# LEVEL II SCOUR ANALYSIS FOR BRIDGE 68 (NFIETH00960068) on TOWN HIGHWAY 96, crossing the DOG RIVER, NORTHFIELD, VERMONT

U.S. Geological Survey
Open-File Report 97-590

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

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By RONDA L. BURNS

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**Pembroke, New Hampshire**

**1997**

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

U.S. GEOLOGICAL SURVEY
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Denver, CO 80225-0286

# 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 68 (NFIETH00960068) ON TOWN HIGHWAY 96, CROSSING THE DOG RIVER, NORTHFIELD, VERMONT

*By* Ronda L. Burns

## INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure NFIETH00960068 on Town Highway 96 crossing the Dog River, 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 30.7-$mi^2$ drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover on the left bank upstream and downstream is pasture while the immediate banks have dense woody vegetation. The right bank upstream is forested and the downstream right bank is pasture. Vermont state route 12A runs parallel to the river on the right bank.

In the study area, the Dog River has an incised, straight channel with a slope of approximately 0.004 ft/ft, an average channel top width of 70 ft and an average bank height of 7 ft. The channel bed material ranges from sand to cobble with a median grain size ($D_{50}$) of 47.9 mm (0.157 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 25, 1996, indicated that the reach was stable.

The Town Highway 96 crossing of the Dog River is a 45-ft-long, one-lane bridge consisting of one 43-foot steel-beam span with a timber deck (Vermont Agency of Transportation, written communication, October 13, 1995). The opening length of the structure parallel to the bridge face is 41.5 ft.The bridge is supported by vertical, concrete abutments with wingwalls. The channel is not skewed to the opening and the opening-skew-to-roadway is zero degrees.

Channel scour 0.5 ft deeper than the mean thalweg depth, was observed under the bridge during the Level I assessment. The scour protection measures at the site included type-1 stone fill (less than 12 inches diameter) along the left bank upstream and type-2 stone fill (less than 36 inches diameter) along the upstream and downstream right banks that extends partially in front of the right wingwalls. 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 0.8 to 1.2 ft. The worst-case contraction scour occurred at the 100-year and 500-year discharges. Abutment scour ranged from 8.5 to 12.2 ft. The worst-case abutment scour occurred at the incipient roadway-overtopping discharge for the right abutment. 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.

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

**NORTH**

Figure 1. Location of study area on USGS 1:24,000 scale map.

Figure 2. Location of study area on Vermont Agency of Transportation town highway map.

## LEVEL II SUMMARY

***Structure Number*** NFIETH00960068 ***Stream*** Dog River

***County*** Washington ***Road*** TH96 ***District*** 6

## Description of Bridge

***Bridge length*** 45 ***ft*** ***Bridge width*** 16.9 ***ft*** ***Max span length*** 43 ***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*** 07/25/96

***Description of stone fill*** Type-2, around the upstream end of the upstream right wingwall and the downstream end of the downstream right wingwall.

***Brief description of piers/abutments*** Abutments and wingwalls are concrete. The footing for the right abutment and its wingwalls is exposed.

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

***Is bridge located on a bend in channel? If so, describe (mild, moderate, severe)*** No

***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*** | 07/25/96 | 0 | 0 |
| ***Level II*** | 07/25/96 | 0 | 0 |

***Potential for debris*** Low.

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

None 07/25/96.

## Description of the Geomorphic Setting

***General topography*** The channel is located within a moderate relief valley with a 400 foot-wide, flat to slightly irregular flood plain on the left and a steep valley wall on the right.

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

***Date of inspection*** 07/25/96

***DS left:*** Steep channel bank to a flood plain

***DS right:*** Steep valley wall

***US left:*** Steep channel bank to a flood plain

***US right:*** Steep valley wall

## Description of the Channel

***Average top width*** 70 ft ***Average depth*** 7 ft

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

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

07/25/96

***Vegetative co*** Trees and brush with grass on the overbank

***DS left:*** Grass with trees on the overbank

***DS right:*** Trees and brush with grass on the overbank

***US left:*** Brush with trees on the overbank

***US right:***

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

None 07/25/96.

***Describe any obstructions in channel and date of observation.***

## Hydrology

***Drainage area*** 30.7 ***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***: -

***Is there a USGS gage on the stream of interest?*** Yes

***USGS gage description*** Dog River at Northfield Falls, VT.

***USGS gage number*** 04287000

***Gage drainage area*** 76.1 ***mi²***

***Is there a lake/p*** No

-

### Calculated Discharges

***Q100*** 5,950 ***ft³/s*** ***Q500*** 8,140 ***ft³/s***

The 100- and 500-year discharges are based on a drainage area relationship [(30.7/76.1)exp 0.75] with the flood frequency determinations at the USGS gage at Northfield Falls in Northfield. The flood frequency values for the gage were determined using a log-Pearson type III analysis on 59 years of stream flow records from 1935 to 1993.

## 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 upstream end of the right abutment (elev. 499.39 ft, arbitrary survey datum). RM2 is a nail 5 ft above the ground surface in an utility pole located 50 ft left of the left abutment on the downstream side of TH 96 (elev. 503.60 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 | -43 | 1 | Exit section |
| FULLV | 0 | 2 | Downstream Full-valley section (Templated from EXITX) |
| BRIDG | 0 | 1 | Bridge section |
| RDWAY | 11 | 1 | Road Grade section |
| APPRO | 61 | 1 | Approach section |

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

### Data and Assumptions Used in WSPRO Model

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

Channel roughness factors (Manning's "n") used in the hydraulic model were estimated using field inspections at each cross section following the general guidelines described by Arcement and Schneider (1989). Final adjustments to the values were made during the modelling of the reach. Channel "n" values for the reach ranged from 0.040 to 0.055, and overbank "n" values ranged from 0.032 to 0.045.

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 0.0041 ft/ft which was estimated from the streambed slope downstream of the bridge on the river profile in the Flood Insurance Study for Northfield, VT (U. S. Department of Housing and Urban Development, November 1977).

The surveyed approach section (APPRO) was 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*** 499.8 ***ft***
***Average low steel elevation*** 497.3 ***ft***

***100-year discharge*** 5,950 ***$ft^3/s$***
***Water-surface elevation in bridge opening*** 497.4 ***ft***
***Road overtopping?*** Yes ***Discharge over road*** 2,304 ***$ft^3/s$***
***Area of flow in bridge opening*** 389 ***$ft^2$***
***Average velocity in bridge opening*** 9.4 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 10.9 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 500.0
***Water-surface elevation at Approach section without bridge*** 497.9
***Amount of backwater caused by bridge*** 2.1 ***ft***

***500-year discharge*** 8,140 ***$ft^3/s$***
***Water-surface elevation in bridge opening*** 497.4 ***ft***
***Road overtopping?*** Yes ***Discharge over road*** 4,463 ***$ft^3/s$***
***Area of flow in bridge opening*** 389 ***$ft^2$***
***Average velocity in bridge opening*** 9.5 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 11.0 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 500.7
***Water-surface elevation at Approach section without bridge*** 498.6
***Amount of backwater caused by bridge*** 2.1 ***ft***

***Incipient overtopping discharge*** 3,390 ***$ft^3/s$***
***Water-surface elevation in bridge opening*** 495.8 ***ft***
***Area of flow in bridge opening*** 325 ***$ft^2$***
***Average velocity in bridge opening*** 10.4 ***ft/s***
***Maximum WSPRO tube velocity at bridge*** 12.6 ***ft/s***

***Water-surface elevation at Approach section with bridge*** 497.5
***Water-surface elevation at Approach section without bridge*** 496.7
***Amount of backwater caused by bridge*** 0.8 ***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 road-overtopping discharge was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 100-year and 500-year discharges 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). Estimates of contraction scour for the 100-year and 500-year discharges were 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 are presented in Appendix F. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

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

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

## Scour Results

| *Contraction scour:* | *100-yr discharge* | *500-yr discharge* | *Incipient overtopping discharge* |
|---|---|---|---|
| | | *(Scour depths in feet)* | |
| *Main channel* | | | |
| *Live-bed scour* | -- | -- | -- |
| *Clear-water scour* | 1.2 | 1.2 | 0.8 |
| *Depth to armoring* | 3.5 | 4.0 | 8.5 |
| *Left overbank* | -- | -- | -- |
| *Right overbank* | -- | -- | -- |

| *Local scour:* | | | |
|---|---|---|---|
| *Abutment scour* | | | |
| *Left abutment* | 8.5 | 9.4 | 9.3 |
| *Right abutment* | 10.9– | 11.5- | 12.2- |
| *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* | 1.7 | 1.8 | 2.1 |
| *Right abutment* | 1.7 | 1.8 | 2.1 |
| *Piers:* | -- | -- | -- |
| *Pier 1* | -- | -- | -- |
| *Pier 2* | -- | -- | -- |

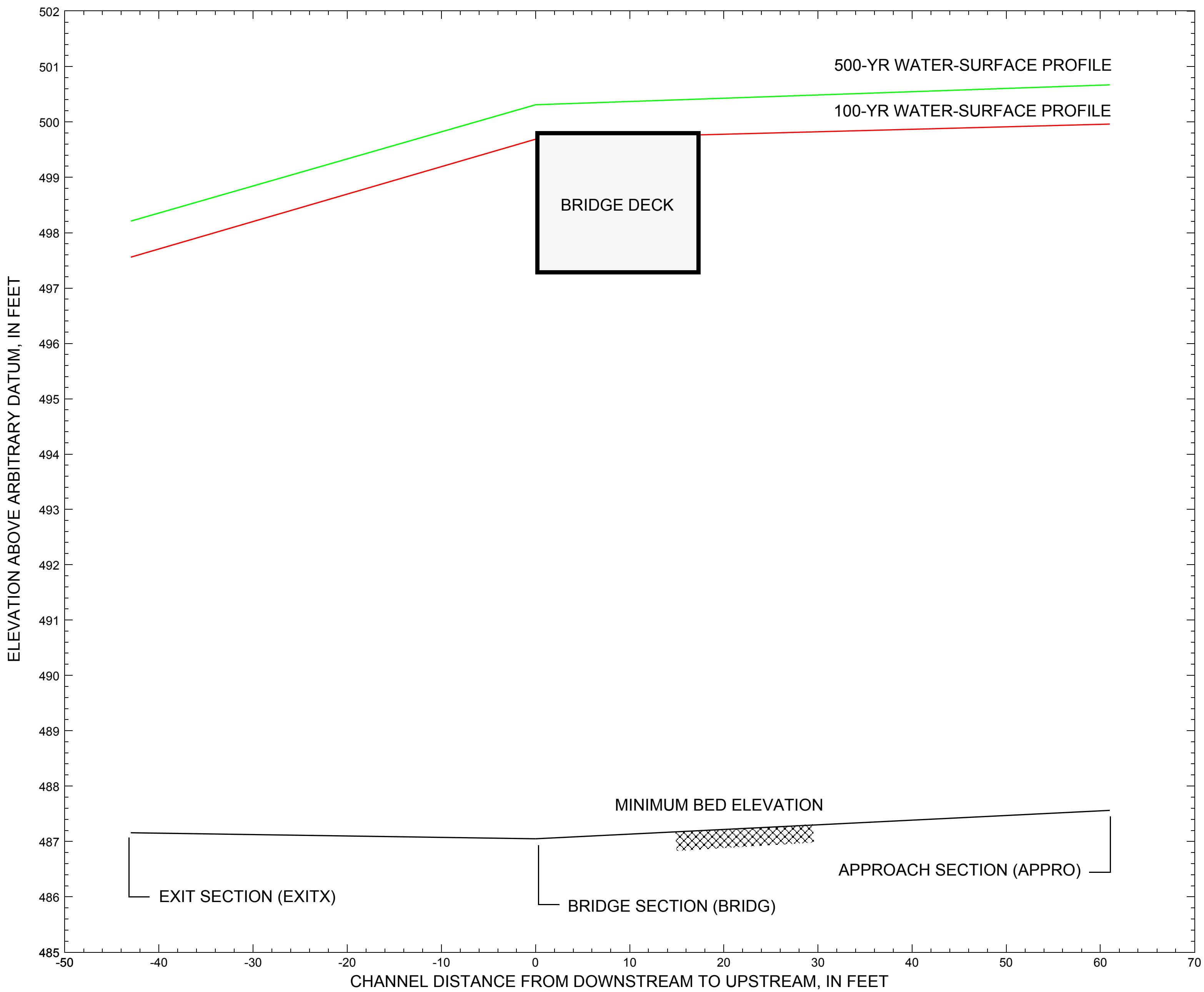


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure NFIETH00960068 on Town Highway 96, crossing the Dog River, Northfield, Vermont.

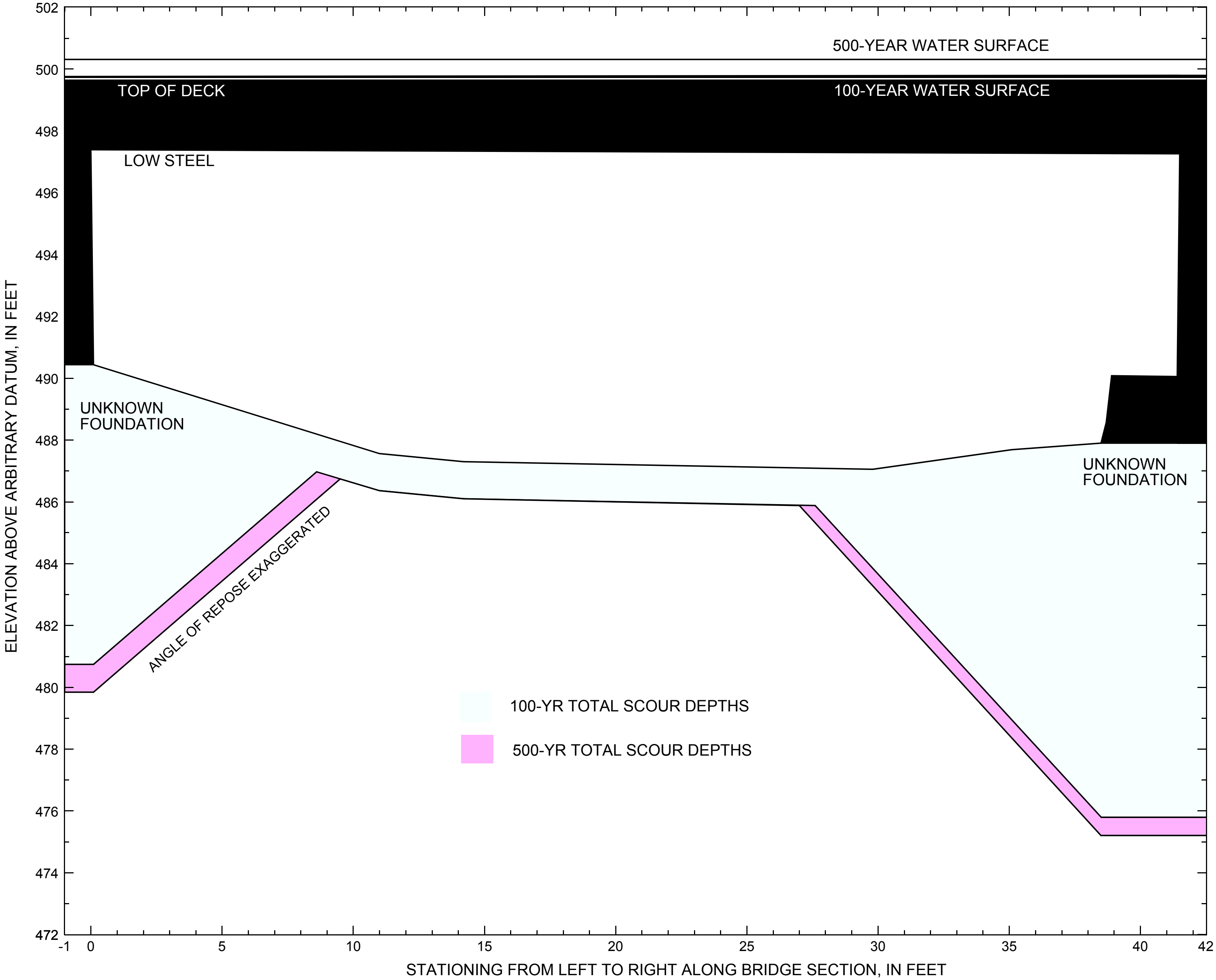


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure NFIETH00960068 on Town Highway 96, crossing the Dog River, Northfield, Vermont.

**Table 1.** Remaining footing/pile depth at abutments for the 100-year discharge at structure NFIETH00960068 on Town Highway 96, crossing the Dog River, 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/pile elevation[2] (feet) | Channel elevation at abutment/ pier[2] (feet) | Contraction scour depth (feet) | Abutment scour depth (feet) | Pier scour depth (feet) | Depth of total scour (feet) | Elevation of scour[2] (feet) | Remaining footing/pile depth (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 100-yr. discharge is 5,950 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | -- | 497.4 | -- | 490.4 | 1.2 | 8.5 | -- | 9.7 | 480.7 | -- |
| Right abutment | 41.5 | -- | 497.3 | -- | 487.9 | 1.2 | 10.9 | -- | 12.1 | 475.8 | -- |

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 NFIETH00960068 on Town Highway 96, crossing the Dog River, 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/pile elevation[2] (feet) | Channel elevation at abutment/ pier[2] (feet) | Contraction scour depth (feet) | Abutment scour depth (feet) | Pier scour depth (feet) | Depth of total scour (feet) | Elevation of scour[2] (feet) | Remaining footing/pile depth (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 500-yr. discharge is 8,140 cubic-feet per second | | | | | | | | | | | |
| Left abutment | 0.0 | -- | 497.4 | -- | 490.4 | 1.2 | 9.4 | -- | 10.6 | 479.8 | -- |
| Right abutment | 41.5 | -- | 497.3 | -- | 487.9 | 1.2 | 11.5 | -- | 12.7 | 475.2 | -- |

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, Roxbury, 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

```
T1        U.S. Geological Survey WSPRO Input File nfie068.wsp
T2        Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
T3        TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER 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           5950.0   8140.0   3390.0
SK          0.0041   0.0041   0.0041
*
XS   EXITX    -43          0.
GR         -504.9, 504.56   -486.6, 498.82   -457.9, 497.22   -327.7, 497.48
GR         -314.1, 496.51   -185.2, 495.48    -12.1, 494.70      0.0, 491.41
GR            4.5, 488.38      8.7, 487.96     13.1, 487.78     24.1, 487.63
GR           31.2, 487.37     36.9, 487.16     42.0, 487.36     44.5, 488.37
GR           51.0, 493.49     58.0, 494.82     84.8, 495.83     90.1, 498.18
GR          110.8, 499.12    129.3, 499.12    133.4, 507.17
*
N           0.045        0.053        0.034
SA                 -12.1         58.0
*
XS   FULLV      0  * * *   0.0017
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    497.32       0.0
GR            0.0, 497.39      0.0, 497.31      0.1, 490.44      6.9, 488.60
GR           11.0, 487.56     14.2, 487.30     19.9, 487.17     29.8, 487.05
GR           35.1, 487.69     38.5, 487.90     38.7, 488.57     38.9, 490.08
GR           41.4, 490.05     41.5, 497.26      0.0, 497.39
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      33.2 * *     45.3     11.8
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     11      16.9     1
GR         -666.8, 520.56   -487.4, 505.85   -367.2, 499.34   -287.8, 498.83
GR         -201.5, 498.26    -78.8, 497.85    -31.1, 499.36      0.0, 499.76
GR           41.4, 499.80     79.8, 498.97    103.6, 498.90    124.6, 498.94
GR          129.9, 509.83
*
AS   APPRO     61          0.
GR         -660.2, 520.56   -415.7, 496.60   -349.5, 496.96   -318.1, 498.31
GR         -167.2, 496.30   -115.5, 497.54    -71.3, 495.14    -12.4, 494.94
GR            0.0, 492.16      4.6, 488.59      6.4, 488.34     16.0, 488.14
GR           26.7, 487.81     30.9, 487.56     38.7, 487.59     42.4, 488.61
GR           52.5, 494.19     56.9, 497.43     86.1, 498.38    109.5, 498.99
GR          118.6, 498.99    125.3, 505.76
*
*    For the incipient over-topping discharge, a wall was created at station
*    -115.5, the high point on the left overbank.
*
N           0.040        0.055        0.032
SA                 -12.4         56.9
*
HP 1 BRIDG   497.39 1 497.39
HP 2 BRIDG   497.39 * * 3646
HP 2 RDWAY   499.69 * * 2304
HP 1 APPRO   499.96 1 499.96
HP 2 APPRO   499.96 * * 5950
*
HP 1 BRIDG   497.39 1 497.39
HP 2 BRIDG   497.39 * * 3710
HP 2 RDWAY   500.31 * * 4463
HP 1 APPRO   500.67 1 500.67
```

APPENDIX B:

# WSPRO OUTPUT FILE

# WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File nfie068.wsp
       Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
       TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
          *** RUN DATE & TIME: 06-12-97  09:47

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      389     35987      0     99                            0
  497.39           389     35987      0     99  1.00      0     42        0

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      497.39     0.0    41.5   388.7   35987.    3646.   9.38

 X STA.         0.0        4.1        6.8        8.9       10.9       12.8
   A(I)            30.6       22.4       19.3       18.7       18.2
   V(I)            5.96       8.16       9.47       9.75      10.00

 X STA.        12.8       14.5       16.2       17.9       19.5       21.2
   A(I)            17.1       17.5       16.9       16.8       16.8
   V(I)           10.63      10.44      10.76      10.85      10.82

 X STA.        21.2       22.9       24.5       26.2       27.8       29.5
   A(I)            16.9       16.9       17.1       17.0       17.4
   V(I)           10.81      10.80      10.65      10.72      10.50

 X STA.        29.5       31.3       33.1       35.1       37.4       41.5
   A(I)            17.6       18.6       19.0       21.7       32.3
   V(I)           10.35       9.82       9.60       8.42       5.64

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

        WSEL     LEW     REW    AREA        K        Q    VEL
      499.69  -373.7   125.0   450.9   15928.    2304.   5.11

 X STA.      -373.7     -301.6     -268.2     -243.7     -224.5     -207.9
   A(I)            37.9       29.4       26.1       23.4       22.0
   V(I)            3.04       3.92       4.41       4.92       5.23

 X STA.      -207.9     -193.3     -179.5     -166.7     -154.5     -143.1
   A(I)            21.0       20.3       19.5       19.1       18.4
   V(I)            5.49       5.67       5.90       6.04       6.27

 X STA.      -143.1     -131.9     -121.0     -110.5     -100.3      -90.0
   A(I)            18.5       18.3       17.9       17.8       18.5
   V(I)            6.24       6.29       6.43       6.46       6.22

 X STA.       -90.0      -79.8      -67.4      -40.1       96.7      125.0
   A(I)            18.4       20.8       28.7       33.0       21.7
   V(I)            6.25       5.54       4.02       3.49       5.31

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1     1349    106356    438    438                        13436
            2      682     81536     69     74                        12134
            3       99      6239     63     63                          708
  499.96          2130    194131    570    574  1.15   -449    120    21807

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

        WSEL     LEW     REW    AREA        K        Q    VEL
      499.96  -450.0   119.6  2129.6  194131.    5950.   2.79

 X STA.      -450.0     -389.3     -348.7     -269.1     -216.9     -179.0
   A(I)           144.3      126.3      167.4      138.4      123.2
   V(I)            2.06       2.36       1.78       2.15       2.42

 X STA.      -179.0     -144.1      -95.2      -69.9      -49.8      -30.3
   A(I)           120.2      139.3      106.6       97.6       95.9
   V(I)            2.48       2.14       2.79       3.05       3.10

 X STA.       -30.3      -11.2        3.8       10.3       16.3       22.2
   A(I)            95.9      108.0       75.0       70.7       71.0
   V(I)            3.10       2.76       3.97       4.21       4.19

 X STA.        22.2       28.1       33.8       39.9       48.1      119.6
   A(I)            70.4       71.2       74.5       85.8      147.9
   V(I)            4.22       4.18       3.99       3.47       2.01
```

# WSPRO OUTPUT FILE (continued)

```
      U.S. Geological Survey WSPRO Input File nfie068.wsp
      Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
      TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
         *** RUN DATE & TIME: 06-12-97  09:47

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      389     35987      0     99                            0
 497.39           389     35987      0     99  1.00      0     42        0

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

     WSEL     LEW     REW    AREA        K        Q    VEL
   497.39     0.0    41.5   388.7   35987.    3710.   9.54

X STA.        0.0         4.1         6.8         8.9        10.9        12.8
  A(I)              30.6        22.4        19.3        18.7        18.2
  V(I)              6.06        8.30        9.64        9.92       10.17

X STA.       12.8        14.5        16.2        17.9        19.5        21.2
  A(I)              17.1        17.5        16.9        16.8        16.8
  V(I)             10.82       10.62       10.95       11.04       11.01

X STA.       21.2        22.9        24.5        26.2        27.8        29.5
  A(I)              16.9        16.9        17.1        17.0        17.4
  V(I)             11.00       10.99       10.84       10.91       10.68

X STA.       29.5        31.3        33.1        35.1        37.4        41.5
  A(I)              17.6        18.6        19.0        21.7        32.3
  V(I)             10.53        9.99        9.77        8.57        5.74

  VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =      11.

     WSEL     LEW     REW    AREA        K        Q    VEL
   500.31  -385.1   125.3   759.4   34985.    4463.   5.88

X STA.     -385.1      -324.1      -289.7      -263.0      -240.1      -220.3
  A(I)              56.5        46.6        41.6        39.4        36.8
  V(I)              3.95        4.79        5.36        5.67        6.07

X STA.     -220.3      -202.3      -186.0      -170.1      -155.3      -140.9
  A(I)              35.7        33.9        33.8        32.4        32.1
  V(I)              6.25        6.59        6.61        6.89        6.95

X STA.     -140.9      -126.8      -113.5      -100.2       -87.2       -74.2
  A(I)              32.1        30.7        31.6        31.3        31.6
  V(I)              6.95        7.26        7.06        7.12        7.06

X STA.      -74.2       -56.7       -11.1        77.7       101.4       125.3
  A(I)              35.5        51.2        61.6        32.3        32.8
  V(I)              6.29        4.36        3.62        6.90        6.80

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1     1662    148993    445    445                        18229
           2      731     91578     69     74                        13472
           3      144     11486     63     64                         1230
 500.67          2537    252056    577    583  1.09   -456    120    28922

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

     WSEL     LEW     REW    AREA        K        Q    VEL
   500.67  -457.2   120.3  2536.8  252056.    8140.   3.21

X STA.     -457.2      -393.3      -356.8      -298.9      -243.0      -202.6
  A(I)             174.5       140.2       170.4       167.1       146.7
  V(I)              2.33        2.90        2.39        2.44        2.77

X STA.     -202.6      -169.9      -135.6       -92.4       -68.3       -47.8
  A(I)             134.4       138.1       154.6       120.8       114.5
  V(I)              3.03        2.95        2.63        3.37        3.55

X STA.      -47.8       -28.4        -7.7         5.7        12.9        19.9
  A(I)             109.6       120.5       119.2        89.6        87.9
  V(I)              3.71        3.38        3.42        4.54        4.63

X STA.       19.9        26.9        33.6        40.7        53.3       120.3
  A(I)              89.4        87.0        92.2       119.9       160.3
  V(I)              4.56        4.68        4.42        3.39        2.54
```

```
      U.S. Geological Survey WSPRO Input File nfie068.wsp
      Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
      TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
         *** RUN DATE & TIME: 06-12-97  09:59

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

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      325     39752     41     55                         5165
 495.79           325     39752     41     55  1.00      0     41     5165

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

       WSEL     LEW     REW    AREA        K        Q    VEL
     495.79     0.0    41.5   325.1   39752.    3390.  10.43

X STA.        0.0        4.7        7.5        9.6       11.5       13.2
  A(I)           28.0       18.9       16.4       15.1       14.6
  V(I)           6.06       8.99      10.35      11.23      11.58

X STA.       13.2       14.9       16.5       18.1       19.7       21.2
  A(I)           14.1       14.0       13.6       13.5       13.5
  V(I)          12.06      12.14      12.50      12.59      12.55

X STA.       21.2       22.8       24.4       25.9       27.5       29.1
  A(I)           13.5       13.5       13.7       13.6       14.3
  V(I)          12.57      12.55      12.37      12.44      11.89

X STA.       29.1       30.8       32.6       34.6       36.9       41.5
  A(I)           14.3       15.5       16.4       18.7       30.1
  V(I)          11.88      10.95      10.34       9.04       5.63

  CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

   WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      192     10935    102    102                         1499
           2      509     50019     69     74                         7817
           3        0         0      1      1                            0
 497.46           701     60954    172    176  1.13   -113     58     7566

  VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      61.

       WSEL     LEW     REW    AREA        K        Q    VEL
     497.46  -114.0    57.8   700.6   60954.    3390.   4.84

X STA.     -114.0      -63.3      -42.2      -23.3       -5.0        2.9
  A(I)           68.2       50.2       46.5       51.9       42.2
  V(I)           2.48       3.37       3.65       3.26       4.02

X STA.        2.9        6.6        9.7       12.7       15.6       18.5
  A(I)           32.1       28.9       27.0       27.3       26.7
  V(I)           5.29       5.87       6.28       6.21       6.36

X STA.       18.5       21.3       24.0       26.8       29.4       32.1
  A(I)           26.3       26.6       26.2       25.8       26.3
  V(I)           6.44       6.38       6.48       6.56       6.46

X STA.       32.1       34.8       37.6       40.6       44.6       57.8
  A(I)           27.2       27.3       29.4       34.3       50.3
  V(I)           6.24       6.21       5.77       4.94       3.37
```

```
       U.S. Geological Survey WSPRO Input File nfie068.wsp
       Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
       TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
          *** RUN DATE & TIME: 06-12-97  09:47

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

EXITX:XS   ******   -463     1284  0.53 *****  498.09  496.71    5950  497.56
       -42 ******     89    92845  1.59 ***** *******    0.68    4.63

FULLV:FV       43   -467     1393  0.44  0.16  498.27 *******    5950  497.83
         0     43     89   102472  1.54  0.00    0.02    0.59    4.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===125 FR# EXCEEDS FNTEST AT SECID "APPRO":  TRIALS CONTINUED.
              FNTEST,FR#,WSEL,CRWS =  0.80    0.81     497.95     497.44
 ===110 WSEL NOT FOUND AT SECID "APPRO":  REDUCED DELTAY.
                   WSLIM1,WSLIM2,DELTAY =   497.33     520.56    0.50
 ===115 WSEL NOT FOUND AT SECID "APPRO":  USED WSMIN = CRWS.
                   WSLIM1,WSLIM2,CRWS =   497.33     520.56     497.44

APPRO:AS       61   -428     1040  0.74  0.27  498.69  497.44    5950  497.94
        61     61     73    77553  1.46  0.15   -0.01    0.82    5.72
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   497.83     497.32

            <<<<<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       43      0      389  1.37 *****  498.76  494.17    3646  497.39
         0 ******     42    35987  1.00 ***** *******    0.54    9.38

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    44.  0.04  0.14  500.06    0.00   2304.  499.69

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   2076.   368.  -374.    -5.   1.8   1.1   5.8   5.1   1.5   3.2
   RT:    228.    79.    46.   125.   0.8   0.6   4.5   4.9   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       28   -449     2132  0.14  0.14  500.10  497.44    5950  499.96
        61     41    120   194412  1.15  0.00    0.00    0.27    2.79

       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     -43.  -464.    89.   5950.   92845.    1284.    4.63  497.56
   FULLV:FV       0.  -468.    89.   5950.  102472.    1393.    4.27  497.83
   BRIDG:BR       0.     0.    42.   3646.   35987.     389.    9.38  497.39
   RDWAY:RG      11.*******  2076.   2304.******************    1.00  499.69
   APPRO:AS      61.  -450.   120.   5950.  194412.    2132.    2.79  499.96

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.71    0.68  487.16  507.17************  0.53  498.09  497.56
   FULLV:FV  ********    0.59  487.23  507.24  0.16  0.00  0.44  498.27  497.83
   BRIDG:BR    494.17    0.54  487.05  497.39************  1.37  498.76  497.39
   RDWAY:RG  ****************  497.85  520.56  0.04******  0.14  500.06  499.69
   APPRO:AS    497.44    0.27  487.56  520.56  0.14  0.00  0.14  500.10  499.96
```

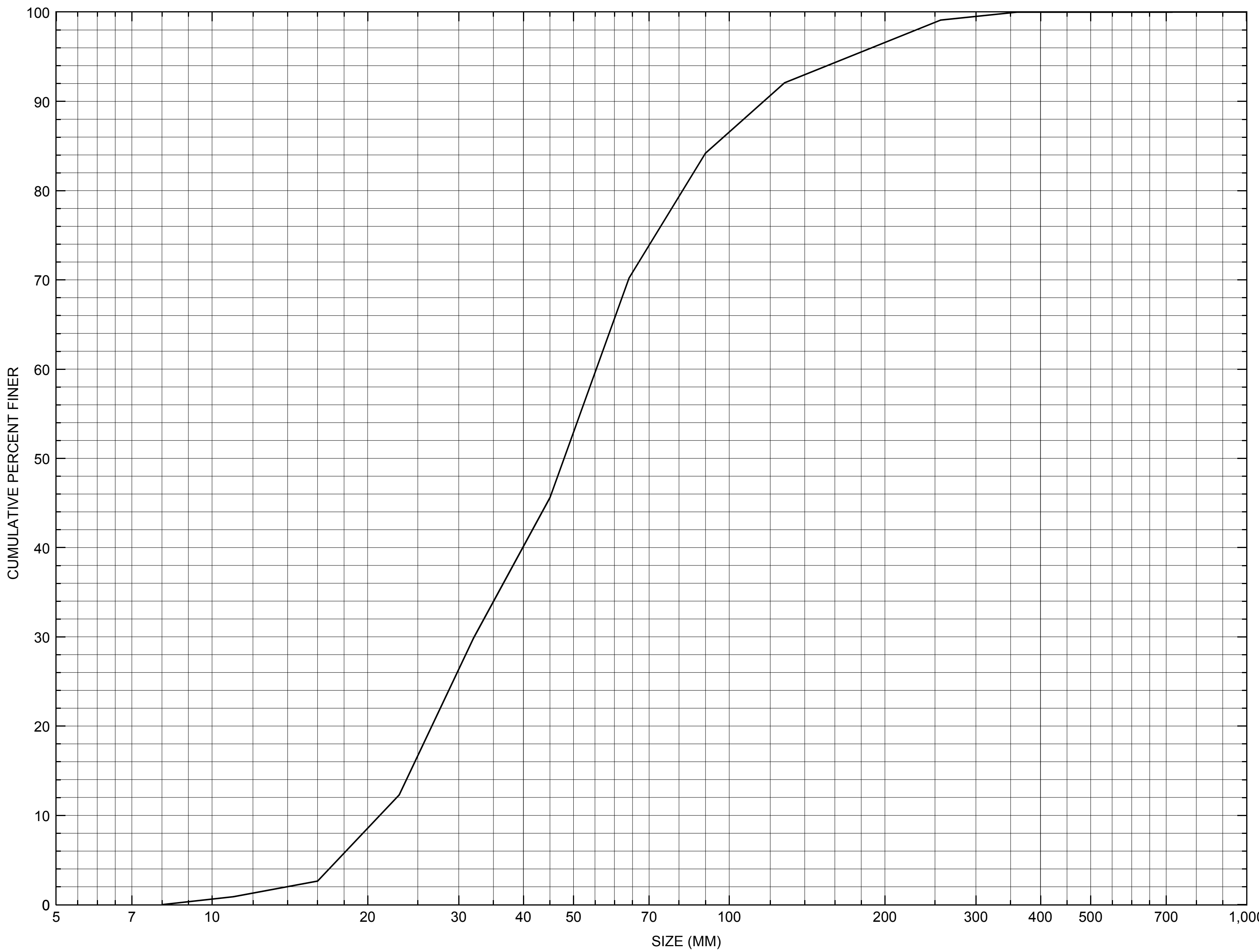
# WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File nfie068.wsp
        Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
        TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
           *** RUN DATE & TIME: 06-12-97  09:47

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

EXITX:XS   ******   -475     1648  0.54 *****  498.76  497.21    8140  498.21
       -42 ******     91   127001  1.43 ***** *******    0.61    4.94

FULLV:FV       43   -478     1739  0.48  0.16  498.92 *******    8140  498.45
         0     43     94   136035  1.40  0.00    0.00    0.56    4.68
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       61   -435     1363  0.76  0.28  499.34 *******    8140  498.58
        61     61     94   105514  1.37  0.14    0.00    0.77    5.97
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===255 ATTEMPTING FLOW CLASS 3 (6) SOLUTION.
                        WS3N,LSEL =   498.45     497.32

            <<<<<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       43      0      389  1.42 *****  498.81  494.25    3710  497.39
         0 ******     42    35987  1.00 ***** *******    0.55    9.54

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   6.  0.800  0.000  497.32 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.    44.  0.05  0.17  500.80    0.00   4463.  500.31

             Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:   3853.   406.  -385.    21.   2.5   1.6   6.8   5.9   2.1   3.1
   RT:    610.   104.    21.   125.   1.4   1.0   5.7   5.6   1.5   3.1

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

APPRO:AS       28   -456     2538  0.17  0.19  500.85  498.20    8140  500.67
        61     49    120   252160  1.09  0.00    0.00    0.28    3.21

       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     -43.  -476.    91.   8140.  127001.    1648.    4.94  498.21
   FULLV:FV       0.  -479.    94.   8140.  136035.    1739.    4.68  498.45
   BRIDG:BR       0.     0.    42.   3710.   35987.     389.    9.54  497.39
   RDWAY:RG      11.******* 3853.   4463.******************    1.00  500.31
   APPRO:AS      61.  -457.   120.   8140.  252160.    2538.    3.21  500.67

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

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO  VHD      EGL     WSEL
   EXITX:XS    497.21    0.61  487.16  507.17************  0.54  498.76  498.21
   FULLV:FV  ********    0.56  487.23  507.24  0.16  0.00  0.48  498.92  498.45
   BRIDG:BR    494.25    0.55  487.05  497.39************  1.42  498.81  497.39
   RDWAY:RG  ****************  497.85  520.56  0.05******  0.17  500.80  500.31
   APPRO:AS    498.20    0.28  487.56  520.56  0.19  0.00  0.17  500.85  500.67
```

```
        U.S. Geological Survey WSPRO Input File nfie068.wsp
        Hydraulic analysis for structure NFIETH00960068   Date: 22-MAY-97
        TH 96 (FAIRGROUND RD) CROSSING THE DOG RIVER IN NORTHFIELD, VT     RLB
           *** RUN DATE & TIME: 06-12-97  09:59

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

EXITX:XS   ******   -283      732  0.50 *****  496.77  493.50    3390  496.27
       -42 ******     86    52920  1.51 ***** *******    0.71    4.63

FULLV:FV       43   -306      800  0.43  0.16  496.95 *******    3390  496.52
         0     43     86    57507  1.53  0.00    0.01    0.65    4.24
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       61    -99      572  0.62  0.26  497.30 *******    3390  496.67
        61     61     56    47332  1.14  0.10   -0.01    0.58    5.92
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

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

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

BRIDG:BR       43      0      325  1.69  0.23  497.48  493.88    3390  495.79
         0     43     41    39787  1.00  0.48    0.00    0.66   10.42

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  497.32 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      11.         <<<<<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       28   -113      701  0.41  0.15  497.87  493.99    3390  497.46
        61     31     58    60963  1.13  0.24    0.00    0.45    4.84

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.733  0.267   44630.     0.    41.   497.32

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -43.  -284.    86.   3390.   52920.     732.    4.63  496.27
   FULLV:FV       0.  -307.    86.   3390.   57507.     800.    4.24  496.52
   BRIDG:BR       0.     0.    41.   3390.   39787.     325.   10.42  495.79
   RDWAY:RG      11.**************       0.******************     1.00********
   APPRO:AS      61.  -114.    58.   3390.   60963.     701.    4.84  497.46

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       0.    41.   44630.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    493.50    0.71  487.16  507.17************  0.50  496.77  496.27
   FULLV:FV  ********    0.65  487.23  507.24  0.16  0.00  0.43  496.95  496.52
   BRIDG:BR    493.88    0.66  487.05  497.39  0.23  0.48  1.69  497.48  495.79
   RDWAY:RG  ****************  497.85  520.56**********************************
   APPRO:AS    493.99    0.45  487.56  505.76  0.15  0.24  0.41  497.87  497.46
```

# APPENDIX C:

# BED-MATERIAL PARTICLE-SIZE DISTRIBUTION




Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure NFIETH00960068, in Northfield, Vermont.

APPENDIX D:

# HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

## Structure Number NFIETH00960068

## 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) 50275

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

Waterway (I - 6) DOG RIVER

Road Name (I - 7): Fairground Road

Route Number C3096

Vicinity (I - 9) 0.01 MI TO JCT W VT12A

Topographic Map Roxbury

Hydrologic Unit Code: 02010003

Latitude (I - 16; nnnn.n) 44074

Longitude (i - 17; nnnnn.n) 72400

## Select Federal Inventory Codes

FHWA Structure Number (I - 8) 10121300681213

Maintenance responsibility (I - 21; nn) 03

Maximum span length (I - 48; nnnn) 0043

Year built (I - 27; YYYY) 1960

Structure length (I - 49; nnnnnn) 000045

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

Deck Width (I - 52; nn.n) 169

Year of ADT (I - 30; YY) 92

Channel & Protection (I - 61; n) 5

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

Waterway adequacy (I - 71; n) 6

Operational status (I - 41; X) A

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

Structure type (I - 43; nnn) 302

Year Reconstructed (I - 106) 0000

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

Clear span (nnn.n ft) -

Number of spans (I - 45; nnn) 001

Vertical clearance from streambed (nnn.n ft) -

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

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

Comments:

**According to the structural inspection report dated 8/22/94, the deck is wood planks and wood runners. The abutments and wingwalls are concrete. The RABUT has a large concrete footing, and each abutment has wood plank backwalls. The RABUT has a random fine vertical crack and small leak just right of center, there are also a few minor fine cracks in the LABUT and wingwalls. Some boulder riprap is present around the ends of both right wingwalls. Channel scour is noted as normal. The embankments show signs of past erosion. Minor gravel bars and debris are noted.**

## Bridge Hydrologic Data

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

Terrain character: -

Stream character & type: -

Streambed material: -

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

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

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

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

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

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

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

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

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

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

Water Surface Elevation Estimates for Existing Structure:

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

Long term stream bed changes: -

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

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

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

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

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

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

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

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

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

Comments:

-

## USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **30.74** $mi^2$

Lake/pond/swamp area **0.03** $mi^2$

Watershed storage *(ST)* **0.1** %

Bridge site elevation **750** ft

Headwater elevation **2733** ft

Main channel length **9.21** mi

10% channel length elevation **770** ft

85% channel length elevation **1640** ft

Main channel slope *(S)* **125.95** 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:

-

Reference Point (*MSL, Arbitrary, Other*): -

Datum (*NAD27, NAD83, Other*): -

Foundation Type: - (*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? - *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:

-

Comments:

-

## Cross-sectional Data

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

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

Comments: -

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Station | 866 | 870 | 890 | 910 | 911 | - | - | - | - | - | - |
| Feature | LCL | - | - | - | LCR | - | - | - | - | - | - |
| Low cord elevation | 757.5 | 757.5 | 757.5 | 757.5 | 757.5 | - | - | - | - | - | - |
| Bed elevation | - | 746.1 | 746.4 | 748.0 | - | - | - | - | - | - | - |
| Low cord to bed length | - | 11.4 | 11.1 | 9.5 | - | - | - | - | - | - | - |
| 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: **JD** Date: **06/11/97**
Computerized by: **JD** Date: **06/11/97**
Reviewd by: **RB** Date: **06/16/97**

Structure Number **NORTTH00960068**

## A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. BURNS** Date *(MM/DD/YY)* **07** / **25** / 19**96**

2. Highway District Number **06**
Mile marker **0**
County **WASHINGTON (023)**
Town **NORTHFIELD (50275)**
Waterway *(I - 6)* **DOG RIVER**
Road Name **FAIRGROUND ROAD**
Route Number **C3096**
Hydrologic Unit Code: **02010003**

3. Descriptive comments:
**This structure is located 0.01 mile from the junction with State Route 12A.**

## B. Bridge Deck Observations

4. Surface cover... LBUS **4** RBUS **6** LBDS **4** RBDS **4** Overall **4**
*(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 **45** *(feet)* Span length **43** *(feet)* Bridge width **16.9** *(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)*

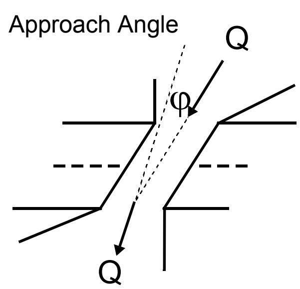
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

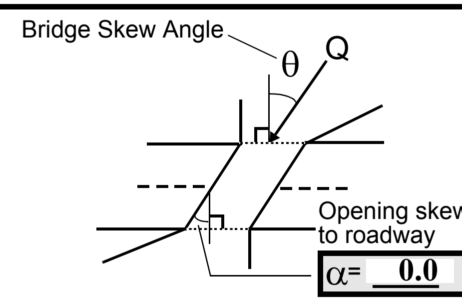
| | Protection | | 13.Erosion | 14.Severity |
|---|---|---|---|---|
| | 11.Type | 12.Cond. | | |
| LBUS | 0 | - | 0 | - |
| RBUS | 2 | 1 | 0 | - |
| RBDS | 2 | 1 | 2 | 1 |
| LBDS | 0 | - | 0 | - |

*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: **0**




17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **1**
Range? **130** feet **US** *(US, UB, DS)* to **100** feet **US**

Channel impact zone 2: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **180** feet **DS** *(US, UB, DS)* to **210** feet **DS**

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

18. Bridge Type: **1a**

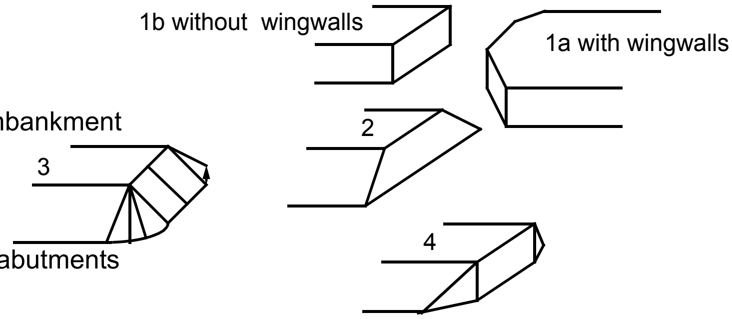
1a- Vertical abutments with wingwalls

1b- Vertical abutments without wingwalls

2- Vertical abutments and wingwalls, sloping embankment
Wingwalls 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. The left banks have trees along the immediate banks and tall grass on the overbanks which changes to lawns, both upstream and downstream. The downstream right bank has tall grass on the streamward side of VT 12A, and a lawn on the bankward side. The upstream right bank has trees along the road embankment and on the bankward side of VT 12A.**
**11. The right bank road embankment protection consists of large concrete blocks at the ends of each wingwall.**
**7. Values are from the VT AOT database. The measured bridge length is forty four and six tenths feet. The measured span length is forty one and four tenths feet. The width is seventeen and one tenth feet.**

## C. Upstream Channel Assessment

| 20. SRD | 21. Bank height (BF) LB | 21. Bank height (BF) RB | 22. Bank angle (BF) LB | 22. Bank angle (BF) RB | 26. % Veg. cover (BF) LB | 26. % Veg. cover (BF) RB | 27. Bank material (BF) LB | 27. Bank material (BF) RB | 28. Bank erosion (BF) LB | 28. Bank erosion (BF) RB |
|---|---|---|---|---|---|---|---|---|---|---|
| **42.5** | **6.5** | | | **9.0** | **2** | **2** | **432** | **432** | **1** | **1** |

23. Bank width **20.0** 24. Channel width **30.0** 25. Thalweg depth **69.5** 29. Bed Material **432**

30 .Bank protection type: LB **1** 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. The right bank protection is concrete fragments that extend from twenty eight to seven feet upstream. The left bank protection is dumped stone which has become vegetated with bushes. It extends from twenty eight feet upstream to eight feet upstream.**
**There is a bedrock outcrop on the upstream right bank from two hundred feet upstream to fifty five feet upstream.**

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

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

37. Material: **-**

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

**NO POINT BARS**

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

41. Mid-bank distance: **35** 42. Cut bank extent: **28** feet **US** (US, UB) to **42** 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.):

**Some roots are exposed on this cut bank. There are two additional cut-banks. The left bank cut bank extends from ninety feet upstream to eighty five feet upstream. The right bank cut bank which is between two bedrock outcrops extends from one hundred and thirty feet upstream to one hundred feet upstream.**

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

47. Scour dimensions: Length **-** Width **-** Depth : **-** Position **-** %LB to **-** %RB

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

**NO CHANNEL SCOUR**

49. Are there major confluences? **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 |
| 38.0 | | 1.0 | | 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.):

**432**

**There is sand along the left abutment that is part of the bank, but at bank-full discharge the abutment would act as a restraint and protrude.**

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 N____ ( 1- Low; 2- Moderate; 3- High)

70. Debris and Ice Comments:

**1**

**-**

| Abutments | 71. Attack ∠(BF) | 72. Slope ∠ (Qmax) | 73. Toe loc. (BF) | 74. Scour Condition | 75. Scour depth | 76. Exposure depth | 77. Material | 78. Length |
|---|---|---|---|---|---|---|---|---|
| LABUT | | - | 90 | 2 | 0 | - | - | 90.0 |
| RABUT | 1 | 0 | 90 | | | 2 | 2 | 41.5 |

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

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

**0**

**2**

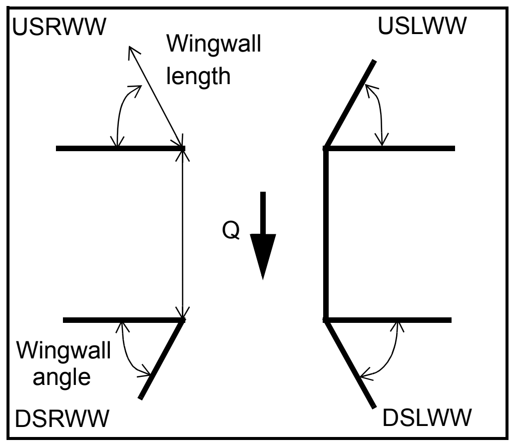
**1**

**The right abutment footing is two feet thick.**

80. Wingwalls:

| | Exist? | Material? | Scour Condition? | Scour depth? | Exposure depth? | 81. Angle? | Length? |
|---|---|---|---|---|---|---|---|
| USLWW: | | | | | | 41.5 | |
| USRWW: | Y | | 1 | | 0 | 1.5 | |
| DSLWW: | - | | - | | Y | 22.5 | |
| DSRWW: | 1 | | 2 | | 0 | 20.0 | |

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




82. Bank / Bridge Protection:

| Location | USLWW | USRWW | LABUT | RABUT | LB | RB | DSLWW | DSRWW |
|---|---|---|---|---|---|---|---|---|
| Type | 1.25 | 0 | Y | 0 | - | 1 | - | - |
| Condition | Y | - | 1 | 1.5 | - | 2 | - | - |
| Extent | 1 | - | 2 | 0 | 2 | 0 | 0 | - |

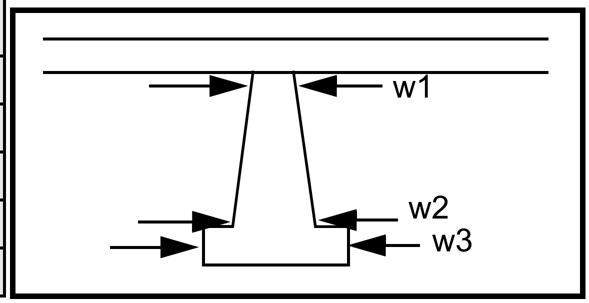
*Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee*
*Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed*
*Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other*

83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
-
-
-
-
-
**0**
-
-
**2**
**1**
**3**

## Piers:

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

| 85. Pier no. | width (w) feet | | | elevation (e) feet | | |
|---|---|---|---|---|---|---|
| | w1 | w2 | w3 | e@w1 | e@w2 | e@w3 |
| Pier 1 | | | | **45.0** | **15.5** | **45.0** |
| Pier 2 | | | | **18.0** | **40.0** | **15.5** |
| Pier 3 | | | - | **60.0** | **14.0** | - |
| Pier 4 | - | - | - | - | - | - |




| Level 1 Pier Descr. | 1 | 2 | 3 | 4 | |
|---|---|---|---|---|---|
| 86. Location (BF) | **e** | **tected** | **the** | **the** | *LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP* |
| 87. Type | **upst** | **with** | **mid-** | **foot-** | ***1**- Solid pier, **2**- column, **3**- bent* |
| 88. Material | **ream** | **con-** | **dle** | **ings.** | ***1**- Wood; **2**- concrete; **3**- metal; **4**- stone* |
| 89. Shape | **and** | **crete** | **of** | **The** | ***1**- Round; **2**- Square; **3**- Pointed* |
| 90. Inclined? | **dow** | **bloc** | **the** | **upst** | *Y- yes; N- no* |
| 91. Attack ∠ (BF) | **nstre** | **ks** | **wing** | **ream** | |
| 92. Pushed | **am** | **and** | **walls** | **and** | *LB or RB* |
| 93. Length (feet) | - | - | - | - | |
| 94. # of piles | **right** | **stone** | **to** | **dow** | |
| 95. Cross-members | **wing** | **that** | **the** | **nstre** | ***0**- none; **1**- laterals; **2**- diagonals; **3**- both* |
| 96. Scour Condition | **walls** | **exte** | **ends,** | **am** | ***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed* |
| 97. Scour depth | **are** | **nd** | **cov-** | **right** | |
| 98. Exposure depth | **pro-** | **from** | **ering** | **wing** | |

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

**walls maximum exposure depths are measured at the wingwall abutment corners.**

**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: 3

Scour dimensions: Length 1 Width 432 Depth: 432 Positioned 1 %LB to 0 %RB

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

**435**
**0**
**2**
-

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

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

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

Confluence comments (eg. confluence name):

**consists of concrete blocks extending from eight to eighty feet downstream. There are some trees leaning into the stream on the left bank. There is some stone fill along the left bank which is covered with sand and vegeta-**

## F. Geomorphic Channel Assessment

107. Stage of reach evolution tio

**1**- Constructed
**2**- Stable
**3**- Aggraded
**4**- Degraded
**5**- Laterally unstable
**6**- Vertically and laterally unstable

108. Evolution comments *(Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors)*:

**n.**

## 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: NFIETH00960068 Town: NORTHFIELD
Road Number: TH 96 County: WASHINGTON
Stream: DOG RIVER

Initials RLB Date: 6/2/96 Checked: SAO

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 | 5950 | 8140 | 3390 |
| Main Channel Area, ft2 | 682 | 731 | 509 |
| Left overbank area, ft2 | 1349 | 1662 | 192 |
| Right overbank area, ft2 | 99 | 144 | 0 |
| Top width main channel, ft | 69 | 69 | 69 |
| Top width L overbank, ft | 438 | 445 | 102 |
| Top width R overbank, ft | 63 | 63 | 0 |
| D50 of channel, ft | 0.157 | 0.157 | 0.157 |
| D50 left overbank, ft | -- | -- | -- |
| D50 right overbank, ft | -- | -- | -- |
| y1, average depth, MC, ft | 9.9 | 10.6 | 7.4 |
| y1, average depth, LOB, ft | 3.1 | 3.7 | 1.9 |
| y1, average depth, ROB, ft | 1.6 | 2.3 | ERR |
| Total conveyance, approach | 194131 | 252056 | 60954 |
| Conveyance, main channel | 81536 | 91578 | 50019 |
| Conveyance, LOB | 106356 | 148993 | 10935 |
| Conveyance, ROB | 6239 | 11486 | 0 |
| Percent discrepancy, conveyance | 0.0000 | -0.0004 | 0.0000 |
| Qm, discharge, MC, cfs | 2499.0 | 2957.5 | 2781.8 |
| Ql, discharge, LOB, cfs | 3259.7 | 4811.6 | 608.2 |
| Qr, discharge, ROB, cfs | 191.2 | 370.9 | 0.0 |
| Vm, mean velocity MC, ft/s | 3.7 | 4.0 | 5.5 |
| Vl, mean velocity, LOB, ft/s | 2.4 | 2.9 | 3.2 |
| Vr, mean velocity, ROB, ft/s | 1.9 | 2.6 | ERR |
| Vc-m, crit. velocity, MC, ft/s | 8.9 | 9.0 | 8.4 |
| 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 | 5950 | 8140 | 3390 |
| (Q) discharge thru bridge, cfs | 3646 | 3710 | 3390 |
| Main channel conveyance | 35987 | 35987 | 39752 |
| Total conveyance | 35987 | 35987 | 39752 |
| Q2, bridge MC discharge,cfs | 3646 | 3710 | 3390 |
| Main channel area, ft2 | 389 | 389 | 325 |
| Main channel width (normal), ft | 41.5 | 41.5 | 41.5 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 41.5 | 41.5 | 41.5 |
| y_bridge (avg. depth at br.), ft | 9.37 | 9.37 | 7.83 |
| Dm, median (1.25*D50), ft | 0.19625 | 0.19625 | 0.19625 |
| y2, depth in contraction,ft | 9.14 | 9.27 | 8.58 |
| ys, scour depth (y2-ybridge), ft | -0.24 | -0.10 | 0.75 |

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 | 5950 | 8140 | 3390 |
| Q, thru bridge MC, cfs | 3646 | 3710 | 3390 |
| Vc, critical velocity, ft/s | 8.86 | 8.96 | 8.44 |
| Va, velocity MC approach, ft/s | 3.66 | 4.05 | 5.47 |
| Main channel width (normal), ft | 41.5 | 41.5 | 41.5 |
| Cum. width of piers in MC, ft | 0.0 | 0.0 | 0.0 |
| W, adjusted width, ft | 41.5 | 41.5 | 41.5 |
| qbr, unit discharge, ft2/s | 87.9 | 89.4 | 81.7 |
| Area of full opening, ft2 | 389.0 | 389.0 | 325.0 |
| Hb, depth of full opening, ft | 9.37 | 9.37 | 7.83 |
| Fr, Froude number, bridge MC | 0.54 | 0.55 | 0 |
| Cf, Fr correction factor (<=1.0) | 1.00 | 1.00 | 0.00 |
| **Area at downstream face, ft2 | N/A | N/A | N/A |
| **Hb, depth at downstream face, ft | N/A | N/A | N/A |
| **Fr, Froude number at DS face | ERR | ERR | ERR |
| **Cf, for downstream face (<=1.0) | N/A | N/A | N/A |
| Elevation of Low Steel, ft | 497.32 | 497.32 | 0 |

| | | | |
|---|---|---|---|
| Elevation of Bed, ft | 487.95 | 487.95 | -7.83 |
| Elevation of Approach, ft | 499.96 | 500.67 | 0 |
| Friction loss, approach, ft | 0.14 | 0.19 | 0 |
| Elevation of WS immediately US, ft | 499.82 | 500.48 | 0.00 |
| ya, depth immediately US, ft | 11.87 | 12.53 | 7.83 |
| Mean elevation of deck, ft | 499.78 | 499.78 | 0 |
| w, depth of overflow, ft (>=0) | 0.04 | 0.70 | 0.00 |
| Cc, vert contrac correction (<=1.0) | 0.94 | 0.94 | 1.00 |
| **Cc, for downstream face (<=1.0) | ERR | ERR | ERR |
| | | | |
| Ys, scour w/Chang equation, ft | 1.15 | 1.21 | N/A |
| Ys, scour w/Umbrell equation, ft | -1.71 | -1.11 | 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 | 3646 | 3710 | 3390 |
| Main channel area (DS), ft2 | 389 | 389 | 325 |
| Main channel width (normal), ft | 41.5 | 41.5 | 41.5 |
| Cum. width of piers, ft | 0.0 | 0.0 | 0.0 |
| Adj. main channel width, ft | 41.5 | 41.5 | 41.5 |
| D90, ft | 0.3823 | 0.3823 | 0.3823 |
| D95, ft | 0.5563 | 0.5563 | 0.5563 |
| Dc, critical grain size, ft | 0.2727 | 0.2823 | 0.3600 |
| Pc, Decimal percent coarser than Dc | 0.191 | 0.176 | 0.113 |
| | | | |
| Depth to armoring, ft | 3.46 | 3.97 | 8.48 |

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 | 5950 | 8140 | 3390 | 5950 | 8140 | 3390 |
| a', abut.length blocking flow, ft | 450 | 457.2 | 114 | 78.1 | 78.8 | 16.3 |
| Ae, area of blocked flow ft2 | 1026 | 1119.4 | 243.5 | 179.9 | 189.2 | 76.9 |
| Qe, discharge blocked abut.,cfs | -- | -- | 785.3 | -- | -- | 300.9 |
| (If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually) | | | | | | |
| Ve, (Qe/Ae), ft/s | 2.43 | 2.91 | 3.23 | 2.47 | 2.89 | 3.91 |
| ya, depth of f/p flow, ft | 2.28 | 2.45 | 2.14 | 2.30 | 2.40 | 4.72 |
| | | | | | | |
| --Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru) | | | | | | |
| K1 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 | 0.82 |

--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)

| | | | | | | |
|---|---|---|---|---|---|---|
| theta | 90 | 90 | 90 | 90 | 90 | 90 |
| K2 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Fr, froude number f/p flow | 0.240 | 0.261 | 0.389 | 0.262 | 0.274 | 0.317 |
| ys, scour depth, ft | 19.53 | 21.48 | 14.49 | 10.92 | 11.50 | 12.15 |

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) | 450 | 457.2 | 114 | 78.1 | 78.8 | 16.3 |
| y1 (depth f/p flow, ft) | 2.28 | 2.45 | 2.14 | 2.30 | 2.40 | 4.72 |
| a'/y1 | 197.37 | 186.74 | 53.37 | 33.91 | 32.82 | 3.46 |
| Skew correction (p. 49, fig. 16) | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Froude no. f/p flow | 0.24 | 0.26 | 0.39 | 0.26 | 0.27 | 0.32 |
| Ys w/ corr. factor K1/0.55: | | | | | | |
| vertical | 10.35 | 11.43 | 11.37 | 10.77 | 11.39 | ERR |
| vertical w/ ww's | 8.49 | 9.37 | 9.33 | 8.83 | 9.34 | ERR |
| spill-through | 5.69 | 6.29 | 6.26 | 5.92 | 6.26 | 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 | 0.54 | 0.55 | 0.66 | 0.54 | 0.55 | 0.66 |
| y, depth of flow in bridge, ft | 9.37 | 9.37 | 7.83 | 9.37 | 9.37 | 7.83 |
| Median Stone Diameter for riprap at: | left abutment | | | right abutment, ft | | |
| Fr<=0.8 (vertical abut.) | 1.69 | 1.75 | 2.11 | 1.69 | 1.75 | 2.11 |
| Fr>0.8 (vertical abut.) | ERR | ERR | ERR | ERR | ERR | ERR |