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Geotechnical Investigation
Proposed Residential Development

705 & 713 Rymal Road East
Hamilton, Ontario
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Prepared for:

Royal Living Development Group
1059 Upper James Street
Hamilton, Ontario
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Landtek File: 19104
May 27, 2019

EXECUTIVE SUMMARY

SCOPE OF SERVICES	
Proposed Development	Limited information regarding the proposed development was available at the time of writing this report, with only a partial conceptual design available. From this, it is understood that the development is anticipated to comprise of townhouse units. It is assumed that the proposed development will also include for a maximum of one level of basement, together with new access roads, at-grade paved parking areas and full site servicing.
Report Deliverables	The Geotechnical Investigation is required to determine the subsurface conditions underlying the site and to provide design and construction recommendations for the proposed new residential development.
SITE DETAILS AND SETTING	
Coordinates	592537, 4783152 **Site Area (approx.)** 8,974 m^2 (2.21 acres)
Site Description	The site is a relatively undeveloped parcel of land, with the topography around the site relatively flat lying with slight undulations. The site is situated approximately 145 m east of Upper Sherman Avenue and 150 m south of Brenda Street, and is bound to the south by Rymal road East. The site is covered predominantly by low-level shrubs, large copse of trees, and unmaintained grassland. Residential premises are situated to the east and north of the site.
Geology	Topsoil was encountered at the ground level. Underlying the topsoil is a fill material consisting of clayey silt and silty clay. The fill extends to approximately 0.6 m to 1.5 m below existing ground level. Underlying the fill material is native clayey-silt and silt material, which extends to depths of between 2.1 m and 4.7 m below existing ground level. Ultimate refusal was encountered at the terminus of the boreholes and is presumed to be on dolostone/limestone bedrock.
Groundwater	Groundwater seepage was encountered at a depth of approximately 3.3 m in one of the fivet boreholes, with the rest of the boreholes remaining open to full drill depth and dry upon completion.
ENGINEERING CONSIDERATIONS	
Foundations	It is assumed that the proposed residential structures will include a maximum of one level of basement. It is considered by Landtek that the anticipated moderately loaded foundations for the proposed residential structures can be supported by conventional concrete footings seated within the native soils and dolostone/limestone bedrock underlying the site.
Settlements	The general limiting of the total settlement to 25 mm and the differential settlement to 19 mm by the recommended geotechnical reaction at the SLS is considered appropriate for foundations in native soils. Settlements for foundations seated within bedrock are to be deemed negligible (i.e. less than 15 mm).
Earthquake Considerations	Based on the soils conditions encountered, and in accordance with Table 4.1.8.4.A. of the current Ontario Building Code, the site is considered to be a ‘C’ Site Class for foundations seated within the overburden soils, and a ‘B’ Site Class for foundations on the dolostone/limestone bedrock
CONSTRUCTION CONSIDERATIONS	
Excavations	The native soils to be encountered during excavation at the site are expected, in general, to behave as “*Type 3”* materials according to the OHSA classification in Part III. Type 3 materials are characteristic of the generally stiff or compact clayey silt and silt soils. The dolostone/ limestone bedrock has strength characteristics that exceed Type 1 soils.
Subsurface Concrete	Experience in the area indicates that the native soils generally have a mild sulphate environment and a low chloride concentration. It is recommended that subsurface concrete at the site have the following characteristics for an S-3 exposure class.
Dewatering	It is expected that any groundwater seepage during excavation work should be able to be controlled by pumping from sumps at the base of the excavation. Water seepage into open excavations is not expected to be a construction issue such that the project would require either registration under the Environmental Activity and Sector Registry framework (i.e. exceeding 50,000 l/day but less than 400,000 l/day) or a Permit To Take Water for amounts greater than 400,000 l/day.

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1.0 INTRODUCTION

Landtek Limited (herein "*Landtek*") is pleased to submit this geotechnical investigation report for the proposed residential development at the site identified as civic addresses 705 and 713 Rymal Road East in Hamilton, Ontario. Authorization to proceed with the work was received from Mr. Alex Arbab of Royal Living Development Group (herein *"RLDG"*). All work was completed in accordance with our proposal reference P19106, dated April 2, 2019.

Limited information regarding the proposed development was available at the time of writing this report, with only a partial conceptual design available. From this, it is understood that the development is anticipated to comprise of townhouse units. It is assumed that the residential structures will include either a ground-bearing floor slab or a maximum of one level of heated basement. The development is also anticipated to include parking areas, access routes and landscaping.

The primary objectives of this investigation are:

- To confirm the subsurface soil and groundwater conditions for foundation design and construction;
- Provide design and construction recommendations with regards to building foundations, floor slabs, pavement structures, and subsurface drainage and utilities; and,
- Assess the characteristics of the soils to be excavated and their suitability for reuse on site.

This report has been prepared for the Client, the nominated engineers, designers, and project managers pertaining to the proposed residential development at 705 and 713 Rymal Road East in Hamilton, Ontario. Further dissemination of this report is not permitted without Landtek's prior written approval. Further details of the limitations of this report are presented in Appendix A.

2.0 SITE SETTING

2.1 Site Location and Surrounding Area

The land to be developed for the residential use is located in Hamilton, Ontario, and is centered at approximate grid reference 592537, 4783152 (UTM 17T coordinates). The approximate Geodetic elevation of the ground surface at the site ranges between 217.75 m and 219.00 m.

The site location is shown in Figure 2.1.1 below.

Figure 2.1.1: Area of Proposed Development

The site is a relatively undeveloped parcel of land of approximately 8974 m^2 (2.21 acres), with the topography around the site relatively flat lying with slight undulations. The site is situated approximately 145 m east of Upper Sherman Avenue and 150 m south of Brenda Street, and is bound to the south by Rymal road East. The site is covered predominantly by low-level shrubs, large copse of trees, and unmaintained grassland. Existing residential premises are situated at the southeasterly section of the site.

2.2 Published Geology

Based on previous geotechnical experience for the area and a review of the existing geological publications for the site area, Ontario Geological Survey (OGS) Map P.993: "*Quaternary Geology of the Grimsby Area*", the native subsurface soil conditions in the area of the site are anticipated to consist of glaciolacustrine clay and silt deposits.

According to the OGS Map 2343 "*Paleozoic Geology of the Grimsby Area*", the superficial geology is underlain by brown or tan dolostone, identified as a member of the Guelph formation.

Information provided by a number of historical borehole and well records from within the vicinity of the site and held by the OGS and Ministry of the Environment, Conservation and Parks (herein *"MOECP*"), generally confirms the anticipated geological conditions beneath the site. Based on the borehole record data from MOECP for Borehole ID 6800311, located at the southerly section of the site, the superficial soil profile confirms the presence of clay and silt deposits to a depth of approximately 4.0 m, with grey limestone bedrock underlying the clay and silt deposits.

3.0 FIELDWORK AND INVESTIGATION METHODOLOGY

Fieldwork undertaken at the site by Landtek included clearance of underground services, borehole layout, borehole drilling and soil sampling, and field supervision. A total of five boreholes (boreholes BH1 to BH5) were drilled on April 12, 2019. All boreholes were logged using those standard symbols and terms defined in Appendix B. The Borehole Location Plan, Drawing 19104-01, and associated borehole logs are provided in Appendix C.

Full time supervision of drilling and soil sampling operations was carried out by a representative of Landtek. The boreholes were drilled using a CME-55 track-mounted drilling rig equipped with continuous flight, solid stem augers, and were advanced to practical refusal on bedrock, at depths of between approximately 2.1 m and 4.7 m below existing ground level.

All soil samples were transported to the Landtek's in-house, Canadian Council of Independent Laboratories (CCIL) certified laboratory and visually examined to determine their textural classification. Moisture content testing was carried out on all samples.

The approximate geodetic elevations at the boreholes were established by Landtek relative to site measurements and with reference to the site topographic survey drawings prepared by Chambers and Associates Surveying Ltd. (herein *"CASL"*) and dated April 25, 2019.

4.0 SUBSURFACE CONDITIONS

4.1 Overview

The borehole information is generally consistent with the geological data identified in Sections 2.2, with the predominant native soils comprising of clay and silt deposits.

The detailed borehole logs are presented in Appendix C, with the ground conditions encountered by the boreholes discussed in the following sections.

4.2 Topsoil

An approximately 100 mm to 300 mm thick layer of topsoil was encountered from ground surface in all the boreholes. Topsoil thicknesses may vary across the site, and the topsoil thicknesses measured at the borehole locations may not be representative of the topsoil depth throughout the site.

4.3 Fill Material

Fill material consisting predominantly of silty clay to clayey silt was encountered in all boreholes below the topsoil and extends to depths of between approximately 0.6 m (boreholes BH3 and BH4) and 1.5 m (borehole BH1) below existing ground level. The fill is brown in colour and contains some organic material. Moisture contents are in the order of 13% to 30%.

4.4 Clayey Silt

Clayey silt was encountered underlying the fill material in all boreholes and extends to depths of between approximately 1.5 m (boreholes BH3 to BH5) and 2.3 m (borehole BH2) below existing ground level. The clayey silt is brown and occasionally grey in colour and contains traces of gravel, shale, and iron staining.

SPT ‘‘N’’ values ranging from 6 to 30 were reported, indicating the clayey silt to be of a firm to very stiff, but generally stiff consistency. Moisture content testing results were recorded between 17 % and 23 %, which are generally representative of a moist clayey silt soil. The moisture content testing results are presented on the borehole logs in Appendix B.

4.5 Silt

Silt deposits were encountered in all boreholes, except borehole BH1, underlying the clayey silt at depths of between 1.5 m (boreholes BH3 to BH5) and 2.3 m (borehole BH2) and extend to depths of between 3.3 m (borehole BH2) and 4.7 m (borehole BH4) below existing ground level. The silt is grey in colour and contains traces of clay, shale and gravel.

SPT ‘‘N’’ values ranging from 12 to 39 were reported, indicating the silt to be of a compact to dense, but generally compact condition. Moisture content testing results were recorded between 12 % and 22 %.

4.6 Bedrock

Ultimate refusal was encountered in all boreholes at depths of between approximately 2.1 m (borehole BH1) and 4.7 m (borehole BH4) below existing ground level and is presumed to be on bedrock.

Although no rotary coring was conducted to confirm bedrock, examination of the bedrock fragments within the overburden soils indicates the bedrock to be dark brown limestone/dolostone. The limestone/dolostone in the vicinity of the site is identified as identified as a member of the Guelph formation, which is very finely crystalline, and includes occasional chert and shale interbeds.

4.7 Groundwater

Groundwater seepage was encountered in one borehole BH2 at a depth of 3.3 m, with the rest of the boreholes remaining open to the maximum drill depth and dry upon completion.

It should be noted that the reported water level is not considered to reflect the long-term stabilized water table and is likely associated with locally perched water. Groundwater conditions and surface water flow conditions are expected to vary according to the time of the year and seasonal precipitation levels. Water seepage is also expected from soil fissures above the water table.

5.0 FOUNDATION DESIGN CONSIDERATIONS

5.1 Shallow Foundations in Native Soils

Fill material was encountered at the ground surface in all boreholes and extends to depths of between approximately 0.6 m and 1.5 m below existing ground level. The fill is considered unsuitable as a bearing stratum due to the high risk of unacceptable settlements. Consequently, it is recommended that any shallow foundations for the residential units should be seated within the underlying native soils or dolostone/limestone bedrock. Based on the ground conditions observed at the borehole locations, it is considered by Landtek that bearing conditions to support the proposed structures on concrete footings can be provided by the native soils and bedrock underlying the site.

Table 5.1.1 summarizes the recommended geotechnical reactions at the Serviceability Limit State (herein "*SLS*") and factored geotechnical resistances at the Ultimate Limit State (herein "*ULS*") for the native soils. Where foundations are seated in bedrock, the SLS State condition will not govern their design as the stress required to induce the typical 25 mm settlement criteria at the SLS is anticipated to exceed the ULS. It should be noted that the design parameters have been determined by Landtek for the design stage only. Where the bearing levels of the footings are at different design elevations, the footing base levels should be stepped along a line of 7V:10H, drawn upwards from the lowest footing, to avoid overlapping stresses.

In accordance with the Ontario Building Code (herein "*OBC*"), 9.12.2.2 (5), and based on local experience, the shallowing of exterior and interior footings to 0.9 m and 0.6 m depth below the basement finished floor level respectively, may be adopted for the proposed development. Such shallowing of foundations is to be limited to only those areas where a minimum of one basement level is to be included. Foundations for at-grade structures are to be seated below the frost penetration depth of 1.2 m for the Hamilton area, per OBC 9.12.2.2 (1).

Subsurface conditions can vary over relatively short distances and the subsurface conditions revealed at the test locations may not be representative of subsurface conditions across the site. Therefore, a Geotechnical Engineer should be engaged during construction to examine the exposed sub-soil quality and condition, and confirm the subsurface conditions are consistent with design assumptions. This is in compliance with field review requirements in the National Building Code, Volume 1, Clause 4.2.2.3.

Table 5.1.1: Recommended Limit State Foundation Design Values

Founding Depth Range	Founding Stratum	Foundation Design Value	
		SLS [1 2]	ULS [3 4]
1.5± m to 3.0± m	Clayey Silt and Silt	120 kPa	180 kPa
3.0± m to 4.0± m	Clayey Silt and Silt	200 kPa	300 kPa
2.0± m to 5.0± m	Dolostone	-	750 kPa

Notes:
1. The National Building Code general safety criterion for the serviceability limit states is: SLS resistance ≥ effect of service loads.
2. Recommended SLS bearing values conform to Estimated Values based on soil types given in Tables K-8 and K-9 of the National Building Codes User's Guide.
3. The ULS resistance factor for shallow foundations is 0.5, as given in Table K-1 of the National Building Code User's Guide.
4. The National Building Code general safety criterion for the ultimate limit states is: factored ULS resistance ≥ effect of factored loads.

5.2 Foundations on Engineered Fill

If engineered fill is required to support building foundations, it is considered by Landtek that such relatively lightly loaded structures can be adequately supported by conventional strip or pad footings founded on the engineered fill for a geotechnical reaction at the SLS of 100 kPa, and a factored geotechnical resistance at the ULS of 150 kPa. It should be noted however, that this is very much dependent upon the nature and condition of the fill placed, the condition of the sub-grade upon which it is being placed, and the methods adopted for the placement and compaction of the fill materials.

Where there is a requirement to raise the existing grade and generate the necessary founding subgrade, the engineered fill must be selected with care, then placed and compacted under strictly controlled conditions. The following recommendations are provided to address the selection of fill material as well as the placement and compaction of engineered fill.

- Processed imported granular material or consistent quality imported clean earth fill, can be considered for engineered fill provided the soil moisture content is within about 2 % of the optimum value of the material. Imported fill should meet the environmental requirements established for the site;
- Engineered fill should only be placed in an area that has been satisfactorily prepared by stripping existing fill and organic soils, and proof rolling the native exposed soil with at least five passes of a minimum 10-ton static pad-foot steel drum type roller;
- Engineered fill should be placed in maximum 300 mm, loose lifts and compacted to a target value of 100 % Standard Proctor Maximum Dry Density (herein "*SPMDD*"). The placement and compaction of each lift should be monitored full time by Landtek, with in-place compaction determined using nuclear moisture/density testing equipment;
- Fill layers that do not meet the compaction requirements, or become wet or frozen, should not be approved for the placement of additional material;
- For engineered fill placement over large areas of varying elevation, the locations of quality control density tests should be recorded by total station survey; and,
- As a precautionary measure and to mitigate cracking, it is recommended that reinforcing steel be provided in footings on engineered fill, and at the top of poured concrete foundation walls. Two 15M bars (continuous) are recommended as a minimum for footing placement. The Structural Engineer should be consulted to confirm the design of such steel reinforcement.

5.3 Frost Susceptibility

The clayey silt to silty sand soils encountered at shallow depths across the site are considered sensitive to water and frost, and their physical and mechanical properties are dependent on in-situ moisture content. As such, the founding soils at the site are considered to have a moderate to high frost susceptibility, being classified as Frost Group "*F4*" (Table 13.1 of the "*Canadian Foundation Engineering Manual*", 4th Edition). However, the identified depths for foundations, as given in Section 5.1 are considered to be below the maximum extents of influence from frost penetration in the Hamilton area.

Should any re-grading be required as part of the proposed development and adjacent to the new structures, it will be important to ensure that the associated exterior footings will have a minimum of 1.2 m of soil cover, or equivalent suitable insulation, for frost protection.

Concerns regarding frost protection to footings are more directed towards those seated within soils. Foundations in the limestone bedrock are generally deemed exempt from any frost protection requirements. This given however, consideration should be given to the use of non-frost susceptible materials as backfill for foundation wall excavations and the installation of foundation drainage in order to minimize the risk of adfreezing.

5.4 Settlement Considerations

Based on the outline information provided for the nature of the proposed redevelopment of the site, it is anticipated that the loads to be applied to the ground by any such structure will be generally moderate intensity. As such, associated settlements are not expected to be large. Therefore, the general limiting of the total settlement to 25 mm and the differential settlement to 19 mm by the recommended geotechnical reaction at the SLS is considered appropriate.

The SLS condition will not govern foundation design in bedrock as the stress required to induce the typical 25 mm settlement criteria at the SLS is anticipated to exceed the ULS. As such. settlements for foundations seated within bedrock are to be deemed negligible (i.e. less than 15 mm).

5.5 Seismic Design Considerations

Based on the soils conditions encountered, and in accordance with Table 4.1.8.4.A. of the current Ontario Building Code (herein "*OBC*"), the site is considered to be a 'C' Site Class for foundations seated within the overburden soils, and a 'B' Site Class for foundations on the limestone bedrock. The acceleration and velocity-based site coefficients, F_a and F_v, should be determined from Tables 4.1.8.4.B. and 4.1.8.4.C. respectively of the OBC for the above recommended Site Class. The seismic design data given in Table 1.2 of Supplementary Standard SB-1 in Volume 2 of the OBC, for selected Municipal locations, should be used to complete the seismic analysis.

5.6 Damp Proofing Considerations

The subsurface areas should be damp proofed and comply with the OBC requirements. As a minimum it is recommended that the damp proofing system include a Delta Drainage Board or MiraDrain 2000 series product, or an approved alternative, along with an asphalt-based spray on wall coating.

6.0 FLOOR SLAB AND PERIMETER DRAINAGE CONSIDERATIONS

Based on the borehole soil conditions and preliminary design information provided to Landtek, it should be possible to construct the lowest (i.e. basement) floor slab level using slab-on-grade methods. The subgrade support conditions are anticipated to be clayey silt and silt, which should provide competent conditions for placing the vapour barrier material. However, after the subgrade has been prepared to the underfloor design elevation it is recommended that the area be assessed by Landtek to determine if there is a need for any remedial work.

It is recommended that a minimum 200 mm layer of clear 19 mm crushed quarried stone be used as the vapour barrier under the floor slab. The vapour barrier stone should meet the requirements of Ontario Provincial Standard Specifications (herein "*OPSS*") 1004 for 19 mm Type II clear stone. If a graded crushed stone is substituted for clear stone, the material should be limited to a maximum of 5 % fines (passing the 0.075 mm sieve). The floor slab thickness should meet the specifications of the project based on anticipated floor loadings.

The finished exterior ground surface should be sloped away from the buildings at a grade in the order of 2 %.

The concrete properties should meet the requirements of OPSS 1350. Contraction and isolation jointing practices should be in accordance with current Portland Cement Association recommendations, as given in the engineering bulletin "*Concrete Floors on Ground*", second edition, by R. E. Spears, and W. C. Panarese.

The design of concrete slabs on native soils may be made on the basis of a value of modulus of subgrade reaction of 25 MPa/m for native subgrade soils.

Perimeter drainage should be provided around all subsurface floor areas where water may accumulate. Underfloor drains may be required depending on excavation and groundwater seepage conditions. Limited groundwater seepage should be anticipated during periods of wet weather. This given, it is recommended that underfloor drains be provided at all deep foundation locations. The drainage system should comply with the OBC and associated amendments. Further details pertaining to perimeter and underfloor drainage systems are provided in Drawings 19104-02 and 19104-03 respectively, in Appendix D.

After the subgrade has been prepared to the underfloor design elevation it is recommended that the area be proof-rolled with a loaded tandem axle dump truck to delineate if there are soft or unstable ground conditions that require repair. This operation should be completed before the underfloor vapour barrier granular material is placed.

7.0 EARTH PRESSURE CONSIDERATIONS ON SUBSURFACE WALLS

The earth pressure, p, acting on subsurface walls at any depth, h, in metres below the ground surface assumes an equivalent triangular fluid pressure distribution and may be calculated using expression (1) below. It is assumed that granular material is used as backfill. Allowances for pressure due to compaction operations should be included in the earth pressure determinations and a value of 12 kPa is applicable for a vibratory compactor and granular material.

If the structure retaining soil can move slightly, the active earth pressure case can be used in determining the lateral earth pressure. For restrained structures and no yielding an "at rest" earth pressure condition should be used. The determination of the earth pressures should be based on the following expression:

$$p = K(\delta h + q) \qquad (1)$$

where:

p	=	the pressure in kPa acting against any subsurface wall at depth, h, in metres (feet) below the ground surface;
K	=	the at rest earth pressure coefficient considered appropriate for subsurface walls; OPSS 1010 Granular B Type 1 (pit-run sand and gravel) material has an effective angle of friction estimated to be 32° with a corresponding at rest earth pressure coefficient, K_o, of 0.45; and,
δ	=	the moist bulk unit weight of the retained backfill; 21.5 kN/m^3.

and,

q	=	the value for any adjacent surcharge in kPa, which may be acting close to the wall; and,
h	=	the depth, in m, at which the pressure is calculated

Granular B backfill should meet OPSS 1010 Type I or Type II material specifications. The granular fill should be compacted to a minimum of 97 % SPMDD, or to the levels and backfilling procedures specified.

Given that bedrock is shallow across the site, the following parameters should be applied for the bedrock when considering lateral pressures on subsurface walls:

- Internal angle of friction (ϕ) should be taken as 26°; and,
- Bulk unit weight (Y) should be taken as 28 kN/m^3.

In designing a subsurface wall within bedrock, a uniform pressure distribution is assumed and is consistent with the maximum earth pressure calculated for the wall where in soil.

8.0 SUBSURFACE CONCRETE

8.1 Concrete Class Considerations

The requirements for subsurface concrete subject to a sulphate and chloride environment are presented in Canadian Standards Association specification, CSA A23.1-14 *"Concrete Materials and Methods of Concrete Construction, Tables 1-4"*. Experience in the area indicates that the native soils generally have a mild sulphate environment and a low chloride concentration. It is recommended that subsurface concrete at the site have the following characteristics for an S-3 exposure class:

- minimum 28-day compressive strength = 25 MPa;
- minimum 56-day strength = 30 MPa;
- maximum water to cement ratio = 0.50;
- cementing materials:
  MS hydraulic cement or MSb; as per tables 3 and 4 respectively in CSA A23.1-14; and,
- air content:
  4 – 7 % for 14 mm to 20 mm nominal size coarse aggregate
  3 – 6 % for 28 mm to 40 mm nominal size coarse aggregate

The concrete should be placed without segregation and should be consolidated to achieve a uniform dense mass.

8.2 Methods for Specifying Concrete

Alternative methods of specifying concrete for a project are outlined in CSA A23.1-14 and allow for "*Performance*" or "*Prescription*" based methods. Each method attaches different levels of responsibility to the owner, the contractor, and the concrete supplier. The pros and cons of each method should be examined prior to completion of the specifications for the project.

9.0 EXCAVATION AND BACKFILL CONSIDERATIONS

9.1 General Excavation Considerations

All temporary excavations and unbraced side slopes in the soils should conform to standards set out in the Occupational Health and Safety Act, Ontario Regulation 213/91 "*Construction Projects*" (herein "*OHSA*"). The subsurface soils to be encountered during excavation at the site are expected, in general, to behave as *"Type 3"* materials according to the OHSA classification in Part III. Type 3 materials are characteristic of the generally stiff or compact "*clayey silt and silt*". The *"limestone/dolostone bedrock*" has strength characteristics that exceed *"Type 1"* soils.

Given the size of the site and the anticipated maximum depths of excavation for the proposed structures, vertical cut excavations are not anticipated during the construction phase. It should be possible to excavate the overburden soils with a hydraulic backhoe. Moist Type 3 soils are expected to be stable for short construction periods at slopes of approximately 45° to the horizontal (i.e. 1V:1H).

Excavation into the dolostone/limestone bedrock will require the use of more unconventional, heavier excavation equipment such as a rock chisel/breaker or a rock-ripping (tiger teeth-fitted) excavator bucket, particularly as the competence of dolostone/limestone bedrock tends to improve very quickly with depth. The dolostone/limestone bedrock is expected to remain relatively stable at near vertical slopes for short periods of time.

Consideration should be given to any existing trench excavations and associated backfill that may be present directly behind cut slopes within the native soils that may appear to be stable on first excavation. In these circumstances, slopes can suddenly slough or collapse due to the affects of the adjacent backfill. Consequently, for excavation conditions that cannot satisfy the OHSA requirements for unbraced 1H:1V side slopes, a trench box system should be used, or temporary shoring should be installed to maintain safe working conditions. This may be more applicable to service trench excavations, though may also apply to basement excavations etc., particularly where in close proximity to new road pavements or associated infrastructure.

Water seepage was encountered during the drilling process in borehole BH2 at a depth of approximately 3.3 m. It should be noted that this groundwater level is not considered to reflect the long-term stabilized water table, and is considered likely to be more representative of water perched within the silt stratum as a result of the low permeability dolostone/limestone bedrock preventing its escape.

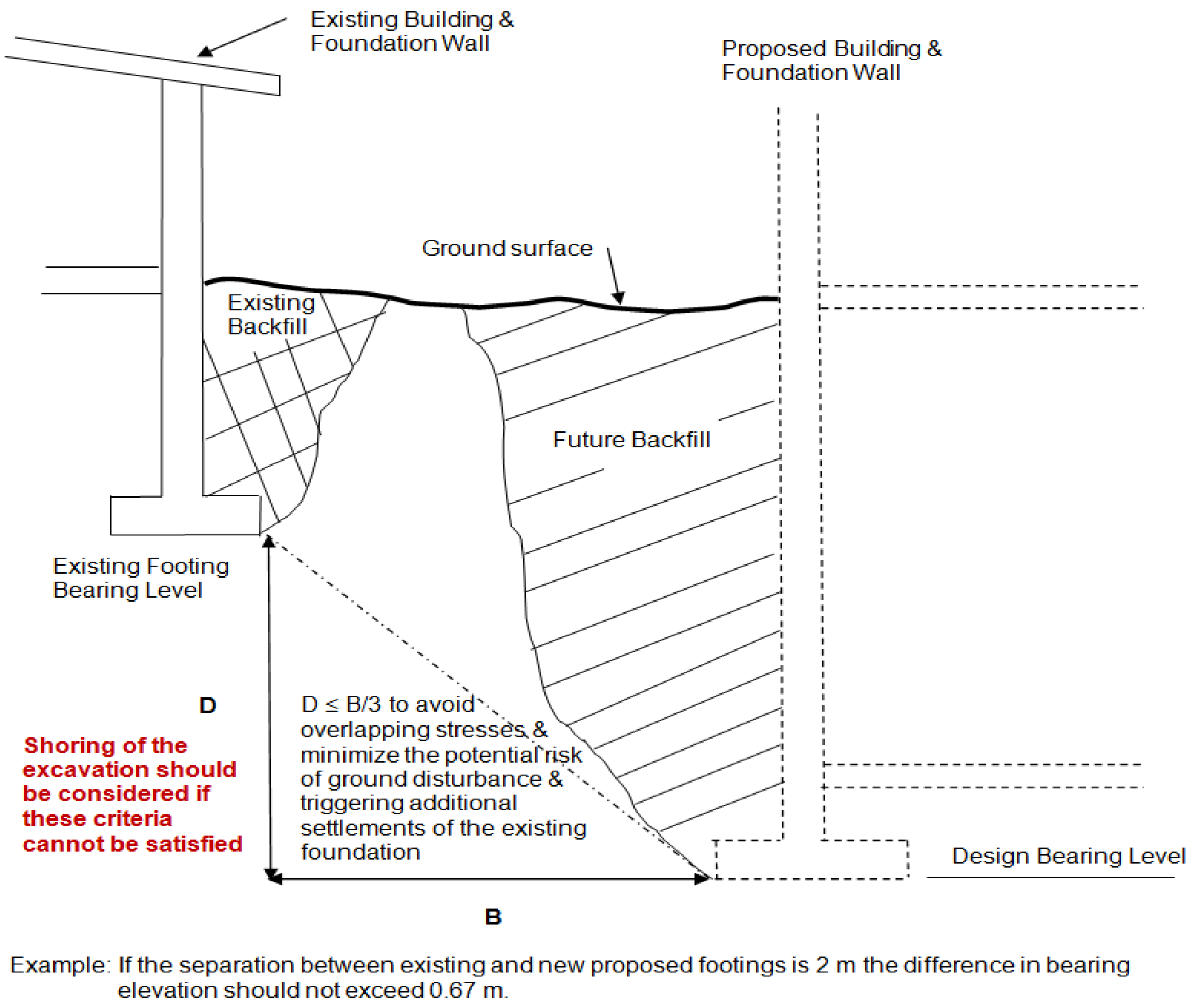
This given, it is expected that any groundwater seepage during excavation work should be able to be controlled by pumping from sumps at the base of the excavation. Water seepage into open excavations is not expected to be a construction issue such that the project would require either registration under the Environmental Activity and Sector Registry (herein "*EASR*") framework (i.e. exceeding 50,000 l/day but less than 400,000 l/day) or a Permit To Take Water (herein "*PTTW*") for amounts greater than 400,000 l/day.

A permeability (k) value of between 1 x 10^{-5} cm/s and 1 x 10^{-6} cm/s should be applied to water volume calculations for the clayey silt and silt deposits.

It should be noted that the design of a temporary shoring system, should one be required, is the responsibility of the Contractor. Therefore, a specialist shoring contractor should be consulted to provide the most appropriate shoring type method and associated installation procedures. In any event, the shoring design should be based on the procedures outlined in the latest edition of the "*Canadian Foundation Engineering Manual*". It is also recommended that lateral and vertical movement of the shoring system be monitored during construction to ensure that movements are within the acceptable range.

Excavations for new foundations should satisfy the criteria given in the example shown in Figure 9.1.1 to avoid overlapping stresses and minimize the risk of undermining existing adjacent structures, including utilities, and/or triggering additional settlements of the existing structures due to soil disturbance.

Figure 9.1.1: Criteria for Assessing Excavation Shoring Requirements (Not to Scale)



9.2 General Backfill Considerations

Backfill next to foundation walls and in service trenches should be selected to be compactable in narrow trench conditions. The overburden soils are expected to be reusable as trench backfill and backfill around the proposed structures on the site. Any variation in the moisture contents of the soils encountered may require selective separation of material to avoid the use of wet soil.

Should excavation in the dolostone/limestone bedrock be required, then the dolostone/limestone can be reused as backfill, provided that the dolostone/limestone particle sizes are broken down to minus 200 mm material, the moisture content of the material is maintained at near optimum levels, the rock particles are mixed with the native soils to reduce void spaces, and the material is placed in maximum lift thicknesses of 300 mm.

Site servicing trench backfill should be uniformly compacted to a density that minimizes the risk of long-term settlements. It is recommended that the target compaction specification for trench backfill be 97 % SPMDD with no individual test below 95 % SPMDD.

During inclement weather the native soils may become too wet to achieve satisfactory compaction. If construction is proposed for late in the year, a reduced level of trench compaction with a higher risk of future settlements is to be anticipated, and it is recommended that provisional contract quantities be established for the supply and placement of imported granular fill under such circumstances. The imported granular should meet the requirements of OPSS 1010 for Granular B Type I material as a minimum requirement.

10.0 SITE SERVICING CONSIDERATIONS

There is no indication that special pipe bedding materials or procedures are required for the installation of services. All bedding cover and backfill materials should be selected in accordance with OPSS 1010 Aggregates – Base, Subbase, Select Subgrade, and Backfill Material.

The pipes should be placed with a minimum bedding thickness in conformance of OPSD 802.010 series (typical 150 mm for flexible pipes, OPSD 802.010, 802.013 and 802.014). The use of normal Class B type bedding is applicable for the pipe.

Bedding material shall be placed in layers not exceeding 300 mm in thickness, loose measurement, and compacted to 95 % of the SPMDD before a subsequent layer is placed. Site servicing trench backfill should be uniformly compacted to a density that minimizes the risk of long-term settlements. Bedding on each side of the pipe shall be completed simultaneously. At no time shall the levels on each side differ by more than the 300 mm uncompacted layer. The remainder of the trench should be backfilled as per the requirements defined in Section 9.0.

It is assumed all services will have a minimum of 1.2 m of soil cover for frost protection. For services installed at shallower depths, suitable insulation for frost protection is recommended.

11.0 SOIL MANAGEMENT CONSIDERATIONS

Construction for the proposed development may involve cut and fill operations. From a geotechnical perspective, and in order to optimize the use of the on-site soils, a Soil Management Plan should be established. The plan objective should be to achieve a self-sustainable development with respect to excavated materials, and control the placement of organic soils so that there is negligible impact on the settlement performance of the compacted fill material.

The soil management criteria should be as follows:

- Surface vegetation, topsoil and organic soils should not be placed within the proposed roadways, below finished subgrade level for pavement construction or building limits. These materials should be placed in landscaped areas where settlements are not critical;

- Excavated soils for structural fill in pavement areas and building floor slab areas, which does not have topsoil or organic matter and are compactable with moisture contents within 2 % to 3 % of the optimum value, should be placed and compacted to a target density of 97 % of the SPMDD with no individual test result below 95 % SPMDD; if engineered fill to support building foundations is being considered it is recommended that a pre-construction meeting be scheduled to review the proposed fill materials, fill placement and compaction procedures, and the testing and inspection requirements;

- Soils to be placed in landscaped areas where settlements are not critical should receive nominal compaction effort in order to achieve at least 90 % of the SPMDD; and,

- Prior to the placement of underfloor granular fill, the exposed subgrade soil should be inspected and proof-rolled using a loaded tandem axle truck and traversing the exposed subgrade for full coverage; the proof-rolling should be monitored by a geotechnical representative of this office to delineate any soft areas which may require repair.

12.0 PAVEMENT CONSIDERATIONS

12.1 At-Grade Pavement Design Considerations

The proposed development is anticipated to include new access road pavements and parking areas. Recommended pavement structure layer thicknesses are provided in Table 12.1.1. Site specific development requirements set out by the Corporation of the City of Hamilton (herein "*City of Hamilton*") may override the recommendations of this report.

The recommended pavement design section takes into account the accepted design practice that the total pavement structure thickness should meet or exceed one-half the anticipated depth of frost penetration for the geographical area (i.e. 1.2 m) or as close as practicable. Should any proposed road pavements be constructed for adoption by the City of Hamilton, then such pavements are to be constructed in accordance with City of Hamilton pavement design requirements.

Table 12.1.1: Recommended Pavement Structure Layer Thicknesses

Pavement Layer	Access and Fire Routes	Light Duty Pavement Areas
Surface Course Asphalt OPSS HL 3	50 mm	50 mm
Binder Course Asphalt OPSS HL 8	60 mm	50 mm
Granular Base OPSS Granular A	150 mm	150 mm
Granular Subbase OPSS Granular B, Type II	350 mm[1]	250 mm[1]
Total Thickness	610 mm	500 mm

Notes:
1. If construction proceeds late in the year (i.e. November and December), the design thickness of pavement granular materials may have to be increased to address potential problems with subgrade instability and facilitate construction vehicle and truck access.

12.2 Deck Pavement Design Considerations

As a minimum, any proposed deck pavement should comprise a minimum 50 mm cover of OPSS HL 3 asphalt. Any bedding or grading material to be placed between the concrete deck and the asphalt pavement surface should comprise either blinding sand or OPSS Granular A material, depending on the thickness of the layer required.

12.3 Pavement Construction Considerations

The overall performance of the pavement structure will greatly depend upon the support provided by the developed subgrade. A number of factors should be considered at the construction stages to ensure that an acceptable subgrade condition is developed and maintained:

- Sub-drains should be installed and should be 100 mm diameter perforated plastic pipe, with outfalls to catch basins at a continuous and uniform grade. The sub-drains should conform to OPSD 216.01;

- Any soft areas of notable deflection to the subgrade should be sub-excavated and replaced with a suitable backfill material approved by a qualified geotechnical engineer and compacted to 98 % of its SPMDD;
- The subgrade should be properly shaped, crowned and then proof-rolled under the full time observation of a geotechnical representative of this office to delineate any soft areas which may require repair before placing the granular materials; and,
- Surface water should not be allowed to pond on the surface of or adjacent to the outside edges of any developed subgrade.

Should the pavements proposed for the development be constructed as a two-stage paving operation it will important to ensure that the following is undertaken to develop the surface of the binder course being used as a "*temporary*" surface during the construction phase:

- The surface is thoroughly cleaned and power washed to remove all residual contaminants;
- All deficiencies are corrected to meet the required design specifications; and,
- A suitable tack coat is appropriately applied immediately prior to the placement of the upper asphaltic concrete course(s).

Such preparatory works are to be completed in accordance with the appropriate OPSS, as required.

12.4 Pavement Materials

Granular Base Course and Subbase

The granular base course materials should meet OPSS Granular "A" specifications. Quarried 20 mm limestone crushed to Granular "A" gradation specifications is recommended. If the option with granular subbase material is used, the granular subbase should meet OPSS Granular B Type II requirements for 100 % crushed quarried bedrock (50 mm crusher-run limestone).

Hot Mix Asphalt

The binder course and surface course asphalt should meet current specifications for HL 8 and HL 3 respectively, as prescribed by the City of Hamilton or, alternatively, OPSS 1150.

The standard asphalt binder grade for the climate conditions in the Hamilton area is PG 58-28. Given the anticipated low volume of commercial truck traffic it is considered that there is no requirement for a bump up to a higher PG grade of asphalt cement.

Compaction

Granular base course and subbase course fill material should be compacted to 100 % SPMDD. Hot mix asphalt should be compacted to the criteria set out by the City of Hamilton.

12.5 Subgrade Considerations

The subgrade conditions and bearing strength may be variable along the road section and some subgrade repairs should be anticipated. It is therefore recommended that, prior to the placement of pavement granular fill, the exposed subgrade soil should be inspected and proof-rolled using a loaded tandem axle truck to traverse the exposed subgrade and provide for full coverage. The proof-rolling should be monitored by a geotechnical representative of this office to delineate any soft areas which may require repair. Repairs should be undertaken to avoid creating "*bathtub*" conditions in the subgrade within the pavement structure.

13.0 CLOSURE

The Limitations of Report, as stated in Appendix A, are an integral part of this report.

Soil samples will be retained and stored by Landtek for a period of three months after the report is issued. The samples will be disposed of at the end of the three-month period unless a written request from the client to extend the storage period is received.

We trust this report will be of assistance with the design and construction of the proposed development. Should you have any questions, please do not hesitate to contact our office.

Yours sincerely,

LANDTEK LIMITED

Isaac Asonya, EIT
Author

LICENSED PROFESSIONAL ENGINEER
R. DI CIENZO
May 27/19
PROVINCE OF ONTARIO

James Dann, B.Eng. (Hons)
Manager, Geotechnical Projects

Ralph Di Cienzo, P. Eng.
Consulting Engineer

APPENDIX A
LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the borehole locations. Subsurface and ground water conditions between and beyond the Boreholes may be different from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the geotechnical investigation. It is recommended practice that Landtek be retained during construction to confirm that the subsurface conditions throughout the site are consistent with the conditions encountered in the Boreholes.

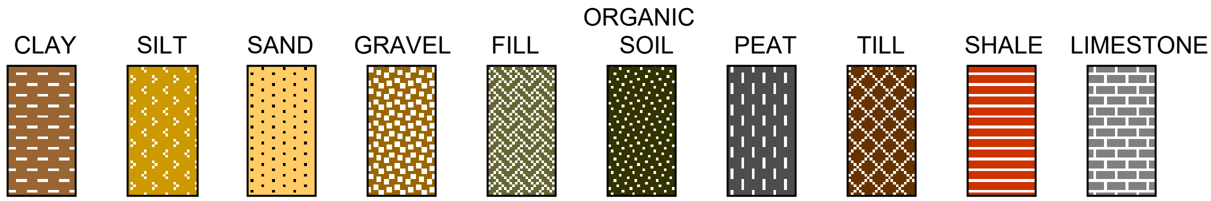
The comments made in this report on potential construction problems and possible remedial methods are intended only for the guidance of the designer. The number of Boreholes may not be sufficient to determine all the factors that may influence construction methods and costs. For example, the thickness and quality of surficial topsoil or fill layers may vary markedly and unpredictably. Additionally, bedrock contact depths throughout the site may vary significantly from what was encountered at the exact borehole locations. Contractors bidding on the project or undertaking construction on the site should make their own interpretation of the factual borehole information, and establish their own conclusions as to how the subsurface conditions may affect their work.

The survey elevations in the report were obtained by Landtek Limited or others, and are strictly for use by Landtek in the preparation of the geotechnical report. The elevations should not be used by any other parties for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Landtek Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

This report does not reflect environmental issues or concerns related to the property unless otherwise stated in the report. The design recommendations given in the report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, it is recommended that Landtek Limited be retained during the final design stage to verify that the design is consistent with the report recommendations, and that the assumptions made in the report are still valid.

APPENDIX B
SYMBOLS AND TERMS USED IN THE REPORT



RELATIVE PROPORTIONS

Term	Range
Trace	0 - 5%
A Little	5 – 15%
Some	15 – 30%
With	30 – 50%

CLASSIFICATION BY PARTICLE SIZE

Boulder -------------------- > 200 mm
Cobble --------------------- 80 mm – 200 mm
Gravel -
Coarse ---------- 19 mm – 80 mm
Fine -------------- 4.75 mm – 19 mm
Sand -
Coarse ---------- 4.75 mm – 2 mm
Medium -------- 2 mm – 0.425 mm
Fine -------------- 0.425 mm – 0.75 mm
Silt ------------------------- 0.075 mm – 0.002 mm
Clay ------------------------ < 0.002 mm

DENSITY OF NON-COHESIVE SOILS

Descriptive Term	Relative Density	Standard Penetration Test
Very Loose	0 – 15%	0 – 4 Blows Per 300 mm Penetration
Loose	15 – 35%	4 – 10 Blows Per 300 mm Penetration
Compact	35 – 65%	10 – 30 Blows Per 300 mm Penetration
Dense	65 – 85%	30 – 50 Blows Per 300 mm Penetration
Very Dense	85 – 100%	Over 50 Blows Per 300 mm Penetration

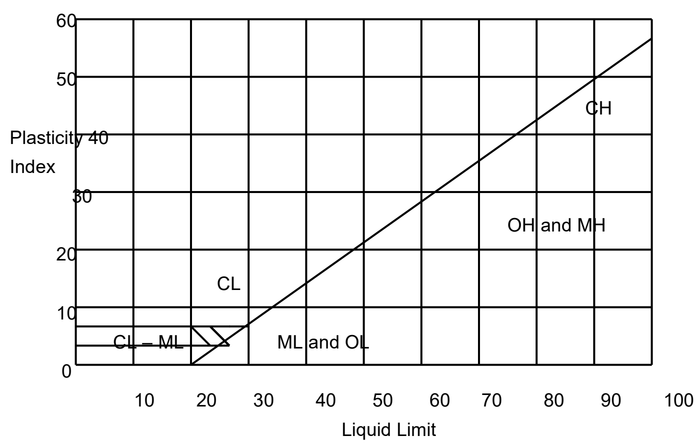
CONSISTENCY OF COHESIVE SOILS

Descriptive Term	Undrained Shear Strength kPa (psf)	N Value Standard Penetration Test	Remarks
Very Soft	< 12 (< 250)	< 2	Can penetrate with fist
Soft	12 – 25 (250 – 500)	2 – 4	Can indent with fist
Firm	25 – 50 (500 –1000)	4 – 8	Can penetrate with thumb
Stiff	50 – 100 (1000 – 2000)	8 – 15	Can indent with thumb
Very Stiff	100 – 200 (2000 – 4000)	15 – 30	Can indent with thumb-nail
Hard	> 200 (> 4000)	> 30	Can indent with thumb-nail

Notes: 1. Relative density determined by standard laboratory tests.
2. N value – blows/300 mm penetration of a 623 N (140 Lb.) hammer falling 760 mm (30 in.) on a 50 mm O.D. split spoon soil sampler. The split spoon sampler is driven 450 mm (18 in.) or 610 mm (24 in.). The “N” value is the Standard Penetration Test (SPT) value and is normally taken as the number of blows to advance the sampler the last 300 mm.

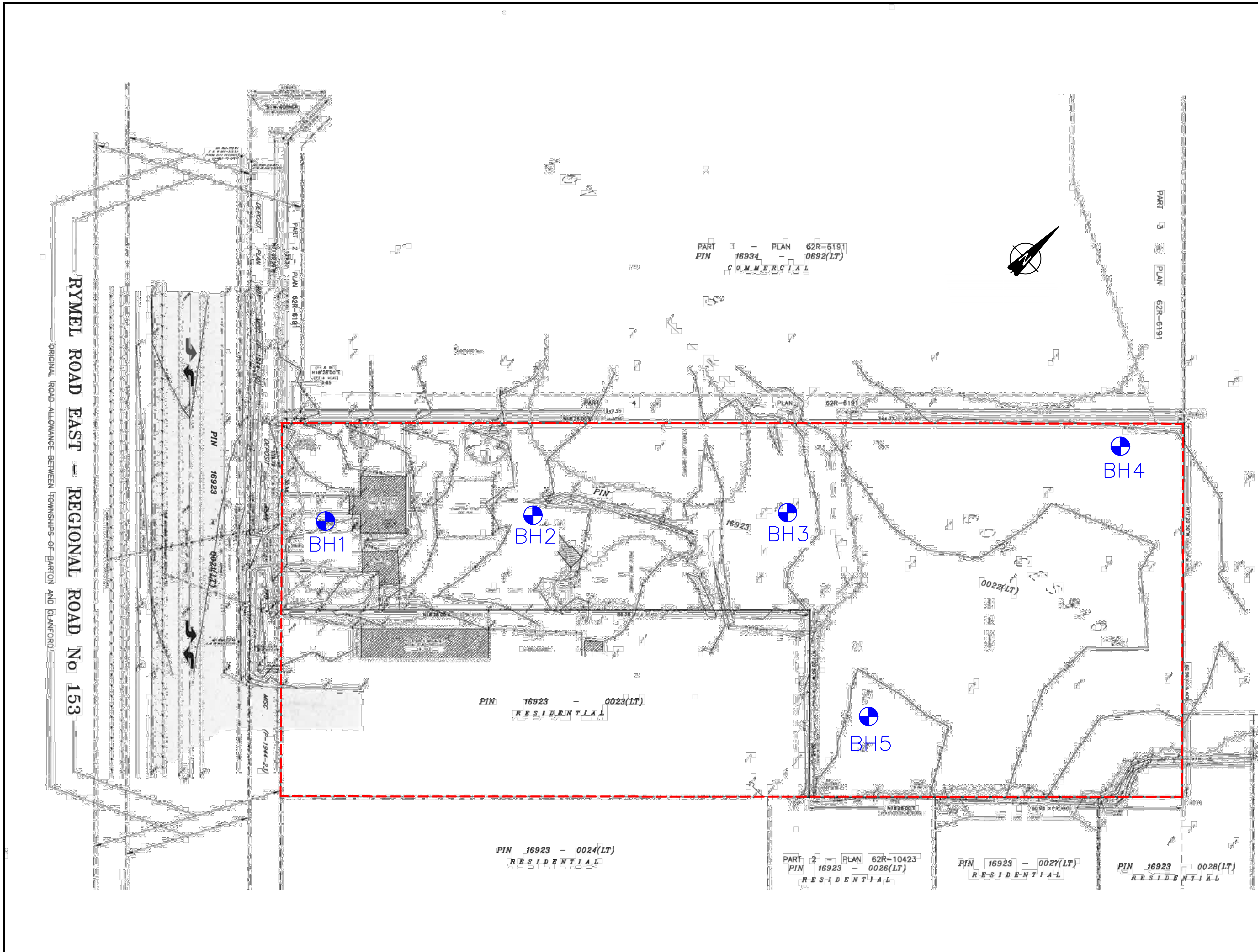
APPENDIX B CONTINUED
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 69 AND D 2488 – 69
(Unified Soil Classification System)

Major Divisions			Group Symbols	Typical Names	Classification Criteria		
Coarse-grained soils More than 50% retained on No. 200 sieve *	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	**GW**	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve . . . . . . GW, GP, SW, SP More than 12% pass No. 200 sieve . . . . . GM, GC, SM, SC 5 to 12% pass No.200 sieve . . . . Borderline classifications requiring use of dual symbols	C_u=D60/D10 greater than 4; C_z = $(D30)^2/(D10xD60)$ between 1 and 3	
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW	
		Gravels with fines	**GM**	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean Sands	**SW**	Well-graded sands and gravelly sands, little or no fines		C_u=D60/D10 greater than 6; C_z = $(D30)^2/$ (D10xD60) between 1 and 3	
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW	
		Sands with fines	**SM**	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils 50% or more passes No. 200 sieve *	Silts and clays Liquid limit 50% or less		**ML**	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Plasticity Chart For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols. Equation of A-line: PI=0.73 (LL-20)		
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silts			
			OL	Organic silts and organic silts of low plasticity			
	Silts and clays Liquid limit greater than 50%		**MH**	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts			
			CH	Inorganic clays of high plasticity, fat clays			
			OH	Organic clays of medium to high plasticity			
	Highly organic soils		**Pt**	Peat, much and other highly organic soils	* Based on the material passing the 3 in. (76mm) sieve.		



APPENDIX C

DRAWING 19104-01 – BOREHOLE LOCATION PLAN
BOREHOLE LOGS



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project location

key

Approximate location of boreholes drilled by Landtek Limited on April 12, 2019.

Borehole locations are considered approximate.

Base plan provided by Chambers and Associates Surveying Ltd.

Key plan provided by google maps.

revisions/ submissions

#	date	description
1	2019-05-22	issued for report

client
Royal Living Development Group

municipality
The Corporation of the City of Hamilton

project
Geotechnical Investigation
705 & 713 Rymal Road East

sheet
Borehole Location Plan

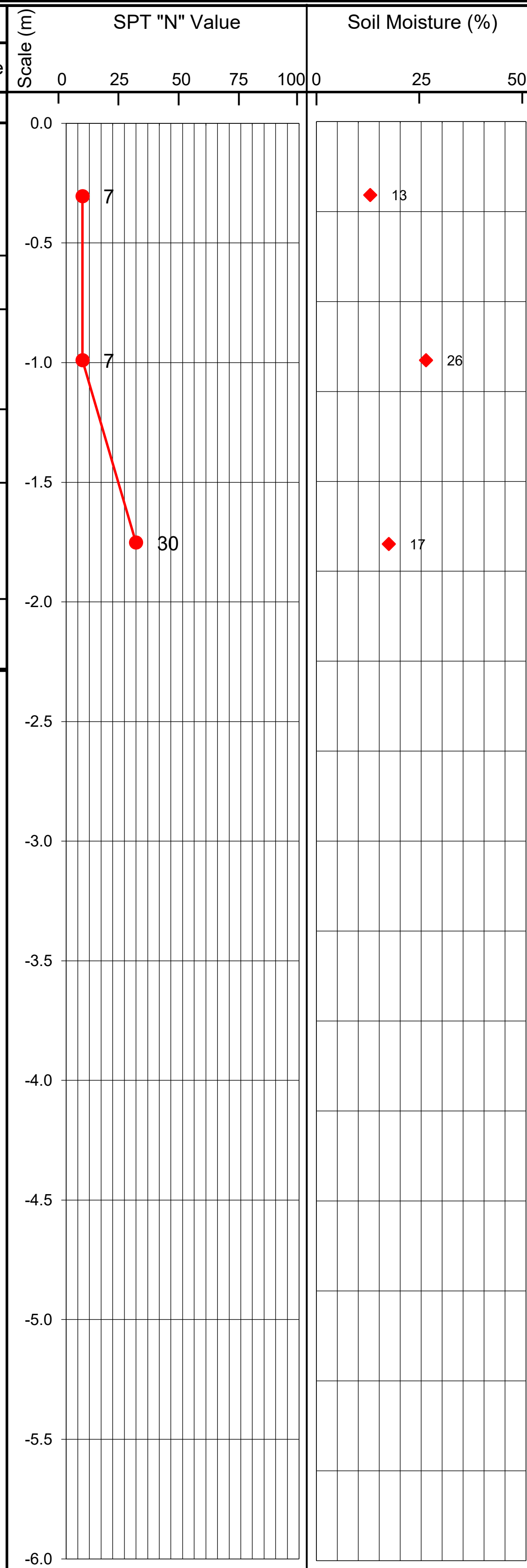
date: May 22, 2019
drawn: RF
checked: IA
project #: 19104
scale: NOT TO SCALE

19104-01

LANDTEK LIMITED BH 1

Project No.:	19104	Drill Date:	April 12, 2019
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	705 & 713 Rymal Road East, Hamilton, Ontario	Datum:	Geodetic (approximate)

Material Description	Symbol	Elev. / Depth	Samples No.	Samples Type	GWL	Monitor Details	Test Data
Ground Surface		218.8					
±100 mm of topsoil		0.0					
FILL: silty clay, brown, firm, moist			1	SS			
0.7 to 1.5 m: clayey silt, brown, firm, very moist			2	SS			
		217.3					
CLAYEY SILT: trace gravel, trace shale, brown, trace iron straining, very stiff, moist		1.5	3	SS			
		216.7					
BOREHOLE REFUSAL ON PRESUMED BEDROCK		2.1					



Notes:
1. On completion, borehole open to 2.1 m.
2. Static groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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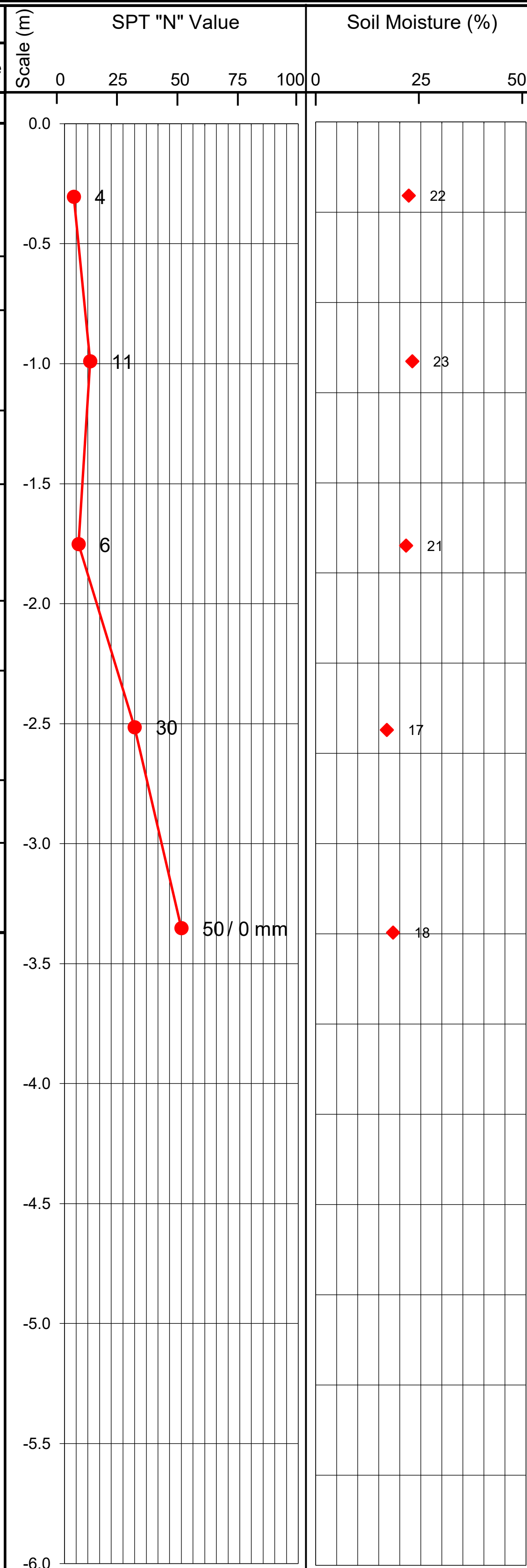
LANDTEK LIMITED

BH 2

Project No.:	19104	Drill Date:	April 12, 2019
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	705 & 713 Rymal Road East, Hamilton, Ontario	Datum:	Geodetic (approximate)

Material Description	Elev. / Depth	Sample No.	Sample Type	SPT "N" Value	Soil Moisture (%)
Ground Surface	217.6				
±150 mm of topsoil	0.0				
FILL: clayey silt, some organic, brown, soft to firm, very moist		1	SS	4	22
	216.9 / 0.7				
CLAYEY SILT: brown, stiff, very moist		2	SS	11	23
1.5 to 2.0 m: trace shale, trace gravel, firm		3	SS	6	21
	215.3 / 2.3				
SILT: trace clay, trace shale, trace gravel, brown, compact to dense, moist		4	SS	30	17
at 3.3 m: wet		5	SS	50 / 0 mm	18
	214.3 / 3.3				
BOREHOLE REFUSAL ON PRESUMED BEDROCK					



GWL | Monitor Details | Test Data

Notes: 1. On completion, borehole open to 3.3 m.
2. Static groundwater at 3.3 m.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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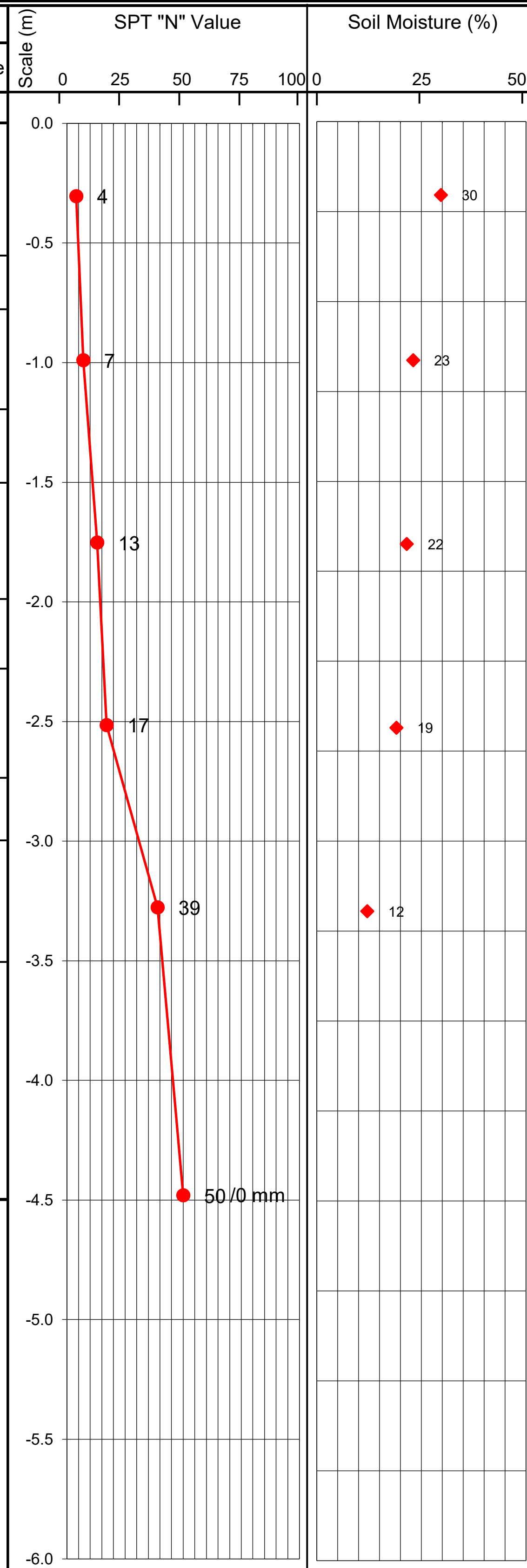
BH 3

Project No.:	19104	Drill Date:	April 12, 2019
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	705 & 713 Rymal Road East, Hamilton, Ontario	Datum:	Geodetic (approximate)

Material Description	Elev. / Depth	Samples No.	Samples Type
Ground Surface	217.7		
±300 mm of topsoil	0.0		
FILL: silty clay, some organic, brown, soft to firm, moist	217.1	1	SS
CLAYEY SILT: brown and grey, firm, moist	0.6 / 216.2	2	SS
SILT: trace clay, trace shale, brown, compact, very moist 2.6 m to 4.5 m: grey 3.0 m to 4.5 m: dense	1.5 / 213.2	3 4 5	SS SS SS
BOREHOLE REFUSAL ON PRESUMED BEDROCK	4.5		



GWL | Monitor Details | Test Data

Notes: 1. On completion, borehole open to 4.5 m.
2. Static groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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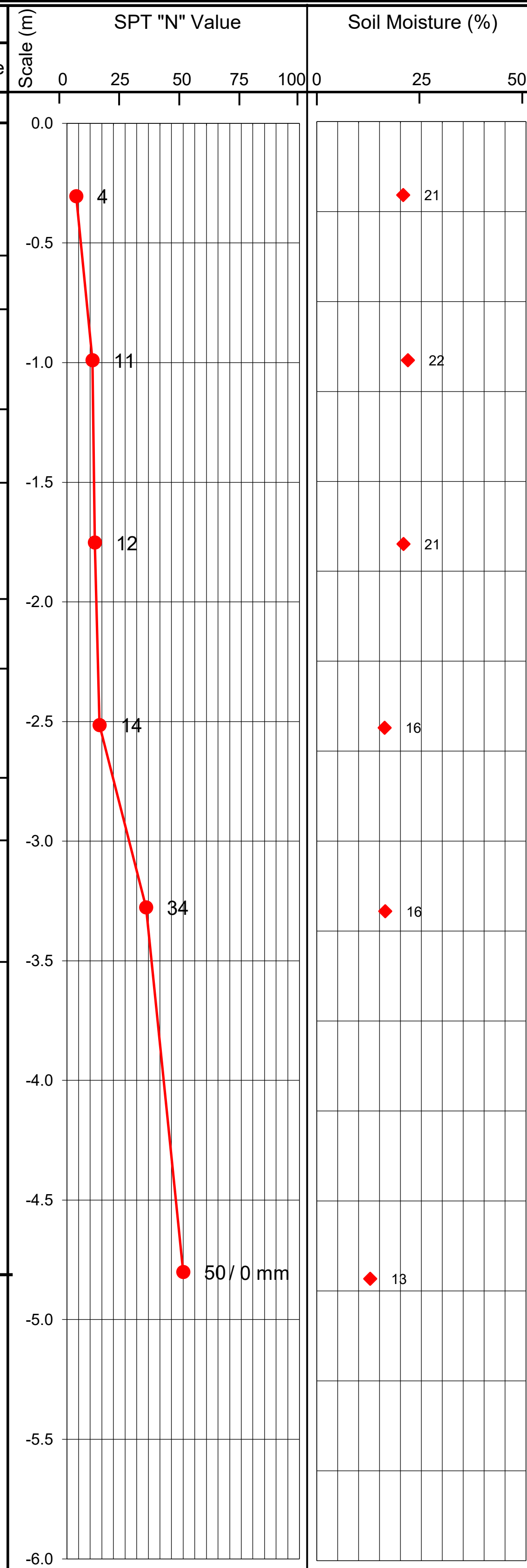
LANDTEK LIMITED BH 4

Project No.:	19104	Drill Date:	April 12, 2019
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	705 & 713 Rymal Road East, Hamilton, Ontario	Datum:	Geodetic (approximate)

Material Description	Elev. / Depth	Samples No.	Samples Type
Ground Surface	217.7		
±300 mm of topsoil	0.0		
FILL: silty clay, some organic, brown, soft, moist	217.1	1	SS
CLAYEY SILT: brown and grey, stiff, moist	0.6 / 216.2	2	SS
SILT: trace clay, trace shale, brown, compact, moist	1.5	3	SS
2.3 to 4.7 m: grey		4	SS
3.0 to 4.7 m: dense		5	SS
4.5 to 4.7 m: trace limestone fragments	213.0		
BOREHOLE REFUSAL ON PRESUMED BEDROCK	4.7		



GWL | Monitor Details | Test Data

Notes:	1. On completion, borehole open to 4.7 m.
	2. Static groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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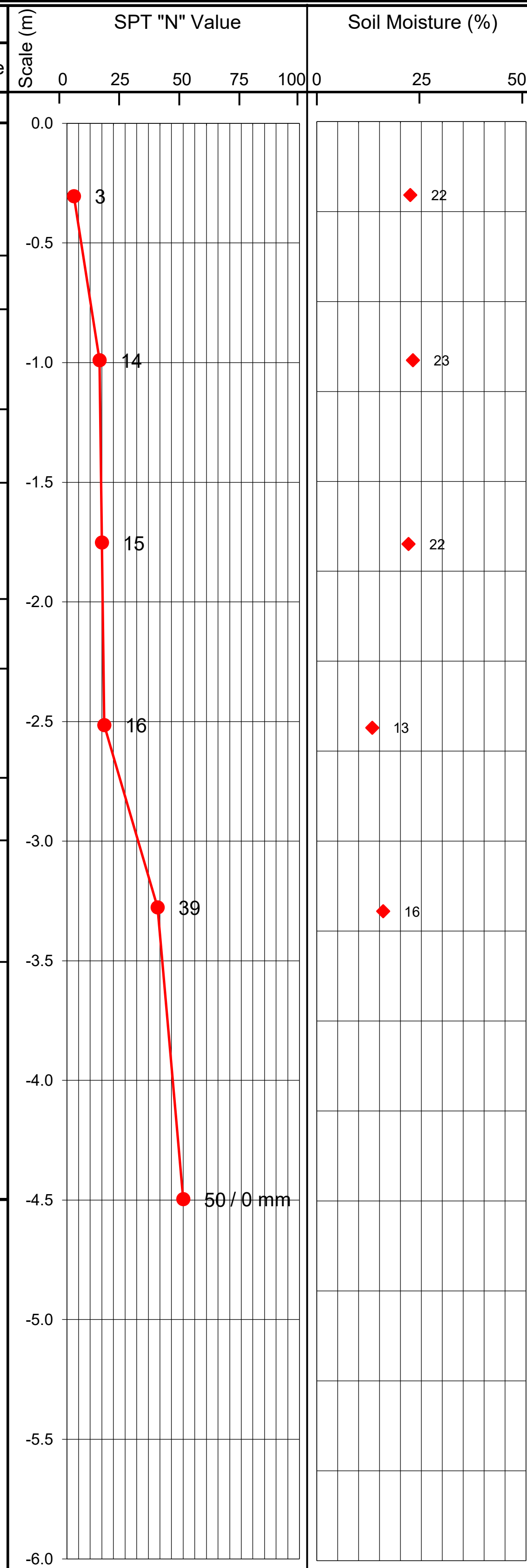
BH 5

Project No.:	19104	Drill Date:	April 12, 2019
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	705 & 713 Rymal Road East, Hamilton, Ontario	Datum:	Geodetic (Approximate)

Material Description	Elev. / Depth	Samples No.	Type	SPT "N" Value	Soil Moisture (%)
Ground Surface	217.3				
±300 mm of topsoil	0.0				
FILL: silty clay, some organic, brown, soft, moist	216.7	1	SS	3	22
CLAYEY SILT: brown and grey, stiff, moist	0.7	2	SS	14	23
	215.8				
SILT: trace clay, trace shale, brown, compact, moist	1.5	3	SS	15	22
2.3 m to 4.5 m: grey		4	SS	16	13
3.0 to 4.5 m: dense		5	SS	39	16
	212.8			50 / 0 mm	
BOREHOLE REFUSAL ON PRESUMED BEDROCK	4.5				



Notes: 1. On completion, borehole open to 4.5 m.
2. Static groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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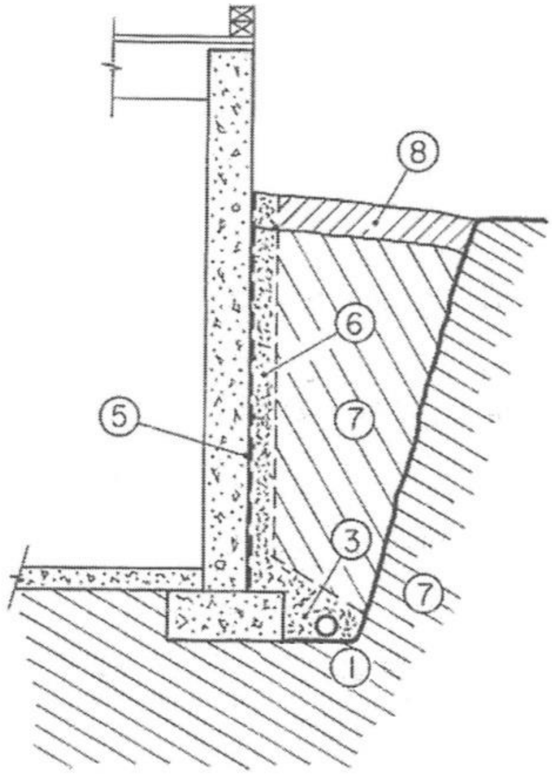
APPENDIX D

DRAWING 19104-02 – ENGINEERING COMMENTARIES – GENERAL REQUIREMENTS FOR DRAINAGE TO BASEMENT STRUCTURES

DRAWING 19104-03 – ENGINEERING COMMENTARIES – GENERAL REQUIREMENTS FOR UNDERFLOOR DRAINAGE SYSTEMS



① 100 mm, perforated or slotted pipe placed below the upper level of the floor slab.;
③ Filter material that is compatible with the grain size characteristics of the fine grained foundation and backfill soils, as well as with the perforations of the pipe;
④ Filter material continuously or intermittently placed next to the foundation wall to intercept water draining from window wells, down exterior walls and from low areas near the building;
⑤ Damp-proofing on wall – optional depending on the quality of the concrete wall;
⑥ Optional use of sheet drain, or synthetic fire blanket, next to the foundation wall to replace the soil filter according to ④;
⑦ Foundation and backfill soils, which may contain fine grained and erosion-susceptible materials;
⑧ "*Topping off*" material is to be graded such that it slopes outwards to lead surface water away from the building. It is usually desirable to use low permeability topsoil to reduce the risk of overloading the drainage pipe.

Based on Figure 12.1, Canadian Foundation Engineers Manual, Fourth Edition, 2006.

Additional Notes:

1. The perforated or slotted drainage pipe is to lead to a positive drainage sump or outlet. The invert of the pipe is to be a minimum of 150 mm below the underside of the proposed floor slab.
2. Backfill materials to the interior of the foundation walls may be clean, organic-free soils that can be compacted to the specified density within in a confined space.
3. Heavy, vibratory compaction equipment should not be used within 450 mm of the foundation wall. Fill is not to be placed or compacted within 1.8 m of the wall unless fill is being placed simultaneously on both sides of the wall.
4. The moisture barrier beneath the floor slab is to comprise at least 200 mm of compacted19mm clear stone or an equivalent free-draining material.
5. Should the 19 mm clear stone require surface blinding then 6mm stone chips are to be used.
6. The slab on grade should not be structurally connected to the foundation wall or footing.

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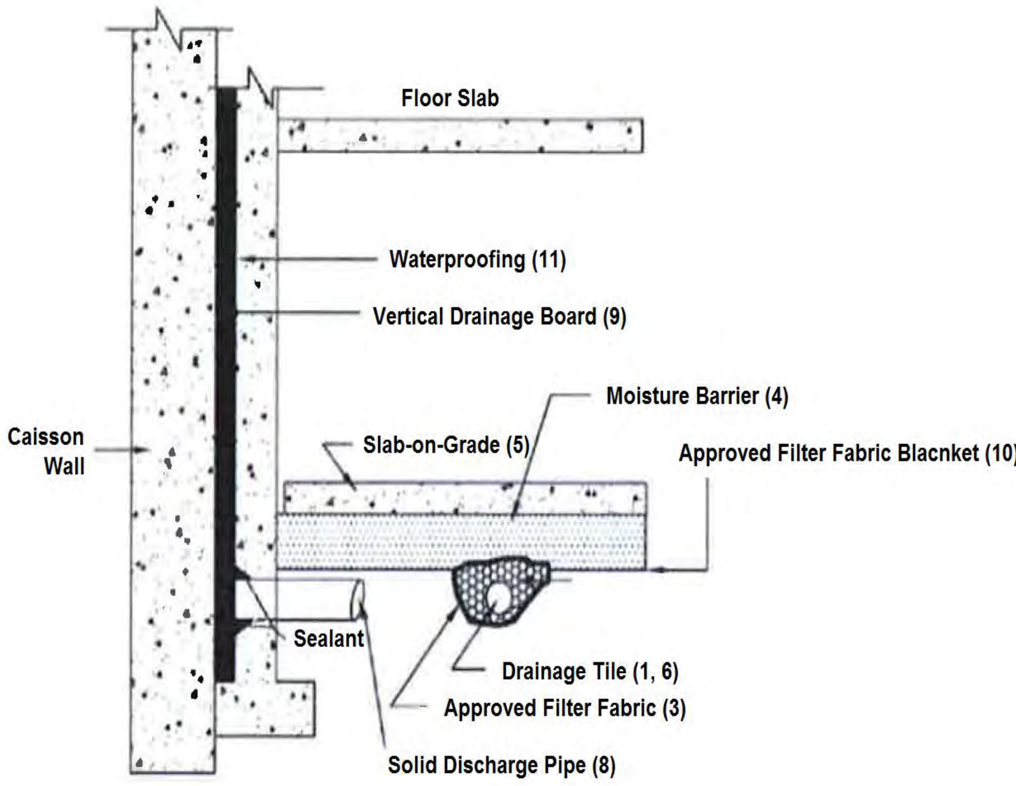
General Requirements for Drainage to Basement Structures			
client	Royal Living Development Group		
project	705 & 713 Rymal Road East, Hamilton, Ontario		
project #	19104	drawing #	2



Notes:

1. Drainage tile to consist of 100 mm diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet, spaced between columns;
2. 19 mm clear stone – 150 mm top and side of drain. If the drain is not on the footing then place 100 mm of 19 mm clear stone below the drain;
3. Wrap the clear stone with an approved filter fabric (e.g. Terrafix 270R or equivalent);
4. Moisture barrier to be at least 200 mm of compacted, 19 mm clear stone or equivalent (and approved), free-draining material. A vapour barrier may be required for specialty floor coverings;
5. Typically, the slab-on-grade is not structurally connected to the wall or footing. However, if it is connected to the walls it should be designed accordingly;
6. Underfloor drain invert to be at least 300 mm below underside of floor slab. Drainage tile should be placed in parallel rows 6 m to 8 m centres one way. Place drains on 100 mm of 19 mm clear stone and 150 mm of 19 mm clear stone on top and sides. Enclose clear stone with filter fabric as prescribed in Note (3);
7. Do not connect underfloor drainage to perimeter drainage. The two systems are to remain separate.
8. Locate solid discharge at the middle of each bay between soldier piles;
9. Vertical drainage board (e.g. MiraDrain 6000 or equivalent) with filter cloth should be continuous from bottom to 1.2 m below exterior finished grade;
10. The entire subgrade is to be sealed with an approved filter fabric as in Note (3) where non-cohesive (silty/sandy/granular) soils are encountered below the groundwater table;
11. The basement walls must be waterproofed using bentonite or an equivalent waterproofing system;
12. The Geotechnical Report should be reviewed for site-specific details. Final detail must be approved before system is considered acceptable.

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General Requirements for Underfloor Drainage Systems			
client	Royal Living Development Group		
project	705 & 713 Rymal Road East, Hamilton, Ontario		
project #	19104	drawing #	3