HYDROLOGY/HYDRAULICS REPORT

OVERVIEW & PURPOSE

Ricker's bridge is located in Turner, Androscoggin County, Maine. The existing bridge is a 36 foot long (24 foot clear) single span steel girder bridge with timber decking that carries Ricker Hill Road over Martin Stream. The existing bridge is structurally deficient, has a sufficiency rating of 15.8 and is programmed for replacement. The existing and proposed conditions have been modeled hydraulically in order to determine water surface elevations, flow rates and water velocities for various flooding conditions. The purpose of this hydrology/hydraulics analysis is to make design recommendations for the proposed structure using available site specific information.

FEMA

The Federal Emergency Management Agency (FEMA) produced a Flood Insurance Study and a Flood Insurance Rate Map (FIRM) for the Town of Turner; they were used as additional resources for this project (see Appendix D). The FEMA FIS provides flood profiles, i.e. water surface elevations for various flow condition as well as peak discharges for Martin Stream (see Appendix D). This study is dated May 5, 2003. Vertical datum shift conversions from NGVD 29 to the NAVD 88 are required for data comparison purposes. Datum conversion was performed using the NGS VERTON program (see Appendix D).

OBSERVED FLOODING

The flood of record for the existing bridge occurred in April of 1987. Eyewitness reports have the flood water elevation for this 100-year event approximately 1ft above the low point on the approach roadway, EL 329.2ft. There was no bridge overtopping at this time (see Appendix D). FEMA's Flood Profile indicates a lower 100-year flood elevation at Ricker's Bridge. Conservatively, the eye witness elevation, 330.2' (NAVD 88), was used to calibrate the hydraulic model.

FREEBOARD

A design exception for Q50 freeboard depth is recommended in order to limit raising profile geometry. By minimizing the rise in profile geometry, approach roadway work, wetlands impacts, right of way impacts and construction costs are all reduced. Accepting some risk and forgoing the BDG recommended 2ft freeboard will be most economical and practical in this case. The recommendation is to limit the proposed bottom chord elevation to EL 327.8ft. This matches the existing bottom chord elevation and effectively matches the existing Q50

freeboard condition. The existing Q50 freeboard is -1.5ft however, the bridge has endured various flooding events over time, the most significant of which being the 100yr event, Flood of 1987. The proposed structure will provide additional hydraulic opening at the bridge, approximately 35% increase. This increased opening will not noticeably improve upon Q50 freeboard, but will significantly reduce water velocities and abutment scour potential.

PEAK FLOWS

Martin Stream drainage basin characteristics produced by the Hydrology Section of MaineDOT Environmental Office are tabulated below. In accordance with MaineDOT policy, the USGS regression equations (Hodgkins, 1999) were used to compute the peak discharges (see Appendix D). The USGS regression equation peak discharges are as follows:

USGS REGRESSION PEAK DISCHARGES

Drainage Area	35.8	mi^2
Wetlands	11	%
Q1.1	468	ft^3/s
Q10	1,715	ft^3/s
Q50	2,515	ft^3/s
Q100	2,887	ft^3/s
Q500	3,798	ft^3/s

The USGS regression equations peak discharges, above, are much higher in comparison to the FEMA peak discharges, below, up to 2 times larger. Upon speaking with the Department's Chief Hydrologist, it would be appropriate, in this case, to model and design using the FEMA flow values since the FIS took into account the effects of increased valley storage combined with a relatively small increase in contributing drainage area. The FEMA peak discharges are as follows:

FEMA PEAK DISCHARGES

Drainage Area	36.3	mi^2
Q10	780	ft^3/s
Q50	1,270	ft^3/s
Q100	1,410	ft^3/s
Q500	1,900	ft^3/s

PROPOSED STRUCTURE

The recommended bridge superstructure consists of a 50' detail-build simple span structure. Acceptable alternatives include but are not limited to: precast/prestressed beams or slabs, steel girders (new or reclaimed from the Department) or any other acceptable

prefabricated bridge structure selected by the Contractor. The bottom chord elevation of the proposed superstructure will be located at the same elevation as the existing bottom chord elevation.

PROPOSED SUBSTRUCTURE

The recommended abutment type is reinforced concrete stub abutments on soil. A design exception is recommended in order to limit the footing depth/location. Riprap scour countermeasures are required. The determination has been made that additional cost associated with deep footings or pile supported foundations is not warranted at this location.

HEC-RAS MODEL

Using FEMA's peak flow data, ground surface topography (MaineDOT field survey) and bridge geometry a computerized model of the site was generated utilizing HEC-RAS v 4.1. HEC-RAS is a computer program developed by the Army Corps of Engineers that models the hydraulics of water flow through natural rivers and other channels. With the aid of HEC-RAS, values for flood flow rates, velocities and elevations were first generated for the existing structure. As a check for accuracy and a method of calibration, the computer model results were compared to the know flood of record elevation. Once the model was calibrated the geometry for the proposed structures were input to create a hydraulic model of the proposed conditions. The existing and proposed hydraulic data is as follows:

HYDRAULICS SUMMARY

		Existing Structure	Recommended Structure
		36' Single Span	50' Single Span
Total Area of Waterway Opening	ft^2	200	270
Headwater elevation @ Q_{10}	ft	327.6	327.6
Headwater elevation @ Q_{25}	ft	328.7	328.8
Headwater elevation @ Q_{50}	ft	329.3	329.4
Headwater elevation @ Q_{100}	ft	329.7	329.6
Headwater elevation @ Q_{500}	ft	331.3	331.3
Freeboard @ Q_{50}	ft	-1.5	-1.6
Flood Of Record (April 1987) Elevation 330.2 ft - Approach roadway overtopping only			
Outlet Velocity @ Q_{10}	ft/s	3.11	2.25
Outlet Velocity @ Q_{25}	ft/s	4.22	3.06
Outlet Velocity @ Q_{50}	ft/s	4.95	3.58
Outlet Velocity @ Q_{100}	ft/s	5.48	3.96
Outlet Velocity @ Q_{500}	ft/s	3.67	3.30

Note: All elevations above are based on North American Vertical Datum (NAVD) of 1988.

SCOUR SUSCEPTIBILITY

The total calculated scour depth is an accumulation of three contributing scour modes – long-term aggradation/degradation, contraction scour and local/abutment scour. FHWA's publication, HEC-18 Evaluating Scour at Bridges 5th Edition and HEC-RAS were used to help determine theoretical scour depth values. Using Q_{500} flow, the calculated scour is as follows:

Long-term aggradation/degradation – The long-term aggradation/degradation of Martin Stream at Ricker's Bridge was qualitatively assessed to be 0ft. Ricker's Bridge lies in a relatively flat and straight section of Martin Stream. Given the flatness, straightness, calmness and low turbidity of Martin Stream at Ricker's Bridge, the determination was made that long-term aggradation/degradation is not a significant factor. Ricker's Bridge site is stable/equalized, no stream stabilization is necessary.

Contraction Scour – Based on the Geotechnical Data Report, the native soil at Ricker's Bridge has median diameter, D_{50} = 0.15mm. Visual inspection of the existing streambed material reveals the D_{50}, from within the top layer of soil is larger than the 0.15mm reported, D_{50} = 2.0mm was used for calculation. See photo below. Using the contraction scour calculating module in HEC-RAS, the maximum calculated scour due to contraction is 0ft. No streambed channel countermeasures are necessary.

Local/Abutment Scour - Using the abutment scour calculating module in HEC-RAS, the maximum calculated scour at the abutments is 18ft. Countermeasures are necessary in order to protect the abutments from scour.

COUNTERMEASURE DESIGN

The calculated local/abutment scour is the scour failure mode of most concern at Ricker's Bridge. To mitigate the abutment scour threat, the proposed abutments will have riprap scour countermeasures designed according to FHWA's HEC-23 Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance 3rd Edition. Riprap is the preferred countermeasure at Ricker's Bridge because of its low cost, availability and ease of installation.

Two MaineDOT riprap standard details exist, 3ft plain and 4ft heavy. These standards were checked for adequacy and use at Ricker's Bridge. Both the plain and heavy riprap standards are adequate, however heavy riprap is recommended, in this case, as it is relatively inexpensive added assurance. Heavy riprap can also be installed on a steeper 1.5 to 1 slope, which reduces ROW and wetland impacts. The limits of riprap shall extend 25ft beyond centerline of abutment on the downstream side in accordance with HEC-23, pg. DG14.11.

SUMMARY

The proposed bridge replacement is an improvement to the hydraulics of Ricker's Bridge. The proposed structure will increase the size of the hydraulic opening at the bridge approximately 35%. The bottom chord elevation and freeboard will remain approximately the same. The larger opening will decrease water velocities and scour potential. The existing bridge site and surrounding area is stable. There is a low point away from the bridge that will act as relief in the event of a flood and help protect the bridge. The structure is susceptible to abutment/local scour; therefore heavy riprap countermeasures are necessary.

Reported by: Joel Veilleux
Date: March 14, 2014