LEVEL II SCOUR ANALYSIS FOR BRIDGE 43 (SPRICYBRIG0043) on BRIDGE STREET, crossing the BLACK RIVER, SPRINGFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-227

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and
FEDERAL HIGHWAY ADMINISTRATION

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By MICHAEL A. IVANOFF and LAURA MEDALIE

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Pembroke, New Hampshire

1997

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 43 (SPRICYBRIG0043) ON BRIDGE STREET, CROSSING THE BLACK RIVER, SPRINGFIELD, VERMONT

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

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure SPRICYBRIG0043 on Bridge Street crossing the Black River, Springfield, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in southeastern Vermont. The 191-mi^2 drainage area is a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consist of some grass, buildings, and pavement. The immediate banks are covered with trees, shrubs and brush.

In the study area, the Black River has an incised channel with a slope of approximately 0.001 ft/ft, an average channel top width of 156 ft and an average bank height of 14 ft. The channel bed material is predominantly cobbles with a median grain size (D_{50}) of 90.7 mm (0.298 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 19, 1996, indicated that the reach was stable.

The Bridge Street crossing of the Black River is a 123-foot-long, two-lane bridge consisting of one 119-foot steel-beam span (Vermont Agency of Transportation, written communication, March 30, 1995). The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 20 degrees to the opening while the opening-skew-to-roadway is 20 degrees.

The scour protection measures at the site were type-2 stone fill (less than 36 inches diameter) along the downstream left bank and the downstream left wingwall. There was also type-1 stone fill (less than 12 inches diameter) along right abutment and the downstream right wingwall. There is a nine foot tall concrete wall along the downstream right bank to 89 feet downstream of the bridge. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and others, 1995). 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.

There was no computed contraction scour. Left abutment scour ranged from 9.9 to 11 ft. The worst-case left abutment scour occurred at the 100-year discharge. Right abutment scour ranged from 6.5 to 11.2 ft. The worst-case right abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

It is generally accepted that the Froehlich equation (abutment scour) gives “excessively conservative estimates of scour depths” (Richardson and others, 1995, p. 47). Usually, computed scour depths are evaluated in combination with other information including (but not limited to) historical performance during flood events, the geomorphic stability assessment, existing scour protection measures, and the results of the hydraulic analyses. Therefore, scour depths adopted by VTAOT may differ from the computed values documented herein.

Springfield, VT. Quadrangle, 1:25,000, 1984

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 SPRICYBRIG0043 ***Stream*** Black River

County Windsor ***Road*** Bridge Street ***District*** 2

Description of Bridge

Bridge length 123 ***ft*** ***Bridge width*** 41 ***ft*** ***Max span length*** 119 ***ft***

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

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

Stone fill on abutment? Yes, right ***Date of inspection*** 09/19/96

Description of stone fill Type-2, along the upstream banks, downstream left wingwall, and the downstream left bank. Type-1, along the right abutment and the downstream right wingwall.

Abutments and wingwalls are concrete.

Brief description of piers/abutments

Yes

20 No

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

Is bridge located on a bend in channel? If so, describe (mild, moderate, severe)

09/19/96

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 96	0 0	09/19/ 0
Level II	Low.		

Potential for debris

None 09/19/96.

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

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley, with a narrow flood plain and steep valley walls on both sides.

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

Date of inspection 09/19/96

DS left: Steep channel bank to a narrow flood plain.

DS right: Moderately sloped channel bank to a narrow flood plain.

US left: Steep channel bank to a narrow flood plain.

US right: Steep channel bank to a narrow flood plain.

Description of the Channel

Average top width 156 ft ***Average depth*** 14 ft

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

Straight and stable with semi-alluvial channel boundaries.

09/19/96

Vegetative co Brush on the bank with grass on the flood plain.

DS left: Trees and brush on bank with grass on the flood plain.

DS right: Brush on the bank with grass on the flood plain.

US left: Trees and brush on bank with grass on the flood plain.

US right:

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

None 09/19/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 191 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: There are factory buildings on the upstream and downstream right bank.

Yes, discontinued 1989

Is there a USGS gage on the stream of interest?

USGS gage description Black River at North Springfield, VT

USGS gage number 01153000

Gage drainage area 158 ***mi²***

No

Is there a lake/p ...

Calculated Discharges

Q100 6,940 ***ft³/s*** ***Q500*** 9,910 ***ft³/s***

The 100- and 500-year discharges at this site are based on a drainage area relationship [(191/194)exp 0.7] with the Black River upstream of Seaver Brook. The Black River upstream of Seaver Brook has flood frequency estimates available in the Flood Insurance Study for Springfield, VT (Federal Emergency Management Agency, June 1979). The drainage area on the Black River upstream of Seaver Brook is 194 square miles. These values were within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans Subtract 161.8 feet from the USGS survey to obtain VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is a VTAOT tablet on top of the downstream end of the right abutment (elev. 501.91 ft, arbitrary survey datum). RM2 is a chiseled X on top of the downstream end of the left abutment (elev. 499.71ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-118	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	23	1	Road Grade section
APPRO	156	2	Modelled Approach section (Templated from APTEM)
APTEM	170	1	Approach section as surveyed (Used as a template)

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

Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.035 to 0.040, and overbank "n" values ranged from 0.040 to 0.050.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user's manual for WSPRO (Shearman, 1990). The slope used was 0.001 ft/ft. The slope was estimated from the 100-year discharge water surface profile slope downstream of the site presented in the Flood Insurance Study for Springfield, VT (FEMA, June 1979).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.004 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.0 *ft*
Average low steel elevation 493.4 *ft*

100-year discharge 6,940 *ft^3/s*
Water-surface elevation in bridge opening 492.9 *ft*
Road overtopping? No *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 1166 *ft^2*
Average velocity in bridge opening 6.0 *ft/s*
Maximum WSPRO tube velocity at bridge 7.6 *ft/s*

Water-surface elevation at Approach section with bridge 493.0
Water-surface elevation at Approach section without bridge 493.1
Amount of backwater caused by bridge N/A *ft*

500-year discharge 9,910 *ft^3/s*
Water-surface elevation in bridge opening 494.5 *ft*
Road overtopping? No *Discharge over road* -- *ft^3/s*
Area of flow in bridge opening 1226 *ft^2*
Average velocity in bridge opening 8.1 *ft/s*
Maximum WSPRO tube velocity at bridge 9.2 *ft/s*

Water-surface elevation at Approach section with bridge 496.4
Water-surface elevation at Approach section without bridge 495.3
Amount of backwater caused by bridge 1.1

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year discharge was computed by use of Laursen's clear water scour equation (Richardson and others, 1995, p. 32, equation 20). The 500-year discharge resulted in submerged orifice flow. Contraction scour at bridges with orifice flow is best estimated by use of the Chang pressure-flow scour equation (oral communication, J. Sterling Jones, October 4, 1996). Hence, the 500-year event contraction scour depth was computed by use of the Chang equation (Richarson and others, 1995, p. 145-146). The results of Laursen's contraction scour equation for the 500-year event were also computed for comparison and can be found in appendix F.

Abutment scour for the 500-year event was computed by use of the Froehlich equation (Richardson and others, 1995, p. 48, equation 28). Variables for the Froehlich equation include the Froude number of the flow approaching the embankments, the length of the embankment blocking flow, and the depth of flow approaching the embankment less any roadway overtopping.

For the 100-year model, the top width of the water surface in the surveyed approach section is 3.6 feet narrower than in the bridge section. Thus, the abutments are not diverting flow into the main channel. This makes computation of abutment scour impossible. In accordance with the Froehlich equation factor of safety (Richardson and others, 1995, p. 48, equation 28), abutment scour was set equal to the depth of flow at the abutments.

Scour Results

Contraction scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(Scour depths in feet)		
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	0.1	0.4	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	11.0	9.9	--
Left abutment	6.5	11.2	--
Right abutment			
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	500-yr discharge	Incipient overtopping discharge
	(D_{50} in feet)		
Abutments:	0.7	1.4	--
Left abutment	0.7	1.4	--
Right abutment			
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

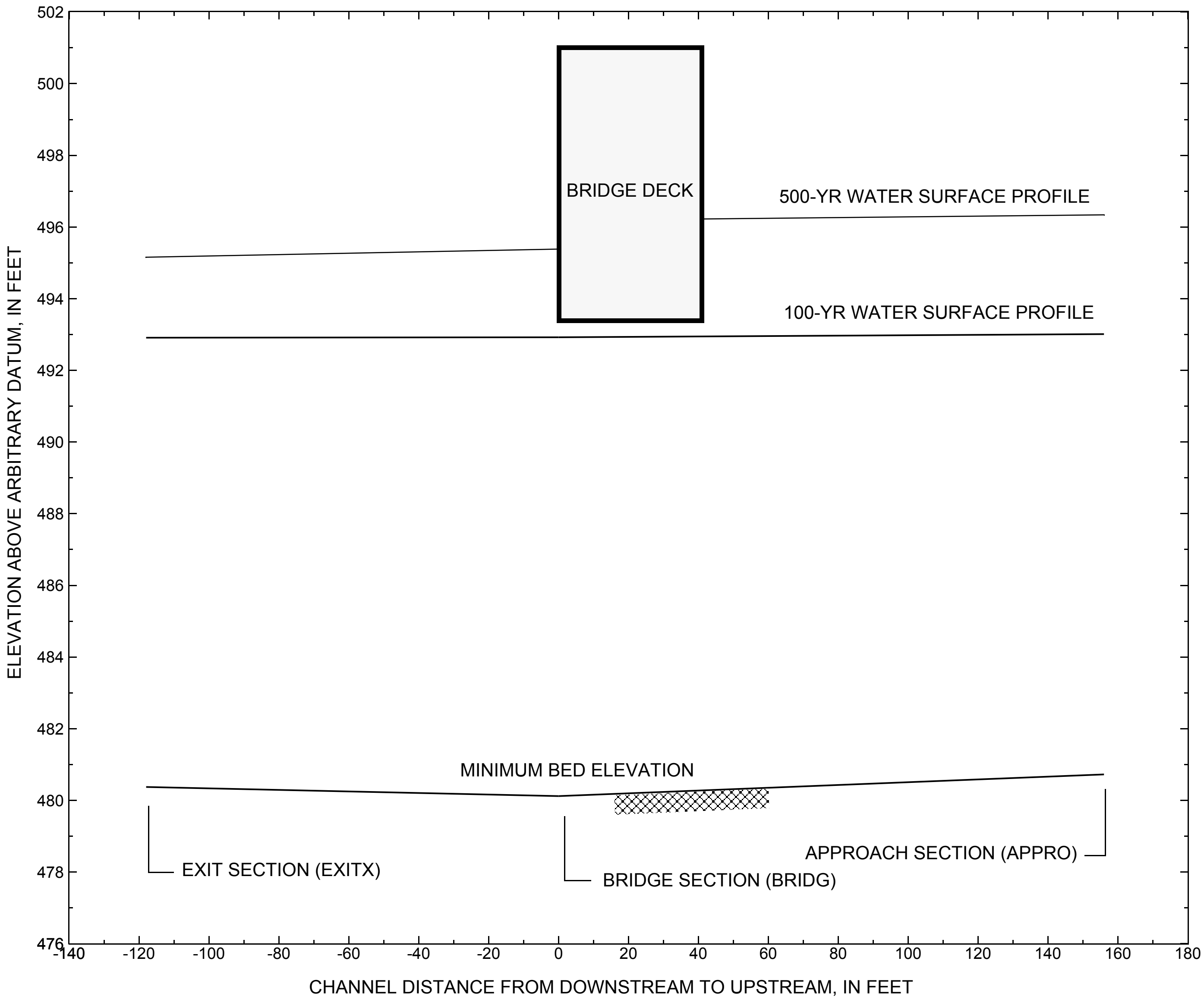

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure SPRICYBRIG0043 on Bridge Street, crossing the Black River, Springfield, Vermont.

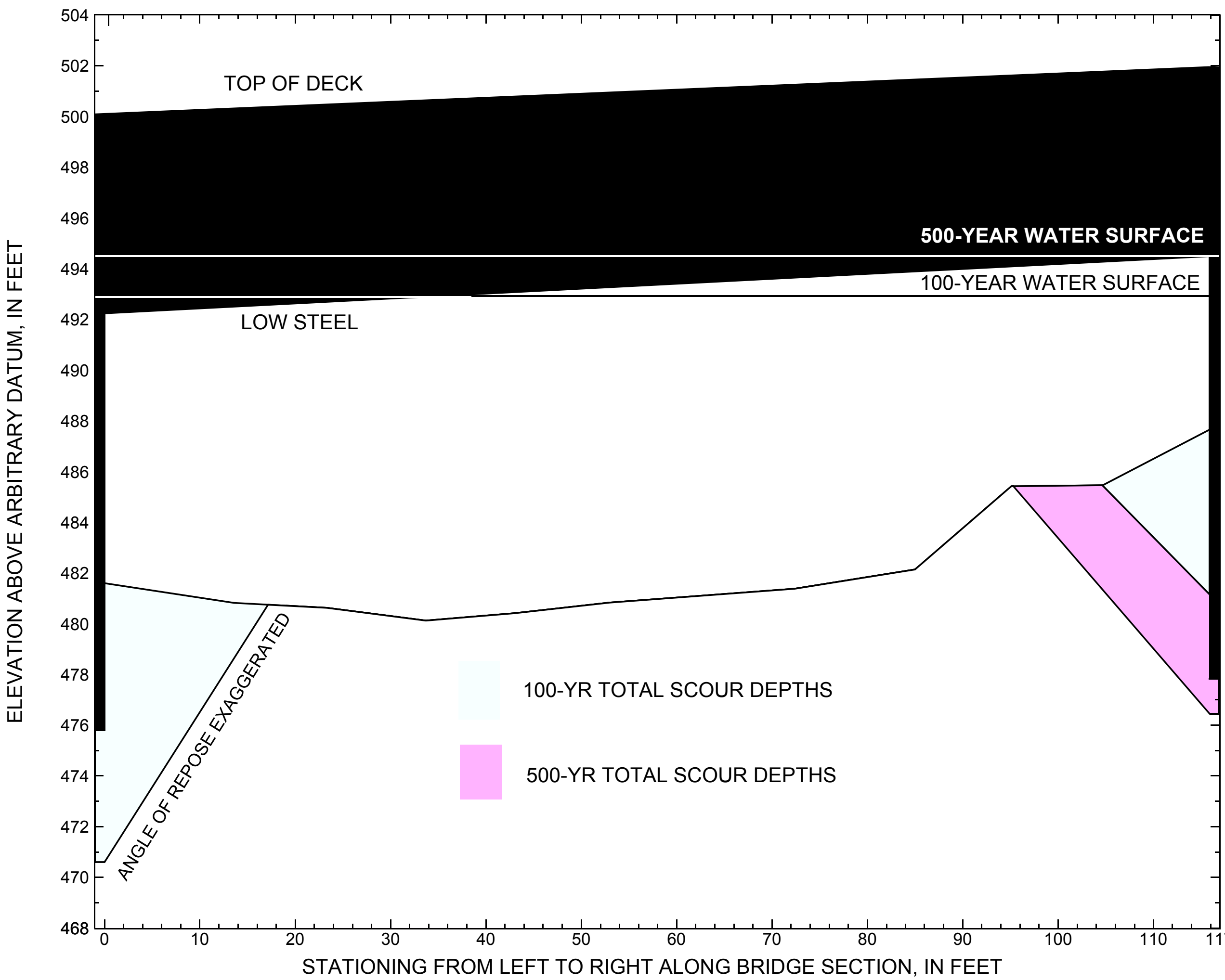

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure SPRICYBRIG0043 on Bridge Street, crossing Black River, Springfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure SPRICYBRIG0043 on Bridge Street, crossing the Black River, Springfield, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 6,940 cubic-feet per second											
Left abutment	0.0	330.1	492.2	475.8	481.6	0.0	11.0	--	11.0	470.6	-5.2
Right abutment	115.9	332.3	494.5	477.8	487.6	0.0	6.5	--	6.5	481.1	3.3

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure SPRICYBRIG0043 on Bridge Street, crossing the Black River, Springfield, Vermont.

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

Description	Station[1]	VTAOT bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 9,910 cubic-feet per second											
Left abutment	0.0	330.1	492.2	475.8	481.6	0.0	9.9	--	9.9	471.7	-4.1
Right abutment	115.9	332.3	494.5	477.8	487.6	0.0	11.2	--	11.2	476.4	-1.4

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

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U.S. Geological Survey, 1984, Springfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File spri043.wsp
T2        Hydraulic analysis for structure SPRICYBRIG0043   Date: 24-JAN-97
T3        Bridge # 43 on Bridge Street over the Black River in Springfield, VT
*
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           6940.0   9910.0
SK          0.0010   0.0010
*
XS   EXITX   -118
GR         -578.3, 516.66   -534.4, 511.23   -456.5, 504.97   -209.6, 495.07
GR          -99.4, 494.59      0.0, 493.66     16.3, 483.16     21.1, 481.95
GR           27.0, 481.22     40.1, 480.79     48.3, 481.35     65.1, 480.65
GR           76.3, 480.37     90.0, 481.29     96.3, 482.05    106.7, 483.84
GR          138.6, 488.23    154.1, 495.16    170.1, 498.01    403.4, 498.72
GR          599.1, 497.75    601.8, 508.98    614.0, 512.31
N           0.040        0.040        0.050
SA                  0.0        154.1
*
XS   FULLV      0  * * *   0.0009
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    493.37      20.0
GR            0.0, 492.24      0.0, 481.60     13.6, 480.82     23.3, 480.63
GR           33.7, 480.12     43.0, 480.41     53.0, 480.83     72.4, 481.38
GR           85.0, 482.14     95.1, 485.42    104.7, 485.46    115.6, 487.65
GR          115.9, 494.49      0.0, 492.24
*        BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      56.1 * *     67.7      8.1
N           0.035
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     23      41.0     1
GR          -41.5, 515.40      0.0, 500.10    116.4, 501.95    167.7, 501.45
GR          167.7, 500.86    474.1, 497.28    476.4, 502.77    491.8, 509.36
*
XT   APTEM    170
*            In FEMA study, flow was not found to leave the left bank
GR            0.0, 499.63     23.2, 484.21     28.1, 482.82     33.3, 481.52
GR           54.9, 481.28     63.6, 480.77     75.3, 481.75     82.3, 481.65
GR           98.4, 481.80    102.1, 482.75    117.8, 495.21    157.6, 499.20
GR          357.5, 499.21    479.4, 497.29    493.5, 508.95
*
AS   APPRO   156
GT            -0.053
N           0.050        0.040        0.050
SA                  0.0        157.6
*
HP 1 BRIDG   492.92 1 492.92
HP 2 BRIDG   492.92 * * 6940
HP 1 APPRO   493.01 1 493.01
HP 2 APPRO   493.01 * * 6940
*
HP 1 BRIDG   494.49 1 494.49
HP 2 BRIDG   494.49 * * 9910
HP 1 APPRO   496.38 1 496.38
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File spri043.wsp
        Hydraulic analysis for structure SPRICYBRIG0043   Date: 24-JAN-97
        Bridge # 43 on Bridge Street over the Black River in Springfield, VT
           *** RUN DATE & TIME: 02-25-97  11:26
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1166    187864     76    158                        25925
   492.92          1166    187864     76    158  1.00      0    116    25925

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       492.92     0.0   115.8  1165.9  187864.    6940.   5.95

X STA.         0.0         9.7        16.6        23.1        29.4        35.3
  A(I)            100.0        75.5        72.9        73.1        69.8
  V(I)             3.47        4.60        4.76        4.75        4.97

X STA.        35.3        39.5        43.8        48.0        52.1        56.2
  A(I)             50.7        50.0        48.7        47.4        46.8
  V(I)             6.85        6.95        7.13        7.31        7.41

X STA.        56.2        60.4        64.5        68.7        73.0        77.4
  A(I)             46.4        46.0        46.1        47.1        46.9
  V(I)             7.47        7.55        7.53        7.36        7.41

X STA.        77.4        82.0        87.1        93.9       102.6       115.8
  A(I)             48.4        50.9        57.2        61.4        80.8
  V(I)             7.17        6.82        6.07        5.66        4.30


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     156.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2     1026    167348    105    112                        18185
   493.01          1026    167348    105    112  1.00     10    115    18185

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     156.

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.01     9.9   115.1  1026.1  167348.    6940.   6.76

X STA.         9.9        26.1        31.5        35.9        40.2        44.2
  A(I)             86.1        55.8        51.1        49.4        46.0
  V(I)             4.03        6.22        6.79        7.03        7.54

X STA.        44.2        48.2        52.1        55.9        59.6        63.2
  A(I)             47.0        45.4        45.2        44.4        43.8
  V(I)             7.39        7.63        7.68        7.81        7.92

X STA.        63.2        66.8        70.7        74.6        78.6        82.7
  A(I)             44.0        45.6        45.1        45.7        46.9
  V(I)             7.89        7.61        7.70        7.60        7.40

X STA.        82.7        86.9        91.1        95.5       100.5       115.1
  A(I)             47.4        48.3        50.0        55.3        83.8
  V(I)             7.32        7.19        6.94        6.28        4.14
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File spri043.wsp
        Hydraulic analysis for structure SPRICYBRIG0043   Date: 24-JAN-97
        Bridge # 43 on Bridge Street over the Black River in Springfield, VT
           *** RUN DATE & TIME: 02-25-97  11:26
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1     1226    156486      0    236                     88137296
   494.49          1226    156486      0    236  1.00      0    116 88137296


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       494.49     0.0   115.9  1225.5  156486.    9910.   8.09

X STA.         0.0        8.2       14.1       19.3       24.5       29.3
  A(I)            84.3       63.4       58.1       58.4       55.5
  V(I)            5.88       7.81       8.52       8.49       8.93

X STA.        29.3       34.0       38.6       43.1       47.8       52.4
  A(I)            55.8       55.2       54.1       55.0       54.6
  V(I)            8.89       8.98       9.16       9.01       9.08

X STA.        52.4       57.2       61.9       66.8       71.7       76.7
  A(I)            55.6       55.4       55.9       57.6       56.4
  V(I)            8.91       8.94       8.87       8.61       8.78

X STA.        76.7       82.0       87.6       94.9      103.7      115.9
  A(I)            59.8       61.5       67.5       72.4       89.0
  V(I)            8.28       8.06       7.34       6.84       5.57


    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     156.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2     1403    250329    125    134                        26650
   496.38          1403    250329    125    134  1.00      5    130    26650


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     156.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.38     4.8   130.0  1402.9  250329.    9910.   7.06

X STA.         4.8       23.4       29.4       33.9       38.2       42.2
  A(I)           114.9       78.0       65.4       64.5       60.0
  V(I)            4.31       6.35       7.57       7.69       8.26

X STA.        42.2       46.1       50.1       53.9       57.7       61.5
  A(I)            58.9       59.7       57.9       57.6       58.4
  V(I)            8.41       8.29       8.55       8.60       8.48

X STA.        61.5       65.2       69.0       72.9       77.1       81.5
  A(I)            57.7       58.7       59.3       61.1       64.4
  V(I)            8.58       8.44       8.36       8.11       7.69

X STA.        81.5       85.8       90.3       95.4      101.1      130.0
  A(I)            64.6       66.4       73.9       82.9      138.4
  V(I)            7.67       7.46       6.71       5.98       3.58
```

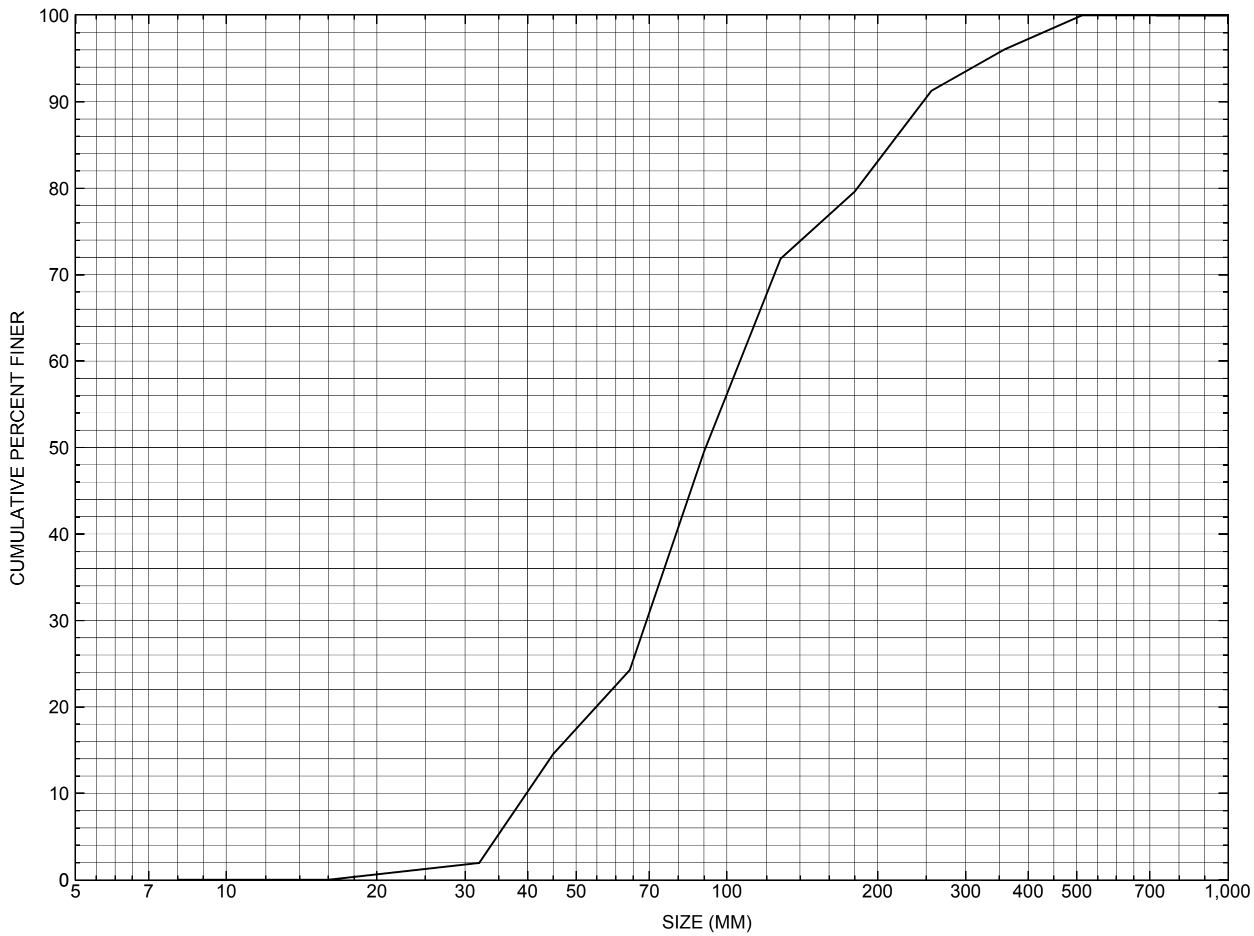
```
        U.S. Geological Survey WSPRO Input File spri043.wsp
        Hydraulic analysis for structure SPRICYBRIG0043   Date: 24-JAN-97
        Bridge # 43 on Bridge Street over the Black River in Springfield, VT
           *** RUN DATE & TIME: 02-25-97  11:26

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

EXITX:XS   ******      1     1366  0.40 *****  493.31  487.02    6940  492.91
      -117 ******    149   219349  1.00 ***** *******    0.29    5.08

FULLV:FV      118      1     1369  0.40  0.12  493.43 *******    6940  493.04
         0    118    149   220116  1.00  0.00    0.01    0.29    5.07
         <<<<<THE ABOVE RESULTS REFLECT “NORMAL” (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      156     10     1034  0.70  0.20  493.79 *******    6940  493.08
       156    156    115   169237  1.00  0.15    0.00    0.38    6.71
         <<<<<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      118      0     1166  0.55  0.15  493.48  487.07    6940  492.92
         0    118    116   187773  1.00  0.01    0.00    0.33    5.95

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  493.37 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      23.        <<<<<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      100     10     1026  0.71  0.17  493.72  487.78    6940  493.01
       156    100    115   167427  1.00  0.08   -0.01    0.38    6.76

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.000  0.000  167561.     6.   122.   492.82

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -118.     1.   149.   6940.  219349.    1366.    5.08  492.91
   FULLV:FV      0.      1.   149.   6940.  220116.    1369.    5.07  493.04
   BRIDG:BR      0.      0.   116.   6940.  187773.    1166.    5.95  492.92
   RDWAY:RG     23.**************      0.******************     1.00********
   APPRO:AS     156.    10.   115.   6940.  167427.    1026.    6.76  493.01

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       6.   122.  167561.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    487.02     0.29  480.37  516.66************  0.40  493.31  492.91
   FULLV:FV  ********     0.29  480.48  516.77  0.12  0.00  0.40  493.43  493.04
   BRIDG:BR    487.07     0.33  480.12  494.49  0.15  0.01  0.55  493.48  492.92
   RDWAY:RG  ***************  497.28  515.40*********************************
   APPRO:AS    487.78     0.38  480.72  508.90  0.17  0.08  0.71  493.72  493.01
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File spri043.wsp
        Hydraulic analysis for structure SPRICYBRIG0043   Date: 24-JAN-97
        Bridge # 43 on Bridge Street over the Black River in Springfield, VT
           *** RUN DATE & TIME: 02-25-97  11:26

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

EXITX:XS   ******   -211     1849  0.50 *****  495.67  488.39    9910  495.17
      -117 ******    154   313235  1.13 ***** *******    0.45    5.36

FULLV:FV      118   -212     1860  0.50  0.12  495.81 *******    9910  495.31
         0    118    154   314932  1.13  0.00    0.01    0.44    5.33
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      156      6     1274  0.94  0.21  496.24 *******    9910  495.30
       156    156    119   228021  1.00  0.22    0.00    0.41    7.78
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   495.31     493.37

            <<<<<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      118      0     1226  1.02 *****  495.51  488.46    9908  494.49
         0 ******    116   156486  1.00 ***** *******    0.44    8.08

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   3.  0.800 ******  493.37 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      23.        <<<<<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      100      5     1403  0.78  0.27  497.16  489.39    9910  496.38
       156    106    130   250344  1.00  0.08    0.00    0.37    7.06

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS    -118.  -212.   154.   9910.  313235.    1849.    5.36  495.17
   FULLV:FV       0.  -213.   154.   9910.  314932.    1860.    5.33  495.31
   BRIDG:BR       0.     0.   116.   9908.  156486.    1226.    8.08  494.49
   RDWAY:RG      23.**************      0.       0.*********    1.00********
   APPRO:AS     156.     5.   130.   9910.  250344.    1403.    7.06  496.38

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    488.39    0.45  480.37  516.66************  0.50  495.67  495.17
   FULLV:FV  ********    0.44  480.48  516.77  0.12  0.00  0.50  495.81  495.31
   BRIDG:BR    488.46    0.44  480.12  494.49************  1.02  495.51  494.49
   RDWAY:RG  ****************  497.28  515.40************  0.51  499.09********
   APPRO:AS    489.39    0.37  480.72  508.90  0.27  0.08  0.78  497.16  496.38
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure SPRICYBRIG0043, in Springfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number SPRICYBRIG0043

General Location Descriptive

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

Date *(MM/DD/YY)* 03 / 30 / 95

Highway District Number *(I - 2; nn)* 02

County *(FIPS county code; I - 3; nnn)* 027

Town *(FIPS place code; I - 4; nnnnn)* 69475

Mile marker *(I - 11; nnn.nnn)* 000080

Waterway *(I - 6)* BLACK RIVER

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

Route Number -

Vicinity *(I - 9)* -

Topographic Map Springfield

Hydrologic Unit Code: 01080106

Latitude *(I - 16; nnnn.n)* 43178

Longitude *(i - 17; nnnnn.n)* 72285

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 20250200431418

Maintenance responsibility *(I - 21; nn)* 04

Maximum span length *(I - 48; nnnn)* 0119

Year built *(I - 27; YYYY)* 1988

Structure length *(I - 49; nnnnnn)* 000123

Average daily traffic, ADT *(I - 29; nnnnnn)* 002490

Deck Width *(I - 52; nn.n)* 410

Year of ADT *(I - 30; YY)* 89

Channel & Protection *(I - 61; n)* 8

Opening skew to Roadway *(I - 34; nn)* 18

Waterway adequacy *(I - 71; n)* 8

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

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

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

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) 117.0

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

Vertical clearance from streambed (*nnn.n ft*) 013.0

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

Waterway of full opening (*nnn.n* ft^2) 1213.

Comments:

The structural inspection report of 8/24/94 indicates the structure is a steel stringer type bridge with a concrete deck and an asphalt roadway surface. The abutment walls and wingwalls are concrete, which are reported in "like-new" condition. There is an older concrete abutment just upstream from the current left abutment, which has some random heavy spalling. The waterway is noted as making a very slight bend into the crossing. The streambed consists of stone and gravel. There is some stone fill noted along the right abutment. The abutment footings are reported as not exposed. Channel scour, streambank erosion, point bars, and debris accumulation problems are all reported as not evident at this site.

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **189.3**

Terrain character: **Mountainous to rolling**

Stream character & type: **Mountainous and a tributary to the Connecticut River.**

Streambed material: **Sandy Gravel**

Discharge Data *(cfs)*: $Q_{2.33}$ **2000** Q_{10} **3500** Q_{25} **4400**

Q_{50} **5200** Q_{100} **6900** Q_{500} **-**

Record flood date *(MM / DD / YY)*: **-** / **-** / **27** Water surface elevation *(ft)*: **-**

Estimated Discharge *(cfs)*: **-** Velocity at Q **25** *(ft/s)*: **6.7**

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

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

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

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

Watershed storage area (*in percent*): **1** %

The watershed storage area is: **2** (*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*)	325.2	327.2	328.2	329.0	330.6
Velocity (*ft / sec*)	4.9	6.1	6.6	7.1	7.7

Long term stream bed changes: **Calculated scour estimated at 2 to 4 feet.**

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

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

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

Upstream distance (*miles*): **0.75** Town: **Springfield** Year Built: **-**

Highway No. : **VT11** Structure No. : **64** Structure Type: **-**

Clear span (*ft*): **148.** Clear Height (*ft*): **27.0** Full Waterway (*ft²*): **4000.**

Downstream distance (*miles*): **1.1** Town: **Springfield** Year Built: **-**

Highway No. : **TH66** Structure No. : **81** Structure Type: **-**

Clear span (*ft*): **152.** Clear Height (*ft*): **15.0** Full Waterway (ft^2): **2280.**

Comments:

Hydraulics report recommends using class II stone fill. The type of foundation indicated is silt and sandy silt material below the bridge footings. Relief over bridge or roadway is not expected for flows less than or equal to the Q100.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **191.30** mi^2 Lake and pond area **2.33** mi^2

Watershed storage *(ST)* **1.22** %

Bridge site elevation **335** ft Headwater elevation **3400** ft

Main channel length **41.79** mi

10% channel length elevation **450** ft 85% channel length elevation **1195** ft

Main channel slope *(S)* **23.77** ft / mi

Watershed Precipitation Data

Average site precipitation ______ in Average headwater precipitation ______ in

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

Average seasonal snowfall *(Sn)* ______ ft

Bridge Plan Data

Are plans available? **Y** *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: **04** / **1987**

Project Number **M - 2500 (7)** Minimum channel bed elevation: **318.7**

Low superstructure elevation: USLAB **330.63** DSLAB **330.11** USRAB **332.51** DSRAB **332.31**

Benchmark location description:

There is no specific benchmark information on the plan. Some other points shown with elevations are: 1) the point on the top streamward edge of the upstream right wingwall concrete where the concrete slope changes from horizontal to downward, elevation 340.0, and 2) The point at the same location as in 1) but on the upstream left wingwall, elevation 338.17.

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

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

If 1: Footing Thickness **3.0** Footing bottom elevation: **314.0***

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? **Y** *If no, type ctrl-n bi* Number of borings taken: **4**

Foundation Material Type: **1** (*1-regolith, 2-bedrock, 3-unknown*)

Briefly describe material at foundation bottom elevation or around piles:

Footing of the right abutment is set in sand, gravel and silt (B1 and B2)
Footing of the left abutment is set in silt (B3 upstream end) and silt (B4 center) with bedrock 14.9 feet below the footing base.

Comments:

***The bottom of the left abutment footing is shown at 314.0 left, and that of the right abutment is shown at 316.0. Additional elevation points: the lowest end on the top of the upstream right wingwall, elevation 337.5; The top streamward edge of the downstream right wingwall where the slope begins to decline, elevation 339.9; The lowest end on the top of the downstream right wingwall, elevation 335.0; The lowest point on the top of the upstream left wingwall, elevation 335.6; The top streamward edge of the downstream left wingwall where the slope begins to decline, elevation 337.7; The lowest point on the top of the downstream left wingwall, elevation 334.5.**

Cross-sectional Data

Is cross-sectional data available? **Y** *If no, type ctrl-n xs*

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

Comments: **Several cross section are available. No reproducible bridge face cross sections.**

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

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

Comments: **FEMA data exists, but its collection predates the bridge construction.**
-

Station		-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

Station	-	-	-	-	-	-	-	-	-	-	-
Feature	-	-	-	-	-	-	-	-	-	-	-
Low cord elevation	-	-	-	-	-	-	-	-	-	-	-
Bed elevation	-	-	-	-	-	-	-	-	-	-	-
Low cord to bed length	-	-	-	-	-	-	-	-	-	-	-

APPENDIX E:

LEVEL I DATA FORM

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

Qa/Qc Check by: **RB** Date: **10/17/96**

Computerized by: **RB** Date: **10/17/96**

Reviewd by: **MAI** Date: **02/25/97**

Structure Number **SPRICYBRIG0043**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L**. **MEDALIE** Date *(MM/DD/YY)* **09** / **19** / 19**96**

2. Highway District Number **02** Mile marker **000080**

County **WINDSOR (027)** Town **SPRINGFIELD (69475)**

Waterway *(I - 6)* **BLACK RIVER** Road Name **BRIDGE STREET**

Route Number **-** Hydrologic Unit Code: **01080106**

3. Descriptive comments:

Located 0.05 miles from the intersection of Bridge Street with VT 11.

B. Bridge Deck Observations

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

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

7. Bridge length **123** *(feet)* Span length **119** *(feet)* Bridge width **41** *(feet)*

Road approach to bridge:

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

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

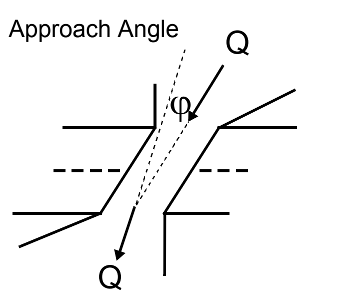
10. Embankment slope (*run / rise in feet / foot*):
US left **0.0:1** US right **0.0:1**

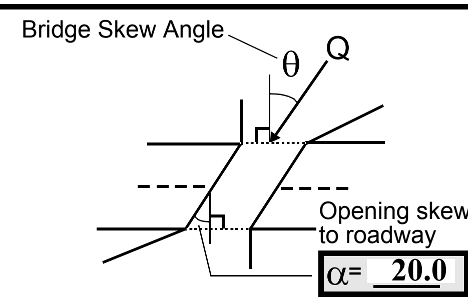
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	0	-
RBUS	0	-	0	-
RBDS	0	-	0	-
LBDS	0	-	0	-

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

Channel approach to bridge (BF):

15. Angle of approach: **0** 16. Bridge skew: **20**





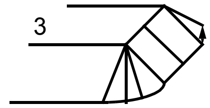
17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **LB** *(LB, RB)* Severity **2**
Range? **250** feet **DS** *(US, UB, DS)* to **480** feet **DS**

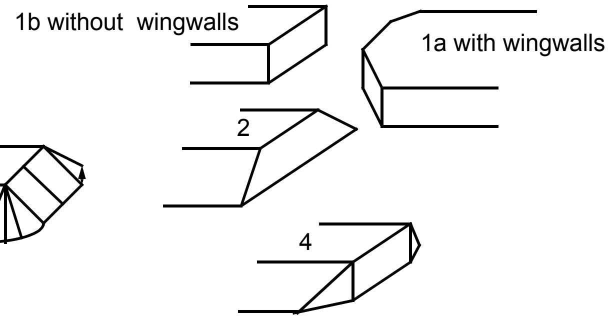
Channel impact zone 2: Exist? **N** *(Y or N)*
Where? **-** *(LB, RB)* Severity **-**
Range? **-** feet **-** *(US, UB, DS)* to **-** feet **-**

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

18. Bridge Type: **1a**

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





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

4. There are industry buildings and parking lots on all flood plains with some lawn on the left flood plain US and DS with forest cover beyond the buildings.
7. Values are from the VT AOT files. Measured bridge width is 41.5 feet between the outside of the curbs, bridge length is 121 ft., and the span length is 116 ft.

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
121.5	**16.7**			**16.5**	**1**	**3**	**23**	**23**	**1**	**1**

23. Bank width **35.0** 24. Channel width **40.0** 25. Thalweg depth **157.6** 29. Bed Material **453**

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

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

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

30. There is "poured concrete" or hardened factory waste along the banks that is sometimes clumpy and in other places it is continuous. There is also other debris such as bricks, metal scraps and wire along the banks. On the left bank the "poured concrete" extends from the end of the old abutment wall to 100 ft. US. On the right bank the "poured concrete" extends from 0 ft. US to 350 ft. US where it meets the bedrock outcrop. At 350 ft. US there is a concrete penstock wall built into the bedrock. There is backwater to the right of this wall and scour just DS of its nose.
26. The left bank is entirely covered with brush and no trees except a willow at 205 ft. US.

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

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

37. Material: -

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

NO POINT BARS

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

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

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

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

NO CUT BANKS

45. Is channel scour present? Y (Y or if N type ctrl-n cs) 46. Mid-scour distance: 300

47. Scour dimensions: Length 150 Width 35 Depth : 2.5 Position 40 %LB to 80 %RB

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

Scour extends from 225 ft. to 375 ft. US. Most of this area is scoured 1 ft. with the deepest scour close to the right bank between 260 ft. to 350 ft. US. Average thalweg depth is 1.5 ft. 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
79.5		2.0		2	7	7	-

58. Bank width (BF) - 59. Channel width (Amb) - 60. Thalweg depth (Amb) 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.):

453

The right abutment wall is 3 ft. high at the US end and 6.5 ft. at the DS end. There is 30 ft. of stone fill with 3 slope breaks between the right edge of water and the right abutment.

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

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

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

70. Debris and Ice Comments:

1

Some minor scarring on a couple of trees.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		0	90	2	0	-	-	90.0
RABUT	1	0	90			2	0	109.0

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

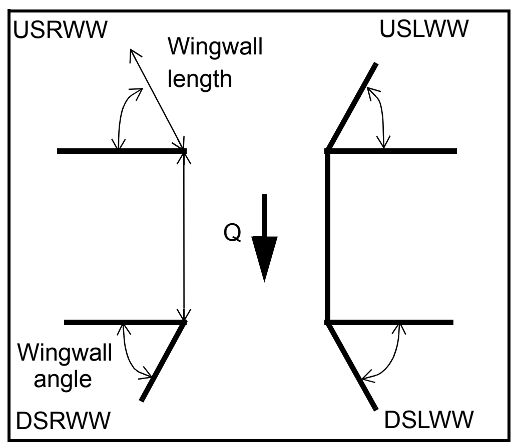
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

-
-
1
-

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						109.0	
USRWW:	Y		1		0	2.0	
DSLWW:	-		-		Y	46.5	
DSRWW:	1		0		-	47.0	

*Wingwall materials: **1**- Concrete; **2**- Stone masonry or drywall; **3**- steel or metal; **4**- wood*



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	0	Y	-	-	-	-	1
Condition	Y	-	1	-	-	-	-	1
Extent	1	-	0	0	0	0	1	-

*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*

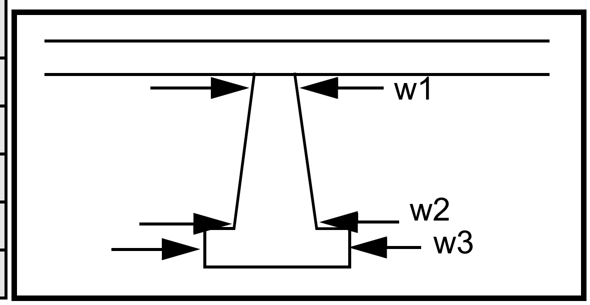
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
1
1
1
1

Piers:

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

85. Pier no.	width (w) feet			elevation (e) feet		
	w1	w2	w3	e@w1	e@w2	e@w3
Pier 1		**9.5**		**110.0**	**25.0**	**21.5**
Pier 2				**25.0**	**25.0**	**80.0**
Pier 3		-	-	**13.5**	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**e US**	**cov-**	**the**	**plan**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**right**	**ered**	**wing**	**e**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**wing**	**by**	**wall**	**exte**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**wall**	**an**	**joins**	**ndin**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**is set**	**eart**	**an**	**g 40**	*Y- yes; N- no*
91. Attack ∠ (BF)	**high**	**hen**	**old**	**ft.**	
92. Pushed	**on**	**bank**	**abut**	**US.**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**the**	**. On**	**ment**	**Ther**	
95. Cross-members	**bank**	**the**	**wall**	**e is**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**and**	**US**	**on**	**also**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**is**	**left**	**the**	**a**	
98. Exposure depth	**half**	**side,**	**same**	**wing**	

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

wall in good shape on the US end of this older abutment. The footing is exposed 2 ft. along the length of the old abutment, but it is not undermined. The wingwall is at a 60 degree angle to the abutment. A 6 in. corrugated metal outfall pipe is laying along the base of the DS left wingwall. There is a trickle of discharge during the assessment. The right abutment protection refers to the flow through type stone fill described in 64. On the US left wingwall there are a couple of large boulders acting as protection.

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 (Amb) - Thalweg depth (Amb) - 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 32 Depth: 345 Positioned 1 %LB to 1 %RB

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

453
2
5
2

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

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

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

Confluence comments (eg. confluence name):

cover is shrubs. The right bank vegetation cover is a few trees and shrubs from the bridge to 100 ft. DS. Then the cover increases to between 76% and 100%. On the right bank there is a 9 ft. high concrete wall extending

F. Geomorphic Channel Assessment

107. Stage of reach evolution fro

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)*:

m the end of the wingwall to 89 ft. DS. The left bank protection extends from the bridge to 400 ft. DS at the bedrock outcrop. It consists of slabs of concrete and other conglomerates dumped mostly at the bottom of the bank. The bedrock on the left bank 400 ft. from the bridge forces a bend towards the right. There is scour at this bend. A sand bar is on the right bank from 40 ft. to 85 ft. DS. It is 22 ft. wide and extends out from the base of the wall. It is cut by discharge from a 2.5 ft. pipe outfall.

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: SPRICYBRIG0043 Town: Springfield
Road Number: Bridge Street County: Windsor
Stream: Black River

Initials MAI Date: 02/20/97 Checked: EMB 02/24/97

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	6940	9910	0
Main Channel Area, ft2	1026	1403	0
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	105	125	0
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.298	0.298	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	9.8	11.2	ERR
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	167348	250329	0
Conveyance, main channel	167348	250329	0
Conveyance, LOB	0	0	8
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0000	0.0000	ERR
Qm, discharge, MC, cfs	6940.0	9910.0	ERR
Ql, discharge, LOB, cfs	0.0	0.0	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	6.8	7.1	ERR
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	10.9	11.2	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

ARMORING

D90	0.808	0.808	0
D95	1.092	1.092	0
Critical grain size,Dc, ft	0.1381	0.2501	ERR
Decimal-percent coarser than Dc	0.879	0.628	0
Depth to armoring,ft	0.06	0.44	ERR

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)

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1026	1403	0
Main channel width, ft	105	125	0
y1, main channel depth, ft	9.77	11.22	ERR
Bridge Section			
(Q) total discharge, cfs	6940	9910	0
(Q) discharge thru bridge, cfs	6940	9910	0
Main channel conveyance	187864	156486	0
Total conveyance	187864	156486	0
Q2, bridge MC discharge,cfs	6940	9910	ERR
Main channel area, ft2	1166	1226	0
Main channel width (skewed), ft	108.8	108.9	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	108.8	108.9	0
y_bridge (avg. depth at br.), ft	10.72	11.25	ERR
Dm, median (1.25*D50), ft	0.3725	0.3725	0
y2, depth in contraction,ft	5.78	7.84	ERR
ys, scour depth (y2-ybridge), ft	-4.94	-3.41	N/A

Pressure Flow Scour (contraction scour for orifice flow conditions)

Hb+Ys=Cq*qbr/Vc   Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)
Chang Equation   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
(Richarson and others, 1995, p. 145-146)

	Q100	Q500	OtherQ
Q, total, cfs	6940	9910	0
Q, thru bridge, cfs	6940	9910	0
Total Conveyance, bridge	187864	156486	0
Main channel(MC) conveyance, bridge	187864	156486	0
Q, thru bridge MC, cfs	6940	9910	ERR
Vc, critical velocity, ft/s	10.95	11.20	N/A
Vc, critical velocity, m/s	3.34	3.41	N/A
Main channel width (skewed), ft	108.8	108.9	0.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	108.8	108.9	0.0
qbr, unit discharge, ft2/s	63.8	91.0	ERR
qbr, unit discharge, m2/s	5.9	8.5	N/A
Area of full opening, ft2	1166.0	1225.5	0.0
Hb, depth of full opening, ft	10.72	11.25	ERR
Hb, depth of full opening, m	3.27	3.43	N/A
Fr, Froude number, bridge MC	0	0.44	0

Cf, Fr correction factor (<=1.0)	0.00	1.00	0.00
Elevation of Low Steel, ft	0	493.37	0
Elevation of Bed, ft	-10.72	482.12	N/A
Elevation of Approach, ft	0	496.38	0
Friction loss, approach, ft	0	0.27	0
Elevation of WS immediately US, ft	0.00	496.11	0.00
ya, depth immediately US, ft	10.72	13.99	N/A
ya, depth immediately US, m	3.27	4.26	N/A
Mean elevation of deck, ft	0	501.02	0
w, depth of overflow, ft (>=0)	0.00	0.00	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.95	ERR
Ys, depth of scour, ft	N/A	-2.67	N/A

Abutment Scour

Froehlich's Abutment Scour

Ys/Y1 = 2.27*K1*K2*(a'/Y1)^0.43*Fr1^0.61+1

(Richardson and others, 1995, p. 48, eq. 28)

	Left Abutment			Right Abutment		
Characteristic	100 yr Q	500 yr Q	Other Q	100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	6940	9910	0	6940	9910	0
a', abut.length blocking flow, ft	--	2.2	0	--	14.1	0
Ae, area of blocked flow ft2	--	13.6	0	--	67.5	0
Qe, discharge blocked abut.,cfs	--	58.6	0	--	241.8	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	--	4.31	ERR	--	3.58	ERR
ya, depth of f/p flow, ft	10.97	6.18	ERR	6.51	4.79	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	110	110	110	70	70	70
K2	1.03	1.03	1.03	0.97	0.97	0.97
Fr, froude number f/p flow	--	0.305	ERR	--	0.289	ERR
ys, scour depth, ft	10.97	9.86	N/A	6.51	11.22	N/A

HIRE equation (a'/ya > 25)

ys = 4*Fr^0.33*y1*K/0.55

(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	0	2.2	0	0	14.1	0
y1 (depth f/p flow, ft)	ERR	6.18	ERR	ERR	4.79	ERR
a'/y1	ERR	0.36	ERR	ERR	2.95	ERR
Skew correction (p. 49, fig. 16)	0.93	0.93	0.93	1.04	1.04	1.04
Froude no. f/p flow	0.18	0.31	N/A	0.30	0.29	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	Qother	Q100	Q500	Qother
Fr, Froude Number	0.33	0.44	0	0.33	0.44	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	10.72	11.25	0.00	10.72	11.25	0.00
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	0.72	1.35	0.00	0.72	1.35	0.00