LEVEL II SCOUR ANALYSIS FOR BRIDGE 11R (ROCKTH0001011R) on TOWN HIGHWAY 1 (VT 121, FAS 125), crossing the SAXTONS RIVER, ROCKINGHAM, VERMONT

U.S. Geological Survey
Open-File Report 97-345

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 11R (ROCKTH0001011R) on TOWN HIGHWAY 1 (VT 121, FAS 125), crossing the SAXTONS RIVER, ROCKINGHAM, VERMONT

By Erick M. Boehmler

U.S. Geological Survey
Open-File Report 97-345

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

Pembroke, New Hampshire

1997

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

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

For additional information write to:

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

Copies of this report may be purchased from:

U.S. Geological Survey
Branch of Information Services
Open-File Reports Unit
Box 25286
Denver, CO 80225-0286

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

OTHER ABBREVIATIONS

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

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

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

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

LEVEL II SCOUR ANALYSIS FOR BRIDGE 11R (ROCKTH0001011R) ON TOWN HIGHWAY 1, (VT121, FAS 125) CROSSING THE SAXTONS RIVER, ROCKINGHAM, VERMONT

By **Erick M. Boehmler**

INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure ROCKTH0001011R on Town Highway 1 crossing the Saxtons River, Rockingham, 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 68.3-mi^2 drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover consists of houses, short grass, and scattered trees except along the immediate river banks, which are tree covered.

In the study area, the Saxtons River has a sinuous channel with a slope of approximately 0.005 ft/ft, an average channel top width of 121 ft and an average bank height of 8 ft. The predominant channel bed materials are gravel and cobbles with a median grain size (D_{50}) of 109 mm (0.359 ft). The geomorphic assessment at the time of the Level I and Level II site visit on September 3, 1996, indicated that the reach was laterally unstable. Lateral instability was evident with respect to a cut-bank on the left bank upstream with slip failure of bank material. Furthermore, there is a wide point bar along the right bank upstream opposite the cut-bank.

The Town Highway 1 crossing of the Saxtons River is a 184-ft-long, two-lane bridge consisting of three steel-beam spans (Vermont Agency of Transportation, written communication, March 30, 1995). The bridge is supported by vertical, concrete, skeletal-style abutment walls with spill-through embankments adjacent to each wall. The channel is skewed approximately 35 degrees to the opening while the opening-skew-to-roadway is 30 degrees.

The only scour protection measure at the site was type-3 stone fill (less than 48 inches diameter) on the spill-through embankments. Additional details describing conditions at the site are included in the Level II Summary and Appendices D and E.

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

There was no computed contraction scour for all modelled flows at this site. Abutment scour ranged from 9.0 to 13.4 feet. The worst-case abutment scour occurred at the 500-year discharge for the left abutment. There are two piers for which computed pier scour ranged from 9.0 to 18.4 feet. The left and right piers in this report are presented as pier 1 and pier 2, respectively. The worst-case pier scour occurred at pier 2 for 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 ROCKTH0001011R ***Stream*** Saxtons River

County Windham ***Road*** TH 1 ***District*** 2

Description of Bridge

Bridge length 184 ***ft*** ***Bridge width*** 39.0 ***ft*** ***Max span length*** 69 ***ft***

Alignment of bridge to road (on curve or straight) Straight, left; Curve, right

Abutment type Spill-through ***Embankment type*** Sloping

Stone fill on abutment? Yes ***Date of inspection*** 9/3/96

Description of stone fill Type-3 on the spill-through embankments adjacent to each abutment wall.

Brief description of piers/abutments Abutments are concrete, skeletal style walls with spill-through embankments. Piers are solid concrete and are wider and longer at the streambed than at the bridge seat elevation.

Is bridge skewed to flood flow according to Yes ***survey?*** Yes ***Angle*** 35

Is there a channel bend in the bridge vicinity? If so, describe (mild, moderate, severe) There is a mild channel bend in the upstream reach.

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	9/3/96	0	0
Level II	9/3/96	0	0

Potential for debris Moderate. There is dense tree cover on the banks upstream and the channel is laterally unstable.

Describe any features near or at the bridge that may affect flow (include observation date) None noted on 9/3/96

Description of the Geomorphic Setting

General topography The channel is located in a moderate relief valley setting with narrow, irregular overbank areas and steep valley walls on both sides.

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

Date of inspection 9/3/96

DS left: Mild sloping channel bank to a narrow overbank.

DS right: Mildly sloping channel bank to a narrow overbank.

US left: Moderately sloping channel bank to a narrow overbank.

US right: Steep channel bank to a narrow terrace.

Description of the Channel

Average top width 121 ***ft*** ***Average depth*** 8 ***ft***

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

Sinuous and laterally unstable with wide point bars and semi-alluvial channel boundaries

9/3/96

Vegetative co

DS left: Trees and brush

DS right: Trees, shrubs, and brush

US left: Trees and brush

US right: Trees and shrubs

Do banks appear stable? No

The assessment on 9/3/96 indicated the reach was laterally unstable. A point bar adjacent to a cut-bank was noted in the upstream reach near the bridge. The bank material at the cut-bank was noted as slumped and the point bar width occupied about 60 percent of the channel width on the right side.

date of observation.

A large deltaic accumulation of material was noted on 9/3/96. It is located on the left bank side of the channel at the downstream face of the bridge where a small tributary stream enters the Saxtons River. The accumulation blocks flows up to three feet in the left span.

Describe any obstructions in channel and date of observation.

Hydrology

Drainage area 68.3 ***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? Yes

USGS gage description Saxtons River at Saxtons River, VT

USGS gage number 01154000 (Discontinued, 1982)

Gage drainage area 72.2 ***mi²***

Is there a lake/p No

Calculated Discharges

Q100 10,600 ***ft³/s*** ***Q500*** 16,000 ***ft³/s***

The 100- and 500-year discharges were taken from the flood insurance study for the town of Rockingham (Federal Emergency Management Agency, 1979). These discharges were based on the period of gaged streamflow records from 1940 through 1982.

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

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

Datum tie between USGS survey and VTAOT plans Subtract 23.9 feet from the USGS arbitrary survey datum to obtain the VTAOT plans' datum.

Description of reference marks used to determine USGS datum. RM1 is the center point of a chiseled "X" on top of the left abutment concrete at the downstream end (elev. 520.43 feet, arbitrary survey datum). RM2 is the center point of a chiseled "X" on top of the 10th concrete guardrail post from the left end of the bridge on the downstream side (elev. 523.14 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	-170	1	Exit section
FULLV	0	2	Downstream Full-valley section (Templated from EXITX)
BRIDG	0	1	Bridge section
RDWAY	26	1	Road Grade section
APPRO	204	2	Modelled Approach section (Templated from APTEM)
APTEM	231	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 0.055, and overbank "n" values ranged from 0.050 to 0.060.

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 0.0053 ft/ft, which was estimated from the 100-year-discharge water surface profile downstream of the site presented in the flood insurance study for the town of Rockingham (FEMA, 1979).

The surveyed approach section (APTEM) was moved along the approach channel slope (0.0022 ft/ft) to establish the modelled approach section (APPRO), one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location also provides a consistent method for determining scour variables.

Bridge Hydraulics Summary

Average bridge embankment elevation 519.5 ***ft***
Average low steel elevation 515.3 ***ft***

100-year discharge 10,600 ***ft³/s***
Water-surface elevation in bridge opening 502.5 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 1200 ***ft²***
Average velocity in bridge opening 8.8 ***ft/s***
Maximum WSPRO tube velocity at bridge 10.2 ***ft/s***

Water-surface elevation at Approach section with bridge 503.8
Water-surface elevation at Approach section without bridge 503.7
Amount of backwater caused by bridge 0.1 ***ft***

500-year discharge 16,000 ***ft³/s***
Water-surface elevation in bridge opening 504.3 ***ft***
Road overtopping? No ***Discharge over road*** -- ***ft³/s***
Area of flow in bridge opening 1420 ***ft²***
Average velocity in bridge opening 11.3 ***ft/s***
Maximum WSPRO tube velocity at bridge 13.2 ***/s***

Water-surface elevation at Approach section with bridge 505.9
Water-surface elevation at Approach section without bridge 505.7
Amount of backwater caused by bridge 0.2

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

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

Scour Analysis Summary

Special Conditions or Assumptions Made in Scour Analysis

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

Contraction scour was computed by use of the clear-water contraction scour equation (Richardson and others, 1995, p. 32, equation 20). For contraction scour computations, the average depth in the contracted section (AREA/TOPWIDTH) is subtracted from the depth of flow computed by the scour equation (Y2) to determine the actual amount of scour.

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

Because the influence of scour processes on the spill-through embankment material is uncertain, the scour depth at the vertical concrete abutment walls is unknown. Therefore, scour depths were applied for the entire spill-through embankment area below the elevation at the toe of each embankment, as shown in figure 8.

Pier scour was computed by use of an equation developed at Colorado State University (Richardson and others, 1995, p. 36, equation 21) for all discharges modeled. Variables for the pier scour equation include pier length, pier width, average depth and maximum velocity (for the froude number) immediately upstream of the bridge, and correction factors for pier shape, flow attack angle, streambed-form, and streambed armoring.

Scour Results

Contraction scour:	*100-yr discharge*	*500-yr discharge*	*Incipient overtopping discharge*
		(Scour depths in feet)	
Main channel			
Live-bed scour	--	--	--
Clear-water scour	0.0	0.0	--
Depth to armoring	0.4	2.9	--
Left overbank	--	--	--
Right overbank	--	--	--

Local scour:			
Abutment scour	9.0	13.4	--
Left abutment	9.1	11.7	--
Right abutment			
Pier scour	9.0	12.1	--
Pier 1	13.7	18.4	--
Pier 2	--	--	--
Pier 3			

Riprap Sizing

	100-yr discharge	*500-yr discharge*	*Incipient overtopping discharge*
		(D_{50} in feet)	
Abutments:	1.5	2.4	--
Left abutment	1.5	2.4	--
Right abutment			
Piers:	1.4	2.3	--
Pier 1	1.4	2.3	--
Pier 2	--	--	--

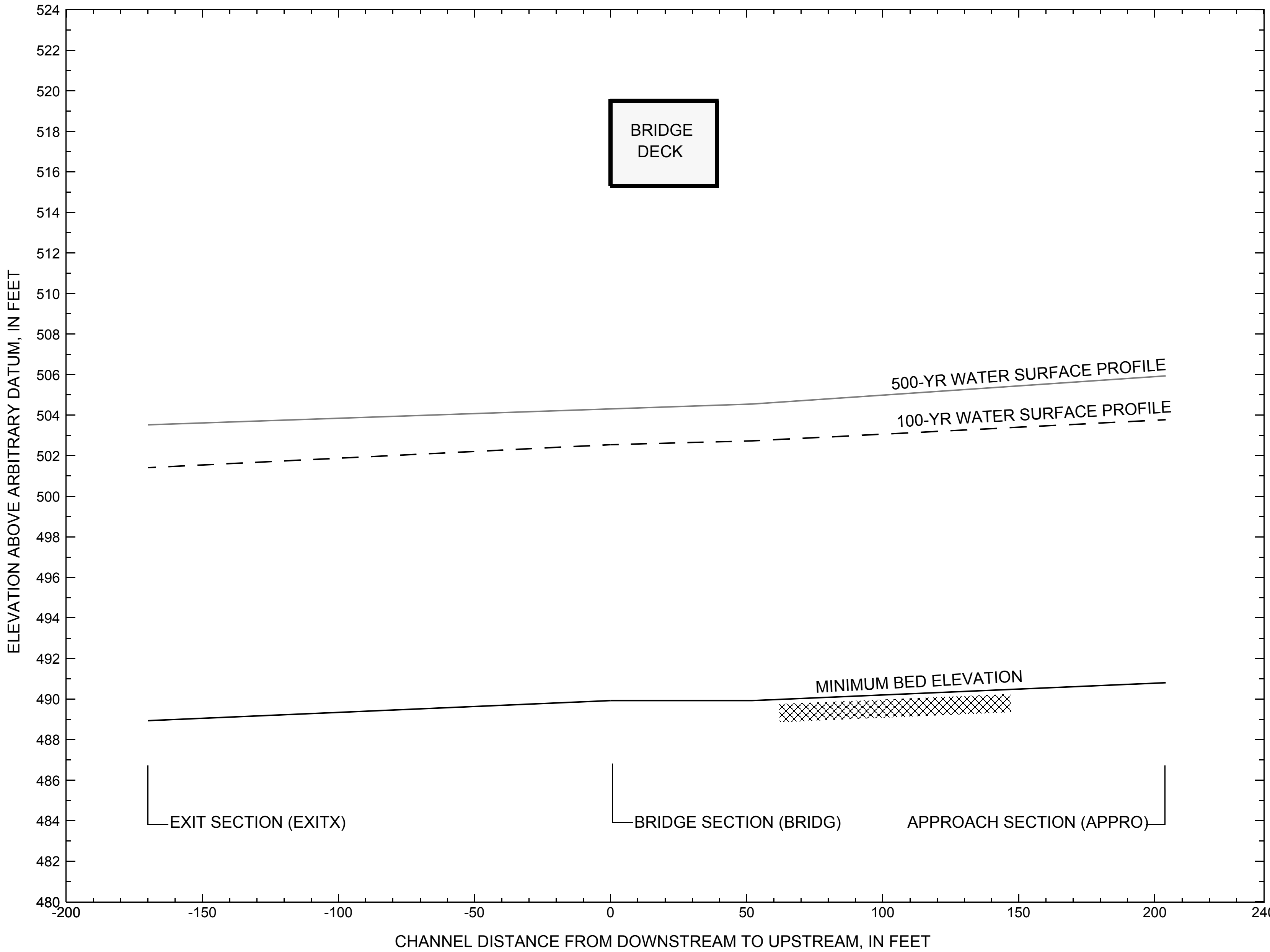


Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure ROCKTH0001011R on Town Highway 1, crossing the Saxtons River, Rockingham, Vermont.

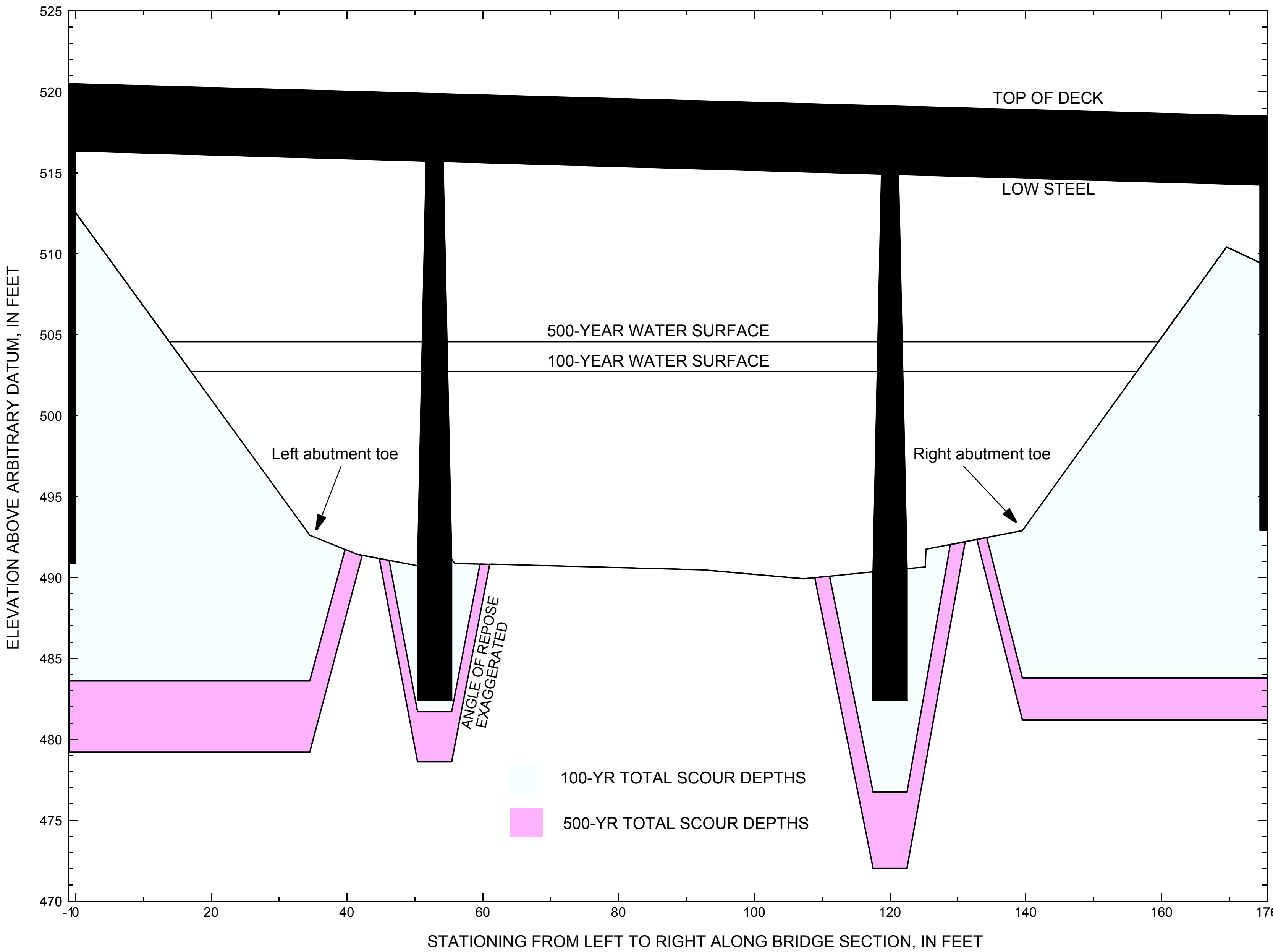


Figure 8. Scour elevations for the 100-yr and 500-yr discharges at structure ROCKTH0001011R on Town Highway 1, crossing the Saxtons River, Rockingham, Vermont.

Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure ROCKTH0001011R on Town Highway 1, crossing the Saxtons River, Rockingham, Vermont.
[VTAOT, Vermont Agency of Transportation; --,no data]

Description	Station[1]	VTAOT Bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
100-yr. discharge is 10,600 cubic-feet per second											
Left abutment	0.0	491.3	516.4	490.9	512.6	--	--	--	--	--	-7.3
Left abutment toe	34.5	--	--	--	492.6	0.0	9.0	--	9.0	483.6	--
Pier 1	52.9	490.6	--	482.4	490.7	0.0	--	9.0	9.0	481.7	-0.7
Pier 2	120.0	489.8	--	482.4	490.4	0.0	--	13.7	13.7	476.7	-5.7
Right abutment toe	139.5	--	--	--	492.9	0.0	9.1	--	9.1	483.8	--
Right abutment	174.5	489.2	514.3	492.9	509.4	--	--	--	--	--	-9.1

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 ROCKTH0001011R on Town Highway 1, crossing the Saxtons River, Rockingham, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

Description	Station[1]	VTAOT Bridge seat elevation (feet)	Surveyed minimum low-chord elevation[2] (feet)	Bottom of footing elevation[2] (feet)	Channel elevation at abutment/ pier[2] (feet)	Contraction scour depth (feet)	Abutment scour depth (feet)	Pier scour depth (feet)	Depth of total scour (feet)	Elevation of scour[2] (feet)	Remaining footing/pile depth (feet)
500-yr. discharge is 16,000 cubic-feet per second											
Left abutment	0.0	491.3	516.4	490.9	512.6	--	--	--	--	--	-11.7
Left abutment toe	34.5	--	--	--	492.6	0.0	13.4	--	13.4	479.2	--
Pier 1	52.9	490.6	--	482.4	490.7	0.0	--	12.1	12.1	478.6	-3.8
Pier 2	120.0	489.8	--	482.4	490.4	0.0	--	18.4	18.4	472.0	-10.4
Right abutment toe	139.5	--	--	--	492.9	0.0	11.7	--	11.7	481.2	--
Right abutment	174.5	489.2	514.3	492.9	509.4	--	--	--	--	--	-11.7

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

SELECTED REFERENCES

Arcement, G.J., Jr., and Schneider, V.R., 1989, Guide for selecting Manning's roughness coefficients for natural channels and flood plains: U.S. Geological Survey Water-Supply Paper 2339, 38 p.

Barnes, H.H., Jr., 1967, Roughness characteristics of natural channels: U.S. Geological Survey Water-Supply Paper 1849, 213 p.

Benson, M. A., 1962, Factors Influencing the Occurrence of Floods in a Humid Region of Diverse Terrain: U.S. Geological Survey Water-Supply Paper 1580-B, 64 p.

Brown, S.A. and Clyde, E.S., 1989, Design of riprap revetment: Federal Highway Administration Hydraulic Engineering Circular No. 11, Publication FHWA-IP-89-016, 156 p.

Federal Highway Administration, 1983, Runoff estimates for small watersheds and development of sound design: Federal Highway Administration Report FHWA-RD-77-158

Federal Emergency Management Agency, 1979, Flood Insurance Study, Town of Rockingham and Village of Bellows Falls, Windham County, Vermont: Washington, D.C., November 1979.

Froehlich, D.C., 1989, Local scour at bridge abutments *in* Ports, M.A., ed., Hydraulic Engineering--Proceedings of the 1989 National Conference on Hydraulic Engineering: New York, American Society of Civil Engineers, p. 13-18.

Hayes, D.C.,1993, Site selection and collection of bridge-scour data in Delaware, Maryland, and Virginia: U.S. Geological Survey Water-Resources Investigation Report 93-4017, 23 p.

Interagency Advisory Committee on Water Data, 1982, Guidelines for determining flood flow frequency: U.S. Geological Survey, Bulletin 17B of the Hydrology Subcommittee, 190 p.

Johnson, C.G. and Tasker, G.D.,1974, Progress report on flood magnitude and frequency of Vermont streams: U.S. Geological Survey Open-File Report 74-130, 37 p.

Lagasse, P.F., Schall, J.D., Johnson, F., Richardson, E.V., Chang, F., 1995, Stream Stability at Highway Structures: Federal Highway Administration Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.

Laursen, E.M., 1960, Scour at bridge crossings: Journal of the Hydraulics Division, American Society of Civil Engineers, v. 86, no. HY2, p. 39-53.

Potter, W. D., 1957a, Peak rates of runoff in the Adirondack, White Mountains, and Maine woods area, Bureau of Public Roads

Potter, W. D., 1957b, Peak rates of runoff in the New England Hill and Lowland area, Bureau of Public Roads

Richardson, E.V. and Davis, S.R., 1995, Evaluating scour at bridges: Federal Highway Administration Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.

Richardson, E.V., Simons, D.B., and Julien, P.Y., 1990, Highways in the river environment: Federal Highway Administration Publication FHWA-HI-90-016.

Ritter, D.F., 1984, Process Geomorphology: W.C. Brown Co., Debuque, Iowa, 603 p.

Shearman, J.O., 1990, User's manual for WSPRO--a computer model for water surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 187 p.

Shearman, J.O., Kirby, W.H., Schneider, V.R., and Flippo, H.N., 1986, Bridge waterways analysis model; research report: Federal Highway Administration Publication FHWA-RD-86-108, 112 p.

Talbot, A.N., 1887, The determination of water-way for bridges and culverts.

U.S. Department of Transportation, 1993, Stream stability and scour at highway bridges, Participant Workbook: Federal Highway Administration Publication FHWA HI-91-011.

U.S. Geological Survey, 1985, Bellows Falls, 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

U.S. Geological Survey, 1984, Saxtons River, 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 rock11r.wsp
T2        Hydraulic analysis for structure ROCKTH0001011R   Date: 31-JAN-97
T3        Town Highway 1 (VT 121 & FAS 125) over Saxtons River, Rockingham   EMB
*
J3         6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
*
Q          10600.0  16000.0
SK          0.0053   0.0053
*
XS   EXITX   -170
GR          -99.1, 511.76    -59.1, 501.45     20.0, 499.57     44.8, 492.20
GR           62.0, 490.18     82.8, 489.63     94.4, 488.93    110.4, 489.69
GR          112.6, 490.23    142.9, 499.00    163.9, 501.64    324.9, 506.18
GR          370.2, 515.62
*
N           0.060        0.050        0.055
SA                  20.0        142.9
*
XS   FULLV      0  * * *   0.00582
*
*             SRD     LSEL    XSSKEW
BR   BRIDG     0    515.31      30.0
GR            0.0, 516.35      0.0, 512.55     34.5, 492.61     41.5, 491.43
GR           51.3, 490.66     55.9, 490.86     92.4, 490.47    107.3, 489.92
GR          125.2, 490.65    125.3, 491.74    139.5, 492.89    169.6, 510.42
GR          174.5, 509.44    174.5, 514.26      0.0, 516.35
*
*           Scour hole removed as it is not present at upstream face...
*           118.2, 487.48    122.8, 488.36    52.9, 514.37     120.0, 513.64
*         BRTYPE  BRWDTH    EMBSS   EMBELV
CD           3      52.6      1.0    519.5
PW        489.92, 10.0   514.91, 5.0   514.91, 2.5   515.72,  2.5
PW        515.72,  0.0
N           0.040
*
*             SRD    EMBWID   IPAVE
XR   RDWAY     26      39.0     1
GR         -172.8, 523.63   -135.5, 522.25    -11.0, 520.07      0.0, 520.49
GR          174.2, 518.51
*
XT   APTEM    231
GR          -45.1, 517.18    -12.6, 503.03     20.0, 502.42     30.6, 499.28
GR           45.3, 492.80     51.7, 492.11     53.3, 491.31     59.2, 491.14
GR           67.6, 490.99     71.3, 490.86     78.0, 491.25     84.9, 492.07
GR          109.1, 495.13    132.3, 496.84    138.8, 502.10    156.0, 501.38
GR          166.7, 509.50    205.2, 513.84    263.9, 514.96
*
AS   APPRO    204  * * *  0.0022
GT
N           0.050        0.055
SA                  20.0
*
HP 1 BRIDG 502.54 1 502.54
HP 2 BRIDG 502.54 * * 10600
HP 2 BRIDG 502.73 * * 10600
HP 1 APPRO 503.77 1 503.77
HP 2 APPRO 503.77 * * 10600
```

APPENDIX B:

WSPRO OUTPUT FILE

WSPRO OUTPUT FILE

```
     U.S. Geological Survey WSPRO Input File rock11r.wsp
     Hydraulic analysis for structure ROCKTH0001011R   Date: 31-JAN-97
     Town Highway 1 (VT 121 & FAS 125) over Saxtons River, Rockingham   EMB
        *** RUN DATE & TIME: 02-20-97  13:30

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

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1     1203    200167    120    127                         21592
502.54          1203    200167    120    127  1.00     17    156    21592

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    502.54    17.3   156.1  1202.7  200167.   10600.   8.81

X STA.        17.3        37.2        44.0        50.0        55.5        60.9
  A(I)             97.4        64.3        60.4        56.0        54.8
  V(I)             5.44        8.24        8.77        9.46        9.67

X STA.        60.9        66.3        71.6        76.7        81.8        87.0
  A(I)             54.9        53.7        53.2        52.9        53.1
  V(I)             9.65        9.87        9.96       10.03        9.98

X STA.        87.0        92.0        97.0       101.9       106.7       111.6
  A(I)             52.4        52.9        52.4        51.8        53.4
  V(I)            10.11       10.02       10.11       10.23        9.93

X STA.       111.6       116.7       122.1       128.8       136.1       156.1
  A(I)             54.7        56.2        65.4        64.6        98.1
  V(I)             9.69        9.43        8.11        8.21        5.40

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

      WSEL     LEW     REW    AREA        K        Q    VEL
    502.73    17.0   156.4  1225.6  205820.   10600.   8.65

X STA.        17.0        36.9        44.0        49.9        55.4        60.9
  A(I)             98.6        67.5        59.7        57.2        57.2
  V(I)             5.38        7.85        8.88        9.27        9.26

X STA.        60.9        66.2        71.6        76.7        81.9        87.0
  A(I)             54.8        55.7        54.1        53.7        53.9
  V(I)             9.68        9.52        9.80        9.87        9.83

X STA.        87.0        92.0        97.0       101.9       106.8       111.6
  A(I)             53.0        53.4        53.0        54.6        53.1
  V(I)            10.01        9.92       10.01        9.71        9.98

X STA.       111.6       116.8       122.3       128.8       136.3       156.4
  A(I)             55.6        58.8        64.8        67.7        99.4
  V(I)             9.54        9.01        8.18        7.82        5.33

 CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     204.

  WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
          1       37      1139     34     35                           215
          2     1135    121600    139    144                         18387
503.77          1172    122740    174    179  1.04    -13    159    16957

 VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     204.

      WSEL     LEW     REW    AREA        K        Q    VEL
    503.77   -14.4   159.2  1171.7  122740.   10600.   9.05

X STA.       -14.4        37.7        44.6        49.3        53.6        57.3
  A(I)            111.6        63.1        53.4        50.1        47.7
  V(I)             4.75        8.40        9.92       10.58       11.12

X STA.        57.3        61.0        64.5        68.1        71.6        75.1
  A(I)             45.8        45.8        45.5        45.3        45.1
  V(I)            11.58       11.56       11.66       11.70       11.76

X STA.        75.1        78.8        82.7        86.8        91.4        96.5
  A(I)             46.4        47.9        48.4        51.4        54.0
  V(I)            11.43       11.07       10.95       10.32        9.81

X STA.        96.5       102.2       108.7       116.5       126.0       159.2
  A(I)             56.7        60.2        65.5        74.5       113.4
  V(I)             9.35        8.81        8.09        7.11        4.67
```

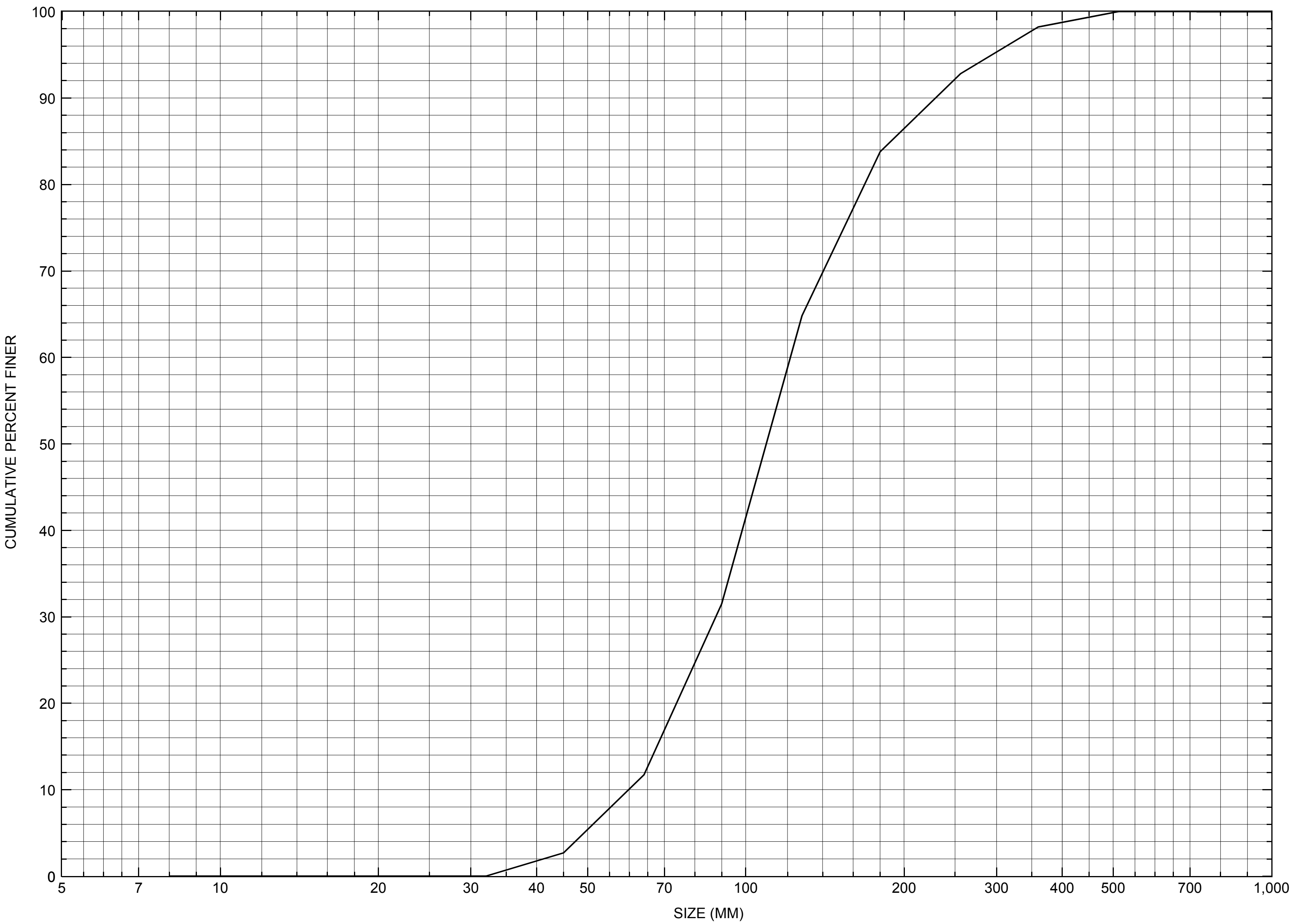
```
       U.S. Geological Survey WSPRO Input File rock11r.wsp
       Hydraulic analysis for structure ROCKTH0001011R   Date: 31-JAN-97
       Town Highway 1 (VT 121 & FAS 125) over Saxtons River, Rockingham   EMB
          *** RUN DATE & TIME: 02-20-97  13:30

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

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1     1418    254921    125    134                         27048
  504.29          1418    254921    125    134  1.00     14    159     27048

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      504.29    14.3   159.1  1417.6  254921.   16000.  11.29

 X STA.        14.3       35.8       43.0       49.2       54.8       60.4
  A(I)            115.9       77.7       70.6       65.7       65.8
  V(I)             6.90      10.30      11.32      12.18      12.17

 X STA.        60.4       65.8       71.2       76.5       81.7       86.9
  A(I)             62.9       63.9       62.0       61.6       61.8
  V(I)            12.72      12.53      12.90      13.00      12.94

 X STA.        86.9       92.0       97.2      102.2      107.1      112.3
  A(I)             61.4       61.9       61.3       60.5       63.7
  V(I)            13.02      12.91      13.05      13.22      12.56

 X STA.       112.3      117.5      123.0      129.9      137.6      159.1
  A(I)             64.1       66.0       76.3       79.4      115.0
  V(I)            12.48      12.13      10.48      10.07       6.95

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

        WSEL     LEW     REW    AREA        K        Q    VEL
      504.55    13.8   159.5  1450.3  263569.   16000.  11.03

 X STA.        13.8       35.8       43.0       49.1       54.7       60.4
  A(I)            120.3       79.2       72.0       66.9       67.0
  V(I)             6.65      10.10      11.11      11.96      11.94

 X STA.        60.4       65.7       71.2       76.4       81.6       86.8
  A(I)             64.1       65.1       63.2       62.7       62.9
  V(I)            12.49      12.30      12.66      12.76      12.71

 X STA.        86.8       92.1       97.1      102.2      107.3      112.2
  A(I)             63.6       62.2       62.5       64.3       62.4
  V(I)            12.57      12.87      12.80      12.44      12.81

 X STA.       112.2      117.5      123.2      130.1      137.7      159.5
  A(I)             65.4       69.4       78.1       79.2      119.8
  V(I)            12.23      11.54      10.24      10.11       6.68

   CROSS-SECTION PROPERTIES:  ISEQ =  5;  SECID = APPRO;  SRD =     204.

    WSEL  SA#     AREA         K   TOPW   WETP  ALPH    LEW    REW      QCR
            1      117      7113     39     40                          1142
            2     1440    177919    142    148                         26018
  505.94          1557    185032    182    188  1.05    -18    162     25263

   VELOCITY DISTRIBUTION:  ISEQ =  5;  SECID = APPRO;  SRD =     204.

        WSEL     LEW     REW    AREA        K        Q    VEL
      505.94   -19.4   162.1  1557.0  185032.   16000.  10.28

 X STA.       -19.4       26.4       39.0       45.5       50.3       54.9
  A(I)            145.8       97.2       77.0       65.6       65.1
  V(I)             5.49       8.23      10.39      12.19      12.28

 X STA.        54.9       59.0       63.1       67.1       71.1       75.1
  A(I)             60.9       61.0       60.6       60.2       60.1
  V(I)            13.14      13.10      13.21      13.28      13.31

 X STA.        75.1       79.3       83.8       88.4       93.7       99.3
  A(I)             61.8       63.7       64.4       68.5       70.6
  V(I)            12.95      12.55      12.42      11.68      11.33

 X STA.        99.3      105.6      113.0      121.1      131.2      162.1
  A(I)             73.9       80.6       83.1       96.8      140.1
  V(I)            10.83       9.92       9.63       8.26       5.71
```

```
        U.S. Geological Survey WSPRO Input File rock11r.wsp
        Hydraulic analysis for structure ROCKTH0001011R   Date: 31-JAN-97
        Town Highway 1 (VT 121 & FAS 125) over Saxtons River, Rockingham   EMB
           *** RUN DATE & TIME: 02-20-97  13:30

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

EXITX:XS   ******    -57     1213  1.33 *****  502.74  498.32   10600  501.41
      -169 ******    162   145582  1.12 ***** *******    0.69    8.74

FULLV:FV      170    -53     1193  1.36  0.92  503.68 *******   10600  502.31
         0    170    161   143000  1.11  0.02    0.00    0.70    8.88
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      204    -13     1152  1.36  1.34  505.02 *******   10600  503.66
       204    204    159   119866  1.04  0.00    0.00    0.64    9.20
         <<<<<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      170     17     1202  1.25  1.04  503.78  498.93   10600  502.54
         0    170    156   200076  1.03  0.00    0.02    0.50    8.82

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   0.   1.  0.985  0.092  515.31 ****** ****** ******

    XSID:CODE     SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      26.        <<<<<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      151    -13     1171  1.32  1.11  505.09  500.64   10600  503.77
       204    153    159   122625  1.04  0.19    0.01    0.63    9.05

       M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
      0.204  0.000  125946.     5.   144.   502.53

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K     AREA     VEL    WSEL
   EXITX:XS    -170.    -58.   162.  10600.  145582.    1213.    8.74  501.41
   FULLV:FV       0.    -54.   161.  10600.  143000.    1193.    8.88  502.31
   BRIDG:BR       0.     17.   156.  10600.  200076.    1202.    8.82  502.54
   RDWAY:RG      26.**************       0.******************    1.00********
   APPRO:AS     204.    -14.   159.  10600.  122625.    1171.    9.05  503.77

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       5.   144.  125946.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX    HF    HO   VHD      EGL    WSEL
   EXITX:XS    498.32    0.69  488.93  515.62************  1.33  502.74  501.41
   FULLV:FV  ********    0.70  489.92  516.61  0.92  0.02  1.36  503.68  502.31
   BRIDG:BR    498.93    0.50  489.92  516.35  1.04  0.00  1.25  503.78  502.54
   RDWAY:RG  ****************  518.51  523.63**********************************
   APPRO:AS    500.64    0.63  490.80  517.12  1.11  0.19  1.32  505.09  503.77
```

```
        U.S. Geological Survey WSPRO Input File rock11r.wsp
        Hydraulic analysis for structure ROCKTH0001011R   Date: 31-JAN-97
        Town Highway 1 (VT 121 & FAS 125) over Saxtons River, Rockingham   EMB
           *** RUN DATE & TIME: 02-20-97  13:30

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

EXITX:XS   ******    -66     1754  1.67 *****  505.19  500.70   16000  503.52
      -169 ******    231   219580  1.29 ***** *******    0.75    9.12

FULLV:FV      170    -66     1727  1.71  0.92  506.13 *******   16000  504.42
         0    170    227   215770  1.28  0.02    0.00    0.76    9.27
         <<<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>>

APPRO:AS      204    -18     1518  1.81  1.36  507.54 *******   16000  505.73
       204    204    162   178317  1.05  0.05    0.00    0.66   10.54
         <<<<<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      170     14     1417  1.98  1.07  506.27  501.28   16000  504.29
         0    170    159   254810  1.00  0.00   -0.02    0.59   11.29

     TYPE PPCD FLOW      C    P/A    LSEL   BLEN   XLAB   XRAB
       3.   0.   1.  1.000  0.087  515.31 ****** ****** ******

    XSID:CODE    SRD   FLEN    HF   VHD     EGL     ERR       Q    WSEL
   RDWAY:RG      26.        <<<<<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      151    -18     1558  1.72  1.15  507.66  503.25   16000  505.94
       204    153    162   185122  1.05  0.26    0.01    0.63   10.27

      M(G)   M(K)       KQ   XLKQ   XRKQ    OTEL
     0.196  0.001  184617.     3.   147.   504.71

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

  FIRST USER DEFINED TABLE.

    XSID:CODE    SRD    LEW    REW       Q        K      AREA     VEL    WSEL
   EXITX:XS    -170.    -67.   231.  16000.  219580.    1754.    9.12  503.52
   FULLV:FV       0.    -67.   227.  16000.  215770.    1727.    9.27  504.42
   BRIDG:BR       0.     14.   159.  16000.  254810.    1417.   11.29  504.29
   RDWAY:RG      26.**************       0.******************    1.00********
   APPRO:AS     204.    -19.   162.  16000.  185122.    1558.   10.27  505.94

    XSID:CODE   XLKQ   XRKQ       KQ
   APPRO:AS       3.   147.  184617.

 SECOND USER DEFINED TABLE.

    XSID:CODE    CRWS     FR#    YMIN    YMAX     HF     HO   VHD      EGL    WSEL
   EXITX:XS    500.70    0.75  488.93  515.62************  1.67  505.19  503.52
   FULLV:FV  ********    0.76  489.92  516.61  0.92  0.02  1.71  506.13  504.42
   BRIDG:BR    501.28    0.59  489.92  516.35  1.07  0.00  1.98  506.27  504.29
   RDWAY:RG  ****************  518.51  523.63**********************************
   APPRO:AS    503.25    0.63  490.80  517.12  1.15  0.26  1.72  507.66  505.94
  ER

 NORMAL  END  OF  WSPRO  EXECUTION.
```

APPENDIX C:

BED-MATERIAL PARTICAL-SIZE DISTRIBUTION



Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure ROCKTH0001011R, in Rockingham, Vermont.

APPENDIX D:

HISTORICAL DATA FORM

United States Geological Survey
Bridge Historical Data Collection and Processing Form

Structure Number ROCKTH0001011R

General Location Descriptive

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

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

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

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

Town *(FIPS place code; I - 4; nnnnn)* 60250

Mile marker *(I - 11; nnn.nnn)* 003360

Waterway *(I - 6)* SAXTONS RIVER

Road Name *(I - 7):* -

Route Number TH001

Vicinity *(I - 9)* 4.1 MI W JCT. U.S.5

Topographic Map Saxtons.River

Hydrologic Unit Code: 01080107

Latitude *(I - 16; nnnn.n)* 43084

Longitude *(i - 17; nnnnn.n)* 72301

Select Federal Inventory Codes

FHWA Structure Number *(I - 8)* 200126011R1314

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

Maximum span length *(I - 48; nnnn)* 0069

Year built *(I - 27; YYYY)* 1954

Structure length *(I - 49; nnnnnn)* 000184

Average daily traffic, ADT *(I - 29; nnnnnn)* 002480

Deck Width *(I - 52; nn.n)* 390

Year of ADT *(I - 30; YY)* 91

Channel & Protection *(I - 61; n)* 6

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

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

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

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

Structure type *(I - 43; nnn)* 402

Year Reconstructed *(I - 106)* 0000

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

Clear span (*nnn.n ft*) -

Number of spans *(I - 45; nnn)* 003

Vertical clearance from streambed (*nnn.n ft*) 022.0

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

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

Comments:

The structural inspection report of 8/10/94 indicates the structure is a three span, continuous steel stringer type bridge with a concrete deck and an asphalt roadway surface. The abutments are the concrete skeletal type, which reportedly have only minor cracks. The wingwalls are concrete, which is in good condition overall. The wingwalls are very short and only exposed at the very top where the flow through abutment embankments end at the wingwall and abutment concrete. Both piers are solid concrete, which have some minor cracks and scaling at the ends of each. The footings of the piers are not exposed. There is some local scour reported at the upstream end of the left pier. In the scour hole, **(Continued, page 31)**

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:

there is heavy stone riprap reported. The waterway proceeds straight through the bridge. The streambed consists of stone and gravel. There is a shallow point bar reported in the right most span and part of the middle span. Debris accumulation is reported as minor at this site. The report indicates that bank erosion is not evident.

USGS Watershed Data

Watershed Hydrographic Data

Drainage area *(DA)* **68.27** mi^2

Lake and pond area **0.30** mi^2

Watershed storage *(ST)* **0.5** %

Bridge site elevation **433** ft

Headwater elevation **2894** ft

Main channel length **16.95** mi

10% channel length elevation **512** ft

85% channel length elevation **1693** ft

Main channel slope *(S)* **92.89** 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? Y *If no, type ctrl-n pl* Date issued for construction *(MM / YYYY)*: 08 / 1953

Project Number S 156(3) Minimum channel bed elevation: 466.0

Low superstructure elevation: USLAB 491.51 DSLAB 491.28 USRAB 489.47 DSRAB 489.21

Benchmark location description:

BM#1, chiseled square, located 147 feet from the center-line of the left abutment, and 17 feet left of the roadway center-line, elevation 500.0

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

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

If 1: Footing Thickness 2.5 Footing bottom elevation: 467.0*

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

If 3: Footing bottom elevation: ______

Is boring information available? Y *If no, type ctrl-n bi* Number of borings taken: 9

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

Briefly describe material at foundation bottom elevation or around piles:

Borings surrounding the right abutment: B1 (downstream bankward corner) stone and boulder, B7 (center bankward) gravel with clay filler, B8 (downstream side of abutment) boulder and stone. Right pier: B2 (downstream bankward side) gravel with clay filler, B3 (upstream bankward side) gravel with clay filler (hard) at the footing depth. Left pier: B4 (upstream streamward side) gravel with clay filler, B5 (downstream streamward side) gravel with clay filler at the footing depth. Left abutment: B6 (streamward side) sharp medium sand small amount of fine gravel with clay filler.

Comments:

***The right and left pier footing base elevation is shown at an elevation of 458.5 with a 3 foot thickness. The left abutment footing base elevation is shown at 467.0 with a 2.5 foot thickness, set on a sharp medium sand with a small amount of fine gravel with clay filler. The right abutment footing base elevation is shown at 469.0, with a 2.5 foot thickness and set on a stone and boulder material. The low superstructure elevations of the piers: pier 1(left) upstream end 490.88 and downstream end 490.63; pier 2(right) upstream end 490.09 and downstream end 489.84.**

Cross-sectional Data

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

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

Comments: **The station and elevation measurements are in feet. The low cord to bed length measurements at the abutments differ from the 9/96 survey.**

Station	315	325	366	400	436	485	491	-	-	-	-
Feature	LAB						RAB	-	-	-	-
Low cord elevation	449.3	449.2	448.7	448.3	447.8	447.3	447.2	-	-	-	-
Bed elevation	435.7	426.3	423.4	423	423.4	432.5	433.1	-	-	-	-
Low cord to bed length	13.6	22.9	25.3	25.3	25.3	14.8	14.1	-	-	-	-

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

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

Comments: **Since the bridge is skewed to the channel, the VTAOT cross sections at the bridge are not reproducible and hence were not retrieved.**

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: 10/9/96
Computerized by: EW Date: 10/9/96
Reviewd by: EMB Date: 2/21/97

Structure Number ROCKTH0001011R

A. General Location Descriptive

1. Data collected by *(First Initial, Full last name)* E. BOEHMLER Date *(MM/DD/YY)* 09 / 03 / 1996

2. Highway District Number 02 Mile marker 003360

County Windsor (025) Town Rockingham (60250)

Waterway *(I - 6)* Saxtons River Road Name -

Route Number TH001 Hydrologic Unit Code: 01080107

3. Descriptive comments:

Located 4.1 miles west of the intersection of TH 1 with US route 5. This roadway also is labeled as State Route 121 and Federal Aid System Route 125.

B. Bridge Deck Observations

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

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

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

7. Bridge length 184 *(feet)* Span length 69 *(feet)* Bridge width 39 *(feet)*

Road approach to bridge:

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

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

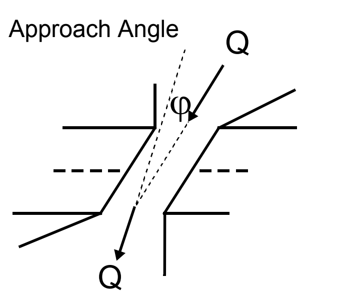
10. Embankment slope (*run / rise in feet / foot*):
US left -- US right --

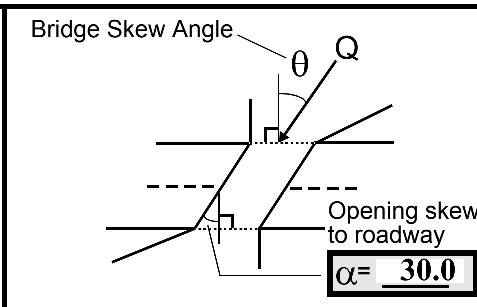
	Protection		13.Erosion	14.Severity
	11.Type	12.Cond.		
LBUS	3	1	0	-
RBUS	3	1	0	-
RBDS	3	1	0	-
LBDS	3	1	0	-

*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: 5 16. Bridge skew: 35





17. Channel impact zone 1: Exist? Y *(Y or N)*
Where? LB *(LB, RB)* Severity 1
Range? 200 feet US *(US, UB, DS)* to 100 feet US

Channel impact zone 2: Exist? Y *(Y or N)*
Where? RB *(LB, RB)* Severity 1
Range? 20 feet UB *(US, UB, DS)* to 95 feet DS

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

18. Bridge Type: 3

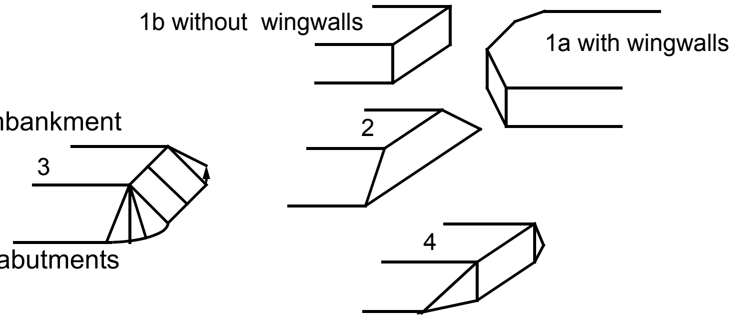
1a- Vertical abutments with wingwalls

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.)

USRB coverage is forest with a strip of grass and brush land bisecting trees on immediate bank and forest on valley wall. USLB has trees and brush along immediate bank with houses and lawn on overbank for entire 300 feet or so up LB side. RBDS coverage is also lawn with a house and tree cover on immediate bank. DSLB cover is also lawn with a house and tree cover on immediate bank. Between 0 feet downstream and 100 feet downstream on LOB is tree cover.

Bridge dimensions measured in field were the same as historical form values.

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
176.0	6.5			8.0	3	4	342	342	2	1

23. Bank width **25.0** 24. Channel width **35.0** 25. Thalweg depth **119.0** 29. Bed Material **345**

30 .Bank protection type: LB **0** RB **0** 31. 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*

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

The channel upstream flows along the LB side. The LB is cut and there is a point bar along the RB side. The channel gradient upstream is moderate and steady. The water surface at this stage is riffle along the side of the point bar and is pooled beyond 400 feet upstream. There is a third point bar upstream on LB extending from 450 feet upstream to 370 feet upstream on LB; it is composed of gravel and cobbles at its upstream end, and grades to sand at its downstream end. The point bar is located at an old bridge crossing where abutments still exist, but deck does not.

33. Point/Side bar present? **Y** (Y or N. if N type ctrl-n pb) 34. Mid-bar distance: **280** 35. Mid-bar width: **60**

36. Point bar extent: **395** feet **US** (US, UB) to **35** feet **DS** (US, UB, DS) positioned **40** %LB to **100** %RB

37. Material: **435**

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

The point bar is long and high, approximately 2.5 to 3 feet higher along crest of point bar material. The point bar is about 20% vegetation covered with more coverage and older growth coverage mainly at downstream end of the bar. Vegetation at upstream end of bar has been swept over by a recent high flow event.

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

41. Mid-bank distance: **240** 42. Cut bank extent: **300** feet **US** (US, UB) to **85** feet **US** (US, UB, DS)

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

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

Near mid-bank, there are water swept young trees and shrubs that have fallen over in flow direction or are leaning in the direction of flow. The thin soil layer present on top of bank material has a ragged edge and overhangs the bank material below. The bank material has slipped down on the bank slope in places, leaving the soil layer on top overhanging. The bank ends where the stone fill abutment slope begins.

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) 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
110.5		**1.0**		**2**	**5**	**5**	**-**

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.):

345

The channel gradient upstream becomes flatter and the water surface pools at this stage from 65 feet upstream to 35 feet under bridge. Both abutments are concrete walls with type 2 stone fill spill-through slopes from the walls to the channel bed. The LB cut-bank upstream ends where the spill-through abutment slope intersects the bank about 85 feet upstream. The bank cutting near this intersection area has not damaged the spill-through slope as slumping or other evidence of erosion of stone fill is not evident. The channel width shown above is the distance between the toe of each spill-through embankment.

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

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

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

70. Debris and Ice Comments:

1

There is some minor debris (sticks, twigs and leaves) caught in tree limbs on upstream point bar. These trees and those at the downstream end of LB cut-bank upstream have been scarred by ice. Trees and shrubs on the point bar and cut-bank are damaged and may be stripped from the bar or bank by subsequent high flow events. The piers are off to the sides of the channel. The left pier would have the greatest tendency to

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	**cap-**	**ture**	**debr**	**is as**	**flow**	**impa**	**cts it**	**90.0**
RABUT	**muc**	**h**	**more**			**so**	**than**	**174.5**

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.):

the right pier.

-

40

0

0

-

-

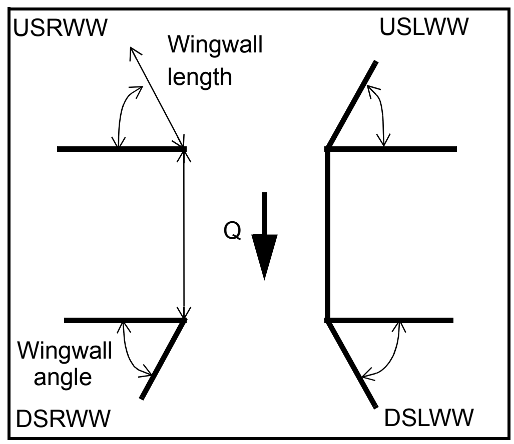
2

5

35

80. Wingwalls:

	Exist?	Material?	Scour Condition?	Scour depth?	Exposure depth?	81. Angle?	Length?
USLWW:	**0**		**0**		**-**	**105.5**	
USRWW:	**-**		**2**		**The**	**0.5**	
DSLWW:	**spill-**		**thro**		**ugh**	**52.5**	
DSRWW:	**slope**		**on**		**RAB**	**52.5**	



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	**UT**	**sta-**	**the**	**the**	**alm**	**belo**	**base**	**90**
Condition	**app**	**ble,**	**top**	**slop**	**ost 1**	**w**	**of**	**degr**
Extent	**ears**	**but**	**of**	**e is**	**foot**	**the**	**the**	**ee**

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

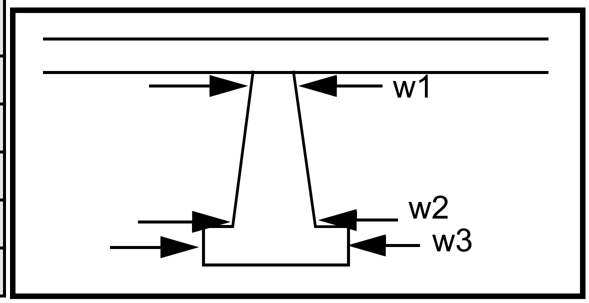
83. Wingwall and protection comments (eg. undermined penetration, unusual scour processes, etc.):
concrete wall as a result of the skeleton type concrete abutment. Both concrete abutment walls are vertical skeleton style walls. The back of the wall may be seen underneath.

N
-

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	-	2.5	5	-	-	-
Pier 3	-	2.5	5	-	-	-
Pier 4	-	-	-	-	-	-



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

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

tion from abutment slopes wraps around ends of abutments at all four corners of structure.

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
-	-			-	Y	MC	L	1	2	1

Bank width (BF) - Channel width (Amb) 52 Thalweg depth (Amb) 52 Bed Material Y

Bank protection type (Qmax): LB 0 RB - Bank protection condition: LB - RB 0

*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
4.5
1.0
MCR
1
2
1
Y
5
RB
-
0
1
1.5
0

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

Cut bank extent: **re is** feet **no** *(US, UB, DS)* to **stone** feet **fill** *(US, UB, DS)*

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

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

tection on pier 2. A small scour hole is evident at the downstream end of pier 2, primarily on the left side. The hole is 33 feet long beginning 13 feet upstream from the downstream end of pier to 20 feet downstream of pier. It is 7 feet wide along pier edge and 1.5 feet deep (ambient thalweg is 1 foot). There is some protection on bed at upstream end of pier 1 mainly on the LABUT side of the pier. Footing is

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

Scour dimensions: Length **1** Width **foot** Depth: **at** Positioned **nos** %LB to **e to** %RB

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

flush with adjacent streambed along mid-span side of pier for 8 feet from upstream end. Scour hole extends from 25 feet upstream of pier 1 to 20 feet along right side of pier and 12 feet along LABUT side of pier. The hole is 4.5 feet at most below ambient thalweg depth. The hole extends 4 feet from the left side of the pier and about 8 feet from the right side of the pier toward the middle of the channel. Piers are inclined since the length

Are there major confluences? **is** *(Y or if N type ctrl-n mc)* How many? **47**

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

Confluence 2: Distance **top** Enters on **and** *(LB or RB)* Type **52** *(**1**- perennial; **2**- ephemeral)*

Confluence comments (eg. confluence name):

feet at base.

F. Geomorphic Channel Assessment

107. Stage of reach evolution **3**

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)*:

3
342
342
0
1
345
0
0
-
-

The channel downstream has a moderately sloping and steady gradient. The water surface at this stage is riffle from about 10 feet under the bridge (from the downstream face) to about 280 feet downstream, where channel makes a 70 degree turn to the right at a bedrock outcrop, which makes up the left bank.

109. **G. Plan View Sketch**

Fr

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: ROCKTH0001011R Town: Rockingham
Road Number: TH 1 (VT 121 & FAS 125) County: Windham
Stream: Saxtons River

Initials EMB Date: 2/20/97 Checked: RF

I. 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	10600	16000	0
Main Channel Area, ft2	1135	1440	0
Left overbank area, ft2	37	117	0
Right overbank area, ft2	0	0	0
Top width main channel, ft	139	142	0
Top width L overbank, ft	34	39	0
Top width R overbank, ft	0	0	0
D50 of channel, ft	0.3589	0.3589	0
D50 left overbank, ft	--	--	--
D50 right overbank, ft	--	--	--
y1, average depth, MC, ft	8.2	10.1	ERR
y1, average depth, LOB, ft	1.1	3.0	ERR
y1, average depth, ROB, ft	ERR	ERR	ERR
Total conveyance, approach	122740	185032	0
Conveyance, main channel	121600	177919	0
Conveyance, LOB	1139	7113	0
Conveyance, ROB	0	0	0
Percent discrepancy, conveyance	0.0008	0.0000	ERR
Qm, discharge, MC, cfs	10501.5	15384.9	ERR
Ql, discharge, LOB, cfs	98.4	615.1	ERR
Qr, discharge, ROB, cfs	0.0	0.0	ERR
Vm, mean velocity MC, ft/s	9.3	10.7	ERR
Vl, mean velocity, LOB, ft/s	2.7	5.3	ERR
Vr, mean velocity, ROB, ft/s	ERR	ERR	ERR
Vc-m, crit. velocity, MC, ft/s	11.3	11.7	N/A
Vc-l, crit. velocity, LOB, ft/s	ERR	ERR	ERR
Vc-r, crit. velocity, ROB, ft/s	ERR	ERR	ERR

Results

Live-bed(1) or Clear-Water(0) Contraction Scour?			
Main Channel	0	0	N/A

Clear Water Contraction Scour in MAIN CHANNEL

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

Approach Section	Q100	Q500	Qother
Main channel Area, ft2	1135	1440	0
Main channel width, ft	139	142	0
y1, main channel depth, ft	8.17	10.14	ERR
Bridge Section			
(Q) total discharge, cfs	10600	16000	0
(Q) discharge thru bridge, cfs	10600	16000	0
Main channel conveyance	200167	254921	0
Total conveyance	200167	254921	0
Q2, bridge MC discharge,cfs	10600	16000	ERR
Main channel area, ft2	1083	1281	0
Main channel width (skewed), ft	105.6	108.2	0.0
Cum. width of piers in MC, ft	8.8	8.6	0.0
W, adjusted width, ft	96.8	99.6	0
y_bridge (avg. depth at br.), ft	11.19	12.86	ERR
Dm, median (1.25*D50), ft	0.448625	0.448625	0
y2, depth in contraction,ft	8.71	12.10	ERR
ys, scour depth (y2-ybridge), ft	-2.48	-0.76	N/A
ARMORING			
D90	0.753	0.753	0
D95	0.965	0.965	0
Critical grain size,Dc, ft	0.3695	0.5698	ERR
Decimal-percent coarser than Dc	0.7	0.316	0
Depth to armoring,ft	0.48	3.70	ERR

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)

Characteristic	Left Abutment 100 yr Q	500 yr Q	Other Q	Right Abutment 100 yr Q	500 yr Q	Other Q
(Qt), total discharge, cfs	10600	16000	0	10600	16000	0
a', abut.length blocking flow, ft	48.3	52	0	19.5	21	0
Ae, area of blocked flow ft2	103.5	193.6	0	66.6	95.2	0
Qe, discharge blocked abut.,cfs	491.3	1193.7	0	311.3	543.7	0
(If using Qtotal_overbank to obtain Ve, leave Qe blank and enter Ve and Fr manually)						
Ve, (Qe/Ae), ft/s	4.75	6.17	ERR	4.67	5.71	ERR
ya, depth of f/p flow, ft	2.14	3.72	ERR	3.42	4.53	ERR
--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)						
K1	0.55	0.55	0.55	0.55	0.55	0.55
--Angle (theta) of embankment (<90 if abut. points DS; >90 if abut. points US)						
theta	60	60	60	120	120	120
K2	0.95	0.95	0.95	1.04	1.04	1.04
Fr, froude number f/p flow	0.571	0.563	ERR	0.446	0.473	ERR
ys, scour depth, ft	9.03	13.38	N/A	9.13	11.73	N/A

HIRE equation (a'/ya > 25)
ys = 4*Fr^0.33*y1*K/0.55
(Richardson and others, 1995, p. 49, eq. 29)

a'(abut length blocked, ft)	48.3	52	0	19.5	21	0
y1 (depth f/p flow, ft)	2.14	3.72	ERR	3.42	4.53	ERR
a'/y1	22.54	13.97	ERR	5.71	4.63	ERR
Skew correction (p. 49, fig. 16)	1.00	1.00	1.00	1.00	1.00	1.00
Froude no. f/p flow	0.57	0.56	N/A	0.45	0.47	N/A
Ys w/ corr. factor K1/0.55:						
vertical	ERR	ERR	ERR	ERR	ERR	ERR
vertical w/ ww's	ERR	ERR	ERR	ERR	ERR	ERR
spill-through	ERR	ERR	ERR	ERR	ERR	ERR

Abutment riprap Sizing

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

Characteristic	Q100	Q500	Qother			
Fr, Froude Number	0.5	0.59	0	0.5	0.59	0
(Fr from the characteristic V and y in contracted section--mc, bridge section)						
y, depth of flow in bridge, ft	11.19	12.86	0.00	11.19	12.86	0.00
Median Stone Diameter for riprap at: left abutment				right abutment, ft		
Fr<=0.8 (spillthrough abut.)	1.51	2.41	0.00	1.51	2.41	0.00
Fr>0.8 (spillthrough abut.)	ERR	ERR	ERR	ERR	ERR	ERR

Pier Scour(both live-bed and clear water scour)

ys/y1=2.0*K1*K2*K3*K4*(a/y1)^0.65*Fr1^0.43
(Richardson and others, 1995, p. 36, eq. 21)

K1, corr. factor for pier nose shape
Sharp nose, 0.9; round nose, cylinder, or cylinder grp., 1.0; square nose, 1.1

K2, corr. factor attack angle (see Table 3, p 37)
K2=[cos(attackangle)+L/a*sin(attackangle)]^0.65

K3, corr. factor for bed condition
Clear-water, plane bed, antidune, 1.1; med. dunes, 1.1-1.2 (see Tab.4,p37)

K4, corr. factor for armoring (the following equations are in Si units)
K4=[1-0.89*(1-Vr)^2]^0.5
Vr=(V1-Vi)/(Vc90-Vi)
V1=0.645*((D50/a)^0.053)*Vc50
Vc=6.19*(y^1/6)*(Dc^1/3)

Note for round nose piers:
ys<=2.4 times the pier width (a) for Fr<=0.8
ys<=3.0 times the pier width (a) for Fr>0.8

Pier 1	Q100	Q500	Qother
Pier stationing, ft	52.9	52.9	0
Area of WSPRO flow tube, ft2	53	62.2	0
Skewed width of flow tube, ft	4.2	4.3	0
y1, pier approach depth, ft	12.62	14.47	ERR
y1 in meters	3.846	4.409	N/A
V1, pier approach velocity, ft/s	10	12.9	0
a, pier width, ft	5	5	0
L, pier length, ft	52	52	0
Fr1, Froude number at pier	0.496	0.598	ERR
Pier attack angle, degrees	0	0	0
K1, shape factor	1	1	0
K2, attack factor	1.00	1.00	ERR
K3, bed condition factor	1.1	1.1	0
D50, ft	0.3589	0.3589	0
D50, m	0.109387	0.109387	0
D90, ft	0.753	0.753	0
D90, m	0.229503	0.229503	0
Vc50,critical velocity(D50),m/s	3.706	3.791	N/A
Vc90,critical velocity(D90),m/s	4.744	4.853	N/A
Vi,incipient velocity,m/s	2.079	2.126	ERR
Vr, velocity ratio	0.364	0.662	ERR
K4, armor factor	0.80	0.95	N/A
ys, scour depth (K4 applicable) ft	9.00	12.12	ERR
ys, scour depth (K4 not applied)ft	ERR	ERR	ERR

Pier 2	Q100	Q500	Qother
Pier stationing, ft	120	120	0
Area of WSPRO flow tube, ft2	53	62.2	0
Skewed width of flow tube, ft	4.2	4.3	0
y1, pier approach depth, ft	12.62	14.47	ERR
y1 in meters	3.846	4.409	N/A
V1, pier approach velocity, ft/s	10	12.9	0
a, pier width, ft	5	5	0
L, pier length, ft	52	52	0
Fr1, Froude number at pier	0.496	0.598	ERR
Pier attack angle, degrees	5	5	0
K1, shape factor	1	1	0
K2, attack factor	1.52	1.52	ERR
K3, bed condition factor	1.1	1.1	0
D50, ft	0.3589	0.3589	0
D50, m	0.109387	0.109387	0
D90, ft	0.753	0.753	0
D90, m	0.229503	0.229503	0
Vc50,critical velocity(D50),m/s	3.706	3.791	N/A
Vc90,critical velocity(D90),m/s	4.744	4.853	N/A
Vi,incipient velocity,m/s	2.079	2.126	ERR
Vr, velocity ratio	0.364	0.662	ERR
K4, armor factor	0.80	0.95	N/A
ys, scour depth, (K4 applicable) ft	13.67	18.41	ERR
ys, scour depth, (K4 not applied)ft	ERR	ERR	ERR

D50=0.692(K*V)^2/(Ss-1)*2*g
(Richardson and others, 1995, p.115, eq. 83)

Pier-shape coefficient (K), round nose, 1.5; square nose, 1.7
Characteristic avg. channel velocity, V, (Q/A):
(Mult. by 0.9 for bankward piers in a straight, uniform reach,
up to 1.7 for a pier in main current of flow around a bend)

Pier 1	Q100	Q500	Qother
K, pier shape coeff.	1.5	1.5	0
V, char. aver. velocity, ft/s	9.8	12.5	0
D50, median stone diameter, ft	1.41	2.29	0.00

Pier 2			
K, pier shape coeff.	1.5	1.5	0
V, char. aver. velocity, ft/s	9.8	12.5	0
D50, median stone diameter, ft	1.41	2.29	0.00