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Geotechnical Investigation
Proposed Commercial Building
2900 Woodroffe Avenue
Ottawa, Ontario

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Submitted to:

Woodroffe Square Inc.
c/o Lloyd Philips & Associates Ltd.
1827 Woodward Dr., Suite 109, Ottawa, ON
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Geotechnical Investigation
Proposed Commercial Building
2900 Woodroffe Avenue
Ottawa, Ontario

May 3, 2019
Project: 64900.01

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GEMTEC Consulting Engineers and Scientists Limited
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Ottawa, ON, Canada
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Woodroffe Square Inc.
c/o Lloyd Philips & Associates Ltd.
1827 Woodward Dr., Suite 109, Ottawa, ON

Re: Geotechnical Investigation
Proposed Commercial Building
2900 Woodroffe Avenue
Ottawa, Ontario

Enclosed is our geotechnical investigation report for the above noted project. This report was prepared by Matthew Rainville, C.E.T. and Johnathan A. Cholewa, Ph.D., P.Eng.

Matthew Rainville, C.E.T. .

MR/JC

Enclosures
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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed commercial building located at 2900 Woodroffe Avenue in Ottawa, Ontario (see Key Plan, Figure 1). 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 report supersedes our previous geotechnical report issued for the subject property (Morey Houle Chevrier Engineering Ltd. report titled: “Subsurface Investigation, Proposed Commercial Development, Woodroffe Avenue, Ottawa, Ontario”, dated December 18, 2000).

2.0 PROJECT DESCRIPTION AND SITE GEOLOGY

2.1 Project Description

It is understood that a one storey office, commercial building will be constructed at the existing commercial plaza located at 2900 Woodroffe Avenue. It is further understood that the proposed building will consist of slab-on-grade construction. The existing at-grade parking along the perimeter of the proposed building will be reinstated as part of the development.

Based on existing site conditions, it is assumed that the proposed building will have a maximum finished floor elevation of about 92.7 metres.

2.2 Site Geology

Surficial geology maps of the Ottawa area indicate that the site is underlain by erosional terraces of marine deposits (silt and clay). Bedrock geology and drift thickness maps of the Ottawa area show that the overburden has a thickness of about 10 to 15 metres and is underlain by interbedded sandstone and dolostone of the March formation.

3.0 METHODOLOGY

3.1 Geotechnical Investigation

The field work for this investigation was carried out on April 10, 2019. During that time, two (2) boreholes, numbered 19-1 and 19-2, were advanced at the site by George Downing Estate Drilling Ltd. to depths of 10.9 and 6.1 metres, respectively, below existing grade (elevations 81.1 and 86.0 metres).

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. Vane shear strength testing was carried out in the clayey deposits.

The field work was observed throughout by a member of our engineering staff who directed the drilling operations and logged the samples and boreholes.

A standpipe piezometer was installed and sealed in the overburden at borehole 19-2 to facilitate groundwater level measurements and groundwater sampling.

Following completion of the drilling, the soil samples were returned to our laboratory for examination by a geotechnical engineer. A sample of the soil recovered from borehole 19-1 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 the laboratory classification tests on the soil samples are provided on the Soils Grading Chart and Plasticity chart in Appendix B. The results of the chemical analysis of a sample of soil 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 the proposed building footprint. The ground surface elevations at the location of the boreholes were determined using a Trimble R10 global positioning system. The coordinates of the boreholes are referenced to NAD83 (CSRS) Epoch 2010, vertical network CGVD2013 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 and excavation, the frequency and recovery of samples, the method of sampling, and the uniformity of the subsurface conditions. Subsurface conditions at other than the test locations may vary from the conditions encountered in the boreholes and test pits. 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 advanced during this investigation.

4.2 Existing Pavement Structure

4.2.1 Asphaltic Concrete

A layer of asphaltic concrete was encountered at surface at both boreholes. The thickness of the asphaltic concrete is about 50 millimetres.

4.2.2 Base/Subbase Material

Base/Subbase material was encountered below the asphaltic concrete at both boreholes. The base/subbase material consists of sand and gravel and extends to depths of about 0.8 to 1.1 metres below surface grade.

4.3 Silty Clay

4.3.1 Grey Brown Silty Clay (Weathered Crust)

A native deposit of grey brown silty clay (weathered crust) was encountered below the existing pavement structure at both borehole locations. The thickness of the weathered crust ranges between 1.8 to 2.1 metres, and extends to a depth of about 2.9 metres below existing grade at both boreholes (approximate elevation of 89.1 to 89.3 metres).

Standard penetration tests carried out within this deposit gave N values ranging between 1 to 6 blows per 0.3 metres of penetration. Based on the standard penetration test results, the weather crust has a stiff to very stiff consistency.

Moisture content testing carried out on samples of the silty clay weathered crust indicate moisture contents ranging from about 28 to 55 percent.

4.3.2 Grey Silty Clay/Clayey Silt

The weathered, grey brown silty clay transitions to a grey silty clay/clayey silt with trace amounts of sand and gravel at a depth about 2.9 metres below existing grade. At borehole 19-1, the grey silty clay has a thickness of about 5.9 metres and extends to a depth of about 8.8 metres below existing grade (elevation 83.1 metres). Borehole 19-2 was terminated within the grey silty clay at a depth of about 6.1 metres below surface grade (elevations 86.0 metres).

In situ vane strength tests carried in the grey silty clay gave undrained shear strength values ranging from about 46 to 96 kilopascals, which reflects a firm to stiff consistency. The remoulded vane shear test values generally ranged from 6 to 12, indicating that the sensitivity of the silty clay is medium to extra-sensitive. One in situ vane strength test, carried out in the lower portion of the silty clay at borehole 19-1, gave an undrained shear strength value of 23 kilopascals. It is likely that this shear strength test at this elevation is not representative of the undrained shear strength of the deposit.

The results of grain size distribution testing on a sample of the grey silty clay are provided on the Soils Grading Chart in Appendix B and summarized in Table 4.1.

Table 4.1 – Summary of Grain Size Distribution Testing

Location	Sample Number	Sample Depth (metres)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
19-1	4	3.8 – 4.4	0.3	1.5	28.4	69.8

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

Table 4.2 – Summary of Atterberg Limit Testing

Borehole	Sample Number	Sample Depth (metres)	Water Content (%)	LL (%)	PL (%)	PI (%)
19-1	4	3.8 – 4.4	61.3	41.1	19.8	21.3

Moisture content testing carried out on samples of the grey silty clay indicate moisture contents ranging from about 31 to 61 percent.

4.4 Glacial Till

A native deposit of glacial till was encountered at borehole 19-1 at a depth of about 8.8 metres below existing grade (elevation 83.1 metres). Glacial till is a heterogeneous mixture of all grain sizes, however, the glacial till encountered at this site can be described as grey silty sand with some clay and gravel. Borehole 19-1 was terminated due to refusal to further augering on a boulder or bedrock at a depth of about 10.9 metres below existing grade (elevation 81.1 metres).

Standard penetration tests carried out in the glacial till gave N values ranging between 7 and 37 blows per 0.3 metres of penetration, which reflects a loose to dense relative density.

Moisture content testing carried out on samples of the glacial till indicate moisture contents ranging from about 7 to 17 percent.

4.5 Groundwater Levels

The groundwater level in the well screen installed in borehole 19-2 was measured on April 16, 2019. A summary of the groundwater level is provided in Table 4.3.

Table 4.3 – Summary of Measured Groundwater (April 16, 2019)

Borehole	Ground Surface Elevation (metres)	Groundwater Level (metres)	Groundwater Elevation (metres)
19-2	92.13	1.8	90.3

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.

4.6 Soil Chemistry Relating to Corrosion

The results of chemical testing on the soil sample recovered from borehole 19-1 are provided in Appendix C and are summarized in Table 4.4.

Table 4.4 – Summary of Corrosion Testing

Parameter	Borehole 19-1 SA2
Chloride Content	574 ug/g
Sulphate Content	495 ug/g
Conductivity	1540 uS/cm
pH	7.63
Resistivity	6.51 Ohm.m

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 Excavation

Based on the available subsurface information, excavations for the structure and services within the site will be carried out through fill material and silty clay.

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 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 within the native soils at this site. As an alternative to sloping the excavations, the service installations could be carried out within a tightly fitting, braced steel trench box, which is specifically designed and approved for this purpose.

The groundwater inflow should be controlled throughout the excavation and pipe laying operations by pumping from sumps within the excavation. Notwithstanding, it should be noted that silty clay deposits are very sensitive to disturbance from ponded water and construction traffic. Some disturbance and loosening of the subgrade materials could occur, and allowance should be made for subexcavation, as discussed further in the following sections of this report.

Depending on the depth of the excavation, in order to avoid subgrade disturbance, allowance could be made for a 50 to 75 millimetre thick mud mat of low strength concrete. The mud mat should be placed over the silty clay subgrade surface immediately after exposure and inspection.

5.3 Groundwater Pumping

Based on our experience, groundwater inflow from the silty clay deposits into the excavations could be controlled by pumping from filtered sumps within the excavations. It is not expected that short term pumping during excavation will have any significant affect on nearby structures and services.

Suitable detention and filtration will be required before discharging water. The contractor should be required to submit an excavation and groundwater management plan for review.

Depending on the depth of proposed services and groundwater level at the time of construction, an Environmental Activity and Sector Registry (EASR) in accordance with Environmental Protection Act Part II may be required. Further details could be provided as the design progresses.

5.4 Grade Raise Restriction

The site is underlain by a deposit of silty clay, which has a limited capacity to support loads imposed by grade raise fill material and, to a lesser extent, the foundations of the proposed 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 pre-consolidation pressure (P_c) and the existing overburden stress (σ_{vo}').

Based on existing site conditions, it is assumed that additional grade raise in the area of the proposed building will be limited to a maximum elevation of about 92.7 metres. As such, for this case we have calculated that the total settlement of the ground should be less than 25 millimetres in the long term. This determination is based on the following assumptions:

- The groundwater lowering due to the proposed additional development at the subject site will be less than 1 metre from the recently measured level. As such, it is important to install seepage barriers along the service trenches, as indicated in this report, to reduce the potential for groundwater level lowering.

- The unit weight of the grade raise material used in the vicinity of the structure is not greater than 22 kilonewtons per cubic metre.

Additional analysis will be required if the finished grades will exceed elevation 92.7 metres.

5.5 Spread Footing Design

Based on the results of the current investigation, the proposed structure could be founded on conventional footings bearing on or within native, undisturbed silty clay.

In areas where subexcavation of disturbed material 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 0.3 metres beyond the footings and then down and out from this point at 1 horizontal to 1 vertical, or flatter.

The bearing pressures for strip or pad footing foundations at this site are based on the necessity to limit the stress increase on the softer grey silty clay layer to an acceptable level so that foundation settlements will not be excessive. Four important parameters in calculating the stress increase on the grey silty clay beneath the weathered crust are:

- The thickness of the soil beneath the base of the foundation and the surface of the softer grey silty clay layer;
- The size, type (i.e. pad or strip) and loading of the foundation;
- The amount of surcharge (fill, etc.) in the vicinity of the foundation; and
- The amount of post-development groundwater lowering at the site.

For preliminary planning and design purposes, foundation bearing values for the proposed building are provided in Tables 5.1.

Table 5.1 – Foundation Bearing Values (Proposed Slab on Grade Building)

Type of Footing	Underside of Footing Elevation (metres)	Maximum Size of Footing (metres)	Net Geotechnical Reaction at Serviceability Limit State[1] (kilopascals)	Factored Net Geotechnical Resistance at Ultimate Limit State (kilopascals)
Exterior Strip	above 90.5	1.5	100	300
Interior Pad	above 90.5	1.8 square	100	300

For the purpose of this assessment, we have considered a long term groundwater lowering at the site equal to 1.0 metre below the measured groundwater level. Provided that any loose or disturbed soil is removed from the bearing surfaces, the post construction total and differential settlement of the footings at SLS should be less than 25 and 20 millimetres.

There are many other possible combinations of founding depths, footing sizes, and thickness of grade raise fills which might be suitable for this site. The final design must be checked by the geotechnical engineer to ensure that overstressing of the softer silty clay soil does not occur, as this could result in excessive settlement and cracking/distress of the structure.

5.6 Foundation Wall Backfill

The foundation walls should be backfilled with imported, free draining, non-frost susceptible granular material such as that meeting OPSS Granular B Type I or II requirements.

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 98 percent of the standard Proctor maximum dry density value using suitable compaction equipment. Where future landscaped areas will exist next to the proposed building and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the standard Proctor maximum dry density value.

Where areas of hard surfacing (concrete, sidewalks, pavement, etc.) will 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 existing, adjacent areas of hard surfacing underlain by 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 up to the underside of the granular subbase of the existing, adjacent hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

5.7 Slab on Grade Support (Slab Surface above Finished Grade)

To provide predictable settlement performance of the concrete slab on grade, the existing pavement structure and fill material should be removed from the area of the proposed slab on grade. Any disturbed soil, organic material, or deleterious material should also be removed to expose the native undisturbed soil deposits.

The subgrade surface should be proof rolled with a vibratory drum roller under dry conditions and any noted soft areas should be sub excavated. The grade within the proposed slab area could be raised, where necessary, with compacted granular material meeting OPSS requirements for Granular B Type I or II. The use of Granular B Type II is preferred under wet conditions. The granular base for the proposed floor slab should consist of at least 150 millimetres of OPSS Granular A. The 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 for concrete floor slabs that are at the finished exterior ground surface level.

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.

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.

5.8 Seismic Site Classification and Liquefaction Potential

Based on the results of the boreholes, it is recommended that seismic Site Class D be used for the design of the proposed building at this site.

In our opinion, there is no potential for liquefaction of the overburden deposits at this site.

5.9 Site Services

5.9.1 Pipe Bedding and Cover

The bedding for the sanitary and storm sewer and watermain laterals should be in accordance with OPSD 802.010/802.013 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.

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 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.

5.9.2 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 a service trench will be located below or in close proximity to existing or future roadway/parking lot areas, acceptable native materials should be used as backfill between the roadway/parking lot 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/parking lot. 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 is expected to be about 1.8 metres. 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.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the reinstatement of the roadways, parking lot, curbs, 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. 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 grey 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 of 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).

5.9.3 Seepage Barriers

The granular bedding in the service trenches could act as a "French Drain", which could promote groundwater lowering. As such, we suggest that seepage barriers be installed along the service trenches at strategic locations, such as where the proposed laterals will meet existing in-site service mains, or where the property meets Woodroffe Drive. The seepage barriers should begin at subgrade level and extend vertically through the granular pipe bedding and granular surround to within the native backfill materials, and horizontally across the full width of the service trench excavation. The seepage barriers could consist of 1.5 metre wide dykes of compacted silty clay. The silty clay should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor dry density value. Locations of the seepage barriers could be recommended as the design progresses.

5.9.4 Winter Construction

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.

5.10 Roadway/Parking Lot Areas

5.10.1 Subgrade Preparation

In preparation for roadway/parking lot construction or reinstatement at this site, any soft, wet or deleterious materials should be removed from the proposed roadway and parking lot areas. This need to include removal of the existing fill materials, provided that some post-construction settlement of the roadway/parking lot can be tolerated.

Prior to placing granular material for the road and parking areas, the exposed subgrade should be inspected and approved by geotechnical personnel. Any soft areas should be subexcavated and replaced with suitable, dry material, meeting OPSS specifications for earth borrow material or Select Subgrade Material that is frost compatible with the materials exposed on the sides of the area of subexcavation. The grade raise material 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.

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

5.10.2 Pavement Structure

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

- 50 millimetres of hot mix asphaltic concrete (Superpave 12.5 Traffic Level B), 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 Traffic Level B over 60 millimetres of Superpave 19.0 Traffic Level B), 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.

5.10.3 Asphalt Cement Type

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

5.10.4 Pavement Transitions

As part of the roadway/parking lot construction, the new pavement will abut the existing pavement at various locations. 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.
- Milling the existing asphaltic concrete at the joint may not be feasible due to its thickness; as such a butt joint between the new and existing asphaltic concrete is considered the preferred option.

5.10.5 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long term performance of the pavement at this site. Where feasible, the subgrade surfaces should be crowned and shaped to drain to 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.

5.10.6 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 standard Proctor maximum dry density value.

6.0 ADDITIONAL CONSIDERATIONS

6.1 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in the sample of soil recovered from borehole 19-1 is 495 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/parking lot 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 to 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.

6.2 Effects of Construction Induced Vibration

Some of the construction operations (such as excavation and granular material 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 any 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.

6.3 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 slabs 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.

6.4 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.

6.5 Design Review

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 development 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.

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.

Matthew Rainville, C.E.T.
Senior Technologist

John Cholewa, Ph.D., P.Eng.
Geotechnical Engineer

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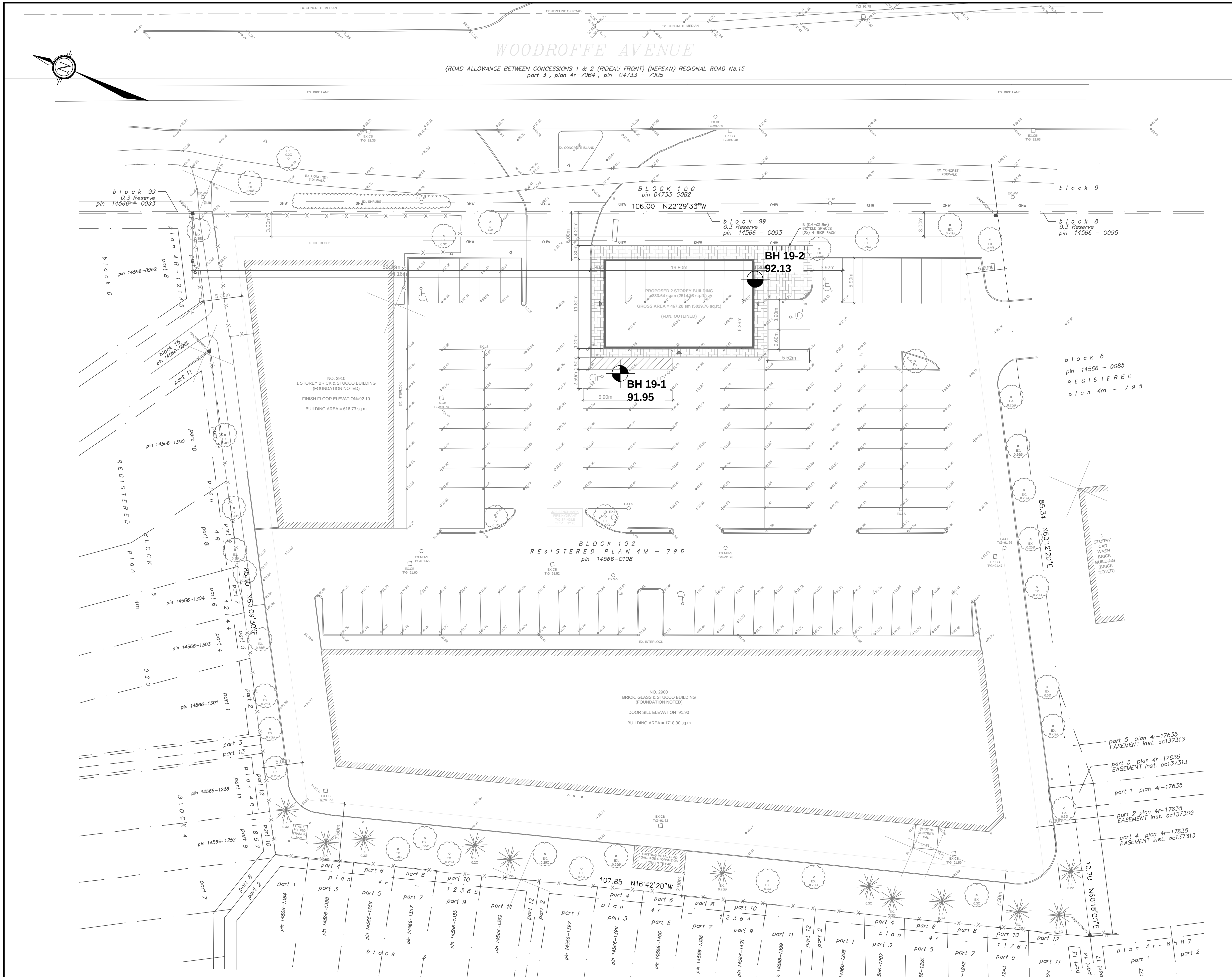

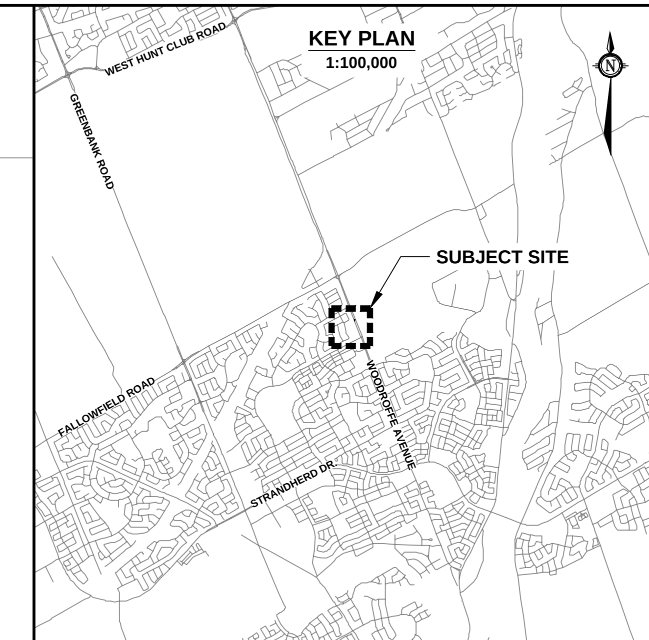

LEGEND

BOREHOLE LOCATION IN PLAN (current investigation by GEMTEC)

BOREHOLE WITH WELL LOCATION IN PLAN (current investigation by GEMTEC)

BH # ← BOREHOLE ID

XX.XX ← GROUND SURFACE ELEVATION, IN METRES GEODETIC DATUM

NOTE:

SITE PLAN SHOWN WAS RECEIVED FROM LLOYD PHILLIPS & ASSOCIATES LTD.

Scale 1:500

0 10 20 30m

GEMTEC
CONSULTING ENGINEERS AND SCIENTISTS

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

Client	WOODROFFE SQUARE INC.	Project 64900.01
Location	2900 WOODROFFE AVENUE OTTAWA, ON	
Drwn by P.C.	Chkd by M.R.	BOREHOLE LOCATION PLAN
Date APRIL 2019	Rev. 0	**FIGURE 1**

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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

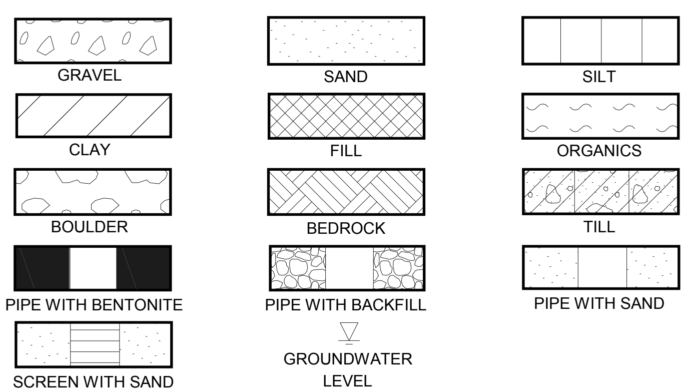
PENETRATION RESISTANCE

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.

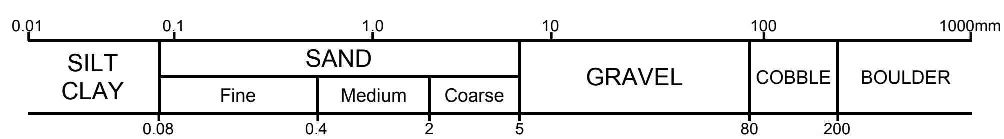
Dynamic Penetration Resistance
The number of blows by a 63.5 kg (140 lb) hammer dropped 760 mm (30 in.) to drive a 50 mm (2 in.) diameter 60° cone attached to 'A' size drill rods for a distance of 300 mm (12 in.).

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



DESCRIPTIVE TERMINOLOGY
(Based on the CANFEM 4th Edition)

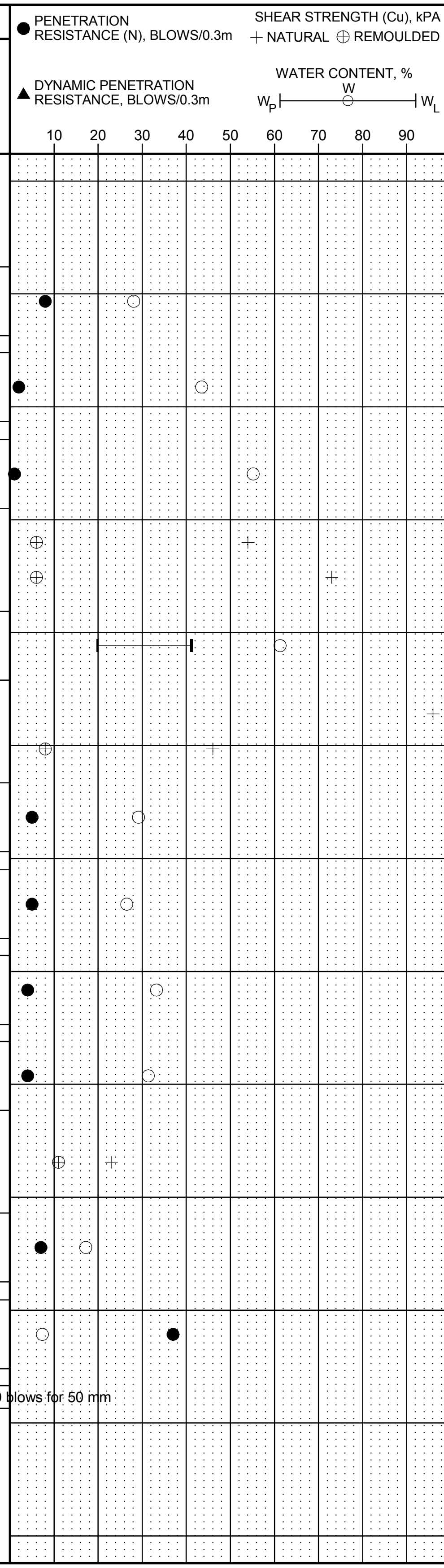
0–10	10–20	20–35	35+
TRACE	SOME	ADJECTIVE	noun > 35% and main fraction
trace clay, etc	some gravel, etc.	silty, etc.	sand and gravel, etc.

RECORD OF BOREHOLE 19-1

CLIENT: Woodroffe Square Inc
PROJECT: 2900 Woodroffe Ave
JOB#: 64900.01
LOCATION: See Borehole Location Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Apr 10 2019

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m	ADDITIONAL LAB. TESTING
0	Power Auger, Hollow Stem Auger (210mm OD)	Ground Surface	91.95					
		Asphaltic Concrete	0.05					
		Grey sand and gravel, trace to some silt (BASE/SUBBASE MATERIAL)						
1		Stiff to very Stiff, grey brown SILTY CLAY (Weathered Crust)	90.83 1.12	1	SS		8	
2				2	SS		2	
				3	SS		1	
3		Firm to stiff, grey SILTY CLAY/CLAYEY SILT, trace gravel and sand (possible seams).	89.05 2.90					
4				4	SS		WH	MH
5				5	SS		5	
6				6	SS		5	
7				7	SS		4	
8				8	SS		4	
9		Grey silty sand, some clay and gravel, possible cobbles and boulders (GLACIAL TILL)	83.11 8.84	9	SS		7	
10				10	SS		37	
				11	SS		> 50 blows for 50 mm	
11		End of borehole Auger Refusal	81.08 10.87					
12								



PIEZOMETER OR STANDPIPE INSTALLATION

Groundwater conditions not observed at time of drilling.

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LOGGED: BW
CHECKED: MR

RECORD OF BOREHOLE 19-2

CLIENT: Woodroffe Square Inc
PROJECT: 2900 Woodroffe Ave
JOB#: 64900.01
LOCATION: See Borehole Location Plan, Figure 1

SHEET: 1 OF 1
DATUM: CGVD2013
BORING DATE: Apr 10 2019

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

DESCRIPTION	ELEV. / DEPTH (m)	NUMBER	TYPE	RECOVERY, mm	BLOWS/0.3m
Ground Surface	92.13				
Asphaltic Concrete	0.05				
Grey sand and gravel, trace to some silt (BASE/SUBBASE MATERIAL)	91.37 / 0.76				
Stiff to very stiff, grey brown SILTY CLAY (Weathered Crust)		1	SS		6
		2	SS		5
		3	SS		1
Firm to stiff, grey SILTY CLAY/CLAYEY SILT, trace gravel and sand (possible seams).	89.26 / 2.87	4	SS		WH
		5	SS		WH
		6	SS		WH
		7	SS		WH
End of Borehole	86.03 / 6.10				

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
10 20 30 40 50 60 70 80 90

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION
Auger cuttings
Bentonite seal
Filter sand
50 mm Diameter, 1.52 metre long well screen

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7 8 9 10 11 12

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
19-04-16	1.8 ▽	90.3

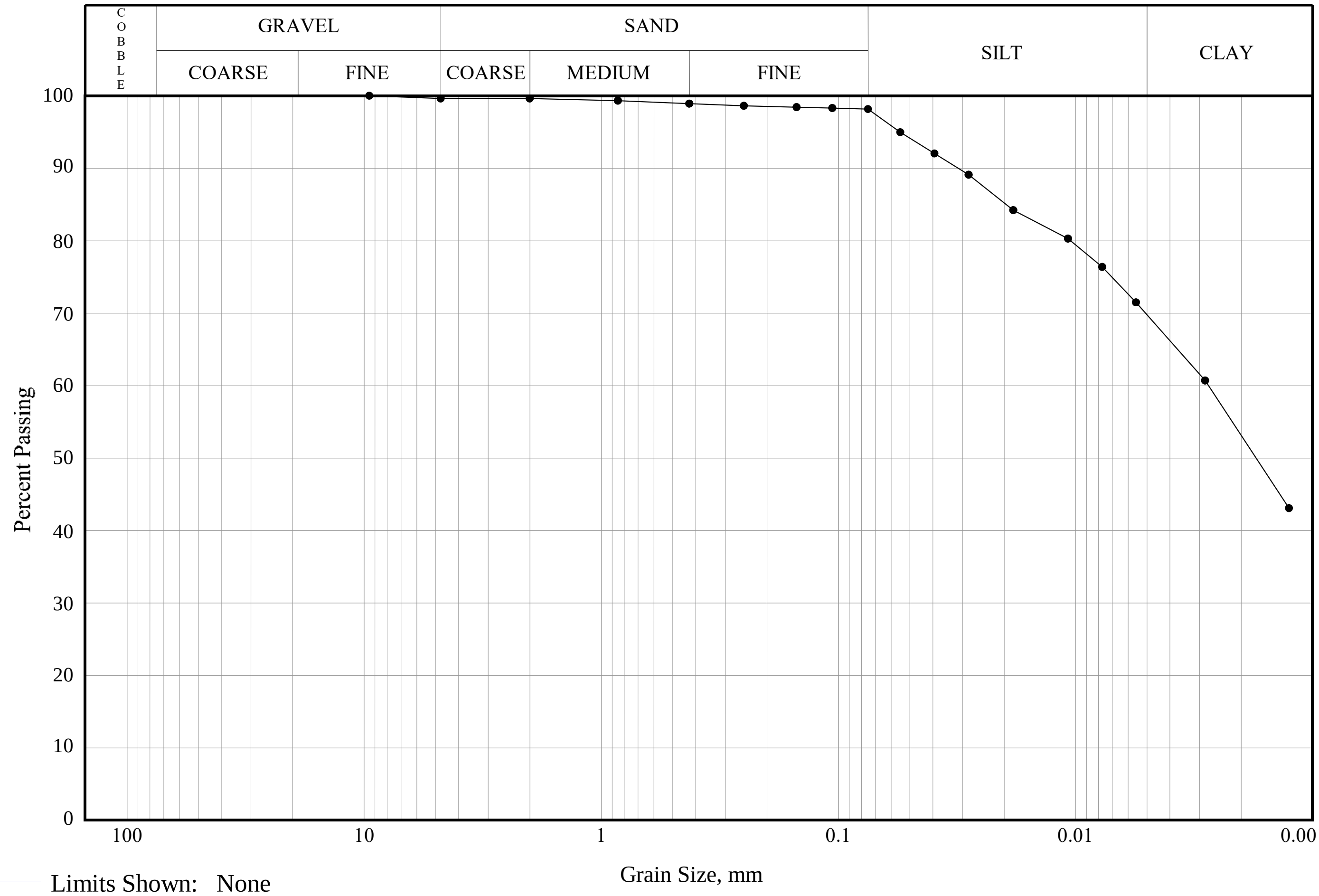
GEMTEC
Consulting Engineers and Scientists

LOGGED: BW
CHECKED: MR

APPENDIX B

Laboratory Testing Results
Soils Grading Chart
Plasticity Chart

Consulting Engineers and Scientists		
Client:	Woodroffe Square Inc.	Soils Grading Chart
Project:	2900Woofroffe Ave, Ottawa, ON	
Project #:	6490001	

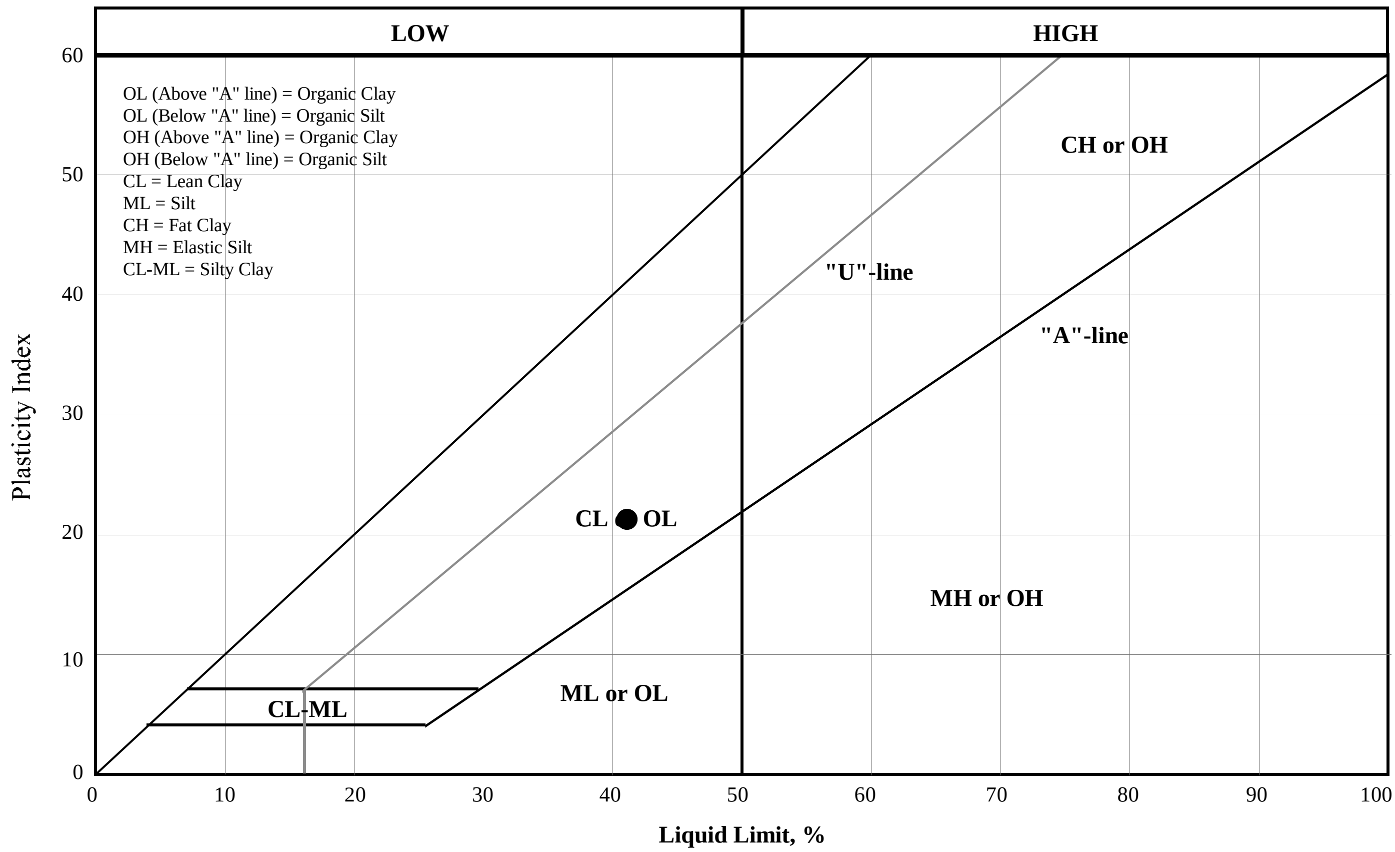


Limits Shown: None

Line Symbol	Sample	Borehole/ Test Pit	Sample Number	Depth	% Cob.+ Gravel	% Sand	% Silt	% Clay
●—	Silty Clay/Clayey Silt, Trace Gravel/Sand	19-1	04	3.81-4.42	0.4	1.5	28.4	69.8

Line Symbol	CanFEM Classification	USCS Symbol	D_{10}	D_{15}	D_{30}	D_{50}	D_{60}	D_{85}	% 5-75µm
●—	Silty clay , trace gravel, trace sand	CL	---	---	---	0.00	0.00	0.02	28.4

GEMTEC Consulting Engineers and Scientists	Client: Woodroffe Square Inc.	Plasticity Chart
	Project: 2900Woodroffe, Ottawa, ON	
	Project #: 6490001	



Symbol	Borehole /Test Pit	Sample Number	Depth	Liquid Limit	Plastic Limit	Plasticity Index	Non-Plastic	Moisture Content, %
●	19-1	04	3.81-4.42	41.1	19.8	21.3	☐	61.29

APPENDIX C

Chemical Analysis of Soil Sample
Relating to Corrosion
(Paracel Laboratories Ltd. Order No. 1916354)

Report to: Woodroffe Square Inc.
Project: 64900.01 (May 3, 2019)

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Certificate of Analysis

GEMTEC Consulting Engineers and Scientists Limited

32 Steacie Drive
Kanata, ON K2K 2A9
Attn: Matt Rainville

Client PO:
Project: 64900.01
Custody:

Report Date: 23-Apr-2019
Order Date: 17-Apr-2019

Order #: 1916354

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1916354-01	19-1 SA2

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Certificate of Analysis
Client: GEMTEC Consulting Engineers and Scientists Limited
Client PO:

Report Date: 23-Apr-2019
Order Date: 17-Apr-2019
Project Description: 64900.01

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	22-Apr-19	22-Apr-19
Conductivity	MOE E3138 - probe @25 °C, water ext	22-Apr-19	22-Apr-19
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	22-Apr-19	22-Apr-19
Resistivity	EPA 120.1 - probe, water extraction	22-Apr-19	22-Apr-19
Solids, %	Gravimetric, calculation	22-Apr-19	22-Apr-19

PARACEL LABORATORIES LTD.

Order #: 1916354

Certificate of Analysis

Client: GEMTEC Consulting Engineers and Scientists Limited

Client PO:

Report Date: 23-Apr-2019

Order Date: 17-Apr-2019

Project Description: 64900.01

	Client ID:	19-1 SA2	-	-	-
	Sample Date:	04/10/2019 09:00	-	-	-
	Sample ID:	1916354-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	72.3	-	-	-
General Inorganics					
Conductivity	5 uS/cm	1540	-	-	-
pH	0.05 pH Units	7.63	-	-	-
Resistivity	0.10 Ohm.m	6.51	-	-	-
Anions					
Chloride	5 ug/g dry	574	-	-	-
Sulphate	5 ug/g dry	495	-	-	-

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						
Resistivity	ND	0.10	Ohm.m						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	27.6	5	ug/g dry	27.5			0.4	20	
Sulphate	48.1	5	ug/g dry	48.4			0.6	20	
General Inorganics									
Conductivity	186	5	uS/cm	186			0.1	5	
pH	7.40	0.05	pH Units	7.44			0.5	10	
Resistivity	53.6	0.10	Ohm.m	53.7			0.1	20	
Physical Characteristics									
% Solids	88.8	0.1	% by Wt.	88.4			0.5	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	121	5	ug/g	27.5	93.3	82-118			
Sulphate	150	5	ug/g	48.4	102	80-120			

Qualifier Notes:

Login Qualifiers :

Received at temperature > 25C

Applies to samples: 19-1 SA2

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

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