LEVEL II SCOUR ANALYSIS FOR BRIDGE 81 (NFIETH00PL0081) on PLEASANT STREET, crossing UNION BROOK, NORTHFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-404

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

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By RONDA L. BURNS and LAURA MEDALIE

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

U.S. GEOLOGICAL SURVEY
Gordon P. Eaton, Director

For additional information write to:

District Chief
U.S. Geological Survey
361 Commerce Way
Pembroke, NH 03275-3718

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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 81 (NFIETH00PL0081) ON PLEASANT STREET, CROSSING UNION BROOK, NORTHFIELD, VERMONT

By **Ronda L. Burns and Laura Medalie**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NFIETH00PL0081 on Pleasant Street crossing Union Brook, Northfield, 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 Green Mountain section of the New England physiographic province in central Vermont. The 6.1-mi^2 drainage area is in a predominantly rural and forested basin. The bridge site is located within a suburban setting in the Town of Northfield with homes, lawns, and pavement on the overbanks. There are trees and brush along the immediate banks.

In the study area, Union Brook has an incised, straight channel with a slope of approximately 0.01 ft/ft, an average channel top width of 41 ft and an average bank height of 4 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 47.7 mm (0.157 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 24, 1996, indicated that the reach was stable.

The Pleasant Street crossing of Union Brook is a 34-ft-long, two-lane bridge consisting of one 29-foot steel-beam span (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 26.6 ft. The bridge is supported by vertical, concrete abutments with wingwalls. The channel is skewed approximately 25 degrees to the opening while the opening-skew-to-roadway is 30 degrees.

A scour hole 0.5 ft deeper than the mean thalweg depth was observed along the upstream left wingwall and upstream end of the left abutment during the Level I assessment. The scour protection measures at the site were type-1 stone fill (less than 12 inches diameter) along the upstream left bank, the upstream left wingwall, and the downstream left bank, and type-2 stone fill (less than 36 inches diameter) along the downstream right bank. There is also a laid-up stone wall in front of the downstream left wingwall. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

Contraction scour for all modelled flows ranged from 0.0 to 0.5 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 4.2 to 13.3 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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

Northfield, VT. Quadrangle, 1:24,000, 1980
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 NFIETH00PL0081 ***Stream*** Union Brook

County Washington ***Road*** Pleasant Street ***District*** 6

Description of Bridge

Bridge length 34 ***ft*** ***Bridge width*** 24 ***ft*** ***Max span length*** 29 ***ft***

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

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

Stone fill on abutment? No ***Date of inspection*** 07/24/96

Description of stone fill Type-1, along the upstream left wingwall and a laid-up stone wall in front of the downstream left wingwall.

Abutments and wingwalls are concrete. There is a 0.5 foot deep scour hole in front of the upstream left wingwall and at the upstream end of the left abutment.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 25

The upstream reach makes a gradual bend into the bridge. The left bank is eroded where the stream flow impacts the bank.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	07/24/96	0	0
Level II	07/24/96	0	0

Potential for debris Moderate. There is significant vegetation cover on the banks upstream.

Describe any features near or at the bridge that may affect flow (include observation date) None. 07/24/96

Description of the Geomorphic Setting

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

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

Date of inspection 07/24/96

DS left: Narrow flood plain.

DS right: Steep channel bank to a narrow overbank.

US left: Narrow flood plain.

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

Description of the Channel

Average top width 41 ***ft***

Average depth 4 ***ft***

Predominant bed material Gravel/Cobbles

Bank material Gravel/Sand

Straight with semi-alluvial channel boundaries and a narrow flood plain on the left.

07/24/96

Vegetative co Trees and brush with short grass on the flood plain.

DS left: Trees and brush with short grass on the overbank.

DS right: Trees and brush with short grass and pavement on the flood plain.

US left: Trees and brush with short grass and pavement on the overbank.

US right:

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

None. 07/24/96

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 6.1 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: The drainage area is rural, but the bridge is located in a suburban setting.

No

--

Is there a USGS gage on the stream of interest?

--

USGS gage description

--

USGS gage number

No

Gage drainage area ***mi²***

-

Is there a lake/p

-

1,590

Calculated Discharges

2,460

The

Q100 ***ft³/s*** ***Q500*** ***ft³/s***

100- and 500-year discharges are from the Flood Insurance Study of the Village of Northfield (U.S. Department of Housing and Urban Development, 1977).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the right abutment (elev. 501.61 ft, arbitrary survey datum). RM2 is a nail in a pole at the intersection of Pleasant and Union Streets (elev. 501.34 ft, arbitrary survey datum). RM3 is the high point of a fire hydrant on the corner of Cotter and Pleasant (elev. 501.64 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-32	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	16	1	Road Grade section
APPRO	55	2	Modelled Approach section (Templated from APTEM)
APTEM	60	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 0.040 to 0.060, and overbank "n" values ranged from 0.035 to 0.055.

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 0.0104 ft/ft which was estimated from the streambed slope downstream of the bridge in the Flood Insurance Study for Northfield, VT (U. S. Department of Housing and Urban Development, November 1977).

Using normal depth as the starting water-surface assumes that the effects of backwater from the Dog River, 780 ft downstream, are negligible. Due to the difference in drainage areas at the confluence, the extent of backwater from the Dog River during flooding on Union Brook is unknown. Using normal depth as the starting water-surface also assumes the effects of backwater from a bridge 700 ft downstream are insignificant.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.014 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 501.4 ***ft***
Average low steel elevation 500.1 ***ft***

100-year discharge 1,590 ***ft³/s***
Water-surface elevation in bridge opening 500.1 ***ft***
Road overtopping? Yes ***Discharge over road*** 545 ***ft³/s***
Area of flow in bridge opening 144 ***ft²***
Average velocity in bridge opening 7.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.1 ***ft/s***

Water-surface elevation at Approach section with bridge 501.3
Water-surface elevation at Approach section without bridge 500.9
Amount of backwater caused by bridge 0.4 ***ft***

500-year discharge 2,460 ***ft³/s***
Water-surface elevation in bridge opening 500.1 ***ft***
Road overtopping? Yes ***Discharge over road*** 1,247 ***ft³/s***
Area of flow in bridge opening 144 ***ft²***
Average velocity in bridge opening 8.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 9.7 ***ft/s***

Water-surface elevation at Approach section with bridge 502.1
Water-surface elevation at Approach section without bridge 501.5
Amount of backwater caused by bridge 0.6 ***ft***

Incipient overtopping discharge 930 ***ft³/s***
Water-surface elevation in bridge opening 498.1 ***ft***
Area of flow in bridge opening 98 ***ft²***
Average velocity in bridge opening 9.5 ***ft/s***
Maximum WSPRO tube velocity at bridge 11.3 ***ft/s***

Water-surface elevation at Approach section with bridge 499.7
Water-surface elevation at Approach section without bridge 499.6
Amount of backwater caused by bridge 0.1 ***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 incipient discharge was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year discharge resulted in unsubmerged orifice flow and 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). Thus, contraction scour for these discharges was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of this analysis are presented in figure 8 and tables 1 and 2. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

For comparison, contraction scour for the discharges resulting in orifice flow was also computed by use of the Laursen clear-water contraction scour equation and the Umbrell pressure-flow equation (Richardson and others, 1995, p. 144) and presented in Appendix F. Furthermore, for the discharge resulting in unsubmerged orifice flow, contraction scour was computed by substituting estimates for the depth of flow at the downstream bridge face in the contraction scour equations. Results with respect to these substitutions are provided in Appendix F.

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

Scour 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	0.5	0.4
Depth to armoring	1.6	2.4	8.1
Left overbank	--	--	--
Right overbank	--	--	--
Local scour:			
Abutment scour			
Left abutment	7.4	7.5	4.2
Right abutment	12.7	13.3	11.3
Pier scour			
Pier 1	--	--	--
Pier 2	--	--	--
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:			
Left abutment	1.2	1.6	1.7
Right abutment	1.2	1.6	1.7
Piers:			
Pier 1	--	--	--
Pier 2	--	--	--

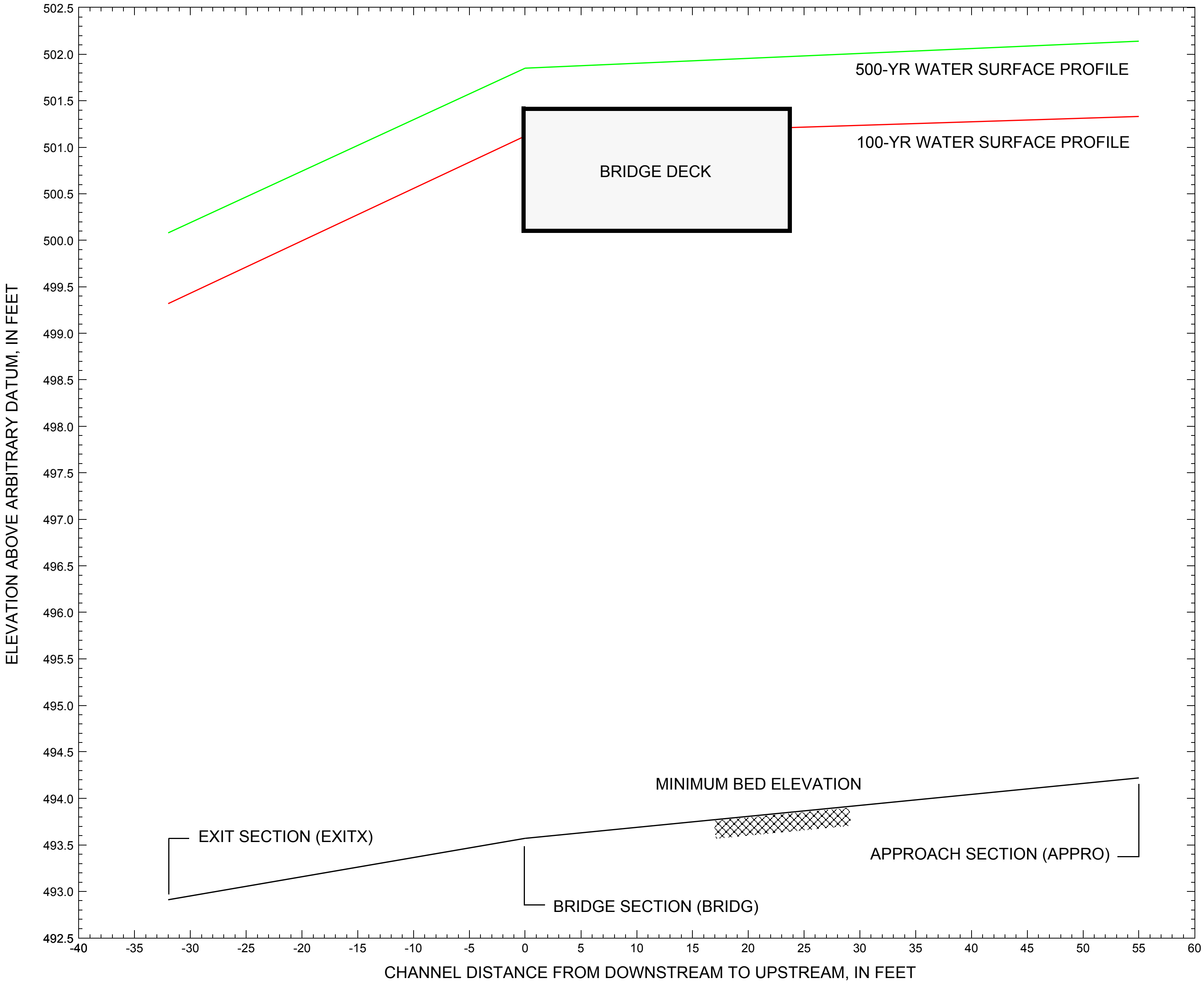

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NFIETH00PL0081 on Pleasant Street, crossing Union Brook, Northfield, Vermont.

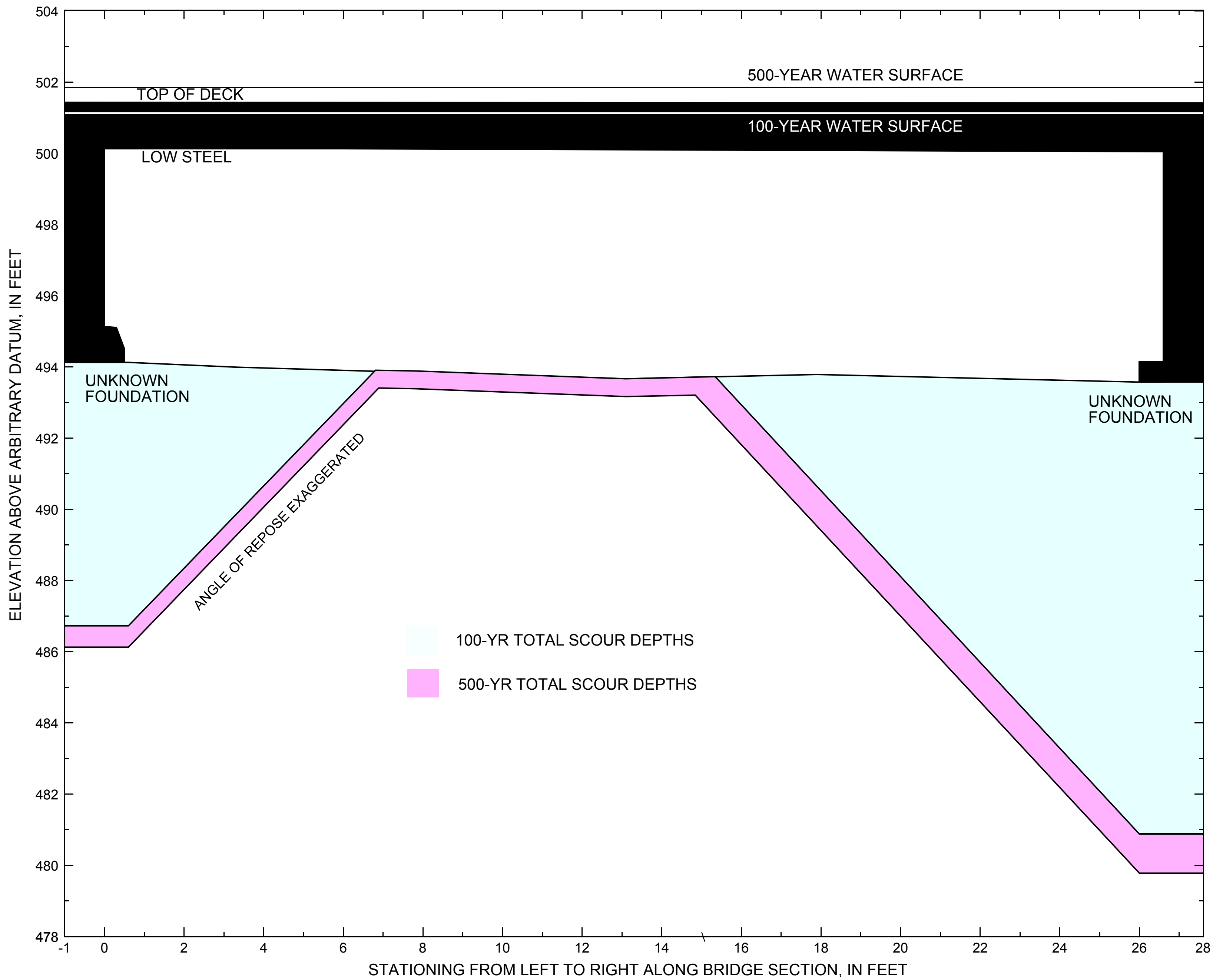

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NFIETH00PL0081 on Pleasant Street, crossing Union Brook, Northfield, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure NFIETH00PL0081 on Pleasant Street, crossing Union Brook, Northfield, 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 elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 1,590 cubic-feet per second											
Left abutment	0.0	--	500.1	--	494.1	0.0	7.4	--	7.4	486.7	--
Right abutment	26.6	--	500.0	--	493.6	0.0	12.7	--	12.7	480.9	--

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 NFIETH00PL0081 on Pleasant Street, crossing Union Brook, Northfield, 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 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 2,460 cubic-feet per second											
Left abutment	0.0	--	500.1	--	494.1	0.5	7.5	--	8.0	486.1	--
Right abutment	26.6	--	500.0	--	493.6	0.5	13.3	--	13.8	479.8	--

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

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U.S. Geological Survey, 1980, Northfield, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1983, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

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T1        U.S. Geological Survey WSPRO Input File nfie081.wsp
T2        Hydraulic analysis for structure NFIETH00PL0081    Date: 01-MAY-97
T3        PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
*
J1         *  *  0.005
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           1590     2460     930
SK          0.0104   0.0104   0.0104
*
XS   EXITX    -32           0.
GR          -92.6, 505.00
GR          -92.6, 500.57    -70.0, 498.44    -40.9, 498.35      0.0, 498.17
GR            8.3, 493.74     10.9, 493.28     14.8, 492.91     18.8, 493.04
GR           25.3, 493.70     33.4, 495.14     38.3, 499.06     91.9, 499.06
GR          108.2, 504.19
*GR           50.8, 500.09     83.6, 499.08     91.9, 498.93
*
N           0.050        0.055        0.055
SA                   0.0         38.3
*
XS   FULLV      0  * * *   0.0228
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    500.08      30.0
GR            0.0, 500.13      0.0, 495.13      0.3, 495.10      0.5, 494.51
GR            0.5, 494.12      3.3, 493.99      7.8, 493.88     13.1, 493.66
GR           17.9, 493.78     26.0, 493.57     26.1, 494.15     26.6, 494.15
GR           26.6, 500.02      0.0, 500.13
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      39.7 * *     51.6      6.5
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     16      24.0     1
*GR         -210.9, 502.28   -134.8, 500.48     75.1, 499.59     82.9, 499.57
GR          -67.2, 505.00    -56.6, 499.15    -29.6, 499.52      0.0, 501.43
GR           26.0, 501.41     57.5, 500.40     82.9, 500.09    101.0, 503.96
*
*    For the incipient over-topping model, a vertical wall was placed at station
*    -56.6 and the left overbank was flattened at the top of the upstream left
*    bank elevation.
*
XT   APTEM     60           0.
GR          -67.2, 505.00
GR          -67.2, 500.70    -40.2, 499.60    -14.2, 499.75      0.0, 499.76
GR            6.8, 495.12      9.3, 494.59     13.2, 494.29     16.9, 494.49
GR           22.3, 494.84     25.4, 495.21     36.2, 496.54     42.9, 500.33
GR           74.2, 500.43    116.1, 503.12
*
AS   APPRO     55  * * *   0.0140
GT
N           0.040        0.060        0.035
SA                   0.0         42.9
*
*    For the incipient over-topping model, a vertical wall was placed at station 0.0.
*
HP 1 BRIDG  500.08 1 500.08
HP 2 BRIDG  500.08 * * 1053
HP 1 BRIDG  499.73 1 499.73
HP 2 RDWAY  501.12 * * 545
HP 1 APPRO  501.33 1 501.33
HP 2 APPRO  501.33 * * 1590
*
HP 1 BRIDG  500.13 1 500.13
HP 2 BRIDG  500.13 * * 1213
HP 2 RDWAY  501.85 * * 1247
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

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        U.S. Geological Survey WSPRO Input File nfie081.wsp
        Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
        PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
           *** RUN DATE & TIME: 06-02-97  09:45

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      144     11171     10     48                         3024
   500.08           144     11171     10     48  1.00      0     27     3024

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

         WSEL     LEW     REW    AREA        K        Q    VEL
       500.08     0.0    26.6   143.8   11171.    1053.   7.32

X STA.         0.0         2.3         3.7         4.8         5.8         6.9
  A(I)             11.7         6.9         6.0         5.6         5.4
  V(I)             4.49        7.59        8.77        9.38        9.77

X STA.         6.9         7.8         8.8         9.8        10.8        11.7
  A(I)              5.3         5.2         5.3         5.3         5.3
  V(I)             9.94       10.08        9.94        9.99        9.93

X STA.        11.7        12.9        14.2        15.5        16.9        18.3
  A(I)              6.5         7.4         7.2         7.5         7.5
  V(I)             8.13        7.16        7.30        6.98        6.98

X STA.        18.3        19.6        21.1        22.6        24.1        26.6
  A(I)              7.4         7.8         8.2         8.6        13.7
  V(I)             7.08        6.74        6.45        6.14        3.85

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      136     12647     23     35                         1878
   499.73           136     12647     23     35  1.00      0     27     1878

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      16.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.12   -60.2    87.7   104.3    3182.     545.   5.22

X STA.       -60.2       -55.8       -53.8       -51.9       -50.0       -48.1
  A(I)              5.1         3.8         3.6         3.7         3.6
  V(I)             5.32        7.16        7.56        7.37        7.52

X STA.       -48.1       -46.0       -44.0       -41.8       -39.6       -37.2
  A(I)              3.7         3.7         3.8         3.9         4.1
  V(I)             7.31        7.31        7.10        7.03        6.72

X STA.       -37.2       -34.8       -32.2       -29.4       -26.1       -21.6
  A(I)              4.1         4.3         4.5         4.9         5.6
  V(I)             6.67        6.39        6.01        5.58        4.90

X STA.       -21.6        52.6        63.6        71.4        78.2        87.7
  A(I)             14.1         7.8         6.6         6.3         7.2
  V(I)             1.94        3.51        4.12        4.33        3.79

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.
     WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
             1      102      4979     67     68                          713
             2      232     17068     43     46                         3062
             3       39      1494     46     46                          205
   501.33           373     23541    157    160  1.14    -66     89     3069

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

         WSEL     LEW     REW    AREA        K        Q    VEL
       501.33   -67.2    89.3   373.3   23541.    1590.   4.26

X STA.       -67.2       -43.1       -30.1       -17.1        -3.0         5.5
  A(I)             28.7        22.9        22.2        23.2        24.5
  V(I)             2.77        3.47        3.58        3.43        3.24

X STA.         5.5         8.2        10.3        12.4        14.3        16.2
  A(I)             16.4        14.4        14.1        13.4        13.7
  V(I)             4.84        5.52        5.64        5.91        5.79

X STA.        16.2        18.2        20.2        22.3        24.6        27.0
  A(I)             13.4        14.0        13.9        14.5        15.1
  V(I)             5.93        5.68        5.70        5.48        5.28

X STA.        27.0        29.7        32.7        36.2        49.9        89.3
  A(I)             15.3        16.6        17.8        27.2        31.8
  V(I)             5.19        4.79        4.46        2.92        2.50
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WSPRO OUTPUT FILE (continued)

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      U.S. Geological Survey WSPRO Input File nfie081.wsp
      Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
      PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
         *** RUN DATE & TIME: 06-02-97  09:45

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      144      9812      0     58                            0
  500.13           144      9812      0     58  1.00      0     27        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      500.13     0.0    26.6   144.1    9812.    1213.   8.42

X STA.        0.0        2.4        3.8        5.2        6.4        7.7
  A(I)            12.0        7.8        7.0        6.8        6.7
  V(I)            5.05       7.76       8.64       8.95       9.11

X STA.        7.7        8.9       10.1       11.2       12.3       13.5
  A(I)             6.5        6.5        6.3        6.3        6.3
  V(I)            9.33       9.39       9.64       9.69       9.63

X STA.       13.5       14.6       15.8       16.9       18.1       19.3
  A(I)             6.3        6.3        6.3        6.5        6.4
  V(I)            9.65       9.70       9.64       9.37       9.47

X STA.       19.3       20.5       21.7       23.0       24.3       26.6
  A(I)             6.6        6.7        7.2        7.5       12.3
  V(I)            9.23       9.06       8.46       8.06       4.93

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      16.

        WSEL     LEW     REW    AREA        K        Q    VEL
      501.85   -61.5    91.1   204.2    7777.    1247.   6.11

X STA.      -61.5      -55.3      -52.5      -49.8      -47.0      -44.2
  A(I)            10.1        7.5        7.1        7.1        7.2
  V(I)            6.18       8.28       8.74       8.79       8.66

X STA.      -44.2      -41.2      -38.3      -35.2      -31.9      -28.5
  A(I)             7.4        7.4        7.4        7.8        8.1
  V(I)            8.43       8.44       8.41       8.03       7.73

X STA.      -28.5      -24.4      -19.3      -10.6       35.2       50.6
  A(I)             8.6        9.5       12.0       24.6       15.2
  V(I)            7.26       6.57       5.20       2.53       4.12

X STA.       50.6       59.2       66.4       73.1       79.5       91.1
  A(I)            11.7       10.9       10.8       10.6       13.2
  V(I)            5.35       5.70       5.78       5.87       4.71

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      156     10078     67     69                         1354
            2      267     21538     43     46                         3775
            3       82      4340     59     59                          548
  502.14           505     35955    169    173  1.07    -66    102     4796

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

        WSEL     LEW     REW    AREA        K        Q    VEL
      502.14   -67.2   101.9   505.1   35955.    2460.   4.87

X STA.      -67.2      -49.1      -38.0      -28.0      -17.5       -6.7
  A(I)            33.9       27.3       25.7       26.4       26.6
  V(I)            3.63       4.51       4.78       4.66       4.63

X STA.       -6.7        4.0        7.8       10.5       13.0       15.4
  A(I)            31.7       24.5       20.1       19.5       19.0
  V(I)            3.88       5.01       6.12       6.32       6.47

X STA.       15.4       17.9       20.5       23.1       26.0       29.1
  A(I)            19.3       19.5       19.6       20.6       21.0
  V(I)            6.37       6.31       6.26       5.96       5.86

X STA.       29.1       32.7       36.9       49.2       65.8      101.9
  A(I)            22.7       24.5       33.1       30.3       39.8
  V(I)            5.42       5.03       3.71       4.06       3.09
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      U.S. Geological Survey WSPRO Input File nfie081.wsp
      Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
      PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
         *** RUN DATE & TIME: 06-02-97  09:39

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1       98      7863     23     31                         1153
 498.09            98      7863     23     31  1.00      0     27     1153

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     498.09     0.0    26.6    98.4    7863.     930.   9.46

X STA.        0.0         2.6         4.2         5.5         6.8         8.0
  A(I)            8.7         5.5         4.8         4.6         4.5
  V(I)           5.36        8.46        9.76       10.14       10.37

X STA.        8.0         9.2        10.3        11.4        12.5        13.6
  A(I)            4.4         4.3         4.3         4.1         4.1
  V(I)          10.67       10.93       10.93       11.33       11.23

X STA.       13.6        14.7        15.8        16.9        18.0        19.2
  A(I)            4.2         4.1         4.2         4.2         4.4
  V(I)          11.14       11.21       11.15       11.08       10.50

X STA.       19.2        20.4        21.6        22.9        24.3        26.6
  A(I)            4.4         4.5         5.0         5.5         8.8
  V(I)          10.60       10.38        9.35        8.51        5.27

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           2      164      9722     42     45                         1840
 499.74           164      9722     42     45  1.00      0     42     1840

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      55.

       WSEL     LEW     REW    AREA        K        Q    VEL
     499.74     0.0    42.0   164.1    9722.     930.   5.67

X STA.        0.0         6.3         8.1         9.7        11.1        12.4
  A(I)           13.8         8.8         7.9         7.5         7.1
  V(I)           3.36        5.31        5.92        6.19        6.54

X STA.       12.4        13.6        14.9        16.1        17.4        18.7
  A(I)            6.8         6.7         6.8         6.8         6.9
  V(I)           6.84        6.90        6.80        6.84        6.73

X STA.       18.7        20.1        21.4        22.9        24.4        26.1
  A(I)            6.9         7.0         7.3         7.3         7.7
  V(I)           6.77        6.67        6.37        6.41        6.05

X STA.       26.1        27.9        29.9        32.1        34.9        42.0
  A(I)            7.9         8.3         8.8        10.0        13.8
  V(I)           5.92        5.57        5.29        4.65        3.37
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        U.S. Geological Survey WSPRO Input File nfie081.wsp
        Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
        PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
           *** RUN DATE & TIME: 06-02-97  09:45

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

EXITX:XS   ******    -78      270  0.76 *****  500.08  499.00    1590  499.32
       -31 ******     93    15581  1.41 ***** *******    0.98    5.88

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
             FNTEST,FR#,WSEL,CRWS =  0.80    1.25     499.48     499.73
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                  WSLIM1,WSLIM2,DELTAY =   498.82     505.73    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                  WSLIM1,WSLIM2,CRWS =   498.82     505.73     499.73
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
             ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                  WSBEG,WSEND,CRWS =   499.73     505.73     499.73

FULLV:FV       32    -75      219  1.06 *****  500.78  499.73    1590  499.73
         0     32     38    12969  1.29 ***** *******    1.05    7.26
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       55    -66      303  0.51  0.60  501.38 *******    1590  500.87
        55     55     82    17957  1.19  0.00    0.00    0.71    5.25
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   502.60       0.00     499.11     499.15
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===240 NO DISCHARGE BALANCE IN 15 ITERATIONS.
                  WS,QBO,QRD =   502.66         0.      1590.
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===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       32      0      144  0.83 *****  500.91  497.84    1053  500.08
         0 ******     27    11171  1.00 ***** *******    0.56    7.32

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.448  0.000  500.08 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD      EGL     ERR       Q    WSEL
   RDWAY:RG      16.    31.  0.14  0.32  501.51    0.00    545.  501.12

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    378.    55.   -60.    -5.   2.0   1.3   6.1   5.3   1.7   3.1
   RT:    166.    53.    35.    88.   1.0   0.6   4.7   5.1   1.0   3.1

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

APPRO:AS       15    -66      373  0.32  0.12  501.65  499.34    1590  501.33
        55     19     89    23546  1.14  0.00    0.00    0.52    4.26

       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
   EXITX:XS     -32.   -79.     93.   1590.   15581.     270.    5.88  499.32
   FULLV:FV       0.   -76.     38.   1590.   12969.     219.    7.26  499.73
   BRIDG:BR       0.     0.     27.   1053.   11171.     144.    7.32  500.08
   RDWAY:RG      16.*******    378.    545.******************    1.00  501.12
   APPRO:AS      55.   -67.     89.   1590.   23546.     373.    4.26  501.33

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS     499.00    0.98  492.91  505.00************  0.76  500.08  499.32
   FULLV:FV     499.73    1.05  493.64  505.73************  1.06  500.78  499.73
   BRIDG:BR     497.84    0.56  493.57  500.13************  0.83  500.91  500.08
   RDWAY:RG   ****************  499.15  505.00  0.14******  0.32  501.51  501.12
   APPRO:AS     499.34    0.52  494.22  504.93  0.12  0.00  0.32  501.65  501.33
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        U.S. Geological Survey WSPRO Input File nfie081.wsp
        Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
        PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT            RLB
           *** RUN DATE & TIME: 06-02-97  09:45

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

EXITX:XS   ******    -86      405  0.82 *****  500.89  499.89    2460  500.08
       -31 ******     95    24100  1.42 ***** *******    0.86    6.08

 ===125 FR# EXCEEDS FNTEST AT SECID "FULLV":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    1.40     500.15     500.62
 ===110 WSEL NOT FOUND AT SECID "FULLV":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   499.58     505.73    0.50
 ===115 WSEL NOT FOUND AT SECID "FULLV":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =    499.58     505.73     500.62
 ===130 CRITICAL WATER-SURFACE ELEVATION  A _ S _ S _ U _ M _ E _ D  !!!!!
              ENERGY EQUATION  N_O_T  B_A_L_A_N_C_E_D  AT SECID "FULLV"
                   WSBEG,WSEND,CRWS =   500.62     505.73     500.62

FULLV:FV       32    -84      372  0.98 *****  501.60  500.62    2460  500.62
         0     32     95    21773  1.44 ***** *******    0.97    6.62
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       55    -66      407  0.63  0.58  502.18 *******    2460  501.54
        55     55     93    26482  1.11  0.00   -0.01    0.71    6.05
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                       WS3N,LSEL =   500.62     500.08

            <<<<<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       32      0      144  1.10 *****  501.23  498.24    1213  500.13
         0 ******     27     9812  1.00 ***** *******    0.64    8.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  500.08 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.    31.  0.15  0.39  502.39    0.00   1247.  501.85

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:    753.    75.   -61.    13.   2.7   1.6   7.0   6.2   2.2   3.2
   RT:    493.    78.    13.    91.   1.8   1.1   5.9   5.9   1.6   3.1

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

APPRO:AS       15    -66      505  0.39  0.19  502.53  501.06    2460  502.14
        55     20    102    35922  1.07  0.00    0.00    0.51    4.87

       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
   EXITX:XS     -32.   -87.    95.   2460.   24100.     405.    6.08  500.08
   FULLV:FV       0.   -85.    95.   2460.   21773.     372.    6.62  500.62
   BRIDG:BR       0.     0.    27.   1213.    9812.     144.    8.42  500.13
   RDWAY:RG      16.*******   753.   1247.*****************     1.00  501.85
   APPRO:AS      55.   -67.   102.   2460.   35922.     505.    4.87  502.14

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

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX     HF     HO  VHD      EGL     WSEL
   EXITX:XS     499.89     0.86  492.91  505.00************  0.82  500.89  500.08
   FULLV:FV     500.62     0.97  493.64  505.73************  0.98  501.60  500.62
   BRIDG:BR     498.24     0.64  493.57  500.13************  1.10  501.23  500.13
   RDWAY:RG  ***************  499.15  505.00  0.15******  0.39  502.39  501.85
   APPRO:AS     501.06     0.51  494.22  504.93  0.19  0.00  0.39  502.53  502.14
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WSPRO OUTPUT FILE (continued)

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        U.S. Geological Survey WSPRO Input File nfie081.wsp
        Hydraulic analysis for structure NFIETH00PL0081     Date: 01-MAY-97
        PLEASANT STREET CROSSING UNION BROOK IN NORTHFIELD, VT             RLB
           *** RUN DATE & TIME: 06-02-97  09:39

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

EXITX:XS   ******    -28      145  0.65 *****  498.95  496.98     930  498.30
       -31 ******     37     9116  1.02 ***** *******    0.77    6.41

FULLV:FV       32      1      127  0.83  0.40  499.43 *******     930  498.60
         0     32     37     7662  1.00  0.09   -0.01    0.69    7.30
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       55      0      156  0.55  0.69  500.10 *******     930  499.55
        55     55     42     9056  1.00  0.00   -0.01    0.54    5.95
         <<<<<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       32      0       98  1.39  0.39  499.48  497.52     930  498.09
         0     32     27     7873  1.00  0.14    0.00    0.81    9.45

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  500.08 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      16.        <<<<<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       15      0      164  0.50  0.21  500.24  498.10     930  499.74
        55     19     42     9740  1.00  0.55    0.02    0.51    5.66

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.358  0.061    9074.     5.    32.   499.46

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW      Q        K      AREA     VEL    WSEL
   EXITX:XS     -32.   -29.    37.    930.    9116.     145.    6.41  498.30
   FULLV:FV       0.     1.    37.    930.    7662.     127.    7.30  498.60
   BRIDG:BR       0.     0.    27.    930.    7873.      98.    9.45  498.09
   RDWAY:RG      16.**************      0.*****************    1.00********
   APPRO:AS      55.     0.    42.    930.    9740.     164.    5.66  499.74

    XSID:CODE   XLKQ   XRKQ      KQ
   APPRO:AS       5.    32.    9074.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    496.98    0.77  492.91  505.00************  0.65  498.95  498.30
   FULLV:FV  ********    0.69  493.64  505.73  0.40  0.09  0.83  499.43  498.60
   BRIDG:BR    497.52    0.81  493.57  500.13  0.39  0.14  1.39  499.48  498.09
   RDWAY:RG  ****************  499.76  505.00**********************************
   APPRO:AS    498.10    0.51  494.22  504.93  0.21  0.55  0.50  500.24  499.74
```
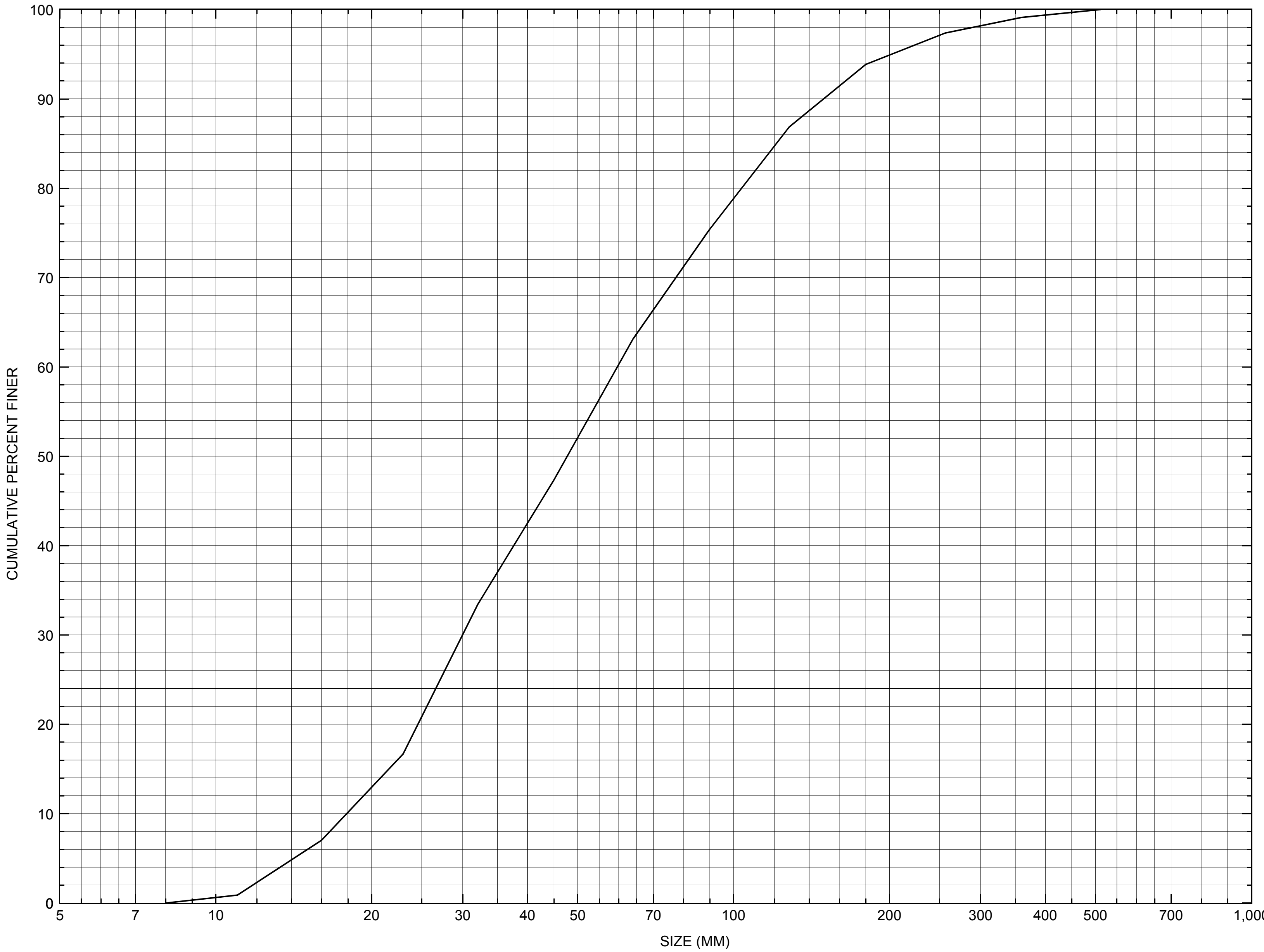

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NFIETH00PL0081, in Northfield, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number NFIETH00PL0081

General Location Descriptive

Data collected by (First Initial, Full last name) L. Medalie

Date (MM/DD/YY) 10 / 13 / 95

Highway District Number (I - 2; nn) 06

County (FIPS county code; I - 3; nnn) 023

Town (FIPS place code; I - 4; nnnnn) 50200

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

Waterway (I - 6) UNION BROOK

Road Name (I - 7): PLEASANT STREET

Route Number C30PL

Vicinity (I - 9) 0.02 MI TO JCT W UNION S

Topographic Map Northfield

Hydrologic Unit Code: -

Latitude (I - 16; nnnn.n) 44091

Longitude (i - 17; nnnnn.n) 72397

Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10121300811213

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0029

Year built (I - 27; YYYY) 1970

Structure length (I - 49; nnnnnn) 000034

Average daily traffic, ADT (I - 29; nnnnnn) 000150

Deck Width (I - 52; nn.n) 240

Year of ADT (I - 30; YY) 92

Channel & Protection (I - 61; n) 6

Opening skew to Roadway (I - 34; nn) 30

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) A

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

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) 25.4

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) 5.7

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

Waterway of full opening (nnn.n ft^2) 144.1

Comments:

According to the structural inspection report dated 8/17/94, the deck is asphalt filled wrinkled tin. Bridge guard rails are fascia mounted, painted I-beam posts with 2 painted wood plank rails. The RABUT, its wingwalls and footing are concrete. The LABUT and its upstream wingwall are concrete faced laid-up stone walls. The downstream left wingwall is a laid-up stone wall with a concrete footing. Both abutments have wood plank backwalls. The LABUT and its upstream wingwall have cracks and leaks overall. Small concrete spalls or popouts are present under several of the beams along the top of each abutment. The RABUT and its wingwalls have a few fine cracks and leaks. **(Continued p. 33)**

Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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:

Each abutment has a buildup of gravel and debris on its top. Stones and boulders are showing along the US & DS channel banks.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **6.1** mi^2 Lake/pond/swamp area **0.005** mi^2

Watershed storage *(ST)* **0.08** %

Bridge site elevation **720** ft Headwater elevation **2386** ft

Main channel length **5.56** mi

10% channel length elevation **780** ft 85% channel length elevation **1770** ft

Main channel slope *(S)* **237.41** 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 BENCKMARK 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 DRILL BORING INFORMATION

Comments:

-

Cross-sectional Data

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

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

Comments: NO CROSS SECTIONAL INFORMATION

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

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

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

Comments: -

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: **09/23/96**

Computerized by: **RB** Date: **09/23/96**

Reviewd by: **RB** Date: **06/03/97**

Structure Number **NFIETH00PL0081**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **L**. **MEDALIE** Date *(MM/DD/YY)* **07** / **24** / 19**96**

2. Highway District Number **06** Mile marker **00000**

County **(023) WASHINGTON** Town **(50200) NORTHFIELD**

Waterway *(I - 6)* **UNION BROOK** Road Name **PLEASANT STREET**

Route Number **C30PL** Hydrologic Unit Code: **-**

3. Descriptive comments:

Located 0.02 miles from the junction with Union Street.

B. Bridge Deck Observations

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

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

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

7. Bridge length **34** *(feet)* Span length **29** *(feet)* Bridge width **24** *(feet)*

Road approach to bridge:

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

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

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

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

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

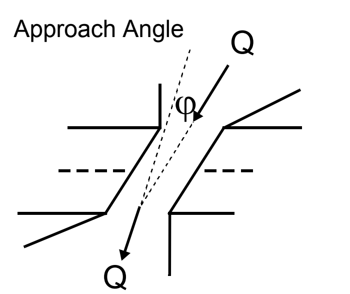
*Bank protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*

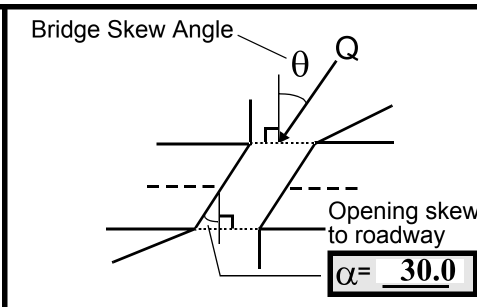
*Erosion: **0** - none; **1**- channel erosion; **2**- road wash; **3**- both; **4**- other*

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

Channel approach to bridge (BF):

15. Angle of approach: **20** 16. Bridge skew: **25**





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

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

Range? **19** feet **US** *(US, UB, DS)* to **35** 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

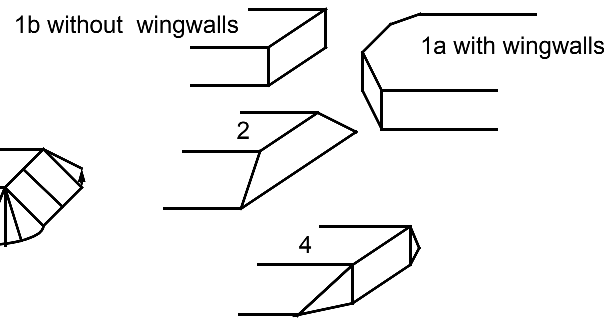
1a- Vertical abutments with wingwalls

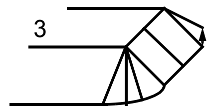
1b- Vertical abutments without wingwalls

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.)

11. On the left bank DS there is a laid-up stone wall between the wingwall and the channel and is described as wingwall protection.
13. The road wash erosion is most pronounced around the ends of the wingwalls.
7. Values are from the VT AOT files. Measured bridge length is 33.5 ft, span length is 26.6 ft, and bridge width is 24 ft.
3. An employee of the highway department said a water main is buried 2 ft deep under the channel 8 ft US of the bridge and has never been exposed. The highway department plans on putting new abutment faces and footings on this bridge. There have been many ice jams where the water flowed over Union Street and did not impact the bridge. Also, the bridge just DS of this bridge has lots of scour problems.

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
29.5	4.5			4.0	4	4	324	23	2	1

23. Bank width 35.0 24. Channel width 30.0 25. Thalweg depth 43.0 29. Bed Material 345

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

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

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

26. On the left bank there is a single large maple at 41 ft US that has a 20 ft crown that provides maximum coverage. Upstream and downstream of this tree there are no other large trees, only shrubs on the bank.
30. A single granite slab, 5 ft x 1.25 ft x 0.75 ft, is resting on the left bank at 26 ft US. It is the only large piece of protection. Smaller pieces of stone, < 12 in, are placed along the bank to at least 200 ft US. The bank also acts as the road embankment for Union Street.

A 7 in diameter culvert that passes under Union Street enters on the left bank at 29 ft US.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **24** 35. Mid-bar width: **18**

36. Point bar extent: **72** feet **US** (US, UB) to **10** feet **UB** (US, UB, DS) positioned **50** %LB to **95** %RB

37. Material: **324**

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

Point bar is 90% covered with grass.

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

41. Mid-bank distance: **175** 42. Cut bank extent: **>250** feet **US** (US, UB) to **19** feet **US** (US, UB, DS)

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

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

The stream makes a long gradual bend that impacts the left bank.

45. Is channel scour present? **Y** (Y or if N type ctrl-n cs) 46. Mid-scour distance: **8**

47. Scour dimensions: Length **7** Width **3** Depth : **0.5** Position **25** %LB to **40** %RB

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

Local channel scour at the US bridge face.

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
29.5		**0.5**		**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.):

435

-

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 2____ *(1- Low; 2- Moderate; 3- High)*

69. Is there evidence of ice build-up? 2___ *(Y or N)* Ice Blockage Potential Y____ *(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		5	90	2	3	0.5	1	90.0
RABUT	1	0	90			2	2	23.0

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

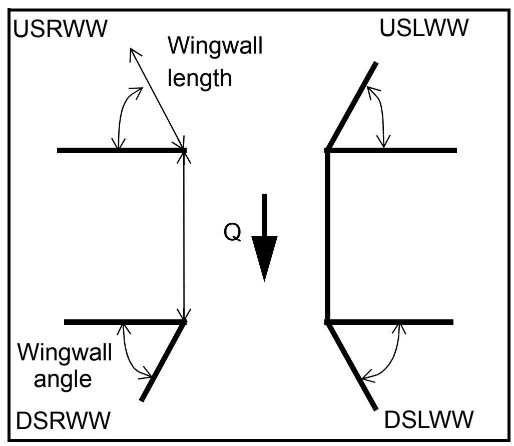
79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):

0
0.5
1
74. The left abutment footing is undermined vertically up to 0.75 ft in spots mostly at the US end. There is no undermining from the DS face to 12 ft under the bridge except at the DS end where a 1.5 ft section of the footing is missing and the bottom of the abutment is undermined 0.5 ft.
75. Average thalweg depth US is 0.5 ft. Scour at the left abutment extends from the DS end of the US left wingwall to 6 ft under the bridge. It is 3.5 ft at the widest point which is even with the US bridge face.
76. On the right abutment the footing is only exposed from the DS bridge face to 8 ft under the bridge.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						23.0	
USRWW:	Y		1		3	0.5	
DSLWW:	0.5		1.5		Y	31.5	
DSRWW:	1		0		-	31.5	

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



82. **Bank / Bridge Protection**:

Location	USLWW	USRWW	LABUT	RABUT	LB	RB	DSLWW	DSRWW
Type	-	0	Y	-	1	-	-	-
Condition	Y	-	1	-	2	-	-	-
Extent	1	-	0	1	0	0	0	-

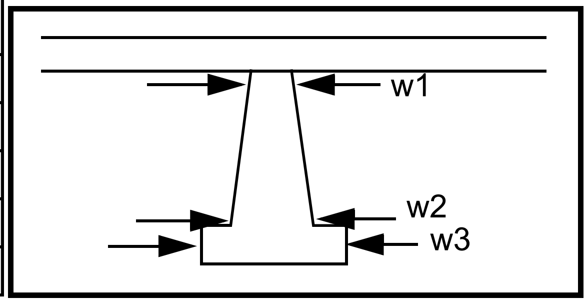
*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*
*Bank / Bridge protection conditions: **1**- good; **2**- slumped; **3**- eroded; **4**- failed*
*Protection extent: **1**- entire base length;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

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
5
1
1
0
-
-

Piers:

84. Are there piers? **80.** (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				**30.0**	**11.5**	**75.0**
Pier 2			**9.0**	**11.0**	**60.0**	**25.0**
Pier 3	**9.0**	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)	**The**	**DS end**	**tec-**	**couple**	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type	**US**	**of**	**tion**	**of**	***1**- Solid pier, **2**- column, **3**- bent*
88. Material	**left**	**the**	**is**	**large**	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape	**wing**	**wing**	**type-**	**stone**	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?	**wall**	**wall.**	**1 at**	**s,**	*Y- yes; N- no*
91. Attack ∠ (BF)	**foot-**	**82.**	**the**	**type-**	
92. Pushed	**ing is**	**The**	**US**	**2**	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles	**expo**	**US**	**end.**	**pro-**	
95. Cross-members	**sed**	**left**	**Ther**	**tec-**	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition	**for 5**	**wing**	**e are**	**tion,**	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	**ft at**	**wall**	**also**	**alon**	
98. Exposure depth	**the**	**pro-**	**a**	**g the**	

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

entire base length, but they are out in the channel rather than close to the wingwall. At the DS left wingwall there is a second wall between the concrete wingwall and the channel. This wall is large stone slabs laid-up in line with left abutment but set back about 9 in.

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: 4______

Scour dimensions: Length 2_____ Width 32_____ Depth: 23_____ Positioned 1____ %LB to 2____ %RB

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

453
1
2
2

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

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

Confluence 2: Distance k,____ Enters on ther____ *(LB or RB)* Type e is____ *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

a gap in the tree cover from 40 ft to 100 ft DS. On the right bank, the vegetation cover is mainly shrubs to 45 ft DS, then further DS the tree cover becomes nearly 100%.

F. Geomorphic Channel Assessment

107. Stage of reach evolution Th____

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)*:

e left bank protection protects the house and lawn. It is composed of a variety of protection materials, such as stones, bricks, old asphalt, and cut stone blocks. This protection extends beyond 200 ft DS.
The right bank protection is just a few cut stones from the end of the wingwall to 30 ft DS.
Between 52 ft and 100 ft DS there is a pooled area that is 1.25 ft deep caused by randomly placed stones across the channel at each end.

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: NFIETH00PL0081 Town: NORTHFIELD
Road Number: PLEASANT ST. County: WASHINGTON
Stream: UNION BROOK

Initials RLB Date: 5/16/97 Checked: EB

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	1590	2460	930
Main Channel Area, ft2	232	267	164
Left overbank area, ft2	102	156	0
Right overbank area, ft2	39	82	0
Top width main channel, ft	43	43	42
Top width L overbank, ft	67	67	0
Top width R overbank, ft	46	59	0
D50 of channel, ft	0.1566	0.1566	0.1566
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.4	6.2	3.9
y1, average depth, LOB, ft	1.5	2.3	ERR
y1, average depth, ROB, ft	0.8	1.4	ERR
Total conveyance, approach	23541	35955	9722
Conveyance, main channel	17068	21538	9722
Conveyance, LOB	4979	10078	0
Conveyance, ROB	1494	4340	0
Percent discrepancy, conveyance	0.0000	-0.0028	0.0000
Qm, discharge, MC, cfs	1152.8	1473.6	930.0
Ql, discharge, LOB, cfs	336.3	689.5	0.0
Qr, discharge, ROB, cfs	100.9	296.9	0.0
Vm, mean velocity MC, ft/s	5.0	5.5	5.7
Vl, mean velocity, LOB, ft/s	3.3	4.4	ERR
Vr, mean velocity, ROB, ft/s	2.6	3.6	ERR
Vc-m, crit. velocity, MC, ft/s	8.0	8.2	7.6
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Main Channel	0	0	0
Left Overbank	N/A	N/A	N/A
Right Overbank	N/A	N/A	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Bridge Section	Q100	Q500	Other Q
(Q) total discharge, cfs	1590	2460	930
(Q) discharge thru bridge, cfs	1053	1213	930
Main channel conveyance	11171	9812	7863
Total conveyance	11171	9812	7863
Q2, bridge MC discharge,cfs	1053	1213	930
Main channel area, ft2	144	144	98
Main channel width (normal), ft	23.0	23.0	23.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23	23	23
y_bridge (avg. depth at br.), ft	6.26	6.26	4.26
Dm, median (1.25*D50), ft	0.19575	0.19575	0.19575
y2, depth in contraction,ft	5.23	5.90	4.70
ys, scour depth (y2-ybridge), ft	-1.03	-0.36	0.44

Pressure Flow Scour (contraction scour for orifice flow conditions)

Chang pressure flow equation   Hb+Ys=Cq*qbr/Vc
Cq=1/Cf*Cc   Cf=1.5*Fr^0.43 (<=1)   Cc=SQRT[0.10(Hb/(ya-w)-0.56)]+0.79 (<=1)
Umbrell pressure flow equation
(Hb+Ys)/ya=1.1021*[(1-w/ya)*(Va/Vc)]^0.6031
(Richardson and other, 1995, p. 144-146)

	Q100	Q500	OtherQ
Q, total, cfs	1590	2460	930
Q, thru bridge MC, cfs	1053	1213	930
Vc, critical velocity, ft/s	8.00	8.19	7.58
Va, velocity MC approach, ft/s	4.97	5.52	5.67
Main channel width (normal), ft	23.0	23.0	23.0
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	23.0	23.0	23.0
qbr, unit discharge, ft2/s	45.8	52.7	40.4
Area of full opening, ft2	144.0	144.0	98.0
Hb, depth of full opening, ft	6.26	6.26	4.26
Fr, Froude number, bridge MC	0.56	0.64	0
Cf, Fr correction factor (<=1.0)	1.00	1.00	0.00
**Area at downstream face, ft2	136	N/A	N/A
**Hb, depth at downstream face, ft	5.91	N/A	N/A
**Fr, Froude number at DS face	0.56	ERR	ERR
**Cf, for downstream face (<=1.0)	1.00	N/A	N/A
Elevation of Low Steel, ft	500.08	500.08	0

Elevation of Bed, ft	493.82	493.82	-4.26
Elevation of Approach, ft	501.29	502.1	0
Friction loss, approach, ft	0.13	0.19	0
Elevation of WS immediately US, ft	501.16	501.91	0.00
ya, depth immediately US, ft	7.34	8.09	4.26
Mean elevation of deck, ft	501.42	501.42	0
w, depth of overflow, ft (>=0)	0.00	0.49	0.00
Cc, vert contrac correction (<=1.0)	0.96	0.95	1.00
**Cc, for downstream face (<=1.0)	0.946683	ERR	ERR
Ys, scour w/Chang equation, ft	-0.31	0.50	N/A
Ys, scour w/Umbrell equation, ft	-0.19	0.51	N/A

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

**Ys, scour w/Chang equation, ft	0.13	N/A	N/A
**Ys, scour w/Umbrell equation, ft	0.16	N/A	ERR

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

y2, from Laursen's equation, ft	5.23	5.90	4.70
WSEL at downstream face, ft	499.73	--	--
Depth at downstream face, ft	5.91	N/A	N/A
Ys, depth of scour (Laursen), ft	-0.68	N/A	N/A

Armoring

Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]

Depth to Armoring=3*(1/Pc-1)

(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	1053	1213	930
Main channel area (DS), ft2	136	144	98
Main channel width (normal), ft	23.0	23	23.0
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	23.0	23.0	23.0
D90, ft	0.4896	0.4896	0.4896
D95, ft	0.6622	0.6622	0.6622
Dc, critical grain size, ft	0.2425	0.2806	0.4172
Pc, Decimal percent coarser than Dc	0.317	0.264	0.134
Depth to armoring, ft	1.57	2.35	8.09

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	1590	2460	930	1590	2460	930
a', abut.length blocking flow, ft	28.8	28.8	1.8	33.2	33.2	17.2
Ae, area of blocked flow ft2	43.9	42.1	3.9	90.1	95	54.7
Qe, discharge blocked abut.,cfs	--	--	13.3	--	--	268.1

(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)

Ve, (Qe/Ae), ft/s	3.27	4.32	3.37	3.84	4.38	4.90
ya, depth of f/p flow, ft	1.52	1.46	2.17	2.71	2.86	3.18

--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	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.455	0.492	0.401	0.491	0.506	0.484
ys, scour depth, ft	7.42	7.50	4.19	12.69	13.33	11.34

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)	28.8	28.8	1.8	33.2	33.2	17.2
y1 (depth f/p flow, ft)	1.52	1.46	2.17	2.71	2.86	3.18
a'/y1	18.89	19.70	0.83	12.23	11.60	5.41
Skew correction (p. 49, fig. 16)	0.90	0.90	0.90	1.07	1.07	1.07
Froude no. f/p flow	0.46	0.49	0.40	0.49	0.51	0.48
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)

Downstream bridge face property	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.56	0.64	0.81	0.56	0.64	0.81
y, depth of flow in bridge, ft	5.91	6.26	4.26	5.91	6.26	4.26
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.15	1.59	ERR	1.15	1.59	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	1.68	ERR	ERR	1.68