VT AGENCY OF TRANSPORTATION **PROGRAM DEVELOPMENT DIVISION**

HYDRAULICS UNIT

TO: Michael Blakslee, District 4
Christopher Bump, District 4 Project Manager

FROM: Fianna Barrows, Structures and Hydraulics Design Engineer

DATE: 24 July 2017

SUBJECT: Granville TH 37 Town Line road over unnamed tributary to Thatcher Brook
Location about 0.5 miles south of intersection with TH 19 (Old Stage road)
GPS coordinates: N 44.577221° W 72.942141°

We have completed our hydraulic study for the above referenced site, and offer the following information for your use:

Hydrology

This site has a steep to moderate drainage basin, which is primarily forested. The total contributing drainage area is about 0.5 square miles. There is an overall length of 5,800 feet from the divide to the site, with a drop in elevation of 1,500 feet, giving an average overall channel slope of 26%. The stream slope at the site was estimated to be about 7%. Using several hydrologic methods, we selected the following design flow rates:

Percent Annual Exceedance Probability	Flow Rate in Cubic Feet per Second (cfs)	
43 %	41	
10 %	80	
4 %	110	- Design Flow - Local Town Road
2 %	140	
1 %	170	- Check Flow

Channel Morphology

This is a perennial stream. Upstream and downstream of the culvert this channel has a steep slope. There were many small drops near the culvert. Sediment transport was evident at the site. Field measurements of bankfull width varied from 11 feet to 13 feet. The Vermont Hydraulic Geometry Relationships anticipate a bankfull width of 9.5 feet for stream channels in equilibrium at this watershed size.

Existing Conditions

The existing structure is a slightly distorted corrugated metal pipe with an average diameter of 4 feet, which provides a waterway opening of 13 square feet. The pipe invert is rusting and the pipe shape is distorted.

Our calculations, field observations and measurements indicate the existing structure does not meet the current standards of the VTrans Hydraulic Manual nor does the existing structure meet state stream equilibrium standards for bankfull width (span length). The existing structure constricts the channel

width, resulting in an increased potential for debris blockage.

This structure results in a headwater depth of 6.6 feet at 4% AEP with water overtopping the roadway below the 1% AEP.

Replacement Recommendations

In sizing a new structure, we attempt to select structures that meet both the current VTrans hydraulic standards, state environmental standards with regard to span length and opening height, and allow for roadway grade and other site constraints.

These recommendations have been modeled assuming that the alignment of the replacement culvert will have a slope of about 7%, which matches the natural channel just upstream and downstream. It is likely the scoured area at the outlet will need to be built up to connect the downstream channel with the stone-fill inside of the pipe. The goal is to maintain a consistent slope from upstream channel, through the structure, to the downstream channel. If the new culvert will have a significant difference in alignment then we can create another model with those numbers.

Based on the above considerations and the information available, we recommend any of the following structures as a replacement at this site:

1. A concrete box with an inside opening span of 12 feet and height of 5 feet. The box invert should be buried 2 feet. This will result in a clear height of 3 feet above streambed, providing 36 square feet of waterway area. Bed retention sills should be added in the bottom. Sills should be 12 inches high at the edges of the box and 6 inches high in the center, creating a V-shape across the full width of the box. Sills should be spaced no more than 8 feet apart throughout the structure with one sill placed at the inlet and one at the outlet. The box should be filled up to the streambed level with streambed stone fill type E2. This structure will result in a headwater depth of 2.1 feet at 4% AEP and of 3.0 feet at 1% AEP.
2. A corrugated metal pipe arch with a span of 123 inches and height of 81 inches, with the invert buried 2 feet. That will result in a clear height of 57 inches above the streambed, providing about 37 square feet of waterway area. Bed retention sills need to be added and filled as described for the box above. This structure will result in approximate headwater depth of 2.7 feet at 4% AEP and of 3.8 feet at 1% AEP.
3. Any similar structure with a minimum clear span of 12 feet and at least 36 square feet of waterway area, that fits the site conditions, could be considered. Please contact the hydraulics unit with alternatives that have significantly different inlet geometry so headwater depths can be calculated. Any structure with a closed bottom should have bed retention sills and a buried invert as described above.

If ledge prevents any of the above structures above from being installed then an open bottom structure could be considered with a clear span and height that match the above structures.

Prior to any further action toward implementation of any of the above recommendations, structure size and type must be confirmed, and may be modified, by the VT ANR River Management Engineer to ensure compliance with state environmental standards for stream crossing structures.

Other regulatory authorities including the US Army Corps of Engineers may have additional concerns or requirements regarding replacement of this structure.

General Comments

If a new box or pipe arch is installed, we recommend it have full headwalls at the inlet and outlet. The headwalls should extend at least four feet below the channel bottom, or to ledge, to act as cutoff walls

and prevent undermining.

It is always desirable for a new structure of this size to have flared wingwalls at the inlet and outlet, to smoothly transition flow through the structure, and to protect the structure and roadway approaches from erosion. The wingwalls should match into the channel banks. Any new structure should be properly aligned with the channel, and constructed on a grade that matches the channel. A new structure should span the natural channel width.

Stone Fill, Type II should be used to protect any disturbed channel banks or roadway slopes at the structure's inlet and outlet, up to a height of at least one-foot above the top of the opening. The stone fill should not constrict the channel or structure opening.

Please note that while a site visit was made, these recommendations were made without the benefit of a survey and are based on limited information. The final decision regarding replacement of this structure must comply with state regulatory standards, and should take into consideration matching natural channel conditions, roadway grade, environmental concerns, safety, and other requirements.

Please contact us if you have any questions or if we may be of further assistance.

FDB

cc: Jaron Borg, A.N.R. River Management Engineer

Hydraulics Project File via NJW