LEVEL II SCOUR ANALYSIS FOR BRIDGE 31 (JERITH00350031) on TOWN HIGHWAY 35, crossing MILL BROOK, JERICHO, VERMONT

Open-File Report 97-767

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

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

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By EMILY C. WILD

U.S. Geological Survey
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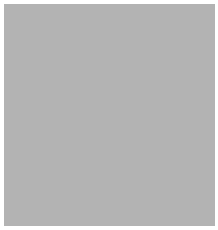

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Pembroke, New Hampshire

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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.

LEVEL II SCOUR ANALYSIS FOR BRIDGE 31 (JERITH00350031) ON TOWN HIGHWAY 35, CROSSING MILL BROOK, JERICHO, VERMONT

By **Emily C. Wild**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure JERITH00350031 on Town Highway 35 crossing Mill Brook, Jericho, 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, gathered 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 and the Champlain section of the St. Lawrence physiographic province in northwestern Vermont. The 15.7-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest upstream of the bridge. The downstream left overbank is pasture. The downstream right overbank is brushland.

In the study area, the Mill Brook has an incised, sinuous channel with a slope of approximately 0.02 ft/ft, an average channel top width of 117 ft and an average bank height of 11 ft. The channel bed material ranges from gravel to boulders with a median grain size (D_{50}) of 81.1 mm (0.266 ft). The geomorphic assessment at the time of the Level I and Level II site visit on July 3, 1996, indicated that the reach was laterally unstable.

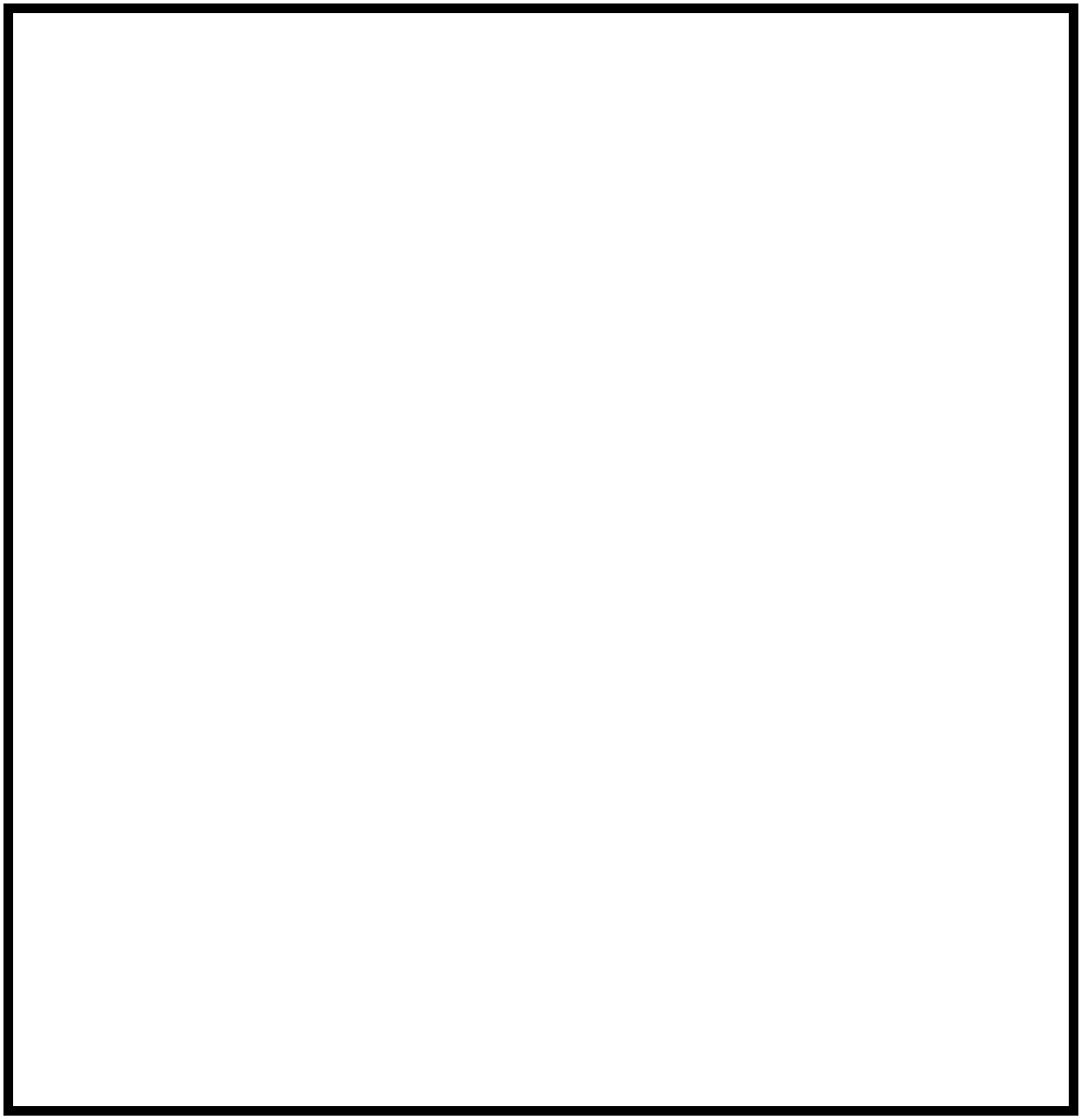
The Town Highway 35 crossing of the Mill Brook is a 53-ft-long, one-lane bridge consisting of a 50-foot steel-beam span with a wooden deck (Vermont Agency of Transportation, written communication, November 30, 1995). The opening length of the structure parallel to the bridge face is 48 ft. The bridge is supported by a vertical, concrete abutment with wingwalls on the left. On the right, the abutment and wingwalls are laid-up stone with a concrete cap. The channel is not skewed to the opening. The roadway is skewed 10 degrees to the opening.

A scour hole 1.5 ft deeper than the mean thalweg depth was observed along the left abutment during the Level I assessment. Scour countermeasures at the site were type-2 stone fill (less than 36 inches diameter) at the upstream and downstream left wingwalls, the upstream and downsteam left channel banks, and the downstream left road embankment. 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). In addition, the incipient roadway-overtopping discharge is analyzed since it has the potential of being the worst-case scour scenario. Total scour at a highway crossing is comprised of three components: 1) long-term streambed degradation; 2) contraction scour (due to accelerated flow caused by a reduction in flow area at a bridge) and; 3) local scour (caused by accelerated flow around piers and abutments). Total scour is the sum of the three components. Equations are available to compute depths for contraction and local scour and a summary of the results of these computations follows.

Contraction scour for all modelled flows ranged from 0.4 to 1.3 ft. The worst-case contraction scour occurred at the 500-year discharge. Left abutment scour ranged from 9.9 to 12.4 ft. Right abutment scour ranged from 13.8 to 17.8 ft. The worst-case abutment scour occurred at the 500-year discharge. Additional information on scour depths and depths to armoring are included in the section titled “Scour Results”. Scoured-streambed elevations, based on the calculated scour depths, are presented in tables 1 and 2. A cross-section of the scour computed at the bridge is presented in figure 8. Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution.

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



Essex Junction, VT. Quadrangle, 1:24,000, 1948, photoinspected 1987

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.

Figure 3. Structure JERITH00350031 viewed from upstream (July 3, 1996).

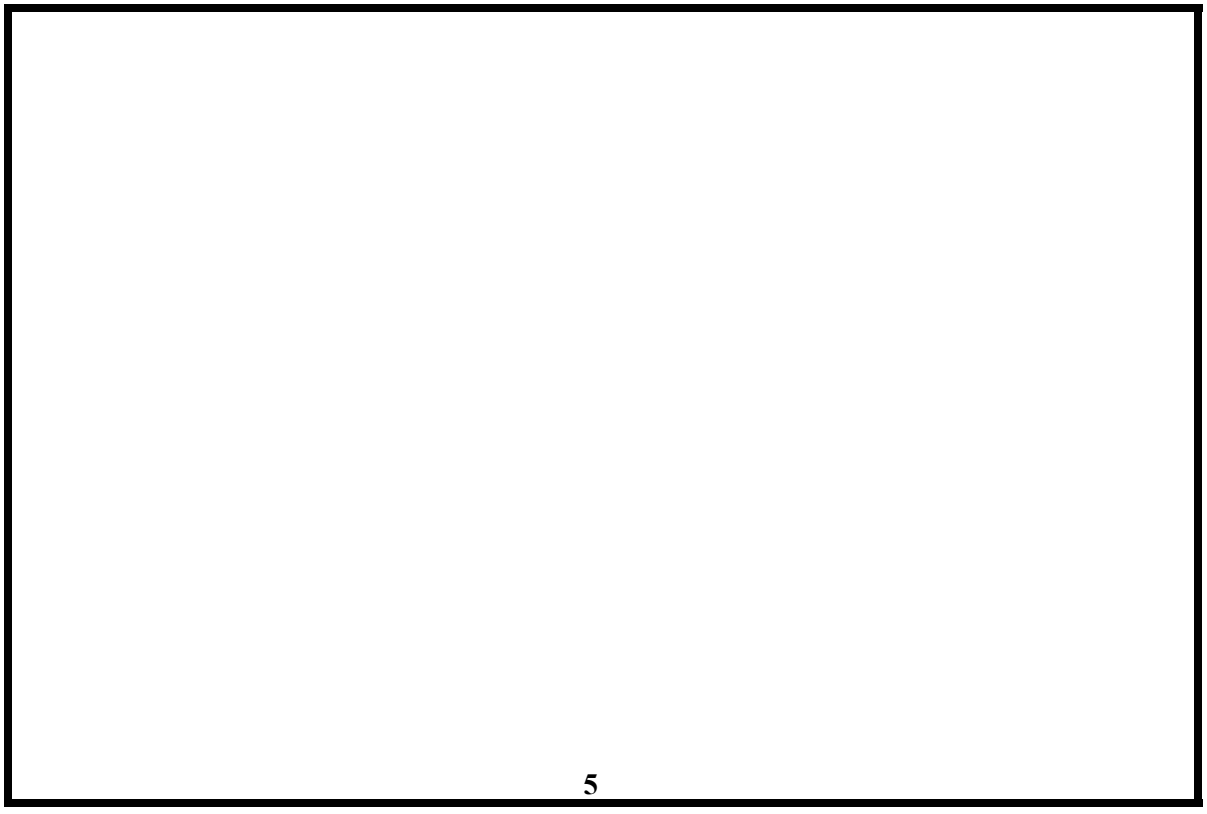
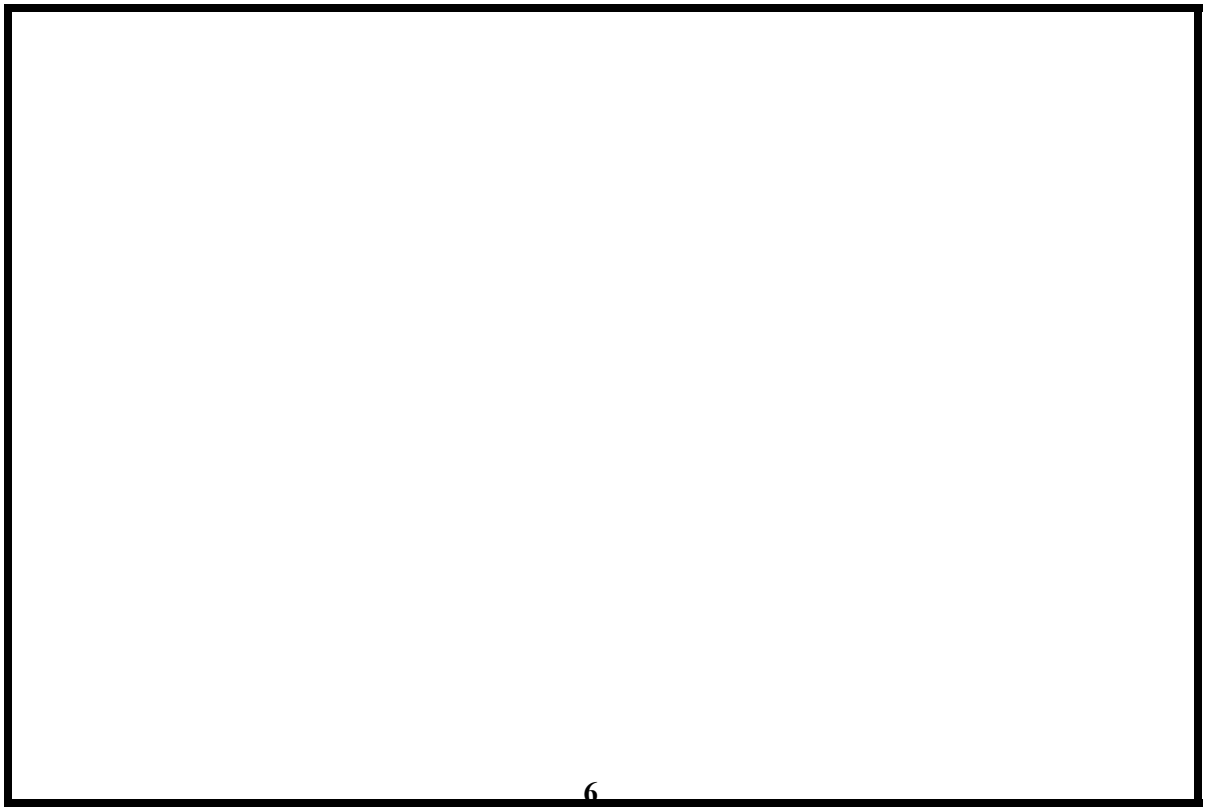


Figure 5. Upstream channel viewed from structure JERITH00350031 (July 3, 1996).



LEVEL II SUMMARY

Structure Number JERITH00350031 ***Stream*** Mill Brook

County Chittenden ***Road*** TH35 ***District*** 5

Description of Bridge

Bridge length 53 ***ft*** ***Bridge width*** 13.8 ***ft*** ***Max span length*** 50 ***ft***

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

Abutment type Vertical, concrete and ***Embankment type*** stone

Stone fill on abutment? Sloping No

Date of inspection 7/03/96

Description of stone fill Type-2, around the upstream and downstream left wingwalls.

Left abutment and left wingwalls are concrete. Right abutment and right wingwalls laid-up stone with a concrete cap. There is a one and a half foot deep scour hole in front of the left abutment.

Is bridge skewed to flood flow according to N ***survey?*** N -- ***Angle***

However, the channel mildly bends in the upstream reach, as well as the downstream reach.

7/03/96

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

	Date of inspection	***Percent of channel blocked horizontally***	***Percent of channel blocked vertically***
Level I	7/03/96	0	0
Level II	7/03/96	0	0

Potential for debris High. In the upstream reach, there is a log across the channel, and some dead trees leaning into the channel at the location of the cut-bank.

Describe any features near or at the bridge that may affect flow (include observation date) The Level I assessment noted no features affecting the flow at or near the bridge during the July 3, 1996 site visit.

Description of the Geomorphic Setting

General topography The channel is located within a moderate relief valley with a narrow, irregualr flood plain.

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

Date of inspection 7/03/96

DS left: Moderately sloped overbank.

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

US left: Steep channel bank with a moderately sloped overbank.

US right: Narrow flood plain to a moderately sloped overbank.

Description of the Channel

Average top width 117 ***ft*** ***Average depth*** 11 ***ft***

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

Sinuous and laterally unstable with non-alluvial channel boundaries and a narrow flood plain.

7/03/96

Vegetative co Lawn.

DS left: Brushland.

DS right: Trees and brush.

US left: Trees and brush.

US right:

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

Light fluvial erosion has resulted in cut-banks upstream and downstream of the bridge. The point bars in the channel are vegetated with small bushes and grass. The extent of these point bars can be found discussed in further detail in Appendix E.

The July 3, 1996 Level I assessment and written communication with the VTAOT, November 30, 1995, have indicated the point bar along the right side of the channel blocks 2/3 of the channel flow under the bridge.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 15.7 ***mi^2***

Percentage of drainage area in physiographic provinces: (approximate)

Physiographic province/section	***Percent of drainage area***
New England/ Green Mountain	80
St. Lawrence Valley/ Champlain	20

Is drainage area considered rural or urban? Rural ***Describe any significant urbanization***: None.

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

USGS gage description --

USGS gage number --

Gage drainage area ***mi^2***

Is there a lake/ No

Calculated Discharges

Q100 3,300 ***ft^3/s*** ***Q500*** 4,750 ***ft^3/s***

The 100- and 500-year discharges are based on VTAOT flood frequency estimates for this site available from the VTAOT database. The values computed are within a range defined by several empirical flood frequency curves (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887).

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

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

Datum tie between USGS survey and VTAOT plans To obtain VTAOT datum, subtract 161.5 feet from USGS arbitrary survey datum.

Description of reference marks used to determine USGS datum. RM1 is a chiseled X on top of the downstream end of the left bridge backwall (elev. 499.34 ft, arbitrary survey datum). RM2 is a chiseled X on top of the upstream end of the right bridge backwall (elev. 499.22 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	-48	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	8	1	Road Grade section
APPRO	63	2	Modelled Approach section (Templated from APTEM)
APTEM	68	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 0.055 to 0.080, and overbank "n" values ranged from 0.045 to 0.095.

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 0.0194 ft/ft which was calculated from thalweg slopes surveyed downstream.

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0297 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 approach also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 499.3 *ft*
Average low steel elevation 496.4 *ft*

100-year discharge 3,300 *ft³/s*
Water-surface elevation in bridge opening 493.6 *ft*
Road overtopping? N *Discharge over road* -- *ft³/s*
Area of flow in bridge opening 286 *ft²*
Average velocity in bridge opening 11.5 *ft/s*
Maximum WSPRO tube velocity at bridge 14.9 *ft/s*

Water-surface elevation at Approach section with bridge 496.2
Water-surface elevation at Approach section without bridge 495.3
Amount of backwater caused by bridge 0.9 *ft*

500-year discharge 4,750 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Road overtopping? Y *Discharge over road* 182 *ft³/s*
Area of flow in bridge opening 419 *ft²*
Average velocity in bridge opening 10.9 *ft/s*
Maximum WSPRO tube velocity at bridge 13.5 *ft/s*

Water-surface elevation at Approach section with bridge 500.0
Water-surface elevation at Approach section without bridge 496.6
Amount of backwater caused by bridge 3.4

Incipient overtopping discharge 4,330 *ft³/s*
Water-surface elevation in bridge opening 496.4 *ft*
Area of flow in bridge opening 419 *ft²*
Average velocity in bridge opening 10.3 *ft/s*
Maximum WSPRO tube velocity at bridge 12.7 *ft/s*

Water-surface elevation at Approach section with bridge 499.5
Water-surface elevation at Approach section without bridge 496.2
Amount of backwater caused by bridge 3.3 *ft*

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour for the 100-year discharge was computed by use of Laursen's clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). At this site, the 500-year and incipient roadway-overtopping discharges resulted in unsubmerged 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 was computed by use of the Chang equation (Richardson and others, 1995, p. 145-146). Results of 100-year and 500-year analysis are presented in figure 8 and tables 1 and 2. The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Additional estimates of contraction scour for the 500-year and incipient roadway-overtopping also were computed by use of Laursen's clear-water scour equation (Richardson and others, 1995, p. 32, equation 20) and the results are presented in Appendix F. Furthermore, for those discharges resulting in unsubmerged orifice flow, contraction scour was computed by substituting alternative estimates for the depth of flow in the bridge at the downstream face in the Chang equation and Laursen's clear-water equation. Contraction scour results with respect to these substitutions also are provided in Appendix F.

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

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.4	1.3	0.8
Depth to armoring	11.6 8.7	8.2	--
Left overbank	--	--	--
Right overbank	--	--	9.9

Local scour:			
Abutment scour	12.4	12.1	13.8
Left abutment	17.8	17.1	--
Right abutment	--	--	--
Pier scour	--	--	--
Pier 1	--	--	--
Pier 2	--	--	2.4
Pier 3	--	--	--

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	2.6	2.6	2.4
Left abutment	2.6	2.6	--
Right abutment	--	--	--
Piers:	--	--	--
Pier 1	--	--	--
Pier 2	--	--	--

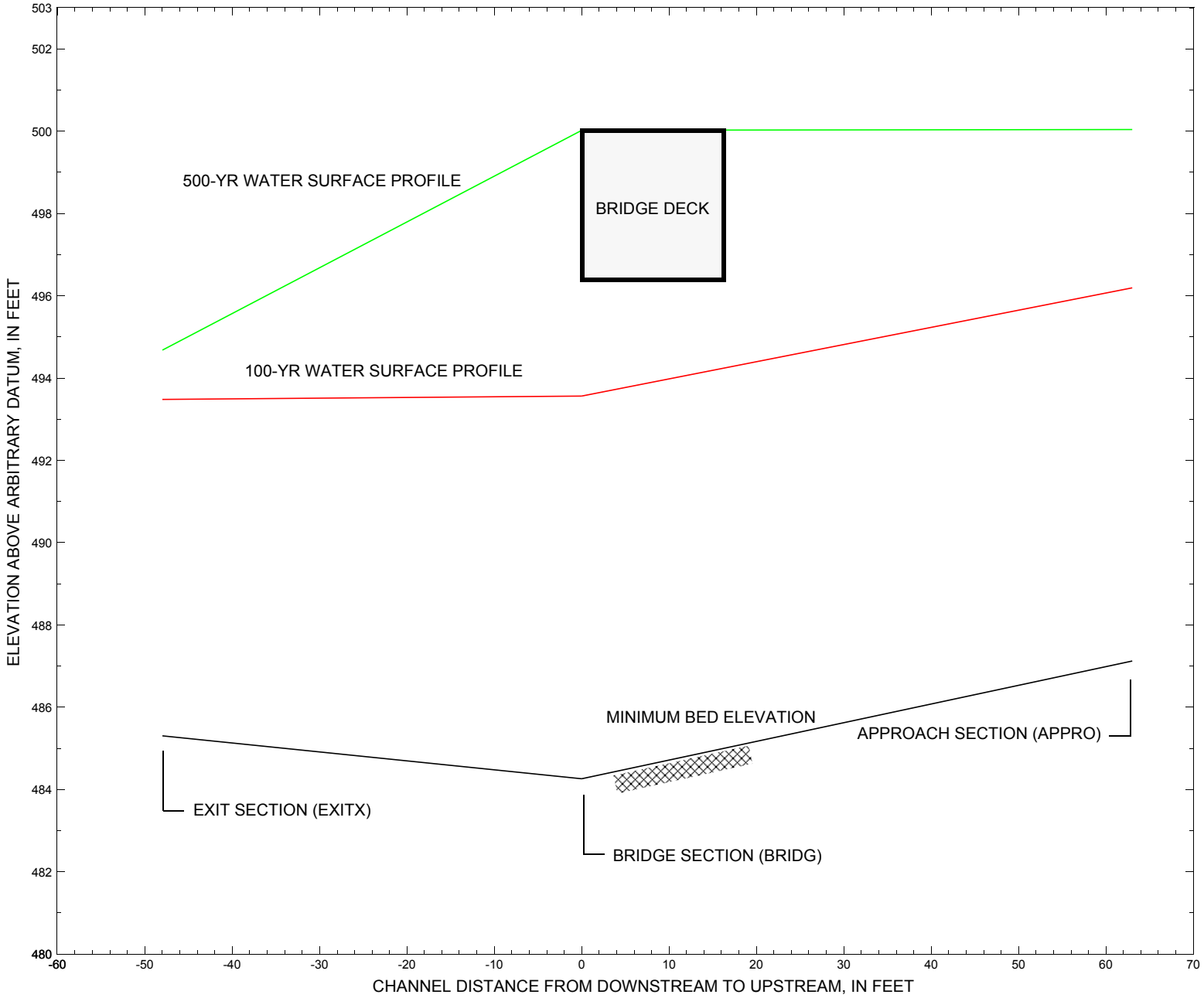


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure JERITH00350031 on Town Highway 35, crossing Mill Brook, Jericho, Vermont.

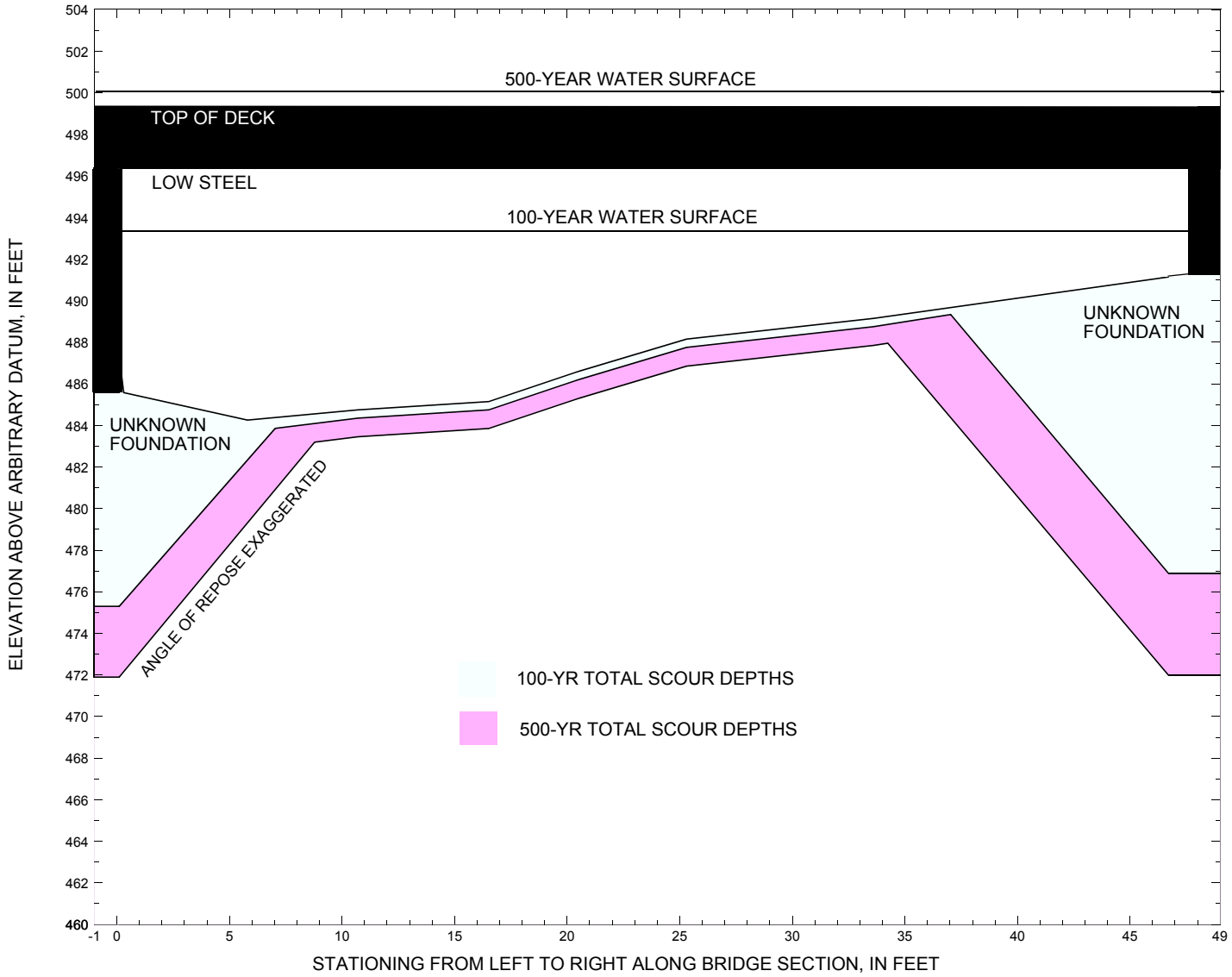


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure JERITH00350031 on Town Highway 35, crossing Mill Brook, Jericho, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure JERITH00350031 on Town Highway 35, crossing Mill Brook, Jericho, 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 3,300 cubic-feet per second											
Left abutment	0.0	334.9	496.4	--	485.6	0.4	9.9	--	10.3	475.3	--
Right abutment	48.0	334.9	496.4	--	491.1	0.4	13.8	--	14.2	476.9	--

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

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure JERITH00350031 on Town Highway 35, crossing Mill Brook, Jericho, 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 4,750 cubic-feet per second											
Left abutment	0.0	334.9	496.4	--	485.6	1.3	12.4	--	13.7	471.9	--
Right abutment	48.0	334.9	496.4	--	491.1	1.3	17.8	--	19.1	472.0	--

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, 1948, Essex Junction, Vermont 7.5 Minute Series quadrangle map: U.S. Geological Survey Topographic Maps, Photoinspected 1987, Scale 1:24,000.

APPENDIX A:

WSPRO INPUT FILE

WSPRO INPUT FILE

```
T1        U.S. Geological Survey WSPRO Input File jeri031.wsp
T2        Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
T3        Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
*
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           3300.0   4750.0   4330.0
SK          0.0194   0.0194   0.0194
*
XS   EXITX    -48           0.
GR         -500.0, 518.02   -293.3, 499.39
GR         -203.3, 499.39    -55.9, 499.26    -33.7, 493.31    -11.1, 490.71
GR            0.0, 488.08      5.7, 486.44      7.4, 485.40     14.8, 485.30
GR           18.9, 485.73     25.0, 485.92     28.7, 486.39     39.7, 489.14
GR           54.4, 490.51     63.2, 494.77    112.4, 495.84    144.1, 500.57
GR          160.3, 505.57    166.9, 505.97    177.4, 506.53    188.1, 506.02
GR          197.8, 506.02    205.2, 505.44    241.8, 510.32
*
N           0.060        0.070        0.045
SA               -55.9         63.2
*
XS   FULLV      0  * * *   0.0000
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    496.39      10.0
GR           0.0, 496.39      0.0, 486.52      0.1, 486.50      0.1, 485.58
GR           5.8, 484.26     10.7, 484.75     16.5, 485.15     20.4, 486.57
GR          25.3, 488.15     33.6, 489.15     46.7, 491.14     48.0, 496.39
GR           0.0, 496.39
*
*         BRTYPE  BRWDTH       WWANGL    WWWID
CD           1      23.4 * *     54.8      5.2
N           0.055
*
*             SRD    EMBWID   IPAVE
XR   RDWAY      8      12.0     2
GR         -367.1, 518.02   -286.4, 511.25   -135.7, 503.31    -26.0, 500.14
GR           0.0, 499.35     48.8, 499.32     57.8, 499.15     73.9, 499.70
GR          131.3, 502.63    199.4, 508.84    220.6, 508.95    231.9, 506.81
GR          237.7, 508.37    246.0, 509.12    281.8, 521.06
*
XT   APTEM     68           0.
GR         -286.5, 515.05   -219.4, 508.45   -161.6, 503.85   -103.5, 502.58
GR          -28.8, 500.91    -15.7, 497.10      0.0, 489.90      2.5, 487.99
GR            4.7, 487.22      8.7, 487.12     15.0, 487.72     27.0, 488.16
GR           33.8, 488.80     47.9, 490.76     49.6, 491.97     72.1, 492.27
GR           87.5, 497.30    101.0, 497.51    157.0, 502.23    217.1, 505.75
GR          229.4, 510.42    234.7, 511.06    256.2, 511.18    272.0, 509.87
GR          298.4, 519.19
*
AS   APPRO     63    0.0297
GT
N           0.095        0.080        0.090
SA                -28.8         87.5
*
HP 1 BRIDG 493.56 1 493.56
HP 2 BRIDG 493.56 * * 3300
HP 1 APPRO 496.19 1 496.19
HP 2 APPRO 496.19 * * 3300
*
HP 1 BRIDG 496.39 1 496.39
HP 2 BRIDG 496.39 * * 4588
HP 1 BRIDG 495.78 1 495.78
HP 2 RDWAY 500.02 * * 182
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
        U.S. Geological Survey WSPRO Input File jeri031.wsp
        Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
        Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
           *** RUN DATE & TIME: 07-25-97  12:23
    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      286     22676     47     57                        4031
   493.56           286     22676     47     57  1.00      0     47     4031


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       493.56     0.0    47.3   286.5   22676.    3300.  11.52

X STA.         0.0        3.1        4.8        6.2        7.5        8.8
  A(I)            25.4       14.6       13.1       11.9       11.4
  V(I)            6.50      11.32      12.63      13.87      14.49

X STA.         8.8       10.1       11.4       12.7       14.0       15.3
  A(I)            11.4       11.1       11.1       11.2       11.1
  V(I)           14.48      14.84      14.92      14.72      14.88

X STA.        15.3       16.7       18.2       19.9       21.9       24.2
  A(I)            11.6       11.8       12.7       13.1       14.1
  V(I)           14.23      13.99      12.96      12.60      11.74

X STA.        24.2       27.0       30.2       33.9       38.8       47.3
  A(I)            15.1       15.5       17.1       19.1       24.2
  V(I)           10.90      10.67       9.63       8.64       6.82

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      63.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      537     30391     98    101                        7131
   496.19           537     30391     98    101  1.00    -13     84     7131


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      63.

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.19   -13.7    84.1   536.6   30391.    3300.   6.15

X STA.       -13.7       -0.2        3.5        6.2        8.7       11.1
  A(I)            41.7       28.2       24.0       22.4       21.2
  V(I)            3.95       5.86       6.88       7.38       7.80

X STA.        11.1       13.6       16.0       18.6       21.2       23.8
  A(I)            21.7       21.1       21.4       21.7       21.4
  V(I)            7.59       7.80       7.71       7.61       7.70

X STA.        23.8       26.6       29.5       32.5       35.8       39.5
  A(I)            22.1       23.0       23.4       24.0       25.6
  V(I)            7.47       7.16       7.06       6.88       6.43

X STA.        39.5       43.9       49.3       57.8       66.4       84.1
  A(I)            27.6       29.6       35.4       35.1       45.9
  V(I)            5.97       5.58       4.66       4.70       3.59
```

```
       U.S. Geological Survey WSPRO Input File jeri031.wsp
       Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
       Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
          *** RUN DATE & TIME: 07-25-97  12:23

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      419     27532      0    111                           0
   496.39           419     27532      0    111  1.00      0     48        0

    VELOCITY DISTRIBUTION:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
         WSEL     LEW     REW    AREA        K         Q    VEL
       496.39     0.0    48.0   419.3   27532.    4588.  10.94

X STA.          0.0         3.0         4.8         6.4         7.9         9.4
  A(I)             33.3        20.6        18.5        17.5        17.4
  V(I)             6.89       11.11       12.39       13.09       13.22

X STA.          9.4        10.8        12.3        13.9        15.4        16.9
  A(I)             17.1        17.1        17.0        17.3        17.1
  V(I)            13.45       13.41       13.46       13.27       13.42

X STA.         16.9        18.6        20.5        22.6        25.0        27.7
  A(I)             18.1        18.7        19.3        20.5        21.4
  V(I)            12.69       12.30       11.88       11.19       10.71

X STA.         27.7        30.5        33.7        37.1        41.2        48.0
  A(I)             22.0        22.9        23.8        25.7        34.0
  V(I)            10.45       10.01        9.64        8.94        6.74

    CROSS-SECTION PROPERTIES:  ISEQ =  3;  SECID = BRIDG;  SRD =       0.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             1      390     36130     47     62                         6378
   495.78           390     36130     47     62  1.00      0     48      6378

    VELOCITY DISTRIBUTION:  ISEQ =  4;  SECID = RDWAY;  SRD =       8.
         WSEL     LEW     REW    AREA        K         Q    VEL
       500.02   -22.0    80.2    58.5     908.     182.   3.11

X STA.        -22.0        -3.6         2.0         6.7        11.1        15.5
  A(I)              5.2         3.6         3.1         3.0         3.0
  V(I)             1.76        2.56        2.89        3.07        3.03

X STA.         15.5        19.8        24.0        28.1        32.2        36.2
  A(I)              2.9         2.9         2.8         2.8         2.8
  V(I)             3.11        3.14        3.23        3.26        3.25

X STA.         36.2        40.3        44.3        48.2        51.9        55.2
  A(I)              2.8         2.8         2.7         2.7         2.6
  V(I)             3.26        3.25        3.31        3.42        3.55

X STA.         55.2        58.0        61.1        64.5        68.5        80.2
  A(I)              2.5         2.4         2.4         2.3         3.2
  V(I)             3.71        3.74        3.80        3.94        2.82

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      63.
     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
             2      946     70785    113    117                        15510
```

```
           3       74      1725     44     44                              543
   500.04          1020     72510    157    161  1.08    -25    131    14173

    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      63.
         WSEL     LEW     REW    AREA        K        Q    VEL
       500.04   -25.8   131.0  1019.5   72510.    4750.   4.66

X STA.       -25.8       -3.3        2.4        6.2        9.5       12.9
  A(I)            86.2       58.2       47.9       42.1       42.6
  V(I)            2.76       4.08       4.96       5.64       5.58

X STA.        12.9       16.1       19.4       22.7       26.1       29.5
  A(I)            40.2       40.9       39.8       40.4       39.8
  V(I)            5.91       5.81       5.96       5.88       5.97

X STA.        29.5       33.0       36.7       40.8       45.2       50.6
  A(I)            40.2       41.3       42.8       44.0       48.8
  V(I)            5.91       5.75       5.55       5.40       4.86

X STA.        50.6       56.8       63.3       69.9       77.9      131.0
  A(I)            49.7       51.3       52.1       56.3      115.1
  V(I)            4.78       4.63       4.56       4.22       2.06
        U.S. Geological Survey WSPRO Input File jeri031.wsp
        Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
        Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
           *** RUN DATE & TIME: 07-25-97  12:23

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      419     27532      0    111                           0
   496.39           419     27532      0    111  1.00      0     48        0


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

         WSEL     LEW     REW    AREA        K        Q    VEL
       496.39     0.0    48.0   419.3   27532.    4330.  10.33

X STA.         0.0        3.0        4.8        6.4        7.9        9.4
  A(I)            33.3       20.6       18.5       17.5       17.4
  V(I)            6.50      10.49      11.69      12.36      12.48

X STA.         9.4       10.8       12.3       13.9       15.4       16.9
  A(I)            17.1       17.1       17.0       17.3       17.1
  V(I)           12.70      12.65      12.70      12.52      12.66

X STA.        16.9       18.6       20.5       22.6       25.0       27.7
  A(I)            18.1       18.7       19.3       20.5       21.4
  V(I)           11.98      11.61      11.21      10.56      10.10

X STA.        27.7       30.5       33.7       37.1       41.2       48.0
  A(I)            22.0       22.9       23.8       25.7       34.0
  V(I)            9.86       9.45       9.09       8.44       6.36

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

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
           1      374     33822     47     61                           5973
   495.42           374     33822     47     61  1.00      0     48     5973

    CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =      63.

     WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
```

```
            2      881     63601    111    115                        14060
            3       50      1027     37     37                          334
   499.46           931     64628    148    152  1.07    -23    124    12836


    VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =      63.

         WSEL     LEW     REW    AREA        K        Q    VEL
       499.46   -23.8   124.1   931.1   64628.    4330.   4.65

X STA.       -23.8       -2.7        2.7        6.2        9.5       12.6
  A(I)            78.9       52.5       42.8       39.9       38.1
  V(I)            2.74       4.12       5.06       5.43       5.68

X STA.        12.6       15.7       19.0       22.1       25.4       28.6
  A(I)            37.0       37.6       36.6       37.1       36.6
  V(I)            5.85       5.76       5.91       5.84       5.91

X STA.        28.6       32.0       35.6       39.5       43.7       48.6
  A(I)            37.0       38.2       39.6       40.7       43.0
  V(I)            5.85       5.67       5.47       5.32       5.03

X STA.        48.6       54.9       61.3       67.9       75.6      124.1
  A(I)            47.9       47.1       48.1       53.5       98.9
  V(I)            4.52       4.60       4.50       4.05       2.19




       U.S. Geological Survey WSPRO Input File jeri031.wsp
       Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
       Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
          *** RUN DATE & TIME: 07-25-97  12:23

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

EXITX:XS   ******    -33      419  0.96 *****  494.44  492.15    3300  493.48
       -47 ******     61    23692  1.00 ***** *******    0.66    7.87

FULLV:FV       48    -37      518  0.63  0.68  495.12 *******    3300  494.49
         0     48     63    32315  1.00  0.00   -0.01    0.50    6.37
        <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       63    -11      451  0.83  0.90  496.13 *******    3300  495.29
        63     63     81    23541  1.00  0.10    0.00    0.59    7.32
        <<<<<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       48      0      287  2.06  0.97  495.62  492.78    3300  493.56
         0     48     47    22690  1.00  0.21    0.00    0.82   11.51

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   1.  1.000 ******  496.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.        <<<<<EMBANKMENT IS NOT OVERTOPPED>>>>>
```

WSPRO OUTPUT FILE (continued)

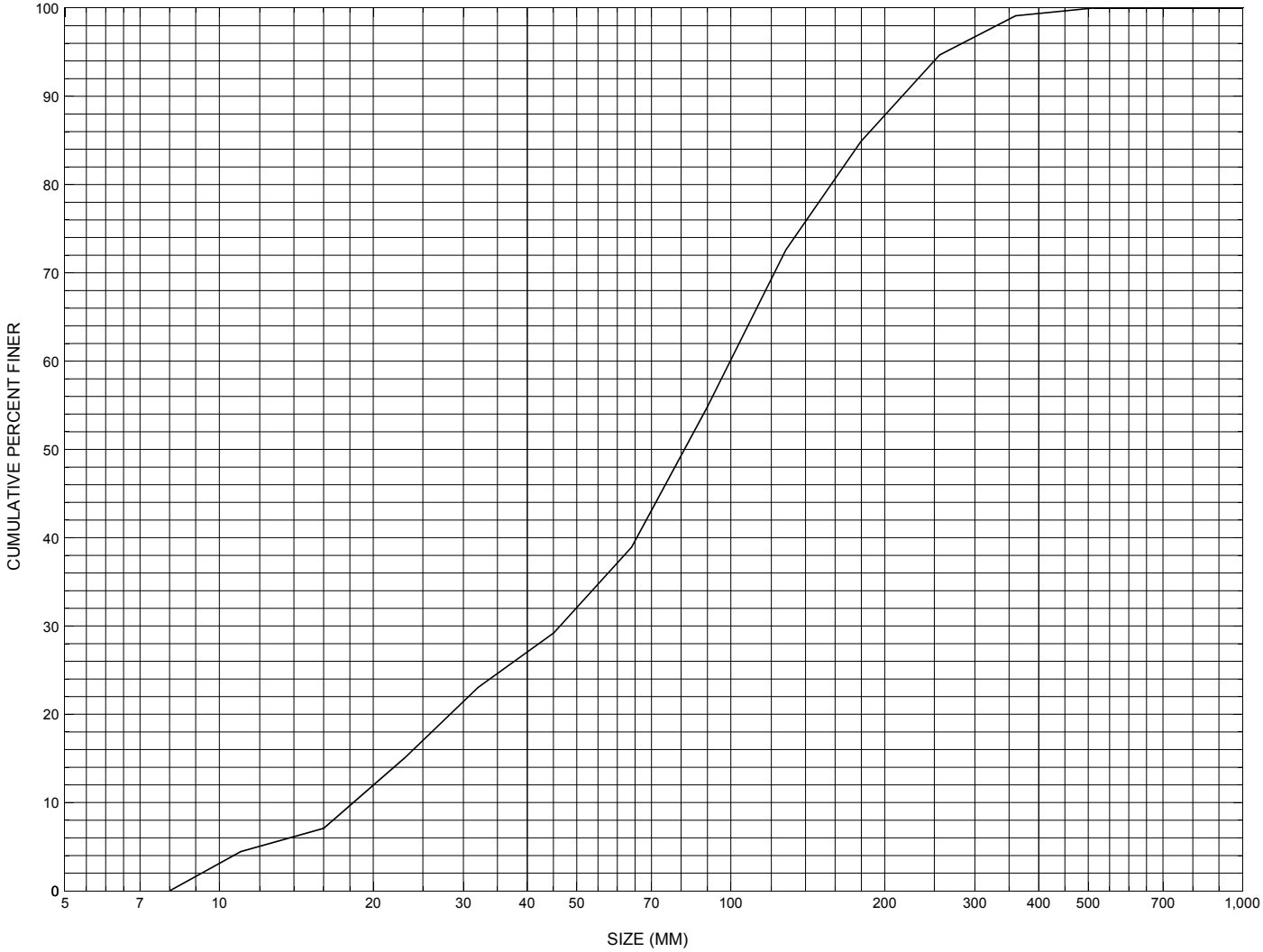
```
        U.S. Geological Survey WSPRO Input File jeri031.wsp
        Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
        Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
           *** RUN DATE & TIME: 07-25-97  12:23

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

EXITX:XS   ******    -38      537  1.22 *****  495.89  493.32    4750  494.68
       -47 ******     63    34073  1.00 ***** *******    0.68    8.84

FULLV:FV       48    -42      675  0.80  0.69  496.58 *******    4750  495.78
         0     48    110    46205  1.04  0.00    0.00    0.60    7.04
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       63    -14      574  1.07  0.92  497.63 *******    4750  496.56
        63     63     85    33498  1.00  0.13    0.00    0.61    8.28
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.29     497.87     498.54     496.39
 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       48      0      419  1.86 *****  498.25  494.13    4588  496.39
         0 ******     48    27532  1.00 ***** *******    0.65   10.94

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   5.  0.485 ******  496.39 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG       8.    51.  0.22  0.37  500.19    0.00    182.  500.02

            Q   WLEN    LEW    REW  DMAX  DAVG  VMAX  VAVG  HAVG  CAVG
   LT:     58.    39.   -22.    17.   0.7   0.5   3.4   3.1   0.7   2.8
   RT:    123.    57.    17.    74.   0.9   0.7   3.9   3.2   0.8   2.8

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

APPRO:AS       40    -25     1020  0.37  0.46  500.41  494.73    4750  500.04
        63     43    131    72531  1.08  0.73    0.00    0.34    4.66
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.   -39.    63.   4750.   34073.     537.    8.84  494.68
   FULLV:FV       0.   -43.   110.   4750.   46205.     675.    7.04  495.78
   BRIDG:BR       0.     0.    48.   4588.   27532.     419.   10.94  496.39
   RDWAY:RG       8.*******    58.    182.       0.       0.    2.00  500.02
   APPRO:AS      63.   -26.   131.   4750.   72531.    1020.    4.66  500.04

 SECOND USER DEFINED TABLE.
```

WSPRO OUTPUT FILE (continued)

```
        U.S. Geological Survey WSPRO Input File jeri031.wsp
        Hydraulic analysis for structure JERITH00350031   Date: 20-JUN-97
        Town Highway 35, Mill Brook, Jericho, Vermont                  ECW
           *** RUN DATE & TIME: 07-25-97  12:23

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

EXITX:XS   ******    -37      504  1.15 *****  495.50  493.00    4330  494.35
       -47 ******     62    31065  1.00 ***** *******    0.67    8.59

FULLV:FV       48    -41      624  0.77  0.69  496.19 *******    4330  495.42
         0     48     93    41917  1.02  0.00    0.00    0.57    6.94
          <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS       63    -13      540  1.00  0.92  497.22 *******    4330  496.22
        63     63     84    30669  1.00  0.12    0.00    0.60    8.02
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

 ===220 FLOW CLASS 1 (4) SOLUTION INDICATES POSSIBLE PRESSURE FLOW.
           WS3,WSIU,WS1,LSEL =   494.04     497.19     497.88     496.39

 ===245 ATTEMPTING FLOW CLASS 2 (5) SOLUTION.

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

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

BRIDG:BR       48      0      419  1.66 *****  498.05  493.87    4331  496.39
         0 ******     48    27532  1.00 ***** *******    0.62   10.33

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       1. ****   2.  0.475 ******  496.39 ****** ****** ******

    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       40    -23      932  0.36  0.45  499.82  494.44    4330  499.46
        63     42    124    64663  1.07  0.68    0.00    0.34    4.65
       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     ****** ****** ******** ****** ******   499.23
                     <<<<<END OF BRIDGE COMPUTATIONS>>>>>
  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS     -48.   -38.    62.   4330.   31065.     504.    8.59  494.35
   FULLV:FV       0.   -42.    93.   4330.   41917.     624.    6.94  495.42
   BRIDG:BR       0.     0.    48.   4331.   27532.     419.   10.33  496.39
   RDWAY:RG       8.**************      0.       0.       0.    2.00********
   APPRO:AS      63.   -24.   124.   4330.   64663.     932.    4.65  499.46

  SECOND USER DEFINED TABLE.
```

APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure JERITH00350031, in Jericho, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number JERITH00350031

General Location Descriptive

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

Date *(MM/DD/YY)* 11 / 30 / 95

Highway District Number *(I - 2; nn)* 05

County *(FIPS county code; I - 3; nnn)* 007

Town *(FIPS place code; I - 4; nnnnn)* 36700

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

Waterway *(I - 6)* MILL BROOK

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

Route Number C3035

Vicinity *(I - 9)* 0.04 MI TO JCT W CL2 TH1

Topographic Map Essex.Junction

Hydrologic Unit Code: -

Latitude *(I - 16; nnnn.n)* 44274

Longitude *(i - 17; nnnnn.n)* 73008

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 10040900310409

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

Maximum span length *(I - 48; nnnn)* 0050

Year built *(I - 27; YYYY)* 1919

Structure length *(I - 49; nnnnnn)* 000053

Average daily traffic, ADT *(I - 29; nnnnnn)* 000100

Deck Width *(I - 52; nn.n)* 138

Year of ADT *(I - 30; YY)* 93

Channel & Protection *(I - 61; n)* 4

Opening skew to Roadway *(I - 34; nn)* 10

Waterway adequacy *(I - 71; n)* 6

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

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

Structure type *(I - 43; nnn)* 303

Year Reconstructed *(I - 106)* 0000

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

Clear span *(nnn.n ft)* 49

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

Vertical clearance from streambed *(nnn.n ft)* 11

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

Waterway of full opening *(nnn.n ft^2)* 539

Comments:

According to the structural inspection report dated 11/22/93, the structure is an I-beam side girder with a wooden deck. The RABUT and its wings are laid up stone with a concrete cap and backwall. The laid up stone has small voids overall. The backwall has a 2" vertical crack just to the right of centerline with 6" vertical cracks on both ends and some movement along the crack lines. The LABUT, wings, backwall, and footing are concrete. The abutment has fine cracks and small leaks overall with alligator cracks and leaks and some spalling on the wing ends. The backwall has a 1/4" diagonal crack near centerline. The abutment has a 6" wide footing, with a 12" wide footing on the left wing. The left half of the abutment is under-

(Continued on page 33)

Bridge Hydrologic Data

Is there hydrologic data available? **Y** *if No, type ctrl-n h* VTAOT Drainage area *(mi²)*: **15.15**

Terrain character: **Hilly, mixed to mountainous, wooded**

Stream character & type:

Streambed material: **Sand and silt with some cobbles and boulders**

Discharge Data *(cfs)*: $Q_{2.33}$ **725** Q_{10} **1600** Q_{25} **2200**

Q_{50} **2750** Q_{100} **3300** 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: **According to a memo in the hydraulics files dated 7/11/95, a large sand, silt, and stone deposit sits adjacent to the right abutment. The river runs under the left portion of the bridge. A portion of the DS end of the LABUT has undergone some mild scour. Approximate 4" of what appears to be the footing is exposed.**

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*)	**328.9**	**331**	**332.5**	**333.6**	**334.6**
Velocity (*ft / sec*)					

Long term stream bed changes:

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

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

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

Upstream distance (*miles*): **2** Town: **Jericho** Year Built: _____

Highway No. : **TH33** Structure No. : **32** Structure Type: **I-beam wood**

Clear span (*ft*): **32.6** Clear Height (*ft*): **8** Full Waterway (ft^2): **260.8**

Downstream distance (*miles*): **.38** Town: **Jericho** Year Built: **1980**

Highway No. : **SA-1 (VT117)** Structure No. : **7** Structure Type: **Comp. rolled**

Clear span (*ft*): **61** Clear Height (*ft*): **9** Full Waterway (ft^2): **549**

Comments:

mined at least 3-1/2' under by 8-12" deep, with small voided areas along the bottom of the left-wing footing. A homemade stone dam extends across the channel just downstream, raising the water level at least 1 to 1.5'. A vegetation covered gravel bar in front of RABUT blocks nearly 2/3 of the channel flow. Much of the channel flow is against the left end and left wing on the LABUT and a scour hole in the area has been partially filled in with boulder fill.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **15.74** mi^2 Lake and pond area **0.01** mi^2

Watershed storage *(ST)* **0.06** %

Bridge site elevation **320** ft Headwater elevation **3680** ft

Main channel length **10.56** mi

10% channel length elevation **500** ft 85% channel length elevation **1590** ft

Main channel slope *(S)* **137.63** 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? Yes *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY):* - / -

Project Number BRO 1445 (22) Minimum channel bed elevation: 322.7

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

Benchmark location description:

-

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

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:

-

Comments:

Bridge survey of 1995 profile plan state: low steel elevation of 334.9 ft and top of bridge (roadway over-flow) 337.9 ft.

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 cord elevation is from the hydraulic report Profile plot by the VT AOT on 7/11/95. The low cord to bed length data is from the sketch attached to bridge inspection report, dated 11/22/93.**

Station	**LAB**				**RAB**	-	-	-	-	-	-
Feature	**334.9**	**334.9**	**334.9**	**334.9**	**334.9**	-	-	-	-	-	-
Low cord elevation	**322.7**	**322.7**	**325.9**	**327.5**	**326.4**	-	-	-	-	-	-
Bed elevation	**12.2**	**12.2**	**9.0**	**7.4**	**6.3**	-	-	-	-	-	-
Low cord to bed length	**11**	**22**	**37**	**49**	-	-	-	-	-	-	-

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: 08/14/96
Computerized by: EW Date: 08/14/96
Reviewd by: EW Date: 08/06/97

Structure Number JERITH00350031

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* M. IVANOFF Date *(MM/DD/YY)* 07 / 03 / 1996

2. Highway District Number 05
County WASHINGTON 007
Waterway *(I - 6)* MILL BROOK
Route Number TH 35
Mile marker 000000
Town JERICHO 36700
Road Name TAR BOX ROAD
Hydrologic Unit Code: 02010005

3. Descriptive comments:
Located 0.04 miles to junction with Town Highway 1.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 4 RBDS 5 Overall 6
*(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 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 53 *(feet)* Span length 50 *(feet)* Bridge width 13.8 *(feet)*

Road approach to bridge:

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

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

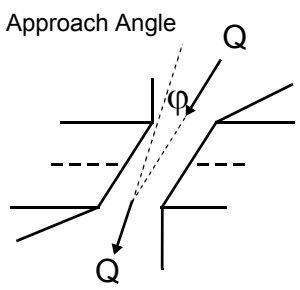
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

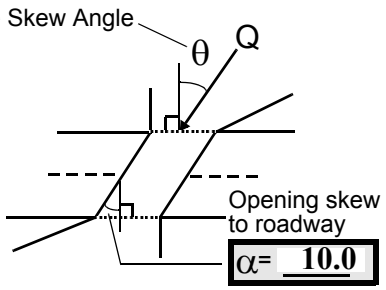
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	0	-	1	2
RBUS	0	-	0	-
RBDS	0	-	2	1
LBDS	2	1	0	-

*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: 0 16. Bridge skew: 0





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 35 feet US *(US, UB, DS)* to 0 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: **1a**

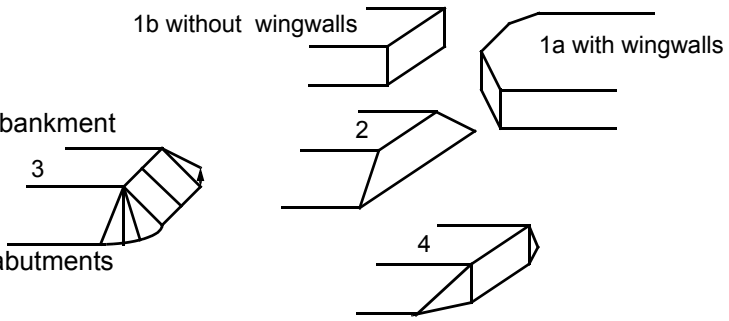
1a- Vertical abutments with wingwalls

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.)

#7: Values from VTAOT database. Measured the following during site visit: bridge length is 54 feet; bridge span is 49 feet; and bridge width is 12 feet.

C. Upstream Channel Assessment

	21. Bank height (BF)		22. Bank angle (BF)		26. % Veg. cover (BF)		27. Bank material (BF)		28. Bank erosion (BF)	
20. SRD	LB	RB	LB	RB	LB	RB	LB	RB	LB	RB
60.5	**13.0**			**9.0**	**4**	**4**	**34**	**34**	**1**	**0**

23. Bank width **20.0** 24. Channel width **10.0** 25. Thalweg depth **119.5** 29. Bed Material **435**

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

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

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

#30: Left bank protection extends from 50 feet upstream to the upstream bridge face.

A side channel during high flows exists along the left bank from 470 feet upstream to 60 feet upstream.

A bedrock waterfall exists 500 feet upstream of the bridge.

33. Point/Side bar present? **Y** *(Y or N. if N type ctrl-n pb)* 34. Mid-bar distance: **40 US** 35. Mid-bar width: **25**

36. Point bar extent: **95** feet **US** *(US, UB)* to **10** feet **DS** *(US, UB, DS)* positioned **50** %LB to **100** %RB

37. Material: **432**

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

Areas of this point bar are vegetated.

An additional point bar exists from 470 feet upstream to 120 feet upstream along the left bank. Trees are present on this 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: **180** 42. Cut bank extent: **300** feet **US** *(US, UB)* to **124** feet **US** *(US, UB, DS)*

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

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

The right bank has an area where 8 feet vertically of exposed material exists. At the base of the exposure is bank material comprised of cobbles and boulders.

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
25.0		**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.):

453

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

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

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

70. Debris and Ice Comments:

-

Many trees are leaning in channel, especially in the cut-bank areas. There are also many logs and trees in channel and along banks where the channel bends upstream.

Abutments	71. Attack ∠(BF)	72. Slope ∠ (Qmax)	73. Toe loc. (BF)	74. Scour Condition	75. Scour depth	76. Exposure depth	77. Material	78. Length
LABUT		**0**	**90**	**2**	**2**	**0**	**0.8**	**90.0**
RABUT	**1**	**0**	**90**			**2**	**0**	**47.5**

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.):

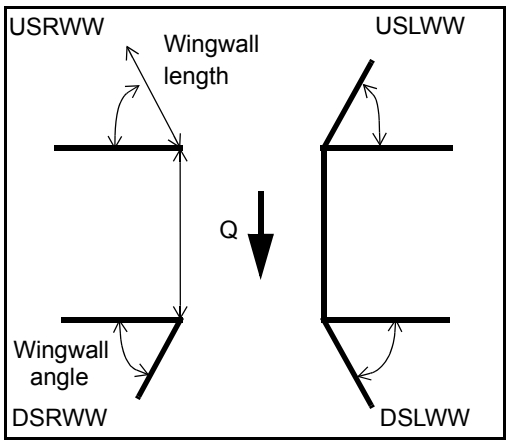
-

-

2

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:						**47.5**	
USRWW:	**Y**		**1**		**2**	**1.0**	
DSLWW:	**0**		**0.8**		**Y**	**15.0**	
DSRWW:	**2**		**0**		**-**	**17.0**	



*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	-	**2**	**Y**	-	**2**	-	-	-
Condition	**Y**	**0**	**2**	-	**4**	-	-	-
Extent	**1**	**0.4**	**0**	**2**	**0**	**0**	**0**	-

*Bank / Bridge protection types: **0**- absent; **1**- < 12 inches; **2**- < 36 inches; **3**- < 48 inches; **4**- < 60 inches; **5**- wall / artificial levee*

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

*Protection extent: **1**- entire base length; **2**- US end; **3**- DS end; **4**- other*

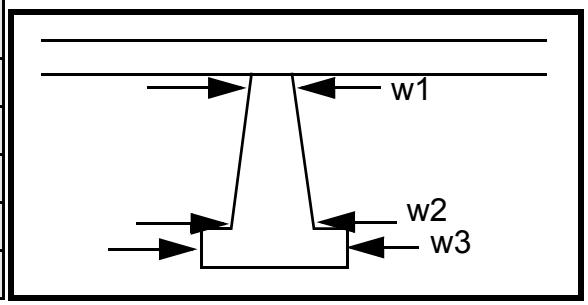
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):

-
-
-
-
-
2
1
3
0
-
-

Piers:

84. Are there piers? **Ch** *(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				**60.0**	**10.5**	**50.0**
Pier 2	**8.0**	**6.5**	**6.0**	**85.0**	**65.0**	-
Pier 3	-	-	-	-	-	-
Pier 4	-	-	-	-	-	-



Level 1 Pier Descr.	1	2	3	4
86. Location (BF)	**anne**	**ing**	**pro-**	**exte**
87. Type	**l is**	**alon**	**tec-**	**nds**
88. Material	**impa**	**g the**	**tion**	**upst**
89. Shape	**cting**	**left**	**begi**	**ream**
90. Inclined?	**the**	**abut**	**ns in**	**.**
91. Attack ∠ (BF)	**upst**	**ment**	**the**	**Larg**
92. Pushed	**ream**	**.**	**mid-**	**e**
93. Length (feet)	-	-	-	-
94. # of piles	**left**	**Upst**	**dle**	**stone**
95. Cross-members	**wing**	**ream**	**of**	**fill**
96. Scour Condition	**wall**	**left**	**the**	**(type**
97. Scour depth	**and**	**wing**	**wall**	**-3) is**
98. Exposure depth	**flow-**	**wall**	**and**	**alon**

LFP, LTB, LB, MCL, MCM, MCR, RB, RTB, RFP

***1**- Solid pier, **2**- column, **3**- bent*

***1**- Wood; **2**- concrete; **3**- metal; **4**- stone*

***1**- Round; **2**- Square; **3**- Pointed*

Y- yes; N- no

LB or RB

***0**- none; **1**- laterals; **2**- diagonals; **3**- both*

***0**- not evident; **1**- evident (comment);*
***2**- footing exposed; **3**- piling exposed;*
***4**- undermined footing; **5**- settled; **6**- failed*

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

g the base of the footing in the channel under the bridge.

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: **2**

Scour dimensions: Length **2** Width **43** Depth: **43** Positioned **0** %LB to **1** %RB

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

543
2
0
1

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

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

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

Confluence comments (eg. confluence name):

from 310 feet downstream to 450 feet downstream, where a waterfall exists and drops 6 feet vertically.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **Lef**

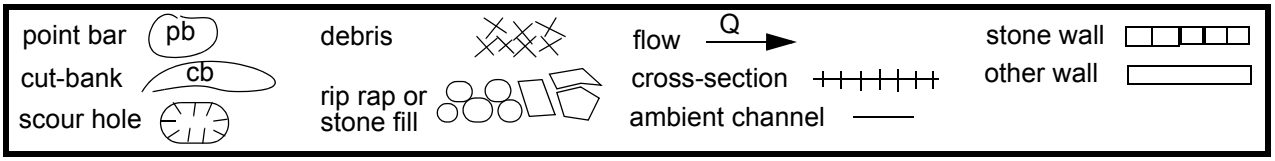
__1__- Constructed
__2__- Stable
__3__- Aggraded
__4__- Degraded
__5__- Laterally unstable
__6__- Vertically and laterally unstable

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

t bank protection extends from end of downstream left wingwall to 20 feet downstream.

N

109. G. Plan View Sketch



APPENDIX F:

SCOUR COMPUTATIONS

SCOUR COMPUTATIONS

Structure Number: JERITH00350031 Town: JERICHO
Road Number: TH 35 County: CHITTENDEN
Stream: MILL BROOK

Initials ECW Date: 7/21/97 Checked:MAI

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	3300	4750	4330
Main Channel Area, ft2	537	946	881
Left overbank area, ft2	0	0	0
Right overbank area, ft2	0	74	50
Top width main channel, ft	98	113	111
Top width L overbank, ft	0	0	0
Top width R overbank, ft	0	44	37
D50 of channel, ft	0.266	0.266	0.266
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	5.5	8.4	7.9
y1, average depth, LOB, ft	ERR	ERR	ERR
y1, average depth, ROB, ft	ERR	1.7	1.4
Total conveyance, approach	30391	72510	64628
Conveyance, main channel	30391	70785	63601
Conveyance, LOB	0	0	0
Conveyance, ROB	0	1725	1027
Percent discrepancy, conveyance	0.0000	0.0000	0.0000
Qm, discharge, MC, cfs	3300.0	4637.0	4261.2
Ql, discharge, LOB, cfs	0.0	0.0	0.0
Qr, discharge, ROB, cfs	0.0	113.0	68.8
Vm, mean velocity MC, ft/s	6.1	4.9	4.8
Vl, mean velocity, LOB, ft/s	ERR	ERR	ERR
Vr, mean velocity, ROB, ft/s	ERR	1.5	1.4
Vc-m, crit. velocity, MC, ft/s	9.6	10.3	10.2
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	3300	4750	4330
(Q) discharge thru bridge, cfs	3300	4588	4330
Main channel conveyance	22676	27532	27532
Total conveyance	22676	27532	27532
Q2, bridge MC discharge,cfs	3300	4588	4330
Main channel area, ft2	286	419	419
Main channel width (normal), ft	46.6	47.3	47.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	46.6	47.3	47.3
y_bridge (avg. depth at br.), ft	6.14	8.86	8.86
Dm, median (1.25*D50), ft	0.3325	0.3325	0.3325
y2, depth in contraction,ft	6.53	8.55	8.14
ys, scour depth (y2-ybridge), ft	0.39	-0.30	-0.72

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	3300	4588	4330
Main channel area (DS), ft2	286	390	374
Main channel width (normal), ft	46.6	47.3	47.3
Cum. width of piers, ft	0.0	0.0	0.0
Adj. main channel width, ft	46.6	47.3	47.3
D90, ft	0.7088	0.7088	0.7088
D95, ft	0.8602	0.8602	0.8602
Dc, critical grain size, ft	0.6181	0.5683	0.5599
Pc, Decimal percent coarser than Dc	0.138	0.164	0.170
Depth to armoring, ft	11.58	8.69	8.20

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	3300	4750	4330
Q, thru bridge MC, cfs	3300	4588	4330
Vc, critical velocity, ft/s	9.57	10.27	10.18
Va, velocity MC approach, ft/s	6.15	4.90	4.84
Main channel width (normal), ft	46.6	47.3	47.3
Cum. width of piers in MC, ft	0.0	0.0	0.0
W, adjusted width, ft	46.6	47.3	47.3
qbr, unit discharge, ft2/s	70.8	97.0	91.5
Area of full opening, ft2	286.0	419.0	419.0
Hb, depth of full opening, ft	6.14	8.86	8.86
Fr, Froude number, bridge MC	0	0.65	0.62
Cf, Fr correction factor (<=1.0)	0.00	1.00	1.00
**Area at downstream face, ft2	N/A	390	374
**Hb, depth at downstream face, ft	N/A	8.25	7.91
**Fr, Froude number at DS face	ERR	0.72	0.73
**Cf, for downstream face (<=1.0)	N/A	1.00	1.00
Elevation of Low Steel, ft	0	496.39	496.39
Elevation of Bed, ft	-6.14	487.53	487.53
Elevation of Approach, ft	0	500.04	499.46
Friction loss, approach, ft	0	0.34	0.45
Elevation of WS immediately US, ft	0.00	499.70	499.01
ya, depth immediately US, ft	6.14	12.17	11.48
Mean elevation of deck, ft	0	499.33	499.33
w, depth of overflow, ft (>=0)	0.00	0.37	0.00
Cc, vert contrac correction (<=1.0)	1.00	0.93	0.94
**Cc, for downstream face (<=1.0)	ERR	0.907833	0.903517
Ys, scour w/Chang equation, ft	N/A	1.31	0.75
Ys, scour w/Umbrell equation, ft	N/A	-0.43	-0.78

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

**Ys, scour w/Chang equation, ft	N/A	2.16	2.04
**Ys, scour w/Umbrell equation, ft	ERR	0.18	0.17

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

y2, from Laursen's equation, ft	6.53	8.55	8.14
WSEL at downstream face, ft	--	495.78	495.42
Depth at downstream face, ft	N/A	8.25	7.91
Ys, depth of scour (Laursen), ft	N/A	0.31	0.23

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	3300	4750	4330	3300	4750	4330
a', abut.length blocking flow, ft	14	26.1	24.1	37.2	83.4	76.5
Ae, area of blocked flow ft2	45.5	115.5	108.1	129.6	333.4	304.3
Qe, discharge blocked abut.,cfs	187.3	--	336.8	568.3	--	1126.7
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.12	3.15	3.12	4.39	3.75	3.70
ya, depth of f/p flow, ft	3.25	4.43	4.49	3.48	4.00	3.98
--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	100	100	100	80	80	80
K2	1.01	1.01	1.01	0.98	0.98	0.98
Fr, froude number f/p flow	0.402	0.264	0.259	0.414	0.331	0.327
ys, scour depth, ft	9.85	12.37	12.14	13.81	17.77	17.13

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)	14	26.1	24.1	37.2	83.4	76.5
y1 (depth f/p flow, ft)	3.25	4.43	4.49	3.48	4.00	3.98
a'/y1	4.31	5.90	5.37	10.68	20.86	19.23
Skew correction (p. 49, fig. 16)	1.02	1.02	1.02	0.97	0.97	0.97
Froude no. f/p flow	0.40	0.26	0.26	0.41	0.33	0.33
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

Isbash Relationship
D50=y*K*Fr^2/(Ss-1) and D50=y*K*(Fr^2)^0.14/(Ss-1)
(Richardson and others, 1995, p112, eq. 81,82)

Characteristic	Q100	Q500	Other Q	Q100	Q500	Other Q
Fr, Froude Number	0.82	0.72	0.73	0.82	0.72	0.73
y, depth of flow in bridge, ft	6.14	8.25	7.91	6.14	8.25	7.91
Median Stone Diameter for riprap at:	left abutment			right abutment, ft		
Fr<=0.8 (vertical abut.)	ERR	2.64	2.61	ERR	2.64	2.61
Fr>0.8 (vertical abut.)	2.43	ERR	ERR	2.43	ERR	ERR
Fr<=0.8 (spillthrough abut.)	ERR	2.31	2.27	ERR	2.31	2.27
Fr>0.8 (spillthrough abut.)	2.15	ERR	ERR	2.15	ERR	ERR