

HYDROLOGY REPORT

Davis Brook originates 3.8 miles upstream of Goodell Bridge in First Davis Pond and converges with several other small streams before the crossing. The total drainage area at the bridge is 39.4 square miles. Upstream of the bridge, Davis Brook runs through a well-defined valley with a wide floodplain 300 to 400 feet in some places. It meanders through the valley bottom and appears to have several beaver dams. The floodplain consists of dense alders and brush. Downstream of the bridge, Davis Brook runs 2.5 miles and meets Big Wilson Stream which eventually drains into Sebec Lake. The floodplain downstream of the bridge varies from fields to forested areas and are generally narrower and better defined than upstream.

A sizable portion of the watershed area (~20 sq. miles) comes from Monson Stream. This water shed contains both Monson Pond and Lake Hebron. Monson Stream converges with Davis Brook upstream of the bridge roughly 1000 feet.

SUMMARY

Drainage Area	39.4	mi ²
Q1.1	462.9	ft ³ /s
Q10	1637.0	ft ³ /s
Q25	2053.1	ft ³ /s
Q50	2374.4	ft ³ /s
Q100	2716.9	ft ³ /s
Q500	3547.6	ft ³ /s

Reported by: Myers, Richard E.

Date: June 28, 2018

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

HYDRAULIC REPORT

The existing and proposed structures were analyzed using HEC-RAS version 4.1.0, river analysis software developed by the U.S. Army Corp of Engineers. The HEC- RAS model for this project represents a 345-foot section of Davis Brook including the bridge. Five cross sections upstream and downstream of the bridge were included in the model. The existing bridge was modeled and run with peak flows with varying boundary conditions until the results correlated with the approximate water surface elevations found in photos of the bridge during the 1987 flood. The following assumptions were made in the hydraulic model:

- Steady Flow Analysis
- Manning's number
 - Upstream:
Channel: 0.045
Overbanks: 0.1
 - Downstream
Channel: 0.04
Overbanks: 0.07
- Expansion and contraction coefficients were left as defaults:
0.3 for expansion and 0.1 for contraction
- Ineffective flow areas
Ineffective flow areas were modeled near the bridge opening at a 45 degree angle measured parallel to flow from the corner of the abutment. These areas were assessed in each cross section within the area of influence of the abutment. This bridge did not overtop from any flow modeled therefore ineffective flow areas were not adjusted for the overtopping condition.
- Subcritical flow regime
- Boundary Conditions
Normal depth boundary conditions were used both upstream and downstream of the bridge. Average slopes were found from USGS maps and were found to be 0.009 upstream of the bridge and 0.014 downstream of the bridge.

The proposed bridge model assumed a 76-foot span on integral abutments with a 30-foot wide deck. The superstructure depth was assumed to be NEXT 36F beams with an 8-inch cast-in-place deck giving a superstructure depth of 44-inches.

The photo of the 1987 flood was found in an inspection report and was taken by an abutter during the storm. It shows the bridge overtopping by 6-12 inches. The abutter was present at the initial public meeting and said ice was caught in the bridge and may have influenced the hydraulics. A report by the U.S. Geological Survey (Open File Report 92-141) shows that rivers in the Dover-Foxcroft area, approximately 10 miles southeast, reached greater than 100 year flows. For calibration of the HEC-RAS model, it was assumed that Davis Brook was experiencing between 100 and 500 year flows at the time of overtopping.

The hydraulic model of the existing bridge was calibrated by altering the Manning's numbers and flows until a reasonable headwater elevation was found for the flood. The assumption was made that the water levels were at least up to the bottom flange in order to catch ice in the bridge. Once the model produced headwater elevations that were above the bottom flange and reasonable Q1.1 headwater elevations, it was considered calibrated. To reach the bottom flange elevation, flows slightly higher than Q100 were used; this is consistent with the available hydrology information for the Dover-Foxcroft area.

It should be noted that HEC RAS issued several warnings about the flow characteristics at the bridge over Q10. These warnings indicated there was a large energy and velocity difference between the bridge and the previous cross section. This is not a surprise when looking at the channel and existing bridge geometry. The bridge restricts the channel increasing velocity to the point critical depth is reached at the bridge. Downstream of the bridge, the water surface elevations are considerably lower than upstream. The warnings were not considered to be a problem with the model but a reflection of the site conditions.

The proposed bridge was modeled after the calibration with a larger hydraulic opening and appropriate beam depth. The flow characteristics changed with the increased hydraulic opening. Velocities and headwater elevations lowered significantly. Most of the constriction is removed with the proposed bridge layout, which is evident in the headwater elevations upstream and downstream (approximately equal). Velocity still increases slightly through the bridge, but the overall magnitude is greatly reduced. At Q100, the bottom chord of the bridge is approximately 1.3 feet from the water surface and at Q50, the bottom chord is about 1.8 feet above the water surface; the latter is smaller than the recommended 2-feet in the Bridge Design Guide, however the hydraulics is significantly improved at the site and there is no overtopping of the bridge at Q100. Considering the site conditions and low priority, the improved hydraulics at the site is considered acceptable.

There is very little scour at the existing bridge with no defined scour hole downstream. Upstream there appears to be some scour; this is probably due to the confluence of flows with a small stream just upstream of the bridge. The stream velocity at the existing bridge is 8.68 fps at Q100, but the streambed material consists of cobbles with some occasional larger stones armoring the channel. The larger hydraulic opening for the proposed bridge lowered outlet velocities from 8.68 fps to 6.06 fps at Q100. Scour was not further analyzed. The piles supporting the integral abutments will be protected by 1.75:1 plain riprap slopes.

SUMMARY

		Existing Structure	Recommended Structure
		36' Span Steel Girder	76' Single Span NEXT F
Total Area of Waterway Opening	ft ²	370	600
Headwater elevation @ Q _{1.1}	ft	373.5	373.2
Headwater elevation @ Q ₁₀	ft	378.6	377.1
Headwater elevation @ Q ₂₅	ft	380.4	378.0
Headwater elevation @ Q ₅₀	ft	381.5	378.6
Headwater elevation @ Q ₁₀₀	ft	382.9	379.2
Headwater elevation @ Q ₅₀₀	ft	385.1	380.5
Freeboard @ Q ₅₀	ft	1.4	1.8
Freeboard @ Q ₁₀₀	ft	0.1	1.3
Flood Of Record (May 1987) Elevation 383 ft			
Outlet Velocity @ Q _{1.1}	ft/s	3.62	2.9
Outlet Velocity @ Q ₁₀	ft/s	6.48	4.71
Outlet Velocity @ Q ₂₅	ft/s	7.37	5.27
Outlet Velocity @ Q ₅₀	ft/s	8.03	5.68
Outlet Velocity @ Q ₁₀₀	ft/s	8.68	6.06
Outlet Velocity @ Q ₅₀₀	ft/s	10.23	6.93

1. Headwater elevations measured approx. 25 feet upstream where water levels become consistent
2. Freeboard measured just before bridge opening in model
3. Velocities measured in first cross section downstream of bridge opening

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