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A REPORT TO
SEAN MASON HOMES

A GEOTECHNICAL INVESTIGATION FOR PROPOSED RESIDENTIAL DEVELOPMENT

VETERAN'S LANE

CITY OF BARRIE

REFERENCE NO. 1901-S014

JUNE 2019

DISTRIBUTION

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1.0 INTRODUCTION

In accordance with written authorization dated January 6, 2019, from Mr. Sean Mason of Sean Mason Homes, a geotechnical investigation was carried out at the property located on both sides of Veteran’s Lane, near the intersection of Veteran’s Drive and Montserrand Street in the City of Barrie.

The purpose of the investigation was to reveal the subsurface conditions and determine the engineering properties of the disclosed soils for the design and construction of the proposed residential development.

The geotechnical findings and resulting recommendations are presented in this Report.

2.0 SITE AND PROJECT DESCRIPTION

The City of Barrie is located within the periphery of Lake Simcoe basin where the glacial till has been partly eroded, in places, by glacial Lake Algonquin and filled with glaciolacustrine sand, silt, clay and reworked till.

The area of investigation is located on both sides of Veteran’s Lane in the City of Barrie. The west portion is triangular, and the east portion is rectangular in shape, with a single storey dwelling in place. The existing site gradient is relatively flat, with trees and vegetation.

According to the Conceptual Site Plan, prepared by Innovative Planning Solutions dated March 13, 2019, the existing structure will be demolished for the construction of a residential subdivision of townhouse blocks, with a potential underground garage in the west portion of the property. The development will be provided with municipal services and driveway access meeting urban standards.

3.0 FIELD WORK

The field work, consisting of five (5) sampled boreholes extending to depths of 6.2 m to 6.6 m, was performed on February 1 and April 25, 2019, at the locations shown on the Borehole Location Plan, Drawing No. 1.

The boreholes were advanced at intervals to the sampling depths by a track-mounted, continuous-flight power-auger machine equipped for soil sampling. Standard Penetration Tests, using the procedures described on the enclosed "List of Abbreviations and Terms", were performed at the sampling depths. The test results are recorded as the Standard Penetration Resistance (or 'N' values) of the subsoil. The relative density of the granular strata and the consistency of the cohesive strata are inferred from the 'N' values. Split-spoon samples were recovered for soil classification and laboratory testing.

The field work was supervised and the findings were recorded by a Geotechnical Technician.

The ground elevation at each borehole location was determined with reference to a temporary benchmark (existing Manhole located at the intersection of Montserrand Street and Veteran's Lane), as shown on Drawing No. 1, having an assumed elevation of 100.0 m. The assumed elevation for the temporary benchmark does not represent the geodetic elevation.

4.0 SUBSURFACE CONDITIONS

The investigation has disclosed that beneath the topsoil and a layer of earth fill, extending to a depth of 0.7 m to 1.6 m from grade, the site is underlain by a stratum of silty sand till with embedded silt deposit.

Detailed descriptions of the subsurface conditions are presented on the Borehole Logs, comprising Figures 1 to 5, inclusive. The revealed stratigraphy is plotted on the Subsurface Profile, Drawing No. 2. The engineering properties of the disclosed soils are discussed herein.

4.1 **Topsoil** (All Boreholes)

The revealed topsoil layer is approximately 10 to 25 cm thick. It is dark brown in colour, indicating appreciable amounts of roots and humus. These materials are unstable and compressible under loads; therefore, the topsoil must be removed for site development.

4.2 **Earth Fill** (All Boreholes)

A layer of earth fill, consisting of silty sand with gravel, cobbles and topsoil inclusions, was contacted below the topsoil. The earth fill extends to a depth of 0.7 m to 1.6 m from the prevailing ground surface.

Due to the unknown history, the earth fill is not suitable to support any structure sensitive to settlement. For structural uses, the fill must be subexcavated, assessed, sorted free of topsoil inclusions, aerated and properly recompacted in layers.

One must be aware that the samples retrieved from boreholes 10 cm in diameter may not be truly representative of the geotechnical and environmental quality of the fill, and do not indicate whether the topsoil was completely stripped. This should be further assessed by laboratory testing and/or test pits.

4.3 **Silty Sand Till** (All Boreholes)

The native silty sand till deposit was encountered below the earth fill. It consists of a random mixture of particle sizes ranging from clay to gravel, with sand and silt exerting the dominant influence on the soil properties. Sample examinations disclosed that the till is slightly cemented and display cohesion when remoulded. Grain size analyses were performed on 3 representative samples and the results are plotted on Figure 6.

The obtained 'N' values range from 13 to over 100, with a median of 35 blows per 30 cm of penetration, showing the relative density of the sand till is compact to very dense, generally being dense.

The natural water content of the soil samples was determined; the results are plotted on the Borehole Logs. The values range from 7% to 14%, with a median of 10%, indicating damp to moist, generally in moist conditions.

The engineering properties of the sand till pertaining to the project are given below:

- Moderate frost susceptibility and soil-adfreezing potential.
- Moderately low water erodibility.
- Relatively low permeable, with an estimated coefficient of permeability of 10^{-5} to 10^{-6} cm/sec, a percolation rate of 40 to 60 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.12
2% - 6%	0.16
6% +	0.23

- A frictional soil, the shear strength is primarily derived from internal friction and is augmented by cementation or cohesion.
- In excavation, the till will be relative stable with steep slope; however, under prolonged exposure, localized sheet collapse may occur.
- A fair pavement-supportive material, with an estimated CBR value of 8% to 10%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm.cm.

4.4 **Silt** (Borehole 5)

The embedded silt deposit was contacted within the silty sand till stratum at a depth between 2.2 m and 3.4 m from grade. It is very fine grained, with some clay and fine sand. Grain size analysis was performed on a representative sample and the result is plotted on Figure 7.

The obtained 'N' values are 26 and 34 blows per 30 cm of penetration, showing the relative density of the silt deposit is compact to dense. The natural water content values of the soil samples are 9% and 14%, indicating moist conditions.

The engineering properties of the silt deposit are given below:

- High frost susceptibility and soil-adfreezing potential.
- Moderately high water erodibility.

- Semi-permeable to low permeable, depending on the clay content, with an estimated coefficient of permeability of 10^{-5} to 10^{-6} cm/sec, a percolation rate of 40 to 60 min/cm, and runoff coefficients of:

Slope	
0% - 2%	0.12
2% - 6%	0.16
6% +	0.23

- A frictional soil, the shear strength is primarily derived from internal friction.
- In excavation, the silt will slough with steep slope and run with the groundwater seepage.
- A poor pavement-supportive material, with an estimated CBR value of 3%.
- Moderately low corrosivity to buried metal, with an estimated electrical resistivity of 5000 ohm.cm.

4.5 Compaction Characteristics of the Revealed Soils

The obtainable degree of compaction is primarily dependent on the soil moisture and, to a lesser extent, on the type of compactor used and the effort applied. As a general guide, the typical water content values of the revealed soils for Standard Proctor compaction are presented in Table 1.

Table 1 - Estimated Water Content for Compaction

Soil Type	Determined Natural Water Content (%)	Water Content (%) for Standard Proctor Compaction	
		100% (optimum)	Range for 95% or +
Earth Fill (silty sand)	9 to 20	10	6 to 13
Silty Sand Till	7 to 14	12	8 to 15
Silt	9 and 14	12	8 to 15

The above values show that most of the in situ soils are suitable for 95% or + Standard Proctor compaction. However, the existing earth fill must be sorted free of topsoil inclusions and deleterious materials, aerated, prior to reuse as structural backfill.

The lifts for compaction should be limited to 20 cm, or to a suitable thickness as assessed by test strips performed by the equipment which will be used at the time of construction.

If the compaction of the soils is carried out with the water content within the range for 95% Standard Proctor dry density but on the wet side of the optimum, the surface of the compacted soil mantle will roll under the dynamic compactive load. This is unsuitable for pavement construction since each component of the pavement structure is to be placed under dynamic conditions which will induce the rolling action of the subgrade surface and cause structural failure of the new pavement. The slab-on-grade, foundations or bedding of the underground services will be placed on a subgrade which will not be subjected to impact loads. Therefore, the structurally compacted soil mantle with the water content on the wet side or dry side of the optimum will provide adequate subgrade strength for the project construction.

The presence of boulders in the till will prevent transmission of the compactive energy into the underlying material to be compacted. The backfill must be sorted free of oversized boulders before reuse for structural backfill and/or construction of engineered fill.

5.0 GROUNDWATER CONDITIONS

The boreholes were checked for the presence of groundwater upon completion. The data was plotted on the Borehole Logs and summarized in Table 2.

Table 2: Groundwater Levels

Borehole No.	Borehole Depth (m)	Ground Elevation (m)	Groundwater Level Upon Completion of Drilling	
			Depth (m)	**Elevation (m)**
1	6.2	101.1	Dry	-
2	6.2	101.6	6.1	95.5
3	6.2	100.6	Dry	-
4	6.3	101.2	6.1	95.1
5	6.6	100.9	5.2	95.7

Free groundwater was recorded near the bottom of Boreholes 2, 4 and 5, at a depth of 5.2 m to 6.1 m from grade, or El. 95.1 m to 95.7 m. The other two boreholes remained dry during drilling and sampling operation.

It is our opinion that the recorded groundwater represents perched water in the earth fill or wet sand seams within the till deposit. It does not represent the continuous groundwater regime.

In excavation, the groundwater yield will be slow in rate and limited in quantity. It can be removed by conventional pumping from sumps.

6.0 DISCUSSION AND RECOMMENDATIONS

The investigation has disclosed that beneath the topsoil and a layer of earth fill, extending to a depth of 0.7 m to 1.6 m from grade, the site is underlain by a stratum of compact to very dense silty sand till with embedded silt deposit of compact to dense in relative density.

Free groundwater was recorded in three boreholes, at a depth of 5.2 m to 6.1 m from grade. The other two boreholes remained dry upon the completion of drilling and sampling. It is our opinion that the recorded groundwater represents perched water in the earth fill or wet sand seams within the till deposit. It does not represent the continuous groundwater regime.

The geotechnical findings which warrant special consideration are presented below:

1. Topsoil must be removed for development.
2. Where the site will be regraded, it is generally more economical to place an engineered fill for normal footing, sewer and pavement construction. The existing earth fill must be subexcavated, sorted free of topsoil inclusions or deleterious materials before it can be reused as engineered fill for site grading.
3. After demolition of the existing structure, the cavity should be backfilled with engineered fill.
4. The sound natural soil and engineered fill are suitable for conventional footing construction. The footings must be designed in accordance with the recommended bearing pressures in Section 6.2 and the footing subgrade must be inspected to ensure that its condition is compatible with the design of the foundation.
5. The construction of a conventional underground parking structure with

subsurface drainage collecting the groundwater and dissipating it into the sewage system has to be pre-approved by the municipality. If the connection for discharge of subsurface water is not approved, the underground parking structure should be designed with a storage cistern to collect and store the subsurface water for irrigation or surface cleaning during the dry season. Alternatively, a submerged “tank” structure designing to resist the hydrostatic pressure can be constructed for the underground parking if an on site storage cistern is not practical.

The recommendations appropriate for the project described in Section 2.0 are presented herein. One must be aware that the subsurface conditions may vary between boreholes. Should this become apparent during construction, a geotechnical engineer must be consulted to determine whether the following recommendations require revision.

6.1 **Site Preparation**

The site will be developed into a residential subdivision with townhouse blocks and driveway access. For site preparation of the development, the existing topsoil must be completely removed and the cavity of the demolished structure must be backfilled properly. The reuse of topsoil will be limited to landscape areas only. Any surplus must be removed off site.

If the site will have to be regraded or additional earth fill is required for site grading, it is generally more economical to place an engineered fill for conventional footings, sewer, pavement and slab construction. The engineering requirements for a certifiable fill are presented below:

1. All the existing topsoil and earth fill must be removed, and the subgrade must be inspected and proof-rolled prior to any fill placement. Badly weathered soils should also be subexcavated, sorted free of topsoil inclusions and any deleterious materials, if any, aerated and properly compacted in layers.
2. Inorganic soils must be used for the fill, and they must be uniformly compacted in lifts 20 cm thick to 98% or + of their maximum Standard Proctor dry density up to the proposed finished grade. The soil moisture must be properly controlled on the wet side of the optimum. If the foundations are to be built soon after the fill placement, the densification process for the engineered fill must be increased to 100% of the maximum Standard Proctor compaction.
3. If imported fill is to be used, it should be inorganic soils, free of any deleterious material with environmental issue (contamination). Any potential imported earth fill from off-site must be reviewed for geotechnical and environmental quality by the appropriate personnel as authorized by the developer or agency, before it is hauled to the site.
4. If the engineered fill is to be left over the winter months, adequate earth cover or equivalent must be provided for protection against frost action.
5. The engineered fill must extend over the entire graded area, and the engineered fill envelope must be clearly and accurately defined in the field and precisely documented by qualified surveyors.
6. Building foundations partially on engineered fill must be reinforced and designed by a structural engineer to properly distribute the stress induced by the abrupt differential settlement (estimated to be 15± mm) between the natural soils and engineered fill.
7. The engineered fill must not be placed during the period from late November to early April when freezing ambient temperatures occur either persistently or intermittently. This is to ensure that the fill is free of frozen soils, ice and snow.
8. Where the fill is to be placed on a bank steeper than 1 vertical:3 horizontal, the

face of the bank must be flattened to 3 + so that it is suitable for safe operation of the compactor and the required compaction can be obtained.

9. Where the ground is wet due to subsurface water seepage, an appropriate subdrain scheme must be implemented prior to the fill placement, particularly if it is to be carried out on sloping ground.
10. The fill operation must be fully supervised and monitored by a technician under the direction of a geotechnical engineer.
11. The footing and underground services subgrade must be inspected by the geotechnical consulting firm that supervised the engineered fill placement. This is to ensure that the foundations are placed within the engineered fill envelope, and the integrity of the fill has not been compromised by interim construction, environmental degradation and/or disturbance by the footing excavation.
12. Any excavation carried out in certified engineered fill must be reported to the geotechnical consultant who supervised the fill placement in order to document the locations of excavation and/or to supervise reinstatement of the excavated areas to engineered fill status. If construction on the engineered fill does not commence within a period of 2 years from the date of certification, the condition of the engineered fill must be assessed for recertification.
13. Despite stringent control in the placement of the engineered fill, variations in soil type and density may occur in the engineered fill. The total and differential settlements of 25 mm and 15 mm, respectively, should be considered in the design of the foundations. They must be properly reinforced and designed by the structural engineer for the project.

6.2 Foundations

The proposed townhouse blocks can be supported on conventional footings founded on the sound native sand till or engineered fill. The Maximum Allowable Soil

Bearing Pressure (SLS) of 150 kPa and Factored Ultimate Soil Bearing Pressure (ULS) of 240 kPa can be used for the design of conventional footings.

There might be a four-storey building with 1-level underground parking at the west portion of the property. The final grade is not known at this stage; the foundation level of this building is assumed below 3 m from the existing ground level. Assuming the subsurface water will be discharged into the municipal sewer or collected and stored in a cistern for irrigation or surface cleaning during the dry season, the structure can be designed on conventional footings founded on the compact to dense silt or sand till. The recommended design bearing pressures for conventional footings are presented below:

- Maximum Allowable Soil Bearing Pressure (SLS) = 250 kPa
- Factored Ultimate Soil Bearing Pressure (ULS) = 400 kPa

The total and differential settlements of footings, designing for the bearing pressures at SLS, are estimated to be 25 mm and 20 mm, respectively.

If the discharge of subsurface water into municipal sewer is not acceptable and a cistern is not favourable, the underground structure should be designed as a “tank” with a raft foundation to resist the hydrostatic pressure. The recommended design bearing pressures for a raft foundation are presented below:

- Maximum Allowable Soil Bearing Pressure (SLS) = 300 kPa
- Factored Ultimate Soil Bearing Pressure (ULS) = 450 kPa

The total and differential settlements of the raft, designing for the bearing pressure at SLS, are estimated to be 25 mm and 20 mm, respectively. A Modulus of Subgrade Reaction of 25 MPa/m can be used for the design of the raft foundation.

Foundations exposed to weathering or in unheated areas, such as the exterior footings near ventilation shaft and ramp-down driveway, should have at least 1.5 m of earth cover for protection against frost action. For unheated underground parking structure, if the entrance to the garage is kept closed most of the time, the earth cover for footings away from entrances and ventilation shaft can be reduced to 0.9 m for perimeter walls and 1.2 m for interior walls and columns.

The foundation subgrade should be inspected by a geotechnical engineer, or a geotechnical technician under the supervision of a geotechnical engineer, to ensure that the revealed conditions are compatible with the foundation design requirements

A concrete mud-slab should be placed beneath the raft foundation immediately after exposure and inspection. If groundwater seepage is encountered in footing excavations, or where the subgrade is found to be wet, the footing subgrade should also be protected by a concrete mud-slab immediately after exposure. This will prevent construction disturbance and costly rectification.

The foundations should meet the requirements specified in the Ontario Building Code and the structure should be designed to resist an earthquake force using Site Classification ‘D’ (stiff soil).

6.3 **Underground Garage and Basement Structure**

In conventional construction of underground structures and basement, the perimeter walls should be dampproofed and provided with a perimeter subdrain (Drawing No. 3). Backfill of open excavation should consist of free-draining granular material unless prefabricated drainage board is installed over the entire wall below grade, such as besides shoring walls (Drawing No. 4). Under-floor weepers

(Drawing No. 5) are also necessary where the subgrade consists of saturated soils. The subdrains should be shielded by a fabric filter and covered with stone filter to prevent blockage by silting, installed on a positive gradient and discharge into a positive outlet.

The Municipality will have to be consulted to allow the discharge of the subsurface water into the municipal system. If the discharge connection is not accepted for the underground parking structure, a storage cistern will be required to collect and store the subsurface water for irrigation or surface cleaning during the dry season. Alternatively, a submerged “tank” structure designing to resist the hydrostatic pressure can be constructed for the underground parking if an on site storage cistern is not practical.

The elevator pit, which normally extends a few metres below the floor level, should be designed as a submerged ‘tank’ structure with waterproofed pit walls and pit floor.

The perimeter walls of the underground structure should be designed to sustain a lateral earth pressure calculated using the soil parameters given in Section 6.8. Any applicable surcharge loads adjacent to the underground structure must also be considered in the design of the foundation walls.

6.4 **Slab-On-Grade Construction**

The subgrade for slab-on-grade should consist of engineered fill or native subsoil. Any new material for raising the grade should consist of organic-free soil compacted to at least 98% of its maximum Standard Proctor dry density.

The slab floor should be constructed on a granular base, consisting of 20-mm

Crusher-Run Limestone, or equivalent, 20 cm thick, compacted to its maximum Standard Proctor dry density.

For a waterproofed underground structure with a raft foundation, the slab-on-grade will be poured on a granular fill above the concrete raft where the underground utilities and pipes will be laid.

At the exterior, the slab-on-grade or concrete sidewalk should be designed to tolerate frost heave. The grading around the slab-on-grade must be such that it directs runoff away from the surface to minimize the frost heave phenomenon generally associated with the disclosed soils.

To prevent frost action induced by cold wintry drafts in areas where vertical ground movement cannot be tolerated, such as building entrances, the interlocking stone pavement and concrete sidewalk must be constructed on free-draining, non-frost-susceptible granular material such as Granular ‘B’. It must extend to 1.5 m below the slab or pavement surface and be provided with positive drainage such as weeper subdrains connected to the storm system. Alternatively, the sidewalks and pavement should be insulated with 50-mm Styrofoam, or equivalent.

6.5 **Underground Services**

The subgrade for underground services should consist of sound native soils or properly compacted earth fill, free of organics. In areas where the subgrade consists of weathered soils, it should be subexcavated and replaced with bedding material compacted to at least 95% or + of its Standard Proctor compaction.

A Class ‘B’ bedding, consisting of compacted 20-mm Crusher-Run Limestone or equivalent, is recommended for construction of the underground services.

The pipe joints should be leak-proof, or wrapped with a waterproof membrane to prevent subgrade migration through leakage at joints resulting from inadvertent faulty installation. Openings to subdrains and catch basins should be shielded with a fabric filter to prevent silting.

In order to prevent pipe floatation when the sewer trench is deluged with water, a soil cover with a thickness equal to the diameter of the pipe should be in place at all times after completion of the pipe installation.

The water main should be protected against corrosion. For estimation of anode weight requirements, the estimated electrical resistivity for the disclosed soils can be used. This, however, should be confirmed by testing the soils along the water main alignment at the time of sewer construction.

6.6 Backfilling in Trenches and Excavated Areas

The backfill in service trenches and excavated areas should be compacted to at least 95% of its maximum Standard Proctor density and increase to 98% below the concrete floor slab. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted with the water content 2% to 3% drier than the optimum to at least 98% of its maximum Standard Proctor dry density.

In normal project construction practice, the problem areas of settlement largely occur adjacent to foundation walls, columns, manholes, catch basins and services crossings. In areas which are inaccessible to a heavy compactor, the interface of the native soils and sand backfill will have to be flooded for a period of at least 1 day.

The narrow trenches for service crossings should be cut at 1 vertical:2 horizontal so that the backfill in the trenches can be effectively compacted. Otherwise, soil arching in the trenches will prevent achievement of the proper compaction. In this case, imported sand fill must be used. Unless compaction of the backfill is carefully performed, the areas at the interface of the native soil and the sand backfill should preferably be flooded for at least 1 day.

One must be aware of the possible consequences during trench backfilling and exercise caution as described below:

- When construction is carried out in freezing winter weather, allowance should be made for these following conditions. Despite stringent backfill monitoring, frozen soil layers may inadvertently be mixed with the structural trench backfill. Should the in situ soils have a water content on the dry side of the optimum, it would be impossible to wet the soils due to the freezing condition, rendering difficulties in obtaining uniform and proper compaction.
- In areas where the construction is carried out during the winter months, prolonged exposure of the trench walls will result in frost heave within the soil mantle of the walls. This may result in some settlement as the frost recedes, and repair costs will be incurred prior to final surfacing of the new pavement and the slab-on-grade construction.
- To backfill a deep trench, one must be aware that future settlement is to be expected, unless the side of the cut is flattened to at least 1 vertical:1.5+ horizontal, and the lifts of the fill and its moisture content are stringently controlled; i.e., lifts should be no more than 20 cm (or less if the backfilling conditions dictate) and uniformly compacted to achieve at least 95% of the maximum Standard Proctor dry density, with the moisture content on the wet side of the optimum.

5.7 Pavement Design

The recommended pavement design for the driveway and surface parking is presented in Table 3.

Table 3 - Pavement Design

Course	Thickness (mm)	OPS Specifications
Asphalt Surface	40	HL-3
Asphalt Binder		HL-8
Light Duty Parking	45	
Heavy Duty and Fire Route	60	
Granular Base	150	OPSS Granular ‘A’ or equivalent
Granular Sub-base		OPSS Granular ‘B’ or equivalent
Light Duty Parking	200	
Heavy Duty and Fire Route	300	

In preparation of the pavement subgrade, topsoil and organic earth fill must be removed. The final subgrade should be inspected and proof-rolled. Any soft spots should be compacted inorganic earth fill. The new fill should consist of organic free material, compacted to 95% + of its maximum Standard Proctor dry density. In the zone within 1.0 m below the pavement subgrade, the backfill should be compacted to at least 98% of its maximum Standard Proctor dry density, with the water content 2% to 3% drier than the optimum.

All the granular bases should be compacted to 100% of their maximum Standard Proctor dry density.

The pavement subgrade will suffer a strength regression if water is allowed to saturate the mantle. The following measures should, therefore, be incorporated into the construction procedures and pavement design:

- If the pavement construction does not immediately follow the trench backfilling, the subgrade should be properly crowned and smooth-rolled to allow interim precipitation to be properly drained.
- Areas adjacent to the pavement should be properly graded to prevent accumulating of large amounts of water during the interim construction period.
- Curb subdrains will be required on both sides of the driveway, connecting into the catch basins for removal of subsurface water. The subdrains should be at least 0.3 m below the subgrade level with granular backfill. They should consist of filter-sleeved weepers to prevent blockage by silting.
- If the pavement is to be constructed during wet seasons and extensively soft subgrade occurs, the granular sub-base should be thickened in order to compensate for the inadequate strength of the subgrade. This can be assessed during construction.

6.8 Soil Parameters

The recommended soil parameters for the project design are given in Table 4.

Table 4 - Soil Parameters

Unit Weight and Bulk Factor	**Unit Weight (kN/m^3)**	**Estimated Bulk Factor**	
	Bulk	**Loose**	**Compacted**
Earth Fill	21.0	1.20	0.95
Silty Sand Till/ Silt	22.0	1.30	1.05

Lateral Earth Pressure Coefficients	**Active K_a**	**At Rest K_0**	**Passive K_p**
Compacted Earth Fill	0.40	0.55	2.50
Silty Sand Till / Silt	0.35	0.50	3.00

Coefficients of Friction	
Between Concrete and Granular Base	0.50
Between Concrete and Sound Natural Soils	0.35

Maximum Allowable Soil Pressure (SLS) For Thrust Block Design	
Engineered Fill and Sound natural Soils	75 kPa

6.9 Excavation

Excavation should be carried out in accordance with Ontario Regulation 213/91. For excavation purposes, the types of soils are classified in Table 5.

Table 5 - Classification of Soils for Excavation

Material	Type
Sound Till	2
Earth Fill, Native Silt	3
Saturated Soils	4

Where sloped excavation is not feasible, a braced shoring will be required. The overburden load and the surcharge from any adjacent structures should be considered in the design of shoring.

Excavation into the till containing boulders may require extra effort and the use of a heavy-duty backhoe. Boulders larger than 15 cm in size are not suitable for structural backfill and/or construction of engineered fill.

In excavation, the groundwater yield will be limited in quantity and slow in rate. It can be drained into sump pits and removed by conventional pumping.

7.0 LIMITATIONS OF REPORT

This report was prepared by Soil Engineers Ltd. for the account of Sean Mason Homes and for review by the designated consultants and government agencies. Use of the report is subject to the conditions and limitations of the contractual agreement.

The material in the report reflects the judgement of Weida (Daric) Yang, B.A.Sc. and Bennett Sun, P.Eng., in light of the information available to it at the time of preparation. Any use which a Third Party makes of this report, or any reliance on decisions to be made based on it, are the responsibility of such Third Parties. Soil Engineers Ltd. accepts no responsibility for damages, if any, suffered by any Third Party as a result of decisions made or actions based on this report.

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LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms commonly employed on the borehole logs and figures, and in the text of the report, are as follows:

SAMPLE TYPES

AS	Auger sample
CS	Chunk sample
DO	Drive open (split spoon)
DS	Denison type sample
FS	Foil sample
RC	Rock core (with size and percentage recovery)
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

PENETRATION RESISTANCE

Dynamic Cone Penetration Resistance:

A continuous profile showing the number of blows for each foot of penetration of a 2-inch diameter, 90° point cone driven by a 140-pound hammer falling 30 inches.

Plotted as '—●—'

Standard Penetration Resistance or 'N' Value:

The number of blows of a 140-pound hammer falling 30 inches required to advance a 2-inch O.D. drive open sampler one foot into undisturbed soil.

Plotted as '○'

WH	Sampler advanced by static weight
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
NP	No penetration

SOIL DESCRIPTION

Cohesionless Soils:

'N' (blows/ft)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

Cohesive Soils:

Undrained Shear Strength (ksf)	'N' (blows/ft)	Consistency
less than 0.25	0 to 2	very soft
0.25 to 0.50	2 to 4	soft
0.50 to 1.0	4 to 8	firm
1.0 to 2.0	8 to 16	stiff
2.0 to 4.0	16 to 32	very stiff
over 4.0	over 32	hard

Method of Determination of Undrained Shear Strength of Cohesive Soils:

x 0.0	Field vane test in borehole; the number denotes the sensitivity to remoulding
△	Laboratory vane test
□	Compression test in laboratory

For a saturated cohesive soil, the undrained shear strength is taken as one half of the undrained compressive strength

METRIC CONVERSION FACTORS

1 ft = 0.3048 metres
1lb = 0.454 kg
1 inch = 25.4 mm
1ksf = 47.88 kPa

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JOB NO.: 1901-S014

LOG OF BOREHOLE NO.: 1

FIGURE NO.: 1

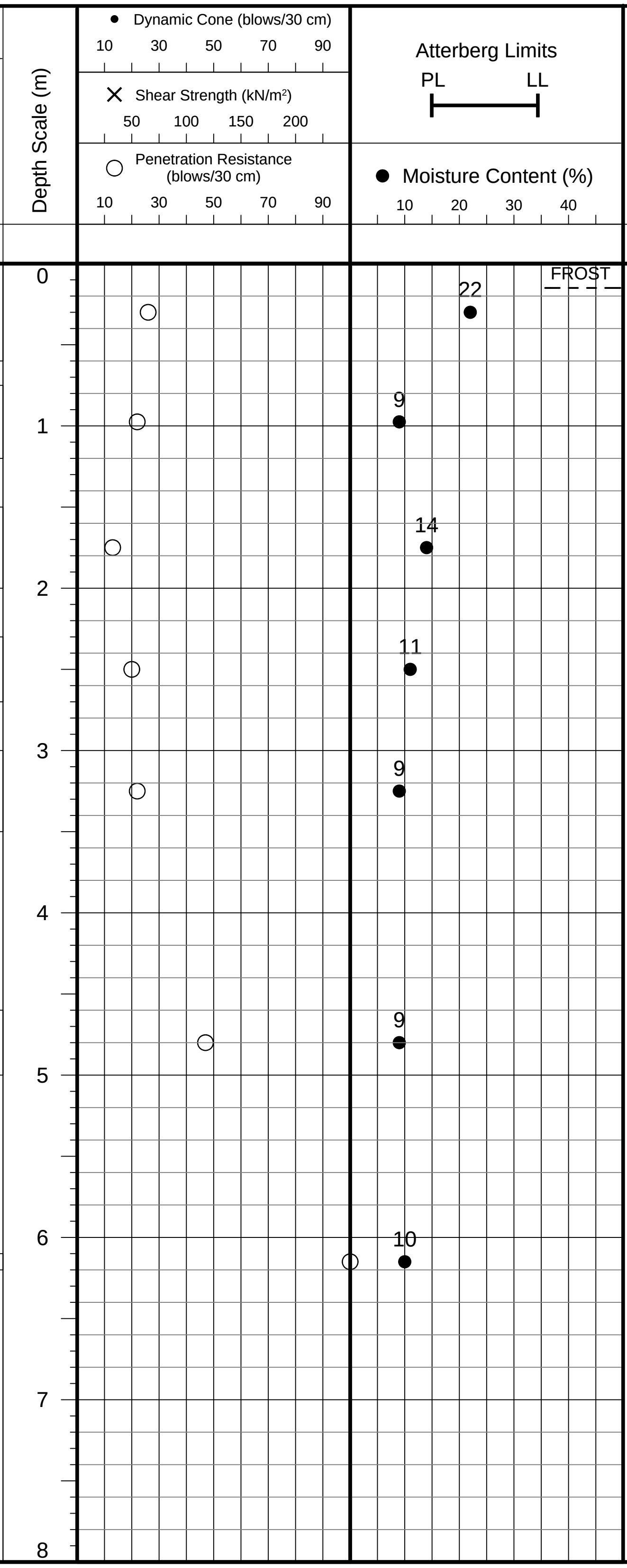
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

DRILLING DATE: February 1, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	SAMPLES Type	SAMPLES N-Value	WATER LEVEL
101.1	Ground Surface				
0.0 0.1	**15 cm TOPSOIL**				
	EARTH FILL brown, silty sand some gravel occ. topsoil inclusions and cobbles	1	DO	26	
		2	DO	22	
99.7 1.4	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	3	DO	13	Dry on completion
		4	DO	20	
		5	DO	22	
		6	DO	47	
		7	DO	50/10	
94.9 6.2	**END OF BOREHOLE**				



Soil Engineers Ltd.

JOB NO.: 1901-S014

LOG OF BOREHOLE NO.: 2

FIGURE NO.: 2

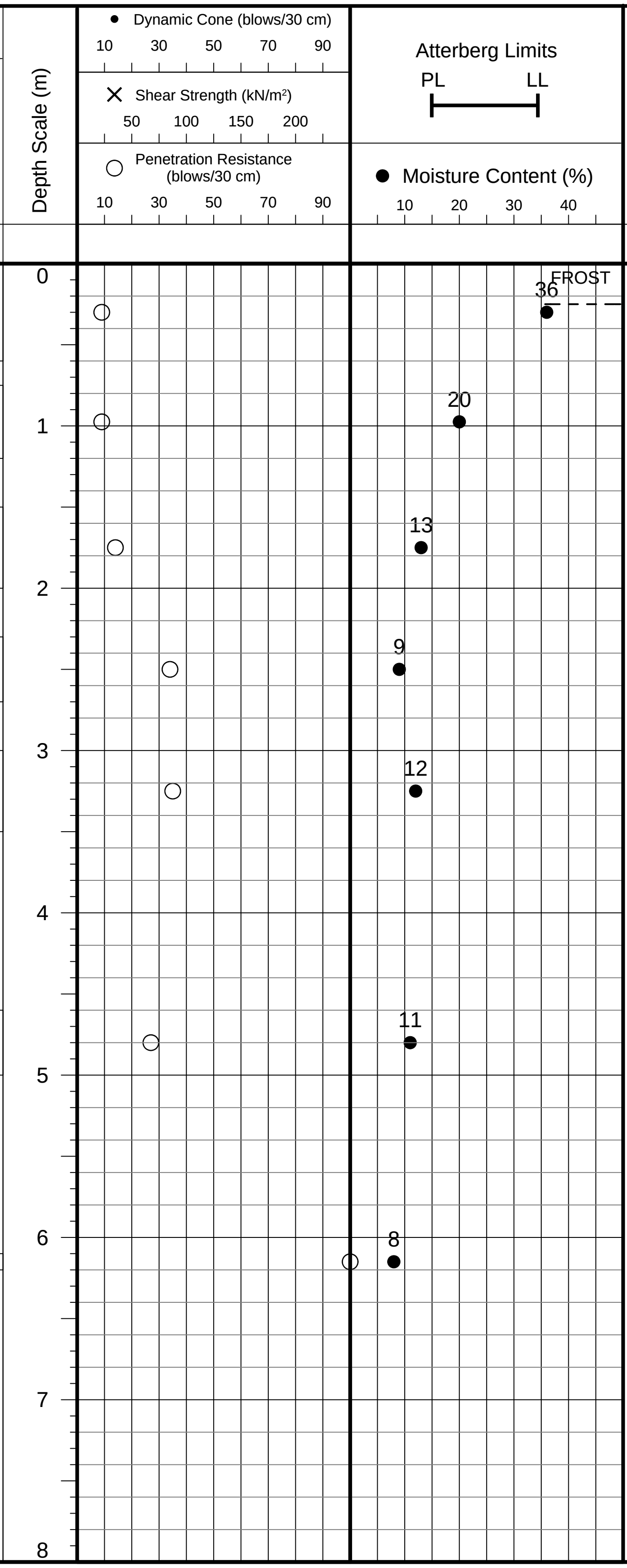
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

DRILLING DATE: February 1, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
101.6	Ground Surface			
0.0	**25 cm TOPSOIL**			
0.3	**EARTH FILL** reddish brown, silty sand occ. gravel and topsoil inclusions	1	DO	9
		2	DO	9
100.2 1.4	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	3	DO	14
		4	DO	34
		5	DO	35
		6	DO	27
		7	DO	50/8
95.4 6.2	**END OF BOREHOLE**			



WATER LEVEL

W.L @ El. of 95.5 m upon the completion of drilling

JOB NO.: 1901-S014

LOG OF BOREHOLE NO.: 3

FIGURE NO.: 3

PROJECT DESCRIPTION: Proposed Residential Development

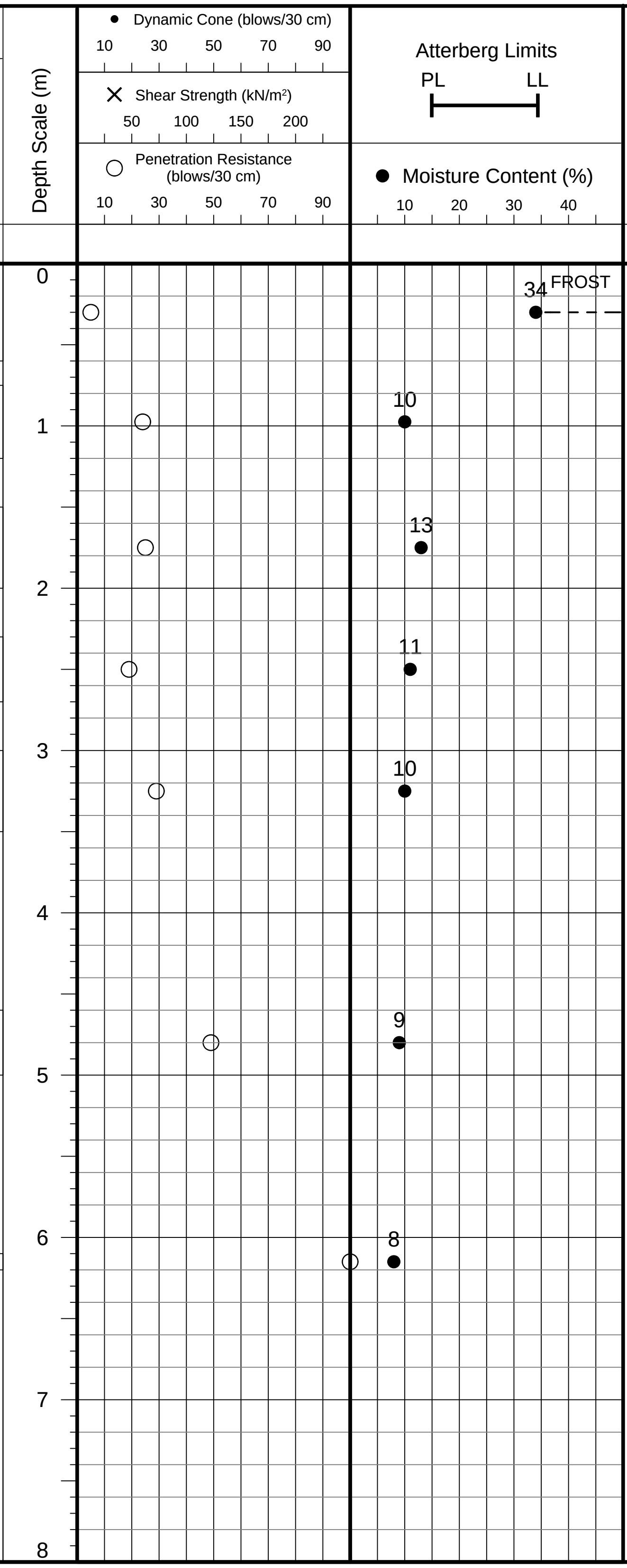
METHOD OF BORING: Flight Auger

PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

DRILLING DATE: February 1, 2019

El. (m) Depth (m)	SOIL DESCRIPTION
100.6	Ground Surface
0.0	**10 cm TOPSOIL**
0.1	**EARTH FILL** brown, silty sand some gravel occ. topsoil inclusions and cobbles
99.9 0.7	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders
94.4 6.2	**END OF BOREHOLE**

SAMPLES		
Number	Type	N-Value
1	DO	5
2	DO	24
3	DO	25
4	DO	19
5	DO	29
6	DO	49
7	DO	50/13



WATER LEVEL

Dry on completion

Soil Engineers Ltd.

JOB NO.: 1901-S014

LOG OF BOREHOLE NO.: 4

FIGURE NO.: 4

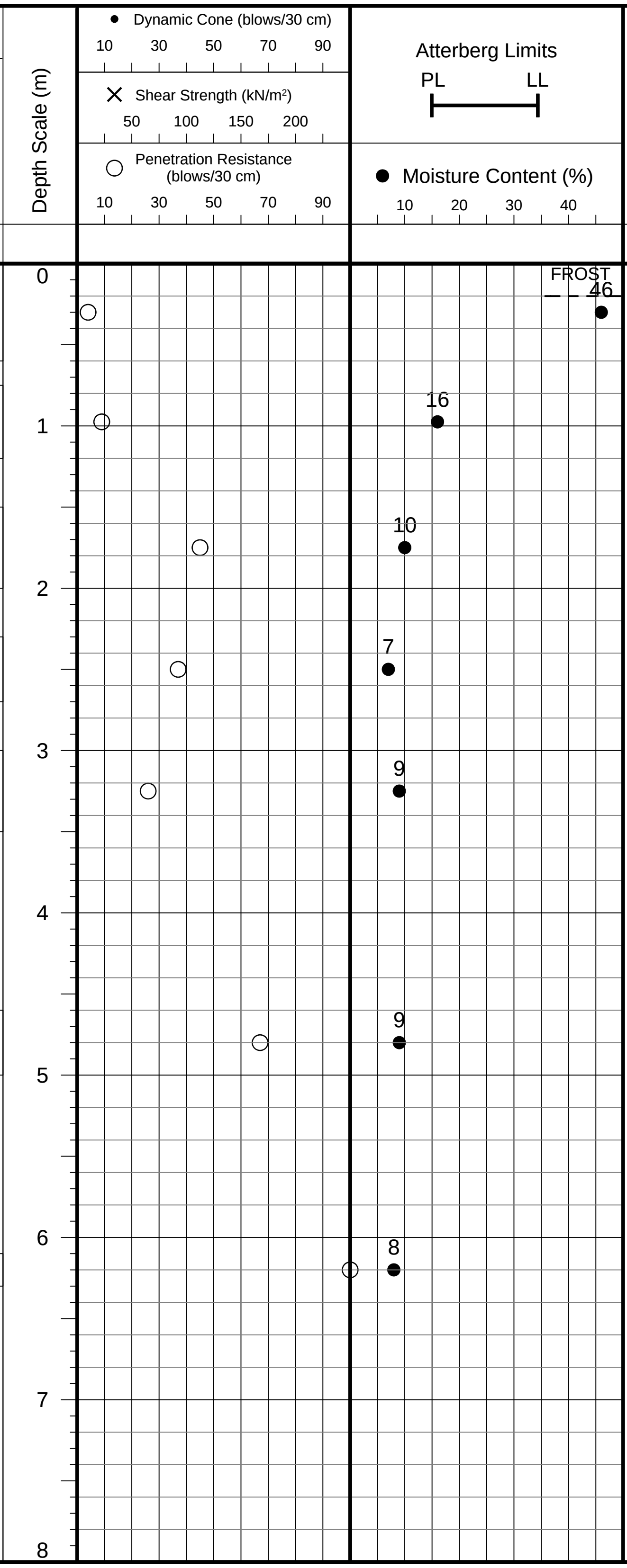
PROJECT DESCRIPTION: Proposed Residential Development

METHOD OF BORING: Flight Auger

PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

DRILLING DATE: February 1, 2019

El. (m) Depth (m)	SOIL DESCRIPTION	SAMPLES Number	Type	N-Value
101.2	Ground Surface			
0.0	**10 cm TOPSOIL**			
0.1	**EARTH FILL** brown, silty sand some gravel occ. topsoil inclusions and cobbles	1	DO	4
		2	DO	9
99.8 1.4	Brown, compact to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders	3	DO	45
		4	DO	37
		5	DO	26
		6	DO	67
		7	DO	50/15
94.9 6.3	**END OF BOREHOLE**			



WATER LEVEL

W.L @ El. of 95.1 m upon the completion of drilling ∇

Soil Engineers Ltd.

JOB NO.: 1901-S014

LOG OF BOREHOLE NO.: 5

FIGURE NO.: 5

PROJECT DESCRIPTION: Proposed Residential Development

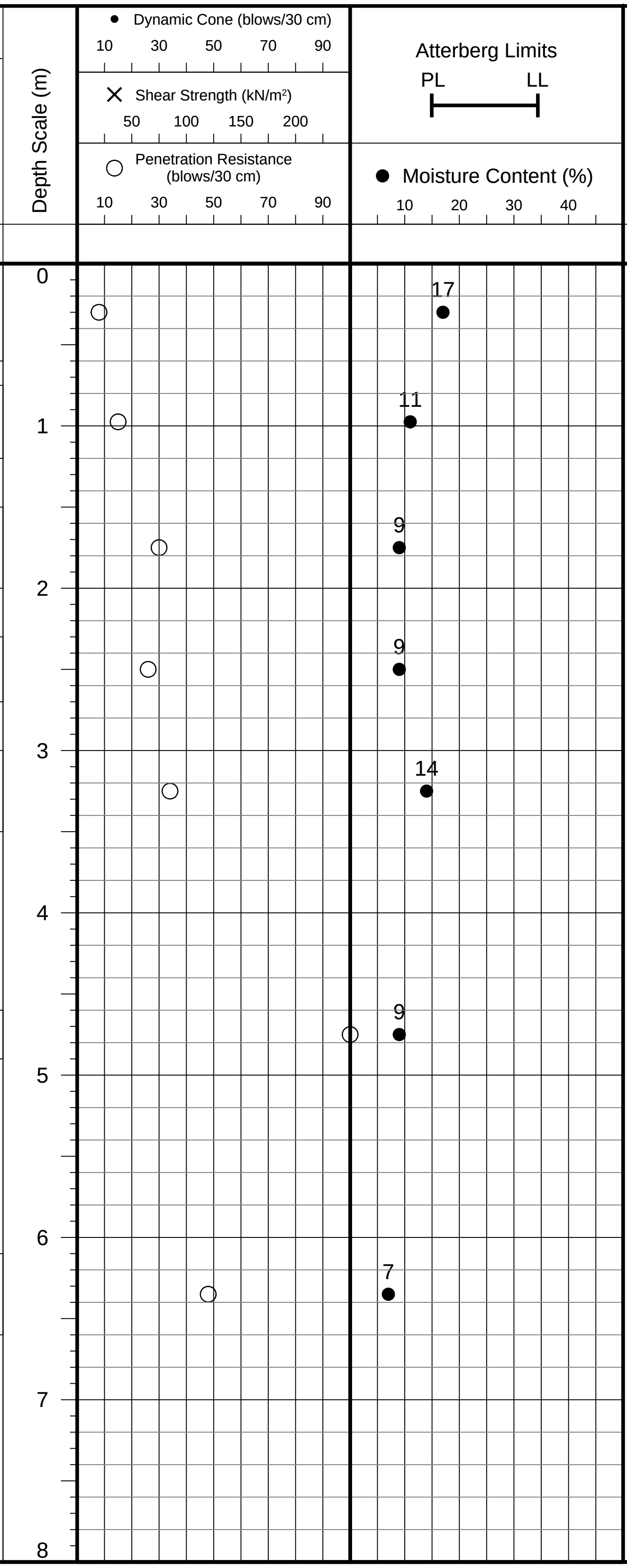
METHOD OF BORING: Flight Auger

PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

DRILLING DATE: 'April, 25, 2019

El. (m) Depth (m)	SOIL DESCRIPTION
100.9	Ground Surface
0.0	**25 cm TOPSOIL**
0.3	**EARTH FILL** brown, silty sand some clay and gravel occ. topsoil inclusions
99.3 1.6	Brown, dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders
98.7 2.2	Brown, compact to dense **SILT** some clay a trace of sand
97.5 3.4	Dense to very dense **SILTY SAND TILL** traces of clay and gravel occ. cobbles and boulders brown / grey
94.3 6.6	**END OF BOREHOLE**

SAMPLES		
Number	Type	N-Value
1	DO	8
2	DO	15
3	DO	30
4	DO	26
5	DO	34
6	DO	50/15
7	DO	48



WATER LEVEL

W.L @ El. of 95.7 m upon the completion of drilling

▽

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ZONING TABLE - RM2 339 Veteran's Drive

PROVISION	REQUIRED	PROVIDED
LOT AREA	720m² (min)	1,484.4m² (0.366ac)
LOT FRONTAGE	21m (min)	52.29m (Montserrand St)
SETBACKS		
FRONT YARD	7.0m (min)	2m
INTERIOR SIDE YARD	1.8m (min)	n/a
EXTERIOR SIDE YARD	3.0m (min)	2m (Veterans Drive)
REAR YARD	7.0m (min)	1.37m (Veterans Lane)
DWELLING UNIT FLOOR AREA	45m² / 1 Bdrm 55m² / 2 Bdrm (min)	45m² / 1 Bdrm 55m² / 2 Bdrm (min)
LOT COVERAGE	35% (max)	28.3%
GROSS FLOOR AREA	60% of lot area (max)	85%
BUILDING HEIGHT	10m (max)	11.0 m
LANDSCAPED OPEN SPACE	35% (min)	45%
AMENITY AREA	144m² (12m²/unit min)	230m²
AMENITY AREA	Consolidated	Unconsolidated
PARKING SPACES	18 (1.5/unit min)	15 with 2 BF (1.2/unit)
TANDEM PARKING SPACES	Not permitted	Permitted
DENSITY	40 u/ha (max)	81 u/ha
SETBACK TO SECONDARY MEANS OF ACCESS	7.0m	2m

ZONING TABLE - RM2 341 Veteran's Drive

PROVISION	REQUIRED	PROVIDED
LOT AREA	720m² (min)	5,237.6m² (1.29ac)
LOT FRONTAGE	21m (min)	123.6m
SETBACKS		
FRONT YARD	7.0m (min)	3m
INTERIOR SIDE YARD	1.8m (min)	1.8m
EXTERIOR SIDE YARD	3.0m (min)	n/a
REAR YARD	7.0m (min)	6m
DWELLING UNIT FLOOR AREA	45m² / 1 Bdrm 55m² / 2 Bdrm (min)	45m² / 1 Bdrm 55m² / 2 Bdrm (min)
LOT COVERAGE	35% (max)	46%
GROSS FLOOR AREA	60% of lot area (max)	105%

LEGEND

⌖	Borehole
▚	Temporary Benchmark

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Borehole Location Plan

SITE: 339 and 341 Veteran's Lane, City of Barrie

DESIGNED BY: DY
CHECKED BY: BS
DWG NO.: 1
SCALE:
REF. NO.: 1901-S014
DATE: June, 2019
REV

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SUBSURFACE PROFILE
DRAWING NO. 2
SCALE: AS SHOWN

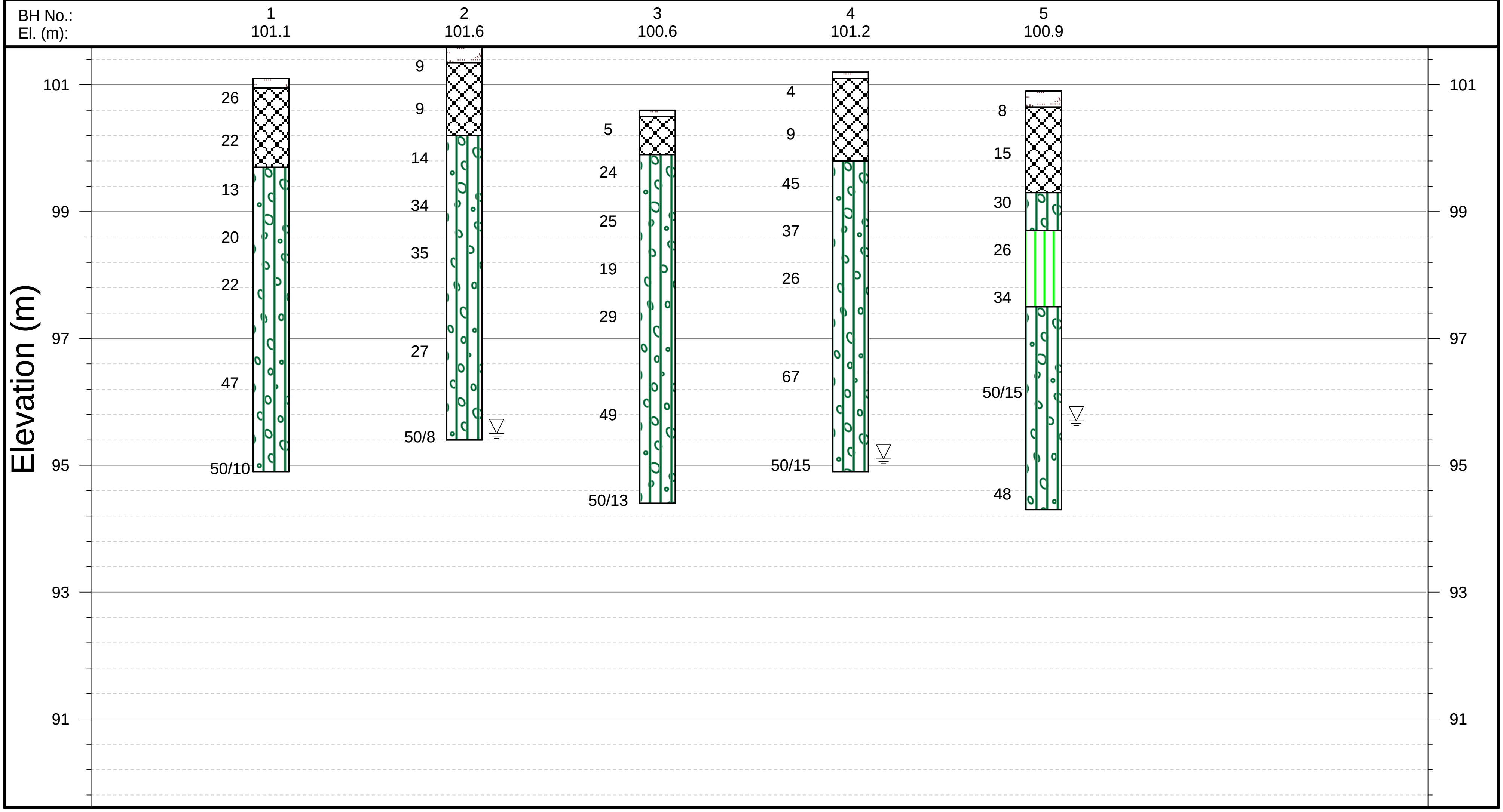
JOB NO.: 1901-S014
REPORT DATE: May, 2019
PROJECT DESCRIPTION: Proposed Residential Development

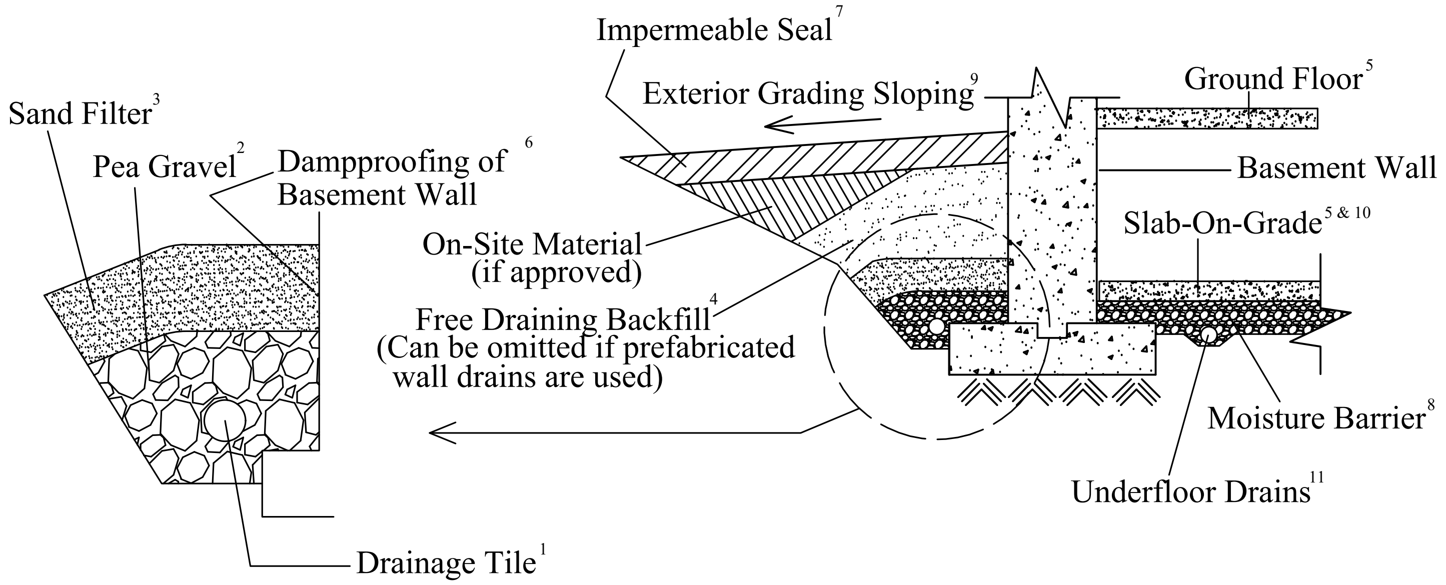
PROJECT LOCATION: Veteran's Lane and McCausland Court, City of Barrie

LEGEND

TOPSOIL FILL SILTY SAND TILL SILT

∇ WATER LEVEL (END OF DRILLING)





NOTES:

1. **Drainage tile**: consists of 100 mm (4") diameter weeping tile or equivalent perforated pipe leading to a positive sump or outlet. Invert to be at minimum of 150 mm (6") below underside of basement floor level.

2. **Pea gravel**: at 150 mm (6") on the top and sides of drain. If drain is not placed on concrete footing, provide 100 mm (4") of pea gravel below drain. The pea gravel may be replaced by 20 mm clear stone provided that the drain is covered by a porous geotextile membrane of Terrafix 270R or equivalent.

3. **Filter material**: consists of C.S.A. fine concrete aggregate. A minimum of 300 mm (12") on the top and sides of gravel. This may be replaced by an approved porous geotextile membrane of Terrafix 270R or equivalent.

4. **Free-draining backfill**: OPSS Granular 'B' or equivalent, compacted to 95% to 98% (maximum) Standard Proctor dry density. Do not compact closer than 1.8 m (6') from wall with heavy equipment. This may be replaced by on-site material if prefabricated wall drains (Miradrain) extending from the finished grade to the bottom of the basement wall are used.

5. **Do not backfill** until the wall is supported by the basement floor slab and ground floor framing, or adquate bracing.

6. **Dampproofing** of the basement wall is required before backfilling

7. **Impermeable backfill seal** of compacted clay, clayey silt or equivalent. If the original soil in the vicinity is a free-draining sand, the seal may be omitted.

8. **Moisture barrier**: 20-mm clear stone or compacted OPSS Granular 'A', or equivalent. The thickness of this layer should be 150 mm (6") minimum.

9. **Exterior Grade**: slope away from basement wall on all the sides of the building.

10. **Slab-On-Grade** should not be structurally connected to walls or foundations.

11. **Underfloor drains*** should be placed in parallel rows at 6 to 8 m (20'-25') centre, on 100 mm (4") of pea gravel with 150 mm (6") of pea gravel on top and sides. The invert should be at least 300 mm (12") below the underside of the floor slab. The drains should be connected to positive sumps or outlets. Do not connect the underfloor drains to the perimeter drains.

*Underfloor drains can be deleted where not required.

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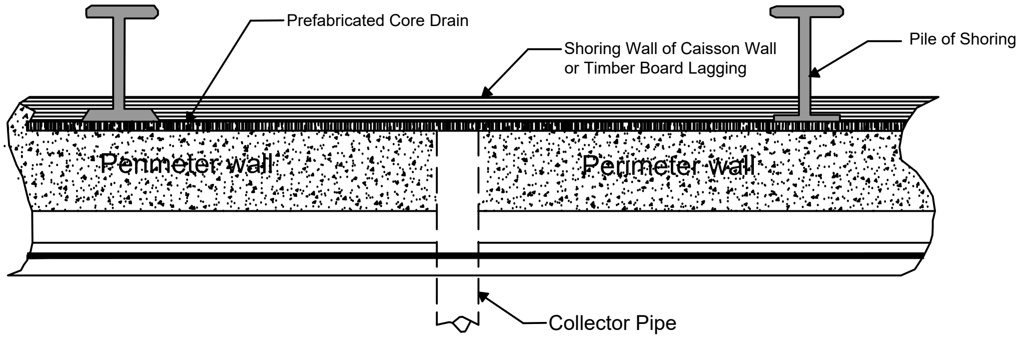
Permanent Perimeter Drainage System

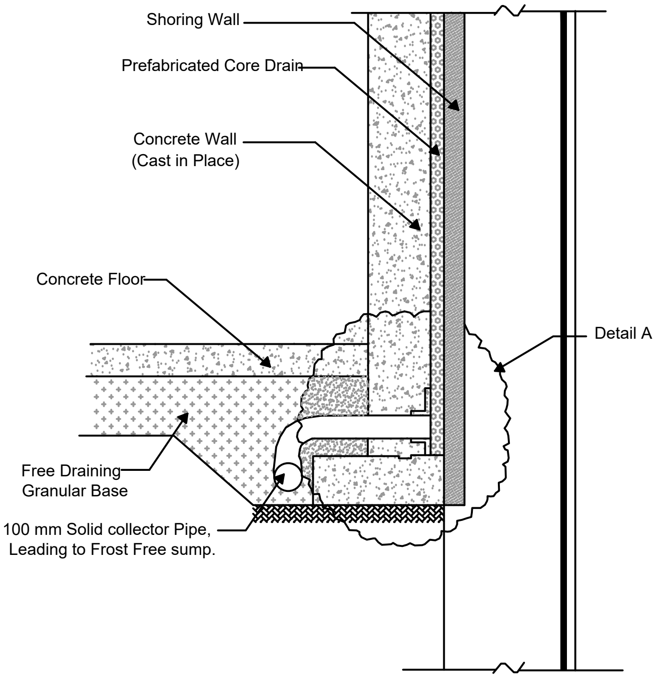
SITE Veteran's Lane, City of Barrie

DESIGNED BY D.Y. **CHECKED BY** B.S. **DWG NO.** 3

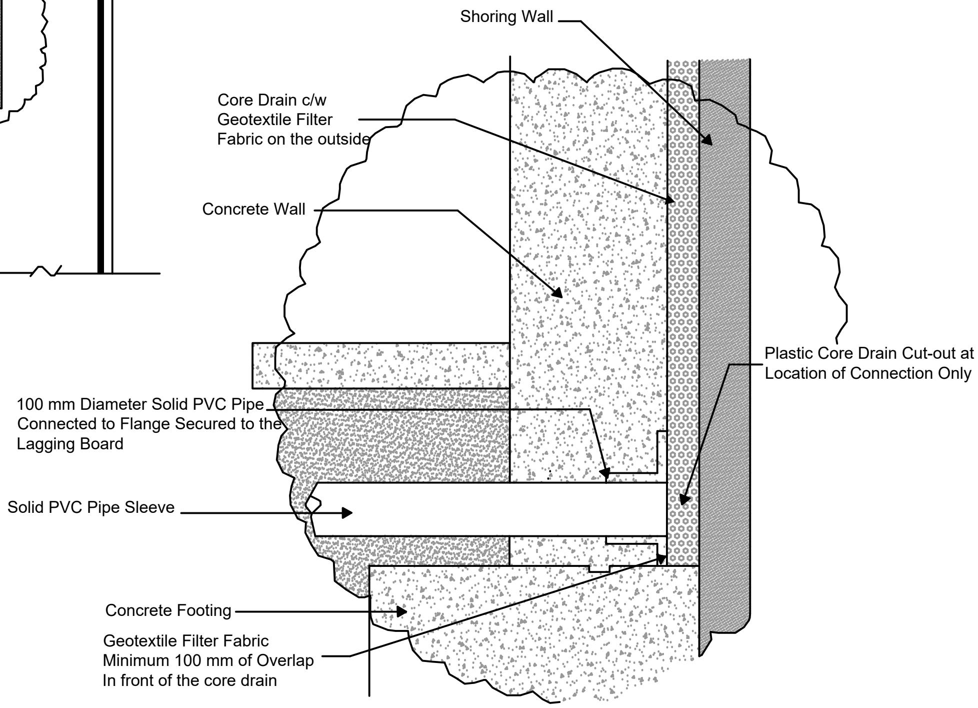
SCALE N.T.S. **REF. NO.** 1901-S014 **DATE** May, 2019 **REV** -



PLAN



TYPICAL SECTION



DETAIL A

NOTES:

1. A continuous blanket of prefabricated drainage system, Miradrain 6000 or equivalent, should extend continuously from the top of footings to the ground surface.

2. All joints of the Miradrain should be taped. All openings above the concrete footing must be covered with filter fabric to prevent intrusion of fresh concrete into the core of the drain.

3. Backfill behind the lagging board must be free draining. Filter fabric or straw should be used to prevent loss of fines behind the lagging.

4. The perimeter drainage and any subfloor drainage systems must be kept separate.

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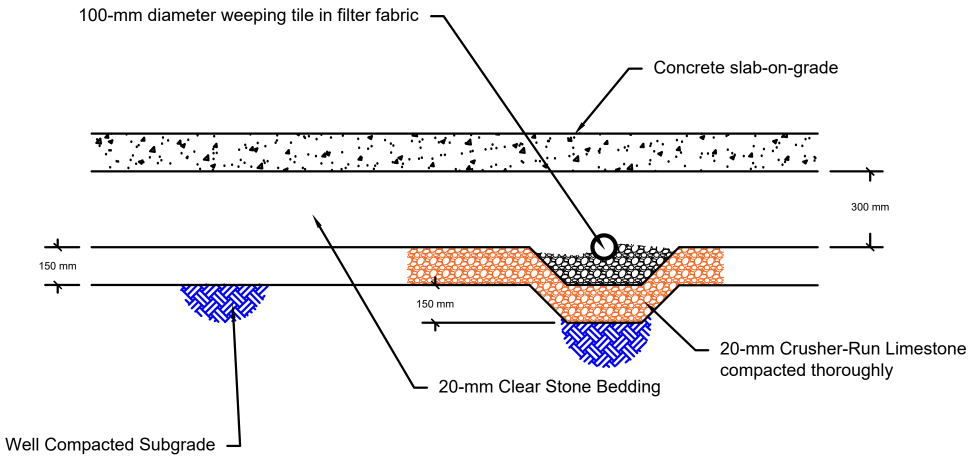
Permanent Perimeter Drainage System with Shoring

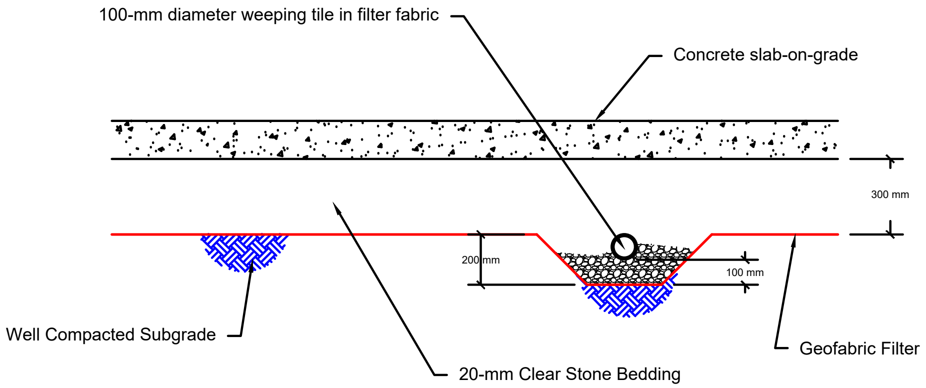
SITE: Veteran's Lane, City of Barrie

DESIGNED BY: D.Y.	**CHECKED BY:** B.S.	**DWG NO.:** 4
SCALE: N.T.S.	**REF. NO.:** 1901-S014	**DATE:** May, 2019

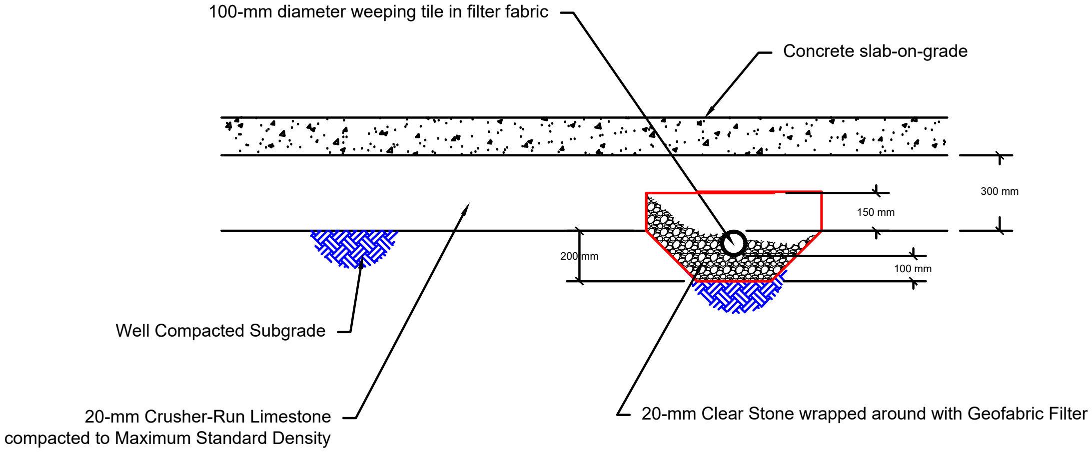
REV -



Option 'A'



Option 'B'



Option 'C'

Note:

1. Weepers should be placed in 6 m grids, draining in a positive gradient towards an outlet or a sump pit for removal by pumping.
2. A 10-mil polyethylene sheet should be specified between the gravel bedding and concrete slab.

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Details of Under-Floor Weepers

SITE: Veteran's Lane, City of Barrie

DESIGNED BY: D.Y. **CHECKED BY:** B.S. **DWG NO.:** 5

SCALE: N.T.S. **REF. NO.:** 1901-S014 **DATE:** May, 2019 **REV** -