HYDROLOGY AND HYDRAULIC REPORTS
WIN 020451.00

(Excerpted from the PDR)

HYDROLOGY REPORT

The drainage basin characteristics for Bradford Brook Bridge on Rte. 11 in Moro Plt. over Bradford Brook were provided by the MaineDOT Environmental Office. The peak flows are calculated using the 1999 USGS full regression equations and no other flow data is available.

SUMMARY

Drainage Area	0.82	mi^2
May Avg. Flow	2.04	ft^3/s
Aug Avg. Flow	0.12	ft^3/s
Q1.1	17.6	ft^3/s
Q10	91.8	ft^3/s
Q25	123.7	ft^3/s
Q50	149.7	ft^3/s
Q100	178.2	ft^3/s
Q500	251.4	ft^3/s

Reported by: Joshua Hasbrouck
Date: February 7, 2014

EXISTING CULVERTS

The existing culverts were analyzed using the HY-8 program version 7.30. No nearby structures or streams exist to affect the tailwater, so the tailwater conditions are modeled as an irregular channel located downstream from the outlet. A Manning's n value of 0.05 was used for the channel (gravel, cobble, bottom with some boulders) and 0.06 for the floodplain (some brush). Based on the USGS topographic map, the stream slope is approximately 20 ft of rise per 500 ft of run, or 4%.

Using the flows calculated with the regression equations and the dimensions of the culvert, the culverts are completely submerged by Q10 flows and the road overtops between Q25 and Q50. Region 5 maintenance has documented flooding over the road in both the May 2008 storms and other large events. The storm in May 2008 was a Q100-500 event according to the USGS report for the area. A 7" inch drop at the downstream end obstructs aquatic organism passage.

Bankfull width was determined by MaineDOT Environmental staff to be 11'. This makes 1.2 Bankfull width 13'.

REPLACEMENT AT 1.2 BANKFULL WIDTH

Concrete Box

The first replacement option is a single 13' span by 6' rise by 62' long rectangular precast concrete box culvert with headwalls and precast toe walls. The ends of the box culvert shall be mitered to match the slope with a single bottom step. To maintain the natural streambed, the culvert will be embedded 2' below the streambed. The tailwater is modeled using the same irregular channel used to evaluate the existing culverts.

The Hw/D for the concrete box is 0.68 at Q50. The 2' embedment provides a natural streambed surface for fish passage, and the velocity for average May flows is 1.799 ft/s, well below 5 ft/s, and also below the tailwater velocity of 2.107 ft/s.

Steel Pipe Arch

The second replacement option is modeled as bankfull width 13'-3" span by 9'-4" rise by 62' long steel pipe arch. The ends of the pipe arch shall be mitered to match the slope with a single bottom step. To maintain the natural streambed, the culvert will be embedded 2' below the streambed. The tailwater is modeled using the same irregular channel used to evaluate the existing culverts.

The Hw/D for the pipe arch is 0.59 at Q50. The 2' embedment provides a natural streambed surface for fish passage, and the velocity for average May flows is 0.027 ft/s, well below 5 ft/s, and also below the tailwater velocity of 2.107 ft/s. The width remains largely unrestricted by the curve of the arch for flows up to Q50.

Horizontal Ellipse

The third replacement option is a 13'-2" span by 8'-9" rise by 62' long steel multiplate horizontal ellipse. The ends of the culvert shall be mitered to match the slope with a single bottom step. To maintain the natural streambed, the culvert will be embedded 4' below the streambed. The tailwater is modeled using the same irregular channel used to evaluate the existing culverts.

The Hw/D for the ellipse is 0.53 at Q50. The 4' embedment provides a natural streambed surface for fish passage, and the velocity for average May flows is 1.944 ft/s, well below 5 ft/s, and also below the tailwater velocity of 2.107 ft/s. The width of flow is constricted by the curve of the ellipse for flows over Q10.

SUMMARY

All the alternatives considered are feasible hydraulically. The final decision on what alternative to use will be based on other factors besides hydraulics, such as constructability, initial cost, and life cycle cost. Please refer to the Summary of Preliminary Design for additional discussion about the proposed alternatives.

SUMMARY

		Existing Structure	Recommended Structure		
		Two 3' Diameter CMP	13' Span 6' Rise Concrete Box	13' Span 9' Rise Steel Pipe Arch	13' Span 9' Rise Horizontal Ellipse
Total Area of Waterway Opening	ft^2	14	52	98	89.6
Headwater elevation @ $Q_{1.1}$	ft	871.78	871.59	871.25	871.47
Headwater elevation @ Q_{10}	ft	875.19	873.12	873.79	873.49
Headwater elevation @ Q_{25}	ft	877.29	872.92	874.54	873.21
Headwater elevation @ Q_{50}	ft	877.55	873.23	874.82	873.54
Headwater elevation @ Q_{100}	ft	877.71	873.56	875.12	873.91
Headwater elevation @ Q_{500}	ft	877.98	874.40	874.77	874.82
Hw/D @ Q_{50}	ft	2.35	0.68	0.59	0.53
Hw/D @ Q_{100}	ft	2.40	0.76	0.63	0.59
Outlet Velocity @ $Q_{1.1}$	ft/s	6.23	1.76	2.51	3.19
Outlet Velocity @ Q_{10}	ft/s	9.19	6.76	6.77	6.55
Outlet Velocity @ Q_{25}	ft/s	10.48	7.66	7.43	7.28
Outlet Velocity @ Q_{50}	ft/s	10.67	8.24	7.97	7.84
Outlet Velocity @ Q_{100}	ft/s	10.78	8.83	8.53	8.33
Outlet Velocity @ Q_{500}	ft/s	10.97	10.13	9.55	9.37

Reported by: Joshua Hasbrouck
Date: February 10, 2014

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

HYDROLOGY AND HYDRAULIC REPORTS
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(Excerpted from the PDR)

HYDROLOGY REPORT

The drainage basin characteristics for Seams Brook Bridge #3409 on Rte. 11 in Hersey over Seams Brook were provided by the MaineDOT Environmental Office. The peak flows are calculated using the 1999 USGS full regression equations and no other flow data is available.

Summary

Drainage Area	1.77	mi^2
Low fish passage flow	0.29	ft^3 / s
High fish passage flow	4.64	ft^3 / s
Ordinary High Water ($Q_{1.1}$)	47.6	ft^3 / s
10-year Flood (Q_{10})	253.8	ft^3 / s
25-year Flood (Q_{25})	343.2	ft^3 / s
Design Discharge (Q_{50})	416.4	ft^3 / s
Check Discharge (Q_{100})	496.2	ft^3 / s
Scour Discharge (Q_{500})	703.6	ft^3 / s

Reported By: Joshua Hasbrouck
Date: July 18, 2013

Existing Culvert

Summary

Invert elevation at inlet	768.38	ft
Invert elevation at outlet	768.33	ft
Total drop along culvert	0.05	ft
Culvert length along invert	56.33	ft
Culvert slope	.05'/56.33' = 0.0008	ft/ft

The existing culvert was analyzed using the HY-8 program version 7.30. No nearby structures or streams exist to affect the tailwater, so the tailwater conditions are modeled as an irregular channel located downstream from the outlet. Based on the USGS topographic map, the stream slope is approximately 60 ft of rise over 5000 ft of length, or 1.2%.

Using the flows calculated with the regression equations and the actual measured dimensions of the culvert, the headwater to culvert depth ratio (Hw/D) at Q50 is 0.91, which is close to the 0.9 used for design according to the Bridge Design Guide. At Q100 the freeboard to the edge of the shoulder is 3.8 ft, greater than the 1' minimum required, but Region 5 maintenance has documented flooding over the road, first in the May 2008 storm and multiple times since. That storm was a Q100-500 event according to the USGS report for the area, and the HY-8 model shows overtopping at just over the Q500 regression equation flow, so the calculated flows should be close to actual values. At very low flows, aquatic organism passage is an issue due to a low water depth, but there are no vertical drops or other obstructions.

Rehabilitation

Alternative 2 (Invert Lining):

The invert lining could be either 5" thick concrete or 2" FRP. Hydraulically, this option was modeled as concrete since it is the more restrictive option. Five downstream weirs with a 3" drops would be required to push water back into the culvert for fish passage. An HY-8 model with the tailwater adjusted for the highest weir gives a headwater to depth ratio of 1.00 at Q50 and an increase in headwater elevation at Q100 of 0.75 ft.

Replacement

Since the existing bridge lasted longer than 50 years, steel would be an acceptable replacement material. However, because of the difficulty of matching the two pieces in staged construction and the lack of a suitable detour, pipe arches are not a practical design option. Multiple sizes of concrete box culvert have been evaluated for hydraulic capacity, with the tailwater conditions modeled using the same irregular channel used to evaluate the existing culvert.

Alternative 3 (Bankfull width):

The first option is a single 13' span by 9' rise by 72' long rectangular precast concrete box culvert with headwalls and precast toe walls. The ends of the box culvert

shall be mitered to match the slope with a single bottom step. To maintain the natural streambed, the culvert will be embedded 2' below the streambed. The Hw/D is 0.82 at Q50.

The 2' embedment provides a natural streambed surface for fish passage, and the velocity for average May flows is 2.62 ft/s, well below 5 ft/s.

Alternative 4 (1.2 Bankfull width):

The second option is a single 16' span by 8' rise by 72' long rectangular precast concrete box culvert with headwalls and precast toe walls. The ends of the box culvert shall be mitered to match the slope with a single bottom step. To maintain the natural streambed, the culvert will be embedded 2' below the streambed. The Hw/D is 0.83 at Q50.

The 2' embedment provides a natural streambed surface for fish passage, and the velocity for average May flows is 2.62 ft/s, well below 5 ft/s.

Summary

For the greatest hydraulic capacity, the preferred alternative is replacement with a large culvert at bankfull or 1.2 bankfull width. However, invert lining is a viable option, so the final decision will be made based on other factors such as cost and environmental regulations rather than hydraulics. See the summary of preliminary design for the recommended option.

HYDRAULIC REPORT

		Existing Structure	Invert Lining	Bankfull	1.2 Bankfull
		12'4" Span 7'9" Rise Steel Pipe Arch		13' Span 9' Rise Precast Box	16' Span 8' Rise Precast Box
Total Area of Waterway Opening	ft^2	71.9	65.3	91	96
Headwater elevation @ $Q_{1.1}$	ft	770.31	770.79	769.34	769.16
Headwater elevation @ Q_{10}	ft	773.16	773.74	772.1	771.57
Headwater elevation @ Q_{25}	ft	774.12	774.75	773.03	772.38
Headwater elevation @ Q_{50}	ft	774.88	775.55	773.74	773.00
Headwater elevation @ Q_{100}	ft	775.69	776.44	774.47	773.67
Headwater elevation @ Q_{500}	ft	778.41	779.11	776.22	775.15
Hw/D Ratio @ Q_{50}	ft	0.91	1.00	0.82	0.83
Hw/D Ratio @ Q_{100}	ft	1.02	1.13	0.92	0.94
Outlet Velocity @ $Q_{1.1}$	ft/s	4.35	3.02	4.35	4.35
Outlet Velocity @ Q_{10}	ft/s	7.13	4.65	7.13	7.13
Outlet Velocity @ Q_{25}	ft/s	7.81	4.89	7.81	7.81
Outlet Velocity @ Q_{50}	ft/s	8.28	4.83	8.28	8.28
Outlet Velocity @ Q_{100}	ft/s	8.74	4.71	8.74	8.74
Outlet Velocity @ Q_{500}	ft/s	9.35	4.17	9.35	9.35

Reported By: Joshua Hasbrouck
Date: September 13, 2013

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