



NORTHEAST INC

Environmental Engineering
Geotechnical Engineering
Water Resources
Hydrogeology

October 10, 2011

Project No. 4707

Board of Selectmen
c/o: Dina Cutting, Administrative Assistant
Town of Lyme
Office of the Selectmen
P. O. Box 126
Lyme, N. H. 03768

RE: Executive Summary

Geotechnical Engineering Services
River Road Riverbank Failure Area
Lyme, New Hampshire

Dear Select Board Members:

This is an executive summary for the HTE Northeast, Inc. (HTE) analysis of the Connecticut riverbank failure located along a 1,000'± section of River Road in the northwest part of Lyme, New Hampshire. A full report summarizing the subsurface explorations performed and reconstruction configuration analyses performed is forthcoming.

I) Introduction

It is HTE's understanding that substantial river bank slope failures occurred on April 30 to May 1, 2011 along the west side of River Road where it is adjacent to the Connecticut River. The slope failures occurred in several areas over a 1,000± foot distance for a portion of River Road just south of North Thetford Road. On June 22nd, the undersigned observed that portions of the southbound (west) lane of River Road were in danger of further failure being imminent.

It is understood that the flood level rose to within a few feet of the road level (the grade of River Road varies from about EL 398± to EL 400±), and that the river level receded relatively quickly. The failure occurred in the interior (and straight) portion of an obtuse bend (southeast, the south, then southwest flow) in the river.

It is further understood that consideration is being given to re-constructing the affected portion of River Road along a new alignment that would be shifted to the east of the current alignment. The establishment of this new alignment would be based on constructing permanent stable new slopes along the adjacent Connecticut River shoreline to the west.

Holden Engineering & Surveying, Inc. (Holden) obtained topographic survey information of the failure area, including topographic data for the easterly 50'± of the river (at normal level), and also 50'± east of the present road, such that accurate cross-sections of slope failure areas could be developed for use in our work. The area has a preliminary surficial geologic mapping as stratified sand & silt outwash, often overlying varved clays. The subsurface explorations performed indicate that the pertinent soil stratigraphy consists of loose to medium dense non-cohesive fine sand/silt alluvium overlying dense granular ice-contact deposits. Varved clay deposits were not present. Bedrock was not encountered to the depths explored.



Geotechnical Services –Executive Summary
River Road Riverbank Failure Area
Lyme, New Hampshire

October 10, 2011
HTE Project No. 4707
Page No. 2

Based on our observations, chronology of events, and results of subsurface explorations, it appears that the failed riverbank section was caused by the following general conditions:

- 1) Long term erosion and undermining of the riverbank due to flow action. Erosion and undermining alone are responsible for depletion of the alluvium riverbank along the east side of the Connecticut River in the area of concern. The frequent raising and lowering of the water level by downstream dam management (Wilder Dam), over time, is a contributing factor. As the soil mass is slowly removed from the bottom of the slope, the overall stability is reduced by the decrease in resisting forces until such time that the slope or a portion of the slope either sloughs or rotates to a more stable condition (classical rotational type failure surface). This situation repeats itself over a long period of time and is being exacerbated during floods.
- 2) Existence of water in the riverbank soils. The high groundwater levels within the slope cross section at the time of the flood increased the driving forces thus tending to destabilize or reduce overall stability, particularly as the flood receded. The saturation of the relatively slow-draining alluvial soils resulted in an unbalanced hydrostatic condition in the slope. Surface runoff from the east is not considered to have been a significant factor in the riverbank failure. Wave action is not considered to have been a factor in the riverbank failure.

It is anticipated that the failure of the subject riverbank was a result of both of these phenomenon in concert. It can be anticipated that future long term riverbank instability will occur, as evidenced by the steepness of the post-flood riverbank and the 'tension cracks' still present along portions of the west side of River Road. Remedial actions will need to consider reconstruction of the affected riverbank and contiguous upstream and downstream sections to a stable configuration (in-part to reduce groundwater impacts), including appropriate riverbank slope surface protection.

It should be noted that the current riverbank configuration is considered unstable and we do not recommend re-opening of the road until a stable riverbank re-construction is implemented.

II) Slope Reconstruction Options

Based on the subsurface explorations (test borings) performed and stability analyses performed, HTE reviewed re-construction configuration options with Holden Engineering & Surveying, Inc. Initially, a stone slope of 1.5 horizontal to 1 vertical (1.5:1) was evaluated, and subsequently considered to be a suitable option per our analyses.

As a second alternative, Holden developed a predominantly soil slope configuration of 3 horizontal to 1 vertical (3:1). It is our opinion that proper re-construction of the subject riverbank area with the depicted Class A stone (toe section) and upper soil material configuration at excavation cut will have satisfactory factor of safety relative to the flood event of May 2011.

Specifically related to the 3 horizontal to 1 vertical (3:1) stone/soil slope configuration, the installation of Envirogrid™ (or similar) cellular units for topsoil surface stabilization between 1' above the 10-year and to 1' above the 50-year flood level (EL 390.75±) is recommended (this is depicted on the updated Holden cross-sections).



**Geotechnical Services –Executive Summary
River Road Riverbank Failure Area
Lyme, New Hampshire**

**October 10, 2011
HTE Project No. 4707
Page No. 3**

III) Recommended Typical Sections

As one alternative, a recommended typical 1.5 horizontal to 1 vertical (1.5:1) stone slope cross-section for the riverbank re-construction was prepared by Holden and submitted to the Town in September 2011. It is our opinion that proper re-construction of the subject riverbank area with the depicted material configuration and underlying Bank-run Gravel replacement fill for excavation cut will have a factor of safety of greater than 1 relative to the flood event of May 2011.

As a second alternative, a recommended typical 3 horizontal to 1 vertical (3:1) stone/soil slope cross-section for the riverbank re-construction, as prepared by Holden, is also considered acceptable. It is our opinion that proper re-construction of the subject riverbank area with the depicted Class A stone (toe section) and upper native soil material configuration at excavation cut (constructed with topsoil cover) will have a factor of safety of greater than 1 relative to the flood event of May 2011.

IV) Construction Considerations

For construction of either alternative, it is recommended: a) that the work be conducted in 100'± wide sections, with complete section construction to at least the 50-year flood level over this width, prior to advancing to the next section and b) that work on a new section should not be initiated unless the two week advance forecast is favorable.

V) Closing

HTE trusts that this executive summary letter will meet your current requirements for assistance to Holden Engineering & Surveying, Inc. with final design of slope stabilization. Please do not hesitate to contact this office should you have any questions.

Very truly yours,

A handwritten signature in dark ink, appearing to read "Roger B. Keilig".

Roger B. Keilig, PE, PG
Sr. Project Manager

cc: Peter Holden, Holden Engineering & Surveying, Inc.