LEVEL II SCOUR ANALYSIS FOR BRIDGE 32 (BURKTH00440032) on TOWN HIGHWAY 44, crossing ROUNDY BROOK, BURKE, VERMONT

Open-File Report 98-554

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 32 (BURKTH00440032) on TOWN HIGHWAY 44, crossing ROUNDY BROOK, BURKE, VERMONT

By MICHELLE M. SERRA AND ERICK M. BOEHMLER

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

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Open-File Reports Unit
Box 25286
Denver, CO 80225-0286

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

BF	bank full	LWW	left wingwall
cfs	cubic feet per second	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 32 (BURKTH00440032) ON TOWN HIGHWAY 44, CROSSING ROUNDY BROOK, BURKE, VERMONT

By **Michelle M. Serra and Erick Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BURKTH00440032 on Town Highway 44 crossing Roundy 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 (FHWA, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the White Mountain section of the New England physiographic province in northeastern Vermont. The 9.24-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is pasture on the upstream right bank and forested on the remaining banks.

In the study area, Roundy Brook has a sinuous channel with a slope of approximately 0.030 ft/ft, an average channel top width of 46 ft and an average bank height of 8 ft. The channel bed material ranges from gravel to boulders under the bridge and downstream, and from silt to gravel in the upstream reach. The median grain size (D_{50}) is 28.7 mm (0.094 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 8, 1995, indicated that the reach was degraded. A crude downstream drop structure has kept the under-bridge bed elevation artificially high, while bed elevations in the upstream and downstream reaches are similar to one another and lower than under the bridge.

The Town Highway 44 crossing of Roundy Brook is a 43-ft-long, one-lane bridge consisting of one 39-foot steel-girder and floorbeam span (Vermont Agency of Transportation, written communication, March 24, 1995). The opening length of the structure parallel to the bridge face is 36.4 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed zero degrees to the opening and the opening-skew-to-roadway is also zero degrees.

No scour holes were noted at this site during the Level 1 assessment. Scour protection at this site consisted of type-2 (less than 36 inches diameter) stone fill on the downstream left and right wingwalls, the upstream right wingwall, and the downstream left bank. During the Level I assessment, the right abutment and downstream right wingwall footings were exposed up to 0.5 ft. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.

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

Contraction scour for all modelled flows ranged from 2.4 to 3.4 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 7.5 to 12.9 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 Davis, 1995, p. 46). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Burke Mountain, VT. Quadrangle, 1:24,000, 1968

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 BURKTH00440032 ***Stream*** Roundy Brook

County Caledonia ***Road*** TH44 ***District*** 7

Description of Bridge

Bridge length 43 ***ft*** ***Bridge width*** 17.5 ***ft*** ***Max span length*** 39 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 8/8/95 Type-

Description of stone fill 2 stone fill on the downstream right and left wingwalls and the upstream right wingwall.

Brief description of piers/abutments The abutments and wingwalls are concrete. The right abutment and the downstream right wingwall footings are exposed 0.5 ft.

Is bridge skewed to flood flow according to Level I survey? Yes ***Angle*** No 0

There is a severe bend in the upstream reach where a cutbank has formed due to the impact of flow on the 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	8/8/95	0	0
Level II	8/8/95	0	0

Potential for debris Potential for debris is high due to the trees and vegetation on the upstream banks.

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

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley with little to no flood plains.

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

Date of inspection 8/8/95

DS left: Moderately sloped channel bank to mildly sloped overbank

DS right: Steep channel bank to moderately sloped overbank

US left: Steep channel bank to moderately sloped overbank

US right: Steep channel bank

Description of the Channel

Average top width 46 ft ***Average depth*** 8 ft

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

Small, perennial stream that is sinuous and degraded with semi-alluvial channel boundaries.

8/8/95

Vegetative co Trees

DS left: Trees

DS right: Trees

US left: Grass, trees, shrubs, and brush

US right: Yes

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

Some trees, fallen into the channel upstream of the bridge, have captured leaves and branches making the debris more dense, as observed on 8/8/95

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 9.24 ***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 as of 8/8/95.

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 1,880 ***ft³/s*** ***Q500*** 2,530 ***ft³/s***

The 100- and 500- year discharges are based on a drainage-area relationship [(9.24/8.1)exp 0.67] with discharge values from the Flood Insurance Study for the town of Burke, at the downstream limit of a detailed study of Roundy Brook (FEMA, 1979). These values were within a range defined by flood frequency curves derived from several empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). Each curve (except the FEMA curve) was extended graphically to the 500-year event.

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of a concrete guard rail post above the US end of the LABUT (elev. 515.14 ft, arbitrary survey datum). RM2 is a chiseled X on top of the concrete along the downstream right bridge face just inside the guard-rail post (elev. 512.85 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	-36	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	10	1	Road Grade section
APPRO	57	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 0.040 to 0.055, and overbank "n" values ranged from 0.040 to 0.070.

Critical depth at the exit section (EXITX) was assumed as the starting water surface for the each modeled discharge. Normal depth was computed at critical depth for the 100-year discharge and below critical depth approximately 0.11 ft for the 500-year discharge by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.0300 ft/ft, which was the 100-year discharge water-surface slope downstream of the bridge in the Flood Insurance Study for Burke, Vermont (FEMA, 1979).

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.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 512.6 *ft*
Average low steel elevation 510.3 *ft*

100-year discharge 1,880 *ft³/s*
Water-surface elevation in bridge opening 500.9 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 159 *ft²*
Average velocity in bridge opening 11.8 *ft/s*
Maximum WSPRO tube velocity at bridge 14.6 *ft/s*

Water-surface elevation at Approach section with bridge 503.3
Water-surface elevation at Approach section without bridge 501.7
Amount of backwater caused by bridge 1.6 *ft*

500-year discharge 2,530 *ft³/s*
Water-surface elevation in bridge opening 501.9 *ft*
Road overtopping? No *Discharge over road* - *ft³/s*
Area of flow in bridge opening 193 *ft²*
Average velocity in bridge opening 13.1 *ft/s*
Maximum WSPRO tube velocity at bridge 16.1 */s*

Water-surface elevation at Approach section with bridge 504.7
Water-surface elevation at Approach section without bridge 503.0
Amount of backwater caused by bridge 1.7 *ft*

Incipient overtopping discharge - *ft³/s*
Water-surface elevation in bridge opening - *ft*
Area of flow in bridge opening - *ft²*
Average velocity in bridge opening - *ft/s*
Maximum WSPRO tube velocity at bridge - *ft/s*

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100- and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). Variables for the Laursen clear-water contraction scour equation include the discharge through the bridge, the width of the channel at the bridge, and the median grain size of the channel bed material. The streambed armoring depth computed for the 100-year discharge suggests that armoring will not limit the depth of contraction scour.

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

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.4	3.4	--
Depth to armoring	29.3	N/A	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour	7.5 8.8	-- 9.2	12.9
Left abutment	---	---	---
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	1.8	2.2
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:	--	1.8	2.2
Left abutment	--	--	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--		
Pier 2			

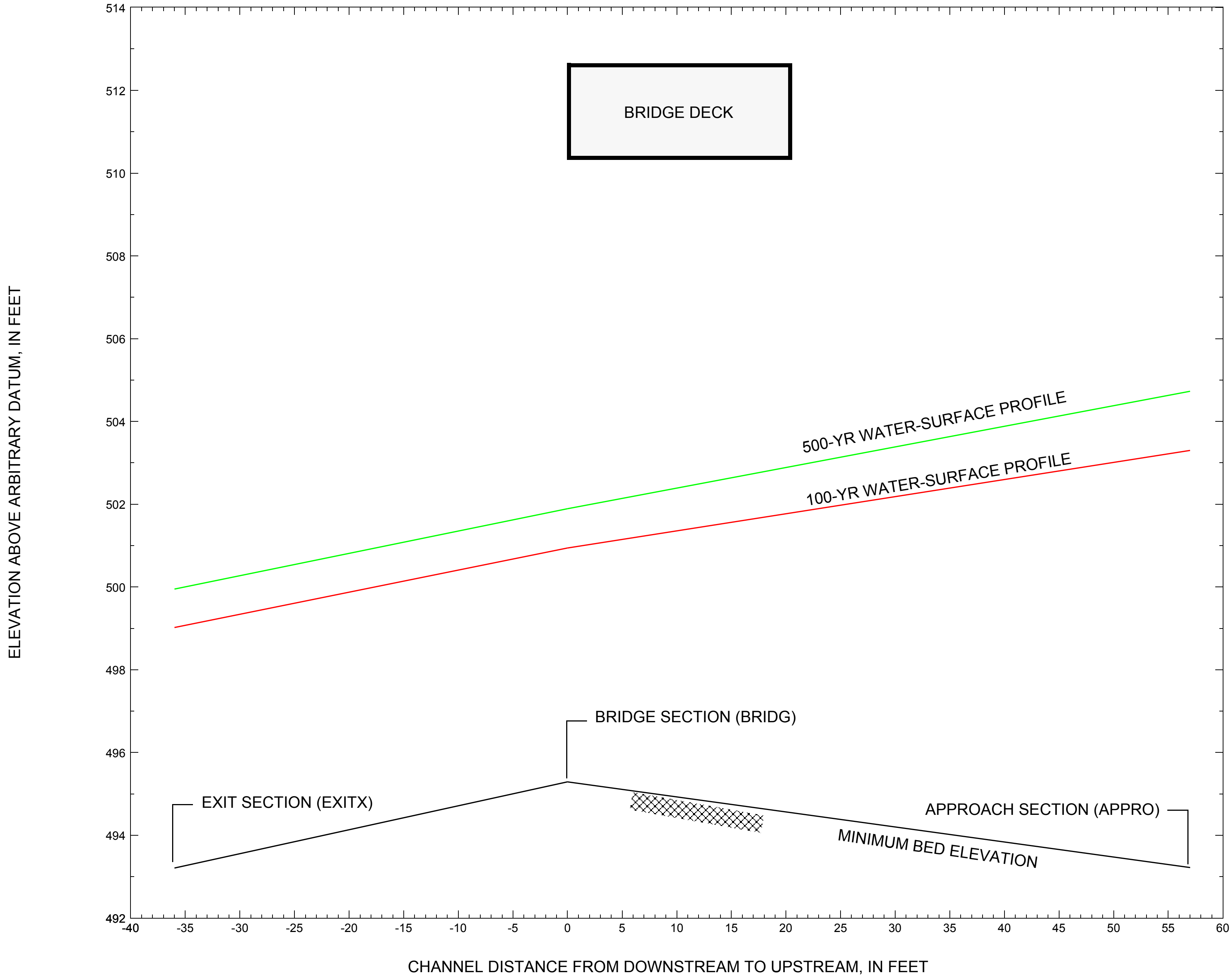

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BURKTH00440032 on Town Highway 44, crossing Roundy Brook, Burke, Vermont.

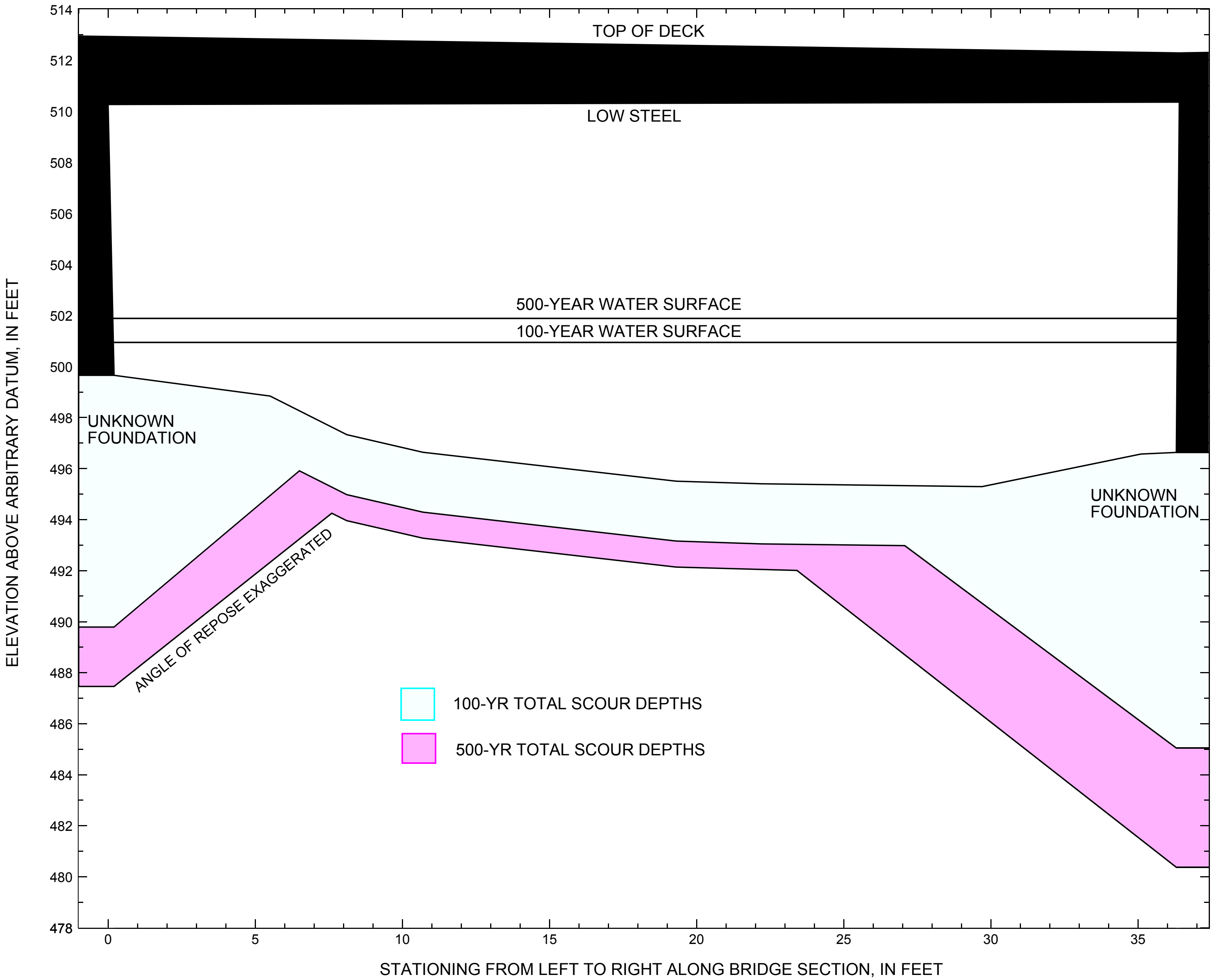

Figure 8. Scour elevations for the 100-year and 500-year discharges at structure BURKTH00440032 on Town Highway 44, crossing Roundy Brook, Burke, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BURKTH00440032 on Town Highway 44, crossing Roundy 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-year discharge is 1,880 cubic-feet per second											
Left abutment	0.0	--	510.3	--	499.6	2.4	7.5	--	9.9	489.8	--
Right abutment	36.4	--	510.4	--	496.6	2.4	9.2	--	11.6	485.0	--

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 BURKTH00440032 on Town Highway 44, crossing Roundy 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-year discharge is 2,530 cubic-feet per second											
Left abutment	0.0	--	510.3	--	499.6	3.4	8.8	--	12.2	487.5	--
Right abutment	36.4	--	510.4	--	496.6	3.4	12.9	--	16.3	480.3	--

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

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U.S. Geological Survey, 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 burk032.wsp
T2        Hydraulic analysis for structure BURKTH00440032   Date: 29-AUG-97
T3        Hydraulic analysis of Bridge 32 in Burke over Roundy Brook
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1880.0   2530.0
SK          0.0300   0.0300
*
XS   EXITX    -36           0.
GR         -118.3, 537.18   -102.0, 517.69    -17.3, 513.87    -14.1, 511.46
GR            0.0, 498.25      6.2, 495.93     12.1, 495.27     13.7, 494.64
GR           23.0, 493.72     26.9, 493.46     28.9, 493.21     32.8, 493.45
GR           35.7, 494.93     37.1, 495.00     41.6, 499.19     48.6, 500.32
GR           66.5, 501.16     85.7, 516.67
*
N           0.070        0.055        0.070
SA                 -17.3         41.6
*
*
XS   FULLV      0  * * *   0.0279
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    510.32       0.0
GR            0.0, 510.27      0.2, 499.65      5.5, 498.84      8.1, 497.33
GR           10.7, 496.64     15.5, 495.99     19.3, 495.51     22.2, 495.40
GR           29.7, 495.29     35.1, 496.57     36.3, 496.63     36.4, 510.36
GR            0.0, 510.27
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      29.9 * *     53.0      7.2
N           0.040
*
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     10      17.5     2
GR          -94.0, 524.18    -84.0, 517.19    -67.1, 517.28     -1.2, 512.52
GR           -1.2, 512.77      0.0, 512.93     37.4, 512.29     39.6, 512.79
GR           40.0, 511.93     65.1, 512.83     91.9, 512.86    117.5, 513.90
GR          136.8, 521.90
*
*
AS   APPRO     57           0.
GR          -92.9, 531.39    -87.0, 530.46    -76.8, 521.21    -44.0, 518.80
GR          -41.2, 517.97    -35.6, 518.73    -17.9, 510.76    -15.3, 508.89
GR           -7.7, 506.11     -4.8, 502.69      0.0, 498.55      1.7, 497.12
GR            2.5, 495.98      9.5, 495.05     13.5, 493.29     16.0, 493.29
GR           17.6, 493.22     18.9, 493.40     19.5, 494.20     21.2, 494.46
GR           23.5, 497.14     25.3, 499.33     37.3, 499.95     64.8, 502.77
GR           70.6, 503.73     81.8, 506.68    104.0, 512.02    130.4, 513.13
GR          200.8, 518.16
*
N           0.065        0.050        0.040
SA                  -7.7         25.3
*
HP 1 BRIDG  500.94 1 500.94
HP 2 BRIDG  500.94 * * 1880
HP 1 APPRO  503.30 1 503.30
HP 2 APPRO  503.30 * * 1880
*
HP 1 BRIDG  501.89 1 501.89
HP 2 BRIDG  501.89 * * 2530
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File burk032.wsp
        Hydraulic analysis for structure BURKTH00440032   Date: 29-AUG-97
        Hydraulic analysis of Bridge 32 in Burke over Roundy Brook
           *** RUN DATE & TIME: 01-13-98  13:57
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      159     14250     36     42                          1889
   500.94           159     14250     36     42  1.00      0     36      1889

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.94     0.2    36.3   158.8   14250.    1880.  11.84

X STA.        0.2        7.6       10.2       12.2       13.9       15.5
  A(I)           14.6       10.0        8.6        8.1        7.4
  V(I)           6.45       9.38      10.95      11.61      12.68

X STA.       15.5       16.9       18.3       19.5       20.7       21.9
  A(I)            7.4        6.9        6.8        6.7        6.5
  V(I)          12.73      13.57      13.84      14.06      14.38

X STA.       21.9       23.1       24.3       25.4       26.6       27.8
  A(I)            6.5        6.6        6.4        6.5        6.7
  V(I)          14.39      14.34      14.64      14.37      14.05

X STA.       27.8       29.0       30.2       31.7       33.3       36.3
  A(I)            6.7        7.1        7.5        8.5       13.3
  V(I)          14.09      13.20      12.49      11.12       7.07

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      57.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      220     21661     31     37                          3349
             3       98      6344     43     43                           844
   503.30           318     28005     73     80  1.09     -4     68      3605

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      57.

         WSEL     LEW     REW    AREA        K        Q    VEL
       503.30    -5.3    68.0   318.2   28005.    1880.   5.91

X STA.       -5.3        2.4        4.6        6.5        8.3        9.9
  A(I)           26.9       16.8       14.6       14.1       13.3
  V(I)           3.49       5.60       6.45       6.69       7.05

X STA.        9.9       11.4       12.7       13.9       15.0       16.1
  A(I)           12.7       12.4       11.7       11.3       11.3
  V(I)           7.37       7.61       8.04       8.32       8.32

X STA.       16.1       17.2       18.4       19.7       21.1       23.2
  A(I)           11.2       11.2       12.9       12.3       16.7
  V(I)           8.38       8.38       7.30       7.64       5.62

X STA.       23.2       27.5       32.3       37.7       44.9       68.0
  A(I)           19.4       17.9       18.7       21.1       31.7
  V(I)           4.85       5.24       5.02       4.45       2.97
```

```
       U.S. Geological Survey WSPRO Input File burk032.wsp
       Hydraulic analysis for structure BURKTH00440032   Date: 29-AUG-97
       Hydraulic analysis of Bridge 32 in Burke over Roundy Brook
          *** RUN DATE & TIME: 01-13-98  13:57

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      193     19183     36     44                         2533
   501.89           193     19183     36     44  1.00      0     36     2533

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.89     0.2    36.3   193.2   19183.    2530.  13.10

 X STA.         0.2         6.4         9.2        11.2        13.0        14.6
   A(I)            17.2        12.1        10.1         9.7         9.2
   V(I)            7.36       10.46       12.47       13.09       13.71

 X STA.        14.6        16.1        17.5        18.8        20.1        21.3
   A(I)             8.6         8.4         8.2         8.0         8.1
   V(I)           14.67       15.00       15.35       15.72       15.58

 X STA.        21.3        22.5        23.7        25.0        26.2        27.4
   A(I)             7.9         7.9         8.0         8.0         8.1
   V(I)           16.08       16.02       15.79       15.87       15.52

 X STA.        27.4        28.7        30.0        31.5        33.2        36.3
   A(I)             8.3         8.5         9.3        10.6        16.8
   V(I)           15.15       14.92       13.58       11.98        7.52

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      57.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      265     28506     32     39                         4333
             3      164     13616     49     49                         1705
   504.73           429     42122     81     88  1.04     -6     74     5485

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      57.

         WSEL     LEW     REW    AREA        K        Q    VEL
       504.73    -6.5    74.4   429.0   42122.    2530.   5.90

 X STA.        -6.5         2.0         4.6         6.8         8.8        10.6
   A(I)            35.6        23.2        19.7        18.6        17.9
   V(I)            3.56        5.44        6.42        6.81        7.08

 X STA.        10.6        12.2        13.7        15.0        16.4        17.7
   A(I)            17.3        16.4        15.5        15.4        15.4
   V(I)            7.30        7.73        8.14        8.24        8.21

 X STA.        17.7        19.2        20.8        23.0        27.0        31.0
   A(I)            16.4        17.2        20.8        24.6        20.4
   V(I)            7.70        7.36        6.08        5.14        6.19

 X STA.        31.0        35.2        39.8        45.7        53.6        74.4
   A(I)            21.1        22.1        24.9        27.5        38.9
   V(I)            5.99        5.73        5.08        4.59        3.25
```

```
        U.S. Geological Survey WSPRO Input File burk032.wsp
        Hydraulic analysis for structure BURKTH00440032   Date: 29-AUG-97
        Hydraulic analysis of Bridge 32 in Burke over Roundy Brook
           *** RUN DATE & TIME: 01-13-98  13:57

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

EXITX:XS   ******      0      167  1.96 *****  500.99  499.01    1880  499.02
       -35 ******     41    10849  1.00 ***** *******    1.00   11.24

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.93     500.22     500.01

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.52     538.18    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.52     538.18     500.01

FULLV:FV       36      0      174  1.82  1.02  502.00  500.01    1880  500.18
         0     36     42    11495  1.00  0.00   -0.01    0.94   10.81
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    0.87     501.68     501.17

 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.68     531.39    0.50

 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.68     531.39     501.17

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                              "APPRO"     KRATIO =  1.45

APPRO:AS       57     -3      210  1.38  1.05  503.05  501.17    1880  501.67
        57     57     54    16696  1.11  0.00    0.00    0.87    8.94
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    1880.      500.94

            <<<<<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       36      0      159  2.18 *****  503.12  500.94    1880  500.94
         0     36     36    14260  1.00 ***** *******    1.00   11.83

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  510.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       27     -4      318  0.59  0.25  503.89  501.17    1880  503.30
        57     28     68    27989  1.09  0.52   -0.02    0.52    5.91

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.374  0.187   22867.    -8.    28.   503.12

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

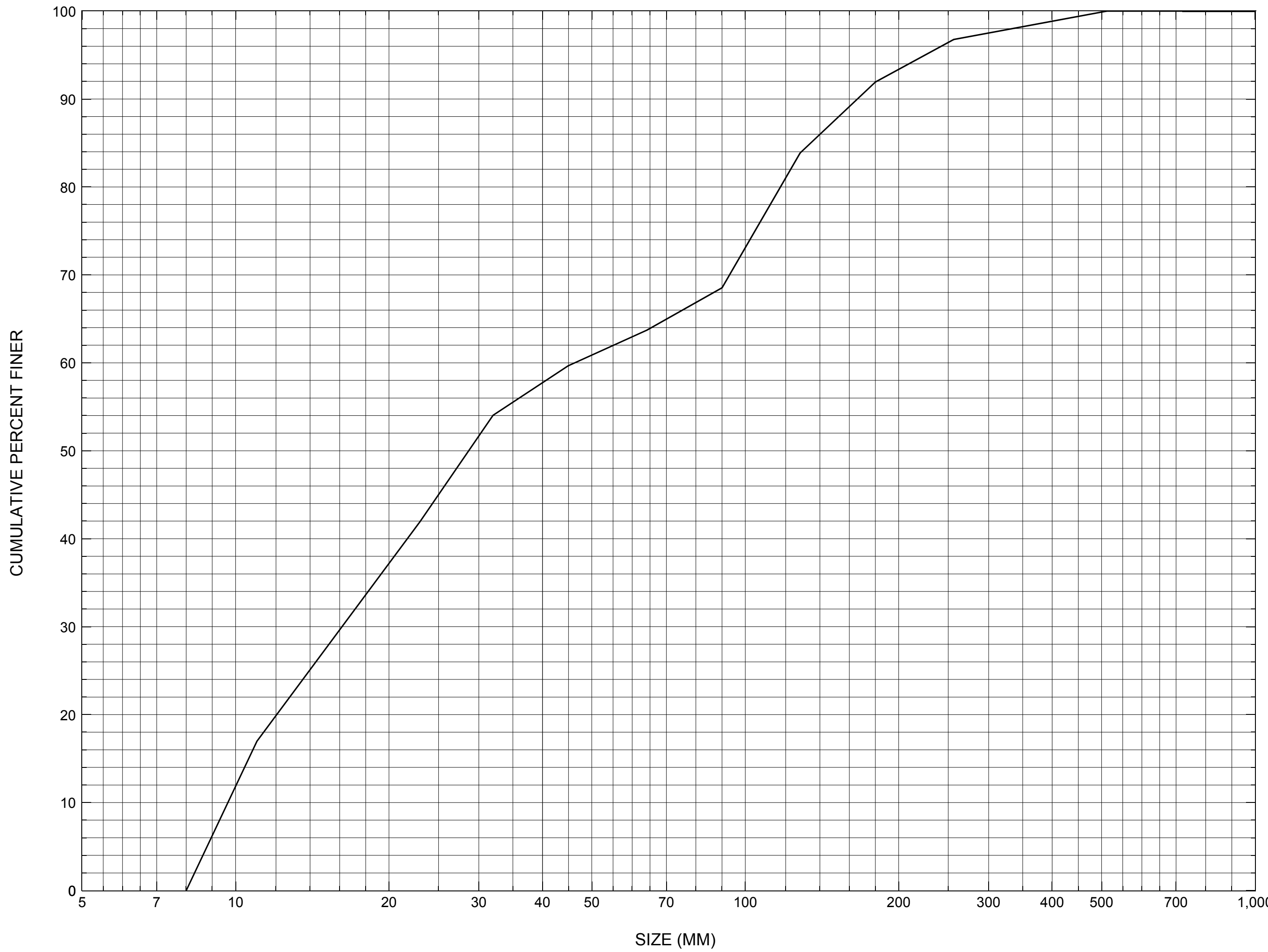
```
 FIRST USER DEFINED TABLE.

   XSID:CODE     SRD     LEW     REW       Q         K      AREA     VEL    WSEL
  EXITX:XS      -36.     -1.     41.   1880.   10849.      167.   11.24  499.02
  FULLV:FV        0.     -1.     42.   1880.   11495.      174.   10.81  500.18
  BRIDG:BR        0.      0.     36.   1880.   14260.      159.   11.83  500.94
  RDWAY:RG       10.**************       0.******************     2.00********
  APPRO:AS       57.     -5.     68.   1880.   27989.      318.    5.91  503.30

   XSID:CODE    XLKQ    XRKQ       KQ
  APPRO:AS       -8.     28.   22867.

SECOND USER DEFINED TABLE.

   XSID:CODE     CRWS     FR#    YMIN    YMAX    HF     HO  VHD      EGL    WSEL
  EXITX:XS    499.01     1.00  493.21  537.18************  1.96  500.99  499.02
  FULLV:FV    500.01     0.94  494.21  538.18  1.02  0.00  1.82  502.00  500.18
  BRIDG:BR    500.94     1.00  495.29  510.36************  2.18  503.12  500.94
  RDWAY:RG  ****************  511.93  524.18***********************************
  APPRO:AS    501.17     0.52  493.22  531.39  0.25  0.52  0.59  503.89  503.30
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File burk032.wsp
        Hydraulic analysis for structure BURKTH00440032   Date: 29-AUG-97
        Hydraulic analysis of Bridge 32 in Burke over Roundy Brook
           *** RUN DATE & TIME: 01-13-98  13:57

 ===015 WSI IN WRONG FLOW REGIME AT SECID "EXITX":  USED WSI = CRWS.
                          WSI,CRWS =   499.84     499.95

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

EXITX:XS   ******     -1      209  2.32 *****  502.26  499.95    2530  499.95
       -35 ******     46    15130  1.01 ***** *******    1.03   12.12

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.02     501.00     500.95

 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   499.45     538.18    0.50

 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   499.45     538.18     500.95

FULLV:FV       36     -1      209  2.32  1.01  503.27  500.95    2530  500.95
         0     36     46    15130  1.01  0.00    0.00    1.03   12.12
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                            "APPRO"     KRATIO =  1.66

APPRO:AS       57     -4      293  1.28  0.96  504.23 *******    2530  502.95
        57     57     66    25121  1.10  0.00    0.00    0.79    8.64
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===285 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D !!!!!
                  SECID "BRIDG"     Q,CRWS =    2530.     501.89

            <<<<<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       36      0      193  2.66 *****  504.56  501.89    2530  501.89
         0     36     36    19205  1.00 ***** *******    1.00   13.09

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  510.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      10.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>

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

APPRO:AS       27     -6      429  0.56  0.22  505.30  502.19    2530  504.73
        57     28     74    42164  1.04  0.52   -0.01    0.46    5.89

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.490  0.246   31881.    -6.    30.  504.59

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -36.    -2.    46.   2530.   15130.     209.   12.12  499.95
   FULLV:FV      0.     -2.    46.   2530.   15130.     209.   12.12  500.95
   BRIDG:BR      0.      0.    36.   2530.   19205.     193.   13.09  501.89
   RDWAY:RG     10.**************      0.******************     2.00********
   APPRO:AS     57.     -7.    74.   2530.   42164.     429.    5.89  504.73

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS      -6.    30.   31881.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF    HO   VHD      EGL    WSEL
   EXITX:XS    499.95    1.03  493.21  537.18************  2.32  502.26  499.95
   FULLV:FV    500.95    1.03  494.21  538.18  1.01  0.00  2.32  503.27  500.95
   BRIDG:BR    501.89    1.00  495.29  510.36************  2.66  504.56  501.89
   RDWAY:RG  ****************  511.93  524.18**********************************
   APPRO:AS    502.19    0.46  493.22  531.39  0.22  0.52  0.56  505.30  504.73
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel underneath structure BURKTH00440032, in Burke, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number BURKTH00440032

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)* ROUNDY BROOK

Road Name *(I - 7):* -

Route Number TH044

Vicinity *(I - 9)* 0.6 MI JCT TH 44 + US 5

Topographic Map Burke Mountain

Hydrologic Unit Code: 01080102

Latitude *(I - 16; nnnn.n)* 44366

Longitude *(i - 17; nnnnn.n)* 71580

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10030200320302

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

Maximum span length *(I - 48; nnnn)* 0039

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

Structure length *(I - 49; nnnnnn)* 000043

Average daily traffic, ADT *(I - 29; nnnnnn)* 000200

Deck Width *(I - 52; nn.n)* 175

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)* 303

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 031.1

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

Vertical clearance from streambed (*nnn.n ft*) 013.2

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

Waterway of full opening (*nnn.n ft*^{2}) 410.3

Comments:

The structural inspection report of 10/31/94 indicates the structure is a steel girder and floor beam system type bridge with a concrete deck. The abutment walls and wingwalls are concrete. A small section of the concrete footing is reported showing on the right abutment. The right abutment concrete is spalled along its base. Both abutment walls have a few small cracks, leaks, and spalls reported. While the footing is exposed on the right abutment, the report indicates undermining and settling are not evident. Some boulder riprap is noted around the ends of each wingwall and some in small areas where bank erosion has occurred during previous flooding on the banks up- and downstream (Continued, page 32).

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

Clear span (*ft*): - Clear Height (*ft*): - Full Waterway (ft^2): -

Comments:

An old log is reported across the channel just upstream of the bridge. Channel scour and point bar development are reported as minor at this site. The foundation type recorded for this bridge is unknown .

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.24** mi^2 Lake/pond/swamp area **0** mi^2

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

Bridge site elevation **890** ft Headwater elevation **2215** ft

Main channel length **10.59** mi

10% channel length elevation **910** ft 85% channel length elevation **1650** ft

Main channel slope *(S)* **93.15** 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:

There is no benchmark information available.

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:

There is no foundation material information available.

Comments:

There are no bridge plans available.

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 8/8/95. The low chord to bed length data are from the sketch attached to a bridge inspection report dated 10/31/94. The sketch was done on 9/10/92.**

Station	0	4.7	13.4	19.7	23	28	33.7	-	-	-	-
Feature	RAB	-	-	-	-	-	LAB	-	-	-	-
Low chord elevation	510.4	510.4	510.4	510.3	510.3	510.3	510.3	-	-	-	-
Bed elevation	496.6	496.1	495.6	496.5	497.1	499.0	498.8	-	-	-	-
Low chord to bed	13.8	14.3	14.8	13.8	13.2	11.3	11.5	-	-	-	-

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

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

Comments: -
-

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

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

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **3/1/96**

Computerized by: **RB** Date: **3/1/96**

Reviewd by: **MS** Date: **5/4/98**

Structure Number **BURKTH00440032**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **E. BOEHMLER** Date *(MM/DD/YY)* **08** / **08** / 19**95**

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

County **Caledonia (005)** Town **BURKE (10450)**

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

Route Number **TH044** Hydrologic Unit Code: **01080102**

3. Descriptive comments:

The bridge is located about 0.6 miles from the intersection of TH044 with US Route 5.

B. Bridge Deck Observations

4. Surface cover... LBUS **6** RBUS **4** 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 **43** *(feet)* Span length **39** *(feet)* Bridge width **17.5** *(feet)*

Road approach to bridge:

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

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

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

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

*Bank protection types: **0**- none; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

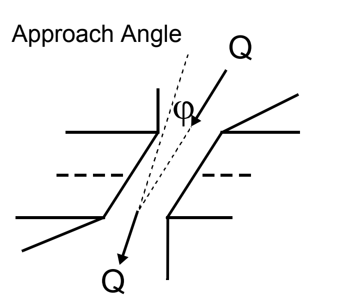
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

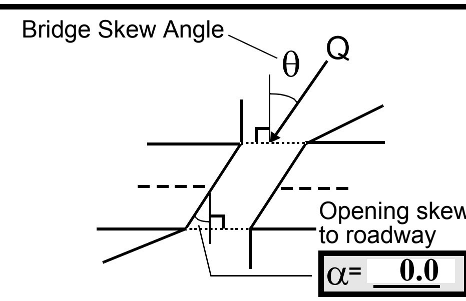
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

*Erosion Severity: **0** - none; **1**- slight; **2**- moderate; **3**- severe*

Channel approach to bridge (BF):

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





17. Channel impact zone 1: Exist? **Y** *(Y or N)*

Where? **LB** *(LB, RB)* Severity **3**

Range? **75** feet **US** *(US, UB, DS)* to **50** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*

Where? **RB** *(LB, RB)* Severity **1**

Range? **0** 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**

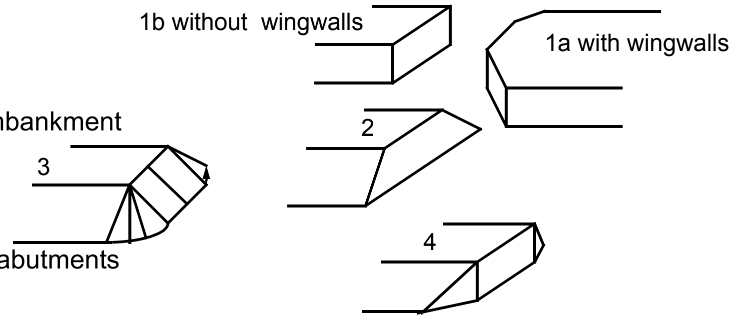
1a- Vertical abutments with wingwalls

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. The bridge dimensions are from the VTAOT files. The measured bridge length was 41.6 feet, the span length was 38.6 feet, and the bridge width was 17.5 feet.

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
38.5	**9.0**			**2.0**	**3**	**1**	**213**	**213**	**2**	**1**

23. Bank width **45.0** 24. Channel width **45.0** 25. Thalweg depth **33.0** 29. Bed Material **231**

30 .Bank protection type: LB **0** RB **0** 31. 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*

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

There is some stone fill on the streambed from 20 feet US to the US face. The water is generally pooled beyond 20 feet US from the US face of the bridge. There are 2 or 3 whole tree trunks lodged on both banks forming a blockage across the channel about 60 feet US. The lodged trees have captured other debris, mainly leaves and branches, resulting in greater blockage along the left-bank side compared to the right-bank side.

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: 65 42. Cut bank extent: 100 feet US (US, UB) to 50 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.):

The bank now is partially protected by a narrow sand-bar ridge that has developed. There is a debris pile that blocks some of the flow along the left bank just DS of the cut-bank.

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.):

The bed material US of the bridge is much sandier and the ambient thalweg is deeper than under the bridge and DS. The bridge channel forms a control and water is generally pooled from 20 feet US of the US face to greater than 200 feet US.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF)		57 Angle (BF)		61. Material (BF)		62. Erosion (BF)	
LB	RB	LB	RB	LB	RB	LB	RB
22.0		4.0		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.):

345

At least part of the boulder bed material is stone fill. Among the boulder-sized stone fill are some blocks of old concrete.

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

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

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

70. Debris and Ice Comments:

2

The upstream banks are well vegetated. The 90 degree bend in the upstream channel and the abundant vegetation attribute to the high debris potential.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		-	90	0	0	0	0	90.0
RABUT	1	5	90			2	2	36.5

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

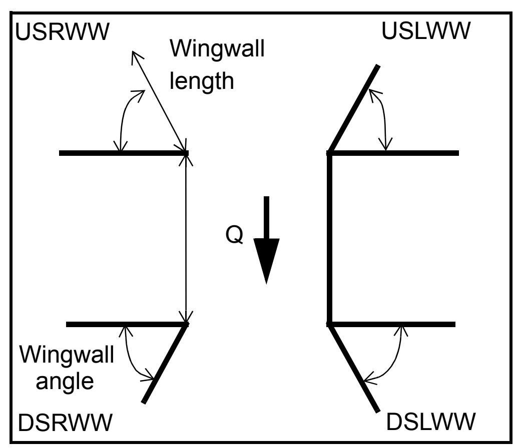
0.5

1

Exposure of the right abutment footing varies from 0.2 to 0.5 feet. There is a sand point bar along the left abutment. The right abutment is unprotected.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						36.5	
USRWW:	Y		1		0	1.0	
DSLWW:	0		0		Y	20.5	
DSRWW:	1		0		0	20.5	



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

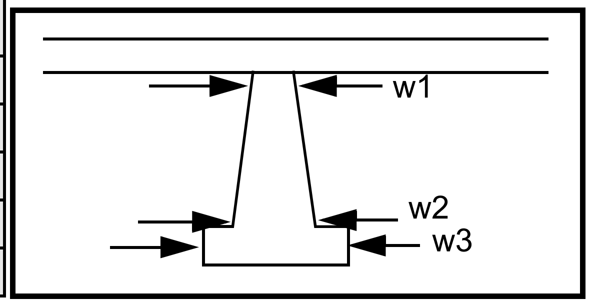
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? **Sto** (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				**60.0**	**12.0**	**45.0**
Pier 2				**12.0**	**35.0**	**11.5**
Pier 3			-	**45.0**	**12.0**	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**ne fill**	**wall.**	**wing-**	**may be**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**pro-**	**The**	**wall**	**cov-**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**tects**	**only**	**is**	**ering**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**the**	**visi-**	**chan**	**stone**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**US**	**ble**	**nel**	**fill.**	*Y- yes; N- no*
91. Attack ∠ (BF)	**right**	**pro-**	**fill**	**The**	
92. Pushed	**wing**	**tec-**	**point**	**DS**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**wall**	**tion**	**-bar**	**left**	
95. Cross-members	**and**	**on**	**mate**	**wing**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**DS**	**the**	**rial**	**wall**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**right**	**US**	**whic**	**is**	
98. Exposure depth	**wing**	**left**	**h**	**pro-**	

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

tected with stone fill.

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: _4____

Scour dimensions: Length _4___ Width _235__ Depth: _543_ Positioned _2__ %LB to _1__ %RB

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

435
2
0
1

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

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

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

Confluence comments (eg. confluence name):

r signs of erosion than the left bank. The trees along the left bank beyond 75 feet DS are leaning at approximately a 30 degree angle from vertical toward the channel. There is a tree from the left bank lying across the

F. Geomorphic Channel Assessment

107. Stage of reach evolution _cha__

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)*:

nnel DS, with its top resting at the top of the right bank near 100 feet DS. Stone fill is found as far as 50 feet DS in the channel. The left bank protection extends from the DS left wingwall to about 25 feet DS.

Y

109. G. Plan View Sketch

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: BURKTH00440032   Town: Burke
Road Number: TH44   County: Caledonia
Stream: Roundy Brook

Initials MMS   Date: 1/13/98   Checked: RLB

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	1880	2530	0
Main Channel Area, ft2	220	265	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	98	164	0
Top width main channel, ft	31	32	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	43	49	0
D50 of channel, ft	0.094	0.094	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	7.1	8.3	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	2.3	3.3	ERR
Total conveyance, approach	28005	42122	0
Conveyance, main channel	21661	28506	0
Conveyance, LOB	0	0	0
Conveyance, ROB	6344	13616	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	1454.1	1712.2	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	425.9	817.8	ERR
Vm, mean velocity MC, ft/s	6.6	6.5	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	4.3	5.0	ERR
Vc-m, crit. velocity, MC, ft/s	7.1	7.2	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

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	1880	2530	0
(Q) discharge thru bridge, cfs	1880	2530	0
Main channel conveyance	14250	19183	0
Total conveyance	14250	19183	0
Q2, bridge MC discharge,cfs	1880	2530	ERR
Main channel area, ft2	159	193	0
Main channel width (normal), ft	36.1	36.1	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	36.1	36.1	0
y_bridge (avg. depth at br.), ft	4.40	5.35	ERR
Dm, median (1.25*D50), ft	0.1175	0.1175	0
y2, depth in contraction,ft	6.76	8.71	ERR
ys, scour depth (y2-ybridge), ft	2.35	3.37	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1880	2530	N/A
Main channel area (DS), ft2	159	193	0
Main channel width (normal), ft	36.1	36.1	0.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	36.1	36.1	0.0
D90, ft	0.5442	0.5442	0.0000
D95, ft	0.7381	0.7381	0.0000
Dc, critical grain size, ft	0.6683	0.7564	ERR
Pc, Decimal percent coarser than Dc	0.064	0.047	0.000
Depth to armoring, ft	29.32	N/A	ERR

Abutment Scour

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

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	1880	2530	0	1880	2530	0
a', abut.length blocking flow, ft	5.5	6.7	0	31.7	38.1	0
Ae, area of blocked flow ft2	19.21	28.06	0	57.65	108.12	0
Qe, discharge blocked abut.,cfs	67.14	99.71	0	212.37	475.75	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	3.50	3.55	ERR	3.68	4.40	ERR
ya, depth of f/p flow, ft	3.49	4.19	ERR	1.82	2.84	ERR
--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	0.330	0.306	ERR	0.481	0.460	ERR
ys, scour depth, ft	7.51	8.82	N/A	9.23	12.89	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

	Left 100 yr Q	500 yr Q	Other Q	Right 100 yr Q	500 yr Q	Other Q
a'(abut length blocked, ft)	5.5	6.7	0	31.7	38.1	0
y1 (depth f/p flow, ft)	3.49	4.19	ERR	1.82	2.84	ERR
a'/y1	1.57	1.60	ERR	17.43	13.43	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.33	0.31	N/A	0.48	0.46	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR

spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	1	1	0	1	1	0
y, depth of flow in bridge, ft	4.40	5.35	0.00	4.40	5.35	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	ERR	0.00	ERR	ERR	0.00
Fr>0.8 (vertical abut.)	1.84	2.24	ERR	1.84	2.24	ERR