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Geotechnical Investigation
Proposed Residential Development
1050 Klondike Road
Kanata, Ontario

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Submitted to:

D.G. Belfie Planning and Development Consulting Ltd.
21 Pinecone Trail
Stittsville, Ontario
K2S 1E1

Geotechnical Investigation
Proposed Residential Development
1050 Klondike Road
Kanata, Ontario

October 19, 2020
Project: 65153.01

experience • knowledge • integrity

GEMTEC Consulting Engineers and Scientists Limited
32 Steacie Drive
Ottawa, ON, Canada
K2K 2A9

October 19, 2020 File: 65153.01

D.G. Belfie Planning and Development Consulting Ltd.
21 Pinecone Trail
Stittsville, Ontario
K2S 1E1

Attention: Ms. Deborah Belfie

Re: Geotechnical Investigation
Proposed Residential Development
1050 Klondike Road
Kanata, Ontario

Enclosed is our geotechnical investigation report for the above noted project, in accordance with our proposal dated July 8, 2020. This report was prepared by Gregory Davidson, P.Eng. and Johnathan A. Cholewa, Ph.D., P.Eng.

G. Davidson

Gregory Davidson, P.Eng.
Geotechnical Engineer

Johnathan A. Cholewa, Ph.D., P.Eng.
Geotechnical Engineer

GD/JC

Enclosures
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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed residential development, located at 1050 Klondike Road in the City of Ottawa, Ontario. The purpose of the investigation was to identify the general subsurface 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.

This investigation was carried out in general accordance with our proposal dated July 8, 2020.

2.0 PROJECT DESCRIPTION AND SITE GEOLOGY

2.1 Project Description

It is understood that plans are being prepared to construct a low rise (4 storey) apartment building at 1050 Klondike Road in Kanata, Ontario. The existing dwelling on the property is to be demolished.

2.2 Site Geology

Surficial geology maps of the Ottawa area indicate that the site is underlain by alluvial sediments of fluvial terraces, sand, silt and clay. Bedrock geology and drift thickness maps indicate that the site is underlain by interbedded sandstone and dolostone bedrock of the March formation at depths of about 3 to 10 metres.

Fill material associated with the existing residential building is also expected to be encountered at the subject site.

3.0 METHODOLOGY

3.1 Geotechnical Investigation

The field work for this investigation was carried out on September 11, 2020. At that time, three (3) boreholes, number 20-1 to 20-3, inclusive, were advanced at the site by George Downing Estate Drilling Limited of Grenville-sur-la-Rouge, Quebec, to depths ranging from about 6.7 to 8.5 metres below existing grade.

Standard penetration tests (SPT) were carried out in the boreholes and samples of the soils encountered were recovered using a 50 millimetre diameter split barrel sampler.

Three (3) standpipe piezometers were installed and sealed in the overburden at all boreholes to facilitate groundwater level measurements.

Following completion of the drilling, the soil samples were returned to our laboratory for examination by a geotechnical engineer. One (1) sample of the soil recovered borehole 20-2 was sent to Paracel Laboratories Ltd. for basic chemical testing relating to corrosion of buried concrete and steel.

The results of the boreholes are provided on the Record of Borehole sheets in Appendix A. The approximate locations and ground surface elevations of the boreholes are shown on the Borehole Location Plan, Figure 1. The results of laboratory testing are provided on the Soils Grading and Plasticity chat in Appendix B. The results of the chemical analysis of soil samples relating to corrosion of buried concrete and steel are provided in Appendix C.

The borehole locations were selected by GEMTEC and positioned on site relative to existing features. The ground surface elevations at the location of the boreholes were determined using a Trimble R10 global positioning system. The elevations are referenced to geodetic datum and are considered to be accurate within the tolerance of the instrument.

4.0 SUBSURFACE CONDITIONS

4.1 General

As previously indicated, the soil and groundwater conditions identified in the boreholes are given on the Record of Borehole sheets in Appendix A. The 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. The precision with which subsurface conditions are indicated depends on the method of drilling, the frequency and recovery of samples, the method of sampling, and the uniformity of the subsurface conditions. Subsurface conditions at other than the borehole 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 or on adjacent properties.

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 groundwater conditions described in this report refer only to those observed at the place and time of observation noted in the report. Groundwater conditions may vary seasonally or as a consequence of construction activities in the area.

The following presents an overview of the subsurface conditions encountered in the boreholes.

4.2 Topsoil

A surficial layer of topsoil fill material was encountered at boreholes 20-2 and 20-3, which was advanced within the existing grassed area at the side and rear of the existing dwelling. The topsoil material consists of dark brown sandy silt with organic material. The topsoil has a thickness of about 100 millimetres.

4.3 Fill Material

Fill material was encountered at all borehole locations from ground surface and/or below the topsoil material. A 200 millimetre thick surficial layer of grey, crushed sand and gravel with trace to some silt was encountered from ground surface at boreholes 20-1. The fill material below the topsoil and/or granular fill material can be described as brown, fine to coarse grained sand with trace to some silt. The fill material extends to depths ranging from about 1.2 to 2.9 metres below existing grade (elevation 73.5 to 76.1 metres).

Standard penetration tests carried out in the fill material gave N values ranging from 4 to 9 blows per 0.3 metres of penetration, which reflect a loose relative density.

Moisture content testing carried out on samples of the fill material indicate moisture contents ranging from about 10 to 21 percent.

4.4 Weathered Silty Clay

Native deposits of brown silty clay (herein referred to as weathered crust) were encountered below the fill material at all borehole locations at depths ranging from about 1.2 to 2.9 metres below existing grade. Standard penetration tests carried out in the weathered silty clay gave N values ranging from 2 to 12 blows per 0.3 metres of penetration, which reflects a stiff to very stiff consistency. Where fully penetrated (borehole 20-1), the weathered crust has a thickness of about 4.9 metres and extends to a depth of about 6.1 metres below existing grade (elevation 71.2 metres). Boreholes 20-2 and 20-3 were terminated within the weathered crust at depths ranging from about 6.7 to 7.6 metres below existing grade (elevation 68.7 to 69.7 metres, geodetic).

The results of grain size distribution testing on samples of the silty clay weathered crust is provided on the Soils Grading chart in Appendix B and summarized in Table 4.1.

Table 4.1 – Summary of Grain Size Distribution Testing (Weathered Silty Clay)

Location	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
20-3	5	3.1 – 3.7	0	1	25	74

The results of Atterberg limit testing carried out on a sample of the weathered silty clay are provided on the Plasticity Chat in Appendix C and summarized in Table 4.2.

Table 4.2 – Summary of Atterberg Limit Testing (Weathered Silty Clay)

Borehole	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI (%)
20-2	8	5.3 – 5.9	36.8	44.1	20.6	23.5

The Atterberg limit testing indicates that the material has low plasticity.

Moisture content testing carried out on samples of the weathered silty clay indicate moisture contents ranging from about 43 to 49 percent.

4.5 Grey Silty Clay

At borehole 20-1, the weathered crust transitions to native, brown grey silty clay at to a depth of about 6.1 metres below existing grade (elevation 71.2 metres). In situ vane shear strength tests carried out in the weathered silty clay gave shear strengths of 69 kilopascals, which indicate a stiff consistency. The remoulded vane shear test values ranged from 8 to 12 kilopascals, indicating that the silty clay can be classified as sensitive.

The results of Atterberg limit testing carried out on a sample of the grey silty clay are provided on the Plasticity Char in Appendix C and summarized in Table 4.3.

Table 4.3 – Summary of Atterberg Limit Testing (Grey Silty Clay)

Borehole	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI (%)
20-1	10	7.6 – 8.2	43.7	38.3	20.0	18.3

The Atterberg limit testing indicates that the material has low plasticity.

Moisture content testing carried out on samples of the grey silty clay indicate moisture contents ranging from about 30 to 49 percent.

It should be noted that the moisture content of the grey silty clay is above the liquid limit value at the tested depth (approximate elevation of 69.7 metres, geodetic datum.

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4.6 Auger Refusal

Practical auger refusal on inferred bedrock was encountered in borehole 20-1 at a depth of about 8.5 metres below existing grade (elevation 68.7 metres).

It should be noted that auger refusal can occur on the surface of bedrock or on boulders within glacial till.

4.7 Groundwater

The groundwater levels measured in the well screens installed in boreholes 20-1 to 20-3 on September 18, 2020 are summarized in Table 4.4.

Table 4.4 – Groundwater Level Observations (September 18, 2020)

Borehole	Depth Below Existing Ground Surface (metres)	Elevation (metres)
20-1	3.8	73.5
20-2	5.3	71.1
20-3	4.2	72.2

It should be noted that the groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

4.8 Groundwater Chemistry Relating to Corrosion

The results of chemical testing of a soil sample from borehole 20-2 are provided in Appendix C and summarized in Table 4.5.

Table 4.5 – Chemical Testing of Soil Sample

BH	Sample	pH	Sulphate Content (micrograms per gram)	Chloride Content (micrograms per gram)	Resistivity (Ohm centimetres)	Conductivity (mircosiemens per centimetre)
20-2	5	7.2	22	24	8,000	125

5.0 GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the boreholes advanced as part of this investigation and the project requirements. It is stressed that the information in the following sections is provided for the guidance of the designers and is intended for 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 offsite sources are outside the terms of reference for this report and have not been investigated or addressed.

5.2 Site Grade Raise Restrictions

The site is underlain by deposits of sensitive silty clay, which have a limited capacity to support loads imposed by grade raise fill material, pavement structures and foundations for the buildings. The placement of fill material must therefore be carefully controlled so that the stress imposed by the fill material does not result in excessive consolidation of the grey silty clay deposit. The settlement response of the silty clay deposit to the increase in stress caused by fill material and groundwater lowering is influenced by variables such as the existing effective overburden pressure, the past pre-consolidation pressure for the silty clay, the compressibility characteristics of the silty clay, and the presence or absence of drainage paths, etc. It is well established that the settlement response of silty clay deposits can be significant when the stress increase is at or near the difference between the preconsolidation pressure (P_c) and the existing overburden stress (σ_{vo}').

Based on the results of the boreholes, the maximum thickness of any grade raise filling should be limited to about **4 metres** above original ground surface (i.e., the surface of the native soil). It should be noted that at boreholes 20-1 to 20-3, the thickness of grade raise fill presently on-site ranges between 1.2 and 2.9 metres (i.e., the grades could be raised by an additional 2.8, 1.1, and 1.6 metres at boreholes 20-1, 20-2, and 20-3, respectively).

The grade raise restriction for the site has been calculated in order to limit the total settlement of the ground to about 25 millimetres in the long term. For design purposes, we have made the following assumptions:

- The groundwater lowering due to the development at this site will be at most 1 metre.
- The unit weight of the grade raise fill material used in the vicinity of the structures is not greater than 22 kilonewtons per cubic metre.

It is recommended that the grading plans be reviewed by the geotechnical engineer as the design progresses to ensure that the guidelines provided in this report have been interpreted as intended.

5.1 Proposed Residential Building

5.1.1 Overburden Excavation and Temporary Shoring

Based on the boreholes advanced in the vicinity of the proposed residential building, the overburden excavations will be carried out mostly through topsoil fill, and fill material and weathered crust. The sides of the excavation 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 fill material at this site can be classified as Type 3 soil and, accordingly, allowance should be made for excavation side slopes of 1 horizontal to 1 vertical, or flatter.

Where space constraints prevent 1 horizontal to 1 vertical side slopes, the sides of the excavation could be supported using a shoring system, such as a soldier pile and lagging shoring wall, or driven interlocking steel sheet piles. The shoring system should be designed to resist lateral earth pressures imposed on the shoring from the weight of the retained soil and any other surcharge loads. The design should also consider soil stratigraphy, the groundwater conditions, the permissible ground movements associated with the excavation and construction of the shoring system, and potential impacts on adjacent structures and utilities. Some unavoidable inward horizontal movement and settlement of the ground behind the retaining walls should be anticipated, which could affect the existing structures and services behind the shoring walls. Further details could be provided if required.

In the event that a granular pad is necessary below the foundations, the excavations should be sized to accommodate a pad of imported granular material which extends at least 0.5 metres horizontally beyond the edge of the footings and down and out from this point at 1 horizontal to 1 vertical, or flatter.

5.1.2 Excavation Adjacent to Existing Structures

For adjacent existing structures/services founded on soil, overburden excavation for the proposed building, if required, should not encroach within a line extending downwards and outwards from the existing foundations and/or pipe invert levels at an inclination of 1 vertical to 1 horizontal.

5.1.3 Groundwater Management

The groundwater levels on September 18, 2020 ranged from about 3.8 to 5.3 metres below existing grade (elevations 71.1 to 73.5 metres, geodetic datum). The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

Groundwater inflow from the overburden excavation should be controlled by pumping from filtered sumps within the excavations to a suitable outlet. It is not expected that short term pumping during excavation will have a significant effect on nearby structures and services.

Based on the measured groundwater levels and anticipated excavation depths (i.e., about 2 metres), it is not expected that a water taking permit (e.g., EASR or PTTW) from the Ministry of the Environment, Conservation and Parks will be required. This can be confirmed once the excavation depths are finalized.

5.1.4 Foundations

Based on the results of the investigation, the proposed building could be founded on/within the native silty clay weathered crust, or on a pad of engineered fill above the native silty clay weathered crust. All fill material should be removed below the proposed foundations and floor slabs.

In areas where subexcavation of disturbed material or fill is required below 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 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. The excavations for the foundation should be sized to accommodate this fill placement.

The spread footing foundations should be sized using the bearing pressures provided in Table 5.1.

Table 5.1 – Foundation Bearing Pressures

Subgrade Material	Geotechnical Reaction at Servicability Limit State (kilopascals)	Factored Geotechnical Resistance at Ultimate Limit State (kilopascals)
Silty Clay Weathered Crust	100[1]	200
Compacted Engineered Fill (min. 0.6 metres thick overlying native soils)	125[1]	250

Notes:

1. Provided that the subgrade surface and engineered fill are prepared as described in this report, the post construction total and differential settlement of the footings at SLS should be less than 25 and 15 millimetres, respectively.

Some of the native soils at this site are sensitive to construction operations, from ponded water and frost action. The construction operations should therefore be carried out in a manner that minimizes disturbance of the subgrade surfaces.

5.1.5 Frost Protection of Foundations

All exterior footings for heated portions of the structure should be provided with at least 1.5 metres of earth cover for frost protection purposes. Footings located within unheated portions of the building or isolated footings outside the building footprint should be provided with at least 1.8 metres of earth cover for frost protection purposes. If the required depth of earth cover is not practicable, a combination of earth cover and polystyrene insulation could be considered. Further details regarding the insulation of foundations could be provided at the detailed design stage, if necessary.

5.1.6 Basement Foundation Wall Backfill and Drainage

In accordance with the Ontario Building Code, the following alternatives could be considered for drainage of the basement foundation walls:

- Damp proof the exterior of the foundation walls and backfill the walls with free draining, non-frost susceptible sand or sand and gravel such as that meeting Ontario Provincial Standard Specifications (OPSS) requirements for Granular B Type I or II. OR

- Damp proof the exterior of the foundation walls and install an approved proprietary drainage material on the exterior of the foundation walls and backfill the walls with native material or imported soil.

Where areas of hard surfacing (concrete, sidewalk, pavement, etc.) abut the proposed building, 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 native materials to reduce the effects of differential frost heaving. It is suggested that granular frost tapers be constructed from the bottom of the excavation or 1.8 metres below finished grade, whichever is less, to the underside of the granular base/subbase material for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

A perforated plastic foundation drain with a surround of clear crushed stone should be installed on the exterior of the foundation walls below the level of the basement floor slab. The drain should outlet by gravity to a storm sewer or a sump from which the water is pumped. To avoid loss of sand backfill into the voids in the clear stone (and possible post construction settlement of the ground around the building), a nonwoven geotextile should be placed between the clear stone and any sand backfill material.

Perimeter foundation drainage is not considered necessary for any slab on grade portions of the proposed structure (i.e., basementless), provided that the floor slab level is above the groundwater level.

Basement foundation walls that are backfilled with a granular material such as that meeting OPSS Granular B Type I or II requirements should be designed to resist "at rest" earth pressures calculated using the following formula:

- $P_o = K_o (\gamma H + q)$

Where,

- P_o = At rest earth pressure at the bottom of the foundation wall (kilopascals)
- K_o = At rest earth pressure coefficient (0.50)
- γ = Unit weight of backfill material (22 kilonewtons per cubic metre)
- H = Height of foundation wall (metres)
- q = Uniform surcharge at ground surface behind the wall to take into account traffic, equipment, or stockpiled soil (typically 10 kilopascals)

Where conditions dictate, allowance should be made in the structural design of the foundation walls for loads due to ground supported vehicles/equipment. For example, the horizontal active load due to a uniform, vertical live load adjacent to the foundation wall could be determined using a horizontal earth pressure coefficient, K_o, of 0.50, times the vertical live load. The effects of other vertical loads (point loads, line loads, compaction loads, etc.) adjacent to or near the foundation walls could be provided, if required.

Heavy construction traffic should not be allowed to operate adjacent to foundation walls for the proposed building (within about 2 metres horizontal) during construction, without the approval of the designers.

5.1.7 Seismic Site Class and Liquefaction Potential

According to Table 4.1.8.4.A of the Ontario Building Code, 2012, Site Class D could be used for the seismic design of the structures bearing on native soils or on engineered fill material over native soils.

In our opinion the soils at this site are not considered to be liquefiable or collapsible under seismic loads.

5.1.8 Basement Slab Support

To provide predictable settlement performance of the basement slab, all fill and debris should be removed from the slab area. The base for the floor slab should consist of at least 200 millimetres of OPSS Granular A or 19 millimetre clear crushed stone.

City of Ottawa documents allow recycled asphaltic concrete and concrete to be used in Granular A and Granular B Type II materials. Since the source of recycled material cannot be determined, it is suggested that any granular materials used beneath the floor slab be composed of virgin material (100 percent crushed rock) only, for environmental reasons.

OPSS Granular A material 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. Compaction of clear crushed stone is not considered essential.

If well graded granular material (such as OPSS Granular A) is used, rather than clear crushed stone below the basement floor slab, we suggest that drainage be provided by means of perforated plastic pipes spaced at about 6 metres horizontally or as required to link any hydraulically isolated areas to the perimeter drain or sump area. If clear crushed stone is used below the basement floor slab, perforated plastic pipes are not considered essential provided that the clear stone can outlet to the sump and pipes are installed to link any hydraulically isolated areas in the basement. The perforated plastic pipes should outlet by gravity to a sump from which the water is pumped.

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.

The floor slab should be wet cured to minimize shrinkage cracking and slab curling. The slab should be saw cut to about 1/3 the thickness of the slab as soon as curing of the concrete permits, in order to minimized shrinkage cracks.

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. The sulphate content of any imported granular material placed below the floor slab should be assessed to determine the appropriate exposure class for the concrete.

5.2 Site Services

5.2.1 Excavation and Dewatering

Excavation and groundwater management for the any site services should be carried out as described in Sections 5.1.1 and 5.1.2.

The groundwater inflow should be controlled throughout the excavation and pipe laying operations by pumping from sumps within the excavation. Notwithstanding, some disturbance and loosening of the subgrade materials could occur, and allowance should be made for subexcavation and additional pipe bedding (sub-bedding) material, as required.

5.2.1 Pipe Bedding and Cover

The bedding for proposed sanitary sewers, storm sewers and watermains should be in accordance with OPSD 802.010/802.013 and 802.031/802.033 for flexible and rigid pipes, respectively. The pipe bedding should consist of at least 150 millimetres of well graded crushed stone meeting OPSS requirements for Granular A. OPSS documents allow recycled asphaltic concrete and concrete to be used in Granular A and Granular B Type II material. Since the source of recycled material cannot be determined, it is suggested that any granular materials used in the service trenches be composed of virgin (i.e., not recycled) material only.

Allowance should be made for subexcavation of any existing fill, organic deposits, or disturbed material encountered at subgrade level.

Allowance should be made to place a subbedding layer composed of 150 to 300 millimetres of OPSS Granular B Type II in areas where wet clayey silt is encountered at the pipe subgrade level to reduce the potential for disturbance.

Cover material, from pipe spring line to at least 300 millimetres above the top of the pipe, should consist of granular material, such as OPSS Granular A.

The use of clear crushed stone should not be permitted for the installation of site services, since it could exacerbate groundwater lowering of the overburden materials due to “French Drain” effects.

The subbedding, bedding and cover materials should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density using suitable vibratory compaction equipment.

5.2.2 Trench Backfill

The general backfilling procedures should be carried out in a manner that is compatible with the future use of the area above the service trenches.

In areas where the service trench will be located below or in close proximity to existing or future roadway areas, 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 section of roadway. 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. The depth of frost penetration in areas that are kept clear of snow and where trench backfill consists of broadly graded shattered rock fill or earth fill is expected to be about 1.8 metres. It is our experience, however, that the frost penetration can be as much as 2.4 metres when the trench backfill consists solely of relatively open graded rock fill. Where cover requirements are not practicable, the pipes could be protected from frost using a combination of earth cover and insulation. Further details regarding insulation could be provided, if required.

It is anticipated that most of the inorganic overburden materials encountered during the subsurface investigation will be acceptable for reuse as trench backfill. Topsoil or other organic material should be wasted from the trench. As indicated above, the moisture content of the grey silty clay is above the liquid limit. As such, this material may become disturbed during excavation and may not be suitable for use as trench backfill. An assessment of the adequacy of this material to be reviewed as trench backfill could be made by a geotechnical personnel at the time of construction. If blast rock is used as backfill within the service trench, it should be mostly 300 millimetres, or smaller, in size and should be well graded. To prevent ingress of fine material into voids in the blast rock, the upper surface of the blast rock should be covered with a thin layer of well graded crushed stone (e.g. OPSS Granular B Type II).

To minimize future settlement of the backfill and achieve an acceptable subgrade for the roadways, curbs, driveways, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor dry density value. Rock fill should be placed in maximum 500 millimetre thick lifts and compacted with a large drum roller, the haulage and spreading equipment, or a combination of both. 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.

The weathered crust and silty clay from the excavations may have moisture contents above optimum for compaction. Furthermore, most of the overburden deposits at this site are sensitive to changes in moisture content. Unless these materials are allowed to dry, the specified densities will not likely be possible to achieve and, as a consequence, some settlement of these backfill materials could occur. Consideration could be implementing one or a combination of the following measures to reduce post construction settlement above the trenches, depending on the weather conditions encountered during the construction:

- Allow the overburden materials to dry prior to compaction.
- Reuse any wet materials in the lower part of the trenches and make provision to defer final paving of any roadways for 6 months, or longer, to allow some the trench backfill settlement to occur and thereby improve the final roadway appearance.
- Reuse any wet materials outside hard surfaced areas and where post construction settlement is less of a concern (such as landscaped areas).

The soils that exist at this site are highly frost susceptible and are prone to significant ice lensing. In order to carry out the work during freezing temperatures and maintain adequate performance of the trench backfill as a roadway subgrade, the service trenches should be opened for as short a time as practicable and the excavations should be carried out only in lengths which allow all of the construction operations, including backfilling, to be fully completed in one working day. The sides of the trenches should not be allowed to freeze. In addition, the backfill should be excavated, stored and replaced without being disturbed by frost or contaminated by snow or ice.

5.3 Corrosion of Buried Concrete and Steel

The measured sulphate concentration from the soil sample 5 from borehole 20-2 was 22 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 groundwater could be batched with General Use (GU) cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) use onsite should be considered in selecting the air entrainment and the concrete mix proportions for any concrete.

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

5.4 Parking Lot

5.4.1 Subgrade Preparation

In preparation for parking construction at this site, all surficial topsoil, fill material and any soft, wet or deleterious materials should be removed from the proposed parking lot areas.

Prior to placing granular material for the internal roads, the exposed subgrade should be inspected and approved by 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.

Similarly, should it be necessary to raise the roadway 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 also be placed in thin 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 parking lot especially under wet conditions.

5.4.2 Pavement Structure

For the access roadways and parking lots, the following minimum pavement structure should be used:

- 100 millimetres of hot mix asphaltic concrete, over
- 150 millimetres of OPSS Granular A base, over
- 450 millimetres of OPSS Granular B, Type II subbase

The hot mix asphalt should consist of the following layers:

- 40 millimetres of Superpave 12.5 (Traffic Level B), over
- 60 millimetres of Superpave 19.0 (Traffic Level B))

It is noted that the above pavement structure meets City of Ottawa Standard Drawing No. R-27 (Rural Local Roadway Cross Section Over Earth) requirements.

The above pavement structure assumes that any trench backfill is adequately compacted, and that the 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 thickness 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 thickness 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.

5.4.3 Asphalt Cement Type

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

5.4.4 Pavement Transitions

As part of the roadway reconstruction, it is assumed that the new pavement will abut the existing pavement at Klondike 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.

5.4.5 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.

5.4.6 Granular Material Compaction

The granular base and subbase materials should be compacted in maximum 200 millimetre thick lifts to at least 99 percent of the standard Proctor maximum dry density value.

5.5 Landscape Design

Where silty clay deposits are present within 3.5 metres of finish grade (which may not be the case where the grade raise fill is relatively thick), we recommend that no deciduous trees should be permitted closer to the houses than the ultimate height of the trees in order to eliminate the risk of ground settlement beneath foundations due to soil shrinkage. For groups of trees or trees in rows, the separation distance should be increased to 1.5 times the ultimate height of the trees.

If reduced tree setbacks are desired, the City of Ottawa 2017 Tree Planting Guidelines could be considered for this development. It is noted that these guidelines are based on minimizing, not eliminating, the potential for ground settlement beneath foundations due to soil shrinkage. According to the City of Ottawa 2017 Tree Planting Guidelines, the tree to foundation setbacks could be reduced to 4.5 metres for small to medium sized trees (i.e., trees with a mature height of less than 14 metres), provided that all the following conditions are met, and an increased risk of possible future foundation settlement can be tolerated:

- For footings within 10 metres of the proposed tree, the underside of footing must be 2.1 metres or greater below finished grade;
- The foundations are reinforced with a minimum of two upper and two lower 15M bars in the foundation wall;
- Grading surrounding the tree must promote draining to the tree root zone; and
- A small size tree (i.e., a tree with a mature height of less than 7.5 metres) must be provided with a minimum of 25 cubic metres of available soil volume. For medium size trees (i.e., trees with a mature height of between 7.5 and 14 metres), a minimum soil volume of 30 cubic metres must be provided.

It is worth noting that the foundation depth requirement could also be satisfied by other means, including: (a) raising the grade to meet the minimum required foundation depth, (b) lowering the footings, (c) installing a root barrier, such as heavy duty polyethylene sheet with no tears or gaps, between the tree and foundation to at least 2.1 metres below finished grade, and/or (d) for footings located within about 10 metres of a proposed tree, the native silty clay can be subexcavated to a depth of about 2.1 metres below finished grade and replaced with compacted engineered fill.

As previously indicated, if measures are taken to satisfy the required minimum foundation depth of 2.1 metres, and the other remaining conditions specified in the City of Ottawa 2017 Tree Planting Guidelines, the risk of possible future foundation settlement is mitigated, not eliminated.

If reduced tree setbacks are desired, but the risk of possible future foundation settlement cannot be tolerated, consideration could be given to installing a root barrier between the tree and foundation to a depth of 3.5 metres below finished grade. Alternatively, the root barrier could fully encapsulate the tree's root system. This assumes no tears or gaps in the barrier. Where service laterals are required to pass through the root barrier, we recommend that the openings cut in the root barrier be kept as small as practicable and that compacted engineered fill be placed around each opening. The engineered fill should extend at least 150 millimetres beyond the perimeter of the opening, and at least 300 millimetres beyond the face of the root barrier.

6.0 ADDITIONAL CONSIDERATIONS

6.1 Effects of Construction Induced Vibration

Some of the construction operations (such as excavation, granular compaction, etc.) will cause ground vibration on and off of the site. The vibrations will attenuate with distance from the source, but may be felt at nearby structures. Assuming that any excavating is carried out in accordance with the guidelines in this report, the magnitude of the vibrations will be much less than that required to cause damage to the nearby structures or services in good condition, but may be felt at the nearby structures. We recommend that preconstruction surveys be carried out on the adjacent structures so that any damage claims can be addressed in a fair manner.

6.2 Winter Construction

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

Any service trenches should be opened for as short a time as practicable and the excavations should be carried out only in lengths which allow all of the construction operations, including backfilling, to be fully completed in one working day. The materials on the sides of the trenches should not be allowed to freeze. In addition, the backfill should be excavated, stored and replaced without being disturbed by frost or contaminated by snow or ice.

6.3 Excess Soil Management Plan

This report does not constitute an excess soil management plan. The disposal requirements for excess soil from the site are provided in our Phase II Environmental report provided under separate cover.

6.4 Design Review

The design details of the proposed building 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.

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 building 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.

7.0 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.

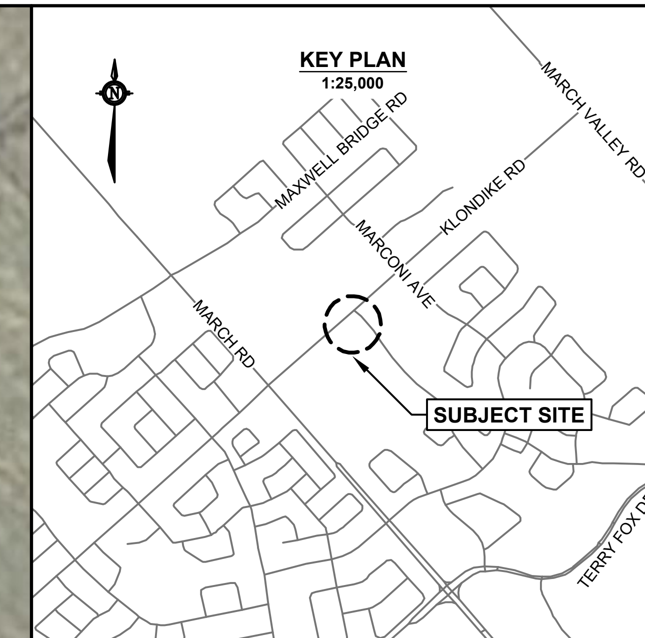
G. Davidson

Gregory Davidson, P.Eng.
Geotechnical Engineer

LICENSED PROFESSIONAL ENGINEER
J. A. CHOLEWA
100119055
19 Oct. 2020
PROVINCE OF ONTARIO

Johnathan A. Cholewa, Ph.D., P.Eng.
Geotechnical Engineer

GD/JC



LEGEND

BOREHOLE LOCATION IN PLAN
(current investigation by GEMTEC)

BH # ← BH ID
XX.XX ← GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

Scale 1:300

0 10 20m

GEMTEC
Consulting Engineers and Scientists

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

Drawing	BOREHOLE LOCATION PLAN
Client	D.G.BELFIE PLANNING AND DEVELOPMENT CONSULTING LTD.
Project 65153.01	GEOTECHNICAL INVESTIGATION 1050 KLONDIKE ROAD OTTAWA, ONTARIO
Drwn by S.L.	Chkd by G.D.
Date OCTOBER, 2020	Rev. 0
	FIGURE 1

APPENDIX A

List of Abbreviations and Terminology
Record of Borehole Sheets

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

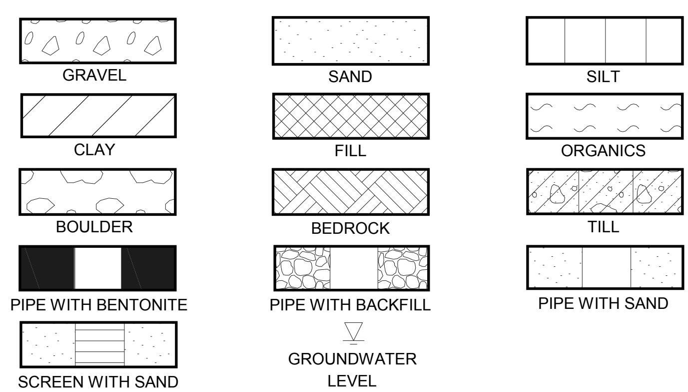
PENETRATION RESISTANCE

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

0.01 | 0.1 | 1.0 | 10 | 100 | 1000mm

SILT CLAY	SAND			GRAVEL	COBBLE	BOULDER
	Fine	Medium	Coarse			

0.08 | 0.4 | 2 | 5 | 80 | 200

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.

GEMTEC

RECORD OF BOREHOLE 20-1

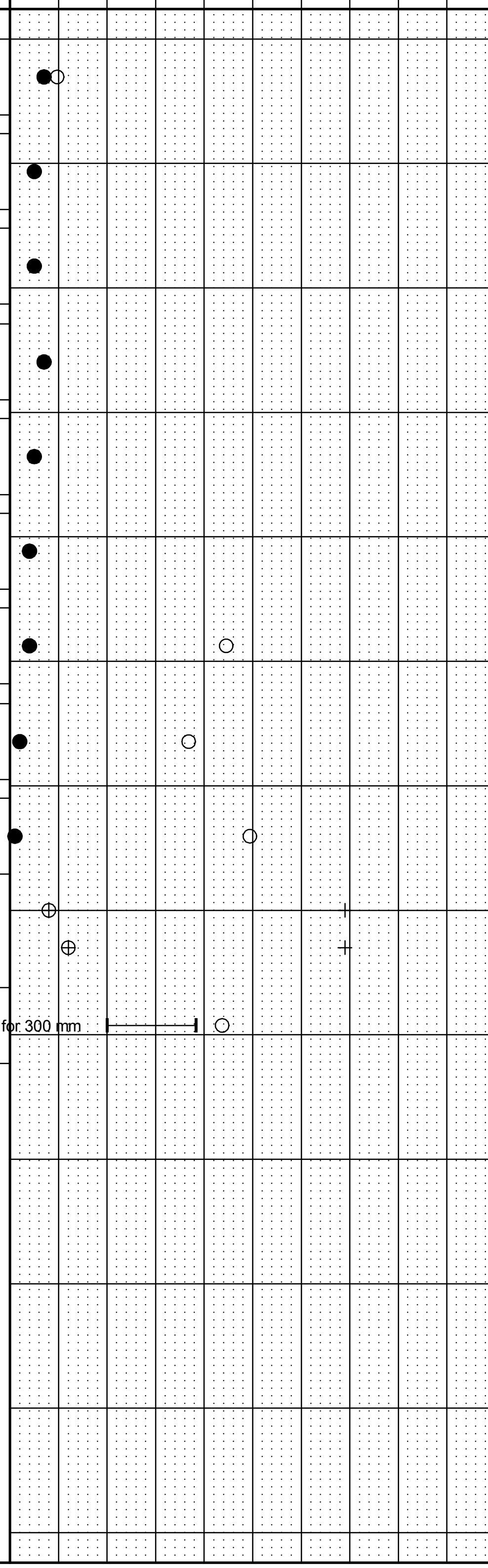
CLIENT: D.G. Belfie Planning and Development Consulting Ltd.
PROJECT: Geotechnical Investigation - Proposed Residentail Development - 1050 Klondike Road
JOB#: 6515301
LOCATION: See Borehole Location Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Sep 11 2020

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

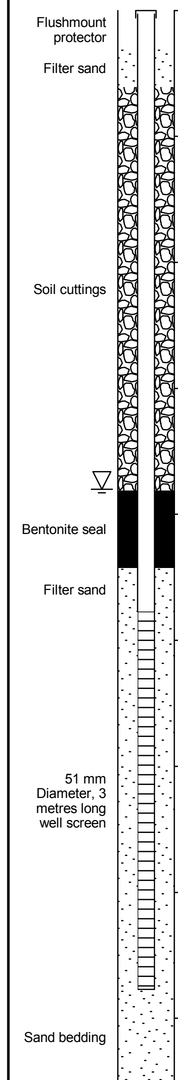
DEPTH (m)	SOIL PROFILE – DESCRIPTION	ELEV. (m) / DEPTH (m)
0	Ground Surface	77.27
	Grey crushed sand and gravel, trace to some silt (FILL MATERIAL)	77.07 / 0.20
	Brown fine to coarse grained sand, trace to some silt (FILL MATERIAL)	76.05 / 1.22
	Stiff to very stiff, brown silty clay (WEATHERED CRUST)	71.17 / 6.10
	Stiff, brown grey SILTY CLAY	68.74 / 8.53
	End of Borehole Auger Refusal	

SAMPLE NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	254	7
2	SS	279	5
3	SS	457	5
4	SS	355	7
5	SS	609	5
6	SS	609	4
7	SS	609	4
8	SS	609	2
9	SS	609	1
10	SS	609	WH for 300 mm



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
20/09/18	3.8 ∇	73.5

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LOGGED: M.L.
CHECKED: G.D.

RECORD OF BOREHOLE 20-2

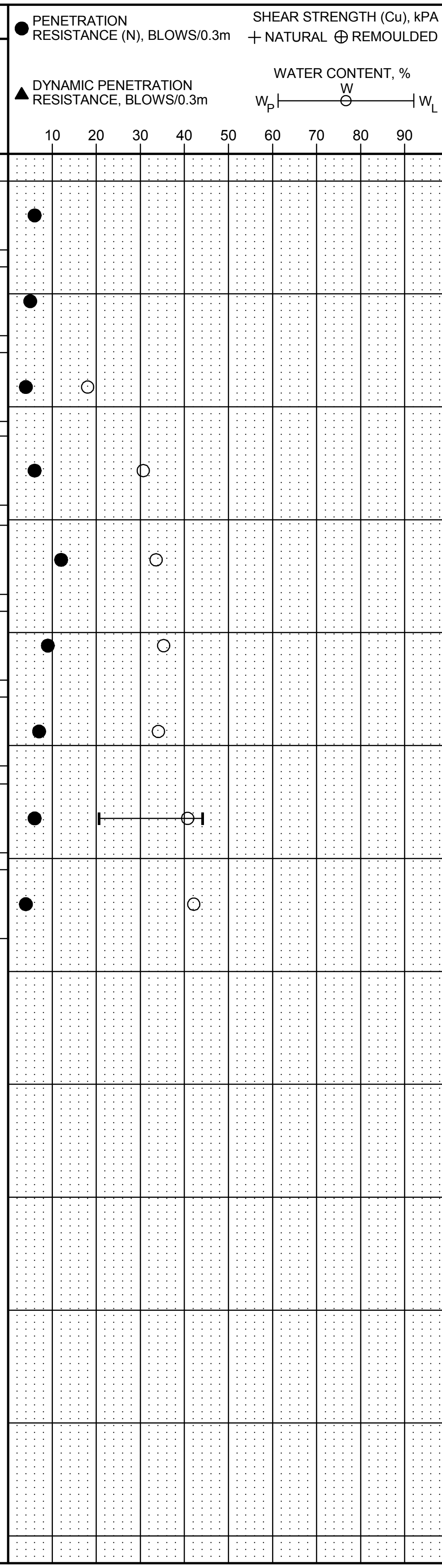
CLIENT: D.G. Belfie Planning and Development Consulting Ltd.
PROJECT: Geotechnical Investigation - Proposed Residentail Development - 1050 Klondike Road
JOB#: 6515301
LOCATION: See Borehole Location Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Sep 11 2020

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

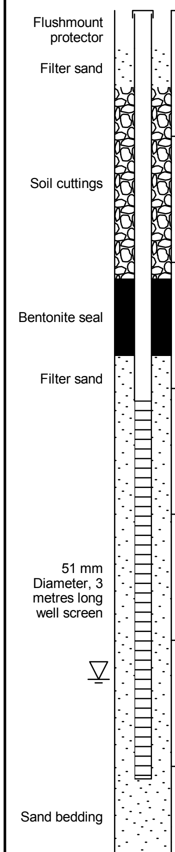
DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)
0	Ground Surface	76.39
	Dark brown sandy silt with organic material (TOPSOIL)	76.29 / 0.10
	Loose, brown fine to coarse grained sand, trace to some silt (FILL MATERIAL)	
3	Stiff to very stiff, brown silty clay (WEATHERED CRUST)	73.51 / 2.88
	End of Borehole	69.69 / 6.70

NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
1	SS	203	6
2	SS	305	5
3	SS	355	4
4	SS	406	6
5	SS	508	12
6	SS	609	9
7	SS	609	7
8	SS	609	6
9	SS	609	4



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION



GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
20/09/18	5.3 ∇	71.1

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Consulting Engineers and Scientists

LOGGED: M.L.
CHECKED: G.D.

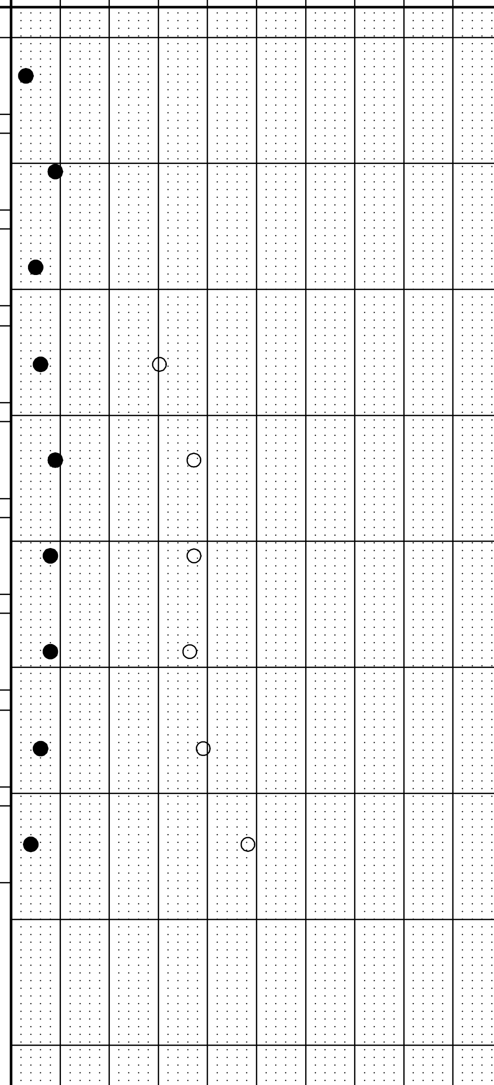
RECORD OF BOREHOLE 20-3

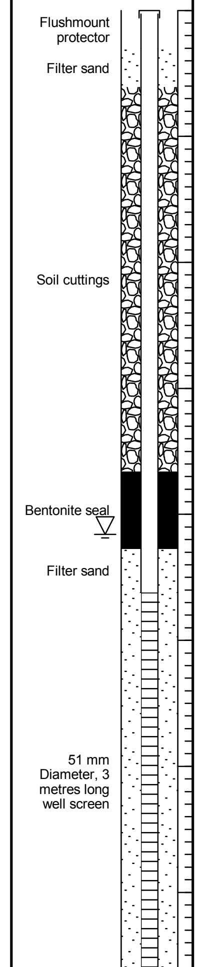
CLIENT: D.G. Belfie Planning and Development Consulting Ltd.
PROJECT: Geotechnical Investigation - Proposed Residentail Development - 1050 Klondike Road
JOB#: 6515301
LOCATION: See Borehole Location Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD28
BORING DATE: Sep 11 2020

BORING METHOD: Power Auger, Hollow Stem Auger (210mm OD)

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING
Ground Surface	76.34					
Dark brown sandy silt with organic material (TOPSOIL)	76.24 / 0.10	1	SS	203	3	
Loose, brown fine to coarse grained sand, trace to some silt (FILL MATERIAL)		2	SS	254	9	
		3	SS	355	5	
Stiff to very stiff, brown silty clay (WEATHERED CRUST)	73.90 / 2.44	4	SS	457	6	
		5	SS	609	9	MH
		6	SS	609	8	
		7	SS	609	8	
		8	SS	609	6	
		9	SS	609	4	
End of Borehole	68.72 / 7.62					





GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
20/09/18	4.2 ∇	72.2

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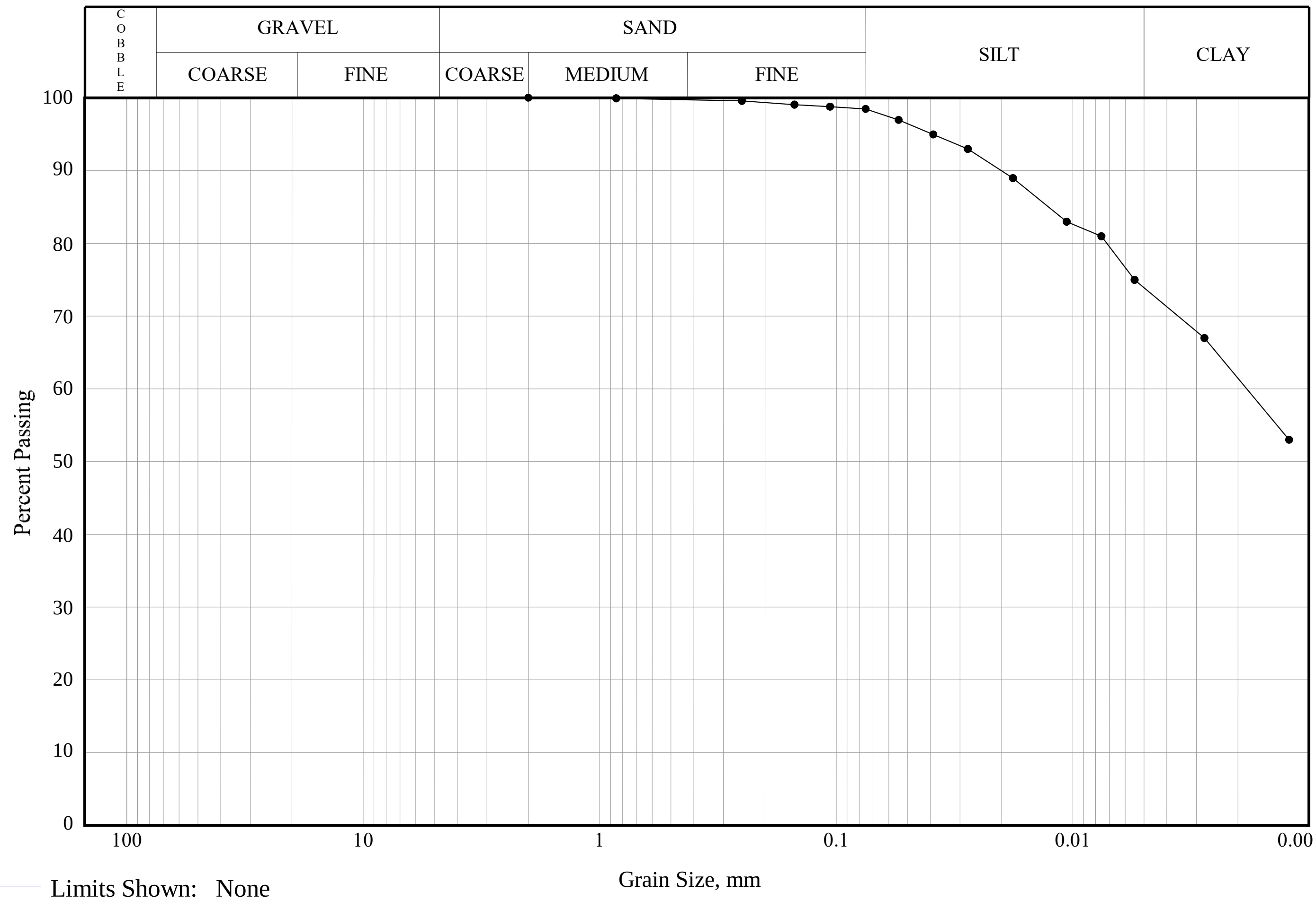
LOGGED: M.L.
CHECKED: G.D.

APPENDIX B

Laboratory Test Results
Soils Grading Chart
Plasticity Chart

GEMTEC Consulting Engineers and Scientists		Soils Grading Chart
Client:	D.G.Belfie Planning and Development Consulting Ltd.	
Project:	Geotechnical Investigation and Phase One ESA, 1050 Kl	
Project #:	6515301	

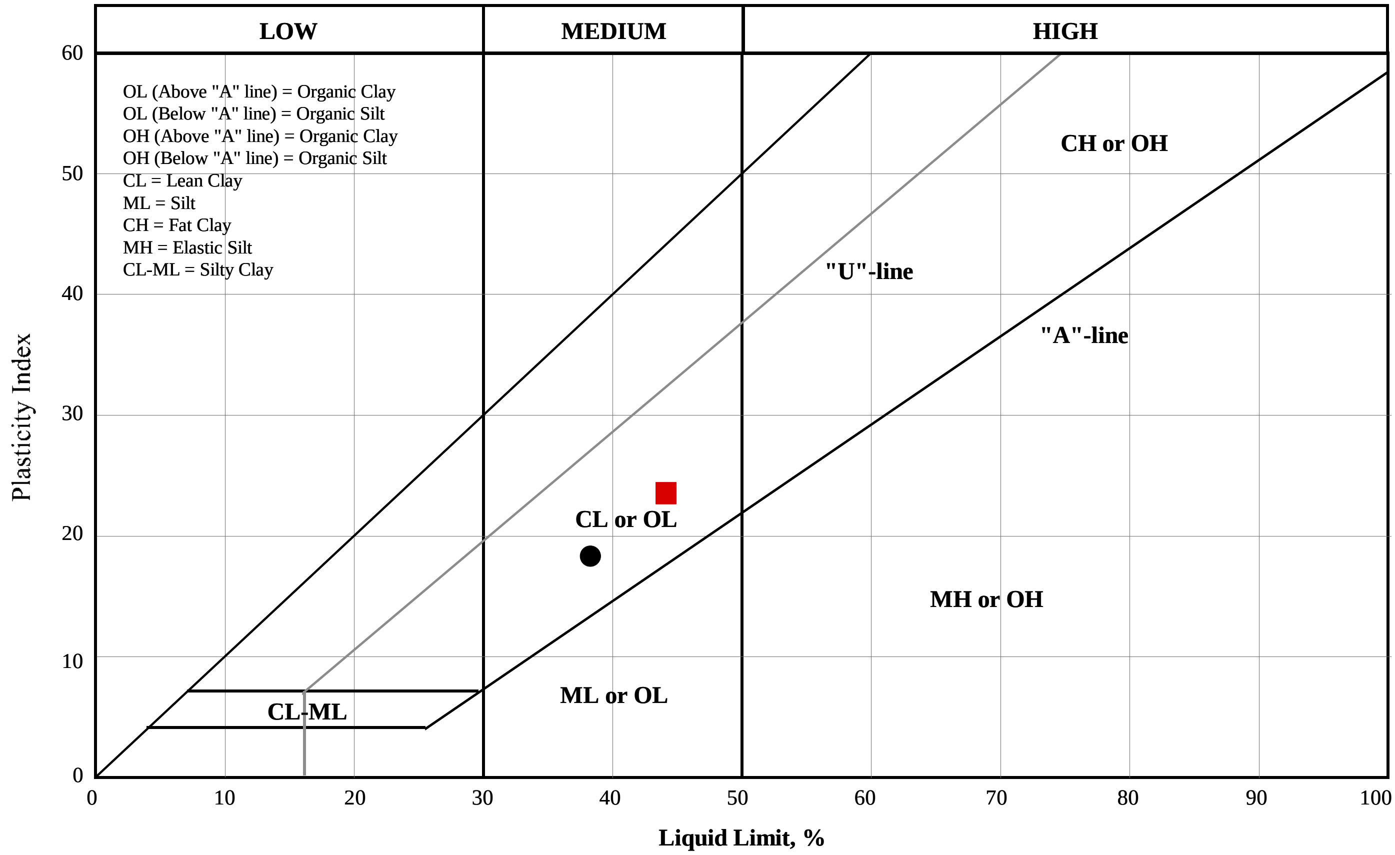


Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
—●—	Weathered Crust	20-3	SA 5	3.05-3.66	0.0	1.5	24.5	73.9

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75µm
—●—	Silty clay , trace sand	N/A	---	---	---	---	0.00	0.01	23.5

GEMTEC Consulting Engineers and Scientists	Client: D.G.Belfie Planning and Development Consulting Ltd.	Plasticity Chart
	Project: Geotechnical Investigation 1050 Klondike	
	Project #: 65153.01	



Symbol	Borehole	Sample Number	Depth	Date Sampled	Liquid Limit	Plastic Limit	Plasticity Index	Non-Plastic	Moisture Content, %
●	20-1	SA 10	7.62-8.23	Sep 24, 2020	38.3	20.0	18.3	☐	43.71
■	20-2	SA 8	5.33-5.94	Sep 24, 2020	44.1	20.6	23.5	☐	36.81

APPENDIX C

Chemical Analysis of Soil Relating to Corrosion
(Paracel Order No. 2039429)

Certificate of Analysis

Client: GEMTEC Consulting Engineers and Scientists Limited

Client PO:

Report Date: 29-Sep-2020

Order Date: 24-Sep-2020

Project Description: 65153.01

	Client ID:	BH20-2 SA5	-	-	-
	Sample Date:	23-Sep-20 14:45	-	-	-
	Sample ID:	2039429-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	74.6	-	-	-
General Inorganics					
Conductivity	5 uS/cm	125	-	-	-
pH	0.05 pH Units	7.20	-	-	-
Resistivity	0.10 Ohm.m	80.0	-	-	-
Anions					
Chloride	5 ug/g dry	24	-	-	-
Sulphate	5 ug/g dry	22	-	-	-

experience • knowledge • integrity

civil
geotechnical
environmental
field services
materials testing

civil
géotechnique
environnementale
surveillance de chantier
service de laboratoire des matériaux

expérience • connaissance • intégrité