HYDROLOGY REPORT

The drainage basin characteristics for Fields Bridge on Gammon/Stetson Road in Sumner-Hartford over the East Branch of Nezinscot River were provided by the MaineDOT Environmental Office Hydrology Unit. The peak flows were calculated using the USGS peak flow regression equations for small, ungaged streams in Maine (see USGS Scientific Investigations Report 2015-5049). The bridge is not located in a FEMA detailed study area. The flood flows reported by MaineDOT were calculated with the NRCS TR-20 rainfall/runoff model. The USGS peak flow regression equations are considered more reliable and are the basis of the peak flow rate summary below.

SUMMARY

Drainage Area	18.5	mi^2
Q1.1	277.4	ft^3/s
Q2	560.0	ft^3/s
Q5	869.0	ft^3/s
Q10	1098.0	ft^3/s
Q25	1405.7	ft^3/s
Q50	1647.2	ft^3/s
Q100	1905.6	ft^3/s
Q500	2545.3	ft^3/s

Reported by: Shannon Beaumont, P.E.
Date: April 23, 2018

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

HYDRAULIC REPORT

The existing and proposed bridges were analyzed using GeoHECRAS version 1.4.0.12361, developed by CivilGEO Engineering Software. The bridge is not in a FEMA detailed study area; therefore no comparison to FEMA could be done. The hydraulic model for this project represents approximately 380 feet of the East Branch of the Nezinscot River, including Fields Bridge. A total of six cross sections, three downstream and three upstream, were used to model the stream. Cross section information outside the limits of survey was taken from USGS Topographic Maps.

The hydraulic analysis assumes steady flow. Default coefficients for expansion and contraction were utilized in the upstream and downstream cross sections, but were adjusted at the bridge to represent the constriction caused by the structure. The flood flows utilized were provided by MaineDOT. All of the flood flows were analyzed using a normal depth boundary condition with upstream and downstream slopes of 0.0028 ft/ft and 0.00056 ft/ft, respectively. These slopes were determined based on USGS Topographic Maps. The bridge is in a rural area with banks consisting of light to heavy brush and trees; therefore a Manning's n of 0.08 was used for the banks on all cross sections. The channel was modeled using a Manning's n of 0.04.

EXISTING 2-SPAN BRIDGE WITH OPEN STEEL GRID DECK

The existing bridge is a two-span steel beam bridge with steel grid deck that is filled with concrete at the shoulders and deck ends. The clear span lengths are approximately 18 feet and 15.33 feet, with a total structure length of 46 feet. This geometry results in a hydraulic opening area of 268 square feet. The substructure consists of concrete abutments on stacked stone and a pier constructed of dry laid boulders with a concrete cap. The pier has an approximate 45-degree angle asymmetrical triangular nose and is 6'-1" wide. Based on a field review of the bridge, the existing bridge causes a slight constriction in the river, which is verified by the differences in both channel slope and water surface elevations upstream and downstream of the bridge as shown in CLD's GeoHECRAS Water Surface Profile. The profile indicates a hydraulic jump in the bridge, which is also an indication of a constriction. The jump is a result of velocity decrease as the water is exiting the bridge into the wider channel.

There is no known history of overtopping of the existing bridge. The hydraulic model appears to correlate this; the model indicates that the structure passes up to 50-year storm with approximately 8.6 inches of freeboard, without overtopping the low point of the road several hundred feet to the south of the bridge. The 100-year storm passes through the existing structure with approximately 4.9 inches of freeboard, but results in overtopping of the low point of the road approximately 3.6 inches. It should be noted however, that the energy grade line elevations are greater than the water surface elevations at the bridge, which result in the model diverting some of the flow to weir flow over the low point of the road at the crossing. The water velocities for the 50- and 100-year storms are 6.28 ft/s and 6.13 ft/s, respectively, inside the bridge at the upstream entrance. The decrease in velocity through the structure from the 50-year storm to the 100-year storm is a result of increased weir flow over the low point of the road decreasing the amount of flow through the bridge.

PROPOSED SINGLE-SPAN BRIDGE WITH PRECAST NEXT 32 D BEAMS

Fields Bridge is slated for complete bridge replacement, therefore a single span bridge with a larger span is recommended. Initially, the upstream channel banks were carried through the structure and matched into the downstream banks, and the abutments were set behind the banks. The resulting clear span was approximately 63 feet, which exceeded the estimated 47-foot bankfull width. The resulting hydraulic opening was 407 square feet, which exceeded the hydraulic opening of the existing bridge by 139 square feet. After evaluation of the superstructure options, this span was decreased to 62 feet and the banks removed, resulting in a clear span of 58 feet and a hydraulic opening of 391 square feet. This still substantially exceeds both the estimated bankfull width and the existing hydraulic opening. The model indicates that the structure passes up to and including the 50-year storm with a freeboard of , approximately 0.5 inches but overtops the low point of the roadway approach approximately 0.1 inches about 100 feet to the south of the bridge. Most of the 100-year storm passes through the proposed structure but submerges the low chord of the bridge approximately 4.2 inches and overtops the low point of the road approximately 3.6 inches. It should be noted that the freeboard is less than existing because the proposed structure is significantly deeper, resulting in a drop of the low chord of 11.6 inches even with a profile raise of approximately 12 inches. The water surface elevations between existing and proposed are not significantly different due to the shallow slope of the channel.

The water velocities for the 50- and 100-year storms are 4.50 ft/s and 4.57 ft/s, respectively, inside the bridge at the downstream section. This is a notable improvement over existing conditions. A scour analysis was not performed since bedrock is shallow and the proposed substructure will be founded on the bedrock.

Per the Maine Bridge Design Guide (BDG) Section 2.3.10.2, a "major riverine bridge" requires a freeboard depth of four feet for the design 50-year storm and "other riverine bridges" require a depth of two feet on smaller bridges where there has been no history of ice jams. Although the East Branch of Nezinscot River is not a smaller stream, due to the low traffic volume and rural location, and no history of ice jams to our knowledge, it was assumed this crossing would be considered an "other riverine bridge". As noted above, the freeboard for the 50-year storm is only 0.5 inches, so it does not meet the freeboard requirement. However, the rural location and low traffic volumes make further raising the roadway profile cost prohibitive.

Hydraulic runs have indicated that increasing the span at this location due to the shallow slope of the channel does not result in any significant improvement in freeboard; however, the proposed opening will convey more flow.

CONCLUSIONS

A single-span NEXT 28-F beam bridge with a profile raise of 12 inches provides the shallowest superstructure. The low chord will be approximately 11.6 inches lower than the existing low chord, and the new structure will provide a hydraulic opening that is significantly greater than the existing structure.

When compared to the existing model, the proposed model shows a decrease in all upstream water surface elevations one bridge span upstream. However, within the bridge itself, the model indicates some slight increases in the water surface elevations at the higher flood events. However, it should be noted that the energy grade elevations remain the same or decrease from existing at all locations and for all storm events. The proposed model actually indicates more of the flow going through the bridge with less weir flow over the road than the existing model; however, due to the proposed raise in the roadway, the proposed weir flow goes through a smaller concentrated area at the low point where the proposed profile matches back into existing resulting in increased overtopping depths. The larger proposed structure's hydraulic opening passes 94% of the 50-year storm flow and 86% of 100-year storm flow as compared to the existing structure's hydraulic opening that passes only 87% of the 50-year storm flow and 78% of the 100-year storm flow. The velocities also significantly decrease through the bridge, which decreases the scour potential.

The proposed bridge does not satisfy the Maine BDG section 2.3.10.2 requirement of two feet of freeboard for the design flow 50-year storm; however, the replacement structure provides a significant improvement over existing. In order to meet this guideline, the road would need to be raised even more than currently proposed as the shallow channel slope means an increase in span has little effect on the water surface elevations and resulting freeboard. The minor changes in the water surface elevations will not adversely affect fish passage.

SUMMARY

		Existing Structure	Recommended Structure
		39' Two-Span Steel Girder	62' Single Span NEXT 28 F Beam
Total Area of Waterway Opening	ft^2	268	391
Headwater elevation @ $Q_{1.1}$	ft	396.19	395.68
Headwater elevation @ Q_2	ft	397.42	396.86
Headwater elevation @ Q_5	ft	398.42	397.80
Headwater elevation @ Q_{10}	ft	398.62	398.37
Headwater elevation @ Q_{25}	ft	399.04	398.70
Headwater elevation @ Q_{50}	ft	399.40	399.08
Headwater elevation @ Q_{100}	ft	399.70	399.45
Headwater elevation @ Q_{500}	ft	400.52	400.45
Freeboard @ Q_{50}	ft	0.72	0.04
Freeboard @ Q_{100}	ft	0.41	-0.35
Outlet Velocity @ $Q_{1.1}$	ft/s	1.99	1.47
Outlet Velocity @ Q_2	ft/s	3.18	2.27
Outlet Velocity @ Q_5	ft/s	4.23	2.96
Outlet Velocity @ Q_{10}	ft/s	4.93	3.42
Outlet Velocity @ Q_{25}	ft/s	5.93	4.21
Outlet Velocity @ Q_{50}	ft/s	5.92	4.50
Outlet Velocity @ Q_{100}	ft/s	5.79	4.57
Outlet Velocity @ Q_{500}	ft/s	3.29	3.38

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