Attention: Mr. Ray Patenaude

Re: Preliminary Stability Assessment
Honey Property Subdivision
Church Street
Russell, Ontario

General

The purpose of this preliminary stability assessment is to establish the ‘Erosion Hazard Limit’ for the portion of the subdivision which will abut the Castor River (refer to Key Plan, Figure 1). This limit constitutes a safe setback for any proposed development along the slope with respect to slope stability. The Erosion Hazard Limit was determined based on the Natural Hazard Policies set forth in Section 3.1 of the Provincial Policy Statements of the Planning Act of Ontario. Current regulations restrict development within the Erosion Hazard Limit.

The slope stability analyses were carried out at Sections ‘A-A’ to ‘G-G’, inclusive, using SLIDE, a state of the art, two dimensional limit equilibrium slope stability program. Sections ‘A-A’ to ‘D-D’ are located within the eastern portion of the site. Sections ‘E-E’ to ‘G-G’ are located within the western portion of the site.

Sections ‘A-A’ to ‘D-D’ were surveyed and provided to us by Annis, O’Sullivan, Vollebekk Ltd. (Ontario Land Surveyors) (refer to Site Plan, Figure 2). The slope profile along Sections ‘E-E’ to ‘G-G’ was inferred from available topographic data.

A site visit was carried out by Houle Chevrier Engineering Ltd. on August 12, 2014. At the time of our site reconnaissance, no signs of deep seated instability, surficial tension cracks or other obvious indications of slope movement were observed at the subject site. Minor erosion was noted along the toe of the slope at the Castor River. The results of the slope stability analyses are provided in Appendix A.
Soil Strength Parameters

The soil conditions used in the stability analyses were based, in part, on the results of borehole 13-101, borehole 13-103, and Seismic Piezocone Test 13-102, which was advanced by Houle Chevrier Engineering in December 2013 as part of a geotechnical investigation for the development of the Honey Property Subdivision. The record of borehole logs and seismic piezocone test results are provided in Attachment B. The slope stability analyses were carried out using silty clay strength parameters based on site specific studies in the Ottawa area. To determine the existing factor of safety against overall rotational failure, the slope stability analyses were carried out using drained soil parameters, which reflect long term conditions. The soil parameters selected are typical values for the Ottawa Valley and are consistent with those values used in published literature.

The following table summarizes the soil parameters used in the analyses:

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Estimated Undrained Shear Strength, $C_u$ (kilopascals)</th>
<th>Effective Angle of Internal Friction, $\varphi$ (degrees)</th>
<th>Effective Cohesion, $c'$ (kilopascals)</th>
<th>Unit Weight, $\gamma$ (kN/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brown silty sand</td>
<td>-</td>
<td>33</td>
<td>0</td>
<td>18.0</td>
</tr>
<tr>
<td>Weathered silty clay</td>
<td>80</td>
<td>30</td>
<td>10</td>
<td>17.0</td>
</tr>
<tr>
<td>Soft and firm, grey silty clay</td>
<td>20 to 30</td>
<td>30</td>
<td>10</td>
<td>17.0</td>
</tr>
</tbody>
</table>

The results of a stability analysis are highly dependent on the assumed groundwater conditions. No information is available on the long term groundwater levels throughout the year; however, as a conservative approach, we have assumed full hydrostatic saturation with the groundwater level at ground surface and groundwater flow horizontally towards the slope.

Existing Conditions

For the purpose of this slope assessment, only deep seated rotational slope failures are considered for the purpose of establishing safe slope setbacks. In other words, shallow surficial slope failures are not considered. The slope stability analyses were carried out using soil parameters, groundwater conditions and a slope profile that attempt to model the slopes in question but do not exactly represent the actual conditions. For the purposes of this study, a computed factor of safety of less than 1.0 to 1.3 is considered to represent a slope bordering on failure to marginally stable, respectively; a factor of safety of 1.3 to 1.5 is considered to indicate a slope that is less likely to fail in the long term and provides a degree of confidence against failure ranging from marginal (1.3) to adequate (1.4 and greater) should conditions vary from the
assumed conditions. A factor of safety of 1.5, or greater, is considered to indicate adequate long term stability.

Based on the site reconnaissance, the slopes along the Castor River were divided into two areas; Area 1 and Area 2. Area 1 is located within the eastern portion of the subject site and includes Sections ‘A-A’ to ‘D-D’. Area 2 is located within the western portion of the subject site and includes Section ‘E-E’ to ‘G-G’. In general, the slopes within Area 1 (i.e., the eastern portion of the site) are steeper than the slopes within Area 2 (i.e., the western portion of the site). For the purposes of this assessment, the erosion hazard limit (setback) within Area 1 is based on the results of the slope stability analyses carried out for Section ‘C-C’ (the most critical location within Area 1 based on slope geometry). The erosion hazard limit within Area 2 is based on the results of the slope stability analyses carried out for Section ‘G-G’ (the most critical location within Area 2 based on slope geometry).

The slope stability analysis indicates that the existing slope at Section ‘C-C’ (i.e., Area 1), in its current configuration but in a fully saturated condition, has a factor of safety against overall rotational failure of 1.2 for static loading conditions, which is considered marginally stable (refer to Figure A1 in Attachment A).

At Section ‘G-G’ (i.e., Area 2), the slope stability analysis indicates that the existing slope, in its current configuration but in a fully saturated condition, has a factor of safety against overall rotational failure of 1.9 for static loading conditions, which is considered stable under “worst case” conditions (refer to Figure B1 in Attachment B).

**Setback Requirements**

**Area 1**

For unstable slopes, the distance from the unstable slope to the safe setback line is called ‘Erosion Hazard Limit’. In accordance with the Ministry of Natural Resources (MNR) Technical Guide “Understanding Natural Hazards” dated 2001, the Erosion Hazard Limit consists of three components: (1) Stable Slope Allowance, (2) Toe Erosion Allowance, and (3) Erosion Access Allowance.

At Section ‘C-C’, the slope stability analysis indicates the existing slope, in its current configuration in a drained condition is considered marginally stable (refer to Figure A1 in Attachment A). Using the same analysis results, a setback from the crest of the slope which would provide a factor of safety of 1.5 was calculated to be about 7.8 metres.

Therefore, for this preliminary analysis, a minimum setback of 7.8 metres measured perpendicular from the crest of the slope along the Castor River is required.

The watercourse is located at the toe of the slope at this site. In accordance with the MNR documents, we have included a Toe Erosion Allowance of 8 metres to allow for continual...
erosion at the toe of the slope. The Toe Erosion Allowance is applied at the crest of the slope (refer to Figure A1 in Attachment A).

The MNR procedures also include the application of a 6 metre wide Erosion Access Allowance beyond the Toe Erosion Allowance to allow for access by equipment to repair a possible failed slope. For the purposes of this preliminary assessment, we have included a 6 metre wide Erosion Access Allowance (refer to Figure A1 in Attachment A). Consideration could be given to constructing a pedestrian/bicycle path within the 6 metre zone defined by the Erosion Access Allowance, provided that heavy and emergency vehicle access is not hindered.

Therefore, the Erosion Hazard Limit for the slopes within Area 1 is located about 21.8 metres from the crest of the existing slopes (refer to Figure 2). We recommend that the top of slope be staked by Houle Chevrier Engineering Ltd. and tied-in by a land surveyor so that the Erosion Hazard Limit can be accurately shown on a plan.

Area 2
At Section ‘G-G’, the slope stability analysis indicates that the existing slope, in its current configurations, has a factor of safety against failure of greater than 1.5 (refer to Figures B1 in Attachment B). Therefore, the Stable Slope Allowance described in the MNR procedures is not required.

As previously indicated, the Castor River is located at the toe of the slopes at this site. In accordance with the MNR documents, we have included a Toe Erosion Allowance of 8 metres to allow for continual erosion at the toe of the slope. The Toe Erosion Allowance is applied at the crest of the slope (refer to Figure B1 in Attachment B).

The MNR procedures also include the application of a 6 metre wide Erosion Access Allowance beyond the Toe Erosion Allowance to allow for access by equipment to repair a possible failed slope. For the purposes of this preliminary assessment, we have included a 6 metre wide Erosion Access Allowance (refer to Figure B1 in Attachment B).

Therefore, the Erosion Hazard Limit for the slopes within Area 2 is located about 14.0 metres from the crest of the existing slopes (refer to Figure 2). We recommend that the top of slope be staked by Houle Chevrier Engineering Ltd. and tied-in by a land surveyor so that the Erosion Hazard Limit can be accurately shown on a plan.

Seismic Slope Stability
Sections ‘C-C’ and ‘G-G’ were also analysed for pseudo-static (seismic) conditions. A seismic coefficient of 0.2 was used in the pseudo-static analysis (i.e., half of the Peak Ground Acceleration for the Ottawa area, based on Seismic Site Class E and the OBC 2012).
For seismic loading conditions, the Erosion Hazard Limit could consist of only the Stable Slope Allowance (i.e., the Toe Erosion Allowance and Erosion Access Allowance are not considered). During a seismic event, the Stable Slope Allowance is the area between the crest of the slope and location where a factor of safety of greater than 1.1 against overall rotational failure is calculated. A Toe Erosion Allowance is not considered since erosion is not the trigger of seismic slope instability. Furthermore, an Erosion Access Allowance is also not considered given that, in general, the philosophy for seismic design corresponds to post-disaster conditions (i.e., to avoid immediate collapse and loss of life).

At Section ‘C-C’, the slope stability analysis indicates that the existing slope, in its current configuration but fully saturated, has a factor of safety against failure of greater than 1.1 for pseudo-static (seismic) conditions at a distance of about 15.0 metres from the crest of the slope (refer to Figure A2 in Attachment A). At Section ‘G-G’, the slope stability analysis indicates that the existing slope has a factor of safety against failure of greater than 1.1 for pseudo-static (seismic) conditions. Therefore, the Erosion Hazard Limit determined for static loading conditions governs for this site.

ADDITIONAL CONSIDERATIONS

The existing vegetation and trees along the slope should be maintained, to ensure the stability of the slope is not affected. As part of the overall site grading for any future development, no additional surface water should be directed towards the slope unless adequate erosion control measures are incorporated. This could cause erosion of the slope and could also negatively affect the stability of the slope. Final plans and finished grades for any proposed development adjacent to the slope should be reviewed by a geotechnical engineer to ensure that the guidelines provided on this report have been interpreted as intended.
We trust that this letter is sufficient for your purposes. If you have any questions concerning this information or if we can be of further assistance to you on this project, please call.

Luc Bouchard, P.Eng.

Craig Houle, M.Eng., P.Eng.
Principal
APPROXIMATE BOREHOLE LOCATION IN PLAN, CURRENT INVESTIGATION BY HOULE CHEVRIER ENGINEERING LTD.
BORROHOLE ELEVATION IN METRES (GEODETIC DATUM)

LEGEND

BH13-103
68.43

SCPTu
13-102
SEISMIC PIEZOCONE TEST

CROSS SECTION LOCATION IN PLAN

EROSION HAZARD LIMIT (APPROXIMATE)

AREA 1

AREA 2

PROJECT NO.

SCALE

DRAWN BY

CHECKED BY

DATE

REVISION NO.

PROJECT

HONEY PROPERTY SUBDIVISION
RUSSELL, ONTARIO

SITE PLAN

SCALE

0 50 100 150
0 25
150m

BH13-101
68.43
BH13-102
68.37
BH13-103
70.52
BH13-104

RIVER

CASTOR

CROSS SECTION LOCATION IN PLAN

SCPTu
13-102

CRAIG STREET

REVISED 50R-360

D.J.R.

L.B.

September 2014

13-538

2

0

B"
ATTACHMENT A

Slope Stability Analyses
Area 1 - Section ‘C-C’
Figures A1 and A2
Loading Conditions: Static
Groundwater Conditions: Full Hydrostatic Saturation
Soil Properties: Drained

Material Properties:
- Material: Silty Sand
- Strength Type:Mohr-Coulomb
- Unit Weight: 18 kN/m³
- Cohesion: 6 kPa
- Friction Angle: 33 degrees
- Water Surface: Water Table

Material Properties:
- Material: Soft Silt/Clay
- Strength Type: Mohr-Coulomb
- Unit Weight: 17 kN/m³
- Cohesion: 10 kPa
- Friction Angle: 30 degrees
- Water Surface: Water Table

Material Properties:
- Material: Firm Silt/Clay
- Strength Type: Mohr-Coulomb
- Unit Weight: 17 kN/m³
- Cohesion: 10 kPa
- Friction Angle: 30 degrees
- Water Surface: Water Table

FIGURE A1

SLOPE STABILITY ANALYSIS
HONEY PROPERTY SUBDIVISION
SECTION C-C

PROJECT: 13-538
DATE: August 2014
Loading Conditions: Pseudo-Static (0.20)
Groundwater Conditions: Full Hydrostatic Saturation
Soil Properties: Drained
ATTACHMENT B

Slope Stability Analyses
Area 2 - Section ‘G-G’
Figures B1 and B2
Loading Conditions: Static  
Groundwater Conditions: Full Hydrostatic Saturation  
Soil Properties: Drained
Loading Conditions: Pseudo-Static (0.20)
Soil Properties: Undrained

Material: Weathered Crust
Strength Type: Undrained
Unit Weight: 17 kN/m³
Cohesion Type: Constant
Cohesion: 80 kPa

Material: Soft Silty Clay
Strength Type: Undrained
Unit Weight: 17 kN/m³
Cohesion Type: Constant
Cohesion: 25 kPa
ATTACHMENT C

Record of Borehole Logs
Seismic Piezocone Test Results
# Record of Borehole 13-101

**Project:** 13-538  
**Location:** See Borehole Location Plan, Figure 2  
**Boring Date:** December 10, 2013  
**Datum:** Geodetic  
**SPT Hammer:** 63.5 kg; drop 0.76 m

## Soil Profile

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Description</th>
<th>Type</th>
<th>Blows/0.3m</th>
<th>Water Content, Percent</th>
<th>Dynamic Penetration Resistance, Bows/0.3m</th>
<th>Hydraulic Conductivity, k, cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Ground Surface</td>
<td>68.43</td>
<td>0.00</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>0</td>
<td>Dark brown silty sand some organic material (TOPSOIL)</td>
<td>68.23</td>
<td>2.00</td>
<td>5</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>0</td>
<td>Very stiff, reddish brown SILTY CLAY (WEATHERED CRUST)</td>
<td>67.94</td>
<td>2.49</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Soft to firm, grey SILTY CLAY</td>
<td>67.01</td>
<td>1.00</td>
<td>1</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>End of Borehole</td>
<td>7.01</td>
<td>0.00</td>
<td>20</td>
<td>40</td>
<td>60</td>
</tr>
</tbody>
</table>

**Additional Lab Testing**

- Bentonite
- Filter Sand
- 51mm diameter, 3.05m long slotted PVC pipe

**Logbook:** A.N.

**Checked:**

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**Power Auger**

**200mm Diameter Hollow Stem Auger**

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**Bentonite Filter Sand**

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**Groundwater level at 0.85 metres below ground surface (elevation 67.58 metres geodetic datum) on January 10, 2014.**
**RECORD OF BOREHOLE 13-103**

**DESCRIPTION**

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>SOIL PROFILE</th>
<th>SAMPLES</th>
<th>HYDRAULIC CONDUCTIVITY, $k$, cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Ground Surface</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.70</td>
<td>Dark brown silty sand some organic material (TOPSOIL)</td>
<td>1</td>
<td>1.52</td>
</tr>
<tr>
<td>0.70</td>
<td>Loose brown SILTY SAND, trace clay</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>1.52</td>
<td>Wet/saturated</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6.71</td>
<td>Soft, grey SILTY CLAY</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>7.62</td>
<td>End of Borehole</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

**BORING METHOD**

- **Power Auger**: 0.36
- **Native Backfill**: 0.16
- **Bentonite**: 0.00

**LOGGED**: A.N.

**CHECKED**: