New Hampshire Geological Survey
New Hampshire Department of Environmental Services
Stream Crossing Assessment Initiative
Geomorphic and Aquatic Organism Passage Screening Tool Summary

The New Hampshire Geological Survey (NHGS), in partnership with the State Stream Crossing Steering Team, has employed a geomorphic compatibility and aquatic organism passage compatibility screening tool to score culverts for these two parameters. These tools are largely borrowed from those developed by the State of Vermont. However, NHGS, with the Steering Team, has made minor adjustments with the scoring algorithms. The purpose of this document is to provide the algorithms currently in use in New Hampshire, and ensure that the slight modifications that have been made are documented.

GEOMORPHIC COMPATIBILITY
The Geomorphic Compatibility score for a stream crossing represents the total sum of five (5) individual variables that are calculated based on collected stream crossing data parameters. The total score determines how the crossing fits into one of five compatibility categories that range from Fully Compatible to Fully Incompatible.

Ratio of Structure Width to Upstream Channel Widths
One key variable that factors into the final score is how undersized the culvert inlet is compared to the incoming stream channel. This is determined through the ratio of the structure inlet width relative to upstream channel width. Per the New Hampshire Stream Crossing Initiative Field Manual (assessment protocol), upstream of a culvert, the first bankfull width of the channel is collected far enough upstream of the crossing such that the measurements are taken outside of the influence of the structure. A total of three are collected, spaced ½ bankfull width apart. Once the upstream bankfull widths are collected, assessors proceed upstream for a total of 10 times the length of the first bankfull width or at least 100 feet from the inlet. The three remaining bankfull widths, which serve as the reference, are then spaced one bankfull width apart.

The ratio of structure width to upstream channel width is calculated by comparing the inlet structure width to the average of the three upstream reference widths. The rationale behind this calculation metric is to use bankfull widths that are as far upstream away from the culvert as possible, and thus, away from the area of direct influence from the crossing.

Input Variables
The variables serving as input to the total screen are as follows:

- Ratio of structure width to upstream channel widths (discussed above)
- Sediment continuity (upstream deposits and downstream scour)
- Structure slope versus channel slope, and break in valley slope
- Approach angle
- Bank armoring and erosion upstream/downstream

Each variable is scored on a scale of 0 to 5, with zero (0) representing the most problematic condition for a variable, and 5 representing the least concern. The thresholds are based upon those developed by Milone and MacBroom (2008), for the State of Vermont.

Individual Variable Scoring

The individual variable scores are determined in the following manner:

Score	% Bankfull Width	Sediment Continuity	Slope	Approach Angle	Erosion and Armoring
5	≥ 120	No upstream deposition or downstream bed scour	Structure slope equal to channel slope, and no break in valley slope	Naturally straight	No erosion **or** armoring
4	100 ≤ % < 120	**Either** upstream deposition or downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height or high downstream banks	N/A	N/A	No erosion **and** intact armoring, **or** low upstream **or** downstream erosion **without** armoring
3	75 ≤ % < 100	**Either** upstream deposition **or** downstream bed scour, **with** either upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Structure slope equal channel slope, with local break in valley slope	Mild bend	Low upstream **or** downstream erosion **with** armoring
2	50 ≤ % < 75	**Both** upstream deposition **and** downstream bed scour, **without** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	Structure slope higher or lower than channel slope, and no break in valley slope	Channelized straight	Low upstream **and** downstream erosion
1	30 ≤ % < 50	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **or** high downstream banks	N/A	N/A	Severe upstream **or** downstream erosion
0	< 30	**Both** upstream deposition **and** downstream bed scour, **with** upstream deposits taller than 0.5 bankfull height **and** high downstream banks	Structure slope higher or lower than channel slope, with local break in valley slope	Sharp bend	Severe upstream **and** downstream erosion, **or** failing armoring upstream **or** downstream

Scoring and Compatibility Category Thresholds

The geomorphic compatibility categories are determined, based on the total summation of individual variable scores in the following manner:

Category Name	Score	Thresholds	Description
Fully Compatible	20 < Score ≤ 25	N/A	These structures are fully compatible with river channel form and process, and are at a low risk of failure. Culvert replacement is not expected over the lifetime of the structure. When replaced, a structure similar to the current one is recommended. Culverts that rank in this category typically provide examples of the proper sizing and construction at sites where replacements are required to ensure compatibility with flow and sediment transport processes.
Mostly Compatible	15 < Score ≤ 20	N/A	These structures are mostly compatible with river channel form and process, and are at a low risk of failure. Culvert replacement is not expected over the lifetime of the structure. When replaced, minor design adjustments are recommended to make the culvert fully compatible with river form and process.
Partially Compatible	10 < Score ≤ 15	N/A	These structures are either compatible with current form or process, but not both, with any compatibility only likely in the short term. Culvert replacement may be needed, given the moderate risk of failure during its design lifetime. When replaced, a redesign of the culvert installation is suggested to improve the compatibility of the culvert with river form and process.
Mostly Incompatible	5 < Score ≤ 10	% Bankfull Width + Approach Angle Score ≤ 2	These structures are typically undersized for the river or stream channel that contains them, and/or are poorly aligned with the channel form, creating a condition where the structures are mostly incompatible with river form and process. As a result, these structures are at a moderate to high risk of structural failure. When replaced, a redesign of the culvert should be initiated to improve the geomorphic compatibility, and is a factor to be considered in long-term stream crossing replacement planning.
Fully Incompatible	0 ≤ Score ≤ 5	% Bankfull Width + Approach Angle Score ≤ 2 **AND** Sediment Continuity + Erosion and Armoring scores ≤ 2	These structures are typically undersized for the river or stream channel that contains them, and/or are typically poorly aligned with the upstream channel form, while also showing a reduced ability to pass sediment through the crossing and an increased risk for erosion. Crossings ranking in this category are not compatible with river form and process and are at a high risk of failure. Culverts ranking in this category should be prioritized for replacements to improve river process compatibility.

AQUATIC ORGANISM PASSAGE (AOP) COMPATIBILITY

The AOP compatibility score is used to identify crossings that may not be capable of passing aquatic organisms from downstream to upstream. Within the New Hampshire State Stream Crossing Initiative, the Fish and Game Department has responsibility for this compatibility scoring algorithm. Based on input from Fish and Game, NHGS maintains the scoring code that implements criteria outlined below, and scores culverts for AOP compatibility upon completion of the QA/QC process for a batch of crossings, as performed by NHGS.

New Hampshire's implementation of the AOP Compatibility tool is largely derived from Milone and MacBroom (2009), who developed the tool for the State of Vermont. However, New Hampshire has slightly modified the scoring, by adding a variable for screening installed either at the culvert inlet or outlet. Any culvert that is assessed as having screening at the inlet or outlet is automatically assigned an AOP category of *No Passage*. This is noted in the scoring metric table below.

Based on the data collected, there are four categories for which a culvert that meets criteria can be assigned for AOP. They are as follows:
Full Passage
Reduced Passage
Passage Only for Adult Trout
No Passage

Variables	**Full Passage**	**Reduced Passage**	**Passage Only for Adult Trout**		**No Passage**	
Condition Statement	**If All Are True**	**If Any Are True**				
Culvert outlet invert type	At Grade **OR** Backwatered	Cascade	Free Fall **AND**		Free Fall **AND**	
Outlet drop (feet)	= 0		>0, <1 Foot **OR**		≥ 1 Foot **OR**	
Downstream pool present			= Yes	= Yes **AND**	= No **OR**	= Yes **AND**
Downstream pool entrance depth / outlet drop				≥ 1	N/A	< 1 **OR**
Water depth in culvert at outlet (feet)					< 0.3 Feet	
# culverts at crossing	1	>1				
Structure opening partially obstructed	= None	≠ None				
Sediment throughout structure	Yes	No				
Screening at inlet or outlet*					Yes	

*If **screening is present at the inlet or outlet**, then category cannot be anything other than *No AOP (Including Adult Salmonids)*.

References

Milone & MacBroom, Inc. 2008. *The Vermont Culvert Geomorphic Compatibility Screening Tool*. Prepared for Vermont Agency of Natural Resources, Department of Environmental Conservation, River Management Program. South Burlington, Vt.

Milone & MacBroom, Inc. 2009. *The Vermont Culvert Aquatic Organism Passage Screening Tool.* Prepared for Vermont Agency of Natural Resources, Department Fish and Wildlife. South Burlington, Vt.