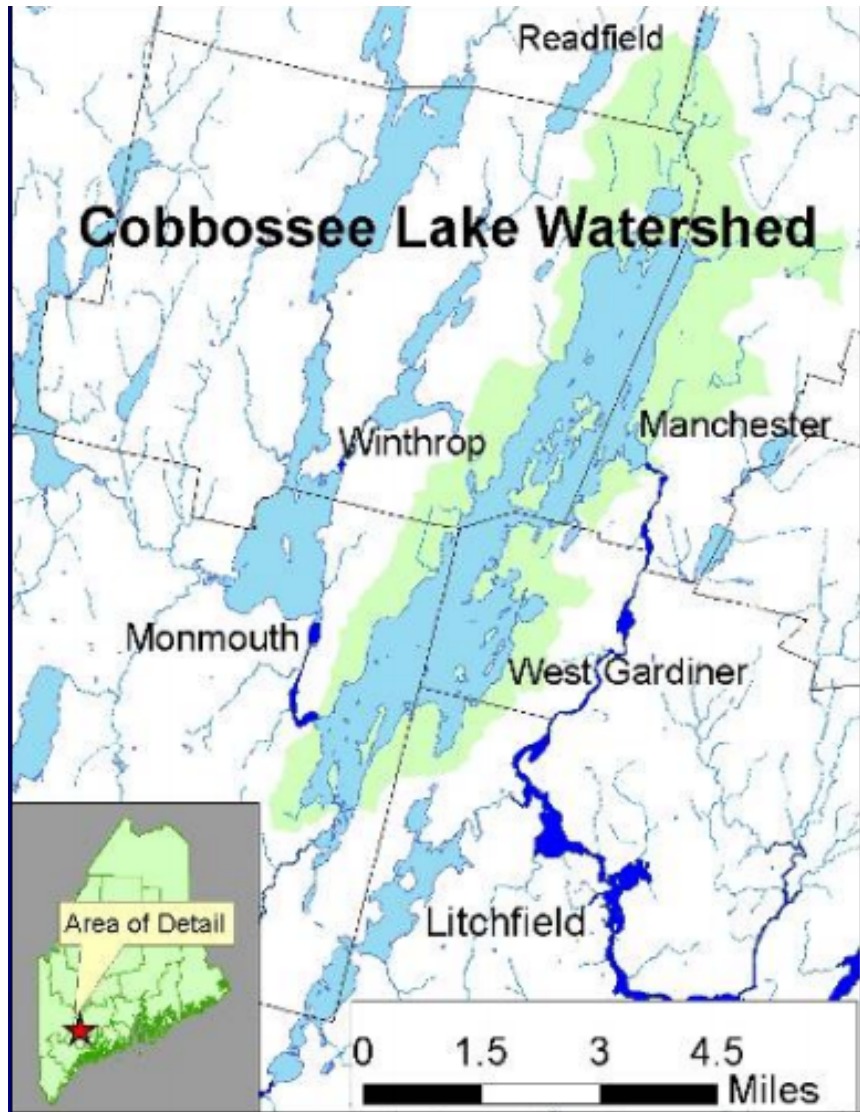


## HYDROLOGY REPORT

Babcock Bridge crosses over Cobbosseecontee Stream on the Litchfield- West Gardiner town line. Cobbosseecontee Stream is about 20 miles long. It originates from the Cobbosseecontee Lake in Manchester and flows through West Gardiner and Litchfield and flows into the Kennebec River in Gardiner. Water flows mainly from northwest to southeast, but switches direction to northeast near the outlet of Pleasant Pond. Figure 1 below is a map that outlines the Cobbossee Watershed, showing the towns where the watershed is located.



**Figures 1. Map of the Cobbossee Watershed**

There are several dams along the Cobbosseecontee Stream. It is first dammed at its confluence from Cobbosseecontee Lake in Manchester by the Cobbosseecontee Lake Dam. This dam is not elevation controlled but does reduce the waterway opening at the start of

Cobbosseecontee Stream. The next dam downstream is just north of the Collins Bridge in West Gardiner Maine, which affects the Cobbosseecontee Stream elevation for approximately 4000 feet, but it should not affect the water level at Babcock Bridge. There are three dams downstream of Babcock Bridge, which are about a mile upstream of Cobbosseecontee Stream’s confluence with the Kennebec River in Gardiner. One of these dams is a hydroelectric dam called the American Tissue Dam, which is scheduled for upgrades in 2021. These upgrades include the installation of eel and diadromous fish passages. Little Falls Dam, which is the dam upstream of the American Tissue Dam, was upgraded for fish passage several years ago. Fish passage at the bridge is not a large concern, since the bridge is located at a pond.



**Figure 6. Clipping of USGS Purgatory Topographic Map (2018)**

According to the Kennebec FIS, the Cobbosseecontee Stream basin includes over 20 lakes and ponds, which have a great dampening influence in peak flows downstream. Figure 6 above is a clipping from the 2018 USGS Purgatory 7.5-minute Topographic Map of the area around Babcock Bridge. As seen from this figure, Horseshoe Pond is downstream left of the bridge. Horseshoe Pond can provide storage during high flow events. The Pond has a total area of about 74 acres and an average depth of 10 feet.

There are two USGS gaging stream stations for the Cobbosseecontee Watershed. One is located on Cobbosseecontee Lake in East Winthrop. The drainage area at the confluence with Cobbosseecontee Lake is 131 square miles. The other is located on Cobbosseecontee Stream in Gardiner. The drainage area at this gage is 219 square miles. Babcock Bridge is about 7 miles downstream of the Cobbosseecontee Lake inlet and 10 miles upstream of the Kennebec River outlet. The drainage area at Babcock Bridge is 162.8 square miles.

According to the Kennebec County Flood Insurance Study (FIS), flooding in Litchfield and West Gardiner occur mainly along the shores of Cobbosseecontee Lake. There is also flooding problems along the shores of several ponds, but Horseshoe Pond is not listed as one of them in the FIS. Two of the most notable flood events in the area occurred in March 1936 and December 1973. The annual chance recurrence interval on Cobbosseecontee Lake for these floods were 0.3% (Q333) and 0.6% (Q167) respectively. The December 1973 flood was a 0.5% annual chance event (Q200) on the Cobbosseecontee Stream and the peak flow was over 6,000 cubic feet per second (CFS) in Gardiner. There was also a flood event in April 2005. According to a Report by the ENSR Corporation (Document No. 12092-003-B, 2007), the peak discharge at the Gardiner stream gaging station during this event was 3,870 CFS, which is slightly higher than the Kennebec FIS Q10 estimate at this location. The estimated discharge at Babcock Bridge, based on the drainage area, is about 3,069 CFS, which is again slightly higher than the Kennebec FIS Q10. The flood elevation at Babcock Bridge was not recorded, but it was likely above the bottom of the concrete beams. Figures 7 and 8 below show the water levels at Babcock Bridge after a rain event on December 2, 2020. According to the USGS website, the peak flow at the Gardiner stream gage on this date is 1320 CFS. The estimated peak discharge at Babcock Bridge is about 1030 CFS, which is less than a Q1.1 event and caused water level that was higher than the bottom chord of the bridge on the upstream side. Babcock Bridge has been closed for safety precautions during high floods, which did not overtop the bridge.



**Figure 7. Downstream Water Level After a Rain Event (December 2, 2020)**



**Figure 8. Upstream Water Level After a Rain Event (December 2, 2020)**

Hydrology was evaluated for Babcock Bridge by the Maine Department of Transportation Environmental Office- Hydrology Section. Peak flows were calculated with techniques described in the USGS Water-Resources Investigations Report 99-4008 (Hodgkins, 1999) and also in the USGS Scientific Investigations Report 2015-4059 (Lombard, 2015). The Kennebec FIS also provided estimated peak flows for Q10, Q50, Q100, and Q500 in various locations along the Cobbosseecontee Stream. The flows at Babcock Bridge were found by scaling the values from one of these locations based on the flood event and the drainage areas. The Kennebec FIS also gave the estimated flood profiles along the Cobbosseecontee Stream for the four discharges. According to the Kennebec FIS, the water-surface elevations for the Cobbosseecontee Stream were taken from historical flood information and a rating curve developed by applying the flow over dam method at the Gardiner Water District Dam located 4.7 miles downstream from the Litchfield-West Gardiner corporate limits. The discharges from the Regression Equations and Kennebec FIS, as well as the Kennebec FIS estimated flood elevations are summarized in the table below.

#### SUMMARY

Flood Event	Regression Equation Discharges		Kennebec FIS Discharges		Kennebec FIS Upstream Elevations		Kennebec FIS Downstream Elevations	
Drainage Area	162.80	mi <sup>2</sup>						
Q1.1	1158.8	ft <sup>3</sup> /s	N/A		N/A		N/A	
Q10	3276.2	ft <sup>3</sup> /s	3066	ft <sup>3</sup> /s	138.6	ft	137.8	ft
Q25	3945.2	ft <sup>3</sup> /s	N/A		N/A		N/A	
Q50	4444.7	ft <sup>3</sup> /s	4217	ft <sup>3</sup> /s	140.9	ft	139.6	ft
Q100	4976.2	ft <sup>3</sup> /s	4693	ft <sup>3</sup> /s	141.8	ft	140.3	ft
Q500	6211.3	ft <sup>3</sup> /s	5904	ft <sup>3</sup> /s	143.2	ft	142.0	ft

Reported by: Nash, Kendra

Date: January 13, 2021

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

## HYDRAULIC REPORT

---

Hydraulic analysis of the existing and proposed bridges was performed using the HEC-RAS 5.0.7 software. A 430 foot length of the Cobbosseecontee Stream that intersects Babcock Bridge was modeled with 3 cross sections upstream and 6 cross sections downstream.

The HEC-RAS models were based on the following assumptions:

- One-directional steady subcritical flow
- Manning's numbers:
  - Channel: 0.045
  - Grass/Dirt: 0.03
  - Trees: 0.15
  - Concrete (old abutments): 0.012
- Default expansion and contraction values, which are 0.3 and 0.1 respectively
- Ineffective flow areas:
  - Existing Bridge: upstream follows the direction of the wingwalls
  - Proposed Bridge: upstream from the end of the bridge follows a 1.5:1 slope
  - Downstream: for both existing and downstream, from the old abutments, following the stream banks
- Obstructions were blocked on the first downstream cross-section to represent the old abutment on downstream left.
- Reach boundary conditions: normal depth with a downstream slope of 0.0000125 ft/ft
- Bridge cross sections:
  - Existing bridge: used upstream and downstream cross sections with existing bridge profile.
  - Proposed bridge: used proposed stream cross sections with proposed bridge profile.
- Existing bridge geometry:
  - 50' span with concrete abutments
  - Upstream low chord elevation: 136.9
  - Downstream low chord elevation: 138.2'
  - Superstructure depth: 4'-7.5" tee beam with HMA surface depth varying 3 to 6"
- Proposed bridge geometry:
  - 69.8' bridge opening at Q1.1 elevation
  - 88' single span with 1.75:1 abutment slopes

- Upstream low chord elevation: 138.5'
- Downstream low chord elevation: 139.7'
- Superstructure depth: 3'-7.25" = 2'-10.25" Steel Welded Plate Girders + 8" concrete deck + 1" concrete wearing surface

The flows estimated by the Environmental Office and the FIS flood estimates were used to analyze the bridge's hydraulics. The FIS flood estimates also included the estimated flood elevations, which were included in the Hydrology Section of this report. The flood elevations from the Kennebec FIS were used to calibrate the model. The water surface elevations for the Cobbosseecontee Stream were taken from profiles that were developed using the USGS E431 step-backwater computer program. In Litchfield, the starting water-surface elevation elevations for the Cobbosseecontee Stream were taken from historical flood information and a rating curve developed by applying the flow over dam method at the Gardiner Water District Dam located 4.7 miles downstream from the Litchfield- West Gardiner Corporate limits. These profiles were calibrated using historical flood information from local landowners.

A sensitivity analysis was performed on the HEC-RAS model by testing a range of downstream slopes from  $1 \times 10^{-5}$  to  $1 \times 10^{-3}$ . This analysis showed that the model is less stable to changes in the downstream slope than is preferred, which is due to the limited extent of the downstream survey data. Since there is good information from the Kennebec FIS on the flood elevations for this location, the downstream slope that most closely matches these known elevations,  $1.25 \times 10^{-5}$ , was used in the final model.

A minimum freeboard depth of 2 feet at Q50 is recommended for "other river bridges" per BDG 2.3.10.2. The existing bridge is estimated to flood at Q50. However, the proposed road over the bridge will be higher than that of the existing. The flood elevations and velocities are summarized below. Appendix E also includes the HEC-RAS printouts for both the existing bridge and proposed bridge analyses.

### SUMMARY

		Existing Structure	Recommended Structure
		50' Concrete Tee Beam	90' Steel Span
Total Area of Waterway Opening	ft <sup>2</sup>		
Headwater elevation @ Q <sub>1.1</sub>	ft	133.6	133.6
Headwater elevation @ Q <sub>10</sub>	ft	139	139
Headwater elevation @ Q <sub>25</sub>	ft	140.4	140.4
Headwater elevation @ Q <sub>50</sub>	ft	141.4	141.4
Headwater elevation @ Q <sub>100</sub>	ft	142.5	142.4
Headwater elevation @ Q <sub>500</sub>	ft	144.6	144.6
Freeboard @ Q <sub>50</sub>	ft	0	
Freeboard @ Q <sub>100</sub>	ft	0	
Outlet Velocity @ Q <sub>1.1</sub>	ft/s	2.1	2.1
Outlet Velocity @ Q <sub>10</sub>	ft/s	3.6	3.6
Outlet Velocity @ Q <sub>25</sub>	ft/s	3.9	3.9
Outlet Velocity @ Q <sub>50</sub>	ft/s	4.1	4.1
Outlet Velocity @ Q <sub>100</sub>	ft/s	4.3	4.3
Outlet Velocity @ Q <sub>500</sub>	ft/s	4.7	4.7

Reported by: Nash, Kendra

Date: April 29, 2021

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