MAINE DEPARTMENT OF TRANSPORTATION
BRIDGE PROGRAM

HYDROLOGY
&
HYDRAULICS
REPORT

For the Replacement of:

Hill Mill Bridge
Over
Hill Mill Stream
In
Stetson, Maine

Br #5629

WIN 019308.00

(Excerpted from PDR)

The Hill Mill Bridge (#5629) on Mullen Road in Stetson spans over the Hill Mill Stream. The Hill Mill Stream originates up in Exeter in the Greenbush Swamp and flows southerly picking up several small tributaries off of the hills. Just north of the project, the stream flows into a small, swampy area. Through the project and beyond, the stream picks up gradient for about 50 feet in elevation before flowing into another swampy area. About 1 mile downstream of the culvert, the Hill Mill flows into the Stetson Stream. Through the project, the channel is well defined, particularly with the presence of bedrock.

Very little information exists on the flow data for the Hill Mill Stream. There is a FEMA flood insurance study and rate map for the town of Stetson from 1991, but the Hill Mill Stream was not studied. The drainage basin characteristics for the bridge were provided by the Maine Department of Transportation Environmental Office - Hydrology Section. The flows were computed using the 1999 USGS full regression equation. These flows were used for design and are as follows:

Summary

Drainage Area = 4.83 mi^2

Ordinary High Water ($Q_{1.1}$) = 83.5 cfs

10 Year Flood (Q_{10}) = 370.3 cfs

25 Year Flood (Q_{25}) = 484.2 cfs

Design Discharge (Q_{50}) = 574.9 cfs

Check Discharge (Q_{100}) = 673.1 cfs

Input from the public is limited. While on site, team members spoke with Mrs. Dickinson who is the land owner on the northwest corner. She reported that she had never seen the road overtop, but that water has reached the top of the arch. She did not give a date when this high water had occurred or any exact height of water.

Reported By: Richard E. Myers, P.E.
Date: August 6, 2012

Note: Relevant data and reports are provided in the appendix of this Preliminary Design Report.

The existing and proposed bridges were analyzed using HY-8, version 7.2, the culvert hydraulic analysis program distributed by the Federal Highway Administration. Each bridge was modeled and run with peak flows. The hydraulic computations require only one representative downstream cross section. Following is a list of parameters used in the existing model:

Stream

- Cross section: Irregular; survey data was used to input stations and elevations of 18 points representing a typical downstream cross section. Bottom of streambed was set at an elevation of 244.49'.
- Stream slope: 0.0295 ft/ft
- Manning's "n": 0.035 main channel
0.080 overbanks

Culvert

- Structural steel plate arch: 14'-0" x 6'-5 ½" plus the 1'-0" footing depth
- Slope: 0.0295 ft/ft
- Mitered ends
- Manning's "n": 0.030 (top/sides)

The results of the analysis are summarized below. Complete input and output is provided in the appendix of this report. Results correlate well with what was witnessed by the public. The existing structure has an HW/D (headwater elevation to culvert depth) ratio of 0.92 at Q50 which is larger than the recommended 0.90 and the arch doesn't pass the Q100 flood event. Therefore, the structure is barely adequate and not up to current standards.

The options investigated for a proposed replacement structure needed to address several issues. The first issue was to satsify environmetal needs. As with any buried structure, in order to satisfy the environmetal agencies and expedite the permitting process, the best solution would be to provide a structure with a span equal to or greater than 1.2 bankfull width and maintain a natural stream bottom. Maintaining a natural stream bottom at this site is very practical since the streambed is mostly bedrock. Trying to put a structure in with a bottom would result in unecessary rock excavation and would not be prudent. Bankfull width at this site was field measured by the MaineDOT Environmental Office and was found to be 17.6 feet; therefore, 1.2 bankfull width is 21.12 feet. Where this type of structure results in a lot greater cost and impacts over options that do not satisfy these criteria but are completely adequate in every other way, these other options can and should be assessed. The next level down from a structure spanning 1.2 bankfull width would be a structure satisfying at least bankfull width.

The second issue to address in investigating replacement options was to ensure an adequate opening for hydraulics, particulary since the existing culvert is inadequate. The third issue to address at this site was to eliminate the rusting issue on the existing structure around the high water mark. The ultimate goal was to satisfy all of the above criteria while minimizing cost and impacts, particulary because the road is a Corridor Priority 4 with only 800 AADT.

As discussed in the Summary of Preliminary Design, several different alternatives were investigated for a replacement structure. Each of the alternatives included cast-in-place concrete footings placed on bedrock. In order to address the rust issue discussed above, particularly for metal structures, it was assumed that the top of footing would be placed at elevation 248.25' which is just above the Q1.1 elevation. The existing top of footing elevation is about 246.8' and the rust extends up about 12 to 18 inches which would be elevation 248.3' maximum. It was found that once the length of the toe of the footing was accounted for in the width of the opening, a 20 foot span structure would be needed at a minimum just to provide for a bankfull width between the faces of the footing. At this point, it was determined that achieving the 1.2 bankfull width criteria would be unreasonable. Increasing the span to achieve 1.2 bankfull width would certainly increase the cost and in the case of metal buried structures, it would reduce the earth cover to the point where minimum cover is no longer satisfied unless the roadway is raised. Raising the road at this site is very undesirable as it would add unnecessary additional cost and impacts to the project. It was also found that with a structure span satisfying only bankfull width, the opening is more than adequate for hydraulics. The recommended option was again analyzed using HY-8. The same stream parameters used in the existing structure model were also used in the proposed structure model. Following is a list of culvert input used for the proposed structure:

- Structural steel plate arch: 20'-0" span x 6'-4" rise plus 1.76' for the footing depth.
- Slope: 0.0295 ft/ft
- Mitered ends
- Manning's "n": 0.030 (top/sides)

The above input resulted in an HW/D ratio equal to an acceptable 0.67 at Q50. In addition, the structure now passes Q100. The results of the analysis are summarized below. Complete input and output is provided in the appendix of this report. It should be noted that both the existing and proposed structures are inlet controlled. Due to this, the tailwater velocity is based on normal depth of the typical downstream cross section which results in the velocities downstream being the same for both structures. Scour of the streambed should not be an issue here since it is mostly bedrock. Plain riprap will be used on the slopes around the structure ends up to the Q50 elevation to prevent washout of the embankment.

SUMMARY

		Existing Structure	**Proposed Bridge**
Unit		14’-0” Span × 6’-5 ½” Rise Steel Arch	20’-0” Span × 6’-4” Rise Steel Arch
	Area of Opening (s.f.)	84	126
	Headwater El. Q1.1	248.21	247.77
	Headwater El. Q10	251.34	250.37
ft	Headwater El. Q25	252.38	251.09
	Headwater El. Q50	253.18	251.67
	Headwater El. Q100	254.05	252.29
	Hw/D @ Q50	0.92	0.67
	Discharge Vel. Q1.1	6.77	6.77
	Discharge Vel. Q10	11.43	11.43
ft/s	Discharge Vel. Q25	12.28	12.28
	Discharge Vel. Q50	12.83	12.83
	Discharge Vel. Q100	13.33	13.33

*Elevations based on NAVD

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