HYDROLOGY REPORT

Hydrology Description

SUMMARY		
Drainage Area	20	mi^2
Q1.1	354	ft^3/s
Q10	1,458	ft^3/s
Q25	1,880	ft^3/s
Q50	2,214	ft^3/s
Q100	2,570	ft^3/s
Q500	3,461	ft^3/s

Reported by: LPO
Date: July 1, 2016

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

HISTORIC INFORMATION

Historical data and past hydraulic analyses of Perley Brook were used to develop and calibrate the hydraulic model for the Perley Brook Bridge. Documents researched included the Flood Insurance Study (FIS) for the Town of Fort Kent, Maine dated July 6, 2016; USGS Scientific Investigations Report 2010-5003 "Flood of April and May 2008 in Northern Maine"; USGS "Flood Inundation Map Library, Fort Kent, Maine" dated September 2012; and Flood Insurance Rate Map (FIRM)/Maine Flood Hazard Map from the FEMA Map Service Center. Pertinent portions of these documents are included in Appendix E.

Northern Maine experienced major floods in 1923, 1973, 1974, 1979 and 1983 but the flood of record occurred in April/May 2008. Historically, all these floods occurred in late April or early May when heavy rain combined with snowmelt runoff. In 2008, the severe flooding occurred from April 28th to May 1st. One week before the flood, USGS streamgage 01013500 located on the Fish River above Perley Brook already had stream flows with annual exceedance probabilities between 10% (Q10) and 50% (Q2) due to snowmelt. Then, at the end of April, Fort Kent received over 3 inches of rain.

The resulting flood closed the International Bridge between Fort Kent and New Brunswick when water levels on the St. John River hit the low steel on the bridge. Damage was extensive in the town of Fort Kent. Over 600 people were evacuated in the region and over 100 homes were flooded. Aroostook County was declared a state of emergency by the State of Maine on April 29, 2008 and a federal disaster area on May 9, 2008.

Flooding occurred on both the St. John and the Fish Rivers. Backwater from the St. John affects flood elevations on the Fish River with the greatest interaction at the mouth of the Fish River. USGS used a step-backwater model using Hydraulic Engineering Centers River Analysis System (HEC RAS) to calibrate highwater marks from the 2008 flood and to create flood boundaries and flood-depth grids for the St. John and Fish Rivers. The peak water-surface elevation at USGS streamgage 01013500 on the Fish River for the 2008 Flood was 524.60 feet. Based on 84 years of streamgage records, 2008 flood had an annual exceedance probability between 0.2% (Q500) and 1% (Q100).

HEC RAS MODEL

HEC RAS version 5.0.3 software was used to analyze the hydraulic performance of the existing and the replacement structures for the Perley Brook Bridge at Route 161. The stream cross sections were created from recent survey. (Refer to Appendix E for plan drawing with contours locating the model sections.) The same Manning's n values of 0.040 and 0.075 for

streambed channel and overbank roughness that were used in the Flood Insurance Study (FIS) were used in the HEC RAS model.

Since the historical records indicate backwater from the St. John affects the flood elevations on the Fish River and, in turn, the flood elevations on Perley Brook, steady flow analyses were performed using known downstream water surface elevations as the boundary conditions. The Route 161 bridge is located approximately 500' above the confluence between Perley Brook and the Fish River. The Flood Profiles from the FIS for the Fish River and Perley Brook were reviewed. (Refer to Appendix E). The 2016 FIS notes that the Fish River flood profile was developed based on data from the 2008 flood while the Perley Brook profile was completed as part of the 1979 FIS. The data from both profiles were reviewed and conservatively, the highest water surface elevations for the annual probability of exceedance of 0.2% (Q500), 1% (Q100), 2% (Q50), and 10% (Q10) were used. Water surface elevations for the 4% (Q25) and 90.9% (Q1.1) annual probability of exceedance were estimated since historical data was not available. The following is a summary of the water surface elevations used as the downstream boundary conditions.

Annual Chance of Flood	Fish River Profile	Perley Brook Profile	Values Used
0.2% (Q500)	522.25'	522.0'	522.25'
1.0% (Q100)	520.25'	520.25	520.25'
2.0% (Q50)	519.50'	519.50'	519.50'
4.0% (Q25)	NA	NA	518.90'
10% (Q10)	517.50'	518.25'	518.25'
90.9% (Q1.1)	NA	NA	510.00'

The upstream boundary condition for the mixed flow regime check was normal depth with an upstream slope of 0. 75% estimated from the stream profile.

EXISTING BRIDGE

The existing structure consists of twin 13' diameter corrugated metal pipes with a total waterway area of 268 sf. The culverts are 114' long with a 1.7% slope. The outlets are perched with a 4-foot scour hole downstream. The existing culverts constrict the stream which has an upstream measured bankfull width of 34 feet.

The HEC RAS results indicate that existing headwater to depth (H/D) ratio is 0.83 and 0.92 at Q50 and Q100, respectively. The existing low point in Route 161 is approximately elevation 528.0'. The calculated headwater elevations are 523.2' and 524.3' at Q50 and Q100 flows, respectively and over the road at elevation 528.6' at Q500. The calculated outlet velocities are 11.8 and 12.6 fps at Q50 and Q100, respectively.

The HEC RAS calculated headwater elevations compare well with those from FIS Flood Profiles at the Route 161 Crossing.

Annual Chance of Flood	HEC RAS	FIS Flood Profile
0.2% (Q500)	528.6' (over the road)	529.5'(over the road)
2008 Flood Streamgage (Between 0.2 and 1.0%)		*524.60'*
1.0% (Q100)	524.3'	523.5'
2.0% (Q50)	523.2'	522.8'
10% (Q10)	520.8'	519.5'

As noted above, the peak water-surface elevation at USGS streamgage 01013500 on the Fish River above the Perley Brook confluence for the 2008 Flood was 524.60 feet which was considered to have an annual probability of exceedance between 1% (Q100) and 0.2% (Q500). This headwater elevation falls between the HEC RAS calculated 1% (Q100) and 0.2% Q500 headwater elevations of 524.3' and 528.6. Furthermore, local observations during the 2008 flood indicated that the headwater was close but did not overtop Route 161 which is consistent with the HEC RAS model results.

RECOMMENDED REPLACEMENT BRIDGE

The proposed structure is a 94' single-span girder bridge supported on integral abutments. The single opening meets bankfull width requirements and improves fish passage. The proposed cross-sectional shape of the channel is based on the simplified approach for integral abutments. The toes of the 1.75 to 1 riprap slopes in front of the abutments are placed approximately one bankfull width apart. The streambed between the riprap toes slopes down at 10 to 1 to the center of the channel. This creates a low point in the channel to ensure fish passage during low flows.

The proposed structure significantly improves hydraulic capacity at the crossing. The single opening bridge increases the waterway area over 300% from 268 sf to 840 sf. The freeboard clearance is 4.9' and 4.2' at Q50 and Q100 flows which exceeds the Bridge Design Guide recommendations of 2' and 1', respectively. The calculated headwater elevations are reduced by 3.8' to 519.4' at Q50 and by 4.2' to 520.1' at Q100. The headwater is approximately 6' below the low point in Route 161 at Q500. In addition, outlet velocities are reduced by over 200% to 5.7 and 6.1 fps at Q50 and Q100. At Q1.1, the calculated stream top is 48' wide at the inlet and 38' wide at the outlet; slightly larger than the 34' bankfull width. Plain riprap slopes are recommended.

SUMMARY

		Existing Structure	Recommended Structure
		Twin 13' Steel Plate Pipe	94' Single Span Steel Girder
Total Area of Waterway Opening	ft^2	268	840
Headwater elevation @ $Q_{1.1}$	ft	516.8	514.6
Headwater elevation @ Q_{10}	ft	520.8	518.2
Headwater elevation @ Q_{25}	ft	522.2	518.8
Headwater elevation @ Q_{50}	ft	523.2	519.4
Headwater elevation @ Q_{100}	ft	524.3	520.1
Headwater elevation @ Q_{500}	ft	528.62	522.0
Freeboard @ Q_{50}	ft	2.2	4.9
Freeboard @ Q_{100}	ft	1.1	4.2
Flood Of Record (May 2008) Elevation 524.6 ft			
Outlet Velocity @ $Q_{1.1}$	ft/s	9.0	4.9
Outlet Velocity @ Q_{10}	ft/s	9.1	4.3
Outlet Velocity @ Q_{25}	ft/s	10.8	5.1
Outlet Velocity @ Q_{50}	ft/s	11.8	5.7
Outlet Velocity @ Q_{100}	ft/s	12.6	6.1
Outlet Velocity @ Q_{500}	ft/s	14.1	6.8

Reported by: JAB
Date: January 25, 2019

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