Hydrology and Hydraulics Report

HYDROLOGY

Dr. Charlie Hebson used the U.S.G.S. Regression Method for Maine to determine the magnitudes of storm discharges at Norton Bridge over Black Stream in Carmel. The results for this standard method are very reliable.

The hydrology parameters and storm discharge rates are:

SUMMARY OF HYDROLOGY DATA
Drainage Area = 19.4 sq. mi.
Discharge (Q10) = 1000 c.f.s.
Design Discharge (Q50) = 1480 c.f.s.
Discharge (Q100) = 1700 c.f.s.
Ordinary High Water (Q1.1) = 260 c.f.s.

HYDRAULICS

The hydraulic evaluation relies on qualitative observations because there is not enough measured data available to develop a hydraulic model by any accepted methodology. Specifically all streamslopes and flood stages have been selected and modified to fit a relatively high observed flood stage. The observed flood stage was assumed to represent the ten year flood. For other projects that are not fast-tracked, a better way to use this sort of hydraulics approximation is to measure velocities and corresponding headwater elevations for a range of flood stages.

Site observations and area contours indicate that the effective streamslopes are quite flat and stream velocities are slow at a wide range of flood occurrence intervals. The available F.E.M.A. Flood Insurance information only shows that there is a Special Flood Hazard Area downstream of Norton Bridge in the U. S. Route 2 area; there is no flood occurrence interval or stage indicated. There are no hydraulic studies available for the upstream or downstream bridges. Years of observations by the Maintenance Division of the performance of the Black Stream bridges provide the most definitive information. Norton Bridge and the bridges upstream appear adequate. The Cross Bridge, which is downstream in the Special Flood Area at U.S. Route #2, is smaller than Norton Bridge, has much more drainage area, and floods relatively easily.

Independently, both Mr. Barry Prescott, Bridge Manager, and Mr. Mark Wiseman of the Region 4 office in Bangor stated that the highest that the stream level reaches at the site in about a ten year period is “two to three feet” below the slab, i.e. near Elevation 132.3 feet. At first, observations from a town representative indicated that the Bridge Maintenance observations were low. However, at the public meeting a long-time resident stated convincing observations that supported Maintenance.

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All of the hydraulics calculations in this report were based on taking this observed flood stage as the Q10 flood at Norton Bridge. Several iterations of the HY-8 program were run with existing stream opening and roughness characteristics to select an effective streamslope. The desired streamslope is the one for which the Q10 Headwater matches the observation. Compared to observed slow flow, the final iteration provided both a reasonable streamslope and a reasonable downstream flow performance curve for this bridge site. The same stream hydraulics model was then used to evaluate bridge replacement alternatives.

This method of analysis is unfortunately very imprecise and localized. It would not be realistic to apply any of this information for Norton Bridge to upstream and downstream sites. The selected effective streamslope for the Norton Bridge site is 0.0011 feet per mile. Further downstream in the Special Flood Hazard area it is likely that the effective streamslope is much flatter.

Consider a limiting streamslope value based on the Q10 stage at Norton Bridge and the water surface elevation of Hermon Pond, Elevation 121.0 feet, three miles downstream. This average slope value for the stream is 0.0007 feet per mile. Though the approximated value for Norton Bridge is low relative to most water crossings, it seems reasonable for the basis of a qualitative analysis. More convincingly, this rough model agrees with past hydraulic performance at the site and should be valid for comparisons of different openings.

This best available model is not a good predictor of hydraulic performance even at this specific site. If better flood performance becomes available, either through Flood Insurance Studies or measurements of a range of stream stages and corresponding velocities, the new information should be used to replace this very rough analysis.

Following is a table of the hydraulic characteristics:

HYDRAULICS SUMMARY

	Existing Bridge 2~14.7′x10.3′ Double Cell	Recommended Bridge Replacement 60′ Prestrs Slabs	Steel Pipe Arches 2 ~ 17′x11.2′
HW El. @ Q50	134.71 ft.	134.41 ft.	135.15 ft.
HW El. @ Q100	135.32 ft.	135.10 ft.	136.09 ft.
Vel. @ Q50	5.25 f.p.s.	3.87 f.p.s.	5.99 f.p.s.
Vel. @ Q100	5.66 f.p.s.	4.15 f.p.s.	6.69 f.p.s.
Ord. High H_2O (Q1.1)	El. 128.66 ft.	El. 128.68 ft.	El. 128.73 ft.
Vel. @ Q1.1	2.07 f.p.s.	2.01 f.p.s.	2.22 ft.
Q50 Clearance	0.12 ft.	0.3 ft.	0.55 ft.

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SCOUR

As in many cases, the potential for scour at this site is quite subjective. The soils are very silty and highly erodible, but the velocities tend to be very slow. The channel is rated as stable and there is little evidence of erosion in the Bridge Inspection records, but the streambed is termed “incised” near the pier and easterly abutment for a short distance. There is no maintenance record of ripraping or erosion repair at Norton Bridge. The only well documented maintenance work on this portion of Black Stream, is for the third bridge upstream in Levant. None of that work, at Black Stream Bridge, Br# 3064, is related to scour or erosion.

Using Q100 velocities and the Equation 8.2 from HEC-23 for calculating riprap size, the designed median size for the riprap would be: existing bridge – 0.9 feet; recommended integral bridge – 0.5 feet; and twin pipe arch alternate 1.25 feet. A rough calculation of the average plain riprap size, assuming a cube-shaped stone, a density of 130 pcf, and given the specified median weight of 50 pounds results in a D50 value of .73 feet. Plain riprap would be adequate for the recommended integral type bridge replacement, but not the existing bridge or the pipe arch alternate.

CONCLUSION

The recommended integral bridge, with sixty foot long voided slabs and a fifty-eight foot span bearing to bearing, is a good hydraulic fit for this site. The integral bridge would lower the headwater slightly at both Q50 and Q100 storm events. The best fitting steel pipe arch option for the bridge replacement is simultaneously too large and too small. Hydraulically it is very small, raising the headwater at Q50 by 0.44 feet and at Q100 by 0.77 feet compared to the existing bridge. In another sense, it is too big, requiring the stream banks to be graded back 80 to 120 feet at each corner. The twin pipe arch configuration has fill at the center of the channel and promotes debris build-up. This is a marshy site were debris is plentiful.

The recommended integral bridge alternative keeps a natural stream bottom and expands it under the bridge to better match the channel upstream and downstream. The pipe arch alternate installs manmade materials over the streambed for 64 feet. Freeboard, storm event velocities, and debris control are all improved with the integral bridge option and made worse with the most viable pipe arch alternate.

Respectfully Submitted ______________________________