LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (ATHETH00090008) on TOWN HIGHWAY 9, crossing BULL CREEK, ATHENS, VERMONT

U.S. Geological Survey
Open-File Report 97-818

Prepared in cooperation with
VERMONT AGENCY OF TRANSPORTATION
and

U.S. Department of the Interior
U.S. Geological Survey

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LEVEL II SCOUR ANALYSIS FOR BRIDGE 8 (ATHETH00090008) on TOWN HIGHWAY 9, crossing BULL CREEK, ATHENS, VERMONT

By ERICK M. BOEHMLER AND RONDA L. BURNS

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U.S. DEPARTMENT OF THE INTERIOR
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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 8 (ATHETH00090008) ON TOWN HIGHWAY 9, CROSSING BULL CREEK, ATHENS, VERMONT

By **Erick M. Boehmler and Ronda L. Burns**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ATHETH00090008 on Town Highway 9 crossing Bull Creek in Athens, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in Appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in Appendix D.

The site is in the New England Upland section of the New England physiographic province in southeastern Vermont. The 9.04-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the left overbank surface cover is shrub and brushland and the right overbank surface cover is pasture.

In the study area, Bull Creek has an sinuous 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 predominant channel bed materials are cobbles and gravel with a median grain size (D_{50}) of 72.1 mm (0.236 ft). The geomorphic assessment at the time of the Level I and Level II site visit on August 14, 1996, indicated that the reach was laterally unstable. There are several point bars and cut banks along the reach in the vicinity of this site.

The Town Highway 9 crossing of Bull Creek is a 32-ft-long, one-lane bridge consisting of one 28-foot steel-beam span (Vermont Agency of Transportation, written communication, April 5, 1995). The bridge is supported by vertical, “laid-up” stone abutments with concrete caps and no wingwalls. The channel is skewed approximately 15 degrees to the opening. The VTAOT bridge records indicate the opening-skew-to-roadway is 9 degrees while that computed from surveyed points is 5 degrees.

A scour hole 1.75 feet deeper than the mean thalweg depth was observed under the bridge during the Level I assessment. The scour hole has lowered the streambed along the entire length of the left abutment and the upstream end of the right abutment. The scour depth at each abutment wall is 0.75 feet deeper than the mean thalweg depth elsewhere in the reach. The only scour protection measure at the site was type-2 stone fill (less than 36 inches diameter) on the upstream banks and downstream left bank. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and 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 1.4 feet. The worst-case contraction scour occurred at the incipient-overtopping discharge of 1730 cubic feet per second, which was less than the 100-year discharge. Abutment scour ranged from 7.6 to 11.4 feet. 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.

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 ATHETH00090008 ***Stream*** Bull Creek

County Windham ***Road*** TH 9 ***District*** 2

Description of Bridge

Bridge length 32 ***ft*** ***Bridge width*** 16.2 ***ft*** ***Max span length*** 28 ***ft***

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

Abutment type Vertical, Stone ***Embankment type*** Sloping near vertical

Stone fill on abutment? No ***Date of inspection*** 8/14/96

Description of stone fill Type-2 on both banks upstream and the left bank downstream.

Brief description of piers/abutments Abutments are non-mortared stone slab walls with concrete caps. There is a 0.75 to 1.75 foot deep scour hole under the bridge.

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

There is a moderate bend in the reach through the bridge. There also is an abrupt shift in the channel to the left between 30 and 15 feet upstream of the bridge.

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

	Date of inspection	*Percent of channel blocked horizontally*	*Percent of channel blocked vertically*
Level I	8/14/96	0	0
Level II	8/14/96	0	0

Potential for debris Moderate. There are some trees and other vegetation on both banks upstream and the channel is laterally unstable.

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

As noted on 8/14/96, the roadway embankment to the right abutment blocks the right half of the upstream channel and redirects flow to the left up to bank full stage.

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with an irregular flood plain and moderately sloping valley walls on both sides.

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

Date of inspection 8/14/96

DS left: Moderately sloping channel bank and valley wall.

DS right: Mildly sloping channel bank and a narrow, irregular flood plain.

US left: Mildly sloping channel bank and a narrow overbank.

US right: Steep channel bank and a wide, irregular flood plain.

Description of the Channel

Average top width 41 ***ft*** ***Average depth*** 4 ***ft***

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

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

8/14/96

Vegetative co

Shrubs, trees, and brush.

DS left: Shrubs and brush.

DS right: Shrubs, brush, and a few trees.

US left: Trees and grass.

US right:

Do banks appear stable? No ***If not, describe location and type of instability and date of observation.***

On 8/14/96, the assessment described several point bars and cut-banks in the channel near the site.

Describe any obstructions in channel and date of observation.

The assessment of 8/14/96 noted a protruding roadway embankment to the right abutment and a moderate bend left in the channel immediately upstream of the bridge. This roadway embankment severely blocks and redirects flow to the left below bank full stages.

Hydrology

Drainage area 9.04 ***mi²***

Percentage of drainage area in physiographic provinces: (approximate)

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

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: --

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

USGS gage description --

USGS gage number --

Gage drainage area -- ***mi²***

Is there a lake/p No

-

Calculated Discharges

Q100 2,160 ***ft³/s*** ***Q500*** 3,000 ***ft³/s***

The 100- and 500-year discharges were based on a flood frequency curve computed by use of the Federal Highway Administration (FHWA, 1983) empirical equation. The Federal Highway Administration curve was within a range of empirical flood frequency curves computed by use of other empirical methods and extrapolated to the 500-year discharge (Benson, 1962; Johnson and Laraway, unpublished draft, 1972; Johnson and Tasker, 1974; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans None

Description of reference marks used to determine USGS datum. RM1 is a chiseled "X" in the concrete cap of the right abutment at the upstream end (elev. 501.14 feet, arbitrary survey datum). RM2 is a chiseled "X" in the concrete cap of the left abutment at the downstream end (elev. 501.63 feet, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

[1]*Cross-section*	*Section Reference Distance (SRD) in feet*	[2]*Cross-section development*	*Comments*
EXITX	-28	1	Exit section
FULLV	0	5	Downstream Full-valley section (Bridge channel points and exit overbank points)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	41	2	Modelled Approach section (Templated from APTEM)
APTEM	53	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 0.045, and overbank "n" values ranged from 0.050 to 0.070.

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 0.0096 ft/ft, which was estimated from the topographic map (U.S. Geological Survey, 1984).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0325 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.

For the incipient-overtopping discharge, WSPRO assumes critical depth at the bridge section. A supercritical model was developed for this discharge. After analyzing both the supercritical and subcritical profiles, it was determined that the water surface profile passes through critical depth within the bridge opening. Thus, the assumption of critical depth at the bridge is a satisfactory solution.

Bridge Hydraulics Summary

Average bridge embankment elevation 501.4 ***ft***
Average low steel elevation 498.9 ***ft***

100-year discharge 2,160 ***ft^3/s***
Water-surface elevation in bridge opening 498.0 ***ft***
Road overtopping? Yes ***Discharge over road*** 1360 ***ft^3/s***
Area of flow in bridge opening 153 ***ft^2***
Average velocity in bridge opening 5.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 6.7 ***ft/s***

Water-surface elevation at Approach section with bridge 499.1
Water-surface elevation at Approach section without bridge 497.6
Amount of backwater caused by bridge 1.5 ***ft***

500-year discharge 3,000 ***ft^3/s***
Water-surface elevation in bridge opening 498.3 ***ft***
Road overtopping? Yes ***Discharge over road*** 2130 ***ft^3/s***
Area of flow in bridge opening 160 ***ft^2***
Average velocity in bridge opening 5.4 ***ft/s***
Maximum WSPRO tube velocity at bridge 7.0 ***ft/s***

Water-surface elevation at Approach section with bridge 499.5
Water-surface elevation at Approach section without bridge 497.9
Amount of backwater caused by bridge 1.6 ***ft***

Incipient overtopping discharge 1,730 ***ft^3/s***
Water-surface elevation in bridge opening 497.1 ***ft***
Area of flow in bridge opening 131 ***ft^2***
Average velocity in bridge opening 13.2 ***ft/s***
Maximum WSPRO tube velocity at bridge 16.6 ***ft/s***

Water-surface elevation at Approach section with bridge 501.0
Water-surface elevation at Approach section without bridge 497.3
Amount of backwater caused by bridge 3.7 ***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.

All of the modeled discharges resulted in free-surface flow through the bridge. Contraction scour for each discharge modeled was computed by use of the Laursen clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20).

Abutment scour for the left 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 right 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	0.0	0.0	1.4
Depth to armoring	0.0	0.0	N/A
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:	100-yr discharge	500-yr discharge	Incipient overtopping discharge
Abutment scour			
Left abutment	9.9	11.4	9.8
Right abutment	7.6	8.3	10.8
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	1.0	1.1	2.3
Right abutment	1.0	1.1	2.3
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

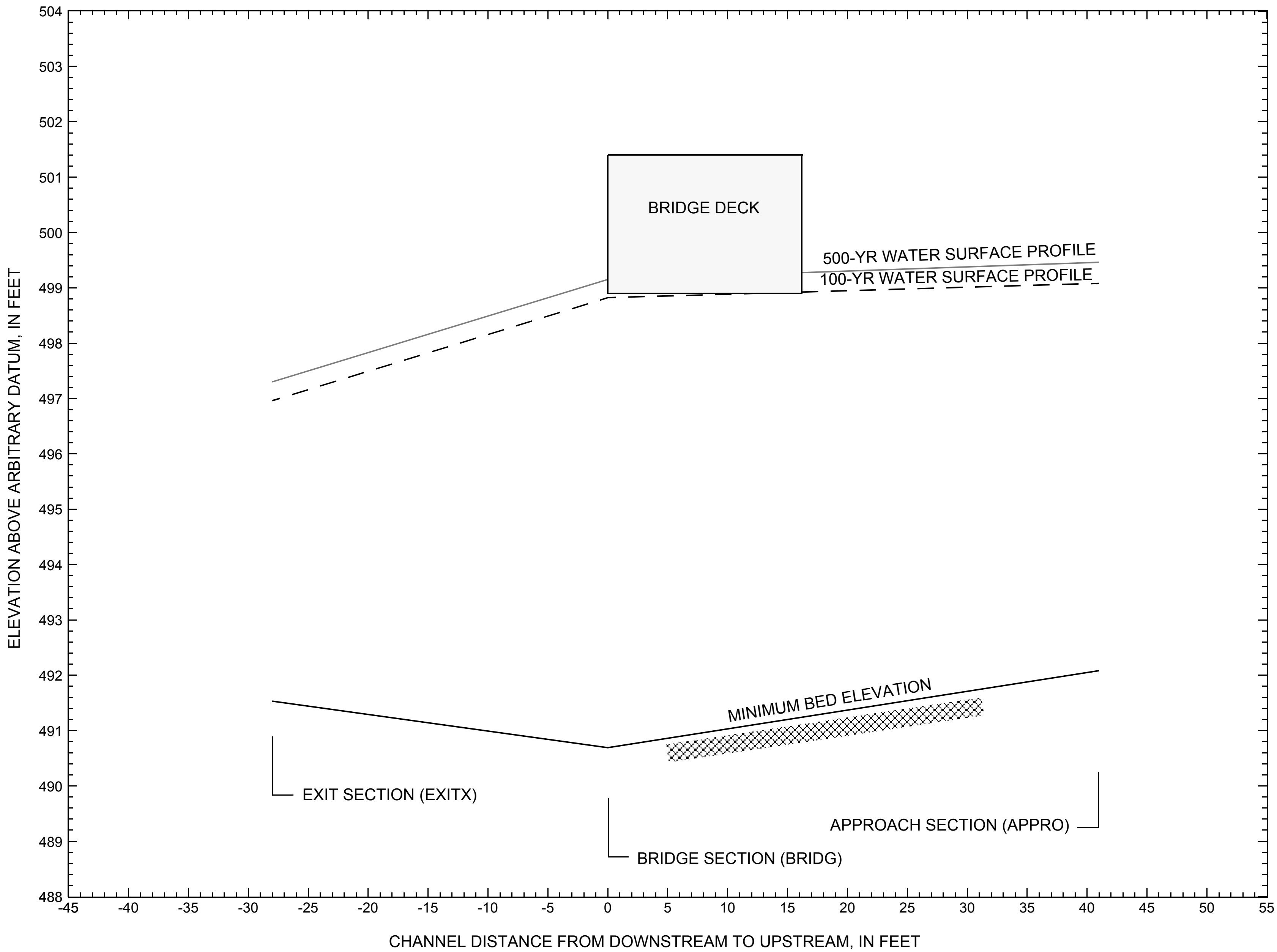

Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ATHETH00090008 on Town Highway 9, crossing Bull Creek, Athens, Vermont.

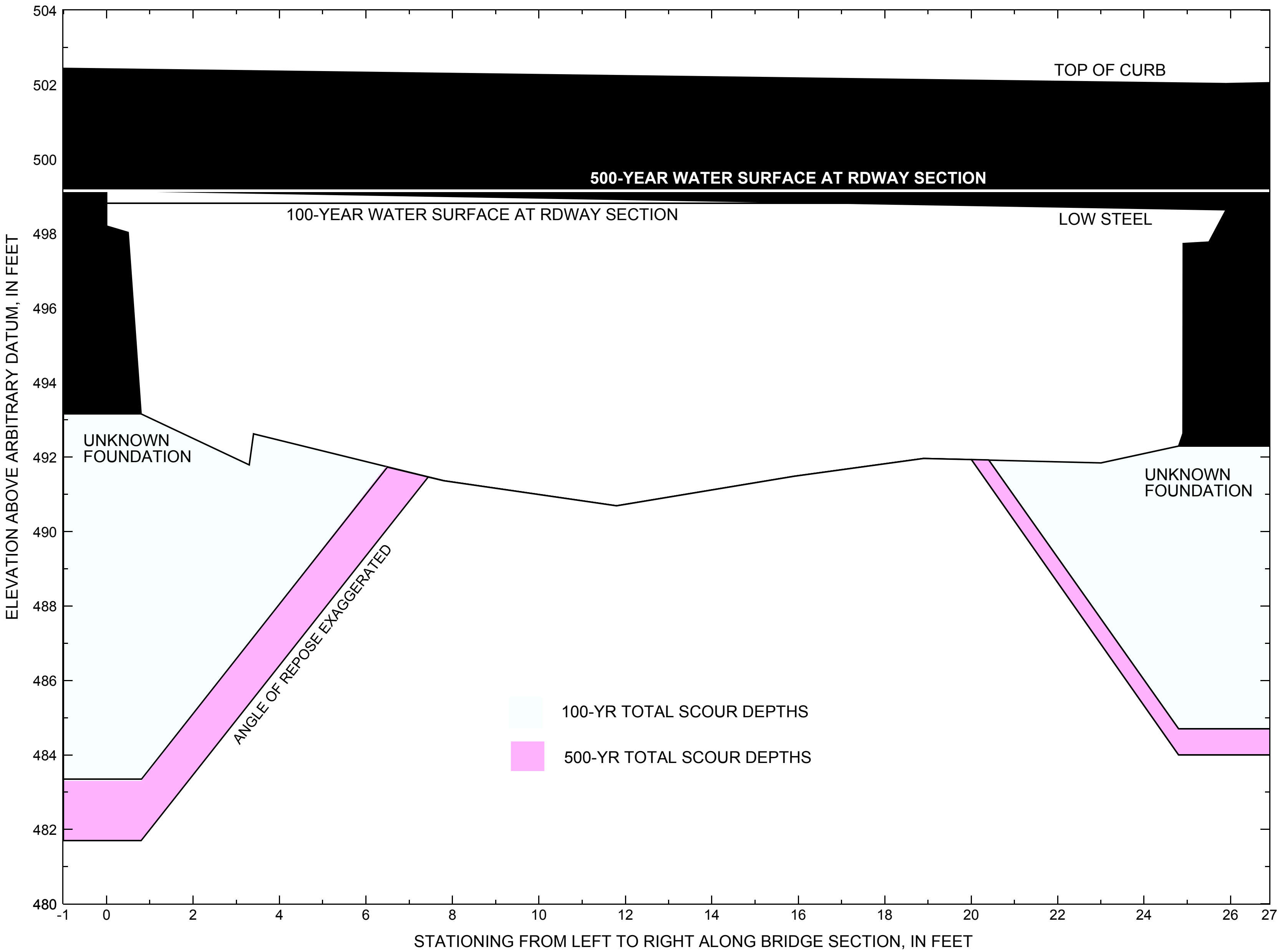

Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ATHETH00090008 on Town Highway 9, crossing Bull Creek, Athens, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ATHETH00090008 on Town Highway 9, crossing Bull Creek, Athens, 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 2,160 cubic-feet per second											
Left abutment	0.0	--	499.2	--	493.2	0.0	9.9	--	9.9	483.3	--
Right abutment	25.9	--	498.6	--	492.3	0.0	7.6	--	7.6	484.7	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure ATHETH00090008 on Town Highway 9, crossing Bull Creek, Athens, 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 3,000 cubic-feet per second											
Left abutment	0.0	--	499.2	--	493.2	0.0	11.4	--	11.4	481.8	--
Right abutment	25.9	--	498.6	--	492.3	0.0	8.3	--	8.3	484.0	--

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

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U.S. Geological Survey, 1984, Townshend, Vermont 7.5 by 15 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Aerial photographs, 1977; Contour interval, 6 meters; Scale 1:25,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File athe008.wsp
T2        Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
T3        Town Highway 9 Bridge Crossing Bull Creek, Athens, VT             EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q           2160.0   3000.0   1730.0
SK          0.0096   0.0096   0.0096
*
XS   EXITX    -28
GR         -136.8, 509.36   -108.5, 504.19    -31.6, 500.19     -8.7, 498.50
GR           -2.1, 495.76      0.0, 492.81     10.7, 492.60     13.7, 491.79
GR           15.1, 491.79     19.8, 491.75     21.3, 491.53     23.7, 492.61
GR           27.0, 494.66     33.6, 495.94     54.7, 496.27     66.6, 494.57
GR           91.2, 496.94    366.9, 495.22    385.2, 496.67    392.0, 494.63
GR          405.1, 494.51    422.5, 496.61    681.1, 502.20    813.9, 507.49
*
N           0.065        0.045        0.050
SA                  -8.7         33.6
*
XS   FULLV      0
GR         -136.8, 509.36   -108.5, 504.19    -31.6, 500.19     -8.7, 498.50
GR           -2.1, 495.76      0.0, 492.81      3.3, 491.79      3.4, 492.62
GR            7.8, 491.36     11.8, 490.69     15.9, 491.48     18.9, 491.96
GR           23.0, 491.84     24.9, 492.29     27.0, 494.66     33.6, 495.94
GR           54.7, 496.27     66.6, 494.57     91.2, 496.94    366.9, 495.22
GR          385.2, 496.67    392.0, 494.63    405.1, 494.51    422.5, 496.61
GR          681.1, 502.20    813.9, 507.49
*
N           0.070        0.045        0.050
SA                  -8.7         33.6
*
*             SRD     LSEL    XSSKEW
BR   BRIDG      0    498.90       5.0
GR            0.0, 499.16      0.0, 498.20      0.5, 498.03      0.8, 493.16
GR            3.3, 492.62      3.4, 491.79      7.8, 491.36     11.8, 490.69
GR           15.9, 491.48     18.9, 491.96     23.0, 491.84     24.8, 492.29
GR           24.9, 492.64     24.9, 497.73     25.5, 497.77     25.9, 498.64
GR            0.0, 499.16
*
*         BRTYPE  BRWDTH
CD            1      15.4
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      16.2      2
GR         -115.1, 508.78    -83.6, 503.02    -43.9, 502.04     -3.5, 501.60
GR           -3.4, 502.49      0.0, 502.42     24.9, 502.03     28.2, 501.98
GR           28.4, 501.13     71.1, 497.87     97.0, 497.45    108.3, 498.18
GR          254.9, 497.60    365.5, 497.86    627.3, 502.82    681.3, 504.79
GR          760.8, 508.89
*
*           EXPECTED SRD =   41 AT ONE BR. LENGTH BUT COMPUTED SRD =   57
*
XT   APTEM     53
GR          -91.8, 508.51    -88.7, 506.88    -87.6, 503.03    -79.9, 499.31
GR          -47.7, 497.00    -11.1, 495.45      0.0, 493.90      2.6, 493.42
```

```
GR          11.0, 493.49     16.0, 494.06     21.1, 493.20     23.3, 492.47
GR          25.7, 493.33     29.0, 497.45     54.7, 496.27     91.2, 496.94
GR         366.9, 495.22    385.2, 496.67    422.5, 496.61    681.1, 502.20
GR         813.9, 507.49
*




*          Note: right of sta. 29 on approach was replaced using exit right
*                overbank points right of sta. 33.6 leaving out points in
*                minor channels and gullies on right overbank of exit section.
*           61.4, 497.23    219.7, 497.46
*          359.4, 497.79    637.3, 502.60    747.7, 509.08
*
AS   APPRO     41  * * *  0.0325
GT
N          0.060        0.040        0.050
SA                 -11.1         29.0
*
HP 1 BRIDG 497.98 1 497.98
HP 2 BRIDG 497.98 * * 803
HP 2 RDWAY 498.82 * * 1357
HP 1 APPRO 499.08 1 499.08
HP 2 APPRO 499.08 * * 2160
*
HP 1 BRIDG 498.28 1 498.28
HP 2 BRIDG 498.28 * * 872
HP 2 RDWAY 499.15 * * 2128
HP 1 APPRO 499.46 1 499.46
HP 2 APPRO 499.46 * * 3000
*
HP 1 BRIDG 497.09 1 497.09
HP 2 BRIDG 497.09 * * 1730
HP 1 APPRO 501.02 1 501.02
HP 2 APPRO 501.02 * * 1730
*
EX
ER
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
       U.S. Geological Survey WSPRO Input File athe008.wsp
       Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
       Town Highway 9 Bridge Crossing Bull Creek, Athens, VT            EMB
          *** RUN DATE & TIME: 03-12-97  11:41

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

    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      153     14897    25     36                          2143
  497.98           153     14897    25     36  1.00      1     26      2143

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

        WSEL     LEW     REW    AREA       K        Q    VEL
      497.98     0.5    25.6   152.8  14897.     803.   5.26

X STA.         0.5        3.5        4.9        6.1        7.1        8.2
  A(I)            14.7        8.4        7.7        6.9        6.7
  V(I)            2.73       4.78       5.23       5.80       5.98

X STA.         8.2        9.1       10.0       10.9       11.7       12.6
  A(I)             6.5        6.3        6.0        6.0        6.1
  V(I)            6.16       6.35       6.69       6.64       6.63

X STA.        12.6       13.4       14.4       15.3       16.3       17.3
  A(I)             6.0        6.3        6.2        6.4        6.8
  V(I)            6.64       6.39       6.46       6.31       5.88

X STA.        17.3       18.4       19.7       20.9       22.4       25.6
  A(I)             6.8        7.3        7.7        8.9       15.0
  V(I)            5.93       5.48       5.22       4.54       2.68

   VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

        WSEL     LEW     REW    AREA       K        Q    VEL
      498.82    58.7   416.2   328.5   9252.    1357.   4.13

X STA.        58.7       83.3       94.9      110.7      138.8      161.5
  A(I)            18.7       14.4       15.7       19.8       18.3
  V(I)            3.62       4.72       4.31       3.42       3.70

X STA.       161.5      180.3      197.3      212.4      226.2      239.2
  A(I)            16.7       16.3       15.4       14.9       14.7
  V(I)            4.06       4.16       4.42       4.55       4.62

X STA.       239.2      251.3      263.0      275.1      287.8      300.8
  A(I)            14.3       14.2       14.3       14.7       14.7
  V(I)            4.74       4.77       4.74       4.60       4.63

X STA.       300.8      315.0      329.9      346.2      364.3      416.2
  A(I)            15.6       15.8       16.7       17.8       25.5
  V(I)            4.35       4.29       4.06       3.81       2.66

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

    WSEL  SA#     AREA         K  TOPW   WETP  ALPH    LEW    REW      QCR
            1      161      7024    69     69                          1396
            2      221     24659    40     43                          2943
            3     1466     86481   526    526                         13884
  499.08          1848    118165   635    638  1.29    -79    555     15769

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

        WSEL     LEW     REW    AREA       K        Q    VEL
      499.08   -80.2   554.8  1847.6  118165.   2160.   1.17

X STA.       -80.2      -16.2       -1.3        7.1       15.6       23.6
  A(I)           141.2       66.1       49.1       49.9       48.4
  V(I)            0.77       1.63       2.20       2.16       2.23

X STA.        23.6       54.7       88.1      128.3      162.1      192.9
  A(I)            94.4       96.9      105.9       97.1       94.6
  V(I)            1.14       1.11       1.02       1.11       1.14

X STA.       192.9      220.9      247.1      271.7      294.8      317.1
  A(I)            90.8       89.8       88.1       86.1       86.4
  V(I)            1.19       1.20       1.23       1.25       1.25

X STA.       317.1      339.5      361.2      388.7      430.4      554.8
  A(I)            89.5       89.9       98.6      117.8      167.2
  V(I)            1.21       1.20       1.10       0.92       0.65
```

```
     U.S. Geological Survey WSPRO Input File athe008.wsp
     Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
     Town Highway 9 Bridge Crossing Bull Creek, Athens, VT             EMB
        *** RUN DATE & TIME: 03-12-97  11:41

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      160     15865     26     37                           2276
498.28           160     15865     26     37  1.00      0     26     2276

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    498.28     0.0    25.7   160.4   15865.     872.   5.44

X STA.        0.0        3.5        4.9        6.1        7.2        8.2
  A(I)            15.6        9.4        7.8        7.5        7.0
  V(I)            2.79       4.66       5.56       5.85       6.20

X STA.        8.2        9.2       10.1       11.0       11.8       12.7
  A(I)             6.8        6.4        6.5        6.3        6.3
  V(I)            6.40       6.80       6.73       6.92       6.93

X STA.       12.7       13.5       14.4       15.3       16.4       17.4
  A(I)             6.3        6.5        6.4        6.9        6.9
  V(I)            6.96       6.70       6.76       6.34       6.35

X STA.       17.4       18.5       19.7       21.0       22.5       25.7
  A(I)             7.1        7.7        8.3        9.3       15.5
  V(I)            6.18       5.70       5.27       4.69       2.81

 VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.

      WSEL     LEW     REW    AREA        K        Q    VEL
    499.15    54.3   433.6   450.1   15032.    2128.   4.73

X STA.       54.3       82.5       95.1      111.7      136.1      156.6
  A(I)            26.3       19.8       21.6       25.2       22.9
  V(I)            4.04       5.37       4.93       4.22       4.65

X STA.      156.6      175.4      192.6      208.1      222.9      236.7
  A(I)            22.5       21.9       20.7       20.6       20.1
  V(I)            4.73       4.86       5.14       5.17       5.29

X STA.      236.7      249.9      262.6      275.7      289.5      303.6
  A(I)            19.8       19.6       19.9       20.5       20.5
  V(I)            5.38       5.42       5.36       5.19       5.19

X STA.      303.6      318.7      334.3      351.3      371.3      433.6
  A(I)            21.3       21.6       22.8       25.7       36.7
  V(I)            4.99       4.93       4.66       4.14       2.90

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1      188      8972     70     70                           1743
          2      236     27558     40     43                           3253
          3     1669    105042    543    544                          16593
499.46          2092    141572    653    656  1.25    -80    572    18983

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

      WSEL     LEW     REW    AREA        K        Q    VEL
    499.46   -81.0   572.4  2092.4  141572.    3000.   1.43

X STA.      -81.0      -18.6       -1.7        7.5       16.6       25.0
  A(I)           155.9       79.2       57.4       56.4       55.3
  V(I)            0.96       1.89       2.61       2.66       2.71

X STA.       25.0       59.4       94.3      131.1      164.9      194.6
  A(I)           113.1      110.7      112.2      110.1      103.1
  V(I)            1.33       1.35       1.34       1.36       1.46

X STA.      194.6      222.6      248.8      273.5      297.6      320.2
  A(I)           101.8      100.1       97.8       99.5       96.3
  V(I)            1.47       1.50       1.53       1.51       1.56

X STA.      320.2      342.7      365.4      397.5      439.6      572.4
  A(I)            99.5      103.2      117.6      132.7      190.6
  V(I)            1.51       1.45       1.28       1.13       0.79
```

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        U.S. Geological Survey WSPRO Input File athe008.wsp
        Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
        Town Highway 9 Bridge Crossing Bull Creek, Athens, VT             EMB
           *** RUN DATE & TIME: 03-12-97  11:41

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

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      131     12064     24     34                          1728
   497.09            131     12064     24     34  1.00      1     25     1728

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

          WSEL     LEW     REW    AREA        K        Q    VEL
        497.09     0.6    24.9   131.0   12064.    1730.  13.21

X STA.        0.6        3.6        4.9        6.1        7.2        8.2
  A(I)           12.4        7.2        6.6        6.1        5.8
  V(I)           6.98      11.97      13.05      14.10      14.89

X STA.        8.2        9.2       10.1       11.0       11.8       12.7
  A(I)            5.7        5.5        5.4        5.2        5.2
  V(I)          15.30      15.71      16.13      16.52      16.57

X STA.       12.7       13.5       14.4       15.4       16.4       17.4
  A(I)            5.3        5.4        5.5        5.5        5.8
  V(I)          16.46      15.90      15.59      15.65      14.96

X STA.       17.4       18.6       19.8       21.1       22.5       24.9
  A(I)            5.9        6.3        6.6        7.4       12.0
  V(I)          14.54      13.74      13.07      11.69       7.19

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

      WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
              1      299     18896     73     74                          3433
              2      299     40768     40     43                          4627
              3     2573    198887    616    616                         29845
   501.02           3171    258551    729    732  1.18    -83    645    34592

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      41.

          WSEL     LEW     REW    AREA        K        Q    VEL
        501.02   -84.2   644.6  3170.5  258551.    1730.   0.55

X STA.      -84.2      -24.9       -2.7        8.6       20.3       43.8
  A(I)          221.1      133.3       87.1       90.7      129.2
  V(I)           0.39       0.65       0.99       0.95       0.67

X STA.       43.8       74.2      108.8      141.8      173.1      202.6
  A(I)          150.0      158.3      154.4      153.1      149.4
  V(I)           0.58       0.55       0.56       0.56       0.58

X STA.      202.6      230.6      257.8      283.8      309.3      334.5
  A(I)          147.3      147.5      145.5      146.2      149.2
  V(I)           0.59       0.59       0.59       0.59       0.58

X STA.      334.5      359.7      388.8      426.3      475.4      644.6
  A(I)          152.6      161.5      179.3      205.2      309.4
  V(I)           0.57       0.54       0.48       0.42       0.28
```

```
       U.S. Geological Survey WSPRO Input File athe008.wsp
       Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
       Town Highway 9 Bridge Crossing Bull Creek, Athens, VT             EMB
          *** RUN DATE & TIME: 03-12-97  11:41

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

EXITX:XS   ******     -4      535  0.46 *****  497.42  496.89    2160  496.96
       -27 ******    439    22042  1.83 ***** *******    0.88    4.04

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                         "FULLV"     KRATIO =  1.58

FULLV:FV       28     -5      742  0.21  0.17  497.59 *******    2160  497.38
         0     28    458    34931  1.62  0.00    0.00    0.52    2.91
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       41    -60      957  0.12  0.12  497.70 *******    2160  497.57
        41     41    485    46181  1.57  0.00   -0.01    0.38    2.26
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   502.44       0.00     498.02     497.45

 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.

 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                   FLOW,Q =    4        84.
             WS1,WSSD,WS3 =   498.35       0.00     498.02

 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                   ITER,QRD =    4      2076.
             WS,WSMIN,WSMAX =   499.45     498.78     500.12

            <<<<<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       28      1      153  0.83  0.58  498.81  494.92     803  497.98
         0     28     26    14890  1.93  0.81    0.01    0.52    5.26

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.719 ******  498.90 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    25.  0.01  0.03  499.09    0.00   1357.  498.82

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     0.    27.   -31.    -3.   0.3   0.1   4.3  20.1   1.0   2.8
   RT:  1357.   358.    59.   416.   1.4   0.9   4.8   4.1   1.2   2.9

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

APPRO:AS       26    -79     1850  0.03  0.25  499.11  496.83    2160  499.08
        41     65    555   118361  1.29  0.04    0.02    0.14    1.17

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.955  0.959    4797.   164.   189. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -28.    -5.   439.   2160.   22042.     535.    4.04  496.96
   FULLV:FV      0.    -6.   458.   2160.   34931.     742.    2.91  497.38
   BRIDG:BR      0.     1.    26.    803.   14890.     153.    5.26  497.98
   RDWAY:RG      8.*******     0.   1357.        0.*********    2.00  498.82
   APPRO:AS     41.   -80.   555.   2160.  118361.    1850.    1.17  499.08

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     164.   189.    4797.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD     EGL    WSEL
   EXITX:XS    496.89    0.88  491.53  509.36************  0.46  497.42  496.96
   FULLV:FV  ********    0.52  490.69  509.36  0.17  0.00  0.21  497.59  497.38
   BRIDG:BR    494.92    0.52  490.69  499.16  0.58  0.81  0.83  498.81  497.98
   RDWAY:RG  ***************  497.45  508.89  0.01******  0.03  499.09  498.82
   APPRO:AS    496.83    0.14  492.08  508.12  0.25  0.04  0.03  499.11  499.08
```

WSPRO OUTPUT FILE (continued)

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

EXITX:XS   ******     -5      687  0.47 *****  497.77  497.21    3000  497.30
       -27 ******    454    30613  1.58 ***** *******    0.79    4.37

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

FULLV:FV       28     -6      888  0.26  0.19  497.95 *******    3000  497.69
         0     28    472    44486  1.47  0.00    0.00    0.53    3.38
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       41    -65     1152  0.15  0.14  498.08 *******    3000  497.92
        41     41    501    60020  1.46  0.00   -0.01    0.39    2.60
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
          WS1,WSSD,WS3,RGMIN =   504.98       0.00     498.78     497.45
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                   FLOW,Q =    4       145.
             WS1,WSSD,WS3 =   498.71       0.00     498.34
 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                   ITER,QRD =    5      2855.
             WS,WSMIN,WSMAX =   499.78     499.45     500.12
 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
          WS3,WSIU,WS1,LSEL =   498.29     499.19     499.47     498.90
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                      YU/Z,WSIU,WS = 1.07     499.35     499.48
 ===270 REJECTED FLOW CLASS 2 (5) SOLUTION.
 ===265 ROAD OVERFLOW APPEARS EXCESSIVE.
                  QRD,QRDMAX,RATIO =    2128.      2117.    1.00

            <<<<<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       28      0      160  0.89  0.56  499.17  495.10     872  498.28
         0     28     26    15871  1.94  0.85    0.00    0.53    5.44

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   4.  0.718 ******  498.90 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    25.  0.01  0.04  499.49    0.00   2128.  499.15

           Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:      0.    75.   -63.    13.   0.9   0.5   5.4  11.5   1.5   2.9
   RT:   2128.   379.    54.   434.   1.7   1.2   5.5   4.7   1.5   3.0

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

APPRO:AS       26    -80     2092  0.04  0.28  499.50  497.08    3000  499.46
        41     65    572   141527  1.25  0.05   -0.01    0.16    1.43

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.957  0.957    6163.   170.   196. ********

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -28.    -6.   454.   3000.   30613.     687.    4.37  497.30
   FULLV:FV       0.    -7.   472.   3000.   44486.     888.    3.38  497.69
   BRIDG:BR       0.     0.    26.    872.   15871.     160.    5.44  498.28
   RDWAY:RG       8.*******     0.   2128.       0.*********    2.00  499.15
   APPRO:AS      41.   -81.   572.   3000.  141527.    2092.    1.43  499.46

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     170.   196.    6163.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    497.21    0.79  491.53  509.36************  0.47  497.77  497.30
   FULLV:FV  ********    0.53  490.69  509.36  0.19  0.00  0.26  497.95  497.69
   BRIDG:BR    495.10    0.53  490.69  499.16  0.56  0.85  0.89  499.17  498.28
   RDWAY:RG  ***************  497.45  508.89  0.01******  0.04  499.49  499.15
   APPRO:AS    497.08    0.16  492.08  508.12  0.28  0.05  0.04  499.50  499.46
```

```
        U.S. Geological Survey WSPRO Input File athe008.wsp
        Hydraulic analysis for structure ATHETH00090008   Date: 12-MAR-97
        Town Highway 9 Bridge Crossing Bull Creek, Athens, VT             EMB
           *** RUN DATE & TIME: 03-12-97  11:41

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

EXITX:XS   ******     -3      436  0.47 *****  497.19  496.68    1730  496.72
      -27 ******    428    17642  1.92 ***** *******    0.92    3.97

 ===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS.
                             "FULLV"     KRATIO =  1.60

FULLV:FV       28     -4      630  0.21  0.17  497.34 *******    1730  497.13
         0     28    447    28187  1.78  0.00   -0.02    0.55    2.75
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       41    -57      822  0.12  0.12  497.44 *******    1730  497.32
        41     41    474    37357  1.68  0.00   -0.02    0.39    2.10
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===215 FLOW CLASS 1 SOLUTION INDICATES POSSIBLE ROAD OVERFLOW.
           WS1,WSSD,WS3,RGMIN =   501.02       0.00     497.09     497.45
 ===260 ATTEMPTING FLOW CLASS 4 SOLUTION.
 ===225 NO ENERGY BALANCE IN 15 ITERATIONS.
                    FLOW,Q =    4       850.
              WS1,WSSD,WS3 =   498.99       0.00     497.76
 ===235 CONTINUE FLOW CLASS 4 COMPUTATIONS.
                    ITER,QRD =    3       880.
              WS,WSMIN,WSMAX =   498.78     497.45     500.12
 ===280 REJECTED FLOW CLASS 4 SOLUTION.
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.
 ===250 INSUFFICIENT HEAD FOR PRESSURE FLOW.
                        YU/Z,WSIU,WS = 1.02     499.02     499.06
 ===270 REJECTED 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       28      1      131  3.55  0.46  500.64  494.83    1730  497.09
         0     28     25    12064  1.31  1.84    0.00    1.15   13.21

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  0.874 ******  498.90 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<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       26    -83     3171  0.01  0.07  501.03  496.69    1730  501.02
        41     64    645   258655  1.18  0.32    0.00    0.05    0.55

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.954  0.960   10433.   156.   180.   501.02

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL   WSEL
   EXITX:XS     -28.    -4.   428.   1730.   17642.     436.    3.97  496.72
   FULLV:FV       0.    -5.   447.   1730.   28187.     630.    2.75  497.13
   BRIDG:BR       0.     1.    25.   1730.   12064.     131.   13.21  497.09
   RDWAY:RG       8.**************      0.       0.*********    2.00********
   APPRO:AS      41.   -84.   645.   1730.  258655.    3171.    0.55  501.02

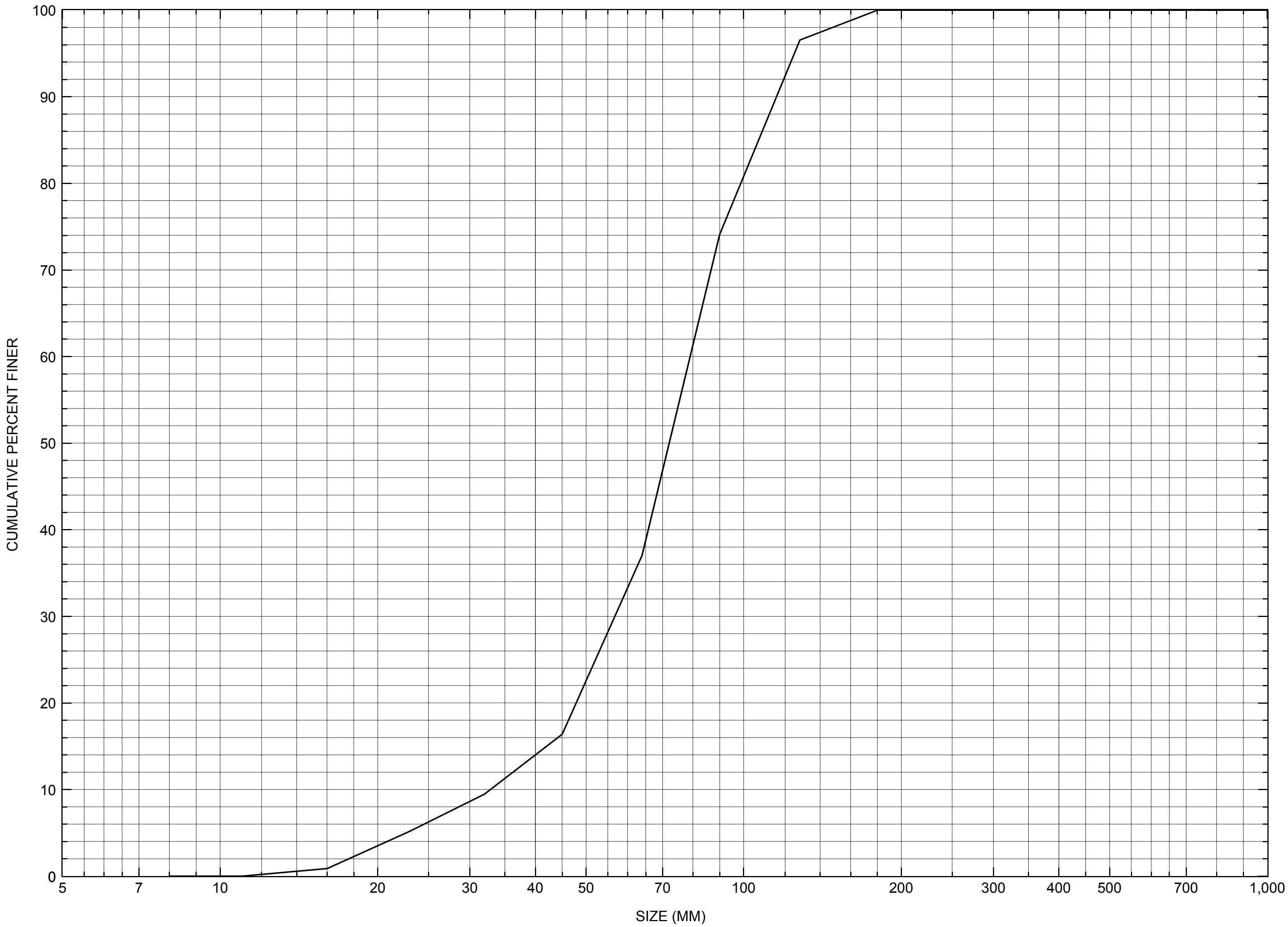
    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS     156.   180.   10433.

 SECOND USER DEFINED TABLE.

    XSID:CODE     CRWS      FR#    YMIN    YMAX    HF    HO  VHD      EGL    WSEL
   EXITX:XS    496.68     0.92  491.53  509.36************  0.47  497.19  496.72
   FULLV:FV  ********     0.55  490.69  509.36  0.17  0.00  0.21  497.34  497.13
   BRIDG:BR    494.83     1.15  490.69  499.16  0.46  1.84  3.55  500.64  497.09
   RDWAY:RG  ****************  497.45  508.89************  0.02  499.07********
   APPRO:AS    496.69     0.05  492.08  508.12  0.07  0.32  0.01  501.03  501.02
  ER
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ATHETH00090008, in Athens, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number **ATHETH00090008**

General Location Descriptive

Data collected by *(First Initial, Full last name)* **M. IVANOFF**

Date *(MM/DD/YY)* **04 / 05 / 95**

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

County *(FIPS county code; I - 3; nnn)* **025**

Town *(FIPS place code; I - 4; nnnnn)* **01900**

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

Waterway *(I - 6)* **BULL CREEK**

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

Route Number **TH009**

Vicinity *(I - 9)* **0.05 MI TO JCT W CL2 TH2**

Topographic Map **Saxtons River**

Hydrologic Unit Code: **01080107**

Latitude *(I - 16; nnnn.n)* **43078**

Longitude *(i - 17; nnnnn.n)* **72340**

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* **10130100081301**

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

Maximum span length *(I - 48; nnnn)* **0028**

Year built *(I - 27; YYYY)* **1991**

Structure length *(I - 49; nnnnnn)* **000032**

Average daily traffic, ADT *(I - 29; nnnnnn)* **000020**

Deck Width *(I - 52; nn.n)* **162**

Year of ADT *(I - 30; YY)* **90**

Channel & Protection *(I - 61; n)* **5**

Opening skew to Roadway *(I - 34; nn)* **09**

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*) **007.5**

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

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

Comments:

The structural inspection report of 07/11/95 indicates the structure is a steel beam type bridge with a timber deck. Both abutments are laid up stone with newer concrete bearing caps and backwalls. The stonework has some random voids which could be filled with chinker stone. There is stone fill upstream from both abutments. There are a few large logs lying along the bank downstream from the right abutment. The waterway makes a sharp turn into the structure and most of the flow is directed into the upstream end of the right abutment. There is some very minor localized scour beneath the structure. It is in the middle of the channel and does not appear to be affecting the substructure. **(Continued, page 34)**

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:

The streambed consists of stone and gravel.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **9.04** mi^2 Lake and pond area **0.10** mi^2

Watershed storage *(ST)* **1.2** %

Bridge site elevation **630** ft Headwater elevation **1693** ft

Main channel length **4.13** mi

10% channel length elevation **728** ft 85% channel length elevation **945** ft

Main channel slope *(S)* **69.89** ft / mi

Watershed Precipitation Data

Average site precipitation -- in Average headwater precipitation -- in

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

Average seasonal snowfall *(Sn)* -- ft

Bridge Plan Data

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

Project Number -   Minimum channel bed elevation: -

Low superstructure elevation: USLAB - DSLAB - USRAB - DSRAB -

Benchmark location description:
NO BENCHMARK INFORMATION

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

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

If 1: Footing Thickness ____ Footing bottom elevation: ____

If 2: Pile Type: ____ (*1-Wood; 2-Steel or metal; 3-Concrete*) Approximate pile driven length: ____

If 3: Footing bottom elevation: ____

Is boring information available? N *If no, type ctrl-n bi* Number of borings taken: -

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

Briefly describe material at foundation bottom elevation or around piles:
NO FOUNDATION MATERIAL INFORMATION

Comments:
NO PLANS.

Cross-sectional Data

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

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

Comments: **This cross section is the upstream face. The low chord elevations are from the survey log done for this report on 8/15/96. The low chord to bed length data is from the sketch attached to a bridge inspection report dated 7/11/94.**

Station	0	0.9	3.4	9.9	13.2	16.5	23	26	-	-	-
Feature	LAB							RAB	-	-	-
Low cord elevation	499.2	499.2	499.1	499.0	498.9	498.9	498.7	498.6	-	-	-
Bed elevation	-	491.2	490.9	489.7	489.3	489.4	489.2	489.3	-	-	-
Low cord to bed length	-	8.0	8.2	9.3	9.6	9.5	9.5	9.3	-	-	-

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: **EW** Date: **10/24/96**

Computerized by: **EW** Date: **10/24/96**

Reviewd by: **EMB** Date: **5/7/97**

Structure Number **ATHETH00090008**

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* **R. BURNS** Date *(MM/DD/YY)* **08** / **14** / 19**96**

2. Highway District Number **02** Mile marker **000000**

County **WINDHAM (025)** Town **ATHENS (01900)**

Waterway *(I - 6)* **Bull Creek** Road Name **-**

Route Number **TH009** Hydrologic Unit Code: **01080107**

3. Descriptive comments:

Located 0.05 miles from the intersection of Town highway 9 with Town highway 2.

B. Bridge Deck Observations

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

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

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

7. Bridge length **32** *(feet)* Span length **28** *(feet)* Bridge width **16.2** *(feet)*

Road approach to bridge:

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

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

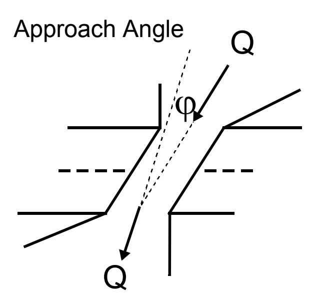
10. Embankment slope (*run / rise in feet / foot*):
US left **--** US right **--**

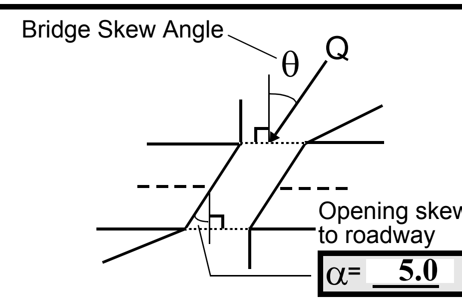
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	1	2	2	1
RBUS	2	1	2	1
RBDS	2	2	2	1
LBDS	2	1	0	-

*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: **10** 16. Bridge skew: **15**





17. Channel impact zone 1: Exist? **Y** *(Y or N)*
Where? **RB** *(LB, RB)* Severity **2**
Range? **30** feet **US** *(US, UB, DS)* to **15** feet **US**

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: **1b**

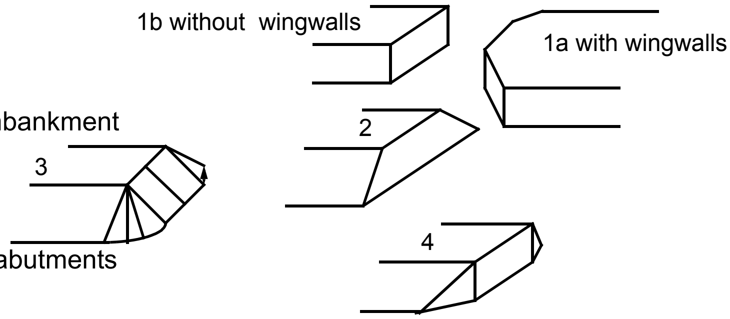
1a- Vertical abutments with wingwalls

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.)

There are shrubs and brush on the DSLB, DSRB and USLB. Surface cover on the downstream overbank areas is pasture. The USRB has trees along the bank with lawn on the overbank.

The bridge dimensions measured in the field are the same as the VTAOT database values.

The upstream left road embankment protection is type 2 stone fill. The US right and DS left road embankment protection also is the bank protection.

Road wash has eroded the finer underlying bank material from between the larger stones of the fill protection on the upstream right road embankment.

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
41.0	1.5			4.0	2	2	234	234	0	1

23. Bank width **10.0** 24. Channel width **50.0** 25. Thalweg depth **40.0** 29. Bed Material **432**

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

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

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

Right bank protection extends from 25 feet upstream to 0 feet upstream.

Left bank protection extends from 5 feet upstream (where confluence enters) to upstream bridge face.

From 15 feet upstream to the upstream bridge face, the bed material is sand (0% LB to 40% RB).

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **36** 35. Mid-bar width: **8**

36. Point bar extent: **46** feet **US** (US, UB) to **15** feet **US** (US, UB, DS) positioned **65** %LB to **85** %RB

37. Material: **432**

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

This bar is a mid-channel bar with no vegetation.

Another mid-channel bar extends from 32 feet upstream to 15 feet upstream. It is positioned 30% LB to 50 % RB, and is comprised of cobbles, gravel, sand as well as vegetation. The bar grades to sand towards the downstream end. At lower flows, these two channel bars could be considered as one point bar.

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

41. Mid-bank distance: **43** 42. Cut bank extent: **65** feet **US** (US, UB) to **23** 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.):

-

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

47. Scour dimensions: Length **49** Width **28** Depth : **1.75** Position **0** %LB to **100** %RB

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

This scour hole occupies the entire channel width at the mid-scour distance indicated. The scour hole extends from 20 feet upstream to 13 feet downstream. At the mid-scour distance, the scour hole spans across channel, between abutments. The upstream end of the scour hole is situated along the right abutment. The downstream end of the scour hole is positioned in the center of the channel. Average thalweg depth is 0.25 feet.

49. Are there major confluences? **Y** (Y or if N type ctrl-n mc) 50. How many? **2**

51. Confluence 1: Distance **5** 52. Enters on **LB** (LB or RB) 53. Type **1** (1- perennial; 2- ephemeral)

Confluence 2: Distance **55** Enters on **RB** (LB or RB) Type **2** (1- perennial; 2- ephemeral)

54. Confluence comments (eg. confluence name):

Confluence 1 is from a culvert under the TH 2 roadway.

Confluence 2 is a run-off channel which runs along TH 9. It is 3 feet wide and 1.5 feet deep.

D. Under Bridge Channel Assessment

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

56. Height (BF) LB	56. Height (BF) RB	57 Angle (BF) LB	57 Angle (BF) RB	61. Material (BF) LB	61. Material (BF) RB	62. Erosion (BF) LB	62. Erosion (BF) RB
25.5		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.):

324

Abutments are laid-up stone walls with concrete caps.

The streambed is mostly gravel and sand with some cobbles at the thalweg and along the base of each abutments.

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

There is significant growth of trees, shrubs, and brush along the immediate banks of this channel. The channel is laterally unstable.

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		15	90	2	1	0.75	0	90.0
RABUT	2	-	90			2	1	26.0

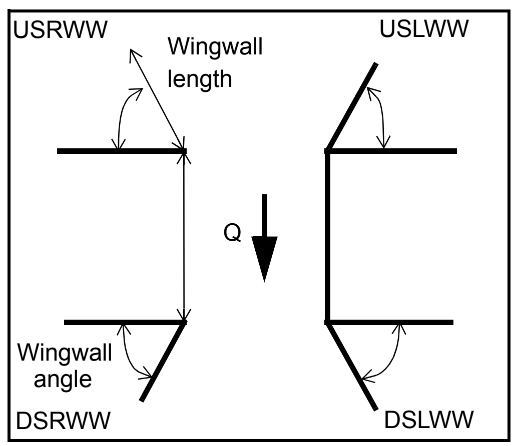
Pushed: LB or RB *Toe Location (Loc.): 0- even, 1- set back, 2- protrudes*
Scour cond.: 0- not evident; 1- evident (comment); 2- footing exposed; 3-undermined footing; 4- piling exposed; 5- settled; 6- failed
Materials: 1- Concrete; 2- Stone masonry or drywall; 3- steel or metal; 4- wood

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

0.75
0
2
Scour exists along the LABUT for the entire base length.
On the RABUT, scour is present only along the upstream half of the abutment.

80. **Wingwalls**:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						26.0	
USRWW:	N		-		-	2.0	
DSLWW:	-		-		N	15.5	
DSRWW:	-		-		-	15.5	



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	-	-	N	-	-	-	-	-
Condition	N	-	-	-	-	-	-	-
Extent	-	-	-	-	-	0	0	-

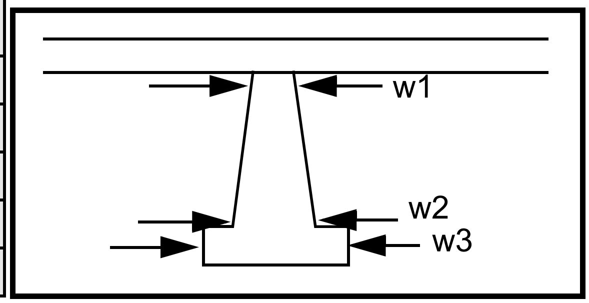
Bank / Bridge protection types: 0- absent; 1- < 12 inches; 2- < 36 inches; 3- < 48 inches; 4- < 60 inches; 5- wall / artificial levee
Bank / Bridge protection conditions: 1- good; 2- slumped; 3- eroded; 4- failed
Protection extent: 1- entire base length; 2- US end; 3- DS end; 4- other

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

Piers:

84. Are there piers? _-____ *(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	-	-	-	-	-	-
Pier 2	-	-	-	-	-	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4	
86. Location (BF)		-	-	-	*LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP*
87. Type		-	-	-	***1**- Solid pier, **2**- column, **3**- bent*
88. Material		-	-	-	***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*
89. Shape		-	-	-	***1**- Round; **2**- Square; **3**- Pointed*
90. Inclined?		-	-	-	*Y- yes; N- no*
91. Attack ∠ (BF)		-	-	-	
92. Pushed		-	-	-	*LB or RB*
93. Length (feet)	-	-	-	-	
94. # of piles		-	-	-	
95. Cross-members		-	-	-	***0**- none; **1**- laterals; **2**- diagonals; **3**- both*
96. Scour Condition		-	-	-	***0**- not evident; **1**- evident (comment); **2**- footing exposed; **3**- piling exposed; **4**- undermined footing; **5**- settled; **6**- failed*
97. Scour depth	N	-	-	-	
98. Exposure depth	-	-	-	-	

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

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
-	-			-	-	NO	PIE	RS		

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.):

2
2
24
24
1
1
342
2
0
1
-
Left bank protection extends from 0 feet downstream to 20 feet downstream.

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 **N** feet **-** *(US, UB, DS)* positioned **NO** %LB to **DR** %RB

Material: **OP**

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

STRUCTURE

Is a cut-bank present? _____ *(Y or if N type ctrl-n cb)* Where? _____ *(LB or RB)* Mid-bank distance: **Y**

Cut bank extent: **34** feet **10** *(US, UB, DS)* to **25** feet **DS** *(US, UB, DS)*

Bank damage: **42** *(**1**- eroded and/or creep; **2**- slip failure; **3**- block failure)*

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

DS
0
30
324

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

Scour dimensions: Length **abov** Width **e** Depth: **dim** Positioned **ensi** %LB to **ons** %RB

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

are for a side bar, which is vegetated at the upstream end.
Another side bar extends from 39 feet downstream to 51 feet downstream. It is positioned from 75 % LB to 100% RB. The mid-bar distance is 43 feet downstream, where it is 43 feet wide. The bar is composed of gravel, sand and cobbles, and it is vegetated along the upstream and streamward edge.

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

Confluence 1: Distance **15** Enters on **0** *(LB or RB)* Type **DS** *(**1**- perennial; **2**- ephemeral)*

Confluence 2: Distance **21** Enters on **DS** *(LB or RB)* Type **1** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

Another cut-bank is on the left bank from 40 feet downstream to 56 feet downstream. Mid-bank distance is 48 feet. Bank is eroded, as well as undermined.

F. Geomorphic Channel Assessment

107. Stage of reach evolution _____

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)*:

Y

Scour is described in #45.

N

109. G. Plan View Sketch

-

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

APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: ATHETH00090008 Town: Athens
Road Number: TH 9 County: Windham
Stream: Bull Creek

Initials EMB Date: 5/6/97 Checked: RF

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	2160	3000	1730
Main Channel Area, ft2	221	236	299
Left overbank area, ft2	161	188	299
Right overbank area, ft2	1466	1669	2573
Top width main channel, ft	40	40	40
Top width L overbank, ft	69	70	73
Top width R overbank, ft	526	543	616
D50 of channel, ft	0.2365	0.2365	0.2365
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.5	5.9	7.5
y1, average depth, LOB, ft	2.3	2.7	4.1
y1, average depth, ROB, ft	2.8	3.1	4.2
Total conveyance, approach	118165	141572	258551
Conveyance, main channel	24659	27558	40768
Conveyance, LOB	7024	8972	18896
Conveyance, ROB	86481	105042	198887
Percent discrepancy, conveyance	0.0008	0.0000	0.0000
Qm, discharge, MC, cfs	450.8	584.0	272.8
Ql, discharge, LOB, cfs	128.4	190.1	126.4
Qr, discharge, ROB, cfs	1580.8	2225.9	1330.8
Vm, mean velocity MC, ft/s	2.0	2.5	0.9
Vl, mean velocity, LOB, ft/s	0.8	1.0	0.4
Vr, mean velocity, ROB, ft/s	1.1	1.3	0.5
Vc-m, crit. velocity, MC, ft/s	9.2	9.3	9.7
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

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

Main Channel	0	0	0

Armoring
Dc=[(1.94*V^2)/(5.75*log(12.27*y/D90))^2]/[0.03*(165-62.4)]
Depth to Armoring=3*(1/Pc-1)
(Federal Highway Administration, 1993)

Downstream bridge face property	100-yr	500-yr	Other Q
Q, discharge thru bridge MC, cfs	803	872	1730
Main channel area (DS), ft2	152.8	160.4	131
Main channel width (normal), ft	25.0	25.6	24.2
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	25.0	25.6	24.2
D90, ft	0.3789	0.3789	0.3789
D95, ft	0.4098	0.4098	0.4098
Dc, critical grain size, ft	0.0998	0.1058	0.6604
Pc, Decimal percent coarser than Dc	0.912	0.904	0.000
Depth to armoring, ft	0.03	0.03	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	2160	3000	1730
(Q) discharge thru bridge, cfs	803	872	1730
Main channel conveyance	14897	15865	12064
Total conveyance	14897	15865	12064
Q2, bridge MC discharge,cfs	803	872	1730
Main channel area, ft2	153	160	131
Main channel width (normal), ft	25.0	25.6	24.2
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	25	25.6	24.2
y_bridge (avg. depth at br.), ft	6.11	6.27	5.41
Dm, median (1.25*D50), ft	0.295625	0.295625	0.295625
y2, depth in contraction,ft	3.43	3.61	6.81
ys, scour depth (y2-ybridge), ft	-2.68	-2.66	1.40

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	2160	3000	1730	2160	3000	1730
a', abut.length blocking flow, ft	80.7	81	84.8	529.3	546.8	619.8
Ae, area of blocked flow ft2	217.8	245.7	379.8	1158.8	1236.2	2613.4
Qe, discharge blocked abut.,cfs	239.1	327.7	198.3	--	--	1367.4
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	1.10	1.33	0.52	1.08	1.33	0.52
ya, depth of f/p flow, ft	2.70	3.03	4.48	2.19	2.26	4.22
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	1	1	1	1	1	1
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	95	95	95	85	85	85
K2	1.01	1.01	1.01	0.99	0.99	0.99
Fr, froude number f/p flow	0.118	0.135	0.043	0.114	0.134	0.045
ys, scour depth, ft	9.91	11.42	9.83	16.08	18.09	16.45

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)	80.7	81	84.8	529.3	546.8	619.8
y1 (depth f/p flow, ft)	2.70	3.03	4.48	2.19	2.26	4.22
a'/y1	29.90	26.70	18.93	241.77	241.86	146.99
Skew correction (p. 49, fig. 16)	1.01	1.01	1.01	0.98	0.98	0.98
Froude no. f/p flow	0.12	0.13	0.04	0.11	0.13	0.04
Ys w/ corr. factor K1/0.55:						
vertical	9.79	11.51	ERR	7.62	8.30	10.79
vertical w/ ww's	8.02	9.43	ERR	6.25	6.81	8.85
spill-through	5.38	6.33	ERR	4.19	4.57	5.94

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	0.52	0.53	1	0.52	0.53	1
y, depth of flow in bridge, ft	6.11	6.27	5.41	6.11	6.27	5.41
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	1.02	1.09	ERR	1.02	1.09	ERR
Fr>0.8 (vertical abut.)	ERR	ERR	2.26	ERR	ERR	2.26