LEVEL II SCOUR ANALYSIS FOR BRIDGE 61 (MTHOTH00100061) on TOWN HIGHWAY 10, crossing PERRY BROOK, MOUNT HOLLY, VERMONT

Open-File Report 98-054

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

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

USGS
science for a changing world
LEVEL II SCOUR ANALYSIS FOR
BRIDGE 61 (MTHOTH00100061) on
TOWN HIGHWAY 10, crossing
PERRY BROOK,
MOUNT HOLLY, VERMONT

By MICHAEL A. IVANOFF

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Pembroke, New Hampshire
1998
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CONVERSION FACTORS, ABBREVIATIONS, AND VERTICAL DATUM

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

**OTHER ABBREVIATIONS**

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

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.
INTRODUCTION AND SUMMARY OF RESULTS

This report provides the results of a detailed Level II analysis of scour potential at structure MTHOTH00100061 on Town Highway 10 crossing Perry Brook, Mount Holly, Vermont (figures 1–8). A Level II study is a basic engineering analysis of the site, including a quantitative analysis of stream stability and scour (U.S. Department of Transportation, 1993). Results of a Level I scour investigation also are included in appendix E of this report. A Level I investigation provides a qualitative geomorphic characterization of the study site. Information on the bridge, gleaned from Vermont Agency of Transportation (VTAOT) files, was compiled prior to conducting Level I and Level II analyses and is found in appendix D.

The site is in the Green Mountain section of the New England physiographic province in west-central Vermont. The 5.38-m² drainage area is in a predominantly rural and forested basin. In the vicinity of the study site, the surface cover is forest.

In the study area, Perry Brook has an incised, sinuous channel with a slope of approximately 0.03 ft/ft, an average channel top width of 28 ft and an average bank height of 2 ft. The channel bed material ranges from sand to boulder with a median grain size ($D_{50}$) of 96.8 mm (0.318 ft). The geomorphic assessment at the time of the Level I and Level II site visit on October 11, 1995, indicated that the reach was stable.

The Town Highway 10 crossing of Perry Brook is a 29-ft-long, one-lane bridge consisting of one 25-foot steel-beam span (Vermont Agency of Transportation, written communication, March 21, 1995). The opening length of the structure parallel to the bridge face is 22.9 ft. The bridge is supported by concrete capped “laid-up” stone abutments and wingwalls. The channel is skewed approximately 5 degrees to the opening while the opening-skew-to-roadway is zero.

The only scour protection measure at the site was type-3 stone fill (less than 48 inches diameter) at the entire base length of the upstream right wingwall, downstream end of the left abutment, along the entire base length of the right abutment, and along the entire base length of the downstream left and right wingwalls. Additional details describing conditions at the site are included in the Level II Summary and appendices D and E.
Scour depths and recommended rock rip-rap sizes were computed using the general guidelines described in Hydraulic Engineering Circular 18 (Richardson and Davis, 1995) for the 100- and 500-year discharges. 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 0.3 to 0.8 ft. The worst-case contraction scour occurred at the 500-year discharge. Abutment scour ranged from 4.6 to 11.7 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 Davis, 1995, p. 46). 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.
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

<table>
<thead>
<tr>
<th>Structure Number</th>
<th>MTHOTH00100061</th>
<th>Stream</th>
<th>Perry Brook</th>
</tr>
</thead>
<tbody>
<tr>
<td>County</td>
<td>Rutland</td>
<td>Road</td>
<td>TH 10</td>
</tr>
<tr>
<td>District</td>
<td>3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Description of Bridge

- **Bridge length**: 29.0 ft
- **Bridge width**: 14.0 ft
- **Max span length**: 25.0 ft

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

- **Abutment type**: Sloping, stone
- **Embankment type**: Sloping

**Stone fill on abutment?** Yes

**Date of inspection**: 10/11/95

**Description of stone fill**: Type-3, along the upstream right wingwall, the downstream end of the left abutment, the right abutment, the downstream left and right wingwalls.

Abutments and wingwalls are concrete capped “laid-up” stone.

**Is bridge skewed to flood flow according to Level I survey?** Yes

**Angle**: 5

**Is bridge located on a bend in channel?** Yes

There is a mild channel bend in the upstream reach.

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

<table>
<thead>
<tr>
<th>Date of inspection</th>
<th>Percent of channel blocked horizontally</th>
<th>Percent of channel blocked vertically</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level I</td>
<td>10/11/95</td>
<td>0</td>
</tr>
<tr>
<td>Level II</td>
<td>10/11/95</td>
<td>0</td>
</tr>
</tbody>
</table>

**Potential for debris**: Moderate. There is some debris caught on boulders and trees leaning over the channel upstream.

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

A large pile of boulders is present along the downstream bridge face, pooling water under the bridge as of 10/11/95.
**Description of the Geomorphic Setting**

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

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

**Date of inspection**  
10/11/95

**DS left:**  
Steep channel bank to steep valley wall.

**DS right:**  
Steep channel bank to steep valley wall.

**US left:**  
Steep channel bank to steep valley wall.

**US right:**  
Steep channel bank to steep valley wall.

**Description of the Channel**

<table>
<thead>
<tr>
<th>Average top width</th>
<th>28</th>
<th>Predominant bed material</th>
<th>Gravel / Cobbles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average depth</td>
<td>2</td>
<td>Bank material</td>
<td>Sinuous but stable</td>
</tr>
</tbody>
</table>

- with non-alluvial channel boundaries.
- 10/11/95

**Vegetative cover on channel banks near bridge:**

**DS left:**  
Trees and brush.

**DS right:**  
Trees and brush.

**US left:**  
Trees and brush.

**US right:**  
Yes

**Do banks appear stable?**  
Yes

**Date of observation:**
- None, 10/11/95.

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

**Drainage area**: 5.38 mi²

**Percentage of drainage area in physiographic provinces**: (approximate)

<table>
<thead>
<tr>
<th>Physiographic province/section</th>
<th>Percent of drainage area</th>
</tr>
</thead>
<tbody>
<tr>
<td>New England/Green Mountain</td>
<td>100</td>
</tr>
</tbody>
</table>

Is drainage area considered rural or urban? **Rural**

Describe any significant urbanization: **None.**

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

<table>
<thead>
<tr>
<th>USGS gage description</th>
<th>USGS gage number</th>
<th>Gage drainage area</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

Is there a lake/pond that will significantly affect hydrology/hydraulics? **No**

<table>
<thead>
<tr>
<th>Calculated Discharges</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Q100</td>
<td>920 ft³/s</td>
</tr>
<tr>
<td>Q500</td>
<td>1,300 ft³/s</td>
</tr>
</tbody>
</table>

The 100-year discharge was obtained from the median of several flood frequency curves based on empirical methods (Benson, 1962; Johnson and Tasker, 1974; FHWA, 1983; Potter, 1957a&b; Talbot, 1887). The 500-year discharge was extrapolated from the median flood frequency curve.
Description of the Water-Surface Profile Model (WSPRO) Analysis

Datum for WSPRO analysis (USGS survey, sea level, VTAOT plans)  USGS survey
Datum tie between USGS survey and VTAOT plans  None

Description of reference marks used to determine USGS datum.  RM1 is a chiseled X on top of a boulder on the upstream right bank 10 ft bankward from the right abutment and 40 ft upstream (elev. 495.82 ft, arbitrary survey datum). RM2 is a nail in a spruce tree 6 ft up from the base, 105 ft bankward from the left abutment along the road, and 22 ft downstream of the center of the road (elev. 514.17 ft, arbitrary survey datum).

Cross-Sections Used in WSPRO Analysis

<table>
<thead>
<tr>
<th>Cross-section</th>
<th>Section Reference Distance (SRD) in feet</th>
<th>Cross-section development</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXITX</td>
<td>-22</td>
<td>1</td>
<td>Exit section</td>
</tr>
<tr>
<td>FULLV</td>
<td>0</td>
<td>2</td>
<td>Downstream Full-valley section (Templated from EXITX)</td>
</tr>
<tr>
<td>BRIDG</td>
<td>0</td>
<td>1</td>
<td>Bridge section</td>
</tr>
<tr>
<td>RDWAY</td>
<td>9</td>
<td>1</td>
<td>Road Grade section</td>
</tr>
<tr>
<td>APPRO</td>
<td>41</td>
<td>1</td>
<td>Approach section</td>
</tr>
</tbody>
</table>

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 0.050 to 0.070.

Normal depth at the exit section (EXITX) was assumed as the starting water surface. This depth was computed by use of the slope-conveyance method outlined in the user’s manual for WSPRO (Shearman, 1990). The slope used was 0.0296 ft/ft, which was estimated from the appropriate topographic map (U.S. Geological Survey, 1986).

The approach section (APPRO) was surveyed one bridge length upstream of the upstream face as recommended by Shearman and others (1986). This location provides a consistent method for determining scour variables.

For the 100-year and 500-year discharges, WSPRO assumes critical depth at the bridge section. Supercritical models were developed for these discharges. After analyzing both the supercritical and subcritical profiles for each discharge, it can be determined that the water surface profile does pass through critical depth within the bridge opening. Thus, the assumptions of critical depth at the bridge are satisfactory solutions.
### Bridge Hydraulics Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value 1</th>
<th>Value 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average bridge embankment elevation</td>
<td>499.6 ft</td>
<td></td>
</tr>
<tr>
<td>Average low steel elevation</td>
<td>498.2 ft</td>
<td></td>
</tr>
<tr>
<td>100-year discharge</td>
<td>920 ft³/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation in bridge opening</td>
<td>491.8 ft</td>
<td></td>
</tr>
<tr>
<td>Road overtopping?</td>
<td>No</td>
<td>Discharge over road: -- ft³/s</td>
</tr>
<tr>
<td>Area of flow in bridge opening</td>
<td>79 ft²</td>
<td></td>
</tr>
<tr>
<td>Average velocity in bridge opening</td>
<td>11.7 ft/s</td>
<td></td>
</tr>
<tr>
<td>Maximum WSPRO tube velocity at bridge</td>
<td>14.9 ft/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section with bridge</td>
<td>495.1 ft</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section without bridge</td>
<td>491.7 ft</td>
<td></td>
</tr>
<tr>
<td>Amount of backwater caused by bridge</td>
<td>3.4 ft²</td>
<td></td>
</tr>
<tr>
<td>500-year discharge</td>
<td>1,300 ft³/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation in bridge opening</td>
<td>493.0 ft</td>
<td></td>
</tr>
<tr>
<td>Road overtopping?</td>
<td>No</td>
<td>Discharge over road: -- ft³/s</td>
</tr>
<tr>
<td>Area of flow in bridge opening</td>
<td>100 ft²</td>
<td></td>
</tr>
<tr>
<td>Average velocity in bridge opening</td>
<td>13.0 ft/s</td>
<td></td>
</tr>
<tr>
<td>Maximum WSPRO tube velocity at bridge</td>
<td>16.9 ft/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section with bridge</td>
<td>496.6 ft</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section without bridge</td>
<td>492.3 ft</td>
<td></td>
</tr>
<tr>
<td>Amount of backwater caused by bridge</td>
<td>4.3 ft²</td>
<td></td>
</tr>
<tr>
<td>Incipient overtopping discharge</td>
<td>-- ft³/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation in bridge opening</td>
<td>-- ft²</td>
<td></td>
</tr>
<tr>
<td>Area of flow in bridge opening</td>
<td>-- ft²</td>
<td></td>
</tr>
<tr>
<td>Average velocity in bridge opening</td>
<td>-- ft/s</td>
<td></td>
</tr>
<tr>
<td>Maximum WSPRO tube velocity at bridge</td>
<td>-- ft/s</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section with bridge</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Water-surface elevation at Approach section without bridge</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Amount of backwater caused by bridge</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>
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 Davis, 1995). Scour depths were calculated assuming an infinite depth of erosive material and a homogeneous particle-size distribution. The results of the scour analyses for the 100- and 500-year discharges are presented in tables 1 and 2 and the scour depths are shown graphically in figure 8.

Contraction scour for the 100-year and 500-year discharges was computed by use of the Laursen clear-water contraction scour equation (Richardson and Davis, 1995, p. 32, equation 20). The streambed armoring depths computed suggest that armoring will not limit the depth of contraction scour.

Abutment scour was computed by use of the Froehlich equation (Richardson and Davis, 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

<table>
<thead>
<tr>
<th>Contraction scour:</th>
<th>100-yr discharge</th>
<th>500-yr discharge</th>
<th>Incipient overtopping discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>(Scour depths in feet)</td>
</tr>
</tbody>
</table>

**Main channel**

- **Live-bed scour**
  - 100-yr discharge: 0.3 ft
  - 500-yr discharge: 0.8 ft
  - Incipient overtopping discharge: --

- **Clear-water scour**
  - 100-yr discharge: 18.1 ft
  - 500-yr discharge: 25.9 ft
  - Incipient overtopping discharge: --

- **Depth to armoring**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

- **Left overbank**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

- **Right overbank**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

**Local scour:**

- **Abutment scour**
  - 100-yr discharge: 11.3 ft
  - 500-yr discharge: 11.7 ft
  - Incipient overtopping discharge: --

- **Left abutment**
  - 100-yr discharge: 4.6 ft
  - 500-yr discharge: 8.4 ft
  - Incipient overtopping discharge: --

- **Right abutment**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

**Pier scour**

- **Pier 1**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

- **Pier 2**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

- **Pier 3**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

### Riprap Sizing

<table>
<thead>
<tr>
<th>100-yr discharge</th>
<th>500-yr discharge</th>
<th>Incipient overtopping discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(D&lt;sub&gt;50&lt;/sub&gt; in feet)</td>
<td></td>
</tr>
</tbody>
</table>

**Abutments:**

- **Left abutment**
  - 100-yr discharge: 1.8 ft
  - 500-yr discharge: 2.2 ft
  - Incipient overtopping discharge: --

- **Right abutment**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

**Piers:**

- **Pier 1**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --

- **Pier 2**
  - 100-yr discharge: --
  - 500-yr discharge: --
  - Incipient overtopping discharge: --
Figure 7. Water-surface profiles for the 100- and 500-yr discharges at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.
Figure 8. Scour elevations for the 100- and 500-yr discharges at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.
Table 1. Remaining footing/pile depth at abutments for the 100-year discharge at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

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<th>VTAOT minimum low-chord elevation (feet)</th>
<th>Surveyed minimum low-chord elevation¹ (feet)</th>
<th>Bottom of footing/pile elevation² (feet)</th>
<th>Channel elevation at abutment²/pier² (feet)</th>
<th>Contraction scour depth (feet)</th>
<th>Abutment scour depth (feet)</th>
<th>Pier scour depth (feet)</th>
<th>Depth of total scour (feet)</th>
<th>Elevation of scour² (feet)</th>
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1. Measured along the face of the most constricting side of the bridge.
2. Arbitrary datum for this study.

100-year discharge is 920 cubic-feet per second

Table 2. Remaining footing/pile depth at abutments for the 500-year discharge at structure MTHOTH00100061 on Town Highway 10, crossing Perry Brook, Mount Holly, Vermont.
[VTAOT, Vermont Agency of Transportation; --, no data]

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

500-year discharge is 1,300 cubic-feet per second
SELECTED REFERENCES


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


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

APPENDIX A:

WS PRO INPUT FILE
T1  U.S. Geological Survey WSPRO Input File mtho061.wsp
T2  Hydraulic analysis for structure MTHOTH00100061  Date: 16-DEC-97
T3  Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT  by  MAI
*  J3        6 29 30 552 553 551 5 16 17 13 3 * 15 14 23 21 11 12 4 7 3
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GR         8.4, 484.81    12.8, 485.06    17.5, 485.16    22.4, 485.04
GR        22.9, 486.12    25.6, 489.66    46.1, 493.71    76.6, 500.77
GR        94.4, 505.70   131.5, 511.28
N        0.070
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*  *  SRD  LSEL  XSSKEW
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GR         4.1, 487.61    4.2, 487.36    6.8, 487.16    8.8, 486.95
GR        11.8, 486.93    14.6, 487.25    18.4, 487.66    19.4, 487.78
GR        21.5, 497.08    22.9, 497.46    22.9, 498.22    0.0, 498.23
*  *  BRTYPE  BRWDTH  EMBSS  EMBELV  WWANGL
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N        0.050
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HP 2 BRIDG  492.95  * * 1300
HP 1 APPRO  496.55  1 496.55
HP 2 APPRO  496.55  * * 1300
*  EX
APPENDIX B:

WS PRO OUTPUT FILE
**WSPRO OUTPUT FILE**

U.S. Geological Survey WSPRO Input File mtho061.wsp
Hydraulic analysis for structure MTHOTH00100061 Date: 16-DEC-97
Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT by MAI
*** RUN DATE & TIME: 01-05-98 15:44

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Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT by MAI
*** RUN DATE & TIME: 01-05-98  15:44

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<th>LEW</th>
<th>REW</th>
<th>AREA</th>
<th>K</th>
<th>Q</th>
<th>VEL</th>
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</thead>
<tbody>
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<td>16.3</td>
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<td>24.0</td>
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<td></td>
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<tr>
<td>V(I)</td>
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<td>1.00</td>
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U.S. Geological Survey WSPRO Input File mth0061.wsp
Hydraulic analysis for structure MTHOTH00100061 Date: 16-DEC-97
Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT by MAI
*** RUN DATE & TIME: 01-05-98 15:44

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

EXITX:XS ****** -43. 154. 0.56 ***** 490.50 489.45 920. 489.94
-22. ****** 27. 5347. 1.00 ***** ******* 0.71 5.99

FULLV:FV 22. -43. 156. 0.54 0.64 491.14 ******* 920. 490.60
  0. 22. 27. 5449. 1.00 0.00 0.00 0.70 5.91
<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

==125 FR# EXCEEDS PNTEST AT SECID "APPRO": TRIALS CONTINUED.
PNTEST,FR#,WSEL,CRWS = 0.80 0.90 491.69 491.45

==110 WSEL NOT FOUND AT SECID "APPRO": REDUCED DELTAY.
WSLIM1,WSLIM2,DELTAY = 490.10 511.38 0.50

==115 WSEL NOT FOUND AT SECID "APPRO": USED WSMIN = CRWS.
WSLIM1,WSLIM2,CRWS = 490.10 511.38 491.45

APPRO:AS 41. -11. 103. 1.25 1.44 492.94 491.45 920. 491.69
41. 41. 23. 4431. 1.00 0.35 0.00 0.90 8.97
<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

==285 CRITICAL WATER-SURFACE ELEVATION A _ S _ U _ M _ E _ D !!!!!
SECID "BRIDG" Q,CRWS = 920. 491.80

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

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

BRIDG:BR 22. 2. 79. 2.13 ***** 493.93 491.80 920. 491.80
0. 22. 20. 5028. 1.00 ***** ******* 1.00 11.70

TYPE PPCD FLOW C P/A LSEL BLEN XLAB XRAB
4. **** 1. 1.000 ***** 498.23 ******* *******

XSID:CODE SRD FLEN HF VHD EGL ERR Q WSEL
RDWAY:RG 9. <<<<EMBANKMENT IS NOT OVERTOPPED>>>>

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

APPRO:AS 23. -23. 280. 0.17 0.29 495.23 491.45 920. 495.06
41. 24. 54. 13635. 1.00 1.01 -0.01 0.31 3.29

M(G) M(K) KQ XLKQ XRKQ OTEL
0.465 0.212 10779. -2. 17. 494.94

FIRST USER DEFINED TABLE.

XSID:CODE SRD LEW AREA Q K AREA VEL WSEL
EXITX:XS -22. -43. 27. 920. 5347. 154. 5.99 489.94
FULLV:FV 0. -43. 27. 920. 5449. 156. 5.91 490.60
BRIDG:BR 0. 2. 20. 920. 5028. 79. 11.70 491.80
RDWAY:RG 9. **************************** 0. 0.00 2.00*****
APPRO:AS 41. -23. 54. 920. 13635. 280. 3.29 495.06

XSID:CODE XLKQ XRKQ Q
APPRO:AS -2. 17. 10779.
SECOND USER DEFINED TABLE.

XSID:CODE CRWS FR# YMIN YMAX HF HO VHD EGL WSEL
EXITX:XS 489.45 0.71 484.81 511.28********** 0.56 490.50 489.94
FULLV:FV ******** 0.70 485.44 511.91 0.64 0.00 0.54 491.14 490.60
BRIDG:BR 491.80 1.00 486.93 498.23********** 2.13 493.93 491.80
RDWAY:RG ************* 499.51 513.75***************
APPRO:AS 491.45 0.31 487.28 511.38 0.29 1.01 0.17 495.23 495.06
U.S. Geological Survey WSPRO Input File mtho061.wsp
Hydraulic analysis for structure MTHOTH00100061 Date: 16-DEC-97
Bridge 61 on Town Highway 10 over Perry Brook Mount Holly, VT by MAI

*** RUN DATE & TIME: 01-05-98 15:44

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

EXITX:XS ***** -45. 193. 0.70 ***** 491.19 489.97 1300. 490.49
-22. 30. 7551. 1.00 ***** ******* 0.74 6.73

FULLV: FV 22. -45. 197. 0.68 0.63 491.85 ******* 1300. 490.49
0. 22. 30. 7766. 1.00 0.00 0.72 6.60

<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

===125 FR# EXCEEDS FNTEST AT SECID "APPRO": TRIALS CONTINUED.
FNTEST,FR#,WSEL,CRWS = 0.80 1.03 492.22 492.31

===110 WSEL NOT FOUND AT SECID "APPRO": REDUCED DELTAY.
WSLIM1,WSLIM2,DELTAY = 490.67 511.38 0.50

===115 WSEL NOT FOUND AT SECID "APPRO": USED WSMIN = CRWS.
WSLIM1,WSLIM2,CRWS = 490.67 511.38 492.31

===130 CRITICAL WATER-SURFACE ELEVATION A_S_S_U_M_E_D !!!!!
ENERGY EQUATION N_O_T B_A_L_A_N_C_E_D AT SECID "APPRO"
WSBEG,WSEND,CRWS = 492.31 511.38 492.31

APPRO:AS 41. -13. 124. 1.70 ***** 494.01 492.31 1300. 492.31
41. 41. 24. 5725. 1.00 ***** ******* 1.00 10.46

<<<THE ABOVE RESULTS REFLECT "NORMAL" (UNCONSTRICTED) FLOW>>>>

===285 CRITICAL WATER-SURFACE ELEVATION A_S_S_U_M_E_D !!!!!
SECID "BRIDG" Q,CRWS = 1300. 492.95

<<<<<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 22. 2. 100. 2.62 ***** 495.57 492.95 1300. 492.95
0. 22. 21. 7093. 1.00 ***** ******* 1.00 12.97

TYPE PPCD FLOW C P/A LSEL BLEN XLAB XRAB
4. **** 1. 1.000 *** 498.23 ******* ****

FIRST USER DEFINED TABLE.

XSID:CODE SRD LEW REW Q K AREA VEL WSEL
EXITX:XS -22. -45. 30. 1300. 7551. 193. 6.73 490.49
FULLV:FV 0. -45. 30. 1300. 7766. 197. 6.60 491.17
BRIDG:BR 0. 2. 21. 1300. 7093. 100. 12.97 492.95
RDWAY:RG 9. ******* 0. ******* 2.00********
APPRO:AS 41. -36. 60. 22248. 1.00 0.88 -0.01 0.27 3.19
M(G) M(K) KQ XLKQ XRKQ OTEL
0.504 0.325 15049. -2. 17. 496.45

SECOND USER DEFINED TABLE.

XSID:CODE CRWS FR# YMIN YMAX HF HO VHD EGL WSEL
EXITX:XS 489.97 0.74 484.81 511.28*************** 0.70 491.19 490.49
FULLV:FV 0.72 485.44 511.91 0.63 0.00 0.68 491.85 491.17
BRIDG:BR 492.95 1.00 486.93 498.23*************** 2.62 495.57 492.95
RDWAY:RG 499.51 513.75***********************
APPRO:AS 492.31 0.27 487.28 511.38 0.25 0.88 0.16 496.70 496.55
APPENDIX C:

BED-MATERIAL PARTICLE-SIZE DISTRIBUTION
Appendix C. Bed material particle-size distribution for a pebble count in the channel approach of structure MTHOTH00100061, in Mount Holly, Vermont.
APPENDIX D:

HISTORICAL DATA FORM
The structural inspection report of 6/24/94 indicates the structure is a steel stringer type bridge with a timber deck. The abutment walls and wingwalls are noted as consisting of large “laid-up” stone with concrete caps on the abutment walls. There is random spalling reported on the concrete caps overall. Also there are several small voids and some resulting displacement and breaking of the laid-up stone work. The channel bed consists of mainly cobbles and boulders. There are several large boulders across the channel at the downstream face of the bridge. The report indicates some small tree limbs scattered along the edges of the channel.
Bridge Hydrologic Data

Is there hydrologic data available?  ____ 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-immediately upstream of the site)

Water Surface Elevation Estimates for Existing Structure:

<table>
<thead>
<tr>
<th>Peak discharge frequency</th>
<th>Q_{2.33}</th>
<th>Q_{10}</th>
<th>Q_{25}</th>
<th>Q_{50}</th>
<th>Q_{100}</th>
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</thead>
<tbody>
<tr>
<td>Water surface elevation (ft)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Velocity (ft/sec)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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):  ____  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 (ft²): ______
Comments:
-

USGS Watershed Data

Watershed Hydrographic Data

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tbody>
<tr>
<td>Drainage area (DA)</td>
<td>5.38 mi²</td>
<td>Lake/pond/swamp area</td>
</tr>
<tr>
<td>Watershed storage (ST)</td>
<td>1.9 %</td>
<td></td>
</tr>
<tr>
<td>Bridge site elevation</td>
<td>1417 ft</td>
<td>Headwater elevation</td>
</tr>
<tr>
<td>Main channel length</td>
<td>5.75 mi</td>
<td></td>
</tr>
<tr>
<td>10% channel length</td>
<td>1476 ft</td>
<td>85% channel length</td>
</tr>
<tr>
<td>Main channel slope (S)</td>
<td>100.37 ft / mi</td>
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Watershed Precipitation Data

<p>| | |</p>
<table>
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<tr>
<td>Average site precipitation</td>
<td>- in</td>
</tr>
<tr>
<td>Average headwater precipitation</td>
<td>- in</td>
</tr>
<tr>
<td>Maximum 2yr-24hr precipitation event (I24,2)</td>
<td>- in</td>
</tr>
<tr>
<td>Average seasonal snowfall (Sn)</td>
<td>- ft</td>
</tr>
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</table>
**Bridge Plan Data**

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

Project Number:  
Minimum channel bed elevation:  

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

Benchmark location description:  
**NO BENCHMARK INFORMATION**

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

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

If 1: Footing Thickness _______  
Footing bottom elevation:  

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

If 3: Footing bottom elevation:  

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

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

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

Comments:  
**NO PLANS.**
Cross-sectional Data

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

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

Comments:  
The low chord to bed lengths, and the distances between the stations were taken from a sketch dated 8/19/92 that was attached to a bridge inspection report. The elevation coordinate was made to match those in the report, they are lined up by the low chord points.

<table>
<thead>
<tr>
<th>Station</th>
<th>Feature</th>
<th>Low chord elevation</th>
<th>Bed elevation</th>
<th>Low chord to bed</th>
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<tbody>
<tr>
<td>0</td>
<td>LAB</td>
<td>498.2</td>
<td>487.6</td>
<td>10.6</td>
</tr>
<tr>
<td>5.6</td>
<td>RAB</td>
<td>498.2</td>
<td>486.8</td>
<td>11.4</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>498.2</td>
<td>487.7</td>
<td>10.5</td>
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<tr>
<th>Station</th>
<th>Feature</th>
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<th>Bed elevation</th>
<th>Low chord to bed</th>
</tr>
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<tbody>
<tr>
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<th>Low chord elevation</th>
<th>Bed elevation</th>
<th>Low chord to bed</th>
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<tr>
<th>Station</th>
<th>Feature</th>
<th>Low chord elevation</th>
<th>Bed elevation</th>
<th>Low chord to bed</th>
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</thead>
<tbody>
<tr>
<td>-</td>
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</tr>
</tbody>
</table>

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

Comments: **-**
APPENDIX E:

LEVEL I DATA FORM
A. General Location Descriptive

1. Data collected by (First Initial, Full last name) M. Ivanoff Date (MM/DD/YY) 10/11/1995
2. Highway District Number 03
   County Rutland (021)
   Waterway Perry Brook
   Route Number TH 10
3. Descriptive comments:
   The site is located 0.75 miles from Town Highway 28.

B. Bridge Deck Observations

4. Surface cover... LBUS 6 RBUS 6 LBDS 6 RBDS 6 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 29.0 (feet) Span length 25.0 (feet) Bridge width 14.0 (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 --

Channel approach to bridge (BF):
15. Angle of approach: 5
16. Bridge skew: 5

17. Channel impact zone 1:
   Exist? Y (Y or N)
   Where? RB (LB, RB) Severity 1
   Range? 20 feet US (US, UB, DS) to 40 feet US

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

Impact Severity: 0-none to very slight; 1-Slight; 2-Moderate; 3-Severe
C. Upstream Channel Assessment

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<th></th>
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<tbody>
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<td>SRD</td>
<td>LB</td>
<td>RB</td>
<td>LB</td>
<td>RB</td>
</tr>
<tr>
<td>17.5</td>
<td>2.0</td>
<td>2.5</td>
<td>4</td>
<td>4</td>
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<tr>
<td>23. Bank width</td>
<td>35.0</td>
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<td></td>
</tr>
<tr>
<td>24. Channel width</td>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Thalweg depth</td>
<td>31.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Bed Material</td>
<td>432</td>
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</table>

<table>
<thead>
<tr>
<th>Bank protection type:</th>
<th>LB</th>
<th>RB</th>
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<tbody>
<tr>
<td>30. Bank protection condition:</td>
<td>LB</td>
<td>RB</td>
</tr>
</tbody>
</table>

18. Bridge Type: 4

1a- Vertical abutments with wingwalls
1b- Vertical abutments without wingwalls
2- Vertical abutments and wingwalls, sloping embankment
  Wingwalls parallel 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. The bridge dimensions are from the VOTA database. The measured bridge length is 29.5 ft, span is 23 ft, width is 14.0 ft.

11. The left bank downstream side of the road approach has some timber failure eight feet from the abutment face. Stones protect the road embankment six ft from the abutment face.

27. The left bank material consists of gravel, cobbles and sand. The right bank material consists of cobbles gravel and sand.

29. The bed material consists of cobbles, gravel and sand.
The point bar consists of sand and small gravel.

Another cut bank exists along left bank from 100 ft to 175 ft upstream with steepened slopes and exposed roots.

The bed material consists of cobbles with gravel and some sand.
65. Debris and Ice  Is there debris accumulation? ___ (Y or N)  66. Where? N (1- Upstream; 2- At bridge; 3- Both)
67. Debris Potential - ___ ( 1- Low; 2- Moderate; 3- High)  68. Capture Efficiency ___ ( 1- Low; 2- Moderate; 3- High)
69. Is there evidence of ice build-up? ___ (Y or N)  70. Debris and Ice Comments:

2

Debris is scattered along the upstream banks with some trees leaning into the channel.

68. Debris capture is likely with large boulders across the downstream bridge face to the end of the wingwalls. Ice blockage will increase with large boulders obstructing flow.

79. Abutment comments (eg. undermined penetration, unusual scour processes, debris, etc.):
0
0
2

77. The abutments consist of “laid up” stone walls with concrete caps.

80. Wingwalls:

<table>
<thead>
<tr>
<th></th>
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<tbody>
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<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>USRWW:</td>
<td>Y</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>DSLWW:</td>
<td>0</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>DSRWW:</td>
<td>2</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
<td>___</td>
</tr>
</tbody>
</table>

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

82. Bank / Bridge Protection:

<table>
<thead>
<tr>
<th>Location</th>
<th>USLWW</th>
<th>USRWW</th>
<th>LABUT</th>
<th>RABUT</th>
<th>LB</th>
<th>RB</th>
<th>DSLWW</th>
<th>DSRWW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>0</td>
<td>0</td>
<td>Y</td>
<td>0</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Condition</td>
<td>Y</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Extent</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

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
84. Are there piers? **80.** *(Y or if N type ctrl-n pr)*

85. **Piers:**

<table>
<thead>
<tr>
<th>Pier no.</th>
<th>width (w) feet</th>
<th>elevation (e) feet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>w1</td>
<td>w2</td>
</tr>
<tr>
<td>Pier 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 2</td>
<td>8.0</td>
<td>9.5</td>
</tr>
<tr>
<td>Pier 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pier 4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

86. Location (BF) **The**

87. Type **upst slum N**

88. Material **ream ped.**

89. Shape **right**

90. Inclined? **wing**

91. Attack \( \langle \) (BF) **wall**

92. Pushed **end**

93. Length (feet) **-**

94. # of piles **has**

95. Cross-members **stone**

96. Scour Condition **s**

97. Scour depth **that**

98. Exposure depth **appe**

---

**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
### E. Downstream Channel Assessment

<table>
<thead>
<tr>
<th>SRD</th>
<th>LB</th>
<th>RB</th>
<th>LB</th>
<th>RB</th>
<th>LB</th>
<th>RB</th>
<th>LB</th>
<th>RB</th>
<th>LB</th>
<th>RB</th>
<th>LB</th>
<th>RB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Bank height (BF)**
- **Bank angle (BF)**
- **% Veg. cover (BF)**
- **Bank material (BF)**
- **Bank erosion (BF)**
- **Bank width (BF)**
- **Channel width**
- **Thalweg depth**
- **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.):

- 
- 
- 
- 

**NO PIERS**

101. Is a drop structure present? **4** *(Y or N, if N type ctrl-n ds)*

102. Distance: **-** feet

103. Drop: **-** feet

104. Structure material: **4** *(1- steel sheet pile; 2- wood pile; 3- concrete; 4- other)*

105. Drop structure comments (eg. downstream scour depth):

- 43
- 435
- 0
- 1
- 4325
- 0
106. Point/Side bar present? 0 (Y or N. if N type ctrl-n pb) Mid-bar distance: _____ Mid-bar width: _____

Point bar extent: The _____ feet left (US, UB, DS) to bank _____ feet ma (US, UB, DS) positioned teri %LB to al %RB

Material: con

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

sists of cobble and gravel. The right bank material consists of cobble, gravel and some boulders. The bed material consists of cobble, gravel, sand and some boulders.

There is a boulder pile between the downstream wing walls. It extends across the entire channel from just below the downstream bridge face to 20 ft downstream.

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

Cut bank extent: nelis feet ana (US, UB, DS) to bran feet che (US, UB, DS)

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

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

85 ft downstream. The flow cuts off a previous bend in the channel forming a mid-channel bar.

Is channel scour present? ____ (Y or if N type ctrl-n cs) Mid-scour distance: ______

Scour dimensions: Length _____ Width _____ Depth: _____ Positioned ____ %LB to N ____ %RB

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

- NO DROP STRUCTURE

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

Confluence 1: Distance _____ Enters on N ____ (LB or RB) Type ____ (1- perennial; 2- ephemeral)

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

Confluence comments (eg. confluence name):

-

-

F. Geomorphic Channel Assessment

107. Stage of reach evolution -

1- Constructed
2- Stable
3- Aggraded
4- Degraded
5- Laterally unstable
6- Vertically and laterally unstable
108. Evolution comments (Channel evolution not considering bridge effects; See HEC-20, Figure 1 for geomorphic descriptors):

- 
- 

NO POINT BARS
A mid-channel bar begins 85 ft to 136 ft downstream. It consists of boulder and cobble. It is 25 feet wide at mid-bar, 105 feet downstream.

Y
RB
30
24
DS
48
DS
109. G. Plan View Sketch

- Point bar (pb)
- Cut-bank (cb)
- Scour hole
- Debris
- Rip rap or stone fill
- Flow (Q)
- Cross-section
- Ambient channel
- Stone wall
- Other wall
APPENDIX F:

SCOUR COMPUTATIONS
SCOUR COMPUTATIONS

Structure Number: MTHOTH00100061             Town:    Mount Holly
Road Number:      TH 10                      County:  Rutland
Stream:           Perry Brook

Initials MAI      Date:    01/05/98 Checked: ECW

I. Analysis of contraction scour, live-bed or clear water?

Critical Velocity of Bed Material (converted to English units)

\[ V_c = 11.21 \times y_1^{0.1667} \times D_{50}^{0.33} \text{ with } S_s = 2.65 \]

(Richardson and others, 1995, p. 28, eq. 16)

Approach Section

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>100 yr</th>
<th>500 yr</th>
<th>other Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total discharge, cfs</td>
<td>920</td>
<td>1300</td>
<td>0</td>
</tr>
<tr>
<td>Main Channel Area, ft²</td>
<td>280</td>
<td>408</td>
<td>0</td>
</tr>
<tr>
<td>Left overbank area, ft²</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Right overbank area, ft²</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Top width main channel, ft</td>
<td>78</td>
<td>96</td>
<td>0</td>
</tr>
<tr>
<td>Top width L overbank, ft</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Top width R overbank, ft</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>D₅₀ of channel, ft</td>
<td>0.3176</td>
<td>0.3176</td>
<td>0</td>
</tr>
<tr>
<td>D₅₀ left overbank, ft</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>D₅₀ right overbank, ft</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

y₁, average depth, MC, ft      | 3.6    | 4.3    | ERR     |

y₁, average depth, LOB, ft      | ERR    | ERR    | ERR     |

y₁, average depth, ROB, ft      | ERR    | ERR    | ERR     |

Total conveyance, approach      | 13622  | 22276  | 0       |
Conveyance, main channel        | 13622  | 22276  | 0       |
Conveyance, LOB                 | 0      | 0      | 0       |
Conveyance, ROB                 | 0      | 0      | 0       |
Percent discrepancy, conveyance | 0.0000 | 0.0000 | ERR     |
Qₘ, discharge, MC, cfs          | 920.0  | 1300.0 | ERR     |
Qₗ, discharge, LOB, cfs         | 0.0    | 0.0    | ERR     |
Qᵣ, discharge, ROB, cfs         | 0.0    | 0.0    | ERR     |

Vₘ, mean velocity MC, ft/s      | 3.3    | 3.2    | ERR     |
Vₗ, mean velocity, LOB, ft/s    | ERR    | ERR    | ERR     |
Vᵣ, mean velocity, ROB, ft/s    | ERR    | ERR    | ERR     |
Vₘ-c, crit. velocity, MC, ft/s  | 9.5    | 9.7    | N/A     |
Vₗ-c, crit. velocity, LOB, ft/s | ERR    | ERR    | ERR     |
Vᵣ-c, crit. velocity, ROB, ft/s| ERR    | ERR    | ERR     |

Results

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

<table>
<thead>
<tr>
<th></th>
<th>100 yr</th>
<th>500 yr</th>
<th>other Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Channel</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Left Overbank</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Right Overbank</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Clear Water Contraction Scour in MAIN CHANNEL

\[ y_2 = \left( \frac{Q_2^2}{(131 \cdot Dm^{2/3} \cdot W_2^2)} \right)^{3/7} \]  
Converted to English Units

\[ y_s = y_2 - y_{bridge} \]

(Richardson and others, 1995, p. 32, eq. 20, 20a)

<table>
<thead>
<tr>
<th>Bridge Section</th>
<th>Q100</th>
<th>Q500</th>
<th>Other Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Q) total discharge, cfs</td>
<td>920</td>
<td>1300</td>
<td>0</td>
</tr>
<tr>
<td>(Q) discharge thru bridge, cfs</td>
<td>920</td>
<td>1300</td>
<td>0</td>
</tr>
<tr>
<td>Main channel conveyance</td>
<td>5035</td>
<td>7097</td>
<td>0</td>
</tr>
<tr>
<td>Total conveyance</td>
<td>5035</td>
<td>7097</td>
<td>0</td>
</tr>
<tr>
<td>Q2, bridge MC discharge,cfs</td>
<td>920</td>
<td>1300</td>
<td>ERR</td>
</tr>
<tr>
<td>Main channel area, ft2</td>
<td>79</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Main channel width (normal), ft</td>
<td>18.4</td>
<td>19.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Cum. width of piers in MC, ft</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>W, adjusted width, ft</td>
<td>18.4</td>
<td>19.1</td>
<td>0</td>
</tr>
<tr>
<td>y_{bridge} (avg. depth at br.), ft</td>
<td>4.29</td>
<td>5.24</td>
<td>ERR</td>
</tr>
<tr>
<td>Dm, median (1.25*D50), ft</td>
<td>0.397</td>
<td>0.397</td>
<td>0</td>
</tr>
<tr>
<td>y2, depth in contraction,ft</td>
<td>4.61</td>
<td>6.00</td>
<td>ERR</td>
</tr>
<tr>
<td>y_s, scour depth (y2-y_{bridge}), ft</td>
<td>0.31</td>
<td>0.77</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Armoring

\[ Dc = \left\{ \frac{(1.94 \cdot V^2)}{(5.75 \cdot \log(12.27 \cdot y/D90))^2} \right\} / [0.03 \cdot (165 - 62.4)] \]

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

(Federal Highway Administration, 1993)

<table>
<thead>
<tr>
<th>Downstream bridge face property</th>
<th>100-yr</th>
<th>500-yr</th>
<th>Other Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q, discharge thru bridge MC, cfs</td>
<td>920</td>
<td>1300</td>
<td>N/A</td>
</tr>
<tr>
<td>Main channel area (DS), ft2</td>
<td>79</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Main channel width (normal), ft</td>
<td>18.4</td>
<td>19.1</td>
<td>0.0</td>
</tr>
<tr>
<td>Cum. width of piers, ft</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Adj. main channel width, ft</td>
<td>18.4</td>
<td>19.1</td>
<td>0.0</td>
</tr>
<tr>
<td>D90, ft</td>
<td>0.9912</td>
<td>0.9912</td>
<td>0.0000</td>
</tr>
<tr>
<td>D95, ft</td>
<td>1.3051</td>
<td>1.3051</td>
<td>0.0000</td>
</tr>
<tr>
<td>Dc, critical grain size, ft</td>
<td>0.8683</td>
<td>0.9816</td>
<td>ERR</td>
</tr>
<tr>
<td>Pc, Decimal percent coarser than Dc</td>
<td>0.126</td>
<td>0.102</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Depth to armoring, ft | 18.07 | 25.93 | ERR |
Abutment Scour

Froehlich’s Abutment Scour
\[ Y_s/Y_1 = 2.27 \cdot K_1 \cdot K_2 \cdot (a'/Y_1)^{0.43} \cdot Fr_1^{0.61} + 1 \]
(Richardson and others, 1995, p. 48, eq. 28)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Left Abutment</th>
<th>Right Abutment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Qt), total discharge, cfs</td>
<td>920</td>
<td>920</td>
</tr>
<tr>
<td>a’, abut.length blocking flow, ft</td>
<td>25.2</td>
<td>34.2</td>
</tr>
<tr>
<td>Ae, area of blocked flow ft2</td>
<td>93.37</td>
<td>65.08</td>
</tr>
<tr>
<td>Qe, discharge blocked abut., cfs</td>
<td>309.73</td>
<td>42.4</td>
</tr>
<tr>
<td>Ve, (Qe/Ae), ft/s</td>
<td>3.32</td>
<td>0.65</td>
</tr>
<tr>
<td>ya, depth of f/p flow, ft</td>
<td>3.71</td>
<td>1.90</td>
</tr>
<tr>
<td>--Coeff., K1, for abut. type (1.0, verti.; 0.82, verti. w/ wingwall; 0.55, spillthru)</td>
<td>0.82</td>
<td>0.82</td>
</tr>
<tr>
<td>--Angle (theta) of embankment (&lt;90 if abut. points DS; &gt;90 if abut. points US)</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>K2</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Fr, froude number f/p flow</td>
<td>0.304</td>
<td>0.083</td>
</tr>
<tr>
<td>ys, scour depth, ft</td>
<td>11.31</td>
<td>4.60</td>
</tr>
<tr>
<td>HIRE equation (a’/ya &gt; 25)</td>
<td>a’ (abut length blocked, ft)</td>
<td>25.2</td>
</tr>
<tr>
<td></td>
<td>yl (depth f/p flow, ft)</td>
<td>3.71</td>
</tr>
<tr>
<td></td>
<td>Skew correction (p. 49, fig. 16)</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Froude no. f/p flow</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Ys w/ corr. factor K1/0.55:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>vertical</td>
<td>ERR</td>
</tr>
<tr>
<td></td>
<td>vertical w/ ww’s</td>
<td>ERR</td>
</tr>
</tbody>
</table>
Abutment riprap Sizing

Ishbash Relationship

\[ D_{50} = y \cdot K \cdot \left( F_r \right)^2 / \left( S_s - 1 \right) \]

\( D_{50} = y \cdot K \left( F_r \right)^{2.14} / \left( S_s - 1 \right) \)

(Richardson and others, 1995, p112, eq. 81,82)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Q100</th>
<th>Q500</th>
<th>Other Q</th>
<th>Q100</th>
<th>Q500</th>
<th>Other Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fr, Froude Number</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>y, depth of flow in bridge, ft</td>
<td>4.29</td>
<td>5.24</td>
<td>0.00</td>
<td>4.29</td>
<td>5.24</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Median Stone Diameter for riprap at: left abutment
Fr\(\leq0.8\)  (vertical abut.) ERR ERR 0.00 ERR ERR 0.00
Fr\(>0.8\)  (vertical abut.) 1.79 2.19 ERR 1.79 2.19 ERR

right abutment, ft
Fr\(\leq0.8\)  ERR ERR 0.00 ERR ERR 0.00
Fr\(>0.8\)  1.79 2.19 ERR 1.79 2.19 ERR