LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (BURKTH00070017) on TOWN HIGHWAY 7, crossing DISH MILL BROOK, BURKE, VERMONT

Open-File Report 97-757

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (BURKTH00070017) on TOWN HIGHWAY 7, crossing DISH MILL BROOK, BURKE, VERMONT

By RONDA L. BURNS and ERICK M. BOEHMLER

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Pembroke, New Hampshire

1997

U.S. DEPARTMENT OF THE INTERIOR
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 17 (BURKTH00070017) ON TOWN HIGHWAY 7, CROSSING DISH MILL BROOK, BURKE, VERMONT

By **Ronda L. Burns and Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BURKTH00070017 on Town Highway 7 crossing Dish Mill Brook, Burke, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the White Mountain section of the New England physiographic province in northeastern Vermont. The 5.9-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest on the upstream banks and the downstream right bank. On the downstream left bank, the surface cover is shrub and brushland while the immediate bank is forested.

In the study area, Dish Mill Brook has an incised, sinuous channel with a slope of approximately 0.04 ft/ft, an average channel top width of 39 ft and an average bank height of 3 ft. The channel bed material ranges from gravel to boulder with a median grain size (D_{50}) of 79.2 mm (0.241 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 7, 1995, indicated that the reach was unstable. Moderate fluvial erosion has resulted in cut-banks on the upstream and downstream channel banks.

The Town Highway 7 crossing of Dish Mill Brook is a 26-ft-long, two-lane bridge consisting of one 23-foot steel-beam span (Vermont Agency of Transportation, written communication, March 3, 1995). The opening length of the structure parallel to the bridge face is 22.5 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 10 degrees to the opening while the opening-skew-to-roadway is zero degrees.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the downstream end of the left abutment and the downstream left wingwall during the Level I assessment. The scour countermeasures at the site included type-1 stone fill (less than 12 inches diameter) at the downstream end of the downstream right wingwall, type-2 stone fill (less than 36 inches diameter) along the upstream right wingwall and upstream right bank, and type-3 stone fill (less than 48 inches diameter) at the downstream end of the downstream left wingwall. 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 1.0 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 8.0 to 11.8 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 and HIRE equations (abutment scour) give “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.

Plymouth, VT. Quadrangle, 1:24,000, 1966
Photoinspected 1983

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 BURKTH00070017 ***Stream*** Dish Mill Brook

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

Description of Bridge

Bridge length 26 ***ft*** ***Bridge width*** 23.2 ***ft*** ***Max span length*** 23 ***ft***

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

Abutment type Vertical, concrete ***Embankment type*** None

Stone fill on abutment? Yes ***Date of inspection*** 8/7/95

Description of stone fill Type-1, at the downstream end of the downstream right wingwall. Type-2, along the upstream right wingwall and upstream right bank. Type-3, at the downstream end of the downstream left wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. There is a one and a half foot deep scour hole in front of the downstream end of the left abutment and downstream left wingwall.

Yes 10

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

There is a moderate channel bend in the upstream reach. A cut-bank has developed in the location where the bend impacts the upstream left bank.

Debris accumulation on bridge at time of Level I or Level II site visit:

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	8/7/95	0	0
Level II	8/7/95	0	0

Potential for debris High. There are cut-banks upstream and downstream and many trees along the bank, some of which have already fallen in the channel upstream.

Describe any features near or at the bridge that may affect flow (include observation date) None as of 8/7/95.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley.

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

Date of inspection 8/7/95

DS left: Moderately sloped channel bank

DS right: Steep valley wall

US left: Steep valley wall

US right: Moderately sloped channel bank

Description of the Channel

Average top width 39 ***ft*** ***Average depth*** 3 ***ft***

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

Sinuous with semi-alluvial channel boundaries.

8/7/95

Vegetative co Trees with shrubs and brush on the overbank

DS left: Trees

DS right: Trees

US left: Trees

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.*** The assessment of 8/7/95 noted cut-banks on the upstream left bank, the downstream right bank and the downstream left bank.

Describe any obstructions in channel and date of observation. None as of 8/7/95.

Hydrology

Drainage area 5.9 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/White 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 1,400 ***ft³/s*** ***Q500*** 1,890 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(5.9/6.4)exp 0.67] with Flood Insurance Study values for Dish Mill Brook at the confluence with the East Branch Passumpsic River in Burke (Federal Emergency Management Agency, 1979). Dish Mill Brook enters the East Branch Passumpsic River downstream of this site and has a drainage area of 6.4 square miles at the confluence. The values used were within a range defined by flood frequency curves developed from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the curb at the downstream right corner of the bridge (elev. 501.50 ft, arbitrary survey datum). RM2 is a chiseled X on top of the curb at the upstream left corner of the bridge (elev. 501.53 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]Cross-section	*Section Reference Distance (SRD) in feet*	*[2]Cross-section development*	*Comments*
EXIT1	-23	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXIT1)
BRIDG	0	1	Bridge section
RDWAY	12	1	Road Grade section
APPRO	47	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. Channel "n" values for the reach ranged from 0.045 to 0.065, and the overbank "n" value was 0.070.

Critical depth at the exit section (EXIT1) was assumed as the starting water surface. Normal depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990) and resulted in a supercritical solution. Because normal depth was within 0.3 ft of critical depth, the critical water surface was assumed to be a satisfactory starting water surface. The slope used was 0.0381 ft/ft, which was estimated from surveyed thalweg points downstream of the bridge.

The surveyed approach section (APPRO) was 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 501.5 ***ft***
Average low steel elevation 498.5 ***ft***

100-year discharge 1,400 ***ft³/s***
Water-surface elevation in bridge opening 498.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 28 ***ft³/s***
Area of flow in bridge opening 142 ***ft²***
Average velocity in bridge opening 9.6 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.6 ***ft/s***

Water-surface elevation at Approach section with bridge 501.2
Water-surface elevation at Approach section without bridge 497.9
Amount of backwater caused by bridge 3.3 ***ft***

500-year discharge 1,890 ***ft³/s***
Water-surface elevation in bridge opening 498.5 ***ft***
Road overtopping? Yes ***Discharge over road*** 458 ***ft³/s***
Area of flow in bridge opening 142 ***ft²***
Average velocity in bridge opening 10.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 12.3 ***ft/s***

Water-surface elevation at Approach section with bridge 501.7
Water-surface elevation at Approach section without bridge 498.6
Amount of backwater caused by bridge 3.1 ***ft***

Incipient overtopping discharge 1,350 ***ft³/s***
Water-surface elevation in bridge opening 498.5 ***ft***
Area of flow in bridge opening 142 ***ft²***
Average velocity in bridge opening 9.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.5 ***ft/s***

Water-surface elevation at Approach section with bridge 501.0
Water-surface elevation at Approach section without bridge 497.8
Amount of backwater caused by bridge 3.2 ***ft***

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

Scour depths were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analysis are presented in tables 1 and 2 and a graph of the scour depths is presented in figure 8.

At this site, the 100-year, 500-year and incipient roadway-overtopping discharges resulted in unsubmerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). The computed streambed armoring depths suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also 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 presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

Scour at the left abutment was computed by use of the HIRE equation (Richardson and others, 1995, p. 49, equation 29) because the HIRE equation is recommended when the length to depth ratio of the embankment blocking flow exceeds 25. The variables used by the HIRE abutment-scour equation are defined the same as those defined for the Froehlich abutment-scour equation.

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	0.6	1.0	0.5
Depth to armoring	16.3	10.3	17.6
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	8.1	8.7	8.0
Right abutment	10.6	11.8	10.4
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	2.1	2.3	2.0
Right abutment	2.1	2.3	2.0
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

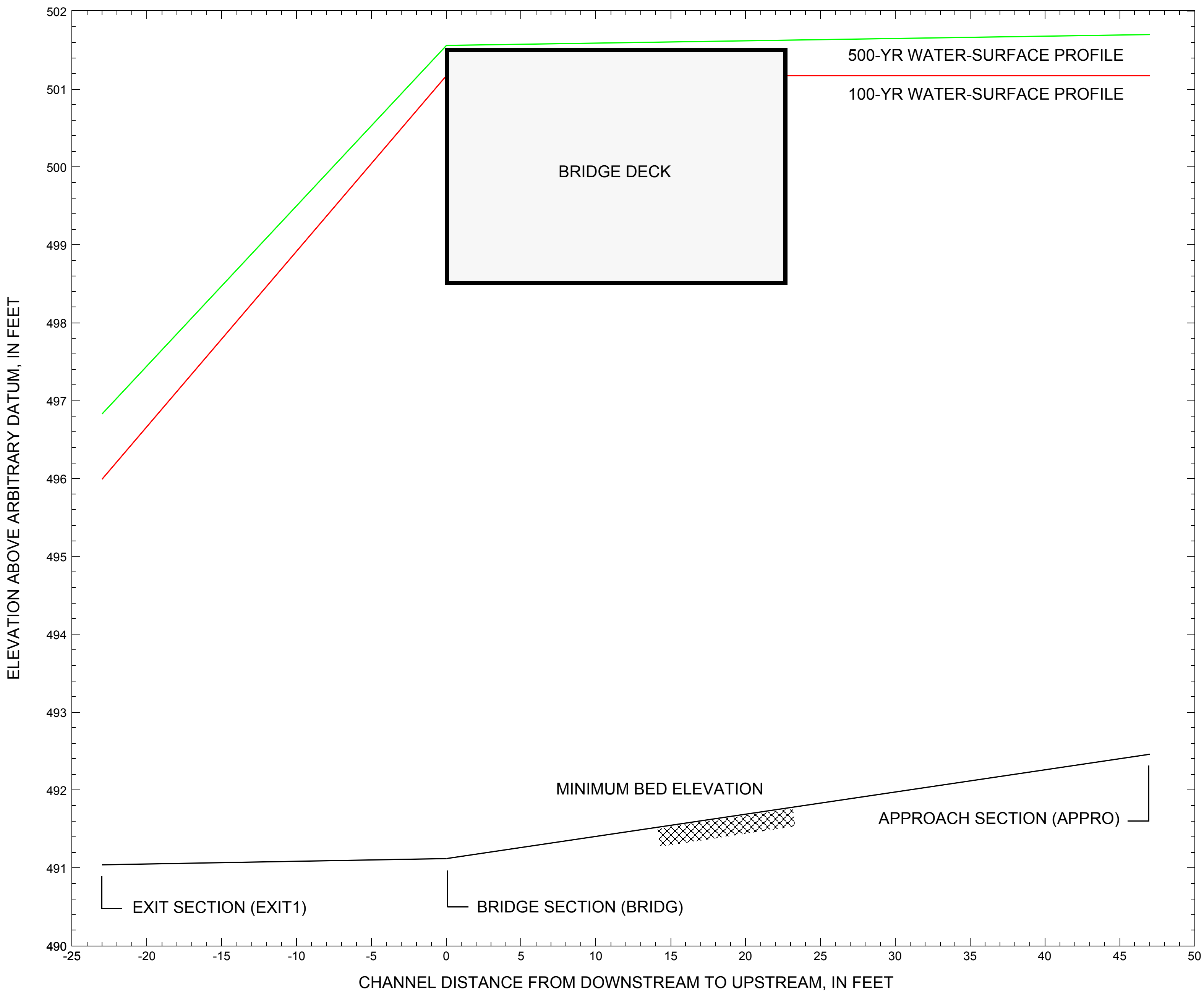

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure BURKTH00070017 on Town Highway 7, crossing Dish Mill Brook, Burke, Vermont.

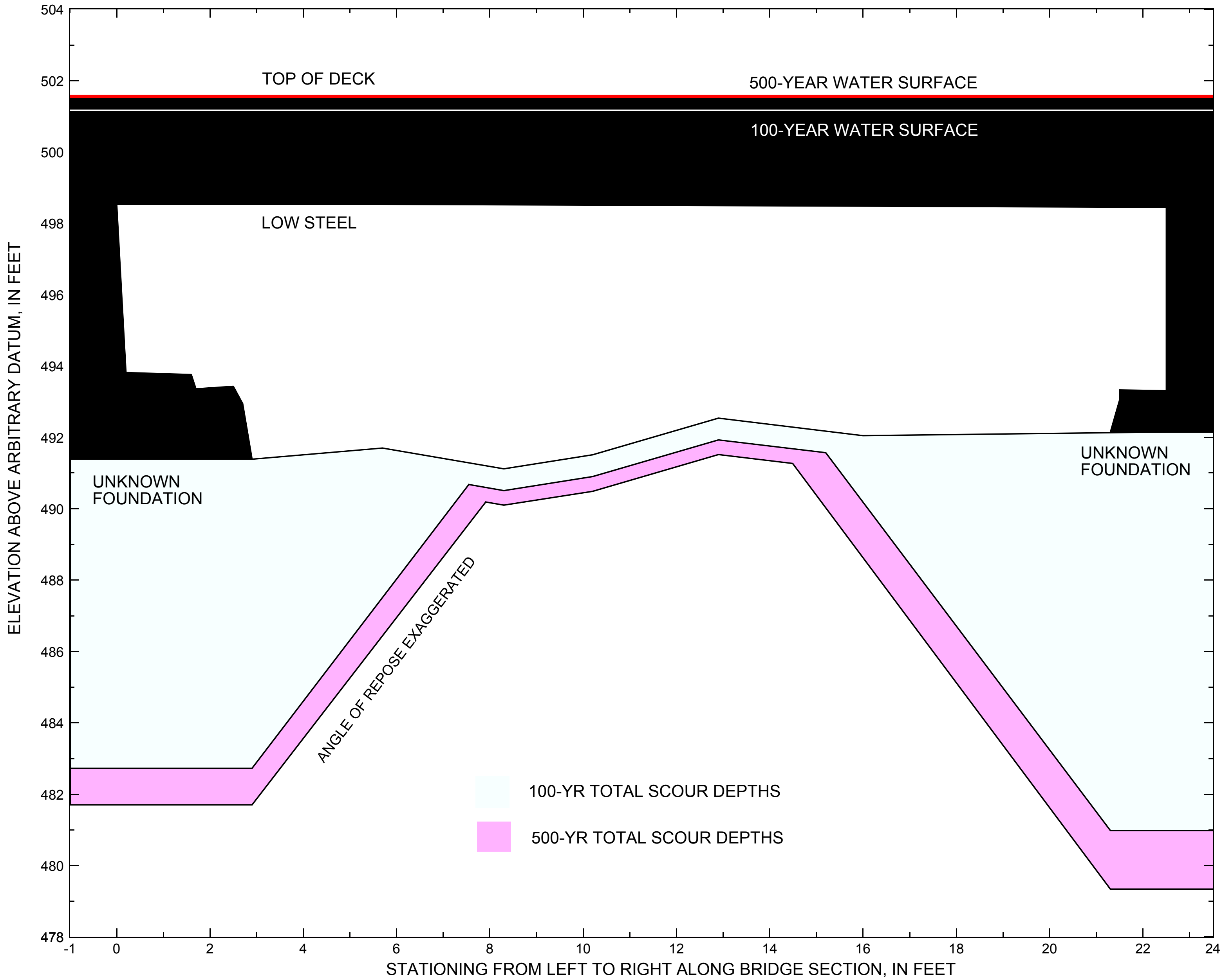

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure BURKTH00070017 on Town Highway 7, crossing Dish Mill Brook, Burke, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BURKTH00070017 on Town Highway 7, crossing Dish Mill Brook, Burke, 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-yr. discharge is 1,400 cubic-feet per second											
Left abutment	0.0	--	498.5	--	491.4	0.6	8.1	--	8.7	482.7	--
Right abutment	22.5	--	498.4	--	492.2	0.6	10.6	--	11.2	481.0	--

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 BURKTH00070017 on Town Highway 7, crossing Dish Mill Brook, Burke, 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-yr. discharge is 1,890 cubic-feet per second											
Left abutment	0.0	--	498.5	--	491.4	1.0	8.7	--	9.7	481.7	--
Right abutment	22.5	--	498.4	--	492.2	1.0	11.8	--	12.8	479.4	--

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, 1988, Burke Mountain, 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 burk017.wsp
T2        Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
T3        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
*
J1         * * 0.01
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1400.0   1890.0   1350.0
SK          0.0381   0.0381   0.0381
*
XS   EXIT1    -23           0.
GR          -45.5, 501.01    -28.3, 499.53
GR          -17.8, 496.07     -4.8, 494.60     -3.3, 493.45      0.0, 492.34
GR            2.5, 491.42      6.0, 491.33      9.2, 491.04     13.3, 491.34
GR           17.3, 491.92     21.9, 491.56     23.6, 492.21     29.0, 494.66
GR           36.7, 496.03     53.5, 499.11     63.0, 500.07     78.9, 506.51
GR           85.7, 508.99     97.0, 510.24    114.0, 510.08
*
N           0.070      0.065      0.070
SA                -4.8       29.0
*
XS   FULLV      0  * * *   0.0155
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    498.48       0.0
GR            0.0, 498.54      0.2, 493.82      1.6, 493.76      1.7, 493.36
GR            2.5, 493.43      2.7, 492.95      2.9, 491.39      5.7, 491.70
GR            8.3, 491.12     10.2, 491.51     12.9, 492.54     16.0, 492.05
GR           21.3, 492.15     21.5, 493.06     21.5, 493.33     22.5, 493.31
GR           22.5, 498.43      0.0, 498.54
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      31.2 * *     43.2      7.2
N           0.045
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     12      23.2     1
GR         -106.3, 511.55    -87.3, 499.63    -45.5, 501.01
GR          -39.1, 501.04     -0.2, 500.97     -0.2, 501.54     25.7, 501.50
GR           25.7, 501.03     72.1, 502.30     91.6, 502.98    110.9, 502.98
GR          125.8, 509.16    134.1, 510.64    149.1, 515.06
*
*    For the 100-year and incipient road-overtopping discharges the last two
*    points on the left, -106.3, 511.55 and -87.3, 499.63, were removed and a
*    vertical wall was placed at station -45.5.
*
AS   APPRO     47           0.
GR          -84.4, 519.36    -53.6, 499.77    -19.9, 499.43    -13.2, 499.26
GR           -9.8, 497.73     -4.4, 496.49     -3.1, 494.19      0.0, 492.78
GR            5.0, 493.27      7.3, 492.59     12.2, 492.46     17.1, 492.85
GR           20.3, 493.65     25.8, 494.22     30.9, 496.78     42.9, 497.71
GR           52.5, 500.03     72.2, 501.95    105.4, 503.68    116.1, 503.84
GR          122.1, 503.84    142.6, 510.86    156.2, 514.75
*
N           0.070       0.055      0.070
SA                -13.2       30.9
*
HP 1 BRIDG  498.54 1 498.54
HP 2 BRIDG  498.54 * * 1365
HP 1 BRIDG  497.17 1 497.17
HP 2 RDWAY  501.17 * * 28
HP 1 APPRO  501.17 1 501.17
HP 2 APPRO  501.17 * * 1400
*
HP 1 BRIDG  498.54 1 498.54
HP 2 BRIDG  498.54 * * 1443
HP 1 BRIDG  497.91 1 497.91
HP 2 RDWAY  501.56 * * 458
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File burk017.wsp
        Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
           *** RUN DATE & TIME: 11-10-97  11:51

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      142      8559      0     58                            0
   498.54           142      8559      0     58  1.00      0     23        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.54     0.0    22.5   142.2    8559.    1365.   9.60

X STA.         0.0        2.6        3.8        4.8        5.8        6.7
  A(I)            12.0        8.6        6.9        6.7        6.4
  V(I)            5.67       7.90       9.82      10.20      10.71

X STA.         6.7        7.6        8.4        9.2       10.1       10.9
  A(I)             6.1        6.0        5.9        6.0        6.0
  V(I)           11.23      11.35      11.62      11.40      11.42

X STA.        10.9       11.9       12.9       14.0       15.0       16.0
  A(I)             6.3        6.5        6.3        6.3        6.4
  V(I)           10.92      10.57      10.75      10.80      10.58

X STA.        16.0       17.0       18.1       19.2       20.4       22.5
  A(I)             6.4        6.6        6.9        7.7       12.1
  V(I)           10.64      10.37       9.83       8.86       5.64

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      113      8476     22     33                         1432
   497.17           113      8476     22     33  1.00      0     23     1432

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       67      1901     43     43                          473
             2      300     27967     44     47                         4445
             3       76      2775     33     34                          650
   501.17           443     32642    120    124  1.40    -55     64     4083

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.17   -55.8    64.2   442.8   32642.    1400.   3.16

X STA.       -55.8      -17.6       -5.8       -1.6        0.6        2.7
  A(I)            58.5       32.9       24.7       18.2       16.9
  V(I)            1.20       2.13       2.83       3.85       4.14

X STA.         2.7        4.7        6.7        8.6       10.3       12.0
  A(I)            16.5       16.3       15.7       15.1       15.2
  V(I)            4.25       4.30       4.47       4.64       4.62

X STA.        12.0       13.8       15.5       17.3       19.3       21.4
  A(I)            14.9       14.7       15.1       15.9       16.0
  V(I)            4.69       4.76       4.62       4.41       4.37

X STA.        21.4       23.7       26.1       29.4       36.9       64.2
  A(I)            16.6       17.0       19.8       32.0       50.9
  V(I)            4.23       4.12       3.53       2.19       1.38
```

```
        U.S. Geological Survey WSPRO Input File burk017.wsp
        Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
           *** RUN DATE & TIME: 11-10-97  11:53

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      142      8559      0     58                            0
  498.54            142      8559      0     58  1.00      0     23        0

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       498.54     0.0    22.5   142.2    8559.    1443.  10.15

X STA.         0.0        2.6        3.8        4.8        5.8        6.7
  A(I)            12.0        8.6        6.9        6.7        6.4
  V(I)            6.00       8.35      10.39      10.79      11.32

X STA.         6.7        7.6        8.4        9.2       10.1       10.9
  A(I)             6.1        6.0        5.9        6.0        6.0
  V(I)           11.87      12.00      12.28      12.05      12.07

X STA.        10.9       11.9       12.9       14.0       15.0       16.0
  A(I)             6.3        6.5        6.3        6.3        6.4
  V(I)           11.54      11.18      11.36      11.42      11.19

X STA.        16.0       17.0       18.1       19.2       20.4       22.5
  A(I)             6.4        6.6        6.9        7.7       12.1
  V(I)           11.25      10.97      10.39       9.36       5.96

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      129     10353     22     34                         1759
  497.91            129     10353     22     34  1.00      0     23     1759

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.56   -90.4    45.1    86.0    1587.     458.   5.33

X STA.       -90.4      -86.8      -85.4      -83.9      -82.4      -80.8
  A(I)             3.9        2.8        2.7        2.7        2.8
  V(I)            5.95       8.18       8.35       8.57       8.24

X STA.       -80.8      -79.0      -77.2      -75.3      -73.1      -70.7
  A(I)             2.9        3.0        3.0        3.3        3.4
  V(I)            7.84       7.71       7.56       7.00       6.71

X STA.       -70.7      -68.0      -64.9      -61.3      -56.9      -50.6
  A(I)             3.6        3.8        4.1        4.4        5.2
  V(I)            6.30       5.99       5.63       5.18       4.43

X STA.       -50.6      -39.3      -27.0      -16.4       -6.9       45.1
  A(I)             6.5        6.5        5.8        5.4       10.1
  V(I)            3.50       3.51       3.92       4.25       2.27

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1       89      3057     43     44                          729
             2      324     31689     44     47                         4974
             3       95      3649     39     39                          843
  501.70            508     38395    126    130  1.43    -56     70     4842

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.70   -56.6    69.6   508.0   38395.    1890.   3.72

X STA.       -56.6      -26.7       -9.0       -3.0       -0.4        1.8
  A(I)            58.5       45.2       30.5       21.6       19.2
  V(I)            1.62       2.09       3.10       4.37       4.92

X STA.         1.8        3.9        6.1        8.1        9.9       11.7
  A(I)            18.1       18.3       18.0       16.9       17.0
  V(I)            5.23       5.17       5.25       5.60       5.57

X STA.        11.7       13.6       15.4       17.3       19.4       21.6
  A(I)            16.9       16.6       17.1       17.6       18.1
  V(I)            5.60       5.68       5.52       5.36       5.23

X STA.        21.6       24.0       26.7       30.3       38.4       69.6
  A(I)            18.3       20.0       22.2       37.9       60.1
  V(I)            5.18       4.71       4.25       2.49       1.57
```

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         U.S. Geological Survey WSPRO Input File burk017.wsp
         Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
         TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
            *** RUN DATE & TIME: 11-10-97  11:51

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      142      8559      0     58                            0
    498.54           142      8559      0     58  1.00      0     23        0

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        498.54     0.0    22.5   142.2    8559.    1350.   9.49

 X STA.        0.0        2.6        3.8        4.8        5.8        6.7
   A(I)            12.0        8.6        6.9        6.7        6.4
   V(I)            5.61       7.81       9.72      10.09      10.59

 X STA.        6.7        7.6        8.4        9.2       10.1       10.9
   A(I)             6.1        6.0        5.9        6.0        6.0
   V(I)           11.11      11.22      11.49      11.27      11.30

 X STA.       10.9       11.9       12.9       14.0       15.0       16.0
   A(I)             6.3        6.5        6.3        6.3        6.4
   V(I)           10.80      10.46      10.63      10.68      10.47

 X STA.       16.0       17.0       18.1       19.2       20.4       22.5
   A(I)             6.4        6.6        6.9        7.7       12.1
   V(I)           10.52      10.26       9.72       8.76       5.57

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      111      8254     22     33                         1394
    497.08           111      8254     22     33  1.00      0     23     1394

     CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      47.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1       60      1597     42     43                          404
              2      293     26880     44     47                         4290
              3       71      2549     32     32                          599
    501.01           424     31026    118    122  1.39    -55     63     3870

     VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      47.

          WSEL     LEW     REW    AREA        K        Q    VEL
        501.01   -55.5    62.6   423.7   31026.    1350.   3.19

 X STA.      -55.5      -14.3       -4.8       -1.2        1.0        3.0
   A(I)            58.0       29.7       22.7       17.6       16.1
   V(I)            1.16       2.27       2.97       3.82       4.18

 X STA.        3.0        5.0        6.9        8.7       10.4       12.1
   A(I)            16.0       15.6       15.0       14.4       14.5
   V(I)            4.22       4.32       4.50       4.69       4.66

 X STA.       12.1       13.8       15.5       17.3       19.2       21.3
   A(I)            14.5       14.3       14.7       15.1       15.4
   V(I)            4.66       4.74       4.60       4.47       4.37

 X STA.       21.3       23.6       25.9       29.2       36.2       62.6
   A(I)            15.9       16.4       19.3       29.0       49.5
   V(I)            4.23       4.12       3.50       2.33       1.36
```

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        U.S. Geological Survey WSPRO Input File burk017.wsp
        Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
        TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
           *** RUN DATE & TIME: 11-10-97  11:51

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXIT1":  USED WSI = CRWS.
                           WSI,CRWS =   495.88     496.01

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

EXIT1:XS   ******    -16      147  1.58 *****  497.58  496.01    1400  496.01
       -22 ******     37     7618  1.12 ***** *******    1.07    9.53

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.43

FULLV:FV       23    -19      193  0.96  0.54  498.13 *******    1400  497.17
         0     23     41    10872  1.17  0.00    0.00    0.78    7.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.87     497.91     497.33
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   496.67     519.36    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   496.67     519.36     497.33

APPRO:AS       47     -9      166  1.18  0.83  499.07  497.33    1400  497.89
        47     47     44    10166  1.06  0.11    0.00    0.88    8.46
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   497.10     500.11     500.27     498.48
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       23      0      142  1.43 *****  499.97  497.02    1365  498.54
         0 ******     23     8559  1.00 ***** *******    0.67    9.60

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.490  0.000  498.48 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    24.  0.04  0.22  501.34    0.00     28.  501.17

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     27.    45.   -46.     0.   0.2   0.2   2.6   3.6   0.3   3.0
   RT:      2.     5.    26.    31.   0.1   0.1   2.2   5.1   0.2   3.0

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

APPRO:AS       16    -55      443  0.22  0.11  501.39  497.33    1400  501.17
        47     16     64    32658  1.40  0.88    0.00    0.34    3.16

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

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   EXIT1:XS     -23.   -17.    37.   1400.     7618.     147.    9.53  496.01
   FULLV:FV       0.   -20.    41.   1400.    10872.     193.    7.24  497.17
   BRIDG:BR       0.     0.    23.   1365.     8559.     142.    9.60  498.54
   RDWAY:RG      12.*******    27.     28.*********       0.    1.00  501.17
   APPRO:AS      47.   -56.    64.   1400.    32658.     443.    3.16  501.17

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF    HO  VHD      EGL    WSEL
   EXIT1:XS     496.01    1.07  491.04  510.24************  1.58  497.58  496.01
   FULLV:FV   ********    0.78  491.40  510.60  0.54  0.00  0.96  498.13  497.17
   BRIDG:BR     497.02    0.67  491.12  498.54************  1.43  499.97  498.54
   RDWAY:RG   ****************  500.97  515.06  0.04******  0.22  501.34  501.17
   APPRO:AS     497.33    0.34  492.46  519.36  0.11  0.88  0.22  501.39  501.17
```

```
       U.S. Geological Survey WSPRO Input File burk017.wsp
       Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
       TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
          *** RUN DATE & TIME: 11-10-97  11:53

 ===015 WSI IN WRONG FLOW REGIME AT SECID “EXIT1”:  USED WSI = CRWS.
                           WSI,CRWS =   496.54     496.84

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

EXIT1:XS   ******    -19      195  1.71 *****  498.56  496.84    1890  496.84
       -22 ******     41    11010  1.17 ***** *******    1.04    9.68

 ===125 FR# EXCEEDS FNTEST AT SECID “FULLV”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.80     497.92     497.20
 ===110 WSEL NOT FOUND AT SECID “FULLV”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.34     510.60    0.50
 ===115 WSEL NOT FOUND AT SECID “FULLV”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.34     510.60     497.20

FULLV:FV       23    -21      241  1.16  0.52  499.06  497.20    1890  497.91
         0     23     45    14461  1.20  0.00   -0.01    0.80    7.86
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID “APPRO”:  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.89     498.64     498.24
 ===110 WSEL NOT FOUND AT SECID “APPRO”:  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   497.41     519.36    0.50
 ===115 WSEL NOT FOUND AT SECID “APPRO”:  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   497.41     519.36     498.24

APPRO:AS       47    -11      207  1.43  0.86  500.05  498.24    1890  498.62
        47     47     47    13577  1.10  0.14    0.00    0.90    9.15
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   501.97       0.00     498.21     499.63
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   497.74     501.01     501.18     498.48
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
           <<<<<RESULTS REFLECTING THE CONSTRICTED FLOW FOLLOW>>>>>

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

BRIDG:BR       23      0      142  1.60 *****  500.14  497.20    1443  498.54
         0 ******     23     8559  1.00 ***** *******    0.71   10.15

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****    5.  0.494  0.000  498.48 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      12.    24.  0.06  0.31  501.95    0.01    458.  501.56

              Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    414.   101.   -90.    11.   1.9   0.8   5.2   5.1   1.2   3.2
   RT:     44.    34.    11.    45.   0.5   0.2   3.4   7.4   0.6   3.1

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

APPRO:AS       16    -56      508  0.31  0.14  502.01  498.24    1890  501.70
        47     17     70    38414  1.43  0.89    0.01    0.39    3.72

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

  FIRST USER DEFINED TABLE.
    XSID:CODE     SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXIT1:XS     -23.   -20.    41.   1890.   11010.     195.    9.68  496.84
   FULLV:FV       0.   -22.    45.   1890.   14461.     241.    7.86  497.91
   BRIDG:BR       0.     0.    23.   1443.    8559.     142.   10.15  498.54
   RDWAY:RG      12.*******   414.    458.*********       0.    1.00  501.56
   APPRO:AS      47.   -57.    70.   1890.   38414.     508.    3.72  501.70

 SECOND USER DEFINED TABLE.
    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    496.84    1.04  491.04  510.24************  1.71  498.56  496.84
   FULLV:FV    497.20    0.80  491.40  510.60  0.52  0.00  1.16  499.06  497.91
   BRIDG:BR    497.20    0.71  491.12  498.54************  1.60  500.14  498.54
   RDWAY:RG  ****************  499.63  515.06  0.06******  0.31  501.95  501.56
   APPRO:AS    498.24    0.39  492.46  519.36  0.14  0.89  0.31  502.01  501.70
```

WSPRO OUTPUT FILE (continued)

```
       U.S. Geological Survey WSPRO Input File burk017.wsp
       Hydraulic analysis for structure BURKTH00070017   Date: 25-JUL-97
       TH 7 CROSSING DISH MILL BROOK IN BURKE, VT                RLB
          *** RUN DATE & TIME: 11-10-97  11:51

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXIT1":  USED WSI = CRWS.
                           WSI,CRWS =   495.81     495.91

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

EXIT1:XS   ******    -15      142  1.56 *****  497.47  495.91    1350  495.91
       -22 ******     36     7287  1.11 ***** *******    1.07    9.51

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                           "FULLV"     KRATIO =  1.44

FULLV:FV       23    -19      188  0.94  0.55  498.02 *******    1350  497.08
         0     23     40    10474  1.17  0.00    0.00    0.78    7.19
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80     0.87     497.82     497.22
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   496.58     519.36    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   496.58     519.36     497.22

APPRO:AS       47     -9      161  1.16  0.83  498.96  497.22    1350  497.81
        47     47     43     9802  1.06  0.11    0.00    0.88    8.39
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   496.98     499.93     500.10     498.48
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       23      0      142  1.38 *****  499.92  496.96    1338  498.54
         0 ******     23     8559  1.00 ***** *******    0.66    9.41

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.487  0.000  498.48 ****** ****** ******

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

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

APPRO:AS       16    -55      424  0.22  0.11  501.23  497.22    1350  501.01
        47     16     63    31010  1.38  0.89   -0.01    0.35    3.19

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   500.96

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXIT1:XS     -23.   -16.    36.   1350.    7287.     142.    9.51  495.91
   FULLV:FV       0.   -20.    40.   1350.   10474.     188.    7.19  497.08
   BRIDG:BR       0.     0.    23.   1338.    8559.     142.    9.41  498.54
   RDWAY:RG      12.**************      0.       0.       0.    1.00********
   APPRO:AS      47.   -56.    63.   1350.   31010.     424.    3.19  501.01

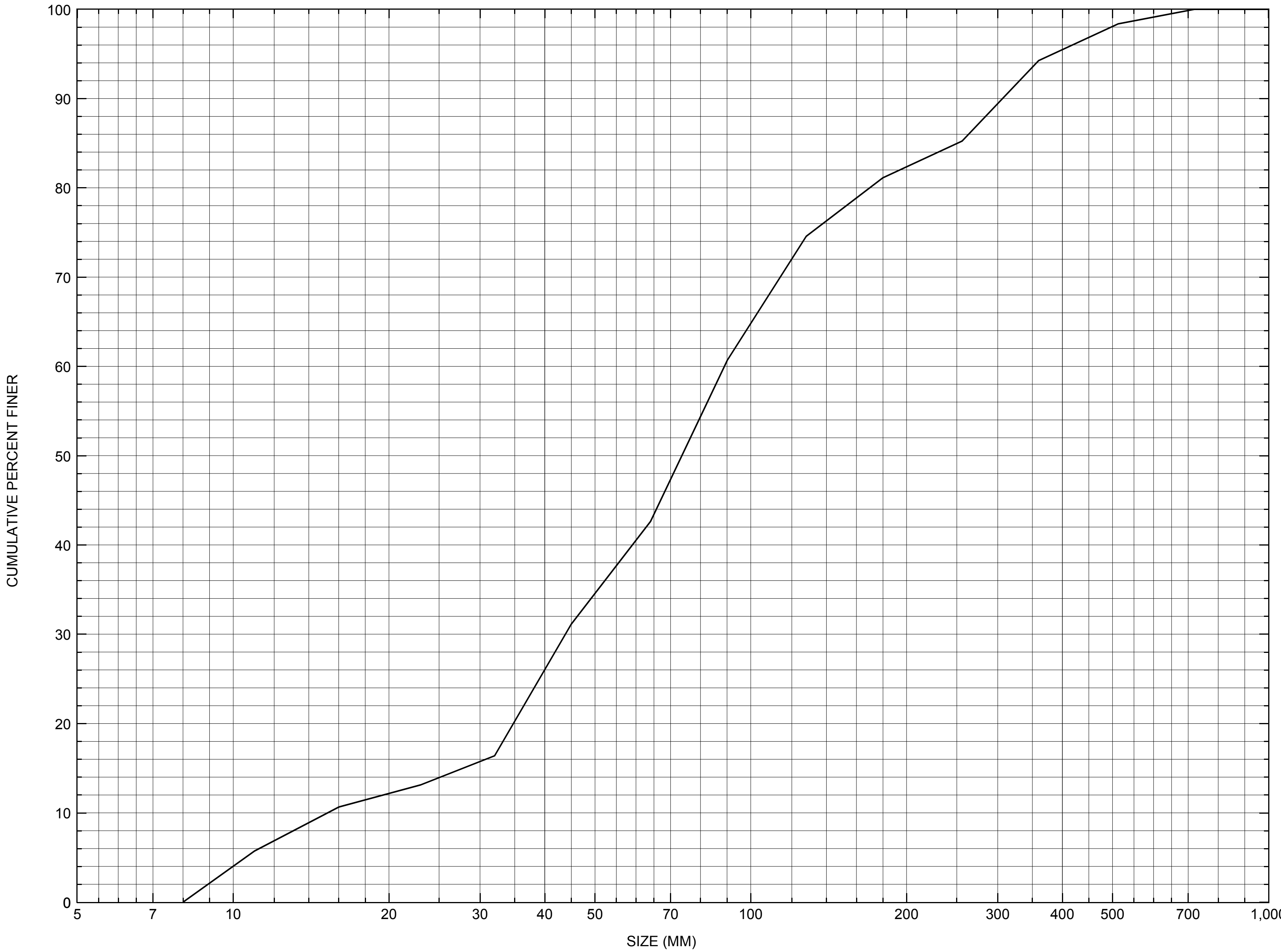
    XSID:CODE   XLKQ   XRKQ        KQ
   APPRO:AS  ***********************

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXIT1:XS    495.91    1.07  491.04  510.24************  1.56  497.47  495.91
   FULLV:FV  ********    0.78  491.40  510.60  0.55  0.00  0.94  498.02  497.08
   BRIDG:BR    496.96    0.66  491.12  498.54************  1.38  499.92  498.54
   RDWAY:RG  ****************  500.97  515.06************  0.22  501.18********
   APPRO:AS    497.22    0.35  492.46  519.36  0.11  0.89  0.22  501.23  501.01
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BURKTH00070017, in Burke, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **BURKTH00070017**

General Location Descriptive

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

Date *(MM/DD/YY)* **03** / **24** / **95**

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

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

Town *(FIPS place code; I - 4; nnnnn)* **10450**

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

Waterway *(I - 6)* **DISH MILL BROOK**

Road Name *(I - 7):* **-**

Route Number **TH007**

Vicinity *(I - 9)* **0.6 MI JCT TH 7 + VT 114**

Topographic Map **Burke.Mountain**

Hydrologic Unit Code: **01080102**

Latitude *(I - 16; nnnn.n)* **44354**

Longitude *(i - 17; nnnnn.n)* **71558**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10030200170302**

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

Maximum span length *(I - 48; nnnn)* **0023**

Year built *(I - 27; YYYY)* **1929**

Structure length *(I - 49; nnnnnn)* **000026**

Average daily traffic, ADT *(I - 29; nnnnnn)* **000800**

Deck Width *(I - 52; nn.n)* **232**

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

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

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

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

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

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

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

Year Reconstructed *(I - 106)* **0000**

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

Clear span (*nnn.n ft*) **023.2**

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

Vertical clearance from streambed (*nnn.n ft*) **007.0**

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

Waterway of full opening (*nnn.n ft²*) **162.4**

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel stringer type bridge with a concrete deck. The abutment walls and wingwalls are concrete. Both wingwalls on the right abutment are cracked off vertically at the corners where the abutment wall meets both wingwalls. The embankment area between the wingwalls and the roadway surface have been paved to prevent further erosion. Riprap is reported as added in front of the right upstream wingwall to help stabilize it. Some of the pavement has broken away and eroded from the embankment at this wingwall. The right abutment footing is exposed and has cracked vertically in a couple of places. The left abutment reportedly (Continued, page 33)

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

Discharge Data *(cfs)*: $Q_{2.33}$ - Q_{10} - Q_{25} -
Q_{50} - Q_{100} - Q_{500} -

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

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

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

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

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

Describe any significant site conditions upstream or downstream that may influence the stream's stage: **This bridge may be eliminated under a proposal to straighten the channel and build a slightly larger bridge where the current bridge no. 16 is located just downstream. The proposal is currently being considered by the Corp. of engineers, who will permit the project and channel straightening if approved.**

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

Upstream distance (*miles*): 0.2 Town: Burke Year Built: 1929

Highway No. : TH07 Structure No. : 18 Structure Type: concrete slab

Clear span (*ft*): 20.2 Clear Height (*ft*): 8.0 Full Waterway (ft^2): 161.6

Downstream distance (*miles*): **0.3** Town: **Burke** Year Built: **1929**
Highway No. : **TH07** Structure No. : **16** Structure Type: **Concrete, steel beam**
Clear span (*ft*): **24.8** Clear Height (*ft*): **7.5** Full Waterway (ft^2): **186.0**

Comments:

has a full-height vertical crack through the wall and its footing. A 6 foot section at the downstream end is reported undermined between 4 and 12 inches vertically with horizontal penetration reaching between 6 and 30 inches. Both abutment walls have a few minor cracks and spalls overall. The report mentions a few boulders present on bank areas where previous erosion has occurred both up- and downstream from the bridge. The foundation type recorded for this bridge site is an unknown foundation. A full hydraulics report does not exist in the files.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **5.95** mi^2 Lake/pond/swamp area **0** mi^2

Watershed storage *(ST)* **0** %

Bridge site elevation **985** ft Headwater elevation **2930** ft

Main channel length **4.24** mi

10% channel length elevation **1070** ft 85% channel length elevation **2030** ft

Main channel slope *(S)* **269.31** 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? **Y** *If no, type ctrl-n xs*

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

Comments: **This cross section is the downstream face. The low chord elevations are from the survey log done for this report on 8/7/95. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 10/31/94. The sketch was done on 10/27/92.**

Station	0	3.2	17.3	21	-	-	-	-	-	-	-
Feature	RAB			LAB	-	-	-	-	-	-	-
Low chord elevation	498.4	498.4	498.5	498.5	-	-	-	-	-	-	-
Bed elevation	493.3	492.1	490.5	493.7	-	-	-	-	-	-	-
Low chord-bed	5.1	6.3	8.0	4.8	-	-	-	-	-	-	-

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

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

Comments: -

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **2/29/96**
Computerized by: **RB** Date: **2/29/96**
Reviewd by: **RB** Date: **8/22/97**

Structure Number **BURKTH00070017**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E**. **BOEHMLER** Date *(MM/DD/YY)* **8** / **7** / 19**95**

2. Highway District Number **07** Mile marker **0000**

County **CALEDONIA 005** Town **BURKE 10450**

Waterway *(I - 6)* **DISH MILL BROOK** Road Name **-**

Route Number **TH07** Hydrologic Unit Code: **01080102**

3. Descriptive comments:
Located about 0.6 miles east of the intersection of TH07 with VT114.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **6** LBDS **5** 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 **26** *(feet)* Span length **23** *(feet)* Bridge width **23.2** *(feet)*

Road approach to bridge:

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

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

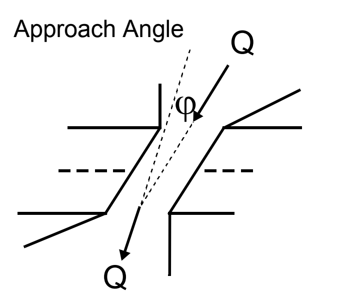
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

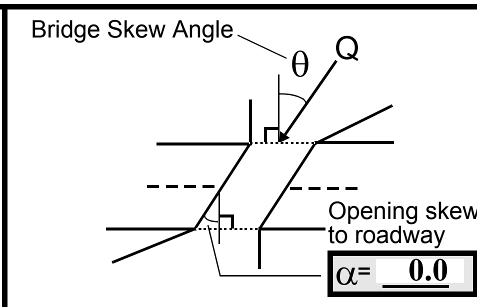
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	0
RBUS	2	1	2	1
RBDS	0	-	2	1
LBDS	0	-	0	0

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

Channel approach to bridge (BF):

15. Angle of approach: **0** 16. Bridge skew: **10**





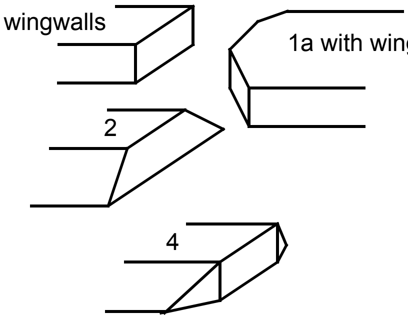
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **115** feet **US** *(US, UB, DS)* to **90** feet **US**

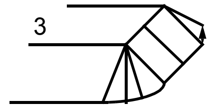
Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **1**
Range? **10** feet **US** *(US, UB, DS)* to **0** feet **DS**

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

18. Bridge Type: **1a**

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
Wingwalls parallel to abut. face
3- Spill through abutments
4- Sloping embankment, vertical wingwalls and abutments
Wingwall angle less than 90°.





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

7. Values from the VT AOT files. Measured values of the bridge length = 26.5 feet, span length = 23.5 feet, and bridge width = 23.3 feet.
4. The surface cover is as indicated except on the DS left bank where shrubs and brush make up 80% of the area with the remaining being tree coverage along the immediate bank.
13. Roadwash on the DS right and left banks is very slight. While there is a road drainage ditch that enters just DS on the right bank, the ditch is well away from the DS right wingwall. There is also a small drainage pipe that takes off roadway water that enters here. The US right wingwall has a history of roadwash erosion according to the historical form. There is fill material in place on the bank just US of the US right wingwall and paving on the road embankment behind the wingwall. There are also many storm drainage gullies in the road embankment material which drain into a larger ditch running parallel with the road embankment to the right bank of the stream. Currently there is only slight erosion here.

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
25.5	**5.0**			**2.5**	**4**	**4**	**534**	**324**	**2**	**1**

23. Bank width **25.0**   24. Channel width **25.0**   25. Thalweg depth **43.0**   29. Bed Material **354**

30 .Bank protection type: LB **0** RB **2**   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.):
The protection on the right bank is in the range of 20 feet US to 10 feet US where the same stone fill begins protecting the US right wingwall.

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? **Y** (Y or if N type ctrl-n cb) 40. Where? **LB** (LB or RB)

41. Mid-bank distance: **100** 42. Cut bank extent: **135** feet **US** (US, UB) to **0** feet **US** (US, UB, DS)

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

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

Whole trees have fallen over with the trunk still in the failed bank material. The bank appears undermined as erosion is concentrated where the soil is in contact with the semi-alluvial bouldery, cobbley, gravel material underneath. There is extensive exposure of tree roots in the eroding soil layer along the entire extent of the left bank US indicated above.

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? **Y** (Y or if N type ctrl-n mc) 50. How many? **1**

51. Confluence 1: Distance **35** 52. Enters on **RB** (LB or RB) 53. Type **2** (1- perennial; 2- ephemeral)

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

54. Confluence comments (eg. confluence name):

The confluence is nameless, but at the mouth has a 15 ft width and forms a cut off channel taking flow during over bank floods, which occurred on about August 4, 1995.

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
29.0		**1.5**		**2**	**7**	**7**	**-**

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

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

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

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

345

The thalweg mainly runs along the left abutment and the bed elevation is about 1 foot lower along the left abutment side than along the right abutment side. Bed erosion also seems concentrated along the left abutment footing.

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 3____ *(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

The stream has a lot of cut banks with lots of trees on the banks lending to a high potential for debris generation but the reach through the bridge is straight and at a high gradient, with few obstructions. For these reasons, debris and ice probably do not accumulate at this site.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		10	90	2	3	1.5	4.0	90.0
RABUT	1	-	90			2	2	22.5

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

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

0

1.5

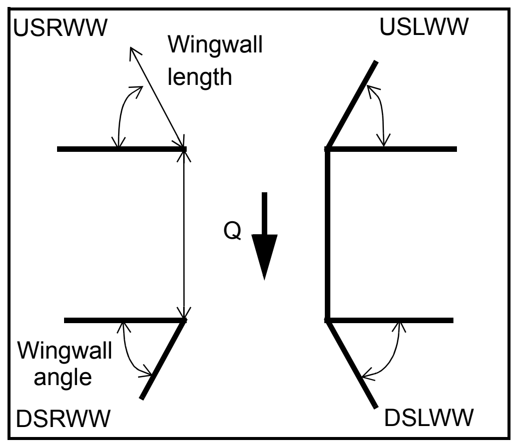
1

The right abutment footing is exposed but not undermined. The exposure varies randomly from 1.0-1.5 feet. The undermined portion of the left abutment is only along the DS end for 8 feet. The footing and subfooting have settled a bit here as there is a vertical crack up through both footings and the height of the left abutment wall about 8 feet under the bridge from the DS face. The remaining portion of the footing/subfooting is only exposed between 1.5 and 2.5 feet. There is a scour hole along the DS end of the left abutment and the DS left wingwall which is 24 feet long, from 7 ft under the bridge to 17 ft DS. It is 8 feet wide and 1.5 feet deep at the deepest point located about 1 foot DS of the DS face and positioned 0% LB - 0% RB.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						22.5	
USRWW:	Y		1		2	2.0	
DSLWW:	0		2.0		Y	24.0	
DSRWW:	1		1		0	25.0	

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	1.0	3	Y	0	-	1	-	-
Condition	Y	1.0	1	0.5	-	1	-	-
Extent	1	3.0	2	0	2	0	0	-

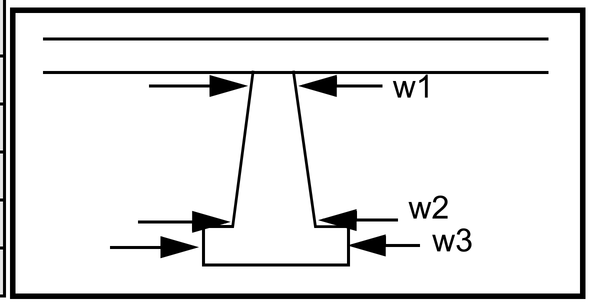
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
3
1
3
1
2
3

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**9.0**		**55.0**	**30.0**	**11.0**
Pier 2		**9.0**	**6.5**	**45.0**	**20.0**	**-**
Pier 3	**-**	**-**	**-**	**-**	**-**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e foot-**	**with**	**right**	**right**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**ing**	**type-**	**wing**	**abut**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**on**	**2**	**wall**	**ment**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**the**	**stone**	**foot-**	**foot-**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**US**	**fill**	**ing is**	**ing**	*Y- yes; N- no*
91. Attack ∠ (BF)	**right**	**its**	**expo**	**abou**	
92. Pushed	**wing**	**entir**	**sed**	**t 0.5**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**wall**	**e**	**near**	**feet,**	
95. Cross-members	**has**	**lengt**	**wher**	**then**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**been**	**h.**	**e it**	**the**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**cov-**	**The**	**meet**	**foot-**	
98. Exposure depth	**ered**	**DS**	**s the**	**ing is**	

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

covered by road embankment fill material, which is slumping as material is eroded along the toe of the fill. The DS left wingwall footing and subfooting are undermined with up to 2 feet of penetration. Protection here is type-3 and includes a very large boulder around and over which the DS left wingwall footing is molded.

E. Downstream Channel Assessment

100.

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

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

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

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

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

Is channel scour present? _____ (Y or if N type ctrl-n cs) Mid-scour distance: 4

Scour dimensions: Length 4 Width 235 Depth: 523 Positioned 2 %LB to 2 %RB

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

345
0
0
-

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

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

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

Confluence comments (eg. confluence name):

F. Geomorphic Channel Assessment

107. Stage of reach evolution ____

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)*:

N

-

NO DROP STRUCTURE

109. G. Plan View Sketch

- Y

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: BURKTH00070017 Town: BURKE
Road Number: TH 7 County: CALEDONIA
Stream: DISH MILL BROOK

Initials RLB Date: 8/5/97 Checked: ECW

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	1400	1890	1350
Main Channel Area, ft2	300	324	293
Left overbank area, ft2	67	89	60
Right overbank area, ft2	76	95	71
Top width main channel, ft	44	44	44
Top width L overbank, ft	43	43	42
Top width R overbank, ft	33	39	32
D50 of channel, ft	0.2414	0.2414	0.2414
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	6.8	7.4	6.7
y1, average depth, LOB, ft	1.6	2.1	1.4
y1, average depth, ROB, ft	2.3	2.4	2.2
Total conveyance, approach	32642	38395	31026
Conveyance, main channel	27967	31689	26880
Conveyance, LOB	1901	3057	1597
Conveyance, ROB	2775	3649	2549
Percent discrepancy, conveyance	-0.0031	0.0000	0.0000
Qm, discharge, MC, cfs	1199.5	1559.9	1169.6
Ql, discharge, LOB, cfs	81.5	150.5	69.5
Qr, discharge, ROB, cfs	119.0	179.6	110.9
Vm, mean velocity MC, ft/s	4.0	4.8	4.0
Vl, mean velocity, LOB, ft/s	1.2	1.7	1.2
Vr, mean velocity, ROB, ft/s	1.6	1.9	1.6
Vc-m, crit. velocity, MC, ft/s	9.6	9.7	9.6
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	1400	1890	1350
(Q) discharge thru bridge, cfs	1365	1443	1350
Main channel conveyance	8559	8559	8559
Total conveyance	8559	8559	8559
Q2, bridge MC discharge,cfs	1365	1443	1350
Main channel area, ft2	142	142	142
Main channel width (normal), ft	22.5	22.5	22.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	22.5	22.5	22.5
y_bridge (avg. depth at br.), ft	6.32	6.32	6.32
Dm, median (1.25*D50), ft	0.30175	0.30175	0.30175
y2, depth in contraction,ft	5.88	6.17	5.83
ys, scour depth (y2-ybridge), ft	-0.44	-0.15	-0.49

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	1365	1443	1350
Main channel area (DS), ft2	113	129	111
Main channel width (normal), ft	22.5	22.5	22.5
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	22.5	22.5	22.5
D90, ft	1.0053	1.0053	1.0053
D95, ft	1.2584	1.2584	1.2584
Dc, critical grain size, ft	0.8706	0.7008	0.8903
Pc, Decimal percent coarser than Dc	0.138	0.169	0.132
Depth to armoring, ft	16.32	10.34	17.56

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	1400	1890	1350
Q, thru bridge MC, cfs	1365	1443	1350
Vc, critical velocity, ft/s	9.61	9.74	9.57
Va, velocity MC approach, ft/s	4.00	4.81	3.99
Main channel width (normal), ft	22.5	22.5	22.5
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	22.5	22.5	22.5
qbr, unit discharge, ft2/s	60.7	64.1	60.0
Area of full opening, ft2	142.2	142.2	142.2
Hb, depth of full opening, ft	6.32	6.32	6.32
Fr, Froude number, bridge MC	0.67	0.71	0.66
Cf, Fr correction factor (<=1.0)	1.00	1.00	1.00
**Area at downstream face, ft2	113	129	111
**Hb, depth at downstream face, ft	5.02	5.73	4.93
**Fr, Froude number at DS face	0.95	0.82	0.96
**Cf, for downstream face (<=1.0)	1.00	1.00	1.00
Elevation of Low Steel, ft	498.48	498.48	498.48
Elevation of Bed, ft	492.16	492.16	492.16
Elevation of Approach, ft	501.17	501.7	501.01
Friction loss, approach, ft	0.04	0.14	0.11
Elevation of WS immediately US, ft	501.13	501.56	500.90
ya, depth immediately US, ft	8.97	9.40	8.74
Mean elevation of deck, ft	501.52	501.52	501.52
w, depth of overflow, ft (>=0)	0.00	0.04	0.00
Cc, vert contrac correction (<=1.0)	0.91	0.90	0.92
**Cc, for downstream face (<=1.0)	0.79	0.862481	0.79
Ys, scour w/Chang equation, ft	0.61	1.02	0.51
Ys, scour w/Umbrell equation, ft	-0.50	0.44	-0.64

**=for UNsubmerged orifice flow using estimated downstream bridge face properties.

**Ys, scour w/Chang equation, ft	2.97	1.90	3.00

**Ys, scour w/Umbrell equation, ft	0.80	1.02	0.75

In UNsubmerged orifice flow, an adjusted scour depth using the Laursen equation results and the estimated downstream bridge face properties can also be computed (ys=y2-ybridgeDS)

y2, from Laursen's equation, ft	5.88	6.17	5.83
WSEL at downstream face, ft	497.17	497.91	497.08
Depth at downstream face, ft	5.02	5.73	4.93
Ys, depth of scour (Laursen), ft	0.86	0.44	0.89

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	1400	1890	1350	1400	1890	1350
a', abut.length blocking flow, ft	55.8	56.6	55.5	41.7	47.1	40.1
Ae, area of blocked flow ft2	121.99	128.18	120	128	147.49	121.8
Qe, discharge blocked abut.,cfs	--	--	239.32	--	--	302.28
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.02	2.48	1.99	2.47	2.88	2.48
ya, depth of f/p flow, ft	2.19	2.26	2.16	3.07	3.13	3.04
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.82	0.82	0.82	0.82	0.82	0.82
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	90	90	90	90	90	90
K2	1.00	1.00	1.00	1.00	1.00	1.00
Fr, froude number f/p flow	0.234	0.261	0.239	0.248	0.283	0.251
ys, scour depth, ft	8.94	9.68	8.95	10.56	11.79	10.42

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)	55.8	56.6	55.5	41.7	47.1	40.1
y1 (depth f/p flow, ft)	2.19	2.26	2.16	3.07	3.13	3.04
a'/y1	25.52	25.00	25.67	13.59	15.04	13.20
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.23	0.26	0.24	0.25	0.28	0.25
Ys w/ corr. factor K1/0.55:						
vertical	9.85	10.57	9.81	ERR	ERR	ERR
vertical w/ ww's	8.07	8.67	8.04	ERR	ERR	ERR
spill-through	5.41	5.82	5.39	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	0.95	0.82	0.96	0.95	0.82	0.96
y, depth of flow in bridge, ft	5.02	5.73	4.93	5.02	5.73	4.93
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR
Fr>0.8 (vertical abut.)	2.07	2.27	2.04	2.07	2.27	2.04