LEVEL II SCOUR ANALYSIS FOR BRIDGE 15 (BURKTH00580015) on TOWN HIGHWAY 58, crossing the WEST BRANCH PASSUMPSIC RIVER, BURKE, VERMONT

Open-File Report 98-380

Prepared in cooperation with

VERMONT AGENCY OF TRANSPORTATION

and

FEDERAL HIGHWAY ADMINISTRATION

U.S. Department of the Interior

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By ERICK M. BOEHMLER AND TIMOTHY SEVERANCE

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Pembroke, New Hampshire

1998

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

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CONTENTS

FIGURES

TABLES

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 15 (BURKTH00580015) ON TOWN HIGHWAY 58, CROSSING THE WEST BRANCH PASSUMPSIC RIVER, BURKE, VERMONT

***By* Erick M. Boehmler and Timothy Severance**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure BURKTH00580015 on Town Highway 58 crossing the West Branch Passumpsic River, 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 39.1-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of shrubs and brush on the downsteam banks and the upstream left bank. The surface cover is forest on the upstream right bank.

In the study area, the West Branch Passumpsic River has an incised, sinuous channel with a slope of approximately 0.006 ft/ft, an average channel top width of 42 ft and an average bank height of 3 ft. The channel bed material ranges from sand to cobbles with a median grain size (D_{50}) of 65.3 mm (0.214 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 9, 1995, indicated that the reach was stable.

The Town Highway 58 crossing of the West Branch Passumpsic River is a 30-ft-long, two-lane bridge consisting of one 26-foot concrete tee-beam span (Vermont Agency of Transportation, written communication, March 24, 1995). The opening length of the structure parallel to the bridge face is 25.3 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 15 degrees to the opening while the opening-skew-to-roadway is zero degrees.

Scour holes 0.75 to 1.0 ft deeper than the mean thalweg depth were observed along both abutment walls. The abutment footings were exposed for 2 ft above the streambed and the left abutment footing was undermined at the time of the Level I assessment. The only scour protection measure at the site was stone fill. Type-1 stone fill (less than 12 inches diameter) was observed along the upstream right bank and the upstream end of the upstream right wingwall. Type-2 stone fill (less than 36 inches diameter) was observed at the downstream end of the downstream right wingwall and along the downstream left bank. Additional details describing conditions at the site are included in the Level II Summary and appendices
D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. In addition, the incipient roadway-overtopping discharge was 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 2.2 to 5.9 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 13.7 to 25.5 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.

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 BURKTH00580015 ***Stream*** West Branch Passumpsic River

County Caledonia ***Road*** TH 58 ***District*** 7

Description of Bridge

Bridge length 30 ***ft*** ***Bridge width*** 20.2 ***ft*** ***Max span length*** 26 ***ft***

Alignment of bridge to road (on curve or straight) Curved on left and straight on right

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

Stone fill on abutment? No ***Date of inspection*** 8/9/95

Description of stone fill Type-1 on the upstream end of the upstream right wingwall and type-2 on the downstream end of the downstream right wingwall.

Brief description of piers/abutments Abutments and wingwalls are concrete. Exposed footings were observed at each abutment for as much as 2 feet above the streambed and the left abutment was slightly undermined on 8/9/95.

Is bridge skewed to flood flow according to Level I survey? Yes ***Angle*** 15

Is bridge located on a bend in channel? Yes

There is a mild channel bend in the upstream reach, which directs flow toward the right abutment. 8/9/95

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	0	0	8/9/95
Level II	0	0	Low.

Potential for debris

A railroad bridge crosses the river about 100 feet downstream of this bridge (8/9/95).

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

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with little to no flood plain and steep valley walls on both sides.

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

Date of inspection 8/9/95

DS left: Steep bank and a narrow, flat overbank (railroad).

DS right: Moderately sloped bank.

US left: Moderately sloped bank and a narrow, irregular overbank.

US right: Steep bank and valley wall.

Description of the Channel

Average top width 42 *ft* ***Average depth*** 3 *ft*

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

Perennial but flashy, and sinuous with semi-alluvial channel boundaries and narrow point bars.

8/9/95

Vegetative co

DS left: Brush with some shrubs.

DS right: Brush with some shrubs and small trees.

US left: Shrubs and small trees with some brush.

US right: Trees.

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

None were observed on 8/9/95.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 39.1 ***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***:

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 3,650 ***ft³/s*** ***Q500*** 5,100 ***ft³/s***

The 100- and 500-year discharges are the same as those discharges selected and modeled in the Flood Insurance Study for the Town of Burke (FEMA, December, 1979) at this site. These discharge values are within the 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 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) NGVD

Datum tie between USGS survey and VTAOT plans None. The USGS surveyed points were increased by 289.8 feet to obtain the National Geodetic Vertical Datum of 1929.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled “X” on top of the upstream concrete guard rail at the right end (elev. 504.40 ft, arbitrary survey datum). RM2 is the center point of a chiseled “X” on top of the downstream guard rail at the left end (elev. 504.05 ft, arbitrary survey datum). RM9 (FEMA, 1979) is a U.S. Coastal and Geodetic Survey Benchmark set in the downstream end of the left abutment concrete of the railroad bridge about 100 feet downstream of this site (elev. 500.71 feet, arbitrary survey datum).

Cross Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
SEC-C	0	5	Flood Insurance Study section “C”
EXITX	41	1	Exit section
FULLV	59	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	59	1	Bridge section
RDWAY	69	1	Road Grade section
APPRO	107	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 0.038 to 0.050, and overbank "n" values ranged from 0.050 to 0.1.

The starting water surface elevation for the 100- and 500-year discharges was the water surface computed at cross section "C" (SEC-C) from the Flood Insurance Study model output for the Town of Burke (FEMA, 1979). For the incipient roadway-overtopping discharge, the starting water surface elevation was obtained based on a rating of the discharges and water surface elevations computed at SEC-C.

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

Bridge Hydraulics Summary

Average bridge embankment elevation 791.9 *ft*
Average low steel elevation 787.7 *ft*

100-year discharge 3,650 *ft³/s*
Water-surface elevation in bridge opening 783.8 *ft*
Road overtopping? No *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 268 *ft²*
Average velocity in bridge opening 13.6 *ft/s*
Maximum WSPRO tube velocity at bridge 20.0 *ft/s*

Water-surface elevation at Approach section with bridge 786.8
Water-surface elevation at Approach section without bridge 785.6
Amount of backwater caused by bridge 1.2 *ft*

500-year discharge 5,100 *ft³/s*
Water-surface elevation in bridge opening 787.8 *ft*
Road overtopping? Yes *Discharge over road* 147 *ft³/s*
Area of flow in bridge opening 366 *ft²*
Average velocity in bridge opening 13.6 *ft/s*
Maximum WSPRO tube velocity at bridge 18.3 *ft/s*

Water-surface elevation at Approach section with bridge 792.5
Water-surface elevation at Approach section without bridge 788.5
Amount of backwater caused by bridge 4.0 *ft*

Incipient overtopping discharge 4,520 *ft³/s*
Water-surface elevation in bridge opening 787.8 *ft*
Area of flow in bridge opening 366 *ft²*
Average velocity in bridge opening 12.4 *ft/s*
Maximum WSPRO tube velocity at bridge 16.7 *ft/s*

Water-surface elevation at Approach section with bridge 791.3
Water-surface elevation at Approach section without bridge 787.4
Amount of backwater caused by bridge 3.9 *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-year discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). At this site, the 500-year discharge and the incipient roadway-overtopping discharge resulted in 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 Davis, 1995, p. 145-146). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the 500-year discharge and the incipient roadway-overtopping discharge also was computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and Davis, 1995, p. 144). Furthermore, contraction scour for these discharges 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 alternative computations are provided in appendix F.

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

Scour Results

Contraction scour:	*100-year discharge*	*500-year discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	2.2	5.9	4.0
Depth to armoring	N/A	20.8	12.5
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	13.7	14.5	14.3
Right abutment	22.4	25.5	24.4
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-year discharge	*500-year discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	3.5	3.6	3.1
Right abutment	3.5	3.6	3.1
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

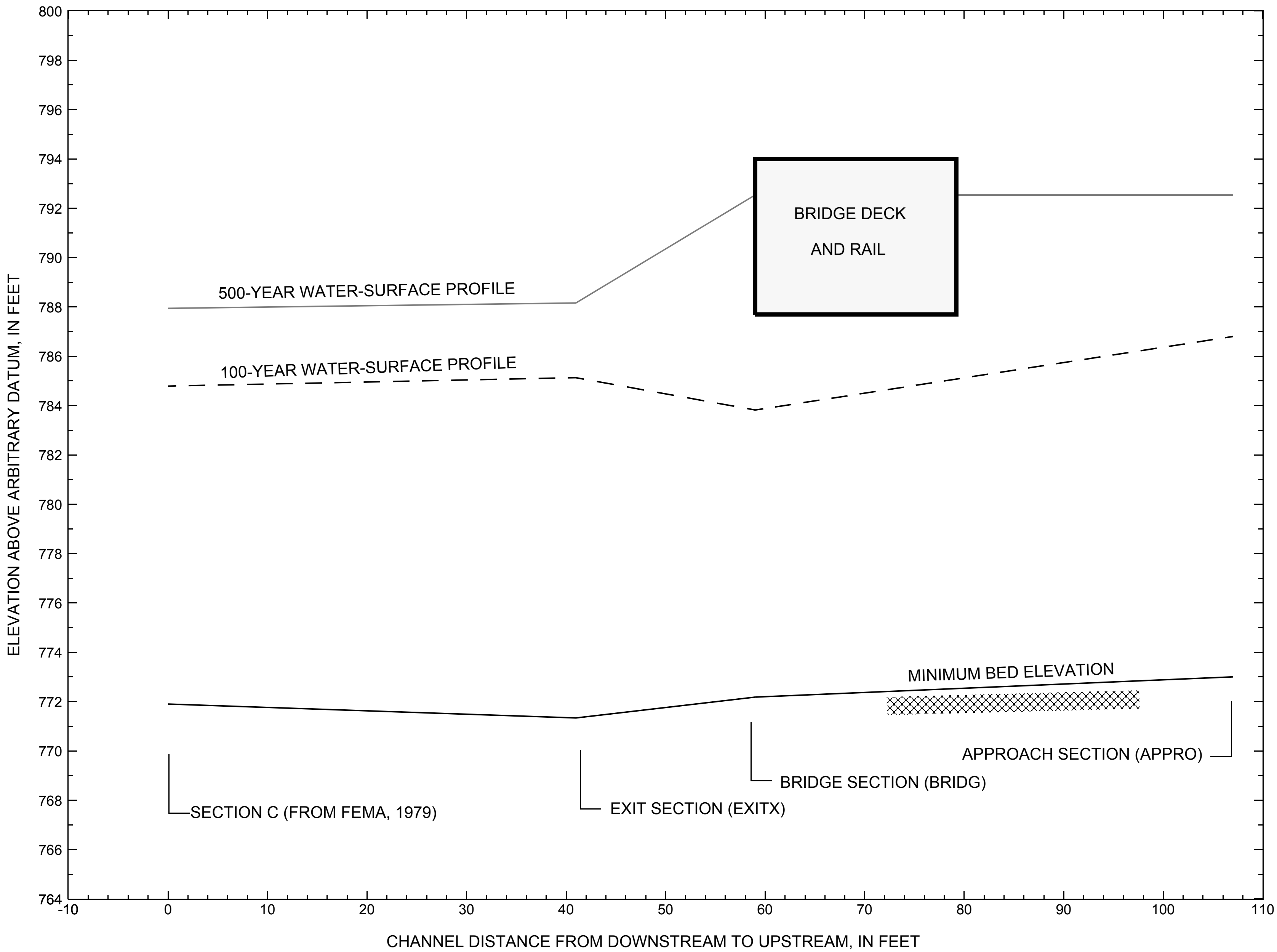

Figure 7. Water-surface profiles for the 100- and 500-year discharges at structure BURKTH00580015 on Town Highway 58, crossing the West Branch Passumpsic River, Burke, Vermont.

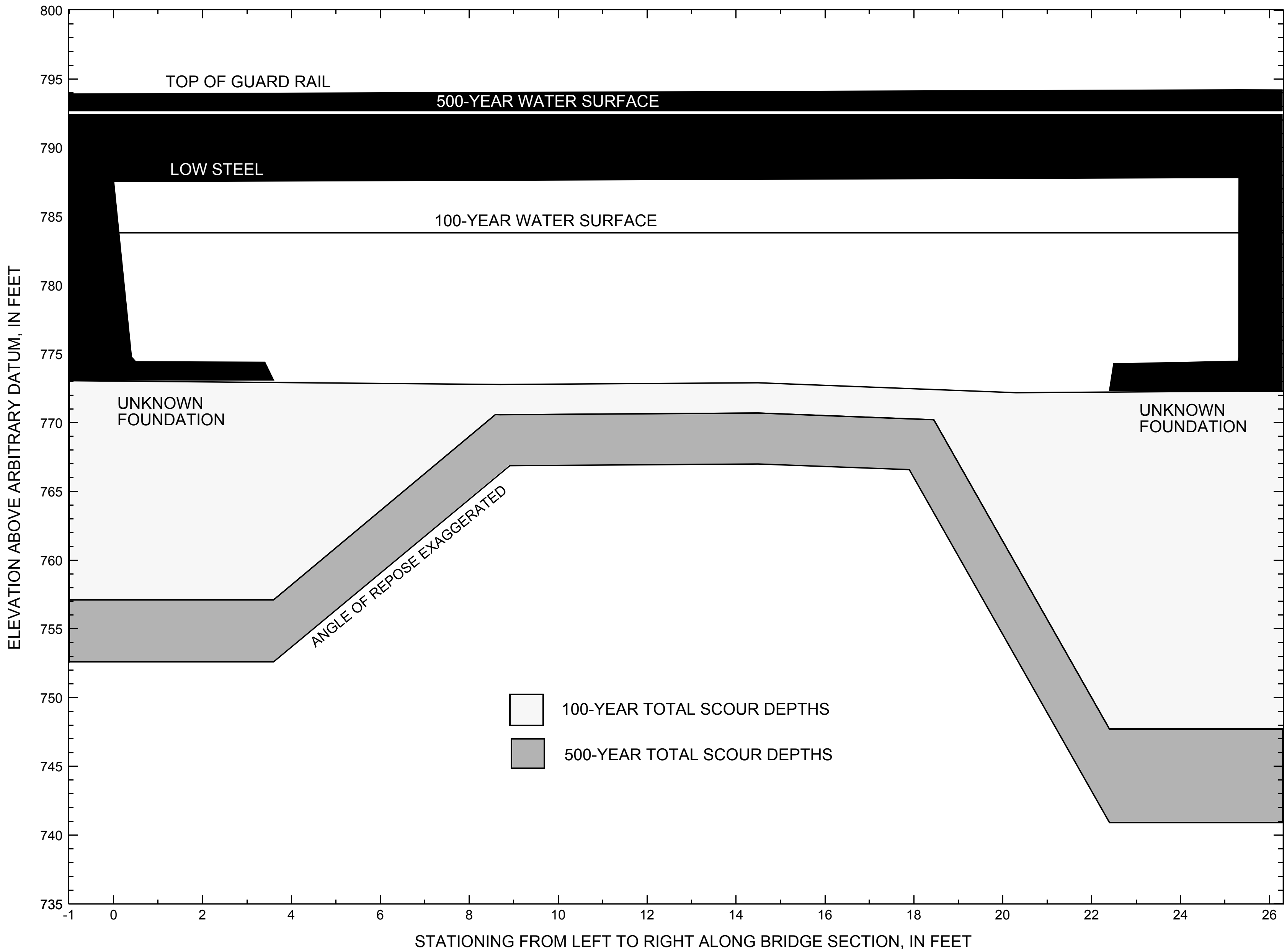

Figure 8. Scour elevations for the 100- and 500-year discharges at structure BURKTH00580015 on Town Highway 58, crossing the West Branch Passumpsic River, Burke, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure BURKTH00580015 on Town Highway 58, crossing the West Branch Passumpsic River, 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 3,650 cubic-feet per second											
Left abutment	0.0	--	787.5	--	773.0	2.2	13.7	--	15.9	757.1	--
Right abutment	25.3	--	787.8	--	772.3	2.2	22.4	--	24.6	747.7	--

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 BURKTH00580015 on Town Highway 58, crossing the West Branch Passumpsic River, 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 5,100 cubic-feet per second											
Left abutment	0.0	--	787.5	--	773.0	5.9	14.5	--	20.4	752.6	--
Right abutment	25.3	--	787.8	--	772.3	5.9	25.5	--	31.4	740.9	--

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, Contour Interval, 20 feet, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File burk015.wsp
T2        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
T3        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
*
J1         * * 0.002
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           3650.0   5100.0   4520.0
WS          784.79   787.94   786.79
*
XS   SEC-C       0
GR         -119.0, 800.10    -98.0, 791.20    -78.0, 788.50    -50.0, 792.00
GR          -43.0, 791.70    -29.0, 790.40    -16.0, 784.50      0.0, 776.00
GR            3.0, 773.00      6.0, 771.90     21.0, 774.00     26.0, 776.00
GR           67.0, 798.10
*
N           0.050        0.040
SA                 -29.0
*
*
XS   EXITX     41           0.
GR         -148.6, 815.20   -117.0, 798.43    -79.9, 790.18    -70.4, 789.52
GR          -62.9, 789.48    -45.6, 791.72    -38.3, 791.30    -25.4, 789.50
GR           -7.8, 779.29     -4.3, 778.38      0.0, 774.79      3.7, 772.30
GR            8.6, 771.34     10.7, 771.76     18.2, 772.62     23.0, 774.75
GR           28.4, 776.94     31.8, 778.76     43.7, 785.38     51.6, 790.96
GR           75.7, 797.38
*
N            0.050           0.040
SA                   -25.4
*
*
XS   FULLV      59
GR         -259.0, 806.00   -184.0, 798.50   -169.0, 799.70   -159.0, 797.00
GR         -151.0, 794.00   -134.0, 793.80   -116.0, 791.70    -67.0, 791.00
GR          -31.0, 779.20    -16.0, 779.20    -11.0, 776.30     -3.1, 776.00
GR           -3.0, 776.00     -2.9, 774.80      0.0, 774.80      0.1, 772.90
GR            8.0, 773.20     20.0, 772.70     20.1, 774.90     22.9, 774.90
GR           23.0, 776.00     23.1, 793.10     65.0, 796.10     97.0, 802.00
*
N           0.040        0.038        0.040
SA                   0.0         20.1
*
*              SRD     LSEL    XSSKEW
BR   BRIDG     59    787.68       0.0
GR             0.0, 787.53      0.4, 774.77      0.5, 774.42      3.4, 774.39
GR             3.6, 773.05      8.7, 772.76     14.5, 772.89     20.3, 772.18
GR            22.4, 772.28     22.5, 774.27     25.3, 774.45     25.3, 787.83
GR             0.0, 787.53
*
*         BRTYPE  BRWDTH        WWANGL    WWWID
CD           1      30.7 * *     43.7     10.5
N            0.042
*
*              SRD    EMBWID   IPAVE
XR   RDWAY      69      20.2     1
GR         -150.2, 812.30   -115.0, 800.05   -108.1, 793.05    -77.1, 792.86
```

```
GR          -3.8, 791.31     -3.5, 793.90     26.5, 794.20     26.6, 792.51
GR          77.7, 797.77    230.8, 820.09    327.9, 829.70
*




AS   APPRO    107           0.
GR        -212.4, 820.53   -183.5, 804.59   -164.3, 799.80   -159.3, 796.11
GR        -131.8, 796.22   -115.5, 794.68   -110.5, 793.44    -96.6, 792.92
GR         -77.6, 791.40    -44.9, 790.50    -21.5, 788.62    -10.1, 779.69
GR          -5.7, 778.43      0.0, 775.87      5.3, 774.76      7.2, 773.90
GR           8.1, 773.98     11.8, 774.08     17.8, 774.17     23.5, 773.98
GR          30.1, 773.00     33.3, 774.21     38.1, 774.62     38.5, 775.08
GR          43.3, 776.26     45.5, 780.86     51.9, 786.11     63.1, 793.29
GR          92.7, 797.62
*
N           0.100         0.050
SA                 -21.5
*
HP 1 BRIDG 783.82 1 783.82
HP 2 BRIDG 783.82 * * 3650
HP 1 APPRO 786.81 1 786.81
HP 2 APPRO 786.81 * * 3650
*
HP 1 BRIDG 787.83 1 787.83
HP 2 BRIDG 787.83 * * 4962
HP 2 RDWAY 792.54 * * 147
HP 1 APPRO 792.54 1 792.54
HP 2 APPRO 792.54 * * 5100
*
HP 1 BRIDG 787.83 1 787.83
HP 2 BRIDG 787.83 * * 4520
HP 1 BRIDG 787.17 1 787.17
HP 1 APPRO 791.37 1 791.37
HP 2 APPRO 791.37 * * 4520
*
EX
ER
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APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             1     268.   30534.   25.    47.                         4969.
   783.82          268.   30534.   25.    47.  1.00     0.    25.   4969.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

         WSEL     LEW     REW    AREA        K        Q    VEL
       783.82     0.1    25.3   268.3   30534.    3650.  13.60

X STA.         0.1        4.9        5.8        6.6        7.5        8.4
  A(I)             45.3        9.5        9.7        9.6        9.5
  V(I)             4.03      19.19      18.76      18.97      19.30

X STA.         8.4        9.3       10.1       11.0       12.0       12.9
  A(I)              9.7        9.8        9.9       10.1       10.1
  V(I)            18.78      18.55      18.49      18.09      18.13

X STA.        12.9       13.8       14.7       15.6       16.5       17.4
  A(I)             10.0       10.0        9.8        9.7        9.8
  V(I)            18.19      18.22      18.53      18.84      18.62

X STA.        17.4       18.2       19.0       19.8       20.6       25.3
  A(I)              9.4        9.6        9.4        9.1       48.2
  V(I)            19.46      19.03      19.42      19.98       3.79

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K  TOPW   WETP  ALPH    LEW    REW     QCR
             2     701.   87921.   72.    81.                        12408.
   786.81          701.   87921.   72.    81.  1.00   -19.    53.  12408.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA        K        Q    VEL
       786.81   -19.2    53.0   701.5   87921.    3650.   5.20

X STA.       -19.2       -3.0        0.1        2.8        5.3        7.6
  A(I)             90.5       32.4       30.3       29.4       29.0
  V(I)             2.02       5.63       6.02       6.21       6.28

X STA.         7.6        9.8       12.0       14.2       16.5       18.8
  A(I)             27.9       28.6       28.1       28.6       28.6
  V(I)             6.54       6.38       6.51       6.37       6.38

X STA.        18.8       21.1       23.3       25.5       27.6       29.6
  A(I)             29.0       28.3       28.5       28.4       27.7
  V(I)             6.29       6.45       6.41       6.42       6.59

X STA.        29.6       31.7       33.9       36.1       38.6       53.0
  A(I)             27.3       28.8       27.9       30.3       91.9
  V(I)             6.68       6.34       6.54       6.03       1.99
```

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     366.   35825.     0.    80.                          0.
   787.83          366.   35825.     0.    80.  1.00     0.    25.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

         WSEL     LEW     REW    AREA        K        Q    VEL
       787.83     0.0    25.3   365.7   35825.    4962.  13.57

X STA.         0.0         4.3         5.3         6.2         7.2         8.1
  A(I)            54.8        14.3        14.0        13.9        14.0
  V(I)            4.53       17.38       17.68       17.88       17.75

X STA.         8.1         9.1        10.0        11.0        11.9        12.9
  A(I)            14.0        14.4        14.2        14.5        14.5
  V(I)           17.77       17.25       17.53       17.14       17.15

X STA.        12.9        13.9        14.9        15.8        16.8        17.7
  A(I)            14.5        14.5        14.3        14.0        13.8
  V(I)           17.08       17.07       17.36       17.67       17.93

X STA.        17.7        18.6        19.5        20.4        21.2        25.3
  A(I)            13.9        13.8        13.5        13.7        57.2
  V(I)           17.86       17.92       18.31       18.16        4.34

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = RDWAY;  SRD =      69.

         WSEL     LEW     REW    AREA        K        Q    VEL
       792.54   -62.0    26.9    35.9     954.     147.   4.10

X STA.       -62.0       -31.6       -29.0       -26.7       -24.6       -22.8
  A(I)             9.8         1.8         1.7         1.6         1.5
  V(I)            0.75        4.15        4.45        4.60        4.97

X STA.       -22.8       -21.0       -19.5       -17.9       -16.6       -16.2
  A(I)             1.5         1.4         1.4         1.3         0.3
  V(I)            5.00        5.30        5.32        5.59       23.77

X STA.       -16.2       -15.6       -14.1       -12.7       -11.3       -10.0
  A(I)             0.6         1.5         1.5         1.5         1.4
  V(I)           12.70        4.86        4.95        4.99        5.11

X STA.       -10.0        -8.7        -7.5        -6.2        -5.1        26.9
  A(I)             1.5         1.4         1.4         1.3         1.7
  V(I)            5.07        5.37        5.21        5.47        4.34

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     130.    2907.    70.    70.                       1001.
             2    1152.  181314.    83.    95.                      24285.
   792.54         1282.  184221.   154.   165.  1.18   -92.    62.  19321.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA        K        Q    VEL
       792.54   -91.8    61.9  1281.7  184221.    5100.   3.98

X STA.       -91.8        -9.9        -5.8        -2.1         1.0         3.8
  A(I)           227.5        56.4        53.8        50.9        48.9
  V(I)            1.12        4.52        4.74        5.01        5.22

X STA.         3.8         6.5         9.1        11.6        14.2        16.8
  A(I)            47.9        47.8        46.9        47.9        47.8
  V(I)            5.32        5.34        5.44        5.33        5.34

X STA.        16.8        19.3        21.8        24.3        26.8        29.1
  A(I)            46.4        46.6        45.7        46.2        44.2
  V(I)            5.50        5.48        5.58        5.52        5.77

X STA.        29.1        31.5        33.9        36.5        39.2        61.9
  A(I)            46.6        46.0        46.1        48.2       189.9
  V(I)            5.48        5.54        5.53        5.29        1.34
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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     366.   35825.     0.    80.                          0.
   787.83          366.   35825.     0.    80.  1.00     0.    25.      0.

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

         WSEL     LEW     REW    AREA         K        Q    VEL
       787.83     0.0    25.3   365.7   35825.    4520.  12.36

X STA.         0.0         4.3         5.3         6.2         7.2         8.1
  A(I)             54.8        14.3        14.0        13.9        14.0
  V(I)             4.12       15.83       16.10       16.29       16.17

X STA.         8.1         9.1        10.0        11.0        11.9        12.9
  A(I)             14.0        14.4        14.2        14.5        14.5
  V(I)            16.19       15.71       15.97       15.61       15.62

X STA.        12.9        13.9        14.9        15.8        16.8        17.7
  A(I)             14.5        14.5        14.3        14.0        13.8
  V(I)            15.55       15.55       15.81       16.10       16.34

X STA.        17.7        18.6        19.5        20.4        21.2        25.3
  A(I)             13.9        13.8        13.5        13.7        57.2
  V(I)            16.27       16.32       16.68       16.55        3.95

    CROSS-SECTION PROPERTIES:  ISEQ =  4;  SECID = BRIDG;  SRD =      59.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1     353.   44078.    25.    53.                       7479.
   787.17          353.   44078.    25.    53.  1.00     0.    25.   7479.

    CROSS-SECTION PROPERTIES:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

     WSEL  SA#     AREA        K   TOPW   WETP  ALPH    LEW    REW     QCR
             1      56.     846.    55.    55.                        322.
             2    1055.  159132.    82.    93.                      21533.
   791.37         1111.  159978.   137.   148.  1.09   -77.    60.  17215.

    VELOCITY DISTRIBUTION:  ISEQ =  6;  SECID = APPRO;  SRD =     107.

         WSEL     LEW     REW    AREA         K        Q    VEL
       791.37   -76.5    60.1  1111.4  159978.    4520.   4.07

X STA.       -76.5        -8.1        -4.1        -0.8         2.1         4.8
  A(I)            162.0        51.2        48.4        45.4        43.5
  V(I)             1.39        4.41        4.67        4.98        5.20

X STA.         4.8         7.4         9.9        12.3        14.8        17.4
  A(I)             44.2        42.6        42.6        43.5        43.4
  V(I)             5.12        5.31        5.30        5.19        5.20

X STA.        17.4        19.8        22.3        24.6        27.0        29.2
  A(I)             42.1        42.3        41.6        42.1        40.3
  V(I)             5.36        5.34        5.43        5.36        5.61

X STA.        29.2        31.5        34.0        36.4        39.1        60.1
  A(I)             41.2        42.9        41.8        43.7       166.4
  V(I)             5.49        5.27        5.41        5.17        1.36
```

WSPRO OUTPUT FILE (continued)

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WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

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

SEC-C:XS   ******   -17.     439.  1.08 *****  785.87  781.60   3650.  784.79
        0. ******    42.   58206.  1.00 ***** *******    0.54    8.32

EXITX:XS      41.   -18.     488.  0.87  0.14  786.00 *******   3650.  785.13
       41.    41.    43.   67644.  1.00  0.00    0.00    0.47    7.48

FULLV:FV      18.   -49.     566.  0.78  0.04  786.05 *******   3650.  785.26
       59.    18.    23.   81186.  1.21  0.00    0.00    0.45    6.45
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      48.   -18.     617.  0.54  0.11  786.15 *******   3650.  785.61
      107.    48.    51.   73375.  1.00  0.00    0.00    0.35    5.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR      18.     0.     268.  2.88  0.12  786.70  781.85   3650.  783.82
       59.    18.    25.   30553.  1.00  0.58   -0.01    0.73   13.60

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  787.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      69.        <<<<<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      17.   -19.     702.  0.42  0.10  787.23  780.31   3650.  786.81
      107.    20.    53.   87963.  1.00  0.44    0.01    0.29    5.20

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.634  0.396   53054.     6.    31.   786.77

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   SEC-C:XS       0.   -17.    42.   3650.   58206.     439.    8.32  784.79
   EXITX:XS      41.   -18.    43.   3650.   67644.     488.    7.48  785.13
   FULLV:FV      59.   -49.    23.   3650.   81186.     566.    6.45  785.26
   BRIDG:BR      59.     0.    25.   3650.   30553.     268.   13.60  783.82
   RDWAY:RG      69.**************       0.******************    1.00********
   APPRO:AS     107.   -19.    53.   3650.   87963.     702.    5.20  786.81

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       6.    31.   53054.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   SEC-C:XS    781.60    0.54  771.90  800.10************  1.08  785.87  784.79
   EXITX:XS  ********    0.47  771.34  815.20  0.14  0.00  0.87  786.00  785.13
   FULLV:FV  ********    0.45  772.70  806.00  0.04  0.00  0.78  786.05  785.26
   BRIDG:BR    781.85    0.73  772.18  787.83  0.12  0.58  2.88  786.70  783.82
   RDWAY:RG  ****************  791.31  829.70**********************************
   APPRO:AS    780.31    0.29  773.00  820.53  0.10  0.44  0.42  787.23  786.81
```
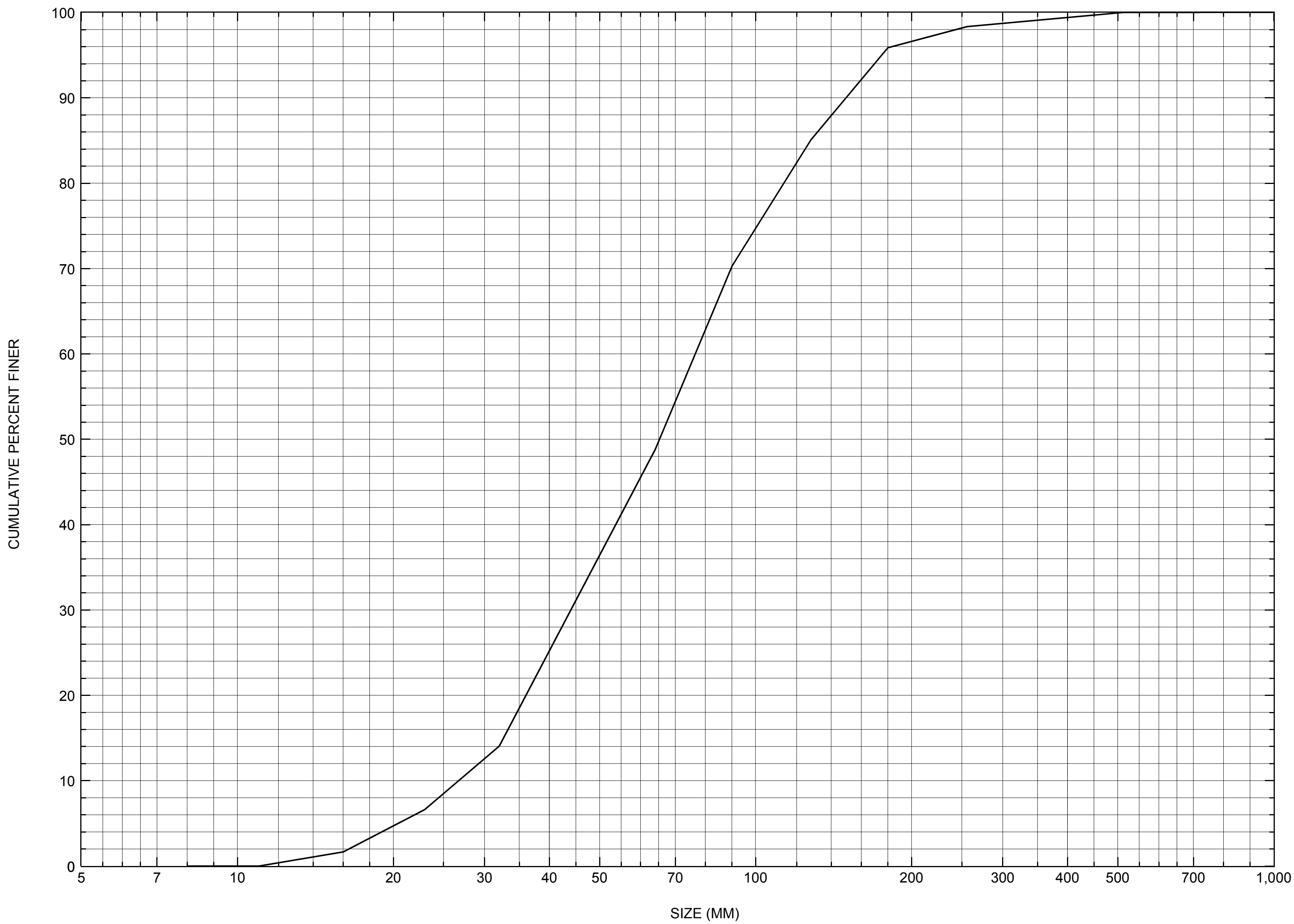

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188             MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

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

SEC-C:XS   ******   -24.     645.  0.97 *****  788.91  783.21   5100.  787.94
        0. ******    48.   96863.  1.00 ***** *******    0.47    7.91

EXITX:XS      41.   -23.     688.  0.85  0.10  789.01 *******   5100.  788.16
       41.    41.    48.  108088.  1.00  0.00    0.00    0.42    7.41

FULLV:FV      18.   -59.     799.  0.76  0.03  789.04 *******   5100.  788.29
       59.    18.    23.  131923.  1.19  0.00    0.00    0.39    6.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      48.   -21.     831.  0.59  0.09  789.13 *******   5100.  788.54
      107.    48.    56.  111094.  1.00  0.00    0.00    0.33    6.14
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =    788.29     787.68

            <<<<<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      18.     0.     366.  2.86 *****  790.69  783.82   4962.  787.83
       59. ******    25.   35825.  1.00 ***** *******    0.63   13.57

     TYPE PPCD FLOW      C     P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800 ******  787.68 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG       69.    28.  0.02  0.29  792.81    0.00    147.  792.54

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    147.    58.   -62.    -4.   1.2   0.6   4.3   4.1   0.9   3.0
   RT:      0.     1.    27.    27.   0.1   0.0   2.4  16.3   0.3   3.0

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

APPRO:AS      17.   -92.    1281.  0.29  0.08  792.83  781.65   5100.  792.54
      107.    20.    62.  184183.  1.18  0.44    0.00    0.26    3.98

       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
   SEC-C:XS        0.    -24.     48.   5100.    96863.     645.    7.91  787.94
   EXITX:XS       41.    -23.     48.   5100.   108088.     688.    7.41  788.16
   FULLV:FV       59.    -59.     23.   5100.   131923.     799.    6.38  788.29
   BRIDG:BR       59.      0.     25.   4962.    35825.     366.   13.57  787.83
   RDWAY:RG       69.*******    147.    147.*********        0.    1.00  792.54
   APPRO:AS      107.    -92.     62.   5100.   184183.    1281.    3.98  792.54

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   SEC-C:XS     783.21    0.47  771.90  800.10************  0.97  788.91  787.94
   EXITX:XS   ********    0.42  771.34  815.20  0.10  0.00  0.85  789.01  788.16
   FULLV:FV   ********    0.39  772.70  806.00  0.03  0.00  0.76  789.04  788.29
   BRIDG:BR     783.82    0.63  772.18  787.83************  2.86  790.69  787.83
   RDWAY:RG   ****************  791.31  829.70  0.02******  0.29  792.81  792.54
   APPRO:AS     781.65    0.26  773.00  820.53  0.08  0.44  0.29  792.83  792.54
```

```
WSPRO         FEDERAL HIGHWAY ADMINISTRATION - U. S. GEOLOGICAL SURVEY
V060188            MODEL  FOR  WATER-SURFACE  PROFILE  COMPUTATIONS

        U.S. Geological Survey WSPRO Input File burk015.wsp
        Hydraulic analysis for structure BURKTH00580015   Date: 22-JAN-98
        Town Highway 58 over the West Branch Passumpsic River, Burke, VT   EMB
           *** RUN DATE & TIME: 05-13-98  09:13

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

SEC-C:XS   ******   -21.     565.  1.00 *****  787.79  782.57   4520.  786.79
        0. ******    46.   81300.  1.00 ***** *******    0.49    8.00

EXITX:XS      41.   -21.     611.  0.85  0.11  787.89 *******   4520.  787.04
       41.    41.    46.   91941.  1.00  0.00    0.00    0.43    7.40

FULLV:FV      18.   -55.     710.  0.76  0.04  787.93 *******   4520.  787.17
       59.    18.    23.  111722.  1.20  0.00    0.00    0.41    6.37
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      48.   -20.     748.  0.57  0.09  788.02 *******   4520.  787.45
      107.    48.    54.   96162.  1.00  0.00    0.00    0.33    6.04
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =    785.51     788.81     788.91     787.68

 ===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      18.     0.     366.  2.37 *****  790.20  783.17   4517.  787.83
       59. ******    25.   35825.  1.00 ***** *******    0.57   12.35

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.462 ******  787.68 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      69.          <<<<<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      17.   -75.    1107.  0.28  0.07  791.62  781.12   4520.  791.34
      107.    20.    60.  159341.  1.09  0.45    0.00    0.26    4.08

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   791.31

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q         K     AREA     VEL    WSEL
   SEC-C:XS       0.    -21.    46.   4520.   81300.     565.    8.00  786.79
   EXITX:XS      41.    -21.    46.   4520.   91941.     611.    7.40  787.04
   FULLV:FV      59.    -55.    23.   4520.  111722.     710.    6.37  787.17
   BRIDG:BR      59.      0.    25.   4517.   35825.     366.   12.35  787.83
   RDWAY:RG      69.**************      0.        0.       0.    1.00********
   APPRO:AS     107.    -75.    60.   4520.  159341.    1107.    4.08  791.34

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX     HF     HO  VHD      EGL    WSEL
   SEC-C:XS     782.57    0.49  771.90  800.10************  1.00  787.79  786.79
   EXITX:XS   ********    0.43  771.34  815.20  0.11  0.00  0.85  787.89  787.04
   FULLV:FV   ********    0.41  772.70  806.00  0.04  0.00  0.76  787.93  787.17
   BRIDG:BR     783.17    0.57  772.18  787.83************  2.37  790.20  787.83
   RDWAY:RG   ****************  791.31  829.70************  0.28  791.60********
   APPRO:AS     781.12    0.26  773.00  820.53  0.07  0.45  0.28  791.62  791.34
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure BURKTH00580015, in Burke, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **BURKTH00580015**

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)* **[West Branch] Passumpsic River**

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

Route Number **TH058**

Vicinity *(I - 9)* **0.1 MI JCT TH 58 + US 5**

Topographic Map **Burke.Mountain**

Hydrologic Unit Code: **01080102**

Latitude *(I - 16; nnnn.n)* **44362**

Longitude *(i - 17; nnnnn.n)* **71582**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10030200150302**

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

Maximum span length *(I - 48; nnnn)* **0026**

Year built *(I - 27; YYYY)* **1922**

Structure length *(I - 49; nnnnnn)* **000030**

Average daily traffic, ADT *(I - 29; nnnnnn)* **000250**

Deck Width *(I - 52; nn.n)* **202**

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)* **7**

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

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

Structure type *(I - 43; nnn)* **104**

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

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

Clear span (*nnn.n ft*) **022.5**

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

Vertical clearance from streambed (*nnn.n ft*) **014.9**

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

Waterway of full opening (*nnn.n* ft^2) **335.2**

Comments:

The structural inspection report of 10/31/94 indicates the structure is a concrete tee-beam type bridge. The abutment walls and wingwalls are concrete and have a few minor fine cracks and small spalls overall. The right abutment has small surface spalls along the bottom of the wall. The left abutment and its wing-walls, according to the report, have one to two foot sections of deep spalling along the bottom of the walls with reinforcement bars exposed. The water is about 2 feet deep along each abutment. Some boulder stone fill is reported protecting the banks upstream and downstream. The banks are noted as showing signs of previous erosion.

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* 39.07 mi^2 Lake/pond/swamp area 0.05 mi^2
Watershed storage *(ST)* 0.1 %
Bridge site elevation 791 ft Headwater elevation 2215 ft
Main channel length 11.45 mi
10% channel length elevation 820 ft 85% channel length elevation 1614 ft
Main channel slope *(S)* 92.48 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*)? **FEMA**

Comments: **This cross section information was retrieved from the Flood Insurance Study data at this bridge (FEMA, 1979)**

Station	256	256.1	259	259	267	279	279	281.9	282	-	-
Feature	LB	-	-	-	-	-	-	-	RB	-	-
Low chord elevation	789.6	789.6	789.6	789.6	789.7	789.8	789.8	789.9	789.9	-	-
Bed elevation	776.0	774.8	774.8	772.9	773.2	772.7	774.9	774.9	776.0	-	-
Low chord to bed	13.6	14.8	14.8	16.7	16.5	17.1	14.9	15.0	13.9	-	-
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: **2/27/96**
Computerized by: **RB** Date: **2/27/96**
Reviewd by: **EMB** Date: **3/27/98**

Structure Number **BURKTH00580015**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **T. SEVERANCE** Date *(MM/DD/YY)* **8** / **9** / 19**95**

2. Highway District Number **07** Mile marker **0000**
County **CALEDONIA 005** Town **BURKE 10450**
Waterway *(I - 6)* **West Branch Passumpsic River** Road Name **Bugbee Road**
Route Number **TH 58** Hydrologic Unit Code: **01080102**

3. Descriptive comments:
Located about 0.1 mile east of the intersection of TH58 with U.S. Route 5.
Cast bridge/post date reads "1923", not "1922" as noted in the historical form.

B. Bridge Deck Observations

4. Surface cover... LBUS **5** RBUS **6** LBDS **5** RBDS **5** Overall **5**
*(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 **1** *(**1**- pool; **2**- riffle)*

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

7. Bridge length **30** *(feet)* Span length **26** *(feet)* Bridge width **20.2** *(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)*

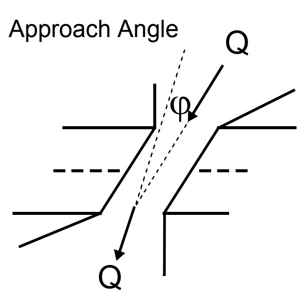
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

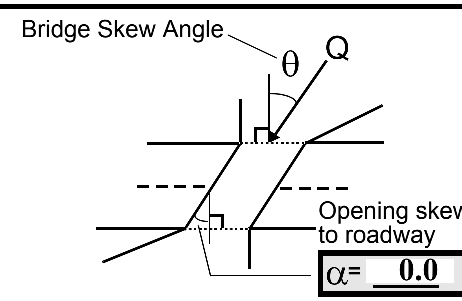
	Protection: 11.Type	Protection: 12.Cond.	13.Erosion	14.Severity
LBUS	0	-	3	3
RBUS	2	2	3	2
RBDS	2	1	2	1
LBDS	2	1	2	3

*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: **25** 16. Bridge skew: **15**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **0** feet **US** *(US, UB, DS)* to **30** feet **DS**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **40** feet **US** *(US, UB, DS)* to **0** feet **US**

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

18. Bridge Type: **1a**

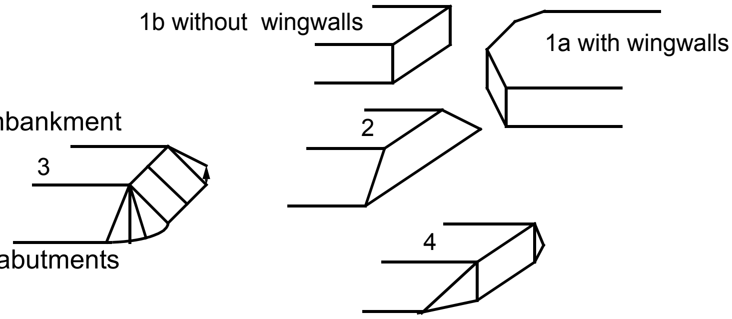
1a- Vertical abutments with wingwalls

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.)

5. Shallow US with riffle. Under the bridge is deeper but flow is still fast and somewhat rippled. DS one bridge length it is rippled along left half of the channel and pooled on the right half. At 2 bridge lengths DS it is pooled and is the US approach section for the railroad bridge.

7. Values are from VT AOT files. Measured bridge length = 30.5 feet, span length = 25.5 feet, and bridge width = 20.02 feet. Span length was a difficult measurment because of a strong current and no good point for attaching the tape.

8. Lowest elevation on roadway is directly above the left abutment. Overflows would occur here first.

11. Some DS left bank protection is as large as 8 feet in length; some is under 36 inches. All protection is stone fill that extends the entire bank. The US left wingwall of the railroad bridge is steel sheet piles that have been installed and backfilled with concrete. This extends into the channel 2 or 3 feet from the railroad bridge left wingwall.

14. There is some stone at the base of the end of the upstream right wingwall that is covered with fines from road wash and does not extend US. On the left bank US, severe roadwash is washing out the embankment over a one bridge length span out from the bridge. A slope of 3 is present. Several guardrail posts footings are close to being exposed. This is also occurring on the left bank DS. On the right bank US the roadwash is eroding the embankment and there is a cutbank US.

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
30.0	**2.5**			**4.5**	**1**	**4**	**1**	**420**	**1**	**2**

23. Bank width **25.0** 24. Channel width **65.0** 25. Thalweg depth **51.0** 29. Bed Material **34**

30 .Bank protection type: LB **0** RB **1** 31. Bank protection condition: LB **-** RB **2**

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.):

27. Some right bank material is organics with much vegetation, roots are exposed.

29. Bed material is a mixture of 65% gravel to 35% cobbles.

30. There is no protection on the left bank. The bank slopes up gradually, 30 degrees for 10 feet, then flattens out. At the US left wingwall the road elevation is high consequently much fill is present. There is no protection from roadwash. Protection is present at the US right wingwall and 5 feet US. At high flow protection will easily be overtopped. This rock fill protection is deflecting flow along the right bank away from the US right wingwall. Some stone fill protection has slumped into the channel.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **44** 35. Mid-bar width: **10**

36. Point bar extent: **40** feet **US** (US, UB) to **50** feet **US** (US, UB, DS) positioned **5** %LB to **50** %RB

37. Material: **34**

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

37. There is an even distribution of gravel and cobbles. At the time of the visit, the bar was entirely submerged by the flow.

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

41. Mid-bank distance: **30** 42. Cut bank extent: **12** feet **US** (US, UB) to **65** 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.):

Rock and silt are at the edge of the water. The bank slopes upwards for a couple feet where the cut bank is located. Roots are exposed at this cut-bank.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **23**

47. Scour dimensions: Length **17** Width **4** Depth : **1.75** Position **60** %LB to **80** %RB

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

US thalweg depth is 1 foot.

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

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

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

54. Confluence comments (eg. confluence name):

NO MAJOR CONFLUENCES

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
43.5		2.0		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.):

23

Bridge constrains flow. Footings are exposed and below water surface. The concrete is eroded at the base of both the left and right abutment. The left abutment and left wingwall have exposed reinforcement bars.

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

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

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

70. Debris and Ice Comments:

2

-

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**	**0.75**	**2**	**90.0**
RABUT	**1**	**-**	**90**			**2**	**2**	**25.5**

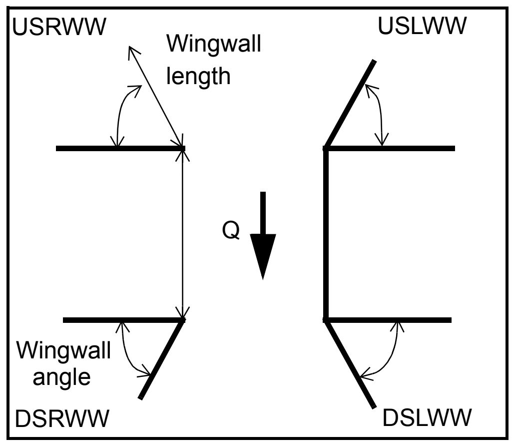
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: *1*- Concrete; *2*- Stone masonry or drywall; *3*- steel or metal; *4*- wood

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

0.75
2
1
74. Scour is present at the left abutment, 0.75 foot at the US footing to 1.5 feet at the DS footing. The DS end of the footing is also undermined. It is possible to probe over 5 feet beneath this end. At the US end of the footing, it is just possible to stick the range pole beneath the footing into loose bed material. Along the right abutment, it is possible to penetrate beneath the footing into loose bed material in places up to 2.5 feet with the range pole, although the footing is not visually undermined.
76. The left abutment exposure is greatest DS and the right abutment exposure is greatest US.
Average thalweg depth = 1.5 feet.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**25.5**	
USRWW:	**Y**		**1**		**2**	**2.0**	
DSLWW:	**0**		**1.5**		**Y**	**20.5**	
DSRWW:	**1**		**2**		**1**	**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	**2**	**2**	**Y**	**0**	**-**	**2**	**-**	**-**
Condition	**Y**	**1**	**1**	**1**	**-**	**2**	**-**	**-**
Extent	**1**	**2**	**2**	**0**	**1**	**0**	**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

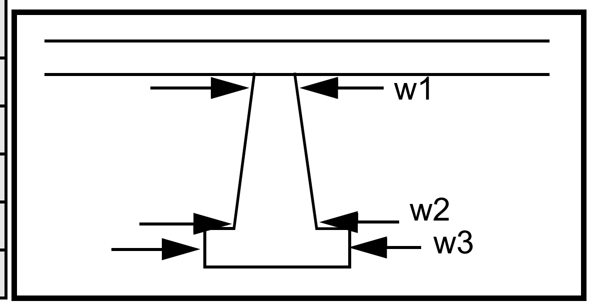
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
0
-
-
0
-
-
2
1
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				**45.0**	**14.5**	**45.0**
Pier 2				**14.5**	**40.0**	**11.0**
Pier 3			**-**	**45.0**	**11.5**	**-**
Pier 4	**-**	**-**	**-**	**-**	**-**	**-**



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e con-**	**is dete-**	**bars**	**partly**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**crete**	**rio-**	**are**	**wash**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**at**	**ratin**	**expo**	**ed**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**the**	**g.**	**sed.**	**out**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**base**	**On**	**At**	**by**	*Y- yes; N- no*
91. Attack ∠ (BF)	**s of**	**the**	**the**	**road**	
92. Pushed	**the**	**left**	**DS**	**wash**	*LB or RB*
93. Length (feet)	**-**	**-**	**-**	**-**	
94. # of piles	**abut**	**bank**	**left**	**. As**	
95. Cross-members	**ment**	**side,**	**wing**	**note**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**s and**	**rein-**	**wall,**	**d**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**wing**	**force**	**back**	**ear-**	
98. Exposure depth	**walls**	**ment**	**fill is**	**lier,**	

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

both guard rails on the left bank US and DS have posts which are almost if not entirely exposed at their base due to heavy roadwash flow.

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: **1**

Scour dimensions: Length **1** Width **7** Depth: **0** Positioned **0** %LB to **1** %RB

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

4
2
0
1

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

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

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

Confluence comments (eg. confluence name):

fill, mainly composed of cobbles and boulders. At 1.5 bridge lengths DS, there is a wingwall for the DS bridge. The base of that wingwall has been built out within the last few years and sheet piles were driven into the bed

F. Geomorphic Channel Assessment

107. Stage of reach evolution **an**

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)*:

d back filled with concrete. This wingwall protrudes 4 feet out into the channel to DS around the bend and parallel with the abutment of the DS railroad bridge.

109. G. Plan View Sketch

- N

point bar	pb	debris		flow	Q	stone wall	
cut-bank	cb	rip rap or stone fill		cross-section		other wall	
scour hole				ambient channel			

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: BURKTH00580015 Town: Burke
Road Number: TH 58 (BUGBEE ROAD) County: Caledonia
Stream: West Branch Passumpsic River

Initials EMB Date: 4/29/98 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 Davis, 1995, p. 28, eq. 16)

Approach Section

Characteristic	100 yr	500 yr	other Q
Total discharge, cfs	3650	5100	4520
Main Channel Area, ft2	701	1152	1055
Left overbank area, ft2	0	130	56
Right overbank area, ft2	0	0	0
Top width main channel, ft	72	83	82
Top width L overbank, ft	0	70	55
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.2141	0.2141	0.2141
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.7	13.9	12.9
y1, average depth, LOB, ft	ERR	1.9	1.0
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	87921	184221	159978
Conveyance, main channel	87921	181314	159132
Conveyance, LOB	0	2907	846
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	3650.0	5019.5	4496.1
Ql, discharge, LOB, cfs	0.0	80.5	23.9
Qr, discharge, ROB, cfs	0.0	0.0	0.0
Vm, mean velocity MC, ft/s	5.2	4.4	4.3
Vl, mean velocity, LOB, ft/s	ERR	0.6	0.4
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	9.8	10.4	10.3
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

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	3650	4962	4520
Main channel area (DS), ft2	268.3	365.7	353
Main channel width (normal), ft	25.2	25.3	25.3
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.2	25.3	25.3
D90, ft	0.4902	0.4902	0.4902
D95, ft	0.5745	0.5745	0.5745
Dc, critical grain size, ft	0.5996	0.5362	0.4833
Pc, Decimal percent coarser than Dc	0.040	0.072	0.104
Depth to armoring, ft	N/A	20.83	12.49

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 Davis, 1995, p. 32, eq. 20, 20a)

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	3650	5100	4520
(Q) discharge thru bridge, cfs	3650	4962	4520
Main channel conveyance	30534	35825	35825
Total conveyance	30534	35825	35825
Q2, bridge MC discharge,cfs	3650	4962	4520
Main channel area, ft2	268	366	366
Main channel width (normal), ft	25.2	25.3	25.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.2	25.3	25.3
y_bridge (avg. depth at br.), ft	10.65	14.45	14.45
Dm, median (1.25*D50), ft	0.267625	0.267625	0.267625
y2, depth in contraction,ft	12.83	16.64	15.36
ys, scour depth (y2-ybridge), ft	2.19	2.19	0.91

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 Davis, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	3650	5100	4520
Q, thru bridge MC, cfs	3650	4962	4520
Vc, critical velocity, ft/s	9.80	10.40	10.27
Va, velocity MC approach, ft/s	5.21	4.36	4.26
Main channel width (normal), ft	25.2	25.3	25.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25.2	25.3	25.3
qbr, unit discharge, ft2/s	144.8	196.1	178.7
Area of full opening, ft2	268.3	365.7	365.7
Hb, depth of full opening, ft	10.65	14.45	14.45
Fr, Froude number, bridge MC	0	0.63	0.57
Cf, Fr correction factor (<=1.0)	0.00	1.00	1.00
**Area at downstream face, ft2	N/A	N/A	353
**Hb, depth at downstream face, ft	N/A	N/A	13.95
**Fr, Froude number at DS face	ERR	ERR	0.60
**Cf, for downstream face (<=1.0)	N/A	N/A	1.00
Elevation of Low Steel, ft	0	787.68	787.68
Elevation of Bed, ft	-10.65	773.23	773.23
Elevation of Approach, ft	0	792.54	791.37
Friction loss, approach, ft	0	0.08	0.07
Elevation of WS immediately US, ft	0.00	792.46	791.30
ya, depth immediately US, ft	10.65	19.23	18.07
Mean elevation of deck, ft	0	794	794
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.93	0.94
**Cc, for downstream face (<=1.0)	ERR	ERR	0.935584
Ys, scour w/Chang equation, ft	N/A	5.87	3.97
Ys, scour w/Umbrell equation, ft	N/A	-1.91	-2.73

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

**Ys, scour w/Chang equation, ft	N/A	N/A	4.65
**Ys, scour w/Umbrell equation, ft	ERR	N/A	-2.23

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	12.83	16.64	15.36
WSEL at downstream face, ft	--	--	787.19
Depth at downstream face, ft	N/A	N/A	13.95
Ys, depth of scour (Laursen), ft	N/A	N/A	1.41

Abutment Scour

Froehlich’s Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a’/Y1)^0.43*Fr1^0.61+1
(Richardson and Davis, 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	3650	5100	4520	3650	5100	4520
a’, abut.length blocking flow, ft	19.3	91.8	76.5	27.7	36.6	34.8
Ae, area of blocked flow ft2	122.9	336.3	274.1	264.9	448.7	406.1
Qe, discharge blocked abut.,cfs	365	--	740.3	1294.1	1683	1516.1
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	2.97	2.52	2.70	4.89	3.75	3.73
ya, depth of f/p flow, ft	6.37	3.66	3.58	9.56	12.26	11.67
--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	0.207	0.221	0.251	0.278	0.189	0.193
ys, scour depth, ft	13.68	14.51	14.30	22.45	25.47	24.39

HIRE equation (a’/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55
(Richardson and Davis, 1995, p. 49, eq. 29)

a’(abut length blocked, ft)	19.3	91.8	76.5	27.7	36.6	34.8
y1 (depth f/p flow, ft)	6.37	3.66	3.58	9.56	12.26	11.67
a’/y1	3.03	25.06	21.35	2.90	2.99	2.98
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.21	0.22	0.25	0.28	0.19	0.19
Ys w/ corr. factor K1/0.55:						
vertical	ERR	16.19	ERR	ERR	ERR	ERR
vertical w/ ww’s	ERR	13.28	ERR	ERR	ERR	ERR
spill-through	ERR	8.90	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 Davis, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.73	0.63	0.6	0.73	0.63	0.6
y, depth of flow in bridge, ft	10.65	14.45	13.95	10.65	14.45	13.95
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	3.51	3.55	3.10	3.51	3.55	3.10
Fr>0.8 (vertical abut.)	ERR	ERR	ERR	ERR	ERR	ERR