



May 26, 2021

Reference No. 11218340

Mr. Robert McDowell



Dear Mr. McDowell:

**Re: Geotechnical and Slope Stability Review  
Proposed Residential Development - 2L49 Lakeshore Road, Wainfleet, Ontario**

At the request of Mr. Robert McDowell (client), GHD has completed a technical review of the November 2010 report entitled *Geotechnical Investigation, Feasibility Study and Slope Stability Assessment Report* (AMEC Report) prepared by AMEC Earth & Environmental a division of AMEC Americas Limited (AMEC) for the proposed residential development at 2L49 Lakeshore Road in the Township of Wainfleet, Ontario (Site or Property). The Site location is shown on Figure 1. Note that all Figures are found in Attachment 1 located at the end of this Review.

This review presents GHD's comments and recommendations on the geotechnical and slope stability information presented in the AMEC Report based on GHD's understanding of the proposed development.

## **1. Site Description and Project Understanding**

The Site is a vacant lot with a gravel driveway access from Lakeshore Road. The topography of the Site slopes downwards from a high elevation of approximately 187 m (CGVD29) above mean sea level (amsl) along the central eastern Property boundary to approximately 181 m amsl at the west Property boundary and Lakeshore Road to the north, and to approximately 178 m amsl towards Lake Erie to the south..

It is our understanding that the proposed residential development has remained unchanged from what was proposed in 2010 and will consist of a one-story residential dwelling with a full basement and a septic system.

The Site is located in the physiographic region of the Haldimand Clay Plain<sup>1</sup>, on the shoreline of Lake Erie. A review of the regional geology maps indicates that the Property is located within a strip of windblown (eolian) deposits consisting of fine to very fine sand and silt and coarse-textured marine deposits of sand and gravel with minor silt and clay<sup>2</sup> along the northern shoreline of Lake Erie as shown in Figure 2. Due to the nature of deposition, eolian deposits have an open (honeycomb) structure with very high void ratios. The clay or calcium carbonate components of eolian deposits play an important role as a

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- 1 Chapman, E.J., and Putnam, D.F., 1984: The Physiographic of Southern Ontario; Ontario Geological Survey. Special Volume 2. 270p. Accompanied by Map P.2715 (coloured), scale 1:600 000.
  - 2 Ontario Geological Survey 2003. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release---Data 128

binder, acting to hold the deposit together. Upon wetting, however, either the water soluble calcium carbonate bonds dissolve or the large negative pore pressures within the clay that are holding the deposit together are reduced, resulting in increased likelihood of shear failure and/or large settlement. This cementation can impart pseudo cohesive properties<sup>3</sup> when samples of eolian deposits are tested for shear strength and can also enable these weakly to moderately cemented deposits to stand at relatively steep slope angles, as is seen at the Site in the photograph below.



**Figure 1.1 Relatively steep shoreline slope**

The bedrock underlying the soil overburden in the region and at the Site, consists of sedimentary rock (limestone, dolostone, shale) of the Detroit River Group, Onondaga Formation<sup>4</sup>, as shown on Figure 3. This bedrock is expected to be encountered between 175 m amsl and 170 m amsl based on the bedrock topography maps<sup>5</sup> as shown on Figure 4.

GHD understands that the Property owner intends to construct a single-storey residential dwelling at the Site complete with a septic system. The geotechnical review and slope stability review are required to confirm the suitability of the Site for the proposed residential development and identify constraints associated with soil bearing capacity and slope stability.

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3 Collins B.D. Sitar N. (2009): Geotechnical Properties of Cemented Sands in Steep Slopes, Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 10, p 1359-1366

4 Ontario Geological Survey 2006. 1:250 000 Scale Bedrock Geology of Ontario; Ontario Geological Survey, Miscellaneous Release-Data 126-revised. ISBN 0-7794-5172-4.

5 Kelly, R.I., Brunton, F.R. and van Haaften, S. 2006. Bedrock topography and overburden thickness mapping, southern Ontario; Ontario Geological Survey, Miscellaneous Release - Data 207, ISBN 1-4249-2550-9.



## **2. Geotechnical Review**

### **2.1 Technical Summary**

The following summary of technical information has been identified by GHD based on a review of the November 2010 report entitled *Geotechnical Investigation, Feasibility Study and Slope Stability Assessment Report* prepared by AMEC Earth & Environmental a division of AMEC Americas Limited (AMEC):

- The report is prepared for a proposed one story dwelling with one level of underground basement.
- Four boreholes were drilled on site, two of which (BH-1 and BH-2) were advanced to 9.8 and 9.6 m below ground surface (m bgs) at the proposed residential dwelling location. The other two boreholes (BH-3 and BH-4) were advanced to depths of 3.1 and 5.2 m bgs at the proposed septic system location. Borehole elevations presented in the report were based on a survey plan dated 1986 and it was assumed that the surface conditions (elevations) had not changed between 1986 and 2010.
- One grain size analysis was completed on the native soil to assess soil permeability for septic system design. Moisture content analysis was completed on all recovered soil samples.
- Subsurface conditions logged in boreholes indicate that the Site is covered by 50 to 100 mm of topsoil and surficial fill material (about 0.2 m in BH-1 and BH-2) which is underlain by a sand deposit. All boreholes were terminated within the sand deposit. The compactness of the soil layers was evaluated based on N values measured during drilling activities which ranged between 2 and more than 50.
- Boreholes were left open upon completion and remained dry. Natural moisture content of the samples ranged from 2 to 7%.
- The report indicates that the native sand is suitable to support the shallow foundations of the proposed residential dwelling. The report recommends a bearing capacity of 80 kPa under Serviceability Limit State (SLS) condition and 120 kPa under factored Ultimate Limit State (ULS) condition for footings founded on the native sand in an undisturbed condition. The total settlement associated with the recommended bearing capacities is reported as 25 mm.
- A minimum soil cover of 1.2 m or equivalent insulation for foundations is recommended to provide frost cover.
- The foundations are recommended to be founded at 183.6 m amsl or deeper on the south side of the proposed residential dwelling and all other footings are recommended to be founded below an upward line extending from the south side of the proposed residential dwelling to the north side of the proposed residential dwelling on a 3 horizontal to 1 vertical (3H:1V) slope.
- The report recommends a Seismic Site Class 'E' for the design of the proposed residential dwelling.
- The soils are classified as Type 3 soil above the groundwater table as per Ontario Occupational Health and Safety Act (OHSA).



- A slope stability assessment was completed for the steepest slope (identified as the south slope) with 1.5H:1V inclination. Signs of instability on the western edge of the slope were observed along with a lack of vegetation and signs of localized erosion due to storm water runoff (approximately 0.5 m deep gully).
- The result of the slope stability assessment shows a factor of safety of 1.1 under static conditions. The report recommends the combination of a retaining wall and a 2H:1V slope for the steep section of the slope to accommodate the proposed residential dwelling. The report also provides a stable top of bank line based on a 2H:1V slope requirement. For erosion protection a layer of clay and vegetation to cover the slope surface is recommended. It is also suggested that regrading be conducted to reduce localized erosion from storm water runoff.
- The report cautions about slope protection on the eastern portion of the Property during construction and recommends protection by means of shoring systems to ensure no damage occurs to the neighbouring structure.
- It is indicated in the report that a single dwelling with a walk-out basement is a feasible option but may require Niagara Peninsula Conservation Authority permit.

## **2.2 Technical Review Comments**

Based on GHD's review of the 2010 AMEC geotechnical report, the following comments are provided:

- In general, the field work completed was appropriate for its purpose. The field program provided was limited but included sufficient subsurface information for preliminary geotechnical recommendations. It is noted that it is common practice to extend geotechnical boreholes to depths extending from the top of the slope to below the toe of slope. Based on slope heights of 8 and 9 m, the boreholes drilled on Site do not extend below the toe of slope elevation.
- Limited soil laboratory testing was completed. Additional soil gradation could provide a better understanding of the soil composition, especially where low N values (soft soils) were encountered.
- The recommended bearing capacities are considered suitable for the encountered soil deposit.
- No recommendation is provided for the design of the basement walls or for shoring design. This may be required for detailed design.
- The National Building Code of Canada requires either a deep borehole (to 30 m below foundation level) or geophysical testing to support a seismic site classification. No geophysical testing was carried out at the Site and the boreholes drilled are not deep enough to provide the seismic site classification. In the absence of this information, conservative values were assumed for the deeper soils. On this basis, the Class E seismic site classification may be overly conservative; however this cannot be confirmed unless additional investigation is completed.
- The slope stability analysis was completed for one of the steepest slopes (1.5H:1V) on Site and resulted in factor of safety above 1 but less than 1.5, which is an industry accepted safety factor. The



report recommends that the slopes be kept at 2H:1V; however the analyses only illustrate the lowest factor of safety and do not show the factor of safety associated with a 2H:1V slope.

- The suggested means of preventing wind and storm water runoff erosion of the slope consists of constructing a vegetated clay layer over the existing grade. Depending on the changes to the slope during the last 10 years and completion of a coastal review, alternative slope remediation measures may be appropriate.

Based on the review of the November 2010 report, recent Site visits and a recent topographical survey completed by GHD, the AMEC 2010 geotechnical investigation is considered appropriate for the proposed residential development. While at this stage additional geotechnical investigation is not considered necessary, recommendations for the design of the basement walls and for shoring design can be included as part of the detailed design, if required.

### **3. Slope Stability Assessment**

The recent topographical survey completed by GHD indicates that slight slope changes have occurred at the Site. Notably, a steep slope of 1.4H:1V was measured at a similar location as was analyzed by AMEC in their 2010 report. On this basis, a slope stability assessment was performed for the existing slope to the south of the proposed residential dwelling. The geometry of the slope is based on the recent topographic survey completed by GHD. Background and Approach

Subsurface soil conditions documented in the AMEC 2010 report were used to estimate soil characteristics for this assessment.

Analyses were performed on two cross sections identified as A-A and D-D on the topographic survey included as Attachment A. The stability analyses are included as Figure 5 to Figure 8 in Attachment B. Both static and pseudo-static (i.e., seismic) conditions were analyzed for the selected cross-sections. Cross-section A-A has the steepest gradient of 1.4H:1V and cross-section D-D has a slope gradient of 2H:1V.

The slope stability analysis was carried out using the SLOPE/W 2019 R2 software package produced by GEO-STUDIO International Ltd. Each trial was modeled using the Morgenstern-Price method, and the optimized critical slip-surface was selected. In general, this approach calculates a factor of safety that represents the ratio of forces resisting a failure (i.e., shear strength, friction, etc.) to those favouring failure (weight, external loading, etc.). Theoretically, a factor of safety of 1.0 or greater would represent a stable slope. The Ontario Ministry of Natural Resources and Forestry (MNRF)<sup>6</sup> has developed a table of recommended minimum factors of safety based on the land use above or below the slope. These factors of safety take into account the consequences or risks to land use or life of a slope failure. The MNRF recommended factors of safety are reproduced below,

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<sup>6</sup> MNRF (2002): Technical Guide, River & Stream Systems: Erosion Hazard Limit, Queens Printing Press, Toronto, p134



**Table 3.1 MNRF Recommended Minimum Factors of Safety**

| No. | Usage                         | Land Use   | Design Minimum Factor of Safety |
|-----|-------------------------------|--|---------------------------------|
| A   | Passive                       | No buildings near slope, farm field, bush forest, timberland, woods, wasteland, badlands, tundra   | 1.10                            |
| B   | Light                         | No habitable structures near slope, recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses                                     | 1.20 to 1.30                    |
| C   | Active                        | Habitable or occupied structures near slope, residential, commercial and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances  | 1.30 to 1.50                    |
| D   | Infrastructure and Public Sue | Public use structures or buildings (i.e., hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas. | 1.40 to 1.50                    |

The above design minimum recommended factors of safety are for static conditions. A minimum factor of safety of 1.5 under static conditions was targeted for this study. For seismic conditions, which is a transient condition, a factor of safety of 1.0, which represents perfect equilibrium conditions was targeted..

The selected geotechnical parameters for the Site soils used in the analysis is summarized in Table 3.1 below.

**Table 3.2 Geotechnical Parameters**

| Material  | Unit Weight (kN/m <sup>3</sup> ) | Cohesion (kPa) Drained (Factored for seismic) | Internal Friction Angle (°) |
|---|----------------------------------|---|-----------------------------|
| Stone Revetment - High Strength Material                                | 26                               | NA  | NA                          |
| Eolian Deposits   |                                  |   |                             |
| Compact Sand/Silt   | 19                               | 6   | 37                          |
| Loose Sand/Silt   | 19                               | 6   | 30                          |
| Compact foreshore (beach) sands   | 19                               | 0   | 30                          |
| Notes:  |                                  |   |                             |
| - Slope/W High Strength Material Model is used for the stone Revetment. |                                  |   |                             |

The groundwater elevation at the Site was assumed to be the same as that of Lake Erie (approximately 175 m asl which is consistent with GHD's observations and those presented in the AMEC 2010 report.

Two scenarios were assumed for the analysis as listed below:

- A global stability of the overall slope under static condition.



- A global stability of the overall slope under pseudo-static condition – in this analysis a horizontal coefficient of 50% of the PGA (under 2% probability of exceedance in 50 years) which is equal to 0.092 at the site location was assumed for seismic loading.

#### 4. Sanitary Service Review

The sanitary design was undertaken in accordance with the 2006 Ontario Building Code (OBC). Since then, the 2012 OBC and 2019 OBC have taken effect, yet the updates do not affect this particular design. It is recommended that the design reference the updated version of code.

#### 5. Discussion and Recommendations

A summary of the analyses is shown in Table 3.2 below, with the analysis for each condition provided on Figure 5 to Figure 8 in Attachment B.

**Table 3.2 Summary of Analyses**

| Analysis                         | Cross-Section/<br>Figure | Gradient<br>(H:V) | Factor of Safety    |            | Stable Slope<br>setback<br>Allowance (m) <sup>(1)</sup> |
|----------------------------------|--------------------------|-------------------|---------------------|------------|---|
|                                  |                          |                   | Minimum<br>Required | Calculated |   |
| Global Stability - Static        | A-A Figure 5             | 1.4:1             | 1.5                 | 1.2        | 5.0   |
| Global stability - Pseudo Static | A-A Figure 6             | 1.4:1             | 1.0                 | 1.0        | 2.0   |
| Global Stability - Static        | D-D Figure 7             | 2.0:1             | 1.5                 | 1.3        | 2.0   |
| Global stability - Pseudo Static | D-D Figure 8             | 2.0:1             | 1.0                 | 1.1        | 1.83  |

Notes:

- (1) Industry accepted guidelines of safe slope allowance (stable top of slope) is based on the factor of safeties of 1.5 for static condition and 1.0 for pseudo-static condition.

Based on the results of the analyses, as summarized in Table 3.2, the following conclusions and recommendations are presented:

- Analyses completed show factors of safety less than 1.5 under static conditions. A factor of safety of 1.5 under static conditions was achieved at 5 m and 2 m, as measured from the top of the slope for the 1.4H:1V and 2H:1V slopes, respectively. A slope stability analysis was not completed for the west slope. Due to the similar steepness of the slope to Section A-A, it is recommended that a Stable Top of Slope setback allowance of 5 m should be used along the west side slope.
- Using the results of analyses discussed in the bullet item above, the recommended long term Stable Top of Slope allowance is shown on Figure 9.

The AMEC 2010 report suggests altering the slope to keep the safe slope inclination of 2H:1V where steeper slopes are present. This would require the removal of the existing vegetative cover on the slopes. It is strongly recommended that the existing vegetative cover not be disturbed as loss of this



growth will reduce the slope stability. As an alternative, the long-term stable top of slope can be considered at an offset distance of 2 m and 5 m inland from the existing top of slope at cross-sections A-A and D-D, respectively, which meets the AMEC 2H:1V slope criterion.

- Construction staging areas should not be located near the top of slope. No heavy construction equipment should be allowed near the top of slope or within the safe slope allowance of 5 m.

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Should you have any questions on the above, please do not hesitate to contact

us. Sincerely,

GHD



May 26, 2021

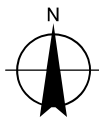
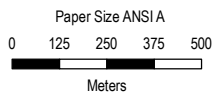
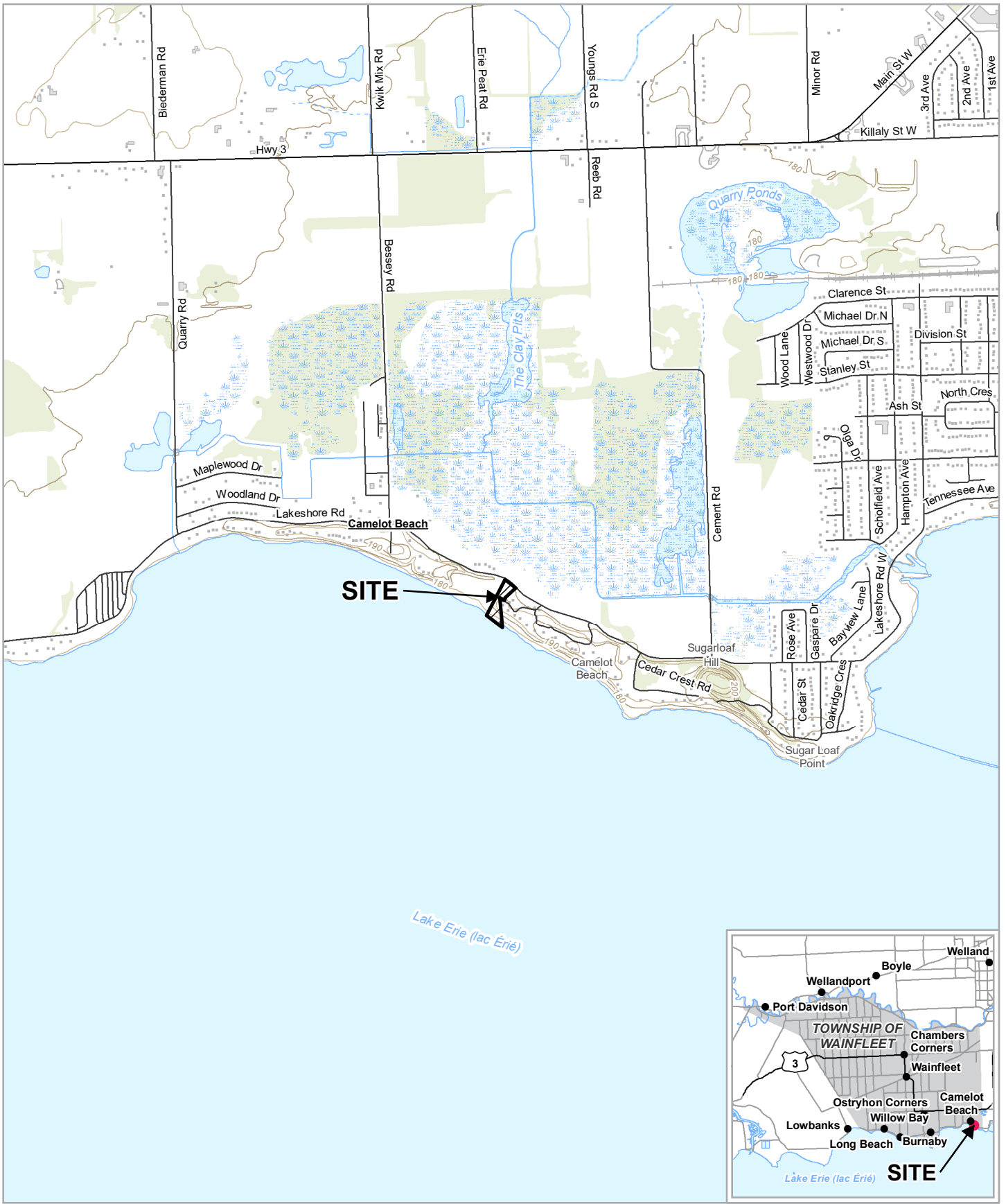
Hassan Gilani, M.Sc., P.Eng.

HG/MG/1

Jennifer Penton, Ph.D.



## **Attachment: Figures 1 to 10**



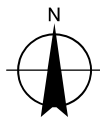
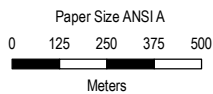
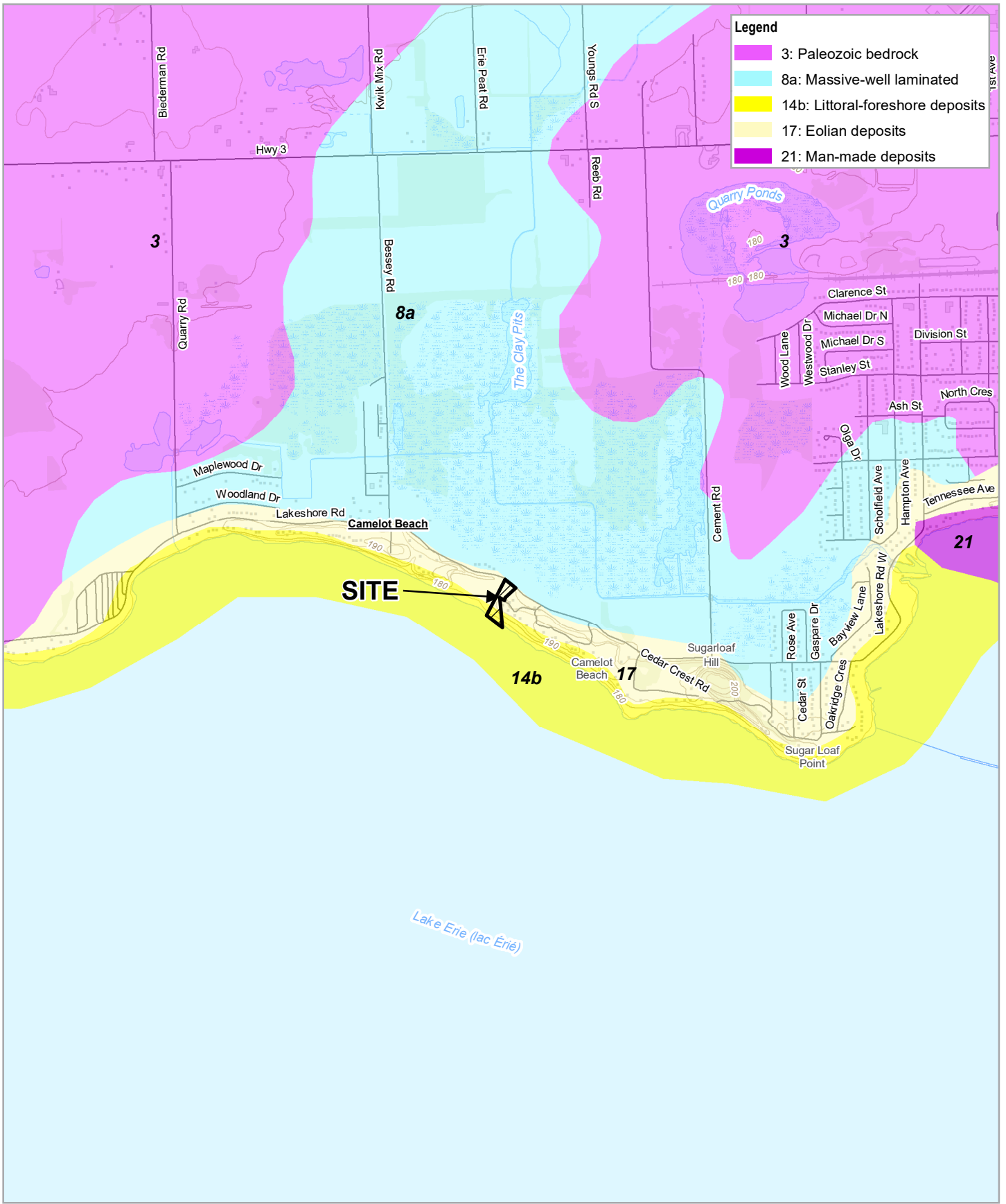
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**2L49 (10288) LAKESHORE ROAD, WAINFLEET, ON**  
**SLOPE STABILITY EVALUATION**

Project No. 11218340  
 Revision No. -  
 Date Nov 17, 2020

Map Projection: Transverse Mercator  
 Horizontal Datum: North American 1983  
 Grid: NAD 1983 UTM Zone 17N

**SITE LOCATION MAP**

**FIGURE 1**



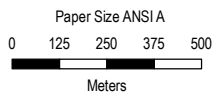
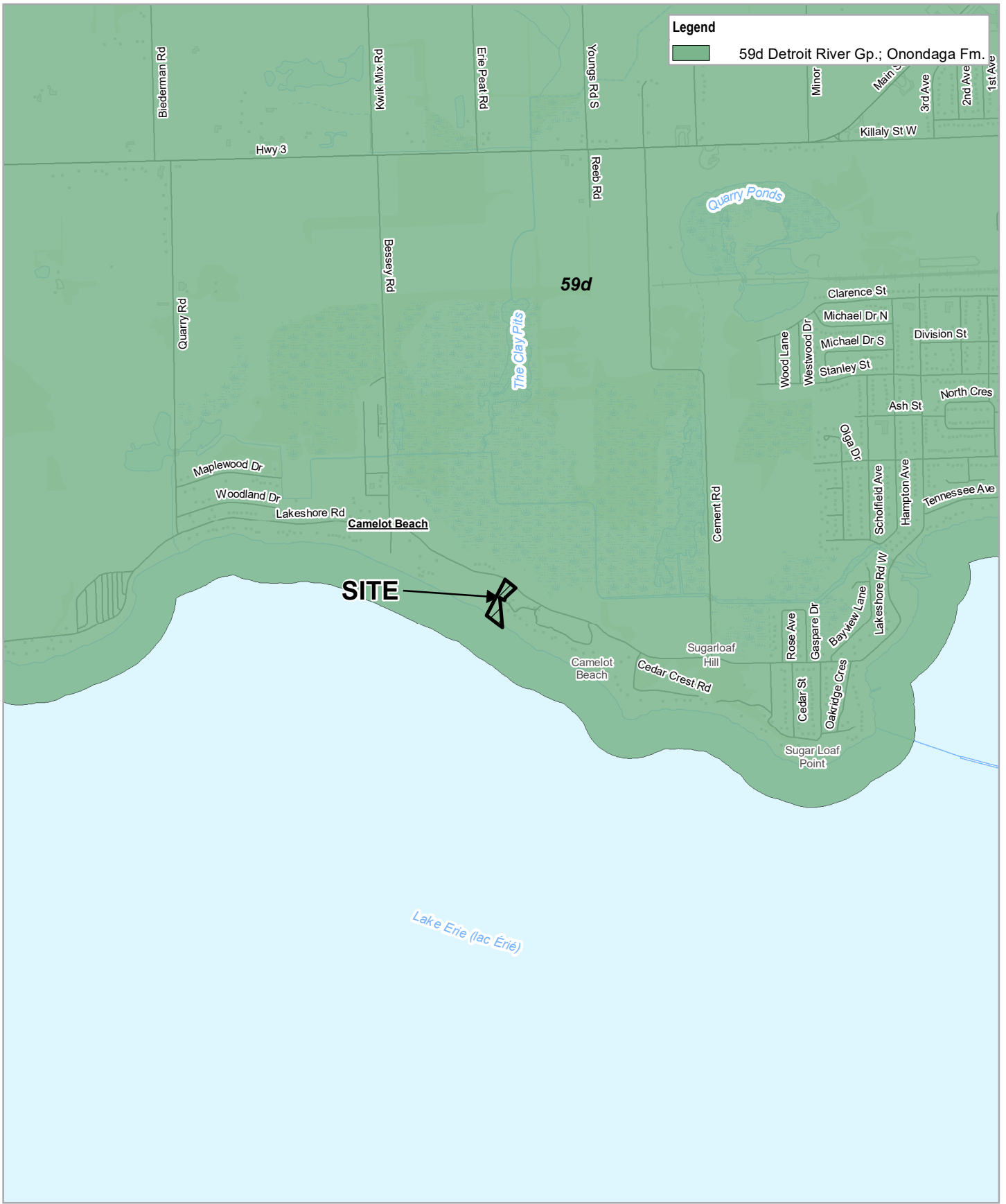
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**2L49 (10288) LAKESHORE ROAD, WAINFLEET, ON**  
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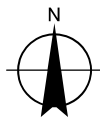
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**SURFICIAL GEOLOGY**

**FIGURE 2**



Map Projection: Transverse Mercator  
 Horizontal Datum: North American 1983  
 Grid: NAD 1983 UTM Zone 17N

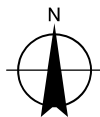
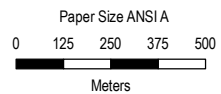


**MCDOWELL RESIDENCE**  
**2L49 (10288) LAKESHORE ROAD, WAINFLEET, ON**  
**SLOPE STABILITY EVALUATION**

Project No. **11218340**  
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 Date **Nov 17, 2020**

**BEDROCK GEOLOGY**

**FIGURE 3**



**MCDOWELL RESIDENCE**  
**2L49 (10288) LAKESHORE ROAD, WAINFLEET, ON**  
**SLOPE STABILITY EVALUATION**

Project No. **11218340**  
 Revision No. -  
 Date **Nov 17, 2020**

Map Projection: Transverse Mercator  
 Horizontal Datum: North American 1983  
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**BEDROCK TOPOGRAPHY**

**FIGURE 4**

| Color       | Name                   | Unit Weight (kN/m <sup>3</sup> ) | Cohesion' (kPa) | Phi' (°) |
|-------------|------------------------|----------------------------------|-----------------|----------|
| Yellow      | Compact Eolian Sand    | 19                               | 6               | 37       |
| Orange      | Compact Foreshore Sand | 18                               | 0               | 37       |
| Light Green | Loose Eolian Sand      | 19                               | 3               | 30       |
| Grey        | Stone Revetment        | 26                               |                 |          |

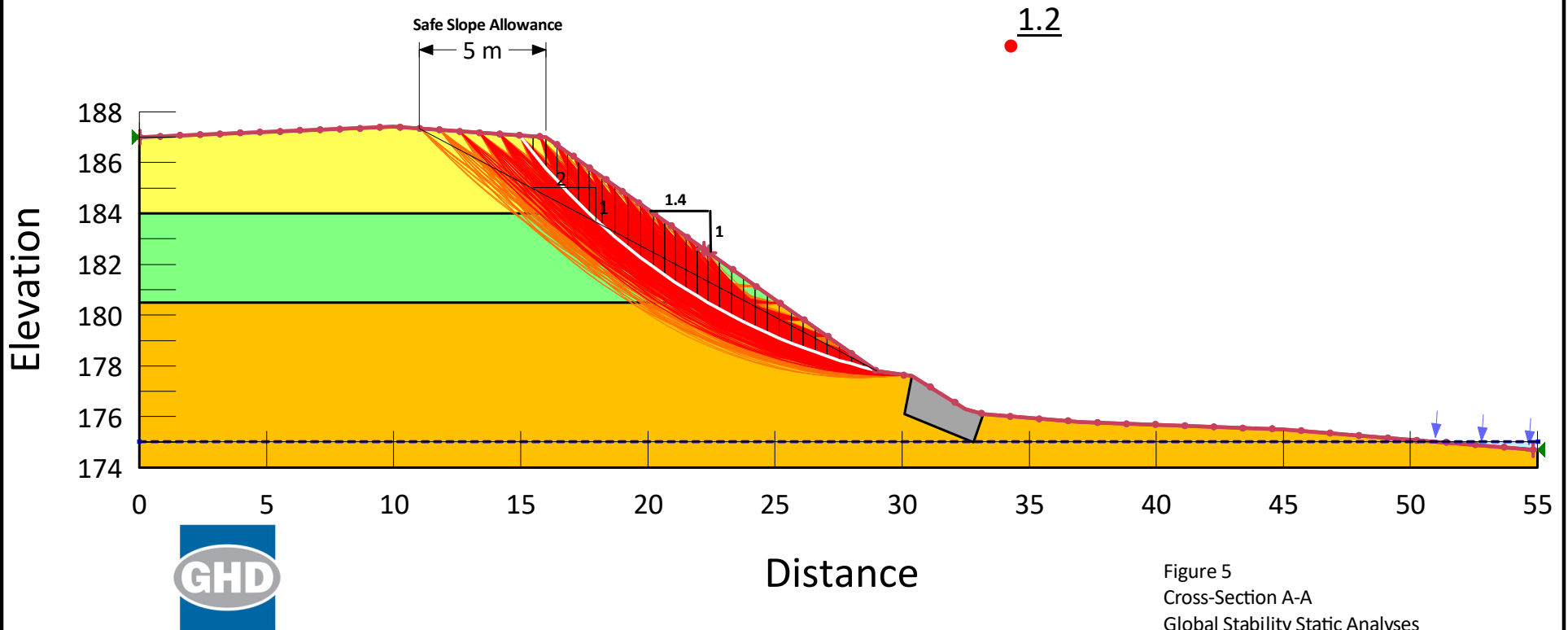


Figure 5  
 Cross-Section A-A  
 Global Stability Static Analyses  
 Proposed Residential Redevelopment  
 2L49 Lakeshore Road, Wainfleet, Ontario

| Color       | Name                   | Unit Weight (kN/m <sup>3</sup> ) | Cohesion' (kPa) | Phi' (°) |
|-------------|------------------------|----------------------------------|-----------------|----------|
| Yellow      | Compact Eolian Sand    | 19                               | 6               | 37       |
| Orange      | Compact Foreshore Sand | 18                               | 0               | 37       |
| Light Green | Loose Eolian Sand      | 19                               | 3               | 30       |
| Grey        | Stone Revetment        | 26                               |                 |          |

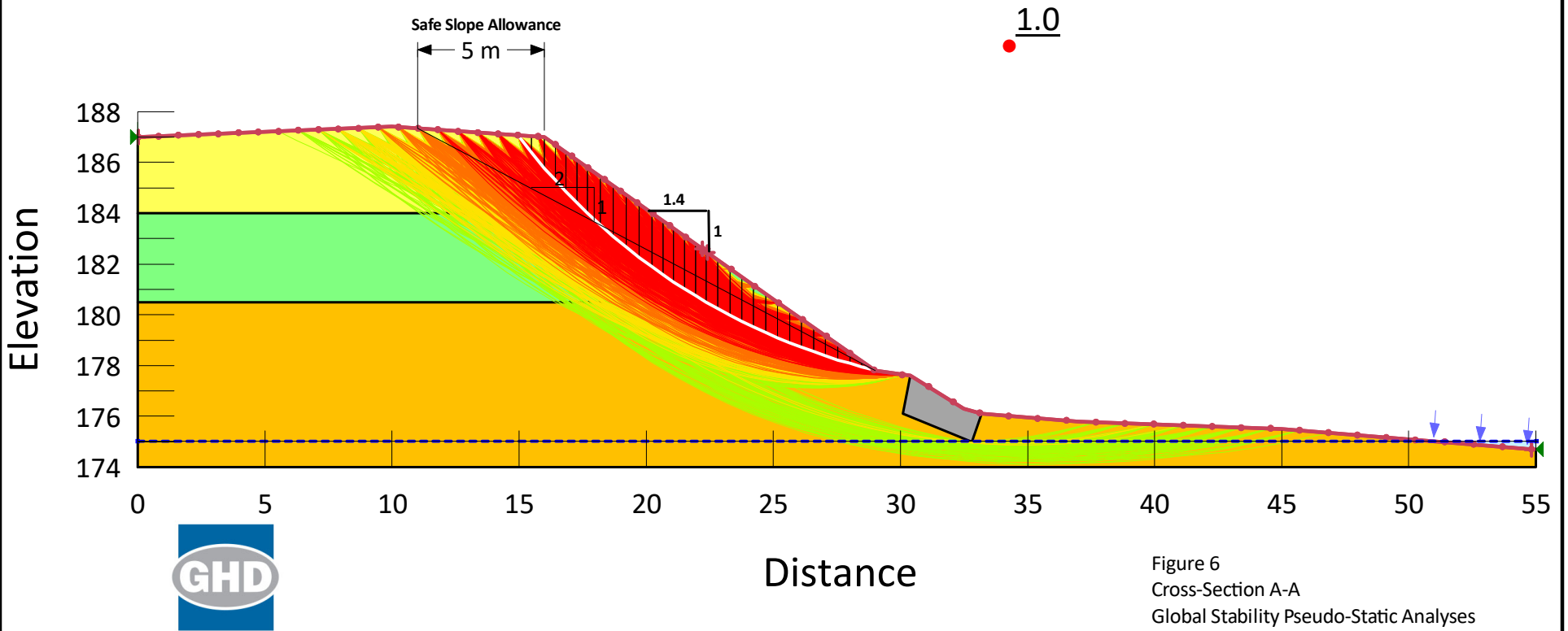


Figure 6  
 Cross-Section A-A  
 Global Stability Pseudo-Static Analyses  
 Proposed Residential Redevelopment  
 2L49 Lakeshore Road, Wainfleet, Ontario

| Color       | Name                   | Model         | Unit Weight (kN/m <sup>3</sup> ) | Cohesion' (kPa) | Phi' (°) |
|-------------|------------------------|---------------|----------------------------------|-----------------|----------|
| Yellow      | Compact Eolian Sand    | Mohr-Coulomb  | 19                               | 6               | 37       |
| Orange      | Compact Foreshore Sand | Mohr-Coulomb  | 18                               | 0               | 37       |
| Light Green | Loose Eolian Sand      | Mohr-Coulomb  | 19                               | 3               | 30       |
| Grey        | Stone Revetment        | High Strength | 26                               |                 |          |

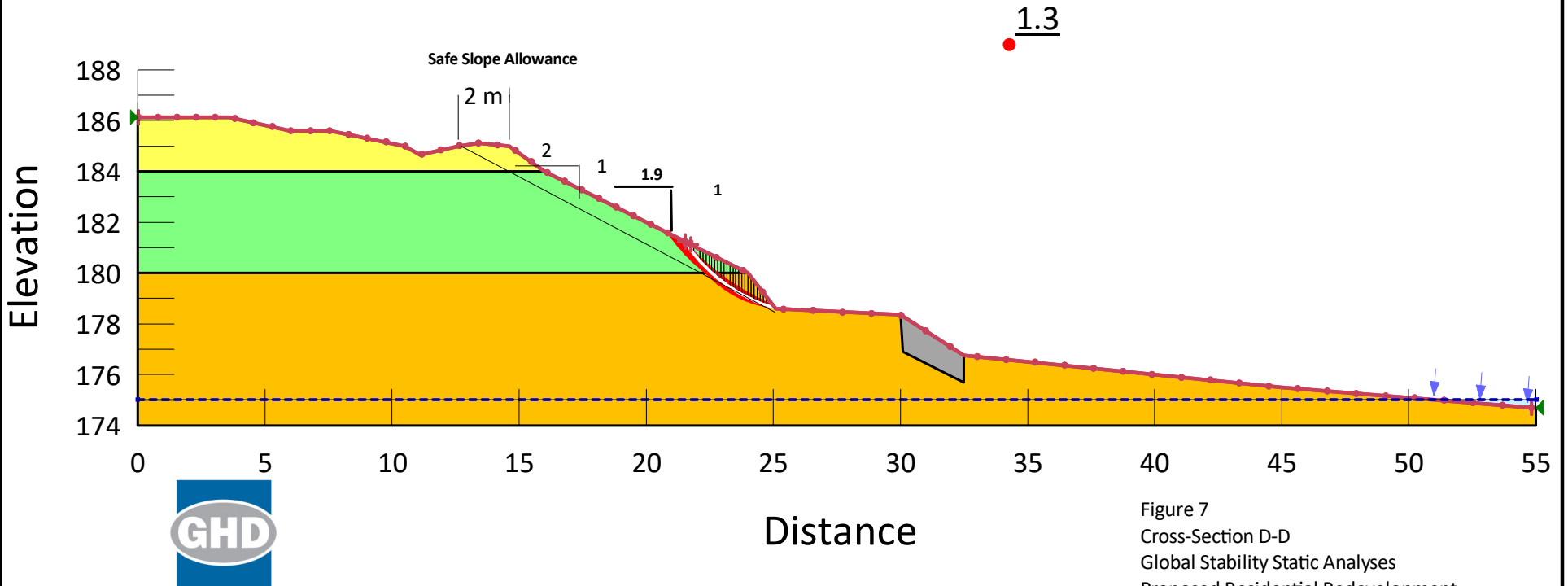


Figure 7  
 Cross-Section D-D  
 Global Stability Static Analyses  
 Proposed Residential Redevelopment  
 2L49 Lakeshore Road, Wainfleet, Ontario  
 11218340

| Color       | Name                   | Model         | Unit Weight (kN/m <sup>3</sup> ) | Cohesion' (kPa) | Phi' (°) |
|-------------|------------------------|---------------|----------------------------------|-----------------|----------|
| Yellow      | Compact Eolian Sand    | Mohr-Coulomb  | 19                               | 6               | 37       |
| Orange      | Compact Foreshore Sand | Mohr-Coulomb  | 18                               | 0               | 37       |
| Light Green | Loose Eolian Sand      | Mohr-Coulomb  | 19                               | 3               | 30       |
| Grey        | Stone Revetment        | High Strength | 26                               |                 |          |

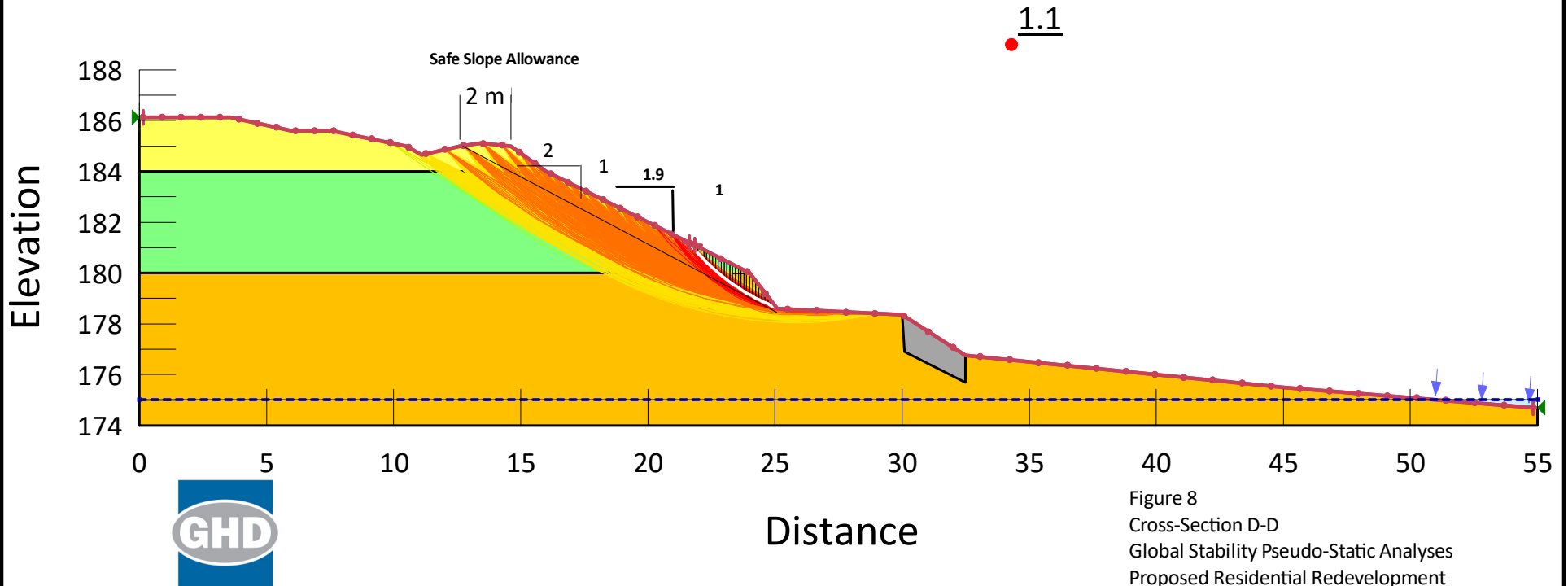
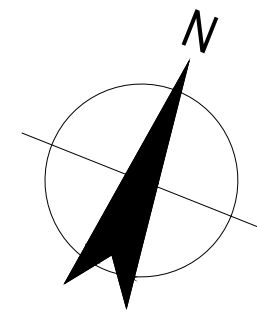


Figure 8  
 Cross-Section D-D  
 Global Stability Pseudo-Static Analyses  
 Proposed Residential Redevelopment  
 2L49 Lakeshore Road, Wainfleet, Ontario  
 11218340



————— LONG TERM STABLE TOP OF SLOPE


**PLAN  
1:250**



**KEY MAP**

| No. | Revision | Drawn | Job Manager | Project Director | Date |
|-----|----------|-------|-------------|------------------|------|
|     |          |       |             |                  |      |

**Drawing Revisions**  
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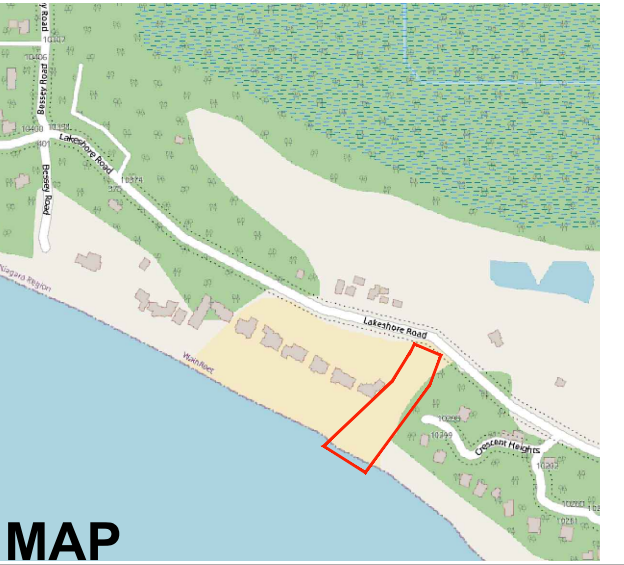
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 Project **2L49 LAKESHORE AVE.  
SHORELINE PROTECTION**

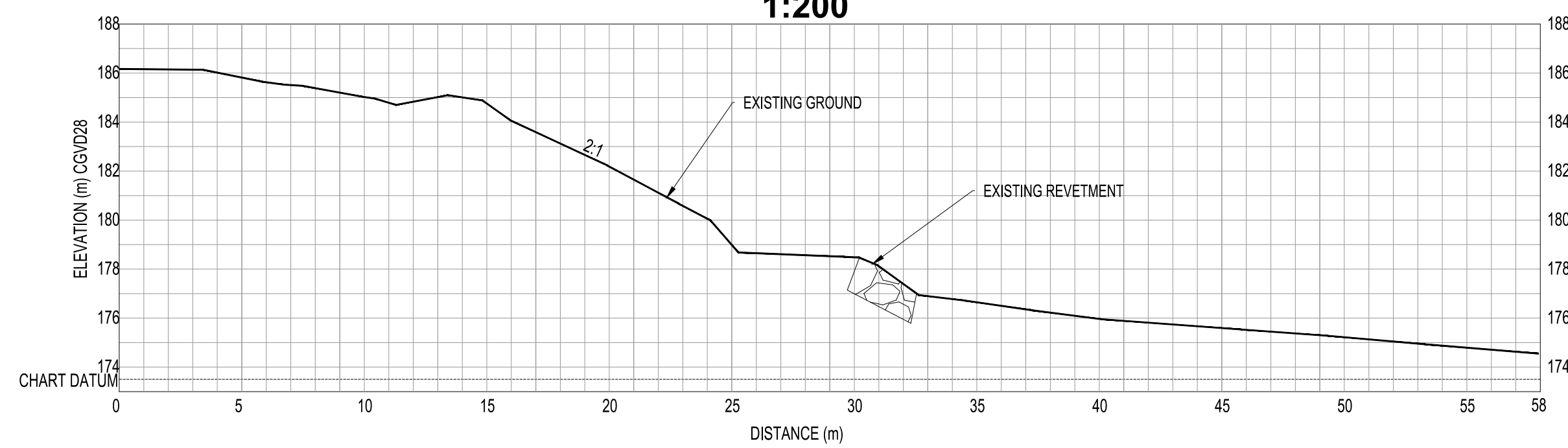
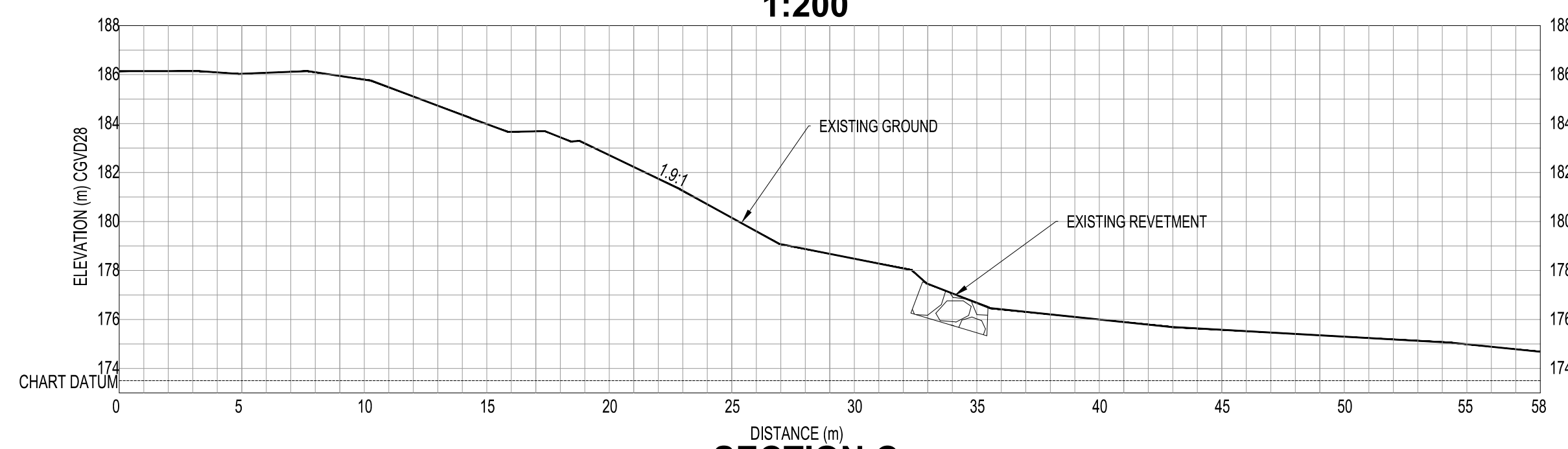
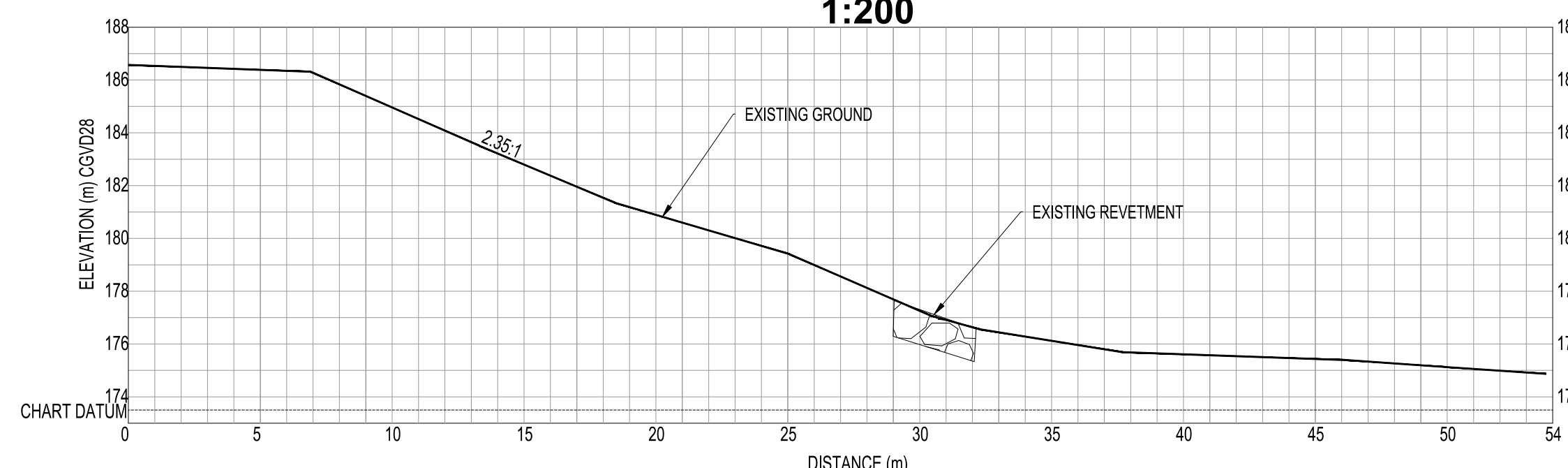
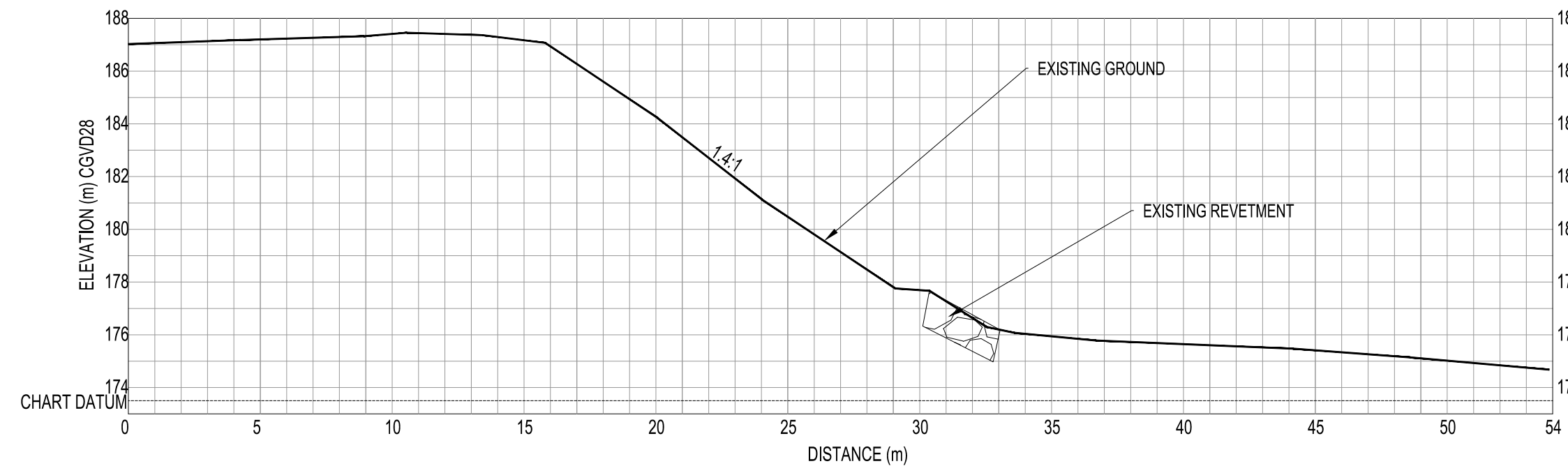
Title **EXISTING  
CONDITIONS**

|                             |               |                     |
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| Drawn                       | J.C.          |                     |
| Designer                    | H.G.          |                     |
| Drafting Check              | J.P.          |                     |
| Design Check                | H.G.          |                     |
| Approved (Project Director) | XXXXXXXXXX    |                     |
| Date                        | December 2020 |                     |

This Drawing must not be used for Construction unless signed as Approved  
 Drawing No. **11218340-Figure 9** Original Size **Arch D**  
 Rev. **001**



**KEY MAP**



| No. | Revision          | Drawn | Job Manager | Project Director | Date       |
|-----|-------------------|-------|-------------|------------------|------------|
| 1.  | ISSUED FOR REVIEW | J.C.  | J.P.        |                  | 2020-11-20 |

**Drawing Revisions**  
Note: \* indicates signatures on original issue of drawing or last revision of drawing

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Client **MR. ROB McDOWELL**

Project **10288 LAKESHORE ROAD W SHORELINE PROTECTION**

Title **EXISTING CONDITIONS CROSS SECTION**

|                             |               |                     |
|-----------------------------|---------------|---------------------|
| Scale                       | AS NOTED      | <b>DO NOT SCALE</b> |
| Drawn                       | J.C.          |                     |
| Designer                    | -             |                     |
| Drafting Check              | J.P.          |                     |
| Design Check                | H.G.          |                     |
| Approved (Project Director) | XXXXXXXXXX    |                     |
| Date                        | NOVEMBER 2020 |                     |

This Drawing must not be used for Construction unless signed as Approved

Drawing No. **11218340-Figure 10**

Original Size **Arch D**

Rev. **001**