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Geotechnical Investigation
Proposed Commercial Development
2885 Carp Road
Ottawa, Ontario

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Submitted to:

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Geotechnical Investigation
Proposed Commercial Development
2885 Carp Road
Ottawa, Ontario

January 30, 2023
Project: 101688.002

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January 30, 2023 File: 101688.002

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PO Box 178 (101-3108 Carp Road)
Carp, Ontario
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Attention: Tim Gilchrist, Associate

Re: Geotechnical Investigation
Proposed Commercial Development
2885 Carp Road
Ottawa, Ontario

Please find enclosed our geotechnical investigation report for the above noted project, in accordance with our proposal dated April 8, 2022. This report was prepared by Mr. Alex Meacoe, P.Eng., and reviewed by Brent Wiebe, P.Eng..

W. Alex Meacoe

Alex Meacoe, P.Eng.

B.

Brent Wiebe, P.Eng.

PS/WAM/BW

Enclosures
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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed commercial development to be located at 2885 Carp Road in the City of Ottawa, Ontario. The purpose of the investigation was to identify the general subsurface and groundwater conditions at the site by means of a limited number of boreholes and, based on the factual information obtained, to provide engineering guidelines on the geotechnical design aspects of the project, including construction considerations that could influence design decisions.

2.0 BACKGROUND

2.1 Project Description

Plans are being prepared for a proposed new commercial development located at 2885 Carp Road in Ottawa, Ontario. The details of the proposed development are not known at this time, but are assumed to consist of a new commercial building with at grade parking and landscaped areas.

The site is currently occupied by a gravel surfaced lot with temporary site trailers.

2.2 Site Geology

Surficial geology maps of the Ottawa area indicate that the site is underlain by sand and silt over glacial till. Bedrock geology maps of the area show that the overburden deposits are underlain by interbedded limestone and shale of the Verulam formation. Drift thickness mapping indicates that the bedrock surface is expected at depths ranging from about 5 to 10 metres below ground surface. Fill material associated with the previous and surrounding development of the site should be anticipated.

3.0 SUBSURFACE INVESTIGATION

3.1 Geotechnical Investigation

The fieldwork for the geotechnical investigation was carried out on May 18, 2022. On that day, two boreholes (numbered 22-01 and 22-02) were advanced at the approximate locations shown on the Site Plan, Figure 1.

The boreholes were advanced with a truck mounted hollow stem auger drill rig supplied and operated by CCC Geotechnical and Environmental Drilling of Ottawa, Ontario. The boreholes were advanced to depths about 6.8 and 6.0 metres below the existing ground surface in boreholes 22-01 and 22-02, respectively.

Standard penetration tests were carried out in the boreholes at regular intervals of depth and samples of the soils encountered were recovered using a 50-millimetre diameter split spoon sampler.

A monitoring well was sealed in the overburden in borehole 22-02 to measure the groundwater levels.

The fieldwork was supervised throughout by a member of our engineering staff who directed the drilling, logged the samples and boreholes, and carried out the in-situ testing. Following completion of the drilling, the soil samples were returned to our laboratory for examination by a geotechnical engineer and for laboratory testing. Selected soil samples were tested for water content and grain size distribution.

One sample of soil obtained from borehole 22-02 was sent to Paracel Laboratories Ltd. for basic chemical testing relating to corrosion of buried concrete and steel.

The borehole locations were selected by GEMTEC and positioned on site relative to existing features. The ground surface elevations at the borehole locations were determined using a precision GPS survey unit.

Descriptions of the subsurface conditions logged in the boreholes are provided on the Record of Borehole Sheets in Appendix A. The results of the laboratory classification testing are provided on the Record of Borehole sheets and in Appendix B. The results of chemical testing completed on one soil sample are provided in Appendix C. The results of the slope stability analysis are provided in Appendix D. The approximate locations of the boreholes are shown on the Site Plan, Figure 1.

3.2 Description of Slope

A site reconnaissance was carried out on June 22, 2022, by a member of engineering staff.

At the time of the site visit, the geometry of the slope along the west side of the site was measured at three locations using precision GPS surveying equipment. The cross sections were positioned at the site by GEMTEC personnel. The locations of the cross sections considered are provided on Figure 1. Cross sections of the slopes are provided in Appendix D.

The geometries of the cross sections are summarized in Table 3.1:

Table 3.1 – Slope Cross Section Height and Slope Inclination

Cross Section	Slope Height (metres)	Overall inclination from horizontal (degrees)
A-A	2.3	33
B-B	2.4	30
C-C	2.2	25

In general, the slopes at the site are vegetated with grass with small to large trees, granular material, cobbles, and boulders. No signs of overall slope instability (i.e., rotational failures) were observed at the site.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil conditions logged in the boreholes from this investigation are provided on the Record of Borehole Sheets in Appendix A. The borehole logs indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. Subsurface conditions at locations other than the test hole locations may vary from the conditions encountered in the boreholes. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and GEMTEC does not guarantee descriptions as exact but infers accuracy to the extent that is common in current geotechnical practice.

The following presents an overview of the subsurface conditions encountered in the boreholes advanced as part of the current investigation.

4.2 Topsoil

Topsoil was encountered at the ground surface in borehole 22-02. The topsoil has a thickness of about 100 millimetres.

4.3 Fill Material

A layer of fill material was encountered at the ground surface in borehole 22-01 and below the topsoil in borehole 22-02. The fill material consists of silty sand with varying amounts of gravel and clay and extends to depths of about 2.3 metres below the existing ground surface.

Standard penetration tests carried out in the fill material gave SPT N values ranging from 7 to 14 blows per 0.3 metres of penetration, which reflect a loose to compact relative density.

The water content of three samples of the fill material ranges from about 11 to 14 percent.

4.4 Glacial Till

Native deposits of glacial till were encountered below the fill material in boreholes 22-01 and 22-02. The glacial till was not fully penetrated in the boreholes but was proven depths of about 6.0 metres below the existing ground surface. Glacial till is a heterogeneous mix of all grain sizes, which at this site is described as sand and gravel, some silt, trace clay. The glacial till in this area is also known to contain cobbles and boulders.

Standard penetration tests carried out in the native deposit of glacial till gave N values ranging from 14 to greater than 50 blows per less than 0.3 metres of penetration, which reflect a compact to very dense relative density. The higher blow counts may reflect the presence of cobbles and boulders in the glacial till deposit rather than the bedrock surface.

One grain size distribution test was carried out on a sample of the glacial till. The results are provided in Appendix B and are summarized In Table 4.1, below.

Table 4.1 – Summary of Grain Size Distribution Test (Glacial Till)

Borehole Number	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
22-01	5	3.1 – 3.7	44	42	11	3

The water content of 10 samples of the glacial till ranges from about 10 to 26 percent.

4.5 Sand

A native deposit of sand, with some silt and gravel was encountered below the glacial till in borehole 22-01. The sand deposit was not fully penetrated in the borehole but was proven to a depth of about 6.8 metres below the existing ground surface.

One standard penetration test carried out in the sand deposit gave an N value of 29 blows per 0.3 metres of penetration, which reflect a compact relative density.

The water content measured on one sample of the sand is about 16 percent.

4.6 Refusal

Auger refusal was encountered in boreholes 22-01 and 22-02 at depths of about 6.8 and 6.0 metres below the existing ground surface, respectively. The auger refusal likely represents the presence of cobbles or boulders within the glacial till deposit or the bedrock surface.

A summary of the refusal depths and elevations is provided in Table 4.2.

Table 4.2 – Summary of Auger Refusal Depth and Elevation

Borehole Number	Ground Surface Elevation (metres)	Depth to Refusal (metres)	Refusal Elevation (metres)
22-01	117.4	6.8	110.6
22-02	117.3	6.0	111.3

4.7 Groundwater Levels

A well screen was sealed in the overburden in borehole 22-02 for measurement of the groundwater level. The groundwater level in the monitoring well was measured on May 25, 2022. The groundwater level depth and elevations are summarized in Table 4.3, below.

Table 4.3 – Summary of Groundwater Levels

Borehole Number	Groundwater Depth (metres)	Groundwater Elevation (metres)	Date
22-02	2.5	114.8	May 25, 2022

The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

4.8 Chemistry Relating to Corrosion

One soil sample obtained from borehole 22-02 was sent to Paracel Laboratories for basic chemical testing relating to corrosion of buried concrete and steel. The results of chemical testing are provided in Appendix C and summarized in Table 4.4, below.

Table 4.4 – Summary of Corrosion Testing

Parameter	Borehole 21-02 Sample 3
Chloride Content (µg/g)	43
Resistivity (Ohm.m)	10.0
Conductivity (µs/cm)	988
pH	7.37
Sulphate Content (µg/g)	889

5.0 RECOMMENDATIONS

5.1 General

The information in the following sections is provided for the guidance of the design engineers and is intended for the design of this project only. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous uses or activities of this site or adjacent properties, and/or resulting from the introduction onto the site from materials from off site sources are outside the terms of reference for this report.

GEMTEC has conducted a Phase One and a Phase Two Environmental Site Assessment for this property, which are provided in separate reports.

5.2 Excavation

The excavations for the proposed commercial development will be carried out through the topsoil, where encountered, fill material, and into the glacial till deposit. The sides of the excavations should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the overburden soils at this site can be classified as Type 3 and, accordingly, allowance should be made for excavation side slopes of 1 horizontal to 1 vertical, or flatter, for soils above the groundwater level. The overburden soils below the groundwater can be classified as Type 4 and, accordingly, allowance should be made for excavation side slopes of 3 horizontal to 1 vertical, or flatter.

Cobbles and boulders should be anticipated in the glacial till. As such, an allowance should be made for removal of boulders from the glacial till during excavation which may require use of larger excavation equipment and possible subexcavation, if boulders are protruding at the underside of footing level.

5.3 Groundwater Management

The groundwater level on May 25, 2022, was measured to be about 2.5 metres below ground surface in borehole 22-02.

Any groundwater inflow into the excavation should be handled from within the excavation by pumping from filtered sumps. Suitable detention and filtration will be required before discharging the water to a sewer or ditch. The amount of groundwater entering the excavation for the construction of the foundations at this site should not exceed 50,000 litres per day and therefore it is not anticipated that an Environmental Activity and Sector Registry (EASR) will be required.

5.4 Foundation Design

Based on the results of the investigation, the proposed commercial development could be founded on footings bearing on or within the native undisturbed glacial till deposits. The topsoil and fill material are considered to be highly compressible and should be removed from below any foundations and slabs on grade.

After the removal of the existing fill material, and where the existing subgrade surface is below the proposed founding level, the grade could be raised with compacted granular material (engineered fill). The engineered fill should consist of granular material meeting Ontario Provincial Standard Specifications (OPSS) requirements for Granular B Type II and should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the material's standard Proctor maximum dry density. To provide adequate spread of load beneath the footings, the engineered fill should extend horizontally at least 0.5 metres beyond the footings and then down and out from this point at 1 horizontal to 1 vertical, or flatter.

For design purposes, exterior footings bearing on the native, undisturbed glacial till, or on a pad of engineered fill above native, undisturbed glacial till should be sized using a geotechnical reaction at Serviceability Limit State (SLS) of 150 kilopascals and a factored geotechnical resistance at Ultimate Limit State (ULS) of 300 kilopascals.

The post construction, total and differential settlement of the footings at SLS should be less than 25 and 15 millimetres, respectively, provided that all loose or disturbed soil is removed from the bearing surfaces.

5.5 Grade Raise Restrictions

The site is underlain by native deposits of glacial till. Based on the borehole information, there are no grade raise restrictions at this site, from a geotechnical perspective. The settlement due to compression of the native soils due to fill placement should be relatively small and should occur during or shortly after the fill placement.

5.6 Frost Protection of Foundation

All exterior footings should be provided with at least 1.5 metres of earth cover for frost protection purposes. Isolated (unheated) footings that are located in areas that are to be cleared of snow should be provided with at least 1.8 metres of earth cover for frost protection purposes. Alternatively, the required frost protection could be provided by means of a combination of earth cover and extruded polystyrene insulation. An insulation detail could be provided upon request.

If the foundation and/or slab on grade are insulated in a manner that will reduce heat flow to the surrounding soil, the foundation depth shall conform to that required for foundations for an unheated space.

5.7 Seismic Design of Proposed Structures

Based on the results of the investigation, it is anticipated that the proposed foundations will be supported on native deposits of glacial till, or a pad of engineered fill constructed above the native deposits. As such, in our opinion, the proposed commercial development should be designed for seismic Site Class D.

There is no potential for liquefaction of the overburden deposits at this site.

5.8 Foundation Wall Backfill and Drainage

The native deposits at this site are frost susceptible and should not be used as backfill against foundations. To avoid frost adhesion and possible heaving, the foundations should be backfilled with imported, free-draining, non-frost susceptible granular material such as that meeting the requirements of OPSS Granular A, or Granular B Type I or II.

Where the backfill will ultimately support areas of hard surfacing (pavement, sidewalks or other similar surfaces), the backfill should be placed in maximum 200 millimetre thick lifts and should be compacted to at least 95 percent of the material's standard Proctor maximum dry density value using suitable vibratory compaction equipment. Light walk behind compaction equipment should be used next to the foundation walls to avoid excessive compaction induced stress on the foundation walls.

Where future landscaped areas will exist next to the proposed structure and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the material's standard Proctor maximum dry density value. Where areas of hard surfacing (concrete, sidewalks, pavement, etc.) abut the proposed structure, a gradual transition should be provided between those areas of hard surfacing underlain by non-frost susceptible granular wall backfill and those areas underlain by existing frost susceptible fill material to reduce the effects of differential frost heaving. It is suggested that granular frost tapers be constructed from 1.5 metres below finished grade to the underside of the granular subbase material for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

It is recommended that roof downspouts discharge to a suitable outlet that will not result in saturation of the backfill material below hard surfaced areas.

The frost susceptible native soils could be considered for foundation wall backfill purposes in soft landscaped areas provided that a suitable bond break is applied to the surface of the foundations to prevent frost jacking. A suitable bond break could consist of at least 2 layers of 6 MIL polyethylene sheeting or a proprietary plastic drainage medium. It is also pointed out that the native soils at this site can be impacted by changes in moisture content and this could affect the ability to compact this material to the required density.

Perimeter foundation drainage is not considered necessary for a slab on grade structure provided that the floor slab level is above the finished exterior ground surface level.

5.9 Slab on Grade Support

To provide predictable settlement performance of the slab on grade, all topsoil, fill material, organic material or disturbed soil and debris should be removed from the slab area. The base for the floor slab should consist of at least 150 millimetres of OPSS Granular A.

OPSS documents allow recycled asphaltic concrete and Portland cement concrete to be used in Granular A material. Since the source of recycled material cannot be determined or controlled, it is suggested that any imported Granular A materials be composed of 100 percent crushed rock only, for environmental reasons.

All imported granular materials placed below the proposed floor slab should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density value.

Underfloor drainage is not considered necessary provided that the floor slab level is above the finished exterior ground surface level. If any areas of the building are to remain unheated during the winter period, thermal protection of the slab on grade may be required. Further details on the insulation requirements could be provided, if necessary.

Proper moisture protection with a vapour retarder should be used for any slab on grade where the floor will be covered by moisture sensitive flooring material or where moisture sensitive equipment, products or environments will exist. The “Guide for Concrete Floor and Slab Construction”, ACI 302.1R-04 should be considered for the design and construction of vapour retarders below the floor slab.

5.10 Proposed Services

5.10.1 Excavation

In the overburden, the excavation for flexible service pipes should be in accordance with Ontario Provincial Standard Drawing (OPSD) 802.010 for Type 3 soil. The excavation for rigid service pipes should be in accordance with OPSD 802.031 for Type 3 soil. The sides of the excavations within overburden soils should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the soils at this site above the groundwater level can be classified as Type 3 soils. Therefore, for design purposes, allowance should be made for 1 horizontal to 1 vertical, or flatter, excavation slopes.

As an alternative or where space constraints dictate, the service installations could be carried out within a tightly fitting, braced steel trench box, which is specifically designed for this purpose.

Groundwater seepage into excavations should be controlled, as necessary, by pumping from within the excavations. It is not expected that short term pumping during excavation will have a significant effect on nearby structures and services.

It should be noted that excavations below the groundwater table will likely present some constraints (i.e., sloughing of soils). Sloughing of the excavation side slopes below the groundwater level could be reduced, where necessary, by advancing thick steel plates along the sides and front of the trench box to below the level of the excavation in combination with pumping from within the excavation. It may be necessary to advance the steel plates below the limits of the excavation in order to reduce the amount of groundwater inflow.

Cobbles and boulders should be anticipated in the glacial till. As such, an allowance should be made for removal of boulders from the glacial till during excavation. In order to advance the trench box, even boulders that partially intrude into the sides of the excavation must be removed, which may result in a wider excavation than anticipated. Further, additional backfill and bedding material may be required to fill any voids left from the removal of boulders.

5.10.2 Trench Backfill

In areas where the service trench will be located below or in close proximity to existing or future areas of hard surfacing (pavement, sidewalk, etc.), acceptable native materials should be used as backfill between the roadway subgrade level and the depth of seasonal frost penetration in order to reduce the potential for differential frost heaving between the area over the trench and the adjacent hard surfaced area. The depth of frost penetration in exposed areas can be taken as 1.8 metres below finished grade. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type I or II.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the driving lanes, parking areas, sidewalks, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the material’s standard Proctor dry density value. The specified density for compaction of the backfill materials may be reduced where the trench backfill is not located below or in close proximity to existing or future areas of hard surfacing and/or structures.

5.11 Access Roadway/Parking Lot Areas

5.11.1 Subgrade Preparation

In preparation for access roadway/parking lot construction at this site, all surficial topsoil, and any soft, wet or deleterious materials should be removed from the proposed roadway areas. It is not considered necessary to remove the existing earth fill from below parking or access roadway areas, provided the proof rolling is carried out as described below.

5.11.2 Proof Rolling

Prior to placing granular material for the roads and parking lots, the exposed subgrade should be inspected and approved by a geotechnical personnel. Any soft areas should be subexcavated and replaced with suitable (dry) earth borrow that is frost compatible with the materials exposed on the sides of the area of subexcavation.

Areas where it will be necessary to raise the roadway/parking lot grades at this site, material which meets OPSS specifications for Select Subgrade Material, Earth Borrow or well shattered and graded rock fill material may be used.

The Select Subgrade material or Earth Borrow should be placed in maximum 300 millimetre thick lifts and compacted to at least 95 percent of the standard Proctor maximum dry density value using vibratory compaction equipment. Rock fill should be placed in maximum 500 millimetre thick lifts and suitably compacted either with a large drum roller, the haulage and spreading equipment, or a combination of both.

Truck traffic should be avoided on the native soil subgrade or the trench backfill within the roadways/parking lot areas especially under wet conditions.

5.11.3 Pavement Structures

For the parking areas to be used by light vehicles (cars, etc.), the following minimum pavement structure is recommended:

- 80 millimetres of hot mix asphaltic concrete (Two 40 millimetre lifts of Superpave 12.5), over
- 150 millimetres of OPSS Granular A base, over
- 300 millimetres of OPSS Granular B, Type II subbase

For parking areas and access roadways to be used by heavy truck traffic, the suggested minimum pavement structure is:

- 100 millimetres of hot mix asphaltic concrete (40 millimetres of Superpave 12.5 over 60 millimetres of Superpave 19.0), over
- 150 millimetres of OPSS Granular A base, over
- 450 millimetres of OPSS Granular B, Type II subbase

The above pavement structures assume that the access roadway and parking lot subgrade surfaces are prepared as described in this report. If the subgrade surfaces become disturbed or wetted due to construction operations or precipitation, the granular subbase thicknesses given above may not be adequate and it may be necessary to increase the thickness of the subbase and/or to incorporate a woven geotextile separator between the subgrade surfaces and the granular subbase material. The adequacy of the design pavement thicknesses should be assessed by geotechnical personnel at the time of construction.

If the granular pavement materials are to be used by construction traffic, it may be necessary to increase the thickness of the granular subbase layer, install a woven geotextile separator between the roadway subgrade surface and the granular subbase material, or a combination of both, to prevent pumping and disturbance to the subbase material. The contractor should be made responsible for their construction access.

5.11.4 Asphalt Cement Type

Performance grade PG 58-34 asphalt cement should be specified for Superpave asphaltic concrete mixes.

5.11.5 Pavement Transition

As part of the access roadway/parking lot construction, the new pavement may abut the existing pavement at Carp Road. The following is suggested to improve the performance of the joint between the new and the existing pavements:

- Neatly saw cut the existing asphaltic concrete;
- Remove the asphaltic concrete and slope the bottom of the excavation within the existing granular base and subbase at 1 horizontal to 1 vertical, or flatter, to avoid undermining the existing asphaltic concrete.
- To avoid cracking of the asphaltic concrete due to an abrupt change in the thickness of the roadway granular materials where new pavement areas join with the existing pavements, the granular depths should taper up or down at 5 horizontal to 1 vertical, or flatter, to match the existing pavement structure.
- Remove (mill off) 40 to 50 millimetres of the existing asphaltic concrete to a distance of 300 millimetres at the joint and tack coat the asphaltic concrete at the joint in accordance with the requirements in OPSS 310.

5.11.6 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long term performance of the pavement at this site. The subgrade surfaces should be crowned and shaped to drain to the ditches and/or catch basins to promote drainage of the pavement granular materials.

Catch basins should be equipped with minimum 3 metre long stub drains extending in two directions at the subgrade level.

5.11.7 Granular Material Compaction

The granular base and subbase materials should be compacted in maximum 300 millimetre thick lifts to at least 98 percent of the material's standard Proctor maximum dry density value.

5.12 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in the sample of soil recovered from borehole 22-02 was 889 micrograms per gram. According to Canadian Standards Association (CSA) "Concrete Materials and Methods of Concrete Construction", the concentration of sulphate can be classified as low. Therefore, any concrete in contact with the native soil could be batched with General Use (GU) cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) use on the roadway should be considered in selecting the air entrainment and the concrete mix proportions for any concrete.

Based on the resistivity and pH of the sample, the soil in this area can be classified as slightly aggressive towards unprotected steel. It should be noted that the corrosivity of the soil or groundwater could vary throughout the year due to the application sodium chloride for de-icing.

6.0 SLOPE STABILITY ANALYSIS

6.1 General

The purpose of this stability assessment is to establish the safe setback distance for the site with respect to slope stability.

The slope stability analysis was carried out at Section A-A using Slope/W, a two dimensional limit equilibrium slope stability program. The results of the slope stability analysis are provided in Appendix D.

6.2 Soil Strength Parameters

The soil conditions used in the stability analyses were based, in part, on the results of the boreholes advanced across the site. The slope stability analyses were carried out using soil strength parameters based on site specific studies in the area of the site. To determine the existing factor of safety against overall rotational failure, the slope stability analysis was carried out using drained soil parameters, which reflect long term conditions

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

Table 6.1 – Slope Stability Soil Strength Parameters

Soil Type	Unit Weight, γ (kN/m^3)	Effective Cohesion, c′ (kilopascals)	Effective Angle of Internal Friction, φ (degrees)
Fill Material	18	0	32
Glacial Till	22	0	38
Sand	19	0	32

The results of a stability analysis are highly dependent on the assumed groundwater conditions. The groundwater levels measured during this investigation at about 114.8 metres, geodetic datum, however, it was assumed that the groundwater level will be at the ground surface at the toe of the slope for this analysis.

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.

6.3 Setback Requirements

The slope stability analysis indicated that the existing slope, has a factor of safety against overall rotational failure of less than 1.0.

Based on the results of the analysis, a factor of safety of 1.5 exists at a setback of about 3.1 metres from the crest of the slope. As such, any development (i.e., building, services, etc.) should be set a minimum of 3.1 metres from the crest of the slope. Alternatively, the slope could be regraded with side slopes of 3 horizontal to 1 vertical, or flatter, and would be considered stable from a geotechnical point of view.

7.0 ADDITIONAL CONSIDERATIONS

7.1 Effects of Construction Induced Vibration

Some of the construction operations (such as granular material compaction and excavation) will cause ground vibration on and off the site. The vibrations will attenuate with distance from the source, but may be felt at nearby structures. However, the magnitude of the vibrations is expected to be much less than that required to cause damage to the nearby structures or services.

7.2 Winter Construction

The soils that exist at this site are highly frost susceptible and are prone to significant ice lensing. If construction is required during freezing temperatures, the soil below the footings and floor slabs should be protected immediately from freezing using straw, propane heaters and insulated tarpaulins, or other suitable means.

7.3 Excess Soil Management Plan

This report does not constitute an excess soil management plan. The disposal requirements for excess soil from the site have not been assessed.

7.4 Well Abandonment

The monitoring wells installed in borehole 22-02 as part of this investigation should be decommissioned by a licensed well technician. The well abandonment could be carried out in advance of, or during the construction.

7.5 Design Review and Construction Observation

The final details for the proposed construction were not available to us at the time of preparation of this report. It is recommended that the design drawings be reviewed by the geotechnical engineer as the design progresses to ensure that the guidelines provided in this report have been interpreted as intended.

In accordance with Section 4.2.2.2 of the Ontario Building Code (2012), the engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed excavations do not materially differ from those given in the report and that the construction activities do not adversely affect the intent of the design. The subgrade surfaces for the proposed structures, access roadways, parking areas and site services should be inspected by experienced geotechnical personnel to ensure that suitable materials have been reached and properly prepared. The placing and compaction of earth fill and imported granular materials should be inspected to ensure that the materials used conform to the grading and compaction specifications.

8.0 CLOSURE

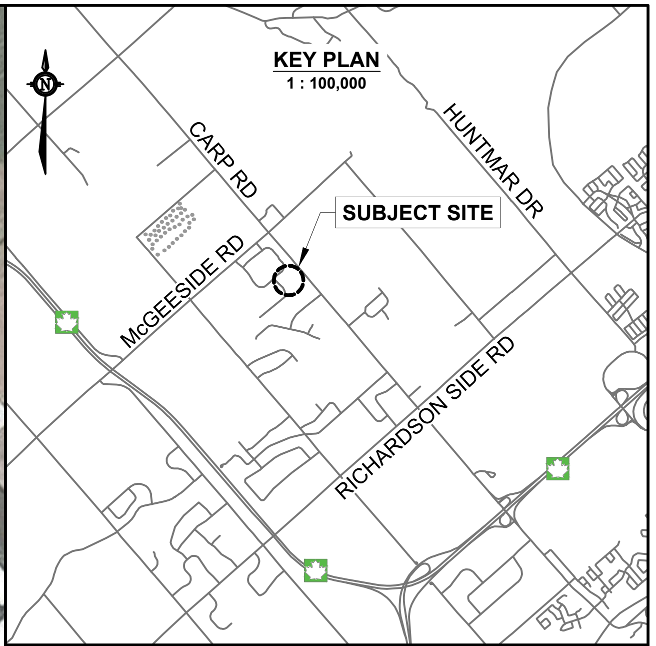
We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

W. Alex Meacoe

Alex Meacoe, P.Eng.
Senior Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
W. A. MEACOE
100162115
Jan 30, 2023
PROVINCE OF ONTARIO

Brent Wiebe, P.Eng.
VP Operations- Ontario



LEGEND

BH # ← BOREHOLE ID
XX.XX ← GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM
⊕ BOREHOLE LOCATION (current investigation by GEMTEC)
— · — · — APPROXIMATE PROPERTY BOUNDARY

Scale
1:1000
0 20 40 60m

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

32 Steacie Drive
Ottawa, ON K2K 2A9
Tel: (613) 836-1422
www.gemtec.ca
ottawa@gemtec.ca

Drawing
SITE PLAN

Client
BELL & ASSOCIATES ARCHITECTURE

Project
101688.002

GEOTECHNICAL INVESTIGATION
2885 CARP ROAD
CARP, ONTARIO

Drwn by	Chkd by
S.L.	W.A.M.

Date	Rev.	
JUNE, 2022	0	**FIGURE 1**

N:\PROJECTS\101600\101688.002\DRAFTING\1.DRAWINGS\101688.002_BH_R0_2022-06.DWG

APPENDIX A

Record of Borehole Sheets
List of Abbreviations and Symbols
Borehole Logs 22-01 and 22-02

ABBREVIATIONS AND TERMINOLOGY USED ON RECORDS OF BOREHOLES AND TEST PITS

SAMPLE TYPES	
AS	Auger sample
CA	Casing sample
CS	Chunk sample
BS	Borros piston sample
GS	Grab sample
MS	Manual sample
RC	Rock core
SS	Split spoon sampler
ST	Slotted tube
TO	Thin-walled open shelby tube
TP	Thin-walled piston shelby tube
WS	Wash sample

SOIL TESTS	
w	Water content
PL, w_p	Plastic limit
LL, w_L	Liquid limit
C	Consolidation (oedometer) test
D_R	Relative density
DS	Direct shear test
G_S	Specific gravity
M	Sieve analysis for particle size
MH	Combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	Organic content test
UC	Unconfined compression test
γ	Unit weight

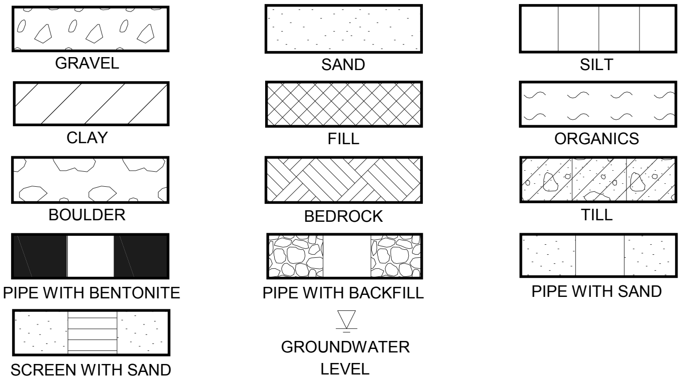
PENETRATION RESISTANCE

Standard Penetration Resistance, N
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 millimetres (30 in.) required to drive a 50 mm split spoon sampler for a distance of 300 mm (12 in.). For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm.

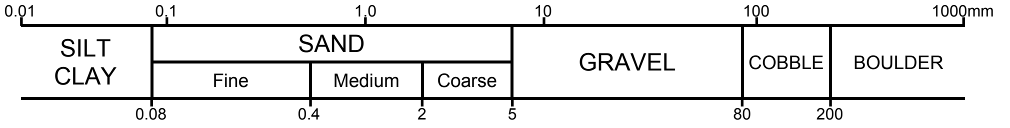
Dynamic Penetration Resistance
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to ‘A’ size drill rods for a distance of 300 mm (12 in.).

WH	Sampler advanced by static weight of hammer and drill rods
WR	Sampler advanced by static weight of drill rods
PH	Sampler advanced by hydraulic pressure from drill rig
PM	Sampler advanced by manual pressure

COHESIONLESS SOIL Compactness		COHESIVE SOIL Consistency	
SPT N-Values	Description	Cu, kPa	Description
0-4	Very Loose	0-12	Very Soft
4-10	Loose	12-25	Soft
10-30	Compact	25-50	Firm
30-50	Dense	50-100	Stiff
>50	Very Dense	100-200	Very Stiff
		>200	Hard



GRAIN SIZE



DESCRIPTIVE TERMINOLOGY

(Based on the CANFEM 4th Edition)

0	10	20	35
TRACE	SOME	ADJECTIVE	noun > 35% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

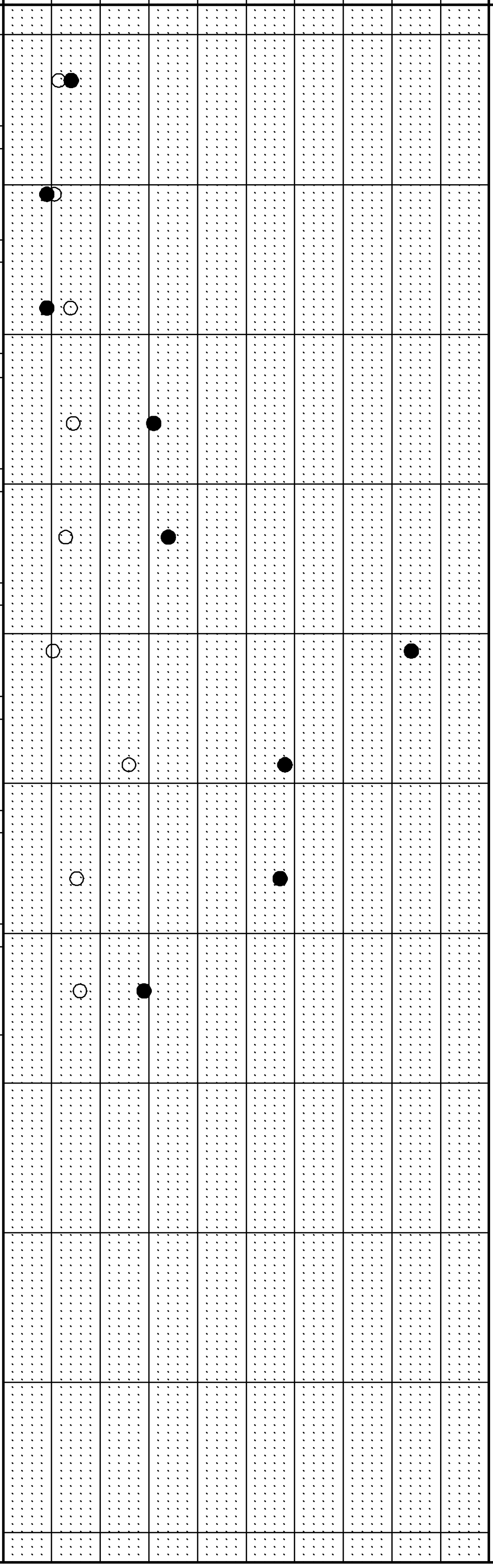
RECORD OF BOREHOLE 22-01

CLIENT: Bell & Associates Architecture
PROJECT: Geotechnical Investigation, Proposed Development, 2885 Carp Road, Ottawa
JOB#: 101688.002
LOCATION: See Site Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: May 18 2022

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
	Power Auger Hollow Stem Auger (108mm OD)	Ground Surface		117.36				
		Loose to compact, brown silty sand, some gravel, trace clay (FILL MATERIAL)			1	SS	205	14
					2	SS	355	9
					3	SS	510	9
		Dense to very dense, grey sand and gravel, some silt, trace clay (GLACIAL TILL)		115.07 2.29	4	SS	455	31
					5	SS	355	34
					6	SS	405	84
					7	SS	560	58
					8	SS	205	57
		Dense, grey brown, SAND, some silt and gravel		111.42 5.94	9	SS	560	29
		End of Borehole Auger Refusal		110.56 6.80				

● PENETRATION RESISTANCE (N), BLOWS/0.3m
▲ DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m
SHEAR STRENGTH (Cu), kPA + NATURAL ⊕ REMOULDED
WATER CONTENT, % W_P ├─ W ─┤ W_L



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

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LOGGED: PS
CHECKED: WAM

GEO - BOREHOLE LOG 101785.001_BH LOGS_2022-05-20.GPJ GEMTEC 2018.GDT 7/29/22

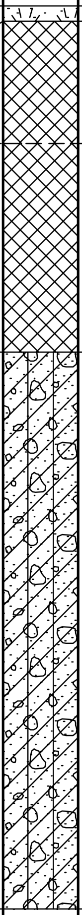
RECORD OF BOREHOLE 22-02

CLIENT: Bell & Associates Architecture
PROJECT: Geotechnical Investigation, Proposed Development, 2885 Carp Road, Ottawa
JOB#: 101688.002
LOCATION: See Site Plan, Figure 1

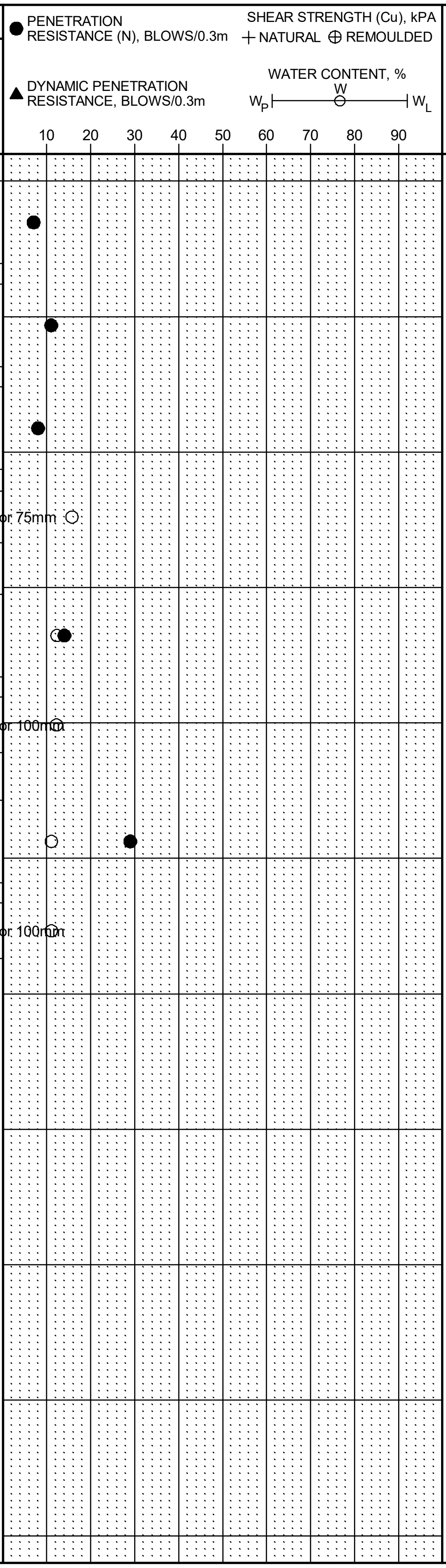
SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: May 18 2022

BORING METHOD: Power Auger — Hollow Stem Auger (108mm OD)

DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	117.27
TOPSOIL	0.10
Loose, brown silty sand (FILL MATERIAL)	116.36 0.91
Loose to compact, dark brown, silty sand, some gravel (FILL MATERIAL)	114.98 2.29
Compact to very dense, grey sand and gravel, some silt, trace clay (GLACIAL TILL)	111.30 5.97
End of Borehole Auger Refusal	

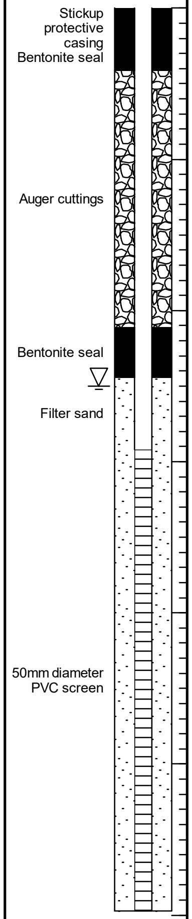


NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	305	7
2	SS	405	11
3	SS	255	8
4	SS	100	>50 for 75mm
5	SS	205	14
6	SS	150	>50 for 100mm
7	SS	355	29
8	SS	205	>50 for 100mm



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
22/05/25	2.5 ▽	114.8

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10

GEMTEC Consulting Engineers and Scientists

LOGGED: PS
CHECKED: WAM

APPENDIX B

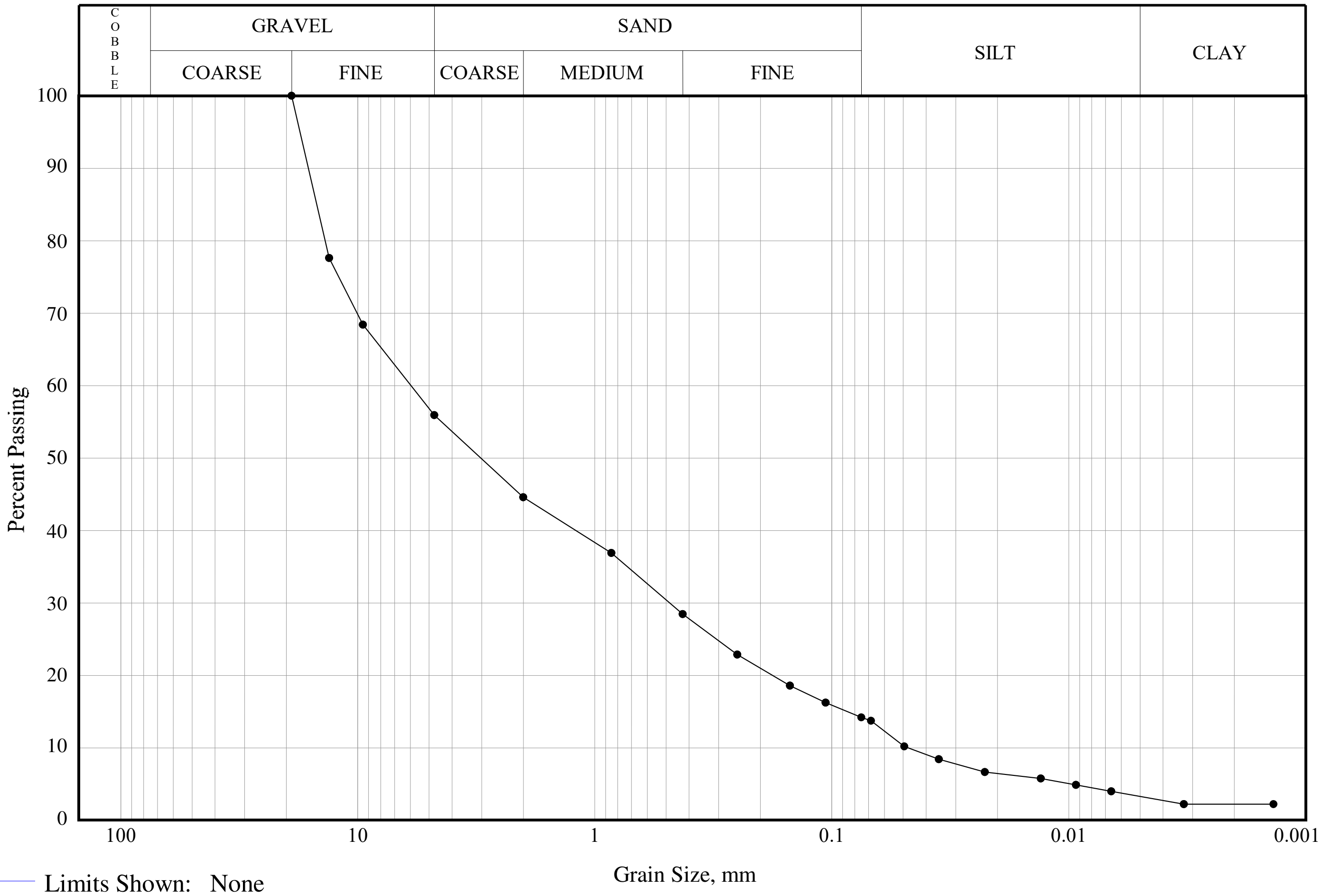
Laboratory Test Results
Soil Grading Chart

Report to: Bell & Associates Architecture
Project: 101688.002 (January 30, 2023)

GEMTEC
Consulting Engineers and Scientists

Client:	Bell & Associates Architecture
Project:	Geotechnical Study / Slope Stability Study Phase One / T
Project #:	101688002

Soils Grading Chart (LS-702/ ASTM D-422)



Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	GLACIAL TILL	22-01	SA 5	3.05-3.66	44.1	41.7	10.9	3.3

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75μm
—●—	Gravel and sand , some silt , trace clay	N/A	0.05	0.09	0.48	3.02	5.96	14.89	10.9

APPENDIX C

Chemical Analysis of Soil Sample
Samples Relating to Corrosion
(Paracel Laboratories Ltd. Order No. 2224088)

Certificate of Analysis

Report Date: 13-Jun-2022

Client: **GEMTEC Consulting Engineers and Scientists Limited**

Order Date: 6-Jun-2022

Client PO:

Project Description: 101688.002

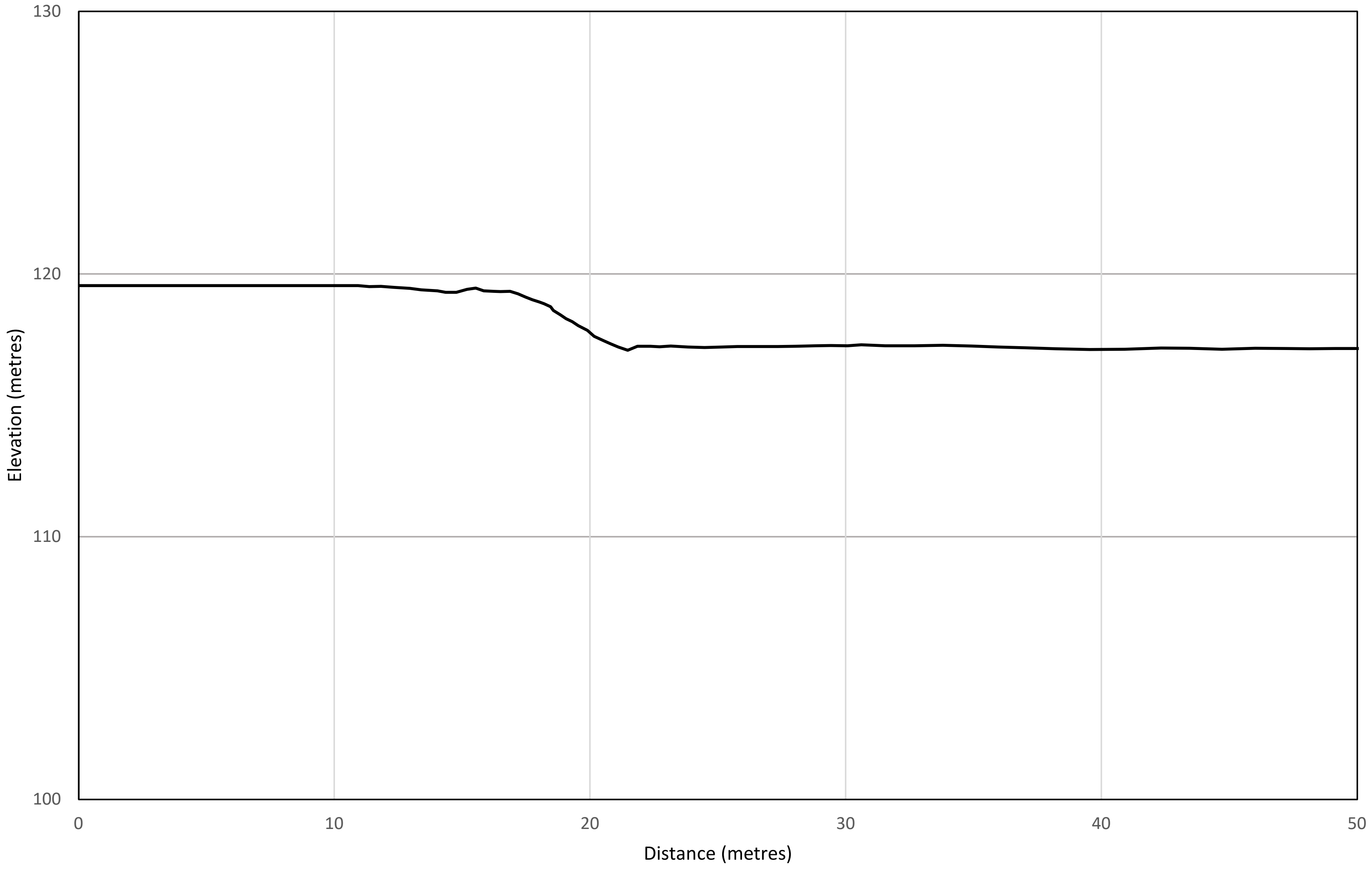
	Client ID:	BH22-02 SA3	-	-	-
	Sample Date:	06-Jun-22 13:45	-	-	-
	Sample ID:	2224088-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	84.3	-	-	-
General Inorganics					
Conductivity	5 uS/cm	998	-	-	-
pH	0.05 pH Units	7.37	-	-	-
Resistivity	0.10 Ohm.m	10.0	-	-	-
Anions					
Chloride	5 ug/g dry	43	-	-	-
Sulphate	5 ug/g dry	889	-	-	-

APPENDIX D

Slope Stability Assessment

Figures D1 to D5

Report to: Bell & Associates Architecture
Project: 101688.002 (January 30, 2023)



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Slope Cross Section AA

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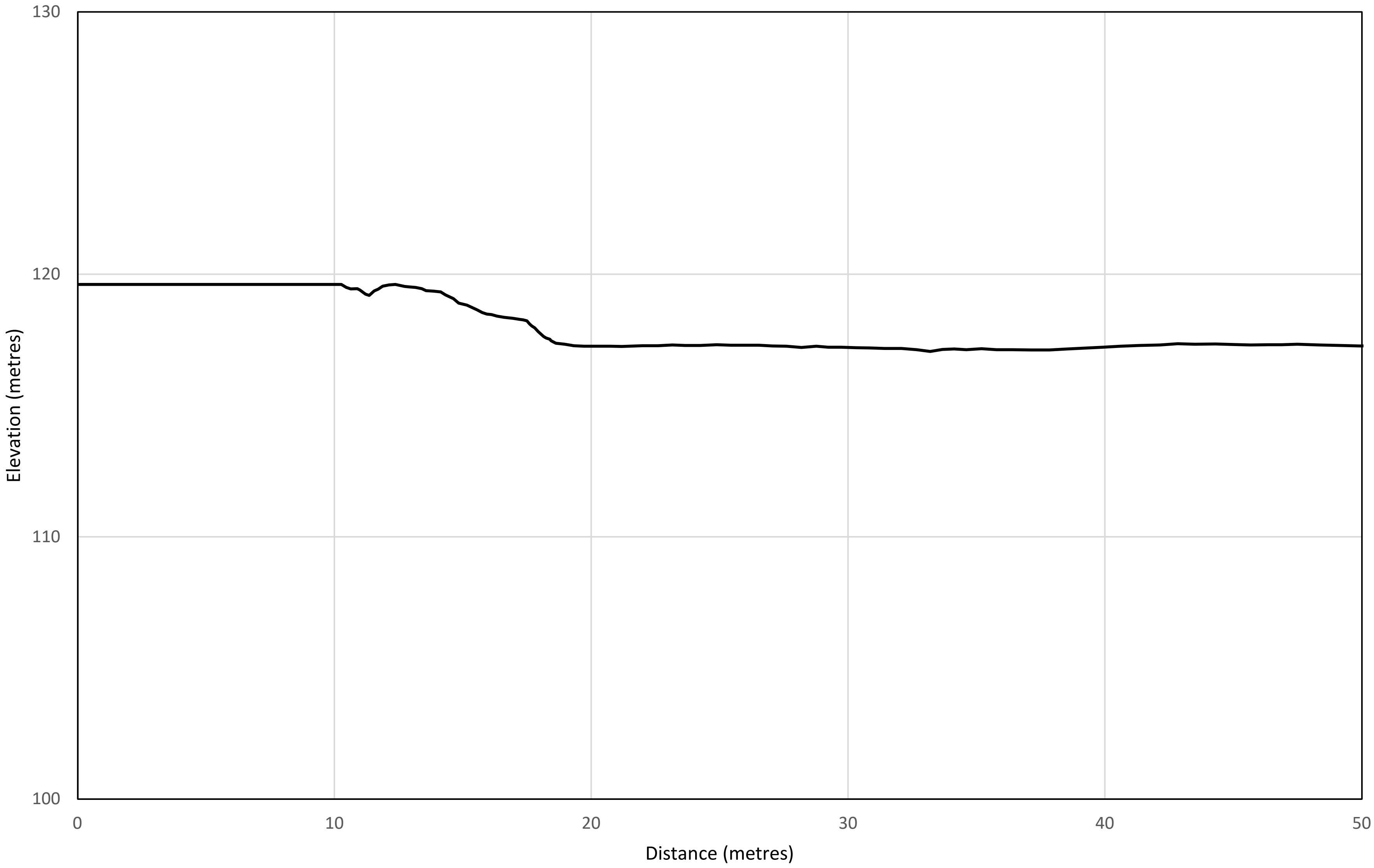
Ottawa, Ontario

Project No.	101688.002
Drawn:	WAM
Date:	19/07/2022

Figure D1



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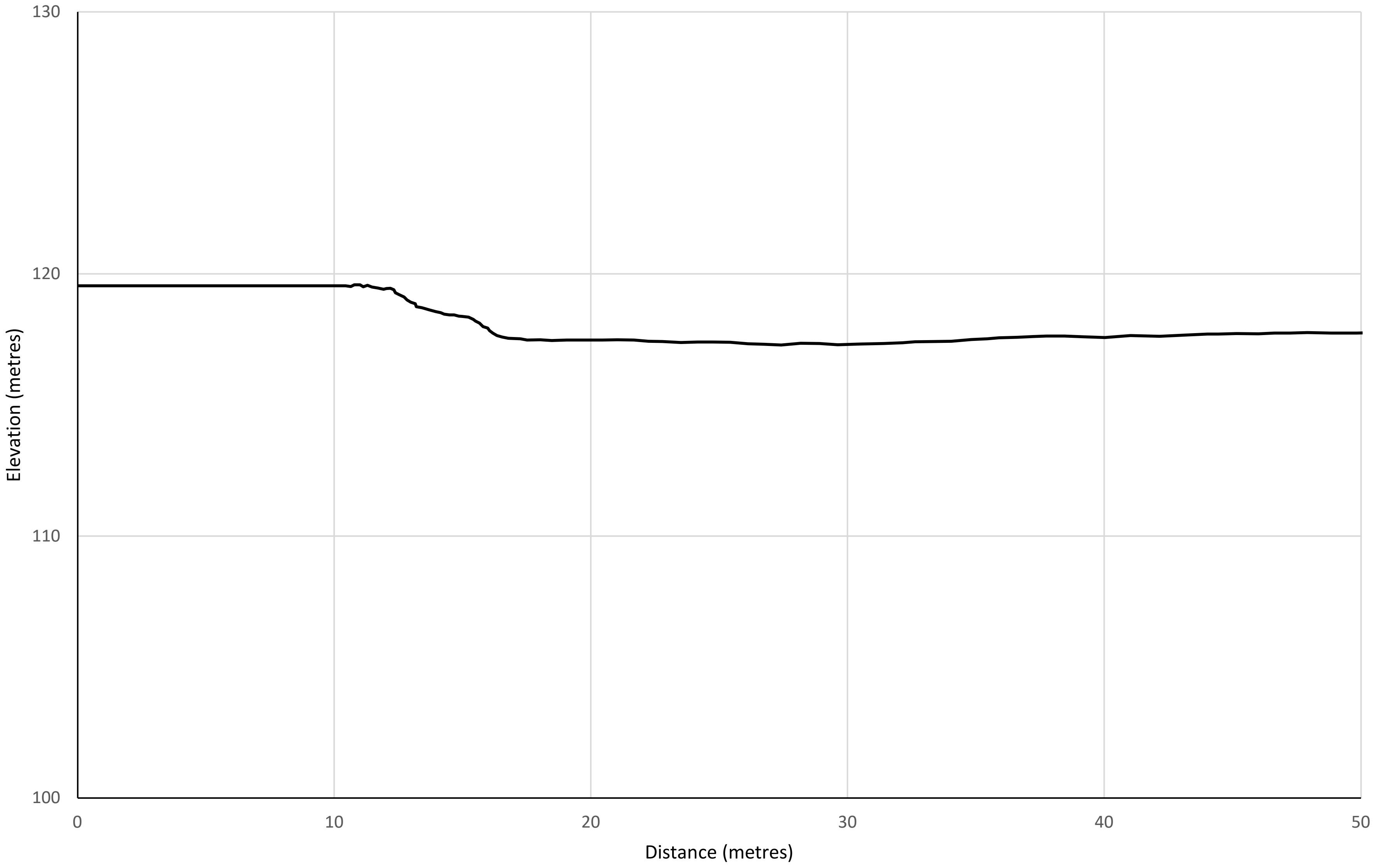
Slope Cross Section BB

2885 Carp Road

Ottawa, Ontario

Project No.	101688.002
Drawn:	WAM
Date:	19/07/2022

Figure D2



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CONSULTING ENGINEERS AND SCIENTISTS

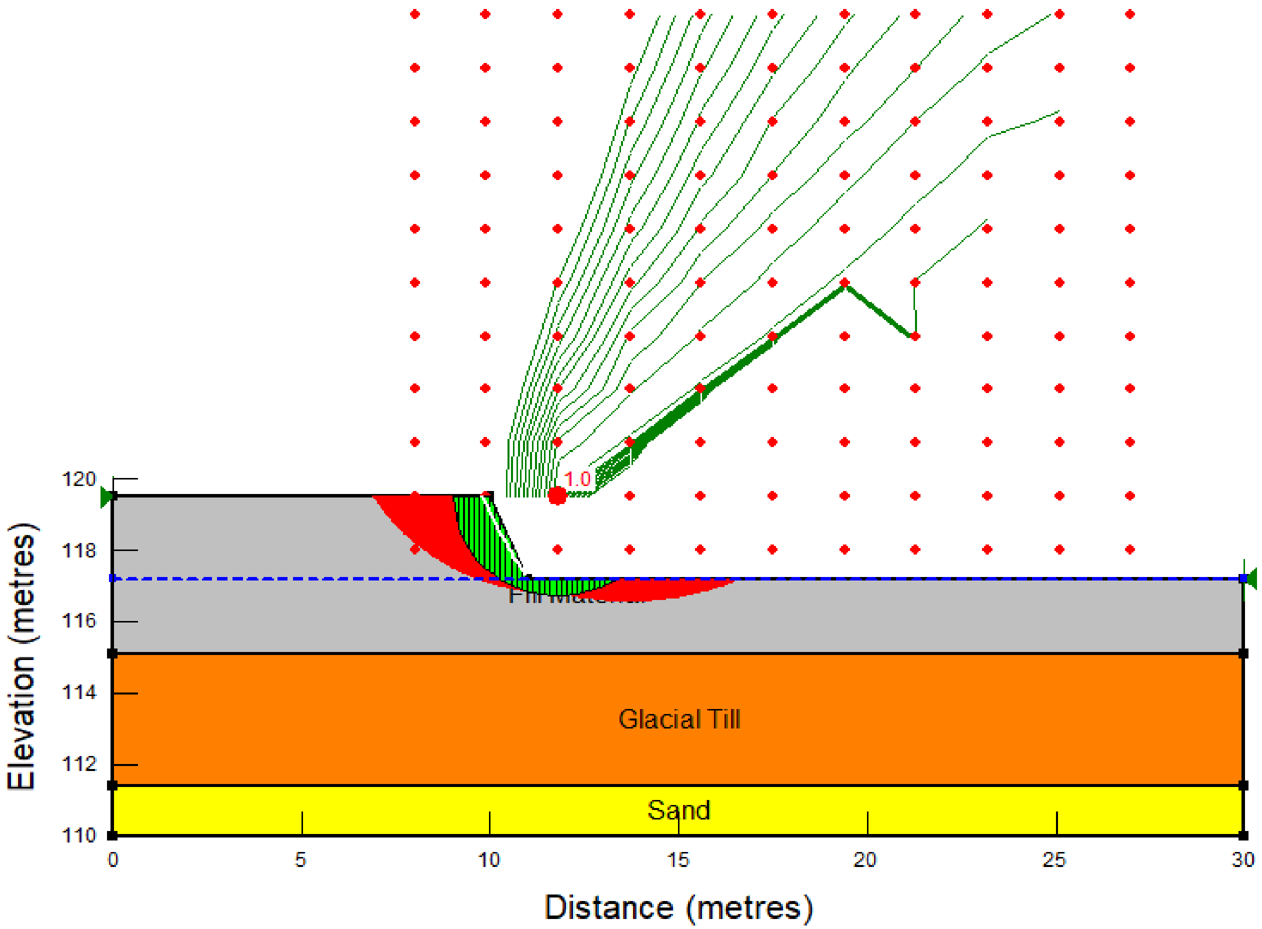
Slope Cross Section CC

2885 Carp Road

Ottawa, Ontario

Project No.	101688.002
Drawn:	WAM
Date:	19/07/2022

Figure D3



Name: Fill Material
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion: 0 kPa
Phi: 32 °
Piezometric Line: 1

Name: Glacial Till
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 38 °
Piezometric Line: 1

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 32 °
Piezometric Line: 1

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Consulting Engineers
and Scientists

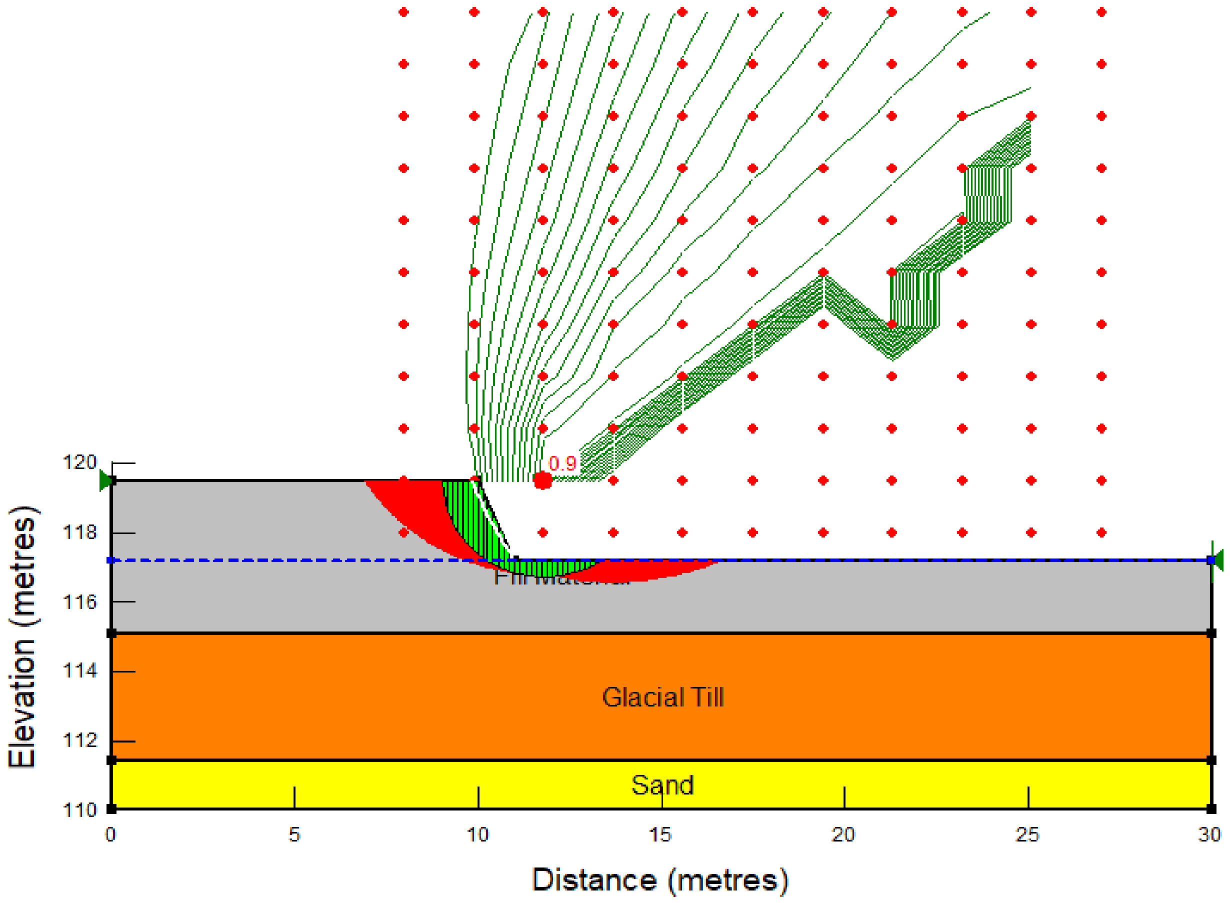
Cross Section AA - Static Analysis

2885 Carp Road

Ottawa, Ontario

Project No.	101688.002
Drawn:	WAM
Date:	19/07/2022

Figure D4



Name: Fill Material
Model: Mohr-Coulomb
Unit Weight: 18 kN/m³
Cohesion: 0 kPa
Phi: 32 °
Piezometric Line: 1

Name: Glacial Till
Model: Mohr-Coulomb
Unit Weight: 22 kN/m³
Cohesion: 0 kPa
Phi: 38 °
Piezometric Line: 1

Name: Sand
Model: Mohr-Coulomb
Unit Weight: 19 kN/m³
Cohesion: 0 kPa
Phi: 32 °
Piezometric Line: 1

Horz Seismic Load: 0.126

GEMTEC
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Cross Section AA - Seismic Analysis

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Ottawa, Ontario

Project No.	101688.002
Drawn:	WAM
Date:	19/07/2022

Figure D5

experience • knowledge • integrity

civil	civil
geotechnical	géotechnique
environmental	environnementale
field services	surveillance de chantier
materials testing	service de laboratoire des matériaux

expérience • connaissance • intégrité