Memorandum

To: Roger Soucy
Project Manager
Maine Department of Transportation

Date: April 5, 2018

Project #: 55182.00

From: Tony Grande
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Re: Caribou, Prestile Brook
WIN 22845.00
Large Culvert Replacement Options

This memorandum was developed to summarize the potential options for the large culvert replacement at Prestile Brook on Route 164 (Main Street) in Caribou, Maine. Route 164 is a Corridor Priority 3 state-aid non-NHS rural major collector road with existing speed limits of 40 mph and 50 mph within the project limits, which extend approximately 500′ north and south of the existing culvert.

Existing Conditions

The existing structure is a 7.5′ W x 8′ H x 120′ L concrete box with a corrugated multiplate extension on the outlet end. The structure is perpendicular to the alignment of Route 164, which is tangent nearly the entire project. In passing through this structure, Prestile Brook makes nearly 90° turns as it enters and then exits the box. The existing roadway typical section above the box culvert is two 12′ wide paved travel lanes with 8′ wide paved shoulders. Grades in and out of the existing culvert are steep at 7% and 8%, respectively. Beyond the shoulders the side slopes vary in grade, but mostly range between 1H:1V to 2H:1V. Gabion walls exist on each side of the road at approximately 30′ from centerline, and are failing in several locations. Approximately 3′ of these walls are visible. *[It is also worth noting that existing side slope conditions vary and include slopes steeper than 2H:1V with varying degrees of erosion, which have been modified through maintenance or emergency repairs.]* The top of the existing box culvert is approximately 30′ below the roadway centerline.

Proposed Replacement Options

VHB is considering multiple replacement options for the large culvert. The proposed typical section above the large culvert would maintain the existing 12′ travel lanes and 8′ paved shoulders, with consistent 2H:1V side slopes. While evaluating replacement options, considerations are being made to account for passage of wildlife such as deer or moose, hydrology improvements including stream realignment, and other factors. Hydraulic design considerations, further detailed later in this document, recommend the stream be realigned to a 15° angle relative to the current alignment of the large culvert; therefore, the structure proposed in each of the Options presented here is placed on this skewed stream alignment. No changes to the horizontal alignment are necessary, however a key component to this project is the vertical profile of Rt. 164, which presently has entrance and exit grades of 7% and 8%, and a sag vertical curve with HLSD of 138′ (design criteria is 425′). While meeting full HLSD was quickly determined to be impractical due to the significant fill required to create such a vertical profile, it would be possible to improve the vertical profile as part of this project. For comparison purposes, we've assumed total reconstruction would be required between stations 95+00 and 101+00 with only pavement rehabilitation assumed outside of those limits.

At present there are four Options:

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1. Option 1A is a pre-cast concrete arch culvert approximately 128′ long under a vertical profile that maintains the existing conditions throughout the project.
2. Option 1B is a 38′ W x 145′ L single span bridge using a vertical profile that modifies the existing conditions enough to accommodate a bridge with a 3% grade instead of a culvert.
3. Option 2A is a pre-cast concrete arch culvert approximately 164′ long under a raised vertical profile that improves sight distance and raises the roadway at least 8′ at the stream crossing.
4. Option 2B is a 38′ W x 160′ L single span bridge at 1% grade and uses a raised vertical profile similar to Option 2A.

Options 1A and 2A, utilizing a concrete arch culvert, would increase the overall hydraulic opening by 500 sf (currently 60 sf). The arch would be approximately 22′ in height from stream bed to its top, and 30′ wide. This size would provide sufficient passage space for deer or moose, and satisfies the opening requirements further explained later in this document. The core difference between Options 1A and 2A is the vertical profile. Under Option 1A the vertical profile of Rt. 164 would be maintained as it is now, while Option 2A would raise the profile by about 8′ at the stream crossing and improve sight distance from the current HLSD of 138′ to 269′. Neither Option 1A nor 2A would impact any nearby driveways significantly. Because of the significant raising of the vertical profile in Option 2A, combined with the proposed 2:1 side slopes throughout the stream crossing area, this option would require approximately 17,500 CY of additional borrow, compared to no additional fill necessary under Option 1A, other than for the proposed 2:1 side slopes throughout the project limits.

Options 1B and 2B, by utilizing a single-span bridge, present greater advantages in hydraulic design and habitat connectivity. Both Options propose the construction of a 38′ W out-to-out (2′-5′-12′-12′-5′-2′) single span bridge that is 145′ long for Option 1B, and 160′ long for Option 2B. Each bridge assumed a structure depth of 6.0′ to 6.5′, with 10′ concrete stub abutments on steel H-piles and 2:1 abutment slopes down to the 25′ wide stream bed. Option 1B would use a vertical profile similar to Option 1A but raised at the stream to place a bridge deck approximately 46′ above the stream. The bridge deck would be at a 3% grade, with vertical curves on either side having HLSD of 127′ and 169′, respectively, that transition to the existing grades. For Option 1B, the bridge deck would be approximately 6′ above the existing road profile at the stream crossing. It is estimated that Option 1B would require no additional borrow and uses the excavation from removal of the existing culvert to create the new 2:1 side slopes with a significant quantity of surplus material, about 6400 CY. Option 2B would use a raised vertical profile similar to Option 2A and would place the bridge deck approximately 50′ above the stream while still minimizing impacts to all nearby driveways. This bridge deck would be at a 1% grade, with vertical curves on either side having HLSD of 137′ and 217′, respectively, that transition to the existing grades. The HLSD values of the transition curves are comparable to the existing sag curve, while the raised vertical profile improves overall travel through the project. Under this option, the bridge deck would be approximately 10′ above the existing road profile at the stream crossing. It is estimated that Option 2B would require only 300 CY of additional borrow and uses the excavation from removal of the existing culvert to create the new 2:1 side slopes.

Hydraulic and Habitat Connectivity

VHB's hydraulic and habitat connectivity analysis includes the following considerations for both a large (>20 ft) culvert replacement and a bridge:

- Hydraulic design: Both options (large culvert or bridge) will meet the 1.2x bankfull width requirement, and will improve hydraulic capacity and reduce debris trapping at the crossing relative to existing conditions. The bridge option would provide slightly better hydraulic performance. VHB will evaluate the hydraulics for the existing culvert to determine if it restricts stream flow downstream of Route 164; if this is the case, VHB recommends further evaluation of potential impacts to the Route 1 and railroad culverts downstream resulting from increased flow through the Route 164 crossing.
- Channel alignment: For both options, raising the roadway profile would extend the embankment fill slope and shift the crossing entrance further upstream. Because the channel bends to the south upstream, the preferred design would shift the entrance to the south, resulting in a structure skew of approximately 15° relative to the roadway. Keeping the crossing entrance at the current location would result in a sharp (>90°) bend in the channel at the crossing entrance, and is not recommended.
- Habitat Connectivity Design: Both options will incorporate a 15-foot wide channel with simulated natural channel bottom for fish passage, and a 10-foot wide shelf set above one bank for moose passage. The culvert structure would need to be at 28 feet wide and 20 feet high at a minimum to meet wildlife passage and openness ratio minimum requirements. The bridge option would be superior for moose passage, and would allow easier construction of the simulated channel bottom.
- Scour: Both options will be designed to accommodate the long-term streambed vertical adjustment profile (VAP), estimated to be 1.5 feet below the existing channel. The primary scour concern would be from lateral channel migration at the upstream entrance of the crossing. Both options would include rip-rap countermeasures behind the stream banks to protect against erosion of the embankment fill slopes.

Conceptual Costs

A conceptual cost estimate was prepared for each of these Options, which factors in some major items such as excavation, pavement, structure cost, and mobilization. Each of these estimates includes a 30% contingency.

1. **Option 1A** is a 128' concrete arch with a cost of **$2.4M**. ($1.21M Structure)
2. **Option 1B** is a 145' single span bridge with a cost of **$2.5M**. ($1.38M Structure)
3. **Option 2A** is a 164' concrete arch with a cost of **$3.4M**. ($1.55M Structure)
4. **Option 2B** is a 160' single span bridge with a cost of **$2.7M**. ($1.52M Structure)