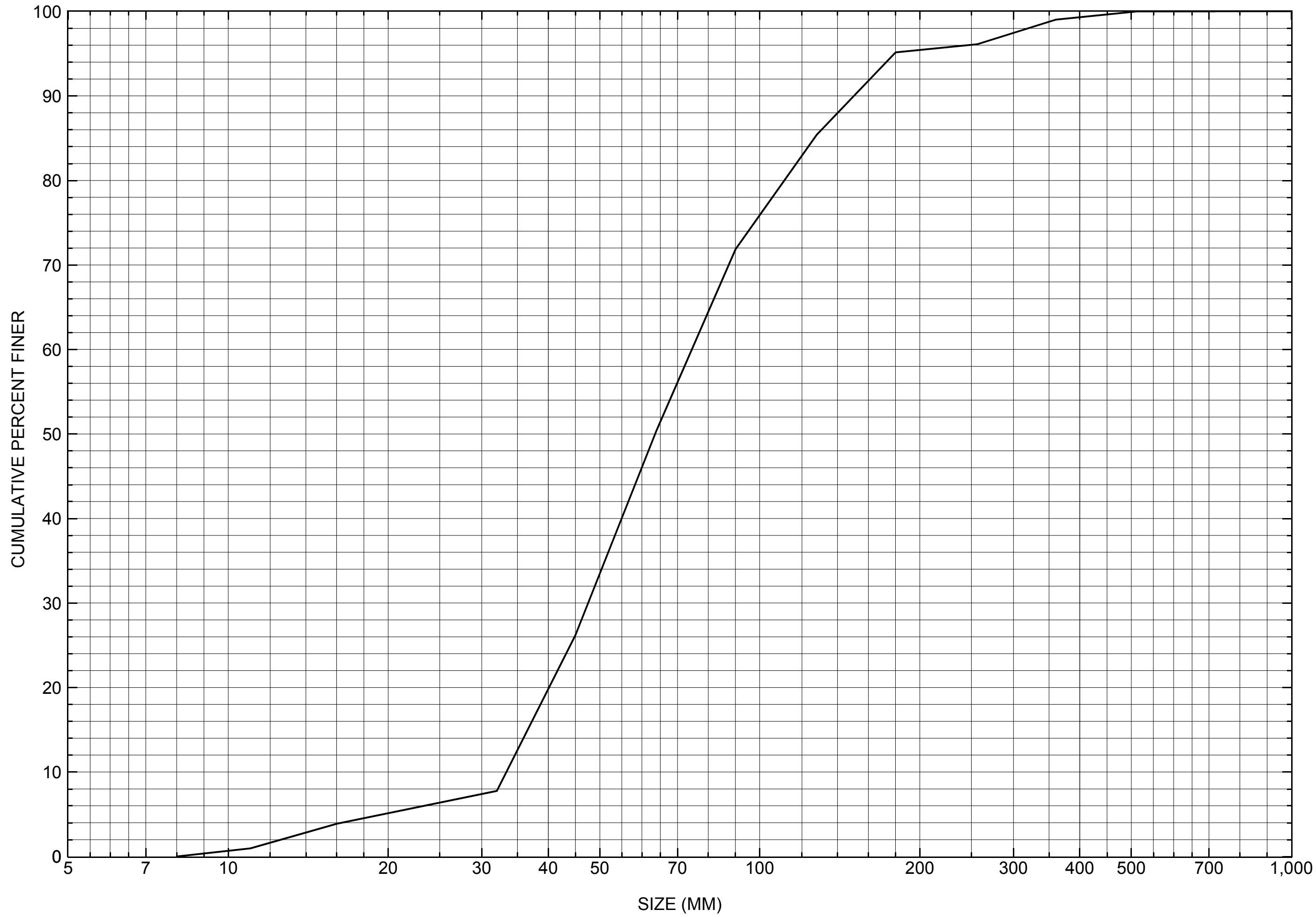
    XSID:CODE    SRD    LEW    REW       Q         K      AREA     VEL    WSEL
   EXITX:XS     -31.    -79.   124.   2570.   42823.      674.    3.82  796.33
   FULLV:FV       0.    -79.   124.   2570.   42630.      671.    3.83  796.45
   BRIDG:BR       0.      0.    45.   2522.   13350.      254.    9.92  796.18
   RDWAY:RG      13.**************       0.       0.        0.    2.00********
   APPRO:AS      72.   -138.    54.   2570.   66183.      909.    2.83  799.04

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF     HO  VHD      EGL    WSEL
   EXITX:XS    793.99    0.44  787.99  808.26************  0.32  796.64  796.33
   FULLV:FV  ********    0.44  788.13  808.40  0.11  0.00  0.32  796.77  796.45
   BRIDG:BR    794.99    0.73  788.28  796.18************  1.53  797.71  796.18
   RDWAY:RG  ****************  799.03  813.22************  0.17  799.15********
   APPRO:AS    795.15    0.27  788.55  811.53  0.38  0.00  0.17  799.22  799.04
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BRNETH00020005, in Barnet, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BRNETH00020005

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 16 / 95

Highway District Number *(I - 2; nn)* 07

County *(FIPS county code; I - 3; nnn)* 005

Town *(FIPS place code; I - 4; nnnnn)* 02875

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

Waterway *(I - 6)* East Peacham Brook

Road Name *(I - 7):* -

Route Number TH002

Vicinity *(I - 9)* 0.15 miles to junction with TH61

Topographic Map Barnet

Hydrologic Unit Code: 01080103

Latitude *(I - 16; nnnn.n)* 44191

Longitude *(i - 17; nnnnn.n)* 72069

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10030100050301

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

Maximum span length *(I - 48; nnnn)* 0046

Year built *(I - 27; YYYY)* 1949

Structure length *(I - 49; nnnnnn)* 000049

Average daily traffic, ADT *(I - 29; nnnnnn)* 000400

Deck Width *(I - 52; nn.n)* 260

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

Channel & Protection *(I - 61; n)* 7

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

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

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 045.2

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

Vertical clearance from streambed (*nnn.n ft*) 007.3

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

Waterway of full opening (*nnn.n ft*^{2}) 330.3

Comments:

The structural inspection report of 9/6/94 indicates the structure is a steel stringer type bridge with a concrete deck. The abutment walls and wingwalls are concrete. Both abutment walls are reported to have only a few fine cracks. The wingwalls are noted as small concrete walls that extend parallel to the abutment walls. The abutments, reportedly are protected with quarried granite blocks which are placed sloping down from the abutment walls forming spill-through ABUTMENTs through the bridge. The streambed is noted as primarily composed of gravel and cobbles. A gravel point bar is reported upstream on the left bank. Some log debris is noted just downstream of the bridge. The report indicates the footings are not in view at the surface and there has been no undermining or settling.

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: Gravel and cobbles

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)* **15.93** mi^2

Lake/pond/swamp area **0.12** mi^2

Watershed storage *(ST)* **0.8** %

Bridge site elevation **794** ft

Headwater elevation **2566** ft

Main channel length **9.414** mi

10% channel length elevation **856** ft

85% channel length elevation **1641** ft

Main channel slope *(S)* **111.19** ft / mi

Watershed Precipitation Data

Average site precipitation - in

Average headwater precipitation - in

Maximum 2yr-24hr precipitation event *(I24,2)* - in

Average seasonal snowfall *(Sn)* - ft

Bridge Plan Data

Are plans available? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 06 / 1950

Project Number SA 63 1949 Minimum channel bed elevation: 92.5

Low superstructure elevation: USLAB 100.67 DSLAB 100.67 USRAB 100.5 DSRAB 100.5

Benchmark location description:

BM#1, [spike in trunk or root of a] 34 inch twin elm tree located about 35 feet left bankward on the roadway from the left abutment and about 15 ft to 20 ft from the centerline of the roadway downstream, near left end of the downstream guard rail, elevation 100.00 ft

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

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

If 1: Footing Thickness 2.0 Footing bottom elevation: 95.7*

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:

-

Comments:

***The bottom of footing elevation shown is proposed for the right abutment. The left bottom of footing elevation is proposed at 95.67 ft. The low superstructure elevations are the minimum and not the average. The abutments are shown as flow through type abutments. Other reference marks: 1) The point on top of the upstream end of the right abutment concrete on the streamward edge where the slope of the concrete changes from horizontal to sloping downward, elevation 103.50, or 2) The same point but on the upstream end of the left abutment, elevation 103.67.**

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: **CG** Date: **02/23/96**
Computerized by: **CG** Date: **02/27/96**
Reviewd by: **MAI** Date: **10/23/97**

Structure Number **BRNETH00020005**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L. Medalie** Date *(MM/DD/YY)* **08** / **23** / 19**96**

2. Highway District Number **07**
   Mile marker **0000000**
   County **Caledonia (005)**
   Town **Barnet (02875)**
   Waterway *(I - 6)* **East Peacham Brook**
   Road Name **-**
   Route Number **TH 02**
   Hydrologic Unit Code: **01080103**

3. Descriptive comments:
The site is located 0.15 miles to the junction with Town Highway 61.

B. Bridge Deck Observations

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

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

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

7. Bridge length **49.0** *(feet)* Span length **46.0** *(feet)* Bridge width **26.0** *(feet)*

Road approach to bridge:

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

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

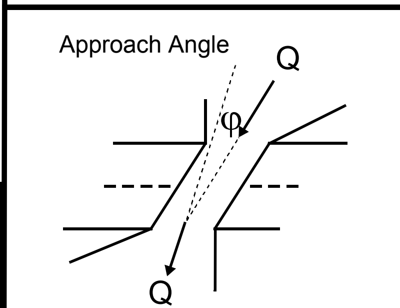
10. Embankment slope (*run / rise in feet / foot*):
US left **1.3:1** US right **1.7:1**

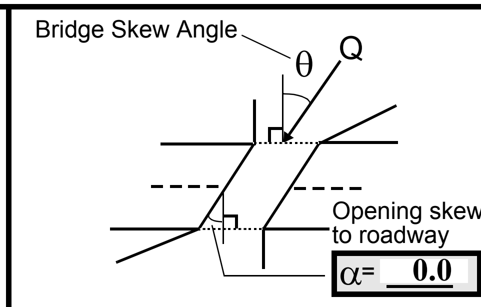
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

*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: **0** 16. Bridge skew: **0**





α= **0.0**

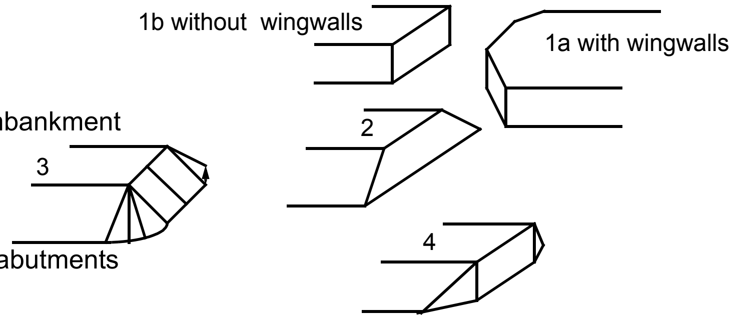
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **70** feet **US** *(US, UB, DS)* to **100** feet **US**

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

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

18. Bridge Type: 3

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.)

7. The bridge dimension values are from the VTAOT. The measured dimensions are bridge length is 48.5 ft, span length is 45.5 ft, and deck width is 25.6 ft.
8. The left bank road approach is even for about 50 feet and then slightly higher.

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
46.0	4.0			4.0	4	4	32	345	1	2

23. Bank width 15.0   24. Channel width 55.0   25. Thalweg depth 49.5   29. Bed Material 345

30 .Bank protection type: LB 2 RB 2   31. Bank protection condition: LB 1 RB 1

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

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

The bank protection is comprised of the stone slabs that form the spill through abutments. The right bank protection extends 18 ft upstream. The left bank protection extends 21 ft upstream.
There are more cut banks, impact zones, downed trees, and side bars beyond 100 ft upstream of the bridge.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **58** 35. Mid-bar width: **15**

36. Point bar extent: **6** feet **US** *(US, UB)* to **100** feet **US** *(US, UB, DS)* positioned **0** %LB to **35** %RB

37. Material: **342**

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

-

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

41. Mid-bank distance: **80** 42. Cut bank extent: **31** feet **US** *(US, UB)* to **100** feet **US** *(US, UB, DS)*

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

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

There are some trees on the cut bank that are tilted at about a 30 degree angle over the stream.

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

There is some minor local scour around boulders 24-33 feet upstream from the bridge.

49. Are there major confluences? **N** *(Y or if N type ctrl-n mc)* 50. How many? -

51. Confluence 1: Distance - 52. Enters on - *(LB or RB)* 53. Type - *(**1**- perennial; **2**- ephemeral)*

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

55. Channel restraint (BF)? LB **2** RB ____ *(**1**- natural bank; **2**- abutment; **3**- artificial levee)*

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
29.5		1.0		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.):

34

-

65. **Debris and Ice** Is there debris accumulation? ____ *(Y or N)* 66. Where? **Y**____ *(1- Upstream; 2- At bridge; 3- Both)*

67. Debris Potential **1**___ *(1- Low; 2- Moderate; 3- High)* 68. Capture Efficiency **2**___ *(1- Low; 2- Moderate; 3- High)*

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

70. Debris and Ice Comments:

1

Some trees have fallen into the channel beginning around 65 ft from the bridge and further upstream. 68. Capture efficiency is moderate because the bridge opening is less than 60% of the bank width.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**45**	**2**	**0**	**-**	**-**	**90.0**
RABUT	**1**	**0**	**45**			**2**	**0**	**44.5**

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.):

-

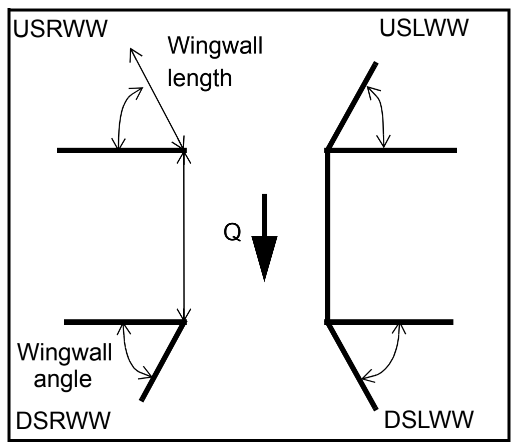
-

1

72. The top concrete section is at an 80 degree 1-2 ft from the top to the bottom. There are blocks of stone at the base of the left and right vertical concrete abutments forming spill-through abutments.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**44.5**	
USRWW:	**N**		**-**		**-**	**0.5**	
DSLWW:	**-**		**-**		**N**	**26.0**	
DSRWW:	**-**		**-**		**-**	**25.5**	



*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	**-**	**-**	**N**	**-**	**-**	**-**	**1**	**1**
Condition	**N**	**-**	**-**	**-**	**-**	**-**	**1**	**1**
Extent	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**-**

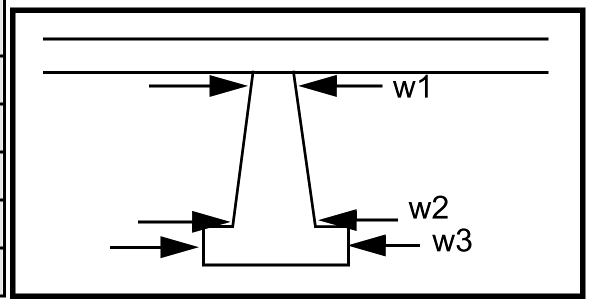
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

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

Piers:

84. Are there piers? 82. (Y or if N type ctrl-n pr)

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



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	All	placed	This	as	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	pro-	stone	pro-	note	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	tec-	bloc	tec-	d in	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	tion	ks	tion	upst	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	for	form	exte	ream	*Y- yes; N- no*
91. Attack ∠ (BF)	the	ing	nds	and	
92. Pushed	abut	the	upst	dow	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	ment	spill	ream	nstre	
95. Cross-members	s	thro	and	am	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	refer	ugh	dow	sec-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	s to	slope	nstre	tions	
98. Exposure depth	the	s.	am	.	

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

The stone blocks are 2.5 ft wide.

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: 3

Scour dimensions: Length 4 Width 432 Depth: 453 Positioned 0 %LB to 1 %RB

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

34
2
2
1

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

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

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

Confluence comments (eg. confluence name):

extends 18 ft downstream.
The right bank protection extends 21 ft downstream. Also, the right bank protection consists of a couple of

F. Geomorphic Channel Assessment

107. Stage of reach evolution hor

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)*:

izontal slabs in the stream bed.

The reach is very straight to 150 ft downstream. The channel makes a sharp bend to the right back towards Town Highway 2. There are several large trees in the channel at 150 ft downstream. The streambed becomes sandy and the right bank becomes moderately eroded beyond 115 ft downstream. There is a scour hole on the left bank and a narrow point bar on the right bank about 160 ft downstream.

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: BRNETH00020005 Town: Barnet
Road Number: TH 2 County: Caledonia
Stream: East Peacham Brook

Initials MAI Date: 10/16/97 Checked: ECW

I. 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	2330	2940	2570
Main Channel Area, ft2	428	539	473
Left overbank area, ft2	354	585	436
Right overbank area, ft2	0	0	0
Top width main channel, ft	63	67	65
Top width L overbank, ft	110	169	127
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2085	0.2085	0.2085
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.8	8.0	7.3
y1, average depth, LOB, ft	3.2	3.5	3.4
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	55633	82863	66157
Conveyance, main channel	40294	56283	46517
Conveyance, LOB	15339	26579	19640
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0012	0.0000
Qm, discharge, MC, cfs	1687.6	1996.9	1807.0
Ql, discharge, LOB, cfs	642.4	943.0	763.0
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	3.9	3.7	3.8
Vl, mean velocity, LOB, ft/s	1.8	1.6	1.7
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.1	9.4	9.3
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	2330	2940	2570
(Q) discharge thru bridge, cfs	2330	2824	2570
Main channel conveyance	13350	13350	13350
Total conveyance	13350	13350	13350
Q2, bridge MC discharge,cfs	2330	2824	2570
Main channel area, ft2	254	254	254
Main channel width (normal), ft	31.9	31.9	31.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	31.9	31.9	31.9
y_bridge (avg. depth at br.), ft	7.97	7.97	7.97
Dm, median (1.25*D50), ft	0.260625	0.260625	0.260625
y2, depth in contraction,ft	7.19	8.48	7.82
ys, scour depth (y2-ybridge), ft	-0.78	0.51	-0.15

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	2330	2940	2570
Q, thru bridge MC, cfs	2330	2824	2570
Vc, critical velocity, ft/s	9.15	9.41	9.25
Va, velocity MC approach, ft/s	3.94	3.70	3.82
Main channel width (normal), ft	31.9	31.9	31.9
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	31.9	31.9	31.9
qbr, unit discharge, ft2/s	73.0	88.5	80.6
Area of full opening, ft2	254.3	254.3	254.3
Hb, depth of full opening, ft	7.97	7.97	7.97
Fr, Froude number, bridge MC	0.67	0.82	0.73
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	N/A
**Hb, depth at downstream face, ft	N/A	N/A	N/A
**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	796.1	796.1	796.1
Elevation of Bed, ft	788.13	788.13	788.13

Elevation of Approach, ft	798.34	800.05	799.04
Friction loss, approach, ft	0.37	0.38	0.38
Elevation of WS immediately US, ft	797.97	799.67	798.66
ya, depth immediately US, ft	9.84	11.54	10.53
Mean elevation of deck, ft	799.68	799.68	799.68
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	0.95	0.90	0.93
**Cc, for downstream face (<=1.0)	ERR	ERR	ERR
Ys, scour w/Chang equation, ft	**0.45**	**2.43**	**1.39**
Ys, scour w/Umbrell equation, ft	-1.44	-0.72	-1.16

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	2330	2824	2570
Main channel area (DS), ft2	254.3	254.3	254.3
Main channel width (normal), ft	31.9	31.9	31.9
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	31.9	31.9	31.9
D90, ft	0.4929	0.4929	0.4929
D95, ft	0.5875	0.5875	0.5875
Dc, critical grain size, ft	0.3031	0.4453	0.3688
Pc, Decimal percent coarser than Dc	0.271	0.129	0.196
Depth to armoring, ft	**2.45**	**9.02**	**4.54**

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	2330	2940	2570	2330	2940	2570
a', abut.length blocking flow, ft	126.5	185.7	143.8	14.2	19.1	16.2
Ae, area of blocked flow ft2	456.24	686.4	549.35	46.45	67.23	55.9
Qe, discharge blocked abut.,cfs	1023.79	--	1188.63	99.66	--	114.38
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.24	2.00	2.16	2.15	1.96	2.05
ya, depth of f/p flow, ft	3.61	3.70	3.82	3.27	3.52	3.45

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

K1	0.55	0.55	0.55	0.55	0.55	0.55

--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	0.208	0.179	0.195	0.209	0.180	0.194
ys, scour depth, ft	**11.59**	**12.40**	**12.20**	**6.23**	**6.71**	**6.53**

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)	126.5	185.7	143.8	14.2	19.1	16.2
y1 (depth f/p flow, ft)	3.61	3.70	3.82	3.27	3.52	3.45
a'/y1	35.07	50.24	37.64	4.34	5.43	4.69
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.21	0.18	0.20	0.21	0.18	0.19
Ys w/ corr. factor K1/0.55:						
vertical	15.63	15.24	16.20	ERR	ERR	ERR
vertical w/ ww's	12.82	12.49	13.29	ERR	ERR	ERR
spill-through	8.60	8.38	8.91	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.67	0.82	0.73	0.67	0.82	0.73
y, depth of flow in bridge, ft	7.97	7.97	7.97	7.97	7.97	7.97
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	2.21	ERR	2.63	2.21	ERR	2.63
Fr>0.8 (vertical abut.)	ERR	3.15	ERR	ERR	3.15	ERR
Fr<=0.8 (spillthrough abut.)	**1.93**	ERR	**2.29**	**1.93**	ERR	**2.29**
Fr>0.8 (spillthrough abut.)	ERR	**2.79**	ERR	ERR	**2.79**	ERR